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Direct Testimony and Schedules
Arik C. Forsman

Before the Minnesota Public Utilities Commission

State of Minnesota

In the Matter of the Application of Minnesota Power
For Authority to Increase Rates for Electric Utility
Service in Minnesota

Docket No. E015/GR-26-199

Exhibit _____

CUSTOMER OVERVIEW AND SALES FORECAST

November 2, 2026

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I. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name and business address.

A. My name is Arik C. Forsman, and my business address is 30 West Superior Street, Duluth, Minnesota 55802.

Q. By whom are you employed and in what position?

A. I am employed by ALLETE, Inc. ("ALLETE"), doing business as Minnesota Power ("Minnesota Power" or the "Company"). My current position is Director – Strategic Accounts.

Q. Please summarize your qualifications and experience.

A. I have been with Minnesota Power for approximately 14 years and have experience in the electric industry that includes strategic account management, customer program development, regional economic development, and human resources.

In my current position with Minnesota Power, I am responsible for several customer focused areas that include customer accounts and relationships for Minnesota Power's commercial, industrial, and wholesale customers. The commercial, industrial, and municipal account team that I lead focuses on strategic account management, Energy Conservation and Optimization ("ECO") programs, and economic and regional development.

Prior to my current role, I held the position of Regional Development Lead. In that role, I was responsible for regional economic development activities, primarily focusing on potential new or expanding commercial and industrial customers. I previously held positions in ALLETE/Minnesota Power's Human Resources department, with a focus on labor/employee relations, talent acquisition, and compensation.

Before joining Minnesota Power, I was employed for three years in human resources for Saint Louis County, Minnesota. I graduated from the University of Minnesota

Duluth with a bachelor's degree in business administration. I am originally from Aurora, Minnesota and have been a lifelong Minnesota resident.

Q. What is the purpose of your testimony?

A. The purpose of this testimony is to provide an overview of Minnesota Power's customer base, the high-quality services and programs Minnesota Power provides to its customers, and the resulting sales, revenues, and overall health and risk profile of our utility. First, my testimony provides an overview of Minnesota Power's customer base and the associated utility service needs of those customer classes. I will also describe Minnesota Power's services to customers, including several areas particularly relevant to current state policy, to the value provided to Minnesota Power's customers, and to the communities the Company serves. My testimony also presents the test year sales and customer count forecast for the 2027 test year, including recent trends in customer count and energy use by customer class. I also describe the methodology used to develop the forecast in order to demonstrate the reasonableness of Minnesota Power's 2027 test year outlook. Further, I provide an overview of Minnesota Power's energy sales trends for all customer classes and economics surrounding the Large Power ("LP") and Very Large Power ("VLP") customer groups from both industry and individual business perspectives and the need for the proposed Sales Adjustment Mechanism to address material variations in LP and VLP sales and allow the resulting revenue increases or decreases to be reflected between rate cases.

Q. Please summarize the 2027 test year energy sales and customer count forecast.

A. The Company's 2027 test year retail sales forecast, as shown in Table 1, is for total retail sales of 7,602,374 megawatt-hours ("MWh"). This is approximately 0.76 percent higher than 2025 actual retail sales (7,544,817 MWh) and about 6.8 percent lower than a historical three-year average (2023–2025). The Company's 2027 test year retail sales forecast is also provided in MP Exhibit ___ (Forsman), Direct Schedule 1. As I detail later in my testimony, the vast majority of this projected change from prior years is attributable to the declining average level of Industrial customer sales related to mines idling production, and increasing volatility of Industrial customer operations. The 2027

test year forecast for other customer classes is otherwise comparable to recent years' actual sales. The Company's test year sales forecast provides a reasonable estimate of 2027 test year sales and customer counts and should be adopted for the purpose of determining the revenue requirement and final rates in this proceeding.

Table 1. 2027 Test Year Energy Sales and Customer Count

	2027 Test Year	
	Energy Sales (MWh)	**Customer Count**
Residential	1,027,912	126,974
Commercial	1,177,148	25,510
Industrial		
Mining and Metals	4,036,704	9
Paper and Pulp	729,435	5
Pipelines	319,723	2
Other Industrial	259,848	393
Total Industrial	5,345,710	409
Public Authorities & Lighting	51,604	1,037
Total Retail	**7,602,374**	**153,930**
Municipals	761,560	
SWLP	1,082,570	
Total Retail and Wholesale	**9,446,504**	

Q. Please discuss any compliance requirements related to the sales forecast from the Company's prior rate cases.

A. Order Point 19 of the Minnesota Public Utilities Commission's ("Commission") November 2, 2010, Order in the Company's 2009 rate case (Docket No. E015/GR-09-1151) required the Company to provide in all future rate cases, "all data used in its test year sales forecast at least 30 days before filing the rate case."[1] This information was e-filed in the current docket by the Company on October 1, 2026 through the Commission's electronic filing system.

[1] *In the Matter of the Application of Minnesota Power for Authority to Increase Rates for Electric Service in Minnesota*, Docket No. E015-GR/09-1151, FINDINGS OF FACT, CONCLUSIONS, AND ORDER at Order Point 19 (Nov. 2, 2010) (eDocket No. 201011-56128-01).

Q. Has Minnesota Power also filed its 2026 Annual Electric Utility Forecast Report?

A. Yes, as required by Minnesota Rules Chapter 7610, Minnesota Power submitted its 2026 Annual Forecast Report ("AFR") on July 1, 2026, in Docket No. E999/PR-26-11. Minnesota Power's 2026 AFR is included in Volume 4, Workpapers, OS-4.

Q. How is your testimony organized?

A. My testimony is organized as follows:

- In Section II, I provide an overview of our customers;
- In Section III, I discuss customer service and economic development;
- In Section IV, I describe the test year sales forecast and methodology;
- In Section V, I describe the customer outlook and sales trends;
- In Section VI, I describe the Company's proposed Sales Adjustment Mechanism; and
- In Section VII, I conclude my testimony.

Q. Are you sponsoring any exhibits in this proceeding?

A. Yes. I am sponsoring the following schedules to my Direct Testimony:

- MP Exhibit ___ (Forsman), Direct Schedule 1 – 2027 Test Year Energy Sales and Customer Count (Sales Forecast);
- MP Exhibit ___ (Forsman), Direct Schedule 2 – Demand Response and Energy Efficiency Studies;
- MP Exhibit ___ (Forsman), Direct Schedule 3 – Customer Income Statistics and Assistance Programs;
- MP Exhibit ___ (Forsman), Direct Schedule 4 – News Articles Regarding Mining, Steel, and Industrial Developments;
- MP Exhibit ___ (Forsman), Direct Schedule 5 – Steel Industry Annual and Sustainability Reports;
- MP Exhibit ___ (Forsman), Direct Schedule 6– City of Hermantown, Information Regarding Potential Google Data Center;
- MP Exhibit ___ (Forsman), Direct Schedule 7 – Minnesota Power's Approved 2024 Test Year Energy Sales Compared to 2025 Actual Energy Sales;

- MP Exhibit ___ (Forsman), Direct Schedule 8 – Comparison of Minnesota Power's 2026 AFR Forecast and 2027 Test Year;
- MP Exhibit ___ (Forsman), Direct Schedule 9 – Iron Ore and Steel Industry Production and Market Data;
- MP Exhibit ___ (Forsman), Direct Schedule 10 – Congressional Research Service, Section 232 Tariffs on Steel and Aluminum (May 18, 2026);
- MP Exhibit ___ (Forsman), Direct Schedule 11 – Corporate Announcements, Press Releases, and Public Disclosures;
- MP Exhibit ___ (Forsman), Direct Schedule 12– World Bank, Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition (2020); and
- MP Exhibit ___ (Forsman), Direct Schedule 13 – NorthMet Project Development and Permitting Materials.

II. CUSTOMER OVERVIEW

Q. What is the purpose of this section of your testimony?

A. In this section, I provide an overview of Minnesota Power's unique customer mix and its impacts on the overall health and risk profile of our utility and region.

A. Minnesota Power's Customers

Q. Please provide an overview of Minnesota Power's customer mix.

A. Minnesota Power serves approximately 150,000 retail electric customers, including some of the nation's largest industrial customers across a 26,000 square mile service area located in central and northern Minnesota. The Company also serves Superior Water Light & Power ("SWLP") in Superior, Wisconsin, and 14 municipal systems as wholesale customers.

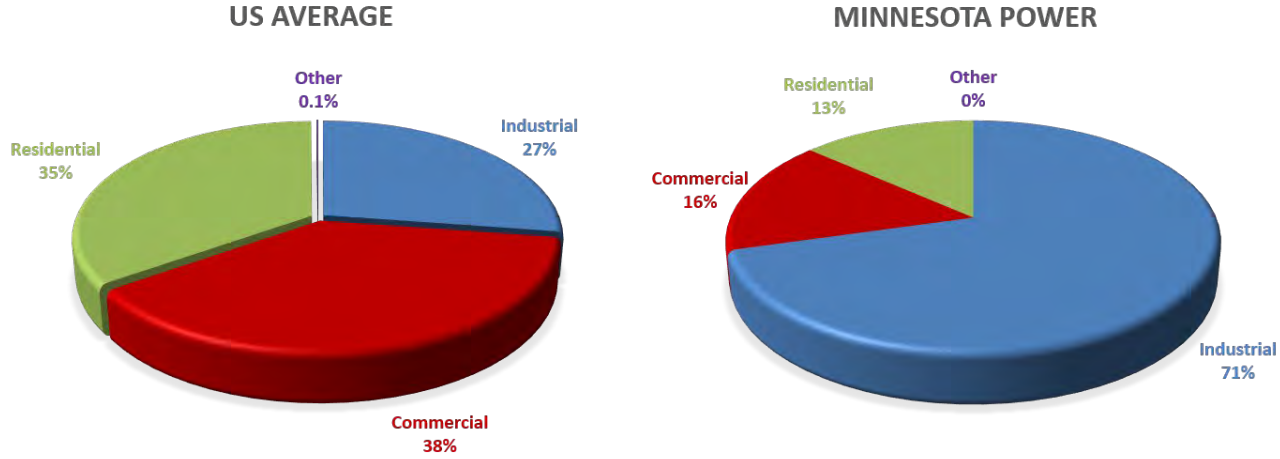
Q. Please describe the customer classes used in Minnesota Power's retail customer and sales forecasts.

A. The Company projects energy use and customer counts for each of its five retail customer classes: Residential, Commercial, Industrial, Public Authorities, and Lighting.

Given its size, the Industrial class is currently segmented into four sectors for forecasting purposes: Mining and Metals, Forest Products, Pipelines, and Other Industrial sectors.

In 2025, Minnesota Power's retail customer mix included approximately 126,500 residential, 25,200 commercial, 400 industrial customers, and 1,060 public authorities and lighting customers. Minnesota Power's system is, however, dominated by large industrial customers with approximately 71 percent of retail kilowatt-hours ("kWh") energy sales to this customer class in 2025 and only 13 percent and 15 percent of sales to residential and commercial customers, respectively. For comparison, the average utility in the United States sells just 23 percent of its retail kWh energy sales to industrial customers and sells 41 percent and 35 percent of retail kWh energy sales to residential and commercial customers, respectively, as shown in Figure 1 below.

Figure 1. Minnesota Power's Customer Mix is Unique



1. Industrial Customers

Q. Who are Minnesota Power's industrial customers?

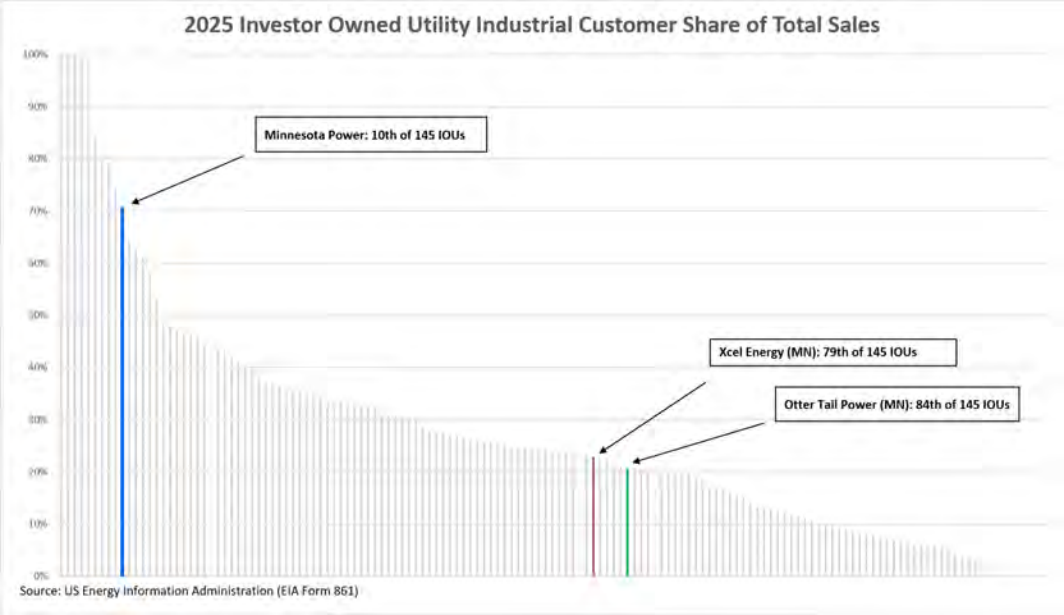
A. Minnesota Power has approximately 400 industrial customers that are served under the Company's Large Light & Power ("LLP") and LP rate schedules. Among the industrial customers are eight active LP customer contracts, each serving at least 10 megawatts ("MW") of load. Two companies manage six taconite-producing facilities under four

LP customer contracts, and four companies manage tissue, paper, and pulp mills under four LP customer contracts. The Company also has two companies that manage pipeline systems under LLP service schedules. These customers are among some of the largest industrial operations in the nation and together constitute the majority of the customer sales on Minnesota Power's system.

Q. How does Minnesota Power's industrial concentration compare to other utilities?

A. Minnesota Power has one of the highest industrial customer concentrations of any utility in the United States, and this concentration is significantly higher than any other utility in Minnesota. According to 2025 energy consumption data from the Energy Information Administration ("EIA"), Minnesota Power had the 10th highest industrial customer energy usage concentration out of 145 investor-owned utilities, including related subsidiaries, with industrial customers representing approximately 73 percent of retail kWh energy sales during that year. This industrial concentration is considerably different than other utilities in the state and most of the nation as illustrated by Figure 2 below.

Figure 2. Industrial Customer Concentrations of Investor-Owned Utilities in the United States



Minnesota Power's large industrial customers are also unique in their size relative to the size of the utility that provides their electric service. Figure 3 below shows that just two companies (*i.e.*, Cleveland-Cliffs, Inc. ("Cleveland-Cliffs") and United States Steel Corporation ("U.S. Steel")) own and operate all six producing taconite mining facilities in Minnesota that accounted for over 50 percent of Minnesota Power retail kWh energy sales in 2025. The forest products category, which accounted for 10 percent of retail kWh energy sales in 2025, is composed of four customers. The pipelines category, which accounted for four percent of retail kWh energy sales in 2025, is composed of two customers. The remaining approximately 390 other industrial customers account for four percent of retail kWh energy sales.

This uniqueness in Minnesota Power's customer mix is rooted in the abundant natural resources of northern Minnesota that serve as the raw material for the nation's steel and forest products and its geographic location along the shortest path for pipelines from oil production fields in North Dakota and Canada to supply major population centers around the lower Great Lakes with petroleum products. As a result, Minnesota Power's large industrial customers primarily consist of taconite, paper and pulp producers, and

pipelines. These industries, like Minnesota Power itself, are a significant component of the regional economy in northern Minnesota. Minnesota Power's current large industrial customers are also concentrated in highly cyclical industries, particularly mining and paper.

This cyclicality and volatility are not theoretical, and reflect another unique element of Minnesota Power's customer concentration. Recent production decisions by taconite producers illustrate that large industrial operations continue to adjust output through abrupt idling or partial idling decisions based on market conditions, corporate strategy, and operational constraints. For example, in 2025, Minorca was fully idled, while Hibbing Taconite experienced a partial idling of operations. These decisions resulted in material reductions in energy consumption over short time frames and are consistent with the historical operating patterns of Minnesota Power's mining customers.

Figure 3. Minnesota Power Retail Energy Sales by Customer Class (2025)



Q. How are Minnesota Power's sales concentrated amongst facility ownership?

A. Minnesota Power has one of the highest concentrations of sales among a small number of customers of any utility in the United States. For example, over half of Minnesota

Power's retail sales are attributed to just two entities, U.S. Steel and Cleveland-Cliffs. Nearly two-thirds of Minnesota Power sales are attributed to just four entities: U.S. Steel, Cleveland-Cliffs, UPM Blandin, and Enbridge.

2. Residential Customers

Q. Please describe Minnesota Power's residential customers.

A. Minnesota Power's approximately 126,500 residential customers take service under the Company's Residential rate schedules. Minnesota Power's residential customers generally use less energy than the Minnesota average, due in part to lower cooling load in the summer months attributable to the cooler northern climate and the longstanding success of Minnesota Power customer engagement in its ECO programs. Minnesota Power's residential customers also tend to have lower incomes than the rest of the state, and the Company has focused on providing affordability programs and rate designs to support the segment of its customer base that is low income, as I describe later in this testimony. From a system-level perspective, the most unique aspect of Minnesota Power's residential class is how small it is relative to the typical utility; Minnesota Power's residential sales accounted for just 13 percent of retail sales and 19 percent of retail revenues in 2025. For the typical U.S. utility, the residential class is generally the largest class of customers as measured by both revenue and kWh energy sales.

3. Commercial Customers

Q. Please describe Minnesota Power's commercial customers.

A. Minnesota Power's approximately 25,200 commercial customers take service under the Company's General Service rate schedules and differ from the typical utility commercial customer mix due to a higher concentration of customers in retail and healthcare-related business segments. Minnesota Power's commercial customers also use about 39 percent less electricity than the average Minnesota commercial customer according to the EIA. Minnesota Power's commercial class is relatively small compared to the typical U.S. utility; the Company's sales to commercial customers accounted for just 15 percent of retail sales and 20 percent of retail revenues in 2025. The commercial

class in a typical utility represents the second largest class of customers as measured by both revenue and kWh energy sales.

4. Public Authorities & Lighting

Q. Please describe Minnesota Power's Public Authorities and Lighting customers.

A. Minnesota Power's public authorities and lighting customers constitute approximately one percent of the Company's retail energy sales. Public authorities customers take service under the Company's Municipal Pumping rate schedule for service to water pumping and sewage disposal facilities; however, this rate schedule is closed to new customers and existing customers are gradually being transitioned to an alternative applicable rate schedule. Lighting customers take service under the Company's Street and Highway Lighting Service rate schedule, which is applicable for governmental subdivisions that take street or highway lighting service within the Company's service territory.

B. Impacts of Minnesota Power's Customer Mix on Sales Forecast Risk

Q. Can you provide more information regarding how the significantly high concentration of industrial customer load and sales affects Minnesota Power's rates and revenues?

A. The high concentration of industrial customer sales and corresponding industry cycles create a uniquely high level of risk for Minnesota Power. During strong production years, these customers' high load factors and large energy consumption contribute to overall efficient use of Minnesota Power's system assets, which contributes to lower electric rates for all customers. However, Minnesota Power's industrial customers are also subject to significant and occasional swings in their operations due to broad economic cycles and industry-specific impacts of global trade and competition, technology evolution, and evolving consumer preferences for the products they manufacture. These industrial customers often respond by fully or partially idling production, and as a result, energy usage by the industrial customer class can change sharply rather than gradually. When facilities fully idle production, system load declines materially over a short period of time. When facilities partially idle, the magnitude and

duration of the reduction is uncertain and difficult to forecast. These step-change operating decisions have occurred repeatedly over time, including most recently in 2025, and contribute to year-to-year variations in energy usage that can exceed the total annual energy consumption of Minnesota Power's residential customer class.

During low production years, the idling of large industrial facilities results in a parallel loss of energy sales and overall system efficiency, both of which contribute to substantial revenue shortfalls for Minnesota Power when the industrial sales forecast is set at higher levels during a rate proceeding. When the industrial customer sales level is set above the typical, average level of production in a rate proceeding, the benefits of Minnesota Power's industrial concentration accrue to customers through lower rates regardless of industrial operating levels, and Minnesota Power is subject to the risk of substantial loss of revenue when facilities are temporarily idled. Inversely, when the industrial sales level is set at lower levels during a rate proceeding, other customers have higher rates regardless of industrial operating levels.

The high concentration of industrial customer sales dramatically increases the risk profile of Minnesota Power compared to other electric utilities in the state and across the nation. This increased risk and volatility has an adverse impact on Minnesota Power's business and financing capabilities, as it puts pressure on ALLETE's credit rating, resulting in higher rates for all customers. This is discussed further in the direct testimony of Company witness Joshua D. Taran.

Q. How does the Company's significantly high concentration of industrial customer load and sales affect the overall efficiency and cost effectiveness of the Company's system?

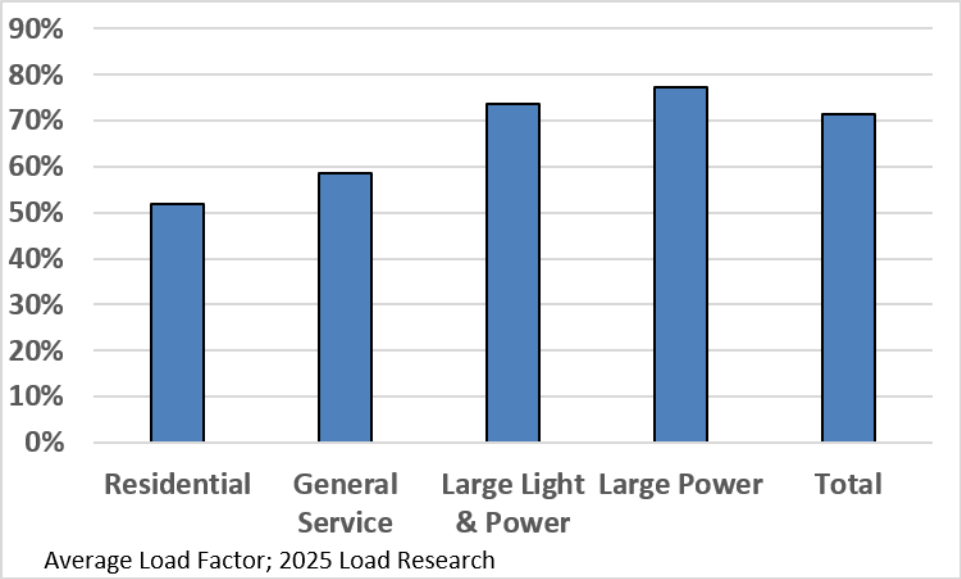
A. Minnesota Power's customer composition impacts the Company in a variety of complex ways, and two of the more significant and straightforward factors are described below.

First, LP industrial customer demand is delivered almost exclusively via an efficient high-voltage transmission system. The high concentration of industrial customers on

Minnesota Power's system means a significant share of total energy is delivered efficiently with minimal energy loss, since their energy is metered and billed at the high-voltage delivery point without any further losses associated with transformation to lower voltage levels and delivery through the distribution system.

Second, the Company's LP industrial customer demand for energy, when they are operating, is extremely consistent. These customers operate 24 hours per day, seven days per week, and 365 days per year, which makes very efficient use of generation and transmission assets. By contrast, residential and commercial customers have extremely variable demand for energy that leaves generation, transmission, and distribution assets under or unutilized during periods of low demand. This variability of demand is measured using a metric called "load factor." A high load factor results in more energy flowing across the fixed system assets providing higher economic efficiency and lower costs, while a low load factor results in less energy flowing across the fixed system assets contributing to less economic efficiency and higher costs per unit of energy. The high concentration of these high load factor industrial customers on Minnesota Power's system raises the system's overall load factor. Minnesota Power's load factor by rate class is shown in Figure 4 below. Note the significantly higher load factor by the LP class compared to Residential and General Service (*i.e.*, commercial customers), which increases the total load factor on Minnesota Power's system.

Figure 4. Load Factor by Rate Class



The industrial customers' high load factors and use of the transmission system for delivery allow Minnesota Power to spread its fixed system costs over a larger quantity of sales when those customers are operating, benefiting all customers through lower average electric rates, independent of any type of specific class rate design and allocation factor. However, a reduction in industrial production does not produce a corresponding reduction in the infrastructure and ongoing work needed to provide reliable electric service. The Company must continue maintaining the shared system that serves its customers and remain prepared to meet industrial customers' requirements consistent with their service agreements and reasonably anticipated operating needs. A temporary or partial idling therefore reduces sales more quickly than it reduces these continuing system costs.

Lower industrial sales also do not suspend the Company's applicable reliability, environmental, or carbon-free energy requirements. Minnesota Power must continue planning and making necessary investments to meet those requirements while evaluating project scope, timing, and opportunities to contain costs. As described in the Direct Testimony of Company witness Joshua G. Rostollan, cost-containment efforts are incorporated into the Company's budgets. Those efforts, however, do not eliminate

the continuing costs of maintaining and transforming the system when industrial sales decline.

Q. How does Minnesota Power's unique customer mix inform the Company's assessment of customer operations, system flexibility, and sales forecast risk?

A. Minnesota Power's unique customer mix affects not only annual energy sales, but also the Company's understanding of customer operations, system needs, and customer-provided flexibility. In particular, the Company maintains contractual relationships with its industrial customers to deliver some of the largest quantities of demand response for a utility of its size at approximately 300 MW, or approximately 20 percent of the peak load. This is the highest percentage of industrial demand response in the state and the second highest percentage in the United States among investor-owned utilities, at a level that is nearly triple the national average demand response level of 6.5 percent in 2025.[2] This represents a unique benefit that Minnesota Power's largest customers provide to the system. This customer-provided flexibility is another reason Minnesota Power closely monitors industrial customer operations and incorporates its understanding of those operations into its assessment of sales forecast risk.

III. CUSTOMER PROGRAMS AND ECONOMIC DEVELOPMENT

Q. What is the purpose of this section of your testimony?

A. In this section, I describe key programs and initiatives Minnesota Power provides to support customers and communities throughout its service territory. These efforts include affordability programs, ECO initiatives, transportation electrification activities, service to large power customers, and regional economic development efforts. Together, these programs support customer needs, promote efficient use of energy, and help strengthen the long-term economic vitality of the region.

[2] MP Exhibit ___ (Forsman), Direct Schedule 2 at 1-45.

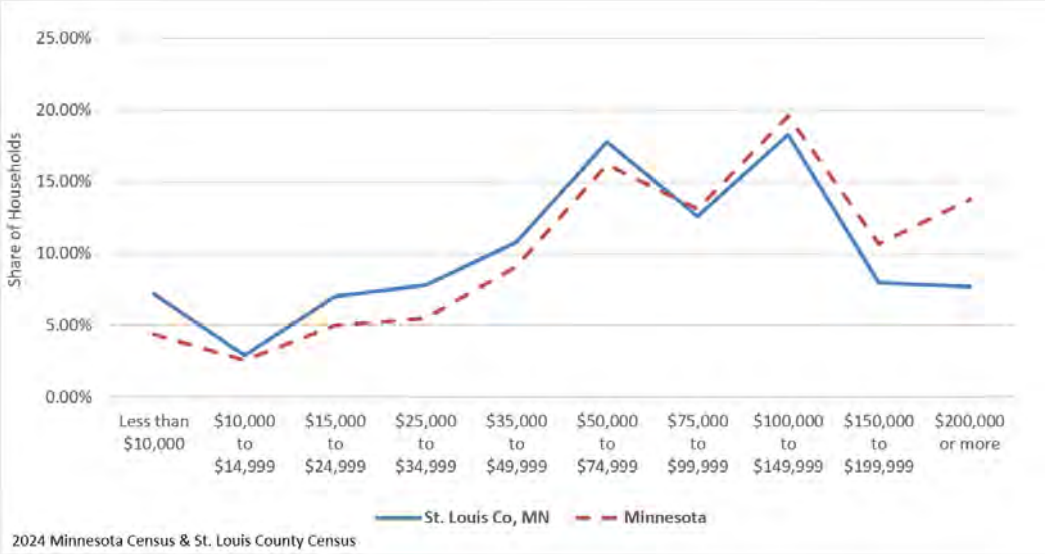
A. Program Support for Low-Income Customers

Q. Are Minnesota Power's low-income residential customers unique in their need for energy assistance?

A. In some ways, yes. Households served by Minnesota Power have household incomes that tend to trend lower than Minnesota as a whole. For example, recent data show that St. Louis County's family poverty rate of 6.7 percent in 2024,[3] remains higher than the statewide rate of 5.7 percent[4] as shown in Figure 5 below.

As a result, a meaningful portion of Minnesota Power's residential customers may need assistance with their electric bill. This is particularly important in northern Minnesota, where cold weather, winter heating needs, and household income constraints are all factors.

Figure 5. Comparison of Household Incomes



Q. Does Minnesota Power offer rates or programs to assist low-income customers?

A. Yes. Minnesota Power complements its customer base with lower-than-average incomes with best-in-class low-income customer programs. Minnesota Power offers an Income- and Usage-Qualified Discount to residential customers who average 1,000

[3] MP Exhibit ___ (Forsman), Direct Schedule 3 at 1-16.
[4] MP Exhibit ___ (Forsman), Direct Schedule 3 at 17-34.

kWh or less per month and have been approved for energy assistance or self-declared as income-eligible. This discount was developed through extensive stakeholder input as part of the Company's residential rate transition efforts and reflects the Company's effort to support affordability while continuing to advance beneficial electrification and system decarbonization.

In addition to rate discounts, Minnesota Power offers a variety of programs and services for income-eligible customers. These include our Customer Affordability of Residential Electricity ("CARE") program, energy efficiency, and solar offerings. I will describe each of these in turn below.

Q. Please discuss recent changes to the CARE program related to energy affordability.

A. Minnesota Power has offered its CARE program to its residential customers since November 1, 2011. This program was created as a result of a 2010 Commission Order in Minnesota Power's general rate case under Docket No. E015/GR-09-1151. Annual reporting and program modifications related to CARE have since been handled through a separately assigned CARE docket.[5]

CARE provides bill assistance to low-income residential customers through two primary forms of discount support. First, the program includes a monthly flat discount, currently $20 per month, for eligible customers. Certain customers who qualify for Minnesota's Energy Assistance Program and are senior or living with a disability are automatically enrolled. Customers can qualify under the federally funded Low Income Home Energy Assistance Program ("LIHEAP"), as determined by application through Energy Assistance Program Service Providers ("EAP") or by completing a self-declaration process, which is only open to first time enrollments in the Income and Usage-Qualified Discount and requires application and qualification for EAP in order to keep the CARE discount for more than one year.

[5] *In the Matter of Minn. Power's Petition for Approval of a Rider for Customer Affordability of Residential Elec.*, Docket No. E015/M-11-409, COMPLIANCE FILING (Dec. 10, 2012) (eDocket No. 201212-81591-01).

Second, CARE includes an affordability credit for qualifying customers whose electric bills exceed a targeted percentage of household income. The affordability discount is designed to provide more meaningful assistance to customers with higher energy burdens and is offered on a first-come, first-served basis.

Q. Please describe Minnesota Power's energy conservation programs that are specifically designed for its low-income customers.

A. Minnesota Power's Energy Partners program focuses on empowering low-income customers to save energy and manage energy costs. The program provides education, in-home energy analysis, direct installation of energy-efficient products, and replacement of inefficient appliances. Low-income customers with electric space heating or electric water heating may also qualify for additional upgrades, such as cold-climate air source heat pumps, programmable thermostats, or heat pump water heaters. Through Energy Partners, Minnesota Power works with local agencies and service providers to deliver practical energy-saving measures to customers who may benefit most from lower usage and lower monthly bills. These efforts help reduce energy burden and monthly bills while also supporting the Company's broader energy efficiency and affordability goals.

Q. Please describe Minnesota Power's solar program for its low-income customers.

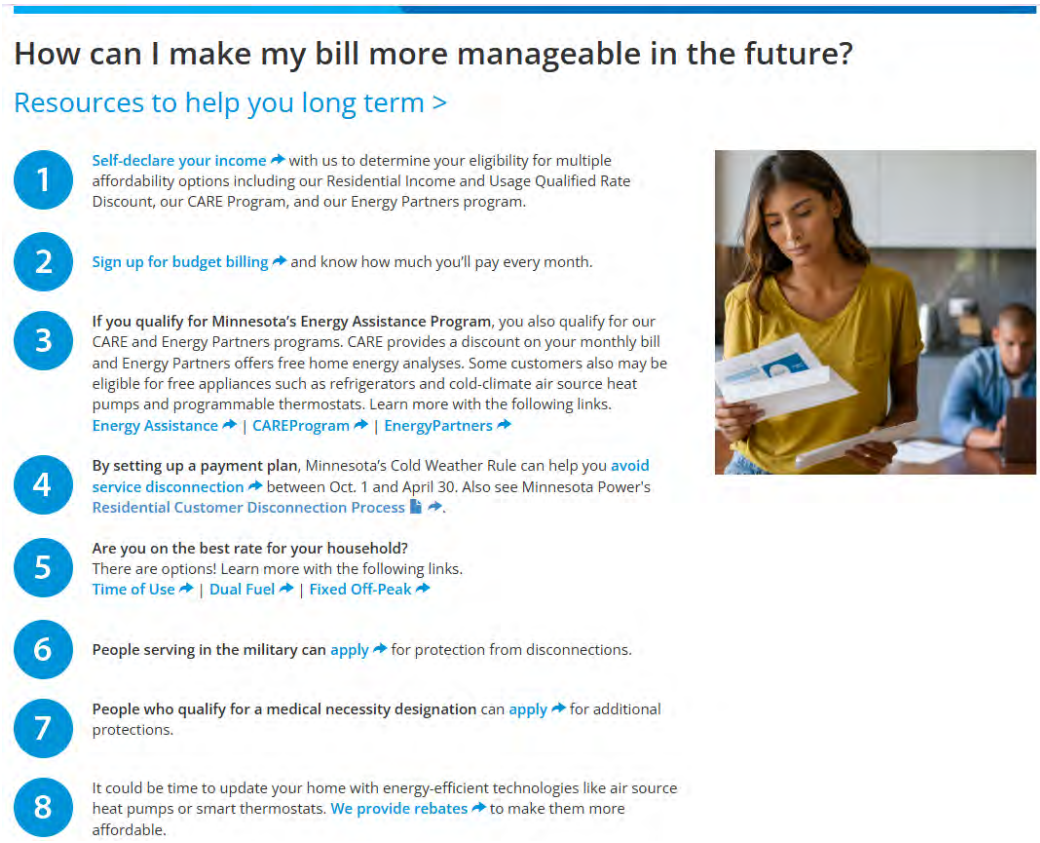
A. Minnesota Power's low-income solar program is designed to expand access to solar power for customers who may otherwise face barriers to participation. The program provides funding for solar projects that benefit low-income customers or facilities that serve low-income customers. Applications may be submitted by customers, community groups, low-income support organizations, solar installers, or developers. A committee of seven Minnesota Power employees and seven regional stakeholders review applications and award funding to projects based upon established eligibility criteria that includes energy conservation, accessibility and empowerment, customer protection and affordability, sustainability and flexibility, community engagement, innovation, and accountability. This program has been successful in supporting 37 projects with

approximately $883,000 in incentives to provide 420 kW of solar to support our low-income customers. By supporting projects that directly benefit low-income customers and community-serving facilities, the program helps broaden participation in renewable energy while maintaining a focus on affordability.

Q. Is Minnesota Power reaching out to support its low-income and economically challenged customers in any other ways?

A. Yes. Minnesota Power has made concerted efforts to connect low-income and economically challenged customers with available energy assistance funding from state and federal agencies, affordability programs, and payment support to help customers get back on track with their energy bills and avoid disconnection. Minnesota Power added outbound calling to customers and prioritized energy assistance links on its app and website so customers see them first upon accessing these channels. A website communication example is shown in Figure 6 below.

Figure 6. Minnesota Power Website Communication for Energy Assistance



Since the Company's last rate case, Minnesota Power also launched the On Track program to provide additional support for residential customers with past-due balances. On Track helps eligible customers through payment arrangements, a 100 percent dollar-for-dollar match on payments made toward past-due balances under those arrangements, and a $20 monthly bill credit for customers who remain current on both their regular monthly bill and their payment arrangement.[6] Unlike many traditional bill assistance programs, On Track does not include income eligibility requirements, allowing the program to reach customers who may not qualify for existing income-based assistance but still need short-term help bringing their accounts current.

It is also important to note that On Track is funded through $3.14 million shareholder-funded commitments associated with the acquisition of ALLETE, rather than through

[6] MP Exhibit ___ (Forsman), Direct Schedule 3 at 35-38.

customer rates. The program is part of the broader package of customer benefits approved in connection with the acquisition and is designed to provide practical assistance with past-due balances while maintaining Minnesota Power's broader focus on affordability, reliability, and customer support.

B. Energy Conservation and Optimization Program

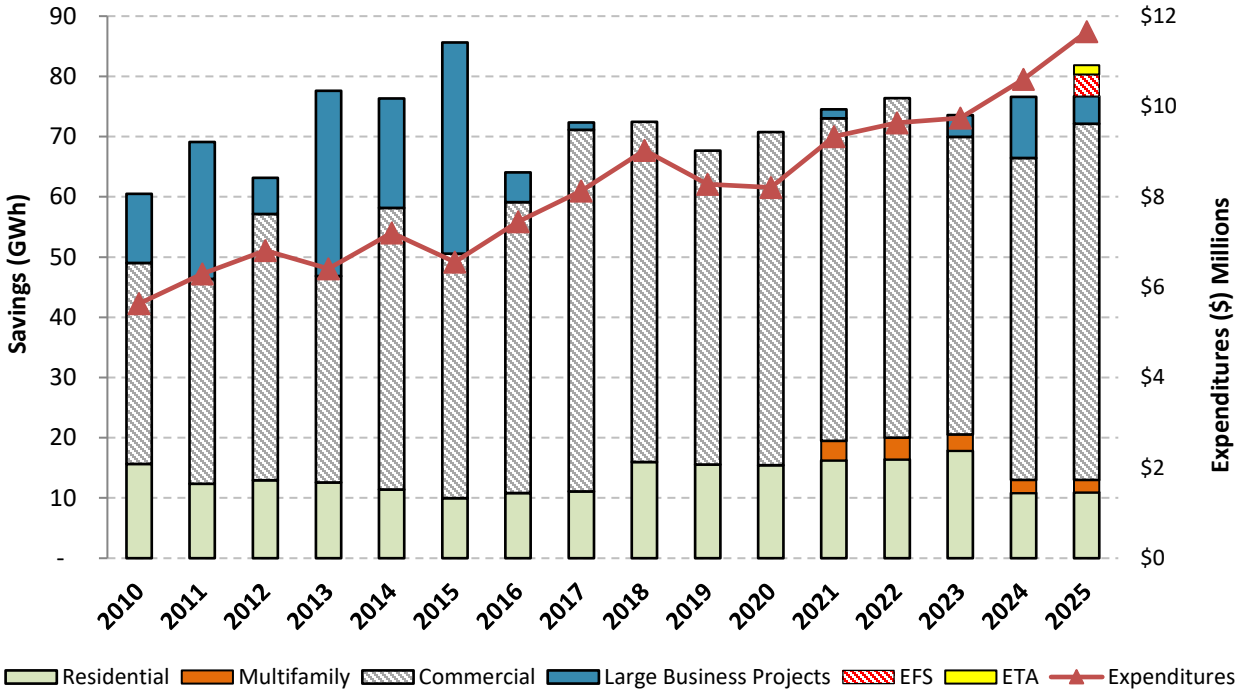
Q. How is Minnesota Power performing with respect to its ECO goals?

A. Minnesota Power has consistently met or exceeded its energy conservation and optimization goals, including in 2025. Minnesota's long-standing Conservation Improvement Program ("CIP") was modernized through the Energy Conservation and Optimization Act of 2021 and is now commonly referred to as "ECO." ECO preserves the core energy-efficiency objectives of CIP while expanding the framework to include additional opportunities such as load management and efficient fuel switching ("EFS"). For Minnesota Power, the 2025 approved kWh savings goal equates to 1.75 percent of ECO-eligible retail sales. Minnesota Power exceeded its 2025 approved savings goal by achieving 3.2 percent savings as a percentage of adjusted sales.[7]

This is an ongoing success story for Minnesota Power and our customers. The Company has exceeded ECO goals every year since 2010, when the 1.5 percent energy-savings goal went into effect. Minnesota Power has also continued to expand energy savings efforts, including the addition of EFS savings beginning in 2025, as shown in Figure 7 below. This strong performance with energy conservation and EFS programs has helped keep customers' total bills lower in a rising rate environment.

[7] *2025 Conservation Improvement Program Consolidated Filing,* Docket Nos. E015/M-26-48, E015/CIP-23-93, CONSOLIDATED FILING (May 1, 2026) (eDocket No. 20265-231388-01).

Figure 7. Minnesota Power CIP Energy Savings 2010-2025



C. Transportation Electrification

Q. Please describe Minnesota Power's Transportation Electrification programs.

A. Minnesota Power continually evaluates emerging technologies, evolving customer needs, and program opportunities to identify the resources and initiatives that can advance beneficial transportation electrification across its service territory. The Company described its current and planned transportation-electrification activities in its 2025 Transportation Electrification Plan ("TEP"), which the Commission approved on September 1, 2026, in Docket No. E015/M-25-140.

Minnesota Power supports transportation electrification through a portfolio of customer- and infrastructure-focused programs. These programs include discounted rates that encourage off-peak electric vehicle ("EV") charging, rebates intended to reduce the upfront cost of EV ownership, and a Make Ready pilot designed to reduce barriers to the deployment of charging infrastructure, with particular emphasis on multi-dwelling-unit ("MDU") properties. The MDU program has been granted deferred accounting treatment; however, Minnesota Power is not seeking recovery of those costs

in this rate case. In addition, the Company has proposed transportation-electrification rebates in its most recent ECO triennial filing. If approved, costs associated with those rebates would be recovered through the ECO cost-recovery mechanism rather than through this rate case.

Minnesota Power also recognizes that reliable, accessible public EV charging infrastructure is an important consideration for EV adoption in northern Minnesota. The Commission previously approved the Company's proposal to install direct-current fast-charging ("DCFC") stations throughout its service territory. These stations are intended to expand public charging access across the region and promote efficient charging behavior through time-based rate structures. The DCFC project is discussed further in the Direct Testimony of Company witness Joshua P. Goutermont.

Q. Does Minnesota Power have plans to propose additional programs to support Transportation Electrification?

A. Yes. As required by the Commission's approval of Minnesota Power's TEP, the Company will develop and propose a commercial-fleet program and report on its progress in developing residential charging options and partnerships for a car-sharing program in its next TEP filing, due November 1, 2028. Any costs associated with future transportation-electrification programs will be proposed and addressed through the TEP process and are not included for recovery in this rate case.

D. Large Power Customer Service Quality

Q. What steps has Minnesota Power taken to continually enhance quality electric service to its LP customers?

A. Minnesota Power has worked diligently with our LP customers to support their needs as their markets change, and one of the primary methods to improve the service for these customers is through the customer specific Electric Service Agreements ("ESA"). A recent example includes Minnesota Power's work with ST Paper and successor Sofidel to support their conversion and ultimate restart of the Duluth mill after Verso Paper closed. Minnesota Power and ST Paper entered into a new ESA on January 29, 2022,

which was approved by the Commission on May 16, 2022, in Docket No. E015/M-22-96. This ESA allowed ST Paper the flexibility of a startup period under LLP rates while the mill was idle and undergoing a conversion, before ultimately advancing to an LP ESA in March 2023 to match the demand and energy needs of the operation once startup was complete. Furthermore, this ESA leveraged the Business Expansion Incentive Rider to help the customer during initial years of operation following the significant reinvestment required to convert the facility to a tissue manufacturing operation. In January 2024, Sofidel acquired the facility from ST Paper and has since broken ground on a $200 million expansion that will add over 160 new jobs to the facility.[8] The expansion has begun commissioning and operations starting in 2026.

Q. What other ways does Minnesota Power support the customer service quality for LP Customers?

A. Minnesota Power meets regularly with LP and LLP customers to understand the energy needs of their businesses, with an ongoing focus on maintaining reliability, while balancing competitiveness with an increasingly renewable power supply. Customer discussions continue to involve corporate sustainability objectives. Minnesota Power is already a leader in the State and ahead of most utilities in the region and nation with a base energy supply that delivers between 50 and 60 percent renewable energy to its customers, and customers have recognized our efforts as we work to comply with new Minnesota requirements for 100 percent carbon-free energy by 2040.[9] However, some customers have sustainability goals that include an even higher obligation for sustainability, a timeline for decarbonization that differs from Minnesota Power's, or business desire for "green products" for certain markets or "zero-emission operations" in general. As a result of these customer conversations, the Company proposed and received approval for a new Voluntary Renewable Energy Rider for industrial customers in the 2023 rate case.

[8] MP Exhibit ___ (Forsman), Direct Schedule 4 at 1-2.
[9] MP Exhibit ___ (Forsman), Direct Schedule 5 at 1-88.

Q. Please discuss any relevant compliance requirements from the Company's prior rate cases.

A. Minnesota Power has continued to comply with Commission directives issued in prior rate cases, including directives related to customer engagement and rate design.

As part of the Commission's Order in Minnesota Power's 2023 Rate Case, the Company committed to discuss and work to address concerns raised by interested customers regarding the off-peak demand charge contained in the LLP Time-of-Day Rider.[10] In response, Minnesota Power conducted outreach and discussions with affected customers to better understand operational impacts and customer concerns related to the rider. These discussions provided valuable feedback regarding customer operations and energy usage patterns and continue to inform the Company's evaluation of rate design and customer service offerings for LLP customers. Notably, the Company's account management team engaged with two LLP customers to describe the benefits of off-peak operation and MP's off-peak rates. Both customers have converted and are experiencing cost reductions through this rate and their operations during off-peak hours.

Also consistent with the Commission's Order in the 2023 Rate Case, Minnesota Power initiated discussions regarding opportunities to mitigate rate concerns for LP and LLP customers and support continued customer operations in Minnesota.[11] The Company has dedicated account management staff who work directly with individual customers to understand how the Company can help meet their unique needs, including competitiveness, operational flexibility, and long-term business investment decisions. A focus in 2026 has been individual conversations with customers to share the Company's approach and gather feedback on plans to replace Demand Response Product C, a pilot that expires in 2028, with a new long-term demand response offering.

[10] *In the Matter of the Application of Minnesota Power for Authority to Increase Electric Service Rates in the State of Minnesota*, Docket No. E015/GR-23-155, ORDER ACCEPTING AND ADOPTING AGREEMENT SETTING RATES at 6 (Nov. 25, 2024) (eDocket No. 202411-212388-01).

[11] *In the Matter of the Application of Minnesota Power for Authority to Increase Electric Service Rates in the State of Minnesota*, Docket No. E015/GR-23-155, ORDER ACCEPTING AND ADOPTING AGREEMENT SETTING RATES at 6 (Nov. 25, 2024) (eDocket No. 202411-212388-01).

The Company also has been engaging with the Midcontinent Independent System Operator, Inc. ("MISO") to provide feedback on demand response programs so that they continue to continue to align with customer needs in the future, including participation with the Resource Adequacy Sub-Committee ("RASC"). The Company also hosts broader key customer meetings at least annually with customers and stakeholders to discuss topics including rates. The Company highlighted the importance of tools such as long-term demand response, as well as how macro trends like load growth opportunities, competitive projects for Integrated Resource Plan ("IRP") implementation, and rate cost allocation are important drivers and ways the Company and customers can work together to address affordability as shown in Figure 8 below. The discussions reinforced the importance of reliable electric service, competitive rates, and constructive engagement between Minnesota Power and its largest energy users.

Figure 8. Minnesota Power 2026 Key Customer Meeting Slide



E. Regional Economic Development

Q. How does the Company support economic development in the region?

A. The Company actively supports economic development in the region through partnerships with public and private sector entities to champion technological research

and development advances that may help transform the resource-based industries and, in doing so, enable them to expand their markets beyond traditional markets. Minnesota Power has engaged with prospective customers exploring large-scale investments in the region, including data center development. While these projects require multiple approvals and are not reflected in the test year, they demonstrate the Company's long-term efforts to diversify its customer base and mitigate reliance on highly cyclical industries. The Company also works with partners to retain and attract business in the region, which supports diversification of the economy and mitigates overall risk of customer loss, which can equate to rising rates for remaining customers. Membership and engagement in organizations like the Itasca Economic Development Corporation and Area Partnership for Economic Expansion are examples of the Company's regional development support.

Q. Can you provide examples of economic development successes that benefit the region?

A. Yes. The Company frequently works with economic development partners to attract and retain economic development across the region.

A recent example of this work is the proposed Google data center in Hermantown. The project is estimated to create hundreds of skilled trades jobs during construction and up to 100 permanent positions upon completion.[12] Minnesota Power's customer cost evaluation estimates that, with the addition of this new customer, there will be significant benefits for existing customers. These benefits will not necessarily remove the need for future rate increases as Minnesota Power transitions away from coal generation and prepares the system to meet the Minnesota Carbon Free Standard; however, customers would see an estimated range of $600 million to $800 million in benefit over the 15-year ESA term, which will help moderate rate increases over time.[13]

[12] MP Exhibit ___ (Forsman), Direct Schedule 6.

[13] *In the Matter of the Application of the Petition for Approval of an Electric Service Agreement between Google and Minnesota Power*, Docket No. E015/M-26-159, PETITION (Mar. 27, 2026) (eDocket No. 20263-229694-01).

At this time, the proposed project has not yet received final regulatory or permitting actions required to commence construction and operations.

Another example is Minnesota Power's work with partners to secure ST Paper's purchase and reinvestment in the Duluth Mill to manufacture tissue paper and new owner Sofidel's subsequent expansion. This enabled the re-establishment of 80 high-paying manufacturing jobs under ST Paper and the promise of an additional 160 jobs upon completion of Sofidel's expansion, including new finishing facilities and automated warehousing, with commissioning and operations beginning in 2026.

Minnesota Power has successfully attracted a 1,000-plus employee aviation manufacturing company, a $20 million co-location data center, a large-scale pet food manufacturing facility, a rotomold plastics facility, and a biotechnology firm. These examples illustrate the proven benefits of Minnesota Power's economic development efforts and investments.

Q. Is the Company seeking recovery of economic development expenses in this rate case?

A. Minnesota Power is only seeking 50 percent recovery for economic development costs in this rate case. This level of recovery is consistent with the Commission's decision in our most recent rate cases, including the 2023 Rate Case,[14] as well as commitments made in the acquisition proceedings for ALLETE.[15]

IV. TEST YEAR SALES FORECAST AND METHODOLOGY

Q. What is the purpose of this section of your Direct Testimony?

A. In this section of my testimony, I provide a summary of the 2027 test year sales forecast and a comparison of recent actual sales with historical test year sales forecasts. I also

[14] *In the Matter of the Application of Minnesota Power For Authority to Increase Rates for Electric Utility Service in Minnesota,* Docket No. E015/GR-23-155, DIRECT TESTIMONY OF FRANK L. FREDERICKSON at 36 (Nov. 1, 2023) (eDocket No. 202311-200095-01).

[15] *In the Matter of the Petition of Minnesota Power for Acquisition of ALLETE by Canda Pension Plan Investment Board and Global Infrastructure Partners*, Docket No. E015/PA-24-198, ORDER APPROVING PETITION FOR ACQUISITION WITH CONDITIONS AND ESTABLISHING OTHER REQUIREMENTS at Settlement Stipulation ¶ 1.66 (December 10, 2025) (eDocket No. 202610-237568-01).

describe the historical accuracy of Minnesota Power's sales forecasts. Further, I provide information regarding the methodology used by Minnesota Power to develop the 2027 test year sales forecast, including a general overview of the AFR forecasting process and the data gathering process for Large Power customers.

A. Overview of 2027 Test Year Sales Forecast

Q. How are the customer counts and sales forecasts for the 2027 test year used in this proceeding?

A. The 2027 test year customer counts and energy sales forecasts are used to calculate projected revenues under current and proposed rates. The forecasts also support the determination of the Company's test year revenue requirement and provide the billing determinants used in the class cost-of-service study and rate-design process. The Company witnesses sponsoring revenue requirements, the class cost-of-service study, and rate design describe those uses in greater detail.

Q. What is the rate impact if the test year sales forecast overstates or understates actual sales?

A. Generally speaking, if actual energy sales are lower than the test year's projected volume of sales, then rates will have been set too low to achieve the revenue requirement. On the other hand, if actual energy sales are higher than the test year forecast, then rates will have been set higher than necessary to achieve the revenue requirement.

Rates set in this rate proceeding should be based on a reasonable estimate of energy sales to ensure Minnesota Power does not over or under recover its revenue requirement. As described earlier in this testimony, Minnesota Power's variability in sales is significantly higher than a typical utility, with a standard deviation significantly more than other utilities in Minnesota. In order to help balance the variability in Minnesota Power's industrial energy sales, the Company is proposing a Sales Adjustment Mechanism to track and true-up over-estimated and under-estimated sales following implementation of final rates as I describe later in this testimony. This proposed rider

can also serve to reduce the impact on customers and the Company of setting the sales too high or too low in this proceeding.

Q. Please summarize Minnesota Power's customer count forecast for the 2027 test year.

A. Minnesota Power's 2027 test year forecast includes 153,930 retail customers. This is an increase of 738 customers (0.5 percent) over 2025 actual retail counts (153,192 retail customers). About 60 percent of the projected customer count increase is attributable to Residential account growth and the remainder of this growth is predominantly Commercial account growth.

Q. Please summarize Minnesota Power's sales forecast for the 2027 test year.

A. The Company's 2027 test year's retail sales forecast of 7,602,374 MWh is 0.1 percent higher than 2025 actual retail sales (7,596,286 MWh) and 8.8 percent lower than a five-year historical average of actual retail sales (8,339,382 MWh).

The Company's 2027 test year energy forecast, which is inclusive of wholesale energy sales, of 9,446,504 MWh is 3.1 percent higher than 2025 actual retail and wholesale sales (9,163,747 MWh) and 3.8 percent lower than a five-year historical average of actual retail and wholesale sales (9,820,102 MWh).

Q. How do actual sales compare with the test year sales forecast for 2024 approved in Minnesota Power's 2023 Rate Case?

A. 2025 actual sales were lower than the 2024 test year sales forecast approved in Minnesota Power's 2023 Rate Case. This was primarily driven by lower sales to Minnesota Power's Mining and Metals customers as shown in Table 2 below.

Table 2. Minnesota Power's Approved 2024 Test Year Energy Sales Compared to Recent Years' Energy Sales in MWh

				Industrial				
	Residential	Commercial	Pub & Light	Mining	Pulp & Paper	Other	Total Ind.	Total Retail
2024 Test Year - MP Filed	1,037,401	1,184,475	53,626	4,675,529	607,348	602,359	5,885,236	8,160,738
2024 Test Year - MPUC Approved	1,046,133	1,199,709	50,166	5,012,543	723,330	595,804	6,331,677	8,627,685
2024 Actuals	983,679	1,152,595	51,699	4,896,466	714,239	592,586	6,203,291	8,391,264
2025 Actuals	1,022,157	1,163,861	51,521	4,049,405	723,531	585,811	5,358,747	7,596,286
2027 Test Year	1,027,912	1,177,148	51,604	4,036,704	729,435	579,570	5,345,710	7,602,374

Q. Please explain why 2025 sales were below the approved 2024 test year sales forecast, particularly for Mining and Metals customers.

A. Actual 2024 and 2025 sales were below the approved 2024 test year forecast primarily because Mining and Metals sales were lower than the levels embedded in the approved forecast. The approved 2024 test year forecast reflected higher operating levels for Mining and Metals customers than ultimately occurred, while actual operations were affected by production reductions, including idling and partial idling decisions by Cleveland-Cliffs facilities in 2025.

These reductions were not gradual changes in ordinary usage. They were material operating decisions that occurred after the test year forecast was developed and approved, and they had a direct effect on Minnesota Power's sales because the Mining and Metals sector represents a large share of total retail energy usage. When one or more taconite facilities reduce production or idle operations, the resulting sales impact is significant and can occur over a relatively short period of time.

Total retail sales in 2025 were 1,031,399 MWh (about 12.0 percent) below the approved 2024 test year level. Table 3 below shows 2025 actual sales compared to the approved 2024 test year level. This comparison is also provided in MP Exhibit___ (Forsman), Direct Schedule 7.

Table 3. Minnesota Power's Approved 2024 Test Year Energy Sales Compared to 2025 Actual Energy Sales

	MPUC Approved Test Year	2025 Sales	Difference (MWh)	% Difference
Residential	1,046,133	1,022,157	(23,976)	-2.3%
Commercial	1,199,709	1,163,861	(35,848)	-3.0%
Industrial				
Mining and Metals	5,012,543	4,049,405	(963,138)	-19.2%
Forest Products	723,330	723,531	201	0.0%
Pipelines	310,455	320,046	9,591	3.1%
Other Industrial	285,349	265,765	(19,584)	-6.9%
Total Industrial	6,331,677	5,358,747	(972,930)	-15.4%
Public Authorities & Lighting	50,166	51,521	1,355	2.7%
Total Retail	**8,627,685**	**7,596,286**	**(1,031,399)**	**-12.0%**
Municipals	468,779	481,489	12,710	2.7%
SWLP	994,294	1,085,972	91,678	9.2%
Total Retail and Wholesale	**10,090,758**	**9,163,747**	**(927,011)**	**-9.2%**

Q. What do you conclude based on this comparison of the 2024 test year to 2025 actual sales?

A. The main conclusion I draw is that the 2024 test year forecast was set too high to be representative of customer operations which are increasing in volatility. The difference was driven primarily by large industrial customer operating decisions, including idling and partial idling activity, rather than by ordinary variation among smaller customer classes. This comparison demonstrates why Minnesota Power's current test year forecast should not rely on a single high-production assumption for Mining and Metals customers.

In my view, the appropriate lesson from this comparison is that the Company's current methodology should reflect a representative level of industrial operations based on recent actual experience, customer-specific information, and broader industry conditions. This approach does not eliminate all forecast risk, but it provides a more balanced and reasonable test year forecast than assuming that all large industrial facilities will operate at higher production levels throughout the test year.

Therefore, the comparison between the approved 2024 test year and 2025 actual sales supports Minnesota Power's current sales forecast methodology and the Company's proposed 2027 test year sales forecast.

B. Forecast Methodology

Q. What process did Minnesota Power use to forecast the number of customers for the 2027 test year?

A. Minnesota Power used the results of its 2026 AFR. The 2026 AFR uses an econometric modeling process to forecast customer count and energy sales based on these series' historical correlation to economic metrics. This process is described in greater detail below and is also fully documented in Minnesota Power's 2026 AFR (Docket No. E999/PR-26-11).

Q. What process did Minnesota Power use to forecast the energy sales for the 2027 test year?

A. The 2027 test year forecast is produced by combining the 2026 AFR's econometric approach to modeling Residential, Commercial, and small Industrial sales with an industry specific approach to forecasting sales for the Company's LP customers.

Q. How does the 2026 AFR forecast of 2027 sales compare to the 2027 test year forecast?

A. The 2027 test year forecast of retail energy sales is 8,442 MWh (0.1 percent) lower than the 2026 AFR's projection of total 2027 retail energy consumption, primarily due to a revised industrial estimate for the 2027 test year. Table 4 compares the two outlooks. This comparison is also provided in MP Exhibit ___ (Forsman), Direct Schedule 8.

Table 4. Comparison of Minnesota Power's 2026 AFR Forecast and 2027 Test Year

	2027 Forecast (2026 AFR)	2027 Test Year	Difference (MWh)	% Difference
Residential	1,027,912	1,027,912	-	0.0%
Commercial	1,177,148	1,177,148	-	0.0%
Industrial		-		
Mining and Metals	4,046,994	4,036,704	(10,290)	-0.3%
Forest Products	701,977	729,435	27,458	3.9%
Pipelines	338,901	319,723	(19,178)	-5.7%
Other Industrial	266,280	259,848	(6,432)	-2.4%
Total Industrial	5,354,152	5,345,710	(8,442)	-0.2%
Public Authorities & Lighting	51,604	51,604	-	0.0%
Total Retail	**7,610,816**	**7,602,374**	**(8,442)**	**-0.1%**
Municipals	481,776	761,560	279,785	58.1%
SWLP	1,091,713	1,082,570	(9,143)	-0.8%
Total Retail and Wholesale	**9,184,305**	**9,446,504**	**262,199**	**2.9%**

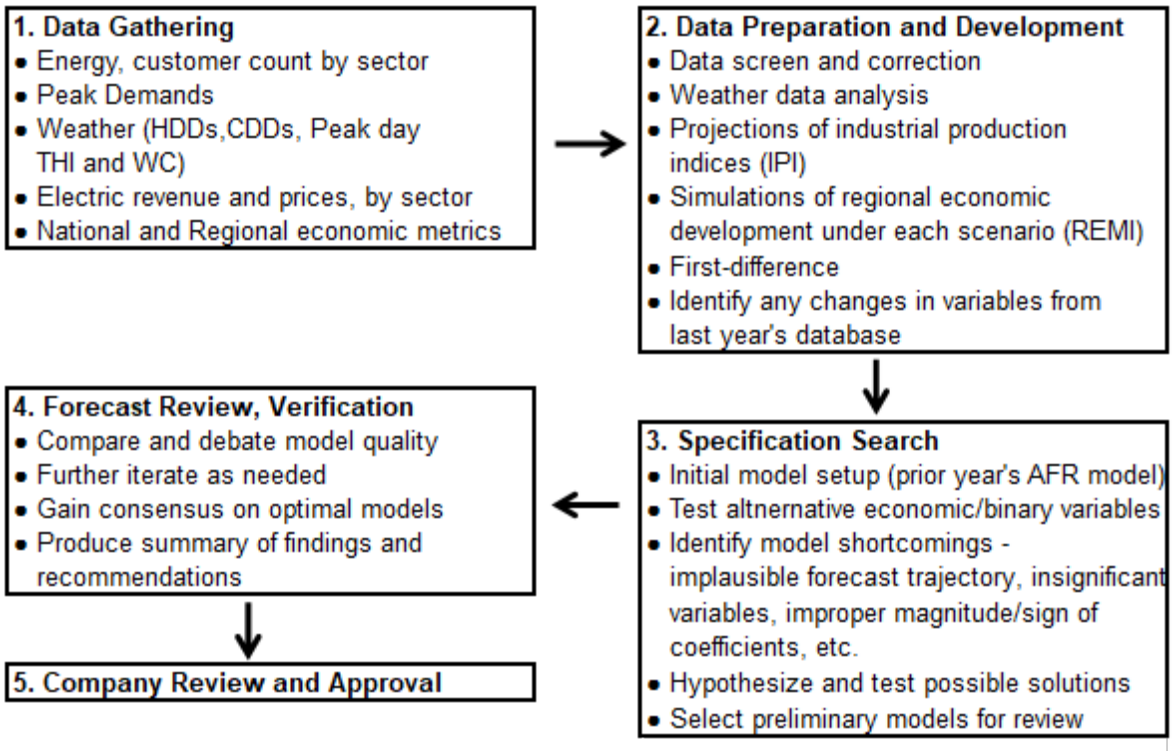
Q. Please describe Minnesota Power's AFR forecast methodology.

A. Minnesota Power forecasts energy usage and customer count by revenue class (as opposed to rate class) using a robust econometric methodology and an extensive variable database of economic indicators. Forecast models are structural and are defined by the mathematical relationships between the forecast quantities and explanatory factors (*i.e.*, historical usage and economic indicators). The forecast models assume a normal distribution and "50/50" probability; given the methodology, there is a 50 percent probability that the actual demand will be less than forecast and a 50 percent probability that the actual demand will be more than forecast. Minnesota Power's forecasting methods are in line with electric industry best practices for ratemaking and long-term utility planning.

Q. What are the steps in developing the AFR?

A. The AFR process flow chart is shown in Figure 9 below. The Minnesota Power forecast process involves several interrelated steps: 1) data gathering, 2) data preparation and development, 3) specification search, 4) forecast review and verification, and 5) internal Company review and approval. The steps of the forecast process are discussed in detail in Section I.A of Minnesota Power's 2026 AFR.

Figure 9. Minnesota Power's Forecast Process



Q. What data was used to develop Minnesota Power's econometric forecasts?

A. Minnesota Power uses a number of third-party data vendors and public sources in its forecast database. Minnesota Power's 2026 AFR describes each data source and documents any adjustments to the raw data for forecasting purposes. For example, some data may need to be interpolated from annual to monthly frequency or denominated in constant/real dollar terms instead of nominal.

Q. What are the sources for the third-party data used to develop the sales forecast?

A. The majority of economic and demographic data used in the forecast are provided by IHS Global Insight, with additional population and gross metropolitan product ("GMP") data obtained from Regional Economic Models, Inc. ("REMI") and data from the Federal Reserve. IHS Global Insight offers comprehensive economic coverage of industries, regions, and countries. REMI is a leading provider of state, local, and national macroeconomic policy analysis models, and the Federal Reserve supplies key

economic data used in the forecasting process. Taken together, these sources provide industry-leading data that Minnesota Power utilizes to develop its sales forecast.

Q. How does Minnesota Power take weather into account in developing its sales forecast?

A. Energy sales forecasts assume "Normal Weather," which is defined as a 20-year (Jan. 2006 to Dec. 2025) historical average consistent with the method used in the Company's 2023 Rate Case and in other recent Minnesota electric utility rate cases.[16] All historical Heating Degree Day ("HDD") and Cooling Degree Day ("CDD") data is derived directly from the National Oceanic and Atmospheric Administration's ("NOAA") monthly records for Duluth International Airport.[17] Further, the Company does not re-calculate or re-create the historical HDD/CDD series from daily temperature data, nor does it deviate from the NOAA's standard 65 degree base for the calculation of HDD/CDD.

Q. Why is "Normal Weather" important to customer sales forecasting?

A. The assumption of normal weather is important because certain customer classes, such as Residential and Commercial, are heavily influenced by weather. If Minnesota Power were to assume very mild weather in the forecast timeframe, then the sales forecast would likely be too low. Assuming extreme weather in the forecast would produce an outlook that is likely to be too high. A 20-year average "Normal Weather" assumption helps ensure the outlooks for weather-sensitive classes are in the middle of possible outcomes and represent a 50/50 forecast with regards to weather. This method is consistent with best practices in forecasting electric utility sales.

[16] *See e.g., In the Matter of the Application of Northern States Power Company, d/b/a Xcel Energy for Authority to Increase Rates for Electric Service in Minnesota*, Docket No. E002/GR-21-630, DIRECT TESTIMONY AND ATTACHMENTS OF SACHIN SHAH at Schedule 2 at 24 (Oct. 3, 2022) (eDocket No. 202210-189482-08) ("Normal weather is based on a 20-year historical time period."); *In the Matter of the Application by Xcel Energy for Authority to Increase Rates for Electric Service in Minnesota*, Docket No. E002/GR-24-320, DIRECT TESTIMONY OF SACHIN SHAH at Ex. DOC___SS-D-5 at page 34 (August 22, 2025) (eDocket No. 20258-222346-06).

[17] Minnesota Power retail customer sales were modeled using Duluth HDD/CDD. Wholesale/municipal sales were modeled using the weather station that is proximate to each specific municipality.

Q. Has Minnesota Power's AFR forecast process produced accurate forecasts?

A. Yes, generally. Table 5 below shows AFR forecasts since the 2016 AFR with current and year-ahead forecast errors highlighted. Since the Company's 2010 AFR forecast, the Company has over-forecasted the year-ahead timeframe by about 3.4 percent. However, swings in demand for taconite production to supply the iron/steel industry are difficult to predict, and larger forecast errors of over 5 percent and as high as 15 percent are evident when these swings occurred in 2020, 2021, and 2025, as well as prior years going back further.

Table 5. Minnesota Power AFR Forecast Error

Forecast	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
AFR 2016	-1.4%	-4.3%	-2.9%	-2.2%	20.4%	10.1%	19.3%	17.9%	19.6%	29.4%
AFR 2017		1.8%	2.5%	3.6%	24.2%	13.1%	19.3%	17.8%	19.7%	29.5%
AFR 2018			1.4%	1.7%	20.4%	9.7%	16.7%	15.1%	16.8%	26.1%
AFR 2019				-1.8%	14.7%	4.2%	12.1%	12.0%	13.7%	22.8%
AFR 2020					-15.7%	-7.8%	-2.2%	-4.0%	-2.9%	6.9%
AFR 2021						-8.7%	-2.7%	-2.9%	-1.3%	6.1%
AFR 2022							-1.2%	-0.9%	0.5%	8.2%
AFR 2023								-4.4%	-4.5%	2.7%
AFR 2024									0.3%	7.9%
AFR 2025										0.9%

N.n%	= *Year-Ahead Foreast*	Avg Year-Ahead Error =	3.4%
N.n%	= Current Year Forecast	Avg Current Year Error =	-2.9%

Q. How did Minnesota Power account for the impact of energy efficiency in its 2026 AFR and test year sales forecasts?

A. The Company's approach to forecasting energy efficiency for the 2026 AFR was to use energy efficiency as an input variable to the regression models. This methodology is referred to as the "Energy Efficiency as a Right Hand Side Variable" or "EE as RHS var" method. Minnesota Power identified this as its preferred approach after research, testing, and review by colleagues at other Midwest utilities, and engaging in discussions with the Department.

Q. What are the benefits of this methodology?

A. The "EE as RHS var" methodology has several advantages over other common energy efficiency forecasting methodologies, including that it:

- Avoids double-counting energy efficiency impacts in the forecast timeframe;
- Accounts for historical and projected conservation resulting from both Company programs and organic, customer-driven efforts;
- Leverages raw sales data in regression modeling: sales data are not adjusted for conservation impacts prior to modeling; and
- Does not require after-the-fact adjustments to econometric outputs—the energy sales forecasts already contain the effects of energy efficiency.

An "Energy Efficiency" variable explains recent trends in customer consumption that cannot be explained by economic, demographic, or weather effects. Further, this method allows the Company to quantify the volume of CIP energy efficiency embedded in the load forecast, which will be useful in a number of applications—including resource plan modeling.

Q. What energy efficiency assumptions were used to forecast energy sales?

A. The Company leveraged the results of the Minnesota State DSM Potential Study[18] funded by the Department and led by the Center for Energy and Environment ("CEE"). Minnesota Power worked closely with CEE to update assumptions in the study and accurately reflect the Company's current customer base, outlook, and to-date historical experience with CIP. The results of this collaborative study update were used to predict energy sales to the Residential and Commercial classes.

[18] MP Exhibit ___ (Forsman), Direct Schedule 2 at 46-181.

Q. What methodology did Minnesota Power employ to calculate the impact of electric vehicles and solar distributed generation in its 2026 AFR and 2027 test year sales forecasts?

A. Electric vehicle and distributed solar impacts were not estimated via an econometric process like the energy efficiency forecasting method described above. Instead, the overall energy sales impact of each new technology was calculated first, and this impact was applied as an arithmetic adjustment to the raw econometric projection. The arithmetic adjustments for both electric vehicle and distributed solar were calculated by combining a projected unit adoption rate with an estimate of per-unit impact on sales. A more complete description of the process and a full documentation of the methodologies are included in the 2026 AFR, Section II.B.7.

Q. What methodology was used to forecast test year sales to the non-Mining and Metals large industrial and wholesale customers?

A. Minnesota Power employs an industry specific approach to forecast sales to our non-Mining and Metals large Industrial and wholesale customers. These large Industrial customers include the following sectors: (1) Forest Products; (2) Pipelines; and (3) Other Industrial.

Q. Please describe this industry specific approach to forecasting large Industrial and wholesale energy sales in the 2027 test year forecast.

A. Projections for each large Industrial sector were developed in cooperation with customers in each sector, taking into account the nuances of the sector. These forecasts are also informed by the national economic trends identified during the AFR modeling process. Individual customer estimates are aggregated to a class total, which constitutes an industry specific forecast approach, and are validated against the econometrically-produced AFR forecasts.

Q. Why is an industry-specific approach necessary for developing the 2027 test year forecast for the non-Mining and Metals large Industrial and wholesale customers?

A. The AFR modeling produces sector (or class-level) forecasts and lacks the necessary detail for short-term forecasting and budgeting processes. The 2026 AFR modeling of the Paper sector uses national and state-level (macro) economic indicators such as Industrial Production Indexes, which are excellent for determining general industry trends and building outlooks for long-term planning, but this modeling will not produce outlooks with sufficient detail for a test year sales forecast.

Q. What is Minnesota Power's forecasting methodology for its Mining and Metals customers?

A. Minnesota Power transitioned from a facility-specific approach to an average operating rate methodology for its Mining and Metals customers because industry consolidation has reduced the ability to forecast where production changes will take place. Beginning in 2020, Cleveland-Cliffs transitioned from a mining company to a vertically integrated steel company through acquisitions, and now U.S. Steel and Cleveland-Cliffs have attained control of all current domestic taconite supply and blast furnaces. As a result of this consolidation, U.S. Steel and Cleveland-Cliffs are able to make decisions within their specific corporations to optimize production based upon product type, production cost, royalty rates, business philosophy, or other strategic factors and Minnesota Power does not have sufficient advance visibility into how those considerations will translate into future facility-specific operating decisions.

Q. Did Minnesota Power use a facility-specific approach for forecasting its Mining and Metals customers' test year sales levels?

A. No. The Company develops an average operating rate for its Mining and Metals customers and applies that rate across all Mining and Metals sales forecasts. The Company also incorporates known facility-specific idled status where applicable. In the 2027 test year forecast, the Company assumed no taconite pellet production at Minorca, reflecting its fully idled status. However, Minorca was assumed to continue consuming a minimal level of energy to support essential site operations and maintenance activities,

while the average operating rate methodology was applied to the remaining operating facilities.

Q. Why is it not reasonable to forecast other individual mine operating decisions for the 2027 test year?

A. Recent experience demonstrates that production decisions at individual taconite facilities are often made at the corporate level and can change quickly in response to market conditions or internal operational considerations. For example, in 2025, one facility was idled while another was partially idled, even though both had been operating earlier in the year. These types of decisions are not driven by predictable local conditions and are not known with sufficient certainty during the development of a rate case test year. As a result, Minnesota Power forecasts a representative average level of Mining and Metals customer operations, while separately reflecting known full idlings, rather than attempting to predict the timing or location of future specific idling decisions.

Q. Can you provide an example of how industry consolidation has impacted specific mining facility operating predictions?

A. Yes. A recent example of how industry consolidation has impacted the predictability of mining operations can be seen in developments affecting Cleveland-Cliffs' Iron Range facilities. Public reporting in 2025 highlighted ongoing uncertainty at facilities such as Hibbing Taconite and Minorca, where local stakeholders and workers indicated that future operating levels and production plans were unclear or subject to change.[19] This uncertainty reflects the broader reality that, following industry consolidation, production decisions are no longer made at the individual facility level. Instead, they are determined based on corporate-wide considerations such as steel demand, inventory levels, and optimization across a portfolio of assets. As a result, even when local conditions may suggest a particular production outlook, actual operating decisions can change with limited advance visibility. This dynamic makes it increasingly difficult for

[19] MP Exhibit ___ (Forsman), Direct Schedule 4 at 3-6.

Minnesota Power to rely on facility-specific forecasts and demonstrates how consolidation has reduced the predictability of individual mining operations.

Q. Do these production decisions by U.S. Steel and Cleveland-Cliffs impact energy sales and Minnesota Power revenue uniformly?

A. No. Each taconite production facility has a different energy intensity per ton due to differing process flow within each facility, ore body configuration, scale of the facility, and product variation. In addition, facilities are served by firm versus non-firm retail service, which have differing revenue associated with the sale due to the nature of the agreements. This variation in energy intensity per ton of taconite production is shown in Table 6 below for a representative full annual production output at each facility.

Table 6. 2025 Taconite Facility Energy Intensity

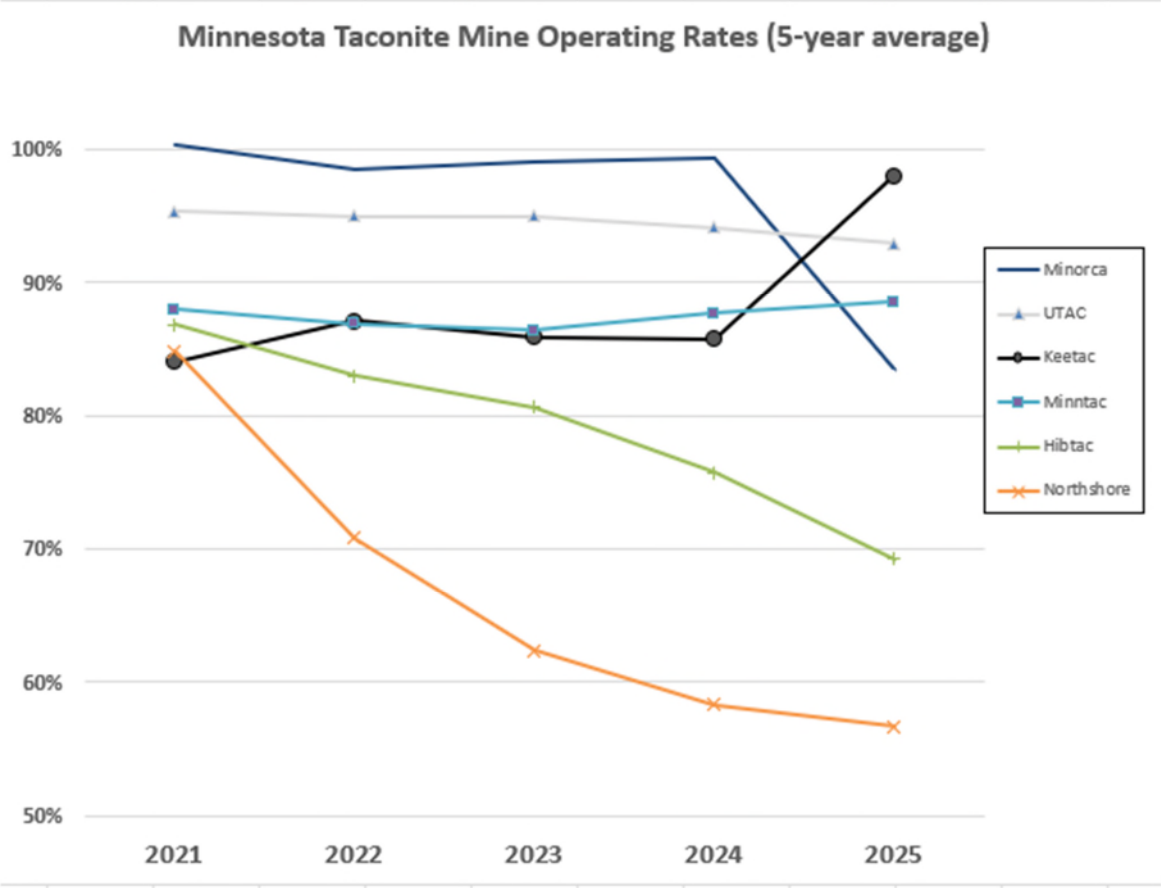
Facility	Production (Dry Long Tons)	Usage (MWh)	kWh/ton
		[TRADE SECRET DATA BEGINS	
Hibtac	2,666,318	[redacted]	
Keetac	4,988,269		
Minntac	12,441,857		
Minorca	544,878		
Northshore (Silver Bay + Babbitt)	3,188,180		
United Taconite	4,695,601		
		TRADE SECRET DATA ENDS]	

Q. What events and factors over the past five years impacted individual mine operating rates?

A. Cleveland-Cliffs' acquisition of AK Steel, ArcelorMittal USA, and Stelco has given the company increased operational flexibility at its facilities due to the elimination of pellet supply agreements with those companies and acquisition of additional mining assets making similar products to Cleveland-Cliffs facilities owned before the purchase. In the past, Cleveland-Cliffs pellet supply agreements were served by specific mines. The acquisition of AK Steel, ArcelorMittal USA, and Stelco allows Cleveland-Cliffs flexibility in how it supplies its newly acquired steel mills based on cost or other strategic reasons. In addition, Cleveland-Cliffs now has ownership of mining facilities capable of making similar products, which gives the company additional optionality on

how it serves steel mill pellet demand. Another factor is specific to Hibbing Taconite, which is exhausting its existing ore body, resulting in a lower facility operating rate. Lastly, U.S. Steel more recently has monetized its iron ore assets in part by selling to third parties, which improved Keetac's operating rate. Historically, Keetac would swing between operation and idle, and had been a Minnesota Power rate case driver. In recent years its operating rate has improved as U.S. Steel implemented this strategy. These facility operation trends are displayed in Figure 10 below, which shows the five-year average operating rates of each facility since 2021.

Figure 10. Five-year Average Minnesota Taconite Mine Operating Rates



Q. How did Minnesota Power forecast the operating rate for the Mining and Metals customers?

A. Minnesota Power forecasted the operating rate for the Mining and Metals customers based upon recent sales levels and the continuation of steel industry trends discussed further in Section V.

C. Large Power Customer Data Gathering Process

Q. Please describe the Company's data gathering process for its LP customers.

A. Minnesota Power gathers customer, industry, and economic information from a variety of sources. The Customer Experience Strategic Accounts team and some members of the Customer Insights and Forecasting Analytics team continually gather information about our LP customers and their industries, as well as global, state, and local economic outlooks.

Our strategic account professionals are in direct contact with our customers. As part of these interactions, we frequently discuss the state of the industry as well as the customers' future production plans. Through these discussions, the Company gauges the operational plans that our customers have at the local level and how Minnesota Power can serve their reliability and energy needs to encourage and foster growth, efficiency, sustainability, and mutual success.

Several Minnesota Power employees are also actively involved in our LP customers' trade organizations, providing yet another source of industry data and information. By way of example, I serve on the board for the Iron Mining Association of Minnesota and engage along with Frank Frederickson, Vice President – Customer Experience & Engineering Services, as an associate member with the American Iron and Steel Institute and Minnesota Forest Industries. In addition, several others from Minnesota Power serve on the boards of organizations like Mining Minnesota and Jobs for Minnesotans, and others actively participate and contribute time, talent, and effort in sub-committees of many of these organizations. Our interactions in these organizations enable us to

identify issues, trends, opportunities, and challenges that the industries face and to further our understanding of their energy needs.

Q. To what extent do LP customers develop their own energy use forecasts?

A. In our experience, LP customers look to Minnesota Power to provide annual energy use forecasts based on the facility production levels they provide the Strategic Accounts team. Some LP customers develop their own energy forecasts based on their projected levels of production, but most of them work with Minnesota Power to either develop the energy use forecasts together or have us develop the forecasts for them. Our detailed historical data and knowledge of customers' operations help both the Company and our customers budget energy requirements for their estimated production levels.

Q. Does Minnesota Power use the energy usage forecasts developed by its customers?

A. While customer forecasts are certainly considered as a part of our sales forecasting process, they do not necessarily form the sole basis for our sales forecast for several reasons. First, the timing of Minnesota Power's need for sales forecast information does not directly align with our customers' budget development timing. Second, our planning timeline extends further into the future than our customers' planning horizons typically provide. Third, our experience through the years is that our customers' forecasts, particularly at the local level, have had inaccuracies due to failure to consider macro business trends and decisions that are outside of local purview and control.

This has become more evident in recent years as our industrial customers have experienced increased variability in demand for their products and industry consolidation has allowed for more production decisions to be made at the corporate level for various business and strategic reasons. To prepare a more accurate sales forecast, we meld our customers' direct information with our own external information and analysis of macro business trends and then forecast production based upon expected production levels.

Q. Are statistical methods like econometric modeling by themselves sufficient to understand the LP customers' likely test year energy usage?

A. No. Econometric modeling is adept at identifying "macro" industry trends and useful in long-term forecasting. However, a purely econometric approach does not incorporate information regarding specific customers, such as a customer's contracts for seaborne exports, whether a local plant may be idled or, conversely, if a customer is planning a capital project addition. This is especially true as technology changes in mining and paper production have enabled increased product substitution by the end customer in these respective industries. For example, the increased concentration of Electric Arc Furnace ("EAF") based steelmaking has enabled greater raw material substitution from scrap, pig iron, or hot briquetted iron ("HBI") which increases the variability in estimating production of taconite for the iron and steel industry as a whole. Similarly in the paper industry, consolidation and reduction in demand has resulted in increased impacts from "grade switching" by printing companies as well as substitution of electronic media to increase variability in raw paper demand for a specific grade produced by a specific mill. As a result, a macro industry metric may infer strong customer operations but a specific local customer operation may be weak, or vice versa.

1. Large Power Customer Industry Data

Q. What are your sources of industry data pertinent to your LP customers' future energy needs?

A. In addition to specific customer input, we use a wide range of industry data, publications, metrics, and government data. For example, our Customer Experience team tracks several relevant industry metrics, including, but not limited to, domestic steel demand, raw steel capacity utilization rates, blast furnace versus EAF production percentages, steel and iron ore pricing levels, steel imports and exports, drill rig counts, iron ore and steel inventory levels, Lake Superior boat traffic, pricing levels for various grades of paper, and business analyst reports of our customers, their industries, their corporate parents, and their competitors.

We also subscribe to numerous industry periodicals and track industry news on a macro level to supplement our knowledge of our customers' industries. For the mining industry, we subscribe and/or review information from Steel Market Update, American Metal Markets, Steel Business Briefing, Skillings Mining Review, and several others. For the paper industry, we obtain and review market information from the American Forest and Paper Association ("AF&PA"), PaperAge Magazine, and pulp and paper industry intelligence from Fastmarkets RISI.

Q. Do you also use broader data about global, state, or local economic trends?

A. Yes, we also use publicly available information from the U.S. Securities and Exchange Commission ("SEC"), the U.S. Census Bureau, American Iron and Steel Institute, Association for Iron & Steel Technology, World Steel Association, the United States Geological Survey, and other sources to provide the information we need for our load forecasting purposes. This includes Institute of Supply Management Manufacturing Indices, consumer spending, exchange rates, savings rates, capital investment rates, Federal Reserve Business Outlook surveys, Industrial Production Indices for steel and paper, the Chicago Index of Activity, and more.

Q. Do historical trends for an LP customer's industry or markets factor into your analysis as well?

A. Yes. Historical and projected industry trends are considered in the development of short and long-term energy requirements forecasts.

Q. How does the Company utilize industry and economic data to develop expectations for LP customer sales in any given year?

A. Industry and economic data is factored in with the customers' historical operating rates and their anticipated future production levels in a combination of micro and macro views to attempt to both validate the sales outlooks and to attempt to anticipate industry cycles.

2. Large Power Customer ESAs and Data

Q. Please describe, in general, how LP ESAs supplement standard tariff rates.

A. LP ESAs, which are considered to be tariffs themselves upon approval, supplement the standard LP tariff rate by specifically outlining connection points, voltage levels, a methodology to determine billing demand, an Incremental Production Service Threshold, a confidentiality agreement, and any terms or conditions that differ from or are additional to the terms and conditions specified in the LP Service Schedule or in any rider or tariff applicable to LP Service. Each of these terms are specifically tailored to customer operating characteristics.

Q. Please describe the methodology in which LP ESAs determine customer billing demand.

A. LP customers nominate their firm demand levels based on the electric load expectations for each calendar month. Nomination frequency for current LP customers varies between monthly and three times per year, with varying advance notice requirements depending on the customer's ESA. These nominations must be equal to or above the Minimum Service Requirement set forth in each customer's ESA. Periodically, as a part of the normal course of business, customers need to take maintenance downtime. In anticipation, a customer must notify Minnesota Power a minimum time set in the ESA ahead of the maintenance period. In exchange, the customer's billing demand will be reduced by the amount of time and level in which they were below their nominated demand level. Each current LP customer has an allowance for scheduled maintenance set in their ESA, which sets the maximum amount their billing demand can be reduced below their nominated demand.

Q. What other benefits do LP ESAs provide to LP and non-LP customers?

A. The ability to customize the general features of the LP tariff to the unique and individual characteristics of each customer is crucial for them to most efficiently align their electric service with their operations. As stated previously, and by way of example, many LP customers would pay higher demand charges when down for scheduled reasons if they were not able to use the provision for scheduled maintenance, leading to an increased

overall rate for the same periods of time in which they are not producing a saleable product.

Another benefit LP customers provide to all of Minnesota Power's customers is their longer-term commitment to purchase a minimum of 182 MW of demand each month, which represents a commitment for approximately 29 percent of their full production electric needs. The Minimum Service Requirement set in each ESA provides a minimum level of contribution, regardless of whether or not a customer is operating, to ensure Company revenue does not drop to zero when the customer idles an operation.

While the Minimum Service Requirement commitment by contracted LP customers is a unique commitment compared to other customer classes, it is also noteworthy that Minnesota Power still has significant sales and revenue risk from our largest customer class due to their ability to reduce nominations by over 65 percent in any given nomination period. A reduction in demand, along with reduced energy sales revenue that correspond with a lower nomination, can result in significant revenue fluctuations for Minnesota Power with only 23 percent of its revenue protected by the minimum service requirements of its LP ESAs as shown in Table 7 below.

Table 7. Large Power Customer Minimum Service Requirement Versus Full Production Revenue

	Minimum Service Requirement	Minimum Demand (Annual $ Millions)	Full Production Nomination (MW)	Full Production Firm Energy (MWh)	Full Production Firm Demand and Energy (Annual $ Millions)	Minimum Revenue vs. Full Production Revenue Variance (%)
	[TRADE SECRET DATA BEGINS					
US Steel Hibtac UTAC/NSM-Babbitt Minorca Blandin Boise Sappi Sofidel	[redacted]					
					TRADE SECRET DATA ENDS]	
Total	**182**	**$ 71.4**	**624**		**$ 304.4**	**23%**

Debt market analysts and rating agencies carefully monitor the status of the Company's LP customers and regularly assess what protections are in place to maintain Company revenue through swings in LP customer operations. This is a unique risk that sets Minnesota Power apart from other utilities and results in higher debt financing costs that ultimately impact customers through higher electric rates.

Q. How does Minnesota Power's participation in the MISO market provide benefits when an LP customer reduces or suspends operations?

A. When an LP customer reduces or suspends operations, Minnesota Power has some ability to replace revenue through MISO market sales when LP customers idle; however, lower market prices and the shift to more renewables in the Company's generation fleet have reduced the amount of revenue it is able to recover. As a result of these challenges, Minnesota Power is proposing a Sales Adjustment Mechanism to address material differences between actual LP and VLP base-rate revenues and the revenues reflected in the test year. The proposed mechanism is symmetrical and would provide customers with timely credits when covered revenues exceed the approved baseline, while also addressing revenue shortfalls when covered revenues fall below the baseline.

Q. Please describe, in general, how the Company works with LP customers to anticipate their energy demands for each year.

A. Minnesota Power works closely with LP customers on an ongoing basis to plan for their future energy needs and to ensure their electric service remains reliable. We devote a great deal of attention to understanding near-term customer operating plans because changes in our customers' operating rates or load additions/subtractions at any LP customer site can have a large impact on our Company. Any significant changes in a LP customer's energy demand will have a material effect on Minnesota Power because this class represents nearly three-quarters of the Company's retail energy sales.

Minnesota Power's Strategic Accounts team works with our customers early in the year to understand their energy needs for the next year. In some cases, we work directly with

our LP customers to calculate their internal energy budget based on production estimates they provide to us. In other cases, we provide customers with historic energy consumption and pricing information at various production levels for use in their budgeting process. In still other cases, we work with customers to identify the amount of power that they will need to purchase from Minnesota Power to supplement their own self-generation. In every case, we are aligned at some level with our customers in the preparation of their operating plans and energy needs for the following year. In some circumstances, our timelines and needs require us to forecast or project customers' load in advance of their normal budget and estimate processes for the upcoming year. In those instances, our processes are very similar, and we typically use the summary information that we derive as the first step in working with customers on their budgeting processes later in the year.

Q. Does Minnesota Power collect information that may be relevant to a customer's energy needs that is not provided directly by the customer?

A. Yes. As noted earlier, the Company collects press releases, SEC documents, articles, and industry group data. Minnesota Power also gathers and analyzes public economic data from Bureau of Economic Analysis and the Federal Reserve, for example, as well as any other information regarding our customers that may be helpful in the forecasting process. These sources of external and third-party information are necessary to round out the estimated average levels of production anticipated for any given year, especially with the increased variability in production levels being experienced in recent years and expected to continue into future years. Further detail about industry trends and forecasting is provided in Section V of my testimony.

Q. Does Minnesota Power adjust its forecast of LP customer needs throughout a given year?

A. Yes. Throughout the year, we adjust our estimates with more granular commitments from our customers as to their short-term operating plans. Most commonly, this is accomplished through an LP customer's written submittal of demand nominations. Current LP customers provide demand nominations for three and four month periods,

depending upon their specific ESA requirements. The demand nomination indicates the amount of power demand requirements above the Minimum Service Requirement or take-or-pay levels specified in the individual LP customer's contract, as indicated earlier in my testimony.

Q. To what extent does Minnesota Power use formal demand nominations to prepare its annual sales budgets?

A. The Company's sales budget for the upcoming year is typically completed by late summer of the prior year. As a result, our sales budgets are completed well ahead of the nomination deadlines for any of the various nomination periods in the next year. For example, four-month nominating customers are required to submit their demand nomination for the first four months of 2027 on December 1, 2026, approximately one month after the filing of this rate case. In addition, formal nominations are of limited use for forward budgeting because our sales budgets are annual budgets, whereas the formal demand nominations cover shorter periods.

Q. Does Minnesota Power also receive energy usage information from LP customers outside of formal nominations?

A. Yes. Minnesota Power receives information from LP customers via pre-nomination predictions that can take several forms. For example, LP customers can provide energy usage information during their budget development process or in response to changes in business plans or projections. This information is received on an ad hoc or as-needed basis and does not follow a strict calendar. Often, these predictions encompass widely varying timeframes. Since the predictions are not binding on the customer, they are sometimes informal and may represent the customer's most optimistic view of their future energy demand.

Q. Does Minnesota Power also receive information from LP customers other than energy usage?

A. Yes. We obtain LP customers' most current production estimates, and we use those production estimates to aid us in our sales budget updates. Minnesota Power also

provides our customers with periodic updates on their energy usage and cost for their use in updating their operating budgets, which allows for information sharing. We have some customers who prepare current estimates on a monthly basis for the balance of the year; others who prepare quarterly updates for the balance of the year; and yet others who prepare rolling two-year forecasts.

Q. How much do historical trends in a specific LP customer's business factor into your analysis, overall?

A. Minnesota Power uses all of the LP customer data at our disposal—including historical energy usage, formal budgets, historical demand nominations, periodic customer updates, pre-nomination predictions, and updated customer production estimates—as tools to help us anticipate customers' future operating levels and energy requirements. For example, the historical trend of taconite production is important for predicting future production as there has been a notable increase in the volatility of production in recent years. This information is combined with the industry information and trends I discussed above to develop the overall projection of a specific LP customer's annual energy requirements.

Q. What data did the Company have for the 2027 test year as it was developing this rate case filing?

A. We used historical trends, industry data, and other customer information, as described above, to develop our test year forecast. As noted above, we did not receive 2027 nominations from LP customers in time for preparation of the 2027 test year LP sales forecast, which is consistent with the usual timing of LP nominations in relation to an initial rate case filing. Minnesota Power anticipates receiving its nominations from its four-month nominating customers on or before December 1, 2026, for the first four months of the 2027 test year. Nominations for the remaining two, four-month nominating periods of the test year are received on or before March 1, 2027 and August 1, 2027, respectively.

Q. Are these test year budgets subject to change as the actual test year progresses?

A. Yes. Take, for example, our 2021 Rate Case where Minnesota Power budgeted energy sales to support a taconite production level of approximately 34 million tons ("MT") in the 2022 test year and the actual taconite production in 2022 was approximately 31.9 MT. During the 2022 test year, all customers started the year at full production levels. If full production would have continued for all 12 months, nearly 38 MT of taconite would likely have been produced in 2022. Instead, two significant changes occurred during the 2022 test year that impacted taconite production levels. U.S. Steel's Minntac facility slowed pellet production following a structure collapse[20] and Cleveland-Cliffs announced the idling of its Northshore mining operations.[21]

The events of the 2022 test year were not isolated. Similar dynamics have continued to occur in subsequent years. In 2025, Minnesota Power again experienced production-related reductions in energy usage when one taconite facility idled and another operated at reduced levels. Whereas the Minnesota Department of Revenue Minerals Tax Office had originally estimated 2025 production at 34 million tons,[22] these reductions resulted in actual tonnage production of 28.5 million tons in 2025.[23] These events further illustrate that changes in mining operations often happen unexpectedly and often do not align with the cadence of rate case proceedings.

Due to the significant impact that any of the Company's LP customers can have on Minnesota Power's overall energy sales, it is important to account for this wide range of production in a test year by forecasting a representative average volume of taconite production that reflects the increasing variability occurring with Minnesota taconite production facilities and lower overall trend in annual production.

[20] MP Exhibit ___ (Forsman), Direct Schedule 4 at 7-9.
[21] MP Exhibit ___ (Forsman), Direct Schedule 4 at 10-13.; *Id*. at 14-15.
[22] MP Exhibit ___ (Forsman), Direct Schedule 4 at 16-19.
[23] MP Exhibit ___ (Forsman), Direct Schedule 4 at 20-24.

Q. How are changes in the budget factored into the Company's analysis during the rate case?

A. The Company and parties can only make updates that are known during the course of the proceeding, and even then, the long-term ramifications of a change in the status of a customer or plant changes cannot always be discerned before the proceeding ends. While Minnesota Power is able to choose when to file rate cases, it does not have control over the timing of its customers' business decisions, despite the significant consequences for the utility.

Q. Is there a more effective way to address the issue of LP volatility in Company revenue and customer rates?

A. Yes. Since a change in operation of one or two large industrial customers have the capability to impact the Company's revenues by a larger amount than its entire residential customer class, Minnesota Power is proposing a Sales Adjustment Mechanism rider, discussed in Section VI of my testimony, to smooth this volatility and to reduce the impact of setting test year industrial production levels either too-high or too-low.

V. CUSTOMER SALES OUTLOOK

Q. What is the purpose of this section?

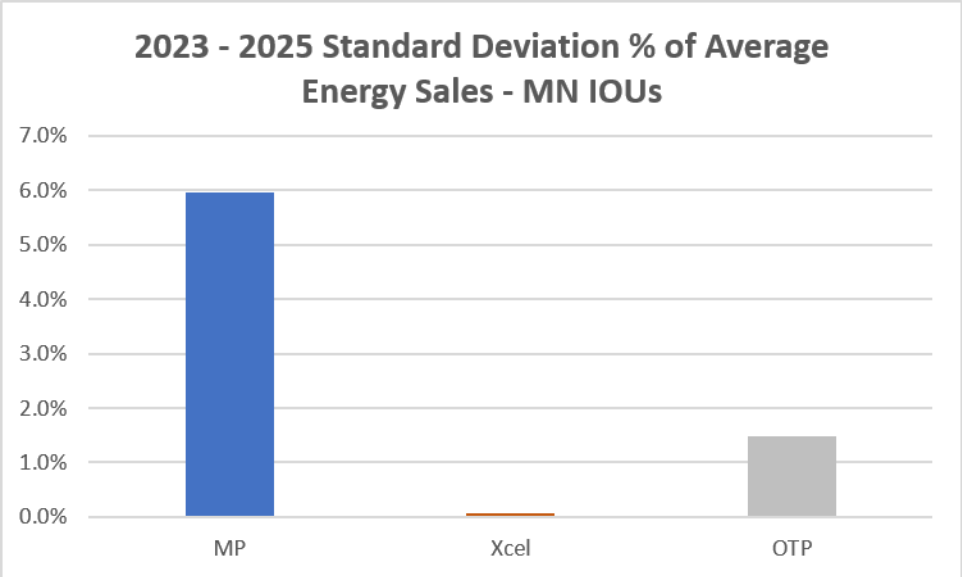
A. In this section, I provide a general overview of Minnesota Power's energy sales trends, followed by more detailed information about the Company's residential, commercial, and industrial customer trends including LP customer industry outlooks. As previously discussed, industrial customers represent the majority of energy sales for Minnesota Power. Sales to Minnesota Power's industrial customers have continued to increase in volatility in recent years and changes in these customers' operations have the greatest impact on the overall revenue and health of Minnesota Power. I describe the Company's data gathering process from these customers and industries and provide forecast information for Minnesota Power's mining, pulp and paper, and other LP customers.

A. General Trends in Energy Sales

Q. Are Minnesota Power's energy sales more volatile than other utilities in the state?

A. Yes. As shown in Figure 11 below, Minnesota Power energy sales have been significantly more volatile than the other investor-owned utilities in Minnesota. Minnesota Power's standard deviation as a percentage of average retail sales from 2023 to 2025 was approximately six percent. Said another way, utilizing standard confidence intervals, Minnesota Power can be 95 percent confident that sales will be within a range of twelve percent of average levels, whereas Xcel Energy and Otter Tail Power Company ("OTP") can be 95 percent confident that their sales will be within a range of less than one percent and three percent, respectively, of average levels.

Figure 11. Minnesota Investor-Owned Utilities Retail Sales' Standard Deviation as Percent of Average Sales (2023-2025)



Q. How do energy sales trends vary by customer class?

A. Residential and commercial customer sales have stagnated or declined since the 2007–2009 Great Recession, contracting -0.4 percent per year (on average) from 2016 to 2025. Residential and commercial customer account growth stagnated in the last decade due to demographic factors like continued low population growth, in particular in the rural regions such as Northeastern Minnesota. The stagnation of population growth, coupled with the reduction in average customer energy use due in part to Minnesota Power's

ongoing success with ECO delivering energy savings that have exceeded the 1.5 percent energy-savings goal every year for sixteen straight years, has resulted in lower energy sales.

Minnesota Power's industrial sector is predominantly natural resource based, and energy sales are largely driven by the global economic conditions and trade policies that determine demand for iron, steel, and paper as well as changes in manufacturing technology and processes that impact future demand for certain types of natural resource-based products such as taconite and printing and writing papers.

Demand for iron ore pellets is highly cyclical and increasingly subject to the steel industry's technological evolution. The Great Recession (2007–2009), increased global steel imports (2015–2016), and the COVID-19 Recession (2020) are each unique economic and trade policy conditions that resulted in the temporary idling of large taconite producing facilities, which in turn resulted in dramatic reductions in Minnesota Power's retail energy sales. In addition, the continued transition from traditional blast-furnace steelmaking toward EAF production places downward pressure on demand for traditional blast-furnace pellets. Recent producer decisions to idle or reduce operations at Minnesota taconite facilities demonstrate that pellet inventory levels, steel demand, facility economics, and corporate production strategies can cause material and difficult-to-predict changes in Minnesota Power's energy sales.

Demand for printing and writing paper has been in systemic decline since the proliferation of digital communication over the past 20 plus years. Sales to Minnesota Power's Forest Products customers have contracted at an average pace of about 6.3 percent per year from 2016 to 2025.

Minnesota Power's sales to wholesale customers have also declined. Independent municipal electric utilities, which until legislative changes to Minnesota energy policy a few years ago, were not required to align with Minnesota's Renewable Energy

Standard. This enabled them to purchase non-renewable and non-carbon free power supply at the lower marginal cost from the wholesale power markets.

Q. Are energy sales to residential and commercial customers generally more stable than to industrial customers?

A. Yes. While Minnesota Power has observed a clear downward trend in sales to Residential and Commercial classes, it is fair to say that any year-to-year changes in sales are small relative to the Industrial class. Historically, it has been exceedingly rare for Residential or Commercial sales to increase or decrease by more than five percent in any year, whereas a decrease of ten percent or more in industrial sales is not unusual for Minnesota Power. This energy sales trend, coupled with the significant Industrial customer sales on Minnesota Power's system create a level of volatility in energy sales that is not seen on other electric utility systems.

B. Residential and Commercial Sales

Q. Has Minnesota Power observed any notable trends in its Residential and Commercial customer classes?

A. Yes. There are long-term trends that correlate with regional demographics and conservation. The long-term view shows sales to both the Residential and Commercial classes have contracted since 2009—the end of the Great Recession (2007–2009). Prior to 2009, Residential and Commercial sales were growing at 1.6 percent per year and 2.6 percent per year, respectively. Since 2009, the pace of annual growth in both the Residential and Commercial sales has slowed to -0.3 percent. In both the Residential and Commercial classes, the pace of customer count growth has slowed and, on average, each individual customer is using less energy due to increases in home and business energy efficiency.

Q. What is driving the general downward trend of sales to the Residential class?

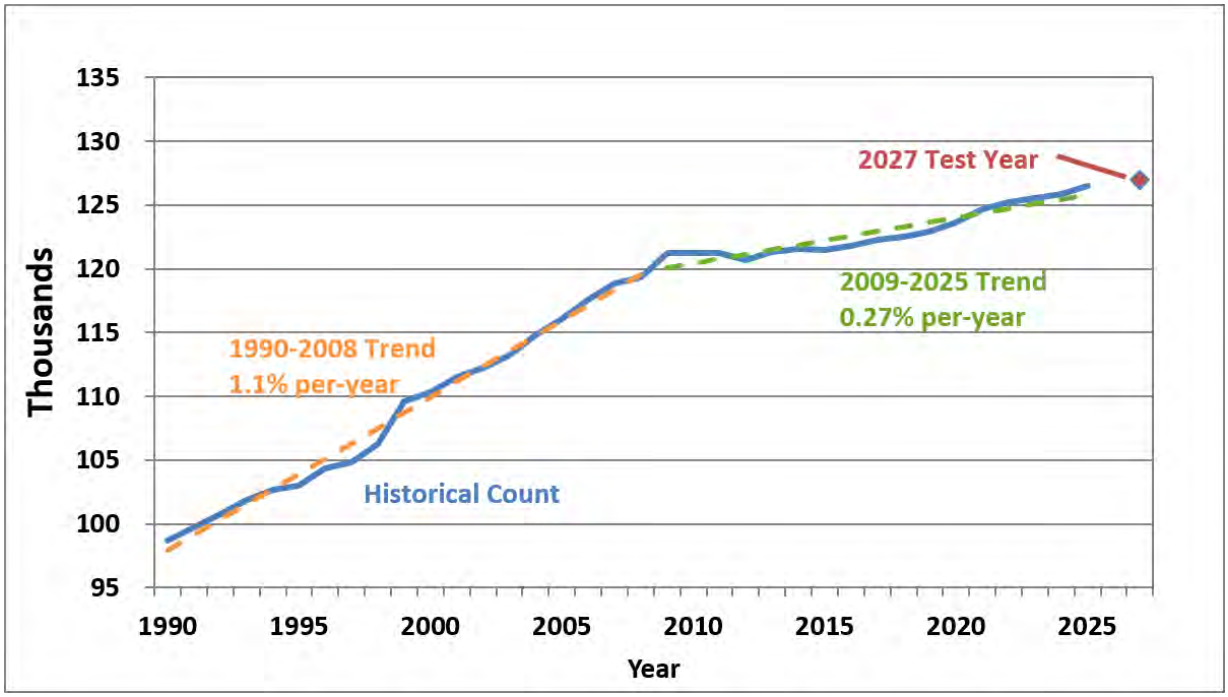
A. There are two factors driving lower sales to the Residential class in recent years: slow to stagnant customer count growth and reduced energy usage per customer. The reduced pace of customer count growth is due to regional demographic and economic factors.

The decreasing average energy use per Residential customer is at least partly driven by the cumulative effects of energy conservation. As a result, sales to the Residential class have declined slightly over the last decade; sales in the years 2008–2010 averaged 1,070,810 MWh, whereas sales over the last three years (2023–2025) have averaged 1,003,300 MWh.

Q. Describe trends in Residential customer counts.

A. The rate of annual Residential customer count growth slowed from an average 1.1 percent pace prior to the Great Recession (1990–2008) to just 0.27 percent per year since 2009. Figure 12 below compares the pre-recession and post-recession trends in Residential customer count growth. In terms of actual customer counts, Minnesota Power was gaining 1,150 Residential customers per year prior to 2009, and new customer growth has slowed to about 330 customers per year in the years since the Great Recession. The reduced pace of new Residential customer growth is consistent with regional population metrics. For example, U.S. Census data demonstrates that the City of Duluth's population, the largest city in Minnesota Power's service area, has increased by only 2.0 percent since 2010.

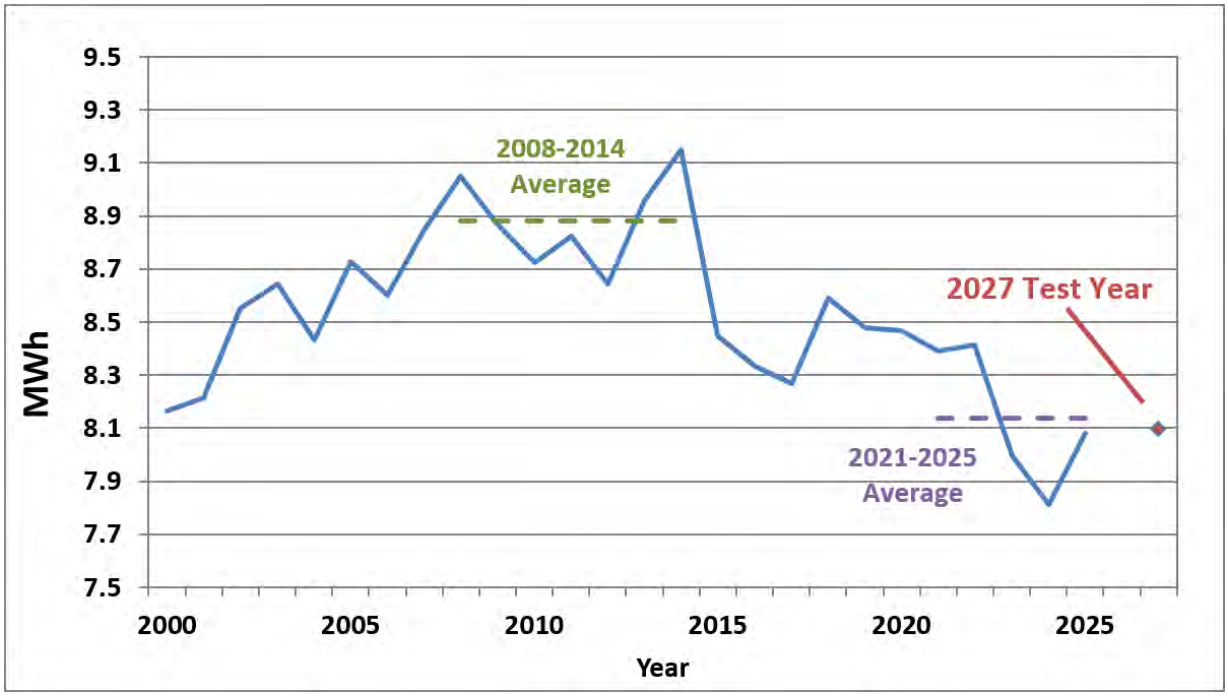
Figure 12. Residential Customer Counts



Q. How has energy use per Residential customer changed in recent years?

A. Energy usage by the average Residential customer has plateaued or decreased in recent years. Figure 13 below shows the average Residential customer's annual energy use averaged about 8,900 kWh in the 2007–2014 timeframe, declining to a 7,960 kWh level in the last three years (2023–2025). The Company attributes the decline in Residential per-customer energy use to both Minnesota Power's conservation programs and customer-driven conservation.

Figure 13. Average Residential Customer's Annual Energy Use

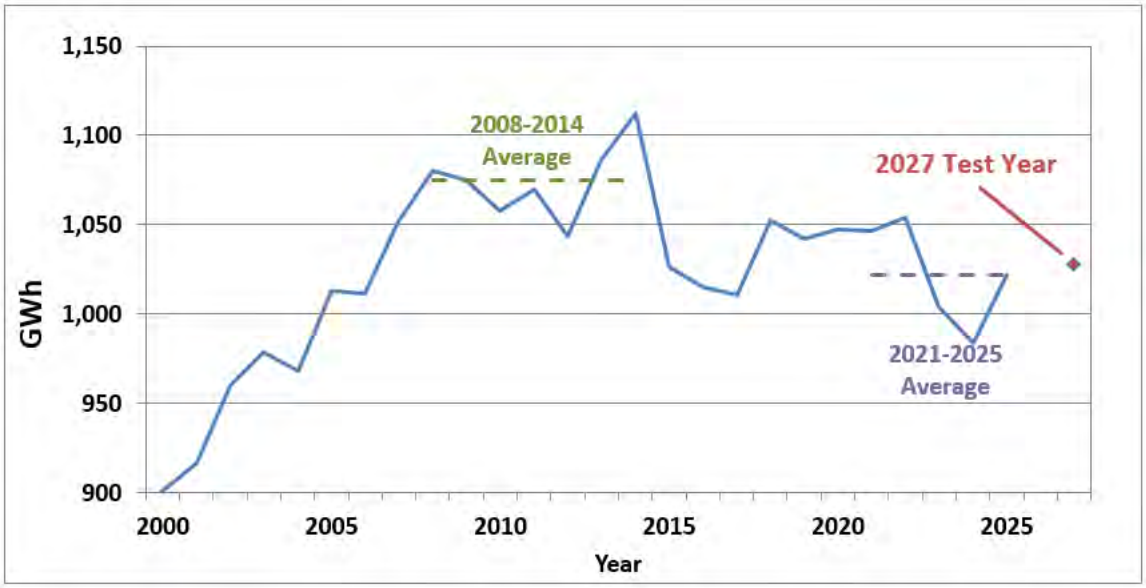


Q. Is the Company's 2027 test year sales forecast consistent with these recent trends for Residential customers?

A. Yes. Figure 12 and Figure 13 above show the test year forecasts of both customer count and average use per-customer are in line with recent trends. The 2027 test year forecast of customer count reflects a continuation of the low 0.2 to 0.3 percent per year growth trend since 2009. The forecast of use per customer is only slightly lower than a recent historical average, but this is in line with the historical downward trend of weather-normalized sales to this class.

The 2027 test year forecast of overall sales to the Residential class is produced by combining the modeled forecasts of customer count and per-customer usage. Figure 14 shows the Company's 2027 test year sales forecast for total Residential sales of 1,027,912 MWh is largely in line with the recent levels of actual sales and reflects a continuation of these trends. The 2027 test year outlook is about 5,750 MWh (0.6 percent) higher than 2025 actual sales and about 6,000 MWh (0.6 percent) higher than the five-year average (2011–2025).

Figure 14. Energy Sales to the Residential Customer Class

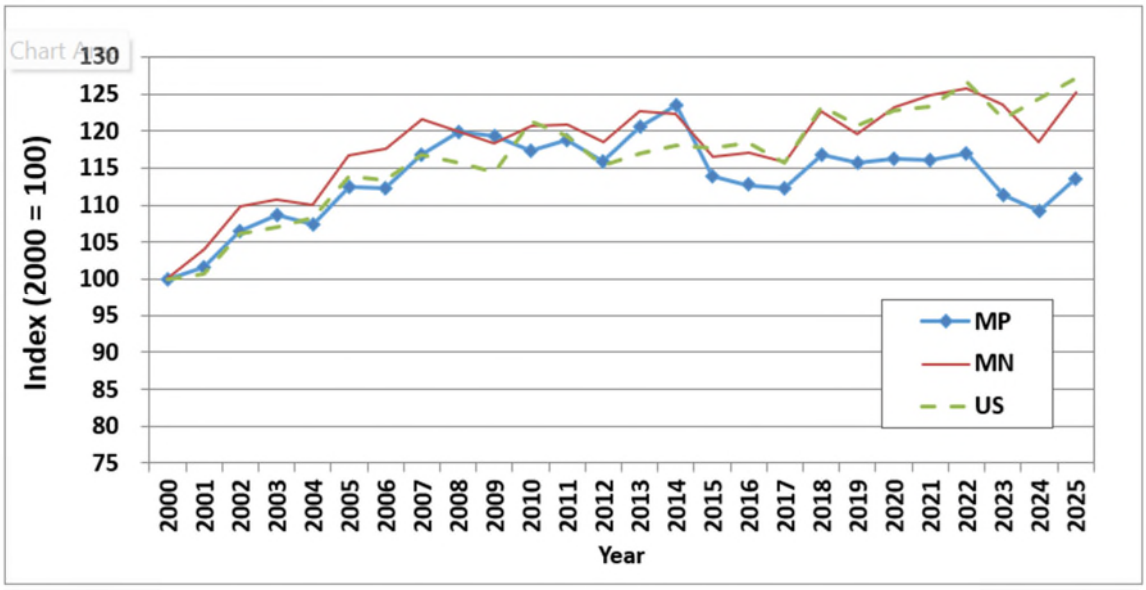


Q. Have the Company's historical sales been consistent with state and national trends for Residential customers?

A. Minnesota Power's sales to Residential customers generally followed historical state and national trends, but growth in state and national energy sales have outpaced Minnesota Power since 2021. Figure 15 shows Residential energy use at the state and national level compared to Minnesota Power's Residential sales with all sales histories indexed to 2000. All three Residential energy usage series in Figure 15 show a change in slope beginning in the 2007–2008 timeframe. Minnesota and national electricity usage grew by 22 percent and 17 percent (respectively) from 2000 to 2007, but electricity consumption in both geographies decreased (by 4.7 percent and 1.0 percent, respectively) from 2007 to 2017. Minnesota Power's Residential sales increased by 17 percent from 2000 to 2007 and then contracted 3.9 percent from 2007 to 2017. From 2017 to 2019, Minnesota and national Residential electricity usage grew by three and four percent, respectively, and Minnesota Power's sales to the class grew by 3 percent. In 2020, Minnesota and national sales growth to Residential customers began to significantly outpace Minnesota Power. From 2019 to 2022, both Minnesota and national sales to Residential customers grew by approximately six percent, whereas

Minnesota Power sales only grew by 1.1 percent over the same period. From 2022 to 2025, national sales grew slightly, Minnesota sales fell modestly (0.5 percent), and Minnesota Power sales again declined more sharply than both, falling 3.0 percent over the same period.

Figure 15. Residential Energy Use Trends: Minnesota Power, State of Minnesota, and U.S.



Q. Please describe recent trends in the Commercial customer class.

A. Similar to the trends seen with the Residential class, Commercial customer count growth and use per customer have also slowed in recent years. Figure 16 shows Commercial customer count grew by about 2 percent per year (350 new accounts per year) in the pre-2009 recession timeframe. Since 2009, this rate has slowed to about 1.1 percent (244 new accounts per year). The slower rate of customer growth is likely following the same demographic and economic trends that have impacted Residential customer growth since the Great Recession (2007–2009).

Figure 16. Commercial Customer Count

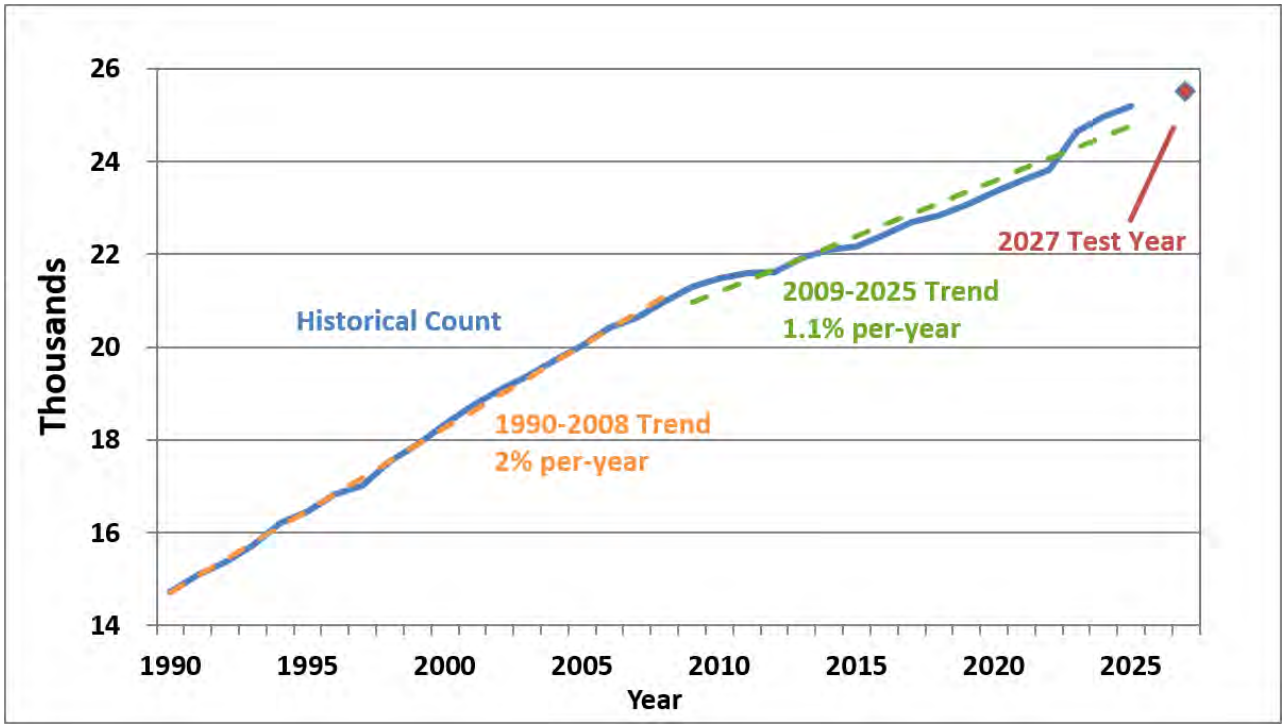
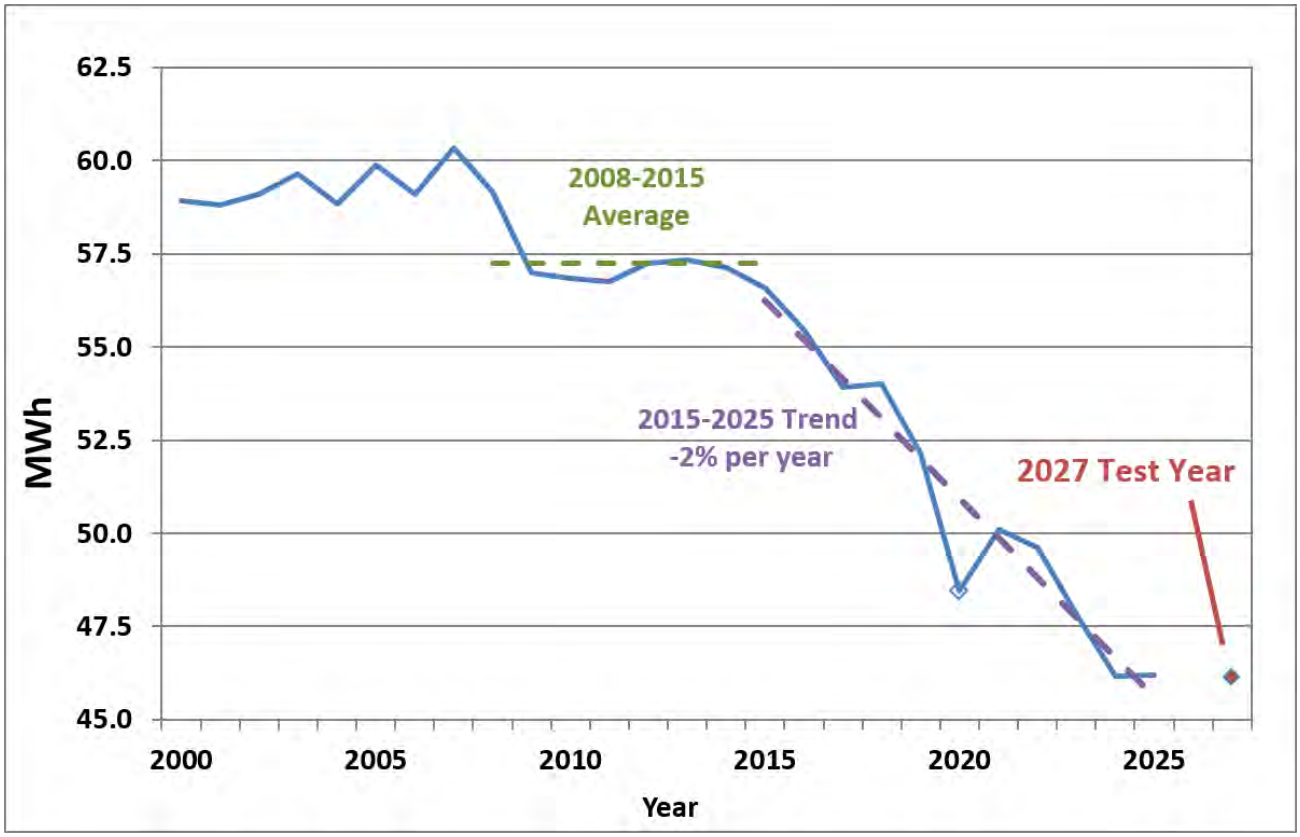


Figure 17 shows the average Commercial customer's annual energy consumption declined approximately 3.7 percent from 2008 to 2009, plateaued for about six years following the Great Recession, and then declined about 2.0 percent per year from 2015 to 2025. Sales to Commercial customers in 2020 were below the trend and depressed due to COVID-19, which had a direct impact on Commercial customer energy consumption. Following 2020, 2021 and 2022 Commercial customer energy intensity recovered modestly from 2020 levels, but continued the general downward trend from pre-COVID-19 levels. From 2023 to 2025 Commercial customer energy intensity fell 1.7 percent. The 2027 test year projection for per-customer Commercial use reflects a slight uptick from recent years but still below pre-Covid level based on past conservation trends and a continuation of the general downward trend.

Figure 17. Average Commercial Customer's Annual Energy Use

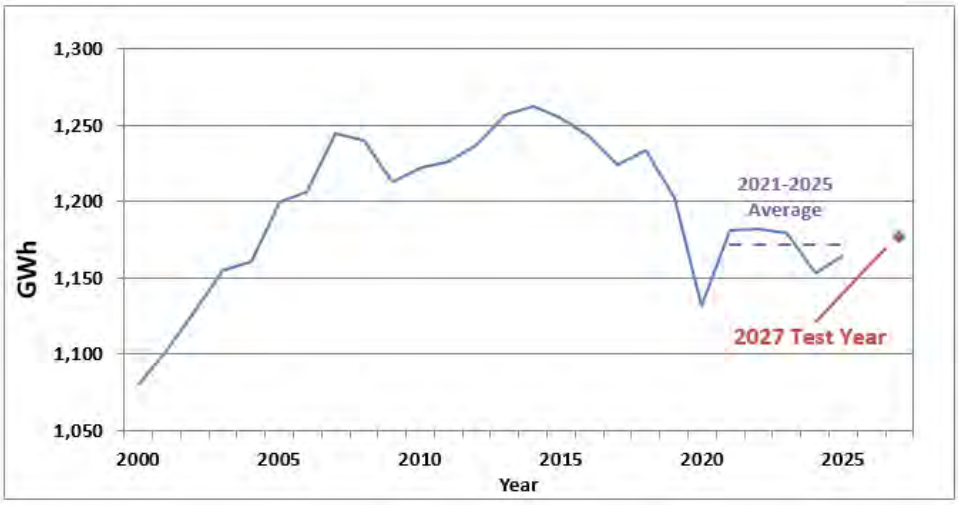


The underlying trend of decreasing per-customer usage is likely due in part to conservation, but also in part may be attributable to commercial customers operating on reduced hours following the COVID-19 pandemic due to business model changes, staffing challenges, optimizing time and days of operations, and more employees working from home.

Q. How does the Company's 2027 test year sales forecast for Commercial customers compare to actual sales in recent years?

A. Figure 18 shows the Company's 2027 test year forecast for Commercial energy sales (1,177,148 MWh) compared to recent historical actuals. The 2027 test year outlook is about 1.1 percent higher than 2025 sales. The 2027 test year outlook for Commercial sales still slightly lags pre- COVID-19 levels. For example, the 2027 test year forecast is about 2.1 percent below 2019 actual sales and 0.5 percent higher than a five-year (2021–2025) historical average of actual sales.

Figure 18. Energy Sales to the Commercial Customer Class



Q. Is the Company's 2027 test year sales forecast consistent with state and national trends for Commercial customers?

A. Minnesota Power's sales to Commercial customers have generally followed state trends, and the national trends are comparable in some respects. Figure 19 shows Commercial energy use at the state and national level compared to Minnesota Power Commercial sales with all sales histories indexed to 2000. All three historical series demonstrate the same flattening of sales starting around 2007 and 2008. Following the COVID-19 pandemic, both Minnesota and Minnesota Power Commercial sales have lagged pre-pandemic levels. United States Commercial sales returned to 2019 levels in 2022 while Minnesota exceeded 2019 levels in 2025, however Minnesota Power Commercial sales have yet to reach the same baseline. The 2027 test year sales forecast reflects the continued recovery from the pandemic, slightly lagging the United States in total.

Figure 19. Commercial Energy Use Trends: Minnesota Power, State of Minnesota, and U.S.



C. Industrial Customer Sales

Q. Earlier you discussed the Company's LP customers at a high level. Can you provide more detail regarding their individual status?

A. Yes. Table 8 below identifies our contracts for electric service for six taconite-producing facilities served through four LP customer contracts and four paper and pulp mills served through four LP customer contracts. Minnesota Power also has a non-firm retail power supply contract with Silver Bay Power Company, which supplies energy to the Northshore Mining Processing Facility in Silver Bay, Minnesota.

Table 8. Minnesota Power Firm Retail LP Customer Contracts[24]

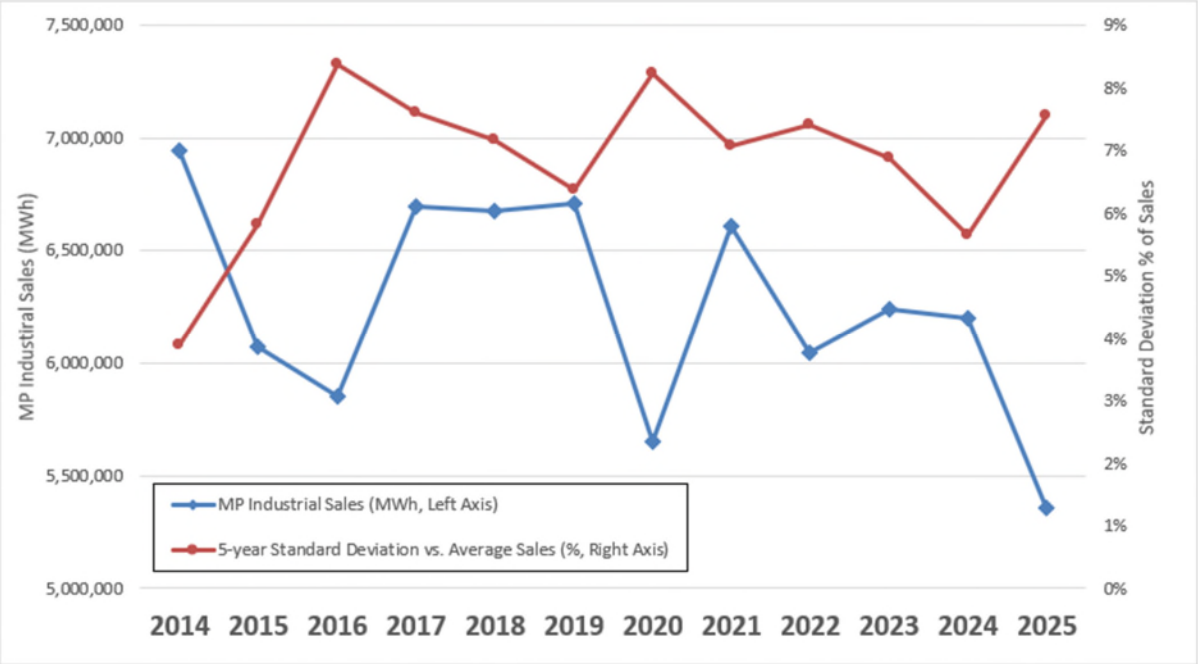
Customer	Industry	Ownership	Earliest Termination Date as of November 2, 2026	Status
Cleveland-Cliffs – Minorca Mine	Taconite	Cleveland-Cliffs.	November 30, 2030	Idled
United Taconite and Northshore Mining Babbitt Mine Operations	Taconite	Cleveland-Cliffs	November 30, 2030	Operating
Hibbing Taconite Co.	Taconite	85.3% Cleveland-Cliffs 14.7% USS Corporation	November 30, 2030	Partially Operating
USS Corporation (USS – Minnesota Ore)	Taconite	USS Corporation	January 27, 2029	Operating
Boise, Inc.	Paper	Packaging Corporation of America	November 30, 2028	Operating
UPM Blandin	Paper	UPM-Kymmene Corporation	November 30, 2030	Operating
Sappi Cloquet LLC	Paper and Pulp	Sappi Limited	November 30, 2030	Operating
Sofidel	Paper and Pulp	Sofidel	November 30, 2030	Operating

Q. What is the overall trend in energy sales to industrial customers in recent years?

A. Since 2014, average annual sales to its LP customers have decreased while the year-to-year variation in sales has increased. Figure 20 below illustrates both of these trends. Minnesota Power sales to its industrial customers fell twelve percent from 2014 to 2025. In addition, standard deviation as a percentage of average sales increased from six percent over the 2014–2018 three-year period to seven percent over the 2022–2025 period.

[24] Minnesota Power also has a non-firm retail power supply contract with Silver Bay Power Company, which supplies the Northshore Mining Processing Facility in Silver Bay, Minnesota, and Minnesota Power serves Mesabi Metallics via a wholesale agreement with Nashwauk Public Utilities.

Figure 20. MP Lower Industrial Sales and Increased Volatility (2014–2025)



Q. Why are the 2027 test year's retail LP sales levels lower than in recent years?

A. There are two key reasons. First, the downward trend in paper production has resulted in loss of customers and load over the past several years at Boise, UPM-Blandin, and Verso Duluth. The restart of the Duluth Mill by ST Paper and successor owner Sofidel to manufacture tissue paper has been a positive outcome amongst this negative trend; however, the energy required for the new operation is a fraction of what was required by the previous operation at the Duluth mill. Second, the Company's assumed test year taconite production level of 30 MT for its retail mining customers which reflects a continuation of recent industry conditions and updated outlooks for Minnesota's iron mining sector. This assumption is informed in part by taconite production of 28.5 MT in 2025 across all six mining facilities[25], as well as recent operational changes at specific plants, including reduced production expectations at Hibbing Taconite and the full idling of Minorca. The 30 MT assumption represents a level that is below the higher production years observed in the late 2010s and 2021, but consistent with more recent production outcomes that reflect both structural and operational changes within the

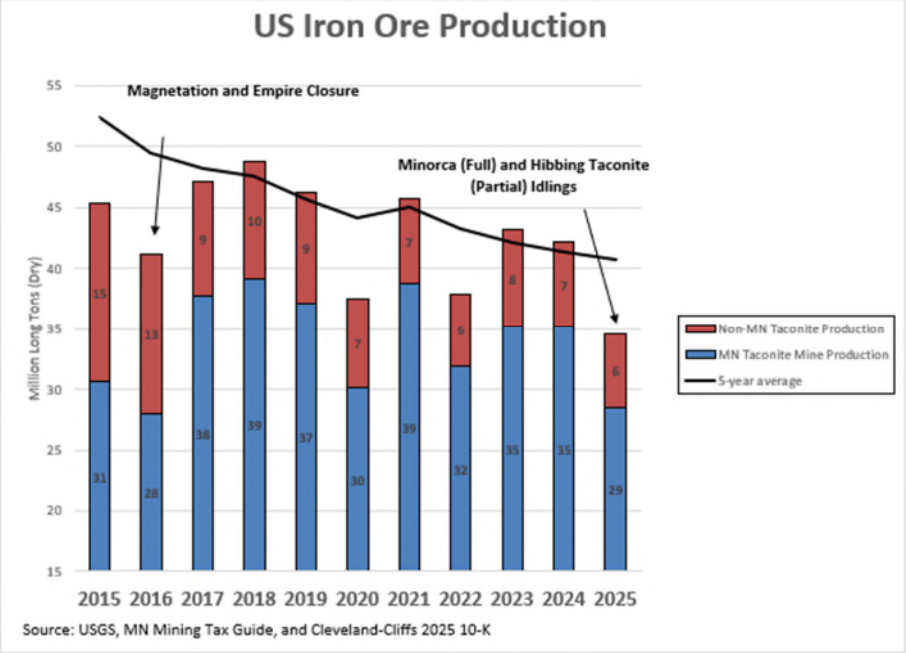
[25] MP Exhibit ___ (Forsman), Direct Schedule 9 at 1.

industry. As discussed later in my testimony, traditional blast furnace steelmaking continues to represent the principal market for Minnesota taconite pellets, while EAF production represents a growing share of North American steelmaking. This transition places downward pressure on demand for traditional blast-furnace pellets and increases the importance of pellet inventories, third-party sales, exports, facility economics, and corporate production-allocation decisions. Recent reductions at Minorca and Hibbing Taconite demonstrate how these factors can affect individual Minnesota facilities and Minnesota Power's energy sales. In addition to these structural demand changes, recent production trends have demonstrated increased variability in annual output due to facility-specific events and corporate-level production decisions. For example, production levels in recent years have been impacted by idling and partial idling of individual mines, and by shifting production strategies among vertically integrated steel producers. These dynamics, such as the partial and full idling of Hibbing Taconite and Minorca, support the Company's use of a 30 MT assumption as a reasonable and representative estimate of expected production over the test year.

Accordingly, the forecast reflects both the lower overall trend in taconite production and the increased volatility in year-to-year output. These conditions result in lower projected energy consumption from mining customers compared to recent high-production periods.

The 30 MT assumption also reflects recent blast furnace operating levels, actual 2025 Minnesota taconite production of 28.5 MT, and the longer-term production trend shown in Figure 21. Future production may also be affected by third-party or seaborne sales, but the timing and magnitude of those opportunities are uncertain and depend on producer-specific business decisions. Taken together, recent actual production, facility operating reductions, and the inability to predict where corporate-level production adjustments will occur support the use of 30 MT as a reasonable aggregate test-year assumption.

Figure 21. United States Iron Ore Production Annual and Five-Year Average



Q. Does Minnesota Power rely on historical sales trend information in developing its customer sales forecast?

A. As I discussed earlier, while historical trends of LP customer sales are taken into account, they are only one of many sources of information that the Company uses to develop a sales forecast that is as accurate and realistic as possible. Below, I describe in more detail the various sources of information gathered by Minnesota Power and how we use them in creating our LP customer sales forecast.

1. Mining and Metal Customers

Q. Please describe Minnesota Power's retail mining customers.

A. As previously noted, Minnesota Power provides electric service to all six of Minnesota's taconite plants. These six taconite plants are owned by two corporations: U.S. Steel and Cleveland-Cliffs. Minnesota Power also provides electric service to NewRange Copper Nickel.

Q. What does the global and regional economic data indicate about the iron mining industry for 2027 and beyond?

A. The outlook for the iron ore and iron ore pellet industry reflects a combination of supportive and challenging factors. Global iron ore markets continue to be influenced by steel demand, decarbonization initiatives, trade policy, and geopolitical developments. While earlier supply disruptions have largely subsided, uncertainty in global supply chains and international trade continues to affect market conditions.

Trade policy continues to be an important determinant of domestic steel production and demand for Minnesota taconite. Since 2018, the United States has maintained Section 232 trade measures on steel imports, with continued policy support for domestic production in recent years.[26] Geopolitical developments also continue to affect global iron ore and pellet trade. Russia's invasion of Ukraine has created ongoing challenges for Ukrainian mining and steel producers, contributing to continued uncertainty in the supply of high-grade iron ore products to global markets. Brazilian iron ore production has largely recovered from the dam failures that affected the industry during the late 2010s. However, pellet production has remained below prior expectations due to weaker demand and lower premiums for high-grade pellets.[27] As a result, pellet markets remain sensitive to shifts in steelmaking practices and environmental policies.

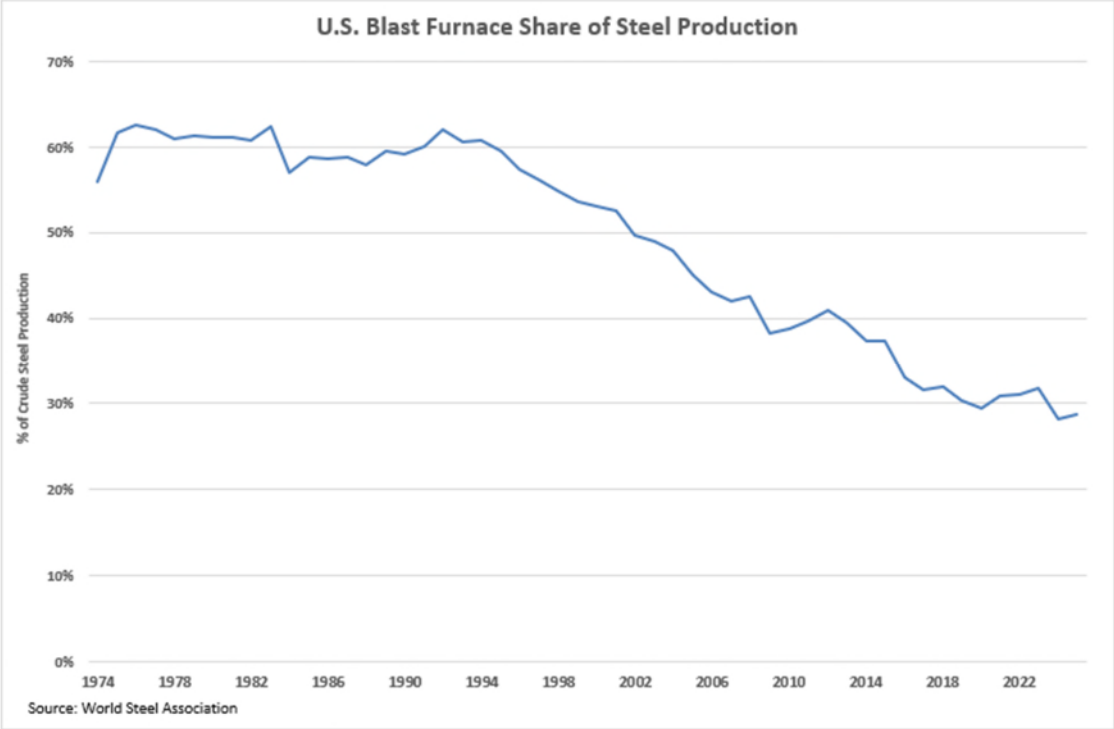
Looking ahead, the long-term outlook for Minnesota's iron ore industry is supported by the continued importance of domestic steel production, growing demand for higher-quality iron ore feedstocks used in lower-carbon steelmaking, and the strategic value of a reliable North American supply chain. However, these factors are offset by exposure to global market cycles, evolving trade policy, and technological changes in steelmaking, all of which contribute to increased variability in customer production levels and energy usage.

[26] MP Exhibit ___ (Forsman), Direct Schedule 10.
[27] MP Exhibit ___ (Forsman), Direct Schedule 9 at 2-4.

Q. What domestic factors are affecting Minnesota Power's mining customers?

A. On the domestic level, Minnesota Power's mining customers face changing demand for the traditional blast-furnace pellets produced by most Minnesota taconite facilities. Figure 22 shows that the blast-furnace share of domestic steel production has declined, which is caused by the increased share produced through EAFs.

Figure 22. United States Blast Furnace Share of Steel Production



Q. How does the change in the blast-furnace share of steel production affect iron ore pellet demand?

A. Currently, approximately 29 percent of all steel produced in the United States is produced by processes that use Minnesota's iron ore pellets. Both Cleveland-Cliffs and U.S. Steel have invested in products that can support newer steelmaking processes. However, most Minnesota taconite production remains tied to traditional blast-furnace steelmaking. As blast-furnace production declines relative to EAF production, demand for traditional taconite pellets faces downward pressure. This does not mean that pellet demand will decline uniformly each year, but it increases the likelihood that producers

will adjust output, inventories, and individual facility operating levels in response to changing market conditions.

Q. What recent evidence demonstrates how pellet inventory conditions and producer decisions can affect taconite production?

A. Recent production experience demonstrates that taconite producers may materially reduce operations at individual facilities to align production and inventories with market requirements. The U.S. Geological Survey estimated that U.S. iron ore production declined from 45.1 million metric tons in 2024 to 38.0 million metric tons in 2025 and attributed the decline in part to the idling of two iron ore mines as part of a producer's strategy to reduce stockpiles.[28] In Minnesota, these actions included the full idling of Minorca and reduced operations at Hibbing Taconite. These decisions directly reduced Minnesota Power's energy sales and illustrate why future operating levels cannot be forecast reliably on a facility-by-facility basis.

Q. How do changing pellet demand, inventory levels, and producer operating decisions affect Minnesota Power's energy sales?

A. Minnesota Power's energy sales are affected not only by domestic steel production, but also by producer decisions regarding pellet inventories, third-party sales, exports, facility costs, product requirements, and the allocation of production among affiliated mining facilities. These factors can result in production shifting among facilities or in the full or partial idling of individual mines with limited advance notice. Because Minnesota Power serves all six Minnesota taconite facilities owned by Cleveland-Cliffs and U.S. Steel, these decisions can materially affect the Company's energy sales and increase year-to-year sales volatility.

Q. Have changing market conditions and producer decisions resulted in reductions or closures of domestic iron ore production capacity?

A. Yes. Domestic iron ore production has experienced temporary idlings, operating reductions, and permanent facility closures for a variety of reasons, including inventory

[28] MP Exhibit ___ (Forsman), Direct Schedule 9 at 5-6.

management, facility economics, mine life, financial conditions, steel demand, and corporate production strategies. Examples include the indefinite idling of Minorca and partial idling of Hibbing Taconite, as well as earlier closures of Cleveland-Cliffs' Empire Mine and Magnetation's iron ore concentrate facilities in Minnesota and pellet plant in Indiana. Although the circumstances differed, these examples demonstrate that available production capacity does not necessarily operate continuously and may be curtailed or permanently removed in response to changing business conditions.

Q. Does Minnesota Power expect this trend towards more EAF and less blast furnace production to continue?

A. Yes. This trend toward EAF production is expected to continue in 2027 and beyond as steelmakers like Nucor, Steel Dynamics, Algoma Steel, ArcelorMittal Dofasco, and U.S. Steel, have announced or commissioned new EAF capacity additions and permanent shutdown of blast furnaces at their operations. Some of these projects are directly targeting the markets of integrated steelmakers, including automotive.[29] Other projects will result in a permanent reduction in North American demand for traditional blast furnace pellets when two Canadian steelmakers, Algoma Steel and ArcelorMittal Dofasco, complete their transitions into EAF steelmaking. Algoma Steel accelerated plans for a permanent closure of its blast furnace, shuttering its No. 7 Blast Furnace in early 2026 and moving exclusively to EAF production.[30] ArcelorMittal Dofasco broke ground in 2022 on its new EAF projects as part of their transition and plans for permanently closing their blast furnaces by 2028 continue.[31]

U.S. Steel, historically known for integrated steelmaking using blast furnaces, has continued to expand EAF production. In addition to its Fairfield, Alabama EAF operations[32], U.S. Steel completed the Big River Steel 2 expansion at Big River Steel Works in Arkansas.[33] Big River 2 nearly doubled the facility's capacity from

[29] MP Exhibit ___ (Forsman), Direct Schedule 4 at 25-29.
[30] MP Exhibit ___ (Forsman), Direct Schedule 4 at 30-35.
[31] MP Exhibit ___ (Forsman), Direct Schedule 4 at 36-41.
[32] MP Exhibit ___ (Forsman), Direct Schedule 11 at 1-2.
[33] MP Exhibit ___ (Forsman), Direct Schedule 11 at 3-5.

approximately three million to six million tons annually. These investments by U.S. Steel highlight how the domestic steel market continues to move towards EAF steel production, even by long-time proponents of traditional integrated steelmakers.

Cleveland-Cliffs has publicly discussed the steel industry's increasing adoption of EAF steelmaking technologies and the potential for greater EAF utilization within its own footprint.[34] The company's HBI facility in Toledo, Ohio provides a key metallic input for EAF steel production, and Cleveland-Cliffs has also began utilizing HBI and scrap steel into blast furnace operations to reduce carbon emissions. These developments reflect broader industry trends toward alternative steelmaking technologies and metallic inputs that may reduce future demand for traditional blast furnace production and, consequently, Minnesota taconite pellets.

Q. Are there any other notable trends among Minnesota Power's mining customers?

A. Yes. In addition to the continued transition towards EAF steelmaking and increased utilization of alternative metallic inputs, the North American steel industry has experienced significant consolidation and ownership changes in recent years. Cleveland-Cliffs acquired A.K. Steel in 2020 and ArcelorMittal U.S.A. later that same year, transforming the company from primarily an iron ore producer into one of the largest flat-rolled steel producers in North American.[35] The ArcelorMittal U.S.A. acquisition included ownership of the Minorca and ArcelorMittal U.S.A.'s 62 percent stake in Hibbing Taconite. Following the acquisition, Cleveland-Cliffs rationalized portions of its integrated steelmaking footprint, including the closure or idling of certain blast furnace assets.[36]

In addition, U.S. Steel completed its acquisition of Big River Steel in 2021, expanding its EAF-based steelmaking capabilities.[37] More recently, U.S. Steel became a subsidiary

[34] MP Exhibit ___ (Forsman), Direct Schedule 4 at 42-46.
[35] MP Exhibit ___ (Forsman), Direct Schedule 11 at 6-9.
[36] MP Exhibit ___ (Forsman), Direct Schedule 4 at 47-54; MP Exhibit ___ (Forsman), Direct Schedule 11 at 10-13.
[37] MP Exhibit ___ (Forsman), Direct Schedule 11 at 14-16.

of Nippon Steel following the completion of Nippon Steel's acquisition of the company in 2025.[38] These transactions reflect an industry that continues to evolve through consolidation, vertical integration, and investment in newer steelmaking technologies.

Q. How are these trends more specifically impacting Minnesota Power's iron mining customers?

A. As of late October 2026, Minnesota Power's mining customers continue to operate in an environment of uncertainty. While some facilities continue to operate at full production, the reductions at Minorca and Hibbing Taconite demonstrate how quickly operating levels can change in response to pellet inventories, domestic steel demand, and corporate-level decisions regarding where production should occur across a portfolio of mining assets. These decisions are increasingly difficult to forecast at the individual facility level and directly affect Minnesota Power's energy sales.

Cleveland-Cliffs' recent production decisions are an example of how these broader trends are affecting Minnesota Power's mining customers. Cleveland-Cliffs fully idled Minorca and reduced operations at Hibbing Taconite as part of production and inventory-management decisions across its portfolio of mining and steelmaking assets. These actions demonstrate how pellet inventories, steel demand, facility economics, and corporate-level production allocation can affect individual Minnesota facilities.

U.S. Steel has also continued to reduce and reposition its blast furnace footprint in aggregate while expanding its EAF steelmaking capabilities. The company indefinitely idled its two blast furnaces at Great Lakes Works in 2020 and later idled the second of two blast furnaces at Granite City Works in response to reduced steel demand until its recent restart in 2026.[39] At the same time, U.S. Steel has continued to invest in EAF production through Big River Steel and related metallics strategies, which further demonstrates the industry's transition away from traditional blast furnace production that relies most directly on Minnesota taconite pellets. Although Nippon Steel has

[38] MP Exhibit ___ (Forsman), Direct Schedule 11 at 17-21.
[39] MP Exhibit ___ (Forsman), Direct Schedule 9 at 7-43; MP Exhibit ___ (Forsman), Direct Schedule 4 at 55-57.

indicated plans to invest in U.S. Steel integrated facilities like Gary Works[40] and Mon Valley[41], including blast furnace-related assets, those investments appear intended to improve the competitiveness of selected facilities rather than reverse the broader industry trend toward increased EAF production and reduced reliance on traditional blast furnace pellets.

As North American blast furnace demand for pellets decreases, both Cleveland-Cliffs and U.S. Steel are investing in new products and strategies to respond to changing domestic steel production trends. Cleveland-Cliff's completed its investment in Northshore in 2019 to produce Direct Reduction Grade ("DR-Grade") pellets, and U.S. Steel completed its own DR-Grade Pellet investment at Keetac in 2024.[42] U.S. Steel has also communicated its objective to utilize low-cost iron ore units as part of a differentiated metallics strategy for its growing EAF assets, including investments in pig iron casting at Gary Works.[43] While these investments create new uses for iron ore pellets, the EAF steelmaking process requires fewer traditional taconite pellets than blast furnace steelmaking. Unless excess pellet capacity is sold into seaborne markets, production must continue to be curtailed, either temporarily or indefinitely, to balance supply with reduced demand.

Q. To what extent do you expect these trends to continue into 2027?

A. We expect these trends and factors to continue in 2027 as domestic steelmakers continue to transition towards EAF steelmaking even further. Reduced domestic demand for traditional iron ore pellets and potentially shipping to the seaborne iron ore pellet market will subject Minnesota Power's customers, and, in turn, Minnesota Power's energy sales, to increased volatility associated with highly volatile global iron ore markets. This provides a further consideration for the increased risk profile of Minnesota Power compared to the average electric utility and the need for the customer rate stabilization mechanism the Company is proposing in this rate case.

[40] MP Exhibit ___ (Forsman), Direct Schedule 11 at 22-23.
[41] MP Exhibit ___ (Forsman), Direct Schedule 4 at 58-60.
[42] MP Exhibit ___ (Forsman), Direct Schedule 11 at 24-25.
[43] MP Exhibit ___ (Forsman), Direct Schedule 5 at 89-227.

Q. What does the global and regional economic data indicate about steel and other precious metal mining industry for 2027 and beyond?

A. The clean energy economy, including continued investment in wind and solar generation, battery storage, transmission infrastructure, and electric vehicles is anticipated to require significant amounts of steel and critical minerals beyond current global demand. These technologies rely on mineral-intensive supply chains, including materials such as iron ore, copper, nickel cobalt, lithium, platinum, palladium, and rare earth elements. As a result, long-term demand for mined materials is expected to remain an important factor in global decarbonization efforts, even though near-term market conditions may vary based on commodity prices, trade policy, financing conditions, and supply chain volatility.

In 2017, The World Bank released a report on "The Growing Role of Minerals and Metals for a Low-Carbon Future"[44], which concluded that a low-carbon future would require substantial quantities of minerals and metals. The World Bank subsequently reaffirmed and strengthened that conclusion in its 2020 report, "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition"[45], stating that "a low-carbon future will be very mineral intensive because clean energy technologies need more materials than fossil-fuel-based electricity generation technologies.
The report highlighted the substantial increase in demand for several key minerals and metals to manufacture cleaner energy technologies, effectively stating the clean energy transition will be significantly mineral intensive.

Northeastern Minnesota's existing and potential future mining industry is well positioned to support this demand because the region has mineral resources, existing industrial infrastructure, and an experienced and talented workforce. However, permitting requirements, legal challenges, financing, and project development timeliness continue to delay development of new mining facilities in the region.

[44] MP Exhibit ___ (Forsman), Direct Schedule 4 at 61-63.
[45] MP Exhibit ___ (Forsman), Direct Schedule 12.

Q. What information specific to each Company mining customer is used in forecasting sales?

A. Below, I walk through each LP mining customer in turn.

a. U.S. Steel

Q. Please describe U.S. Steel's operations in Minnesota Power's service territory.

A. U.S. Steel wholly owns both the Minntac and Keetac facilities and owns 14.7 percent of Hibbing Taconite Company. These facilities produce iron ore pellets primarily for use in U.S. Steel-owned blast furnaces and, in recent years, for third-party sales. U.S. Steel has also invested in Keetac to make DR-Grade, which supports U.S. Steel's broader metallics and EAF strategy.

Q. What type of agreement does the Company have with U.S. Steel?

A. The Company has an LP ESA with USS Corporation for its Minnesota Ore Operations of Minntac and Keetac. As of November 2, 2026, the earliest termination date for this ESA is January 27, 2029.

Q. Have there been any notable changes to U.S. Steel's business since the Company's last rate case?

A. Yes, as I described earlier in my testimony, U.S. Steel has experienced significant ownership and strategic changes. U.S. Steel became a subsidiary of Nippon Steel following completion of Nippon Steel's acquisition of the company. Nippon Steel has indicated plans to continue investing in U.S. Steel's North American operation, including $800 million of pledged capital investment in Minnesota.[46]

In Minnesota, U.S. Steel's completed investments at Keetac to support production of Direct Reduction Grade pellets reflect the continued strategic importance of Minnesota ore assets and may support U.S. Steel's broader metallics and EAF strategy. At the same time, Keetac has historically been a swing facility for U.S. Steel. Keetac was idled

[46] MP Exhibit ___ (Forsman), Direct Schedule 4 at 64-68.

during the import-driven steel downturn of 2015–2016 and resumed operations in February 2017 after a 22-month idling. Keetac ran at full production until April 2020, when U.S. Steel announced it would idle the facility and lay off 375 employees[47] before announcing its restart later that year.[48] These developments are important, but they do not eliminate the uncertainty associated with future facility-level production decisions. Even with Nippon Steel's acquisition and continued investment in U.S. Steel's assets, production levels at Minntac, Keetac, and Hibbing Taconite remain subject to steel demand, pellet inventories, third-party sales opportunities, metallics strategy, and corporate-level production decisions.

Q. What sources of information have been relevant to Minnesota Power's determination of a reasonable 2027 forecast of sales to U.S. Steel?

A. The Company has considered a variety of information sources, including direct communications with U.S. Steel, customer nominations, historical operating and usage patterns, and industry data. In addition, the Company reviews publicly available information regarding U.S. Steel's operations and strategic direction.

Q. How do these assumptions align with broader industry and economic trends affecting the mining business?

A. The Company's test year forecast assumptions for U.S. Steel are generally consistent with the mining industry economic trends and historical average production as discussed earlier.

b. Cleveland-Cliffs

Q. Please describe Cleveland-Cliffs operations in Minnesota Power's service territory.

A. Cleveland-Cliffs wholly owns Northshore Mining Company, Minorca, and United Taconite LLC. Cleveland-Cliffs also owns 85.3 percent of Hibbing Taconite Company. These facilities produce iron ore pellets for use in Cleveland-Cliffs owned blast

[47] MP Exhibit ___ (Forsman), Direct Schedule 4 at 69-72.
[48] MP Exhibit ___ (Forsman), Direct Schedule 4 at 73-76.

furnaces. Northshore Mining Company also produces DR-Grade iron ore pellets for further processing at its HBI facility in Toledo, Ohio.

Q. Please summarize the notable changes to Cleveland-Cliffs' business since the Company's last rate case?

A. As I discussed, since Minnesota Power's last rate case Cleveland Cliffs has continued to adapt its business to evolving steel industry production trends and raw material requirements.

Q. What type of agreement does the Company have with Cleveland-Cliffs?

A. The Company has an LP ESA with United Taconite LLC and with Northshore Mining's Babbitt mine operations, an LP ESA with Minorca, and an LP ESA with Hibbing Taconite Company. As of November 1, 2026, the earliest termination date for these LP ESAs is November 30, 2030. The Company also has a non-firm retail power supply agreement with Silver Bay Power Company, which provides energy to the Northshore Mining processing facility in Silver Bay, Minnesota.

Q. How does the Company's test year sales assumptions for Cleveland-Cliffs align with broader industry and economic trends affecting the mining business?

A. The Company's test year forecast assumptions for Cleveland-Cliffs are generally consistent with the mining industry economic trends and historical average production as discussed earlier.

c. Mesabi Metallics

Q. Please provide some background on Mesabi Metallics' history in Minnesota.

A. In 2008, Essar Steel Minnesota, a predecessor to Mesabi Metallics, broke ground on what was expected to be the first fully integrated mine-to-steel production facility in North America. At that time, the project had been in development for over a decade

and, despite construction, was awaiting certain financing.[49] The state of Minnesota contributed more than $70 million to the project in support of its development and the steel mill component of the project was dropped in approximately 2016, after which Essar Steel Minnesota filed for Chapter 11 bankruptcy in 2016. The company emerged from bankruptcy in 2017 as Mesabi Metallics, which was reclaimed by Essar Group in 2019, continues construction of the iron ore mine and processing facility, and is continuing repayments to the state of Minnesota.

Q. What is the current status of the Mesabi Metallics iron ore mine and processing project?

A. The facility is progressing toward completion of construction, and public reporting has indicated continued advancement of the project toward commercial operations. While Minnesota Power provides direct retail electric service to a small portion of the Mesabi Metallics facility, most of the Mesabi Metallics facility is in the service territory of Nashwauk Public Utilities, which receives wholesale electric service from Minnesota Power to serve its municipal load, including Mesabi Metallics. Minnesota Power maintains ongoing communication with Nashwauk Public Utilities and Mesabi Metallics regarding expected system needs and continues to monitor developments associated with the project.

Like other Mining and Metals customers, Mesabi Metallics will operate in global iron ore and steel markets, and its near-term production and energy usage may therefore vary based on commodity demand, pricing, trade conditions, and other market factors outside their control. Accordingly, although the test year forecast appropriately reflects Mesabi Metallics' contractual commitments, the timing and level of actual energy sales remain subject to near-term uncertainty. Actual energy usage will also remain subject to commissioning progress, operating conditions, commodity markets, and other factors affecting the timing and level of production. A proposed steel plant in Iowa that would

[49] *In the Matter of the Application of Minnesota Power For Authority to Increase Rates for Electric Utility Service in Minnesota*, Docket No. E015/GR-09-1151, Rebuttal Testimony of Michale Perala at 15 (Apr. 29, 2010) (eDocket No. 20104-49852-01).

use Minnesota taconite pellets from Mesabi Metallics has been announced, but is not expected to begin producing steel until 2030.[50]

Q. In light of the current status of the facility, what is Company's approach to Mesabi Metallics in this case?

A. The Company has included approximately **[TRADE SECRET BEGINS ▉ TRADE SECRET ENDS]** MW of projected wholesale sales to Nashwauk Public Utilities, attributed to the Mesabi Metallics load, in the 2027 test year forecast. This assumption is based on Mesabi Metallics' contractual obligations associated with 2027 service and reflects the Company's effort to recognize contractual commitments in a manner that moderates the overall rate impact to retail customers.

However, actual usage to date remains significantly below the 2027 test year MW level and has generally been less than **[TRADE SECRET BEGINS ▉ TRADE SECRET ENDS]** MW. Therefore, the 2027 test year MW assumption should not be understood as being based on demonstrated operating history or current actual load. Rather, for now, it is a ratemaking assumption based on the contractual obligation for 2027. The Company plans to provide an update on Mesabi Metallics in rebuttal testimony.

Minnesota Power will continue to monitor actual usage, customer communications, construction and commissioning progress, and other relevant information. If actual load continues to remain materially below the assumed 2027 test year MW level, that difference will represent a meaningful variance from the test year forecast and illustrates the broader risk associated with large industrial customer load uncertainty. If it is higher, the increase in sales will help reduce the revenue deficiency. This is the type of volatility that must be addressed in a balanced way so that neither customers nor the Company bear the full consequences of a single forecast assumption that may differ materially from actual operations.

[50] MP Exhibit ___ (Forsman), Direct Schedule 4 at 77-82.

d. PolyMetNewRange Copper Nickel

Q. How long has the PolyMet/NewRange Copper Nickel mine been in development in Minnesota?

A. In 1989, PolyMet leased mineral rights from U.S. Steel. The environmental review process began in 2004, and PolyMet acquired the Erie Plant near Hoyt Lakes, Minnesota in 2005. Minnesota Power entered into an ESA with PolyMet Mining Corporation in December of 2006. This ESA was approved by the Commission in 2007 (Docket No. E-015/M-07-221), and has been discussed in past Minnesota Power rate cases.

Q. Please describe the joint venture between PolyMet and Teck Resources.

A. On February 15, 2023, PolyMet closed a 50:50 joint venture with Teck American Inc., a subsidiary of Teck Resources Limited ("Teck"), that places their respective NorthMet and Mesaba resources under single management.[51] In doing so, PolyMet and Teck became equal owners in PolyMet Mining, Inc., which was renamed NewRange Copper Nickel LLC.

Q. Please describe NewRange Copper Nickel's current activities in Minnesota Power's service territory and any notable changes to NewRange Copper Nickels' operations since the Company's last rate case.

A. The NewRange Copper Nickel NorthMet project is located near the community of Hoyt Lakes, Minnesota. When operational, this non-ferrous mining operation will produce copper, nickel, palladium, cobalt, and other minerals used in clean energy and industrial supply chains. The project continues to have long-term regional economic development potential, but it also continues to face significant permitting, legal, and project development uncertainty. Since the Company's last rate case, the status of the NorthMet project has changed materially.

In 2023, the U.S. Army Corps of Engineers ("USACE") revoked the project's previously issued permit under Section 404 of the Clean Water Act.[52] The USACE has

[51] MP Exhibit ___ (Forsman), Direct Schedule 13 at 1-8.
[52] MP Exhibit ___ (Forsman), Direct Schedule 13 at 9-10.

indicated that NewRange intends to submit a new Section 404 permit application for the proposed development of the NorthMet Mine. The project is also listed on the federal permitting dashboard with environmental review and permitting shown as in progress and an estimated completion date in 2028.[53]

State permitting also remains unresolved. The Minnesota Department of Natural Resources stayed the contested case process related to the Permit to Mine while NewRange evaluates potential project design changes, including tailings storage options, water treatment approaches, production efficiency, and carbon reduction measures.[54] If NewRange proposes material changes to the project design, additional environmental review, permitting, and public comment opportunities may be required. As a result, although NewRange continues to maintain and advance the project and has publicly discussed additional studies and potential improvements, the timing of construction and commercial operation remains uncertain. Following resolution of outstanding federal and state permitting requirements, legal challenges, project design decisions, and financing, construction would still require a multi-year period before commercial operations could begin. Accordingly, startup of the NewRange Copper Nickel NorthMet project remains outside the 2027 test year.

Q. What sources of information have been relevant to understand NewRange's plans and status?

A. The Company communicates directly with New Range Copper Nickel on an ongoing basis and also reviews publicly available information from public disclosures, federal and state permitting materials, the federal permitting dashboard, and public reporting regarding the project. These sources provide information regarding the status of permitting, litigation, project studies, potential design changes, and development milestones. Minnesota Power also continues to monitor project activity and customer communications to understand the potential timing and magnitude of any future electric service requirements.

[53] MP Exhibit ___ (Forsman), Direct Schedule 13 at 11-14.
[54] MP Exhibit ___ (Forsman), Direct Schedule 13 at 15-17.

Q. What are the key assumptions included in forecasts of Minnesota Power sales to NewRange Copper Nickel for the 2027 test year?

A. The 2027 test year includes a minimal level of NewRange Copper Nickel load, consistent with idle levels. Once in operation, Minnesota Power will supply power to the NewRange Copper Nickel NorthMet Project via a ten-year ESA that was approved by the Commission in 2007. But this timeline is still several years into the future, even assuming no further permitting delays or legal challenges.

e. Former Magnetation Sites

Q. What is the status of the former Magnetation iron ore mine and processing project?

A. The former Magnetation sites—specifically Plant 2, Plant 4, and the Jesse Mine Loadout—were purchased out of bankruptcy by ERP Iron Ore LLC ("ERP"). ERP never operated the facilities and declared bankruptcy. In the latest round of bankruptcy, all of the Company's contracts with ERP were rejected by the bankruptcy court. Minnesota Power disconnected electric service to the ERP facilities in its service territory in the spring of 2018. The bankruptcy trustee has sold the aforementioned assets, Plant 2 was dismantled, and Prairie River Minerals was awarded the right to purchase the Plant 4 and Jesse Mine Loadout assets. Prairie River Minerals also never operated the facilities and declared bankruptcy, and Minnesota Power disconnected electric service in the summer of 2019. A new company, MagIron LLC, has purchased the Plant 4 and Jesse Mine Loadout assets from the bankruptcy trustee, and Minnesota Power has reconnected general service to the facilities. MagIron LLC has been doing pilot scale bench testing with the Minnesota Natural Resources Research Institute but has no firm timetable for construction and commencement of commercial production.

Q. What level of sales are assumed for the former Magnetation facilities in the Company's sales forecast for 2027?

A. No sales to the customer are reflected in the 2027 industrial customer test year sales forecast as usage at the former Magnetation facilities under our general service rate

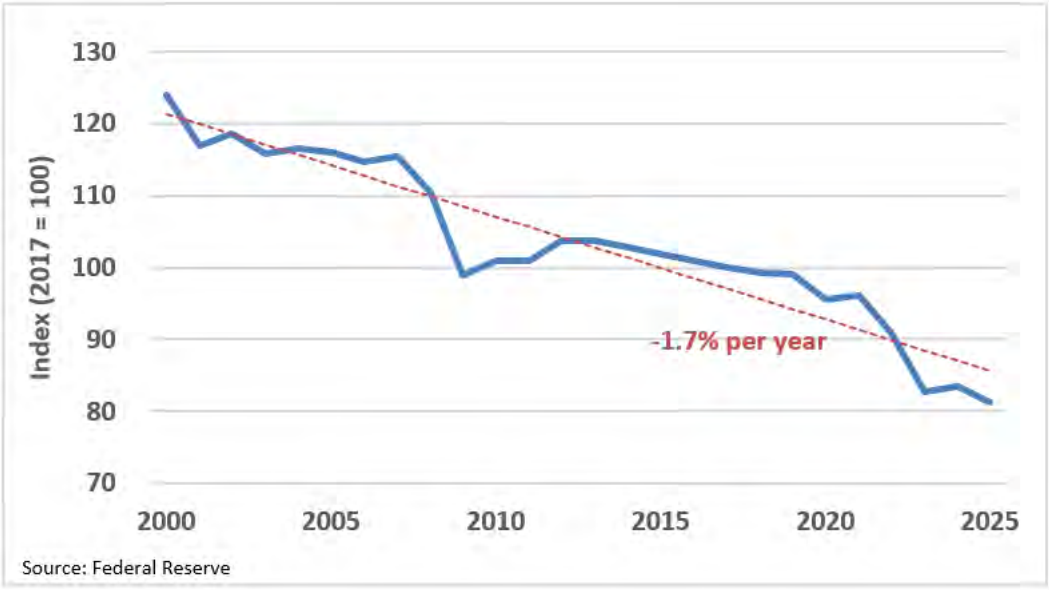
schedule is limited to lighting and building heat and reflected in our test year sales for the general service schedule.

2. Paper and Pulp Customers

Q. Please describe the Company's customers in the Paper and Pulp sector.

A. Minnesota Power currently serves four operating pulp and paper mills, each producing a different paper product (or paper "grade"): (a) Blandin Paper Company ("Blandin") in Grand Rapids, which produces Coated Ground Wood ("CGW"); (b) Boise in International Falls, which produces an Uncoated Free Sheet ("UFS"); (c) Sappi in Cloquet, which produces Coated Free Sheet ("CFS"); and (d) Sofidel in Duluth, which produces recycled tissue for the away from home market ("tissue"). The mills that produce printing and writing papers continue to face a secularly declining North American paper market due to electronic substitution and changing consumer preferences. By contrast, tissue consumption has been comparatively more stable, although tissue producers remain exposed to input costs, labor transportation, and broader economic conditions. Figure 23 below shows an index of U.S. paper production since 2000. Production has declined by 1.7 percent per year (CAGR) for the last two decades.

Figure 23. U.S. Index of Industrial Production for Paper



Minnesota Power annual sales to Paper and Pulp customers declined by about 775,279 MWh (52 percent) from 2014 to 2025. Reductions in sales have occurred for two reasons: (1) customers reducing energy costs through energy conservation and by increasing their own generating capabilities to reduce purchases from Minnesota Power, and (2) permanent paper machine shutdowns or mill closures. These reductions in sales have occurred with some regularity.

Q. Please provide additional details regarding the overall reduction in sales to Minnesota Power's Paper and Pulp customers.

A. In late 2013, Boise idled two paper machines resulting in an approximate **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]** MWh reduction in annual sales. In 2015, Boise installed a new turbine generator that displaced Minnesota Power deliveries and reduced annual sales by about **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]** MWh. In mid-2016, the Sappi Turbine Generator 5 transitioned to Sappi ownership and resulted in an approximate **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]** MWh reduction in annual sales. In late 2017, Blandin idled its Paper Machine # 5, resulting in an annual sales reduction of about **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]** MWh. In mid-2020, the Verso mill in Duluth idled the entire mill and later decided to permanently shut down the mill, resulting in an annual sales reduction of about **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]** MWh.[55]

In 2013, Sappi converted some of its processes to a chemical cellulous product that is used in textiles. In 2021, ST Paper purchased the Duluth mill from Verso and converted the mill tissue production. ST Paper later sold the mill, which has again been operational since early 2023, to Sofidel. While Sofidel has expanded the mill, this expansion has had a limited impact on sales and Sofidel's annual energy requirements are about **[TRADE SECRET DATA BEGINS** [redacted] **TRADE SECRET DATA ENDS]**

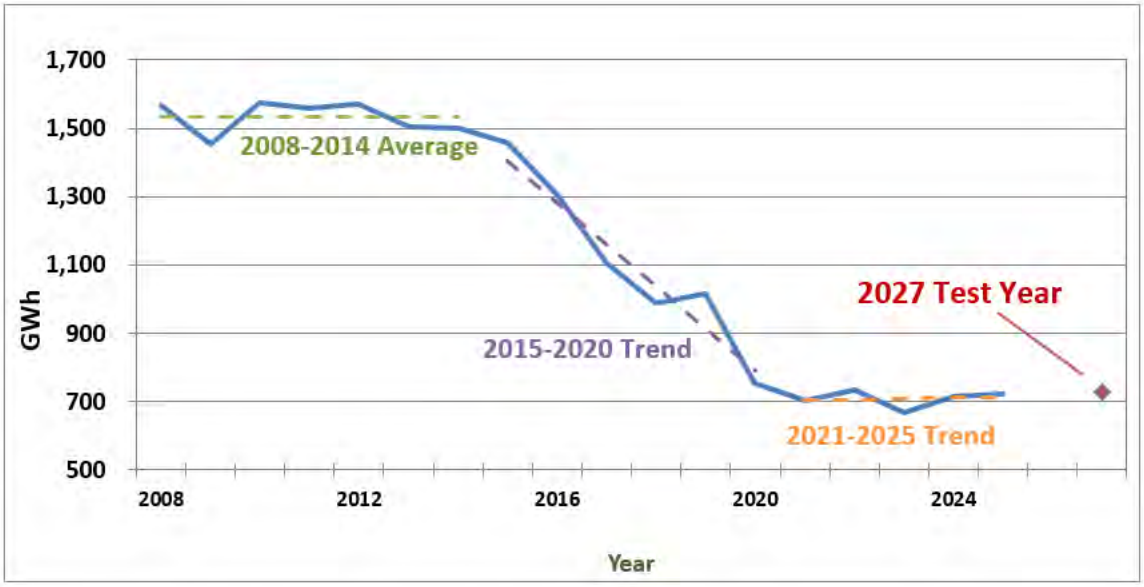
[55] MP Exhibit ___ (Forsman), Direct Schedule 11 at 26-29.

MWh, which are about 75 percent less than the prior requirements of the Verso Duluth mill.

Q. How does the Company's 2027 test year forecast for Paper and Pulp customers compare to actual sales in recent years?

A. Figure 24 shows the Company's 2027 test year forecast for the Forest Products Industrial sector (729,435 MWh) is in line with other recent years.

Figure 24. Energy Sales to the Forest Products Industrial Sector



Q. Please describe the assumptions for Paper and Pulp customers in the Company's test year forecast.

A. The Company's 2027 test year forecast for the Forest Products Industrial sector of 729,435 MWh assumes production and energy requirements at all paper mills remain in line with current levels.

Q. What does the data collected and reviewed by the Company indicate about the future of the pulp and paper industry for 2027 and beyond?

A. The Company reviews reports and data from sources such as PaperAge, Quad Paper Services, AF&PA, Pulp and Paper Products Council, the Minnesota DNR's monthly

Wood Markets Update, Specialty Print Communications, GlobalNewswire, Vantage Market Research, and Fastmarkets RISI. Metrics considered include mill operating and capacity rates, demand indicators such as magazine advertising pages, catalog mailings, postage rates, imports, exchange rates, and pricing.

In general, graphic paper demand remains in secular decline as electronic substitution and changing consumer preferences continue to reduce demand for magazines, catalogs, advertising insert, office paper, and other traditional paper uses. More than half of market demand for graphic paper has declined since the late 2000s, and this demand is not expected to return to prior levels. Recent industry data continues to show weakness in printing and writing papers, including a 14 percent decline in printing-writing capacity in 2025 and a reduction of nearly 55 percent of overall capacity since 2015.[56]

At the same time, the broader pulp and paper industry is not declining uniformly. Packaging, tissue, and certain pulp products have generally shown more stable or resilient demand than graphic paper, although those markets also remain exposed to inflation, interest rates, inventory cycles, imports, and broader economic conditions. As a result, mills and producers across industry segments continue to evaluate machine shutdowns, mill closures, conversions, and product mix changes to align capacity with demand.

Capacity rationalization remains important for the industry. In graphic paper markets, continued capacity reductions are generally necessary to support operating rates and price stability as demand declines. Some mills can convert equipment to packaging, tissue, specialty paper, or market pulp production, but not all facilities are capable of economic conversion. As a result, more mill closures, machine shutdowns, and conversion are expected to remain necessary as the industry continues to adjust to lower long-term demand for printing and writing papers.

[56] MP Exhibit ___ (Forsman), Direct Schedule 11 at 30-35.

For Minnesota Power's paper and pulp customers, these trends support a forecast that assumes continued operations at current levels, while recognizing that the sector remains exposed to structural demand decline, input cost pressure, and customer-specific operating decisions.

Q. What information specific to each Paper and Pulp customer is used in forecasting sales?

A. Below, I walk through each LP Paper and Pulp customer in turn.

a. Blandin

Q. Please describe Blandin's operations in Minnesota Power's service territory.

A. Blandin Paper Company is a groundwood pulp and papermaking facility that operates a single paper machine producing Light Weight Coated papers used for catalogs, magazines, advertising inserts, direct mail, and other commercial products. Blandin is wholly owned by UPM, a Finland based corporation.

Q. What type of agreement does the Company have with Blandin?

A. The Company has an LP ESA with Blandin Paper Company for its operations in Grand Rapids, Minnesota. As of November 1, 2026, the earliest termination date for this ESA is November 30, 2030.

Q. Have there been any notable changes to Blandin's business since the Company's last rate case?

A. No. Blandin has continued to operate in a graphic paper market that remains structurally challenged due to electronic substitution and reduced demand for magazines, catalogs, advertising inserts, and other coated groundwood paper uses. The 2027 test year forecast assumes Blandin continues to operate at levels generally consistent with recent operating history and current customer expectations.

Q. What sources of information have been relevant to Minnesota Power's determination of a reasonable 2027 forecast of sales to Blandin?

A. To forecast Blandin's 2027 energy purchases, the Company relied upon the Incremental Production Service Threshold ("IPST") set forth in the ESA, UPM's quarterly and annual reports, the aforementioned customer and industry data, and conversations with the customer.

Q. How do these assumptions align with broader industry and economic trends affecting the pulp & paper business?

A. They are consistent with declines in the paper and pulp business described earlier in my testimony.

b. Boise

Q. Please describe Boise's operations in Minnesota Power's service territory.

A. Boise is a kraft pulp and paper facility that operates two paper machines producing Uncoated Freesheet papers used for office and copy papers. Boise is wholly owned by Packaging Corporation of America ("PCA").

Q. What type of agreement does the Company have with Boise?

A. The Company has a LP ESA with Boise, Inc., for its operations at International Falls, Minnesota. As of November 1, 2026, the earliest termination date for this ESA is November 30, 2028.

Q. Have there been any notable changes to Boise's business since the Company's last rate case?

A. No. Boise continues to operate at similar levels to what was approved in the 2023 Rate Case.

Q. What sources of information have been relevant to Minnesota Power's determination of a reasonable 2027 forecast of sales to Boise?

A. To forecast Boise's 2027 energy purchases, the Company relied upon the IPST set forth in the ESA, PCA's quarterly and annual reports, the aforementioned customer and industry data, and conversations with the customer.

Q. How do these assumptions align with broader industry and economic trends affecting the pulp & paper business?

A. They are consistent with declines in the paper and pulp business described earlier in my testimony.

c. Sappi

Q. Please describe Sappi's operations in Minnesota Power's service territory.

A. Sappi is a kraft pulp and paper facility that operates two paper machines producing Coated Freesheet papers used for communications and packaging and market pulp for both paper and fabric markets. Sappi is wholly owned by Sappi Limited.

Q. What type of agreement does the Company have with Sappi?

A. The Company has a LP ESA with Sappi Cloquet, LLC, for its operations in Cloquet, Minnesota. As of November 1, 2026, the earliest termination date for this ESA is November 30, 2030.

Q. Have there been any notable changes to Sappi's business since the Company's last rate case?

A. No. Sappi continues to operate at similar levels to what was approved in the 2023 Rate Case.

Q. What sources of information have been relevant to Minnesota Power's determination of a reasonable 2027 forecast of sales to Sappi?

A. To forecast Sappi's 2027 energy purchases, the Company relied upon the IPST set forth in the ESA, Sappi's quarterly and annual reports, the aforementioned customer and industry data, and conversations with the customer.

Q. How do these assumptions align with broader industry and economic trends affecting the pulp & paper business?

A. They are consistent with declines in the paper and pulp business described earlier in my testimony.

d. Sofidel

Q. Please describe Sofidel's operations in Minnesota Power's service territory.

A. Sofidel purchased the Duluth Mill from ST Paper in 2024, which had previously acquired the facility from Verso in 2021 and converted the facility from producing supercalendered advertising paper using groundwood pulp to producing tissue using recycled fiber. ST Paper commenced operations in early 2023, and became an LP customer on March 1, 2023, pursuant to the LP ESA approved by the Commission in Docket No. E015/M-22-96 on May 16, 2022. Following its acquisition of the facility, Sofidel has continued tissue production at the Duluth mill and has announced a significant expansion of the facility, including additional converting and warehousing capabilities.

Q. What type of agreement does the Company have with Sofidel?

A. The Company has an LP ESA with the Duluth mill operations. The agreement was originally entered into with ST Paper, LLC, and the facility was subsequently acquired by Sofiel in 2024. As of November 1, 2026, the earliest termination date for this ESA is November 1, 2030.

Q. Have there been any notable changes to what is now Sofidel's Duluth mill since the Company's last rate case?

A. Yes. The most notable change is Sofidel's 2024 acquisition of the Duluth mill from ST Paper. Since acquiring the facility, Sofidel has continued tissue manufacturing operations and announced a major expansion of the mill to add downstream converting, packaging, and warehousing capabilities. This ownership change and expansion support the long-term continuation and growth of tissue manufacturing operations in Minnesota Power's service territory. However, because the announced expansion is focused primarily on converting, packaging, and warehousing rather than the addition of major new tissue-production capacity,[57] Minnesota Power expects any incremental electric load growth to be modest relative to the existing mill load.

Q. What sources of information have been relevant to Minnesota Power's determination of a reasonable 2027 forecast of sales to Sofidel?

A. To forecast Sofidel's 2027 energy purchases, the Company relied upon the IPST set forth in the ESA, the aforementioned customer and industry data, and conversations with the customer.

Q. How do these assumptions align with broader industry and economic trends affecting the pulp & paper business?

A. They are consistent with the stable to growing demand for tissue products described earlier in my testimony.

3. Pipeline

Q. What types of customers are included in the Pipeline Industrial class?

A. The Pipeline sector includes all pipeline operating industrial customers.

[57] MP Exhibit ___ (Forsman), Direct Schedule 4 at 83-85.

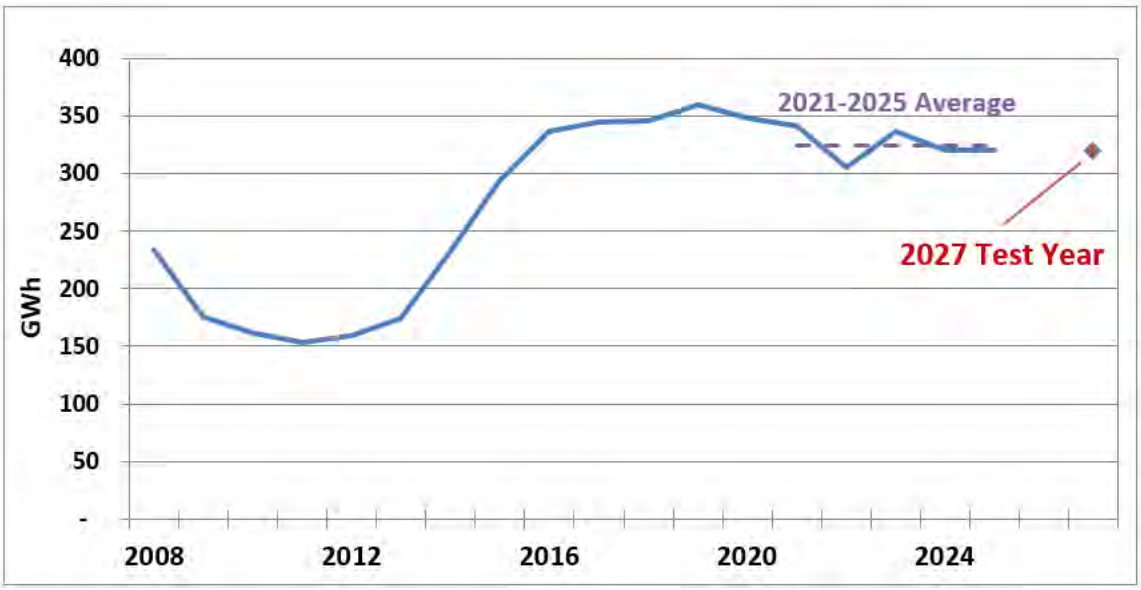
Q. Please describe recent trends in the Company's Pipelines and Other Industrial sector.

A. Pipeline energy sales increased by approximately 14 percent on average annually from 2011 to 2017. Sales plateaued from 2017 to 2021 before falling 12 percent in 2022 after one of Minnesota Power's pipeline customers commissioned a new pipeline in late 2021. From 2022 – 2025, pipeline sales have averaged approximately 320,000 MWh per year.

Q. How does the Company's 2027 test year forecast for Pipelines and Other Industrial customers compare to actual sales in recent years?

A. Figure 25 shows the Company's 2027 test year forecast of Pipelines energy sales compared to recent trends. The 2027 test year forecast of 319,723 MWh is generally consistent with sales over the past four years and reflects a continuation of the lower, more stable level of pipeline sales observed since 2022.

Figure 25. Energy Sales to the Pipelines Sector



Q. Please describe the test year outlook's assumptions for Minnesota Power's Pipelines customers.

A. The Company's 2027 test year forecast for the Pipeline sector of 319,723 MWh. This forecast reflects the lower and more stable level of pipeline energy sales observed since 2022, following the operational changes associated with Enbridge Line 3. The test year outlook assumes pipeline operations will remain generally consistent with recent actual sales levels, with no material new load additions or reductions expected during the test year.

4. Other Industrial Customers

Q. What types of customers are included in the Other Industrial classes?

A. The Industrial sectors includes all Non-Mining, Non-Paper, and Non-Pipeline Industrial customers. Foundries/casting/recycling and food product manufacturing each currently comprising about 27 percent of the class, respectively.

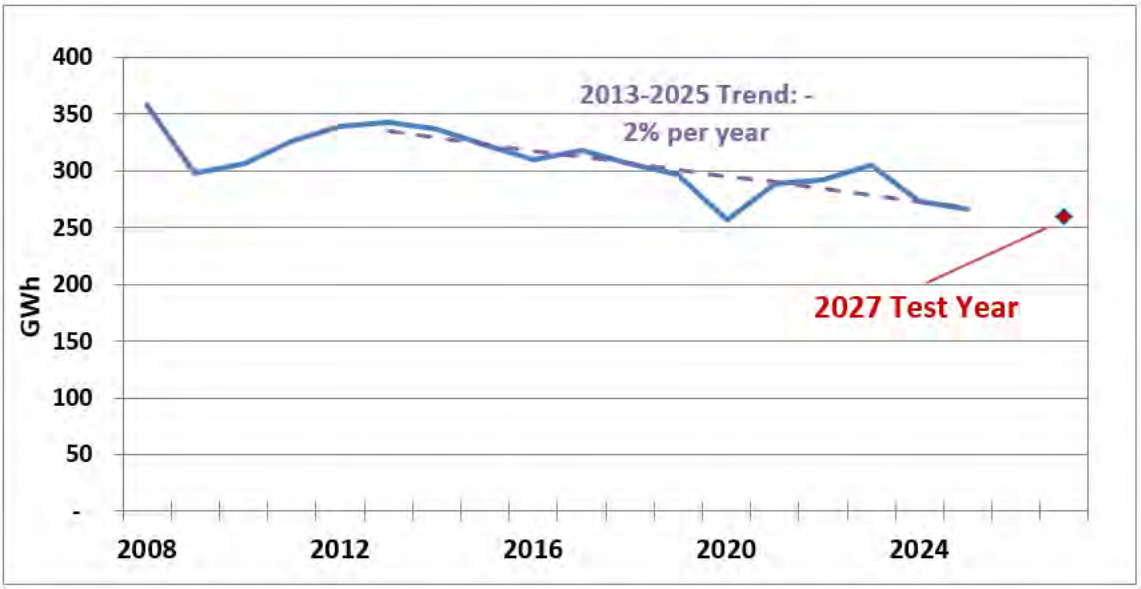
Q. Please describe recent trends in the Company's Other Industrial sector.

A. The Other Industrial sector has contracted by about 2 percent per year from 2015 to 2025. This loss of load is due to a few noteworthy customer facility closures, including: the Banta Publishing plant in Long Prairie, the Central Minnesota Renewables/Green Biologics plant in Little Falls, the Diamond Brand match and toothpick factory in Cloquet, International Bildrite in International Falls, and Northern Foundry in Hibbing. Although sales recovered after the COVID-19 pandemic, including among foundry customers, the sector remain below earlier historical levels.

Q. How does the Company's 2027 test year forecast for Pipelines and Other Industrial customers compare to actual sales in recent years?

A. Figure 26 shows the Company's 2027 test year forecast of Other Industrial energy sales compared to recent trends. The 2027 test year forecast of 259,848 MWh is 2 percent lower than 2025 sales following historical trends.

Figure 26. Energy Sales to Other Industrial Sector



Q. Please describe the test year outlook's assumptions for Minnesota Power's Pipeline and Other Industrial customers.

A. The Company's 2027 test year forecast for the Pipeline and Other Industrial sectors of 319,723 MWh and 259,848 MWh, respectively, are based upon the aforementioned industry specific approach for its Pipeline and larger Other Industrial customers and AFR 2026 forecasted levels for its smaller Other Industrial customers.

5. Very Large Load Customers

Q. Does the 2027 test year sales forecast include energy sales to customers taking service under Minnesota Power's proposed Very Large Power class?

A. No. Minnesota Power is currently seeking Commission approval of a new Very Large Power ("VLP") tariff and an associated ESA with Google. Google is the only prospective customer with an executed ESA that currently would be eligible for service under the proposed VLP class. Because the proposed service schedule and ESA remain subject to Commission approval and Minnesota Power does not expect the Google facility to begin taking electric service during 2027, the Company's 2027 test year forecast includes no customers, energy sales, or revenues in the VLP class.

Q. Why is the VLP class nevertheless identified in the Company's customer and sales information?

A. The VLP class is identified to provide a complete description of Minnesota Power's proposed customer-class structure and to distinguish prospective VLP service from the Company's existing Large Power customer class. Its inclusion does not reflect an assumption that VLP sales will occur during the 2027 test year.

The VLP class is also identified because it is included in Minnesota Power's proposed Sales Adjustment Mechanism, which, if approved, will allow customers to benefit from sales to Google or other VLP customers if operations should ramp up prior to the Company's next rate case.

6. Overall Industrial Customers

Q. Please summarize the overall test year sales forecast for the Industrial customer class.

A. The Company's 2027 test year Industrial forecast (5,345,710 MWh) is the summation of the Mining, Forest Products, Pipelines, and Other Industrial forecasts described above. The 2027 test year's Industrial sector forecast is about 0.2 percent lower than actual 2025 Industrial sales (5,358,747 MWh) which already reflected the reduced sales resulting from the indefinite idling of Minorca and the partial idling of Hibbing Taconite Company.

D. Wholesale Customer Sales

Q. What is Minnesota Power's forecast for its required wholesale customers?

A. The Company's 2027 test year forecast for the required wholesale customer class, which includes sales to SWLP and Minnesota Power's 14 municipal customers, is 1,844,131 MWh. This is 276,670 MWh (17.7 percent) higher than actual 2025 sales and 363,410 MWh higher than a five-year (2021–2025) historical average of actual sales to this class.

VI. SALES ADJUSTMENT MECHANISM

Q. Does Minnesota Power have a proposal to address and mitigate the financial impacts related to operational volatility of Large Power customers between rate cases?

A. Yes. The Company is proposing a Sales Adjustment Mechanism for the 2027 test year.

Q. Has Minnesota Power previously proposed a mechanism addressing variations in Large Power sales?

A. Yes. Minnesota Power proposed a Large Power Sales True-Up Mechanism in its 2021 rate case and a revised Customer Rate Stabilization Mechanism in its 2023 rate case. The Commission did not approve those proposals. Since then, the Company has continued to evaluate how best to address the revenue and rate impacts associated with significant fluctuations in Large Power sales – both where risk of decline and opportunity for growth exist. The proposed Sales Adjustment Mechanism reflects lessons learned from those prior proceedings and incorporates updated terminology, methodology, covered customer classes, and anticipated load-growth opportunities.

Q. What customer classes would be included in the Sales Adjustment Mechanism calculation of revenue variability between rate cases?

A. The Company would include the LP customer class, along with the proposed VLP customer class that may have load growth occur between rate cases.[58]

Q. Please explain at a high-level how the Company's proposed Sales Adjustment Mechanism would work.

A. The Sales Adjustment Mechanism is designed to address future differences, should they occur between rate cases, between the level of LP and VLP base rate revenue authorized by the Commission and actual base rate revenue from these classes. Following the conclusion of the current rate case, Minnesota Power would annually track base rate revenues for the entire LP class and proposed VLP class compared to a baseline level

[58] *See In the Matter of the Petition of Minnesota Power for Approval of Modifications to its Large Power Tariff*, Docket No. E015/M-26-126, PETITION (Feb. 18, 2026) (eDocket No. 20262-228274-01).

established for the 2027 test year. This calculation would also account for margins associated with the loss of load. Any resulting difference would be reported to the Commission through an annual compliance filing. Under the Company's proposal, all customers would then receive either a credit or surcharge through a new tariff rider, as described in the Direct Testimony of Company Witness Leah N. Peterson, to reconcile the difference between actual and authorized revenues.

Q. What are the components of LP and VLP base rate revenues?

A. LP and VLP base rate revenues currently include four components: customer charge, demand charges, transmission demand, and firm energy. These revenues exclude fuel and purchased energy costs, which are already incorporated in Minnesota Power's fuel adjustment clause, and also exclude revenues related to other LP and VLP customer programs, such as demand response. The revenues related to these products are not included in the Company's proposed Sales Adjustment Mechanism because they are not factored into base rates and, therefore, including them would not result in an apples-to-apples comparison to the baseline revenues established in this rate case.

Q. How is the true-up variance amount determined in the proposed Sales Adjustment Mechanism?

A. The true-up variance amount is determined through a two-step process. First, the Company calculates the difference between LP and VLP base rate revenues in the current period to the baseline LP and VLP revenue amount established in this proceeding. Second, in the case of a loss of LP or VLP[59] load, the Company adjusts this amount by adding any margins received from replacement sales due to loss of LP or VLP customer load.

[59] While Minnesota Power does not have any sales to VLP customers in the test year, there may be sales to VLP customers in future years. *See e.g., In the Matter of the Application of the Petition for Approval of an Electric Service Agreement between Google and Minnesota Power*, Docket No. E015/M-26-159, Petition (Mar. 27, 2026) (eDocket No. 20263-229694-01).

Q. Why does the sales true-up calculation add the margins from sales due to loss of LP and VLP load?

A. Sales margins due to loss of LP and VLP customer load are added because these are amounts the Company has already captured to help mitigate reductions in customer load between rate cases. These are sales margins that do not flow back to customers through the fuel adjustment clause. As a result, they need to be added to the sales adjustment calculation to reduce the amount of under-recovery the Company experienced due to lost LP and VLP sales.

Q. How would the Company determine the LP and VLP portion of margins on sales due to the loss of customer load?

A. Minnesota Power tracks margins on sales due to loss of customer load on a monthly basis. Because these types of sales are made in batches and are not directly attributable to a specific customer load reduction, an allocator is necessary to determine which portion of the sales due to loss of customer load should be attributable to the LP and VLP classes. The Company proposes to use an LP and VLP allocation factor on a monthly basis and apply it to the total monthly margins on sales due to loss of customer load. The allocation factor would be calculated by taking total LP and VLP loss of load (this is the loss of load as compared to the baseline and recorded in MWs) divided by total retail and resale loss of customer load. Table 9 below shows how the LP and VLP portion of margins on sales due to loss of customer load would be calculated.

Table 9. Calculation of LP and VLP Margins Due to Loss of Sales

Calculation of Annual LP and VLP Margins Due to Loss of Sales	
a. Total Margins from Loss of Sales	Calculated monthly: includes total sales due to loss of load (retail and wholesale) less fuel and MISO costs (in dollars)
b. LP and VLP reduction in MWs	Monthly MW reduction, if any, for LP and VLP classes compared to baseline (in MWs)
c. Retail and wholesale reduction in MWs	Monthly MW reduction, if any, for retail (which includes the LP and VLP classes) and wholesale compared to baseline (in MWs)
d. LP and VLP portion of MW reduction	= b / c (in percent)
e. LP and VLP Margins from Loss Sales - month	= a * d (in dollars)
f. LP and VLP Margins from Loss Sales - annual	= sum of e (January through December)

Q. Can you provide an example of how the Sales Adjustment Mechanism would be calculated?

A. Yes. Table 10 below shows how LP and VLP actual base rate revenues are compared to the baseline.

Table 10 Example of Sales Adjustment Mechanism

	Example of Sales Adjustment Mechanism ($ in Millions for example purposes only)	Actual Revenue Compared to Baseline Revenue: Example 1 Decrease in LP Revenue	Example 2 Increase in VLP Revenue	Example 3 Decrease in LP Revenue and Increase in VLP Revenue
	MPUC Approved Baseline Revenue 1/			
A	LP Baseline Rate Revenue	$ 500	$ 500	$ 500
B	VLP Baseline Rate Revenue	$ -	$ -	$ -
C	***TOTAL* Baseline Rate Revenue (C) = (A + B)**	**$ 500**	**$ 500**	**$ 500**
	Actual Base Rate Revenue2/			
D	LP Base Rate Revenue	$ 460	$ 500	$ 460
E	VLP Base Rate Revenue	$ -	$ 100	$ 100
F	***TOTAL* Actual Base Rate Revenue (F) = (D + E)**	**$ 460**	**$ 600**	**$ 560**
E	**Variance to Baseline Revenue (E) = (C - F)**	**$ 40**	**$ (100)**	**$ (60)**
	(Credit) / Surcharge	***Surcharge***	***(Credit)***	***(Credit)***

1/ LP and VLP Baseline Rate Revenue reflects the amounts approved in most recent rate case
2/ LP and VLP Base Rate Revenue = customer charge + firm demand + firm energy

If the Sales Adjustment Mechanism is approved in this case, the new baseline would be the 2027 test year and the actuals would reflect future years following approval of the Sales Adjustment Mechanism. The Sales Adjustment Mechanism may be positive or negative on customer bills, depending on how the most recent year of revenues compares to the baseline amount.

Q. How would the Sales Adjustment Mechanism be billed or credited to customers?

A. The Company proposes to annually apply the true-up variance (the amount over or under recovered from LP and VLP customers) to all customer classes during the following year as a new tariff titled Sales Adjustment Mechanism. The amount of the variance that each customer class would be apportioned would be based on the approved rate design (from the most recent rate case) during the year. The Company would use projected billing units to spread that variance out within each class. For example, in 2029 the Company would calculate the true-up variance for 2028 based on the approved rate design that was used during 2028. That variance for each rate class would be applied to customer bills in 2030 using projected 2030 billing units. Applying the variance to base revenues from the projected year's budget would ensure that the true-up mechanism would utilize the most recent estimate of sales to help ensure the adjustment is zeroed out in 12 months.

Q. What does the Company propose regarding annual compliance filings on the Sales Adjustment Mechanism?

A. Minnesota Power proposes to make compliance filings annually by March 1, reporting on the variance of net revenues for the previous year compared to the baseline and a proposal for updating the tariff. The updated tariff would need Commission approval before being implemented. If the current rate case is concluded and the Sales Adjustment Mechanism is approved before December 2027, the Company would true-up the 2027 base revenue to track the variance and would make the first annual compliance filing by March 1, 2028.

Q. When would the Sales Adjustment Mechanism end?

A. The Sales Adjustment Mechanism would remain in effect until the Company's next rate case, at which time the Commission would have the opportunity to review the mechanism's performance and determine whether to continue or modify its use.

Q. How would the Sales Adjustment Mechanism benefit customers?

A. The Sales Adjustment Mechanism would help more appropriately align the risks and benefits associated with changes in LP and VLP customer load between rate cases, while also reducing revenue and cost recovery volatility resulting from changes in the operations of existing LP customers.

For customers, the mechanism would allow the benefits of incremental LP and VLP customer load growth, in particular the new load from prospective VLP customers such as the proposed Google data center in Hermantown, to be shared with other customer classes more quickly when sales exceed the baseline established in the rate case. As a result, customers would be able to realize the benefits of new large load additions on a more timely basis rather than waiting until the Company's next general rate case. At the same time, it would provide a more balanced approach to addressing downside risk when LP customer operations decline.

VII. CONCLUSION

Q. Does this complete your testimony?

A. Yes.

Schedule 1 – Minnesota Power Retail Operations MWh Sales and Customer Counts 2027 Test Year.

	2027 Test Year	
	Energy Sales (MWh)	**Customer Count**
Residential	1,027,912	126,974
Commercial	1,177,148	25,510
Industrial		
Mining and Metals	4,036,704	9
Paper and Pulp	729,435	5
Pipelines	319,723	2
Other Industrial	259,848	393
Total Industrial	5,345,710	409
Public Authorities & Lighting	51,604	1,037
Total Retail	**7,602,374**	**153,930**
Municipals	761,560	
SWLP	1,082,570	
Total Retail and Wholesale	**9,446,504**	

2025 Assessment of

Demand Response and Advanced Metering



Staff Report
FEDERAL ENERGY REGULATORY COMMISSION
December 2025

2025 Assessment of

Demand Response and Advanced Metering

Pursuant to Energy Policy Act of 2005
Section 1252(e)(3)



Staff Report
FEDERAL ENERGY REGULATORY COMMISSION
December 2025

The matters presented in this staff report do not necessarily represent the views of the Federal Energy Regulatory Commission, its Chairman, or individual Commissioners, and are not binding on the Commission.

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1. Introduction

This report is the Federal Energy Regulatory Commission (FERC or Commission) staff's twentieth annual report on demand response and advanced metering, which is required annually by Section 1252(e)(3) of the Energy Policy Act of 2005 (EPAct 2005). Demand response is defined as changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.[1] The Energy Information Administration (EIA) defines advanced metering infrastructure (AMI) (also referred to as "advanced meters" throughout this report) as meters that measure and record usage data, at a minimum, in hourly intervals and provide usage data at least daily to energy companies and may also provide data to consumers.[2] The information presented in this report is based on publicly available data that is used to estimate demand response potential in retail and wholesale markets.[3]

Consistent with the method first adopted in the 2021 report, this report presents data according to the nine U.S. Census Divisions, broken down by state in the Appendix, to continue to fulfill the regional reporting requirements of EPAct 2005.[4]

[1] *See also infra* note 61.

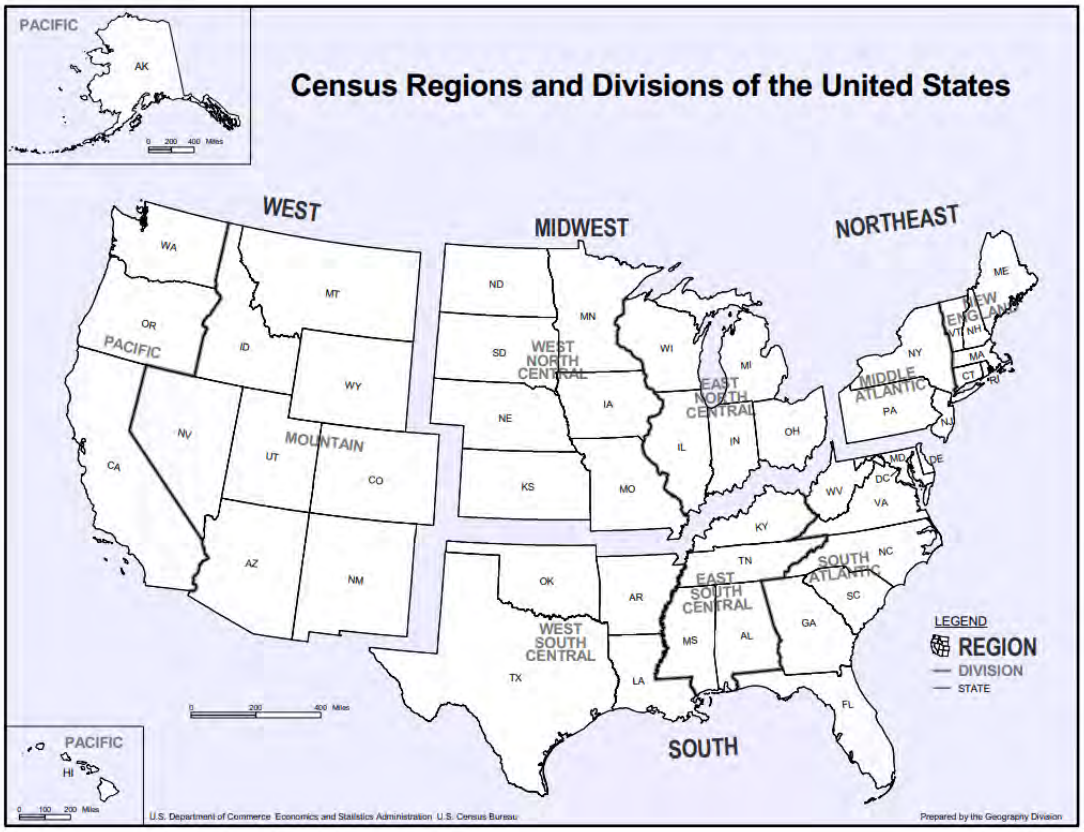
[2] Advanced meter data are used for billing and other purposes. According to EIA's definition, advanced meters include basic hourly interval meters and extend to real-time meters with built-in two-way communication capable of recording and transmitting instantaneous data.

Other types of meters currently in use—such as standard electromechanical, standard solid state, and automated meter reading (AMR) meters, which collect data for billing purposes only and transmit these data one way—are not considered advanced meters for the purposes of this report. *See* EIA, Form EIA-861: Annual Electric Power Industry Report Instructions at 17-18, http://www.eia.gov/survey/form/eia_861/instructions.pdf.

[3] The latest publicly available retail electricity data for the report is for the year 2023 while the latest publicly available wholesale electricity data is for the year 2024.

[4] "[T]he Commission shall prepare and publish an annual report, *by appropriate region*, that assesses demand response resources…." *See* Energy Policy Act of 2005, Pub. L. No. 109-58, § 1252(e)(3), 119 Stat. 594 (2005) (emphasis added).

Figure 1-1: Map of US Census Divisions



Highlights of this report include the following:

- From 2022 to 2023, the number of advanced meters in operation in the United States increased by approximately 9.1 million to a total of 128.4 million, representing a 7.6% annual increase. According to EIA data, the 128.4 million advanced meters in operation represent 76.8% of the 167.2 million total meters in operation across all customer classes.

- The nationwide advanced meter penetration rate for each customer class was greater than 70%. At the regional level, the advanced meter penetration rate continues to vary by Census Division and customer class. In the Pacific and West South Central Census Divisions, advanced meter penetrations rates were greater than 80% for each customer class.

- From 2023 to 2024, total demand response participation in the seven U.S. wholesale markets increased by approximately 217 MW or 0.7 %, to a total of 33,272 MW. Demand response totals increased in five of those wholesale markets but declined in two. Approximately 6.5% of the wholesale market peak demand for all Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) could be met by demand response resources in 2024. The sum of the non-coincident peak demands across all RTOs and ISOs was approximately 515 GW in 2024, compared to 512 GW in 2023.

- State regulators continue to consider and approve proposals to implement different types of time-varying rates and other opportunities to leverage flexible demand. For example, in August 2024 the Maine Public Utilities Commission (Maine Commission) initiated an inquiry to consider the implementation of time-of-use rates for customers of the state's independently owned utilities. State governments also took actions exploring, or enabling the use of, flexible loads and distributed energy resources (DERs) for peak demand reduction. For example, the governor of Virginia signed a law directing Dominion Energy to launch a virtual power plant (VPP) pilot program consisting of DER aggregations totaling up to 450 MW.

This report addresses the six requirements included in section 1252(e)(3) of EPAct 2005, which directs the Commission to identify and review:

(A) saturation and penetration rate of advanced meters and communications technologies, devices and systems (Chapter 2);

(B) existing demand response and time-based rate programs (Chapter 5);

(C) the annual resource contribution of demand resources (Chapter 3);

(D) the potential for demand response as a quantifiable, reliable resource for regional planning purposes (Chapter 4);

(E) steps taken to ensure that, in regional transmission planning and operations, demand resources are provided equitable treatment as a quantifiable, reliable resource relative to the resource obligations of any load-serving entity, transmission provider, or transmitting party (Chapter 5); and

(F) regulatory barriers to improved customer participation in demand response, peak reduction, and critical period pricing programs (Chapter 6).

2. Saturation and Penetration Rate of Advanced Meters

This chapter presents the national and regional penetration rates of advanced meters in the United States as well as state developments related to grid modernization and advanced metering. Table 2-1 provides estimates of advanced meter penetration rates from 2014 through 2023. According to EIA data, as of December 2023, utilities had installed and were operating 128.4 million advanced meters out of the 167.2 million total meters in the United States. This represents an advanced meter penetration rate of 76.8% and an increase of 9.1 million advanced meters, or 7.6%, from 2022 to 2023.

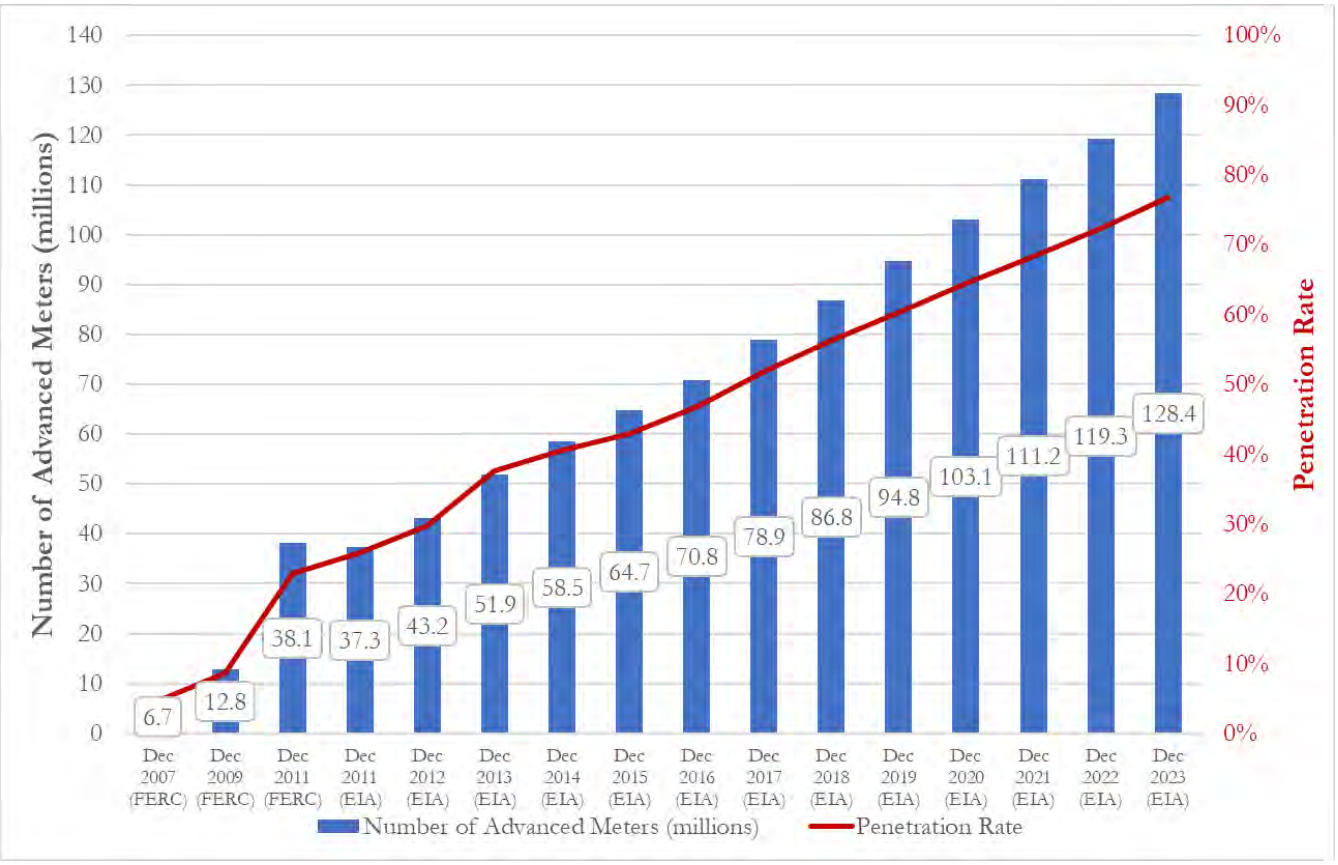
Table 2-1: Estimates of Advanced Meter Penetration Rates in the United States (2014 – 2023)

Data Source	Data as of	Number of Advanced Meters (millions)	Total Number of Meters (millions)	Advanced Meter Penetration Rate
2014 Form EIA-861[1]	Dec 2014 (EIA)	58.5	144.3	40.5%
2015 Form EIA-861[1]	Dec 2015 (EIA)	64.7	150.8	42.9%
2016 Form EIA-861[1]	Dec 2016 (EIA)	70.8	151.3	46.8%
2017 Form EIA-861[1]	Dec 2017 (EIA)	78.9	152.1	51.9%
2018 Form EIA-861[1]	Dec 2018 (EIA)	86.8	154.1	56.4%
2019 Form EIA-861[1]	Dec 2019 (EIA)	94.8	157.2	60.3%
Institute for Electric Innovation[2]	Dec 2019 (IEI)	99.0	157.2	63.0%
2020 Form EIA-861[1]	Dec 2020 (EIA)	103.1	159.7	64.6%
Institute for Electric Innovation[2]	Dec 2020 (IEI)	107.4	159.7	67.2%
2021 Form EIA-861[1]	Dec 2021 (EIA)	111.2	162.8	68.3%
Institute for Electric Innovation[2]	Dec 2021 (IEI)	115.3	162.8	70.8%
2022 Form EIA-861[1]	Dec 2022 (EIA)	119.3	165.0	72.3%
Institute for Electric Innovation[3]	Dec 2022 (IEI)	120.0	165.0	72.3%
2023 Form EIA-861[1]	Dec 2023 (EIA)	128.4	167.2	76.8%

Sources: [1]EIA-861 Advanced Meters data files 2014-2023. [2]IEI, *Electric Company Smart Meter Deployments: Foundation for a Smart Grid* 2021. [3]IEI, *Smart Meters at a Glance* (2024).
Notes: Commission staff has not independently verified the accuracy of EIA or Edison Foundation (IEI) data. Values from source data are rounded for publication. A table containing the data for 2007 through 2023 is in Appendix II.

Figure 2-1 shows advanced meter growth in the United States from 2007 through 2023. During that 16-year period, the number of advanced meters increased by 121.7 million meters, from 6.7 million in 2007 to 128.4 million in 2023. Over the same period, the advanced meter penetration rate increased from 4.7% to 76.8%.

Figure 2-1: Advanced Meter Growth in the United States (2007–2023)



Sources: FERC, *Assessment of Demand Response and Advanced Metering* 2008-2012; EIA-861 Advanced Meters data files 2011-2023.
Note: The left axis, Number of Advanced Meters (millions), corresponds to the blue columns. The right axis, Penetration Rate, corresponds to the red line.

Table 2-2 below provides estimates of advanced meter penetration rates by Census Division and retail customer class for 2023. Utilities reported aggregate totals of advanced meters that represent penetration rates above 80% in five of the nine Census Divisions: East North Central, East South Central, Pacific, South Atlantic, and West South Central. As shown in Table 2-2, utilities in the West South Central Census Division reported advanced meter totals that represent an advanced meter penetration rate of 90.1%, the highest rate reported by utilities in any Census Division. In contrast, utilities in the New England Census Division reported totals representing an advanced meter penetration rate of 25.4%, making it the only Census Division with a penetration rate below 50%.

Table 2-2 also shows the overall advanced meter penetration rate for the residential, commercial, and industrial customer classes. The total advanced meter penetration rate across all regions for each of the customer classes was greater than 70%. Overall, utilities reported the highest number of advanced meters in

the residential class, which registered a penetration rate of 77.3%. Closely following this reported total, the industrial and commercial customer classes registered advanced meter penetration rates of 74.5% and 73.3%, respectively.

However, the advanced meter penetration rates for each customer class varied among Census Divisions. For example, the residential customer class had the highest advanced meter penetration rates in the East North Central, East South Central, Mountain, Pacific, South Atlantic, and West South Central Census Divisions. The industrial customer class had the highest advanced meter penetration rates in the Middle Atlantic, New England, and West North Central Census Divisions. Each customer class had advanced meter penetration rates above 80% in the Pacific and West South Central Census Divisions.

Table 2-2: Advanced Meter Penetration Rate by Census Division and Customer Class (2023)

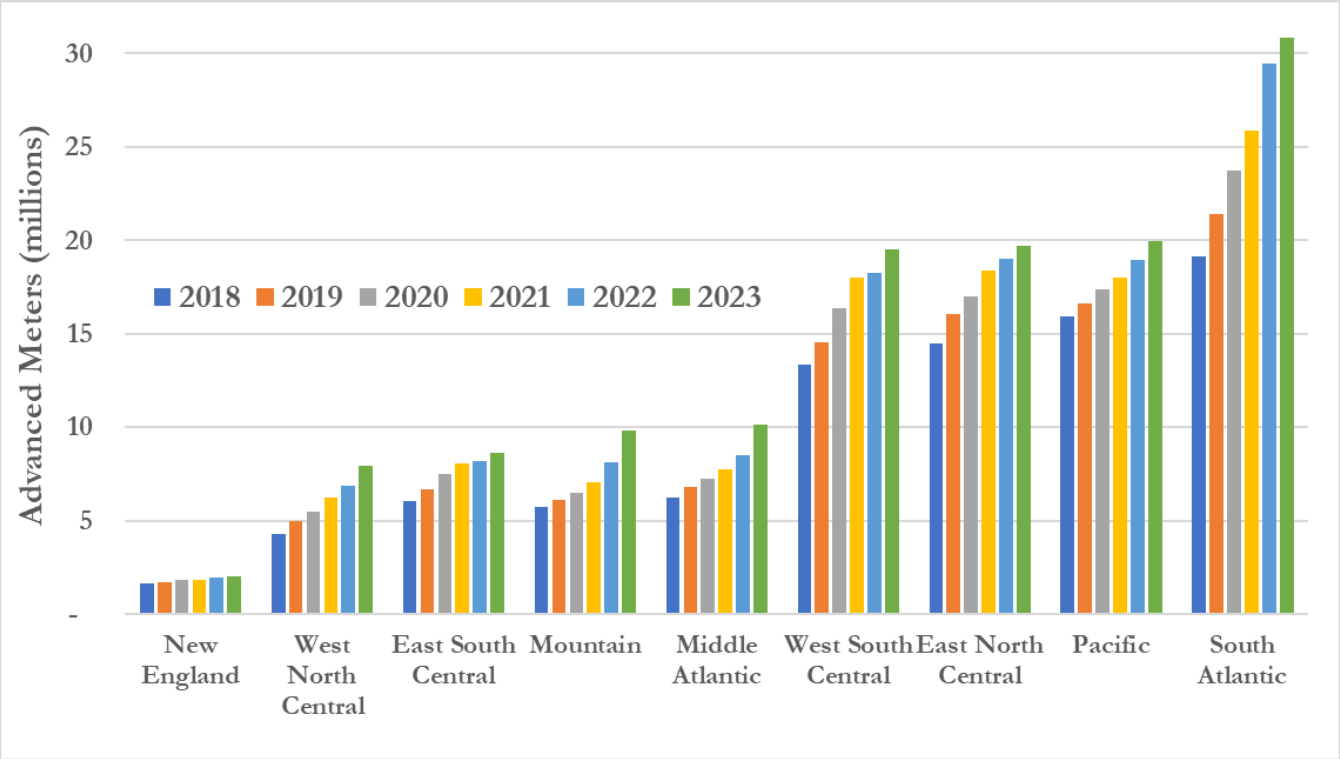
Census Division	Customer Class			
	Residential	Commercial	Industrial	All Classes
East North Central	81.7%	78.1%	71.2%	81.3%
East South Central	83.0%	78.2%	78.9%	82.3%
Middle Atlantic	53.1%	46.6%	65.6%	52.3%
Mountain	77.1%	65.8%	69.9%	75.7%
New England	25.4%	25.4%	25.5%	25.4%
Pacific	83.3%	83.2%	83.0%	83.3%
South Atlantic	89.0%	86.0%	66.5%	88.6%
West North Central	67.2%	60.1%	72.5%	66.4%
West South Central	90.5%	87.9%	80.0%	90.1%
All Regions	77.3%	73.3%	74.5%	76.8%

Sources: 2023 Form EIA-861 Advanced_Meters_2023 data file and 2023 Form EIA-861 Utility_Data_2023 data file.
Notes: Transportation sector data collected by EIA contain a relatively small number of meters and are not reported separately here. Although some utilities may operate in more than one state and Census Division, EIA data are reported by utility at the state level. Commission staff has not independently verified the accuracy of EIA data.

Figure 2-2 below shows the number of advanced meters in operation by Census Division from 2018 to 2023. Over this period, the number of advanced meters showed an upward trend across all Census Divisions. Utilities in all nine Census Divisions reported more advanced meters in operation in 2023 than in 2022. The Mountain Census Division experienced the largest increase from 2022 to 2023, where utilities reported over 1.6 million more advanced meters, an increase of 20%. Within the Mountain Census Division, the utilities that reported the largest increases in the number of advanced meters include PacifiCorp in Utah (850,000 advanced meters in 2023), Public Service Co. of Colorado (354,000), Tucson Electric Power Co. in Arizona (60,000), and El Paso Electric Co. in New Mexico (56,000).

Over the same period, utilities also installed more advanced meters in the Middle Atlantic (1,639,000 new meters), South Atlantic (1,365,000), West South Central (1,232,000), West North Central (1,040,000), Pacific (1,009,000), East North Central (660,000), East South Central (434,000), and New England (96,000) Census Divisions.

Figure 2-2: Number of Advanced Meters by Census Division (2018 – 2023)



Sources: EIA-861 Advanced Meters data files 2018 – 2023.

Developments and Issues in Advanced Metering

State Legislative and Regulatory Activities Related to Advanced Metering

Several states have taken actions related to AMI.[5] We discuss some of those actions here.

Colorado. On May 20, 2025, the governor of Colorado signed a bill requiring utilities to notify residential customers prior to installing AMI and to explain their right to refuse AMI installation.[6] The law requires qualifying utilities that plan to deploy AMI for residential customers on or after September 1, 2025, to submit a customer communication plan to the Colorado Public Utilities Commission on or before December 31, 2025, that includes information regarding how utilities will: (1) communicate with residential customers before installing AMI on their properties, with the requirement that communications must be sent out 90, 60, and 30 days before the installation; (2) communicate the residential customer's right to not have AMI installed and receive non-advanced meters instead if requested; and (3) communicate to new

[5] *See supra* note 2.

[6] Smart Meter Opt-In Program, H.B. 25-1175, 75th Gen. Assemb. (2025) (Colo.) (enacted),https://leg.colorado.gov/sites/default/files/2025a_1175_signed.pdf.

residential customers about whether the property already has AMI installed and their right to have non-advanced meters instead if requested.[7] The law also requires qualifying utilities that plan to deploy AMI for residential customers on or after September 1, 2025, to: (1) make reasonable efforts to notify the customer before arriving at the customer's property and provide an opportunity to defer or reject the AMI installation; (2) maintain a phone line and a public website with information regarding customers' right to remove AMI and replace it with non-advanced meters; (3) only install AMI that complies with Federal Communications Commission requirements for radio frequency; and (4) establish and maintain a public website that includes information on customer data privacy and radio frequency communications in relation to AMI.[8]

Kentucky. On July 22, 2025, the Kentucky Public Service Commission (Kentucky Commission) issued an order granting the Kentucky Power Company's (Kentucky Power) application for a certificate of public convenience and necessity (CPCN) for the deployment of AMI, granting its request to establish a regulatory asset to recover the cost of AMI deployment, and rejecting its request for deviations and waivers from certain regulations.[9] Kentucky Power proposes to replace its AMR meters with AMI throughout its service territories, and plans to begin installation in 2026 with full deployment expected by the end of 2029.[10] In granting the CPCN, the Kentucky Commission found that Kentucky Power had demonstrated that the proposed AMI project is needed to provide adequate, efficient, and reasonable service and that it evaluated alternatives and analyzed the cost and benefits of the options to determine that AMI installation was not wasteful duplication.[11] In granting Kentucky Power's request to establish a regulatory asset for the installation of the AMI meters, the Kentucky Commission stated that it will review all capital expenditures related to the project for reasonableness in a future rate case and set certain requirements for reporting of expenses and project progress.[12]

New Mexico. On February 6, 2025, the New Mexico Public Regulation Commission (New Mexico Commission) issued a Notice of Proposed Rulemaking (NOPR) initiating a proceeding to establish a statewide framework for electric utility grid modernization and distribution system planning that includes

[7] *Id.* at 2.

[8] *Id.* at 3.

[9] *Electronic Application of Application of Kentucky Power Company for (1) a Certificate of Public Convenience and Necessity Authorizing the Deployment of Advanced Metering Infrastructure; (2) Request for Accounting Treatment; and (3) All Other Necessary Waivers, Approvals, and Relief*, Docket No. 2024-00344, (Kentucky Commission, July 22, 2025), https://psc.ky.gov/pscscf/2024%20Cases/2024-00344//20250722_PSC_ORDER.pdf.

[10] *Id.* at 3-4.

[11] *Id.* at 10-11.

[12] *Id.* at 13-17.

new requirements for AMI programs.[13] Among other items, the NOPR proposes new requirements related to AMI deployment, performance standards, and integrated planning. For example, each utility would be required to: (1) quantify the benefits of its AMI proposal and demonstrate how the utility will fully use the technology; (2) demonstrate how the technology would enable two-way communication, enable real-time monitoring, and support grid applications such as demand response, time-of-use rates, outage management, and integration of DERs; and (3) show that AMI data communications are capable of receiving continuous signals from all regions of the service territory. Except for projects replacing equipment at the end of its useful life or required to comply with legal requirements, the proposed rule also requires utilities to justify all grid modernization investments and include a comparison against traditional distribution alternatives. The NOPR record closed on May 30, 2025. Issuance of a final rule is still pending.

New York. On June 13, 2025, the New York Public Service Commission (New York Commission) accepted a petition from National Grid to revise its bill estimation procedures for both gas and electric residential customers with AMI meters in advance of the completed implementation of the Company's AMI network.[14] In November 2020, the New York Commission approved National Grid's plan to implement AMI in its upstate New York electric and gas service territories over the course of approximately six years, including installing meters and back-office information technology, such as a meter data management system.[15] The bill estimation procedures are necessary for cases where National Grid cannot collect meter readings due to reasons such as an inaccessible meter, a broken meter, or adverse weather conditions.[16] The revised bill estimation procedures will use either: (1) calculated or scaled average daily usage from National Grid's meter data management system or (2) estimated usage from its customer service system for customers with a non-AMI meter, or an AMI meter for which the meter data management system cannot provide a meter reading or estimate.[17]

Rhode Island. On May 20, 2025, the Rhode Island Public Utilities Commission (Rhode Island Commission) issued an order approving Rhode Island Energy's Advanced Metering Functionality (AMF) Business Case and cost recovery for the deployment of an AMF-based metering system with certain

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[13] *In the Matter of a Rulemaking to Implement the Grid Modernization Statute, NMSA 1978, Section 62-8-13 (2021) of the Public Utility Act,* Docket No. 22-00089-UT, (New Mexico Commission, Feb. 6, 2025), https://api.realfile.rtsclients.com/PublicFiles/9ce35ae9dd194163979349178e937b5f/25457dc8-956a-4748-8f47-ea8441b775e5/22-00089-UT-2025-02-06-NOPR%20Order.pdf

[14] *Petition of Niagara Mohawk Power Corporation d/b/a National Grid for Approval of Advanced Metering Infrastructure Bill Estimation Procedures,* Case 23-M-0658 (New York Commission June 13, 2025).

[15] *Id.* at 2.

[16] *Id.* at 4.

[17] *Id.* at 4-5.

conditions.[18] Rhode Island Energy's proposal defines AMF as "the functionality that comes from the broader deployment of [AMI] hardware and software solutions needed to utilize the smart meter data in a timely and efficient manner."[19] The Rhode Island Commission found that there is a need for Rhode Island Energy to transition its AMR-based metering system to a system that uses AMF, however; the Rhode Island Commission rejected the proposed AMF cost recovery factor and instead directed Rhode Island Energy to recover costs through the existing infrastructure, safety, and reliability process.[20] The Rhode Island Commission set a capital cost recovery cap of $15.3 million and excluded meter data management system costs from eligibility for rate base recovery. Additionally, the Rhode Island Commission set certain conditions related to (1) meter functionality; (2) service quality mechanisms, and (3) how the AMF program will interact with certain other Rhode Island Energy customer-facing programs.[21] The order provides customers with the option to opt out of the installation of the new meters.[22]

[18] *In RE: Rhode Island Energy Advanced Metering Functionality Business Case and Cost Recovery Proposal*, Docket No. 22-49-EL, (Rhode Island Commission, May 20, 2025), https://ripuc.ri.gov/sites/g/files/xkgbur841/files/2025-05/RI%20Energy%2022-49-EL%20Ord25353%20AMF%20%28final%29%205-20-25%20w-Seal.pdf.

[19] *Id.* at 1.

[20] *Id.* at 24-25.

[21] *Id.* at 26-29.

[22] *Id.* at 5-6.

3. Annual Resource Contribution of Demand Resources

This chapter summarizes the annual potential resource contribution from retail and wholesale demand response programs at the national and regional levels using the latest publicly available data from EIA and RTOs and ISOs. FERC staff does not independently verify the accuracy of EIA data, but rather presents the data as they were reported by EIA.

Retail Demand Response Programs

Table 3-1 below presents data on potential peak demand savings for 2022 and 2023 from retail demand response programs by Census Division. The term "potential peak demand savings" refers to "the total demand savings that could occur at the time of the system peak hour assuming all demand response is called."[23] From 2022 to 2023, potential peak demand savings in the United States increased by approximately 94 MW, or 0.3%, from 30,448 MW in 2022 to 30,542 MW in 2023. On a regional basis, however, only three of the nine Census Divisions experienced increases in annual peak demand savings from 2022 to 2023.

Table 3-1: Potential Peak Demand Savings (MW) from Retail Demand Response Programs by Census Division (2022 and 2023)

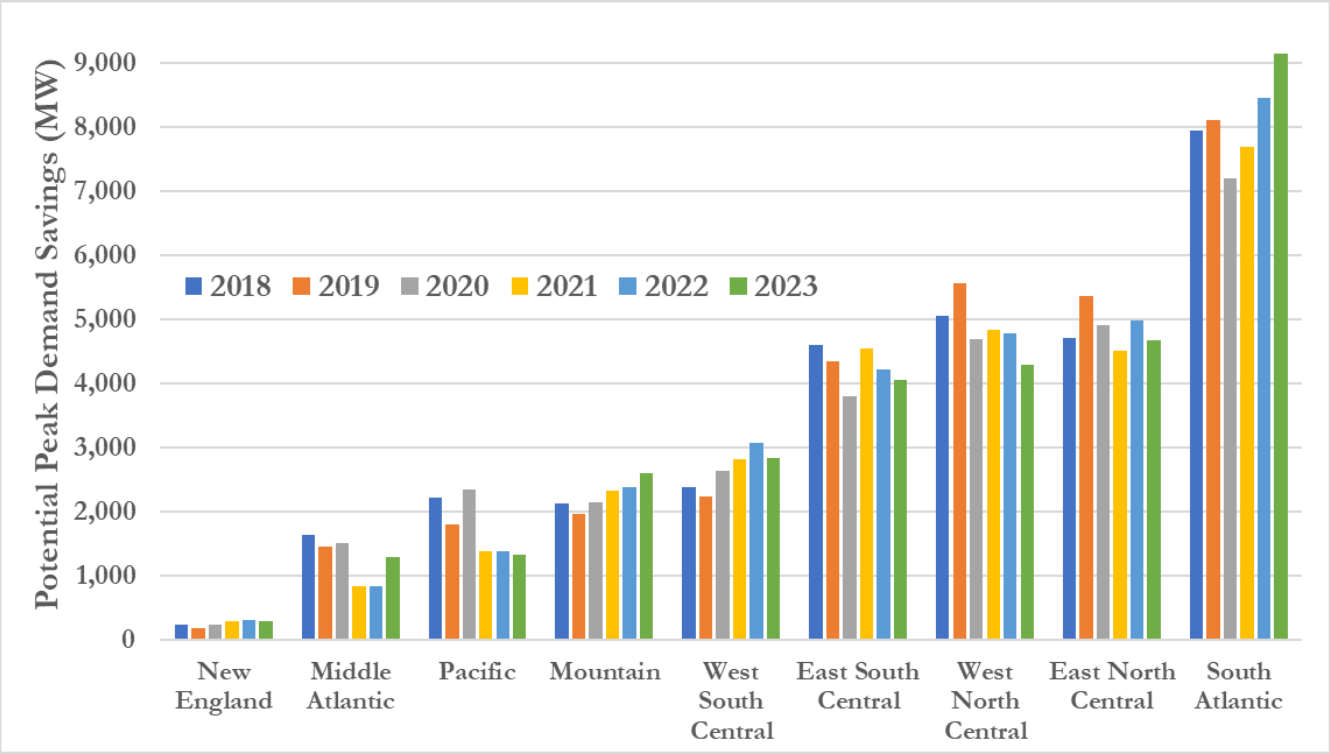
Census Division	Annual Potential Peak Demand Savings (MW)		Year-over-Year Change	
	2022	2023	MW	%
East North Central	4,974.0	4,680.8	-293.2	-5.9%
East South Central	4,223.4	4,062.6	-160.8	-3.8%
Middle Atlantic	842.1	1,303.7	461.6	54.8%
Mountain	2,389.4	2,602.7	213.2	8.9%
New England	309.2	295.1	-14.0	-4.5%
Pacific	1,390.3	1,330.0	-60.3	-4.3%
South Atlantic	8,449.2	9,146.4	697.2	8.3%
West North Central	4,787.4	4,285.9	-501.5	-10.5%
West South Central	3,082.6	2,834.7	-247.8	-8.0%
Total	**30,447.6**	**30,542.0**	**94.4**	**0.3%**

Sources: 2022 Form EIA-861 Utility_Data_2022 data file, 2022 Form EIA-861 Demand_Response_2022 data file, 2023 Form EIA-861 Utility_Data_2023 data file, 2023 Form EIA-861 Demand_Response_2023 data file.
Notes: Although some utilities may operate in more than one state and Census Division, EIA data are reported by utility at the state level. Commission staff has not independently verified the accuracy of EIA data, and Commission staff is aware that there may be inconsistencies between data reported to EIA and other data sources. Values from source data are rounded for publication

[23] EIA, Form EIA-861 Instructions at 16. *See also* Form EIA 861 Schedule 6, Part B: Demand Response Programs.

Figure 3-1 below shows changes in potential peak demand savings from retail demand response programs by Census Division for 2018 through 2023. Over this period, the amount of potential peak demand savings varied significantly by each Census Division. From 2022 to 2023, the Middle Atlantic, Mountain, and South Atlantic Census Divisions experienced increases in potential peak demand savings. In aggregate, utilities in the South Atlantic Census Division reported the largest increase, reporting approximately 697 MW, or 8.3%, more potential peak demand savings in 2023 than in 2022. Utilities in the South Atlantic Census Division with notable potential peak demand savings increases include Duke Energy Progress in North Carolina and South Carolina Public Service Authority (Santee Cooper), which reported approximately 356 MW and 120 MW of additional peak demand savings, respectively. Utilities in the Middle Atlantic Census Division reported approximately 462 MW, or 54.8%, more potential peak demand savings in 2023, the largest percent increase among Census Divisions. Utilities in the Middle Atlantic Census Division with notable increases in potential peak demand savings increases include Consolidated Edison Co. and Niagara Mohawk Power Corp., both in New York, reporting approximately 93 MW and 50 MW of additional peak demand savings, respectively. Finally, in the Mountain Census Division, Public Service Co. of Colorado reported approximately 149 MW more potential peak demand savings in 2023 than 2022, the largest increase in that Census Division.

Figure 3-1: Potential Peak Demand Savings (MW) from Retail Demand Response Programs by Census Division (2018 – 2023)



Sources: EIA-861 Demand Response data files 2018 – 2023.

While potential peak demand savings increased nationwide, six of the nine Census Divisions experienced aggregate decreases in potential peak demand savings from 2022 to 2023. In the East North Central Census Division, for instance, potential peak demand savings decreased largely because of declines at utilities in the states of Michigan and Indiana. Similarly, utilities reported aggregate decreases at the state level in

Kentucky, Tennessee, and Mississippi in the East South Central Division; Massachusetts and New Hampshire in the New England Census Divisions; and California and Oregon in the Pacific Census Division. The declines in the West North Central and West South Central Census Divisions occurred primarily in two utilities that reported large decreases in potential peak demand savings.

Table 3-2 below presents the relative contribution of retail potential peak demand savings in 2023 from the residential, commercial, and industrial customer classes. In 2023, utilities reported approximately 14,000 MW of potential peak demands savings from the industrial customer class, which is the largest share—45.3%—of potential peak demand among customer classes. The relative contributions to potential peak demand savings by the residential and commercial customer classes in 2023 were 31.7% and 23.0%, respectively. The customer class with the largest amount of potential peak demand savings varied for each Census Division. The residential class provided the largest amounts of potential peak demand savings in the Mountain, New England, South Atlantic, and West North Central Census Divisions. The commercial class provided the largest amount of potential peak demand savings in the Middle Atlantic Census Division. The industrial class provided the largest amounts of potential peak demands savings in the East North Central, East South Central, Pacific, and West South Central Census Divisions.

Table 3-2: Potential Peak Demand Savings (MW) from Retail Demand Response Programs by Census Division and Customer Class (2023)

Census Division	Customer Class			
	Residential (MW)	Commercial (MW)	Industrial (MW)	All Classes (MW)
East North Central	861.92	829.38	2,989.50	4,680.80
East South Central	363.28	104.00	3,595.32	4,062.60
Middle Atlantic	242.06	928.50	133.18	1,303.74
Mountain	1,233.79	414.02	954.86	2,602.66
New England	128.45	106.78	59.90	295.13
Pacific	454.84	290.03	585.14	1,330.00
South Atlantic	3,997.15	2,601.26	2,547.99	9,146.41
West North Central	1,924.58	824.56	1,536.78	4,285.92
West South Central	460.56	936.59	1,437.59	2,834.74
Total	**9,666.60**	**7,035.11**	**13,840.27**	**30,541.98**

Sources: 2023 Form EIA-861 Demand_Response_2023 data file and 2023 Form EIA-861 Utility_Data_2023 data file.
Notes: Although some utilities may operate in more than one state and Census Division, EIA data are reported by utility at the state level. Commission staff has not independently verified the accuracy of EIA data. Values from source data are rounded for publication.

Wholesale Demand Response Programs

Table 3-3 below presents estimates of participation in wholesale demand response programs in the seven RTOs and ISOs[24] in 2023 and 2024. Demand response participation increased in the wholesale markets overall by approximately 217 MW, or 0.7%, from 2023 to 2024. On a regional basis, demand response totals increased in five of the wholesale markets but declined in two of them. ERCOT experienced the largest annual increase, reporting approximately 486 MW more demand response resources in 2024. Based on the reported data, approximately 6.5% of the wholesale market non-coincident peak demand for all RTOs and ISOs could be met by demand response resources in 2024. The sum of the non-coincident peak demands across all RTOs and ISOs was approximately 515 GW in 2024.

In CAISO, demand response capacity increased by approximately 219 MW, or 5.3%, from 4,154 MW in 2023 to 4,373 MW in 2024. Third party demand response participation[25] averaged 188 MW in 2024, which is down from 210 MW reported in 2023.[26] Utility demand response participation also declined in 2024, averaging 986 MW, which is down from 1,175 MW reported in 2023.

ERCOT experienced the largest net annual increase in demand response resources among organized wholesale electricity markets. From 2023 to 2024, demand response resource participation increased by approximately 486 MW, or 13.5%, from 3,613 MW to 4,099 MW. Demand response resource participation increased in ERCOT's Emergency Response Service by 286 MW, in Contingency Reserve Service[27] by 299 MW, and in Non-spinning Reserves by 215 MW. In contrast, demand response resources participating in ERCOT's Responsive Reserve Service decreased by 279 MW.

ISO-NE reported approximately 431 MW of Active Demand Capacity Resources enrolled in July 2024, the month with the highest peak demand in ISO-NE that year. This represents a 25 MW, or 5.5%, decrease in enrolled demand response compared to the 456 MW of Active Demand Capacity Resources in September 2023, the month with the highest peak demand in ISO-NE that year.

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[24] The RTOs and ISOs include the California Independent System Operator (CAISO), Electric Reliability Council of Texas (ERCOT), ISO New England (ISO-NE), Midcontinent Independent System Operator (MISO), New York Independent System Operator (NYISO), PJM Interconnection (PJM), and Southwest Power Pool (SPP).

[25] Third party demand response is operated by non-utility providers under contract to supply demand response for utilities. *See* CAISO, *Demand Response Issues and Performance 2024* at 8 (Mar. 2025), https://www.caiso.com/documents/demand-response-issues-and-performance-2024-mar-14-2025.pdf.

[26] CAISO, *2024 Annual Report on Market Issues & Performance* at 319 (Aug. 2025), https://www.caiso.com/documents/2024-annual-report-on-market-issues-and-performance-aug-07-2025.pdf.

[27] The ERCOT Contingency Reserve Service (ECRS) allows resources that both do and do not have under-frequency relays to provide this reserve service. This contrasts with ERCOT's Responsive Reserve Service (RRS) which allow resources controlled by high-set under-frequency relays to provide reserve service. *See* ERCOT, *2024 Annual Report on Demand Response in the ERCOT Region* at 6 (Feb. 2025), https://www.ercot.com/misdownload/servlets/mirDownload?doclookupId=1080511461.

Table 3-3: Demand Response Resource Participation in RTOs and ISOs (2023 and 2024)

RTO/ISO	2023		2024		Year-over-Year Change	
	Demand Response Resources (MW)	Percent of Peak Demand[8]	Demand Response Resources (MW)	Percent of Peak Demand[8]	MW	Percent
CAISO[1]	4,154.3	9.3%	4,373.0	9.0%	218.8	5.3%
ERCOT[2]	3,612.8	4.2%	4,099.1	4.8%	486.3	13.5%
ISO-NE[3]	456.0	1.9%	431.0	1.7%	-25.0	-5.5%
MISO[4]	12,663.0	10.1%	12,954.0	10.6%	291.0	2.3%
NYISO[5]	1,708.7	5.5%	1,920.9	6.1%	212.2	12.4%
PJM[6]	9,666.8	6.7%	8,526.0	5.7%	-1,140.8	-11.8%
SPP[7]	793.0	1.4%	968.0	1.8%	175.0	22.1%
Total	**33,054.5**	**6.5%**	**33,272.0**	**6.5%**	**217.4**	**0.7%**

Sources for demand resource data: [1] CAISO, 2023 and 2024 Annual Reports on Market Issues and Performance. Totals for Figure 15.3 were confirmed with the CAISO Department of Market Monitoring; [2] Estimated based on ERCOT, 2023 and 2024 Annual Reports of Demand Response in the ERCOT Region; [3] ISO-NE Monthly Market Operations Report April 2024 and December 2024; [4] Potomac Economics, 2023 and 2024 State of the Market Reports for the MISO Electricity Markets; [5] NYISO, 2023 and 2024 Annual Reports on Demand Response Programs; [6] PJM, 2023 and 2024 Demand Response Operations Markets Activity Reports. Totals represent "unique MW" (see *infra* note 31); [7] SPP, 2023 and 2024 State of the Market Reports; [8] Sources for peak demand data: CAISO 2023 and 2024 Annual Reports on Market Issues and Performance; ERCOT 2023 & 2024 Demand and Energy Reports; ISO-NE Net Energy and Peak Load Report; Potomac Economics, 2023 and 2024 State of the Market Reports for the MISO Electricity Markets; NYISO Power Trends Reports 2023 and 2024; 2023 and 2024 PJM State of the Market Report, Vol. 2; SPP 2023 and 2024 State of the Market Reports.
Notes: Commission staff has not independently verified the accuracy of the data from the sources listed. Values from source data are rounded for publication.

MISO experienced an increase in demand response resources of approximately 291 MW, or 2.3%, from 12,663 MW in 2023 to 12,954 MW in 2024. Participation increased for Load-Modifying Resources[28] by 428 MW and for Demand Response Type I and II Resources by 167 MW. In contrast, resource participation in the Emergency Demand Response program decreased by 95 MW.[29]

[28] Load-Modifying Resources (LMRs) are capacity resources obligated to curtail in emergencies and to help satisfy planning reserve margin requirements. *See* Potomac Economics, *2024 State of the Market Report for the MISO Electricity Markets* at 98 (Jun. 2025), https://www.potomaceconomics.com/wp-content/uploads/2025/06/2024-MISO-SOM_Report_Body_Final.pdf.

[29] The values reported for Demand Response Type I and II, and Emergency Demand Response may include resources cross-registered as Load-Modifying Resources. *See Id.* at 98.

In NYISO, demand response resource registration increased by approximately 212 MW, or 12.4%, from 1,709 MW in 2023 to 1,921 MW in 2024. Demand response participation increased in NYISO's reliability-based demand response programs[30] by 195 MW and in its economic-based Demand-Side Ancillary Service Program by 19 MW.

PJM experienced a decrease in registered demand response of approximately 1,141 MW, or 11.8%, from 9,667 MW in 2023 to 8,526 MW in 2024. From 2023 to 2024, participation decreased in PJM's Economic program by 300 MW and in its Load Management program by 789 MW.[31]

SPP reported approximately 968 MW of demand response participation from 121 demand response resources in 2024. This represents a 175 MW, or 22.1%, increase from 2023, when SPP reported at total of 793 MW of demand response participation. in 2023 to 968 MW in 2024.[32]

Demand Response Deployments

RTOs and ISOs deploy demand response resources to balance supply and demand and to avoid the cost of dispatching additional generation or involuntarily curtailing load. In June 2025, a heat wave in the Mid-Atlantic and Northeast resulted in near record-breaking peak demand for electricity, which led some grid operators to issue hot weather alerts and calls for demand response. An overview of some of those actions is provided below.

In ISO-NE, demand peaked at 26,024 MW on the evening of June 24, 2025, the highest level seen in the region since 2013.[33] ISO-NE issued a Power Caution after an unexpected loss of generation and declared an Energy Emergency Alert 1. Declaring a Power Caution allows ISO-NE to take certain actions to

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[30] NYISO's reliability-based demand response programs include the Emergency Demand Response Program and the Installed Capacity – Special Case Resource Program. *See* NYISO, *2024 Annual Report on Demand Response Programs* at 1-2 (Feb. 2025), https://www.nyiso.com/documents/20142/49931415/NYISO-2024-Annual-Report-on-Demand-Response-Programs.pdf/d0a21acb-eda1-09b6-a7c0-62e627f0b01d.

[31] The values for Economic and Load Management programs may include resources registered to participate in both programs. The total demand response resource participation reported here represents "unique MW." According to PJM, unique MW "represent total estimated demand reduction assuming full Load Management and Economic reductions." *See* PJM, *2024 Demand Response Operations Markets Activity Report* at 3 (Mar. 2025), https://www.pjm.com/-/media/DotCom/markets-ops/dsr/2024-demand-response-activity-report.pdf.

[32] SPP, *State of the Market 2024* at 41 (May 2025), https://www.spp.org/documents/73953/2024_annual_state_of_the_market_report.pdf. [33] ISO Newswire, *Hot Weather Updates: Week of June 23, 2025* (June 2025), https://isonewswire.com/2025/06/25/hot-weather-updates-week-of-june-23-2025/.

[33] ISO Newswire, *Hot Weather Updates: Week of June 23, 2025* (June 2025), https://isonewswire.com/2025/06/25/hot-weather-updates-week-of-june-23-2025/.

maintain system reliability including activating operating reserves, initiating voltage reductions, requesting emergency imports from neighboring regions, or, if needed, requesting conservation.[34]

Similarly, NYISO issued Energy Alerts and Energy Emergencies on June 24, 2025, due to an Operating Reserve deficiency.[35] The Operating Reserve deficiency was caused by high demand, stressed system conditions, and resource performance issues. These factors led NYISO to activate demand response resources among several other corrective actions including curtailing exports, dispatching generation to optimize 30-minute reserves, and purchasing emergency energy.

PJM issued Maximum Generation and Load Management Alerts during the period June 23 – 25, 2025, due to high energy demand resulting from extreme heat.[36] Such alerts from PJM notify demand response resources that they may be called upon, advise transmission owners and generators to be in a state of readiness to be dispatched if needed, and inform neighboring regions that PJM exports may be curtailed. During this period, among other actions, PJM deployed demand response resources that reduced system peaks by more than 4,000 MW. Peak demand reached approximately 162,000 MW on June 24, 2025, the third-highest all-time peak demand in PJM.

Separately, on August 11, 2025, PJM deployed demand response to maintain system reliability and minimize a load shed event after the loss of a substation in the Baltimore Gas & Electric (BGE) transmission zone.[37] Overall, PJM and BGE demand response programs reduced load by 230 MW. PJM stated that demand response and voltage reduction action that day reduced the magnitude and duration of the load shed event, from potentially 1,200 MW of load shed down to a loss of 20 MW lasting 28 minutes.

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[34] *See* ISO-NE, *What Is a Capacity Deficiency?*, https://www.iso-ne.com/about/what-we-do/in-depth/capacity-deficiency.

[35] *See* NYISO, *Major Emergency Report June 24, 2025, Operating Reserve Deficiency* (2025), https://www.nysrc.org/wp-content/uploads/2025/07/7.3.3-EC-Presentation-Major-Emergency-06.24.2025-Attachment-7.3.3.pdf.

[36] PJM Inside Lines, *Maintaining Grid Reliability Through Highest Peaks in a Decade* (July 2025), https://insidelines.pjm.com/maintaining-grid-reliability-through-highest-peaks-in-a-decade/.

[37] PJM Inside Lines, *PJM Details Its Actions to Minimize Aug. 11 Baltimore Load Shed Event* (Sep. 2025), https://insidelines.pjm.com/pjm-details-its-actions-to-minimize-baltimore-load-shed-event/.

4. Potential for Demand Response as a Quantifiable, Reliable Resource for Regional Planning Purposes

As detailed in previous years' Assessments of Demand Response and Advanced Metering, regulatory bodies, reliability coordinators, RTOs and ISOs, and utilities continue to use demand response as a quantifiable, reliable resource for regional planning purposes, including meeting planning requirements, reducing demand, and meeting changing system needs in the energy and ancillary services markets. For example, on September 29, 2025, the California Public Utilities Commission (California Commission) issued an order instituting a rulemaking to assess and improve the consistency, predictability, reliability, and cost-effectiveness of demand response resources by updating the California Commission's demand response guiding principles, as well as its policies and data system and process requirements.[38] The order states that the California Commission, the California Energy Commission, and the California Legislature have all recognized the critical role of demand response in promoting reliability and reducing costs borne by ratepayers.[39] Other examples of state legislators and regulatory bodies recognizing demand response as a quantifiable, reliable resource can be found in Chapter 5: Developments and Issues in Demand Response. Additionally, as detailed earlier in this report, RTOs and ISOs deploy demand response resources to balance supply and demand and to avoid the cost of dispatching additional generation or involuntarily curtailing load. For details on the potential resource contribution from demand response programs and deployment of demand response resources in RTOs and ISOs, see Chapter 3: Wholesale Demand Response Programs and Demand Response Deployments.

[38] *Order Instituting Rulemaking to Enhance Demand Response in California*, Docket No. R 25-09-004, (California Commission Sep. 29, 2025) https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M582/K072/582072320.PDF.

[39] *Id.* at 5.

5. Existing Demand Response and Dynamic Pricing Programs

This chapter presents regional information on retail demand response[40] and dynamic pricing[41] programs, based on EIA data. Again, FERC staff does not independently verify the accuracy of EIA data, but rather reports the data as they were reported by EIA. This chapter also summarizes selected recent federal, regional, state, and industry actions and developments related to demand response.

Enrollment in Retail Demand Response and Dynamic Pricing

Table 5-1 below presents enrollment by customer account in retail incentive-based demand response programs for each of the nine Census Divisions in 2022 and 2023. U.S. customer enrollment in these programs increased by approximately 247,000 customers, or 2.4%, from 10.3 million customers in 2022 to 10.6 million customers in 2023. This growth can be attributed to increased enrollment reported by utilities in the East North Central, East South Central, Middle Atlantic, New England, Pacific, and South Atlantic Census Divisions.

[40] Demand-side management (DSM) programs are designed to modify patterns of electricity usage, including the timing and level of electricity demand. DSM programs include direct load control, interruptible, demand bidding/buyback, emergency demand response, capacity market, and ancillary service market programs. Previously, EIA referred to these programs as "incentive-based" demand response programs. *See* EIA, *Form EIA-861S Annual Electric Power Industry Report (Short Form) Instructions* at 3, https://www.eia.gov/survey/form/eia_861s/instructions.pdf; EIA, *Form EIA-861 Annual Electric Power Industry Report Instructions,* Schedule 6 Part B, https://www.eia.gov/survey/form/eia_861/instructions.pdf; and FERC, *A National Assessment of Demand Response Potential* (2009), https://www.ferc.gov/sites/default/files/2020-05/06-09-demand-response.pdf.

[41] Dynamic pricing programs, also known as time-based rate programs, are designed to modify patterns of electricity usage, including the timing and level of electricity demand. They include time-of-use prices, as well as real-time pricing, variable peak pricing, critical peak pricing, and critical peak rebate programs. *See* EIA, *Form EIA-861S Annual Electric Power Industry Report (Short Form) Instructions* at 3-4, https://www.eia.gov/survey/form/eia_861s/instructions.pdf; and EIA, *Form EIA-861 Annual Electric Power Industry Report Instructions,* Schedule 6 Part C, https://www.eia.gov/survey/form/eia_861/instructions.pdf.

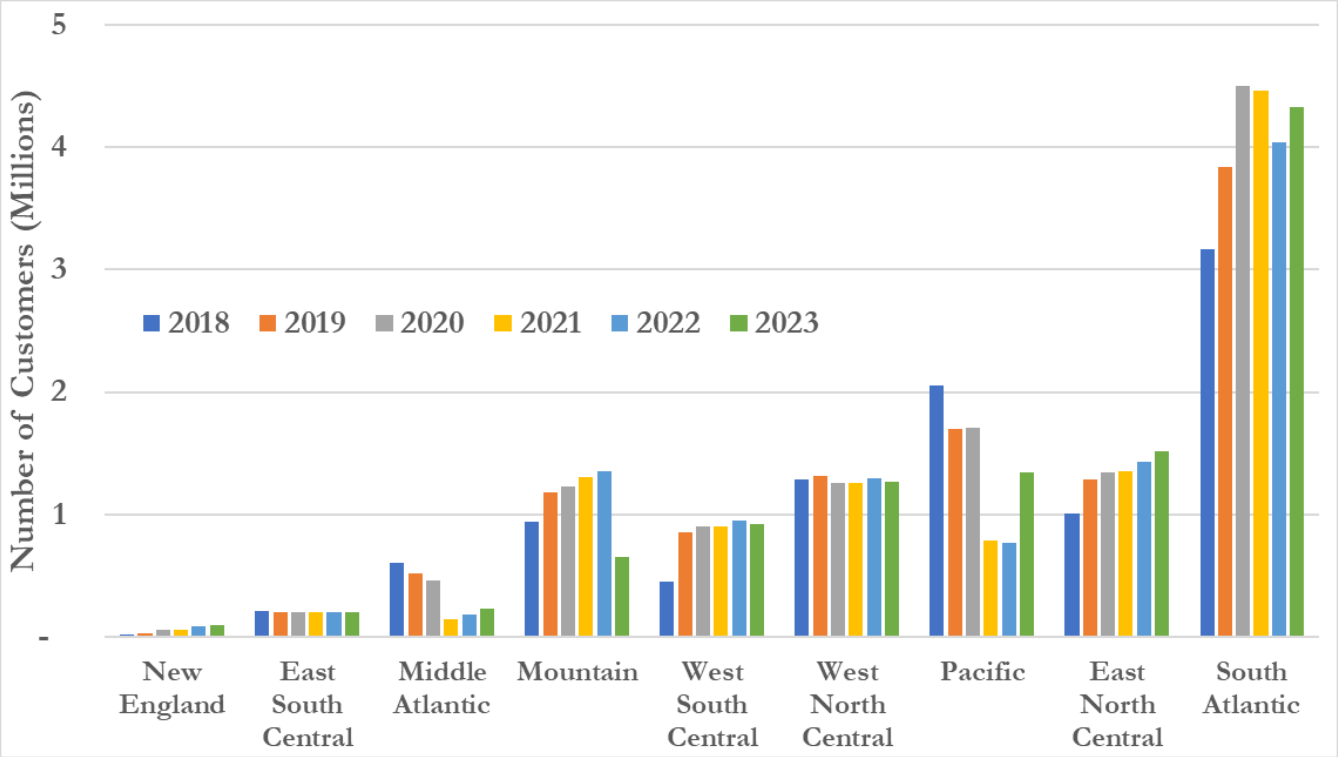
Table 5-1: Customer Enrollment in Retail Demand Response Programs by Census Division (2022 and 2023)

Census Division	Enrollment in Retail Demand Response Programs		Year-over-Year Change	
	2022	2023	Customers	%
East North Central	1,431,542	1,516,053	84,511	5.9%
East South Central	203,712	204,373	661	0.3%
Middle Atlantic	184,804	230,625	45,821	24.8%
Mountain	1,356,157	653,102	-703,055	-51.8%
New England	86,732	100,576	13,844	16.0%
Pacific	773,107	1,348,727	575,620	74.5%
South Atlantic	4,034,799	4,328,784	293,985	7.3%
West North Central	1,295,155	1,265,964	-29,191	-2.3%
West South Central	953,766	919,050	-34,716	-3.6%
Total	**10,319,774**	**10,567,254**	**247,480**	**2.4%**

Sources: 2022 Form EIA-861 Utility_Data_2022 data file, 2022 Form EIA-861 Demand_Response_2022 data file, 2023 Form EIA-861 Utility_Data_2023 data file, and 2023 Form EIA-861 Demand_Response_2023 data file.
Notes: Although some utilities may operate in more than one state and Census Division, EIA data are reported by utility at the state level. Commission staff has not independently verified the accuracy of EIA data. Values from source data are rounded for publication.

Figure 5-1 below shows changes in enrollment by customer account in retail incentive-based demand response programs in each Census Division from 2018 to 2023. Over this period, trends in customer enrollment in such programs varied across Census Divisions. From 2022 to 2023, utilities in six of the nine Census Divisions experienced increases in customer enrollment in retail incentive-based demand response programs. In aggregate, utilities in the Pacific Census Division reported the largest increase among Census Divisions, reporting approximately 576,000 additional customers, or a 74.5% increase. This increase can primarily be attributed to Puget Sound Energy Inc. in Washington State, which reported approximately 525,000 customers enrolled in retail incentive-based demand response programs in 2023. Utilities in other Census Divisions also experienced notable increases in retail demand response programs enrollment. These include Potomac Electric Power Co. in Maryland (344,000 additional customers enrolled), Delmarva Power in Delaware (116,000) and Delmarva Power in Maryland (77,000) in the South Atlantic Census Division; and DTE Electric Co. (54,000) and Consumers Energy Co. (37,000) in Michigan in the East North Central Census Division.

Figure 5-1: Customer Enrollment in Retail Demand Response Programs by Census Division (2018 – 2023)



Sources: EIA-861 Demand Response data files 2018 – 2023.

While nationwide customer enrollment in retail demand response programs grew from 2022 to 2023, utilities in the Mountain, West North Central, and West South Central Census Divisions reported approximately 703,000, 20,000, and 35,000 fewer customers enrolled. The decline in the Mountain Census Division was due primarily to one utility that reported approximately 720,000 fewer customers enrolled in 2023 compared to 2022. The decreases in the West North Central and West South Central Census Divisions resulted from aggregate declines reported by utilities in Arkansas, Kansas, Oklahoma, Minnesota, Missouri, North Dakota, South Dakota and Texas.

Turning to dynamic pricing, Table 5-2 below illustrates customer enrollment in retail dynamic pricing programs for each of the nine Census Divisions in 2022 and 2023. From 2022 to 2023, U.S. customer enrollment in these program programs increased by approximately 2.6 million customers, or 16.9%. Seven Census Divisions experienced aggregated increases in customer enrollment. The East North Central Division experienced the largest aggregate increase, with utilities reporting approximately 1.5 million additional customers enrolled in retail dynamic pricing programs in 2023. The significant annual enrollment increases in the East North Central Division resulted from a large rise in customers enrolled in Michigan, mostly from Consumers Energy Co. Utilities in the East South Central, Middle Atlantic, Mountain, New England, West North Central, and West South Central Census Divisions also reported more customers enrolled in retail dynamic pricing programs in 2023 compared to 2022. While overall enrollment in retail dynamic pricing programs increased nationwide, the Pacific and South Atlantic Census Divisions experienced aggregated decreases in customer enrollment. Utilities in the South Atlantic and Pacific Census

Divisions reported approximately 350,000 and 211,000 fewer customers, respectively, enrolled in retail dynamic pricing programs in 2023.

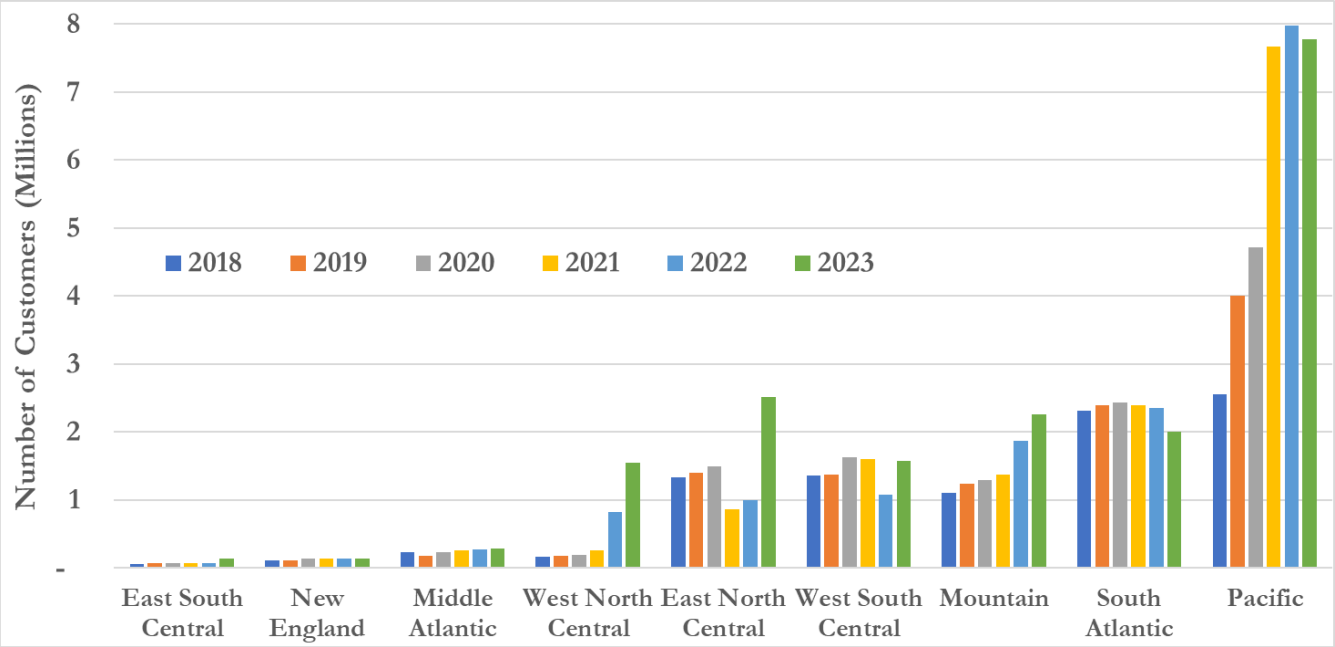
Table 5-2: Customer Enrollment in Retail Dynamic Pricing Programs by Census Division (2022 and 2023)

Census Division	Enrollment in Dynamic Pricing Programs		Year-over-Year Change	
	2022	2023	Customers	%
East North Central	997,574	2,512,498	1,514,924	151.9%
East South Central	69,859	141,917	72,058	103.1%
Middle Atlantic	276,014	279,248	3,234	1.2%
Mountain	1,868,528	2,253,880	385,352	20.6%
New England	136,319	144,308	7,989	5.9%
Pacific	7,983,495	7,772,829	-210,666	-2.6%
South Atlantic	2,357,868	2,005,858	-352,010	-14.9%
West North Central	828,644	1,549,726	721,082	87.0%
West South Central	1,078,678	1,579,824	501,146	46.5%
Total	**15,596,979**	**18,240,088**	**2,643,109**	**16.9%**

Source: 2022 Form EIA-861 Dynamic_Pricing_2022 data file, 2022 Form EIA-861 Utility_Data_2022 data file, 2023 Form EIA-861 Dynamic_Pricing_2023 data file, and 2023 Form EIA-861 Utility_Data_2023 data file.
Note: Although some utilities may operate in more than one state and Census Division, EIA data are reported by utility at the state level. Commission staff has not independently verified the accuracy of EIA data. Values from source data are rounded for publication.

Figure 5-2 below shows customer enrollment in retail dynamic pricing programs in each Census Division from 2018 through 2023. Over this period, customer enrollment showed a consistent upward trend across all Census Divisions except for the East North Central, West South Central, and South Atlantic Census Divisions. Customer enrollment fluctuated in the East North Central and West South Central Census Divisions and remained relatively stable in the South Atlantic Census Divisions over the same time. Utilities in the Pacific Census Division continued to report the largest aggregate number of customers enrolled in retail dynamic pricing programs, with approximately 7.8 million customers enrolled in 2023, however, the total number of enrolled customers declined by 201,666 customers or 2.6% between 2022 and 2023. Notably, Southern California Edison reported approximately 150,000 more customers enrolled in retail dynamic pricing programs in 2023 compared to 2022. Utilities in other Census Divisions also experienced significant increases in customer enrollment from 2022 to 2023. For example, Consumers Energy Co. of Michigan in the East North Central Census Division reported 1.5 million additional customers enrolled in retail dynamic pricing programs in 2023. Public Service Co. of Oklahoma in the West South Central Census Division and Public Service Co. of Colorado in the Mountain Census Division also reported 465,000 and 350,000 additional customers, respectively, enrolled in retail dynamic pricing programs in 2023. While the Pacific Census Division reported the largest aggregate number of customers enrolled, the East North Central, West North Central, and West South Central Census Divisions reported the highest year-over-year increases from 2022 to 2023, with approximately 1.5 million, 720,000, and 500,000 more customers, respectively, enrolled in retail dynamic pricing programs.

Figure 5-2: Customer Enrollment in Retail Dynamic Pricing Programs by Census Division (2018 – 2023)



Sources: EIA-861 Dynamic Pricing data files 2018 – 2023.

FERC Demand Response Orders and Activities

MISO Modification to Demand Resource Participation Requirements (ER25-1729-000)

On July 18, 2025, the Commission accepted MISO's proposal to revise its tariff revisions to modify its demand resource participation requirements.[42] MISO stated that its proposal was aimed at ensuring that the participation of demand resources is less prone to Tariff violations, potential gaming, market manipulation, and fraud, and will reduce or prevent: (1) payments for nonexistent or overstated curtailments; (2) inaccurate or inflated baselines on which curtailments are based; and (3) fraudulent registration of resources.[43] MISO stated that it submitted its filing in response to four Commission orders[44] that addressed assertions of tariff violations, market manipulation, and fraud relating to certain demand resources'

[42] *Midcontinent Independent System Operator, Inc.*, 192 FERC ¶ 61,060 (2025).

[43] MISO, Transmittal, Docket No. ER25-1729, at 1, 7 (filed Mar. 21, 2025).

[44] *See Big River Steel LLC & Entergy Ark. LLC,* 184 FERC ¶ 61,111 (2023); *Linde Inc. and Northern Indiana Public Service Company LLC,* 186 FERC ¶ 61,009 (2024); *Ketchup Caddy, LLC & Philip Mango*, 186 FERC ¶ 61,132 (2024); *Voltus, Inc. & Gregg Dixon*, 190 FERC ¶ 61,008 (2025).

participation in MISO's markets.[45] Notably, the accepted tariff revisions: (1) clarify the expectation that demand resources should respond to MISO's instructions, require demand resources to attest in writing that they made a load reduction in response to MISO's instructions, and require that demand resources submit meter data demonstrating the load reduction to MISO within a specified timeframe; (2) explicitly allow MISO's Independent Market Monitor to mitigate the offers of demand response resources if the offer is not deemed economic; (3) set the baseline load for a resource by using the five lowest average load days over the prior 45-day period should a resource have too few non-event days rather than the five highest average load days across the entire 45-day period; and (4) clarify that any entity offering into MISO's markets must have the legal right to make the resource available to respond to a scheduling instruction on the terms it submits, whether through ownership or a contractual relationship.

MISO Elimination of Dual Registration of Demand Response (ER25-2050-000)

On July 18, 2025, the Commission accepted MISO's proposed tariff revisions to remove the ability for market participants to register a resource both as an Emergency Demand Response resource and as a Load Modifying Resource in the MISO Planning Resource Auction.[46] MISO noted in its proposal that market participants had an incentive to register demand-side resources as both Load Modifying and Emergency Demand Response resources.[47] Prior to the Commission's Order accepting its tariff changes, under MISO's Emergency Operating Procedures, Load Modifying Resources were dispatched prior to deploying Emergency Demand Response Resources, which are dispatched using Security Constrained Economic Dispatch.[48] This sequencing deployed resources compensated through capacity payments prior to resources only compensated through energy payments.[49] Previously, a resource that had registered as both types of resources and offered its Emergency Demand Response resource as zero megawatts would receive Capacity payment compensation for its Load Modifying Resource participation while reducing the likelihood of being called to perform as either type of resource.[50]

[45] MISO, Transmittal, Docket No. ER25-1729 (filed Mar. 21, 2025).

[46] *Midcontinent Independent System Operator, Inc.*, 192 FERC ¶ 61,059, at P 1 (2025). MISO, Transmittal, Docket No. ER25-2050, at 1, 7 (filed Apr. 21, 2025).

[47] *Id.* at P 6.

[48] *Id.* at P 8.

[49] *Id.* at P 8.

[50] *Id. at P* 8.

PJM Automating Bid Duration for Economic Load Response Participants (ER24-3135-000, -001)

On September 27, 2024, PJM filed proposed tariff revisions to allow Economic Load Response (ELR) participants to specify a maximum down time during which end-use loads may be curtailed, and a minimum release time between load curtailments.[51] On November 26, 2024, the Commission accepted PJM's proposed revisions subject to a further compliance filing.[52] Under the system in place at the time, PJM had committed ELR participants to curtail load in both the day-ahead energy market and the real-time energy market when the projected locational marginal price for energy was projected to be greater than an ELR participant's offer price, subject to parameter constraints. ELR participants could specify certain offer parameters when submitting their energy offers, except for a maximum down time, or the maximum amount of time that load may be curtailed, and a minimum release time, or the minimum amount of time that must pass before load can be curtailed again after being dispatched in the same operating day. PJM stated that ELR participants could limit bid durations manually by marking a demand response resource as unavailable for specific times, but the proposed tariff revisions would extend the ability to automate bid duration parameters for ELR participants.[53] On February 27, 2025, the Commission accepted PJM's compliance filing defining maximum down time and minimum release time.[54]

PJM Expansion of DR Availability Window and Amendments to Winter Peaking Load Methodology (ER25-1525)

On May 5, 2025, the Commission accepted PJM's proposal to revise Article 1 of the PJM Reliability Assurance Agreement Among Load Serving Entities (RAA) to modify the definitions of Annual Demand Resource and Summer-Period Demand Resource and the calculation of Winter Peak Load.[55] PJM proposed to redefine Annual Demand Resource and Summer-Period Demand Resource to provide for a 24-hour availability window throughout the year effective with the 2027/2028 delivery year as opposed to specified seasonal availability windows defined in its RAA. PJM also proposed to revise the Effective Load Carrying Capability accreditation calculation of demand resources by amending the definition of Winter Peak Load for demand resources to base the Winter Peak Load calculation on each demand resource customer's load during a PJM-selected consistent peak hour across five coincident peak days in winter.

Commission Enforcement Activity

On January 6, 2025, the Commission issued an order approving a Stipulation and Consent Agreement that resolved the Commission's Office of Enforcement's investigation of an aggregator of retail customers,

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[51] PJM, Transmittal, Docket No. ER24-3135 (filed Jan. 23, 2025).

[52] *PJM Interconnection, L.L.C.,* 189 FERC ¶ 61,146 (2024).

[53] *Id.* at PP 3, 5.

[54] *PJM Interconnection, L.L.C.*, Docket No. ER24-3135-001 (Feb. 27, 2025) (delegated order).

[55] *PJM Interconnection, L.L.C.,* 191 FERC ¶ 61,103 (2025).

Voltus, Inc. (Voltus), and its former CEO, and whether they violated MISO's Tariff or Commission regulations.[56] In the Stipulation and Consent Agreement, Voltus agreed to disgorge $7,080,543 in revenue that it earned during the Relevant Period, pay a civil penalty of $10,919,457 to the United States Treasury and provide compliance monitoring reports to the Commission's Office of Enforcement. In addition, the CEO agreed to pay a civil penalty of $1,000,000 to the United States Treasury, step down from Voltus's Board of Directors, neither pursue nor accept any role with Voltus or any Voltus successor entity or affiliate going forward.

On December 5, 2024, the Commission issued an Order Assessing Civil Penalties (Order) against Ketchup Caddy, LLC (Ketchup Caddy) and its co-owner for violations of the Federal Power Act, the Commission's regulations, and the MISO's Tariff. Specifically, the Commission found that these parties engaged in fraudulent activity and market manipulation, and offered uncontracted resources into MISO's capacity market without the demand resources' knowledge or consent.[57] The Commission assessed civil penalties of $25,000,000 plus interest against Ketchup Caddy and $1.5 million plus interest against its co-owner, as well as ordered $506,502 in disgorgement, plus interest. After filing a complaint in the United States District Court for the Central District of Illinois[58], Enforcement staff obtained a default judgment in the amount of $26,323,033.17 against Ketchup Caddy and $2,262,137.99 against its co-owner.[59] Enforcement staff will take steps to execute on the judgment.

Other Federal Demand Response Activities

Federal Communications Commission

On June 9, 2025, the Federal Communications Commission (FCC) issued a declaratory ruling granting Edison Electric Institute's petition requesting clarification that utilities have prior express consent under the Telephone Consumer Protection Act to send non-telemarketing demand response calls and texts when customers give their phone numbers to a utility.[60] The FCC confirmed that such calls and texts are closely related to utility service and thus utilities can make critical, time-sensitive demand response communications to their customers without having to receive additional consent from each customer.[61] In the ruling, the

[56] *Voltus Inc. and Gregg Dixon*, 190 FERC ¶ 61,008 (2025).

[57] *Ketchup Caddy, LLC and Philip Mango,* 189 FERC ¶ 61,176 (2024).

[58] *FERC v. Ketchup Caddy, LLC, et al.* (C.D. Ill. 25-cv-3116).

[59] *Id.,* ECF No. 8.

[60] *In the Matter of Rules and Regulations Implementing the Telephone Consumer Protection Act of 1991 Edison Electric Institute Petition for Declaratory Ruling.* CG Docket No. 02-278 (FCC, June 9, 2025), https://docs.fcc.gov/public/attachments/DA-25-496A1.pdf.

[61] *Id.,* at 4.

FCC ensured that the Telephone Consumer Protection Act and their implementing rules do not impede demand response communications that help ensure reliable utility services.

Developments and Issues in Demand Response

State Legislative and Regulatory Activities Related to Demand Response and Dynamic Pricing

Arizona. On March 12, 2025, the Arizona Corporation Commission (Arizona Commission) issued an order approving Arizona Public Service Company's (APS) new bring-your-own-device (BYOD) battery pilot plan, which will provide compensation to participating APS customers for allowing their personal battery storage systems to be dispatched to provide aggregate demand response capacity.[62] Customers must agree to participate in up to 60 dispatch events per year, with each event lasting one to four hours between 4 p.m. and 10 p.m. between May 1 and October 31. Participating customers will be compensated with an annual $110/kW capacity payment based on seasonal average kW performance. The plan caps participation at 5,000 residential customers and requires pricing that does not shift costs to non-participating customers.

California. On April 14, 2025, the California Energy Commission adopted the fourth edition of its Demand Side Grid Support (DSGS) Program Guidelines.[63] The DSGS Program offers incentives to electric customers that provide load reduction and backup generation to support the state's electric grid during extreme events from May to October.[64] The fourth edition of the DSGS Program Guidelines makes several updates and clarifications regarding incentive options, eligibility, and participation requirements. Most notably, it creates a new option for participation in the DSGS Program, under which third-party load flexibility providers, publicly-owned electric utilities, and community choice aggregators are eligible to serve as load flexibility VPP aggregators. Load flexibility VPPs could consist of dispatchable HVAC equipment controlled by smart thermostats, electric water heaters, electric vehicle supply equipment, stationary behind-the-meter batteries, or residential smart electric panels. Flexibility VPPs must aggregate a minimum of 200 kW across all aggregations, 100 kW in at least one single aggregation, or 50 kW in at least 3 aggregations to be eligible to participate. Additionally, each participating site in a load flexibility VPP must not be registered to participate in CAISO wholesale demand response programs or be a distribution service customer of Pacific Gas and Electric Company.

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[62] *Application for Approval of New Bring-Your-Own-Device Battery Pilot Plan of Administration*, Docket No. E-01345A-22-0144, (Arizona Commission Mar. 12, 2025), https://docket.images.azcc.gov/0000213209.pdf?i=1750103440552.

[63] *Resolution Adopting the Demand Side Grid Support Program Guidelines, Fourth Edition*, Docket No. 22-RENEW-01, (CEC Apr. 14, 2025), https://efiling.energy.ca.gov/GetDocument.aspx?tn=262675&DocumentContentId=99274.

[64] *See* CEC, *Demand Side Grid Support (DSGS) Program Guidelines, Fourth Edition* (Apr. 2025), https://efiling.energy.ca.gov/GetDocument.aspx?tn=262658.

Delaware. On July 16, 2025, the governor of Delaware signed a Delaware State Senate joint resolution directing the Delaware Sustainable Energy Utility[65] (DESEU) to study the costs and benefits of adopting energy storage systems, both in front of and behind the customer meter.[66] All electric public utilities in Delaware are required to participate in the study. The DESEU must work with the State Energy Office, the Delaware Public Service Commission, the Division of the Public Advocate, the University of Delaware, the electric public utilities in Delaware, and other interested stakeholders. The study will cover regulatory issues, the potential value of battery storage for demand reduction, the use of battery storage to avoid or defer investments in distribution and transmission infrastructure, and the incremental benefits of storage when paired with renewable energy systems. The study will also identify grid service value streams, including local peak demand reduction, resilience, and voltage stabilization. Additionally, the study will explore the best use and optimal siting of energy storage, land use and environmental impacts, community and legal issues, procurement and ownership frameworks, and participation incentives. The resolution also directs the DESEU to work with Delmarva Power & Light Company, the Delaware Municipal Electric Corporation, the Delaware Electric Cooperative, and one independent power producer to develop and deploy at least one pilot project involving battery storage systems. The pilot projects should focus on addressing grid challenges, such as peak load reduction, resilience, and hosting capacity improvements. The DESEU must publish a progress report on the study and pilots by December 31, 2025, and a comprehensive final report by June 1, 2026.

Maine. On April 23, 2025, the Maine Commission issued an order approving the Efficiency Maine Trust's Sixth Triennial Plan, which will be in effect from July 1, 2025, to June 30, 2028.[67] The plan aims to achieve annual savings of 148,000 MWh of electricity and a 45.6 MW reduction in summer peak demand from the Efficiency Maine Trust electricity programs.[68] Most relevant to this report, the plan will continue a demand response program to temporarily reduce the load of commercial and industrial customers at times of peak

[65] The Delaware Sustainable Energy Utility (DESEU), also known as Energize Delaware, is a nonprofit organization offering programs and resources to help residents and businesses save money through clean energy and efficiency. It was created in 2007 by the state of Delaware to foster a sustainable energy future. *See* Energize Delaware, *About Us,* https://energizedelaware.org/about-us/.

[66] Delaware Sustainable Energy Utility Energy Storage Systems Study and Battery Storage Pilot Resolution, S.J.R. No. 3, 153rd Gen. Assemb. (2025) (Del.) (enacted), https://legis.delaware.gov/json/BillDetail/GenerateHtmlDocumentEngrossment?engrossmentId=37067&docTypeId=6.

[67] *Efficiency Maine Trust Request for Approval of the Triennial Plan for Fiscal Years 2026-2028*, Docket No. 2024-00310, (Maine Commission Apr. 25, 2025). https://mpuc-cms.maine.gov/CQM.Public.WebUI/Common/ViewDoc.aspx?DocRefId={00476E96-0000-CE1A-921C-02405F5749AF}&DocExt=pdf&DocName=2024-000310%20ORDER%20on%20STIP%204.25.25%201.pdf.

[68] *Id.* at 3.

demand during the summer. Through the demand response program, program partners directly compensate participants based on their average kW reductions.[69]

Maryland. On February 4, 2025, the Maryland Public Service Commission (Maryland Commission) issued a notice[70] initiating a new docket and request for comments related to the implementation of VPPs and vehicle-to-grid services in Maryland to facilitate implementing FERC Order No. 2222[71] and the goals of the Maryland DRIVE Act[72]

On April 11, 2025, the Maryland Commission issued an order, directing investor-owned utilities and the Southern Maryland Electric Cooperative to submit reports on their distributed energy resource management system (DERMS) plans and conceptual reports on DER registration, device-level metering repositories, customer information sharing, and communications protocols within six months.[73] Additionally, the order requires Potomac Edison to file a conceptual report on non-AMI solutions to facilitate VPP implementation. Following the submission of the reports on October 11, 2025, the Maryland Commission held a technical conference on December 3, 2025, to consider stakeholder comments.[74]

Minnesota. On March 17, 2025, Xcel Energy filed a petition with the Minnesota Public Utilities Commission (Minnesota Commission) proposing to replace its Energy Action Days behavioral demand response program with a new Peak Time Rebate (PTR) program as part of its Energy Conservation and

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[69] *See* Efficiency Maine, *Efficiency Maine Trust's Triennial Plan VI Approved* (April 2025), https://www.efficiencymaine.com/efficiency-maine-trusts-triennial-plan-vi-approved/. *See also* Efficiency Maine, *Demand Response Program Incentive Calculation Methodology* (May 2025), https://www.efficiencymaine.com/docs/Demand_Response_Incentive_Calculation_Methodology.pdf.

[70] *In the Matter of Transforming Maryland's Electric Distribution Systems to Ensure that Electric Service is Customer-Centered, Affordable, Reliable and Environmentally Sustainable in Maryland*, Case No. 9778, (Maryland Commission Feb. 4, 2025) https://webpscxb.psc.state.md.us/DMS/case/9778.

[71] *Participation of Distributed Energy Res. Aggregations in Mkts. Operated by Reg'l Transmission Orgs. & Indep. Sys. Operators, Order No. 2222*, 172 FERC ¶ 61,247 (2020), order on reh'g, Order No. 2222-A, 174 FERC ¶ 61,197 (2021), order on reh'g, Order No. 2222-B, 175 FERC ¶ 61,227 (2021).

[72] The Maryland DRIVE Act requires the Maryland Commission to adopt regulations to establish bidirectional EV charging programs allowing EVs to not only draw power from the grid, but also to supply electricity back. *See* DRIVE Act, H.B. 1256, 2024 Gen. Assemb. (2024) (Md) (enacted), https://mgaleg.maryland.gov/2024RS/Chapters_noln/CH_476_hb1256t.pdf.

[73] *Order on Implementation of FERC Order No. 2222 and Virtual Power Plants in Maryland*, Case No. 9778 at 31, (Maryland Commission Apr. 11, 2025) https://webpscxb.psc.state.md.us/DMS/case/9778.

[74] *Notice of Technical Conference and Request for Comments*, Case No. 9778, (Maryland Commission Oct. 14, 2025) https://webpscxb.psc.state.md.us/DMS/case/9778.

Optimization[75] portfolio.[76] This filing is to comply with orders from the Minnesota Commission directing Xcel Energy to propose procedural pathways for additional demand response and load flexibility programs and to evaluate a proposal for a peak-time rebate program for Xcel Energy.[77] Xcel proposes to work with the Minnesota Department of Commerce to implement and recover the costs for the PTR program through the Energy Conservation and Optimization process. Xcel Energy states that the PTR program would directly reward or rebate customers who respond.[78] Under the PTR program, customers would earn a rebate of $1/kWh reduction and receive a yearly rebate on their electric bill based on participation.[79] Xcel Energy plans to implement the program in 2026 and expects to enroll approximately 15,500 customers in the first year.[80]

On May 15, 2025, the Minnesota Commission issued an order accepting Xcel Energy's revised proposal of a time-of-use rate for residential customers.[81] Participation in the new time-of-use rate is voluntary, employing an opt-in approach, and establishes an on-peak period of 6:00 p.m. to 9:00 p.m.[82]

South Carolina. On May 12, 2025, the governor of South Carolina signed the "South Carolina Energy Security Act" into law, which includes provisions encouraging the expansion of DSM programs within the state.[83] The law declares that expanding utility investment and customer access to cost-effective DSM programs is in the public interest because it will result in more efficient use of existing resources, promote

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[75] Minnesota's Energy and Optimization Program is overseen by the Minnesota Department of Commerce and helps households and businesses use electricity and natural gas more efficiently. *See* Minnesota Commerce Department, *Energy Conservation and Optimization*, https://mn.gov/commerce/energy/conserving-energy/eco/.

[76] *Petition In the Matter of a Peak Time Rebate Program for Northern States Power Co. d/b/a Xcel Energy to Further the Commission's Advanced Rate Design Efforts in Docket No. E002/CI-24-115*, Docket No. E-002/M-24-432, (Minnesota Commission Mar. 17,2025) https://www.edockets.state.mn.us/documents/%7BB07CA595-0000-C51B-9544-BC6C5D999B7E%7D/download?contentSequence=0&rowIndex=11

[77] *Id.* at 1-2. (citing *Order Approving Transmission Cost Recovery Rider Revenue Requirement and Denying Performance Incentive Mechanisms*, Docket No. E002/M-23-467, (MN PUC Dec. 4, 2024); *Notice of and Order for Hearing*, Docket No. E002/GR-24-320, (Minnesota Commission Dec. 30, 2024)).

[78] *Id.* at 5.

[79] *Id.* at 9.

[80] *Id* at 12.

[81] *Order Approving Revised Opt-in Proposal and Setting Reporting Requirements*, Docket No. E-002/M-23-524, (Minnesota Commission May 15, 2025) https://www.edockets.state.mn.us/documents/%7B90D8D596-0000-C316-998D-0637F9661E8B%7D/download?contentSequence=0&rowIndex=3.

[82] *Id.* at 7.

[83] South Carolina Energy Security Act, H.B. 3309, 126th Gen. Assemb. (2025) (S.C.) (enacted),https://www.scstatehouse.gov/sess126_2025-2026/bills/3309.htm.

lower energy costs, mitigate the increasing need for new generation and associated resources, and assist customers in managing their electricity usage to better control their electric bill. Accordingly, the law directs the South Carolina Public Service Commission (SC Commission) to require utilities to plan and invest in all reasonable, prudent, and available demand-side resources that are cost-effective, energy efficient technologies. The law also requires utilities to submit an annual report regarding their DSM programs to the SC Commission and adds incentives for programs using customer-sited DERs.

Texas. On June 20, 2025, the governor of Texas signed a law directing the Texas Public Utility Commission (Texas Commission) to require ERCOT to develop a demand management service that enables mandatory curtailment of large loads, such as data centers, during firm load shed events.[84] The law applies to large load customers with a demand of at least 75 MW that interconnect to ERCOT on or after January 1, 2026. The law also calls on ERCOT to develop a reliability service to competitively procure demand reductions from large load customers to be deployed in the event of an anticipated emergency condition. In developing this service, the law states that ERCOT must (1) specify the periods when the service may be used to maintain reliability during extreme weather events; (2) provide at least 24 hours' advance notice before initiating a curtailment event and require large load customers to remain curtailed for the duration of the energy emergency alert event or until the load is recalled; and (3) prohibit participation by large load customers that curtail in response to wholesale electricity prices or that participate in other reliability or ancillary services.

On the same day, the governor of Texas also signed a law creating the Texas Energy Waste Advisory Committee to make recommendations for coordinating and improving state agency and interagency programs that reduce energy waste, increase energy efficiency, and enhance demand response programs in order to increase reliability of electric service in ERCOT.[85]

Virginia. On May 2, 2025, the governor of Virginia signed a law directing Dominion Energy to launch a VPP pilot program.[86] Specifically, the law requires that Dominion Energy petition the Virginia State Corporation Commission (Virginia Commission) to conduct a pilot program to evaluate methods to optimize demand through various technology applications including the establishment of VPPs by December 2025. The law requires that the pilot program evaluate grid capacity needs as well as the ability of VPPs to provide grid services, such as peak-shaving, during times of peak demand. It also stipulates that the pilot program consist of DER aggregations totaling up to 450 MW from resources in multiple geographic regions of the state. In conducting the pilot program, the law requires the utility to evaluate methods to holistically optimize demand, including by reviewing enrollment and performance incentives for participants; incentives for purchasing battery storage devices; operational parameters for grid services; mechanisms for disenrollment for nonperforming participants; and development of a preliminary program

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[84] An Act Relating to Electricity Planning, Interconnection, Operation, and Service Costs for Large Loads, S.B. 6, 89th Leg., Reg. Sess. (2025) (Tex.) (enacted), https://capitol.texas.gov/tlodocs/89R/billtext/pdf/SB00006F.pdf#navpanes=0.

[85] Texas Energy Waste Advisory Committee Act, H.B. 5323, 89th Leg., Reg. Sess. (2025) (Tex.) (enacted), https://capitol.texas.gov/tlodocs/89R/billtext/html/HB05323F.htm.

[86] Community Energy Act, S.B. 1100, 2025 Gen. Assemb. (2025) (Va.) (enacted), https://lis.blob.core.windows.net/files/1079987.PDF.

tariff. The utility has until November 15, 2026, to petition the Virginia Commission for a program tariff to allow residential, commercial, and industrial customers to enroll directly or through an aggregator. The pilot program will end by July 1, 2028, after which the Virginia Commission will review the results and evaluate the pilot program's effectiveness in providing grid services during times of peak demand. On September 15, 2025, Dominion Energy initiated a stakeholder process to help develop the VPP program and solicited stakeholder feedback through the end of October 2025.[87] On December 1, 2025, Dominion Energy submitted its proposed VPP pilot program to the Virginia Commission.[88]

[87] Dominion Energy, *Virtual Power Plant*, https://www.dominionenergy.com/virginia/save-energy/virtual-power-plant.

[88] *Application of Virginia Electric and Power Company for approval of its Virtual Plant Pilot Program under §56:585.1:16 of the Code of Virginia*, Docket No. PUR-2025-00211, (Virginia Commission Dec. 1, 2025) https://www.scc.virginia.gov/docketsearch/DOCS/89hy01!.PDF.

6. Regulatory Barriers to Improved Customer Participation in Demand Response, Peak Reduction, and Critical Pricing Programs

Electric load growth resulting from the electrification of buildings, manufacturing, and transportation, as well as from data centers, is driving state regulators and decision-makers to develop solutions that can manage these loads to cost-effectively meet power system needs. They continue to evaluate demand response, peak reduction, and critical peak pricing programs as tools to provide demand flexibility and improve system reliability. This chapter discusses barriers that may be limiting customer participation in such programs and efforts to address them.

Implementing Time-varying Rates

Evidence suggests that the lack of advanced meters may no longer be a primary barrier to participation in dynamic pricing programs. While enrollment in retail dynamic pricing programs in the United States continues to grow (see Chapter 5: Developments and Issues in Demand Response), according to EIA data, only roughly 11% of all electric customers are enrolled in a dynamic pricing program, which is relatively low compared to the penetration rate of advanced meters at 76.8%.[89]

Resources for the Future published a working paper that presented a synthesis of literature that examines the factors influencing customer responsiveness to time-based electricity rates.[90] The working paper found that providing control technologies, such as programmable thermostats, improves the effectiveness of time-based rate designs in reducing peak demand. In addition, event-based rates, such as critical peak pricing and peak-time rebates, lead to greater peak demand reductions compared to time-of-use rates. While the working paper does not suggest a solution, it appears that several factors affect, and may be barriers to, customer enrollment in time-varying rate programs.

As detailed in previous years' Assessments of Demand Response and Advanced Metering, state regulators continue to examine how to optimize time-varying rate design to maximize grid value while accommodating evolving customer needs and creating incentives for customers to use time-varying rates. For example, the Maine Commission initiated an inquiry to consider the implementation of time-of-use rates for customers of the state's IOUs.[91] The inquiry focuses on rate design issues such as time-of-use time periods; whether the

[89] Sources: 2023 Form EIA-861 Dynamic_Pricing_2023, 2023 Form EIA-861 Sales_Ult_Cust_2023, and 2023 Form EIA-861 Advanced_Meters_2023 data files.

[90] Resources for the Future, *Different Prices for Different Slices: A Meta-Analysis of Time-Based Electricity Rates* at 3, (March 13, 2025), https://www.rff.org/publications/working-papers/different-prices-for-different-slices-a-meta-analysis-of-time-based-electricity-rates/

[91] *Inquiry of Time of Use Rates for Delivery and Standard Offer,* Docket No. 2024-00231 (Maine Commission, Aug. 28, 2024). https://mpuc-cms.maine.gov/CQM.Public.WebUI/MatterManagement/MatterFilingItem.aspx?FilingSeq=125184&CaseNumber=2024-00231.

time-of-use rate should be opt-in, out-out, or mandatory; the interaction with other rates offered by utilities; the effect that expected changes in seasonal load variability will have on demand response; and lessons learned from other jurisdictions.[92] The inquiry will also address customer education on time-of-use rates and modeling and monitoring the pricing of such rates.

Opportunities for Data Center Demand Response Participation

While technical requirements may constitute a barrier to some data centers serving as flexible loads, there is potential flexibility that may allow certain large loads to participate in demand response, peak reduction, or other critical peak pricing programs. For example, state decision-makers and utilities can allow data centers to participate in demand response and other peak reduction programs where possible. As discussed in Chapter 5, Texas enacted legislation directing ERCOT to develop a demand management service that enables mandatory curtailment of large loads, such as data centers, during firm load shed events (see Chapter 5: Developments and Issues in Demand Response). Recently, Google entered agreements with Indiana Michigan Power and the Tennessee Valley Authority for Google to provide demand response from its data centers.[93] Google will target machine learning workloads at the data centers to reduce its power demand. In addition, the U.S. Department of Energy's Secretary of Energy Advisory Board Working Group on Powering AI and Data Center Infrastructure explored options for supporting data center power demands, in a report issued in July 2024.[94] Among other topics, the report examined secure operational frameworks that allow data centers to optimize their energy consumption, contribute to grid peak load management, and provide other grid services. The report makes recommendations in several areas and includes a proposed taxonomy of concepts to characterize flexibility needs of the grid and to explore opportunities for data centers to participate.

[92] *Id.* at 5-6.

[93] Google, *How We're Making Data Centers More Flexible to Benefit Power grids* (Aug. 2025), https://blog.google/inside-google/infrastructure/how-were-making-data-centers-more-flexible-to-benefit-power-grids/.

[94] DOE, *Recommendations on Powering Artificial Intelligence and Data Center Infrastructure* at 3, 6 (July 2024), https://www.energy.gov/sites/default/files/2024-08/Powering%20AI%20and%20Data%20Center%20Infrastructure%20Recommendations%20July%202024.pdf.

Appendix I: List and Map of Census Divisions

This report assesses advanced meter penetration, retail demand response, and retail dynamic pricing programs by Census Division. The current Census Divisions and states are listed below.

Division 1, New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

Division 2, Middle Atlantic: New Jersey, New York, Pennsylvania

Division 3, East North Central: Indiana, Illinois, Michigan, Ohio, Wisconsin

Division 4, West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota

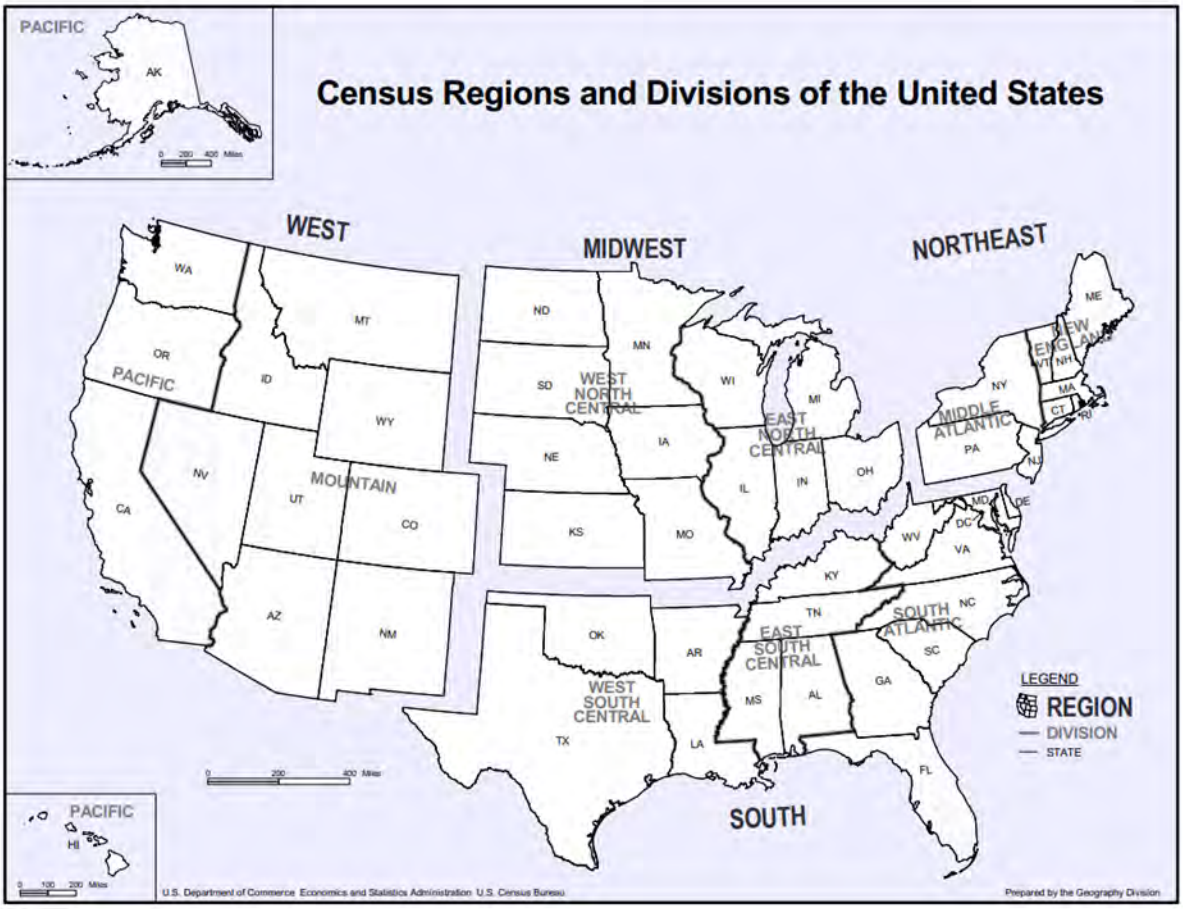
Division 5, South Atlantic: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia

Division 6, East South Central: Alabama, Kentucky, Mississippi, Tennessee

Division 7, West South Central: Arkansas, Louisiana, Oklahoma, Texas

Division 8, Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming

Division 9, Pacific: Alaska, California, Hawaii, Oregon, Washington


Census Regions and Divisions of the United States
PACIFIC
AK
WEST
MIDWEST
NORTHEAST
SOUTH
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
MN
IA
MO
WI
IL
MI
IN
OH
NY
PA
ME
VT
NH
MA
CT
RI
NJ
MD
DE
DC
WV
VA
KY
TN
NC
SC
GA
FL
AL
MS
LA
AR
OK
TX
WEST NORTH CENTRAL
EAST NORTH CENTRAL
MIDDLE ATLANTIC
NEW ENG LAND
SOUTH ATLANTIC
EAST SOUTH CENTRAL
WEST SOUTH CENTRAL
MOUNTAIN
PACIFIC
HI
LEGEND
REGION
DIVISION
STATE
U.S. Department of Commerce Economics and Statistics Administration U.S. Census Bureau
Prepared by the Geography Division

Appendix II: Estimates of Advanced Meter Penetration Rates in the United States (2007 – 2023)

Data Source	Data as Of	Number of Advanced Meters (millions)	Total Number of Meters (millions)	Advanced Meter Penetration Rate
2008 FERC Survey[1]	Dec 2007 (FERC)	6.7	144.4	4.7%
2010 FERC Survey[1]	Dec 2009 (FERC)	12.8	147.8	8.7%
2012 FERC Survey[1]	Dec 2011 (FERC)	38.1	166.5	22.9%
2011 Form EIA-861[2]	Dec 2011 (EIA)	37.3	144.5	25.8%
2012 Form EIA-861[2]	Dec 2012 (EIA)	43.2	145.3	29.7%
2013 Form EIA-861[2]	Dec 2013 (EIA)	51.9	138.1	37.6%
2014 Form EIA-861[2]	Dec 2014 (EIA)	58.5	144.3	40.5%
2015 Form EIA-861[2]	Dec 2015 (EIA)	64.7	150.8	42.9%
2016 Form EIA-861[2]	Dec 2016 (EIA)	70.8	151.3	46.8%
2017 Form EIA-861[2]	Dec 2017 (EIA)	78.9	152.1	51.9%
2018 Form EIA-861[2]	Dec 2018 (EIA)	86.8	154.1	56.4%
2019 Form EIA-861[2]	Dec 2019 (EIA)	94.8	157.2	60.3%
Institute for Electric Innovation[3]	Dec 2019 (IEI)	99.0	157.2	63.0%
2020 Form EIA-861[2]	Dec 2020 (EIA)	103.1	159.7	64.6%
Institute for Electric Innovation[3]	Dec 2020 (IEI)	107.4	159.7	67.2%
2021 Form EIA-861[2]	Dec 2021 (EIA)	111.2	162.8	68.3%
Institute for Electric Innovation[3]	Dec 2021 (IEI)	115.3	162.8	70.8%
2022 Form EIA-861[2]	Dec 2022 (EIA)	119.3	165.0	72.3%
Institute for Electric Innovation[4]	Dec 2022 (IEI)	120.0	165.0	72.3%
2023 Form EIA-861[1]	Dec 2023 (EIA)	128.4	167.2	76.8%

Sources: [1]FERC, *Assessment of Demand Response and Advanced Metering* 2008-2012. [2]EIA-861 Advanced Metering data files 2011-2023. [3]IEI, *Electric Company Smart Meter Deployments: Foundation for a Smart Grid* 2021. [4]IEI, *Smart Meters at a Glance* (2024).
Note: Commission staff has not independently verified the accuracy of EIA or Edison Foundation (IEI) data. Values from source data are rounded for publication.

Appendix III: List of Acronyms

AI: Artificial intelligence

AMI: Advanced metering infrastructure

AMF: Advanced metering functionality

AMR: Automated meter reading

APS: Arizona Public Service Company

BGE: Baltimore Gas & Electric

BYOD: Bring your own device

CAISO: California Independent System Operator

CEC: California Energy Commission

CPCN: Certificate of public convenience and necessity

DER(s): Distributed energy resource(s)

DESEU: Delaware Sustainable Energy Utility

DOE: Department of Energy

DSGS Program: CEC Demand Side Grid Support Program

DSM: Demand-side management

EIA: Energy Information Administration

ECRS: ERCOT Contingency Reserve Service

ELR: PJM Economic Load Response

EPAct 2005: Energy Policy Act of 2005

ERCOT: Electric Reliability Council of Texas

FCC: Federal Communications Commission

FERC: Federal Energy Regulatory Commission

GW: Gigawatt

GWh: Gigawatt-hour

HVAC: Heating, ventilation, and air conditioning

IEI: Edison Foundation Institute for Electrical Innovation

IOU: Investor-owned utility

ISO(s): Independent System Operator(s)

ISO-NE: ISO New England

LIPA: Long Island Power Authority

LMR(s): MISO Load-Modifying Resource(s)

MISO: Midcontinent Independent System Operator

MW: Megawatt

NOPR: Notice of Proposed Rulemaking

NYISO: New York Independent System Operator

NYSERDA: New York State Energy Research and Development Authority

PJM: PJM Interconnection

PTR: Xcel Peak Time Rebate program

RAA: PJM Reliability Assurance Agreement Among Load Serving Entities

RRS: ERCOT Responsive Reserve Service

RTO(s): Regional Transmission Organization(s)

SPP: Southwest Power Pool

VPP(s): Virtual power plant(s)

Minnesota Energy Efficiency Potential Study: 2020–2029

Contract # 121430
Publication Date: December 4, 2018

Conservation Applied Research and Development (CARD) FINAL Report

Prepared for: Minnesota Department of Commerce, Division of Energy Resources
Prepared by: Center for Energy and Environment, Optimal Energy and Seventhwave







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DISCLAIMER

This report does not necessarily represent the view(s), opinion(s), or position(s) of the Minnesota Department of Commerce (Commerce), its employees or the State of Minnesota (State). When applicable, the State will evaluate the results of this research for inclusion in Conservation Improvement Program (CIP) portfolios and communicate its recommendations in separate document(s).

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Definition of Acronyms

ACEEE	American Council for an Energy Efficient Economy
AMI	Advanced metering infrastructure
ASHP	Air source heat pump
BBTu	Billion British thermal units
C&I	Commercial and industrial
CARD	Conservation Applied Research and Development program
CEE	Center for Energy and Environment
CIP	Conservation Improvement Program
COMMERCE	Minnesota Department of Commerce
COU	Consumer-owned utility
CT	Combustion turbine
DER	Division of Energy Resources, Minnesota Department of Commerce
DOE	Department of Energy (U.S.)
Dth	Dekatherm
EISA	Energy Independence and Security Act of 2007
EERS	Energy efficiency resource standard
EM&V	Evaluation, measurement, and verification
EPA	Environmental Protection Agency (U.S.)
G&T	Generation and transmission
GWh	Gigawatt-hour
HVAC	Heating, ventilation, and air conditioning
IoT	Internet of Things
IOU	Investor-owned utility
KW	Kilowatt
kWh	Kilowatt-hour
LED	Light-emitting diode

MEEA	Midwest Energy Efficiency Alliance
MMBTu	Million British thermal units
MWh	Megawatt-hour
MPUC	Minnesota Public Utilities Commission
PUC	Public Utilities Commission
SMMPA	Southern Minnesota Municipal Power Agency
SCT	Societal Cost Test
T&D	Transmission and distribution
TRM	Minnesota Technical Reference Manual
UCT	Utility Cost Test

Executive Summary

Minnesota has a thirty-plus year history of leadership in energy efficiency policy and achievements. In order to continue to maximize the benefits of cost-effective energy efficiency resource acquisition by utilities, the project team, consisting of Center for Energy and Environment (CEE), Optimal Energy (Optimal) and Seventhwave, was commissioned to:

- Estimate statewide electric and natural gas energy efficiency and carbon-saving potential for 2020-2029;
- Produce data-driven and stakeholder-informed resources defining market segments, end uses, measures, and programs that could be targeted in the decade ahead to realize the state's cost-effective energy efficiency potential; and
- Engage stakeholders in order to help advance robust energy policies and energy efficiency programs in the state, and to inform future efficiency portfolio goals.

Overview of the Conservation Improvement Program

The Conservation Improvement Program (CIP) helps Minnesota households and businesses use electricity and natural gas more efficiently – conserving energy, reducing carbon dioxide emissions, and lessening the need for new utility infrastructure. CIP is funded by ratepayers and administered by electricity and natural gas utilities.

Minnesota policymakers have long recognized the promotion of energy efficiency as a cornerstone of the state's energy policy. CIP began in Minnesota in the 1980s to motivate utility spending on energy efficiency. The 2007 Next Generation Energy Act established Minnesota's energy efficiency resource standard, requiring utilities develop plans to achieve energy savings of 1.5% of average annual retail sales each year. Minnesota Statute 216B.241 outlines the statutory requirements for utility CIP programs that are designed to meet Minnesota's 1.5% energy savings goal. Currently, 140 of Minnesota's 213 electric and natural gas utilities are covered under Minnesota Statute 216b.241.

The Minnesota Department of Commerce, Division of Energy Resources oversees CIP to ensure that ratepayer dollars are used effectively in achieving the 1.5% energy savings goal and that energy savings are reported as accurately as possible. Minnesota utilities operate a wide array of residential, commercial, and industrial CIP programs targeted to both retrofits as well as new construction projects.

Typical utility programs for residential customers include:

- Energy audits, where a trained energy consultant examines a home and offers specific advice on energy improvements;
- Rebates on high-efficiency heating, cooling, and water-heating appliances; efficient lighting; and low-flow showerheads and faucet aerators; and
- Air-conditioner cycling programs, which allow the utility to manage its peak energy demand in return for discounted electric bills for participating customers.

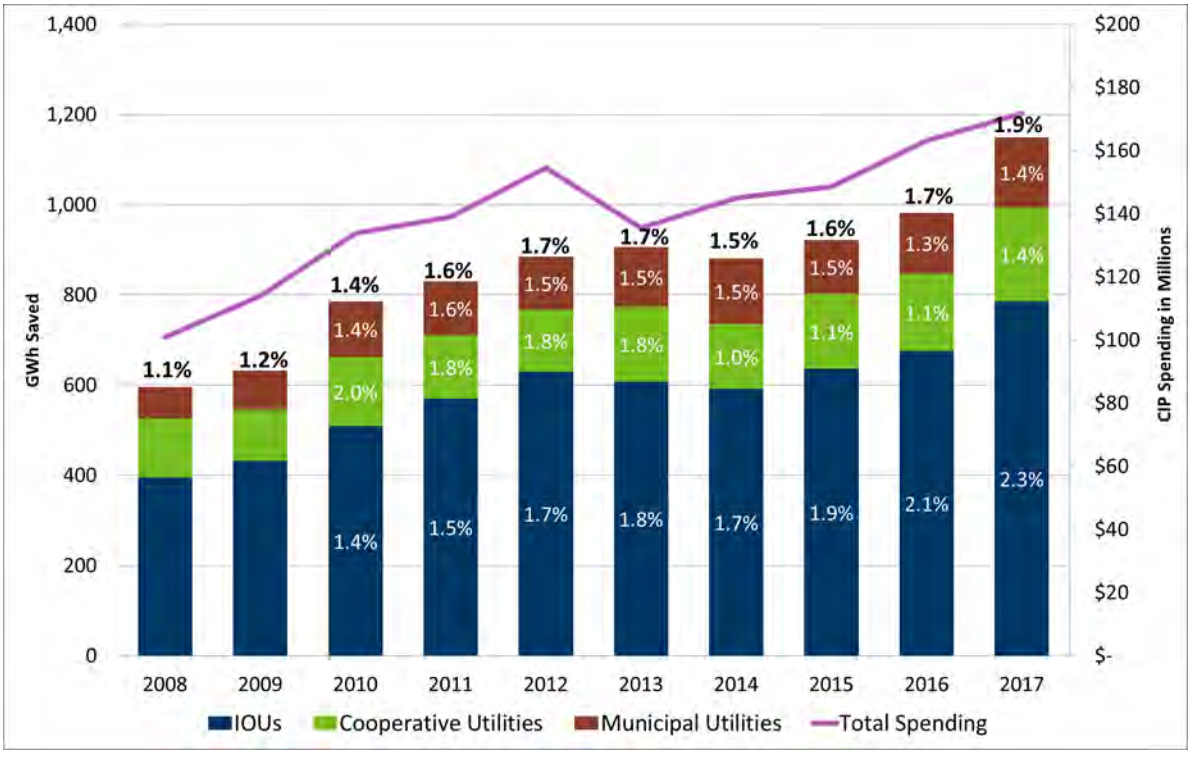
Typical utility programs for commercial or industrial customers include:

- Rebates for high-efficiency boilers, chillers, and rooftop units; high efficiency motors and drives; high-efficiency lighting and lighting control systems;
- Building recommissioning studies; and
- Manufacturing process improvements that reduce energy intensity and improve productivity.

Minnesota electric utilities, as a whole, have met or exceeded the 1.5% annual energy savings goal each year since 2011 (Figure ES-1). Minnesota gas utilities, overall, have met the 1% minimum, but only exceeded the 1.5% goal in 2017 (Figure ES-2). Both electric and natural gas utilities have seen a steady increase in achievements over the last decade.

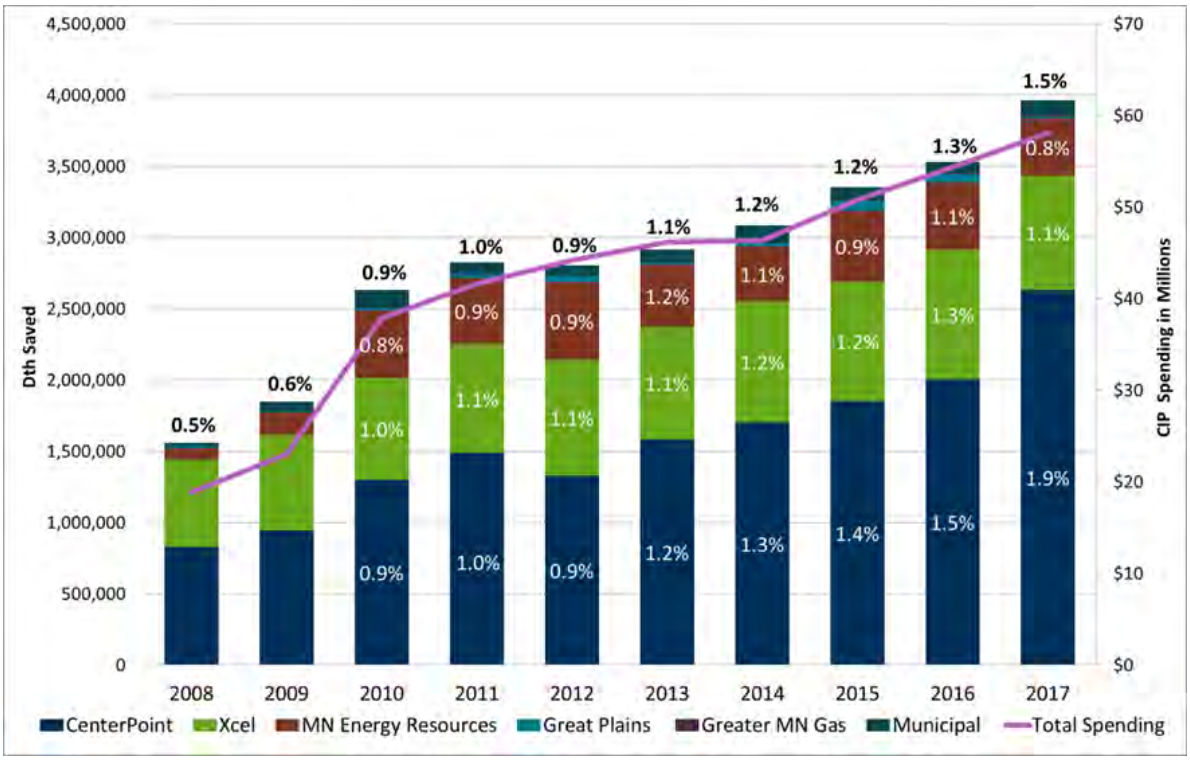
An independent review examining the economic impact of CIP found that every one dollar that is spent on CIP returns four dollars to the state's economy. This return on investment is created through job growth, economic surplus, lower utility costs, and environmental benefits. The analysis also found that CIP has resulted in aggregate net benefits to society from 2008 to 2013 of approximately $3.3 billion, with each program year providing net electric and natural gas benefits to society ranging from $315 million to $919 million.[1]

Figure ES-1. Historical energy efficiency spending and savings achievements of Minnesota electric utilities (in gigawatt-hours and as a percentage of total sales), 2008-2016.



[1] Minnesota Department of Commerce. *The Aggregate Economic Impact of the Conservation Improvement Program 2008-2013*. October 2015. Page 5 (http://mn.gov/commerce-stat/pdfs/card-report-aggregate-eco-impact-cip-2008-2013.pdf).

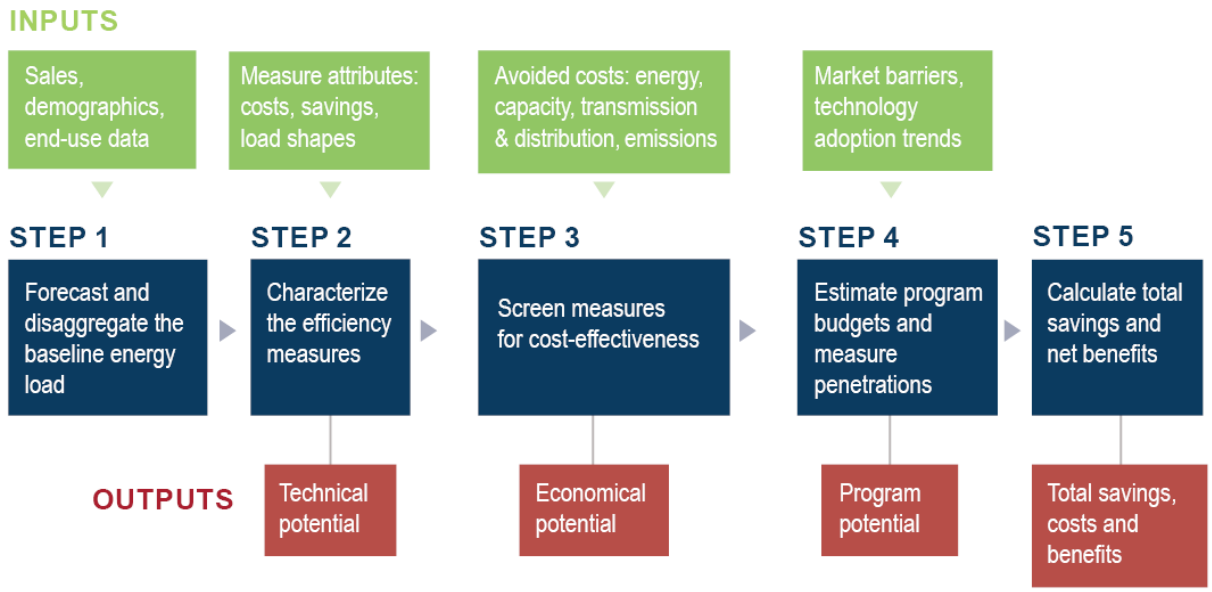
Figure ES-2. Historical energy efficiency spending and savings achievements of Minnesota natural gas utilities (in dekatherms and as a percentage of total sales), 2008-2016.



Project methodology

The modeling approach to estimating potential savings followed best practices for conducting energy efficiency potential studies, and involved the five steps referenced in Figure ES-3 (see Chapter 3 for a detailed explanation of each of these steps in the analysis). Separate models were created for seven different analysis regions of the state, and aggregated to sum statewide potential.

Figure ES-3. Modeling approach used for this study.



The model relies on a large number of assumptions about the energy savings and costs of energy efficiency measures, existing baselines of efficiency in Minnesota building stock, the impact of future codes and standards on savings, the avoided costs of energy saved, and other parameters. To develop these assumptions, the project team collected a large amount of data from existing sources, including past Conservation Applied Research and Development (CARD) program research projects, confidential cost data supplied by utilities, U.S. Department of Energy data sets, U.S. Census data, and other sources. In addition, the project team conducted 1,797 phone surveys of building owners, managers and contractors, and 136 on-site surveys of Minnesota residential and commercial buildings.

303 separate measures were included in the model, about 20% of which are not currently included in Minnesota's Technical Reference Manual (TRM).[2] Each measure was characterized for up to 16 separate building types, resulting in 3,378 separate measure permutations.

Cost-effectiveness screening was done at the measure level, and relied on utility-provided costs for six different peak and off-peak periods. The measure characterization included determining load shapes for

2 The Department oversees development of the TRM, which is a list of CIP-eligible energy efficiency measures, associated technical assumptions, and energy-savings calculations for use by utilities in their CIP plans. Minnesota TRM Webpage: mn.gov/commerce/industries/energy/utilities/cip/technical-reference-manual/.

each measure according to the same periods, so that the model could capture the time-value of each energy efficiency measure.

In addition to total economic potential (i.e., the total potential if all possible measures were installed that meet cost-effectiveness criteria), two program scenarios were calculated:

- ***Maximum achievable potential:*** This is the subset of economic potential that is achievable considering market barriers, given the most aggressive program scenario possible. This study assumed financial incentives would cover 100% of the incremental cost of each measure, along with very aggressive marketing and program designs to achieve maximum market penetration of the measures.
- ***Program potential***: The program potential is a subset of the maximum achievable, given constraints in implementation. This study assumed that financial incentive levels are dropped to 50% of the incremental cost of each measure, which is a typical scenario used for planning purposes in Minnesota,[3] and a good benchmark for aggressive programs nationally. The project team still assumed aggressive marketing and program designs for this scenario.

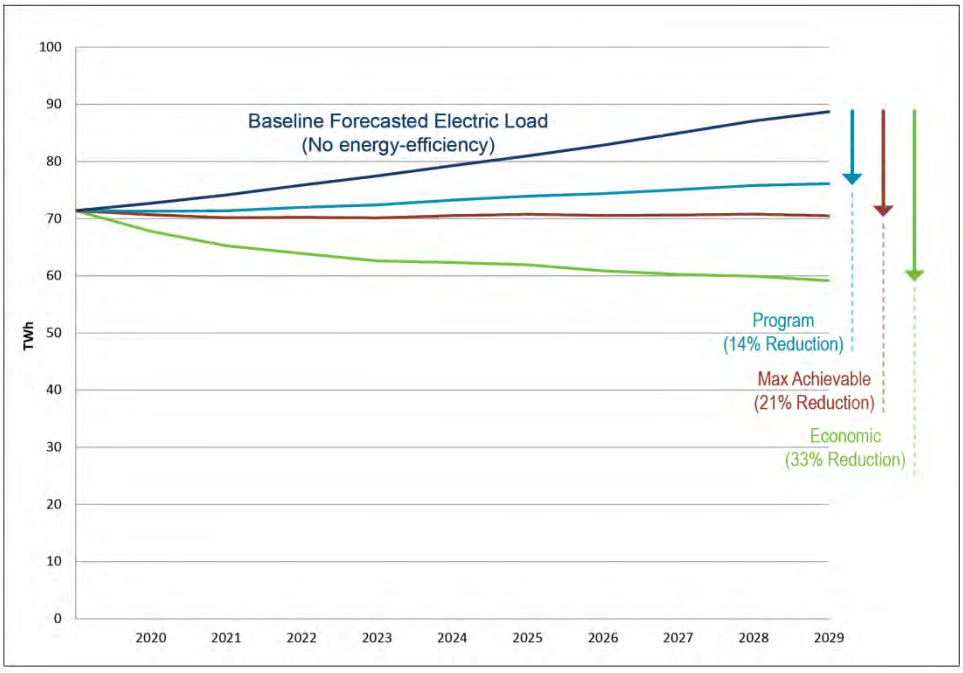
The outputs of this study represent the study team's best effort to identify statewide energy efficiency potential, if all utilities in the state employed the best practices in program implementation discussed in this report, and provided incentives at the levels specified in the two program scenarios for this study. While this study employed best practices for conducting energy efficiency potential studies and used the best data available to support the assumptions, there are limitations to this study, as there are in any potential study. We discuss some of the specific limitations in more depth at the end of chapter three.

[3] Xcel Energy, for example, typically will use a 50% incentive scenario when conducting their potential studies.

Results – electric utilities

Statewide, the study estimates the economic potential of energy efficiency could decrease forecasted electric load by 33%, and program potential could reduce load by 14% in 2029 (Figure ES-4).

Figure ES-4. Cumulative annual electric energy savings potential compared to forecasted load for economic, max achievable, and program scenarios.



The incremental annual program savings ranges from 1.4% to as high as 2.0%, with maximum achievable potential in the range of 2.0% to 2.9% (Table ES-1)[4]. Since the study assumes equal program success across utility territories, there is very little difference in potential between investor-owned utilities and consumer-owned utilities, which includes both cooperative and municipal utilities, with only slight variations due to differences in their overall customer mix.

[4] Consistent with how behavioral savings are counted by utilities now, the "average savings methodology" was applied to (only) residential behavioral measures. (For full discussion of this issue, see pg. 81-94, "Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines," Illume, et. al, a CARD project. Available at: http://mn.gov/commerce-stat/pdfs/card-report-energy-efficiency-behavorial-prog.pdf). The application of the average savings method lowered incremental potential about 10% a year. For comparison, the 10-year incremental average for the program scenario, without applying the average savings method, would be 2.0% for IOUs, 2.0% for cooperative utilities, and 1.9% for municipal utilities; for the maximum achievable scenario, savings would be 3.0% for IOUs, 2.8% for cooperative utilities, and 2.7% for municipal utilities.

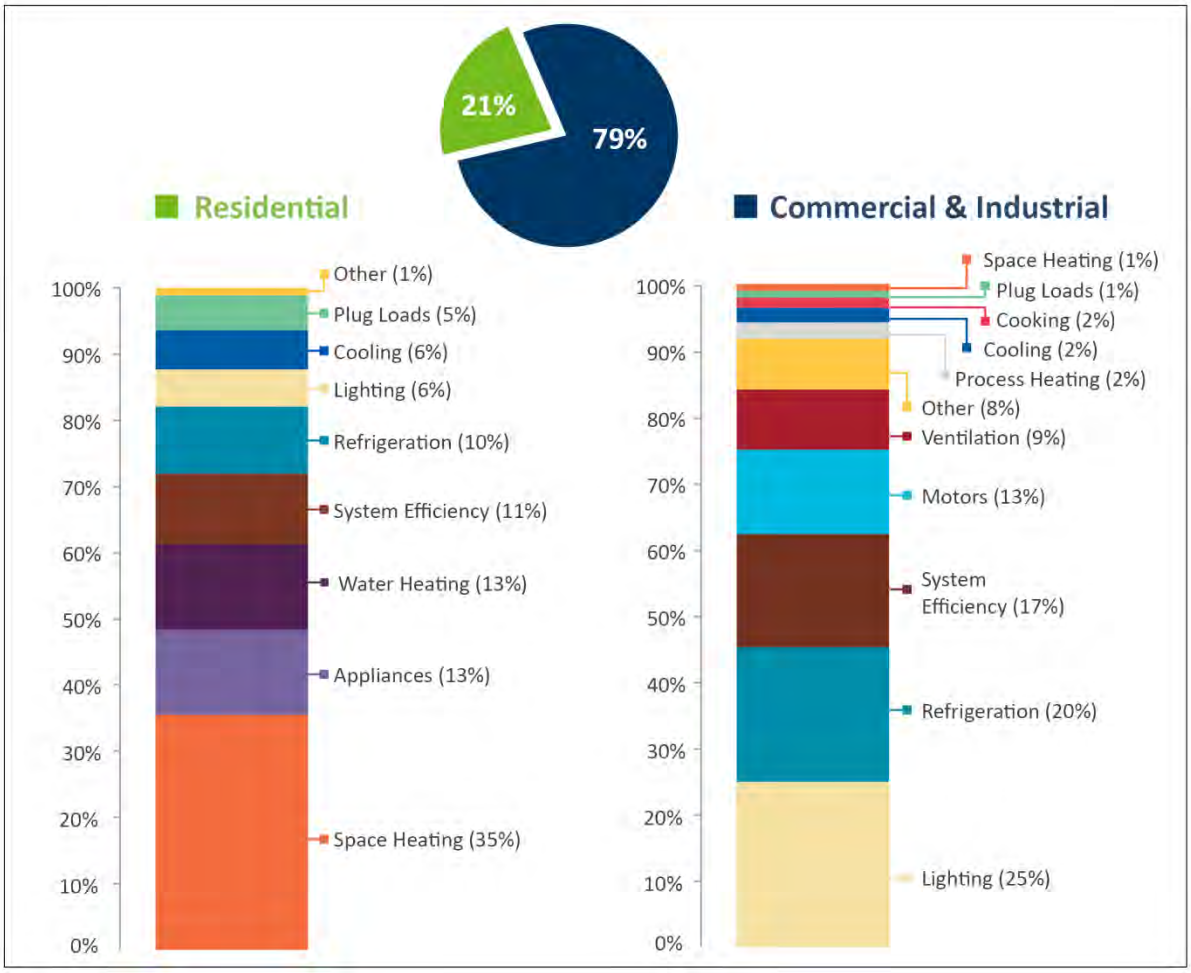
Table ES-1. Incremental annual electric energy savings from maximum achievable and program scenarios as a percentage of total sales.

	Investor-Owned Utilities		Cooperative Utilities		Municipal Utilities	
Year	Max achievable	Program	Max achievable	Program	Max achievable	Program
2020	2.6%	1.8%	2.4%	1.7%	2.4%	1.7%
2021	2.9%	2.0%	2.7%	1.9%	2.7%	1.9%
2022	2.4%	1.6%	2.0%	1.4%	2.3%	1.5%
2023	2.6%	1.8%	2.3%	1.6%	2.4%	1.7%
2024	2.8%	1.9%	2.4%	1.7%	2.5%	1.8%
2025	2.8%	1.9%	2.5%	1.7%	2.5%	1.8%
2026	2.8%	2.0%	2.4%	1.7%	2.6%	1.8%
2027	2.9%	2.0%	2.4%	1.7%	2.5%	1.8%
2028	2.9%	2.0%	2.4%	1.7%	2.5%	1.7%
2029	2.8%	1.9%	2.4%	1.7%	2.5%	1.7%
10-year average	**2.7%**	**1.9%**	**2.4%**	**1.7%**	**2.5%**	**1.7%**

Within end uses, space heating is responsible for nearly half of residential savings at the end of the study period, while lighting declines to a small fraction of total savings (Figure ES-5). Although only 17% of residential customers have electric space heating, these customers use substantial amounts of energy to heat their homes, and there is a large opportunity for energy savings in these homes. The single-largest measures driving these savings are air-source heat pumps, as discussed further below. Appliances are the next largest end use, in total (with space heating) accounting for over half of total residential potential.

In the commercial and industrial sector, lighting, refrigeration, and system energy account for approximately 60% of total program potential in 2029 (Figure ES-5). While lighting still remains the largest source of savings for the commercial and industrial sector, it declines from well over half of potential in most utilities' current portfolios, to just over 20% in 2029. System energy includes whole-building measures that address multiple end-uses, and includes savings from measures like integrated building design and advanced building controls.

Figure ES-5. Cumulative annual electric energy savings by end use in 2029 as a percentage of total savings for the residential and commercial & industrial sectors (program scenario).



Results – natural gas utilities

For natural gas, the study estimates the state could economically decrease forecasted sales by 33%, with program potential to reduce sales by about one-third of that, or 11%, by 2029 (Figure ES-6). The incremental annual natural gas savings over the study period increases from 0.7% in 2020, and levels off at 1.4% of annual sales around the middle of the decade for program potential. Maximum achievable potential starts at 1.2% and increases to 2.3% of annual sales over the study period (Table ES-2).

Figure ES-6. Cumulative annual natural gas energy savings potential compared to forecasted sales for economic, max achievable, and program scenarios.

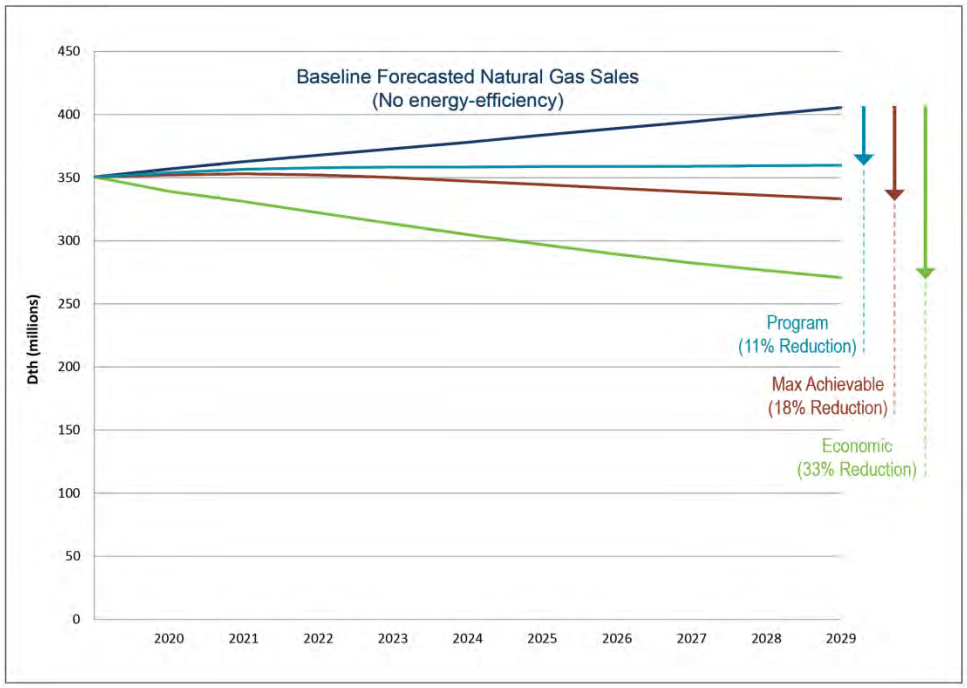
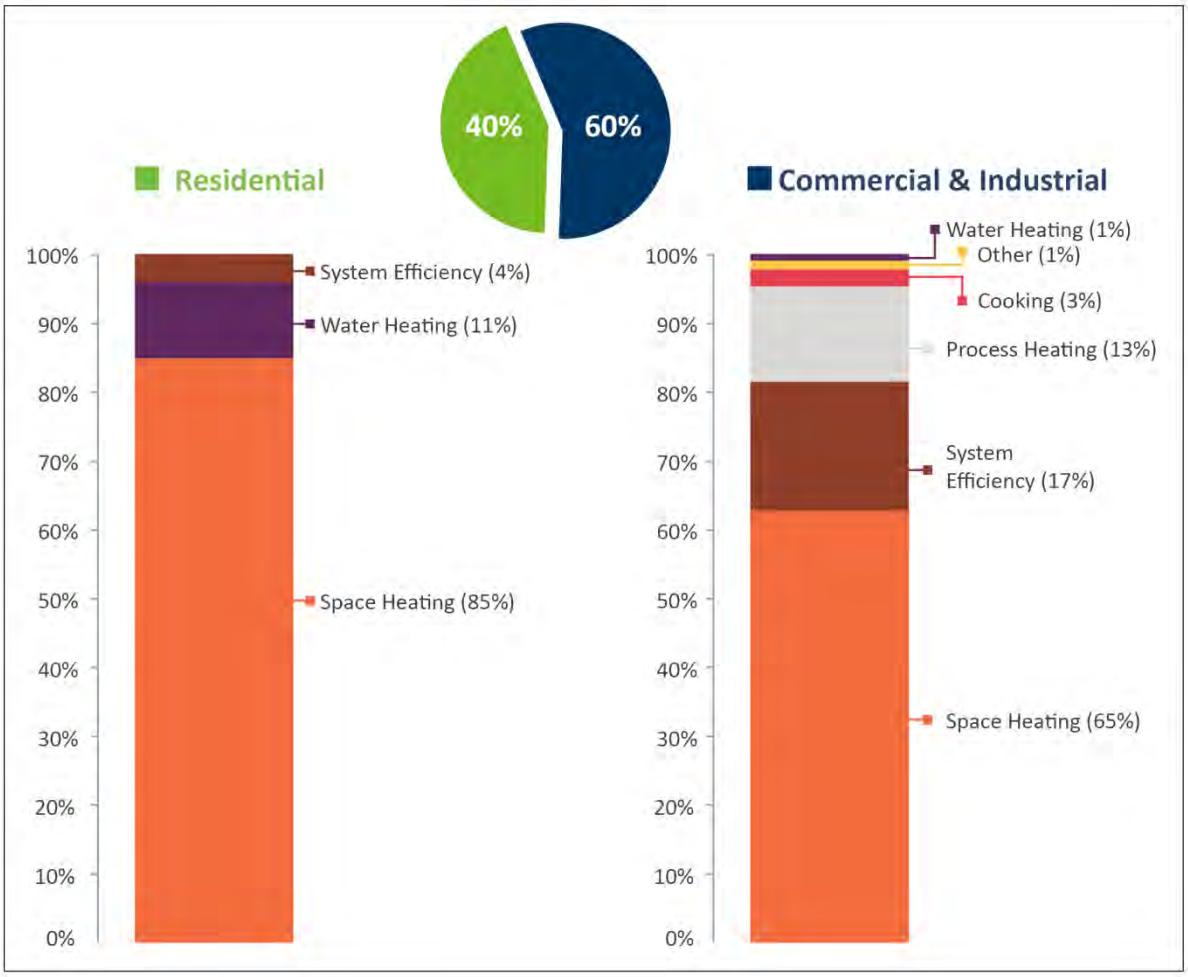


Table ES-2. Incremental annual natural gas energy savings from maximum achievable and program scenarios as a percentage of total sales.

	All utilities	
Year	**Max achievable**	**Program**
2020	1.2%	0.7%
2021	1.4%	0.9%
2022	1.7%	1.1%
2023	2.0%	1.2%
2024	2.2%	1.4%
2025	2.2%	1.4%
2026	2.2%	1.4%
2027	2.3%	1.4%
2028	2.3%	1.4%
2029	2.3%	1.5%
Average	**2.0%**	**1.2%**

Space heating dominates the end use potential for the residential sector as well as the commercial and industrial sectors (Figure ES-7).

Figure ES-7. Cumulative annual natural gas energy savings by end use in 2029 as a percentage of total savings for the residential and commercial & industrial sectors (program scenario).



Efficiency measures implemented in the program scenario would result in a cumulative annual reduction in carbon dioxide emissions in 2029 of 5.5 million tons for electric utilities, and 2.8 million tons for natural gas utilities.

Program findings and recommendations

The project team conducted a review of utility energy efficiency programs in Minnesota and nationally to make recommendations about program implementation that will be useful for utilities, regulators, and other stakeholders in designing and implementing programs for 2020 and beyond.

In reviewing current programs in Minnesota, the study team found that:

- Minnesota currently has some of the lowest-cost and best-performing conservation programs in the country;
- Utilities in Minnesota — both investor-owned utilities and consumer-owned utilities — have been proactive in designing and implementing comprehensive, effective and innovative program models;
- Smaller utilities (the majority of Minnesota utilities, by number) face additional challenges in implementing programs;
- Deep relationships with trade allies have helped utilities deliver programs;
- The most successful consumer-owned utility programs involve cooperation among utilities; and
- Some utilities have achieved enhanced performance through joint natural gas-electric programs.

Based on the technical work done for this study, the study team found that:

- Residential electric programs will need to transition from lighting to cold climate air source heat pumps in order to capture the largest potential of savings;
- Lighting declines in importance for the commercial and industrial sector, but still represents a large portion of total potential savings;
- Refrigeration is another large source of electric potential savings; and
- Space heating measures continue to dominate natural gas potential, with smart thermostats being the largest new source of potential savings.

In order to continue to achieve high savings in the future, the study team provides the following recommendations for utilities implementing CIP programs:

- Continue to test promising new approaches;
- Offer comprehensive program designs for larger and harder-to-reach customers;
- Develop upstream incentives and associated program support in selected markets;
- Incorporate operational savings into commercial and industrial programs;
- Employ segment-specific strategies to reach customers;
- Deepen trade ally engagement and training efforts;

- Incorporate advanced metering infrastructure (AMI)-enabled capabilities into programmatic strategies;
- Leverage interest by local governments in energy efficiency; and
- Improve coordination amount utilities through coordinating more closely on trade ally outreach and training, and working toward further coordinated implementation of programs.

Policy conclusions

The following policy conclusions represent the project team's effort to identify solutions that will help ensure Minnesota continues to maximize cost-effective energy efficiency resources into the next decade. Extensive stakeholder outreach was done for this study; the project team attempted to synthesize this outreach in crafting the conclusions, seeking common ground where possible. The project team also used relevant data from this study to inform the recommendations.

The recommendations are organized around three issue areas:

- Achievement of CIP goals;
- Regulatory oversight of CIP; and
- Incorporating demand-response and efficient fuel-switching into CIP.

The conclusions are summarized in Table ES-3, along with key stakeholder input and findings from this study.

Table ES-3. Summary of policy findings, stakeholder input, and study conclusions.

Topic Area	Relevant findings from potential study	Stakeholder input	Conclusions
Achievement of CIP goals	Meeting or exceeding, on average, the current CIP goal of 1.5% for electric utilities and the statutory minimum of 1.0% for gas utilities is achievable in the 2020-2029 timeframe. Achieving savings targets is likely to require increased but still cost-effective spending. The existing incentive structure has been effective at motivating investor-owned utilities to exceed their energy-savings goals.	Small consumer-owned utilities report facing additional challenges in implementing programs; thus, it may not be possible for them to achieve the same energy-savings level as the investor-owned utilities. More emphasis on lifetime savings is justified, but the first-year savings goal is still preferred as the main statutory CIP goal.	***The 1.5% savings goal can continue to be achieved using the existing flexibility to adjust goals when justified.*** Lifetime savings could be better measured and tracked through the annual reporting process, rather than a statutory change. Consider allowing consumer-owned utilities to report savings in a multi-year framework.
Regulatory oversight of CIP	CIP programs in the 2020s will need to expand into new end uses and technologies, increasing the complexity of regulatory issues. Results from Commerce-funded conservation applied research and development projects inform this potential study's estimates and pave the way for increased savings from new end uses.	The stakeholder survey shows mostly strong support for current Department regulation. Most stakeholders support a practical approach that minimizes confusion and provides regulatory clarity.	***Clarity on key regulatory topics could be accomplished through the creation of a CIP guide.*** Consider creating a formal advisory committee for CIP regulatory topics to increase transparency and avenues for stakeholder coordination on CIP implementation. Continue to have strong research and development to support future energy savings.
Incorporating demand-response & efficient fuel-switching into CIP	Demand-response programs will increasingly be needed for integrating carbon-free renewables onto the grid, and to balance high load with high-generation times. With appropriate safeguards, efficient fuel-switching could significantly increase overall efficiency, decrease emissions, and reduce costs for consumers.	There is strong electric utility support for incorporating demand-response and efficient fuel-switching into CIP. Public interest concerns were raised about investor-owned utilities receiving incentives for load-building activities. Public interest concerns were raised about demand-response and fuel-switching diluting or competing for limited capital with energy efficiency efforts. Both demand-response and fuel-switching programs are customer-facing programs, like CIP.	***Consider whether to incorporate "integrated demand-side management" into the CIP framework — with appropriate safeguards.*** In crafting specific policy for integrating demand-response and fuel-switching, safeguards should ensure end-use efficiency is not decreased; utility incentives for investor-owned utilities should be considered separately (demand-response) or not provided (fuel-switching).

Chapter 1: Introduction

Minnesota has a thirty-plus year history of leadership in energy efficiency policy and achievements. This has been the result of common sense state policy focusing on cost-effective prioritization of efficiency as a resource that has had broad support from utilities and other stakeholders. However, state efficiency leaders recognize some significant challenges ahead for utility-driven efficiency that will need to be addressed. In particular, lighting standards and other standards and codes will reduce the baseline for calculating savings, and current low-market energy costs are reducing potential avoided cost savings from energy efficiency.

To help inform this transition, the state has embarked upon an ambitious study, the goal of which is not only to assess the technical and economic potential for utility-funded efficiency in the years ahead, but to craft a program and policy approach that will help address some of the identified challenges.

Specifically, the ***objectives of this study*** are to:

- Estimate statewide electric and natural gas energy efficiency and carbon-saving potential for 2020-2029;
- Produce actionable resources about which market segments, end uses, measures, and programs should be targeted in the decade ahead to realize the state's cost-effective energy efficiency potential; and
- Engage stakeholders in order to help advance robust energy policies and energy efficiency programs in the state, and to inform future efficiency portfolio goals.

This report summarizes the results of this study, and is divided into the following chapters:

The ***Executive Summary*** in the preceding pages provides an overall summary of key findings, background, and recommendations.

Chapter 2: Background provides additional background information on the state's Conservation Improvement Program and other energy efficiency policies, and summarizes key findings from the stakeholder work that was done for this project.

Chapter 3: Methodology summarizes the methodology and data sources used for this study, along with some of the caveats and limitations of energy efficiency potential studies in general. Detailed information on the methodology is provided in Appendix A.

Chapter 4: Results presents the key results from the study, including technical, economic, and program potential.

Chapter 5: Program Findings and Recommendations provides findings and recommendations for future programs from a review of both Minnesota and national energy efficiency programs.

Chapter 6: Policy Conclusions presents the policy conclusions of the study team. These conclusions are significantly informed by the Advisory Committee and other stakeholder work conducted as part of the study.

A rich knowledge base of background information and data was developed for this study – including primary data collected from Minnesota building stock and input from stakeholders involved in energy efficiency policy and implementation. Much of this background material is presented in the appendices, listed below, which can be downloaded as separate reports.

Appendix A: Methodology and Data Sources provides more detail on the methodology and data sources used for this study, which is summarized in Chapter 3.

Appendix B: Detailed Model Results presents more detailed results from the potential study modeling for each of the seven analysis areas.

Appendix C: Energy Efficiency Measures describes the screening process used for selecting measures to include in the study, as summarized in Chapter 3.

Appendix D: Behavioral Measures and Approaches provides background on current practices, and describes the behavioral measures and approaches selected for inclusion in the study.

Appendix E: Load Management and Demand-Response provides background on the current state of load management and demand-response efforts, and describes the measures selected for the study.

Appendix F: Low-Income Sector Market Study provides an analysis of the low-income sector, with recommendations for utility low-income programs.

Appendix G: Rural Utility and Agriculture Sector Market Study provides an analysis of rural utility opportunities for energy efficiency, including the agricultural market sector.

Appendix H: Small Commercial Market Sector Study provides an analysis of energy efficiency opportunities in the small commercial sector.

Appendix I: Energy Efficiency Program Benchmarking Report presents the results of the program benchmarking research of Minnesota utilities and utilities in other states.

Appendix J: Residential Buildings Primary Data Collection Report presents the results of the primary data collection efforts in residential single-family homes, and how this was used in the modeling.

Appendix K: Commercial Large Buildings Primary Data Collection Report presents the results of the primary data collection in commercial large buildings, and how this was used in the modeling.

Appendix L: Trade Ally Survey Report presents the results of the primary data collection in commercial large buildings, and how this was used in the modeling.

Appendix M: Minnesota HVAC Sales Data Report presents a summary of the heating, ventilation, and air conditioner (HVAC) sales data that was purchased for this study.

Appendix N: Advisory Committee Membership and Policy Comments lists the Advisory Committee members for this project and contains the policy comments submitted for this project.

Appendix O: Review of Past Minnesota Energy Efficiency Potential Studies is an analysis of how past study estimates of potential compare to actual energy efficiency achievements in the years subsequent to the analysis.

Appendix P: Analysis of Workforce Impacts of Modeled Energy Efficiency Programs is an analysis of the likely workforce implications of future energy efficiency programs, which informs program recommendations related to trade allies, training organizations, and workforce partners.

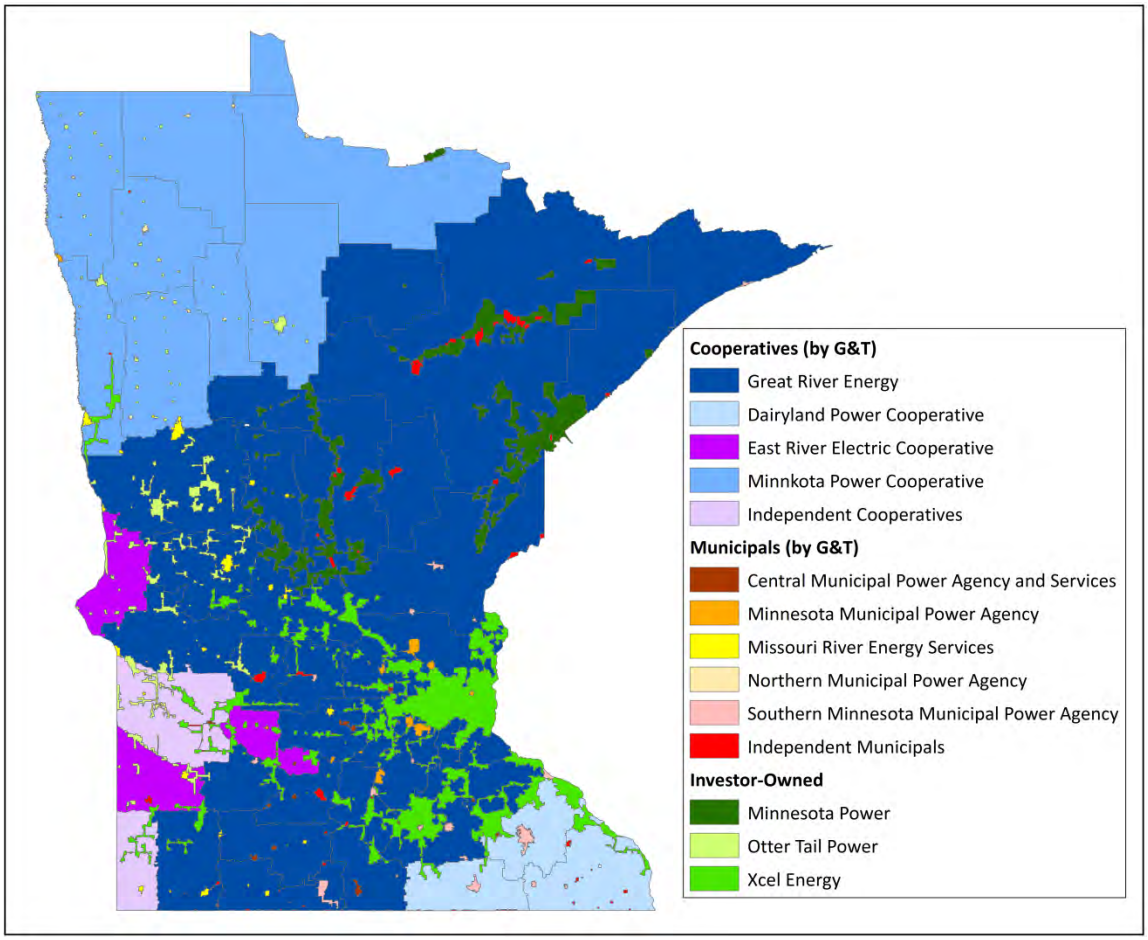
These documents, and others, are available on the project website: www.mncee.org/mnpotentialstudy.

Chapter 2: Background

Minnesota's energy utilities

Minnesota has a total of 176 electric utilities and 37 natural gas utilities.[5] Of the electric utilities, three are investor-owned utilities (IOUs), 47 are cooperatively-owned, and 126 are municipally-owned.

Figure 1. Minnesota electric utility territory map.



While cooperative and municipal electric utilities (together, "consumer-owned utilities," or COUs) serve the largest geographic territory of the state, the electric IOUs serve a majority of the state's population centers and commercial/industrial hubs (Figure 1). In 2016, 62% of the state's electric load was served by the IOUs, 23% by cooperative utilities, and 15% by municipal utilities.

[5] There are 19 municipal utilities and one investor-owned utility (Xcel Energy) in Minnesota that provide both electric and natural gas service. These combination utilities are counted separately in both the electric and natural gas totals.

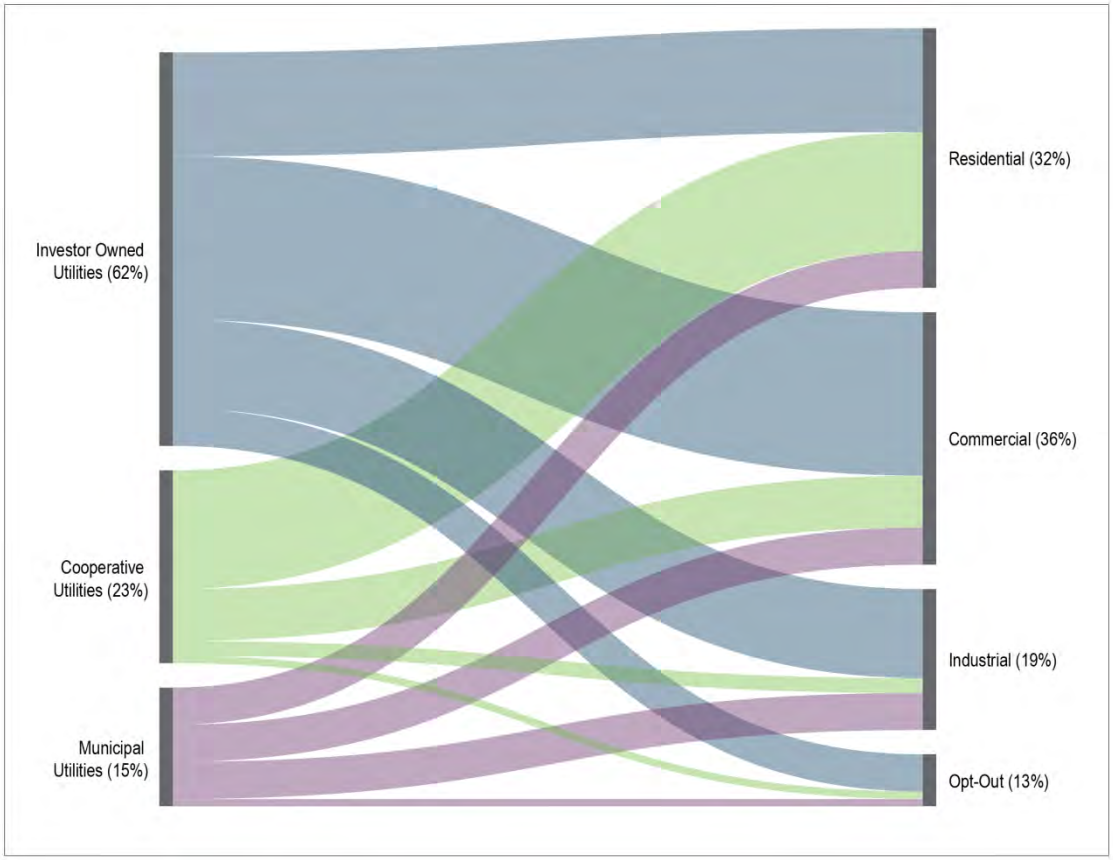
The majority of individual COUs aggregate their purchase and bulk transfer of energy among several generation and transmission (G&T) organizations (Table 1). These organizations themselves are member-based, and allow the COUs to realize efficiencies of scale in generating and transmitting power to their customers. There are two cooperative utilities and 24 municipal utilities that independently meet their generation and transmission needs, representing 0.5% and 2.3% of Minnesota's total energy load, respectively.

Table 1. Generation and transmission entities serving Minnesota consumer-owned utilities.

Generation and Transmission Organization	Number of Utility Members	Percent of total MN load served
Great River Energy	28	18.7%
Southern Minnesota Municipal Power Agency	18	4.3%
Missouri River Energy Services	24	4.0%
Minnesota Municipal Power Agency	12	2.8%
Minnkota Power Cooperative	8	2.0%
Dairyland Power Cooperative	3	1.8%
Central Municipal Power Agency / Services	12	0.7%
Northern Municipal Power Agency	21	0.6%
East River Electric Power Cooperative	3	0.5%
TOTAL:	**129**	**35.4%**

Generally, electric cooperative utilities tend to have a higher proportion of residential customers in their overall customer profile than electric municipal utilities and electric investor-owned utilities, which tend to be more equally balanced between residential, commercial, and industrial customers (Figure 2).

Figure 2. Minnesota electric utility loads by utility type and sector.[6]

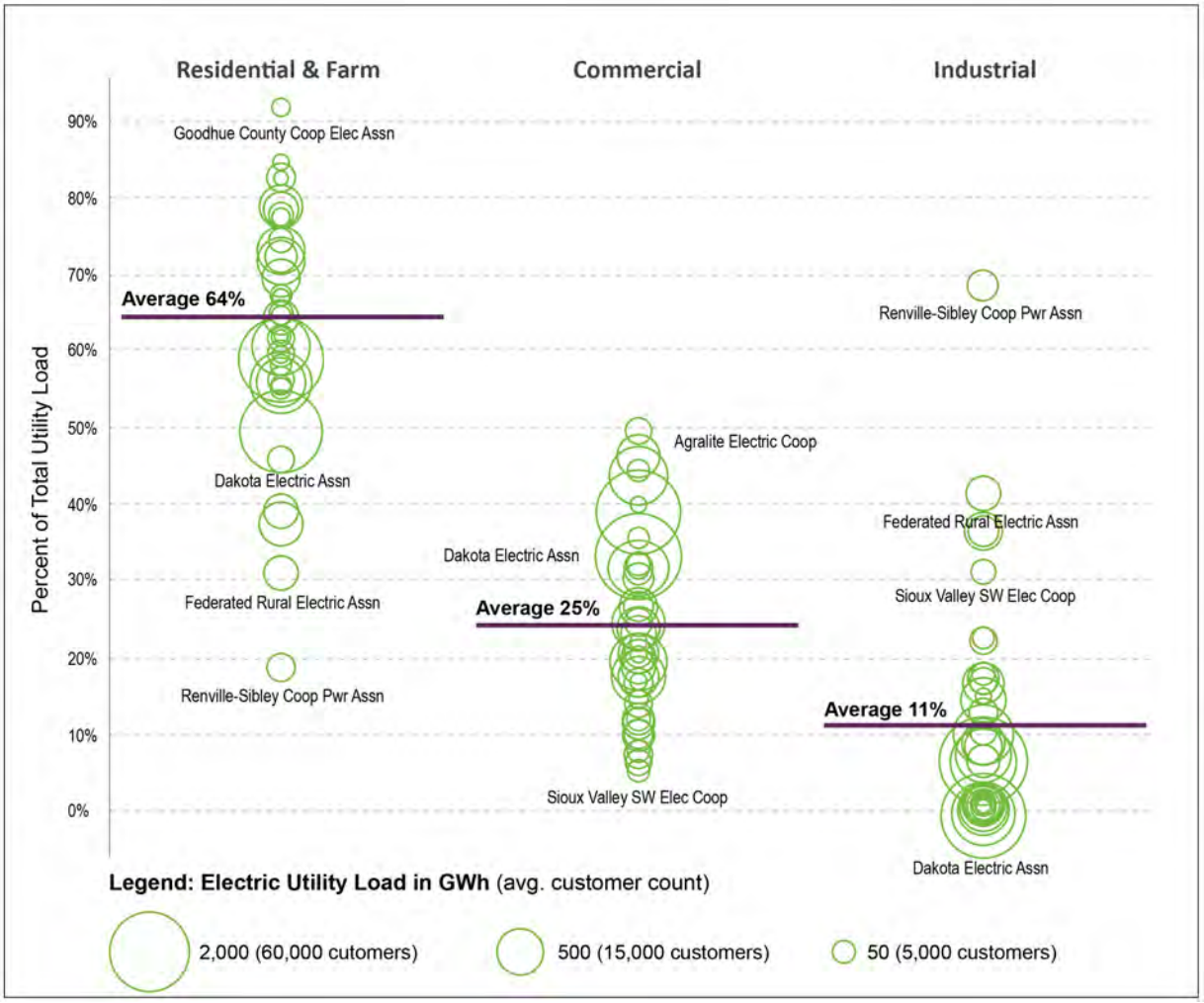


However, there is significant diversity of customer profile within each of the utility business types. Some municipal utilities serve only residential customers. Several electric cooperative utilities serve less than 10% of residential customers, and some investor-owned utilities serve as little as 12% of residential customers.[7] Figure 3 shows each cooperative electric utility in Minnesota and its particular mix of residential, commercial, and industrial loads.

[6] In 1999, the Minnesota Legislature authorized large customer facilities meeting certain criteria to opt-out from participating in and paying for CIP. Laws of Minnesota 1999, chapter 140.

[7] Utility "customer profiles" refer to the proportion of utility sales by customer type, based on 2016 Energy Information Administration data.

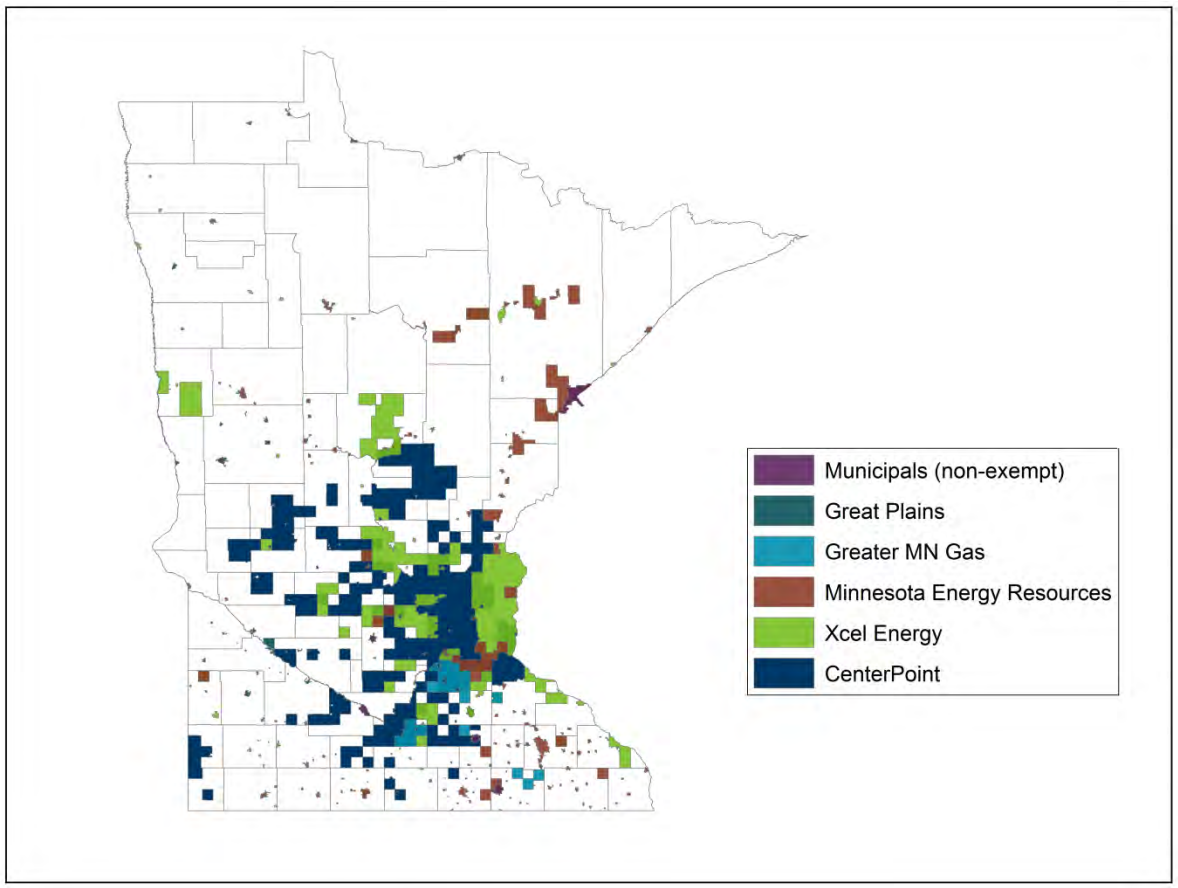
Figure 3. Distribution of electric energy loads by sector for Minnesota's cooperative utilities.



Minnesota has five IOU and 30 municipally-owned natural gas utilities (Figure 4). The IOUs served 94% of the state's natural gas sales; with the remaining 6% served primarily by municipal utilities (Figure 5). There is less variation among utilities in the proportion of residential, commercial, and industrial customers compared to the electric utilities. Approximately 66% of Minnesota residential households have natural gas service — 17% heating with electricity and 12% served by delivered fuels, primarily propane.[8]

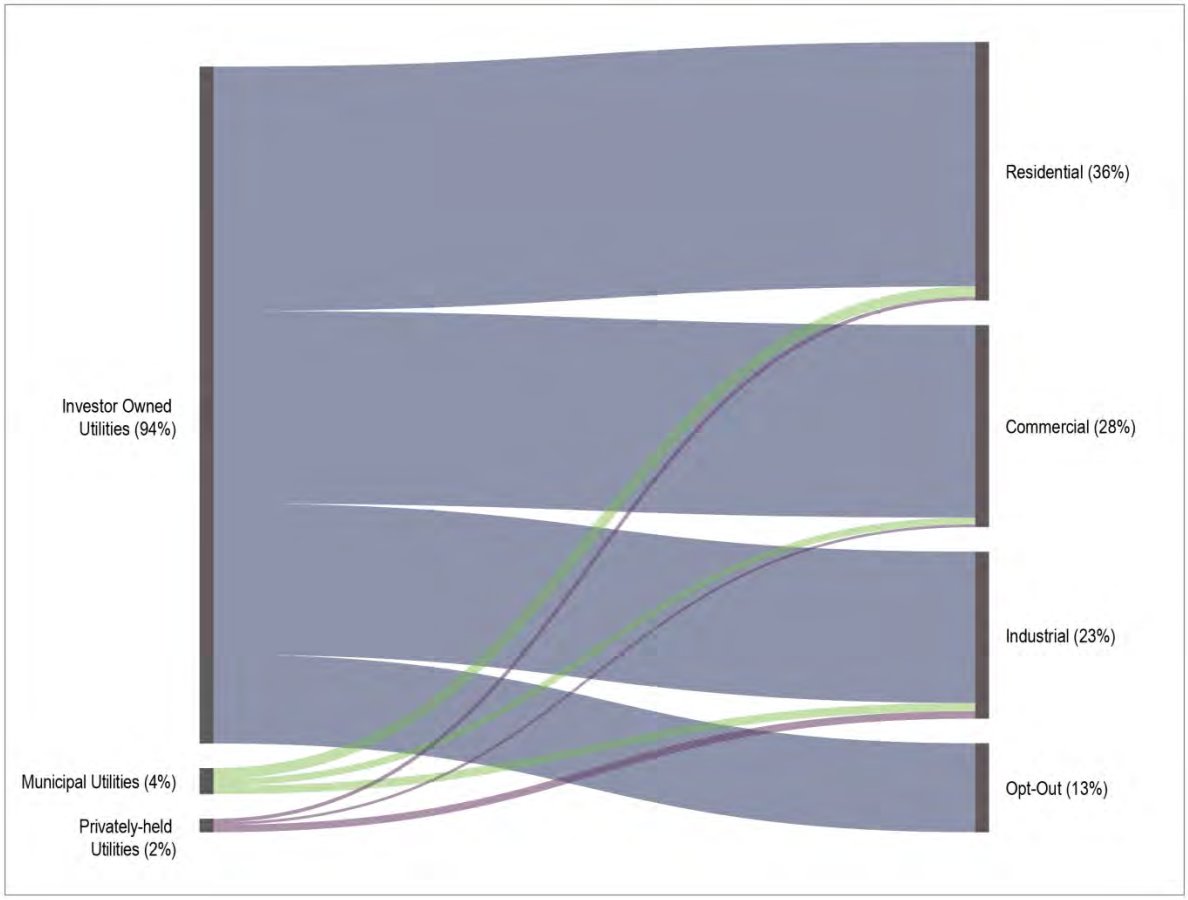
[8] American Community Survey, 2016. Note that among renter-occupied households, 35% heat their homes with electricity.

Figure 4. Minnesota natural gas utility territory map.[9]



[9] Natural gas utility service territories are considered trade secret. Figure 4 provides an approximation of Minnesota's natural gas service areas based on the municipalities and townships that natural gas utilities report that they serve.

Figure 5. Minnesota natural gas utility sales by utility type and sector.



The history of energy efficiency policy in Minnesota

Minnesota policymakers have long recognized the promotion of energy efficiency as a cornerstone of the state's energy policy. This is reflected in Minnesota statute, which states that "cost-effective energy savings are preferred over all other energy resources," and that "cost-effective energy savings should be procured systematically and aggressively."[10]

Minnesota has required utility-funded energy efficiency programs since the early 1980s. In 1983, the first Conservation Improvement Program (CIP) legislation was passed, requiring utilities with annual revenues over $50 million to operate an energy conservation program. In 1989, that requirement was expanded to all investor-owned utilities. Throughout the 1980s and 1990s, the Minnesota legislature

[10] See 2017 Minnesota Statutes, Section 216B.2401 (https://www.revisor.mn.gov/statutes/cite/216B.2401).

continued to build on the initial CIP legislation, passing additional utility energy conservation provisions, including:

- requiring utilities to spend a percentage of their gross revenues to help customers save energy;
- requiring utilities to have programs to help low-income customers reduce their energy use and save money on their bills; and
- allowing IOUs to collect financial incentives set by the Minnesota Public Utilities Commission to offset the impact of energy sales lost due to energy conservation.[11]

Since its inception, CIP has been constantly evolving to better capture and optimize the benefits of energy conservation and address market and technological changes. In addition to the policies noted above, many changes to the CIP statute have occurred over the years – the statute has been amended 36 times since it was enacted 38 years ago.[10]

Minnesota's energy efficiency efforts and achievements accelerated significantly in 2007, with the addition of an Energy Efficiency Resource Standard (EERS) of 1.5% of energy sales for both electric and natural gas utilities to CIP. The EERS, which was enacted in 2007 and took effect in 2010, remains in place today. Minnesota is one of the few states whose EERS applies to both IOUs and COUs.

Of the 213 utilities in Minnesota, 122 are under CIP requirements (79 municipal utilities, 35 distribution cooperatives, and eight investor-owned utilities).[12] About 13% of electric load and gas sales are exempt from paying for or participating in energy efficiency through CIP, under Minnesota's large customer opt-out provision.[13]

Historical CIP achievements

Since passage of the EERS in 2007, Minnesota utilities have increased their investments and achievements in CIP. Annual CIP energy savings and expenditures, for both natural gas and electric utilities, have been moving in an upward trend since that landmark legislation. CIP energy savings and expenditures reached a peak in 2017.[14] Total CIP electric energy savings in 2016 were equivalent to the

[11] The current financial incentive plan framework is based on a shared savings model. The shared savings model allows utilities to keep a portion of the net benefits generated by their energy conservation achievements each year, while sharing the vast majority of those benefits with their customers. The Department of Commerce, Division of Energy Resources. *Report on the Impacts of the 2010-2014 Shared Savings Demand-Side Management (DSM) Financial Incentive on Investor-Owned Utility Conservation.*

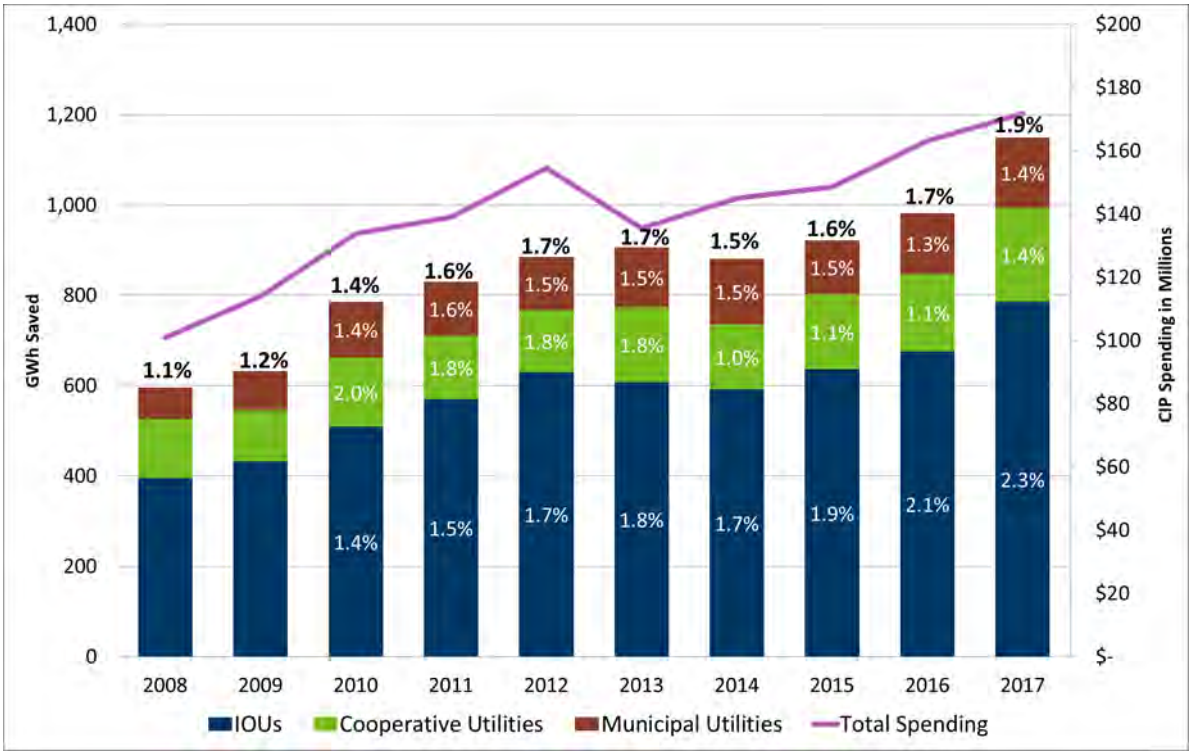
[12] Legislation passed in 2017 exempted municipal and electric cooperative utilities from the energy efficiency program requirements under Minnesota's CIP statute based upon a threshold of the number of cooperative members (for cooperative utilities) or the number of retail customers (for municipal utilities). Municipal natural gas utilities that fall below a minimum annual throughput threshold were already exempt from the CIP statute requirements. Minnesota Statute 216B.241.

[13] In 1999, the Minnesota Legislature authorized large customer facilities meeting certain criteria to opt-out from participating in and paying for CIP. Laws of Minnesota 1999, chapter 140.

[14] 2017 CIP achievement projections are based on CIP Status Report compliance filing data. The COU spending and savings data were compiled from Energy Savings Platform (ESP) reporting data on October 22, 2018.

annual energy usage of nearly 80,000 single-family homes.[15] Total CIP natural gas savings in 2016 were equivalent to the annual energy usage of nearly 18,000 single-family homes.[16]

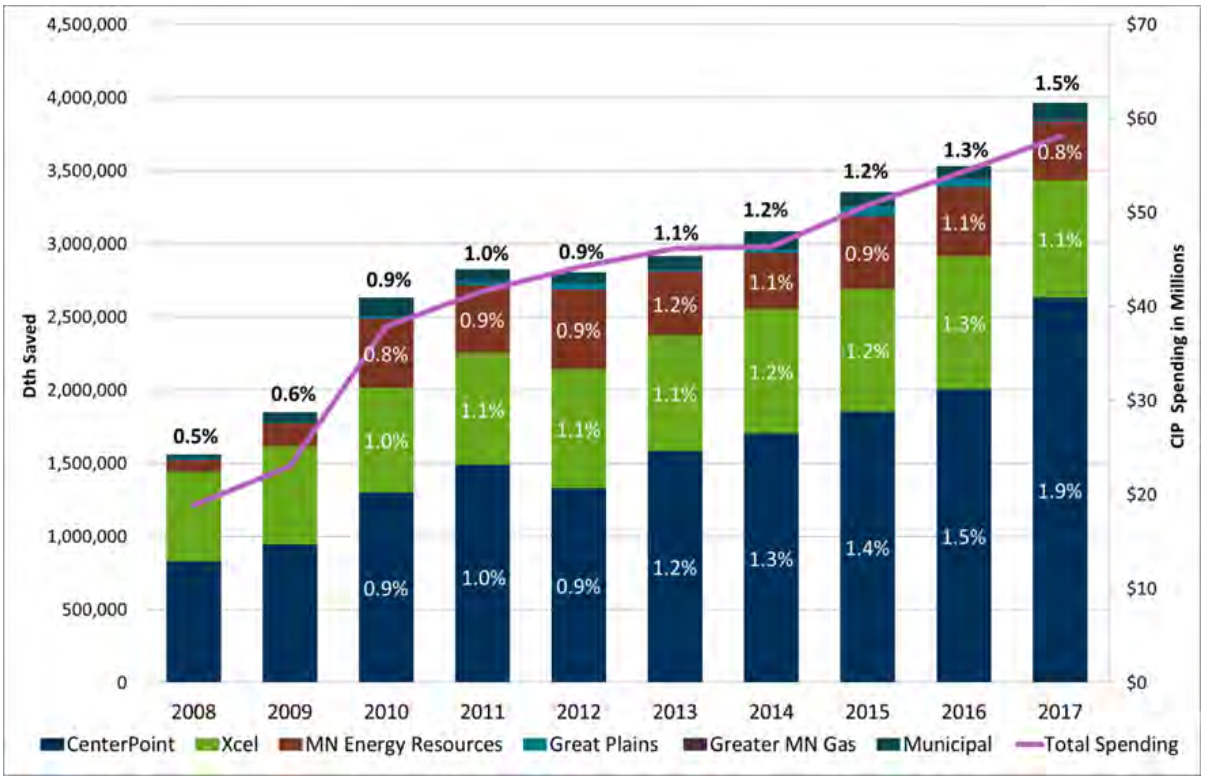
Figure 6. Historical energy efficiency spending and savings achievements of Minnesota electric utilities (in gigawatt-hours and as a percentage of total sales), 2008-2016.



[15] According to https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

[16] According to https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Figure 7. Historical energy efficiency spending and savings achievements of Minnesota natural gas utilities (in dekatherms and as a percentage of total sales), 2008-2016. [17]



Regulatory oversight of CIP

Regulatory oversight for CIP activities, goals, and achievements has been provided by the Minnesota Department of Commerce ("the Department") or its predecessor, the Minnesota Department of Public Service, since the late 1980's.[18] Currently, utilities that are subject to the CIP statute file CIP plans with the Department, which oversees the review and approval process. Municipal and cooperative utilities file annual plans with the Department through the state's online platform. IOUs file their CIP plans, called "Triennial Plans," every three years, and are required to provide more information and analysis than municipal and cooperative utility annual plans. The IOUs' Triennial Plans include their expected

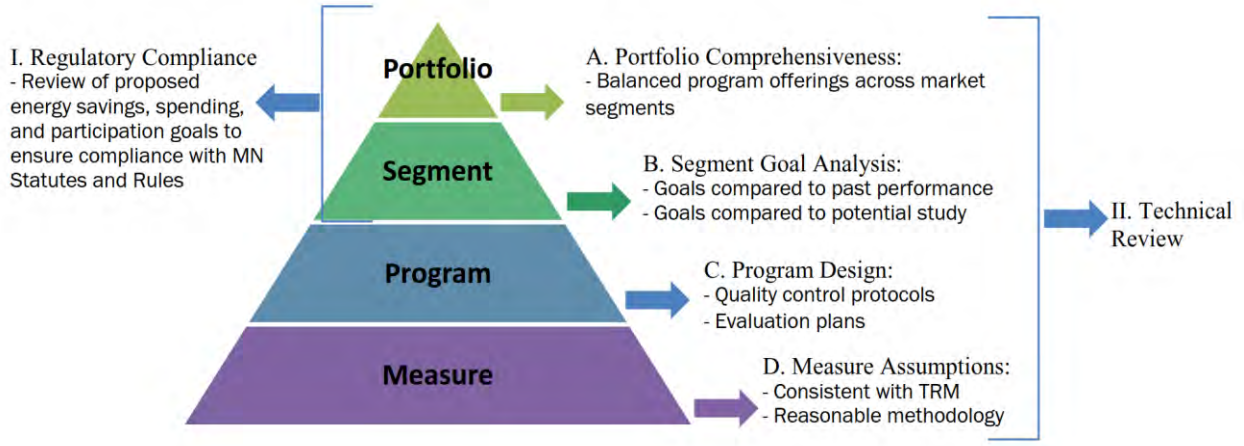
[17] The project team would add one caveat to the interpretation of Figure 7, which shows particularly high achievements in 2017. CenterPoint Energy's achievements in that year were unusually high, and driven by a particularly large custom rebate project that was responsible for over one-third of its total savings that year. CenterPoint reported nearly 40% of total savings coming from custom rebates in 2017 (six times higher than the previous year's achievements). Removing that single project would likely result in lower 2017 statewide savings than were achieved in the previous two years.

[18] State of Minnesota Department of Public Service. *Statement of Need and Reasonableness in the Matter of the proposed Amendments to Rules Governing Conservation Improvement Programs and Utility Renewable Resource Pilot Programs, Minn. Rules Chapter 7840, to be re-codified as Minn. Rules Parts 7690.0100 - 7690.1500.* November 22, 1989 (https://www.leg.state.mn.us/archive/sonar/SONAR-01563.pdf).

program portfolio activities, goals, budgets, estimated cost-effectiveness, energy savings calculations, and technical assumptions. The COUs report their expenditures and energy savings performance from the previous year, along with their budgets and energy savings goals, and updated program designs for the following year.

The Department conducts a regulatory and technical review of IOU proposed plans and may order modifications (Figure 8).[19] The Department may recommend changes to COU CIP plans, but generally does not mandate that the changes be made. Between Triennial Plan filings, IOUs may request permission for changes to their approved CIP portfolio, to add or remove activities, or change goals and budgets. Program modifications are subject to a similar review process as the CIP Triennial Plan filings.

Figure 8. Department of Commerce CIP technical and regulatory review for investor-owned utilities.



To ensure that reasonable calculations are used by the utilities to calculate their CIP performance, a key part of the Department staff's role is to establish approved technical assumptions that the utilities are required to use — including prescriptive measure algorithms in the Minnesota Technical Reference Manual (TRM)[20] to estimate energy savings, providing uniform natural gas cost-effectiveness inputs through the Inputs to BENCOST for Natural Gas CIPs document,[21] and standardizing the methodology for calculating transmission and distribution avoided costs.[22]

The Department oversees development of the TRM, which is a list of CIP-eligible energy efficiency measures, associated technical assumptions, and energy-savings calculations for use by utilities in their CIP plans. The Minnesota TRM is updated annually but receives a comprehensive review and rewrite

[19] Per Minnesota Statutes § 216B.241, and Minnesota Rules, part 7690.0500.

[20] Minnesota TRM Webpage: mn.gov/commerce/industries/energy/utilities/cip/technical-reference-manual/.

[21] Inputs to BENCOST for Natural Gas 2017-2019 CIP, February 19, 2016. Docket no: 16-36. www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={C952168E-C6B2-4994-90DF-852677019F0E}&documentTitle=20162-118479-01.

[22] Deputy Commissioner's Decision – Avoided T&D Cost Study for Electric 2017-2019 CIP Triennial Plans, September 29. 2017. Docket no: 16-541. www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={E0B7CD5E-0000-C01B-B43D-58AB61CE562A}&documentTitle=20179-135899-01.

every three years, ahead of the CIP Triennial Plan filings. Utilities may also propose their own energy efficiency measures, technical assumptions, and energy savings calculations. However, these utility-proposed measures and technical assumptions receive additional scrutiny and review by the Department.

Each spring, the Department reviews and approves annual compliance reports for the IOUs called "Status Reports." The reports provide information about each utility's energy conservation program achievements, including participation, expenditures, energy savings, and cost-effectiveness.[23] The COUs file their annual achievements through the state's online saving reporting platform.[24]

The IOUs file a full accounting of their CIP expenses (including a request for approval of any financial incentives) with the Minnesota Public Utilities Commission for review and approval. Typically, CIP program costs and the CIP financial incentive are recovered within twelve months of being incurred through a rate rider.

Cost-effectiveness framework

The foundation of Minnesota's energy conservation framework is cost-effectiveness. Minnesota's CIP statute states that no utility is "required to make energy conservation investments to attain the energy-savings goals of this subdivision that are not cost-effective; even if the investment is necessary to attain the energy-savings goals."[25]

Tests for cost-effectiveness involve a calculation of the total benefits of achieved energy savings and the total costs to achieve those energy savings, in dollar terms. To determine whether or not the overall benefits exceed the costs of the energy conservation activity, the costs to capture energy savings are tested against the costs avoided by the energy savings. Results are reported in terms of the net present value dollars or as a ratio (i.e., benefits/costs). A project is considered cost-effective if the benefit-to-cost ratio is greater than one and the net present value of benefits (net benefits) is greater than zero.[26]

Cost-effectiveness of Minnesota's CIP is reported at the program, sector (i.e., residential, commercial, and industrial), and overall CIP portfolio level. The Department requires utilities to meet cost-effectiveness standards at the sector level. This approach "recognizes that individual programs are often linked together and not intended to operate in isolation; for example, energy audit projects are

[23] Minnesota Rules: 7690.0550, Program Status Report. The IOUs publish these reports on the eDockets on-line filing system.

[24] Minnesota's online platform for filing CIP data is called the Energy Savings Platform (http://www.energyplatforms.com/MN.aspx).

[25] Minnesota Statutes 2018, section 216B.241, subdivision 1c, paragraph (f).

[26] For more background on the use of cost-effectiveness tests in energy efficiency portfolio planning, and more details of their calculation, see: California Public Utilities Commission: *California Standard Practice Manual: Economic Analysis of Demand-Side Management Programs and Projects.* 2001. And: Environmental Protection Agency. *Understanding Cost-Effectiveness of Energy Efficiency Programs: Best Practices, Technical Methods, and Emerging Issues for Policy-Makers.* November, 2008 (https://www.epa.gov/sites/production/files/2017-06/documents/understanding_costeffectiveness_of_energy_efficiency_programs_best_practices_technical_methods_and_emerging_issues_for_policy-makers.pdf).

intended to identify conservation opportunities and drive participation in equipment rebate programs."[27]

The primary tests used to evaluate CIP program and portfolios are the societal test and the utility test.[28]

The utility cost-benefit test (UCT) (also called the "program administrator test") considers cost-effectiveness from the perspective of the utility that is paying for the energy conservation program. It compares the costs incurred by the utility to fund energy efficiency programs against the benefits of the avoided energy that the utility would have had to acquire had the energy not been saved (i.e., the avoided costs for generation, transmission, distribution, and capacity). Significantly, net benefits as calculated by the UCT are the basis for the calculation of utility incentives for the IOUs, under Minnesota's current incentive mechanism. Since participants' costs are not included in the UCT, all other things being equal, lower utility incentive payments will increase the utility cost-effectiveness of a CIP program. Thus, utilities seeking to maximize the UCT have an incentive to lower overall CIP incentives, while still motivating customers to choose the efficient option.

The societal cost-benefit test (SCT) considers the overall cost-effectiveness of energy efficiency to society. In addition to the costs the utility pays for energy efficiency, it also includes the costs that customers pay for efficiency measures (Figure 9).

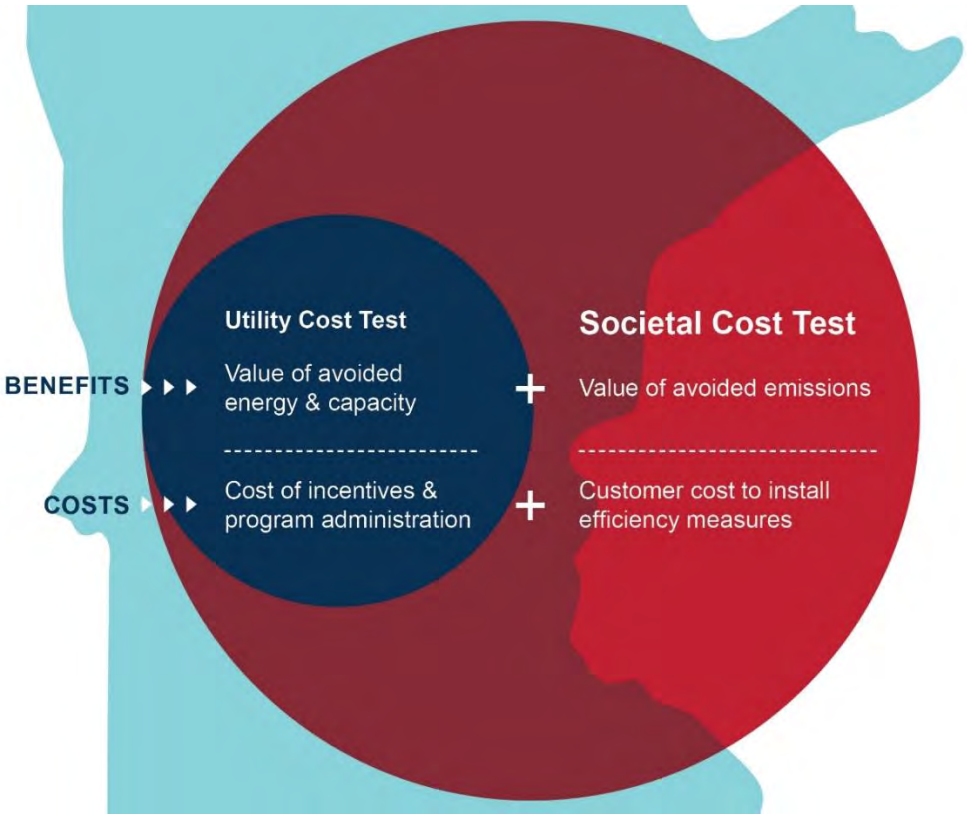
On the benefits side, in addition to the avoided cost of saved energy, it also considers the environmental benefits from reduced air emissions as a result of using less energy. In contrast to the UCT, lowering the utility incentive costs has no impact on the SCT results, as lowering the utility incentive would increase the cost that the participant had to pay for a given CIP measure, resulting in no net change in cost-effectiveness.

Since the SCT is the primary test used by the Department in evaluating CIP portfolios, and is the broadest cost-effectiveness test, the SCT is used as the primary screen for cost-effectiveness in this study, as described further in Chapter 3.

[27] Department of Commerce. *Proposed Decision CenterPoint Energy's 2017-2019 Natural Gas Conservation Improvement Program Triennial Plan Docket Nos. G008/CIP-16-119, G008/CIP-16-119.01, G008/CIP-16-119.02*. September 19, 2016.

[28] In addition to these two tests, the Department requires utilities to calculate two additional cost-effectiveness tests in preparing and reporting on their CIP plans: participant cost-benefit test and the ratepayer impact test. These tests assess costs and benefits for groupings of ratepayers within the utility and have narrower applications; they were not used for this study. Within the Venn diagram in Figure 9, these tests would be subcomponents of the utility cost test.

Figure 9. Comparison of societal and utility cost-benefit test inputs as used in Minnesota.



The Cadmus Group recently conducted a cost-effectiveness analysis of the CIP electric and natural gas program portfolios. Cadmus found that, based on the societal test, Minnesota's CIP resulted in aggregate net benefits to society from 2008 to 2013 of approximately $3.3 billion, with each program year providing net electric and natural gas benefits to society ranging from $315 million to $919 million.[29]

Long-term planning for energy efficiency

The CIP process described above is how utilities procure efficiency within the period of the Triennial Plans. Energy efficiency is also considered as a long-term resource for electric utilities by the Minnesota Public Utilities Commission (MPUC) in their review of utility Resource Plans. These plans extend out 15 years, and utilities are required to show how efficiency will help them meet their long-term resource needs. The MPUC has the authority to order utilities to pursue more energy efficiency if the record supports that. Any utility that plans to file for a Certificate of Need for a new generation resource is required to show that they are pursuing all cost-effective energy conservation prior to a certificate being

[29] Minnesota Department of Commerce. *The Aggregate Economic Impact of the Conservation Improvement Program 2008-2013.* October 2015. Page 5. http://mn.gov/commerce-stat/pdfs/card-report-aggregate-eco-impact-cip-2008-2013.pdf.

issued[30]. Many of the data inputs developed to support utility resource planning is used in utility efficiency programs (e.g., forecasts of future avoided costs to be used for calculating energy efficiency cost-effectiveness).

Stakeholder perspectives on the existing CIP framework

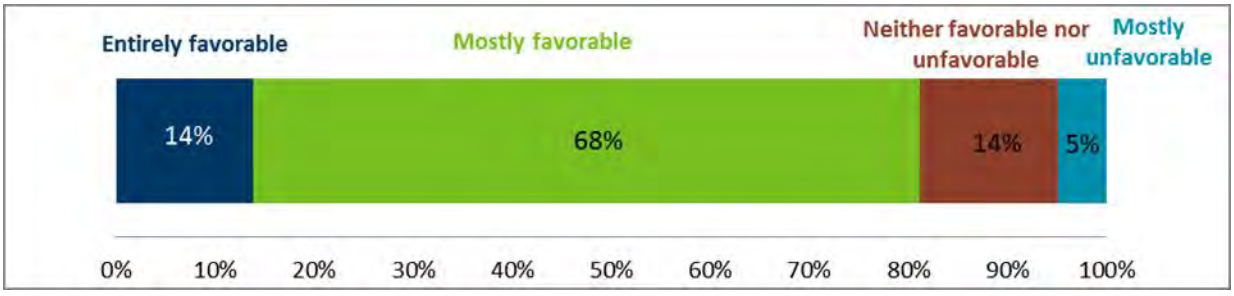
Utility, business, and public interest stakeholders have always played a large role in the planning and implementation of CIP in Minnesota, and their perspectives will continue to be important as regulators plan for the future of CIP. To help inform this study, the project team conducted a survey of nearly 40 stakeholders, which included utilities, business groups, consumer groups, and environmental groups (Table 2). Below are some of the survey's key findings. Additional stakeholder findings are discussed in Chapter 6 (Policy Conclusions).

Table 2. Stakeholders participating in survey.

Stakeholder sector	Number taking survey
Investor-owned utilities	9
Cooperative utilities	4
Municipal utilities	8
Business organizations	7
Consumer/government organizations	6
Clean energy organizations	4
Total:	**38**

Over 80% of stakeholders reported having a favorable experience with CIP, with a small minority reporting unfavorable experiences (Figure 10).

Figure 10. Stakeholder experiences with CIP.



According to one municipal utility stakeholder:

> *"We've had some good success stories with saving our commercial or industrial customers a significant amount of money and they're able to expand their operations because of savings we*

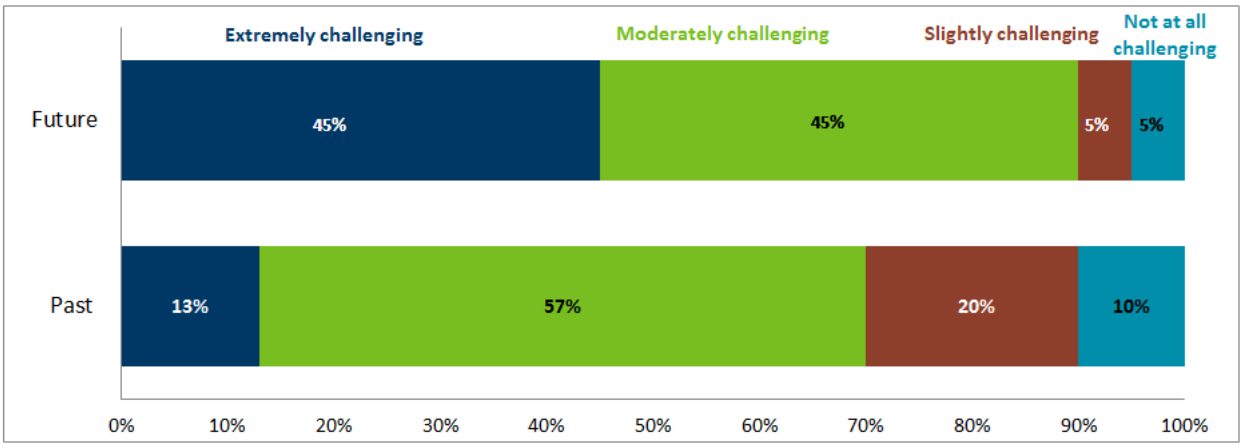
[30] 216B.2401 ENERGY SAVINGS POLICY GOAL: The legislature finds that energy savings are an energy resource, and that cost-effective energy savings are preferred over all other energy resources. https://www.revisor.mn.gov/statutes/cite/216B.2401.

found for them. I think it's a win-win. It helps build relationships with our customers and helps us defer systems expansions and helps keep rates down."

IOUs particularly cited the regulatory process as a positive experience for them; in particular the ability to make investments in energy efficiency with a high degree of confidence that they would receive cost-recovery and incentives from those investments.

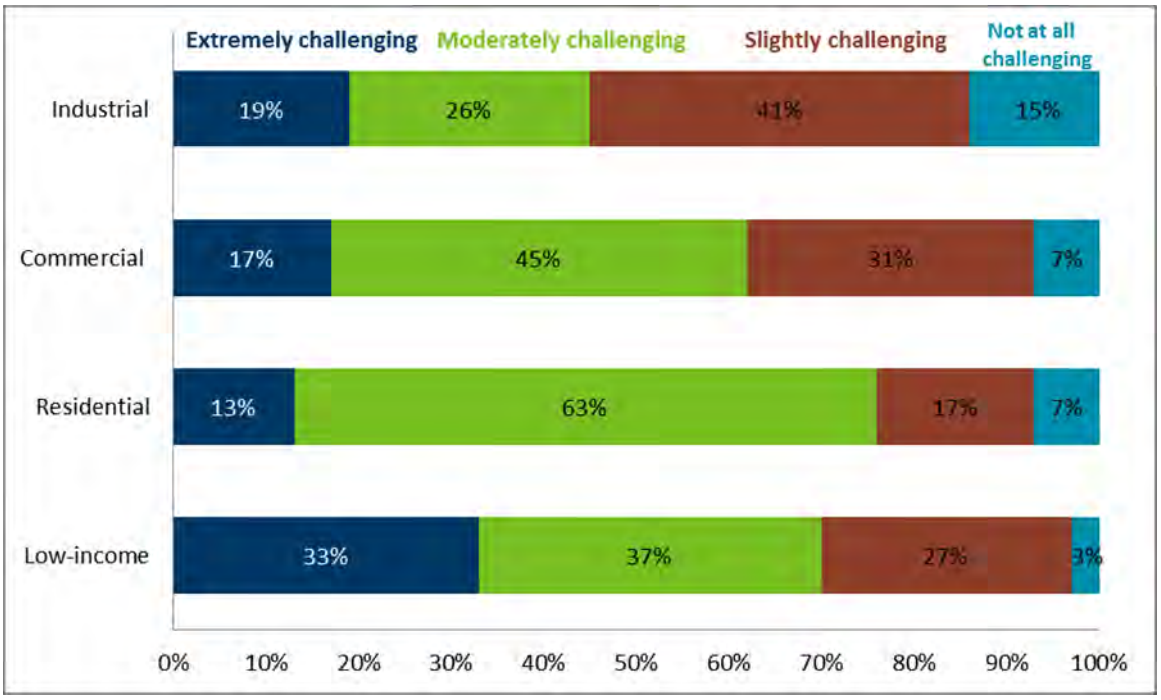
However, while stakeholders believe that it has been relatively easy to meet the state goals in recent years, most believe that it will become harder in the coming years (Figure 11).

Figure 11. Stakeholder perceptions of how challenging it is to meet CIP savings requirements now and in the future.



Stakeholders also report that they are most challenged with reaching residential customers – and in particular low-income residential customers (Figure 12).

Figure 12. Stakeholder perceptions of how challenging it is to reach customers with energy efficiency programs (by sector).



According to one stakeholder:

> *"I think sometimes low-income [customers] aren't in tune with utility programs and [we struggle with] how to get them educated with the programs. There may be language barriers in some communities; culture barriers, and I think just knowing who those customers are can be challenging."*

Greater emphasis on lifetime savings may be warranted

When asked which metric for energy efficiency was most important, stakeholders identified lifetime energy savings as the most important. Currently, the greatest emphasis is on first-year savings. A couple of quotes from stakeholders on this topic:

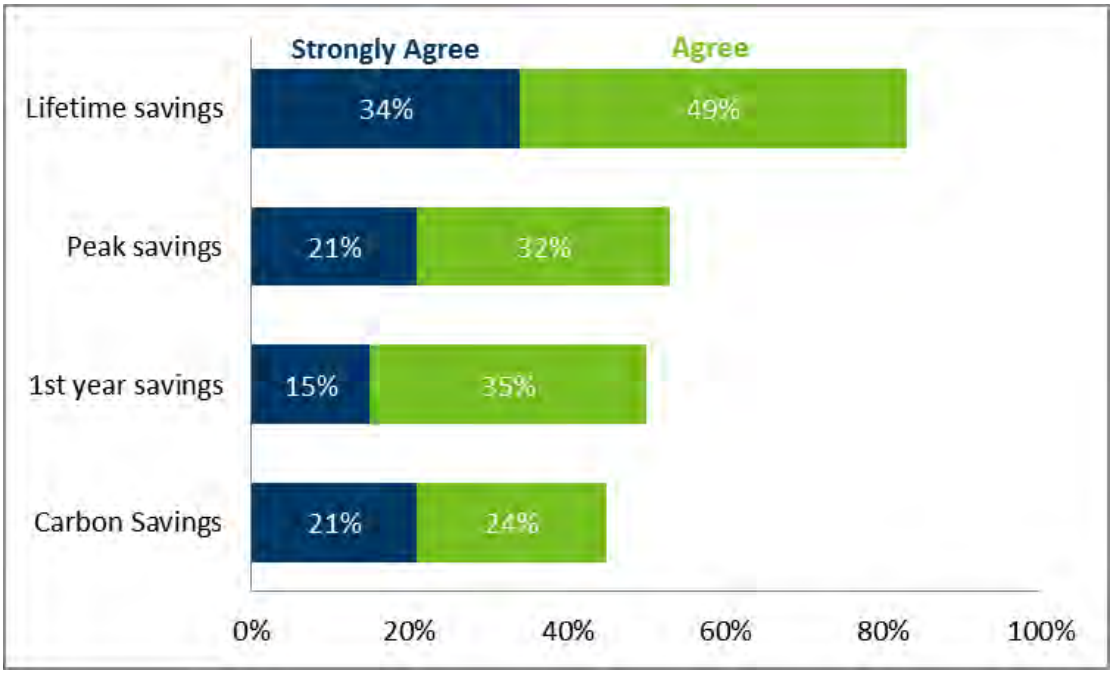
> *"One of the problems I've had with CIP is not being able to capture savings through the life cycle of the savings implemented. So I can only capture the first year, I don't get 2-3-4 years of savings out of it. I don't like the fact that I don't get multi-year savings out of a multi-year program."*

> *" … Some of the measures that could have long-term overall savings may be expensive upfront or have small year-by-year savings, so I think it's important to measure not just first-year savings."*

However, other stakeholders emphasized that first-year savings were more easily understood by the broader public:

> *"First-year savings are well known, well understood, and they're really important. Lifetime savings are good, but when you're encouraging first-year savings and encouraging cost-effectiveness, you're going to get lifetime savings. I also think first-year savings is an easier-to-understand goal. It's easier to explain to public stakeholders who don't understand this stuff, and that's really important."*

Figure 13. Stakeholder views of what metrics should be used to measure CIP success.



Chapter 3: Methodology

This chapter summarizes the methodology and key data sources employed in the calculations of energy efficiency potential. The scope of the study includes the calculation of economic and achievable utility-driven energy efficiency for Minnesota electric and natural gas utilities for the period 2020 to 2029. No calculation of fuel switching (e.g., from propane to electricity for space heating to increase overall fuel efficiency) was included in the analysis, although this issue is discussed further in Chapter 6.

A comprehensive description of the methodology and data sources is found in Appendix A. The methodology the project team used is consistent with national best practices for conducting potential studies. By its nature, estimating the potential for energy efficiency for more than a decade into the future involves a large number of technology and market assumptions. An effort was made to ensure the maximum amount of transparency in documenting these assumptions.

Types of potential calculated

Four levels of potential were calculated for this study, as described below and summarized in Figure 14.

- ***Technical potential:*** Technical potential is a necessary step to assessing the full economic and achievable potential. It represents in theory the maximum amount of energy use that could be displaced by efficiency. However, as with virtually all studies, the modelling did not include many energy efficiency measures that are technically possible, but realistically are not practical or typically pursued because of cost or other reasons.[31] In this study, technical potential represents implementing all of the most aggressive energy efficiency measures that were identified for inclusion in the modeling (Step 2 in the following section).

- ***Economic potential***: This is the subset of the technical potential that is cost-effective, based on the societal cost test, as used in Minnesota. Most measures that did not pass the cost-effectiveness screen were removed from the analysis, but all cost-effective measures were assumed to be fully implemented regardless of market barriers.[32] This is described in Step 3 below.

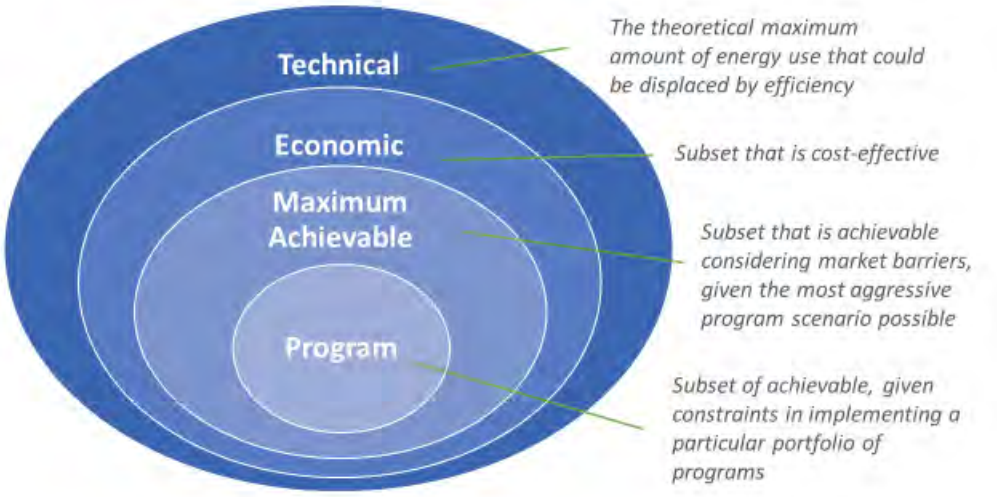
- ***Maximum achievable potential:*** This is the subset of economic potential that is achievable considering market barriers, given the most aggressive program scenario possible. In this study, the project team assumed financial incentives would cover 100% of the incremental costs of each measure, along with very aggressive marketing and program designs to achieve maximum market penetration of the measures. The process for estimating measure penetrations and budgets is described in Step 4 below.

[31] Since it is known technically how to build super insulated buildings that have no heating loads; for example, true technical potential approaches 100% for some end uses and is not particularly useful to report.

[32] To avoid double counting, where there was more than one measure that could be used to address a specific efficiency opportunity, the project team assumed full penetration of the highest saving measure option.

- ***Program potential***: The program potential is a subset of the maximum achievable, given constraints in implementation. This study assumed that financial incentive levels are dropped to 50% of the incremental cost of the measure, which is a typical scenario used for planning purposes in Minnesota,[33] and a good benchmark for aggressive programs nationally. The project team still assumed aggressive marketing and program designs for this scenario.

Figure 14. Types of potential calculated for this study.



Primary data collection

This study used hundreds of data sources to develop inputs to the models, including past CARD studies, utility-provided data, residential audit data, secondary data from the northern Midwest region, U.S. Department of Energy studies, and others. Many of these sources are listed in the following section. In addition, the project team undertook additional data collection efforts to fill in some of the gaps of these other data sources. This included three components:

- Residential building phone and on-site surveys;
- Commercial large building phone and on-site surveys; and
- Energy efficiency contractor (trade ally) surveys.

In total, over 136 on-site surveys and 1,797 telephone surveys were completed (Table 3).

[33] Xcel Energy, for example, typically will use a 50% incentive scenario for planning purposes and for conducting their potential studies.

Table 3. Summary of primary data collection efforts.

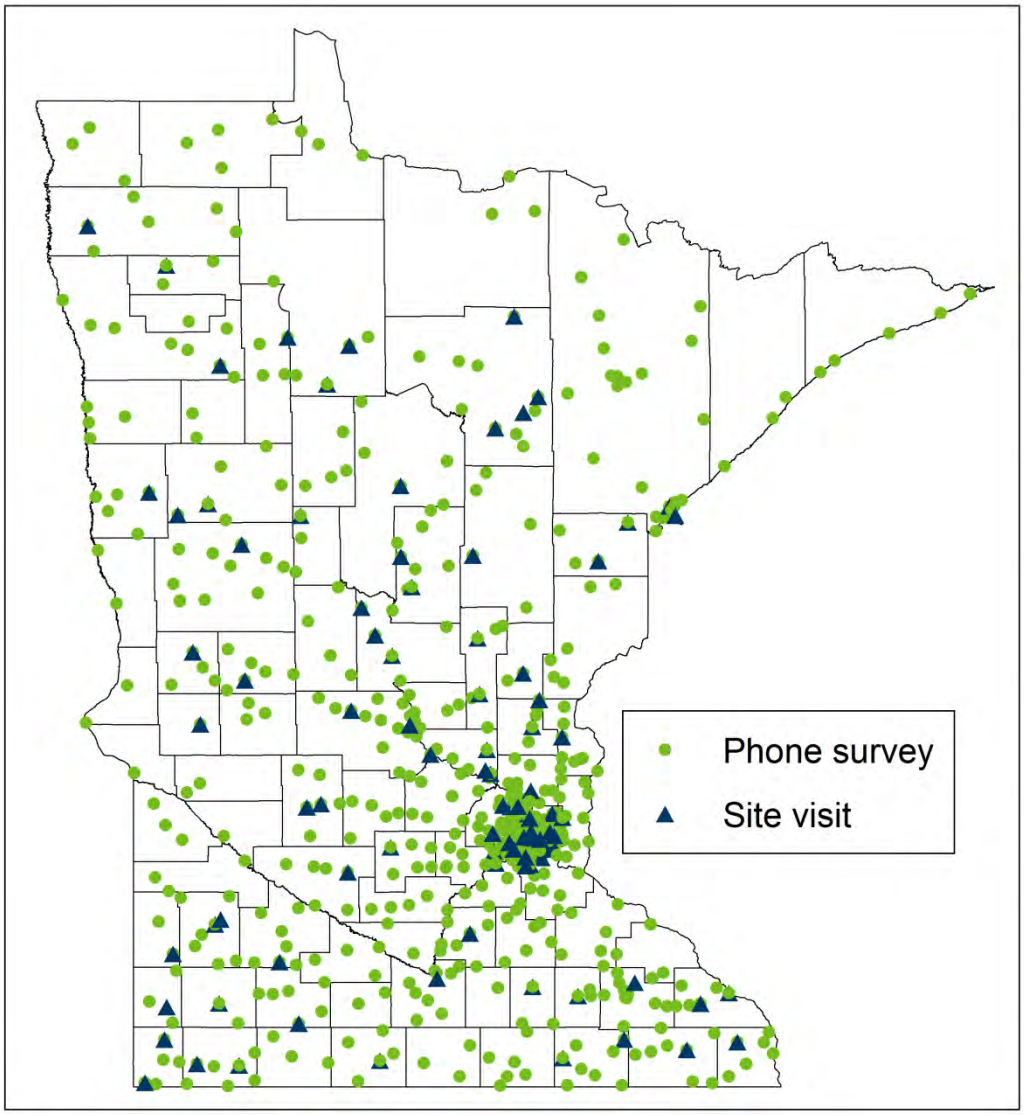
Sector	Phone surveys completed	On-site surveys completed
Residential building data collection	1,491	106
Large commercial building data collection	201	30
Total trade ally surveys (subtotals below)	105	-
HVAC contractors	*29*	-
New construction design professionals	*20*	-
Insulation contractors	*20*	-
Electricians	*26*	-
Plumbers	*10*	-
Total:	**1,797**	**136**

The data collection efforts were conducted throughout the state, with an emphasis on non-metro areas (Figure 15). While the project team did collect data in many different utility territories across the entire state, the sample sizes for different territories were not large enough to distinguish statistically significant differences among utility territories, or even the seven analysis regions in the state that were used for modeling.

In addition, the project team contracted with D+R International to purchase statewide data on HVAC sales.

In total, this primary data collection helped to inform key parameters of the study, such as the prevalence of measure opportunities and existing levels of measure saturation. The primary data collection effort is discussed more thoroughly in Appendices I, J, K, and L.

Figure 15. Map of statewide primary data collection sites.[34]



Analysis regions

To account for the diversity of utility types in Minnesota, as well as climate differences from the northern and southern parts of the state, the state was split into seven different analysis regions (Figure 16). A separate model was used for each region, and for the presentation of statewide potential, the results of these individual models were aggregated together. This gave the study team the ability to use separate assumptions and data for each of these analysis areas, rather than global assumptions for the state. For example, as discussed later in this chapter, different assumptions were used for the avoided

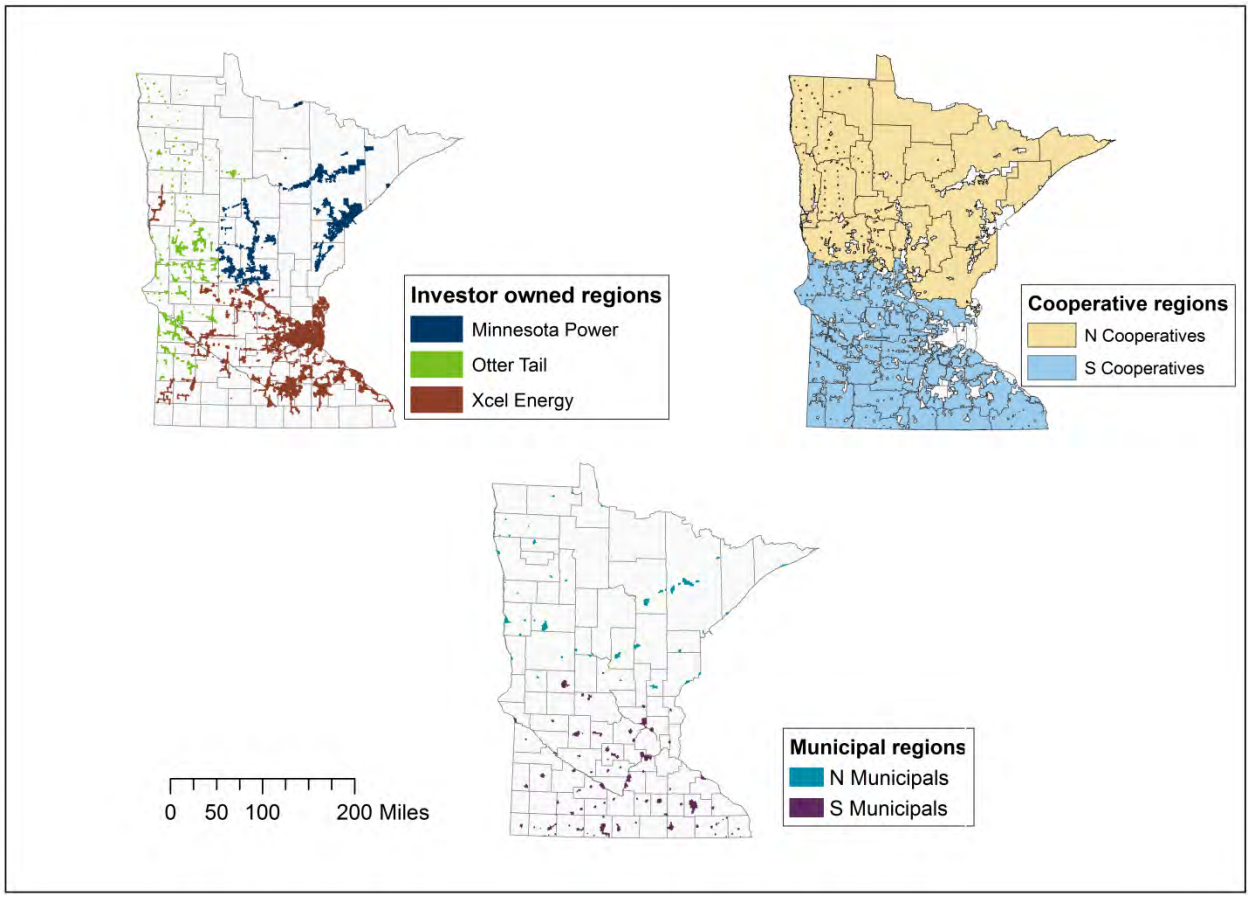
[34] Due to data privacy considerations, the points on this map represent primary data collection sites by zip code. Many zip codes had more than one phone survey or site visit, but are still represented by a single point.

cost of energy for each of the seven regions, to reflect utility-specific differences among IOUs, cooperative utilities, and municipal utilities.

The seven regions are based on the territories of electric utilities in the state as follows:

- Separate regions for the territories of each of the three electric IOUs (Xcel Energy, Minnesota Power, Otter Tail Power).
- A northern and southern model for groupings of cooperative utilities and municipal utilities respectively (four models total: northern cooperatives, southern cooperatives, northern municipals, and southern municipals).

Figure 16. Map of seven regions used for the analysis.



The model conducted an integrated analysis of both electric and natural gas potential, so the natural gas potential was also calculated for these same regions. While this did not allow for setting utility-specific parameters for the natural gas utilities, it did allow for the consideration of climate and other differences across a given utility's territory. For example, the model is able to account for climatic differences across Minnesota Energy Resources' territory, which spans from Worthington in the southern end of the state to International Falls in the northern end of the state. While the initial groupings were related to electric utility territories, the project team also disaggregated the gas potential in each model to develop the natural gas potential separately for the five IOUs (CenterPoint Energy, Xcel Energy gas, Minnesota Energy Resources, Great Plains Natural Gas, and Greater Minnesota

Gas), as well as groupings of northern municipal and southern municipal gas utilities. This process included disaggregation of gas potential in each electric territory by sector, building type, and end use to develop customized gas utility results. These results are reported in Appendix B.

Although some of the major model inputs were varied by analysis region, data and study limitations limited how many of the inputs the project team could make region-specific. Some of these major inputs are shown in Table 4, which are discussed further later in this chapter, and in Appendices A and B. The major differences between electric and natural gas utility territories, in terms of using statewide analysis versus region-specific inputs, include, but are not limited to, the use of region-specific avoided cost inputs for electric utilities and customized disaggregation of customer loads by sector, building type and end use, load forecasts, and weather impacts.[35]

Table 4. List of select model inputs, and whether they varied by analysis region or were statewide.

Region-specific inputs
Demographic and energy usage data by sector and building type[36]
Avoided electric energy and capacity costs (electric utilities only)
Impact of weather on gas and electric measure savings
Statewide inputs
Avoided natural gas energy and capacity costs (the same for all gas utilities)
Energy efficiency measures included in modeling
Existing measure saturation levels
Program budgets and incentive costs for modeled programs[37]
Market penetrations for modeled energy efficiency programs
Societal discount rate[38]

Steps in calculating potential

There are two general approaches commonly used to calculate energy efficiency potential: the "bottom-up" approach and the "top-down" approach. While both approaches use detailed measure level data inputs, a top-down approach applies those bottom-up measure data to actual applicable baseline loads, whereas a pure bottom-up approach assumes certain quantities of measures are adopted and does not link directly to actual baseline loads. The top-down approach was used for this study and involves five

[35] Typically the Department defines statewide avoided commodity costs that all natural gas utilities use for CIP purposes, while electric utilities use utility-specific avoided energy costs.

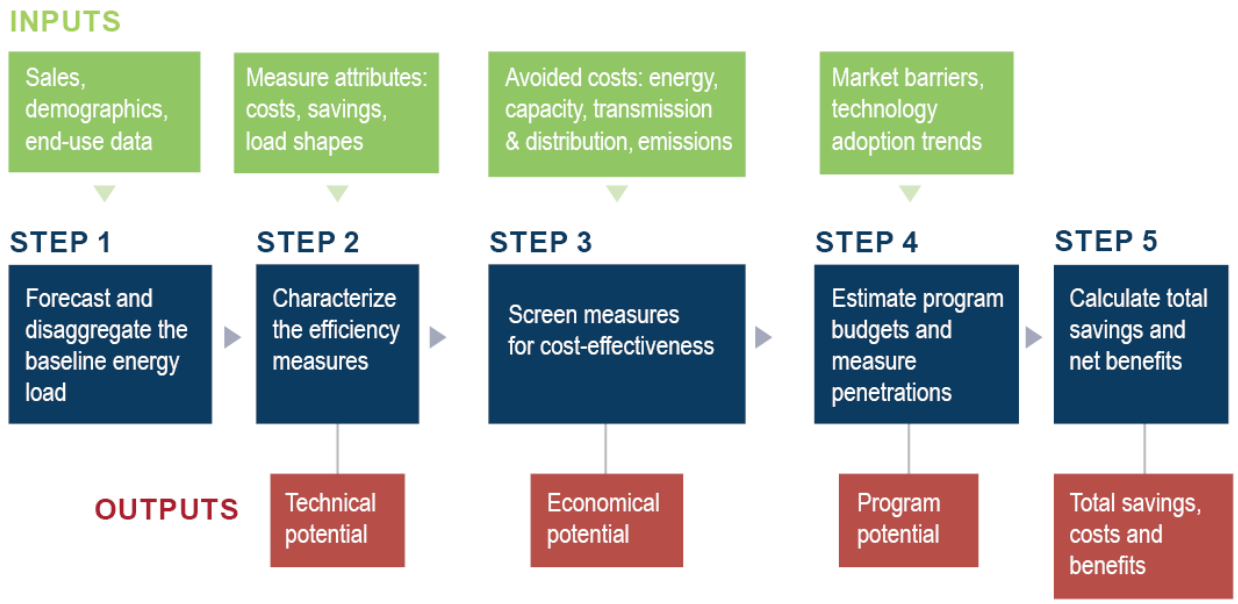
[36] This includes the proportion of energy consumed by 16 different building types and 14 (electric) or 6 (gas) different energy end uses (refer to Figure 18 for electric & Figure 19 for gas for a list of the building types and sectors). Other demographic information was also region-specific, such as the proportion of low-income customers.

[37] The budgets are modeled to scale with measure implementation, so costs vary based on the quantity of measures installed, but the program and incentive costs for a given measure do not vary by region.

[38] As discussed further in the below "Step 3" section, a rate of 2.55% was used for the societal discount rate, consistent with Department guidance.

major steps. The approach is illustrated in Figure 17, and described in more detail in Appendix A. Major data sources used for each of the steps are summarized at the end of this section in Table 7.

Figure 17. Modeling approach used for this study.



Step 1: Forecast and disaggregate the baseline energy load

Sales forecasts were obtained from publicly filed Integrated Resource Plans as well as directly from nine different utilities or utility associations. In the event a utility's forecast did not project to 2029, the project team extrapolated by assuming the sales grew by the same rate as the last five years of the forecast. When available, the team obtained forecasts separately for commercial, industrial, and residential. The known industrial opt-out loads were subtracted from the total sales figures, so all results reflect only the potential from non-opted out loads.

Since the forecasts were developed using econometric models, they implicitly include some impacts of future efficiency programs, along with past and future codes & standards trends. Therefore, the project team first adjusted the forecasts upward to remove the impacts of continued efficiency programs, based on historical levels of energy efficiency achievement. This helped ensure that the potential study reflects the full efficiency potential over and above a no-program scenario with only naturally occurring and known codes and standards impacts.

The study team then used a variety of data and methods to disaggregate total energy sales into 16 different building types (three residential, twelve commercial, and the industrial sector). For each of these building types, the energy load was further disaggregated into 19 separate end uses for electric utilities (Figure 18), and seven end uses for gas utilities (Figure 19). These building types and end-uses were used to classify the measures according to their applicability to different building types and end-uses, as discussed in the next section. This ensures that the potential of any given set of measures is limited by the total energy used in each relevant building sector and end use for those measures.

Figure 18. Statewide electric energy load by building type segments and end use.

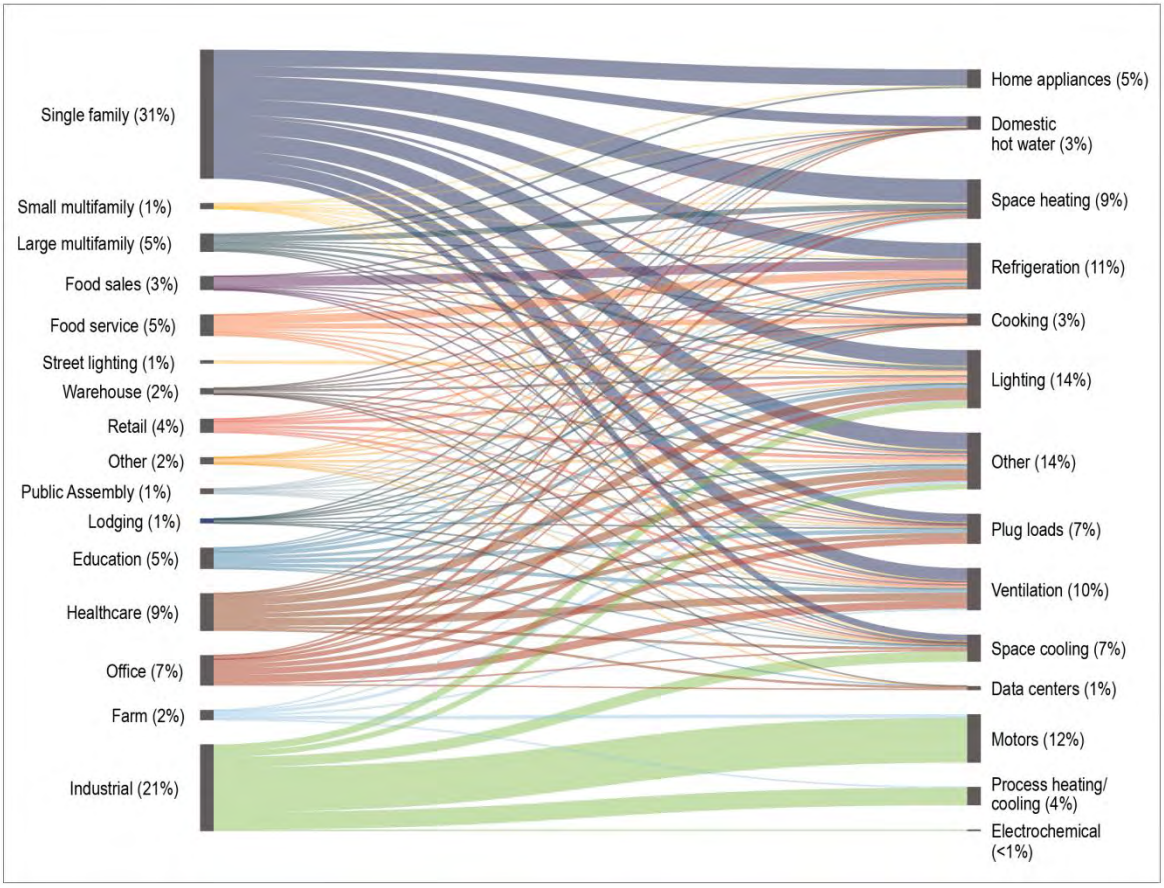
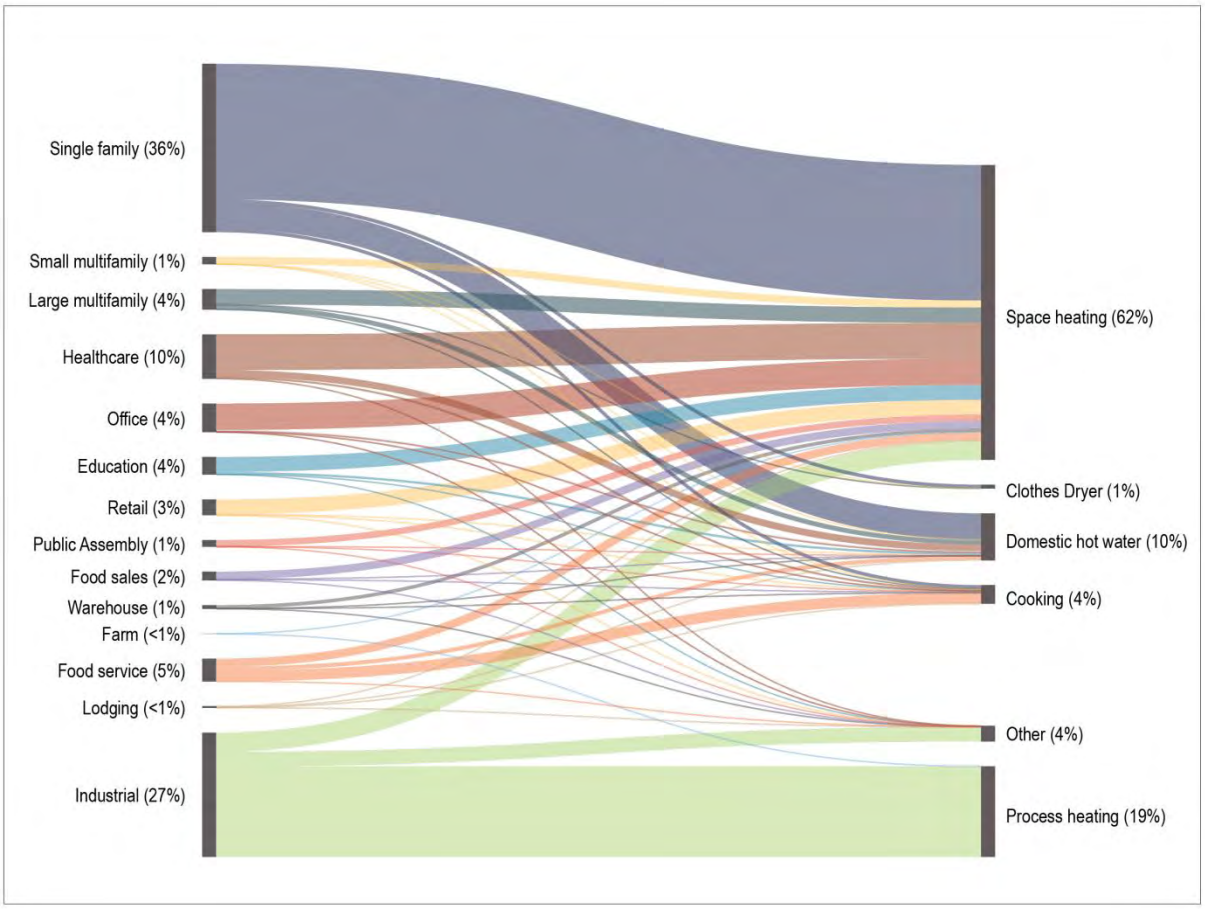


Figure 19. Statewide natural gas energy sales by sector, building type segments, and end use.



Step 2: Characterize the efficiency measures

The study team undertook an extensive investigation of measures to include for the study, described in Appendix C. Based on this review, a total of 303 measures were selected for inclusion in the study (Table 5); of these, 69 were gas-only technologies, 181 were electric-only, and 53 saved both gas and electricity. No fuel-switching measures were included. Each technology or practice was then analyzed individually by four market approaches as applicable (i.e., retrofit, replacement, renovation or new construction, as discussed below) and by the 16 individual building segments. In some cases, separate tiers of efficiency levels of a given technology were also analyzed as separate measures (e.g., “Tier 1” simple programmable thermostats and “Tier 3” smart thermostats). This resulted in modelling of a total of 3,378 individual measure permutations.

Table 5. Source of measures selected for the study.

Source of measure	Residential	Commercial/ Industrial	Total
Conventional (MN & other state's TRMs)	84	156	240
Emerging Tech Screening	18	18	36
Behavioral Program Screening	10	7	17
Demand-Response Screening[39]	5	5	10
Total	**117**	**186**	**303**

Once the measures were selected, measure-specific assumptions were defined for each measure, including:

- Energy savings from the baseline (including any baseline shifts over the study period);
- Annual energy and electric coincident peak demand savings (adjusted for differing climate regions where applicable);
- Incremental cost;
- Future O&M and capital replacement cost impacts;
- Lifetime;
- Existing efficiency measure penetration;
- Measure load shapes; and
- Applicability to specific building types and end uses.

Measures were also characterized according to which types of markets they could apply to:

Retrofit – This refers to measures that are non-time-discretionary. In other words, customers can adopt them at any point and they are not dependent on some other market activity to happen. This includes equipment that is replaced prior to the end of its useful life, such as the early replacement of an inefficient boiler with a more efficient version before the boiler fails or requires extensive repairs. It also includes new measure adoptions where the measure had not been there before, such as for many controls and building envelope measures. For most early replacement measures, the incremental cost reflects the entire equipment and labor cost of the retrofit, and the initial baseline energy usage is the existing measure or usage, which is often below current code and standard market practices.[40]

Replacement– This includes measures that are time dependent, including replace-on-failure or end-of-life, such as a boiler that is at the end of its useful life and is replaced with a more efficient version. Significantly, the incremental cost for replacement measures is the difference between a new inefficient baseline version and the efficient version. Likewise, the baseline for calculating energy savings is not the equipment that was replaced, but the inefficient, new version of the equipment, which is often set by current code or standards, or based on typical market practice. Also significant is that replacement, like new construction and renovation, are time-sensitive opportunities that can only be captured at the time of some other natural market event or investment. As a result, the magnitude of eligible opportunities is

[39] Per current CIP policy, demand-response measures were only included if they also had energy consumption savings.

[40] A baseline shift was generally applied at the point where it was expected that the average existing equipment would naturally be replaced with code level equipment.

more limited than with retrofit measures, and successfully intervening in the market at the appropriate time can be challenging.

New construction & renovation – This includes measures that are installed in new buildings, or those undergoing major renovation, that are above the applicable energy code. This can include, for example, a high-efficiency furnace. The baseline energy use is typically the currently applicable standard or code for the measure.

Step 3: Screen measures for cost-effectiveness

Measures were screened for cost-effectiveness using the societal cost-effectiveness test (SCT), which is the primary test used by the Department for assessing proposed utility programs (see discussion in Chapter 2). The SCT considers the full incremental cost of each measure, whether it is the utility or participant that pays for that cost. For behavioral measures, the estimated cost of running the program was used for screening the measures, since often the measure itself is zero cost. Note that for screening purposes, program administration costs are not included in the initial cost-effectiveness screening. This is because adding or deleting a single measure rarely has a substantial impact on administrative, EM&V, or other non-measure costs.

There are four primary sources of benefits from the measures: avoided energy costs, avoided generation, transmission and distribution capacity costs, and a monetized value for emissions reduction benefits. Shifts in capital replacement cycles were also quantified. The project team attempted to use avoided cost assumptions consistent with existing Department guidance and policy where possible. For example, one of the main assumptions was the use of the current Department-approved societal discount rate of 2.55%, which is the rate used to discount the future value of CIP energy savings and other benefits. Additional assumptions and details of the approach can be found in Appendix A.

Avoided energy costs

For electric utility systems, the value that efficiency brings in reducing energy usage varies with the time period (both the time of day and the season of the year) that the energy reduction occurs. It is generally more valuable to reduce energy during times of high-energy usage than at other times because utilities must draw on increasingly more expensive generation resources to meet the higher demand.

Therefore, the study's model separated avoided energy costs into six time periods, developed from hourly avoided energy costs from selected IOUs. The load shape curves for each measure were used to estimate energy savings during each period, and for peak demand impacts. The model used utility-specific avoided costs for all the IOUs. For the municipal utility regions the model used a weighted average of Southern Minnesota Municipal Power Agency's (SMMPA) and Central Minnesota Municipal Power Agency's (CMMPA) avoided cost data. For the cooperative utility regions the analysis used avoided costs provided by GRE. The time period definitions are shown below in Table 6, along with the average prices in those periods for the start of the study period for SMPPA; the only utility that provided non-trade-secret pricing data (from MISO). Appendix A provides more detail on the approach used to develop the costs for each region.

Table 6. Avoided cost period definitions and average costs for Southern Minnesota Municipal Power Agency (2020 projections).

Period	Period definition	% of total hours for year	Avg price in 2020 ($/MWh)
Summer on-peak	Jun-Aug: weekdays 9 a.m. – 10 p.m.	10%	$30
Summer off-peak	Jun-Aug: weekdays 10 p.m. – 9 a.m.	8%	$17
Winter on-peak	Nov-Mar: weekdays 8 a.m. – 10 p.m.	17%	$26
Winter off-peak	Nov-Mar: weekdays 10 p.m. – 8 a.m.	12%	$19
Shoulder on-peak	Apr-May & Sep-Oct: Weekdays 7 a.m. – 11 p.m. + All weekend days 9 a.m. – 11 p.m.	33%	$27
Shoulder off-peak	Apr-May & Sep-Oct: Weekdays 11 p.m. – 7 a.m. + All weekend days 11 p.m. – 9 a.m.	20%	$16

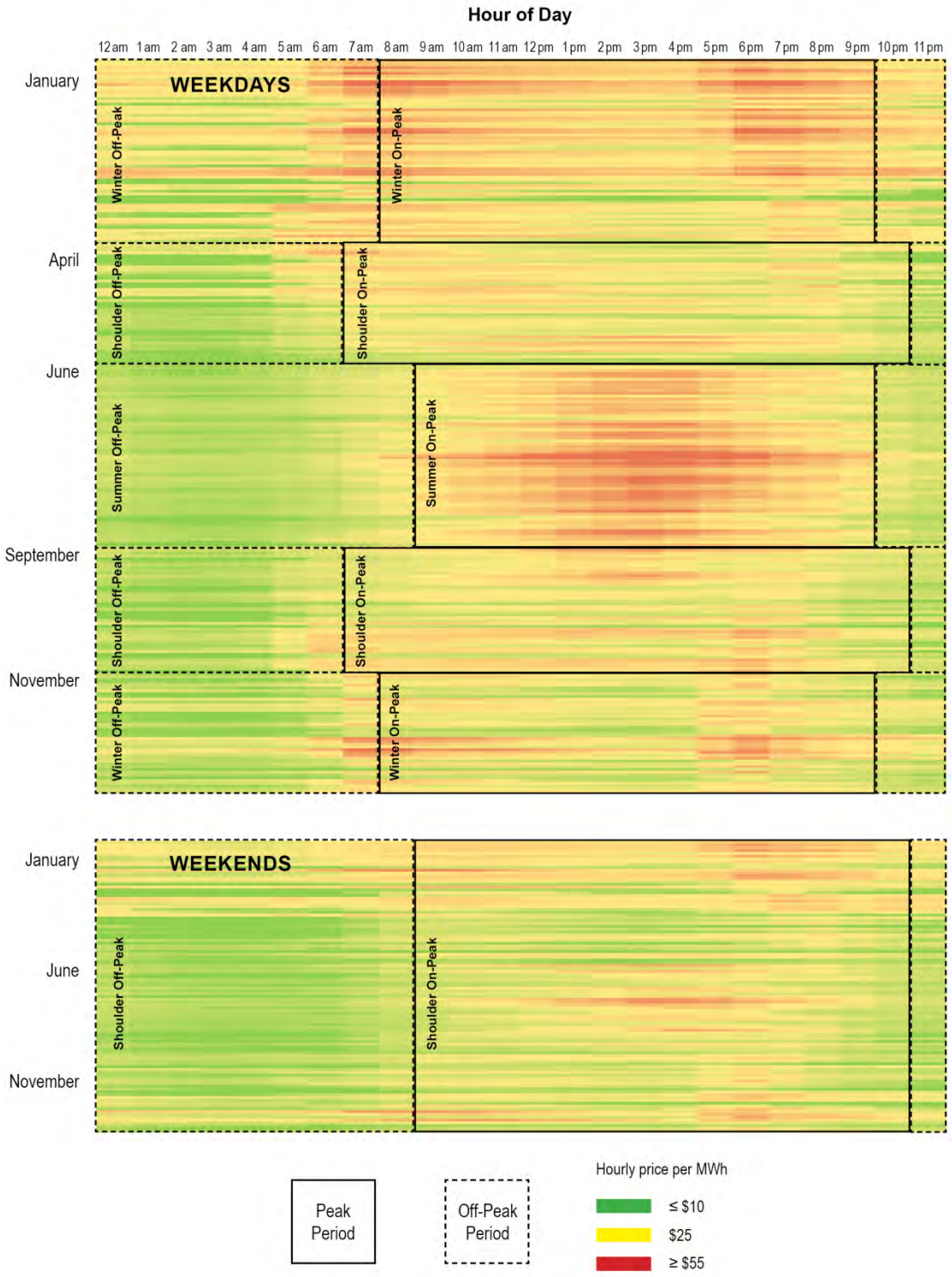
Figure 20 shows these periods superimposed on the (8760) hourly energy prices, for one year of one of the data sets used for the analysis.[41] The boxed areas in the figure represent the peak and off-peak times (summer, winter, and shoulder).

While Minnesota is primarily a summer peaking state (experiencing the highest hourly costs in summer months), northern parts of the state can be winter peaking, and other parts of the state can be close to being winter peaking, due to the high prevalence of electric space heating in some parts of the state. Although SMMPA is in the southern part of the state, you can a prominent price spike in the winter, as shown in Figure 20; although the peak hours are different compared to summer. Winter peaking occurs early the morning, and later in the evening, compared to summer peak periods primarily in the mid-afternoon.[42] Thus, the study's model attempts to capture the price differentials in the summer as well as winter peaks.

[41] Data set received from SMMPA, based on MISO projections of 2020 energy costs.

[42] The difference in hours between winter peaking and summer peaking demonstrated in Figure 20 is perhaps due to the primarily residential nature of winter peaking, compared to the higher commercial A/C load that play a greater role in driving the peak summer periods.

Figure 20. Hourly projected 2020 avoided electricity costs for Southern Minnesota Municipal Power Agency, overlaid with the peak and off-peak periods used for modeling.



For natural gas utilities, the project team used the Department-approved avoided energy and capacity costs for all utilities and regions.[43] The team escalated the avoided commodity costs by the Energy Information Administration's 2017 Annual Energy Outlook estimates of future wholesale natural gas commodity price increases. The 2020 estimated avoided commodity cost for gas is $4.85/Dth.

While avoided gas costs also vary by time period like electricity, the project team analyzed the recent daily commodity price changes and determined that applying daily or period specific costs and impacts at the measure level would yield very little difference in benefits in Minnesota. This likely reflects ample pipeline supply and storage facilities in Minnesota. Therefore, all measures and programs are screened based on annual average costs, consistent with current Department guidance.

Avoided generation capacity costs

For electric utilities, capacity avoided by energy efficiency has traditionally been based on the projected cost to build a new natural gas simple-cycle combustion turbine (CT) generation facility. The project team received utility-specific estimates of this cost from several utilities and used a single weighted-average capacity value of $61.50/kW-yr (2018$). This is based on the assumption that the cost to build a new CT will not likely vary significantly depending on which utility retains ownership, and that utilities can have wholesale transactions between them. Note that since this is a statewide study, the study's model implicitly assumes that there is an avoided capacity value for all the utilities included in this analysis, even though some individual utilities may not need to add capacity for the next decade or more.

Avoided transmission and distribution capacity costs

For the IOU electric utilities, the project team used utility-specific transmission and distribution (T&D), based on constant valuation costs from the most recent Department decision that establishes a consistent methodology statewide for T&D avoided cost estimation.[44] The team used a weighted average of the three IOUs results to represent the northern and southern municipal and cooperative utility models.

While the Department decision for gas utility avoided costs also quantifies peak avoided transmission (pipeline) capacity costs, the Department-approved methodology bundles the capacity costs into the commodity charge based on typical load shapes. The project team also included an additional local distribution system capacity costs based on the Department-approved values for CenterPoint and Minnesota Energy Resources, bundled into a single composite commodity charge.[45] The study, therefore, did not separately estimated gas peak-day impacts and benefits. The total T&D 2020 capacity cost translates into an annual average value of $1.29/Dth (2018$).

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[43] MN EDocket No. G999/CIP-16-36. The project team also relied on this decision for some additional global assumptions, such as inflation and discount rates.

[44] Minnesota Department of Commerce, Decision in Docket No. E999/CIP-16-541, September 29, 2017. Note that while the Decision calls for use of the discrete choice T&D cost estimations for the current 2017-2019 plan, the project team deemed these less appropriate than the constant valuation estimations for a longer term potential study.

[45] Both CenterPoint Energy and Minnesota Energy Resources provided identical distribution capacity cost estimates, so they were applied statewide.

Avoided emissions

The benefits of cleaner air because of avoided criteria pollutants[46] and carbon dioxide (CO_2) have long been included as a benefit in CIP. The project team updated the values used for these pollutants based on the latest MPUC ruling on externalities in the power generation sector, per guidance from the Department. Although not currently in the most recent Department guidance document, the Department expects to include these values in a future version of its guidance document.[47] These are the same values that are applied in Integrated Resource Planning proceedings before the MPUC.[48] The study's model used a single state-wide value[49] for calculating the emissions intensity in lbs/MWh, which resulted in a total value of $17.65/MWh for electric, and $1.84/Dth for gas (2018$). Of the total emissions factor, CO_2 represents 74% of the total impact for electric, and 84% of the impact for gas.

While emissions rates for electric can be expected to decline over the study period as the grid becomes increasingly powered by renewables, the project team did not attempt to model this in this study. The model could not easily accommodate this, and the team did not have good data on projected statewide emissions declines over the study period. Based on existing filed Integrated Resource Plans, the statewide CO_2 emissions rate is expected to decrease 12% from 2020 to 2029.[50]

Other than avoided emissions benefits, no other non-energy benefits were included in the modeling, even though water benefits and benefits from reduced maintenance are allowable under current CIP guidance, and used by some utilities in their calculation of net benefits.

Step 4: Estimate program budgets and measure penetrations

The project team defined two achievable scenarios — a "maximum achievable" scenario and a constrained "program potential" assuming 50% of the measure costs on average are covered by programs, with a 50% customer contribution. The maximum achievable scenario assumes that 100% of the incremental measure cost was covered by programs with no customer contribution. While in theory a program could provide even larger financial incentives, this is unlikely for numerous policy reasons and it is common practice to assume 100% cost coverage for maximum achievable potential scenarios. In practice, there are many reasons why rebating 100% of the measure cost may not be desirable, so the project team also analyzed a scenario that assumes 50% of the measure costs are covered by the program, which is more consistent with current Minnesota program planning.

For all achievable scenarios, the study did not model specific, detailed program designs. Rather, measures were bundled into appropriate broad program markets, which collectively cover all efficiency

[46] Criterial pollutants in include sulfur dioxide (SO_2), particular matter less than 2.5 microns ($PM_{2.5}$), carbon monoxide (CO), oxides of nitrogen (NO_x), and lead (Pb).

[47] The last guidance document, for natural gas utilities, was released in 2016. Docket No. G999/CIP-16-36, "In the matter of Inputs to BENCOST for Natural Gas 2017-2019, Conservation Improvement Program," February 19, 2016.

[48] MPUC Docket No. 15-21, Xcel Energy 2015 Integrated Resource Planning Docket.

[49] MPUC Docket No. 14-643, Order Updating Environmental Cost Values. https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={5066BD60-0000-C71B-9B5B-305CF65BCAE1}&documentTitle=20181-138585-01.

[50] See Table 19 for projected statewide emissions rates, and footnote 61 for description of how this was calculated.

opportunities and do not include any double counting. For example, the study distinguished between new and existing buildings, between retrofit and market driven opportunities, and by particular market segments. The project team assumed well designed, marketed, and implemented programs, with optimal administrative and delivery frameworks to support success. The team recognizes that this implicitly assumes some coordination, or more likely, jointly delivered efforts spanning across utility territories and fuels to provide consistent market messages and benefits from appropriate economies of scale.[51]

In addition to financial incentives, there are administrative, marketing, technical support, and other costs to running programs. The project team estimated program budgets based on benchmarking typical ratios of measure-related to non-measure-related spending by Minnesota and other utilities.

The study's model projected annual penetration rates for each measure based on a market adoption model, which requires measure-specific awareness and willingness-to-adopt factors as inputs. The determination of individual measure awareness, willingness, and overall market penetration potential was informed by a review of Minnesota — and other national programs, other program literature and evaluations, and the levels of financial and non-financial barriers associated with each measure. The implicit participant cost-benefit is another factor used in the adoption model (e.g., the more cost-effective to the participant, the higher market adoption). This is discussed further in Appendix A.

Step 5: Calculate total savings and net benefits

The model applies all the inputs developed as discussed above (and in more detail in Appendix A), and performs year-by-year calculations to roll up all impacts, costs, and benefits; applying the appropriate penetrations to each set of measure and load inputs for all 3,278 measures. The model accounts for the rolling impact over time of building and equipment stock and associated load adjustments based on prior measures assumed to be adopted. It also accounts for measure interaction and mutual exclusivity with other measures.

[51] For example, the project team implicitly assumed that a small muni still has the maximum achievable because it could contract to deliver programs through third parties, or aggregate its programs with other smaller utilities to achieve scale.

Table 7. Summary of major data sources used for each step of potential study.

	1. Forecast sales & disaggregate energy load	2. Characterize the energy efficiency measures	3. Screen for cost-effectiveness	4. Estimate program budgets and measure penetrations
Utility-provided load forecasts from the IOUs and several municipal and cooperative utility aggregators	•			
Primary data collected for this study	•	•		•
Other available Minnesota studies, such as CARD-funded energy-use characterization studies	•	•		
Other available studies from outside Minnesota, with a preference for those in neighboring states	•	•		
U.S. Department of Energy, Energy Information Agency data on 2016 utility load	•			
Sales data by customer type reported by utilities to the State of Minnesota	•			
American Community Survey and other U.S. Census data for Minnesota	•			
Commercial Building Energy Consumption Survey (2015) (CBECS) for the Northern Midwest region, U.S. Energy Information Agency	•	•		
Residential Energy Consumption Survey (2015) (RECS) for the Northern Midwest region, U.S. Energy Information	•	•		
Manufacturing Energy Consumption Survey (2015) (MECS) U.S. Energy Information Agency	•			
Minnesota Technical Reference Manual, version 2.0		•		
Current and likely future codes & standards		•		•
Baseline and appliance saturation surveys		•		•
Utility-specific assumptions found in utility Triennial CIP plans		•		•
Utility-specific program evaluations or other data sources		•		•
Weather data		•		
Engineering analyses		•		
Utility-specific avoided energy costs for each hour of the year (if available)			•	
Department of Commerce assumptions for cost-effectiveness screening			•	
Utility-provided avoided capacity costs			•	
Historical CIP information on program achievements and budgets				•

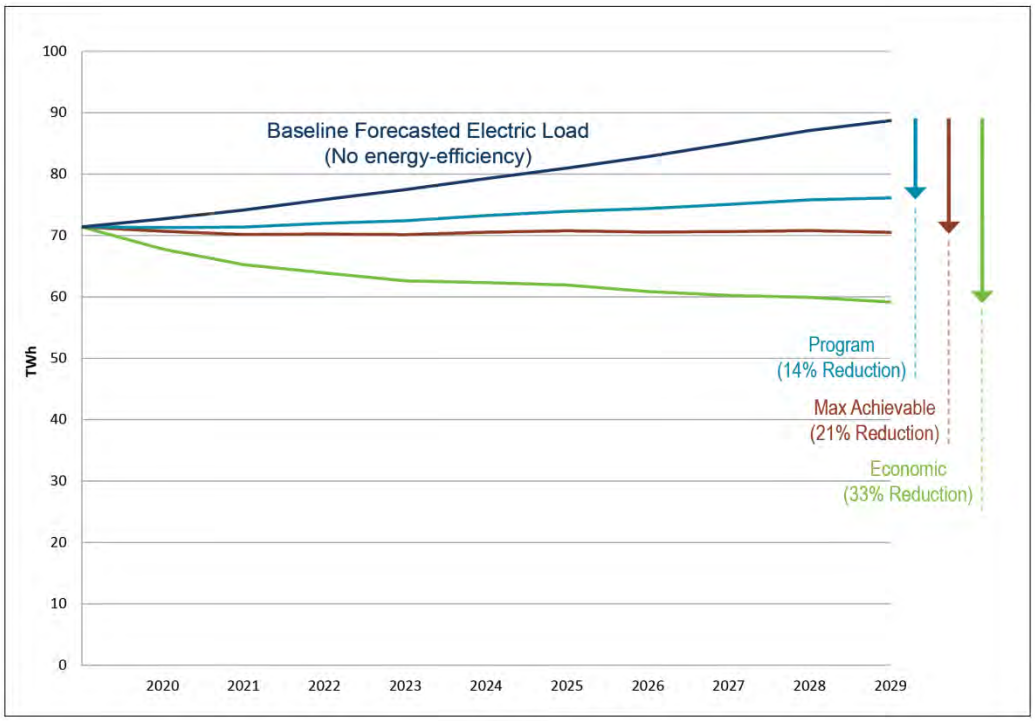
Chapter 4: Results

Below, modeling results are provided with a focus on the program potential.[52] Detailed results for each of the geographic regions modeled for the study are available in Appendix B.

Electric potential

Statewide, the study estimates that the state could economically decrease forecasted electric load by 33%, with program potential to reduce load by 14% in 2029 (Figure 21). In other words, the modeling suggests that the program scenario will be able to capture just under half of the total economic potential.

Figure 21. Cumulative annual electric energy savings potential compared to forecasted load for economic, max achievable, and program scenarios.



[52] Note that the project team does not present technical potential here, as it is more of a stepping stone to economic potential and not meaningful to readers in and of itself — as discussed in the methodology chapter, the *true* technical potential (not modeled here) would include wildly uneconomic measures that would result in a technical potential of saving energy that would approach 100%. In contrast, the model only included measures that had a possibility of being economic measures.

The incremental annual program savings ranges from around 1.5% in the initial part of the decade, leveling off at around 1.9% near the end of the decade, with maximum achievable potential in the range of 2.0% to 2.9% (Table 8).[53] There is a slight dip in achievements in 2022 because of the elimination of lighting savings due to lighting standards that go into effect in 2021,[54] which then rises as non-lighting measures start to take hold after 2022. Since the model assumed equal program success across utility territories, there is very little difference in potential between the IOUs and COUs, with the slight difference due to differences in their overall customer mix.

Note that the total of the incremental annual savings for 2020-2029 in Table 8 does not add up to the cumulative annual potential shown in Figure 21. This is because not all measures installed during that period have a lifetime that extends to 2029 (for example, behavioral measures have a one-year lifetime in the model), resulting in some measures not contributing to the cumulative efficiency potential in that year.

Table 8. Incremental annual electric energy savings from maximum achievable and program scenarios as a percentage of total sales.

	Investor-Owned Utilities		Cooperative Utilities		Municipal Utilities	
Year	Max achievable	Program	Max achievable	Program	Max achievable	Program
2020	2.6%	1.8%	2.4%	1.7%	2.4%	1.7%
2021	2.9%	2.0%	2.7%	1.9%	2.7%	1.9%
2022	2.4%	1.6%	2.0%	1.4%	2.3%	1.5%
2023	2.6%	1.8%	2.3%	1.6%	2.4%	1.7%
2024	2.8%	1.9%	2.4%	1.7%	2.5%	1.8%
2025	2.8%	1.9%	2.5%	1.7%	2.5%	1.8%
2026	2.8%	2.0%	2.4%	1.7%	2.6%	1.8%
2027	2.9%	2.0%	2.4%	1.7%	2.5%	1.8%
2028	2.9%	2.0%	2.4%	1.7%	2.5%	1.7%
2029	2.8%	1.9%	2.4%	1.7%	2.5%	1.7%
10-year average	**2.7%**	**1.9%**	**2.4%**	**1.7%**	**2.5%**	**1.7%**

[53] Consistent with how behavioral savings are counted by utilities now, the "average savings methodology" was applied to (only) residential behavioral measures. (For full discussion of this issue, see pg. 81-94, "Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines," Illume, et. al, a CARD project. Available at: http://mn.gov/commerce-stat/pdfs/card-report-energy-efficiency-behavorial-prog.pdf). The application of the average savings method lowered incremental potential about 10% a year. For comparison, the 10-year incremental average for the program scenario, without applying the average savings method, would be 2.0% for IOUs, 2.0% for cooperative utilities, and 1.9% for municipal utilities; for the maximum achievable scenario, savings would be 3.0% for IOUs, 2.8% for cooperative utilities, and 2.7% for municipal utilities.

[54] This is the EISA (Energy Independence and Security Act of 2007) standards. There is still some debate as to how much and how soon this would impact energy-efficiency programs, with some utilities planning for a more gradual phase-out, but the project team conservatively assumed no savings from screw-in bulbs after 2021 in this study's modeling.

Table 9. Incremental annual electric energy savings in gigawatt-hours from maximum achievable and program scenarios.

	Investor-Owned Utilities		Cooperative Utilities		Municipal Utilities	
Year	Max achievable	Program	Max achievable	Program	Max achievable	Program
2020	1,050	720	470	330	300	210
2021	1,190	820	550	390	360	250
2022	1,000	690	420	290	300	210
2023	1,100	750	480	340	330	230
2024	1,200	830	530	380	360	250
2025	1,230	850	560	390	370	260
2026	1,270	870	560	400	380	270
2027	1,320	910	580	410	390	270
2028	1,360	940	590	420	400	280
2029	1,300	890	600	420	410	280

Within the residential sector, the space heating end use is responsible for nearly 40% of residential cumulative savings at the end of the study period, while lighting declines to a small fraction of total savings (Figure 22). Although only 17% of residential customers have electric space heating, these customers use substantial amounts of energy to heat their homes, and there is a large opportunity for energy savings in these homes. The single-largest measures driving these savings are air source heat pumps (Figure 23).[55] Appliances are the next largest end use, in total (with space heating) accounting for over half of total potential.

Within the C&I sector, lighting, refrigeration, and system energy account for approximately 60% of total cumulative program potential savings in 2029 (Figure 22). While lighting still remains the largest source of savings for the commercial and industrial sector, it declines from well over half of potential in most utilities current portfolios, to just over 20% in 2029. System energy includes whole-building measures that address multiple end uses, and includes savings from measures like integrated building design and advanced building controls.

[55] The multifamily segment makes up 18 percent of the total space heating savings, and 16 percent of the total air-source heat pump savings.

Figure 22: Cumulative annual electric energy savings by end use in 2029 as a percentage of total savings for the residential and commercial & industrial sectors (program scenario).

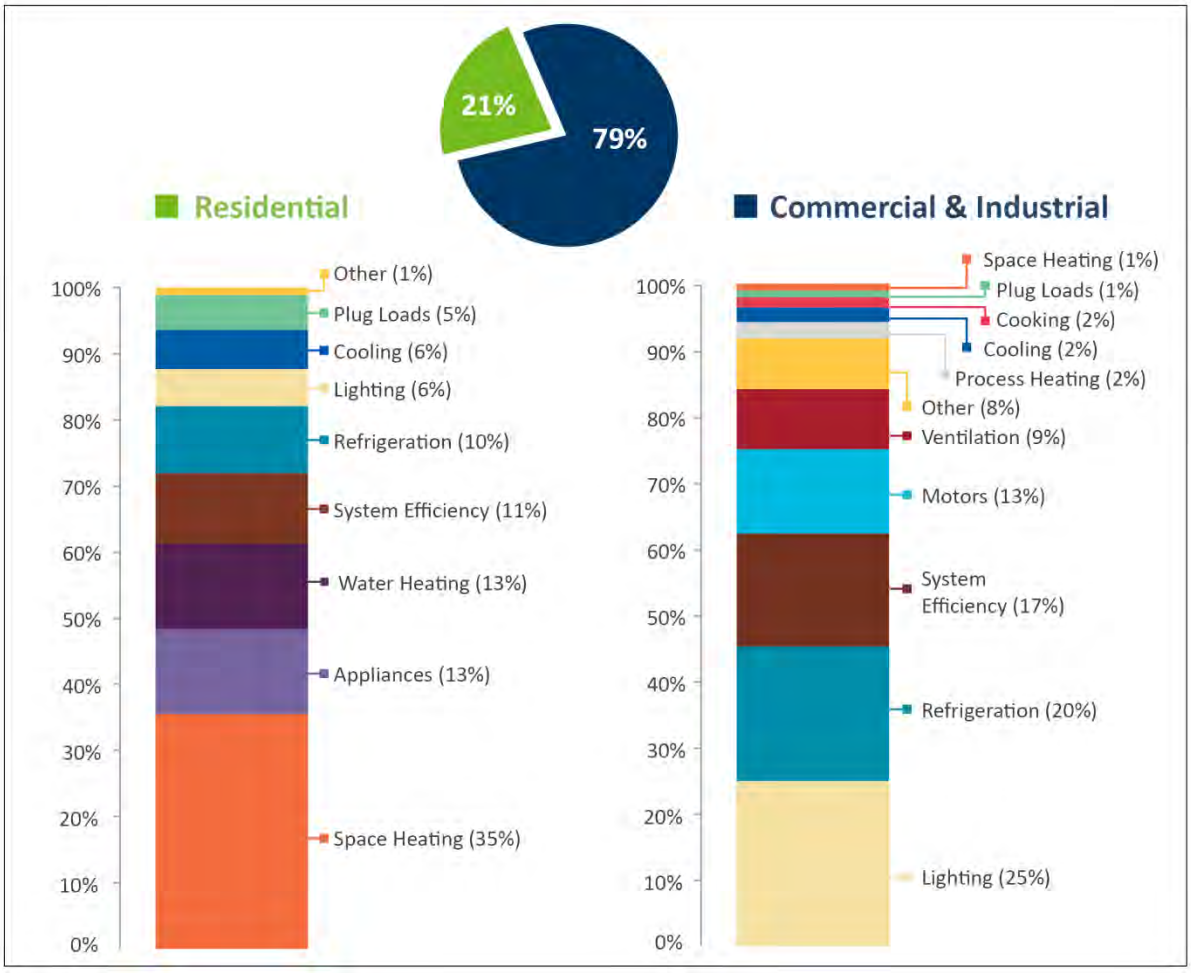


Figure 23. Breakout of measure types within residential electric space heating, 2029 cumulative annual savings, program scenario.

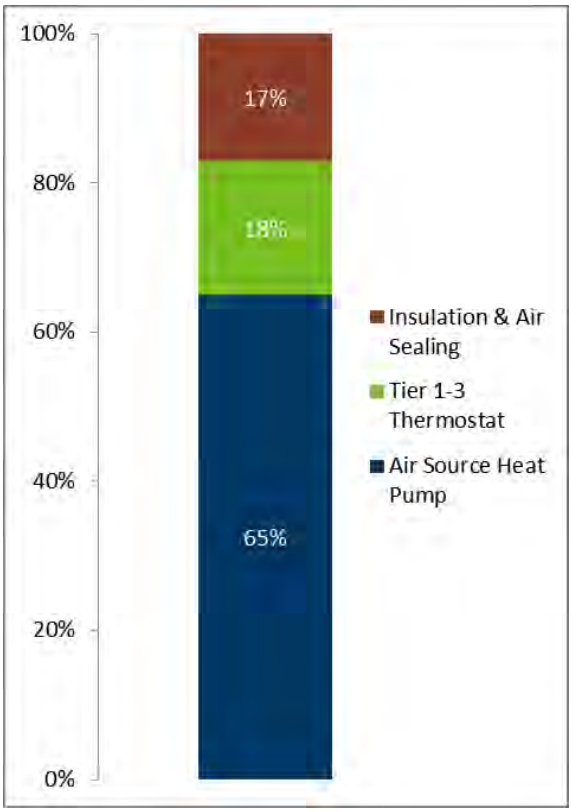


Figure 24 shows the potential organized by building type. Within the building types modeled for this study, industrial has the largest potential, followed by single-family and healthcare.

Figure 24. Cumulative annual electric energy savings in 2029 by building type segment, program scenario.

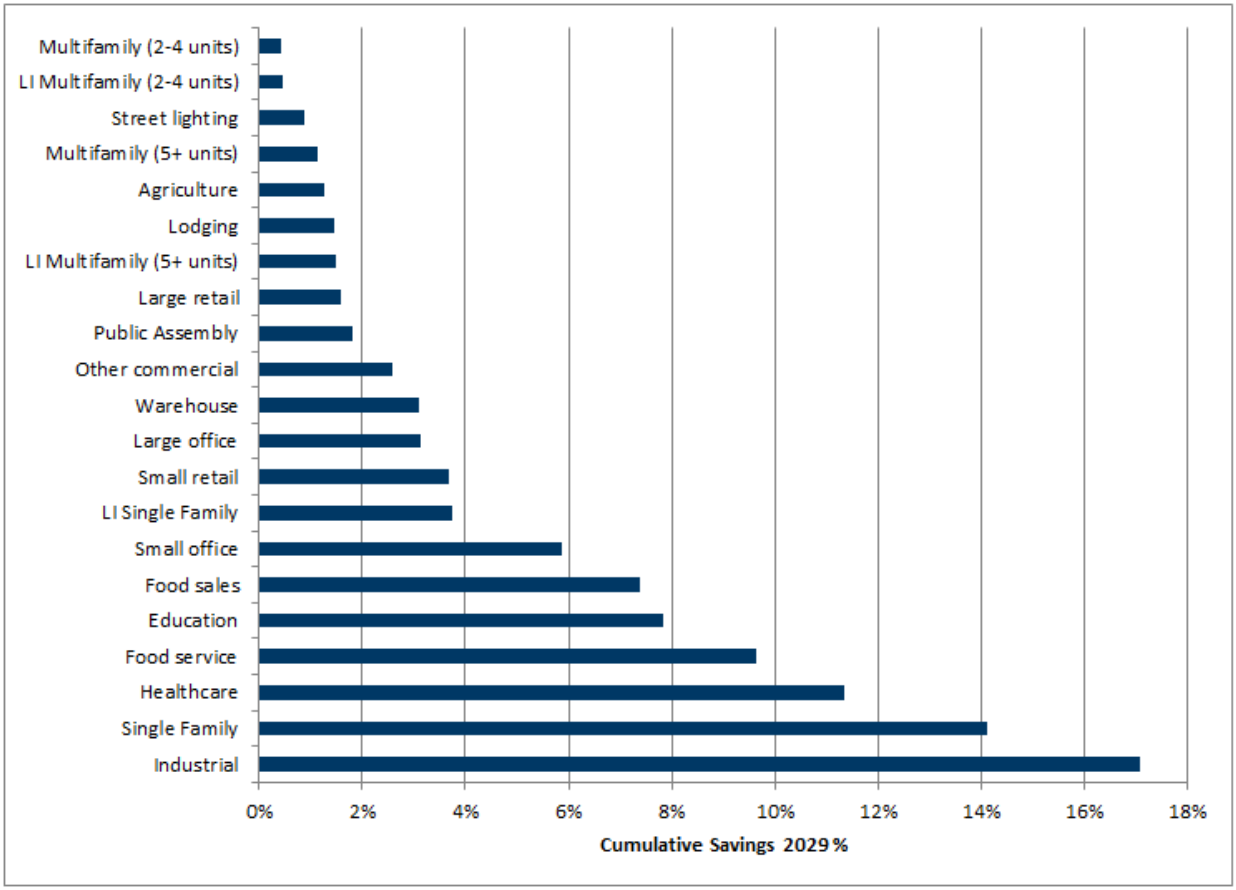


Table 10 and Table 11 present the top residential and commercial electric measures, respectively, each of which is described in the text below.

Table 10. Top residential electric measures, program scenario.

Residential measure name	Cumulative annual 2029 energy (MWh) savings	Percent of total residential energy savings potential
Cold climate ductless mini-split air source heat pump	356,000	13%
Tier 1-3 thermostat	258,000	10%
ES clothes washer	240,000	9%
Cold climate central air-source heat pump	230,000	9%
Home energy reports	227,000	9%
Fridge and freezer removal	159,000	6%
Advanced power strip	146,000	5%
Water heater insulation	142,000	6%
ES refrigerator & freezer	109,000	4%
Attic insulation & air sealing	109,000	4%

Cold climate ductless mini-split air source heat pump: This measure applies to Minnesota households that use electric resistance baseboards as their main heating source. This technology saves energy by transferring heat from outside the home to the inside via a vapor-compression cycle – the same technology used by refrigerators and air conditioners. Thus, by moving (and not creating) heat, these systems are able to produce more heat energy into the house than the energy required to run the heat pump, resulting in system efficiencies (energy output per unit of input energy, or the coefficient of performance) greater than 100%. Some of the rated efficiencies (under optimal conditions) are as high as 400% for new ASHPs. A backup heating source is typically needed for this technology when used for space heating, as their efficiencies are lowest at lower temperatures when the most heating output is needed. Recent advances in cold climate, high-efficiency versions of this technology allow useful heat energy to be extracted at temperatures of -10 degrees or lower. The project team assumes the existing electric baseboard heat remains and is used for back-up heat. Ductless mini-splits can be used for cooling as well, at efficiencies that are substantially greater than typical air conditioning systems; they have an outside unit, similar to a central air conditioner which connects to the inside with a “header” that supplies heating and cooling to a single room (Figure 26). Multiple units can be installed to heat or cool multiple, or all, rooms in a single house or apartment.

This technology is applicable to housing units that use electric baseboard. This includes most of the electrically heated multifamily units in the state, which are predominantly rental units. As typically the tenants, and not the building owner, pay the electric bills for these multifamily buildings, this creates an additional barrier (the “split incentive”) for programs promoting this technology. Thus, the adoption rates in the modeling are substantially lower for the multifamily sector than the single-family sector for this technology. As shown in Figure 25, the largest fraction of electrically heated homes is in the northwest part of the state.

Figure 25. Electric home heating percentages in Minnesota utility territories.

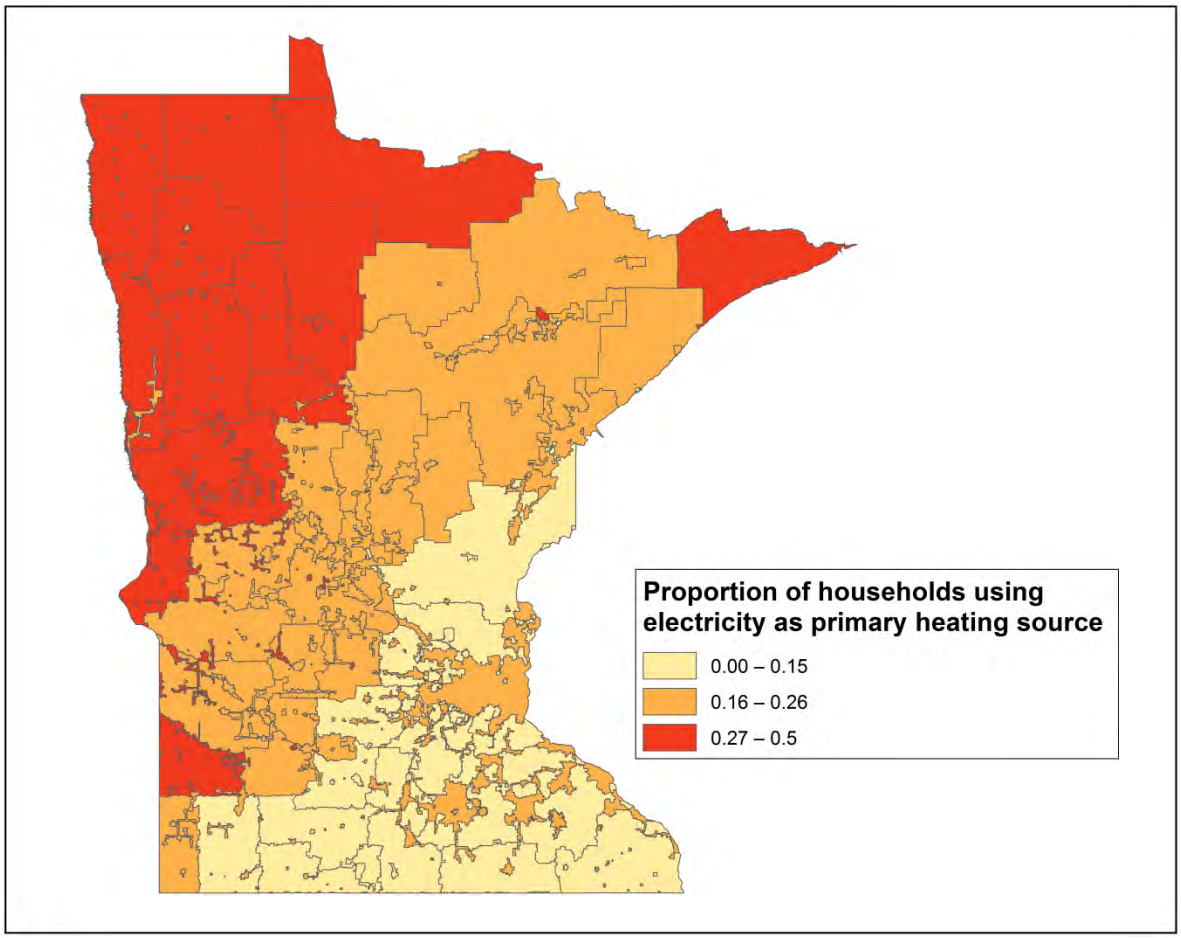
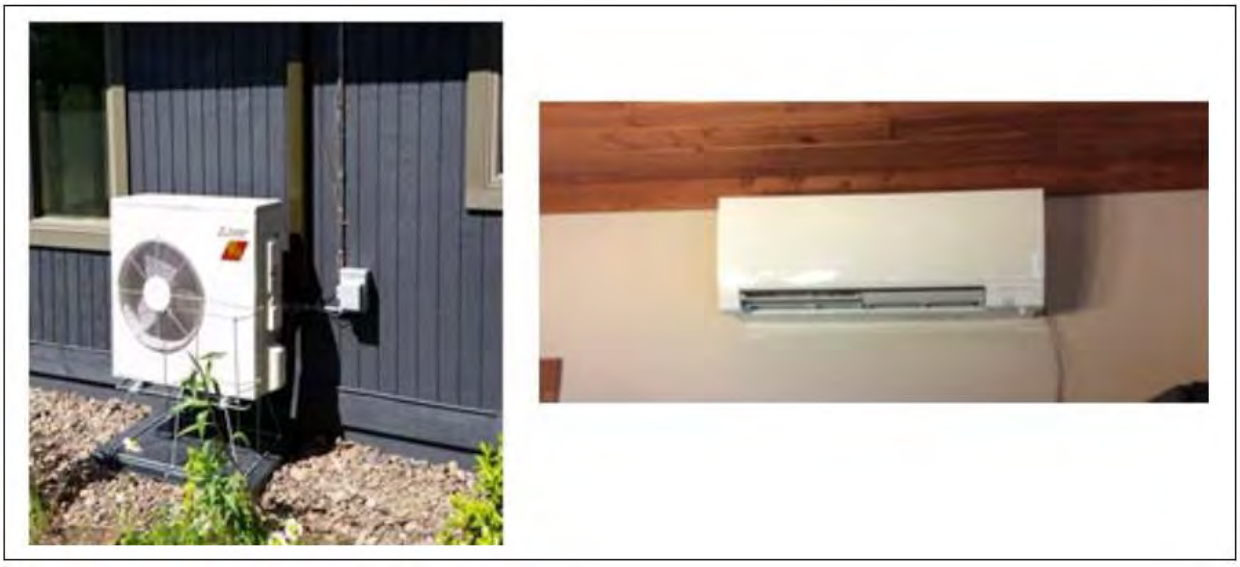
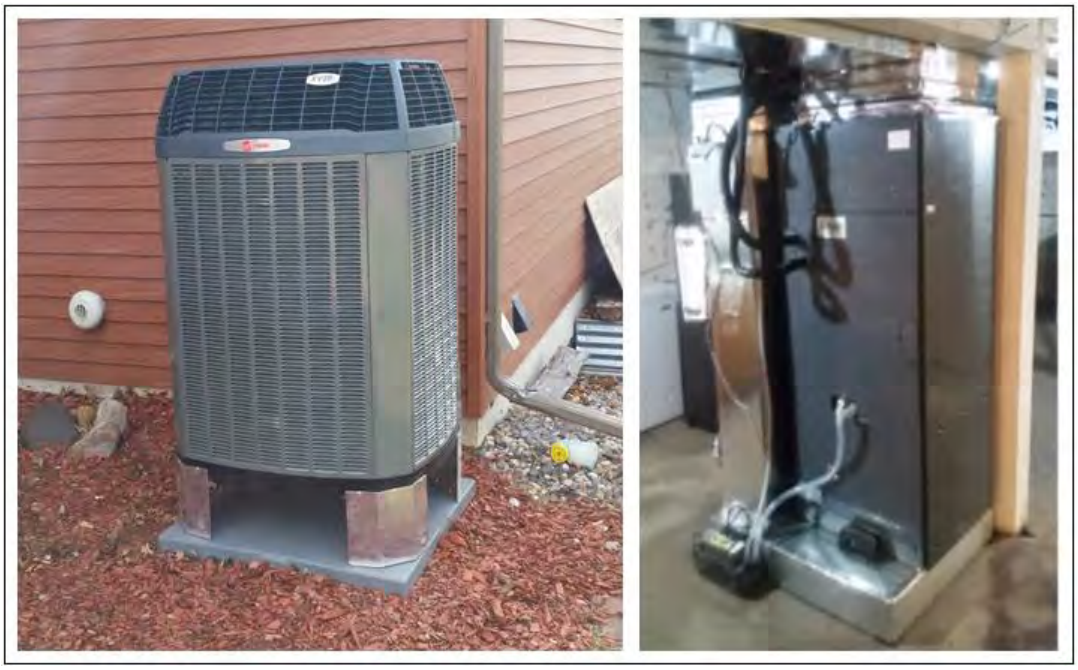


Figure 26. Example of installed cold climate ductless mini-split air-source heat pump.



Cold climate central air source heat pump: This measure is either replacing an electric furnace central heating system with an ASHP or a higher efficiency option when installing a baseline efficiency ASHP. ASHP's work similarly to a ductless mini-split heat pump system — but can heat the whole home with one system — similar to a forced air natural gas furnace (Figure 27). The home needs to have an existing duct system to implement this technology. Savings of over 50% are possible for this technology. A backup heating source is generally needed with a central air source heat pump. This technology can also efficiently cool homes as well, offering savings over typical central A/C systems.

Figure 27. Example of installed cold climate central air-source heat pump



Tier 1-3 thermostat: A tier 3 thermostat, or smart thermostat, is a Wi-Fi enabled thermostat that has analytical capabilities that 'learn' a customer's temperature preferences, can adjust temperature to weather forecasts, and adjust temperature when a person is out of the house. The customer can also save energy by scheduling temperature and setting or changing temperature while the customer is out of the home. A tier 2 thermostat is able to be controlled and scheduled through Wi-Fi devices but does not have analytical capabilities. A tier 1 thermostat is a programmable thermostat that cannot connect to the Internet.

ENERGY STAR clothes washer: An ENERGY STAR clothes washer uses less water and electricity than a baseline model. ENERGY STAR clothes washers typically have sensors to reduce water usage and increase spin times to reduce drying time.

Home energy reports: This is a behavioral measure targeting the highest 20% energy users with home energy reports. These reports describe the customer's energy usage and compare them to their 'neighbor's energy usage.' Numerous studies have shown that these reports save energy by motivating people to cut down their energy consumption through conservation or efficient product upgrades.

Fridge and freezer removal: A majority of homes in Minnesota use a secondary fridge or freezer; these units are usually older and often substantially less efficient than the home's main fridge or freezer. Thus, a large energy savings opportunity is realized when homeowners decide to retire their secondary fridge or freezer through a utility program. One concern brought up by advisory committee members with this type of program design is that participants could be 'free-riders,' meaning they were already planning to get rid of their old fridge and participated in the program because of the free recycling and rebate. Studies have shown that typical free ridership for these programs are around 50 – 70%. Utilities may need to design their programs to limit free ridership, or adjust baseline savings to account for free riders. The project team limited participation in the program scenario modeling but did not adjust baseline savings.

Attic insulation & air sealing: Adding insulation & air sealing in the attic greatly increases the efficiency of the home because the majority of heat energy lost in the home is through the attic, if poorly insulated. This measure saves both electric space heating and space cooling energy.

Advanced power strips: The advanced analytics built into the power strip achieve energy savings by powering off devices when they are not in use. For example, a cable box, television, gaming system, and a charger could all be automatically disconnected from the power source by the advanced power strip when the devices are not in use. This is achieved through electronic sensors that power down devices after a period of time. The Minnesota Technical Reference Manual shows that a tier 2 power strip has the potential to reduce plug load consumption by 30%.

Water heater insulation: This measure saves energy by installing an insulating water heater jacket over an existing electric water heater without adequate insulation. This saves energy by reducing the amount of hot water energy that is "lost" during water heater standby times

Energy Star refrigerator & freezer: Upgrading to an ENERGY STAR model refrigeration at the time of purchases can energy when compared to the federal minimum energy efficiency standard. ENERGY STAR models typically have better insulation to prevent heat loss and more efficient cooling evaporators.

Table 11: Top commercial electric measures, program scenario.

Measure name	Cumulative annual 2029 energy (MWh) savings	Percent of total commercial energy savings potential
Integrated Building Design	797,000	10%
Variable Speed Drive	789,000	10%
Improved Lighting Design	489,000	6%
Integrated Lighting Controls	482,000	6%
High-efficiency Small Walk-In	458,000	6%
Deep Energy Retrofit	318,000	4%
LED Tube Replacement Lamps	304,000	4%
Evaporator Fan Speed Controls	295,000	4%
ECM Fan Motors	292,000	4%
High-efficiency built-up refrigeration	260,000	3%

Variable speed drive: Variable speed drives are an energy efficient technology that save energy by reducing electric motor speeds to match system requirements. Variable speed drives are commonly used in HVAC and process load applications.

***Integrated building design*:** Reflects comprehensive and optimized design of new buildings and large-scale renovations, addressing all end uses and interactions between them on a systems basis. Measures include improved air barrier performance, minimum IAQ performance, lighting controls, improved lighting power density, improved mechanical equipment efficiency, demand-controlled ventilation, and other measures. This measure is similar to Xcel Energy's Energy Design Assistance program.

***Improved lighting design*:** Improved lighting, including switching from fluorescent to LED lighting, has historically been one of the most important utility run energy efficiency programs in terms of total energy savings. This measure includes the application of emerging lighting technology and design principles in new construction, including LEDs, daylighting, advanced lighting controls, and fixture layouts.

Integrated lighting controls: Installation of fixture integrated controls to adjust for scheduling, occupancy, varying lighting needs, daylight, and system maintenance. This saves energy by lowering the amount of time lights are on and/or the power draw of the fixture.

High-efficiency small walk-In: Refrigeration equipment for businesses such as grocery stores, convenience stores, and restaurants can account for as much as 60% of electricity consumption. This measure targets this end use with the installation of a high-efficiency small walk-in fridge or freezer, including economizers and evaporator fans (Figure 28).

Figure 28. Example of a high-efficiency commercial walk in refrigerator.



Deep energy retrofit: This is a bundle of measures that is intended to target buildings going under major renovations to add additional energy efficiency measures while the building is already undergoing significant capital improvement. These measures may include adding insulation, improving windows, adding lighting control system, or installing more efficient heating, ventilation, and air conditioning (HVAC) systems.

***LED tube replacement lamps*:** This includes retrofits of fluorescent lamps with LED tubes. Linear fluorescent technology makes up a significant fraction of all commercial lighting energy use.

Evaporator fan speed controls: Replacement of an existing, working standard-efficiency shaded-pole evaporator fan motor in refrigerated/freezer display cases or walk-in coolers with a high-efficiency electronically commutated motor (ECM) and controls to minimize operation.

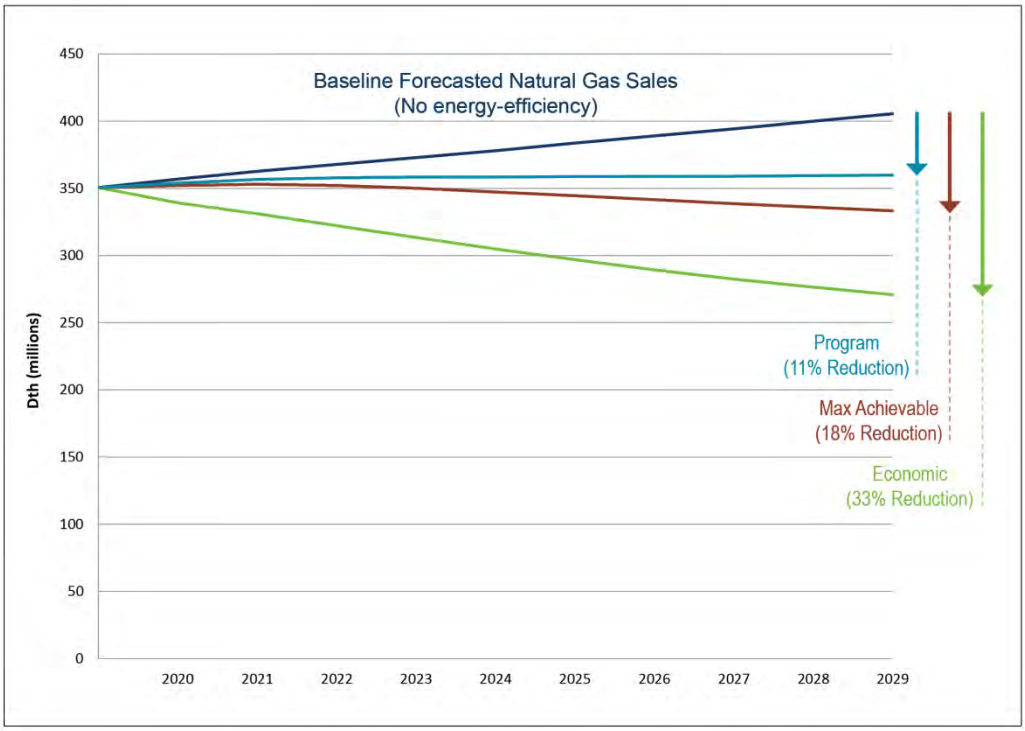
ECM fan motor: An electronically commutated motor (ECM) fan motor is applied within fan-powered terminal boxes, fan coils, and HVAC supply fans on small unitary equipment. ECM motors are more efficient than standard motors because fan speed can be adjusted according to demand (note the project team assumes ECMs are now baseline efficiency for residential furnaces).

High-efficiency built-up refrigeration: This is a bundle of measures that apply to large refrigeration systems for grocery stores and refrigerated warehouses. It includes high-efficiency compressors, better design and controls, high-efficiency motors and variable frequency drives to improve the efficiency of the entire refrigeration system.

Natural gas potential

For natural gas, the study estimates the state could economically decrease forecasted loads by 33%, with program potential to reduce load by 11% in 2029 (Figure 29). Thus, the modeling estimates that about one-third of total economic potential could be captured in the program scenario.

Figure 29. Cumulative annual natural gas energy savings potential compared to forecasted sales for economic, max achievable, and program scenarios.



The incremental annual natural gas savings increases from 0.7% in 2020, and levels off at 1.4% of annual sales around the middle of the decade for program potential (Table 12). Maximum achievable potential starts at 1.2% and increases to 2.3% of annual savings over the study period.[56]

[56] As with electric potential, and consistent with how behavioral savings are counted by utilities now, the "average savings methodology" was applied to residential behavioral measures. This lowered incremental potential about 10% a year. For comparison, without this adjustment, the un-adjusted 10-year average annual incremental savings would be 1.3 percent for the program scenario, and 2.1 percent for the maximum achievable scenario.

Table 12. Incremental annual natural gas energy savings from maximum achievable and program scenarios as a percentage of total sales.

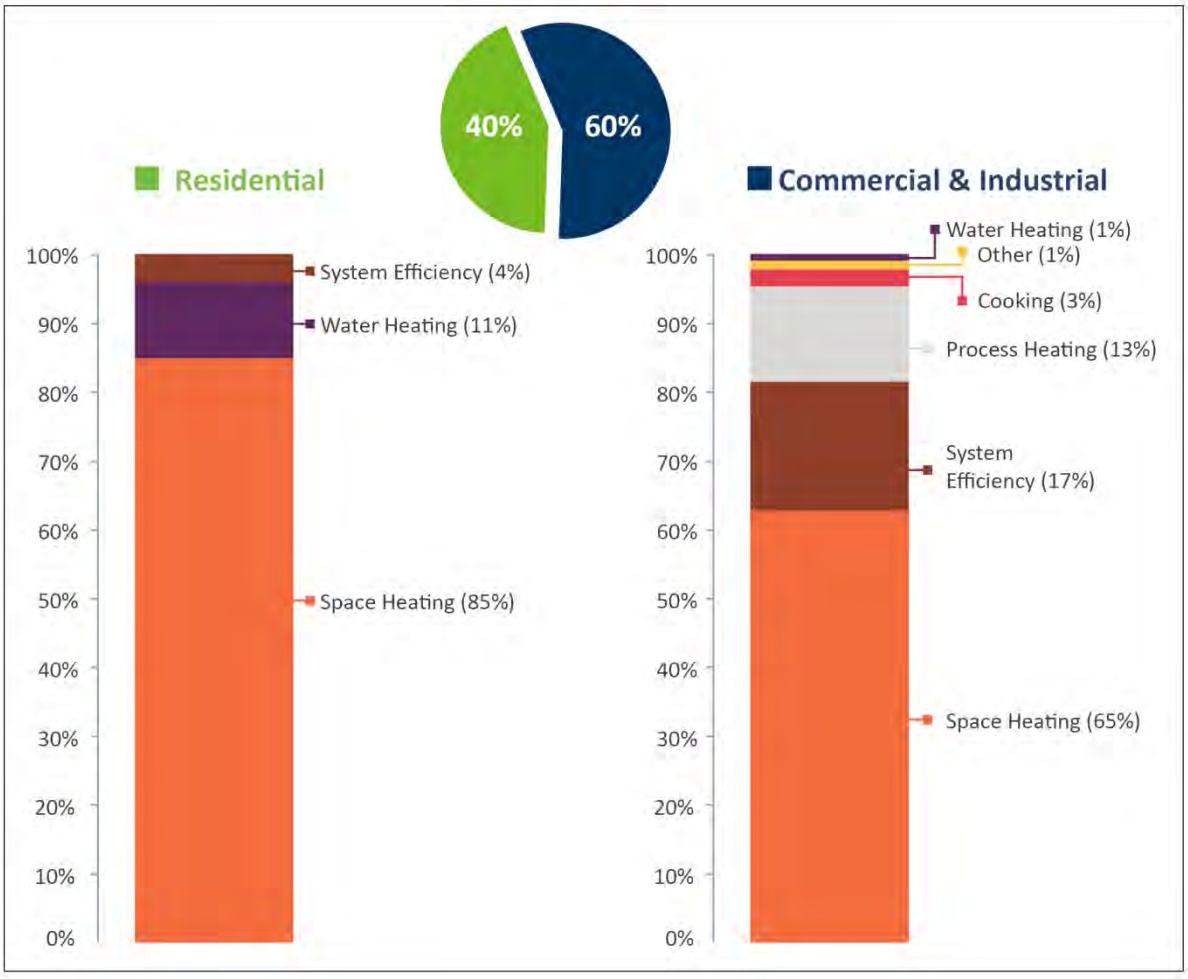
	All utilities	
Year	Max achievable	Program
2020	1.2%	0.7%
2021	1.4%	0.9%
2022	1.7%	1.1%
2023	2.0%	1.2%
2024	2.2%	1.4%
2025	2.2%	1.4%
2026	2.2%	1.4%
2027	2.3%	1.4%
2028	2.3%	1.4%
2029	2.3%	1.5%
Average	**2.0%**	**1.2%**

Table 13. Incremental annual natural gas energy savings from maximum achievable and program scenarios in thousands of dekatherms.

	All utilities	
Year	Max achievable	Program
2020	4,200	2,700
2021	5,100	3,300
2022	6,300	4,000
2023	7,300	4,600
2024	8,300	5,200
2025	8,500	5,400
2026	8,700	5,500
2027	8,900	5,600
2028	9,200	5,800
2029	9,500	5,900

Space heating dominates the end use potential for the residential as well as the commercial and industrial sectors (Figure 30). While the commercial/industrial sector still represents the majority of potential savings, the residential sector is nearly as important, representing 40% of total savings (well above the residential portion of total natural gas sales).

Figure 30. Cumulative annual natural gas energy savings by end use in 2029 as a percentage of total savings for the residential and commercial & industrial sectors (program scenario).



Reflecting the importance of the residential sector, single family represents the single largest source potential – over 30% – among the building types modeled for this study, followed by industrial and healthcare (Figure 31).[57]

[57] Note that for single family and small multifamily the study treats low-income and non-low-income separately.

Figure 31. Cumulative annual natural gas energy savings in 2029 by segment as a percentage of total natural gas energy savings, program scenario.

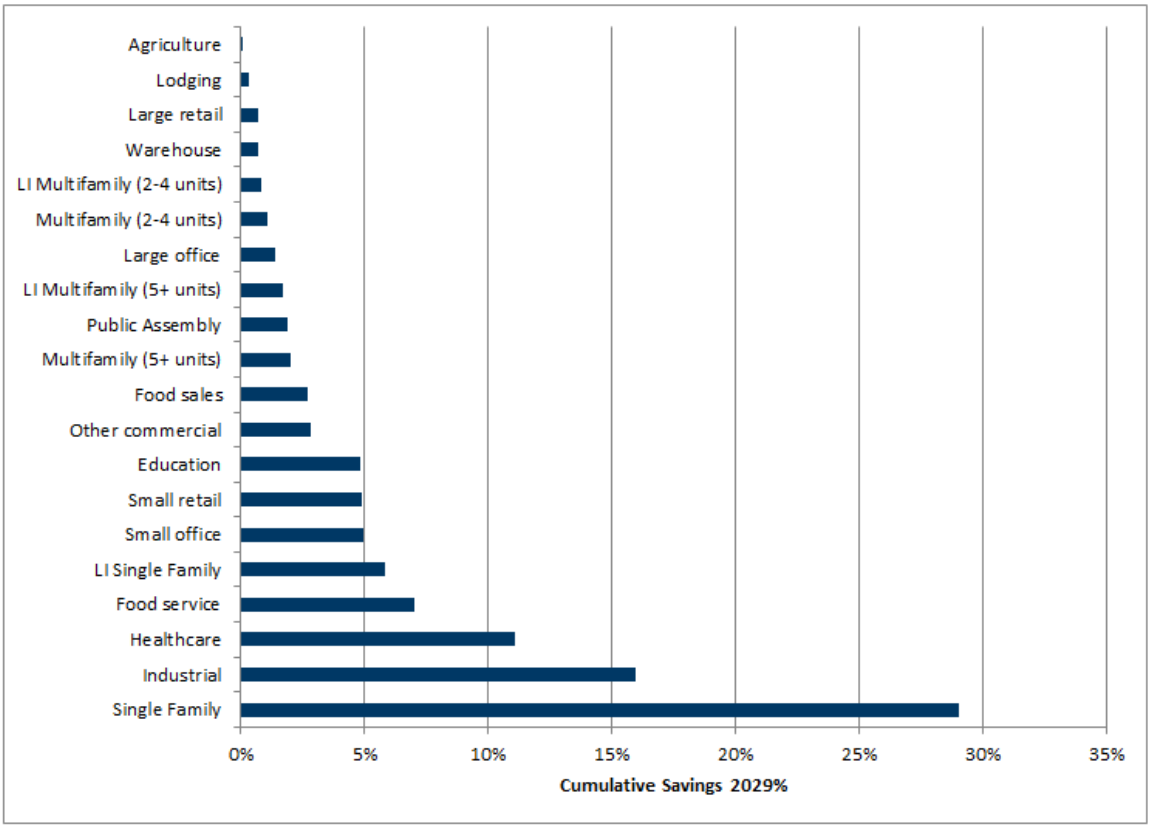


Table 14 and Table 15 present the top residential and commercial natural gas measures, respectively, each of which is described in the text below.

Table 14: Top residential natural gas measures, program scenario.

Measure Name	Cumulative 2029 energy savings (Dth, thousands)	Percent of total residential energy savings potential
Condensing furnace	5,200	28%
Tier 1-3 thermostat	4,600	25%
Attic insulation & air sealing	2,300	12%
Boiler	1,900	10%
Aerosol envelope sealing	1,100	6%
Tankless water heater	750	4%
Wall insulation	520	3%
Home energy reports	500	3%
Storage water heater	470	3%
Electronic ignition hearth	450	2%

Tier 1-3 thermostat: A tier 3 thermostat is a Wi-Fi enabled thermostat that has analytical capabilities that 'learn' a customer's temperature preferences, can adjust temp to weather forecasts, and can automatically adjust temp when one is out of the house.

Condensing furnace: This system saves energy by installing a condensing furnace instead of a non-condensing system. Condensing systems capture the latent heat of water vapor in the flue gases, increasing the overall efficiency of the heating system.

Attic insulation & air sealing: Adding insulation & air sealing in the attic greatly increases the efficiency of the home because the majority of heat energy lost in the home is through the attic, if poorly insulated. This measure saves both natural gas heating and space cooling energy.

Condensing Boiler: This measure is a more efficient hydronic boiler — it works similarly to a condensing furnace that allows more heat energy to be utilized because it condenses water vaper in the flue gases, releasing and capturing heat that would otherwise be lost.

Aerosol envelope sealing: This is a new construction/emerging technology measure where the innovative aerosol envelope sealing is used in the construction process that allows the builder to develop an air tight seal inside the house by effectively sealing many hard to reach areas (like electrical outlets) with relative ease (Figure 32). This saves energy by reducing the amount of air infiltration inside the home, thus, when the house is heating, less energy is lost through the home's envelope. This is the only emerging technology for gas savings in the list of top measures.

Figure 32. Example of aerosol sealing in a new construction application



Tankless Water Heater: An instant water heater is more efficient than storage water heaters, mainly because instant water heaters only use heat water when it is needed (Figure 33). This is more efficient than a storage water heater because there is less energy lost in the tank during standby times when hot water is not needed.

Figure 33. Example of a tankless water heater



Home energy reports: This is a behavioral measure targeting the highest 20% energy users with home energy reports. These reports describe the customer's energy usage and compares them to their

'neighbor's energy usage.' Numerous studies have shown that these reports save energy by motivating people to cut down their energy consumption through conservation or efficient product upgrades.

Storage gas water heater: A more efficient storage water heater is able to save some gas energy by having better insulation, heat traps, and an efficient combustion system to use gas more efficiently than a baseline model.

Wall insulation: This measure involves filling wall cavities with insulation in older homes with little or no wall insulation.

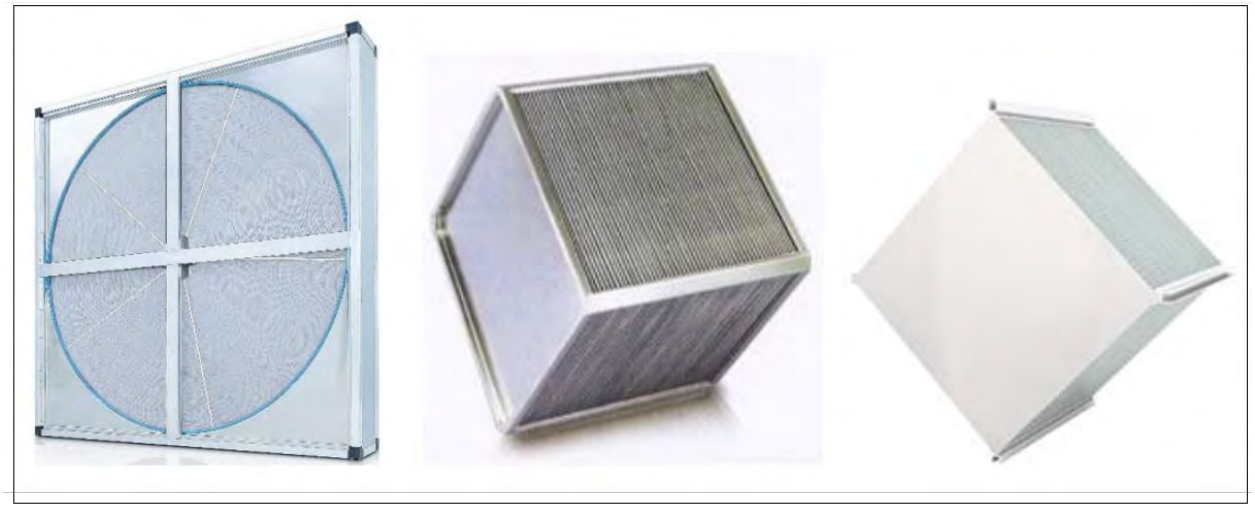
Electronic ignition hearth: This measure includes replacement of an existing hearth/artificial fireplace using a standing pilot with a unit using electronic ignition. This ensures that the pilot light is on only when the fireplace is on, compared to the standard pilot light that is on all the time.

Table 15: Top commercial natural gas measures, program scenario.

Measure Name	Cumulative 2029 energy savings potential (Dth, thousands)	Percent of total commercial energy savings potential
Energy recovery ventilator	3,600	16%
Demand control ventilation	2,900	13%
Boilers	2,600	12%
Condensing furnaces	2,500	11%
Smart thermostat	2,000	9%
Integrated building design	1,600	7%
Kitchen DCV	1,400	6%
Condensing RTUs	1,000	4%
Deep energy retrofit	900	4%
Commissioning	700	3%

Energy recovery ventilator: Energy recovery ventilators are able to save both heating and cooling energy when installed in commercial buildings. They save energy by preheating/precooling incoming air from outside of the building by utilizing the already heated/cooled outgoing air (Figure 34). By preheating/precooling the cold/warm air with the inside air, less energy is required to maintain an appropriate indoor temperature.

Figure 34. Example of three common types of energy recovery ventilators.



Demand control ventilation: This measure saves energy by adjusting the amount of ventilation that is required in a commercial building by analyzing the indoor air quality.

Boilers: Installing an energy efficient boiler saves a significant amount of gas that goes toward space heating or process heat. New condensing boilers are able to achieve efficiencies of over 95%, older boilers typically have efficiencies below 80% (Figure 35). Commercial boilers typically last over 20 years meaning the savings from installing condensing commercial boilers persist for a long time.

Figure 35. Example of a condensing boiler in a commercial application.



Condensing furnaces: This is a commercial version of the residential measure. Many small commercial buildings (e.g. convenience stores, restaurants, and small businesses) use residential-type furnaces for their heating needs.

Smart thermostat: A tier 3 thermostat is a Wi-Fi enabled thermostat that also has analytical capabilities that 'learn' a customer's temperature preferences, can adjust temp to weather forecasts, and adjust temp when the building is not in use. These can save significant amounts of energy by setting back the temperature when the commercial building is not in use.

Integrated building design: Reflects comprehensive, optimized design of new buildings addressing all end uses and interactions between them on a systems basis. Measures include, but are not limited to, improved air barrier performance, minimum IAQ performance, improved mechanical equipment efficiency, and demand-controlled ventilation.

Kitchen demand-control ventilation: Demand-control ventilation for kitchen applications is able to save large amounts of energy because the sensors in this technology automatically adjust fan speed in response to cooking demand in the kitchen. Typically baseline equipment runs all day at full load regardless of the need.

Condensing RTUs: Condensing roof-top units (RTUs) are an emerging technology that has the potential to reduce heating energy in many commercial applications. Condensing RTUs are similar to residential condensing heating equipment, but have much higher heating capacities and typically incorporate condensate treatment systems.

Deep energy retrofit: This applies to commercial spaces that are undergoing a substantial remodel, when major equipment is being replaced anyway, allowing deeper savings to be achieved.

Commissioning: Whole-building commissioning of new buildings ensures optimized design, installation, and operation of systems.

Program costs and net benefits

Overall, the model calculated the annual budgets for each year to range from $205 - $380 million per year for electric, and $102 - $241 million per year for gas for the program scenario (Table 16). The costs of the maximum achievable scenario are more than double the costs of the program scenario (Table 17).

Table 16. Estimated annual statewide budgets and incremental savings, program scenario.

	Electric			Natural gas		
Year	Budget (millions)	Incremental savings	Lifetime cost ($/kWh)	Budget (millions)	Incremental savings	Lifetime cost ($/Dth)
2020	$205	1.70%	$0.017	$102	0.70%	$2.70
2021	$237	2.00%	$0.017	$124	0.90%	$2.70
2022	$250	1.60%	$0.017	$150	1.10%	$2.70
2023	$282	1.70%	$0.017	$177	1.20%	$2.70
2024	$315	1.80%	$0.017	$206	1.40%	$2.80
2025	$329	1.80%	$0.017	$214	1.40%	$2.80
2026	$346	1.90%	$0.017	$220	1.40%	$2.90
2027	$363	1.90%	$0.017	$225	1.40%	$2.90
2028	$380	1.90%	$0.017	$234	1.40%	$2.90
2029	$379	1.80%	$0.017	$241	1.50%	$2.90

Table 17. Estimated annual statewide budgets and savings, maximum achievable scenario.

	Electric			Natural gas		
Year	Budget (millions)	Incremental savings	Lifetime cost ($/kWh)	Budget (millions)	Incremental savings	Lifetime cost ($/Dth)
2020	$521	2.40%	$0.020	$303	1.10%	$4.20
2021	$603	2.80%	$0.021	$370	1.40%	$4.30
2022	$643	2.20%	$0.026	$450	1.70%	$4.30
2023	$728	2.40%	$0.027	$537	1.90%	$4.40
2024	$808	2.60%	$0.027	$625	2.10%	$4.60
2025	$840	2.60%	$0.027	$651	2.10%	$4.60
2026	$875	2.60%	$0.027	$669	2.10%	$4.60
2027	$906	2.60%	$0.027	$683	2.10%	$4.60
2028	$934	2.60%	$0.027	$713	2.20%	$4.60
2029	$917	2.50%	$0.027	$734	2.20%	$4.60

The project team would note that even the program scenario budgets are significantly higher than current budgets, even for similar amounts of savings. For instance, in 2017 the statewide spending on electric energy efficiency was approximately $160 million, to achieve a savings level of 1.9%. In the model, statewide electric energy savings of 1.7% is achieved in 2020 at a cost of $205 million, which is about 20% higher than the actual spending in 2017.

For example, in 2017 Xcel Energy averaged spending of approximately 34% of measured incremental costs on rebates, whereas the project team assumes spending of 50% of incremental costs in the program scenario. The program assumption of 50% incentive costs is consistent with what Xcel Energy and other utilities use for planning purposes, even while they have historically met or exceeded their savings goals at less than their planning target. Thus, there is reason to believe that for the level of savings projected in the program scenario, utilities' actual spending could be significantly lower than projected by the model. However, that is not to say that some level of increased spending won't be necessary compared to historical levels — the modeling suggests this will be the case, with total costs per kWh and per Dth rising over the study period.

A limitation of the modeling approach is that it can only use a single discount rate for calculating both societal and utility net benefits for a given model run. Gas and electric programs are also modeled as combined programs, and thus the net benefits are also calculated as a combined value for both gas and electric. As the project team used the societal test for the economic screening, we also used the societal discount rate for calculating net utility benefits, presented in Table 18. The team notes that a forthcoming Conservation Applied Research and Development (CARD) project reviewing Minnesota cost-benefit tests has recommended that the Department change the discount rate to the utility test to the societal discount rate, and thus, according this CARD project, this project's approach is reasonable.

However, current Department guidance directs utilities to use the weighted average cost of capital (WACC) for the utility test discount rate. Therefore, the project team conducted a sensitivity analysis to

calculate the net utility benefits using the WACC discount rate,[58] while still conducting economic screening using the societal test discount rate. The impact of the higher discount rate decreases cumulative 2029 utility net benefits in the program scenario from $9.0 billion to $4.0 billion (Table 18).

Table 18. Cumulative 2020-2029 net benefits for maximum achievable and program scenarios.

	Societal cost test		Utility cost test (societal discount rate)		Utility cost test (WACC rate)	
	Max achievable	Program	Max achievable	Program	Max achievable	Program
Total net benefits (millions)	$14,500	$10,100	$8,000	$9,000	$1,700	$4,000
Benefit-cost ratio	2.1	2.2	1.6	2.8	1.2	2.2

Although the study's model used the SCT as the primary screen for determining cost-effectiveness, we did examine the impact of screening measures for cost-effectiveness using the utility cost test at the higher discount rate as well. If measures were screened out that did not pass the utility cost test using the WACC, this would lower overall potential by 0% for electric and 2% for natural gas for the program scenario. For the maximum achievable scenario, eliminating measures that did not pass the utility cost test using the WACC would reduce savings more dramatically – by 21% for electric, and 32% for natural gas.

Note that the level of savings reduction reported does not imply that this entire level of savings is not achievable if measures were to be screened according to the utility cost test using the WACC as a discount rate. While the scenarios modeled only a 50% incentive (program) or a 100% incentive (maximum achievable) for all measures in a given scenario, measure incentives for individual measures could be calibrated so that they would pass the utility cost test; i.e., a portfolio could have incentives set lower than 100%, for that portion of measures that were not cost-effective at 100% incentives, and have all measures be cost-effective for both the utility cost test and the societal cost test. Savings in this case would be higher than the program level, but lower than the maximum achievable level.[59]

[58] This study's analysis used a nominal discount rate of 7.3%, which approximates the weighted average of the IOUs reported weighted average cost of capital.

[59] As described in Chapter 2, the utility cost test only includes the cost of the incentive in the denominator, not the total cost of the measure. Thus, a given measure will increase in cost-effectiveness as the incentive is lowered. Given this fact, the technical interpretation of the results of this sensitivity are: For electric utilities, 79% of the total savings in the maximum achievable scenario is still cost-effective if screened at the measure level using the utility cost test (with the WACC as the discount rate), while 21% of the savings reported is cost-effective at a lower incentive than 100%. For gas utilities, 68% of the total savings in the maximum achievable level is cost-effective using the utility test (with the WACC as the discount rate), while 32% of the savings is cost-effective at a lower incentive than 100%. For the savings that is not cost-effective at the 100% incentive level, lowering the incentive level will to some extent also lower participation (because less people will participate the lower the incentive), and thus total savings.

The modeled program scenarios will have a substantial impact on CO_2 emissions reductions. Statewide, the study projects a cumulative annual decrease in carbon dioxide equivalent emissions (CO_2e) of 5.5 million tons from electric utilities (Table 19), and 2.8 million tons from natural gas utilities in 2029 (Table 20).

Table 19. Carbon dioxide emission reductions (tons CO_2e) from electric utility savings for maximum achievable and program scenarios.[60]

		Max achievable		Program	
Year	Emissions factor (tons CO_2e/MWh[61])	Incremental annual CO_2 decrease	Cumulative annual CO_2 decrease	Incremental annual CO_2 decrease	Cumulative annual CO_2 decrease
2020	0.494	992,500	992,500	692,500	692,500
2021	0.479	1,094,300	1,913,200	764,000	1,330,100
2022	0.479	919,000	2,683,600	637,000	1,858,200
2023	0.457	966,000	3,346,700	670,300	2,314,320
2024	0.457	1,053,500	3,990,900	733,000	2,754,600
2025	0.457	1,082,800	4,665,400	754,400	3,215,500
2026	0.439	1,073,400	5,390,800	747,900	3,718,900
2027	0.439	1,110,100	6,286,800	774,000	4,342,900
2028	0.439	1,141,400	7,158,900	795,800	4,949,700
2029	0.439	1,127,800	7,989,800	787,400	5,528,600

[60] Total avoided carbon dioxide equivalent emissions (CO_2e) over the course of the study period is a sum of the annual "Cumulative annual CO_2 decrease" column. The total emissions reduction from electric efficiency savings is 44,418,600 tons CO_2e for the max achievable scenario and 30,705,320 tons CO_2e for the program scenario.

[61] This is a statewide emissions factor, calculated for future years based on utilities' Integrated Resource Plans if available, and extrapolated for the rest of the state. Note that individual utilities' emission factors may vary considerably from this statewide average, especially in future years. The emissions factors were calculated as described for the "Existing Resource Plan" scenario in this paper: Jennifer Edwards, et.al, "Brrrrr…! The Outlook for Beneficial Electrification in Heating Dominant Climates," ACEEE Summer Study, 2018. Available at: https://www.mncee.org/MNCEE/media/PDFs/Brrrrr%E2%80%A6!-The-Outlook-for-Beneficial-Electrification-in-Heating-Dominant-Climates.pdf

Table 20. Carbon dioxide emission reductions (tons CO_2e) from natural gas utility savings for maximum achievable and program scenarios.[62]

		Max achievable		Program	
Year	Emissions factor (tons CO_2/1,000 Dth)	Incremental annual CO_2 decrease	Cumulative annual CO_2 decrease	Incremental annual CO_2 decrease	Cumulative annual CO_2 decrease
2020	60.5	287,800	287,800	180,500	180,500
2021	60.5	344,700	579,800	217,200	367,300
2022	60.5	418,000	944,600	264,200	600,600
2023	60.5	477,900	1,374,900	301,500	874,900
2024	60.5	536,700	1,867,400	337,500	1,187,500
2025	60.5	554,000	2,369,300	347,100	1,504,700
2026	60.5	568,600	2,872,200	355,000	1,822,000
2027	60.5	582,400	3,369,800	362,800	2,135,000
2028	60.5	605,800	3,866,800	376,100	2,447,200
2029	60.5	622,900	4,372,200	385,500	2,763,400

Segment analysis

The project team conducted a more detailed look at two hard-to-reach segments: low-income, small businesses, and the customers of small COU utilities. This section presents some of this study's key findings, with the full reports found in Appendices F, G, and H.

Low-income segment

For the purposes of the study, the project team defines "low-income" as households with income at or below 200% of the Federal Poverty Guideline (FPG).[63] By this definition, there are roughly half a million low-income households in Minnesota, representing almost one in four households in the state. Note that while this definition is used by the U.S. Department of Energy (DOE) Weatherization Assistance Program and a number of utility Conservation Improvement Programs (CIP), other metrics are also used, particularly for determining eligibility of multifamily properties.

The housing type mix of low-income households is fundamentally different from that of the non-low-income population in the state. While nearly nine out of ten non-low-income households resides in a

[62] Total avoided carbon dioxide equivalent emissions (CO_2e) over the course of the study period is a sum of the annual "Cumulative annual CO_2 decrease" column. The total emissions reduction from natural gas efficiency savings is 21,904,800 tons CO_2e for the max achievable scenario and 13,883,100 tons CO_2e for the program scenario.

[63] The 2018 Federal Poverty Guideline is $12,140 in annual income for the first household member, plus $4,320 for each additional member. This analysis is based on Census survey data for 2011 through 2015, and uses the FPG for each survey year.

single-family home, about a third of low-income households live in a multifamily building (Table 21). Looked at another way, only about one in five residents of a single-family home is low-income, but roughly half of apartment dwellers can be classified as such. This makes multifamily energy efficiency improvements an important consideration for programs targeting this population. This basic demographic fact is noted in a recent set of evaluation reports examining utility low-income CIP programs prepared by APPRISE, Inc., and this report examines the issue in more detail in Appendix F.[64]

Table 21. Housing mix for low-income and non-low-income households in Minnesota.

Type of home	Low-Income	Non-Low-Income
Single-family	57%	85%
Multifamily (2-4 units)	8%	3%
Multifamily (5+ units)	35%	12%
Total	**100%**	**100%**

Source: Census American Community Survey (2011-2015).

Low-income households are also more likely to heat their home with expensive fuels such as electricity. This is partly a reflection of the fact that these households are more likely to be apartment dwellers, where electric heat is more common, but the difference between low-income and non-low-income households persists to some extent even within housing type (Table 22).

Moreover, low-income households are more likely to reside in older homes than are non-low-income households. A useful dividing line is 1980, because most homes built prior to the 1980s were not subject to energy codes and are more likely to be under-insulated or leaky.[65] More low-income households reside in pre-1980s housing stock than do non-low-income households.

Table 22. Heating fuel by housing type and household income level.

Heating fuel	Overall		Single-family		Multifamily	
	Low-Income	Non-Low-Income	Low-Income	Non-Low-Income	Low-Income	Non-Low-Income
Natural gas	55%	70%	61%	72%	48%	58%
Electricity	26%	14%	13%	10%	43%	34%
Other	19%	16%	26%	18%	9%	8%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Census American Community Survey (2011-2015).

Since low-income households have less disposable income for energy efficient upgrades, there are some aspects of low-income households, and housing stock, where there are more remaining opportunities

[64] See "Low Income CIP Evaluation Study: Summary Report," prepared by APPRISE, Inc. for the Minnesota Department of Commerce, Division of Energy Resources, December 31, 2017. Available at: http://mn.gov/commerce-stat/pdfs/card-low-income-cip-evaluation.pdf. Four additional detailed reports can be found via the CARD Research Project Search Engine (https://mn.gov/commerce/industries/energy/utilities/cip/card-grant-search/)

[65] The first energy conservation code in Minnesota came into effect in 1976.

for energy efficiency improvements than the general population. For example, the single-family survey conducted for the study revealed that the saturation of programmable thermostats in low-income households is less than that of non-low-income households (by about 14 percentage points — 56% vs. 70%). Similarly, data from the State's low-income weatherization program suggests that even after controlling for home age, low-income households have more opportunities for shell measures such as insulation and air sealing. These differences are incorporated into the modeling.

Notably, about half of the achievable electric potential for low-income customers of municipal utilities — and a third of the natural gas potential — is the multifamily segment. The APPRISE study noted that while Minnesota's investor-owned utilities have made efforts to address the low-income multifamily segment, municipal utilities largely have not done so. The analysis here suggests that there is untapped savings potential among low-income multifamily properties in municipal-utility service territories. Unsurprisingly, the models show little low-income potential in the multifamily segment for cooperative electric utilities, which tend to be dominated by single-family housing.

Space heating measures dominate the low-income savings potential for both electricity and natural gas. This is not surprising for natural gas, where most consumption is in fact for this end use. For electricity, it reflects the significant savings that can be achieved from offsetting or eliminating resistance electric heat with heat pumps, particularly opportunities for using ductless heat pumps to offset baseboard resistance electric heat in multifamily buildings.

The modeling estimates suggest that programs targeting low-income households have the potential to achieve cost-effective first-year savings of 1.4 percent of annual electric sales and 1.3 percent of natural gas utility sales for low-income households under the program scenario (Table 23 and Table 24). This represents 24 percent of the total achievable electricity savings potential in the residential sector and 21 percent of the total residential potential for natural gas.

Table 23. Statewide electric energy efficiency potential by low-income housing type.

Low-income customer segment	Projected mean annual 2020-2029 Sales (GWh)	Incremental energy efficiency potential*	
		(GWh)	% of segment sales
Single-family	4,735	68	1.4%
Small multifamily (2-4 units)	556	7	1.2%
Large multifamily (5+ units)	1,788	23	1.3%
Total	**7,080**	**98**	**1.4%**

*Mean of first-year savings potential for 2020-2029 under the 50% Incentive Scenario.

Table 24. Statewide natural gas energy efficiency potential by low-income housing type.

Low-income customer segment	Projected mean annual 2020-2029 sales (Dth, thousands)	Incremental energy-efficiency potential*	
		(Dth, thousands)	% of segment sales
Single-family	21,454	287	1.3%
Small multifamily (2-4 units)	2,638	39	1.5%
Large multifamily (5+ units)	6,410	81	1.3%
Total	**30,502**	**407**	**1.3%**

*Mean of first-year savings potential for 2020-2029 under the 50% Incentive scenario.

Small business segment

According to the U.S. Census Bureau's 2013 County Business Patterns (CBP), there are roughly 138,000 small businesses in Minnesota, accounting for 94% of all businesses in the state and employing over one million people. The majority of small businesses in Minnesota employ fewer than five people and only one-tenth employ 20 or more.

The results from the modeling suggests that programs targeting three business segments in the small commercial sector (small office, retail, and food service) have the potential to achieve cost-effective annual incremental savings of 2.6% percent annual electric utility sales for small commercial businesses (Table 25) and 2.0% of natural gas sales (Table 26). This represents 31% of the total achievable electricity savings potential in the commercial sector and 39% of the total commercial potential for natural gas.

Table 25. Statewide electric program potential by small commercial segment.

Small commercial business segment	Projected mean annual 2020-2029 sales (GWh)	Incremental achievable program potential*	
		(GWh)	% of segment sales
Office	3,831	78	2.0%
Retail	1,918	49	2.6%
Food Service	3,993	127	3.2%
Total	**9,742**	**254**	**2.6%**

*Mean of first-year savings potential for 2020-2029 under the 50% Incentive scenario.

Table 26. Statewide natural gas program potential by small commercial segment.

Small commercial business segment	Projected mean annual 2020-2029 sales (Dth, thousands)	Incremental achievable program potential*	
		(Dth, thousands)	% of segment sales
Office	10,715	230	2.2%
Retail	10,424	228	2.2%
Food Service	18,662	331	1.8%
Total	**39,801**	**788**	**2.0%**

Small consumer-owned utilities

Small consumer-owned utilities face unique opportunities and challenges in achieving energy efficiency goals. For this section, and Appendix G which is dedicated to this topic, the project team focuses on electric cooperatives with fewer than 50 customers per square mile and municipal electric utilities with fewer than 10,000 customers. This includes all but three of Minnesota's 47 electric cooperatives, and 119 of 124 municipal electric utilities in the state.[66] Combined, these utilities account for about a quarter of statewide electricity sales. Legislation enacted in 2017 exempts 18 smaller cooperatives and 51 municipal electric utilities from CIP requirements. These utilities are included in a few results reported here, but omit them from most of the analysis results.

Rural electric cooperatives

Minnesota's 44 rural electric cooperatives serve an astonishing 87% of Minnesota's land area, yet account for only 18% of electricity sales. While "rural cooperative" may bring to mind farms, most of the electricity sold by rural cooperatives is actually for homes (including farm residences) and businesses.

Nearly all homes in rural cooperative service areas are single-family structures, including about half of Minnesota's 80,000 manufactured homes. Notably, almost 30% of homes served by rural cooperatives in the northern half of the state are seasonal properties that are not typically occupied year-round. Since rural residences served by cooperatives are typically outside natural-gas service areas, residential customers of rural cooperatives are about twice as likely as the state as a whole to have electric heat or an electric water heater. Similarly, these homes also have a much higher prevalence of deliverable heating fuels such as propane. And, as might be expected, the saturation of air conditioning is lower among northern cooperatives.

Rural cooperatives have significantly fewer industrial customers and somewhat less commercial load than other utilities. On the other hand, more than 80% of the electricity used for farm operations in the

[66] Excluded electric cooperatives are: Dakota Electric, Connexus Energy and Wright-Hennepin Electric Cooperative. Excluded municipal electric utilities are Rochester, Moorhead, Shakopee, Austin and Owatonna.

state is sold through rural electric cooperatives — though the project team estimates that these sales still account for only about 11% of rural cooperative sales on average.[67]

Farm electricity consumption can be divided into various livestock operations, crop production, and irrigation. These are not uniformly distributed among rural cooperatives; some cooperatives are much heavier in some types of farms than others. For example, dairy farms account for as little as zero and as much as 60% of total farm-operation load among Minnesota's 44 rural cooperatives. The energy efficiency models take these regional differences into account.

The 44 rural electric cooperatives account for 17% of the achievable statewide electric potential under the program scenario. Only 17% of this potential is attributable to the 18 CIP-exempt rural cooperatives, while 83% is in the service areas of the 26 rural cooperatives with CIP requirements. This report confines the remainder of the discussion to rural cooperatives with CIP requirements, but relative results are substantially the same if CIP-exempt utilities are also included.

The models project an average annual achievable energy efficiency potential of 1.6% of electricity sales among the cooperatives with CIP requirements (Table 27). At the end of the 10-year analysis period (2029), the models estimate 13% savings from achievable program activity over the period — with 41% of this attributable to the Residential sector, 49% to the Commercial sector, and 10% to the Industrial sector.

Table 27. Energy efficiency for rural electric cooperatives with CIP requirement, by sector.

Sector	Projected mean annual 2020-2029 Sales (GWh)	Incremental energy efficiency potential*	
		(GWh)	% of sector sales
Residential	7,026	100.7	1.4%
Commercial	4,414	90.3	2.0%
Industrial	1,250	17.7	1.4%
Total	**12,691**	**208.8**	**1.6%**

*Mean of first-year savings potential for 2020-2029 under the program scenario.

While nearly all agricultural potential is in the form of retrofits to existing equipment, more than a third of the estimated potential for non-farm commercial customers — and a fifth of the residential-sector potential — is estimated to be associated with new construction and/or renovation activities (a result that largely mirrors the statewide proportions for achievable potential in these markets). Since most rural areas are not seeing significant growth, this potential is mainly associated with renovation of existing homes and businesses.

Residential customers of rural cooperatives overwhelmingly live in single-family homes, so it is no surprise that 95% of the achievable potential in this sector lies within this housing type. Offsetting electric resistance heat with central and ductless heat pump dominates the measures in the residential sector, accounting for a third of the estimated achievable potential in 2029.

[67] "Farm" sales reported by utilities are considerably higher, because these generally include farm residences, which are accounted for separately here.

In the commercial sector, achievable potential is more evenly distributed among businesses, though unsurprisingly, there is little potential for savings in large offices and retail establishments. As noted above, renovation measures lead the list of measures in this segment.

Farm opportunities are led by variable-speed drives, lighting measures, and measures associated with dairy farms.

Small municipal utilities

The most notable aspect of small municipal utilities is that they tend to have a proportionately higher industrial load. On average, almost 40% of electricity sales by small municipal utilities goes to industrial customers, though a third have no industrial load at all, while a few sell nearly 80% of their electricity to industrial customers. The median small municipal utility with industrial load has only 10 industrial customers, though a few have more than 200.

Homes served by small municipal utilities tend to mirror the statewide composition of Minnesota housing, with a mix of single-family and multifamily dwellings. Similarly, the distribution of commercial businesses served by these utilities resembles that of the state as a whole, with the exception of fewer large commercial properties found in larger urban areas.

The 119 small municipal utilities in the state account for 12% of the achievable statewide electric program potential. Only 10% of this potential is attributable to the 51 CIP-exempt municipal utilities, while 90% is in the service areas of the 73 small municipal utilities with CIP requirements. The remainder of the discussion omits CIP-exempt municipal utilities.

The models suggest that small municipal utilities have average annual achievable energy efficiency potential of 1.7% of electricity sales, with the residential and industrial sectors showing about 1.3% incremental potential and the commercial sector showing 2.6% (Table 28). At the end of the 10-year analysis period (2029), the models estimate 15% savings from achievable program activity over the period — with 17% of this attributable to the Residential sector, 50% to the Commercial sector, and 33% to the Industrial sector.

Table 28. Energy efficiency for small municipal utilities with CIP requirements, by sector.

Sector	Projected mean annual 2020-2029 Sales (GWh)	Incremental energy efficiency potential*	
		(GWh)	% of sector sales
Residential	2,789	36.1	1.3%
Commercial	2,760	73.0	2.6%
Industrial	3,607	46.8	1.3%
Total	9,156	155.9	1.7%

*Mean of first-year savings potential for 2020-2029 under the program scenario.

Challenges faced by rural cooperatives and small municipal utilities

The primary challenge for rural cooperatives and small municipal utilities to make energy efficiency inroads is one of scale. The average rural cooperative has electricity sales that are less than 10% of the sales of Otter Tail Power, which is the smallest investor-owned electric utility that implements CIP activities in the state. Small municipal utilities have even fewer sales, averaging only 2% of Otter Tail Power's load. For the most part, these smaller utilities lack adequate staffing and other resources for implementing CIP programs, and any fixed costs associated with operating CIP programs must be spread across a much smaller base.

The scale issue is addressed somewhat through joint programs, through power marketing membership organizations. Minnesota has four cooperative-utility membership organizations and six municipal power pools, collectively involving 41 of 48 rural cooperatives and 70 of 118 small municipal electric utilities (in additional to three cooperatives in the Twin Cities area and three larger municipal utilities that have been excluded here). Most of these organizations coordinate umbrella efficiency programs for their members. This pooling of resources can help smaller utilities achieve CIP energy efficiency goals, though these efforts are sometimes complicated by the fact that some of the organizations have membership that spans across multiple states. Two of these organizations, Great River Energy and the Southern Minnesota Municipal Power Agency, have achievable potential that meets or exceeds that of the investor-owned utilities. However, the scale of the remaining cooperative and municipal utilities falls short of that of the smallest investor-owned electric utility in the state (Otter Tail Power). Moreover, 19 municipal utilities with CIP requirements are not members of any power-pool association.

Another scale challenge that rural cooperatives and small municipals face is marshaling the expertise needed to address energy efficiency opportunities for a small number of large customers with unique characteristics. For rural cooperatives, this issue largely manifests itself in the form of larger livestock operations. For example, the project team estimates that about 90% of the electricity used for raising turkeys in Minnesota is associated with a few hundred farms scattered across about a dozen rural cooperatives in the state, few of which have more than 15 farms. It is hard to envision serious efforts to incentivize turkey farm energy savings under such circumstances in the absence of some sort of collaborative cross-utility effort. Similar issues arise with industrial customers of small municipal utilities.

Tool to estimate individual utility potential

As part of the study scope, the project team is developing a tool that will allow the user to view estimated potential for individual utilities or groups of utilities, as well as for individual customer segments and measures.[68] This will allow users to produce more customized outputs of the data than is possible to present in this report.

This tool is not meant to provide accurate estimates of potential from any given utility. This would not be a reasonable expectation, given the inherent limitations of the number of statewide or region-wide (and not utility-specific) assumptions that were used for this model. However, it will reflect utility-specific differences in customer composition, climate and sector-level sales – and this alone can be

[68] This tool will be available a month or so after the release of this report, and will be made available on the project website: www.mncee.org/mnpotentialstudy

helpful in understanding the types of programmatic strategies or measures that might be pursued in an individual utilities' territory, or what scale might be achieved from joint programmatic approaches across multiple utilities' territory.

Limitations in modeling

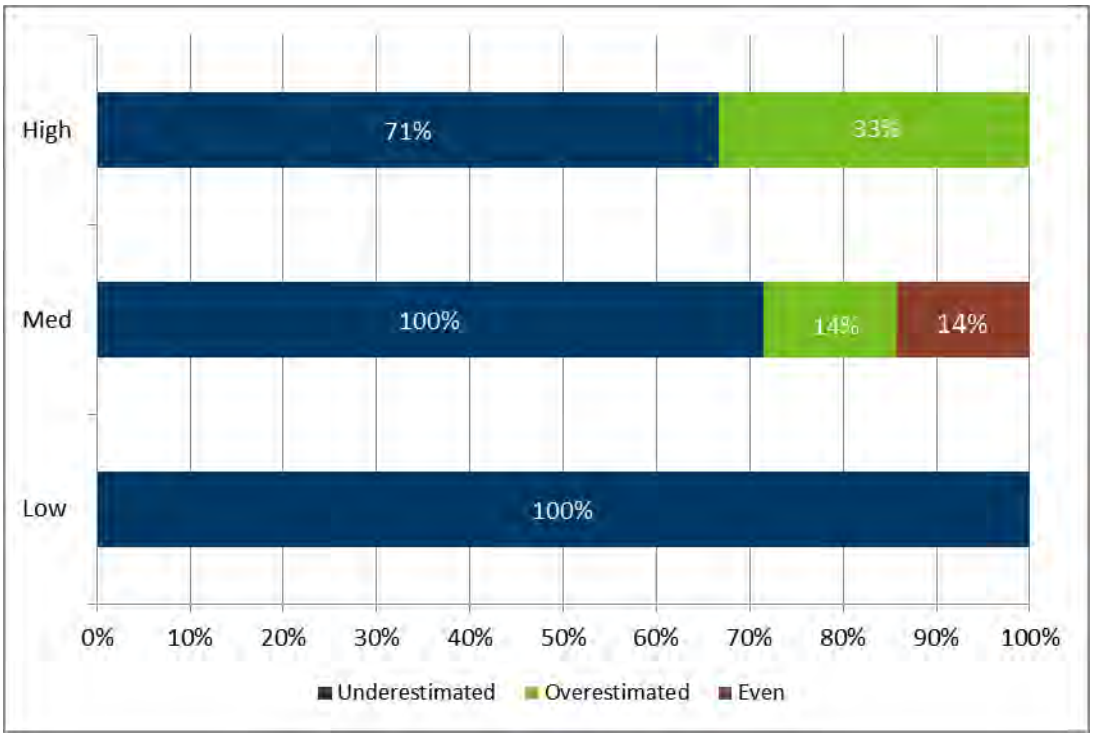
While this study employed best practices for conducting energy efficiency potential studies and used the best data available to support the assumptions, it is worth discussing the limitations of this, or any, potential study. There have been many studies suggesting that most potential studies underestimate actual achievable potential. For example, a recent meta-analysis of 55 potential studies across all regions of the United States indicates average maximum achievable savings of about 1.5% per year, despite numerous jurisdictions currently exceeding these levels.[69] In fact, the American Council for an Energy-Efficient Economy (ACEEE) did not find a single study that indicated levels being consistently achieved in some New England states were possible. Some of the key drawbacks include:

- It is impossible to include all potential opportunities, and many customized and site-specific solutions often account for a large portion of actual efficiency opportunities;
- Studies tend to model business as usual based on the types of programs and savings activity already occurring. As a result, because virtually no jurisdiction truly pursues all cost-effective efficiency with no budget limitations, this calibrates studies to much lower levels being modeled as achievable; and
- The longer the study period, the lower the annual efficiency potential is generally assumed, and the less certain the study becomes. This is both because practitioners will spread out whatever potential is quantified over the entire time frame, and because they tend to focus on current opportunities and underestimate ongoing technology advancement — which, historically, has always reduced costs, improved performance, and expanded efficiency opportunities. For example, while many jurisdictions have aggressively invested in efficiency programs for 25 years, they have found that levels of efficiency potential (as a share of load forecasts) have remained relatively stable. In short, technology advancement can often keep up with natural and program efficiency improvements.

The project team analyzed 12 recent Minnesota potential studies (both statewide, and for individual utilities) to compare the potential reported in those studies to the actual energy savings achieved by Minnesota utility companies. Many of the potential studies analyzed had a number of scenarios calculated (e.g., 100% incentive, 50% incentive, business as usual, etc.). Typically, the high scenarios corresponding to the project team's maximum achievable potential scenario — the low and medium scenarios correspond to the project team's program achievable scenario. Overall, the study's analysis found that 84% of scenarios in these potential studies underestimated potential when compared to actual energy savings achievements by Minnesota utilities. Furthermore, all of the low scenarios underestimated the actual amount of potential achieved. Appendix O has more details on the analysis, including citations for the 12 potential studies that were analyzed.

[69] Max Neubauer, et. al, "Cracking the TEAPOT: Technical, Economic, and Achievable Potential Studies," ACEEE, 2014. Available at: https://aceee.org/research-report/u1407.

Figure 36. Comparison of past Minnesota studies of energy efficiency potential under various scenarios, compared to actual utility achievements after the potential study was completed.



Below is more detail on some of the specific issues.

The further out in time, the less accurate the projections are. The project team used the best available data to calibrate the model to the 2020 start date, and to make projections and forecasts about the future. As with all forecasting, however, the farther out in the future you model, the greater the level of uncertainty and potential error.

The adoption of individual technologies and overall program participation could happen much faster, or slower, than predicted by the model. Unlike the market-driven measures, which are tied to an event like replace-on-fail or major renovation, retrofits can happen at any time. Therefore, the rate of adoption tends to be driven not only by what is achievable, but also significantly by the level of effort and resources devoted to capturing the efficiency. Since the study period is 10 years, the project team chose to spread out retrofit adoptions over that time period, with some ramp up in early years, and then relative stable levels of effort. This is also true for the economic potential, where the model assumed 10% of the eligible opportunities are captured each year. While many studies simply assume 100% capture of retrofit measures immediately when modeling technical and economic potential, the project team believes that spreading this activity out over the study period more closely aligns with real-world efforts and makes comparisons between economic and achievable scenarios more useful. Many measures can be adopted as either retrofits or market-driven opportunities. An assumption that all customers adopt all cost-effective retrofit measures in the first year will remove all future opportunities for additional efficiency through market-driven programs at the time of natural turnover. This is because everything is assumed to have already been replaced with efficient equipment.

In terms of overall penetration forecasts, this is inherently uncertain, as is true with all future projections. While the project team used the best available data, experience and knowledge of past

trends has shown that measure adoptions vary significantly (either higher or lower) than past projections.

It is likely this study has not included technologies and programmatic strategies that could have a major impact on future energy efficiency. It is hard to predict the unknowns. However, vast sums of money are going into the research and development of clean energy technologies today, and it is virtually certain that there will be new technologies (or that technologies that the team determined are not cost-effective) that will be the new LEDs of the future. Ten years ago, no energy efficiency potential study that the project team is aware of included the amount of penetration that LEDs currently have in the market. Historically, improvements in technologies and programmatic strategies have more than offset the increasing baselines over time from rising codes and standards, along with natural efficiency adoption. The team has yet to see a situation where we are approaching physical limits on efficiency improvements in most end uses.

This study makes projections for gross energy savings but does not adjust for the natural adoption of energy efficiency, which is already accounted for in the sales forecasts used to derive the potential. The natural adoption of energy efficiency is what would occur in the absence of utility-funded efficiency programs. Two terms that are used in the industry related to this concept are "gross savings," which is the total of utility-caused and naturally occurring energy savings, and the "net-to-gross" ratio, which is the ratio of net utility-caused savings to total savings. The project team estimated the current net-to-gross ratio in Minnesota, based on program evaluation studies conducted by Xcel Energy, and found it to be very close to the national average of about 85% (that is, 85% of the total gross savings claimed through utility programs can be attributed to utility programs). This suggests that the vast majority of savings claimed by utility-run programs currently are attributable to those programs and is a testament to good program design.

As markets are transformed by utility-funded efficiency programs, utilities have stopped giving incentives. The project team was careful in the selection of measures to choose technologies for which the markets are not yet transformed and adjust savings for those measures that might be transformed during the study period. For example, this study assumes that the market for LED screw-in bulbs will be totally transformed by 2021 in the study's model, regardless of what may happen with national lighting standards. However, the markets for some of the technologies modeled in the study may become transformed more quickly than predicted here.

A related issue is that the spillover effect is also not considered in the modeling. Spillover refers to when customers are influenced by the utility to purchase the efficient equipment, but do not submit paperwork. For some measures, utilities may be causing savings, but not all of those savings are being claimed by utilities. Note, that this is one reason the project team recommends midstream program models; they typically have a much higher rate of rebate adoption by customers.

Not all utilities in Minnesota can be expected to achieve the high program penetration assumed here without changes to how they run programs. In particular, the most aggressive programs require more sophisticated program designs, as discussed in chapter 6. These program designs target particular niche markets or require specialized capabilities to implement, which can be hard to do in a relatively small market. For example, programs that target refrigeration loads in small businesses through a combination of direct install measures, specialized technical assistance, and targeted prescriptive rebates have proven to be successful in many utility territories. However, if a small utility only has one grocery store and two gas stations that might benefit from such a program, it is hard to justify the costs to create such a program. Some level of aggregation or sharing of program models, among smaller COUs will likely be necessary in order to achieve the savings predicted here.

The model assumes that market barriers and technology adoption curves are uniform statewide, which could overstate or understate potential for utilities where this is not true. This is related to limitation listed above. The project team did not have sufficient data resolution to support different assumptions for different analysis regions of the state or different utilities on penetration levels of efficiency measures.

Fuel switching measures were not included in the study scope, and no heating efficiency measures were included for customers that heat with delivered fuel. Delivered fuel companies are not subject to CIP requirements, and measures that result in fuel switching are not allowed within CIP, with certain exceptions. Thus, the potential presented here will underestimate total potential if fuel switching measures were to be included. In particular, cold climate air source heat pumps would likely be a cost-effective measure for customers on delivered fuels and could represent a large potential — for example, in rural areas where a high fraction of residential customers heat with delivered fuels. The Department is launching a stakeholder group to discuss fuel switching issues.

Chapter 5: Program Findings and Recommendations

The Center for Energy and Environment project team conducted a review of utility energy efficiency programs in Minnesota and nationally, to inform inputs used in the model for the program scenarios, and to make recommendations about program implementation that will be useful for utilities, regulators and other stakeholders in designing and implementing programs for 2020 and beyond.

This study used the following data sources in making these findings and recommendations:

- Interviews with representatives of nine Minnesota utilities or groups of utilities;
- Review of survey responses from 38 Minnesota stakeholders;
- Review of public Minnesota utility filings and trade-secret, utility-provided data;
- A literature review of best practices in program design; and
- Consultation with three national organization (E Source, ACEEE and NAM) on non-Minnesota best practice programs.[70]

In addition, the project team conducted a more in-depth study of three difficult-to-serve segments: low-income, small business, and small utilities/agricultural (Appendices F, G and H). This project's trade ally survey (Appendix L) also helped to inform these recommendations.

Further background on research conducted for the Programs Chapter is found in Appendix I.

Current programs in Minnesota

This section summarizes the project team's findings on current program implementation in Minnesota.

Minnesota currently has some of the lowest cost and best performing programs in the country

Nationally, Minnesota has long been a top-achieving state for energy efficiency program achievements. The American Council for an Energy-Efficient Economy (ACEEE) compiles rankings of top states annually, and Minnesota has long been the leading Midwestern state, and consistently in the top 10 nationally. Minnesota ranks the highest in the nation for natural gas efficiency achievements.[71]

Furthermore, compared to other top-performing states, Minnesota acquires efficiency at the lowest cost (Table 29). Part of the reason for this can be attributed to Minnesota's slightly lower energy costs

[70] All three organizations worked under contract to CEE. E Source provided information on best practice programs based on their experience following and supporting utilities across the U.S., with benchmarked program metrics. The American Council for an Energy-Efficient Economy (ACEEE) provided customized information on best practice programs from around the U.S. across utility types and customer sectors, in addition to a number of publicly available papers documenting high-performing programs. Newcomb Anderson McCormick (NAM) provided information and insight on California best practice programs.

[71] Minnesota averaged 1.4% net natural gas savings in 2016 – one of only five states in the country to achieve higher than 1.0% savings (Berg 2017).

compared to costal states. Based on interviews with Minnesota stakeholders, the project team would also attribute this to the practical nature of implementers in Minnesota. Virtually every practitioner that the team talked to cited the creation of customer value through their programs as a primary motivation for their work, and the importance of spending utility dollars wisely.

Table 29: Cost of efficiency for top-ranking states (2016 net incremental savings).[72]

State	ACEEE Ranking	Electric spending ($/kWh)	Gas spending ($/therm)
Massachusetts	1	$0.34	$7.39
California	2	$0.35	$6.02
Rhode Island	3	$0.37	$5.89
Vermont	4	$0.39	$3.68
Oregon	5	$0.29	$3.56
Connecticut	6	$0.43	$6.17
Washington	7	$0.21	$3.83
New York	7	$0.27	$5.12
Minnesota	9	$0.19	$1.76
Maryland	10	$0.33	$9.88

Utilities in Minnesota – both IOUs and COUs – have been proactive in designing and implementing comprehensive, effective, and innovative program models.

In addition to high achievements, Minnesota utilities have also been recognized for their innovative and comprehensive programs. Although not a comprehensive list, Table 30 lists 19 national awards that Minnesota utilities have received for the CIP programs they run.

[72] Note that this is presented in dollars per kWh or therm of first-year savings, not lifetime savings – the lifetime savings would be a much lower cost than presented in this table. For example, the average lifetime of Xcel Energy's measures are over 10 years – at $0.19/kWh of first-year savings, this would be less than 2 cents/kWh of lifetime savings. Table derived from tables in: Berg, A., S. Nowak, M. Kelly, S. Vaidyanatha, M. Showmaker, A. Chittum, M. DiMascio and H. DeLucia. 2017. The 2017 State Energy Efficiency Scorecard. Washington, DC: American Council for an Energy-Efficient Economy (http://aceee.org/sites/default/files/publications/researchreports/u1710.pdf).

Table 30: Minnesota CIP programs winning national awards.

Utility or utility association	Program name (& organization giving award)	Year
Otter Tail Power	House Therapy for Low-Income Homes (E Source)	2018
SMMPA	ENERGY STAR Partner of the Year (U.S. EPA/DOE)	2016
Xcel Energy	Computer Efficiency Program (MEEA)	2013
Xcel Energy & CenterPoint Energy	Home Energy Squad (ACEEE)	2013
Austin Utilities, Owatonna Public Utilities, Rochester Public Utilities, & MN Energy Resources	Energy Efficient Cities (ACEEE)	2013
CenterPoint Energy	Foodservice Program (ACEEE)	2013
CenterPoint Energy	Custom Rebate Program (ACEEE)	2008 & 2013
Xcel Energy	Self-Direct Custom Efficiency (ACEEE)	2008 &2013
Xcel Energy	One-Stop Efficiency Shop (ACEEE)	2008 & 2013
Xcel Energy	ENERGY STAR Partner of the Year - Sustained Excellence (U.S. EPA/DOE)	2010, 2011 & 2012
SMMPA	ENERGY STAR Award for Excellence in ENERGY STAR Promotion (U.S. EPA/DOE)	2010
Xcel Energy	Lighting Efficiency (ACEEE)	2008
Xcel Energy	Energy Design Assistance - Custom Consulting (ACEEE)	2008
Rochester Public Utilities	Commercial Programs' Communication Plan (MEEA)	2008
CenterPoint Energy	Non-Profit Affordable Housing Project (ACEEE)	2008
Great River Energy	ENERGY STAR National Product Campaign Award (U.S. EPA/DOE	2004
Minnesota Power	ENERGY STAR Excellence in Energy Efficiency and Environmental Education (U.S. DOE)	2004
SMMPA	ENERGY STAR Award for National Campaign Promotion (U.S. EPA/DOE)	2004
SMMPA	ENERGY STAR Award for Leadership in Energy Efficiency (U.S. EPA/DOE)	2003

Minnesota utilities, including cooperative and municipal utilities, were also some of the first in the nation to pilot residential behavior programs.

Smaller utilities face additional challenges in implementing programs

Smaller utilities, predominately in rural areas of the state, have additional program implementation challenges due to lack of scale. This makes it difficult to find both qualified implementers and qualified contractors to install efficient equipment. According to one utility stakeholder interviewed for this project:

> *"As you get out into rural Minnesota, there's quite a bit less density. That density does have an impact on how aggressive you might be able to be. It doesn't really afford you to look at doing*

door-to-door programs, and it also limits the number of alternative providers. Not necessarily cooperative providers, but other providers of energy efficiency services, which we all rely on to deliver the programs. When you get into very rural areas, there's a challenging business proposition for some of the third-party providers to be able to deliver services at a level that is cost-effective for our membership."

In addition, it is harder for smaller utilities to achieve scale in implementing their programs, which can be particularly challenging for upstream program designs (discussed more below) or other more sophisticated program approaches that reach specific market segments. Smaller utilities may be able to overcome this shortcoming by aggregating their programs with other utilities (also discussed further below).

Deep relationships with trade allies have helped utilities deliver programs

Many of the utilities the project team interviewed stressed the importance of their relationships with energy efficiency contractors, widely referred to as "trade allies" by efficiency program administrators. These trade allies include HVAC, electricians, architecture and engineering firms, and others that install energy efficiency equipment. These contractors have immense influence on the efficiency choices their customers make, and most utilities are proactive in working closely with them. A well-educated and trained workforce of trade contractors is critical to the success of utility programs. The larger utilities often have multiple staff that are assigned specifically to managing these relationships, and they conduct active communications campaigns, trainings, and events to keep their trade allies educated and engaged.

It is also a symbiotic relationship. Utility incentives and awareness-building of energy efficiency create business opportunities for contractors and help employ thousands of workers across the state.

The survey of trade allies (Appendix L) shows that a high percentage of contractors across the state report that they currently work with their utilities, although non-metro contractors are slightly less likely to do so (Table 31). The contractors that were interviewed generally find utility programs easy to participate in. A very high percentage also report that utility programs have helped their business, with the exception of new construction trade allies (architects and residential home builders).[73] Overall, a majority of contractors would find value in additional utility-provided training and information, although lighting and HVAC contractors were less likely to find that valuable (Table 32).

[73] The project team interprets this to mean that rarely, if ever, do new construction trade allies see a building built due to the presence of utility incentives (which is to be expected); whereas for electrical contractors, utility incentives get more people to retrofit their lighting than would occur without utility incentives.

Table 31: Trade allies surveyed, by location and utility interaction.

	Count	Percent that reported worked with utility
Metro	56	84%
Non-metro	49	71%

Table 32: Trade ally feedback on utility programs.

	Plumbing Contractors	Electrical Contractors	HVAC Contractors	Insulation Contractors	Residential Home Builders	Architects
Worked with utility programs in the past	90%	100%	100%	85%	80%	80%
Utility programs are easy to participate in	80%	92%	93%	60%	40%	40%
Utility programs have helped business	60%	77%	90%	60%	30%	40%
Utilities should provide additional rebates to increase participation	60%	12%	65%	25%	70%	20%
Utilities should provide additional training and info to increase participation	50%	23%	35%	50%	80%	50%

The most successful COU programs involve cooperation among utilities

As discussed above, rural and smaller utilities face challenges in implementing programs due to lack of scale and other issues. Many of these utilities have been able to overcome, or partially overcome, these challenges by aggregating their programs together. The most common aggregation approach is for the generation and transmission (G&T) provider to run programs on behalf of, or in partnership with, their distribution cooperative and/or municipal utilities. However, other approaches have been successful. All of the G&Ts are involved with helping their members implement programs to a greater or lesser extent. Some of them serve more as a decentralized resource to individual utilities that implement their own programs, while others take a more active and engaged role in implementing programs, including providing staffing for on-site work with individual customers.

A few examples of aggregation in Minnesota include:

- ***Great River Energy*** (GRE), the G&T for the majority of cooperatives in Minnesota, uses a decentralized approach in aggregating programs. They design programs and marketing materials for their members, including an efficiency program guidebook, but rarely get involved in running individual programs. The individual cooperatives tailor the program designs and incentive levels to their needs, and generally run their own programs.
- ***Minnkota Power Cooperative***, the G&T for eight northern cooperatives in Minnesota. In addition to aggregating programs for their distribution cooperative utilities, they do so for a

number of municipal utilities which have solicited their services. Minnkota not only does the marketing and promotion, but coordinates with third-party service providers to run tailored programs on behalf of their members.

- The ***Southern Minnesota Municipal Power Agency*** (SMMPA) has developed, marketed, implemented, and reported CIP programs for their members for many years. SMMPA has three technical staff that work directly with businesses in their 15 smaller member cities. SMMPA's three largest members (Rochester, Austin, and Owatonna) have internal staff to do the majority of their own marketing, program implementation, and CIP reporting. However, SMMPA works with their largest members on program design, implementation, and marketing to ensure consistency in program offerings, and to share best practices.
- ***Missouri River Energy Services*** (MRES) is G&T for 24 municipal utilities in Minnesota, and coordinates energy efficiency program implementation for their members. They package their energy efficiency program under the "Bright Energy Solutions" brand.

While there are many examples of individual COUs achieving high performance, the project team found that in general, the most impact occurred when multiple utilities were working together and pooling resources. Committed and talented utility staff were responsible for superior performance as well.

Some utilities have achieved enhanced performance through joint natural gas-electric programs

Operating joint gas and electric programs when there are opportunities for both gas and electric savings measures can achieve efficiencies in program implementation, as well as decreased confusion from customers. In recent years, Xcel Energy and CenterPoint Energy have increasingly run joint programs, such as their Multifamily Buildings Efficiency Program. This program has been popular with multifamily building owners, because it offers a comprehensive energy assessment for their total energy needs, and includes in-unit direct installs of both gas and electric savings measures in a single appointment. This saves them time and hassle, and can reach deeper savings than would otherwise be the case, as it would be far less cost-effective to set up separate appointments for installing electric measures and gas measure. Given the limited attention that most facility managers have for energy issues, a fragmented approach would likely reach fewer customers.

Outside of municipal gas utilities (where they are likely to be the electric provider as well), it is not common for municipal electric utilities to run joint gas electric programs, although there are a few examples of utilities that do cooperate with their gas provider (e.g., Rochester Public Utilities, Worthington Public Utilities, and Kasson Utilities).

Insights from potential modeling

This section outlines insights for programs from the potential study's modeling.

Residential electric programs will need to transition from lighting to ASHPs as the largest source of savings

For electric utilities, residential programs will need to undergo a major transition away from lighting and toward non-lighting technologies — in particular, air source heat pumps (AHSPs). There are two general types of ASHPs that were modeled for the potential study: ducted (which distributes heat and cooling throughout the home through central ductwork) and ductless, referred to as ductless mini-splits. This study assumes from the modeling that the market for all LED screw-in bulbs will be transformed by 2021, which is the vast majority of residential lighting.[74] Currently, residential lighting makes up 70% or more of residential savings, so this will be a large transition.

As there was no fuel switching modeled for this study, all of the savings from customer adoption of air source heat pumps is from the 17% of residential customers in Minnesota that heat primarily with electric heat. The savings are large from this segment of customers because their usage of electricity is very high, and there is so much energy to be saved. These customers have electric loads that are roughly double customers who heat with other sources of energy. An efficient ASHP serving heating loads for an entire single-family home can save over 9,000 kWh, or roughly $1,000, per year in heating costs versus heating with electric heat. Note that many utilities offer off-peak thermal storage rates, where customers can get a cheaper electric rate if they use special thermal storage resistance heating units. For these customers, the economics of switching to an ASHP will be less attractive.

Minnesota has about 353,000 total households with electric resistance heat; the majority (201,000) are multifamily, with about 153,000 single-family households on electric resistance heat.[75] However, the proportion of single-family homes and multifamily homes that are electric varies significantly by utility type (Table 33). Of the multifamily units, almost all are rental units, with the majority (53%) being low-income. Each of these segments will require a different approach. While there is a strong economic incentive for single-family owner-occupied homes to adopt ASHPs to reduce their energy bills, the owners of multifamily rental buildings where the tenant pays the bills (as is almost always the case for electrically heated multifamily) are particularly hard to address with CIP programs because of the split incentive. Larger incentives and other strategies may be required to achieve a foothold in the multifamily segment. As a large proportion of electrically heated multifamily units are low-income, coordination with federally funded weatherization programs may be another opportunity to address this segment.

[74] The project team notes that there is some uncertainty over whether "specialty bulbs," which are arguably not covered by the federal EISA standards, will truly be transformed by 2021, so there is a possibility that there may be some residential lighting savings from these bulbs in the years after 2021; but for the modeling purposes, the team assumes all savings from specialty bulbs goes away in 2021.

[75] Still, the overall load of single-family homes with electric heat is larger than the total multifamily homes with electric heat, because the average multifamily home has a significantly lower heating load than the average single-family home.

Table 33. Proportion of homes with electric resistance heating, by utility analysis region.

	Percent of homes with electric resistance heating					
Utility region	**Single family**	**Small multifamily[76]**	**Large multifamily**	**All homes**	**Portion low-income[77]**	**Total ASHP program savings potential (GWh)**
Xcel Energy	4%	19%	39%	13%	44%	130
MN Power	9%	31%	51%	16%	45%	30
Otter Tail Power	19%	45%	67%	28%	41%	30
N Municipals	10%	30%	59%	22%	50%	30
S Municipals	3%	35%	49%	13%	52%	40
N Cooperatives	19%	52%	61%	21%	29%	160
S Cooperatives	11%	35%	44%	14%	31%	170
Statewide total	**9%**	**25%**	**42%**	**15%**	**40%**	**590**

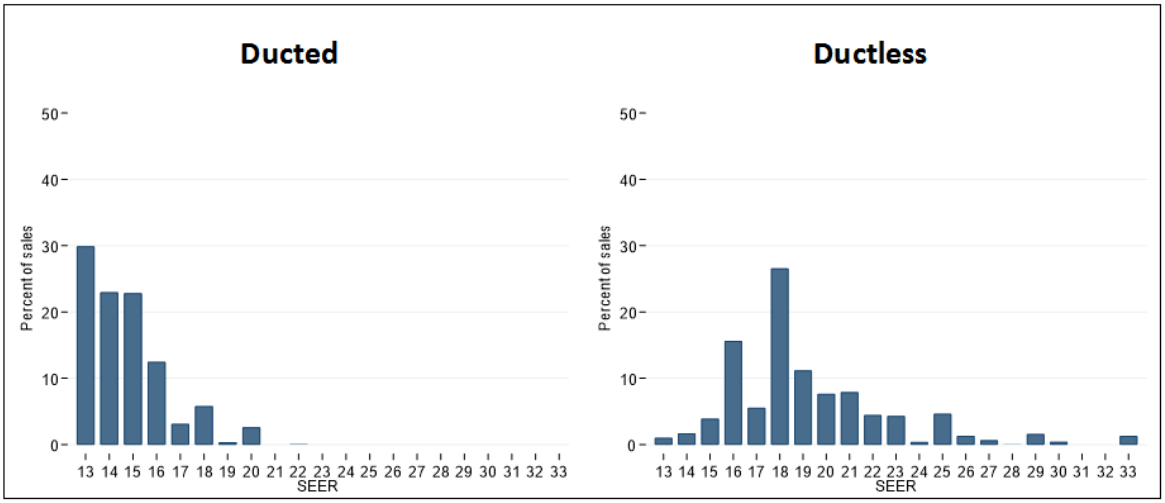
In designing effective ASHP programs, research suggests several features will be important in maximizing savings from these programs:

1. ***Utility programs can help push people to the most efficient ASHP option, which will increase space heating as well as A/C savings***. ASHP's are capable of achieving high efficiencies in both space heating as well as air conditioning, but current market data shows that consumers are not currently selecting the highest efficiency option. While the technology exists today to achieve efficiencies of over 22 SEER for ducted and approaching 30 SEER for ductless, the highest efficiency models represent only a fraction of sales currently (Figure 37).

[76] Small multifamily is defined as 2-4 units; large multifamily is 5 or more units.

[77] That is, the portion (of the total homes with electric heat) that are low-income; thus, 40% of electrically-heated homes in Minnesota are low-income.

Figure 37: Efficiencies of air-source heat pumps sold in Minnesota (2013-2016) for ducted and ductless types.[78]



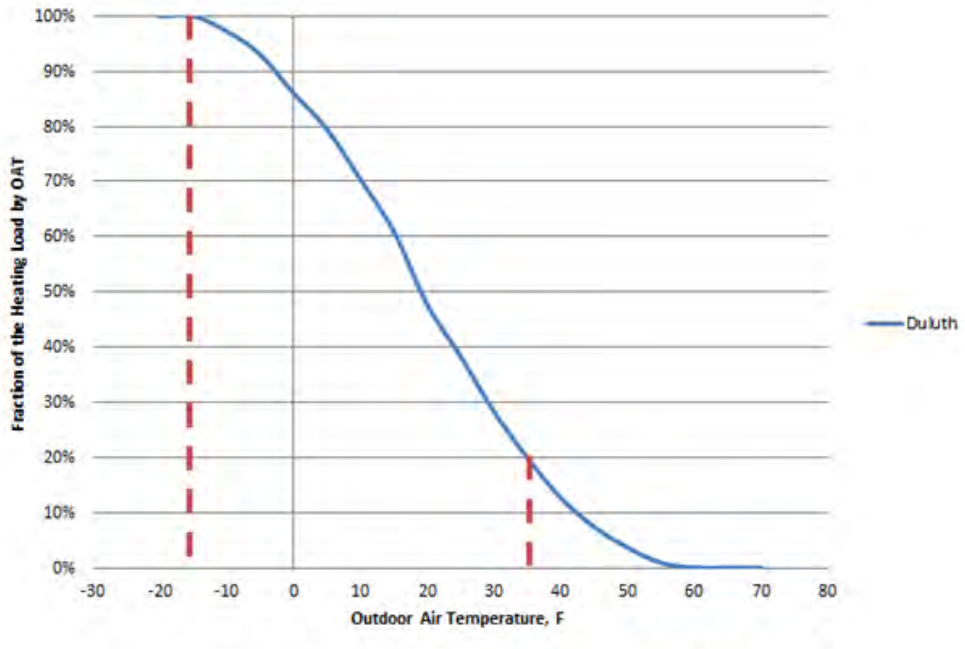
2. ***Building envelope measures can be pursued concurrently with ASHP retrofits, which can further increase savings.*** Completing building envelope measures (attic insulation, air sealing, and wall insulation) concurrently with ASHP installation can decrease the size and cost of ASHP equipment, and result in additional savings.

3. ***Contractor training and quality control are crucial for achieving the full energy-savings potential of ASHPs.*** Field research in Minnesota has shown that contractor installation of ASHPs is frequently sub-optimal, and that utility intervention can help to dramatically increase the realized efficiency of ASHP systems. The largest source of error identified is in setting overly conservative default setpoints.

   For example, Figure 38 below demonstrates the importance of correctly setting the backup heat setpoints when installing a cold climate ASHP. If the setpoints are set at 35 degrees (i.e., the ASHP does not heat below 35 degrees, and the backup heating source meets all heating needs), only a maximum of 20% of the heating load can be met by the ASHP. However, the rated capacity of newer cold climate heat pumps reach down to -20 degrees, and while they operate at lower coefficients of performance at these lower temperatures, they can still provide an energy savings benefit in weather conditions far below zero degrees.

[78] From data collected for this study. See Appendix L for a full description of the data sources.

Figure 38. Fraction of heating load by outdoor air temperature for Duluth, MN.



Lighting declines in importance for the C&I sector, but still represents a large portion of total savings

The C&I sector is impacted by the transformation of the LED screw-in market, but there is still a lot of potential from other lighting types and lighting controls, representing about 20% of the total C&I cumulative potential in 2029. The study's model shows that several LED fixture types will be important in capturing this efficiency, including high-bay, troffers, tube replacement, and exterior lighting.

Another important aspect of lighting savings is controls for lighting, such as sensor-based and/or Power Over Ethernet (PoE) enabled controls. Lighting controls, although they are controlling more efficient fixtures, represent over 20% of the lighting savings and will be important for utility lighting programs to promote.

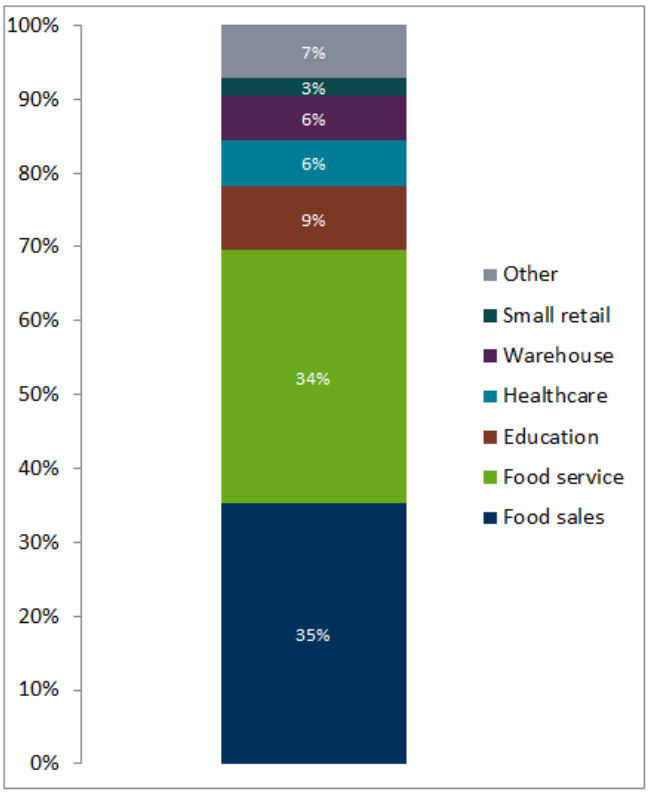
While this study's modeling shows that lighting in the C&I sector will continue to be a steady opportunity through the entire study period, it is possible that the market will be transformed more quickly, resulting in higher savings in the early years of the study, and less in the latter half of the study period as the market becomes transformed.

Refrigeration is another large source of electric potential

Refrigeration represents about one-fifth of the total 2029 cumulative potential. Nearly 90% of this potential is in the commercial/industrial sector, and of this, nearly two-thirds is concentrated in the food sales and food services segment (Figure 39). The food sales segment includes grocery stores, food markets, gas stations, and convenience stores. The food service segment includes fast food and other restaurants and cafeterias, bars, catering services or reception halls, and coffee, bagel, doughnut and ice

cream shops. Programs will need to effectively target these segments with refrigeration measures to reach the overall electric potential.

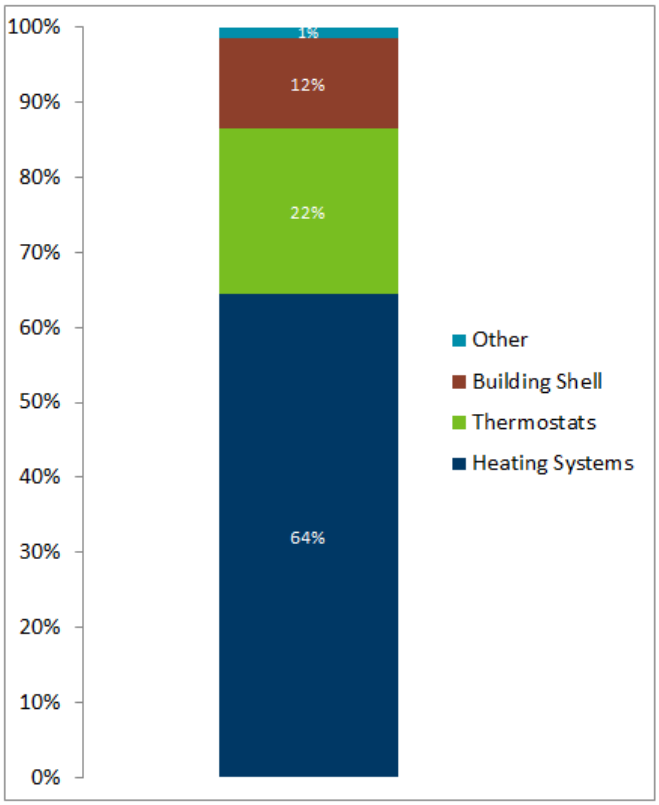
Figure 39. Refrigeration end use electric energy savings potential by building segment (cumulative 2029 program potential).



Space heating measures continue to dominate natural gas potential, with smart thermostats as the largest new source of potential

The space heating end use represents over two-thirds of total natural gas potential, as shown in Chapter 4. Within this end use, improving the heating system efficiency is the largest single group of measures (Figure 40). Although programmable thermostats are not new to gas portfolios, the improved savings potential of smart thermostats results in that technology being the second-most important opportunity for energy savings, followed by building shell measures and industrial space heating measures. Not only are smart thermostats a large source of natural gas savings, but they also provide substantial electric benefits for those spaces with cooling.

Figure 40. Breakout of measure types within residential natural gas space heating, 2029 cumulative annual savings, program scenario.



Among building shell measures, advanced air sealing in new construction is the largest source of new potential that is not currently in the market, representing 4% of overall space heating savings potential.

Best practice recommendations for utilities

This section presents the project team's recommendations for utilities in Minnesota, as well as the regulators who oversee utility program investment, for the continued improvement of CIP program implementation in 2020 and beyond. The study's modeling assumed the adoption of all of these best practices to achieve the market penetration assumed in the program and maximum achievable scenarios.

As the previous section has shown, there is much exemplary work that is happening with current CIP programs, which can be built upon to create successful programs in 2020 and beyond. While the measures pursued and the programmatic strategies used to implement them will need to change, the process of this change will be less a transformation and more an evolution of CIP that builds upon the solid foundation of current practices. Consequently, this study's recommendations are aimed at what the project team believes are good focus areas for that evolution.

1. Continue to test promising new approaches

In the review of Minnesota and national programs, the team found Minnesota utilities to have been a test-bed of innovative program and technology approaches for over a decade. This includes IOUs, but Minnesota is unique in the participation levels of a large number of cooperative and municipal utilities as well.

For example, a handful of Minnesota municipal and IOU utilities were among the first in the nation ten years ago to pilot what were then cutting-edge residential behavioral programs run by OPOWER, which provided monthly feedback reports for their customers. Shortly afterwards, several cooperative utilities started a behavioral program run by Minnesota software company Accelerated Innovations, that provided even more frequent feedback of smart meter usage data to their customers via a mobile app or web interface.

It was in Minnesota that a cost-effective method of inserting wall insulation into older homes, called the "dense pack" method, was invented in Minnesota as part of low-income weatherization efforts, and was eventually incorporated into weatherization programs across the country.

Minnesota recently funded research on air source heat pump application in cold climate settings, which was the basis for this study's finding of large potential from this technology in the coming years.

Continued investment in testing out and evaluating new approaches will be essential to developing the new sources of efficiency that we do not know about currently, but could be transformational in future years. Capturing more energy efficiency is a very technology-forward endeavor, and Minnesota will need to continue to be at the forefront of testing and evaluating this technology to be able to fully capture its potential.

2. Offer comprehensive program designs for larger and harder-to-reach customers

Comprehensive program designs work with customers to identify energy savings opportunities that they might not have been aware of, and help provide implementation support to make it easy for them to implement energy efficiency actions. These programs have been proven successful in getting savings beyond lighting for large customers, and in reaching small business customers that traditionally are hard to get to participate in CIP offerings. For example, Minnesota Energy Resource's C/I Turn Key Program offers a wide range of technical audit and project management services in order to achieve savings from some of their largest customers.

One type of comprehensive program design that has recently seen a lot of buzz is called "strategic energy management." Generally employed for large industrial customers (but also increasingly for large commercial customers), strategic energy management is defined as:

> *… a holistic approach to managing energy use in order to continuously improve energy performance, by achieving persistent energy and cost savings over the long term. It focuses on business practice change from senior management through the shop floor, affecting organizational culture to reduce energy waste and improve energy intensity. [Strategic energy*

management] emphasizes equipping and enabling plant management and staff to impact energy consumption through behavioral and operational change.[79]

Strategic energy management often involves pursuing operational savings, or using existing equipment more efficiently, as well as traditional capital projects that replace existing equipment with more efficient versions. Thus, appropriate measurement and verification approaches are necessary for this program approach. Although they don't generally call it "strategic energy management," utilities in Minnesota have been implementing this concept for their largest customers.[80] It has proven to be an effective method, especially for getting savings beyond lighting. It is, however, initially a very labor-intensive approach, but SEM typically continues to provide significant and very low-cost program savings for about 5-6 years. A key of SEM is that it includes development of a customer-specific M&V approach and tool that will allow for utility tracking and claiming large savings in real time, somewhat similar to current efforts being explored around M&V 2.0. While so far SEM has seen its greatest application among only the very largest of commercial and industrial customers, there are substantial opportunities among somewhat smaller customers as well.

Utilizing the concepts of strategic energy management is not limited to the big utilities either. One implementer working for smaller utilities in Minnesota talked about working with industrial customers using strategic energy management concepts:

"Most industrial customers are interested in saving energy, but limited by time. You can build these relationships with industrial customers that are long-term [and] ongoing [by] interacting with them on a regular basis. We set up teams bringing in people from across teams, accounting, engineering, and now you got a team that's out there pushing hard for doing energy efficiency projects."

The challenge for utilities going forward will be to incorporate some of the insights from strategic energy management and similar approaches, and to cost-effectively apply them to smaller customers. They will need to develop solutions for the other 99% that have a significantly smaller load than the top 1% that are the target of current strategic energy management programs today.

3. Develop upstream incentives and associated program support in selected markets

Upstream programs target incentives to manufacturers, distributors, or contractors rather than to individual customers. This can provide greater market penetration, is often easier for the customer (since they don't have to fill out rebate forms), and have cost efficiencies in program delivery. Minnesota utilities currently have upstream and midstream programs for lighting and other products. However, increasingly these programs are spreading beyond lighting to HVAC and other sectors, with appliances being a crucial one for electric utilities with a high faction of residential load.

Upstream programs can be a difficult model for individual smaller utilities to do without coordinating with nearby utilities, or even statewide, since their territories may not intersect well with a given

[79] From "Strategic Energy Management Minimum Elements," Consortium for Energy Efficiency, 2014.

[80] For example, Xcel Energy has two programs that could be considered strategic energy management: its Process Efficiency program for large industrial customers, and its Commercial Efficiency program for very large commercial customers.

distributor's territory. Utilities may also be reluctant to participate in these types of programs because they get little to no recognition from their customers when they participate in the program. This is due to the transaction (since it occurs upstream of the customer) often being invisible to the customer.

A national upstream effort was started recently for appliances, called the ENERGY STAR Retail Products Platform (ESRPP). The ESRPP, coordinated by the U.S. Environmental Protection Agency, allows participants to leverage each other's resources. This helps to avoid duplication of effort and redundancy across neighboring service territories, and to streamline operations. The focus is providing retailers with incentives from utilities, along with other energy efficiency program sponsors, to change their inventories to sell increasing numbers of ENERGY STAR certified products. Xcel Energy was an early participant in this effort, and savings from this effort are part of its CIP portfolio.

This effort could make sense for more utilities in Minnesota to join, pool their efforts, and cost-effectively address the residential sector. Pursuing upstream incentives are likely necessary for utilities to capture the full potential from this end use, particularly for residential appliances and smart thermostats. However, cooperative-owned utilities might have a harder time justifying this expense to their customer-members versus something they can more directly explain.

4. Incorporate operational savings into commercial and industrial programs

Operational savings is also called "intelligent efficiency"[81] or "systems efficiency." It involves moving beyond individual equipment efficiency and improving the equipment operations to only use as much energy as is needed for occupant comfort and other outputs. Much of this potential for capturing savings from improving the efficiency of the overall system is enabled by new technologies. Efficiency from the "Internet of Things" (IoT) is largely operational savings as well, achieved from using sensors and controls to optimize existing HVAC equipment, motors, fans, burners, and more. This is a large area of savings in this study for utilities with load in the commercial sector.

Building recommissioning is an example of a current utility program offering that is common in Minnesota that achieves operational savings for building owners. Within the commercial/institutional building segment, new program models are emerging as well, which focus on more continuous commissioning approaches. The approach, much like recommissioning 20 years ago, has not been perfected yet, but it is a good area for pilots and innovation.

5. Employ segment-specific strategies to reach customers

Energy efficiency programs rarely cite mass market approaches, such as buying radio ads, as being sufficient for people to enroll in programs. However, they often report the failure of mass-market approaches in increasing program sign-up rates by decision-makers, particularly for business customers. In the commercial sector in particular, segment-specific strategies, often based on relationship building, are a proven engagement method. An example of a segment-specific approach is working with specialized trade allies, like small-business refrigeration service contractors (a trusted source of information on refrigeration upgrades by many convenience store owners), to effectively reach the convenience store market and reduce energy waste from refrigeration end use.

[81] See Rogers, Ethan and E. Junga, "Intelligent Efficiency Technology and Market Assessment," American Council for an Energy-Efficient Economy, Washington D.C., 2017. https://aceee.org/topics/intelligent-efficiency.

The best programs employ these types of segment-specific strategies because market dynamics related to energy efficiency can vary dramatically from one segment (e.g., education) to another (e.g., retail). One might be most receptive to efficiency measures only when they have financing for broader initiatives, but will invest in long-payback items, while another might invest immediately, but only in items with less than a five-year payback. Each segment requires a different approach for the optimally successful program portfolio. This requires market research — from studies, personally knowing the market actors (often the best approach), or from some other source. Data analytics, on the energy usage patterns of customers, can be a good source of segmentation data. The research then determines the best segment-specific approach to use.

6. Deepen trade ally engagement and training efforts

Further developing trade ally relationships can be an important strategy to bring overall program costs down. Trade allies already have a sales force to sell energy efficiency to the market, and they can provide great leverage in implementing efficiency programs.

Training is another area where utilities have played a greater role in recent years. How a piece of equipment gets installed is often as important as the choice of equipment for realizing the full savings potential from retrofits, and in new construction. This is especially true of newer types of equipment that contractors are not as familiar with, which increasingly represents where the savings potential exists. Air source heat pumps, for example, commonly are not installed with the correct setpoints that would maximize the energy and cost savings for the customer. This is because contractors are unfamiliar with the technology and want to minimize potential call-backs. Utility training can play a role in helping their customers to get the full energy savings from the equipment they are helping to pay the customer to install.

Utilities playing a role in contractor training has had some success in Minnesota. Prior to utilities requiring certification of insulation contractors, virtually no contractors were certified in the proper techniques for air sealing and insulating existing attic and wall spaces. However, utilities started to require this certification, and partially compensated employers for the training and expense of getting certified. A majority of insulation contractors in the state are now certified, and the workforce for efficiency in Minnesota has advanced.

One concern faced by both trade allies and utilities in Minnesota is a workforce shortage, particularly in the skilled trades involved in installing energy efficient equipment. Contractors struggle to find enough qualified applicants to fill open positions, which limits their productivity and has the potential to limit their ability to meet customer demand for efficiency services. Both utilities and trade allies could engage with the state workforce development system, funded through the Department of Employment and Economic Development (DEED) and administered at the local and regional level, to help address workforce challenges. Particular attention is needed on supporting small and mid-size businesses in adjusting their practices to more effectively attract and retain qualified workers, and in providing quality on-the-job training to both entry-level and skilled new hires. A variety of services and supports are available to employers through the workforce system to help them find and implement effective solutions that will enable them to support expansion of energy efficiency in Minnesota.

Table 34 shows the mixture of jobs that can be expected to be supported, meaning retained or created, by total efficiency spending during the study period (2020-2029) under the program scenario. It is important to note that during the study period there will be a large wave of retirements taking place in the energy efficiency sector, so while the jobs supported may not be new, a significant proportion of

them will be filled by new workers. The calculation of these jobs numbers is fully explained in Appendix P.

Table 34. Expected workforce supported by total CIP spending over the course of the study period (program scenario).

Direct job type	Expected job-years[82]	% of total job-years
HVAC technicians	10,500	21%
Electricians	5,100	10%
Insulation installers	2,200	5%
Mechanical engineers	2,100	4%
Architects	2,000	4%
Plumbers, pipefitters	1,800	4%
Retail salespersons	1,400	3%
Weatherization technicians	1,100	2%
Stationary engineers and boiler operators	700	2%
Other	3,500	7%
Total direct job-years	30,400	62%
Indirect job-years (*Not listed above)	18,900	38%
TOTAL JOB-YEARS	**49,300**	**100%**

7. Incorporate AMI-enabled capabilities into programmatic strategies

Advanced Metering Infrastructure (AMI) includes smart meters and all the accompanying infrastructure that enables two-way communication between customers and their utility through the customer's billing meter. It opens up new possibilities for engagement by customers in their energy usage. Rather than receiving billing information once a month, customers can now receive usage information on a nearly instantaneous basis. This information and the engagement opportunity can be leveraged by energy efficiency programs.

Currently, Minnesota as a whole has a relatively low level of AMI adoption. Minnesota cooperatives are ahead of other utilities in AMI adoption, and most of them are also taking advantage of opportunities to engage customers in energy efficiency. For example, many of the cooperatives with AMI provide their customers with the "MyMeter" service and behavioral program.[83] This provides a web and mobile phone application dashboard for customers to track their energy usage in intervals of one hour or less.

8. Leverage interest by local governments in energy efficiency

Local governments are increasingly interested in how they can improve their overall energy efficiency, and that of their residents and businesses. The Minnesota GreenStep Cities, a voluntary program for cities interested in enacting sustainability actions, reports that 122 cities in Minnesota currently

[82] A job-year represents a single job retained or created for one year. A single job maintained over the course of the ten year study period is equivalent to ten job-years.

[83] The MyMeter platform is run by St. Paul-based software company Accelerated Innovations.

participate in the program.[84] All of these cities, and more, are interested in doing what they can to promote energy efficiency, and could potentially partner with utility programs.

Several utilities in Minnesota have undertaken efforts to leverage city interest in energy efficiency. Xcel Energy, through its Partners in Energy offering, provides extensive support for local governments in developing and implementing a local energy action plan.[85] Some of the implementation efforts that local governments can help with are:

- Cross-marketing of utility energy efficiency programs. For example, cities can market efficiency on their water bills sent to customers;
- Funding for completing energy efficiency upgrades. Several metro area cities offer bonus incentives for homeowners and businesses to complete upgrades, and tie their incentive to the utility incentive; and
- Community efforts can help recruit and mobilize "trusted messengers" for energy efficiency campaigns, and increase the penetration and effectiveness of utility marketing efforts.

Utilities have only just begun to explore the possibilities of how to leverage this opportunity, and should continue to develop partnerships in this area.

Recommendations for coordination among utilities

In addition to the program and portfolio recommendations above, the project team also suggests the following strategies to enhance coordination among utilities. Some of this can be accomplished by individual utilities working together, while other strategies may need the state or another actor to play a lead or facilitating role.

1. Coordinate more closely on trade ally outreach and training

Unsurprisingly, the trade ally survey indicated that trades contractors are an important component of the success of CIP programs. It also indicated several areas of improvement for utilities in better engaging them, including education and training. Trade allies are not recommending some key technologies to their customers because they are not familiar enough with them.[86] This is a common chicken-and-egg program with emerging energy efficiency technologies, and is a strong argument for coordinated, utility-funded efforts to overcome this barrier. Since many contractors work across utility territories, this is a good area for utility cooperation.

[84] See: MN Green Step Cities website (https://greenstep.pca.state.mn.us)

[85] See: Xcel Energy's Partners in Energy website (https://www.xcelenergy.com/working_with_us/municipalities/partners_in_energy)

[86] For example, many plumbing contractors in the survey reported concerns about the performance and feasibility of tankless water heaters and do not actively promote them, even though utilities provide incentives for this technology.

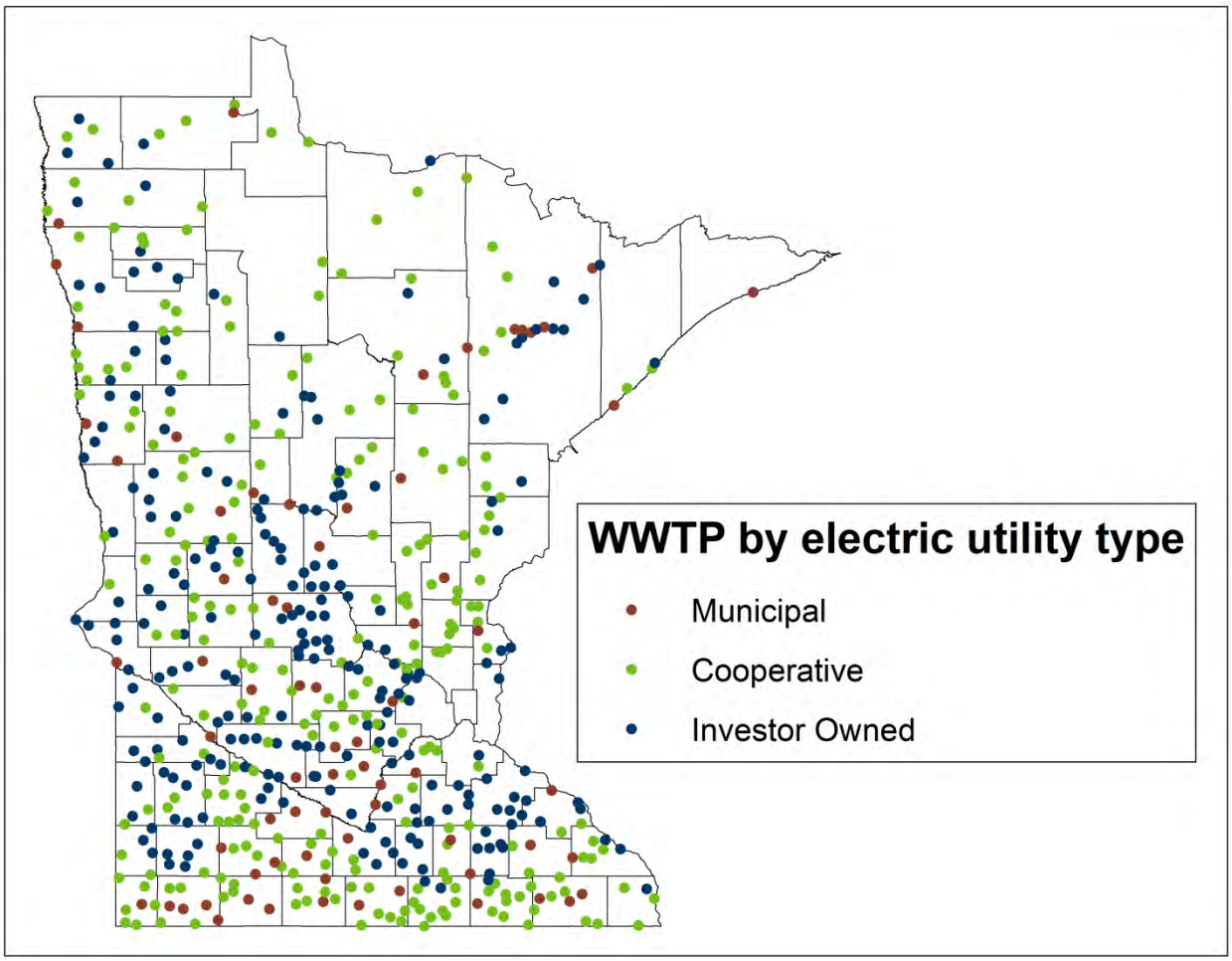
Utilities can play a key role in bringing new technologies to existing training programs preparing workers for energy efficiency jobs. They can also work with technical colleges to develop customized training classes for groups of contractors, to teach new skills or technologies to incumbent workers. Both approaches would benefit from close collaboration with the state workforce development system and other workforce partners to facilitate identification of transferrable skills and abilities to inform curriculum design, and of available funding streams to support training.

2. Work further toward coordinated and/or joint implementation of programs

The project team's research suggests that coordinated approaches to program implementation can result in enhanced program results. Some types of program designs are also more easily or economically accomplished at scale — some apply to specialized business segments that an individual utility may have only a few or even one instance of in their service territory. This is not enough to build a program around, but when combined with other utility service territories, can make sense to address the segment in a holistic fashion.

For example, the Minnesota Technical Assistance Program (MnTAP) at the University of Minnesota has a current CARD grant to look at operational savings through wastewater treatment plants (WWTP). They are using a cohort model, where many facilities join together to commit to savings, along with sharing best practices. It relies on a critical mass of participation and is not suitable for addressing a single facility at a time. Having multiple facilities participate concurrently is critical for the program design to be successful. In total, Minnesota has 211 WWTPs that would be good candidates for targeting operational savings (Figure 41). Of this total, 74 are located in utilities with only one wastewater treatment plant. This may be a good opportunity for an "opt-in" program model, where interested utilities could opt into the program. This may be enough to get a critical mass sufficient for the program to be successful.

Figure 41. Location of non-metro wastewater treatment plants by electric utility type



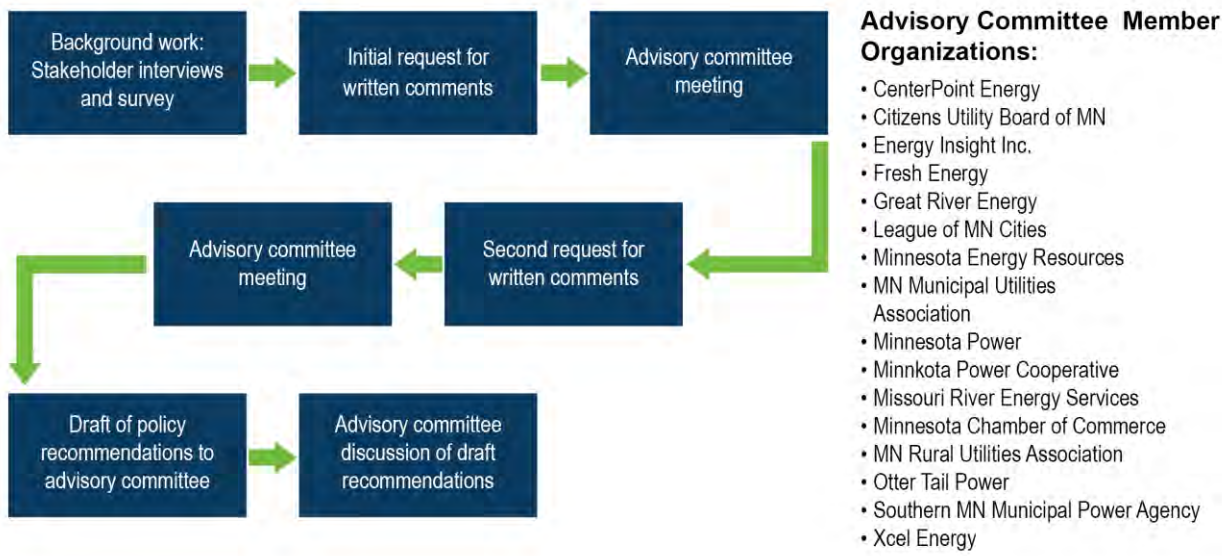
Chapter 6: Policy Conclusions by Topic Area

The following chapter represents the project team's effort to inform Conservation Improvement Program (CIP) discussions and ensure Minnesota continues to maximize cost-effective energy efficiency resources into the next decade. For three important issue areas, this chapter discusses the study's findings, summarizes the stakeholder input received, and presents conclusions for consideration by policymakers.

This study's stakeholder outreach process (Figure 42) began with individual interviews and a survey to broadly understand how stakeholders perceive CIP and what topics related to CIP are of most importance to them (see Chapter 2 for key survey results).

A project advisory committee, composed of 13 CIP stakeholders representing utilities, clean energy organizations, consumer advocacy organizations, and businesses provided input on the policy topic areas — including two rounds of written comments (see Appendix N for list of committee members and submitted comments).

Figure 42. Process for gathering stakeholder input into policy discussion and organizations represented on the advisory committee.



The three topic areas discussed were: 1) achievement of CIP goals; 2) regulatory oversight of CIP; and 3) the integration of efficient fuel-switching and demand-response programs in CIP, summarized in Table 35.

Table 35. Summary of policy findings, stakeholder input, and study conclusions.

Topic Area	Relevant findings from potential study	Stakeholder input	Conclusions
Achievement of CIP goals	Meeting or exceeding, on average, the current CIP goal of 1.5% for electric utilities and the statutory minimum of 1.0% for gas utilities is achievable in the 2020-2029 timeframe. Achieving savings targets is likely to require increased but still cost-effective spending. The existing incentive structure has been effective at motivating investor-owned utilities to exceed their energy- savings goals.	Small consumer-owned utilities report facing additional challenges in implementing programs; thus, it may not be possible for them to achieve the same energy-savings level as the investor-owned utilities. More emphasis on lifetime savings is justified, but the first-year savings goal is still preferred as the main statutory CIP goal.	***The 1.5% savings goal can continue to be achieved using the existing flexibility to adjust goals when justified.*** Lifetime savings could be better measured and tracked through the annual reporting process, rather than a statutory change. Consider allowing consumer-owned utilities to report savings in a multi-year framework.
Regulatory oversight of CIP	CIP programs in the 2020s will need to expand into new end uses and technologies, increasing the complexity of regulatory issues. Results from Commerce-funded conservation applied research and development projects inform this potential study's estimates and pave the way for increased savings from new end uses.	The stakeholder survey shows mostly strong support for current Department regulation. Most stakeholders support a practical approach that minimizes confusion and provides regulatory clarity.	***Clarity on key regulatory topics could be accomplished through the creation of a CIP guide.*** Consider creating a formal advisory committee for CIP regulatory topics to increase transparency and avenues for stakeholder coordination on CIP implementation. Continue to have strong research and development to support future energy savings.
Incorporating demand-response & efficient fuel-switching into CIP	Demand-response programs will increasingly be needed for integrating carbon-free renewables onto the grid, and to balance high load with high-generation times. With appropriate safeguards, efficient fuel-switching could significantly increase overall efficiency, decrease emissions, and reduce costs for consumers.	There is strong electric utility support for incorporating demand-response and efficient fuel-switching into CIP. Public interest concerns were raised about investor-owned utilities receiving incentives for load-building activities. Public interest concerns were raised about demand-response and fuel-switching diluting or competing for limited capital with energy efficiency efforts. Both demand-response and fuel-switching programs are customer-facing programs, like CIP.	***Consider whether to incorporate "integrated demand-side management" into the CIP framework — with appropriate safeguards.*** In crafting specific policy for integrating demand-response and fuel-switching, safeguards should ensure end-use efficiency is not decreased; utility incentives for investor-owned utilities should be considered separately (demand-response) or not provided (fuel-switching).

Topic Area 1: Achievement of Conservation Improvement Program (CIP) goals

One of the main objectives of this study was to estimate the potential for utility-funded energy efficiency in the next decade. This is relevant to determining if the current CIP goals in the statute are achievable for the next decade.

The CIP statute sets a 1.5% annual energy savings target for utilities of all utility types:

> *Each individual utility and association shall have an annual energy-savings goal equivalent to 1.5 percent of gross annual retail energy sales unless modified by the commissioner under paragraph (d). The savings goals must be calculated based on the most recent three-year weather-normalized average. A utility or association may elect to carry forward energy savings in excess of 1.5 percent for a year to the succeeding three calendar years, except that savings from electric utility infrastructure projects allowed under paragraph (d) may be carried forward for five years. A particular energy savings can be used only for one year's goal.*[87]

The statute also allows electric utility infrastructure and combined heat and power projects to count toward the 1.5% goal, but sets a 1% minimum energy-savings requirement from traditional end-use energy conservation activities for those utilities subject to CIP:

> *A utility or association may include in its energy conservation plan energy savings from electric utility infrastructure projects approved by the commission under section 216B.1636 or waste heat recovery converted into electricity projects that may count as energy savings in addition to a minimum energy-savings goal of at least one percent for energy conservation improvements.*[88]

The statute also recognizes the important differences between utilities by allowing the Commissioner of the Minnesota Department of Commerce to adjust a utility's annual energy-savings target, "based on its historical conservation investment experience, customer class makeup, load growth, a conservation potential study, or other factors the commissioner determines warrants an adjustment."[89] The CIP statute precludes the Commissioner from setting "an annual energy-savings goal of less than one percent of gross annual retail energy sales from energy conservation improvements" for the investor-owned utilities (IOUs), but does not restrict the ability of the Commissioner to adjust the CIP goal to less than 1% for the consumer-owned utilities (COUs).[90]

[87] MN Stat 2018, section 216B.241, subd. 1c, paragraph (b).

[88] MN Stat 2018, section 216B.241, subd. 1c, paragraph (d).

[89] MN Stat 2018, section 216B.241, subd. 1c, paragraph (d).

[90] MN Stat 2018, section 216B.241 subd. 1c, paragraph (d).

Achievement of CIP Goals: Relevant findings

Meeting or exceeding, on average, the current CIP goal of 1.5% (electric utilities) or the statutory minimum of 1.0% (gas utilities) is achievable in the 2020-2029 timeframe.

The results of this study indicate that, overall, Minnesota's electric utilities should be able to continue to meet or exceed their annual 1.5% energy efficiency resource goal in the next decade (Table 36). It also found that while it will be more difficult for gas utilities to meet or exceed the 1.5% goal (Table 36), as they have only done so once in the past decade, they should be able to meet or exceed the 1% minimum requirement, as has been accomplished in the recent past.

Table 36. Summary of projected average incremental annual savings and budgets, 2020-2029.

	Electric utilities		Natural gas utilities	
	Max achievable	Program	Max achievable	Program
Average incremental annual savings	2.60%	1.80%	2.20%	1.30%
Average annual budget (millions)	$777	$309	$573	$189

Achieving savings targets is likely to require increased, but still cost-effective, spending.

Modeling completed for this study indicates that meeting or exceeding the CIP targets could come at a higher cost than in the past. Lighting (in particular LEDs) has been a great boon in recent years for achieving low-cost efficiency gains for electric utilities. However, achievement of savings goals in the future will require expansion to new end uses beyond lighting and, for gas utilities, reaching harder-to-reach customers. The modeling suggests that savings targets can still be cost effectively achieved, but energy efficiency portfolios may not be as cost effective as they have been in the past.

Many of the strategies for achieving savings in the future work better at scale, and smaller COUs — unless they coordinate and aggregate their individual efforts more closely — could have difficulty achieving savings targets.

The existing incentive structure has been effective at motivating investor-owned utilities (IOUs) to exceed statutory minimum goals.

As discussed in Chapter 2, the IOUs receive incentives for meeting or exceeding their CIP goals, based on the share of net benefits their CIP programs create. While selling less energy is not a natural business model for utilities, these incentives have helped to make it in their business interest to pursue CIP vigorously, even beyond the statutory minimum. Electric IOUs have surpassed their statutory minimum

goals in six of the eight years that the statute has been in effect — in some cases, significantly exceeding the 1.5% goal. As an example, Otter Tail Power achieved 3.0% savings in 2017. This suggests that the incentives structure that is part of the CIP framework has been effective at motivating utilities to pursue cost-effective CIP programs that go beyond the statutory minimum.

Achievement of CIP Goals: Stakeholder feedback

Small consumer-owned utilities (COUs) report facing additional challenges in implementing programs; thus it may not be possible for them to achieve the same energy-savings level as the investor-owned utilities (IOUs).

Throughout the CIP policy stakeholder process, a number of stakeholders discussed challenges in meeting CIP energy savings goals due to unique utility characteristics. This was particularly true for Minnesota's small COUs.

The Southern Minnesota Municipal Power Agency (SMMPA), which provides wholesale electric service and CIP programming to a number of municipal utilities with diverse and sometimes challenging customer profiles, explained how the current energy savings goal paradigm falls short for some utilities:

> *"[E]xpecting each individual utility to achieve 1.5 [percent] savings every year may not be a realistic expectation… Utilities with high load growth and utilities with no load growth all have the same CIP savings goal – 1.5 percent – which seems unfair. It would be helpful if issues like this could somehow be factored into setting the CIP goal. The Department currently provides some flexibility to utilities by allowing aggregation and carry-forward savings provisions. But not all utilities have an opportunity to aggregate, and the carry-forward term is rather short compared to the average lifetime of the energy savings. Allowing for some additional flexibility by allowing utilities to adjust CIP targets based on statewide potential studies (a), or by the type and proportion of customers they serve (b), seems reasonable."*[91]

Banding several utilities together for tracking, reporting, and achieving energy savings is a strategy that many cooperative and municipal utilities employ to manage the cost and difficulty of capturing the cost-effective efficiency potential available to them. Aggregation of CIP services allows costs and expertise to be shared and spread among more utilities and customers. Extending aggregation to more COUs that are currently not aggregated could reduce the cost, regulatory burden, and administrative burden of achieving the annual CIP target.

[91] Southern Minnesota Municipal Power Agency, Response to Second Request for Written Comments, Page 1, Question 4.

More emphasis on lifetime savings is justified, but the first-year savings goal is still preferred as the main statutory CIP goal.

Minnesota expresses CIP goals in terms of "first-year savings" goals, or the sum of the annual incremental savings from all the energy efficiency measures that are installed in that year. However, many of these measures last for 10 years or more, and measuring CIP by its first-year impact could understate the long-term impact of energy efficiency. Also, a focus on first-year savings can overemphasize the importance of short-lived measures, as these are given equal weight to longer-lived measures in CIP.[92]

Many CIP stakeholders suggested that lifetime energy savings should play a greater role in CIP. Eighty-three percent of respondents to the CIP stakeholder survey said that they agree or strongly agree that lifetime savings should be used to measure CIP success (See Figure 13 in Chapter 2).

Stakeholders noted two specific benefits of using lifetime energy savings as a measure of CIP achievements. First, lifetime energy savings are more representative of the resource value of energy savings than first-year energy savings.

As explained by the American Council for an Energy-Efficient Economy (ACEEE),

> *"While it is important to assure annual incremental progress (as opposed to simply setting a long-term goal to hit some time in the future), there is now widespread recognition in the industry that in order for energy efficiency to be a true utility system resource, it must have a lasting and cumulative impact on the utility system."*[93]

In written comments, Great River Energy (GRE), an electric cooperative owned by its 28 member cooperatives, stated that:

> *"First-year savings is an understandable metric, but it does not reflect the true lifetime impacts of the efficiency improvements. Cumulative savings that highlight the total savings that have been realized through ongoing programmatic efforts seem to best reflect the energy efficiency resource impacting a utility's operations. A benchmark that incorporates cumulative savings from energy efficiency is an indicator of a utility's "good faith effort" toward the promotion of*

[92] Although notably, current DER guidance is for behavioral measures to use the "Average Savings Method" for reporting first-year savings for these programs, which is a more conservative way to report savings from behavioral programs, compared to other states. For full discussion of this issue, and other approaches, see pg. 81-94, "Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines," Illume, et. al, a CARD project. Available at: http://mn.gov/commerce-stat/pdfs/card-report-energy-efficiency-behavorial-prog.pdf.

[93] American Council for an Energy-Efficient Economy, response to Second Request for Written Comments, Page 3, Question 3.

energy efficiency and allows a more forgiving lens of evaluation vis-à-vis a first-year savings approach that would seemingly punish utilities for not making the goal every year."[94]

Similarly, the Southern Minnesota Municipal Power Agency (SMMPA), a wholesale joint action agency created by its 18 member municipal utilities stated that, "SMMPA has long believed that incremental/first-year savings do not reflect the true lifetime savings impacts and carbon impacts from DSM."[95]

Another benefit of using lifetime savings as a main metric for the success of CIP is that first-year energy savings are not always indicative of a utility's long-term program performance. Some other states have moved away from first-year goals to metrics like "cumulative persistent energy savings," which is the metric that the state of Illinois uses to account for lifetime savings.[96] This type of goal accounts for the lifetime savings of energy efficiency and provides a long-range view of utility performance. It is also less susceptible to the annual ups and downs from natural fluctuations in customer participation. These annual fluctuations can be particularly relevant for smaller utilities, for which one or two large projects determine whether the utility meets annual first-year energy saving goals.

Despite the many stakeholders who support a greater emphasis on lifetime energy savings in CIP, other stakeholders stated that the existing first-year energy savings CIP goals were working well and saw no need for a statutory change. Also, Minnesota's IOUs currently factor the lifetime value of energy savings into the calculation of their financial incentive, so it is a very important metric already for them. As CenterPoint Energy stated, the current CIP goal framework works well, "if utilities continue to receive a financial incentive that is based on net benefits achieved by CIP."[97]

Though first-year savings do not capture the full value of energy conservation, it is a simple metric that is relatively easy to calculate, track, and report. SMMPA noted the complexities involved in moving to a lifetime savings goal and said that, "[E]ven some of our member utilities fail to consider lifetime benefits simply because the current CIP goals only focus on first-year savings."[98] CenterPoint Energy discussed the additional challenge for utilities in incorporating policy changes into program plans, stating, "The

[94] Great River Energy, Response to First Request of Written Comments, Page 5, Question 6.
[95] Southern Minnesota Municipal Power Agency, Response to First Request for Written Comments, Page 2, Question 6.
[96] In 2016, Illinois passed the "Future Energy Jobs Bill" which enacted new energy efficiency goals, including that the largest utility, Commonwealth Edison, attain 21.5% "cumulative annual persisting savings" by 2030. See: http://www.ilga.gov/legislation/publicacts/99/PDF/099-0906.pdf.
Also, note that this study reports the "cumulative annual 2029 savings," which is identical in concept to how Illinois changed their statute, and represents the total impact of CIP from measures installed in 2029, as well as other measures that still have a "life" in 2029, and are continuing to save energy even though they were installed in previous years.
[97] CenterPoint Energy, Response to Second Request for Written Comments, Page 3, Question 3.
[98] Southern Minnesota Municipal Power Agency, Response to First Request for Written Comments, Page 2, Question 6.

transition between one goal framework and another can be disruptive to programs and planning as stakeholders adapt to the new framework."[99]

In the end, most stakeholders agreed that while lifetime savings as a CIP metric had its merits; changing the statute to a lifetime savings metric would be complicated, and not likely worth the effort. Outside of a statutory change, there may be simpler ways to emphasize the lifetime savings of CIP. Better tracking and reporting of lifetime savings, without a statutory change to CIP, was one of the stakeholder suggestions.

In addition, some of the COUs suggested that the annual savings goal could be a multi-year goal, rather than a single-year target each year. This could help to solve the issues that some smaller utilities have with annual fluctuations in achievements, without having to change to a lifetime savings framework. SMMPA noted the value of this more long-range view of utility performance:

> *"Instead of having an annual savings goal, maybe a longer term (5, 10, or 15-year) savings goal makes more sense. Doing that would also eliminate the need for the messy/unfair carry-forward savings policy that utilities currently operate under, and eliminate the stigma of being "non-compliant" for not achieving the savings goal every year (even though you may actually exceed 1.5 percent on average)."*[100]

Achievement of CIP goals: Conclusions

The 1.5% savings goal can continue to be achieved, and the existing flexibility of the statute can be used to adjust individual utility goals when justified.

The current CIP annual energy-savings target of 1.5% of gross annual retail energy sales could be retained, and the flexibility inherent in the CIP statute utilized to adjust that target to fit the circumstances of any particular cooperative or electric or natural gas utility. The Department already uses the existing flexibility for natural gas utilities that have achievements of less than 1.5%, and this could continue to be utilized in the 2020-2029 framework.

This study's modeling indicates that even higher achievements, beyond 1.5%, may be possible, although this would likely come at a higher cost. Past history suggests that IOUs in particular could exceed the statutory minimum if financial incentives continue to be in place to encourage investment in all cost-effective energy efficiency.

[99] CenterPoint Energy, Response to First Request for Written Comments, Page 3, Question 6.

[100] Southern Minnesota Municipal Power Agency, Response to First Request for Written Comments, Page 2, Question 5.

Lifetime savings could be better measured and tracked through the annual reporting process, rather than a statutory change.

Although stakeholders did not support changing the statute away from the first-year savings framework, most agreed that a greater emphasis on lifetime savings was justified, and could help ensure CIP is focused on long-term impact and resource acquisition.

Currently, there is no consistent reporting of lifetime impacts by utilities, so it is hard to even know what the lifetime impacts of CIP are. A logical starting point is to start tracking this impact. The Department could require IOUs to consistently report lifetime savings by program, so that they and other stakeholders could start to track the impact CIP programs have not only on first-year savings, but also lifetime savings. Since utilities already internally track this information (some include this data in their CIP filings already), it should not be difficult. This information will be useful over time in understanding which programs have the greatest impact on long-term resource acquisition, and what the total impact is, over a period of time, of CIP. This information does not consistently exist for IOUs currently.

While COUs report according to the Department's online tool, which can already calculate lifetime savings by program, this tool reportedly is not consistent with the Minnesota Technical Reference Manual (TRM) lifetime assumptions. This inconsistency could be corrected in the next iteration of the tool, so that COUs can more accurately report lifetime savings.

Consider allowing consumer-owned utilities (COUs) to report savings in a multi-year framework.

Allowing COUs to meet a multi-year savings goal, rather than a fixed annual goal of 1.5% per year, might be helpful for these utilities. This could still be expressed as first-year savings, but could help smooth out years where they were under the goal, and years when they were over the goal. For example, instead of a 1.5% goal in each of the next five years, an individual utility could have a goal to reach 7.5% savings over the five-year period.

Topic Area 2: Regulatory oversight of CIP

In addition to recommending program changes, the project team also considered how the Department's oversight of CIP may need to expand in response to the future challenges of CIP.

Regulatory oversight: Relevant findings

Conservation improvement programs in the 2020s will need to expand into new end uses and technologies, increasing the complexity of regulatory issues.

In its role overseeing CIP, the Minnesota Department of Commerce (Department) must review utility technical assumptions for reasonableness, which is particularly important for the IOUs, since those assumptions can drive incentives that they receive for meeting or exceeding CIP goals. The modeling has shown that CIP programs will need to increasingly reach new end uses like space heating and refrigeration, incorporate new technologies such as smart thermostats, and use enhanced programmatic strategies including strategic energy management.

Some of these technologies do not have a long track record of savings, and nuances of program implementation could impact savings. For example, different thermostat models, or installation methods, could affect the level of savings that is actually achieved from smart thermostats. These technologies and methods, while currently being used in CIP, may become a bigger part of CIP savings over time.

Enhanced programmatic strategies likewise might call for different methods to validate energy savings. For instance, those strategies employing smart meters data may require new, data-intensive savings validation methods.

For all of these reasons, the project team expects the Department's review of CIP programs in the 2020s to become more complex, compared to recent years.

Past Department Conservation Applied Research and Development (CARD) projects have helped to inform potential study estimates, and paved the way for increased savings from new end uses.

The Conservation Applied Research and Development (CARD) program is overseen by the Department, and is intended to help identify new technologies and programmatic approaches for CIP programs. This potential study was funded by CARD, as well as numerous other research projects that informed the inputs into this study.

For example, one of the major findings of this report is that cold-climate air source heat pumps (ASHPs) are a major new source of savings for CIP in the future. The technical inputs that the study team used were informed by a CARD-funded project that field tested new cold-climate ASHPs, and verified the

heating load that could be achieved in Minnesota's climate. As CIP programs are very technology-forward, and traditional CIP programs such as lighting will need to be replaced, it appears that continuing research of this type will be important in order to pave the way for increased savings from new end uses.

Regulatory Oversight: Stakeholder input

Stakeholder survey shows mostly strong support for current Department regulation.

This study's stakeholder survey showed that over 80% of stakeholders reported having a favorable experience with CIP, with a small minority reporting unfavorable experiences (Figure 10, Chapter 2). This was confirmed by individual interviews, where most utilities and other stakeholders reported they found the regulatory approach of the Department to work well for them.[101]

Most stakeholders support a practical approach that minimizes confusion and provides regulatory clarity.

Individual conversations with stakeholders also emphasized their value on practicality, and getting things done in a 'common-sense' manner.

For example, Minnesota regulators do not require a "net-to-gross" calculation for savings (see discussion on page 89 for net-to-gross issues), which, in states that do this, tends to increase the regulatory burden of efficiency programs, to the benefit of having increased confidence in net savings values. However, from the study team's work reviewing utility portfolios, utilities do tend to manage their programs to minimize "free riders" — or participants that would have participated anyway without any incentives.[102] The issue of net-to-gross is important for utility-attributed savings, and yet lots of time, funding, and regulatory filings can be spent on the topic without much of a change in result. Most stakeholders supported the practical approach taken in Minnesota of dealing with net-to-gross issues

[101] COUs were more likely than other stakeholders to express dissatisfaction with the CIP regulatory process, which stemmed both from some of the increased challenges they face (see Chapters 4 and 5 for more discussion of this) and a greater likelihood to believe that CIP regulation is unnecessary for COUs.

[102] Especially for the smaller utilities, this policy of minimal spending on program evaluation is a practical reality. One can envision millions of dollars being spent on evaluation if every utility in the state separately did intensive program evaluations of all of their programs, and especially for small utilities, this could become a substantial portion of their overall program expenses. The study team's experience in talking with both large and small utility program managers (including and especially COUs), is that they do express concern that lighting or other programs may face too much free-ridership in the future, and thus dilute the value of the dollars they spend on CIP programs. The two main ways of managing the freeridership issue, without doing net-to-gross evaluations are: 1) utilize good program design, and/or eliminate programs that have high free-ridership issues; 2) adjust the savings level for programs with high freeridership, so that the utility claims a blend of the savings from program-influenced participants and free riders. Both methods are reportedly used by Minnesota utilities.

with good program design, or adjusting the baseline of measures to account for free ridership, rather than extensive evaluation and regulatory filings.[103]

Stakeholders also indicated that increased regulatory clarity would be helpful on some topics. For example, stakeholders repeatedly noted the important role that they expect operational savings to play in future CIP portfolios. In the CIP stakeholder survey, 73% of respondents stated that behavioral and operational savings should have greater emphasis in CIP.[104] Minnesota Power stated in response to the second request for written comments:

> *"This type of program offering [operational savings] has significant potential that could be pursued if there were 1) a more clearly established method for incentivizing non-asset driven investments and 2) published criteria for calculating associated (influenced) energy savings. With such a path in place, these activities could be more specifically and explicitly incorporated into CIP programs and more customers could benefit from these efforts."*

Stakeholders also pointed to savings from codes and standards as another area for regulatory clarity. More generally, stakeholders noted that there is no single place for looking up CIP regulatory policy; it is scattered across multiple dockets spanning 20 years. Looking up a given policy in these dockets can be time-consuming and tedious.

Regulatory oversight of CIP: Conclusions

Clarity on key regulatory topics could be increased through the creation of a CIP guide.

The stakeholder discussion above, and in Appendix N, suggests a few areas where utilities may be able to expand current program offerings with increased regulatory clarity. In addition, it is sometimes hard for utilities to find existing CIP regulatory guidance, as it is not gathered together in one location. One solution would be for the Department to create a CIP guide, to increase clarity on key regulatory topics. Other states, such as Illinois, have done similar guidebooks that have been well-received.[105] Recognizing

[103] Note that when considering efficiency programs from the societal perspective (as was done for this report, by using the societal cost test to screen measures), the issue of net-to-gross is less important. This is because the viewpoint is whether society as a whole benefits from a particular energy efficiency measure, regardless of whether the participant or the utility was the "cause" of installing that particular measure. The net-to-gross issue is more important from the utility perspective, and for the utility cost test, as only the utility investment is considered, not the participant's contribution.

[104] Although, through written comments, stakeholders noted the distinct and important difference between behavioral and operational savings. Xcel Energy stated, "Operational savings involve activities that optimize existing systems without installing new equipment, such as programming or adjusting settings. These savings persist long after the action has been taken." Xcel goes on to say, "In contrast, behavioral programs require longer-term intervention in order to create some level of persistence, if it persists at all (See Appendix N).

[105] See "Illinois Energy Efficiency Policy Manual Version 1.1, A Manual Guiding the Operation of Illinois Energy Efficiency Programs," Available at: http://ilsagfiles.org/SAG_files/Subcommittees/IL_EE_Policy_Manual_Subcommittee/2017_Revision/IL_EE_Policy_Manual_Version_1.1_5-5-17_FINAL.pdf.

that it could take time to create such a document all at once, there may be other methods to achieve increased regulatory clarity.

Consider creating a formal advisory committee for CIP regulatory policy to increase transparency and avenues for stakeholder coordination on CIP implementation.

The Department has a strong history of actively engaging stakeholders in decision-making, as the stakeholder outreach conducted for this project demonstrates. The Department could consider formalizing this stakeholder involvement by establishing a standing advisory committee of CIP stakeholders. The purpose of this body would be to provide input to the Department of Commerce on CIP regulatory policy issues. Doing so would allow the Department to engage the advisory committee as needed to proactively consider regulatory policy issues and obtain stakeholder guidance.

Continue to have strong research and development to support future energy savings.

CIP programs are very technology-forward, and a strong, coordinated Minnesota-specific research and development agenda is crucial for optimal performance of these programs. It would be beneficial to utilities and their customers for the Department to continue to focus the CARD program on new technologies and new approaches in order to generate savings well into the future.

Topic Area 3: Incorporating demand-response and efficient fuel-switching into CIP

Demand-response is shifting load from a period of high demand to a period of low demand (Appendix E provides a thorough discussion of different types of programs and technologies for accomplishing this). For IOUs, demand-response is allowed within CIP only if the demand-response program also saves energy. This limitation leaves out a large number of demand-response strategies that could benefit customers (see Appendix E).

The study team defines efficient fuel-switching as projects that result in converting a customer from use of one fuel to the use of another, lead to a net increase of the use of electric energy or natural gas, and result in an overall net decrease in energy consumption on a fuel-neutral basis. Fuel-switching is currently not allowed in CIP, except in limited circumstances for low-income customers with delivered fuels or customers of non-CIP regulated natural gas utilities.[106] In recent years, many organizations have made the case for programs to encourage fuel-switching in cases where it has clear energy efficiency, cost-reduction, and emissions benefits; particularly for electric utilities.[107] Natural gas utilities, and other energy providers, have urged more caution in approaching the fuel-switching issue.[108]

Cost-recovery and regulatory oversight treatment, similar to that of CIP, could motivate utilities to pursue these demand-side management activities further; this may result in additional benefits to Minnesota utility customers. Additionally, demand-response and efficient fuel-switching (both customer-facing activities that act on customer energy end uses) provides opportunities for synergy when pursued in coordination with energy conservation — increasing net benefits for utility customers, an approach known as "integrated demand-side management."

[106] CIP Policy Guidelines: Energy Savings from Delivered Fuels, Minnesota Division of Energy Resources, August 3, 2012. Available at: http://mn.gov/commerce-stat/pdfs/conserve-prog-delivered-fuels.pdf.

[107] See, for example: David Farnsworth, et. al, "Beneficial Electrification: Ensuring Electrification in the Public Interest," Regulatory Assistance Project, 2018. Available at: https://www.raponline.org/knowledge-center/beneficial-electrification-ensuring-electrification-public-interest/.

[108] See "Implications of Policy-Driven Residential Electrification," American Gas Association, prepared by ICF, 2018. Available at: https://www.aga.org/globalassets/research--insights/reports/AGA_Study_On_Residential_Electrification.

Incorporating demand-response and efficient fuel-switching: Relevant findings

Demand-response programs will increasingly be needed for integrating carbon-free renewables onto the grid and to balance high load with high-generation times.

Some of the energy pricing forecasts suggest there will increasingly be times of the year that the marginal cost of energy is very low or zero.[109] This is due to increasing penetrations of wind and other intermittent resources on the grid. Demand-response programs can help to balance these resources, and shift load from times of high-cost and high-emissions, to times of lower cost and lower emissions. Thus, demand-response can play a role in enabling more carbon-free generation on the grid, and lowering overall carbon levels in the state.

With appropriate safeguards, efficient fuel-switching could significantly increase overall efficiency, decrease emissions, and reduce costs for consumers.

While a comprehensive evaluation of potential savings through efficient fuel-switching was beyond the scope of this study, other research and data collected for this study suggest that efficient fuel-switching could result in further energy savings for Minnesotans. One potential use-case of efficient fuel-switching was examined by using data on the 278,000 single-family propane households in Minnesota and data on cold-climate air-source heat pumps (ASHP)s. When replacing propane with ASHPs, initial findings show that existing propane customers could cost effectively install air source heat pumps while maintaining propane furnaces as back-up heat, and save the equivalent of 2,600 GWh per year in heating fuel.[110] This represents 3.6% of all projected retail electricity sales in 2020. This would result in reduced emissions and customer heating costs as well as reduced energy consumption.[111]

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[109] While most of the utility-provided pricing forecasts used for this study are not publicly available, some utilities have released information demonstrating increased hours of the year with low costs, presumably driven by increased renewables penetration. See: Xcel Energy Modification Request, June 6, 2018, Docket No. E,G002/CIP-16-115: 2017-2019 Minnesota Electric and Natural Gas Conservation Improvement Program.

[110] AHSP annual savings (9,372 kWh/yr) is estimated from a field study of savings in a propane house, in Ben Schoenbaurer, "Cold-Climate Air-Source Heat Pump," Conservation Applied Research and Development grant, 2017. The house that the field study was conducted in had a design heating load of 32,000 btu/hr at -11F and a balance point of 60F. This results in a heating load in line with RECS 2009 data for the Midwest. See: https://www.cards.commerce.state.mn.us/CARDS/security/search.do?documentId=%7B339B1EA5-AA5C-422E-AEC5-CA58A8EE10CA%7D.

[111] This is for MN statewide projected grid emissions and other assumptions as documented in: Jennifer Edwards et. al, "Brrrrr…! The Outlook for Beneficial Electrification in Heating Dominant Climates," ACEEE Summer Study 2018. Available at: https://www.mncee.org/MNCEE/media/PDFs/Brrrrr%E2%80%A6!-The-Outlook-for-Beneficial-Electrification-in-Heating-Dominant-Climates.pdf.

Incorporating demand-response and efficient fuel-switching: Stakeholder input

There is strong electric utility support for incorporating demand-response and efficient fuel-switching into CIP.

Throughout the policy stakeholder process, numerous stakeholders discussed the benefits of demand response and efficient fuel-switching, and noted the importance of both activities. Some stakeholders felt strongly that demand-response and fuel-switching that reduces energy consumption should be included in CIP. They noted that both demand-response and efficient fuel-switching can, under certain circumstances, provide customer, utility system, and environmental benefits; similar to energy conservation. Eighty-two percent of respondents in the CIP stakeholder survey stated that demand-response should be allowed in CIP, and 65% of respondents thought that electrification (a type of fuel-switching) should be allowed in CIP.

Otter Tail Power, for example, explained:

> *"Otter Tail believes it is imperative to include the benefits of demand-response (DR), carbon reduction, and electrification in CIP. As stated in previous comments, Otter Tail supports including any program in CIP which provides net benefits to customers by saving energy, shifting energy usage to low-cost periods, reducing carbon emissions, or reducing overall fuel consumption."*[112]

Still other stakeholders indicated that CIP should remain separate from demand-response and electrification. CenterPoint Energy stated,

> *"[I]n CenterPoint Energy's view, the purpose of CIP is and should remain energy efficiency. Existing statute already allows for load management which reduces overall energy consumption to be included within CIP. Load management efforts which do not reduce energy consumption should not be paid for using funds collected from customers for energy efficiency programs. Encouragement of measures that further goals other than energy efficiency should not come at the expense of energy efficiency."*[113]

Given the seemingly stark difference in opinion on this matter, the study team engaged further with stakeholders to understand the reasons underlying stakeholder's strong opinions on this topic. Through that engagement, the team determined that stakeholders have different interpretations of what it means to include demand-response or electrification "in CIP." The team found that CIP means different things to different stakeholders. From one perspective, CIP is a utility regulatory structure overseen by the Department of Commerce, rather than the Minnesota Public Utilities Commission. From another, it

[112] Otter Tail Power Company, Response to Second Request for Written Comment, Page 2, Question 2.

[113] CenterPoint Energy, Response to Second Request for Written Comments, Page 2, Question 2.

is a cost-recovery mechanism for a set of customer-facing utility programs. From a third, CIP ensures that utilities are actively seeking to reduce customer's energy consumption through policies designed to overcome the disincentives of energy conservation to the traditional utility business model. Through this deeper understanding of how stakeholders think of CIP, the team determined that there was less conflict of opinion than previously thought and that both demand-response and efficient fuel-switching may have a place in CIP.

Public interest concerns were raised about investor-owned utilities (IOUs) receiving incentives for load-building activities.

Stakeholders pointed out that energy efficiency, demand-response, and efficient fuel-switching all have different impacts on the utility business model and policies must reflect those differences. For example, there is a fundamental disincentive for a utility to implement energy efficiency programs that decrease its sales. This same disincentive does not apply to demand-response programs (although, a utility may face different disincentives for demand-response), and clearly does not apply to load-building — which is inherently in the economic interest of energy utilities.

Public interest concerns were raised about demand-response and efficient fuel-switching diluting or competing for limited capital with energy efficiency efforts.

Many stakeholders indicated that they would not want efforts to pursue demand-response or efficient fuel-switching to offset or replace energy conservation activities. The American Council for an Energy-Efficient Economy (ACEEE) stated in written comments:

> *"Demand-response itself may be an appropriate objective for the state, but it should not be pursued at the expense of achieving energy savings (i.e., DR should not take CIP funds, and DR goals should not detract from energy savings goals). To the extent that Minnesota wants to encourage demand-response, a parallel set of goals and associated incentives could very well be set up and applied, but should not detract from CIP energy-savings goals and incentives."*[114]

Both demand-response and efficient fuel-switching programs are customer-facing programs, like CIP.

Stakeholders also see the potential for synergies in the implementation of energy conservation programs, demand-response activities, and efficient load building efforts. At the same time, they caution against separate, duplicative efforts at the program level for those particular types of programs where a combined approach would make sense. As Fresh Energy stated in written comments:

[114] American Council for and Energy-Efficiency Economy, Response to First Request for Written Comments, Page 2, Question 3.

> *"CIP currently provides utilities with a powerful customer engagement structure to deliver energy savings and provide some education on energy use. Creating a new but similar structure focused on demand-response may be duplicative and create confusion if it competes with CIP outreach for customer attention. In addition, if the utility is approaching a customer about demand-response there may be opportunities to implement significant energy savings as well, which would be lost if two siloed programs are operating simultaneously. Therefore, it may be more efficient to house demand-response efforts under this framework within CIP but establish separate goals and incentives."*[115]

Often technologies that are being promoted for energy efficiency and fuel-switching are the same. For example, according to this study's modelling results, the single largest electric energy efficiency opportunity in the residential sector is air source heat pumps for customers that heat with electricity. Similarly, this same technology offers potential energy savings from efficient fuel-switching as well.

Incorporating demand-response and efficient fuel-switching into CIP: Conclusions

Consider whether to incorporate "integrated demand-side management" into CIP framework – with appropriate safeguards.

Utility programs could be encouraged to facilitate cost-effective, efficient fuel-switching improvements and demand-response as a matter of state policy, through a framework similar to CIP, with distinct goals, cost-recovery, and appropriate incentives. As discussed above, the business model impacts of CIP, demand-response, and fuel-switching are distinct and different. Therefore, different incentive structures are required for demand-response activities, and no incentive is required for efficient fuel-switching.

Opportunities at the program level for coordinating services to customers for energy efficiency, demand-response, and efficient fuel-switching should be evaluated for incorporation into CIP. These programs could benefit from a coordinated regulatory oversight framework. Where such coordination of program elements is appropriate, this could provide multiple benefits for utility customers.

If pursued, it would be important to develop separate goals, metrics, and criteria for each of the three activities. Similarly, any utility performance incentives should be structured uniquely for each activity and based upon the impact on the utility business model. The project team further recommends that decision makers and stakeholders undertake a robust exploration of the potential overlap between energy efficiency, demand-response, and efficient fuel-switching. This will help in developing clear criteria for how and under what policy mechanism to assign costs and credit benefits for specific activities and achievements.

[115] Fresh Energy, Response to Second Request for Written Comments, Page 2, Question 2.

The Department's review of fuel-switching through a CIP docket[116] and stakeholder process, which it plans to kick-off in the coming months, should provide a strong foundation for this discussion.

[116] Docket Number CIP-18-402.

Table: ACSST1Y2021.S1702

POVERTY STATUS IN THE PAST 12 MONTHS OF FAMILIES

United States® Census Bureau

Note: The table shown may have been modified by user selections. Some information may be missing.

DATA NOTES	
TABLE ID:	S1702
SURVEY/PROGRAM:	American Community Survey
VINTAGE:	2021
DATASET:	ACSST1Y2021
PRODUCT:	ACS 1-Year Estimates Subject Tables
UNIVERSE:	None
MLA:	U.S. Census Bureau. "POVERTY STATUS IN THE PAST 12 MONTHS OF FAMILIES." American Community Survey, ACS 1-Year Estimates Subject Tables, Table S1702, . Accessed on 26 Oct 2026.
FTP URL:	None
API URL:	https://api.census.gov/data/2021/acs/acs1/subject
USER SELECTIONS	
GEOS	St. Louis County, Minnesota
TOPICS	Poverty
EXCLUDED COLUMNS	None

Table: ACSST1Y2021.S1702

APPLIED FILTERS	None
APPLIED SORTS	None
PIVOT & GROUPING	
PIVOT COLUMNS	None
PIVOT MODE	Off
ROW GROUPS	None
VALUE COLUMNS	None
WEB ADDRESS	https://data.census.gov/table/ACSST1Y2021.S1702?q=St.Louis+Minnesota+poverty
TABLE NOTES	
	Although the American Community Survey (ACS) produces population, demographic and housing unit estimates, it is the Census Bureau's Population Estimates Program that produces and disseminates the official estimates of the population for the nation, states, counties, cities, and towns and estimates of housing units for states and counties.
	Supporting documentation on code lists, subject definitions, data accuracy, and statistical testing can be found on the American Community Survey website in the Technical Documentation section.
	Source: U.S. Census Bureau, 2021 American Community Survey 1-Year Estimates

Table: ACSST1Y2021.S1702

	Data are based on a sample and are subject to sampling variability. The degree of uncertainty for an estimate arising from sampling variability is represented through the use of a margin of error. The value shown here is the 90 percent margin of error. The margin of error can be interpreted roughly as providing a 90 percent probability that the interval defined by the estimate minus the margin of error and the estimate plus the margin of error (the lower and upper confidence bounds) contains the true value. In addition to sampling variability, the ACS estimates are subject to nonsampling error (for a discussion of nonsampling variability, see ACS Technical Documentation). The effect of nonsampling error is not represented in these tables.
	Dollar amounts are adjusted to respective calendar years. For more information, see: Change to Income Deficit.
	The categories for relationship to householder were revised in 2019. For more information see Revisions to the Relationship to Household item.
	The 2021 American Community Survey (ACS) data generally reflect the March 2020 Office of Management and Budget (OMB) delineations of metropolitan and micropolitan statistical areas. In certain instances the names, codes, and boundaries of the principal cities shown in ACS tables may differ from the OMB delineations due to differences in the effective dates of the geographic entities.
	Estimates of urban and rural populations, housing units, and characteristics reflect boundaries of urban areas defined based on Census 2010 data. As a result, data for urban and rural areas from the ACS do not necessarily reflect the results of ongoing urbanization.

Table: ACSST1Y2021.S1702

	Explanation of Symbols:- The estimate could not be computed because there were an insufficient number of sample observations. For a ratio of medians estimate, one or both of the median estimates falls in the lowest interval or highest interval of an open-ended distribution. For a 5-year median estimate, the margin of error associated with a median was larger than the median itself.N The estimate or margin of error cannot be displayed because there were an insufficient number of sample cases in the selected geographic area. (X) The estimate or margin of error is not applicable or not available.median- The median falls in the lowest interval of an open-ended distribution (for example "2,500-")median+ The median falls in the highest interval of an open-ended distribution (for example "250,000+").** The margin of error could not be computed because there were an insufficient number of sample observations.*** The margin of error could not be computed because the median falls in the lowest interval or highest interval of an open-ended distribution.***** A margin of error is not appropriate because the corresponding estimate is controlled to an independent population or housing estimate. Effectively, the corresponding estimate has no sampling error and the margin of error may be treated as zero.
COLUMN NOTES	None

Table: ACSST1Y2021.S1702

	St. Louis County, Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
Families	48,000	±1,830	7.1%	±1.6
With related children of householder under 18 years	20,357	±1,433	9.5%	±3.0
With related children of householder under 5 years	4,066	±898	4.8%	±4.8
With related children of householder under 5 years and 5 to 17 years	2,974	±604	20.3%	±11.1
With related children of householder 5 to 17 years	13,317	±1,373	8.5%	±3.2
RACE AND HISPANIC OR LATINO ORIGIN				
Families with a householder who is--				
White alone	44,714	±1,844	7.0%	±1.7
Black or African American alone	N	N	N	N
American Indian and Alaska Native alone	597	±242	16.9%	±11.6
Asian alone	N	N	N	N
Native Hawaiian and Other Pacific Islander alone	N	N	N	N
Some other race alone	N	N	N	N
Two or more races	N	N	N	N
Hispanic or Latino origin (of any race)	N	N	N	N

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Families	36,346	±1,644	4.5%	±1.6
With related children of householder under 18 years	12,219	±1,199	2.8%	±1.9
With related children of householder under 5 years	2,779	±743	0.2%	±0.4
With related children of householder under 5 years and 5 to 17 years	2,019	±520	5.5%	±4.7
With related children of householder 5 to 17 years	7,421	±1,017	3.0%	±2.8
RACE AND HISPANIC OR LATINO ORIGIN				
Families with a householder who is--				
White alone	34,629	±1,613	4.6%	±1.7
Black or African American alone	N	N	N	N
American Indian and Alaska Native alone	283	±196	0.0%	±29.5
Asian alone	N	N	N	N
Native Hawaiian and Other Pacific Islander alone	N	N	N	N
Some other race alone	N	N	N	N
Two or more races	N	N	N	N
Hispanic or Latino origin (of any race)	N	N	N	N

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Families	7,842	±1,239	18.9%	±6.8
With related children of householder under 18 years	5,705	±992	23.9%	±8.4
With related children of householder under 5 years	751	±469	18.9%	±23.1
With related children of householder under 5 years and 5 to 17 years	810	±395	56.2%	±27.1
With related children of householder 5 to 17 years	4,144	±874	18.6%	±8.1
RACE AND HISPANIC OR LATINO ORIGIN				
Families with a householder who is--				
White alone	6,919	±1,169	18.6%	±7.0
Black or African American alone	N	N	N	N
American Indian and Alaska Native alone	215	±99	37.7%	±22.6
Asian alone	N	N	N	N
Native Hawaiian and Other Pacific Islander alone	N	N	N	N
Some other race alone	N	N	N	N
Two or more races	N	N	N	N
Hispanic or Latino origin (of any race)	N	N	N	N

Table: ACSST1Y2021.S1702

	St. Louis County, Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
White alone, not Hispanic or Latino	44,675	±1,857	7.0%	±1.7
Householder worked	31,593	±1,857	4.0%	±1.6
Householder worked full-time, year-round in the past 12 months	19,902	±1,614	0.8%	±0.9
Householder 65 years and over	12,718	±943	4.7%	±2.3
Family received --				
Supplemental Security Income (SSI) and/or cash public assistance income in the past 12 months	4,141	±1,116	16.8%	±7.5
Social security income in the past 12 months	17,125	±1,122	7.1%	±2.5
EDUCATIONAL ATTAINMENT OF HOUSEHOLDER				
Less than high school graduate	1,342	±571	13.2%	±9.3
High school graduate (includes equivalency)	9,523	±1,173	12.8%	±4.7
Some college, associate's degree	18,785	±1,414	9.4%	±3.1
Bachelor's degree or higher	18,350	±1,385	1.2%	±0.8
NUMBER OF RELATED CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No child	27,643	±1,369	5.3%	±2.0

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
White alone, not Hispanic or Latino	34,623	±1,613	4.6%	±1.7
Householder worked	22,795	±1,615	1.1%	±0.9
Householder worked full-time, year-round in the past 12 months	15,066	±1,376	0.8%	±1.1
Householder 65 years and over	11,069	±914	5.0%	±2.5
Family received --				
Supplemental Security Income (SSI) and/or cash public assistance income in the past 12 months	2,241	±875	11.9%	±10.4
Social security income in the past 12 months	14,111	±996	6.5%	±3.3
EDUCATIONAL ATTAINMENT OF HOUSEHOLDER				
Less than high school graduate	503	±282	6.0%	±8.0
High school graduate (includes equivalency)	6,699	±1,002	14.2%	±6.9
Some college, associate's degree	12,648	±1,298	4.7%	±1.9
Bachelor's degree or higher	16,496	±1,287	0.4%	±0.4
NUMBER OF RELATED CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No child	24,127	±1,345	5.4%	±2.2

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
White alone, not Hispanic or Latino	6,886	±1,171	18.7%	±7.0
Householder worked	5,323	±984	17.0%	±8.7
Householder worked full-time, year-round in the past 12 months	2,996	±718	0.0%	±3.4
Householder 65 years and over	1,408	±483	1.8%	±2.3
Family received --				
Supplemental Security Income (SSI) and/or cash public assistance income in the past 12 months	1,531	±639	22.9%	±13.2
Social security income in the past 12 months	2,405	±642	9.9%	±9.1
EDUCATIONAL ATTAINMENT OF HOUSEHOLDER				
Less than high school graduate	629	±400	22.3%	±22.1
High school graduate (includes equivalency)	1,461	±589	15.5%	±13.5
Some college, associate's degree	4,781	±936	21.2%	±9.8
Bachelor's degree or higher	971	±363	10.3%	±10.4
NUMBER OF RELATED CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No child	2,137	±608	5.4%	±5.3

Table: ACSST1Y2021.S1702

	St. Louis County, Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
1 or 2 children	16,640	±1,429	7.7%	±2.8
3 or 4 children	3,371	±647	18.0%	±9.9
5 or more children	346	±245	11.3%	±19.7
NUMBER OF OWN CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No own child of the householder	29,598	±1,477	5.7%	±1.7
1 or 2 own children of the householder	14,850	±1,383	7.3%	±3.2
3 or 4 own children of the householder	3,206	±661	17.4%	±9.8
5 or more own children of the householder	346	±245	11.3%	±19.7
NUMBER OF PEOPLE IN FAMILY				
2 people	27,299	±1,619	6.9%	±1.7
3 or 4 people	16,367	±1,430	7.2%	±3.0
5 or 6 people	3,893	±909	7.0%	±4.0
7 or more people	441	±256	8.8%	±14.9
NUMBER OF WORKERS IN FAMILY				
No workers	10,094	±1,064	17.7%	±4.8
1 worker	14,855	±1,689	8.6%	±3.1
2 workers	19,393	±1,526	1.7%	±0.9
3 or more workers	3,658	±764	0.0%	±2.8
INCOME DEFICIT				

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
1 or 2 children	9,492	±1,121	2.5%	±2.0
3 or 4 children	2,420	±573	4.1%	±4.3
5 or more children	307	±240	0.0%	±27.7
NUMBER OF OWN CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No own child of the householder	24,873	±1,360	5.3%	±2.1
1 or 2 own children of the householder	8,773	±993	2.5%	±2.1
3 or 4 own children of the householder	2,393	±576	4.1%	±4.4
5 or more own children of the householder	307	±240	0.0%	±27.7
NUMBER OF PEOPLE IN FAMILY				
2 people	21,278	±1,365	5.8%	±2.4
3 or 4 people	11,472	±1,096	2.0%	±1.7
5 or 6 people	3,204	±807	5.7%	±4.3
7 or more people	392	±252	0.0%	±22.7
NUMBER OF WORKERS IN FAMILY				
No workers	8,801	±943	12.7%	±5.5
1 worker	7,294	±1,076	4.4%	±3.0
2 workers	17,187	±1,538	1.2%	±0.8
3 or more workers	3,064	±735	0.0%	±3.3
INCOME DEFICIT				

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
1 or 2 children	5,004	±942	18.2%	±7.7
3 or 4 children	701	±330	64.9%	±25.4
5 or more children	0	±157	-	**
NUMBER OF OWN CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No own child of the householder	3,046	±726	9.2%	±7.5
1 or 2 own children of the householder	4,195	±910	18.9%	±9.4
3 or 4 own children of the householder	601	±305	67.9%	±27.5
5 or more own children of the householder	0	±157	-	**
NUMBER OF PEOPLE IN FAMILY				
2 people	3,685	±911	16.3%	±6.7
3 or 4 people	3,607	±840	21.9%	±11.3
5 or 6 people	540	±355	16.9%	±18.2
7 or more people	10	±17	0.0%	±100.0
NUMBER OF WORKERS IN FAMILY				
No workers	1,088	±352	51.3%	±17.9
1 worker	5,253	±1,035	15.6%	±7.8
2 workers	1,238	±424	8.5%	±8.8
3 or more workers	263	±185	0.0%	±31.1
INCOME DEFICIT				

Table: ACSST1Y2021.S1702

	St. Louis County, Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
Mean income deficit for families (dollars)	9,267	±1,702	(X)	(X)
TENURE				
Owner occupied	41,726	±1,733	4.2%	±1.3
Renter Occupied	6,274	±1,188	26.0%	±8.3
ALL FAMILIES WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS				
50 percent of poverty level	1,254	±442	(X)	(X)
125 percent of poverty level	4,513	±829	(X)	(X)
150 percent of poverty level	6,050	±1,057	(X)	(X)
185 percent of poverty level	8,061	±1,104	(X)	(X)
200 percent of poverty level	9,134	±1,171	(X)	(X)
300 percent of poverty level	16,403	±1,505	(X)	(X)
400 percent of poverty level	23,348	±1,763	(X)	(X)
500 percent of poverty level	30,758	±1,861	(X)	(X)

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Mean income deficit for families (dollars)	9,760	±3,143	(X)	(X)
TENURE				
Owner occupied	33,796	±1,605	3.1%	±1.4
Renter Occupied	2,550	±650	23.0%	±13.0
ALL FAMILIES WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS				
50 percent of poverty level	(X)	(X)	(X)	(X)
125 percent of poverty level	(X)	(X)	(X)	(X)
150 percent of poverty level	(X)	(X)	(X)	(X)
185 percent of poverty level	(X)	(X)	(X)	(X)
200 percent of poverty level	(X)	(X)	(X)	(X)
300 percent of poverty level	(X)	(X)	(X)	(X)
400 percent of poverty level	(X)	(X)	(X)	(X)
500 percent of poverty level	(X)	(X)	(X)	(X)

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Mean income deficit for families (dollars)	8,653	±2,398	(X)	(X)
TENURE				
Owner occupied	5,255	±1,068	10.3%	±5.7
Renter Occupied	2,587	±700	36.3%	±13.9
ALL FAMILIES WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS				
50 percent of poverty level	(X)	(X)	(X)	(X)
125 percent of poverty level	(X)	(X)	(X)	(X)
150 percent of poverty level	(X)	(X)	(X)	(X)
185 percent of poverty level	(X)	(X)	(X)	(X)
200 percent of poverty level	(X)	(X)	(X)	(X)
300 percent of poverty level	(X)	(X)	(X)	(X)
400 percent of poverty level	(X)	(X)	(X)	(X)
500 percent of poverty level	(X)	(X)	(X)	(X)

Table: ACSST1Y2021.S1702

POVERTY STATUS IN THE PAST 12 MONTHS OF FAMILIES

United States® Census Bureau

Note: The table shown may have been modified by user selections. Some information may be missing.

DATA NOTES	
TABLE ID:	S1702
SURVEY/PROGRAM:	American Community Survey
VINTAGE:	2021
DATASET:	ACSST1Y2021
PRODUCT:	ACS 1-Year Estimates Subject Tables
UNIVERSE:	None
MLA:	U.S. Census Bureau. "POVERTY STATUS IN THE PAST 12 MONTHS OF FAMILIES." American Community Survey, ACS 1-Year Estimates Subject Tables, Table S1702, . Accessed on 26 Oct 2026.
FTP URL:	None
API URL:	https://api.census.gov/data/2021/acs/acs1/subject
USER SELECTIONS	
GEOS	Minnesota
TOPICS	Poverty
EXCLUDED COLUMNS	None

Table: ACSST1Y2021.S1702

APPLIED FILTERS	None
APPLIED SORTS	None
PIVOT & GROUPING	
PIVOT COLUMNS	None
PIVOT MODE	Off
ROW GROUPS	None
VALUE COLUMNS	None
WEB ADDRESS	https://data.census.gov/table/ACSST1Y2021.S1702?q=Minnesota+poverty
TABLE NOTES	
	Although the American Community Survey (ACS) produces population, demographic and housing unit estimates, it is the Census Bureau's Population Estimates Program that produces and disseminates the official estimates of the population for the nation, states, counties, cities, and towns and estimates of housing units for states and counties.

Table: ACSST1Y2021.S1702

	Supporting documentation on code lists, subject definitions, data accuracy, and statistical testing can be found on the American Community Survey website in the Technical Documentation section. Sample size and data quality measures (including coverage rates, allocation rates, and response rates) can be found on the American Community Survey website in the Methodology section.
	Source: U.S. Census Bureau, 2021 American Community Survey 1-Year Estimates
	Data are based on a sample and are subject to sampling variability. The degree of uncertainty for an estimate arising from sampling variability is represented through the use of a margin of error. The value shown here is the 90 percent margin of error. The margin of error can be interpreted roughly as providing a 90 percent probability that the interval defined by the estimate minus the margin of error and the estimate plus the margin of error (the lower and upper confidence bounds) contains the true value. In addition to sampling variability, the ACS estimates are subject to nonsampling error (for a discussion of nonsampling variability, see ACS Technical Documentation). The effect of nonsampling error is not represented in these tables.

Table: ACSST1Y2021.S1702

	Dollar amounts are adjusted to respective calendar years. For more information, see: Change to Income Deficit.
	The categories for relationship to householder were revised in 2019. For more information see Revisions to the Relationship to Household item.

Table: ACSST1Y2021.S1702

	The 2021 American Community Survey (ACS) data generally reflect the March 2020 Office of Management and Budget (OMB) delineations of metropolitan and micropolitan statistical areas. In certain instances the names, codes, and boundaries of the principal cities shown in ACS tables may differ from the OMB delineations due to differences in the effective dates of the geographic entities.
	Estimates of urban and rural populations, housing units, and characteristics reflect boundaries of urban areas defined based on Census 2010 data. As a result, data for urban and rural areas from the ACS do not necessarily reflect the results of ongoing urbanization.

Table: ACSST1Y2021.S1702

	Explanation of Symbols:- The estimate could not be computed because there were an insufficient number of sample observations. For a ratio of medians estimate, one or both of the median estimates falls in the lowest interval or highest interval of an open-ended distribution. For a 5-year median estimate, the margin of error associated with a median was larger than the median itself.N The estimate or margin of error cannot be displayed because there were an insufficient number of sample cases in the selected geographic area. (X) The estimate or margin of error is not applicable or not available.median- The median falls in the lowest interval of an open-ended distribution (for example "2,500-")median+ The median falls in the highest interval of an open-ended distribution (for example "250,000+").** The margin of error could not be computed because there were an insufficient number of sample observations.*** The margin of error could not be computed because the median falls in the lowest interval or highest interval of an open-ended distribution.***** A margin of error is not appropriate because the corresponding estimate is controlled to an independent population or housing estimate. Effectively, the corresponding estimate has no sampling error and the margin of error may be treated as zero.
COLUMN NOTES	None

Table: ACSST1Y2021.S1702

	Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
Families	1,427,221	±11,101	5.5%	±0.3
With related children of householder under 18 years	646,410	±8,562	8.6%	±0.6
With related children of householder under 5 years	116,827	±4,738	8.9%	±1.7
With related children of householder under 5 years and 5 to 17 years	121,951	±4,532	12.4%	±1.8
With related children of householder 5 to 17 years	407,632	±8,395	7.4%	±0.6
RACE AND HISPANIC OR LATINO ORIGIN				
Families with a householder who is--				
White alone	1,181,404	±9,643	4.0%	±0.3
Black or African American alone	77,033	±3,808	18.0%	±2.6
American Indian and Alaska Native alone	8,944	±1,258	20.4%	±6.3
Asian alone	64,531	±2,730	8.0%	±1.9
Native Hawaiian and Other Pacific Islander alone	N	N	N	N
Some other race alone	32,042	±2,700	12.0%	±3.6
Two or more races	62,945	±4,028	10.5%	±2.1
Hispanic or Latino origin (of any race)	61,587	±2,944	12.9%	±2.3

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Families	1,122,121	±11,359	2.7%	±0.2
With related children of householder under 18 years	456,426	±7,129	3.2%	±0.4
With related children of householder under 5 years	84,979	±4,140	2.2%	±0.7
With related children of householder under 5 years and 5 to 17 years	89,502	±3,826	5.4%	±1.1
With related children of householder 5 to 17 years	281,945	±6,708	2.8%	±0.5
RACE AND HISPANIC OR LATINO ORIGIN				
Families with a householder who is--				
White alone	973,276	±10,113	2.2%	±0.2
Black or African American alone	39,409	±2,982	7.5%	±2.3
American Indian and Alaska Native alone	3,295	±688	6.3%	±5.3
Asian alone	42,080	±2,438	3.8%	±1.5
Native Hawaiian and Other Pacific Islander alone	N	N	N	N
Some other race alone	21,128	±2,265	9.3%	±4.3
Two or more races	42,611	±3,280	4.9%	±1.7
Hispanic or Latino origin (of any race)	40,021	±2,972	8.2%	±2.6

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Families	203,499	±6,395	18.0%	±1.5
With related children of householder under 18 years	129,401	±5,283	25.3%	±2.1
With related children of householder under 5 years	19,899	±2,361	33.6%	±6.6
With related children of householder under 5 years and 5 to 17 years	22,503	±2,328	36.9%	±6.7
With related children of householder 5 to 17 years	86,999	±4,850	20.5%	±2.4
RACE AND HISPANIC OR LATINO ORIGIN				
Families with a householder who is--				
White alone	137,817	±5,395	13.7%	±1.3
Black or African American alone	27,580	±2,714	32.5%	±5.8
American Indian and Alaska Native alone	3,888	±803	35.5%	±12.7
Asian alone	14,799	±2,045	19.5%	±6.1
Native Hawaiian and Other Pacific Islander alone	N	N	N	N
Some other race alone	6,346	±1,267	17.2%	±8.0
Two or more races	13,069	±2,149	25.8%	±6.7
Hispanic or Latino origin (of any race)	13,377	±1,757	21.3%	±5.5

Table: ACSST1Y2021.S1702

	Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
White alone, not Hispanic or Latino	1,171,578	±9,398	4.0%	±0.3
Householder worked	1,072,575	±10,276	3.8%	±0.3
Householder worked full-time, year-round in the past 12 months	759,141	±10,027	1.5%	±0.2
Householder 65 years and over	316,254	±4,763	3.9%	±0.5
Family received --				
Supplemental Security Income (SSI) and/or cash public assistance income in the past 12 months	96,669	±4,064	17.1%	±1.9
Social security income in the past 12 months	384,158	±6,059	4.0%	±0.5
EDUCATIONAL ATTAINMENT OF HOUSEHOLDER				
Less than high school graduate	66,679	±3,559	19.5%	±2.6
High school graduate (includes equivalency)	274,218	±7,502	9.8%	±1.0
Some college, associate's degree	465,311	±8,801	6.2%	±0.7
Bachelor's degree or higher	621,013	±9,331	1.6%	±0.2
NUMBER OF RELATED CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No child	780,811	±8,956	2.9%	±0.3

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
White alone, not Hispanic or Latino	966,814	±9,897	2.2%	±0.2
Householder worked	829,108	±10,142	1.6%	±0.2
Householder worked full-time, year-round in the past 12 months	594,142	±8,946	0.8%	±0.2
Householder 65 years and over	277,843	±4,428	3.2%	±0.4
Family received --				
Supplemental Security Income (SSI) and/or cash public assistance income in the past 12 months	54,001	±2,944	7.7%	±1.9
Social security income in the past 12 months	327,147	±5,831	3.0%	±0.4
EDUCATIONAL ATTAINMENT OF HOUSEHOLDER				
Less than high school graduate	40,730	±2,699	15.4%	±2.9
High school graduate (includes equivalency)	192,546	±5,766	4.5%	±0.8
Some college, associate's degree	346,104	±7,902	2.6%	±0.4
Bachelor's degree or higher	542,741	±9,042	1.1%	±0.2
NUMBER OF RELATED CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No child	665,695	±8,326	2.4%	±0.3

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
White alone, not Hispanic or Latino	135,170	±5,190	13.6%	±1.3
Householder worked	157,038	±5,450	13.1%	±1.5
Householder worked full-time, year-round in the past 12 months	101,358	±4,595	4.3%	±1.1
Householder 65 years and over	29,134	±2,412	7.9%	±2.5
Family received --				
Supplemental Security Income (SSI) and/or cash public assistance income in the past 12 months	31,899	±2,996	30.8%	±3.8
Social security income in the past 12 months	41,213	±2,759	10.0%	±2.6
EDUCATIONAL ATTAINMENT OF HOUSEHOLDER				
Less than high school graduate	16,421	±2,187	30.2%	±6.3
High school graduate (includes equivalency)	51,584	±3,506	26.8%	±3.5
Some college, associate's degree	81,990	±3,904	19.3%	±2.6
Bachelor's degree or higher	53,504	±3,881	3.7%	±1.3
NUMBER OF RELATED CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No child	74,098	±3,608	5.1%	±1.2

Table: ACSST1Y2021.S1702

	Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
1 or 2 children	494,964	±9,244	7.3%	±0.7
3 or 4 children	135,351	±5,183	11.1%	±1.5
5 or more children	16,095	±1,780	29.9%	±5.8
NUMBER OF OWN CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No own child of the householder	818,065	±9,525	3.4%	±0.3
1 or 2 own children of the householder	465,420	±8,785	6.8%	±0.7
3 or 4 own children of the householder	128,988	±5,106	11.2%	±1.5
5 or more own children of the householder	14,748	±1,859	31.0%	±6.2
NUMBER OF PEOPLE IN FAMILY				
2 people	703,507	±9,430	4.8%	±0.4
3 or 4 people	542,516	±9,192	5.6%	±0.5
5 or 6 people	155,019	±4,953	6.9%	±1.0
7 or more people	26,179	±2,468	16.2%	±3.9
NUMBER OF WORKERS IN FAMILY				
No workers	206,077	±4,638	14.1%	±1.0
1 worker	375,695	±9,267	9.9%	±0.7
2 workers	661,134	±9,611	1.6%	±0.3
3 or more workers	184,315	±5,551	1.1%	±0.5
INCOME DEFICIT				

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
1 or 2 children	343,386	±7,429	2.1%	±0.4
3 or 4 children	102,484	±4,139	4.9%	±0.9
5 or more children	10,556	±1,602	19.7%	±5.9
NUMBER OF OWN CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No own child of the householder	681,589	±8,433	2.4%	±0.3
1 or 2 own children of the householder	331,069	±7,163	2.0%	±0.4
3 or 4 own children of the householder	99,462	±4,055	4.9%	±0.9
5 or more own children of the householder	10,001	±1,570	20.3%	±6.1
NUMBER OF PEOPLE IN FAMILY				
2 people	549,550	±7,407	2.6%	±0.3
3 or 4 people	417,023	±8,520	1.8%	±0.3
5 or 6 people	134,905	±4,589	3.9%	±0.8
7 or more people	20,643	±2,318	14.1%	±3.9
NUMBER OF WORKERS IN FAMILY				
No workers	173,921	±3,827	6.6%	±0.7
1 worker	214,424	±6,110	4.7%	±0.7
2 workers	574,110	±8,927	1.3%	±0.3
3 or more workers	159,666	±5,326	0.8%	±0.4
INCOME DEFICIT				

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
1 or 2 children	102,433	±4,768	21.8%	±2.2
3 or 4 children	22,513	±2,799	36.8%	±5.5
5 or more children	4,455	±1,327	48.7%	±14.4
NUMBER OF OWN CHILDREN OF THE HOUSEHOLDER UNDER 18 YEARS				
No own child of the householder	88,193	±4,013	7.6%	±1.5
1 or 2 own children of the householder	90,866	±4,587	21.9%	±2.3
3 or 4 own children of the householder	20,538	±2,761	38.3%	±5.7
5 or more own children of the householder	3,902	±1,284	53.8%	±15.7
NUMBER OF PEOPLE IN FAMILY				
2 people	98,575	±4,824	13.0%	±1.9
3 or 4 people	86,343	±4,800	20.8%	±2.4
5 or 6 people	14,330	±2,268	31.7%	±6.7
7 or more people	4,251	±1,092	29.9%	±13.1
NUMBER OF WORKERS IN FAMILY				
No workers	24,023	±2,844	57.2%	±4.7
1 worker	105,518	±5,152	18.8%	±2.0
2 workers	57,531	±3,787	3.7%	±1.2
3 or more workers	16,427	±2,219	5.5%	±3.8
INCOME DEFICIT				

Table: ACSST1Y2021.S1702

	Minnesota			
	All families			
	Total		Percent below poverty level	
Label	Estimate	Margin of Error	Estimate	Margin of Error
Mean income deficit for families (dollars)	10,745	±531	(X)	(X)
TENURE				
Owner occupied	1,197,330	±10,532	3.2%	±0.2
Renter Occupied	229,891	±7,705	17.6%	±1.4
ALL FAMILIES WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS				
50 percent of poverty level	32,821	±3,144	(X)	(X)
125 percent of poverty level	108,208	±5,614	(X)	(X)
150 percent of poverty level	142,952	±6,086	(X)	(X)
185 percent of poverty level	198,557	±7,367	(X)	(X)
200 percent of poverty level	224,058	±7,473	(X)	(X)
300 percent of poverty level	406,164	±7,849	(X)	(X)
400 percent of poverty level	602,555	±8,431	(X)	(X)
500 percent of poverty level	785,575	±9,192	(X)	(X)

Table: ACSST1Y2021.S1702

	Married-couple families			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Mean income deficit for families (dollars)	9,596	±600	(X)	(X)
TENURE				
Owner occupied	1,009,039	±10,800	2.0%	±0.2
Renter Occupied	113,082	±5,440	9.0%	±1.5
ALL FAMILIES WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS				
50 percent of poverty level	(X)	(X)	(X)	(X)
125 percent of poverty level	(X)	(X)	(X)	(X)
150 percent of poverty level	(X)	(X)	(X)	(X)
185 percent of poverty level	(X)	(X)	(X)	(X)
200 percent of poverty level	(X)	(X)	(X)	(X)
300 percent of poverty level	(X)	(X)	(X)	(X)
400 percent of poverty level	(X)	(X)	(X)	(X)
500 percent of poverty level	(X)	(X)	(X)	(X)

Table: ACSST1Y2021.S1702

	Female householder, no spouse present			
	Total		**Percent below poverty level**	
Label	**Estimate**	**Margin of Error**	**Estimate**	**Margin of Error**
Mean income deficit for families (dollars)	12,396	±770	(X)	(X)
TENURE				
Owner occupied	120,198	±5,411	9.8%	±1.4
Renter Occupied	83,301	±4,594	29.8%	±2.8
ALL FAMILIES WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS				
50 percent of poverty level	(X)	(X)	(X)	(X)
125 percent of poverty level	(X)	(X)	(X)	(X)
150 percent of poverty level	(X)	(X)	(X)	(X)
185 percent of poverty level	(X)	(X)	(X)	(X)
200 percent of poverty level	(X)	(X)	(X)	(X)
300 percent of poverty level	(X)	(X)	(X)	(X)
400 percent of poverty level	(X)	(X)	(X)	(X)
500 percent of poverty level	(X)	(X)	(X)	(X)

Translation: Select Language

On Track Program

If your household is eligible, Minnesota Power's On Track Program offers a monthly discount on your electric bill and will apply a 100% match toward your past due balance if you make regular payments under a payment arrangement.

Enroll Now Opt Out

A New Way to Catch Up

The On Track Program helps eligible residential customers with past-due balances get back on track. There are no income requirements to qualify. We understand that catching up after a balance grows can be hard. The On Track Program is designed to help you move forward with a clear plan and manageable payments.

How the Program Works

If you join On Track:

- Your past-due balance is placed into a monthly payment agreement called a payment arrangement for up to 24 months, based on your past-due balance at the time of enrollment.
- You make a set payment each month toward that balance.
- Minnesota Power will match each payment you make toward your payment arrangement. If you make all of your payments on time and you receive the match, your past-due balance will be caught up in half the time.

- You also receive a $20 bill credit each month you are in the program.
- You must stay current on both your regular monthly bill and your payment arrangement to stay on the program.
- Space in the program is limited and enrollment is first-come, first-served.
- The amount of time you receive matching payments and the $20 bill credit depends on the amount of your past-due balance when you enroll. The following table shows the On Track support by past-due balance.

How Much You Owe	Payment Arrangement Length	Months with Payment Match	Months with $20 Credit
Less than $200	6 months	3 months	3 months
$200–$499	12 months	6 months	6 months
$500 or more	24 months	12 months	12 months

What You Receive While in the Program

When you pay your full monthly Minnesota Power bill on time, including your payment arrangement amount:

- Minnesota Power matches your payment on your payment arrangement.
- You receive a $20 bill credit.
- Payment matching and bill credits last for up to half the original length of your payment arrangement. As an example, if your payment arrangement for your past-due balance is set for twelve months and you make all your payments on time and receive the match, your past-due balance could be caught up in six months.

How to Get Started

You can apply using one of these options:

- **Apply online**
- Call the Minnesota Power On Track program team at **877-627-0584**
- By mail with a paper application (**download form**) — mail your application to:

  Minnesota Power, Attn: Customer Service - On Track
  30 West Superior Street
  Duluth, Minnesota 55802

Program Rules & Requirements

- On Track is available for your primary residence if there is a past-due balance of 30 days or more.
- You cannot be enrolled in the Affordability Discount (percent of bill discount) under Minnesota Power's CARE Program.
- This program does not erase your past-due balance.
- Your monthly bill has two parts: your regular monthly electric charges and a monthly payment arrangement amount. Both must be paid each month.
- You must stay current to remain enrolled. If you miss two payments in a row, you will be removed from the program and will no longer qualify for payment matching, past-due payment protection, or monthly bill credits. Benefits already applied to your bill will not be removed.
- You may enroll only once per program year. The On Track program year is from July through June annually, while funding lasts.
- If you have been removed from the On Track program in the existing program year, you do not qualify.

Still Have Questions?

Review the FAQs below. If your question isn't answered there, contact us at:

Phone: **877-627-0584**
Email: **OnTrack@mnpower.com**

FAQs

My Situation is Complicated, Will On Track Work for Me?

There is no way to guarantee that any one program will work for everybody; however, we have dedicated account specialists who will work with you to create a plan to fit your unique circumstances. On Track is more than just a payment arrangement, it's a collaborative process to come up with long-term goals for managing your ongoing Minnesota Power bill. Contact our account specialists at **877-627-0584** today to get started.

I Just Enrolled, What Next?

Once your application is processed your payment arrangement will start with your next bill. Here are some ways to help enhance the benefits of your arrangement.

1. Check your bill each month to stay up to date on your arrangement.
2. Check out **MyAccount** ↗, our online portal where you can view, pay and manage your bill online. MyAccount also offers alerts that can help you stay up to date as your bills become available or are due.

3. Though there is no requirement to reduce your usage to stay in the program, finding ways to reduce your bill each month can make it easier to stay up to date with your bill.
    i. The **Time of Day** billing option could help reduce your bill by making changes to not only how much energy you use, but when you use energy in your home.
    ii. You may also benefit from a **Home Health Check** offered by our Programs and Services team. This service can help you identify inefficiencies in your home. You may also benefit from installing a wall outlet power meter to help identify appliances that are drawing excessive amounts of energy, such as: Space Heaters and Electric Fireplaces.
    iii. Minnesota Power also offers a variety of **Rebates and Services** to help with updating your home with energy efficient appliances.

How do I Opt Out?

You may **opt out of On Track online** at any time. You may also call or email us to make that request.

I received a letter saying I would be enrolled in the program, but I didn't see it on my bill. Why?

The On Track Program is available to residential customers with past-due balances at the time of enrollment. Letters were sent to customers with a past-due balance at that time. If you paid your balance, we thank you for your payment. Those who do not have a past-due balance at the time of enrollment are not eligible for On Track. If your circumstances change, you may apply, while program funding lasts.

Groundbreaking for $200 million dollar expansion at Sofidel in Duluth

By WDIO
Updated: April 11, 2025 - 6:04 PM
Published: April 11, 2025 - 3:29 PM



Celebrating the expansion at Sofidel

A big moment for Sofidel in Duluth on Friday, as leaders celebrated the start of a $200 million dollar expansion project.

Sofidel bought the plant in West Duluth last year. And now, they are going to be adding 160 jobs and a secondary finishing process.

Right now, the 100 workers make giant rolls of tissue paper. Those are shipped to other facilities, where they are finished into toilet paper, paper towels, and napkins that we buy at stores like Costco.

Once the finishing building and automated warehouse are done next year, then that can stay right on site in Duluth.

Sofidel was started by two men in Italy, and has grown into the 5th largest tissue paper producer in the world.

CEO Luigi Lazzareschi spoke at the event on Friday.

The plan is to have the new finishing buildings ready to start operation in the first quarter of 2026.

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FEATURED

Hibbing Taconite, Minorca miners remain in the dark

By LEE BLOOMQUIST FOR MESABI TRIBUNE
Apr 21, 2026

Whatever plans Cleveland-Cliffs Inc. has for Hibbing Taconite and Minorca Mine remains unclear.

The Cleveland-based iron ore and steelmaker made no mention about the future of the two Iron Range taconite plants in its first quarter earnings call Monday.

“We haven’t heard anything,” Chris Johnson, United Steelworkers (USW) Local 2705 president at Hibbing Taconite said. “Every time, we’re hoping they will say something about Hibbing Taconite and Minorca and the rest of the idled stuff, but they never do. So we continue without any information.”

Cleveland-Cliffs’ Minorca Mine near Virginia about a year ago was placed on indefinite idle.

Hibbing Taconite was placed on partial idle, running one of three pellet production lines.

About 650 steelworkers were laid off from the two taconite plants.

Extended unemployment benefits for many of the miners runs out in weeks.

About 200 Hibbing Taconite steelworkers will run out of unemployment benefits May 24, Johnson said.

The expiration of unemployment benefits for other Hibbing Taconite steelworkers laid-off at a later date will follow, he said.

“With unemployment running out, we were hoping we would hear something,” Johnson said following Monday’s earnings call. “We’re disappointed we didn’t.”

Al King, USW Local 6115 president at Minorca Mine said he and union members are extremely frustrated.

“The longer this drags on the more frustrating it is,” King said. “It’s just extremely frustrating to see members leave just because they (Cliffs) don’t communicate. We still have 400 Cleveland-Cliffs employees out of work. I already have people cleaning out their houses to move south.”

King said Cleveland-Cliffs had said it would keep the union updated on the removal of equipment from Minorca Mine, “but I haven’t heard from them in probably six months, something we agreed on.”

King said it’s understood that Cliffs is a publicly-traded company and has a business to run, but a lack of communication is leaving everyone hanging.

“They just tell us to hang in there,” King said. “We produce pellets safely, but with the plant closure and other plant closures, it’s been really tough to be on this end of this. People are slowly being forced to make decisions with no information and that’s the hard part.”

With unemployment for hundreds of steelworkers due to run out and no word from Cleveland-Cliffs, miners at both taconite plants have major decisions to make, Johnson said.

That includes leaving the area, he said.

“If the guys haven’t already made plans to do something, I guess they will have to,” Johnson said. “Some may wait until school is out to do something and then move their kids.”

The continued unknown future of Hibbing Taconite and Minorca Mine along with the announcement that Minnesota Twist Drill in Chisholm and Triumph Twist Drill in Hibbing will shut down, is concerning for the Iron Range, Johnson said.

Shutdown of the drill bit manufacturing operations will result in the loss of 78 jobs, according to a Saturday Mesabi Tribune story.

“We need something to happen up here,” Johnson said. “It’s not going to be a good May. People are really feeling it financially and emotionally. We need something positive to happen.”

USW 6115 is working to support miners and families, King said.

“Our local’s focus is finding members new jobs up here and creating our own safety net through grants or whatever to help people buy food,” King said.

Cleveland-Cliffs reported first quarter revenues of $4.9 billion, up $600 million from the fourth quarter of 2025.

Steel shipments were 4.1 million tons, up 338,000 tons from the fourth quarter 2025.

The company also reported a GAAP (generally accepted accounting principal) net loss of $229 million in the first quarter and adjusted EBITDA (earnings before interest, taxes, deductions, and amortization) of $95 million, including an $80 million one-time energy cost impact driven by cold weather, the company said.

Lourenco Goncalves, Cleveland-Cliffs chairman, president and chief executive officer said the company sees clear signs of a positive trend and sustained improvement.

“What’s fundamentally different today is that trade enforcement is working, our customers are engaged and our order book is full,” Goncalves said. “This company spent the last couple years fixing what needed to be fixed. That work is largely behind us. The footprint has been right-sized and to finally have the platform to perform and deliver. From here, the focus is on execution. Running reliable operations, serving customers at the highest level, generating cash and allowing the strength of this market to flow through the income statement.”

Cleveland-Cliffs is 100 percent owner of Minorca Mine and majority owner of Hibbing Taconite.

United States Steel Corp. is Hibbing Taconite minority owner.

TOP STORY

Minntac pellet production slowed by structure collapse

Three of taconite plant's pellet-making lines idled by conveyor system failure

LEE BLOOMQUIST | FOR MESABI TRIBUNE
Feb 8, 2022



SUBMITTED

As Steve Bonach looked over the collapse of an iron ore pellet conveyor structure at United States Steel Corp.'s Minntac Mine in Mountain Iron on Monday morning, he was sickened.

“It's sickening just looking at it,” Bonach, United Steelworkers Local 1938 president at Minntac Mine said. “It really is. But things happen and we'll get through it.”

A “house” on the head end of the structure collapsed onto the pellet stockpile below it Saturday morning between 9:30 and 10:00 a.m. as the conveyor structure was transporting pellets, Bonach said.

Plans were already in place to fix the structure, Bonach said.

The area had been cordoned off and was off-limits to workers, he said.

Nobody was injured in the collapse.

“It was all blocked off,” Bonach said. “They were in the process of shoring up the structure to the “A” frame. Part of the head end of the 043 (belt) collapsed and nobody knows why.”

The conveyor system transports iron ore pellets from Minntac's Step I & II agglomerator to an outside stockpile.

Minntac's agglomerator Lines 3, 4 and 5, which feed iron ore pellets onto the conveyor system, are shut down as a result of the collapse, Bonach said.

Lines 6 & 7, which are newer pellet-making lines in a separate Step III agglomerator building, are still operating.

But the collapse has, for now, put a crimp in the taconite plant's iron ore pellet production.

“Line 5 was due for a major (maintenance repair),” Bonach said. “They're moving that up now. They're idling Lines 3 and 4 because they need the heat in the building. They want to do the Line 5 major, but they want to run Lines 3 and 4 with a temporary conveyor to be able to run it (pellets) out of the building.”

The Mine Safety and Health Administration and St. Louis County Mine Inspector are investigating the incident.

Another structural failure on a different portion of the gallery occurred about 12 days ago, according to Bonach.

Minntac Mine is North America's largest taconite facility.

It began producing iron ore pellets in 1967 and today employs about 1,300 hourly workers.

“First and foremost, we are thankful that no one was hurt,” Rep. Dave Lislegard of Aurora, whose district includes Minntac said. “The Minntac facility is critical to our region, the state and the U.S. steel industry. As a delegation, we will rally behind the facility and provide assistance as we are able to get them back to full production as soon as possible.”

United States Steel Corp. did not reply to emails for comment on Monday.

The company on Saturday issued a statement:

“Today at Minntac we had a structural failure on the conveyor system. We are investigating the cause and developing plans for repair. The area was cordoned off at the time of the incident, so there was no one in the area. There was no danger to personnel at any time, and there were no injuries. At this time, we do not anticipate impact to our customers or supply chain.”

As of Monday, there was no information on potential layoffs, Bonach said.

“The crusher and concentrator are running right now and they will keep running the pit,” Bonach said. “There's no word on layoffs. We're hoping we can absorb everybody into this major and the maintenance people with clean up (of the collapse. Hopefully, we'll avoid a layoff.”

With the Great Lakes shipping season idle for winter, most of the iron ore pellets produced at northeastern Minnesota's six taconite plants are stockpiled at docks and the plants.

“They said it's not going to affect the customers on the product side,” Bonach said. “We're filling up the docks right now. If there's any good that comes out of it, it's a good time for it to happen. Hopefully, we'll weather this storm and it won't affect anyone's employment.”

Duluth News Tribune

BUSINESS

Cliffs to idle Northshore Mining as fight over royalty fees intensifies, scrap metal lessens need for pellets

The company does not want to pay "absurdly high" royalty fees to Mesabi Trust and is using more scrap metal in its electric arc furnaces.



Cleveland-Cliffs' Northshore Mining in Silver Bay. (Clint Austin / 2020 file / News Tribune)

By Jimmy Lovrien
February 11, 2022 at 11:04 AM

Share

DULUTH — Cleveland-Cliffs will idle its Northshore Mining operations in Babbitt and Silver Bay amid a royalties dispute and as the use of scrap metal in its electric arc furnaces reduces the need for its pellets.

The Silver Bay pellet plant and the Babbitt mine will idle May 1 and last into at least the fall as the company moves production of direct-reduced grade pellets to its Minorca Mine in Virginia, Cliffs CEO Lourenco Goncalves said in a year-end earnings call with investors Friday morning.

Layoffs are expected for 410 of Northshore's 580 employees, Cliffs spokesperson Pat Persico said in an email to the News Tribune. Some will be hired at Cliffs' other Minnesota operations, she added.

The announcement intensifies Cliffs' efforts to get out of what it has called "absurdly high" royalty fees it pays to Mesabi Trust, (https://www.duluthnewstribune.com/business/amid-royalties-dispute-cliffs-says-it-will-move-dr-pellet-production-from-northshore-to-minorca) a publicly traded trust that collects royalties from Cliffs based on the volume of shipments from Northshore, the price of taconite and the amount of taconite that was mined from land owned by the trust — namely the Peter Mitchell Mine in Babbitt, which supplies Northshore with ore.

"Because we are now able to produce (direct-reduced) grade pellets at Minorca, and mainly due to the ridiculous royalty structure we have in place with the Mesabi Trust, we will be idling all production at our Northshore Mine. ... No production, no shipments, no royalty payments,"Goncalves said in the call.

It came in the same call where Cliffs announced a record profit of $3 billion in 2021 on a record revenue of $20.4 billion.

In October, the company announced it was moving production of its direct-reduced, or DR, grade pellets to its Minorca Mine in Virginia and away from its Northshore Mining plant in Silver Bay to avoid Mesabi Trust's royalty fees.

The October announcement came just weeks after an arbitrator ruled in favor of Mesabi Trust on unpaid royalty fees.

Mesabi Trust's Deutsche Bank manager declined to comment on the idling of Northshore.

In its quarterly report filed Jan. 28(https://www.sec.gov/ix?doc=/Archives/edgar/data/65172/000155837022000678/msb-20220128x8k.htm) , Mesabi Trust said it received nearly $21 million in royalty payments from Cliffs during the fourth quarter of 2021.

Asked if Northshore would keep running if Mesabi Trust were to lower its royalty fees, Persico said: "Cleveland-Cliffs has adjusted its full-year iron ore pellet production volume expectation to correspond to internal steelmaking needs for this year. This adjustment of iron ore pellets reflects our internal use of hot-briquetted iron (HBI) production and increased use of scrap in our steelmaking. We will be curtailing iron ore pellet production and temporarily idling Northshore Mining."

Cliffs spent spent $100 million on Northshore's direct-reduced or DR-grade pellet plant, which opened in 2019, and can produce 3.5 million tons of DR-grade pellets per year.

Goncalves has said he never would have built the plant at Northshore, which also produces traditional pellets meant for blast furnaces, if he had known that Cliffs would buy ArcelorMittal USA and its Minorca Mine in 2020.

The DR-grade pellets supply Cliffs' new Toledo hot briquetted iron plant, which in turn feeds electric arc furnaces.

Because the company uses more scrap metal in its electric arc furnaces, the idling could be prolonged, Goncalves said.

Babbitt Mayor Andrea Zupancich told the News Tribune that she was "stunned" by Friday's announcement.

She said that the only positive she got out of it was that it would idle mostly during the summer — and hopefully not any longer.

"It's not only the miners that are affected, it's absolutely everyone else in town that's affected," Zupancich said. "It's the school that's affected, it's the government that's affected, it's the businesses in town that are affected, it's the bars and restaurants in town that are all affected. So it's a massive trickle-down effect."

This story was updated several times with additional quotes from company, trust and city officials and with additional information from the call. The final version was published at 2:27 p.m. Feb. 11. The initial version was posted at 10:38 a.m. Feb. 11.

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By Jimmy Lovrien(https://www.duluthnewstribune.com/jimmy-lovrien)

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BUSINESS

Cliffs maintains plans to idle Northshore Mining operations on Iron Range

The company will close the operations in Babbitt and Silver Bay on May 1.

By Mike Hughlett (https://www.startribune.com/mike-hughlett/6370445/) Star Tribune

APRIL 22, 2022 — 4:27PM

Cleveland-Cliffs is maintaining plans to temporarily shut down its Northshore Mining operations in Babbitt and Silver Bay on May 1.

Cliffs, Minnesota's largest iron ore operator, said in February it would idle the facilities this spring amid a royalty dispute and changing operational strategies. Together, the operations employ 500 people.

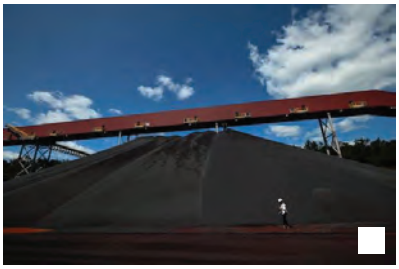
During an earnings conference call Friday, Cliffs CEO Lourenco Goncalves said the company has "space capacity."

"We are treating Northshore in Minnesota as our swing producer," he said. "We are not planning to run Northshore at this time because we feel that that would not be the right thing to do."

Northshore's mine in Babbitt and the taconite processing plant in Silver Bay are expected to be closed for at least four months. The shutdown will be a significant economic blow to both Silver Bay and the Iron Range.

Cleveland-based Cliffs is in a long-running dispute with Mesabi Trust, a publicly traded company that gets all of its revenue from royalties paid by Cliffs for ore mined in Babbitt. Goncalves has called the royalty payments "absurdly high."

In 2019, Cliffs spent $100 million upgrading Northshore's operations to produce a better grade of iron for steelmaking. But that supply is now being sourced from the Minorca mine near Virginia, Minn., which Cliffs has owned since buying ArcelorMittal USA in late 2020.



AARON LAVINSKY, STAR TRIBUNE

The Northshore taconite processing and shipping facility in Silver Bay and the Babbitt mine will idle this spring due in part to a

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Through acquisitions over the past couple of years, Cliffs — which also owns two other Iron Range taconite operations — has transformed itself into a full-fledged integrated steelmaker.

The company is shifting away from selling iron ore to other steel companies. It also acquired a scrap-steel firm last fall, which can supply its steelmaking operations in place of some iron ore.

Cliffs reported strong first quarter earnings Friday. It posted net profits of $801 million, or $1.50 a share, up from $41 million or 7 cents a share a year earlier. Analysts were forecasting per-share earnings of $1.40.

Cliffs' stock closed Friday at $28.95, down 63 cents on a down day for the market. The company's stock rose from about $19 in February, before the Russian invasion of Ukraine, to as high as $32.71 in late March.

Ukraine and Russia are major iron and steel producers, and the war has constricted global supplies of both.

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Mike Hughlett covers energy and other topics for the Star Tribune, where he has worked since 2010. Before that he was a reporter at newspapers in Chicago, St. Paul, New Orleans and Duluth.

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https://www.mesabitribune.com/news/local/2024-iron-ore-pellet-production-slips/article_4668743c-b3fb-11ef-a9a5-73be3d40267f.html

FEATURED

2024 iron ore pellet production slips

By LEE BLOOMQUIST FOR MESABI TRIBUNE
Dec 7, 2024

Iron ore pellet production at northeastern Minnesota's six taconite plants in 2024 is expected to take a small dip compared to 2023.

Total iron ore pellet production for 2024 is estimated to be about 34.4 million dry, long tons, according to the Minnesota Department of Revenue Mineral Tax Office.

That compares to just over 35.1 million dry, long tons in 2023, according to the Mineral Tax Office.

Sales challenges in the domestic new vehicle industry coupled with high interest rates have put a crimp in the demand for steel used to manufacture cars and trucks, say steelworker officials.

Iron ore pellets are the raw material used to make steel in the blast furnaces of integrated steelmakers.

"Blast furnaces are down, automakers didn't recover like everybody hoped for in 2024 and it trickles down to us," John Arbogast, United Steelworkers District 11 staff representative said. " We're hoping interest rates come down and auto sales go up."

Three of the six taconite plants, Hibbing Taconite Co., United Taconite and Minorca Mine produced less in 2024 than 2023.

Hibbing Taconite's estimated 2024 production is 5.1 million tons, about 1.4 million tons less than the roughly 6.5 million tons produced in 2023.

United Taconite's production is estimated to slip about 178,000 tons, from a little over 4.9 million tons in 2023 to 4.8 million tons in 2024.

Minorca Mine is projected for 2024 to produce just over 2.5 million tons compared to close to 2.7 million tons in 2023.

Hibbing Taconite, United Taconite and Minorca Mine are all operated by Cleveland-Cliffs Inc.

Hibbing Taconite continues to inch toward running out of crude ore and is running two of its three pellet production lines, according to USW officials.

All of the tonnages are calculated as dry, long tons (2,240 pounds per ton) by the Mineral Tax Office and do not include flux, an additive that's used in pellet production.

While Hibbing Taconite, United Taconite and Minorca Mine production totals are estimated to be down, the three other taconite plants are projected to see increases for 2024.

Cleveland-Cliffs' Northshore Mining Co. is estimated to have the largest production increase of the six taconite plants over last year with more than 3.8 million tons produced in 2024 compared to just over 3.0 million tons in 2023.

United States Steel Corp.'s Keetac plant in Keewatin is estimated to finish 2024 with 5.0 million tons produced, up from a little more than 4.8 million tons in 2023.

United States Steel Corp.'s Minntac Mine in Mountain Iron is projected in 2024 to produce 13.1 million tons, up about 100,000 tons from just over 13.0 million tons last year.

With several weeks remaining in 2024, the estimated totals could change depending on pellet demand, weather, mechanical issues, or other factors.

As the domestic steel industry goes, so does northeastern Minnesota iron ore pellet production.

It's always hard to predict what iron ore pellet production could be in 2025, however, the Mineral Tax Office expects an overall dip of about 420,000 tons compared to 2024.

Total production for 2025 is estimated to be 34.0 million tons, according to the Mineral Tax Office.

That includes an roughly70,000-ton decline at Minorca Mine, a 150,000-ton dip at Northshore Mining Co., a 200,000-ton drop at Keetac, and a 100,000-ton decline at Minntac Mine.

Hibbing Taconite in 2025 is estimated to hold steady at 5.1 million tons.

United Taconite is projected to see a 100,000-ton increase, according to the Mineral Tax Office.

Meanwhile, workforce continues to be a focus for Iron Mining Association of Minnesota (IMA) member businesses, Kristen Vake, IMA executive director said.

"In fact, between Minntac and Keetac, more than 100 people have been hired so far this year, with more coming up," Vake said. "The opportunities to work in this industry are available now. These are good-paying jobs with great benefits. Strike

while the iron is hot if you have any interest in becoming a miner."

Permitting reform and rule implementations for mine operations will be monitored, Vake said.

Dust mitigation, sulfate standards and mercury rules are among issues that local mining companies are working on and investing in solutions, Vake said.

To boost the steel industry, hopes are that the auto industry will pick up in 2025.

Inventory of new light vehicles on the ground or in transit is expected to be around three million units for most of 2025, according to NADA.

That's up from 2.8 million units in September 2024.

"Cars are awfully expensive, people are holding off and it's hurting the Iron Range," Arbogast said. "We're hoping the market changes. We're hopeful and optimistic that we'll turn the corner in 2025."

TOP STORY

Iron ore pellet production takes a slide in 2025

By LEE BLOOMQUIST FOR MESABI TRIBUNE
Dec 12, 2025



Newly made DR grade pellets are set out for visitors to see outside the new Keetac plant during a ribbon cutting event.

MARK SAUER/FILE

Northeastern Minnesota iron ore pellet production has taken a dive in 2025.

Total pellet production for the year is estimated to be 28,550,000 dry, long tons, according to the Minnesota Department of Revenue Minerals Tax Office.

The total is a significant drop from 34.6 million tons produced in 2024 and 34.5 million tons in 2023.

“It’s not good news, that’s for sure,” John Arbogast, United Steelworkers District 11 staff representative said. “And the start of 2026 isn’t looking any better.”

Cleveland-Cliffs Inc.’s indefinite idling of Minorca Mine near Virginia and partial idling of Hibbing Taconite Co. near Hibbing and Chisholm, are the two biggest factors in the decline.

Minorca Mine this year produced only 550,000 tons, according to the minerals tax office.

That compares to 2024 when Minorca Mine produced nearly 2.6 million tons, according to the minerals tax office.

Minorca Mine in May was indefinitely idled as Cleveland-Cliffs said it needed to reduce pellet inventory.

There’s no indication when or if Minorca Mine will restart.

Hibbing Taconite will produce 2.8 million tons in 2025, according to the minerals tax office.

In 2024, Hibbing Taconite produced over 5.2 million tons, according to the minerals tax office.

Hibbing Taconite is running out of crude ore and has been running only one of three iron ore pellet production lines.

Between the two taconite plants, about 600 miners are out of work.

Cleveland-Cliffs' two other northeastern Minnesota taconite plants fared better in 2025.

Cleveland-Cliffs' United Taconite in Eveleth and Forbes is forecast to produce 4.5 million tons, according to the minerals tax office.

United Taconite in 2024 produced a little more than 4.8 million tons.

The company's Northshore Mining Co. facility in Babbitt and Silver Bay is expected to finish the year at 3.1 million tons, according to the minerals tax office.

Northshore Mining Co. in 2024 produced a little more than 3.8 million tons.

United States Steel's Minnesota Ore Operations at Minntac Mine and Keetac in Keewatin, both had solid years in 2025.

Minntac Mine, North America's largest taconite plant, is forecast to finish the year with 12.6 million tons, according to the minerals tax office.

However, that's down from just over 13 million tons in 2024.

Keetac is estimated to finish with 5 million tons, about 79,000 tons less than 2024.

It's been a difficult year for many people, but there's also positives, Kristen Vake, Iron Mining Association executive director said.

U.S. Steel's iron ore pellet production is consistent with previous years, Vake said.

"There has been a lot of chatter about blast furnaces being a thing of the past," Vake said. "That could not be further from the truth. U.S. Steel has announced continued investment in blast furnaces at places like Gary Works in Indiana and at the Mon

Valley near Pittsburgh—and the pellets feeding those furnaces will come from the Iron Range."

Finishing the year with an industry total of less than 30 million tons means producers won't be eligible for a Taconite Economic Development Fund (TEDF) rebate.

The rebate each year provides producers with a 25.1 cent per-ton rebate of the Production Tax if the industry produces 30 million or more tons in a year.

The Production Tax is a tax based on the amount of iron concentrate or pellets produced at each taconite plant.

Along with matching dollars from each producer, the rebate is designed to help the iron and steelmakers reinvest in their northeastern Minnesota taconite facilities.

"If it's going to affect the rebates, that's not good," Arbogast said.

The Production Tax is a major source of revenue to municipalities, school districts and counties within the Taconite Assistance Area.

The tax also provides funding to the Minnesota Department of Iron Range Resources and Rehabilitation, Range Association of Municipalities and Schools (RAMS), United States Hockey Hall of Fame, and for property tax relief.

"Cities, townships and school districts are telling us that budgets are tight, so a reduction of any size can be impactful," Paul Peltier, RAMS executive director said. "Any short-term decline in distributions is expected to be generally muted due to the three-year rolling average, with more effect felt in the out years. Although we are unaware of any plans to restart Minorca, and HibTac is operating at reduced capacity, we potentially see good news on the horizon. We are hopeful that a restart at the Granite City mill and the future opening of Mesabi Metallics will at a

minimum, contribute to stabilizing local tax revenue. We are working with cities, townships, and schools to support and connect them with information and resources to understand their individual financial situations."

The 2025 Production Tax payable by producers in 2026 is $3.427 per taxable ton, according to the minerals tax office.

The Production Tax for 2026 payable in 2027 is estimated at $3.513 per taxable ton, a 2.5 percent increase over 2025, according to the minerals tax office.

Nucor sets completion timeframe; expects WV mill to help in auto, appliance markets

By JIM ROSS jross@hdmediallc.com
Jan 29, 2026



The Nucor Steel West Virginia mill at Apple Grove, Mason County, shown on Aug. 16, 2025, was about 60% complete at the time and remains on track for completion late in 2026, company officials say. This photo was taken at the southern end of the complex where scrap steel will be melted to make new steel.

JIM ROSS | HD Media

Nucor Corp. is counting on its new West Virginia mill's location in the Ohio Valley to give it better penetration in auto and appliance markets, its executives said in their quarterly conference call on Tuesday.

"We're on schedule to complete construction of our new mill in West Virginia by year end. Once online, this mill will begin supplying some of the cleanest and most advanced sheet steel in North America, serving automotive, construction and industrial customers," Leon Topalian, Nucor's chairman and CEO, said during the call.

Steve Laxton, Nucor's chief operating officer and chief financial officer, added, "West Virginia will be done at the end of this year, and that team is doing a fantastic job moving that project forward."

He said the $4 billion undertaking along W.Va. 2 in Apple Grove, Mason County, about 47 miles southwest of downtown Charleston is "a big, complex mill," and it will not be contributing to earnings by the end of 2027.

Tuesday morning's call followed the Monday afternoon release of Nucor's fourth-quarter and full-year earnings report for 2025. Nucor said it earned $378 million in the fourth quarter compared to $287 million in the same period in 2024. Earnings for the full year totaled $1.744 billion, down from $2.027 billion in 2024.



'Looks like a steel mill': Nucor WV is 75% complete and on schedule, company says
By Jim Ross jross@hdmediallc.com. 2 min to read



WV manufacturers will need 7,000 new workers in 3 years, MAMC survey says
By Jim Ross jross@hdmediallc.com 2 min to read

'Wonderful time for a ramp up of a new facility in W.Va.'

During the call, Topalian and others noted the federal government protecting the domestic steel industry through tariffs and anti-dumping measures. The mill in Mason County and other new Nucor facilities are coming online as Nucor's existing mills run at 85% capacity,

Topalian said.

Present circumstances “really creates a wonderful time for a ramp up of a new facility in West Virginia. And so, we see more opportunities there as well,” he said. “The Northeast and Midwest corridors provide some unique geographic opportunities for Nucor, and again, I think from a cost position, that mill is going to provide a significant value for our shareholders.”



The air gas separation unit at Nucor Steel West Virginia, seen on June 25, 2025, is visible for miles along W.Va. 2 and can be seen across the Ohio River from Ohio 7.

JIM ROSS | HD Media

Noah Hanners, executive vice president of sheet production, said about a third of the Mason County mill’s production will go into the automotive market. Some of that steel will be used in parts that are exposed, which is an area where steel from electric arc furnaces has not been used widely, but Nucor has been qualified, he said.

In the markets for consumer durables such as appliances, there has been demand growth as companies reshore production, he added.



The Nucor Steel West Virginia mill rises along the Ohio River in Apple Grove, Mason County, on April 30, 2025.

SEAN McCALLISTER | Gazette-Mail file photo

“We’re going to have the capabilities to match what is really robust growth and demand for us,” Hanners said.

Last year, Nucor brought several new facilities online, including its new rebar micro mill at Lexington, North Carolina; its Kingman, Arizona, melt shop; its Alabama Towers and Structures facility and a coating complex at Crawfordsville, Indiana.

The new sheet steel mill is the largest project Nucor has undertaken. Last year it spent about $950 million on its construction, according to materials included with its earnings report.

Jim Ross is development and opinion editor of The Herald-Dispatch and a former business reporter and editor.

MORE INFORMATION



Nucor Steel West Virginia mill 85% complete, on schedule for 2027 production



Algoma Steel turns off blast furnace, steel now entirely made with new EAF

EAF steelmaking launches a new era for Algoma Steel.

Elaine Della-Mattia

Published Jan 19, 2026 • Last updated Jan 19, 2026 • 3 minute read

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Algoma Steel officially shuts down its blast furnace and coke oven steelmaking process on Jan. 17, 2026. PHOTO BY FILE PHOTO /Postmedia

A tradition of making blast furnace and coke oven steel at Algoma Steel for nearly 125 years has ended.

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The Sault Ste. Marie steelmaker has said that blast furnace operations have winded down, and a decommissioning process will begin.

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Algoma Steel has made the transition to electric arc furnace steelmaking, touted as the largest single decarbonization projects in Canada.

Algoma Steel said the No. 7 Blast Furnace was commissioned in 1975 and has been used throughout Algoma's production years. The No. 7 coke battery, built in 1959, the No. 8 coke battery, built in 1967, and the No. 9 coke battery, built in 1978, will also be shut down and no longer needed as part of the EAF steelmaking process.

The company's announcement said Algoma steel is now producing steel exclusively through its EAF steelmaking. The new steel is called Volta and the new steel reduces carbon emissions by up to 70 per cent annually.

The Volta name reflects the new process, one that is powered by Ontario's clean electricity grid and pays tribute to Alessandro Volta, who first harnessed electricity in 1800. The trademark, that includes a lightning bolt through it, also signifies the transition to the largest electricity consumer and electrifying the business.

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Traditional iron ore and coke-making operations are now replaced with a new process that will see the EAF accept and burn large amounts of recycled metal and transform it into steel with huge megawatts of power, altering the longtime, traditional steelmaking process.

The bitter-sweet transformation comes at a time coupled with global trade pressures, the search for new markets and more than 1,000 employees receiving layoff notices that take effect March 23.

The $987-million transformation that replaces Algoma's blast furnaces with two new EAFs is the most expensive construction project in Sault Ste. Marie's history. In 2021, it received $420 million in financial support from the federal government to support the transition through the repayable Strategic Innovation Fund.

Mayor Matthew Shoemaker also issued a a statement following the end of the coke making and blast furnace operations.

"For 125 years, Algoma Steel has made its product using blast furnaces powered by coal and coke – made possible through the hard work and dedication of thousands of steelworkers," the statement reads.

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improved environmental performance – won't be fully realized unless the federal and provincial governments match their investment in the transition with investment in the community and workers who made it possible," it states.

Shoemaker said the city has been aggressively advocating for the development of a new port, a business plan is completed, and a partnership has been formed to create a modern multi-modal hub to improve domestic trade flow and strengthen supply chains.

"It will enhance connectivity between Northern and Southern Ontario, the Prairies, Atlantic Canada and international markets – unlocking value across Canada's steel, forestry, mining, agriculture and energy sectors. This is exactly the kind of nation-building infrastructure that the Federal and Provincial governments are prioritizing right now to strengthen domestic manufacturing capacity and enhance economic security," Shoemaker states.

The port project is part of the city's delegation at this week's Rural Ontario Municipal Association conference in Toronto.

"Building a port is our next step – an opportunity to meet a national need while creating the next generation of industrial careers in Sault Ste. Marie," Shoemaker said.

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Hamilton

ArcelorMittal Dofasco quietly extends 'green' steel timeline from 2028 to 2050, gets $50M more from Ottawa

Dofasco says while its timeline has been 'drawn out,' it has the same decarbonization ambitions

Samantha Beattie · CBC News · Posted: Jan 14, 2026 3:00 AM CST | Last Updated: January 14

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ArcelorMittal Dofasco steel production facility is located on Hamilton's waterfront. (Patrick Morrell/CBC)

comments

ArcelorMittal Dofasco has quietly extended its timeline by 22 years to phase out coal for "decarbonized" steelmaking, says a federal government document, aiming for 2050 instead of 2028.

Ontario's largest emitter of greenhouse gases is also receiving $50 million more from the federal government for the project, according to an amendment posted to the Government of Canada's website last March.

It was posted after the U.S. first imposed tariffs on Canadian steel and shortly before the federal election.

The change brings Ottawa's total contribution to $450 million.

"The government has given the company a kind of loophole to continue its regular emissions for a much longer time," said Evan Ubene with Environment Hamilton.

ArcelorMittal Dofasco said in a statement it has extended the timeline but its "ambitions and intentions" have not changed. The additional $50 million is needed for a "technical configuration change in the [direct reduced iron] module plans."

Ubene said he happened to find the changes online, posted as an amendment, when searching for any sort of project update.

That's in stark contrast to the high-profile media events in 2022, initially announcing the transition.



Former prime minister Justin Trudeau was among those in attendance for the groundbreaking ceremony at ArcelorMittal Dofasco on Oct. 13, 2022. (Bobby Hristova/CBC)

Then, company officials, the prime minister and Ontario premier all told reporters Dofasco would decommission its blast furnaces and coke plants in place of direct reduced iron technology (DRI) and electric arc furnaces (EAFs) — all by 2028.

The province and Dofasco also pledged money to the $1.8-billion project.

Instead of relying on coal, the steel plant would be fuelled by natural gas and eventually hydrogen, reducing greenhouse gas emissions by 60 per cent, as well as harmful airborne pollutants, officials said in 2022.

The Ontario Ministry of Economic Development, Job Creation and Trade said Dofasco has spent none of the money the province has set aside for EAFs, totalling $500 million.

“We continue to work closely with ArcelorMittal Dofasco and companies across the steel sector to ensure they are positioned to take advantage of domestic opportunities and find new markets for made-in-Ontario steel," said spokesperson Christy Arnold.

Iron production moving to Quebec

Federal agency Innovation, Science and Economic Development Canada told CBC Hamilton it still expects Dofasco to transition from blast furnaces to EAFs and reduce emissions by three million tonnes a year — as originally planned.

The "only change," said spokesperson Riyadh Nazerally, is that DRI production will not happen at Dofasco.

Instead, the iron will be produced at ArcelorMittal's DRI facility in Contrecoeur, Que.

How this will impact jobs in Hamilton is unclear. The original project proposal said it would "maintain 4,600 full-time jobs within Canada."

The amendment now says instead that the project will "support thousands of jobs during the engineering and construction phases."

The federal government said the timeline was extended to reflect the "full contractional period" but that the project's completion date remains 2028.

Dofasco did not say anything in its statement about DRI being done in Quebec instead.

'No one knows what's really planned'

The amendment has added "watered down and vague" language to what's being proposed and when the changes will happen, said Ubene.

“Now, no one knows what’s really planned,” he said. “And when they keep delaying it, Hamilton residents have to keep breathing that air in.”

The original plan specified that the project will use the “more modern steelmaking practices” of DRI and EAFs.

But last year, the project was amended to say Dofasco will replace its furnaces and coke plants but doesn’t specify with what.

It remains unclear if Dofasco will continue to produce some iron using its coke plants in Hamilton, or get all it all from Quebec.

“It is very concerning that this language [of DRI and EAFs] seems to have been removed and makes the scope of the project agreement unclear,” said Ubene.

“The government should be directing public funds towards workers to support them in a transition away from fossil fuels, but here they are giving public funds to a billion-dollar company and making it very easy for that company to avoid doing the right thing.”

ArcelorMittal Dofasco misses key milestones in $1.8B 'green' steel project promised for 2028

Ford government eyes 'green steel' as way to catch up on cutting carbon emissions

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While the project is still aiming to reduce greenhouse gas emissions by the same amount, Ubene said that’s impossible if Dofasco continues to rely on coal.



Hamilton resident Jochen Bezner has been demanding more transparency from Dofasco on its emissions. (Samantha Beattie/CBC)

At a community meeting last October, Dofasco told the public that its "decarbonization project" has gone through several engineering phases and it is proceeding with "extreme caution" because of the U.S. tariffs on Canadian steel.

It said there were no "major updates" at the time, even though the amendment had gone through, unannounced, eight months before.

Jochen Bezner, a longtime citizen member of Dofasco's community liaison committee, said he was never informed of the "major" project changes despite attending quarterly meetings with the steelmaker.

"At this point [Dofasco] as well as the federal government owes Hamilton an answer and clarification regarding what all of this means going forward," Bezner said.

The next community meeting with Dofasco will take place on Jan. 20.

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Cliffs will move toward EAFs in next decade: Goncalves

Market: Coking coal, Metals | 24/08/21

Integrated steelmaker Cleveland-Cliffs will likely lean even further into electric arc furnace (EAF) steelmaking over the next decade.

Over time the company will move away from integrated steelmaking, which currently supplies significant volumes to the automotive industry, chief executive Lourenco Goncalves told *Argus.*

"We cannot have blast furnaces only for the automotive industry, you have to have them for everything," Goncalves said. "If one day I feel like I do not have the automotive industry, you will see us shutting down blast furnaces and going to

Speak to a specialist

Goncalves said that shift could happen in the next 10 years. "Will it happen under my watch? Probably, probably, because I do not plan to retire anytime soon, and I do not plan to die."

The shift would have significant implications for the North American steel industry because Cleveland-Cliffs is the largest flat-rolled steelmaker in the region and is one of the largest overall steelmakers.

Cliffs currently operates eight blast furnaces and four EAF mills.

An upcoming maintenance outage at Cleveland-Cliffs' Indiana Harbor No. 7 blast furnace — the largest in the US — will allow the mill to consume more hot-briquetted iron (HBI), a metallic that the company makes internally at a new plant in Toledo, Ohio.

That increased HBI consumption is forcing Cleveland-Cliffs to integrate its scrap buying internally, which Goncalves announced it will do on 1 September.

By Rye Druzin

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Demo marks end of steel era in Kentucky city

Demolition progress in Ashland, Kentucky, signals end of former steel mill complex.



Image provided by Dreamstime.

BRIAN TAYLOR, SENIOR EDITOR

PUBLISHED FEBRUARY 09, 2022

The redevelopment of a decades-old steelmaking complex in Ashland, Kentucky, gained attention this week with the collapse of large furnace structure.

According to -based WSAZ-TV,) the demolition of the Amanda Furnace at the former AK Steel blast furnace/basic oxygen furnace (BOF) site near Ashland was noticeable from “miles away” on Tuesday, Feb 8.

The station says “social media lit up,” Tuesday morning, with some people making comparisons to or mistaking the activity for an earthquake.

2019. That decision was not reversed when Cleveland-based Cleveland-Cliffs acquired AK Steel later that year.

WSAZ quotes Cleveland-Cliffs as saying it will prepare the site for redevelopment, stating, “The entire project will be a positive cash flow generator for Cleveland-Cliffs and certainly a positive for the Ashland area.”

A video clip of the explosion that took down the Amanda Furnace can be viewed on **this web page**.

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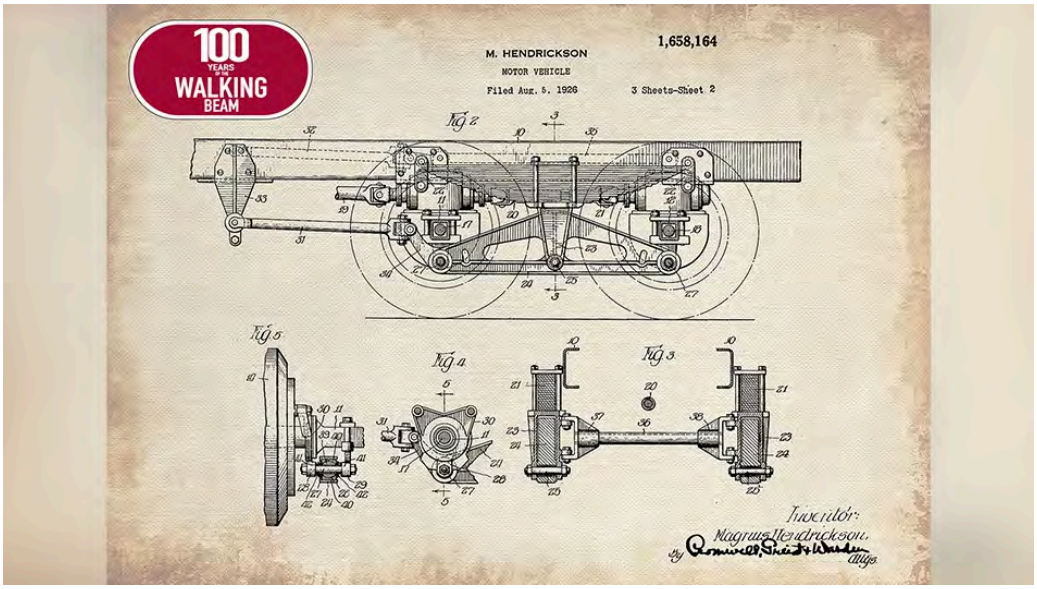
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U.S. Steel to idle Blast Furnace B at Granite City works, says it is temporary



us steel

By First Alert 4 Staff

Published: Sep. 18, 2023 at 2:43 PM CDT

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GRANITE CITY (KMOV) -- U.S. Steel will idle its last operating blast furnace at the Granite City Works plant, citing “risk mitigation” after the announcement of the UAW autoworkers strike.

A U.S. Steel spokesperson confirmed Monday that Blast Furnace 'B' will be temporarily idled. The spokesperson said any layoffs would happen in phases but did not say how many workers would be laid off.

"Following the announcement of UAW strike actions, we are executing our risk mitigation plan to ensure our melt capacity is balanced with our order book. As a result, we have decided to temporarily idle blast furnace 'B' at Granite City Works and are reallocating volumes as needed to other domestic facilities to efficiently meet customer demand.

We thank our employees for working to ensure the temporary idling of the furnace will be conducted safely and efficiently. We do not take these decisions lightly and will continue to monitor and assess market conditions."

— *U.S. Steel Press Office*

There are currently around 1,450 employees at Granite City Works. U.S. Rep. Nikki Budzinski, whose Congressional district covers Granite City, called the decision to idle the furnace an "outrage."

"U.S. Steel's decision to idle operations in Granite City and lay off workers is an outrage. And their effort to blame this announcement on the United Auto Workers strike is a shameful attempt to pit working people against one another. We must hold them accountable.

"No company should be allowed to hand a pink slip to workers without notice and without recourse. In Congress, I'm actively working to strengthen the Worker Adjustment and Retraining Notification (WARN) Act and improve assistance available to impacted workers through the Workforce Innovation and Opportunity Act (WIOA). My team and I stand ready to assist the steelworkers affected by this announcement.

"I've been in touch with U.S. Steel, the United Steelworkers and the Mayor of Granite City as we continue to learn more about the extent of layoffs and the resources available to those put out of work. I believe in the working men and

local and national economy. I will never stop fighting to protect their jobs and their livelihoods."

— U.S. Rep. Nikki Budzinski

In a statement on U.S. Steel's decision, U.S. Senate Majority Whip Dick Durbin (D-IL) said the decision to idle the furnace will "have a significant impact on its workers and the local economy."

> *"Steel production is a key component of our nation's economic health. It is also a major source of employment throughout the country and in the State of Illinois, where the steel industry supports thousands of jobs. Idling blast furnace 'B' at Granite City Works—even temporarily—will have a significant impact on its workers and the local economy.*
>
> *"I urge U.S. Steel to work closely with the community and employees to ease these impacts and reopen blast furnace 'B' as soon as possibl*
>
> *— U.S. Senate Majority Whip Dick Durbin*

First Alert 4 has reached out to the local United Steelworks Union for comment. U.S. Steel recently declined a billion-dollar buyout offer from a rival company.

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DIVE BRIEF

US Steel doubles investment to more than $2B for oldest plant

The company plans to construct a new hot strip mill at the Edgar Thomson plant and improve related Mon Valley Works facilities over the next three years.

Published June 9, 2026



Nathan Owens
Reporter



U.S. Steel's Edgar Thomson plant in Braddock, Pennsylvania, on March 10, 2018. The company plans to invest more than $2 billion constructing a hot strip mill at the location and on other related operations. Drew Angerer via Getty Images

Dive Brief:

- U.S. Steel plans to invest up to $2.5 billion updating its Mon Valley Works operations near Pittsburgh, to improve steel yields and product quality, as well as reduce energy consumption, the company said Monday.

- As part of its investment, the steelmaker will construct a "state-of-the-art" hot strip mill at the Edgar Thomson plant in Braddock, Pennsylvania, and improve related Mon Valley Works facilities over the next three years, according to an economic impact analysis.
- The investment — which is more than double what U.S. Steel initially planned — could generate up to $1.7 billion for the state's economy and support up to 6,381 jobs, the analysis shows. The new facility is set to replace an 87-year-old mill at the nearby Irvin plant.

Dive Insight:

In August 2024, Japan-based Nippon Steel agreed to spend at least $1 billion upgrading or constructing a hot strip mill in Southwest Pennsylvania after its merger with U.S. Steel was completed.

The scope of the project has since expanded. Today, U.S. Steel is evaluating two potential investment blueprints: a $2 billion scenario and a $2.5 billion scenario. In addition to product output, quality and energy improvements, the new mill would expand the range of steel products that Mon Valley Works can produce for automotive, appliance and industrial markets.

"The Mon Valley Works is where the American steel industry was first forged, and this investment is proof that its best days are still ahead," U.S. Steel CEO David Burritt said in a statement.

The new hot mill will feature two reheat furnaces, an "upgraded casting process capable of producing thicker, higher-quality slabs" and a new ladle metallurgy furnace, according to an investment fact sheet provided by U.S. Steel. Construction is set to begin later this year, with production expected during the second half of 2029.

As part of the investment, U.S. Steel said it will also build a slag recycler to support the new hot strip mill. Construction has already begun on the recycler, and the investments are expected to support continued steelmaking in the region for decades to come.

As part of its $2.5 billion commitment, U.S. Steel expects to generate up to $58 million in state and local tax revenue, the economic impact analysis shows. If the company went with its $2 billion scenario, the investment would generate up to $1.4 billion for the state's economy and support 5,105 jobs. It would also generate $46.4 million in state and local tax revenue. Parker Strategy Group conducted the analysis.

"This investment means thousands of good-paying jobs protected, a world-class facility, and steel that will supply American automakers and manufacturers for generations. This is what investing in America looks like," Burritt said.

The Edgar Thomson plant has been operating for more than 150 years and is the last integrated steel producer in Pennsylvania with blast furnaces and basic oxygen furnaces. This makes it an integral part of Mon Valley Works and other U.S. Steel locations, according to a 2020 plant operations and environmental report.

Businessman and philanthropist Andrew Carnegie first opened the plant in 1875 as part of Carnegie Steel. He later sold his company to banker J.P. Morgan in 1901, who merged Carnegie with nine other steel companies to form the foundation of U.S. Steel.

The Edgar Thomson plant is considered a national historic landmark.

PRESS RELEASE | JULY 18, 2017

Clean Energy Transition Will Increase Demand for Minerals, says new World Bank report

WASHINGTON, July 18, 2017 – A new report released today by the World Bank highlights the potential impacts that the expected continuing boom in low-carbon energy technologies will have on demand for many minerals and metals.

Using wind, solar, and energy storage batteries as key examples of low-carbon or "green" energy technologies, the report, ***"The Growing Role of Minerals and Metals for a Low-Carbon Future"*** examines the types of minerals and metals that will likely increase in demand as the world works towards commitments to keep the global average temperature rise at or below 2°C.

According to the report, minerals and metals expected to see heightened demand include: aluminum, copper, lead, lithium, manganese, nickel, silver, steel, and zinc and rare earth minerals such as indium, molybdenum, and neodymium. The most significant example is electric storage batteries, where the rise in relevant metals: aluminum, cobalt, iron, lead, lithium, manganese, and nickel—grow in demand from a relatively modest level under 4°C to more than 1000 percent under 2°C.

The report shows that a shift to a low-carbon future could result in opportunities for mineral-rich countries but also points to the need for these countries to ensure they have long-term strategies in place that enable them to make smart investment decisions. In readiness for growth in demand, countries will need to have appropriate policy mechanisms in place to safeguard local communities and the environment.

"*With better planning, resource-rich countries can take advantage of the increased demand to foster growth and development*," said **Riccardo Puliti, Senior Director and Head of the Energy and Extractive Industries Global Practice at the World Bank**. "*Countries with capacity and infrastructure to supply the minerals and metals required for cleaner technologies have a unique opportunity to grow their economies if they develop their mining sectors in a sustainable way*."

The future demand for specific metals is not only a function of the degree to which countries commit to a low-carbon future, it is also driven by intra-technology choices. The low-carbon technologies that emerge as most applicable and beneficial, will play an important role in defining the commodity marketplace of the next 50 years. For example, the three leading forms of alternative vehicles — electric, hybrid, and hydrogen — each have different implications for metal demand: electric vehicles require lithium; hybrid vehicles use lead; and hydrogen-powered vehicles use platinum.

Demand for individual metals and minerals will reflect the component mix of low-carbon technologies, corresponding with economic changes and technical developments. To position themselves well, countries will need reliable sources of economic data and market intelligence, as well as the capacity to turn that information into plans, investments, and sustainable operations.

Based on current trends, it is expected that Chile, Peru, and (potentially) Bolivia, will play a key role in supplying copper and lithium; Brazil is a key bauxite and iron ore supplier; while southern Africa and Guinea will be vital in the effort to meet growing demand for platinum, manganese, bauxite, and chromium**.** China will continue to play a leading role in production and reserve levels in practically every key metal required under low-carbon scenarios. India is dominant in iron, steel, and titanium, while Indonesia, Malaysia, and Philippines have opportunities with bauxite and nickel.

A "green" technology future has the potential to be materially intensive, the report states. Increased extraction and production activities could also have significant impacts on local water systems, ecosystems, and communities. As countries develop their natural resource endowments, it will be critical that sustainability, environmental protection, and options to recycle materials be integrated into new operations, policies and investments.

"The Growing Role of Minerals and Metals for a Low-Carbon Future" report is intended to contribute to a richer dialogue around the opportunities and challenges for resource-rich countries that a low-carbon future presents. The analysis is designed to support policy-makers and other stakeholders in the areas of extractives, clean energy and climate change to better understand the issues involved and identify areas of common interest.

PRESS RELEASE NO: 005

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What the U.S. Steel sale means for Minnesota's Iron Range

Part of the Nippon Steel's national security agreement with Trump administration includes $800M in local investments, few job protections.

Jerry Burnes

June 19, 2025 3–4 minutes



U.S. Steel officials talk with Takahiro Mori, a Nippon Steel executive, in May 2024 at a ribbong cutting event for Keewatin Taconite. (Jerry Burnes/Iron Range Today)

Nippon Steel completed its purchase of U.S. Steel on Wednesday, placing two Iron Range mines under new ownership with some oversight from the federal government under a national security pact.

The deal includes a "golden share" that gives President Donald J. Trump and future administrations an ability to block certain actions and some leverage to enforce promises made by the Japanese steelmaker.

In practice, the arrangement is a permanent single share of preferred stock in U.S. Steel that allows the president or a designee to effectively serve on the company's board.

As part of the pact, a number of potential activities by the company are disallowed without approval of the president, ranging from moving its headquarters to following through on investments.

ALSO READ: *A look at the 'golden share' agreement in the U.S. Steel-Nippon Steel partnership (NPR News)*

For the Iron Range, the deal intends to send about $800 million in investments to U.S. Steel mines between 2025 and 2028 as part of a larger promise to spend $11 billion domestically. That total also calls for construction of a new $1 billion mini mill at an undetermined location.

Nippon is set to spend $200 million in 2025 and 2026, and $300 million in 2027 and 2028 at the company's Minntac and Keetac facilities, subject to approvals and permits, according to SEC filings.

No details have been provided on the scope of those local investments, and a spokesperson for U.S. Rep. Pete Stauber told Iron Range Today recently that particulars were still unknown.

The United Steelworkers (USW) have been the biggest opponent of the merger since it was announced in December 2023, and supported U.S. Steel rival Cleveland-Cliffs to acquire the company.

Union officials were miffed that the company didn't consult with them before agreeing to the Nippon Steel sale, and have sought written assurances from the new parent company that would protect contracts, jobs and retiree benefits.

Nippon has said it would honor current collective bargaining agreements with USW, which are set to expire next year, but little-to-no language concerning workers and jobs was present in the national security pact publicized Wednesday.

The deal calls for the company to maintain base salaries of current employees until 2030, and is meant to safeguard against plant closures, idles or sales up to June 18, 2035, including at Minntac and Keetac.

But it also carved out an exception for temporary plant idles, which typically include layoffs and a more open-ended timeline than the term implies.

That's the current case at two Cliffs facilities on the Iron Range. The company announced temporary idles in March, impacting 630 miners at Hibbing Taconite and Minorca Mine.

Company officials anticipated a six-month down period, but union leaders have expressed concern over the winterizing process at Minorca – calling it instead an "indefinite idle" period, and whether the full workforce at HibTac will ever return.

USW President Dave McCall said Wednesday that union would work to hold Nippon responsible to its promises.

"Our current agreement expires in September 2026," he said, "and rest assured, if our job security, pensions, retiree health care or other hard-earned benefits are threatened, we are ready to respond with the full strength and solidarity of our membership."

More broadly, the Keetac and Minntac facilities would stand to benefit from a cash infusion.

Keetac recently finalized upgrades to produce of DR-grade pellets to feed electric-arc furnaces, and was reportedly a facility of interest for Nippon from the start. It also faces a large unknown with its water permits and state sulfate standards, which could present a significant cost hurdle.

Minntac also has permit renewals on the horizon, as well as general maintenance at the largest taconite mine in the United States.

Nippon will also have to navigate a 25% ownership stake in Minntac by Cliffs, stemming from a pandemic-era decision by U.S. Steel to sell part of the mine to Stelco in 2020. Terms of the deal appear to allow the company a clean out in 2027, but at a cost of $120 million. Stelco was purchased by Cliffs last year.



AROUND THE RANGE

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AROUND THE RANGE

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POLITICS

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Duluth News Tribune

BUSINESS

US Steel will idle Keetac, lay off 375 employees

It's the second Iron Range mine to announce an idling and layoffs this week as steel demand tumbles during the COVID-19 pandemic.



U.S. Steel's Keetac facility. (file photo / News Tribune)



By Jimmy Lovrien
April 16, 2020 at 12:40 PM

Share

U.S. Steel will idle its Keetac mine and processing facility in Keewatin and lay off 375 of its 423 employees as the COVID-19 pandemic continues to hurt demand for steel(https://www.duluthnewstribune.com/business/energy-and-mining/5006183-Iron-Range-mines-face-looming-recession-triggered-by-COVID-19) .

Keetac is the second Minnesota mine and plant to idle and lay off employees. On Monday, Cleveland Cliffs announced it would idle Northshore Mining(https://www.duluthnewstribune.com/business/energy-and-mining/5040979-Cliffs-will-idle-Northshore-Mining-Tilden-Mine-until-late-summer) in Silver Bay and Babbitt until at least mid-August, laying off 470 of its 570 employees.

U.S. Steel's decision follows "operational adjustments" it announced in March, U.S. Steel spokesperson Meghan Cox said in an email to the News Tribune on Thursday afternoon. Cox would not say if U.S. Steel's other Minnesota facility, Minntac in Mountain Iron, would also be affected.

"After further study of current demand, we must make additional adjustments to our raw materials production and indefinitely idle our Keetac facility to respond to the sudden and dramatic decline in business conditions resulting from the worldwide COVID-19 pandemic," Cox said.

Cox said 75 employees with fewer than three years of experience would be laid off first, but a total of 375 union and non-union employees will be laid off over the next month.

Dan Pierce, United Steelworkers Local 2660 president and a diesel mechanic at Keetac, told the News Tribune on Thursday that layoffs would begin Sunday for people with fewer than three years of experience, and the union sent letters to members Wednesday informing them of the layoffs.

As of Thursday morning, the union continued to negotiate additional layoffs with U.S. Steel.

"We're in the process of negotiating with the company for employees that have three years or more," Pierce said.

Over the last month, U.S. Steel has idled two of its blast furnaces at Gary Works plant in Indiana as demand for steel sunk.

Demand for steel has fallen not only from consumer markets, but also from companies such as General Motors, Ford and Fiat Chrysler voluntarily shuttering plants to help curb the spread of coronavirus. All three halted production in March. Other factories requiring steel have also closed.

In the last month, capacity utilization of the country's blast furnaces has fallen from 80.5% to 56.1%, according to the Iron and Steel Institute(https://www.steel.org/industry-data?mc_cid=b35ecd2ff4&mc_eid=942e2bb46d) .

Iron ore pellets produced on the Iron Range from mined taconite supply many of those blast furnaces. Keetac produces about 6 million net tons of pellets each year for U.S. Steel's steelmaking plants.

Reached by phone Thursday, Keewatin Mayor William King summed up the situation for the town of about 1,000 residents: "It sucks."

King, a 40-year resident of Keewatin, said unlike past shutdowns, some of the businesses in town are already closed due to the pandemic. He's not sure all three of Keewatin's restaurants and bars will survive if the order to halt dine-in service and the mine shutdown last a long time.

"They might have been able to get by a month, maybe two. But if this continues, then when they open up, there's nobody to come," King said. "Then it's gonna be really tough for their small businesses."

Ben DeNucci, an Itasca County Commissioner representing the district that includes Keewatin, said he's also worried about area small businesses.

"It's challenging to own and operate a small business. So with a pandemic, it just makes things even harder," DeNucci said. "We are very concerned about how this is all going to shake out, how businesses are going to get through it. We have a real level of concern in Itasca County about the current state and the future, and then when you add on a layoff of this nature, it just compounds that."

And, DeNucci said, mining jobs are the area's "good" jobs.

"Those are family-sustaining, good-paying jobs," he said.

For now, King said he hopes all the Keetac workers will be able to get by on unemployment.

"Hopefully, these guys, once they start laying them off, won't have any trouble getting into unemployment," King said.

This story was updated at 5:25 p.m. April 16 with additional information and quotes from Mayor William King and County Commissioner Ben DeNucci. It was originally posted at 1:40 p.m. April 16.

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By Jimmy Lovrien(https://www.duluthnewstribune.com/jimmy-lovrien)

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Duluth News Tribune

BUSINESS

US Steel will restart Keetac next month

Nearly 400 workers will return to work at the mine in December.



U.S. Steel's Keetac facility. (File / News Tribune)



By Jimmy Lovrien
November 05, 2020 at 6:06 PM

Share

The only Iron Range mine still shut down due to the pandemic is set to restart.

U.S. Steel announced Thursday that it would be restarting the Keetac iron ore mine and pellet plant in Keewatin, which has been indefinitely idled since May, leaving 375 employees out of work(https://www.duluthnewstribune.com/business/energy-and-

mining/5090981-US-Steel-will-idle-Keetac-lay-off-375-employees) after the pandemic caused the demand for steel to fall.

But next month they'll be back to work.

"We will resume operations in mid-December," U.S. Steel spokesperson Amanda Malkowski told the News Tribune. "We're starting to recall workers as soon as today."

In an emailed statement, U.S. Steel said the decision comes as demand for steel improves.

"We are encouraged by the increase in demand and believe this restart will best support our customers," U.S. Steel said. "This will also ensure that we have sufficient iron ore supply where it is needed to meet that demand. We expect to fill nearly 400 positions as part of this restart and will work with the United Steelworkers to recall employees that may have been affected by the idle."

In a call with investors last week, U.S. Steel CEO David Burritt said the company was considering reopening Keetac to rebuild an inventory of iron ore pellets before locks on the Great Lakes close for winter.

The Soo Locks, which connect Lake Superior to the rest of the Great Lakes, are generally closed mid-January to mid-March due to ice. Ships loaded with ore in Lake Superior pass through the locks to reach steel mills along other Great Lakes.

Dan Pierce, a diesel mechanic at Keetac and president of United Steelworkers Local 2660, which represents workers at Keetac, said Thursday the restart was "awesome news" and a "stress reliever," especially just before the holidays.

"We have a huge amount of new members that lost their insurance at the end of October, and we were slated to have another big bunch lose their insurance at the end of November," Pierce said.

"So this is a big relief for a lot of young families and members that have never been through it before."

Pierce said the company will reach out to members Friday and some people will begin returning to work to get the plant ready for restart soon.

In a statement Thursday evening, Gov. Tim Walz applauded U.S. Steel's decision.

“This is a good day for the Iron Range and for an industry that’s a pillar of Minnesota’s economy,” Walz said. “The decision to reopen Keetac will restore hundreds of good-paying union jobs for Minnesotans in the Northland. I’m excited to see Minnesotans get back to work.”

As pandemic-induced restrictions swept the U.S. this spring, demand for steel fell, causing iron ore mines in Minnesota to idle.

At its height, Keetac, Cleveland-Cliffs' Northshore Mining in Babbitt and Silver Bay and ArcelorMittal-managed Hibbing Taconite had all idled. Additionally, U.S. Steel's Minntac in Mountain Iron lowered production and laid off 260 of its workers.

Layoffs at the three idled facilities and Minntac totaled approximately 1,760 workers, more than one-third of the 4,105 total jobs at the Iron Range's six mines in 2019.

Most of the mines reopened and recalled employees by mid to late summer but Keetac remained idled.

Due to its small size, Keetac is usually the last mine to restart after downturns. It produced just over 5 million tons of pellets and employed 451 people last year while Minntac produced 13 million tons of pellets and employed 1,460 people.

But its restart is a sign of improving demand for steel and the iron ore pellets used in its production.

In the spring, the country's blast furnace utilization fell from 81.6% on March 7 to 51.1% on May 2. Last week, it reached 70.4%, according to the American Iron and Steel Institute.

Burritt last week said he was confident demand would remain high.

"We believe today's market demand is sustainable and will continue into next year," Burritt said. "As vacations, movies, concerts and dining out have been replaced by vehicle and appliance sales and home improvement projects, we have continued to see a noticeable increase in steel demand."

This story was updated several times with additional information from U.S. Steel and quotes from USW Local 2660 President Dan Pierce. The final version was published at 7:06 p.m. Nov. 5. The initial version was posted at 3:46 p.m. Nov. 5.

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Business and Economic News

The Associated Press and MPR News Staff · September 28, 2026 12:44 PM

· **UPDATED:** SEPTEMBER 28, 2026 4:55 PM

Trump announces $15 billion steel mill planned for Iowa, using ore from Minnesota mine



Speeches are given at the new Mesabi Metallics iron ore mine on Sept. 17 in Nashwauk. The White House on Monday is slated to announce plans for a new steel plant in Iowa, using ore from the Minnesota mine.
Erica Dischino for MPR News

Listen Trump announces $15 billion steel mill planned for Iowa, using ore from Minnesota mine

ON AIR
THE WORLD WITH MARCO WERMAN

2026 ELECTION HUB
Your ballot, voting information and the latest updates

President Donald Trump on Monday announced plans for a new $15 billion steel plant in eastern Iowa that would be one of the largest in the United States — and use iron ore mined in Minnesota.

The new mill in eastern Iowa will be built by Mesabi Metallics, a Minnesota-based company owned by India's Essar Group, an industrial conglomerate. The White House said the plant will begin producing steel in 2030 and create more than 2,000 jobs in the United States. When it's fully built out, it's expected to produce 10 million tons of steel a year, more than any other in the U.S.

The steel plant will be supplied by the new $2.5 billion iron ore mine that Mesabi developed on Minnesota's Iron Range and officially opened earlier this month. It's the first new iron ore mine in the state in a half-century.

The resulting steel will be produced from start to finish in the United States, the White House said.

The president touted the 50 percent tariffs on steel imports that he imposed last year as the impetus for the steel plant.

"Our steel industry is roaring back to life. Everyone is building their plants here because they don't want to pay tariffs," Trump said in the Oval Office. "It's really not that complicated."

Earlier Blast, at last: Minnesota's first new iron ore mine in 50 years targets new era of steelmaking

The Mesabi Metallics mine's opening comes at a critical time in northeastern Minnesota, after closures last year at two of the region's six taconite facilities.

Mesabi has hired more than 200 workers so far, out of a planned 350 full-time employees at the mine near Nashwauk.

But news that Mesabi plans to build a steel plant in Iowa — and not in

ON AIR
THE WORLD WITH MARCO WERMAN

0:00 / 0:00

GOP state Rep. Spencer Igo on a planned $15 billion steel mill in Iowa

Igo said the mine is a “big win” for the Range — but he said Mesabi’s next investment going to Iowa “should frustrate everyone who cares about the future of northern Minnesota.”

“We cannot keep watching billions of dollars in investment and thousands of good-paying jobs go elsewhere and pretend there is nothing we can do about it,” Igo wrote. “The people of the Iron Range want this opportunity, and we have the workers, the resources, and the communities ready to support these projects. State leaders need to start making Minnesota a place where companies want to build and create jobs, not a place they look to leave behind. The most important part of public policy is partnership, and the state of Minnesota is missing that.”

Mesabi Metallics said the new Iowa steel plant will “reshape American steelmaking with a supply chain that is 100 percent American: mined, melted and poured.”

Mesabi CEO Joe Broking said in a statement Monday that the steel plant announcement “bolsters the long-term economic strength of Mesabi Metallics’ mine and pellet plant in Nashwauk, Minnesota, by tying it to a low-cost steel facility.”

“Mesabi Metallics is looking forward to further investment in Minnesota, and we look forward to continuing our work with the state to expand the mine capacity and build an additional hot briquetted iron facility in Minnesota,” Broking said.

Hot briquetted iron is a purer form of iron is used to feed smaller steel mills known as electric arc furnaces.

Broking added: “We have greatly appreciated the support of Governor Walz and the work of the DNR and MPCA to successfully permit the first new iron mine in Minnesota in 50 years.”

Broking told Itasca County officials earlier this month that Mesabi Metallics

ON AIR
THE WORLD WITH MARCO WERMAN

But he also told commissioners that before making the investment, the company needs to see more efficient state permitting and more competitive incentives. He also said Mesabi would need to regain control of state mineral leases that were awarded to rival mining company Cleveland-Cliffs in 2023.

The White House is framing Monday's steel plant announcement as part of Trump's push to revitalize American steel.

It comes as Trump is trying to energize Republican voters as his party faces challenging midterm elections. Iowa has found itself with competitive races for the Senate and the governor's mansion this year.

- Defense company to buy Wisconsin shipyard with plans to invest $350M
- Meta ordered to pay New Mexico $25 billion for deceiving users about privacy on Facebook
- Reporter poses as problem gambler and finds sports betting sites reward addiction
- 'The corn cannibalized itself': How a dry summer walloped southwestern Minnesota

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https://www.fox21online.com/news/sofidel-begins-expansion-construction-in-duluth/article_79e80f53-e20c-57e0-8323-c8d4206cddc5.html

Sofidel Begins Expansion Construction in Duluth

By Emily Halling
Nov 14, 2024



DULUTH, Minn.– Sofidel, the Italian paper company specializing in toilet paper, and tissue paper manufacturing took over the once vacant paper mill along I-35.

The company is eager to breathe new life into this property.

Sofidel decided to invest in Duluth because of two things. First, it was a new facility in terms of paper machine. And the second reason is because of secure workforce. The work force that is here is very committed and very dedicated to the mill, and to the plant," said Sofidel Integration Manager Simone Giacomelli.

Before Sofidel was in the picture, the factory used to produce paper for newspapers and magazines.

Over the years, this is the 7th company that has taken over that mill.

The rise of the internet saw a big decrease in demand for these products.

"That market was sort of in a doom state within a decade of the completion of the original mill. Now the Duluth mill stayed competitive right until the very end. Which was July 5th of 2020.And that was during the height of COVID. And that was kind of the last straw for the facility as it was," said Sofidel Site Operations Manager, Gary Wargin.

Sofidel initially received a 5-million-dollar incentive from the state to expand this plant in October of this year.

Those funds are going towards the 200-million-dollar expansion project, that began construction two weeks ago.

"This is going to create 160 additional jobs on top of what we have currently on the mill site. It's going to help other local industries that support the paper industry. You know, when you think of transportation, trucking, shipping, those types of things," said Wargin.

The completed project is expected to be 600,000 square feet.

The expansion will improve how things are operated at the plant.

"The expansion of the operation is going to include two major things. First, we're going to take our current paper production, and convert it into finished product paper. Second thing is, we're going to have a full automated warehouse and shipping facilities constructed on site. So, we can go to direct customer locations right out of the Duluth site," said Wargin.

The expansion will be complete in mid 2026.

In the meantime, they are already hiring for machine operators, and tissue converting operations manager.

SUSTAINABILITY REPORT

2022 | CLEVELAND-CLIFFS INC.



CLIFFS



View of Beaver River in Minnesota, as seen from the section of the Superior Hiking Trail that traverses through Cleveland-Cliffs' Northshore Mine property

OUR CORE VALUES

Cleveland-Cliffs' Core Values are at the heart of everything we do. These important tenets guide our daily actions and decisions. Our Core Values help us maintain the trust we have built with our stakeholders and with each other. We focus on doing what is best for our people, the environment and our business. Our Core Values provide a strong foundation from which we operate and we are proud to demonstrate these values every day.



Safe Production

Cliffs is committed to keeping each other safe through proper training and procedures, well-maintained equipment and good housekeeping.



Bias for Action

Cliffs is committed to removing barriers to action, implementing plans for success and executing those plans.



Recognize and Reward Achievement

Cliffs is committed to recognizing employees and celebrating successes, praising personal performance and thanking others for their work.



Ethical Behavior

Cliffs is committed to conducting business with honesty, fairness, integrity and complying with all applicable laws.



Customer Focus

Cliffs is committed to listening to our customers, being responsive and on time, meeting quality expectations and helping our customers succeed.



Creating Economic Value

Cliffs is committed to doing the right thing the first time, gaining efficiencies and achieving breakthroughs in productivity and technology.



Teamwork

Cliffs is committed to including each other in decision-making, knowing when to take the lead and when to be a team player, and recognizing the value of working together to succeed.



Group and Individual Accountability

Cliffs is committed to holding each other to high standards of performance and conduct, being responsible for achieving results and walking the talk.



Trust, Respect, and Open Communication

Cliffs is committed to maintaining open and honest communications to build trust, accepting and encouraging others' viewpoints and promoting workplace diversity.



Environmental Stewardship

Cliffs is committed to going beyond compliance, proactively addressing potential impacts and being a responsible steward of our resources and a good neighbor to the communities where we operate.

ABOUT THIS REPORT

Cleveland-Cliffs' Sustainability Report 2022 covers information and data for calendar year 2022, unless otherwise noted. Report content and disclosures reference the Global Reporting Initiative (GRI) Standards and the Sustainability Accounting Standards Board (SASB) Standards for Iron & Steel Producers and Metals & Mining. Cliffs reports on our progress against our sustainability goals on an annual basis and regularly engages with stakeholders throughout the year around sustainability topics. We obtained external limited assurance for our consolidated Scope 1 and 2 GHG emissions data, which is detailed in our **Statement of GHG Emissions** at the back of this report. We welcome questions and feedback about this report to **sustainability@clevelandcliffs.com**.

Our past reports are available in the **Fact Center**.

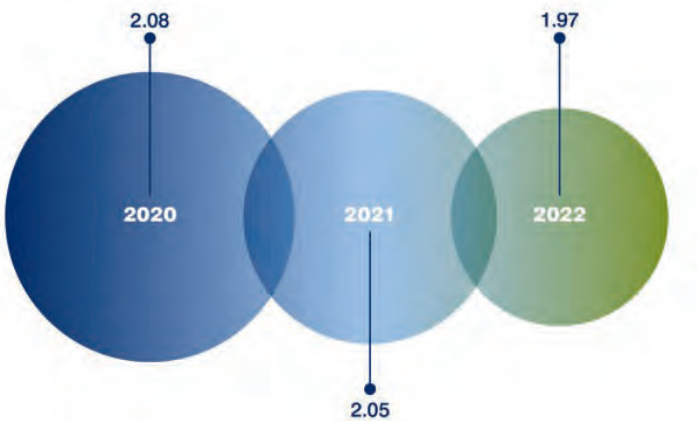
Absolute Scope 1 + 2 GHG emissions below reduction goal ahead of target year 2030.

Cleveland-Cliffs' Scope 1+2 GHG Emissions Intensity

The charts below show the year-over-year trend of our combined Scope 1 and 2 greenhouse gas (GHG) emissions intensity values for: company-wide; integrated basic oxygen furnace (BOF) facilities; and electric arc furnace (EAF) facilities. **All values are reported in tonnes carbon dioxide equivalent (CO_2e) per tonne of crude steel.** Please refer to the map in this report for facilities covered under each data set.

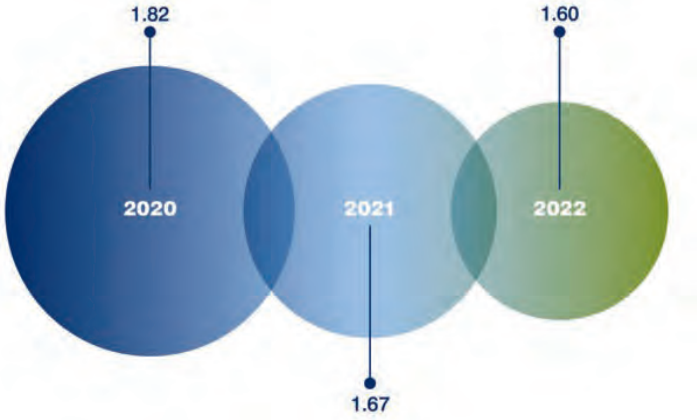
Company-wide Emissions Intensity

This chart shows facility-wide Scope 1 and 2 location-based emissions from all Cliffs production operations, with the combined production of crude cast steel from both BOF and EAF steel shops as the denominator. Scope 1 emissions are inclusive of facility-wide process and combustion emissions as reported to U.S. EPA; onsite mobile equipment emissions; and facility-wide process and combustion emissions from facilities below the U.S. EPA reporting threshold.



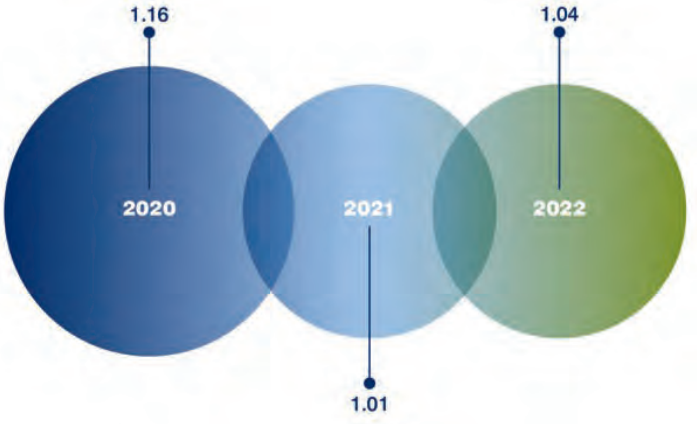
Average Emissions Intensity of our Integrated Mills[1]

This chart shows facility-wide Scope 1 and 2 location-based emissions from all Cliffs integrated BOF facilities, with the production of crude cast steel from BOF shops as the denominator. Our integrated mills are primarily suppliers of steel for automotive uses.

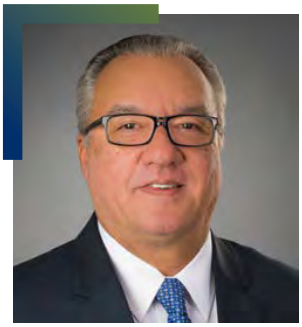


Average Emissions Intensity of our Specialty Steel Mills[1]

This chart shows facility-wide Scope 1 and 2 location-based emissions from all Cliffs EAF facilities, with the production of crude cast steel from EAF shops as the denominator. Three of our EAFs operate in tandem with argon-oxygen decarburization units for the production of electrical steel and stainless steel.



[1] Scope 1 emissions include facility-wide process and combustion emissions as reported to the U.S. EPA and onsite mobile equipment emissions.



LETTER FROM LOURENCO

Dear Stakeholders:

The key to our 175-year longevity at Cleveland-Cliffs has been the ability to adapt and reinvent ourselves throughout our long history. The transformational acquisitions we completed in 2020 represented our latest evolution, and 2022 was the year we finally made our presence felt as the largest flat-rolled steelmaker in North America. We recorded full-year revenue of $23 billion, the highest in our nearly two-century history. We also recorded near-record highs for Adjusted EBITDA and free cash flow, which were only surpassed by our performance in 2021.

With this strong profitability, we were able to dramatically transform our balance sheet in 2022, reducing debt and net post-retirement liabilities by over $3 billion. The size of these liabilities has been a consistent focus of our shareholders since our transformation, and I am pleased to have delivered this immense reduction in such short order. In addition, even with these major improvements to our balance sheet, we were still able to return healthy levels of capital to our shareholders.

We believe that our leading position as an automotive supplier is a strength of our business that will promote our future success. Our steel's surface quality, formability and strength characteristics, as well as our company-wide devotion to meeting demanding service and delivery needs, sets us far apart from any competing material supplier, steel or otherwise.

The main reason we have such a strong position in the automotive market is because of our commitment to blast furnace/basic oxygen furnace (BOF) steelmaking. Supplying highly-specified automotive-grade materials, particularly exposed parts, dictates the use of blast furnaces and BOFs. We believe that this will continue to be the case; and over time, we are confident we will be able to drive sustained reductions in carbon emissions from our integrated steelmaking footprint. This includes the success we have had thus far with using more hot briquetted iron (HBI) and scrap throughout our operations, as well as facilitating emerging technologies, such as carbon capture and hydrogen usage.

Our 27,000 employees have been vital to our recent success, and I thank all of our employees, particularly our union workforce, for their continued buy-in. In 2022, we successfully negotiated new 4-year labor contracts with our United Steelworkers (USW) partners, covering more than half of our employee base. Cliffs and the unions representing our workforce share the same goals. Through our established relationship with all unions, we will continue to collaborate and accomplish these goals together.

Cliffs is about more than just making steel. This year's Sustainability Report once again reports on our progress in pursuit of our environmental, social and governance (ESG) goals, including our commitment to reduce GHG emissions 25% by 2030 from 2017 levels, a Performance Data Table to consolidate our sustainability metrics, as well as updates on a variety of our partnerships and collaborations with our neighboring communities, stakeholders and like-minded organizations as we continuously strive for improved ESG performance.

As I have stated before, Cleveland-Cliffs has been, and continues to be, built for future generations. The decisions that we are making today will resonate for decades, and we do not take that responsibility lightly. We look forward to the future success these actions will bring.

Sincerely,



LOURENCO GONCALVES
Chairman, President and Chief Executive Officer

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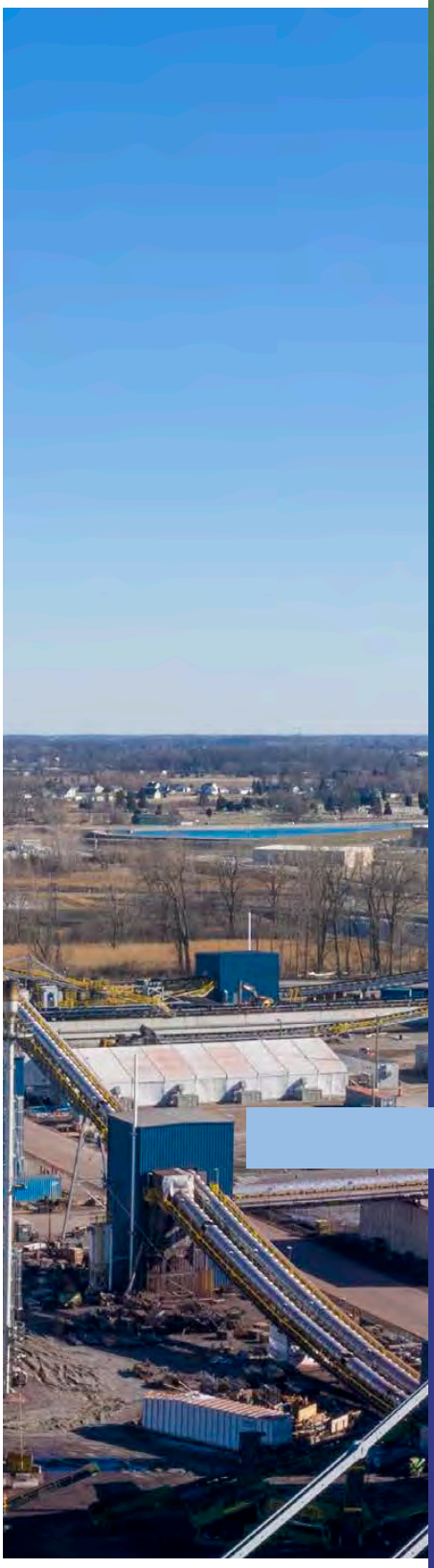
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Direct Reduction plant in Toledo, Ohio



01

We Are Cleveland-Cliffs

Cleveland-Cliffs is the largest flat-rolled steel producer and the largest manufacturer of iron ore pellets in North America. We are the only integrated steel company to use significant amounts of pre-reduced feedstock (HBI) in our blast furnaces.

ABOUT CLEVELAND-CLIFFS

Cleveland-Cliffs Inc. (Cleveland-Cliffs or Cliffs) is vertically integrated from mined raw materials, direct reduced iron and ferrous scrap to primary steelmaking and downstream finishing, stamping, tooling and tubing. We are the largest supplier of steel to the automotive industry in North America and we serve a diverse range of other markets due to our comprehensive offering of flat-rolled steel products. Headquartered in Cleveland, Ohio, we employ approximately 27,000 people across our operations in the United States and Canada.

We have dedicated our technical and engineering resources to anticipating our customers' ever-evolving needs. As a fully-integrated steel enterprise, creating innovative, high-value steel solutions is one of our strategic priorities—favoring higher-margin, specialty products. By inviting collaboration between our customers, research groups and operations, we are developing solutions to new use cases and enhancing our competitive advantage.

Cleveland-Cliffs values being a good corporate citizen, and over the last year we continued to demonstrate our commitment to the environment, our people and ethical and responsible business practices. Through efforts to reduce our GHG emissions we are working to preserve the environment for future generations. Our strategic actions of optimizing our asset footprint and raw material mix, particularly our unique practice of using significant amounts of HBI in our blast furnaces, along with production levels of crude steel, have all contributed to reductions in our GHG emissions. Upgrades to existing onsite energy recovery for power generation and the addition of renewable energy are important to manage Cliffs' emissions levels below our 2030 GHG goal. Through work with the U.S. Department of Energy, industry organizations and academic institutions, we are collaborating with like-minded organizations to advance clean energy technologies. Through our partnership with our labor unions, we seek to revitalize manufacturing in the United States, and through that, support and grow a vibrant American middle class. Through dedication to our local communities, we are supporting our neighbors in tangible ways to enable our shared success.

For more information about Cleveland-Cliffs, please see our most recent Annual Report on Form 10-K filed with the U.S. Securities and Exchange Commission located in the **Investors section of our corporate website.**

Cleveland-Cliffs Ranked 171 on Fortune 500 List

In May 2022, Cleveland-Cliffs announced our ranking on the Fortune 500 list for the first time since our transformation from a mining company to the largest flat-rolled steel company and largest supplier of steel to the automotive industry in North America. Our 2021 revenue of $20.4 billion earned us the ranking of 171 on the list for 2022, surpassing our previous highest ranking ever of 366 in 2012. The Fortune 500 list ranks companies that are incorporated and operate in the United States by total revenues for their respective fiscal years.

"Our inclusion on this year's Fortune list of companies —particularly our position well within the 200 largest ones—is another demonstration of our remarkable transformation. Despite all the challenges imposed by the COVID-19 pandemic and the long-lasting consequences to supply chains still affecting our clients as of today, we grew tenfold in just two years, from $2 billion in revenues in 2019 to over $20 billion in revenues in 2021," said Lourenco Goncalves, Chairman, President and Chief Executive Officer.

2022 By The Numbers

#171 Rank on Fortune 500 List

14.8M Net Tons of Steel Sold

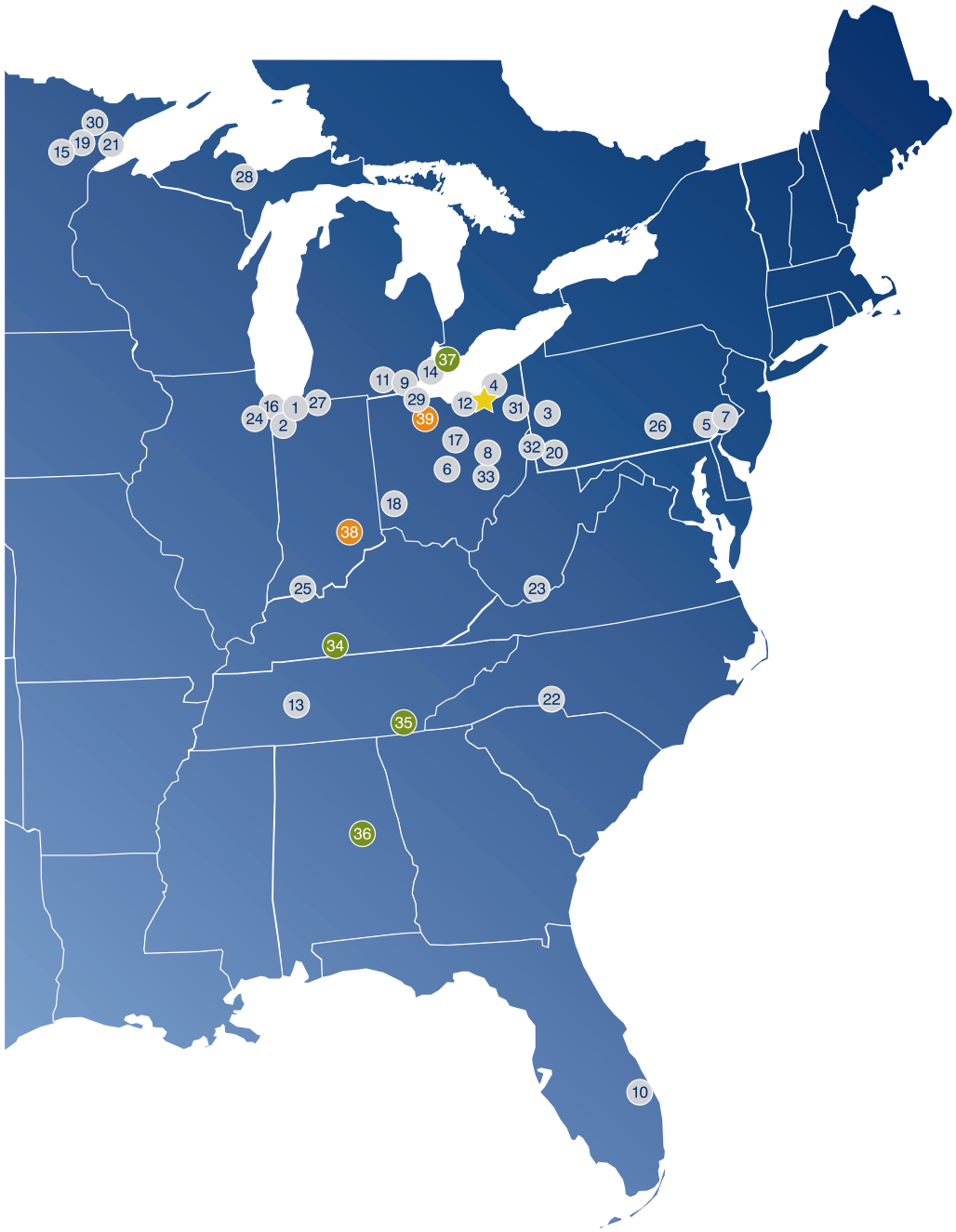
31% of Production Directed to Automotive Sector—Highest in the Industry

27K Employees

70% of Workforce Represented by Unions

Company Offices & Operations

Cleveland-Cliffs' manufacturing facilities are primarily in the United States, as shown in the map below. In addition to our corporate headquarters in Cleveland, Ohio, we have offices in West Chester, Ohio; Chicago, Illinois; Burns Harbor, Indiana; and Detroit, Michigan; as well as our Research and Innovation Center in Middletown, Ohio.



Cleveland-Cliffs Headquarters

Steelmaking

1 Burns Harbor
2 Burns Harbor Plate & Gary Plate
3 Butler Works
4 Cleveland Works
5 Coatesville
6 Columbus, OH
7 Conshohocken
8 Coshocton Works
9 Dearborn Works
10 FPT — Florida Locations (2)
11 FPT — Michigan Locations (12)
12 FPT — Ohio Locations (5)
13 FPT — Tennessee Locations (2)
14 FPT — Ontario Location (1)
15 Hibbing Taconite Company
16 Indiana Harbor
17 Mansfield Works
18 Middletown Works
19 Minorca Mine
20 Monessen Coke
21 Northshore Mining Company
22 Piedmont
23 Princeton Coal
24 Riverdale
25 Rockport Works
26 Steelton
27 Tek & Kote
28 Tilden Mine
29 Toledo Direct Reduction Plant
30 United Taconite
31 Warren
32 Weirton
33 Zanesville Works

Tooling & Stamping

34 Bowling Green
35 Cleveland, TN
36 Sylacauga
37 Windsor & Ontario

Tubular

38 Columbus, IN
39 Walbridge



Cleveland-Cliffs Rings NYSE Closing Bell

Representatives from Cleveland-Cliffs' Board of Directors and executive management team **rang the closing bell** at the New York Stock Exchange on May 3, 2022, to celebrate the Company's 175th anniversary. Headquartered in Cleveland, Ohio, and operating in the Great Lakes region since 1847, Cliffs was first listed on the New York Stock Exchange in 1960.

"For nearly two centuries, Cleveland-Cliffs has been instrumental in building modern society in the United States through the domestic steel industry. Companies with this type of longevity are incredibly rare. Cleveland-Cliffs has achieved this through its resilience, innovation and constant reinvention which has kept the company relevant and adaptive to an ever-changing world for generations."

LOURENCO GONCALVES
Chairman, President and Chief Executive Officer

OUR SUSTAINABILITY PRIORITIES

This report is structured around five sustainability priorities: Steel for a Sustainable Society; Our Commitment to the Environment; Empowering Our People; Connecting with Our Communities; and Acting with Integrity. We believe these priorities are important tenets of our Company's identity, and we take regular action to demonstrate these tenets. As an iron and steel producer working toward a sustainable future, we need to develop innovative steel solutions while maintaining our environmental compliance. This is critical to managing and growing our business. Our dedicated and hardworking employees are key to our success. Engaging with our operating communities will sustain Cleveland-Cliffs over the long term. And, above all, leading with integrity and employing ethical business practices are foundational to Cliffs.

Alignment to the Sustainable Development Goals

We operate our business in a way that supports the **United Nations' Sustainable Development Goals (SDGs)—a blueprint of 17 global goals shared by United Nations member states for the long-term sustainability of our planet and its people.** Through our actions and focused sustainability initiatives, we aim to create impact in our communities in alignment with the SDGs highlighted here.

Empowering Our People

Investing in our employees' safety and success is a top priority. We offer various opportunities for professional development and growth, competitive compensation and benefits and meaningful work. We strive to sustain and empower the American middle class for generations to come.



Connecting with Our Communities

Through educational opportunities for students and prospective employees, we provide the tools people need to develop a long career at Cleveland-Cliffs. Through charitable giving, volunteering and thoughtful engagement, we support our local communities for a prosperous future.



Steel for a Sustainable Society

We manage our business in a way that tangibly impacts the well-being of our society. We strive to responsibly utilize raw materials for cleaner iron and steelmaking to develop sustainable steel solutions for the transition to a low-carbon economy. Cliffs pays above industry average total compensation and provides meaningful work. This way of doing business ensures a thriving workforce and local communities, and drives us to do our part in the fight against climate change.



Our Commitment to the Environment

As an iron and steel producer with mining activities, we have a responsibility to mitigate environmental impacts for the good health and safety of our people and communities; advance the clean energy transition with our sustainable steel solutions; and combat climate change by pursuing decarbonization solutions that reduce emissions, increase renewables and restore land and habitat where possible.



Acting with Integrity

As an iron and steel producer with mining activities, we have a responsibility to mitigate our climate impacts—as a company through our own initiatives as well as through partnerships to develop and advance decarbonization initiatives for a sustainable future.





Coil of Cleveland-Cliffs Steel



02

Steel for a Sustainable Society

Steel is critical to the development of clean energy technologies that will make society's transition to a low-carbon future a reality. From upgrading our electrical grid and developing renewable energy, to producing alternative fuels and powering electric vehicles, steel will be necessary to advance these sustainable solutions.

STEEL: A RESILIENT BUSINESS

Cleveland-Cliffs operates a strategic portfolio of iron and steel technologies in North America, including efficient blast furnaces and BOFs, EAFs and a state-of-the-art Direct Reduction (DR) plant to produce HBI. Our extensive experience with modern steelmaking through our vertically integrated value chain ensures we will continue to meet the growing demand for steel made sustainably. As society transitions to a low-carbon future, the infrastructure needed to deliver new and cleaner technologies and power sources such as an efficient electrical grid; renewable electricity; electric vehicle (EV) motors; carbon capture and sequestration; and alternative fuels such as clean hydrogen, will all require steel. Today, Cliffs produces the advanced and specialty grades of steel necessary for these emerging decarbonization solutions, doing our part as we collectively move toward a clean energy economy.

Cliffs has demonstrated its commitment to sustainable steelmaking pathways, engaging with suppliers, customers, technology providers, government agencies and academia to explore opportunities for collaboration. We are utilizing methods for emissions reduction, such as optimizing recycled content, while maintaining the product quality specifications our customers need. Steel is the most recycled material in the world and can be continually recycled into new products. All of Cleveland-Cliffs steel is made with recycled content, and following its end use, 100% of that same steel can be recycled in some form. During 2022, Cliffs recycled over 6.5 million tons of steel scrap and recovered iron materials. Through our Ferrous Processing and Trading Company (FPT) business, we source prime scrap primarily from pre-consumer scrap—for example, from our automotive customers. This scrap is generated during the manufacture of steel products. We can also source prime scrap through post-consumer scrap, which comes from a steel product at the end of its useful life. Our prime scrap processing capabilities enable our closed-loop steel recycling process and ultimately allow Cliffs to optimize productivity at our EAFs and BOFs. For more detail on our recycled content, please visit our **corporate website.**

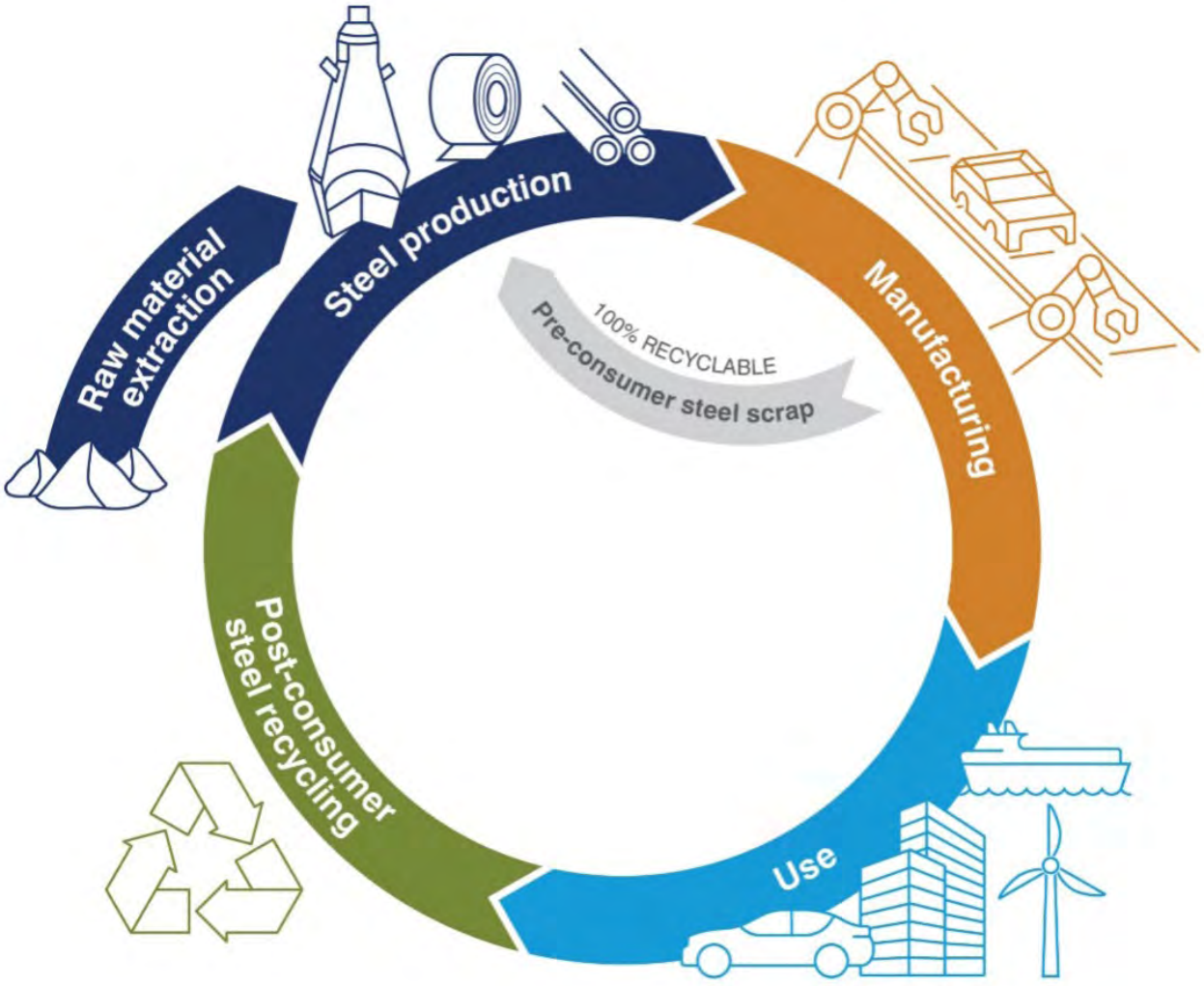
Not all steel scrap is created equal, and low-impurity prime scrap supply is being outpaced by increased demand. The most demanding steel grades need high-purity sources of iron, a demand that Cliffs can fulfill with our U.S.-based, vertically integrated footprint. This vertical integration enables us to avoid global supply chain disruptions of imported iron metallics like pig iron. Using our iron ore mined and pelletized in Minnesota and Michigan, we internally produce the metallics our products need. Cleveland-Cliffs' ironmaking facilities across the Midwest include blast furnaces that are among the most efficient in the world, as well as our DR plant in Toledo, Ohio.

6.5M

Tons of steel scrap and recovered iron materials recycled in 2022

We are the first and the only producer of HBI in the Great Lakes region. From this modern plant, Cliffs produces high-quality, low-cost and low-carbon intensive HBI that can be used in our blast furnaces as a productivity enhancer, or in our BOFs and EAFs as a premium scrap alternative. We use HBI to stretch our hot metal production, lowering carbon intensity and reliance on coke. As a result of our internal usage of HBI, coupled with our ongoing evaluation of coke use strategies, we idled our coke facility at Middletown Works (Ohio) during the third quarter of 2021 and permanently closed our Mountain State Carbon coke plant in the first quarter of 2022. With increasing tightness in the scrap market, we expect our blast furnaces and our DR plant to support our metallics needs. In 2022, our DR plant produced approximately 1.6 million metric tons of HBI.

Closed-Loop Steel Recycling



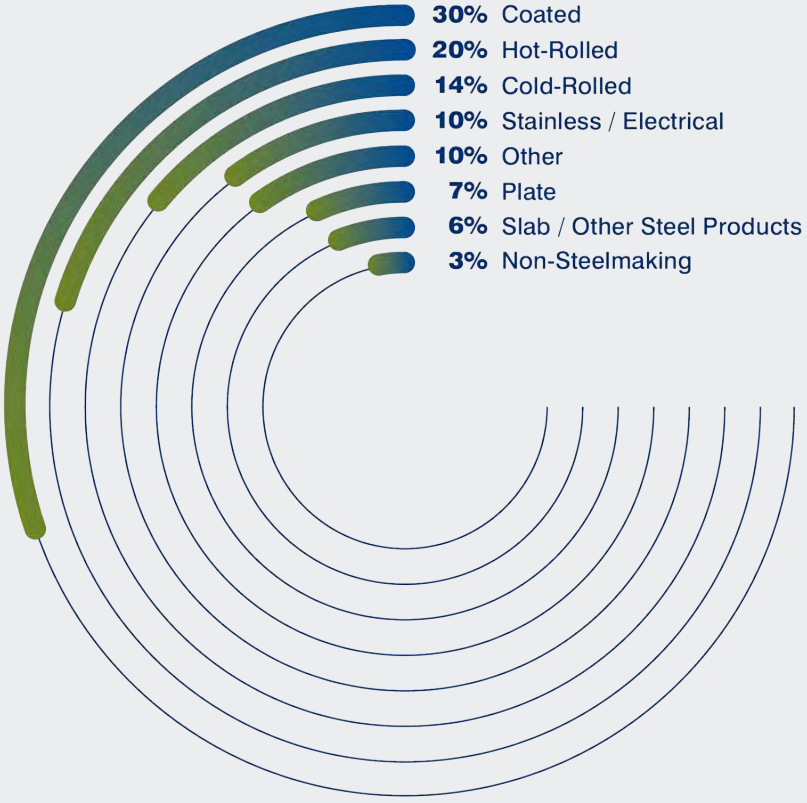
Diversified End Markets & Value Added Products

Cleveland-Cliffs is a specialized iron and steelmaking company primarily serving four broad market categories: automotive; distributors and converters; infrastructure and manufacturing, which includes electrical power; and steel producers, which consume iron ore and metallics and further process semi-finished materials. We manufacture difficult-to-produce, high-quality steel products that help our customers meet their own product requirements. The quality of our steel is appealing to end users because of its strength, surface quality and formability.

Our automotive products include advanced high strength steels (AHSS) utilized in vehicles to enable lightweighting for fuel efficiency as well as enhanced safety. We believe that we offer steel products that are stronger, less expensive, have competitive weight savings, are easier to repair, and are more environmentally friendly than alternative materials. Cliffs works with our automotive customers to develop products such as steels with greater heat resistance for exhaust systems that support new, fuel-efficient engines that run at higher temperatures.

Cliffs also produces flat carbon steels for non-automotive applications as well as specialty steels such as galvanized and aluminized, stainless, electrical, tinplate, plate, and rail. For the infrastructure and manufacturing markets, our catalog of steel products supports applications for military defense, power transmission and distribution transformers, medical equipment, appliances and heating, ventilation and air conditioning (HVAC), food preservation, and more. For example, our stainless steel grades are utilized in a variety of applications for mass transit, such as frames for passenger buses and rail cars. Our plate

2022 Product Mix (By Revenue)

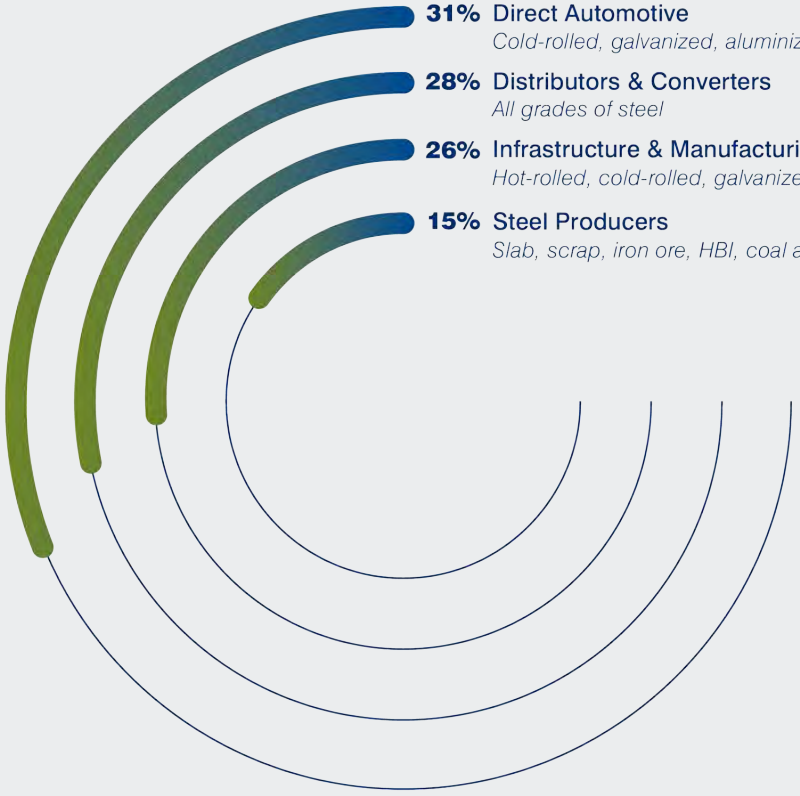


products can be used in wind towers to help advance the production of renewable energy.

As the sole producer of specialty electrical steels such as grain oriented and non-oriented electrical steel (GOES and NOES) in the United States, Cliffs supplies the steels necessary for upgrading an aging electrical grid and enabling power transmission through transformers and EV charging stations. NOES supports the adoption of battery EVs through traction motors, and our AHSS provide protection through battery enclosures. In our Sustainability Report 2021, we highlighted a project to develop new steel alloys for specific resistivity to reduce core losses in electric motors suitable for a wide range of applications, such as large industrial fans or in-wheel motors in transportation systems. The goal was for the new electrical steels to be nearly 40% more efficient when compared to commercially available NOES. We are pleased to report that this project, in conjunction with the U.S. Department of Energy (DOE) and Oak Ridge National Laboratory, has moved into the final phase where mill-produced sample material is being evaluated in a motor to demonstrate the proposed efficiency improvement.

Virtually all of the grades of steel we produce are sold to the steel distributors and converters market, which generally represents downstream steel service centers that source and fabricate our steel according to their customers' needs. The steel producers market represents third-party sales to other steel producers, including those who operate blast furnaces and EAFs, as well as sales of raw materials and semi-finished goods, including iron ore pellets, coal, coke, HBI, scrap, slab and other steel products.

2022 End-Markets (By Revenue)



31% Direct Automotive
Cold-rolled, galvanized, aluminized, NOES and stainless

28% Distributors & Converters
All grades of steel

26% Infrastructure & Manufacturing
Hot-rolled, cold-rolled, galvanized, plate, GOES, stainless, tinplate and rail

15% Steel Producers
Slab, scrap, iron ore, HBI, coal and coke

Advancing the Clean Energy Transition

Amongst a broad range of materials, steel is the most critical to the transition to a low-carbon economy.[1] As demand for renewable power continues to grow, large quantities of steel will be needed for applications such as solar and wind energy. In 2022, President Biden signed the Inflation Reduction Act (IRA) into law, offering significant funding and incentives for developing clean energy technologies and infrastructure. Leveraging the complementary investments of the Infrastructure Investment and Jobs Act of 2021, the IRA will help financially support developments in decarbonization solutions. These laws, which incentivize companies to make significant investments, should encourage increased demand for the steel grades that Cleveland-Cliffs produces. Additionally, these laws offer bonuses to the incentives for projects made with domestically produced components and raw materials such as iron and steel. From steel plate for wind farms to galvanized steel for solar arrays, Cliffs' product portfolio can serve both traditional and emerging domestic energy markets.

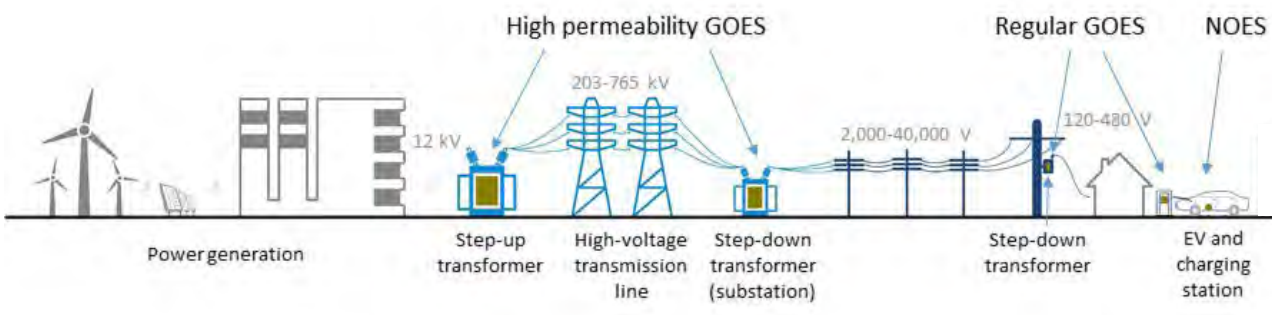
Advancing the EV Transition

Cleveland-Cliffs is the largest supplier of steel to the North American automotive industry. Our steel is a critical engineering material for the automotive sector today, and for the transition to EVs in the future. Cliffs steel is cost-effective against other materials and enhances the affordability of EVs for consumers. All of Cleveland-Cliffs' steels are fully melted and produced in the United States. Incentives like the new federal EV tax credit (established through the IRA) have requirements for domestically sourced materials and components and is likely to support further growth of the domestic EV market share.

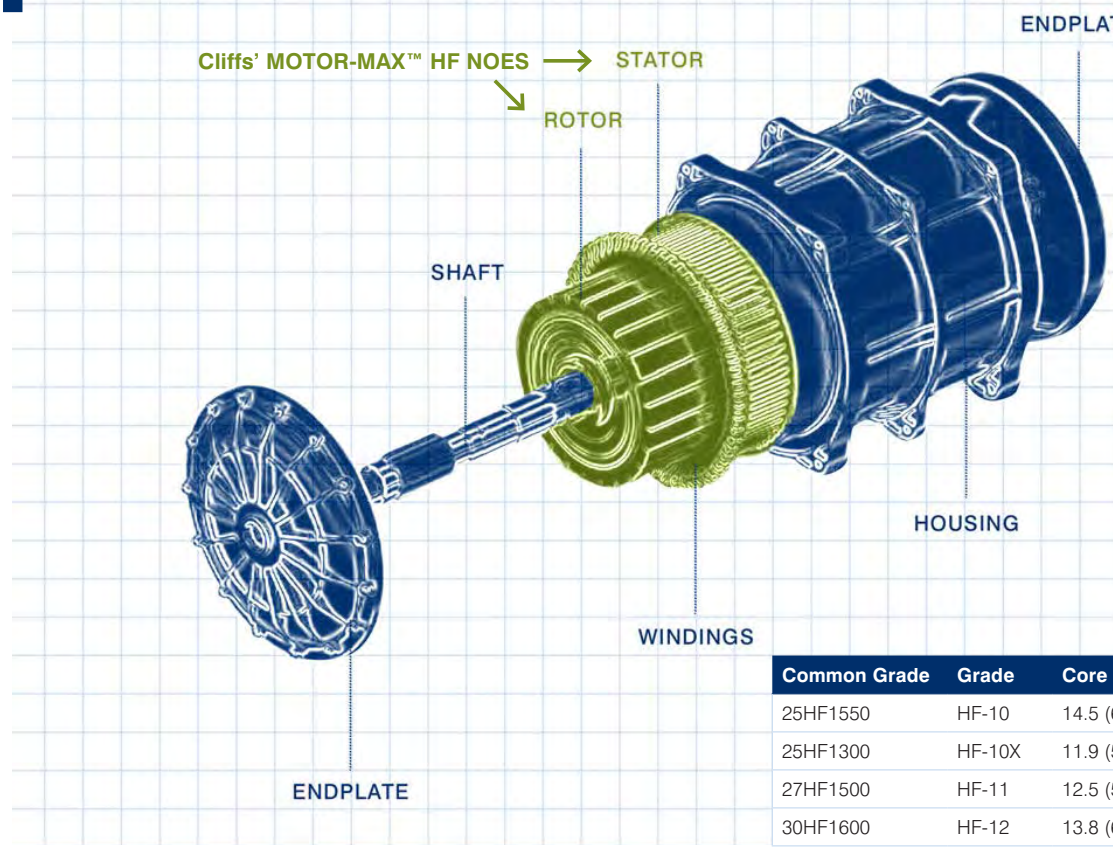
Because the American transportation sector accounts for more than 29% of GHG emissions in the United States (compared to the American steel sector's 1%), it is imperative that we continue collaborating with our automotive customers on ways to decarbonize the automotive industry. We focus on high-quality, technologically advanced steel to develop the products customers need ranging from AHSS and exposed surface quality grades to electrical steels and steel battery enclosures. For example, Cliffs' engineering teams are actively engaging with several automotive original equipment manufacturers (OEMs) to help optimize their battery enclosure designs to incorporate the most advanced high strength steel grades currently available. The battery enclosure is an integral component of the battery EV architecture and is paramount in the protection of the battery in the event of a crash. Protecting the batteries is so critical, that some OEMs have referred to the battery pack as a "6th passenger" in a vehicle. Steel provides not only the needed strength for the task, but also has a lower emissions life cycle when compared to other more expensive and higher carbon intensive materials like aluminum, magnesium and carbon fiber.

[1] "The raw materials challenge: How the metals and mining sector will be at the core of enabling the energy transition." McKinsey & Company, January 2022.

Cleveland-Cliffs' Electrical Steels



MOTOR-MAX™ Electrical Steels



Common Grade	Grade	Core Loss W/kg (W/lb)
25HF1550	HF-10	14.5 (6.60)
25HF1300	HF-10X	11.9 (5.40)
27HF1500	HF-11	12.5 (5.67)
30HF1600	HF-12	13.8 (6.30)

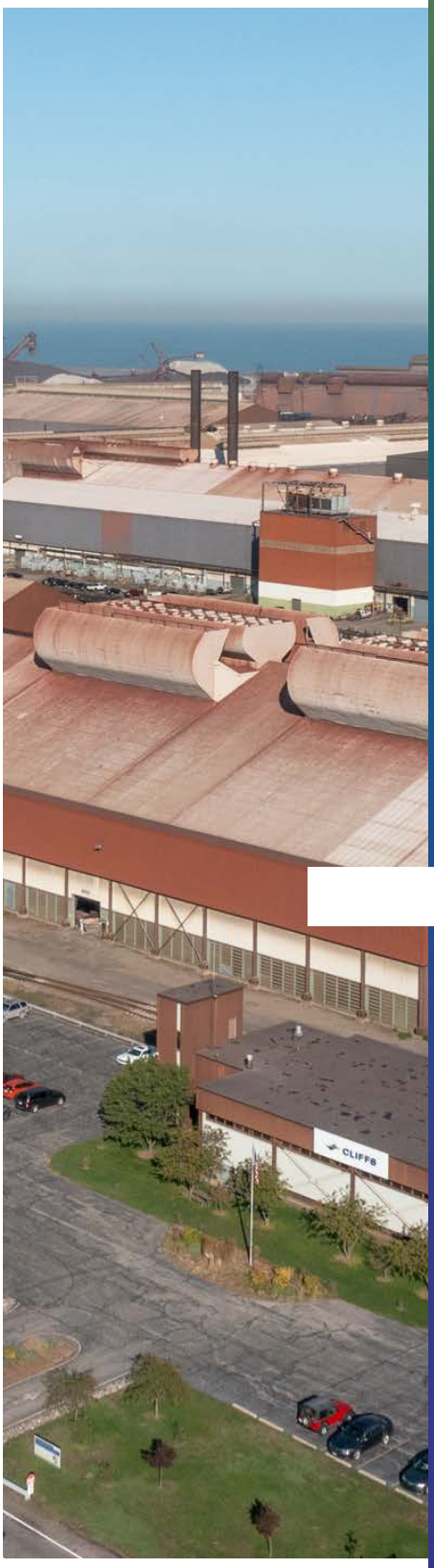
As the only North American producer of high-efficiency NOES—a critical component of EV motors—we are well positioned to help advance the adoption of EVs going forward. In December 2022, Cleveland-Cliffs announced the new MOTOR-MAX™ product line of NOES for high frequency motors and generators. MOTOR-MAX High Frequency Non-Oriented Electrical Steels (HF NOES) brand of electrical steels are designed for high speed motors, EV traction motors, aircraft generators and other rotating equipment. From research to production, Cleveland-Cliffs has the experience and capabilities to produce the quality electrical steels necessary for these distinctive high performance applications to meet a broad range of customer technical requirements.

As demand for electrical steels increases for EV traction motors, Cliffs is at the forefront of this market as the only producer of automotive-quality electrical steels located in North America. EV traction motors are one of the most crucial components of electric vehicles, and utilizing MOTOR-MAX HF NOES will improve the overall efficiency and performance of the motor. With a reliable, domestic supply of MOTOR-MAX electrical steels, automotive OEMs have a dependable source for their production of EV motors in the United States. Additionally, the growing demand for EVs has fueled the requirement for charging stations' infrastructure nationwide, and Cliffs has the resources in place to play a leadership role with our GOES products.

Cliffs is able to make MOTOR-MAX HF NOES and other electrical steel products in our EAFs utilizing a mix of high-quality DRI and recycled steel scrap. We maintain control over the entire production cycle that occurs wholly in the United States. Cleveland-Cliffs' technique to produce electrical steels (like MOTOR-MAX HF NOES) results in lower GHG emissions than steel mills utilizing more carbon-intensive energy sources and production methods.



Burns Harbor, Indiana integrated facility on Lake Michigan



03

Our Commitment to the Environment

Cleveland-Cliffs remains committed to operating our business in an environmentally responsible manner. Going beyond compliance, we continually seek opportunities to minimize our impacts and engage with our local communities to ensure we are a good neighbor. One of the most important issues impacting our planet is climate change, and we are doing our part to reduce our GHG emissions by pursuing proven and breakthrough technologies for decarbonization.

ENVIRONMENTAL MANAGEMENT

Cleveland-Cliffs takes great pride in our environmental management program and efforts. Our business is highly regulated, and we understand the importance of maintaining compliance and going beyond what is expected to be a good corporate citizen. Throughout 2022, Cliffs' environmental management team continued to be proactive in engaging with our local communities and mitigating potential risk where possible. This included implementing new tools and internal reporting to better track data, such as statistical control of water permit data and utilizing Failure Mode Effect and Root Cause Analysis for issues and near misses. These practices help the team analyze trends over time to improve performance long-term, prevent or minimize recurring issues and reduce the number of environmental-related incidents and community concerns. As a result of these efforts, Cliffs reduced both reportable environmental incidents and environmental-related community complaints from 2021 to 2022.

Environmental performance is driven by our operating teams at each facility, who work closely with the site environmental staff to achieve optimal environmental performance. The operations are supported by a core team of corporate environmental regulatory, permitting and compliance experts. One key way Cliffs continuously improves our environmental performance is through maintenance of our ISO certifications. For example, our Columbus Coatings facility in Ohio—which restarted in mid-2021—is our most recent facility to achieve ISO 14001:2015 certification. For a complete list of site certifications, please visit our **corporate website.** With the acquisition of FPT in late 2021, Cliffs added more than 20 sites to our operating footprint that brought new and different environmental compliance requirements. In 2022, we added internal capacity and expertise to our team to manage these sites and help integrate them into a well-established culture of striving for 'beyond compliance'. Cliffs continued to invest in our facilities to increase our ability to manage environmental issues and maintain compliance, while being a good neighbor to our operating communities.

$133M

Invested for environmental capital expenditures in 2022

Additionally, we hold ourselves accountable to achieving excellent environmental and sustainability performance by incorporating associated Strategic Initiatives into our Executive Management Performance Incentive (EMPI) program. In 2022, several Strategic Initiatives were sustainability focused.

We are pleased to report that we made achievements for each of the initiatives and will continue to make progress in the coming year. For more information on our 2022 Strategic Initiatives, please see our most recent **Proxy Statement.**

Climate & GHG Emissions

While the American steel industry is among the cleanest in the world, Cleveland-Cliffs has engaged in a number of decarbonization initiatives to address our GHG emissions and do our part to help combat global climate change. Throughout the year, we continued to demonstrate results in reducing our emissions against our 2030 goal.

Climate-Related Governance & Risk Management

Cliffs prioritizes GHG emissions reduction at the highest level of our corporate governance structure through our Strategy and Sustainability Committee of the Board of Directors. Led by our Chairman, President and Chief Executive Officer Lourenco Goncalves, the Committee directs strategy for climate-related risks and opportunities and is ultimately responsible for Cliffs' environmental and sustainability performance. The Committee is supported in these efforts by Cliffs' executive leadership team, including our Executive Vice President, Environmental & Sustainability, who leads Cliffs' environmental compliance obligations, sustainability management activities and reporting.

Enterprise risk management is a key component of our overall business strategy. Cleveland-Cliffs' most recent physical climate risk assessment, conducted in 2022, utilized third-party analysis to help identify climate-related physical risks across our footprint under RCP4.5 and RCP8.5 scenarios. Cliffs' long-term, climate-related physical risks were modeled and determined to be low. Additional information regarding our climate-related risks, opportunities and strategy will be presented separately in our 2022 Task Force for Climate-related Financial Disclosures (TCFD) report.

Since 2021, Cliffs has actively participated in an Expert Advisory Group (EAG), convened by the Science Based Targets initiative to develop a Steel Sectoral Decarbonization Approach (SDA) toward near zero GHG emissions by 2050 in alignment with the Paris Agreement. The SDA intends to outline a methodology for setting science-based targets and a decarbonization pathway. Currently, Cliffs continues to participate in the EAG and looks forward to the finalized SDA for evaluation.

GHG Emissions Reduction Initiatives

Cleveland-Cliffs regularly tracks our progress against our goal of 25% reduction of combined absolute Scope 1 and 2 GHG emissions by 2030 from 2017 levels. In 2022, Cliffs' Scope 1 and 2 GHG emissions were already below our reduction goal ahead of the target year of 2030. This was achieved through strategic actions such as optimizing our asset footprint and raw material mix, particularly our unique practice of using significant amounts of HBI in our blast furnaces to reduce our coke rates, along with production levels of crude steel. Previously announced upgrades to existing onsite energy recovery for power generation and the addition of renewable energy are important to manage Cliffs' emissions levels below our GHG goal. While we are proud of these results, we will continue to focus our GHG reduction efforts by prioritizing our efficient operations and actionable, commercially viable technologies and solutions. Cliffs has dedicated resources for research and development of decarbonization technologies for the primary iron and steel sector. We are working with commercial and academic partners to investigate and advance projects focused on improving energy efficiency, industrial electrification, carbon capture utilization and storage (CCUS), and clean electricity and fuels such as hydrogen.

Scope 1 + 2 GHG emissions below reduction goal ahead of target year 2030

Carbon Capture

Cliffs remains a proud member (and the only steel producer) of the DOE's Better Climate Challenge, a voluntary platform for organizations to set ambitious, portfolio-wide operational GHG emissions reduction goals. To align with our corporate goal, we committed to a 25% reduction in GHG emissions within 10 years. Additionally, Cliffs pursues various partnership opportunities with the DOE and like-minded organizations to help us meet and exceed these ambitious goals. For example, we are looking forward to the next phase of research for carbon capture in the iron and steel industry as the initial Burns Harbor Carbon Capture study comes to a close. We are now pursuing support from and collaboration with the DOE and other partners for Front-End Engineering and Design of large scale carbon capture and sequestration from blast furnace gas at our Burns Harbor integrated iron and steel facility located in Northwest Indiana. The project aims to capture up to 2.8 million tons of carbon dioxide (CO_2) per year for permanent geological sequestration. Although much work remains to make CCUS a viable solution in the future, Cliffs is investing significant resources into the potential of carbon capture technology and will continue to explore.

Hydrogen

Cleveland-Cliffs' state-of-the-art DR plant is hydrogen ready. The facility currently reforms natural gas to produce HBI and was engineered to replace up to 30% of the natural gas with hydrogen without modifications. While fuel switching for wide-spread clean hydrogen replacement in the global iron and steel industry will require large quantities of clean hydrogen that are not currently available, Cliffs is doing our part to help facilitate the commercial deployment of clean hydrogen as a decarbonization strategy. Throughout 2022, we engaged in discussions with other companies, universities and national research laboratories with the goal of leveraging potential funding under the DOE's Regional Clean Hydrogen Hubs Funding Opportunity Announcement to develop and implement clean hydrogen solutions for our industrial applications in place of carbon-based natural gas. During 2022, Cliffs joined the Great Lakes Clean Hydrogen coalition —a coordinated hydrogen hub effort to transition the Midwest into a leading low-carbon fuel production center, attracting major investment, new businesses and job creation. In addition to our DR facility, Cliffs is also investigating the usage of hydrogen injection into our blast furnaces and other processes to reduce emissions.

Burns Harbor, Indiana



GHG Emissions Performance

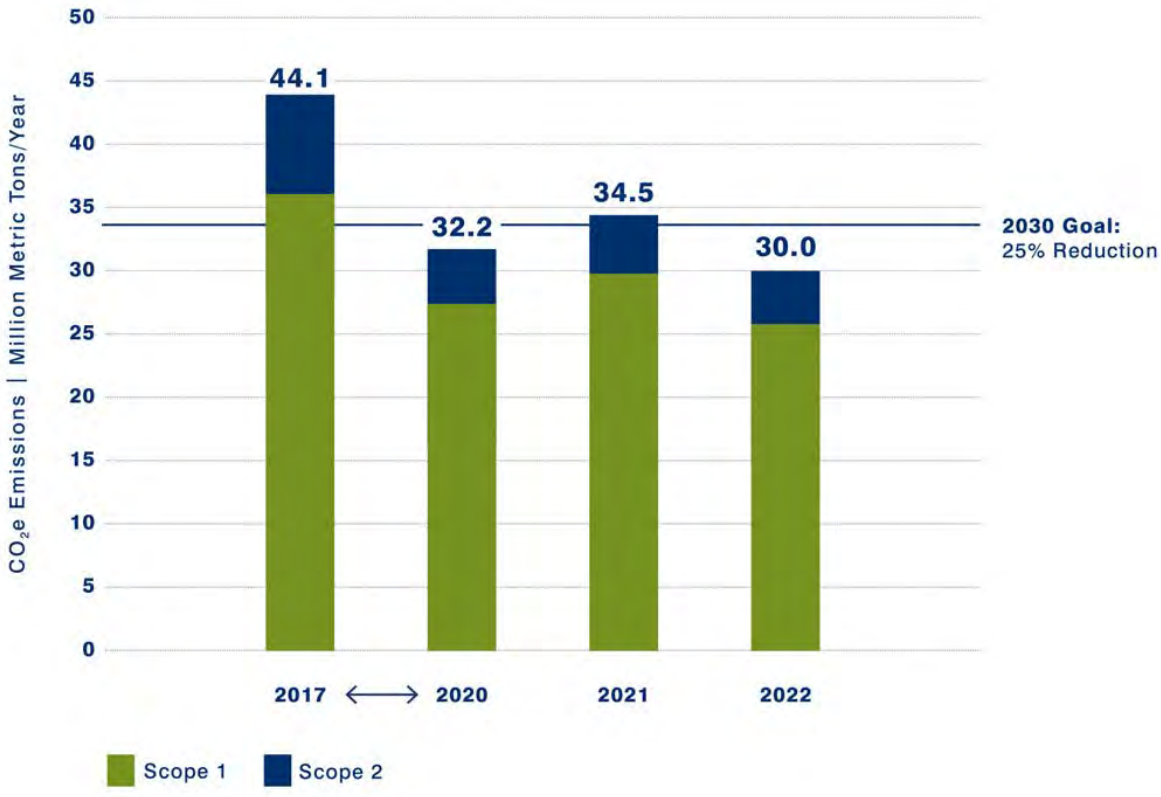
Cleveland-Cliffs tracks and reports our absolute GHG emissions in this annual sustainability report, as well as to government regulatory agencies and third-party sustainability ratings platforms. We also report select GHG intensities for our business. Cliffs discloses these metrics and additional GHG and climate-related information, such as our supplier climate engagement and relevant upstream Scope 3 emissions, in our annual Climate Change submission to CDP, an international nonprofit organization that manages the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts. We are pleased to report that Cliffs maintained a 'B' score for our Climate Change response in 2022.

Our Scope 1 and 2 GHG emissions performance from our production facilities is presented in the chart below. One of the key strategic priorities in our GHG reduction commitment was enhancing our GHG emissions transparency, along with publishing our sustainability reports. To that end, we obtained external limited assurance for our consolidated Scope 1 and 2 GHG emissions data for 2022, which is detailed in our **Statement of GHG Emissions** at the back of this report. Additional information on our broader emissions performance is located in the **Performance Metrics,** in the back section of this report.

CDP DISCLOSER 2022

As a CDP Discloser, Cleveland-Cliffs is recognized as a company that values environmental transparency and taking action.

Consolidated Scope 1 & 2 GHG Emissions



Energy

Energy efficiency remains a key focus of Cleveland-Cliffs' environmental strategy. As an energy-intensive business, it is critical that Cliffs is a responsible energy consumer. We work collaboratively with the DOE and leverage opportunities for project support and funding relative to decarbonization technologies. Our leadership team engaged with U.S. Secretary of Energy Jennifer Granholm and her staff several times throughout the year on the topic of decarbonization challenges facing the domestic iron and steel sector. Through the DOE's Better Plants® program, we are committed to a 10% reduction in energy intensity over 10 years. We also have access to important tools and expertise such as In-Plant Training, where companies host and participate in energy savings assessments and associated training on specific industrial systems such as steam and process heating.

In our Sustainability Report 2021, Cliffs announced a target to purchase 2 million megawatt hours (MWh) annually of renewable power that is newly developed or additional to the existing power grid. Throughout 2022, our team evaluated several commitments that support this target. In December, Cliffs executed a 15-year power purchase agreement with EDP Renewables SA for 180 megawatts (MW) of the 200-MW Headwaters III Wind Farm in Randolph County, Indiana. The wind farm is expected be operational in 2025 and will annually power the equivalent of more than 54,000 Indiana homes.

We have also committed to participate in three regulated utilities' voluntary renewable energy programs. In addition to fulfilling 35% of our Dearborn Works, Michigan, integrated mill's power needs with solar-generated electricity, we have entered into an agreement that will supply 10% of our power needs with solar-generated electricity at our Weirton, West Virginia, facility. Cliffs has also agreed to participate in a Green Power program at our Indiana Harbor and Burns Harbor integrated mills in Northwest Indiana. We understand that these suppliers' new solar power generating facilities are anticipated to begin operation in late 2023 and late 2024, respectively.

Four of our iron ore mining and pelletizing operations are served by Minnesota Power (MP). As of the most recent estimate available, MP's overall renewables percentage for retail customers in 2021 was 50%, which equates to just over one million MWh of renewable energy for the grid that supplies these Minnesota facilities.

Through the U.S. Department of Energy's Better Plant program, Cleveland-Cliffs aims to increase resilience and reduce our carbon footprint through improvements in energy efficiency.

Cleveland-Cliffs internally recovers energy from valuable byproduct gases from our Burns Harbor, Cleveland Works, Indiana Harbor and Warren facilities. Cliffs is pleased to report that the powerhouse upgrades at our Cleveland Works (Ohio) integrated mill are scheduled to be completed in early 2023. This includes installation of a new "G" generator to increase onsite power-generating capacity while reducing flaring of blast furnace gas and the amount of purchased electricity as well as associated Scope 2 emissions. The new generator will also replace two older and less efficient onsite generators and will allow Cleveland Works to recover energy and produce most of its power needs onsite.

Our Burns Harbor facility received a 2022 Energy Achievement Award given by the Association for Iron & Steel Technology's Energy & Utilities Technology Committee, for the installation and implementation of two new walking beam reheat furnaces. The award recognizes an individual, group and/or organization that has implemented and achieved energy conservation or a significant improvement in energy-related productivity through the application of new technology, practices and/or engineered methods in the iron- and steel-producing sector.



"G" generator installation at the powerhouse at our Cleveland Works facility

Air Quality

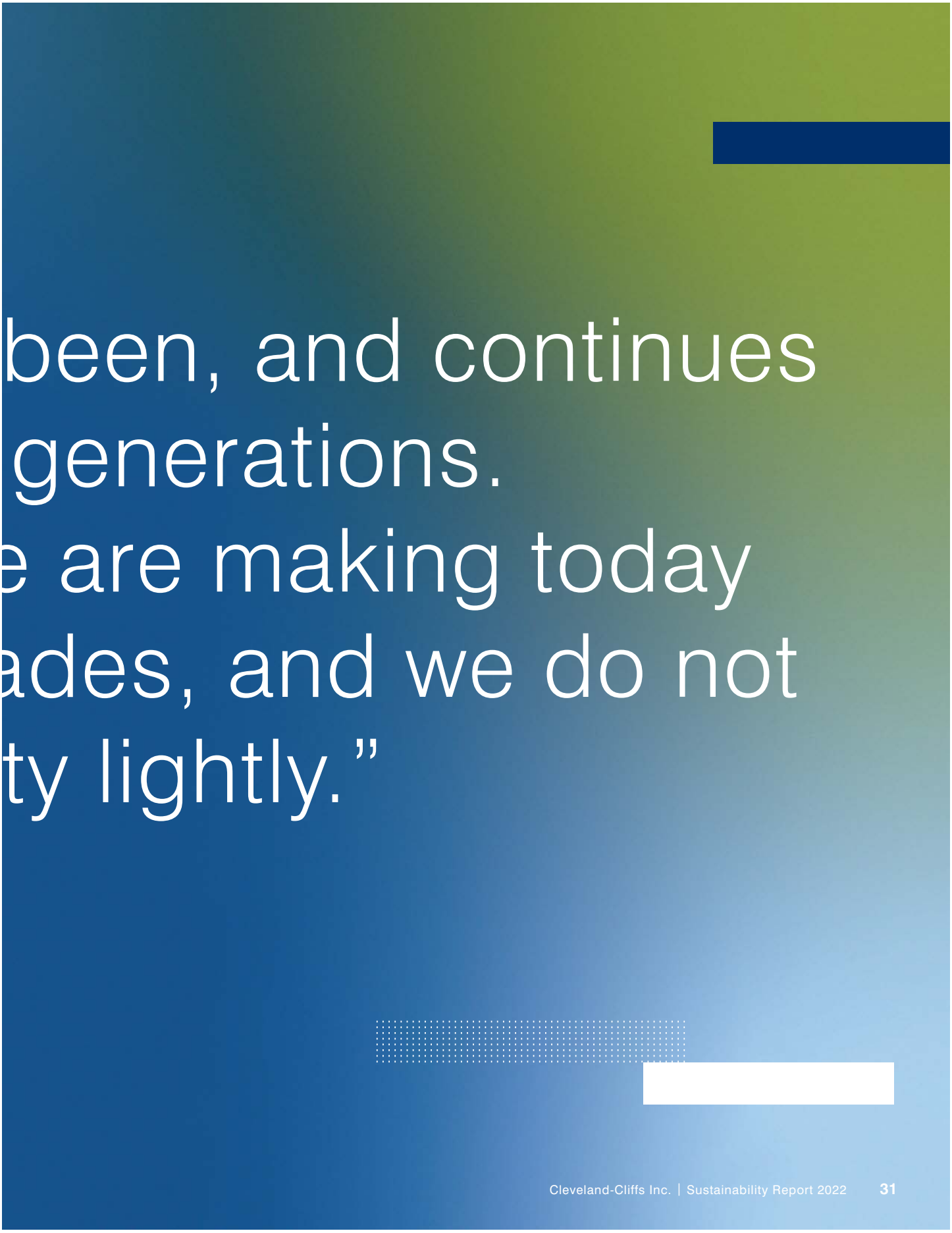
Cleveland-Cliffs continued to make progress on important air quality projects in 2022 while complying with our air permits and maintaining open dialogue with the communities where we operate. Cliffs works with our slag processing vendors to employ best practices for fugitive air emissions reduction, such as expanded use of water fogging suppression systems and use of dust bosses at our facilities. At our Burns Harbor facility, we are working with our slag processor to implement slag granulation which will reduce fugitive air emissions and improve slag byproduct reuse.

Cliffs is also reinvesting in our emissions control systems at our Dearborn Works and Riverdale facilities. These projects include rebuilding and upgrading the electrostatic precipitators (ESP) at the BOFs. The ESPs are the primary emissions control devices that work in concert with the secondary baghouse emissions control systems. At Dearborn Works, the ESP upgrade is scheduled to be completed in 2023, and will improve performance of the emissions control system. At Riverdale, the ESP upgrade began in late 2022 and will continue into 2023. Two new modules were added to increase redundancy and replace a decommissioned module that was constructed in the 1960s. These new modules will also allow isolation of units to do maintenance while still having three sections operating for compliance.

At our iron ore mine operations, we have continued to employ best practices for dust control at our tailings basin operations. In 2022, this included implementing a new piece of low-ground-pressure equipment at our Tilden mine (Michigan) that can work on soft ground areas of the tailings basin sooner in the calendar year than we have been able to in the past. We plan to continue using this equipment in the future as it can do more work in less time than traditional machines.

"Cleveland-Cliffs has
to be, built for future
The decisions that we
will resonate for deca
take that responsibili

LOURENCO GONCALVES
Chairman, President and Chief Executive Officer


been, and continues
generations.
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ty lightly.”

Water & Wastewater

Like energy, water is a vital input to our iron and steelmaking operations, and our Core Values include being responsible stewards of this essential natural resource. One hundred percent of water withdrawn for our iron and steelmaking is freshwater and none of the water withdrawn or discharged by Cleveland-Cliffs is in a known area of water stress. Cliffs has invested more than $70 million in powerhouse upgrades at our Cleveland Works facility in a continued effort to use water efficiently. In addition to increasing onsite power-generating capacity, the new "G" generator will allow for conversion from 'once-through' cooling water to closed-cycle cooling. The closed-cycle cooling is expected to reduce approximately 28 million gallons per day in discharge to the Cuyahoga River. Once the "G" generator is brought online and the existing "C" generator is tied in, the total recycled/reused water within the Cleveland Works footprint is expected to increase to roughly 95%. The tie-in, which will take several years to complete, will begin after regulatory approval is obtained in 2023.

In our Sustainability Report 2021, Cliffs introduced two water treatment technology pilot projects as part of the DOE's Industrial Technology Validation program. During 2022, one pilot project was installed at Cleveland Works, and project data gathering was completed during the fall. The DOE was onsite to evaluate the project and initial findings were promising. A detailed report is expected to be issued by the DOE in 2023 based on their assessment of this data. The second pilot project is planned for installation and data collection in early 2023. The alternative technology yielded significant reduction in solid waste from process water, and preliminary data shows it could also increase process water reuse.

At Burns Harbor, we continue to employ an ammonia water treatment system (piloted in 2021) to reduce nutrient loading to the East Branch of the Little Calumet River and Lake Michigan. Reducing ammonia from our discharge helps us maintain compliance while improving wastewater discharge parameters. In 2022, we expanded our treatment capabilities and made enhancements to this system. The improvements allowed for longer operating time, which subsequently led to a further reduction in nutrient loadings for a total of approximately 95%. In 2023, the system winterization will be completed to allow for continuous operation. This system is best available technology as defined by U.S. EPA and it will continue to allow Burns Harbor to reduce pollutant loadings and ensure permit compliance.

620B+

Gallons of water recycled in 2022 is equal to 940K Olympic-sized swimming pools

Waste & Hazardous Materials

Cleveland-Cliffs strives to be a responsible steward of our resources by optimizing our waste byproducts where possible. During 2022, we undertook a number of successful projects that we believe are sustainable over the long term.

Two projects that increased recycling and reduced waste disposal occurred at our Dearborn Works and Riverdale sites. Dearborn Works partnered with our slag processer, Levy, to find a new use for basic oxygen furnace runway slag. Levy's trademarked and proprietary product—'Duraberm'—uses Dearborn Works' co-products to make harder, more durable roadways. Through this project, we recycled 128,000 tons of product that could have previously been landfilled.

At our Riverdale facility, we partnered with a firm to install a process to generate usable materials from a previously landfilled slag byproduct. Two products are generated—high iron content chips and fines—that are recycled back into the steel process, as well as non-metallic sands that can be beneficially reused commercially. This has resulted not only in a reduction of approximately 70,000 tons per year of landfilled material, but also a substantial cost savings.



(Left) *Photo of road before Duraberm application* ***(Right)*** *Photo of road after Duraberm application*

In our Sustainability Report 2021, we discussed a project at our Weirton facility, in which we partnered with a firm to pilot a process (off-site) to generate usable base oils from high-volume lubricants. This pilot was successful, and based on lessons learned the vendor installed an onsite processing system that isolated three different lubricants that were comingled prior to treatment, limiting opportunities for their reuse. These reprocessed oils can be sold as feedstock for other products to other industries. Additionally, the partner firm is seeking approval from our customers to reuse several high value lubricants in order to improve recycling of our rolling oils. The onsite processing system has significantly improved dewatering of the lower-value used oil, which is then utilized internally—increasing value and reducing transportation costs. Not only is this process more cost-effective, it can be scaled to other facilities in our footprint.

In addition to waste optimization, Cliffs continues to make investments in remediating land acquired from our legacy companies, including beneficial reuse of materials recovered by these sites where possible.

Land Management & Biodiversity

As North America's largest flat-rolled steel producer and manufacturer of iron ore pellets, Cleveland-Cliffs has a significant geographical footprint. For this reason, we act as responsible stewards of the land and recognize its natural resources and biodiversity. We continue to partner with like-minded organizations, such as Wildlife Habitat Council (WHC) and National Fish and Wildlife Fund, to assist us in these important efforts as well as support other conservation projects around the United States.

200K

Tons of steel byproducts diverted from landfill and recycled from two integrated mills in 2022

In our Sustainability Report 2021, we discussed our work on the Duck Creek Wetland Restoration and Nutrient-Reduction project near our DR facility in Toledo, Ohio. In 2022, Cliffs continued to make progress. In partnership with Toledo-Lucas County Port Authority and Ohio Department of Natural Resources (ODNR), this project aimed to improve ecological habitat by restoring and developing:

- More than four acres of new upland pollinator habitat (including invasive species control and seeding and stabilizing of existing habitat)
- More than 11 acres of new/expanded wetland
- Nearly an acre of new backwater channels
- Increased stream length by more than 900 linear feet

Through this project, Cliffs has engaged with multiple entities to acquire the necessary permits, and project funding has been extended through year-end 2023 to complete the project. Upon completion, our DR plant will manage a multi-year maintenance and monitoring program in conjunction with ODNR and associated research universities.

609

Acres of land reclaimed in 2022 is equal to 460 football fields

Biodiversity Conservation

At our Weirton facility we are working to convert a former lagoon site to a pollinator garden to enhance habitat in a low-intensity use area of the facility. Eradication of non-native and aggressive species was completed in fall 2022, and soil samples were collected to prepare for pollinator garden seeding to occur in spring 2023. Cliffs also engaged WHC to help determine baseline monitoring requirements of this project for its Conservation Certification program.

We continue to maintain Conservation Certification at Burns Harbor, through the efforts of our plant beautification team. In late October, the team successfully planted 1,000 plugs of native grasses and flowers at the East Gate of the facility. Additionally, the site welcomed youth day campers and chaperones from the Dunes Learning Center for a half-day program that consisted of a presentation on steelmaking where the campers could watch the process in real time via a live feed video from inside the mill. The campers also helped plant 80 plugs of milkweed in our onsite butterfly garden.

At our Northshore Mine (Minnesota), hikers are enjoying the Superior Hiking Trail that traverses through this property. Cliffs supported an access agreement that allowed the Superior Hiking Trail to connect our neighboring communities of Beaver Bay and Silver Bay. The 300-mile trail stretches from Duluth, Minnesota into Canada, and provides hikers with access to the natural terrain along Lake Superior.

Not only does Cliffs take care of the land we currently own and operate, but we also value the importance of reclamation and remediation for potential future reuse. In 2022, the Pennsylvania Coal Alliance recognized our non-operational North Fork Mine with its Reclamation Award for Best Overall Project. The award was presented to Cliffs in recognition of outstanding reclamation of a surface mining operation where improved land use, water quality and other environmental benefits were achieved, based on ratings set forth by the Pennsylvania Department of Environmental Protection.

At our Lackawanna, New York, property, former home to a Bethlehem Steel integrated facility, we are engaged with the Great Lakes Restoration Initiative to help facilitate cleanup of property as part of the Gateway shipping canal. This remediation project also includes a public participation process to explore future development of a passive recreation area on the property along Lake Erie.



*Rhiannon Ulatowski **(right)**, Environmental Engineer at our Burns Harbor facility, accepting the award for Conservation Certification from Wildlife Habitat Council*



Burns Harbor Plant Beautification Team planting trees



Steel slab at Cleveland Works' Hot Strip Mill



04
Empowering Our People

Safe Production is the most important Core Value at Cleveland-Cliffs. We strive for safety excellence through proper training and protective equipment to ensure our people go home safely to their families. We aim to provide meaningful work for our employees as well as an attractive benefits package and opportunities for professional growth. Cliffs is proud of our strong union partnerships and we value the diversity of our workforce.

HEALTH & SAFETY

Cleveland-Cliffs aims to create and foster a safe working environment for all, and we strive toward zero injuries. By adopting and leading in accordance with our corporate Safety Policy, as well as applicable regulations from the Occupational Safety and Health Administration and the Mine Safety and Health Administration, we strive for a safe and healthy environment for all who work at our sites. A large part of this effort includes diligent monitoring and tracking of our safety performance, as well as best practice sharing for continuous improvement. Cliffs focuses on proactive safety training and specific initiatives to achieve progress against our internal objectives and external benchmarks.

Safety Management

Management of health and safety remains consistent at both the corporate and plant levels. Our plant managers are responsible for the overall safety of their assets, equipment and people, including contractors and visitors. They are expected to identify opportunities to improve safety practices and performance, and emphasize the importance of safe working conditions for all. Site safety managers and engineers support the plant managers in this work. Incidents and near-misses are reviewed weekly, with corrective actions documented and implemented as soon as possible.

During 2022, we identified, reviewed and updated the most critical Safety Standards to provide consistent programs across our steelmaking operations. These included standards for:

- Overhead Crane Operation
- Confined Space Programs
- Employees Working at Height
- Railroad Safety Operation and Maintenance
- Energy Isolation / Lock-out and Tag-out

Our life saving rules are designed to keep our employees safe from serious injury or fatality. Below are the Life Saving Rules for all of our operations. Additionally, we provide support and training on various industrial hygiene concepts such as monitoring airborne contaminants and assessing physical hazards to relevant site personnel and union safety leadership. We continue to utilize the brief/debrief process, as well as recommend controls, measure performance and share best practices to achieve safety program targets.

Life Saving Rules


Bypassing Safety Controls


Confined Space


Driving


Energy Isolation


Fit for Duty


Hot Work


Line of Fire


Molten Metal


Safe Mechanical Lifting


Take 5


Working at Height

Safety Programs & Initiatives

In 2022, we continued to offer targeted safety programs and initiatives at our sites, including:

- In October, we held another Employee Health Week at our Burns Harbor facility. We hosted regional health organizations that set up informational booths to provide our people COVID-19 booster and flu vaccines, conducted health screenings and offered giveaways for participation. We also distributed a bag of locally grown fresh fruit and vegetables to every employee, which had been a much-appreciated activity from the prior year's Employee Health Week.
- Separately, Burns Harbor partnered with the American Heart Association to install a hands-only CPR training kiosk at our Deerfield Woods Training Center. The life-saving lesson takes approximately five minutes, and includes a video lesson followed by a practice session and a 30-second test. Every year more than 350,000 people go into cardiac arrest outside of a hospital and 90% of these people do not survive, so this kiosk is a small way that our employees may help save a life.



Hands-only CPR training kiosk in action at our Deerfield Woods Training Center in Burns Harbor, Indiana

2022 Safety Metrics

1.36
Total recordable incident rate (company-wide)

100%
Onsite workforce covered by an occupational health and safety management system

57M+
Employee hours worked

28
Average hours of health and safety training per employee

	2020	2021	2022
Total Recordable Incident Rate	1.18	1.37	1.36
Average hours of health, safety, and emergency response training (employees)	8	20	28

Safety Performance

Several of our sites were recognized in 2022 for their commitment to safety. Cleveland-Cliffs received the Midwest Regional Award presented by the Association of State Dam Safety Officials. Cliffs owns and operates five tailings storage facilities, and we have taken proactive steps to ensure the safety of these dams against potential failures. Through regular assessment, Cliffs updated our emergency action plans, reinforced thousands of feet of dam embankment and modified operations to reduce safety risks. Cliffs developed positive working relationships with state dam safety staff in Michigan and Minnesota (where our iron ore mines are located), keeping them apprised of operational status and long-term planning and seeking feedback as necessary.

In July 2022, Lake Superior & Ishpeming Railroad Co. (LS&I) won the 2021 Jake Award, given by the American Short Line and Regional Railroad Association. LS&I is a wholly owned subsidiary of Cleveland-Cliffs that transports our pellets from our Tilden mine to our dock in Marquette, Michigan. To win this award a member railroad must perform better than the Class II and III industry average injury frequency rate as reported by the Federal Railroad Administration during the prior year. The Jake Awards are named for the late Lowell S. "Jake" Jacobson, former president and General Manager of the Copper Basin Railway in Arizona. Mr. Jacobson was passionate about promoting railroad safety and created an awards program to honor fellow small-railroad colleagues and their commitment to safety.



Spotlight On: Sentinels of Safety

In October 2022, our Northshore Mine in Minnesota received the National Mining Association's (NMA) 2021 Sentinels of Safety Award for outstanding performance in the Large Metal/Nonmetal Mill category. The NMA's Sentinels of Safety Award recognizes coal and mineral mining operations in 10 categories for recording the most hours in a calendar year without a single lost-time injury. Established in 1925 by then Commerce Secretary Herbert Hoover, a former mining engineer, the Sentinels of Safety Award program remains the most prestigious recognition of mine safety in the United States, and continues to foster a strong safety commitment across the U.S. mining industry.

Talent Management

Building on the foundational work that began in 2021 as we harmonized our legacy systems, the Cleveland-Cliffs' Human Resources (HR) team achieved a year of integration and development. Notably, the HR Team finalized internal and salaried recruitment policies, including a defined selection and interview process for salaried hiring. The new program rollout comprised user training for the HR team, interview teams and hiring managers to ensure everyone was aligned on these new policies and process.

We established the Cleveland-Cliffs Talent Center, comprised of the following disciplines: Talent Acquisition and Development, College Programs and Skilled Craft & Apprenticeship Training. The Talent Center strives to be a center of excellence that creates a motivated workforce that will come to Cliffs not just for a job, but remain for a career. Through the Talent Center, we aim to employ consistent processes and programs that attract and retain high-quality employees, developing their skills and continuously supporting them to thrive.

Talent Acquisition and Development

During 2022, Cleveland-Cliffs added expertise to our Talent Acquisition team, who serve as internal advisors and business partners to our various corporate departments. The Talent Acquisition team works closely with our broader HR team and internal stakeholders to build efficient and consistent recruiting and hiring processes across the Company. The Talent Acquisition team also specializes in employment branding and compliance.

Throughout the year, we made enhancements to our external Careers site to better highlight current job openings and showcase Cliffs' company culture. Here, prospective employees can find information on topics ranging from Company history, employment benefits, career paths and hiring process to our efforts around diversity, equity and inclusion. In 2022, we launched an internal employee referral program for current salaried employees that pays a bonus if their referral is hired into an eligible position.

The success of our business is fundamentally connected to the well-being of our people. Accordingly, we are committed to the health, safety and wellness of our employees. We provide our employees and their families with access to a variety of innovative, flexible and convenient health and wellness programs, including benefits that provide protection and security so they can have peace of mind concerning events that may require time away from work or that impact their financial well-being; that support their physical and mental health by providing tools and resources to help them improve or maintain their health and encourage engagement in healthy behaviors; and that offer choice so they can customize their benefits to meet their needs and the needs of their families. We are pleased to report from 2021 to 2022 our median employee annual total compensation increased from approximately $125,000 to approximately $132,000.

Cleveland-Cliffs employees and their families participate in the 2022 Walk to End Alzheimer's at the Cleveland Metroparks Zoo



Developing our managers is critical to ensuring our workforce has leaders that demonstrate and encourage the Cleveland-Cliffs Core Values every day. In 2022, the Talent Development team offered two pilot programs for new managers. Based on initial feedback from these programs, we will offer a New Manager Development program in 2023 for newly hired or promoted managers. This program will provide helpful tools and resources for new managers to engage with their employees by cultivating trust through personal actions.

The Talent Development team also supports the College Programs team and its new hires by offering a New Graduate Development program specifically for college students hired into Cliffs across all of our locations and departments. This program focuses on developing our new college hires to continuously learn and leverage internal resources at Cliffs within their first year of employment.

Spotlight On: Tyren Walker

Cliffs employees can come from many different places and backgrounds, but they also come from our local communities. Tyren Walker grew up in Coshocton, Ohio, and graduated from Coshocton High School in 2020. He started working in fast food when he was 16 and became an assistant manager after he graduated. Living in a small town, he always heard people talk about good jobs in the area with reputable companies, Cleveland-Cliffs being one of them. He decided to look into employment and applied at our Coshocton Works plant. He was hired in September 2021 and quickly fell in love with the job. Though he had no experience in steelmaking, he went through extensive training and job shadowing where fellow employees took Tyren under their wing and helped onboard him as a Laborer. Six months after being hired, Tyren was promoted to an Operating Technician in the Finishing department, where he ensures that the steel has the correct specifications before being shipped to the customer.



"I'm a people person. Since the day I was hired, my coworkers have always been nice and helpful to me, and every day I learn something new. We are like a family here, and that is what keeps me working at Cleveland-Cliffs."

TYREN WALKER

College Programs

In 2022, 186 students from over 40 schools across the United States joined Cleveland-Cliffs through our internship/co-op programs. We are pleased to report that we hired 127 new permanent, full-time employees through our New College Graduate program in 2022. Additionally, Cliffs has increased our participation in college recruiting efforts at several Historically Black Colleges & Universities (also known as HBCUs) including Howard University and Florida A&M University.

Skilled Craft and Apprenticeship Training

Cleveland-Cliffs continues its commitment to local, state and community college partnerships to develop and secure local talent by offering opportunities for safe, rewarding and well-paying manufacturing careers. For example, our Cleveland Works facility renewed its partnership with Cuyahoga Community College and finalized revamped mechanical and electrical curriculums for students to earn a Steelworker for the Future technical certificate. Kickoff of this newly designed and innovative program commenced in January 2023 with initial internships to be offered during summer 2023. The program aims to produce graduates after one year rather than the previous two-year period.

Our Burns Harbor facility's electrical maintenance partnership with Ivy Tech Community College (Ivy Tech) produced two graduates who participated in plant internships and were subsequently hired in 2022, with two more students in the 2023 pipeline. The Burns Harbor Training Committee also developed a state-of-the-art HVAC training program with Ivy Tech for internal Cliffs employees, and the program graduated four HVAC Technicians in 2022. Our Indiana Harbor facility continued its partnership with Ivy Tech to offer electrical skills training through the Craft Recruiting Program, which has placed 21 Advanced Manufacturing - Industrial Electrical graduates into full-time employment at Indiana Harbor since its inception.

Other notable partnerships include:

- **Coshocton Works, Ohio** – partnered with Career and Technology Education Centers of Licking County and created a training program meeting state-required apprenticeship standards. Coshocton Works also certified in-house instructors to provide electrical, mechanical and safety training to employees.
- **Minorca Mine, Minnesota** – partnered with Minnesota North College to create a blueprint reading instructional course for supervisors and welders. The training course reduced the expensive alternative of hiring outside contractors.
- **Rockport Works, Indiana** – used the Training, Performance, Compliance learning management system platform to develop online craft training programs. Ten Rockport Works operating employees started the program in Q1 2023.
- **Middletown Works, Ohio** – continued its summer work program for local high school students providing exposure to manufacturing while allowing participants to earn money toward their future career goals. Middletown Works as well as Rockport Works collectively hired 34 summer workers in 2022.

In 2022, several of our facilities were recipients of state and federal training grants allowing them to expand training initiatives and assist in their efforts to develop stronger, more advanced skilled craft programs.

186

Students participated in internship/co-op programs at Cliffs in 2022

Diversity, Equity & Inclusion

At Cleveland-Cliffs, we aim to create a workplace that allows employees to thrive and grow—both personally and professionally—by providing opportunities for training and development as well as engagement with peers based on common interests. We publicly acknowledge this commitment with our OneCliffs Way of Doing Business: Our Code of Business Conduct and Ethics affirming that we do not make employment-related decisions nor will we discriminate based on race, color, religion, national origin, age, military or veteran status, disability, sex (including sexual orientation and gender identity), genetic information or any other characteristic protected by applicable law. Most importantly, we do not tolerate any form of harassment or intimidation anywhere in our Company, especially actions directed at those in a protected or underrepresented class. Cleveland-Cliffs is pursuing new opportunities to embrace diversity, equity and inclusion (DEI) in the coming year.

Veterans and Women at Cleveland-Cliffs

The HR Team expanded our veteran hiring and retention efforts with a goal of fostering a military- and veteran-friendly work environment to attract and retain talent. In 2022, we certified two HR Team members as Certified Military Veteran Recruiters (CMVR), who serve as trained experts in military veteran recruitment best practices. Our CMVRs along with other HR Team members, attended many veteran recruiting fairs at both universities and on-base in Norfolk, Virginia. Additionally, we identified resources to establish an internal Veterans Business Resource Group (BRG) in early 2023.

The Women's Network BRG is also slated to commence in 2023 with year-long development opportunities and events planned. For the fourth consecutive year, Cliffs participated in the Women MAKE America Awards, formerly known as the STEP Ahead Awards, which recognize women in science, technology, engineering and production careers who exemplify leadership within their companies. We are pleased to report that Erin Bowers, Process Engineer at our Tilden mine in Michigan, was recognized as a 2023 Honoree.

Employees from Burns Harbor and Indiana Harbor participate in Women's Build Day with Habitat for Humanity NWI in Lake Station





Spotlight On: Rose Davis

Rose Davis has worked in the steel industry for more than 30 years, and she has no plans to slow down any time soon. As a Lead Account Manager in our Commercial Plate group, Rose uses her experience and expertise to maintain longstanding relationships with our customers while helping to mentor employees who are new to the industry and to Cliffs. Her personal passion for advancing DEI fuels her drive to continue making a difference at Cleveland-Cliffs and beyond.

Over the last two years, Rose has sought out opportunities both internally and externally to educate peers on, and promote, DEI concepts. As a member of the DEI Committee for the Metals Service Center Institute, Rose has participated in panel discussions with other women of color to speak about her journey in the steel industry and where she has seen change occur over time. The DEI Committee serves as a helpful forum for professionals across the industry to ask questions and brainstorm ways to advance DEI in their own companies, such as establishing programming and attracting and retaining diverse talent.

Internally, Rose engages with Cliffs senior leaders around enhancing our DEI program and where she sees opportunities for the future. Rose began her career with Inland Steel after graduating from college, and stayed with the company through its various iterations to what it is today. During her tenure in the steel industry, she has seen how each iteration of the company approached DEI, and believes Cliffs is well-positioned to make a significant impact in this space. She recognizes that there are more women in the industry overall, including in management positions, and she is pleased to see this evolution.

Personally, Rose remembers one piece of advice that has stuck with her all these years: build your own personal board of directors. In addition to her mother—the most important board member—Rose has sought out influential people in both her personal and professional life that she has trusted to provide her guidance and support. While she believes in advocating for yourself and owning your career, she also believes you cannot do it alone. Looking ahead, Rose sees herself continuing to positively represent Cliffs in her current role, and hopes to be part of cultivating the DEI conversation for years to come.

Labor Relations

In 2022, Cleveland-Cliffs continued our strong track record of positive labor relations with our union partners. More than 90% of Cliffs' hourly workforce are represented by three prominent unions—USW, United Auto Workers (UAW) and International Association of Machinists and Aerospace Workers (IAMAW). We are pleased to report that during 2022, three new labor contracts were successfully ratified for more than 15,000 represented union workers across our operating footprint:

- In June, a new 3-year labor agreement with the UAW was ratified, covering employees at our Butler Works, Pennsylvania facility.
- In September, a new 47-month labor agreement with the USW was ratified, covering employees at our legacy iron ore mining operations.
- In October, a new 4-year labor agreement with the USW was ratified, covering employees at 13 of our operating locations.

We look forward to continuing productive dialogue with our labor partners in 2023 as a number of other site agreements reach expiration and will be renegotiated. Cliffs strongly believes that these positive partnerships with our unions help us remain competitive and protects our customers and their supply chains from disruptions due to labor disagreements.

We pride ourselves on maintaining consistent communications with our unions as the foundation of our approach to labor relations, and we encourage open dialogue at all levels of the Company. Employees are provided multiple avenues to raise concerns, ask questions or make suggestions on how to enhance their working experience. We are pleased to report that Cliffs did not experience any strikes or lockouts in 2022.

The market for skilled workers remains competitive, and in 2022, we continued to work with our union partners to attract and retain new talent. Company-wide, Cliffs hired more than 2,600 bargaining unit team members in 2022. As we prepare and develop the next generation of our workforce, we are committed to collaborating with our unions to provide meaningful work, excellent compensation packages and safe working conditions to promote pride as a Cleveland-Cliffs employees.

"Cleveland-Cliffs is a people oriented company. These labor agreements, covering more than half of our entire workforce, support that statement. Going forward, we will continue to promote our employees' well-being as the basis of our success for the benefit of our clients and our long-term shareholders."

LOURENCO GONCALVES
Chairman, President and Chief Executive Officer

Spotlight On: Katie Betters

After 14 years as a police officer, Katie Betters was ready for a career change. The mental and physical strain of the job was starting to take its toll, and Katie was looking forward to a fresh start. Her father worked at our Hibbing Taconite mine (HibTac) in Minnesota for 24 years as a maintenance mechanic, and Katie remembers taking tours of the mine as a child during Family Days.

Katie joined Cliffs as a production truck driver in 2019. After a little over two years in this role, she was promoted to Supervisor. It seemed a natural fit for Katie, because, as a truck driver, she understood how everything should work in the pit. As Supervisor, Katie is responsible for dispatching the entire pit. She sets up shifts for the crew, such as the truck drivers and shovel operators, inventorying the trucks and assigning drivers to each one. If any issues arise during the shift, she coordinates mechanics and electricians to troubleshoot. She has also trained new truck drivers, and continues to maintain open lines of communication with her colleagues to help answer questions.

A hunting accident unfortunately forced Katie's father to retire early from Cliffs, and this motivated her to become a firearms safety instructor for the Minnesota Department of Natural Resources in 2014. Since then, she has taught firearms safety to hunters both young and old, and as a Supervisor in a leadership role, she is involved in weekly safety talks at the mine. During her tenure as a police officer, Katie received a Distinguished Service Award for helping to save several young adults from a home due to a carbon monoxide leak. Additionally, Katie is also a certified emergency medical technician. HibTac has its own emergency response team that Katie serves on, which provides emergency medical support as first responders while the ambulance is on its way.

Katie is a clear leader in all aspects of her life. Her philosophy is simple: she believes that everyone is human, and she is always willing to listen to others' ideas about how to accomplish common goals. A healthy respect of one another and our opinions goes a long way. She is the type of person you want to have on your team in both good times and times of crisis, and Cliffs is proud to have her on our team.





Cleveland-Cliffs employees collecting food for annual Souper Bowl Food Drive



05

Connecting with Our Communities

We value the communities where we operate and their contributions to Cleveland-Cliffs. Through two-way dialogue, Cliffs can keep a pulse on what is important to our communities to ensure we act as a good neighbor. Through The Cleveland-Cliffs Foundation, we create tangible impact through strategic partnerships and significant financial support to like-minded organizations.

STAKEHOLDER ENGAGEMENT

We believe it is vitally important to listen to and work with our stakeholders. Various groups throughout our Company regularly engage with a range of internal and external stakeholders to build and maintain two-way dialogue with our host communities, public officials and neighbors. Each year, Cliffs enhances our outreach efforts to ensure fairness and inclusivity of different stakeholder perspectives. This helps us prioritize activities and more effectively address issues important to our stakeholders.

Community Engagement

Throughout 2022, Cleveland-Cliffs worked to build brand awareness and recognition to demonstrate our continued commitment to the regions where we operate. Through our Government and Community Relations team, Cliffs gets to know and supports the communities located in and around our major operational hubs.

An important tool in helping us support our communities is our Community Inquiry Program, which helps foster dialogue and provides us valuable information when community stakeholders have questions regarding our operations. In 2022, Cleveland-Cliffs received and responded to over 300 inquiries through this Program. Not only does the Program aid us in addressing potential community concerns, it helps us collaborate cross-functionally with our internal colleagues to strengthen our response. We track information gleaned from these interactions to determine the appropriate course of action, develop best practices and evaluate and improve program performance.

Another key aspect of our community relations work is our inclusion of Environmental Justice (EJ) principles. EJ as defined by the U.S. EPA is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation and enforcement of environmental laws, regulations and policies.

Additionally, Cliffs' employees continue to engage with local civic and community organizations, including chambers of commerce, economic development organizations, neighborhood associations and nonprofit stakeholders. These relationships allow us to incorporate the input of relevant community stakeholders into business decisions that may impact the community.

We occasionally bring our communities into Cliffs' facilities, where appropriate. For example, each year we hold National Manufacturing Days in partnership with The Manufacturing Institute. These Days allow local students to explore a career in steelmaking through tours of our operations. The first Friday of October is traditionally reserved for Manufacturing Day, and hundreds of local students toured our facilities, including Dearborn Works, Burns Harbor, Rockport Works, and Mansfield Works. Both Burns Harbor and Rockport Works hosted three different tours each, welcoming students from multiple schools.

Community Open Houses

In 2022, Cliffs reached out to numerous communities to facilitate thoughtful dialogue with our Company leadership, most notably through our community open houses. Throughout 2022, we held open houses at several of our largest steel mills, including:

- Burns Harbor
- Riverdale
- Dearborn Works
- Cleveland Works
- Indiana Harbor











(From top to bottom) Burns Harbor, Dearborn Works, Riverdale, Cleveland Works, Indiana Harbor

These events provided another critical opportunity for community stakeholders to directly engage with representatives from Cliffs. Open houses were held in a central location in the community, after normal business hours, in order to "bring Cliffs into the community." The format allowed for one-on-one dialogue with Cliffs' senior leadership and plant personnel and included resources for communities where English is a second language. Collectively, approximately 430 community members attended these open houses. This successful effort built stronger partnerships with our community members and opened new lines of communication with our stakeholders, while advancing EJ concepts in our operating communities.

Charitable Giving

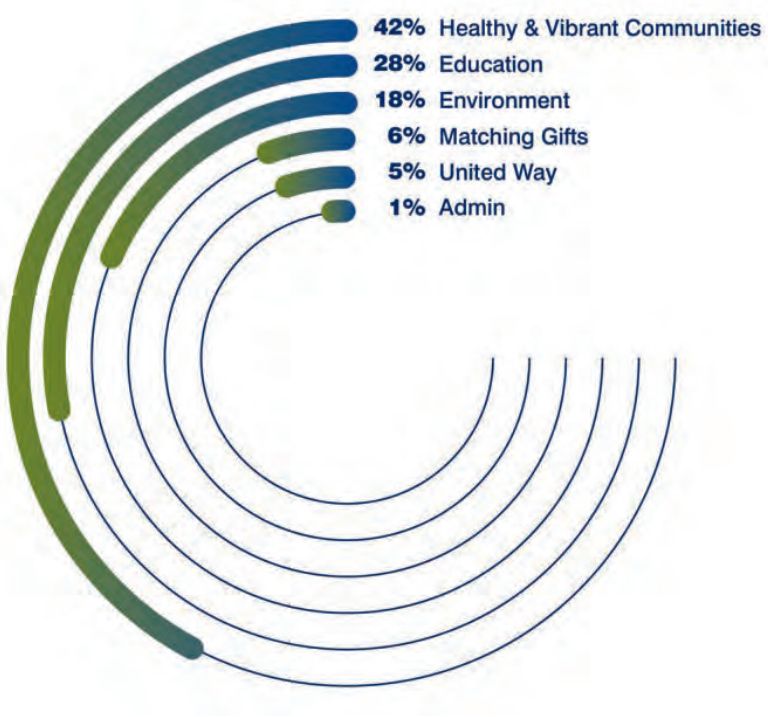
Cleveland-Cliffs conducts charitable giving through a number of vehicles:

- The Cleveland-Cliffs Foundation, which makes donations to community organizations, facilitates employee matching gifts and funds a multi-year college scholarship program for children of employees
- Site-specific programs and events, such as employee volunteering
- Strategic partnerships, such as with the Cleveland Cavaliers among others

$7.4M

Donated to our local communities in 2022

2022 Giving by Program Area



The Cleveland-Cliffs Foundation

Established in 1962, The Cleveland-Cliffs Foundation (The Foundation) serves as a dedicated resource for our charitable giving activities in the communities where we operate. We partner with and invest in local organizations and initiatives that focus on promoting education, protecting the environment and supporting healthy and vibrant communities. This also includes initiatives such as employee matching gifts and our scholarship programs.

Employee Giving and Matching Gift Program

Administered by The Foundation, the Employee Giving and Matching Gift Program supports causes most important to our employees. Through this program, employees are encouraged to donate to nonprofit organizations they care about and The Foundation matches these donations up to $1,500 per employee per year. In 2022, Cliffs offered employees a special opportunity to directly support relief efforts for Hurricane Ian, which raised more than $10,000 and was matched by the Foundation. The Foundation matched more than $434,000 in employee donations in 2022.

~$434K

In employee donations matched in 2022

Scholarship and Education Programs

The Foundation proudly supports two signature college scholarship programs. In 2022, we continued to expand our Sons and Daughters Scholarship Program to award 40 new competitive college scholarships to children of Cleveland-Cliffs employees. Additionally, 75 children received scholarship renewal awards. The Louie F. Cox African American Scholarship supports African American students who either live in Butler or Warren County (Ohio) or will graduate from a high school located in one of these counties. Two new scholarships (valued at $20,000 each) and six renewals were awarded in 2022.

Healthy & Vibrant Communities

The Foundation was proud to support the Cleveland Metroparks in their efforts to build a new outdoor bike park at the Ohio and Erie Canal Reservation. The Cleveland-Cliffs Bike Park creates a new outdoor complex that includes several first-of-its kind features in the region, including a public-use paved pump track, outdoor competition course, professionally paved jump line and youth-focused bike playground. The Cleveland-Cliffs Bike Park offers a unique experience for bike riders of all ages and skill levels and is free for all visitors.

In 2021 and 2022, The Foundation contributed $1 million each year to address food security. Simultaneously in 2022, our employees donated more than 200,000 pounds of food through our Souper Bowl Food Drive, which resulted in donations to area food pantries in our local communities. The Foundation made a significant donation to World Central Kitchen —an organization that provides meals in response to humanitarian, climate and community crises —to support their relief efforts in Ukraine.



James Graham, chair of The Cleveland-Cliffs Foundation, cuts the ribbon to open the new Cleveland-Cliffs Bike Park



Spotlight On: Family Days

On September 24, 2022, we welcomed approximately 8,000 employees and family members to our Middletown Works (Ohio) integrated mill for Family Day. This event was an opportunity to showcase all the great work we do at this facility, including through a virtual tour of the mill via a virtual reality experience. Cliffs employees and their families enjoyed food, games, face painting, bounce houses, train rides and more throughout the day. Additionally, through our partnerships with the Cincinnati Reds and FC Cincinnati, representatives from the teams as well as their mascots made a special appearance. A great time was had by all, and we look forward to continuing the Family Day tradition in the future.

Earlier in the month, we hosted a Summer Safe Family Day for the Hot Strip Mill at our Indiana Harbor facility. More than 200 employees, friends and family were in attendance. Attendees learned about the importance of a safe working environment, and had the opportunity to tour the Hot Strip Mill followed by a picnic lunch.

National Fish & Wildlife Foundation

Cliffs has supported the National Fish & Wildlife Foundation for the last 15 years through specific funds that are focused on conservation projects near our operational hubs: Sustain Our Great Lakes, Southeast Michigan Resilience Fund and Chi-Cal Rivers Fund. Through these funds, we advance environmental conservation near our facilities for the benefit of our local communities and beyond. In 2022, these three funds awarded $18.1 million to more than 50 projects. Additionally, we indirectly support the important work done by organizations such as the U.S. Fish & Wildlife Service, U.S. Forest Service and U.S. Department of Agriculture. Also in 2022, Cliffs expanded our support to include the Central Appalachia Habitat Stewardship Fund, which funds projects located in the Appalachian regions of Maryland, New York, Ohio, Pennsylvania, Virginia and West Virginia.

Employee-Driven Support

Many of our Cliffs employees live in or near our operating communities, reinforcing the importance of supporting our local neighborhoods. Through United Way campaigns conducted across our operating footprint, Cliffs employees donated to support basic needs and social services for our local communities. With all donations matched by The Foundation, more than $1 million was donated to support United Way initiatives in these communities.

Employee volunteering efforts continued to thrive in 2022 across our operating footprint. The following are numerous examples of the generosity of our Cliffs team members.

Maumee Valley Habitat for Humanity

In October 2022, employees from our Toledo DR plant joined the Maumee Valley Habitat for Humanity for “Rock the Block.” The event, sponsored by the Foundation, hosted dozens of volunteers to clean up parks, plant flowers, clear and trim brush and provide exterior repairs in an effort to revitalize the Birmingham neighborhood adjacent to the Toledo DR plant.

Support to Encourage Low-Income Families Home Repair Program

Middletown Works employees volunteer to provide home repairs to area residents through the Support to Encourage Low-Income Families Home Repair program. The program provides free home repairs and mobility modification to area seniors, people with disabilities and other families who are unable to physically or financially complete the repairs.

Project Playhouse

Coshocton Works employees partnered with Habitat for Humanity to support their Project Playhouse effort. Employees were matched with an area child to design a one-of-a-kind playhouse that provides a safe place to play.

Brandywine Clean-Up

Cliffs and our employees in Coatesville, Pennsylvania were proud to sponsor the Brandywine Clean-Up, hosted by the Brandywine Red Clay Alliance, an organization that works to promote the restoration, conservation and enjoyment of the natural resources of the Brandywine and Red Clay watersheds. A group of Coatesville employees joined local neighbors to clear debris from area roads, trails and streams. Additionally, the group worked to clean-up remaining flood debris from Hurricane Ida that impacted the area in summer 2021.

STEM-Focused Engagement Opportunities

Employees from our Toledo DR plant volunteered at a variety of STEM-focused engagement opportunities in 2022, including ones held at the Imagination Station and the American Heart Association’s STEM Goes Red event. Collectively, these events provided hands on activities while introducing youth to careers in engineering and other STEM fields.

Reforestation Program

Employees at our United Taconite mining operation collected pinecones from black spruce pine trees on our property to donate to the Minnesota Department of Natural Resources (MNDNR) for their reforestation program. The MNDNR will use the cones to seed approximately 5,000 acres to reforest MNDNR-managed land.

Audubon Society & Dunes Calumet Audubon Society

Employees at our Indiana Harbor facility worked with the Indiana Audubon Society and Dunes Calumet Audubon Society to install a falcon box prior to nesting season. The falcon box provides a safe nesting area for peregrine falcons and allows the Indiana Department of Natural Resources to monitor chick development and band them to determine where they migrate once they leave the nest.

Adopt-A-Road

Dearborn Works employees participate in the county's Adopt-A-Road program. Periodically, employees pick up litter from the roadside in South Dearborn, near our facility. The program works to keep the county's roadways clean and attractive for commuters and area residents.

Spotlight On: IRONMAN Jay Parks

James 'Jay' Parks, Shipping Unit Tech at our Coshocton Works, Ohio, facility, qualified for the 2022 IRONMAN 70.3 World Championship in St. George, Utah. The triathlon race, which took place on October 28-29, consisted of swimming, biking and running. Cliffs was proud to support Jay and outfit him with race gear as he chased his dream of competing at an elite level. Typically, Jay wears Cliffs-branded gear to all the events he competes in, such as 5k races, marathons and other triathlons. We look forward to cheering Jay on as he competes in the Boston Marathon in April 2023 and the Ironman 70.3 World Championships in Lahti, Finland, in August 2023.



Strategic Partnerships

During 2022, Cliffs expanded (and established new) strategic partnerships in our local communities. Working closely with The Foundation and Community Relations, our internal team facilitates these strategic partnerships to continue building Company awareness externally while working with like-minded organizations to engage with our employees and give back to our communities.

Cleveland Cavaliers

In early 2022, Cliffs and the Cleveland Cavaliers (Cavs) announced an expansion of our existing multi-year agreement that put our logo on the player uniforms for the 2022-2023 season. We are proud of our presence in the Great Lakes region, and this partnership allows us to have greater visibility across multiple fronts. Cliffs is the only steel company to have a jersey patch partnership with a major North American sports team. Cliffs has been headquartered in Cleveland since 1847 and operating in the Great Lakes region for more than 175 years, and this expanded partnership serves as a point of pride for both our employees and our hometown basketball team.

Cavs All-Star point guard Darius Garland hails from Gary, Indiana (near two of our largest steelmaking facilities that are located in Northwest Indiana) and his grandparents worked within the steel industry, providing another great connection between our organizations. Garland donates his time and talent by conducting free basketball camps for children, all of which are presented by Cliffs. In 2022, he conducted camps in Cleveland, Ohio, Northwest Indiana and Nashville, Tennessee, which were attended by 200 children in each location. Through our partnership with the Cavs we continue to support the Read to Achieve program, which encourages a love of reading and provides reading materials to children throughout Northeast Ohio. In 2022, we engaged with approximately 48,000 students through this program.

Another important aspect of our Cavs partnership is our support of the Boys and Girls Clubs of America (Clubs). The Foundation pledged a significant amount of new funding to support Clubs serving our host communities. Clubs within Cliffs' operating footprint were encouraged to apply for competitive grant dollars to support capital- and program-related expenses that encourage healthy lifestyles. In 2022, the Foundation awarded a total of nearly $500,000, dispersed among the following Clubs in our host communities:

- Central Ohio
- Chicago
- Cliff Hagan Boys and Girls Clubs (Rockport, Indiana)
- Hamilton (Ohio)
- Harrisburg
- Northeast Ohio
- Northland (Hibbing, Minnesota)
- Northwest Indiana
- Ocoee Region (Cleveland, Tennessee)
- Philadelphia
- Toledo
- West Chester/Liberty



Darius Garland conducting a youth basketball camp



Darius Garland, point guard for the Cleveland Cavaliers, wearing a game jersey with the Cleveland-Cliffs jersey patch

"Being from Gary, Indiana, I know first-hand how important Cliffs and steel are to communities, both here in Cleveland and across our region. Every time I put this jersey on and see the Cliffs patch on the chest, I'll be reminded of these people and motivated by the hard-working mentality that they bring every day."

DARIUS GARLAND
Point Guard, Cleveland Cavaliers



Spotlight On: Community Tours

Cliffs and the Cavs teamed up on the Bigger Than Basketball Community Tour for its first stop in Mansfield, Ohio. This new initiative focuses on providing resources for underserved populations in each community by teaming up with local agencies to help identify specific needs such as clothing, food security and recreation. Each visit on the tour includes fun with the Cavs such as youth basketball clinics and appearances from their entertainment teams.

In Mansfield, Cliffs and the Cavs partnered with The New Store, Friendly House and Children's Hunger Alliance of Richland County. The day kicked off at The New Store, a program of Richland County Children's Auxiliary that serves more than 2,000 youth annually, including supplying them with new clothing for the school year. Our Mansfield Works facility has been supporting The New Store for many years and we were pleased to continue this support in a meaningful way. The New Store organizes an annual winter coat drive, and more than 900 youth received winter coats as well as a Cliffs/Cavs branded winter hat. Thanks to a generous donation by the Children's Hunger Alliance, each child took home a shelf-stable meal as well. Members of the Cavs Powerhouse Dance Team and Cavaliers Better Halves (spouses and significant others of Cavs players and coaches) attended the event alongside Cliffs employees.

The second event of the day took place at Friendly House, a community center that provides after school programming for the immediate neighborhood and community. One hundred youth attended and received winter coats, hats and meals. The youth also participated in a Cavs Academy Basketball Clinic, a Powerhouse Dance Clinic and enjoyed a special appearance by Cavs mascot Sir CC.

Cleveland Guardians

Cleveland-Cliffs is the presenting partner of PlayBall! CLE, an initiative of Cleveland Guardians Charities that provides financial support and educational resources to underserved baseball, softball and adaptive organizations throughout Northeast Ohio. This program aims to support youth players, coaches and volunteers to ensure every league within the program is positively impacting the lives of the youth they serve. The partnership between Cleveland Guardians Charities and local youth leagues involves a number of benefits to help increase representation and growth of baseball and softball in marginalized communities, including attending a Guardians game during the regular season. More than 5,800 people from 11 participating leagues attended three PlayBall! CLE events at Progressive Field and League Park.

Additionally, we provided opportunities for our Cleveland Works and Mansfield Works employees to attend a Guardians game during the regular season. More than 2,000 employees and their families from Cleveland Works attended games in September, including enjoying a pregame meal, ballpark experiences and watching Department Administrator Ryan Howell throw out the ceremonial first pitch. Mansfield Works employees and their families attended games in August and participated in the same experiences.

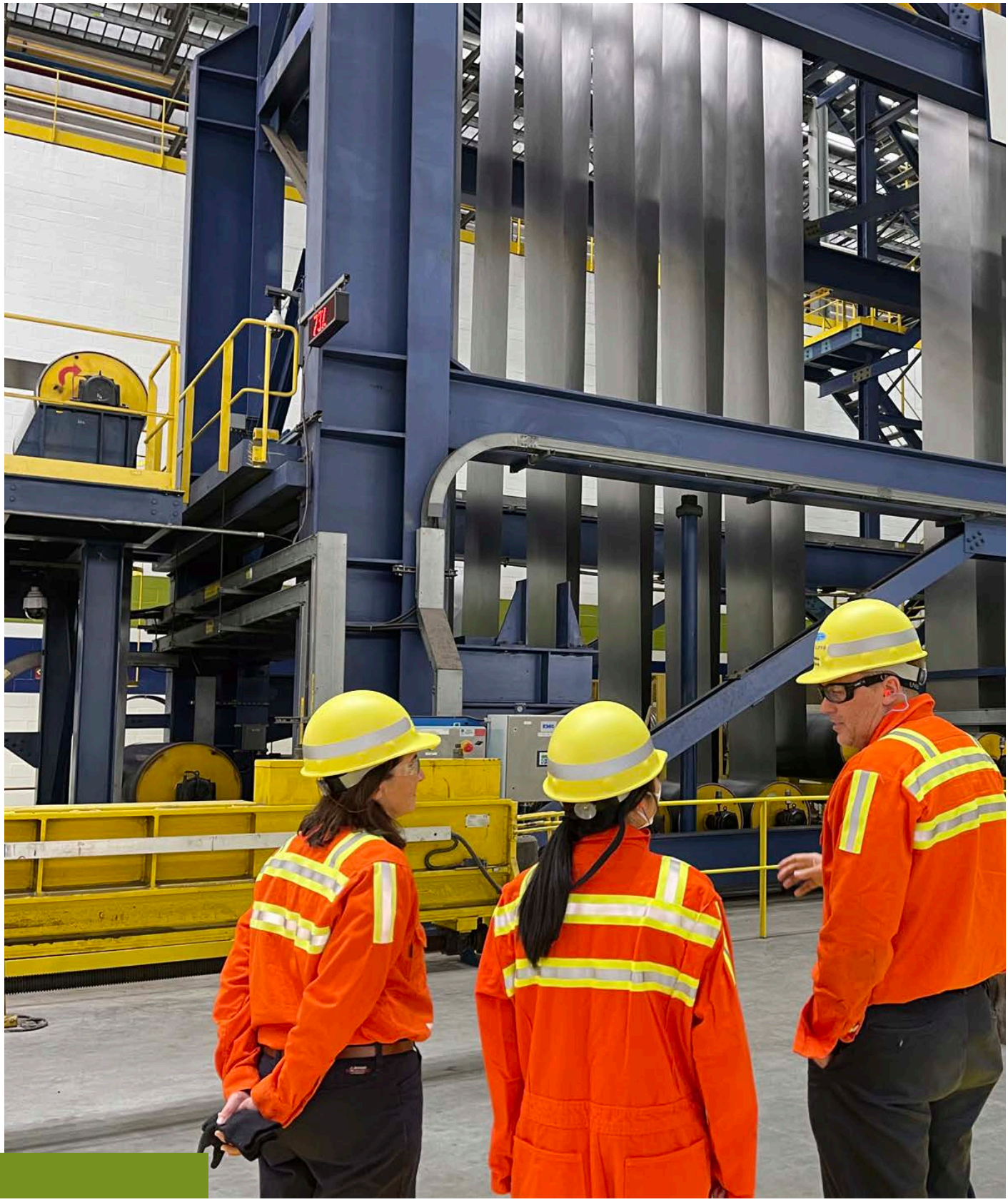
Cincinnati Reds & FC Cincinnati

Cliffs engages in partnerships with the Cincinnati Reds and FC Cincinnati due to their proximity to our Middletown Works, Ohio, facility. Through our partnership with the Reds, we have provided local employees the opportunity to watch batting practice or throw out the ceremonial first pitch before a regular season game, as well as attend the game. Over the past year we have worked to bring the Fun at Bat program to Middletown and its surrounding communities. Fun at Bat is a nationwide initiative with an emphasis on character development, functional movement, active play and fun through the game of baseball. We look forward to launching this initiative in 2023 with students from the Middletown School District.

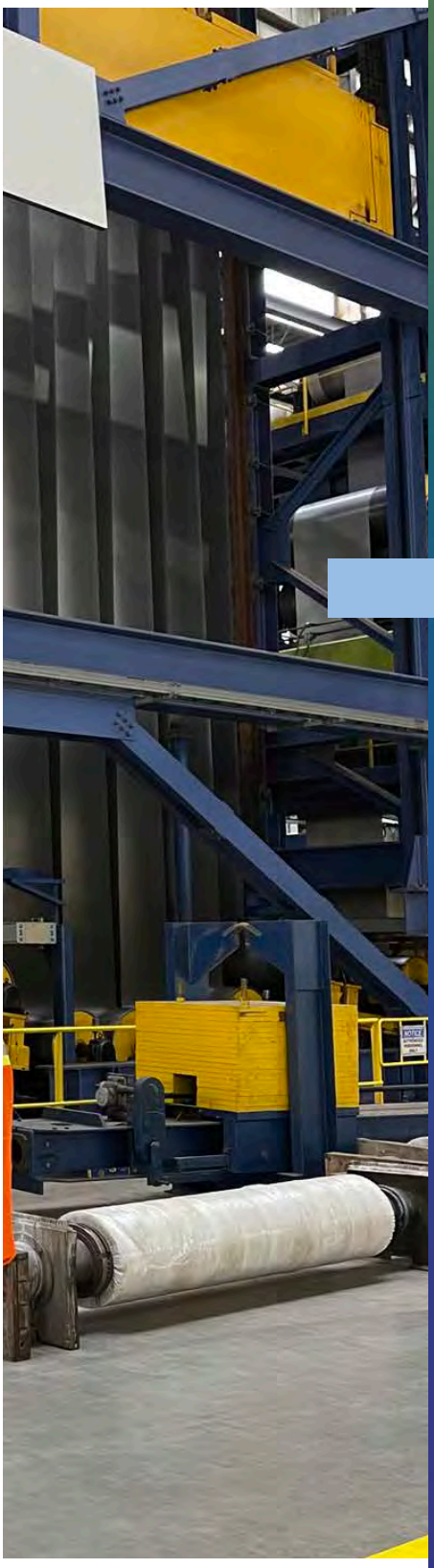
Through our multi-year partnership with FC Cincinnati —a Major League Soccer club located in Cincinnati, Ohio—we participated in a social media campaign to recognize local high school soccer teams in the Greater Cincinnati region (including near Middletown). Weekly voting was facilitated throughout the high school soccer season, which culminated in a winner for Team of the Year. The recipient, Taylor Men's High School Soccer team, was acknowledged at the final FC Cincinnati home game of the season on October 2, 2022. Additionally through our partnership, Cliffs has a brand presence at FC Cincinnati's stadium, and we provide home game tickets to our employees as well as to the Team of the Week. Cliffs 'presents' the club's "Street Team," which travels across the region to promote the club, and we look forward to also presenting a soccer match during the 2023 season.

Ryan Howell, Department Administrator at our Cleveland Works facility, throws out the first pitch at a Cleveland Guardians game





Hot-Dipped Galvanizing Line at Dearborn Works



06

Acting with Integrity

Strong corporate governance and ethical business practices serve as the foundation of Cleveland-Cliffs' company culture. We believe in honesty, fairness and treating everyone with respect—from our Board of Directors to our employees, and our customers to our suppliers.

CORPORATE GOVERNANCE

The Cleveland-Cliffs Board of Directors (the Board) is comprised of 10 directors, nine of which are deemed independent under the New York Stock Exchange director independence standards. There are four Committees of the Board: Audit, Governance and Nominating, Compensation and Organization, and Strategy and Sustainability. All Committees are comprised entirely of independent directors, except the Strategy and Sustainability Committee, which is chaired by our Chairman, President and Chief Executive Officer Lourenco Goncalves. Cliffs' Corporate Governance Guidelines serve as the framework within which the Board conducts its business.

Our Strategy and Sustainability Committee provides essential oversight of Cliffs' risks, opportunities and projects related to business strategy and sustainability. The Strategy and Sustainability Committee's charter also includes oversight of climate-related risks and opportunities, and the Committee regularly engages with management regarding Cliffs' employee health and safety programs and ESG initiatives.

The Board participates in their regularly scheduled meetings and ad hoc meetings as appropriate to actively engage with senior management, stay informed on significant issues and developments and oversee Cliffs' strategic direction. Cliffs continually enhances its approach to corporate governance as our business grows and evolves. It is critical that we maintain positive relations with our stakeholders and investors to meet expectations, and we welcome two-way dialogue to promote open communication.

For 2022, we established new Strategic Initiatives for our EMPI program, some of which were ESG-focused. For example, the Compensation and Organization Committee approved initiatives aimed at developing a renewable energy portfolio and emissions reduction targets that are science-based, as well as participating in emerging technologies such as carbon capture and sequestration. For more information about our corporate governance and executive compensation practices, please see our most recent **Proxy Statement** filed with the U.S. Securities and Exchange Commission.

Core Values, Ethics & Compliance

Cleveland-Cliffs' employees embody our Core Values every day through their hard work and dedication to the success of our business. The shared focus on our Core Values as the foundation for our business dealings provides us the ability to overcome challenges and helps us maintain trust with our colleagues and external stakeholders. Our OneCliffs Way of Doing Business outlines the necessary behaviors we are expected to follow to uphold our Core Values. Our Ethics Committee, led by our Chairman, President and Chief Executive Officer, Lourenco Goncalves, and comprised of our executive leadership, continues to oversee the investigation of reported potential ethics violations and to determine appropriate follow-up measures. Our Ethics Committee has the important responsibility of ensuring that Cliffs operates according to all applicable laws, rules and regulations while maintaining the highest standards of ethics and integrity.

Our employees are the eyes and ears of Cleveland-Cliffs. Raising concerns can help our Company improve processes and solve problems quickly and effectively. There are various channels for reporting concerns: to supervisors or trusted managers; to HR personnel at local operating sites or offices; to a member of the Ethics Committee; to an attorney in our Legal Department; or via our Ethics Helpline, which can be accessed by phone or through an online platform. Cliffs takes reported concerns seriously and does not allow retaliation against employees for reporting concerns in good faith. All of our non-represented salaried employees are required to complete training on our OneCliffs Way of Doing Business via an online learning platform. Starting in 2023, this training will take place in January of each year.

Compliance goes hand-in-hand with ethics and integrity. Respect for human rights is imperative to responsible business practices and we comply with all applicable laws and regulations governing human rights. In 2022, we enhanced our Human Rights Policy to make explicit our commitment to both the United Nations' Universal Declaration of Human Rights and the United Nations' Guiding Principles on Business and Human Rights. All of our corporate policies work together to promote a well-rounded culture of ethical business practices.

With more than 27,000 employees across our operating footprint, Cleveland-Cliffs takes cybersecurity very seriously. We have a dedicated Information Technology Security team that aligns our approach to cyber threats with the National Institute of Standards and Technology cybersecurity framework. Cliffs has a cross-functional Information Security Committee, chaired by our Chief Information Officer, that oversees policy and investment in this area. The Chief Information Officer reports biannually to the Board of Directors via the Audit Committee on information security risks and cybersecurity status and plans.

Enterprise Risk Management

Cleveland-Cliffs manages risk at all levels of our Company. We utilize a proven methodology that provides value to all aspects of our business. Our Enterprise Risk Management (ERM) process captures a wide variety of risks, including key ESG risks. In 2021, executive management identified key operations for an in-depth enterprise risk review based on size and history of the facilities.

2022 Director Highlights

7.1
Years of average tenure

30%
Ethnically diverse

4
New directors joined the Board in the last 4 years

30%
Women

90%
Independent

In 2022, we completed risk reviews for the majority of our integrated operations, EAF facilities, finishing facilities and mining operations—repeating those that were completed in 2021 to continually build on the integrity of the program. We plan to complete remaining sites in 2023 and to conduct risk reviews on a continuing cadence thereafter.

Identified risks continue to be managed by facility leadership at the facility level. Each risk has an associated timeline and owner who regularly reviews the status of risk mitigation with facility management. Executive management is kept apprised of how the ERM process progresses across our operational footprint so they are prepared to discuss specific risk reviews with facility managers who report directly to them; can identify trends in risks; determine potential capital expenditures associated with identified risks; and allow analysis within the context of our overall business strategy.

Public Policy & Advocacy

Involvement in public policy and advocacy allows Cleveland-Cliffs to represent its interests and educate policymakers on matters that relate to the future success of the steel industry in the United States. Cliffs conducts direct advocacy with policymakers at the local, state and federal levels on relevant and timely policy matters. For example, in 2022, we worked with the U.S. Department of Commerce, the Office of the United States Trade Representative and steel industry advocates in Congress to urge the continuation of stringent steel Section 232 tariffs and quotas. We also partnered with the USW, the American Iron and Steel Institute and other organizations to inform and influence the ongoing U.S. government negotiation of the Global Arrangement on Sustainable Steel with the European Union.

Cleveland-Cliffs' Chairman, President and Chief Executive Officer, Lourenco Goncalves, was personally involved in conducting bipartisan advocacy in support of passage of the Creating Helpful Incentives to Produce Semiconductors and Science Act of 2022 (CHIPS Act). The CHIPS Act will provide necessary government incentives for the establishment of new microchip manufacturing capabilities in the U.S. Given Cliffs' position as the largest producer of steel for the North American automotive industry, passage of the CHIPS Act will be critical to remedying supply chain bottlenecks restricting automotive production volumes and, by extension, steel consumption by the automotive sector.

Cliffs was an active participant in four U.S. International Trade Commission (USITC) Five-Year Sunset Reviews of existing Anti-Dumping (AD) and Countervailing Duty (CVD) orders on the following steel products: Corrosion-Resistant, Cold-Rolled, Hot-Rolled and Cut-to-Length Steel Plate. The USITC conducted reviews of cases that were initially brought by the domestic steel industry and the USW successfully in 2015 and 2016 in response to a surge of dumped and subsidized steel imports at that time. Mr. Goncalves testified at all four USITC Sunset Review hearings in 2022, addressing the importance of maintaining these orders so that, among other things, Cliffs can earn an adequate rate of return on our capital needed to reinvest into our business for the future. These successful sunset reviews resulted in the continuation of the AD/CVD orders for most countries subject to the cases for a minimum of five additional years.

Cliffs is the definitive steel industry leader with respect to its partnership with the DOE toward pursuing GHG emissions reductions and energy efficiency opportunities across its operating footprint. In August 2022, Cliffs hosted U.S. Secretary of Energy Jennifer Granholm and Congresswoman Marcy Kaptur, Chair of the House Appropriations Subcommittee on Energy and Water, at its state-of-the-art Toledo DR Plant. This visit served as an opportunity to highlight our modern plant and to discuss how Cliffs' usage of HBI from this plant results in substantial GHG emission reductions, particularly from reduced coke rates in our blast furnaces.

In follow up to Secretary Granholm's Toledo visit, Mr. Goncalves met with the Secretary in her Washington, D.C. office in October 2022. The two discussed Cliffs' ability to utilize hydrogen as a replacement for fossil fuels in its steelmaking furnaces when hydrogen is commercially available in the future. Mr. Goncalves and Secretary Granholm also discussed other areas of partnership between Cliffs and the DOE related to the Better Plants and Better Climate Challenge Initiative programs.

Following passage of the Inflation Reduction Act in August 2022, Cliffs worked with senior staff from the White House Domestic Policy Office to participate in a series of announcements related to President

Biden's "Buy Clean" initiatives. In September, Cliffs hosted U.S. Secretary of Transportation Pete Buttigieg, White House Climate Advisor Ali Zaidi and Robin Carnahan, Administrator of the General Service Administration. As part of the "Buy Clean" announcements, these officials held up Cliffs' Toledo DR Plant as an example of the type of innovative, forward-thinking, clean manufacturing investment that the "Buy Clean" policy is meant to spur.

Cliffs was particularly active in accommodating public official visits in 2022, hosting the following individuals, among others:

- U.S. Secretary of Energy, Jennifer Granholm
- U.S. Secretary of Transportation, Pete Buttigieg
- U.S. General Services Administrator, Robin Carnahan
- White House National Climate Advisor, Ali Zaidi
- U.S. Senator Rob Portman (Ohio)
- U.S. Representative Marcy Kaptur (Ohio)
- U.S. Representative Frank Mrvan (Indiana)
- U.S. Representative Chrissy Houlahan (Pennsylvania)
- U.S. Representative Max Miller (Ohio)
- U.S. Representative Warren Davidson (Ohio)
- U.S. Representative Tim Ryan (Ohio)
- U.S. Representative Bill Johnson (Ohio)
- U.S. Representative Mike Kelly (Pennsylvania)
- State Representative Dave Lislegard (Minnesota)
- State Representative Pat Boy (Indiana)
- State Senator Rodney Pols (Indiana)
- State Senator Scott Hutchinson (Pennsylvania)
- State Representative Paula Hicks-Hudson (Ohio)
- Dearborn Michigan Mayor Abdullah Hammoud

U.S. Secretary of Transportation Pete Buttigieg (middle) tours Cleveland-Cliffs Direct Reduction facility in Toledo, Ohio





U.S. Secretary of Energy Jennifer Granholm meets with Cleveland-Cliffs Chairman, President and Chief Executive Officer Lourenco Goncalves in Washington, D.C.

Value Chain Engagement

As a vertically integrated iron and steel producer, Cleveland-Cliffs manages a unique value chain both upstream and downstream. While we own and produce many of our raw materials, we rely on our suppliers to provide other critical materials necessary for the steelmaking process, as well as transportation of these materials and finished products.

Cliffs engages in due diligence on sourced raw materials in accordance with our Conflict Minerals Policy, as well as Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Protection Act relating to the use of conflict minerals. We cascade our expectations to our suppliers to adhere to our Code of Business Conduct and Ethics, Code of Conduct for Cliffs Suppliers, Human Rights Policy, Environmental Policy and Conflict Minerals Policy to ensure we are aligned in our shared values and responsible business practices. All of these documents are publicly available on our **corporate website.**

We engage with our suppliers to understand their sustainability performance. In 2022, we enhanced our supplier engagement program further by surveying our top suppliers (by total annual spend) to inquire about their own sustainability goals and targets. This engagement is driving meaningful dialogue between Cliffs and our top suppliers, which we aim to expand in the coming year. In addition, we improved our CDP Supplier Engagement Rating to an A-, demonstrating our leadership in engaging suppliers around sustainability.

Supplier Diversity

Maintaining a diverse supply chain is important to Cliffs. We believe that suppliers from diverse backgrounds bring unique perspectives to the table and innovative ideas to a critical industry with a long history. In 2022, we spent $365 million with diverse suppliers and have a target to increase this spend year over year. As we advance our business strategy and sustainability goals, we want to partner with suppliers that are not afraid to think outside the box.

$365M

Spent with diverse suppliers in 2022

Supplier Performance

As a key supplier in our own customers' value chains, Cliffs regularly responds to requests for information relative to our sustainability strategy and initiatives through various channels, including EcoVadis, a provider of business sustainability ratings. Cliffs is pleased to report that we retained our Silver medal for sustainability achievement in 2022 while increasing our overall scores. Where appropriate, we will continue to prioritize EcoVadis and other customer requests (such as CDP) as a way to uncover opportunities for collaboration in achieving shared sustainability goals.

Cleveland-Cliffs' performance as a valued supplier was recognized several times in 2022. Nissan awarded us their Monozukuri Spirit award at their Regional Supplier Appreciation and Awards event at The Country Music Hall of Fame and Museum. The Monozukuri Spirit award is given to suppliers that embrace the Monozukuri mindset: a cross-functional effort between purchasing, quality, supply chain, manufacturing, logistics, product planning, design and engineering that encourages a collaborative exchange of improvement ideas between Nissan and its suppliers. Monozukuri is the Japanese term for 'manufacturing', and the broader meaning encompasses a synthesis of technological prowess, know-how and spirit of Japan's manufacturing practices.

In June, representatives from Cliffs were recognized by Subaru of Indiana Automotive (SIA) for exceptional performance over the past year at their annual awards ceremony in the Greater Lafayette, Indiana area. Cleveland-Cliffs was awarded the Special Recognition Award – Excellence in Partnership for going above and beyond effort as identified by SIA management. SIA is Subaru's only manufacturing facility outside of Japan and currently makes the Ascent, Impreza, Legacy and Outback models for North America.

Cleveland-Cliffs is honored to be an EcoVadis silver award recipient, underscoring our commitment to corporate social responsibility and sustainable procurement.

Cleveland-Cliffs representatives accept the Special Recognition Award — Excellence in Partnership from Subaru of Indiana Automotive



Spotlight On: Hightowers Petroleum Co.

Yudell Hightower was on his way to Detroit for a job at Chrysler when his train made a stop in Middletown, Ohio. He had a few friends here and decided to stay, taking a job at Armco Steel (now Cleveland-Cliffs). While working at Armco, Yudell began building his fuel business in 1957. In 1982, his son Stephen (Steve) built upon the family's legacy business by founding Hightowers Petroleum Co. (HPC) as a wholesale fuel distributor. From there, the business has evolved and grown into an energy solutions enterprise that serves customers across 42 states.

HPC began delivering gasoline and diesel fuel to Middletown Works in 2009. Since then, we have expanded our partnership to include multiple sites with plans to add more in 2023. HPC serves several of our automotive customers, which helps create synergies in understanding the operational demands of heavy manufacturing. Having found a niche in these types of markets, HPC recognizes the need for timeliness and standardization in the products it delivers, and strives for continuous improvement through programs like ISO certification.

When asked about the relationship between Cliffs and HPC, Chief Operating Officer Stephen L. Hightower II said the companies have 'grown together.' "Each plant operates differently and with different needs, and HPC has learned to adapt to these varied needs to work with existing suppliers to create efficiencies for Cliffs," Stephen said. He believes that Cliffs and HPC share the same values of treating suppliers with respect, fostering two-way dialogue to work through issues and creating opportunities for mutual success over the long-term.

Sustainability is an important shared value, and HPC is walking the talk. They are a U.S. EPA SmartWay program member, which helps companies advance supply chain sustainability by measuring, benchmarking and improving freight transportation efficiency. This helps HPC and its carrier partners determine the most efficient routes for product delivery. HPC also has an in-house professional dedicated to sustainability, and the company plans to publish its first ESG report in 2023. Stephen believes that growth occurs through innovation, and HPC continues to evolve its business with the changing landscape. For example, HPC recently partnered with one of the largest producers of renewable diesel with the goal of building a distribution infrastructure network across the United States to serve customers in the Midwest and beyond. HPC has also established a turnkey EV charging company as the world moves toward EV adoption.

With all the success the Hightower family has achieved over the last 60 years, they are most proud of having built a business in which the whole family can participate. And, the business provides the opportunity to give back to the city of Middletown. Stephen organized a group that helped raise $8 million to rebuild the Robert "Sonny" Hill Jr. Community Center, one of the oldest and most recognizable institutions in Middletown, originally founded by Armco Steel in 1947. Cliffs values like-minded companies like HPC for continued future success.



Members of the Hightowers family who lead the family business

PERFORMANCE METRICS

Performance metrics for 2020 and 2021 are listed in the following tables as reported in our Sustainability Report 2020 and Sustainability Report 2021, respectively, at the time of each report publishing. Performance metrics listed for 2022 cover the calendar year ending December 31, 2022.

Environmental Performance

Metric	2020	2021	2022	Units
Energy				
Total energy consumed	349,909,354	439,929,345	380,523,579	Gigajoules
Grid electricity consumption	30,552,696	38,099,122	33,113,203	Gigajoules
Percentage of energy from grid	9%	9%	9%	%
Purchased steam consumption	1,514,715	772,108	778,276	Gigajoules
Self-generated electricity	9,360,655	9,217,005	6,909,687	Gigajoules
Total fuel consumed	317,841,943	401,058,115	344,530,118	Gigajoules
Percentage coal and coke	55%	49%	45%	%
Percentage of natural gas	44%	49%	53%	%
Total energy intensity	23	26	25	Gigajoules/t crude steel
GHG Emissions & Air Quality				
Direct scope 1 GHG emissions	27.5	29.2	25.4	million metric tons CO_2e
Indirect scope 2 GHG emissions (location-based)	4.7	5.3	4.6	million metric tons CO_2e
Scope 1 and Scope 2 GHG emissions	32.2	34.5	30.0	million metric tons CO_2e
Scope 1 and 2 GHG emissions intensity (company-wide)	2.08	2.05	1.97	total t CO_2e/t crude steel
Scope 1 and 2 GHG emissions intensity (integrated BF/BOF average)	1.82	1.67	1.60	total t CO_2e/t crude steel
Scope 1 and 2 GHG emissions intensity (EAF average)	1.16	1.01	1.04	total t CO_2e/t crude steel
Nitrogen oxide (NO_x)	31,798	35,293	31,857	metric tons
Sulfur dioxide (SO_x)	17,871	19,790	16,474	metric tons
Volatile organic compounds (VOC)	2,050	2,881	2,625	metric tons
Carbon monoxide (CO)	121,294	151,273	127,106	metric tons
Particulate matter (PM)	12,094	18,246	15,649	metric tons
Particulate matter (PM_{10})	8,483	10,109	7,697	metric tons
Particulate matter ($PM_{2.5}$)	4,758	6,648	5,386	metric tons
HAPS	92	90	72	metric tons
Lead	3	4	3	metric tons
MnO	3	—	—	metric tons
PAHs	2	4	4	metric tons

Metric	2020	2021	2022	Units
Waste & Wastewater[5]				
Water intake total	1,567,560	1,165,435	1,092,703	Megaliters/thousand m^3
Surface water (fresh)	1,438,333	1,053,275	964,082	Megaliters/thousand m^3
Stormwater	98,546	72,974	88,710	Megaliters/thousand m^3
Ground water	10,440	12,446	11,402	Megaliters/thousand m^3
Produced municipal water	20,241	26,740	28,508	Megaliters/thousand m^3
Water discharge total	1,398,161	942,736	1,040,865	Megaliters/thousand m^3
Surface water (fresh)	1,391,021	933,564	1,033,353	Megaliters/thousand m^3
Municipal POTW	7,141	9,172	7,511	Megaliters/thousand m^3
Water consumption	169,398	222,698	51,838	Megaliters/thousand m^3
Water recycled	2,055,070	1,823,051	2,349,315	Megaliters/thousand m^3
Water recycled	57	156	215	%
Waste Management				
Hazardous waste generated	554,431	680,609	575,876	metric tons
Hazardous waste recycled	139,119	180,989	146,060	metric tons
Hazardous waste recycled	25	27	25	%
Hazardous waste disposal total	415,312	499,618	430,506	metric tons
Incineration (with energy recovery)	6	296	228	metric tons
Incineration (without energy recovery)	1,266	1,480	1,263	metric tons
Landfilling	19,222	14,520	17,359	metric tons
Other disposal	2,874	7,975	3,620	metric tons
Onsite other disposal	391,944	475,347	408,036	metric tons
Non-hazardous waste generated	2,547,220	2,092,430	2,508,822	metric tons
Non-hazardous waste recycled	1,446,025	1,017,969	1,136,523	metric tons
Non-hazardous waste recycled	57	49	45	%
Non-hazardous waste disposal total	1,101,195	1,074,699	1,372,300	metric tons
Incineration (with energy recovery)	11,372	9,518	7,208	metric tons
Incineration (without energy recovery)	165	358	158	metric tons
Landfilling	636,396	1,050,361	1,349,084	metric tons
Other disposal	449,507	14,254	15,573	metric tons
Onsite other disposal	3,755	208	276	metric tons

Metric	2020	2021	2022	Units
Environmental Capital Expenditures				
Environmental capital expenditures	33.5	62	133	Million USD
Spills				
Number of reportable spills	139	205	198	# of events
Total volume of reportable spills	138.8	113	134	m^3
Mining Reclamation				
Area reclaimed during the current year	46	80	246	hectares
Area disturbed during the current year	94	104	154	hectares
Area of land yet to be reclaimed	10,566	12,576	12,544	hectares
Total area of land reclaimed	2,140	2,399	2,585	hectares
Total mine facility footprint	33,394	33,286	33,333	hectares
Tailings & Overburden				
Overburden generated	136,900,274	135,844,084	158,473,916	metric tons
Tailings generated	55,229,309	66,138,322	52,347,232	metric tons

Social & Governance Performance

Disclosure Title	Metric	2020	2021	2022
Labor Practices				
Minimum notice periods regarding operational changes	Minimum number of weeks provided to employees prior to implementing significant operational changes that affect them	60 days	60 days	60 days
	Is notice period specified in collective bargaining agreements/contracts (Y/N)	Y	Y	Y
Percentage of employees covered by collective bargaining agreements, broken down by US or Foreign employees	Percentage of employees covered by collective bargaining agreements	72%	72%	70%
Number of strikes and lockouts	Number of strikes and lockouts	0	0	0
Duration of strikes and lockouts	Duration of strikes and lockouts	0	0	0

Disclosure Title	Metric	2020	2021	2022
Labor Practices				
Workers covered by an occupational health and safety management system	Number of employees and non-employees working onsite covered by an occupational health and safety management system based on legal requirements/recognized standards	30,790	31,472	35,381
	Percentage of employees and non-employees working onsite covered by an occupational health and safety management system based on legal requirements/recognized standards	98.6%	100.0%	100.0%
	Number of employees and non-employees working onsite covered by an occupational health and safety management system that has been internally audited	30,790	31,472	35,381
	Percentage of employees and non-employees working onsite covered by an occupational health and safety management system that has been internally audited	78.6%	100.0%	100.0%
	Number of employees and non-employees working onsite covered by an occupational health and safety management system that has been audited or certified by external party	28,178	15,940	17,112
	Percentage of employees and non-employees working onsite covered by an occupational health and safety management system that has been audited or certified by external party	78.6%	51.0%	48.0%
Work-related injuries	The number of fatalities as a result of work-related injury (employees)	0	2	2
	The rate of fatalities as a result of work-related injury (employees)	0.000	0.008	0.007
	The number of high-consequence work-related injuries (excluding fatalities) (employees)	86	124	122
	The rate of high-consequence work-related injuries (excluding fatalities) (employees)	0.34	0.47	0.42
	The number of recordable work-related injuries (employees)	328	407	436
	The rate of recordable work-related injuries (employees)	1.31	1.53	1.51
	The number of hours worked (employees)		53,224,430	57,847,953
	The number of fatalities as a result of work-related injury (onsite non-employees)	0	0	0
	The rate of fatalities as a result of work-related injury (onsite non-employees)	0.000	0.000	0.000
	The number of high-consequence work-related injuries (excluding fatalities) (onsite non-employees)	8	18	12
	The rate of high-consequence work-related injuries (excluding fatalities) (onsite non-employees)	0.14	0.27	0.16
	The number of recordable work-related injuries (onsite non-employees)	36	67	63
	The rate of recordable work-related injuries (onsite non-employees)	0.63	1.01	0.82
	The number of hours worked (onsite non-employees)	11,491,087	13,248,108	15,326,578
MSHA all-incidence rate		3.05	3.95	3.86
Near miss frequency rate (NMFR)		1.45	2.19	2.23
Average hours of health, safety, and emergency response training (employees)		8	20	28
Average hours of health, safety, and emergency response training (non-employees)		1	1	1

Disclosure Title	Metric	2020	2021	2022
Employee Engagement & DEI				
Diversity of governance bodies	Percent board of directors—female	33%	30%	30%
	Percent board of directors—male	67%	70%	70%
	Percent board of directors <30 years old	0%	0%	0%
	Percent board of directors 30-50 years old	8%	0%	0%
	Percent board of directors > 50 years old	92%	100%	100%
	Percent board of directors ethnically diverse	25%	30%	30%
Diversity of employees	Percent of female employees (non-union)	18%	20.4%	19.6%
	Percent of male employees (non-union)	82%	79.6%	80.4%
	Percent of female employees (union)	8%	8.7%	9.3%
	Percent of male employees (union)	92%	91.3%	90.7%
	Percent of employees <30 years old		11.7 %	12.9%
	Percent of employees 30-50 years old		49.3%	49.4%
	Percent of employees > 50 years old		39%	37.7%
	Percent of employees ethnically diverse		16.8%	17.5%
	Number of new hires <30 years old		1,324	1,376
	Number of new hires 30-50 years old		1,721	1,884
	Number of new hires > 50 years old		497	554
	Rate of new hires <30 years old		37.4%	36.1%
	Rate of new hires 30-50 years old		48.6%	49.4%
	Rate of new hires > 50 years old		14.0%	14.5%
	Number of new hires—female		552	604
	Number of new hires—male		3,035	3,212
	Rate of new hires—female		15.4%	15.8%
	Rate of new hires—male		84.6%	84.2%
	Salary Turnover		7.6%	2.7%
	Hourly Turnover		3.9%	8.4%
	Total Turnover		4.7%	11.1%
Supplier Diversity	Total diverse supplier spend	$288 million	$392 million	$365 million
Training & Development	Average hours of training on environmental, energy or technical topics for relevant employees		6	6
	Number of employees receiving training on company policy		100%	100%
	Number of employees receiving tuition reimbursement (whole or part)		63	59
	Number of employees in apprenticeship training programs	244	808	717

Disclosure Title	Metric	2020	2021	2022
Human Rights & Community Relations				
Operations with local community engagement, impact assessments, and/or development programs	Percentage of operations with implemented local community engagement, impact assessments, and/or development programs	100%	100%	100%
Charitable contributions	Total monetary charitable contributions (corporate and Foundation)	$6.5 million	$6.5 million	$7.4 million
	Total Monetary Employee Contributions (matching gifts to nonprofits)	$873,000	$495,000	$434,000
Percentage of (1) proved and (2) probable reserves in or near areas of conflict		0%	0%	0%
Percentage of (1) proved and (2) probable reserves in or near indigenous land		0%	0%	0%
Number of site shutdowns due to pending regulatory permits or other political delays related to community concerns, community or stakeholder resistance or protest, and armed conflict		0	0	0
Customer Welfare, Selling Practices and Product Labeling				
Incidents of non-compliance concerning the health and safety impacts of products and services		0	0	0
Incidents of non-compliance with regulations for product labeling		0	0	0
Incidents of non-compliance with regulations for marketing communications		0	0	0
Customer Privacy	Substantiated complaints concerning breaches of customer privacy and losses of customer data	0	0	0
Governance				
Communication and training covering anti-corruption policies and procedures	Percent of board members receiving communication and training on anti-corruption policies and procedures	100%	100%	100%
	Percent of employees receiving communication and training on anti-corruption policies and procedures	100%	100%	100%
Confirmed incidents of corruption and actions taken		0	0	0
Production in countries with 20 lowest rankings in Transparency International's Corruption Perception Index (metric tons)		0	0	0
Competitive Behavior				
Legal actions for anti-competitive behavior, anti-trust, and monopoly practices	Number of legal actions pending or completed for anti-competitive behavior and violations of anti-trust and monopoly laws	Zero Agency Actions	Zero Agency Actions	Zero Agency Actions

STATEMENT OF GREENHOUSE GAS (GHG) EMISSIONS

Management of Cleveland-Cliffs Inc. (Cliffs or the Company) is responsible for the completeness, accuracy and validity of the Statement of GHG Emissions. Management is also responsible for the collection, calculation and presentation of the information included in the Statement of GHG Emissions and for the selection of the criteria, which management believes provide an objective basis for measuring and reporting on the Statement of GHG Emissions.

Management asserts that the Statement of GHG Emissions for the year ended December 31, 2022 are presented in accordance with The Greenhouse Gas Protocol: *A Corporate Accounting and Reporting Standard (Revised Edition*), published by the World Resources Institute/World Business Council for Sustainable Development.

Information outside of the Statement of GHG Emissions, including linked information, was not subject to Deloitte & Touche LLP's review and, accordingly, Deloitte & Touche LLP does not express a conclusion or any form of assurance on such information. Further, any information relating to periods prior to the calendar year ended December 31, 2022, or information relating to forward-looking statements, targets, goals and progress against goals, was not subject to Deloitte & Touche LLP's review and, accordingly, Deloitte & Touche LLP does not express a conclusion or any form of assurance on such information.

Base Year

Cleveland-Cliffs measures progress toward our GHG emissions reduction goal against a base year of 2017. The base year of 2017 was chosen, as this is the year the company began its GHG reduction journey and announced the strategic plan to begin construction of the Toledo IronUnits Direct Reduced Iron facility. The 2017 base year includes consolidated Scope 1 and Scope 2 location-based emissions. If significant changes occur in the configuration of Cliffs assets or if significant emission changes are found that make a material impact on our footprint, the base year will be recalculated to reflect those changes. These changes may include, but are not limited to, transfers of ownership that necessitate the merging of reduction targets or emissions, structural changes in the company that may impact base year emissions, the outsourcing and insourcing of emitting activities, significant adjustment of calculation methodologies, or the discovery of significant errors (individually or collectively) which Cliffs determines to have a material impact on the reported emissions footprint.

Targets

For discussion of Cleveland-Cliffs' GHG emissions reduction targets see the Climate & GHG Emissions section of the Sustainability Report 2022.

Boundary

Cleveland-Cliffs' organizational GHG boundary includes emissions from its production facilities under operational control. In the case where ownership is shared and Cliffs has operational control of the asset, reporting includes the entirety of emissions from this facility. Locations and emissions not included in the boundary definition are de minimis emissions sources that are expected to be insignificant compared the company's Scope 1 and 2 footprint such as stand-alone offices or shutdown legacy locations undergoing remediation, reclamation and/or redevelopment. Variable Interest Entities (VIE), where Cliffs does not have ownership and operational control, are excluded from the organizational GHG boundary. Cliffs reports consolidated Scope 1 and Scope 2 GHG emissions representing approximately 70 facilities.

Calculation Methodologies

When calculating Scope 1 emissions, data is collected from facilities within multiple data systems following internal processes for corporate level consolidation. Calculation methodologies for site level stationary Scope 1 emissions are based upon the applicable regulatory requirements of individual facilities including **US EPA 40 CFR 98**. Regulatory-required emissions factors are prioritized and where these do not exist, other published factors and calculation methodologies are used, including **US EPA Factor Hub** and Canada's National Inventory Report. Cliffs consolidated Scope 1 emissions include emissions from Cliffs-operated mobile equipment. Mobile Scope 1 emissions are determined using facility fuel consumption volumes and US EPA emission factors from the aforementioned US EPA Factor Hub.

Consolidated Scope 2 emissions in the covered GHG Emissions statement are determined using location-based methodology for Scope 2 accounting. Emissions are calculated by multiplying the amount of company-purchased utilities consumed by the appropriate regional factors for that geographic location. The most recently published **US EPA eGRID** factors (eGrid2021) are used for US-based locations. Factors from Canada's National Inventory Report 1990-2020 are used for Canada-based locations. Scope 2 market-based emissions will be reported separately later this year once supplier emission factor data is fully available. Market-based emissions do not significantly differ from location-based emissions.

Global Warming Potential (GWP)

Global Warming Potential (GWP) factors were developed to measure the amount of energy the emissions of one ton of gas will absorb relative to one ton of carbon dioxide. For both Scope 1 and Scope 2 emissions, Cleveland-Cliffs uses the IPCC Fourth Assessment Report (AR4) 100-year GWP values outlined in US EPA 40 CFR 98 for all data, including the base year, to maintain consistency between disclosures.

Gas	100-Year GWP
CH_4	25
N_2O	298

GHG Emissions Report

Reported emissions are based on the calendar year January 1 to December 31, 2022. The following emissions statement includes three of the seven GHG emissions covered under UNFCCC/Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Cliffs does not have emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfurhexafluoride (SF_6), or nitrogen trifluoride (NF_3). Emissions are reported in metric tons and metric tons of carbon dioxide equivalents (CO_2e). Emissions data for direct CO_2 emissions from biologically sequestered carbon (e.g., CO_2 from burning biomass/biofuels), are reported separately from the scopes. No biogenic emissions were applicable in CY2022.

Cleveland-Cliffs Consolidated GHG Emissions for CY2022 and Base Year
(Million Metric Tons of CO_2e)

	Base Year 2017	CY2022
Scope 1	35.5	25.4
Scope 2 (Location-Based)	8.6	4.6
Gross Scope 1 and 2 (Location-Based)	44.1	30.0

Cleveland-Cliffs Consolidated Scope 1 Emissions by GHG for CY2022

Greenhouse Gas	Million Metric Tons	Million Metric Tons of CO_2e
Carbon Dioxide	25.3	25.3
Methane	0.0	0.1
Nitrous Oxide	0.0	0.0

Cleveland-Cliffs Consolidated Scope 2 Location-Based Emissions by GHG for CY2022

Greenhouse Gas	Million Metric Tons	Million Metric Tons of CO_2e
Carbon Dioxide	4.6	4.6
Methane	0.0	0.0
Nitrous Oxide	0.0	0.0

LIMITED ASSURANCE REPORT

Independent Accountant's Review Report
Management of Cleveland-Cliffs Inc.
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We have reviewed management of Cleveland-Cliffs Inc.'s (the "Company") assertion that the accompanying Statement of Greenhouse Gas (GHG) Emissions for the year ended December 31, 2022 (the "Statement of GHG Emissions") is presented in accordance with the Greenhouse Gas Protocol: *A Corporate Accounting and Reporting Standard (Revised Edition)*, published by the World Resources Institute/World Business Council for Sustainable Development (the "GHG Protocol"). The Company's management is responsible for its assertion. Our responsibility is to express a conclusion on management's assertion based on our review.

Our review was conducted in accordance with attestation standards established by the American Institute of Certified Public Accountants (AICPA) in AT-C section 105, *Concepts Common to All Attestation Engagements*, and AT-C section 210, *Review Engagements*. Those standards require that we plan and perform the review to obtain limited assurance about whether any material modifications should be made to management's assertion in order for it to be fairly stated. The procedures performed in a review vary in nature and timing from, and are substantially less in extent than, an examination, the objective of which is to obtain reasonable assurance about whether management's assertion is fairly stated, in all material respects, in order to express an opinion. Accordingly, we do not express such an opinion. Because of the limited nature of the engagement, the level of assurance obtained in a review is substantially lower than the assurance that would have been obtained had an examination been performed. We believe that the review evidence obtained is sufficient and appropriate to provide a reasonable basis for our conclusion.

We are required to be independent and to meet our other ethical responsibilities in accordance with the Code of Professional Conduct issued by the AICPA. We applied the Statements on Quality Control Standards established by the AICPA and, accordingly, maintain a comprehensive system of quality control.

The procedures we performed were based on our professional judgment. In performing our review, we performed analytical procedures and inquiries. For a selection of the disclosures within the Statement of GHG Emissions, we performed tests of mathematical accuracy of computations, compared amounts to underlying records, or observed the data collection process.

The preparation of the Statement of GHG Emissions requires management to interpret the GHG Protocol, make determinations as to the relevancy of information to be included, and make estimates and assumptions that affect the reported information. Measurement of Scope 1 and Scope 2 GHG emissions includes estimates and assumptions that are subject to inherent measurement uncertainty resulting, for example, from accuracy and precision of GHG emission conversion factors. Obtaining sufficient, appropriate review evidence to support our conclusion does not reduce the inherent uncertainty in the amounts and disclosures. The selection by management of different but acceptable measurement methods, input data, or assumptions, may have resulted in materially different amounts or disclosures being reported.

Our review was limited to the disclosures in the Statement of GHG Emissions. All other information presented within the Company's Sustainability Report, including linked information, any information relating to periods prior to the year-ended December 31, 2022, or information relating to forward looking statements, targets, goals and progress against goals, was not subject to our review. Accordingly, we do not express a conclusion or any form of assurance on such information.

Based on our review, we are not aware of any material modifications that should be made to management of Cleveland-Cliffs Inc.'s assertion that the accompanying Statement of GHG Emissions of Cleveland-Cliffs Inc. for the year ended December 31, 2022 is presented in accordance with the GHG Protocol, in order for it to be fairly stated.

Deloitte & Touche LLP

April 3, 2023

CONTENT INDEX

The Cleveland-Cliffs 2022 Sustainability Report provides a comprehensive overview of the Company's ESG programs and performance. All disclosures in this Table refer to the GRI Standards, published in 2016, and subsequent updates, as well as the Iron & Steel and Metals & Mining SASB Standards, published in 2018, and subsequent updates.

GRI Index

GRI Standard	Disclosure	#	Location of Content
General Disclosures 2021			
Organization and reporting practices	Organizational details	2-1	About Cleveland-Cliffs
	Entities included in the organizations' sustainability reporting	2-2	About Cleveland-Cliffs
	Reporting period, frequency and contact point	2-3	About This Report
	External Assurance	2-5	Statement of GHG Emissions
Activities and workers	Activities, value chain and other business relationships	2-6	Steel for a Sustainable Society; Value Chain Management
	Employees	2-7	Performance Metrics
Governance	Governance structure and composition	2-9	Corporate Governance
	Nomination and selection of the highest governance body	2-10	**Corporate Governance Guidelines**
	Chair of the highest governance body	2-11	Corporate Governance
	Role of the highest governance body in overseeing the management of impacts	2-12	**Strategy and Sustainability Committee Charter**
	Delegation of responsibility for managing impacts	2-13	**Corporate Governance Guidelines**
	Role of the highest governance body in sustainability reporting	2-14	**Strategy and Sustainability Committee Charter**
	Conflicts of interest	2-15	**Conflict of Interest Policy; Cleveland-Cliffs 2023 Proxy Statement**
	Communication of critical concerns	2-16	**Cleveland-Cliffs 2023 Proxy Statement; Performance Metrics**
	Collective knowledge of the highest governance body	2-17	**Cleveland-Cliffs 2022 Form 10-K**
	Evaluation of the performance of the highest governance body	2-18	**Corporate Governance Guidelines**
	Remuneration policies	2-19	**Cleveland-Cliffs 2022 Form 10-K**
	Process to determine remuneration	2-20	**Cleveland-Cliffs 2022 Form 10-K**
	Annual total compensation ratio	2-21	**Cleveland-Cliffs 2022 Form 10-K**
Strategy, policies and practices	Statement on sustainable development strategy	2-22	Letter From Lourenco
	Policy commitments	2-23	Core Values, Ethics & Compliance
	Embedding policy commitments	2-24	Acting With Integrity
	Process to remediate negative impacts	2-25	Community Engagement; Core Values, Ethics & Compliance
	Mechanisms for seeking advice and raising concerns	2-26	Core Values, Ethics & Compliance
	Compliance with laws and regulations	2-27	Performance Metrics
	Membership assocations	2-28	Public Policy & Advocacy
Stakeholder engagement	Approach to stakeholder engagement	2-29	Connecting with Our Communities
	Collective bargaining agreements	2-30	Performance Metrics

GRI Standard	Disclosure	#	Location of Content
Topic Standards			
Economic Performance 2016	Direct economic value generated and distributed	201-1	**Cleveland-Cliffs 2022 Form 10-K**
	Financial implications and other risks and opportunities due to climate change	201-2	**Cleveland-Cliffs 2022 Form 10-K; Climate & GHG Emissions**
	Defined benefit plan obligation and other retirement plans	201-3	**Cleveland-Cliffs 2022 Form 10-K**
Indirect Economic Impacts 2016	Infrastructure investments and services supported	203-1	Community Engagement
Anti-Corruption 2016	Operations assessed for risks related to corruption	205-1	Enterprise Risk Management; Performance Metrics
	Communication and training about anti-corruption policies and procedures	205-2	Core Values, Ethics & Compliance; Performance Metrics
	Confirmed incidents of corruption and actions taken	205-3	Performance Metrics
Anti-competitive Behavior 2016	Legal actions for anti-competitive behavior, anti-trust, and monopoly practices	206-1	Performance Metrics
Materials 2016	Recycled input materials used	301-2	Steel for a Sustainable Society
Energy 2016	Energy Consumption within the organization	302-1	Performance Metrics
	Energy consumption outside the organization	302-2	Performance Metrics
	Energy intensity	302-3	Performance Metrics
	Reduction of energy consumption	302-4	Energy
Water & Effluents 2018	Interactions with water as a shared resource	303-1	Water & Wastewater
	Management of water discharge-related impacts	303-2	Water & Wastewater
	Water withdrawal	303-3	Performance Metrics
	Water discharge	303-4	Performance Metrics
	Water consumption	303-5	Performance Metrics
Biodiversity 2016	Habitats protected or restored	304-3	Land Management & Biodiversity; Performance Metrics
Emissions 2016	Direct (Scope 1) GHG emisisons	305-1	Performance Metrics; Statement of GHG Emissions
	Energy indirect (Scope 2) GHG emissions	305-2	Performance Metrics; Statement of GHG Emissions
	Other indirect (Scope 3) GHG emissions	305-3	**2022 CDP Climate Change**
	GHG emissions intensity	305-4	Performance Metrics
	Reduction of GHG emissions	305-5	Climate & GHG Emissions; Performance Metrics
	Nitrogen oxides, sulfur oxides, and other significant air emissions	305-7	Performance Metrics
Waste 2020	Waste generation and significant waste-related impacts	306-1	Waste & Hazardous Materials
	Management of significant waste-related impacts	306-2	Steel for a Sustainable Society; Waste & Hazardous Materials
	Waste generated	306-3	Performance Metrics
	Waste diverted from disposal	306-4	Performance Metrics
	Waste directed to disposal	306-5	Performance Metrics

GRI Standard	Disclosure	#	Location of Content
Topic Standards			
Supplier Environmental Assessment 2016	New suppliers that were screened using environmental criteria	308-1	Value Chain Engagement
Employment 2016	New employee hires and employee turnover	401-1	Performance Metrics
	Benefits provided to full-time employees that are not provided to temporary or part-time employees	401-2	Talent Management
Labor/Management Relations 2016	Minimum notice periods regarding operational changes	402-1	Performance Metrics
Occupational Health and Safety 2018	Occupational health and safety management system	403-1	Health & Safety
	Hazard identification, risk assessment, and incident investigation	403-2	Health & Safety
	Occupational health services	403-3	Health & Safety
	Worker participation, consultation, and communication on occupational health and safety	403-4	Health & Safety
	Worker training on occupational health and safety	403-5	Health & Safety
	Promotion of worker health	403-6	Health & Safety
	Workers covered by an occupational health and safety management system	403-8	Performance Metrics
	Work-related injuries	403-9	Health & Safety; Performance Metrics
	Work-related ill health	403-10	Performance Metrics
Training and Education 2016	Average hours of training per year per employee	404-1	Performance Metrics
	Programs for upgrading employee skills and transition assistance programs	404-2	Talent Management; Performance Metrics
Diversity and Equal Opportunity 2016	Diversity of governance bodies and employees	405-1	Corporate Governance; Performance Metrics
Local Communities 2016	Operations with local community engagement, impact assessments, and development programs	413-1	Community Engagement; Performance Metrics
Supplier Social Assessment 2016	New suppliers that were screened using social criteria	414-1	Value Chain Engagement
Customer Health and Safety 2016	Incidents of non-compliance concerning the health and safety impacts of products and services	416-2	Performance Metrics
Marketing and Labeling 2016	Incidents of non-compliance concerning product and service information and labeling	417-2	Performance Metrics
	Incidents of non-compliance concering marketing communications	417-3	Performance Metrics
Customer Privacy 2016	Substantiated complaints concering breaches of customer privacy and losses of customer data	418-1	Performance Metrics

SASB Index

Topic	Accounting Metric	Code	Location of Content
Greenhouse Gas Emissions	Gross global Scope 1 emissions, percentage covered under emissions-limiting regulations	EM-MM-110a.1 EM-IS-110a.1	Performance Metrics
	Discussion of long-term and short-term strategy or plan to manage Scope 1 emissions, emissions reduction targets, and an analysis of performance against those targets	EM-MM-110a.2 EM-IS-110a.2	Climate & GHG Emissions
Air Quality	Air emissions of the following pollutants: (1) CO (2) NOx (excluding N2O) (3) SOx (4) particulate matter (PM10) (5) mercury (Hg) (6) lead (Pb) (7) volatile organic compounds (VOCs) (8) manganese (MnO) (9) polycyclic aromatic hydrocarbons (PAHs)	EM-MM-120a.1 EM-IS-120a.1	Performance Metrics
Energy Management	(1) Total energy consumed, (2) percentage grid electricity, (3) percentage renewable	EM-MM-130a.1 EM-IS-130a.1	Performance Metrics
	(1) Total fuel consumed (2) percentage coal (3) percentage natural gas (4) percentage renewable	EM-IS-130a.1	Performance Metrics
Water Management	(1) Total fresh water withdrawn (2) total fresh water consumed, percentage of each in regions with High or Extremely High Baseline Water Stress (3) percentage recycled	EM-MM-140a.1 EM-IS-140a.1	Water & Wastewater; Performance Metrics
Waste & Hazardous Materials	Total weight of tailings produced	EM-MM-150a.5	Performance Metrics
	Total weight of waste generated, amount and percentage hazardous, percentage recycled	EM-MM-150a.7 EM-IS-150a.1	Performance Metrics
	Description of waste and hazardous materials management policies and procedures for active and inactive operations	EM-MM-150a.10	Waste & Hazardous Materials
Biodiveristy Impacts	Description of environmental management policies and practices for active sites	EM-MM-160a.1	Environmental Management
Security, Human Rights & Rights of Indigenous Peoples	Percentage of (1) proved and (2) probable reserves in or near areas of conflict	EM-MM-210a.1	Performance Metrics
	Percentage of (1) proved and (2) probable reserves in or near indigenous land	EM-MM-210a.2	Performance Metrics
Community Relations	Discussion of process to manage risks and opportunities associated with community rights and interests	EM-MM-210b.1	Community Engagement
Labor Relations	Percentage of active workforce covered under collective bargaining agreements, broken down by U.S. and foreign employees	EM-MM-310a.1	Labor Relations; Performance Metrics
	Number and duration of strikes and lockouts	EM-MM-310a.2	Labor Relations; Performance Metrics
Workforce Health & Safety	(1) MSHA all-incidence rate (2) fatality rate (3) near miss frequency rate (NMFR) (4) total recordable incident rate (TRIR) and (5) average hours of health, safety, and emergency response training for (a) full-time employees and (b) contract employees	EM-MM-320a.1 EM-IS-320a.1	Health & Safety; Performance Metrics

CONTENT INDEX

Topic	Accounting Metric	Code	Secondary Entry	Location of Content
Business Ethics & Transparency	Description of the management system for prevention of corruption and bribery throughout the value chain	EM-MM-510a.1		Core Values, Ethics & Compliance
	Production in countries that have the 20 lowest rankings in Transparency International's Corruption Perception Index	EM-MM-510a.2		Performance Metrics
Supply Chain Management	Discussion of the process for managing iron ore and/or coking coal sourcing risks arising from environmental and social issues	EM-IS-430a.1		**Cleveland-Cliffs 2022 Form 10-K**
Activity Metics	Production of (1) metal ores and (2) finished metal products	EM-MM-000.A		**Cleveland-Cliffs 2022 Form 10-K**
	Total number of employees, percentage contractors	EM-MM-000.B		Performance Metrics
	Raw steel production, percentage from: (1) basic oxygen furnace processes, (2) electric arc furnace processes	EM-IS-000.A		**Cleveland-Cliffs 2022 Form 10-K**
	Total iron ore production	EM-IS-000.B		**Cleveland-Cliffs 2022 Form 10-K**
	Total coking coal production	EM-IS-000.C		**Cleveland-Cliffs 2022 Form 10-K**

FORWARD-LOOKING STATEMENTS

This report contains statements that constitute "forward-looking statements" within the meaning of the federal securities laws. All statements other than historical facts, including, without limitation, statements regarding our current expectations, estimates and projections about our industry or our businesses, are forward-looking statements. We caution investors that any forward-looking statements are subject to risks and uncertainties that may cause actual results and future trends to differ materially from those matters expressed in or implied by such forward-looking statements. Investors are cautioned not to place undue reliance on forward-looking statements. Among the risks and uncertainties that could cause actual results to differ from those described in forward-looking statements are the following: continued volatility of steel, iron ore and scrap metal market prices, which directly and indirectly impact the prices of the products that we sell to our customers; uncertainties associated with the highly competitive and cyclical steel industry and our reliance on the demand for steel from the automotive industry, which has been experiencing supply chain disruptions, such as the semiconductor shortage, and higher consumer interest rates, which could result in lower steel volumes being demanded; potential weaknesses and uncertainties in global economic conditions, excess global steelmaking capacity, oversupply of iron ore, prevalence of steel imports and reduced market demand, including as a result of inflationary pressures, the COVID-19 pandemic, conflicts or otherwise; severe financial hardship, bankruptcy, temporary or permanent shutdowns or operational challenges of one or more of our major customers, including customers in the automotive market, key suppliers or contractors, which, among other adverse effects, could disrupt our operations or lead to reduced demand for our products, increased difficulty collecting receivables, and customers and/or suppliers asserting force majeure or other reasons for not performing their contractual obligations to us; disruptions to our operations relating to an infectious disease outbreak or the COVID-19 pandemic, including workforce challenges and the risk that novel variants will prove resistant to existing vaccines or that new or continuing lockdowns in China will impact our ability to source certain critical supplies in a timely and predictable manner; risks related to U.S. government actions with respect to Section 232 of the Trade Expansion Act of 1962 (as amended by the Trade Act of 1974), the United States-Mexico-Canada Agreement and/or other trade agreements, tariffs, treaties or policies, as well as the uncertainty of obtaining and maintaining effective antidumping and countervailing duty orders to counteract the harmful effects of unfairly traded imports; impacts of existing and increasing governmental regulation, including potential environmental regulations relating to climate change and carbon emissions, and related costs and liabilities, including failure to receive or maintain required operating and environmental permits, approvals, modifications or other authorizations of, or from, any governmental or regulatory authority and costs related to implementing improvements to ensure compliance with regulatory changes, including potential financial assurance requirements, and reclamation and remediation obligations; potential impacts to the environment or exposure to hazardous substances resulting from our operations; our ability to maintain adequate liquidity, our level of indebtedness and the availability of capital could limit our financial flexibility and cash flow necessary to fund working capital, planned capital expenditures, acquisitions, and other general corporate purposes or ongoing needs of our business; our ability to reduce our indebtedness or return capital to shareholders within the currently expected timeframes or at all; adverse changes in credit ratings, interest rates, foreign currency rates and tax laws, including adverse impacts as a result of the Inflation Reduction Act of 2022; the outcome of, and costs incurred in connection with, lawsuits, claims, arbitrations or governmental proceedings relating to commercial and business disputes, antitrust claims, environmental matters, government investigations, occupational or personal injury claims, property damage, labor and employment matters, or suits involving legacy operations and other matters; uncertain availability or cost, due to inflation or otherwise, of critical manufacturing equipment and spare parts; supply chain disruptions or changes in the cost, quality or availability of energy sources, including electricity, natural gas and diesel fuel, or critical raw materials and supplies, including iron ore, industrial gases, graphite electrodes, scrap metal, chrome, zinc, coke and metallurgical coal; problems or disruptions associated with transporting products to our customers, moving manufacturing inputs or products internally among our facilities, or suppliers transporting raw materials to us; the risk that the cost or time to implement a strategic or sustaining capital project may prove to be greater than originally anticipated; uncertainties associated with natural or human-caused disasters, adverse weather conditions, unanticipated geological conditions, critical equipment failures, infectious disease outbreaks, tailings dam failures and other unexpected events; cybersecurity incidents relating to, disruptions in, or failures of, information technology systems that are managed by us or third parties that host or have access to our data or systems, including the loss, theft or corruption of sensitive or essential business or personal information and the inability to access or control systems; liabilities and costs arising in connection with any business decisions to temporarily or indefinitely idle or permanently close an operating facility or mine, which could adversely impact the carrying value of associated assets and give rise to impairment charges or closure and reclamation obligations, as well as uncertainties associated with restarting any previously idled operating facility or mine; our level of self-insurance and our ability to obtain sufficient third-party insurance to adequately cover potential adverse events and business risks; uncertainties associated with our ability to meet customers' and suppliers' decarbonization goals and reduce our greenhouse gas emissions in alignment with our own announced targets; challenges to maintaining our social license to operate with our stakeholders, including the impacts of our operations on local communities, reputational impacts of operating in a carbon-intensive industry that produces greenhouse gas emissions, and our ability to foster a consistent operational and safety track record; our actual economic mineral reserves or reductions in current mineral reserve estimates, and any title defect or loss of any lease, license, easement or other possessory interest for any mining property; our ability to maintain satisfactory labor relations with unions and employees; unanticipated or higher costs associated with pension and OPEB obligations resulting from changes in the value of plan assets or contribution increases required for unfunded obligations; uncertain availability or cost of skilled workers to fill critical operational positions and potential labor shortages caused by experienced employee attrition or otherwise, as well as our ability to attract, hire, develop and retain key personnel; the amount and timing of any repurchases of our common shares; and potential significant deficiencies or material weaknesses in our internal control over financial reporting. Forward-looking and other statements in this report regarding our GHG reduction plans and goals are not an indication that these statements are necessarily material to investors or required to be disclosed. In addition, historical, current and forward-looking GHG-related statements may be based on standards for measuring progress that are still developing, internal controls and processes that continue to evolve and assumptions that are subject to change in the future. For additional factors affecting our business, refer to Part I – Item 1A. Risk Factors of our Annual Report on Form 10-K for the year ended December 31, 2022, and our other filings with the U.S. Securities and Exchange Commission.



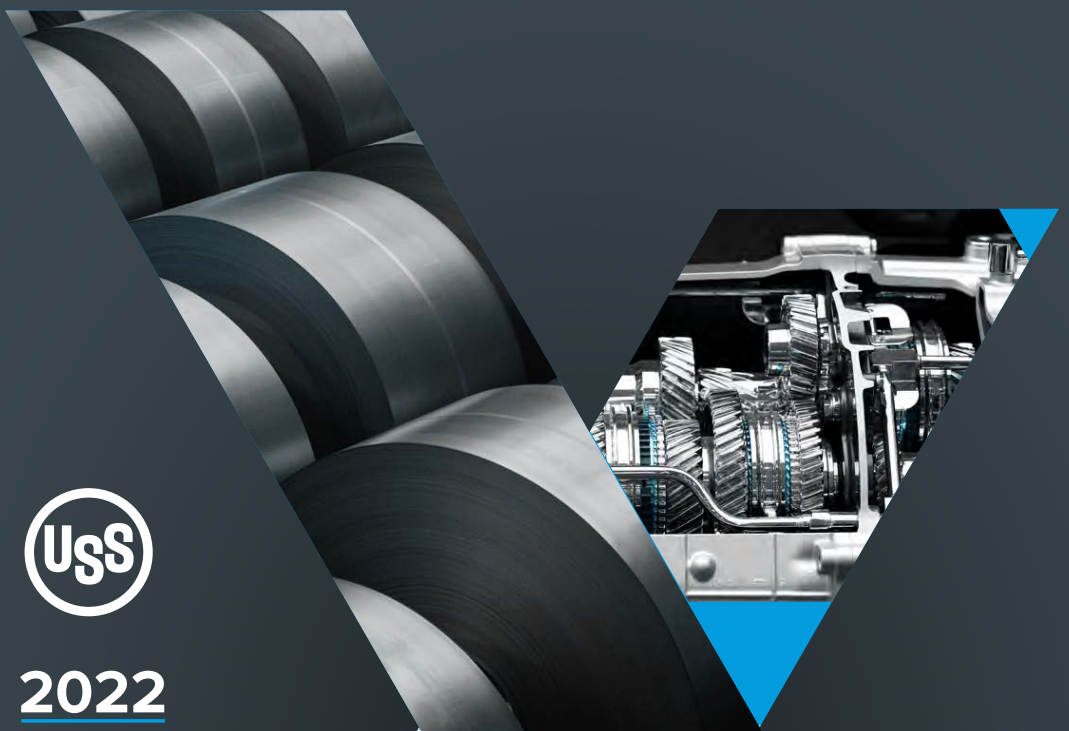
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BEST FOR ALL®



2022 Annual Report







BEST FOR ALL®

A Message From Our Chief Executive Officer

2022 was the second best year of financial performance in U. S. Steel's 122-year history, delivering profitable solutions by growing our competitive advantages, improving through-cycle performance and developing quality products that exceed our customers' needs. Our strategic execution, footprint optimization, financial strategy and operating improvements allowed us to deliver historically excellent financial results as we navigated market headwinds and uncertainty—from supply chain challenges, inflationary pressures and softening demand—to continue our transition to **Best for All®** faster. Our balanced approach to capital allocation allowed us to pass on our success to our stockholders, with approximately $900 million in direct returns in 2022 through our stock buyback program and quarterly dividends.

Our #1 core value is and always has been Safety First. In 2022, we improved yet again our industry-leading safety performance, with 0.05 OSHA Days Away from Work—our fourth consecutive year of a new record. This accomplishment, driven by our hard-working employees and their commitment to achieve a zero-injury environment, has not gone unnoticed. Both the National Safety Council and the World Steel Association (worldsteel) awarded U. S. Steel safety programs with Safety Excellence Awards. Notably, our USSK team has shown resiliency in a challenging year and provided unwavering support to those affected by the ongoing war in Ukraine, embodying our S.T.E.E.L. Principles as they provide aid to their neighbors. Thank you to all of our employees for your tireless commitment to safety.

Best for All Strategic Projects—On Time, On Budget

Best for All means providing our customers with profitable steel solutions while creating a more sustainable future for all our stakeholders. And we have put our money where our mouth is by pre-funding our strategic investments to get to the future faster. Our strategic projects provide the framework to growing our competitive advantages in low-cost iron ore, mini mill steelmaking, and best-in-class finishing capabilities as we reduce our carbon, cost and capital intensity.

This year, we focused on the advancement of our metallics strategy to expand our low-cost iron ore competitive advantage. We began this advancement by completing, ahead of schedule, a $60 million investment in our pig iron capabilities at Gary Works, which will produce up to 500,000 tons of pig iron annually and provide a critical raw material input for our electric arc furnaces. In addition, we broke ground on our facility to produce direct reduced (DR)-grade pellet capabilities at our Minnesota Ore Operations Keetac plant.

In February 2022, we broke ground in Osceola, Arkansas on the Company's next-generation sustainable and technologically advanced steel mill—the most advanced in North America and the largest private project in the history of Arkansas. The new facility is being constructed next to our existing Big River Steel facility, and is expected to feature two electric arc furnaces with three million tons per year of advanced steelmaking capability, a state-of-the-art endless casting and rolling line, and advanced finishing capabilities. Our team has been successfully mitigating inflationary headwinds to keep the project on-time and on-budget, with operations projected to begin at the end of 2024.

In addition to expanding our mini mill steelmaking capabilities, we continue to enhance our existing sustainable steel technology at Big River Steel in order to capture strategic market share. The construction of our non-grain oriented (NGO) electrical and coating lines at Big River Steel remain on-budget and on-time. Our NGO line is expected to be operational by third quarter this year and the coating line is expected to be operational by second quarter 2024.

See the "Strategic Investment in Competitive Advantages" page for more information about how these projects align with our sustainability goals.



Financial Strategy

The work we completed in 2022 has created a strong foundation and an unwavering commitment to continue to progress our Best for All strategy. Our objective remains to lower capital and carbon intensity while increasing value for our investors. Our balance sheet has been transformed, with no significant debt due until 2029. Our financial results in 2022 demonstrate the long-term value creation of our strategy, and I am bullish about our future as we enter 2023 from a position of strength.

We maintain historically high cash and liquidity and well-funded pension and OPEB plans, which along with our pre-funded investments give us confidence to continue to execute the transition to Best for All. Our 2022 free cash flow generation enabled balanced investment in high return growth projects, while returning 50% of free cash flow to stockholders through direct returns. In particular, 2022 demonstrated our resiliency to safely navigate market headwinds such as softened demand and lower prices, as our strategy focuses on through-cycle profitability. Management actions also bolster this execution as we make mindful adjustments to our integrated steelmaking footprint and leverage diverse end-market exposure.

In Closing

We greatly appreciate the invaluable support of all of our stakeholders—stockholders, customers, suppliers, employees and communities. The information contained in this Annual Report demonstrates the effectiveness of our Best for All strategy, and we look forward to continuing our journey to Best.

Now let's get back to work—safely.

David B. Burritt



$2.5B

Net earnings of $2.5 billion, or $9.16 per diluted share

$4.2B

Adjusted EBITDA of $4.2 billion

$5.9B

Liquidity of $5.9 billion, including cash of $3.5 billion

$1.8B

Free Cash Flow of $1.8 billion

34%

34% Return on Capital Employed (ROCE)

*Year-end 2022

Business Overview

Founded in 1901, U. S. Steel is a leading steel producer. With an unwavering focus on safety, the Company's customer-centric Best for All strategy is advancing a more secure, sustainable future for U. S. Steel and our stakeholders. We are executing on our strategy by investing where we have distinct cost and capability advantages to be a steel solutions provider for our customers.

By offering the sustainable steels that our customers are increasingly demanding, we are achieving world-competitive positioning in strategic, high-margin end markets, and delivering high-quality, value added products and innovative solutions utilizing a lower carbon footprint than previously only available through the traditional integrated steelmaking model.

Annual Raw Steel Production Capability (net tons)

22.4M

13.2M	3.3M	5.0M	0.9M
North American Flat Rolled	Mini Mill	U. S. Steel Europe	Tubular

Steel Customer Markets We Serve:

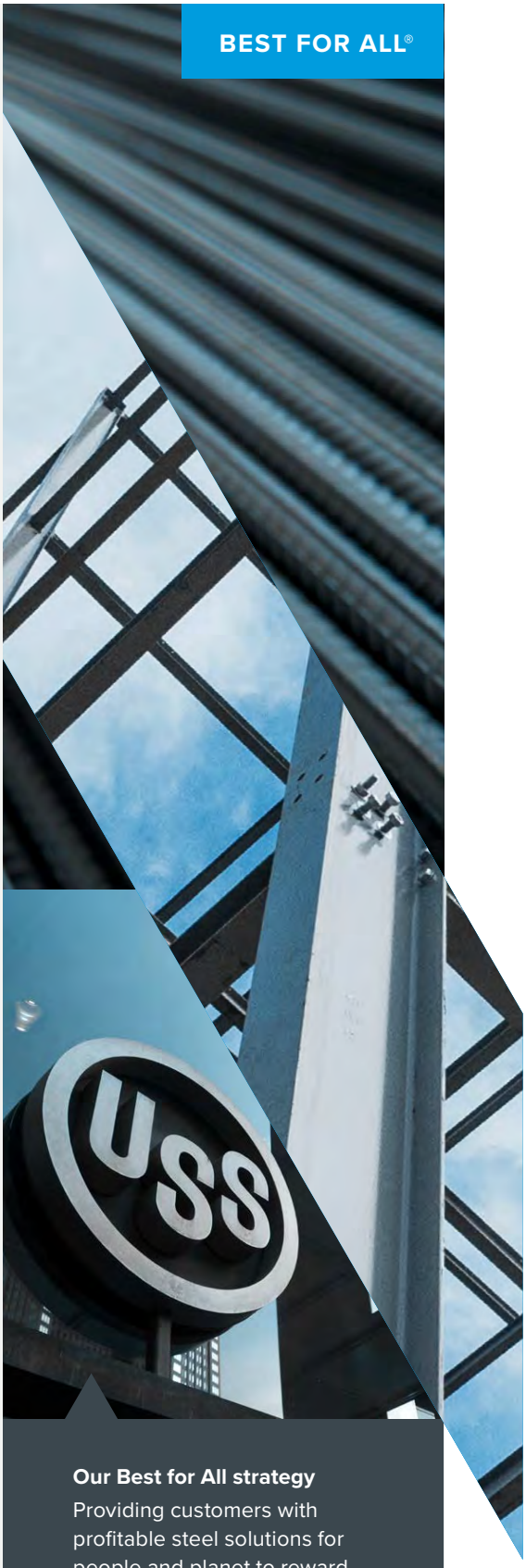
- Automotive & Transportation
- Construction
- Containers & Packaging
- Appliances & Electrical Equipment
- Service Centers/ Further Conversion
- Oil, Gas & Petrochemicals

Innovative Products

verdeX®— produced with up to **70%–80%** less Scope 1 and Scope 2 GHG emissions

Advanced high-strength steels (AHSS)— allow auto customers advancement in vehicle design, fuel efficiency and safety

Various coated steel sheet products— improve corrosion performance in cars, trucks, buildings, storage containers and numerous other applications



Our Best for All strategy
Providing customers with profitable steel solutions for people and planet to reward stockholders.

BEST FOR ALL®

Strategic Investment in Competitive Advantages

We are investing and focusing in areas where we have cost or capability advantages to differentiate U. S. Steel from the competition, while advancing our sustainability initiatives and supporting our customers.

Low-Cost Iron Ore

Our mining assets in Minnesota continue to provide a key competitive advantage through the delivery of low-cost iron units for our steelmaking facilities. We're strategically investing in them to develop a differentiated metallics strategy, which will provide higher quality raw materials to our growing EAF assets and provide supply chain resiliency with secure access to key production inputs. In addition, we completed our Gary Works pig iron project, which is expected to provide nearly 50% of Big River Steel's ore-based metallic needs.

Mini-Mill Steelmaking

We're continuing our transition to a mini mill footprint, expanding our Big River Steel Works with the construction of "Big River 2," our second 3-million-ton mini mill in Arkansas. BR2's capabilities will produce steel with lower carbon emissions and serve key end markets, including those central to the decarbonization of the automotive industry.

Best-in-Class Finishing

We're constructing new best-in-class finishing capabilities to complement those already located at our Gary Works and Pro-Tec joint venture. The NGO electrical steel line will open up new markets for our U.S. operations and support the growing electric vehicle demand. The coating line under construction at BRS will produce galvalume steel for exposed building panels and other high-end applications and hot-dipped galvanizing steel for appliance and construction, expanding our presence in value-added construction and improving our product mix in strategic markets.



Sustainability - ESG Highlights

Our Best for All strategy is aligned with our sustainability objectives, as we focus on sustainable steel solutions and industry-leading low-carbon process technologies. Our stakeholders, including our customers, investors, employees and the communities where we work and live, demand these solutions, and we continue to deliver with our transformative strategic execution. In 2022, we received recognition from several organizations for our sustainability efforts, including:

ResponsibleSteel™

In April 2022, Big River Steel achieved the first-ever ResponsibleSteel site certification in North America. The ResponsibleSteel Standard encompasses criteria in topics such as health and safety, greenhouse gas emissions, water stewardship and biodiversity, human rights, labor rights and community relations.

Human Rights Campaign (HRC)

Diversity, equity and inclusion continues to be an integral part of our business. For the third straight year, U. S. Steel received a perfect score of 100 on the HRC's Corporate Equality Index. This recognition also earned our company a designation as a "Best Place to Work for LGBTQ+ Equality."

Ethisphere

U. S. Steel was named one of the World's Most Ethical Companies® for 2022 by Ethisphere. This award recognizes companies based on an assessment of culture, environmental and social practices, ethics and compliance, governance, and leadership and reputation.

See our ESG Data Hub at
www.ussteel.com/sustainability/esg-data-hub for more information on our ESG performance.



Greenhouse Gas Reduction Goals (Scope 1 and Scope 2)

By 2030, 20% GHG emission intensity reduction, compared with the 2018 baseline year

By 2050, net-zero emissions





BEST FOR ALL®

U. S. Steel Leadership Team

Senior Leadership Team

David B. Burritt
President & Chief Executive Officer

Daniel R. Brown
Senior Vice President of Advanced Technology Steelmaking & Chief Operating Officer of Big River Steel Works

James E. Bruno
Senior Vice President – European Solutions & President – U. S. Steel Košice

Scott D. Buckiso
Senior Vice President & Chief Manufacturing Officer – North American Flat-Rolled Segment

Tara A. Carraro
Senior Vice President & Chief Communications Officer

Richard L. Fruehauf
Senior Vice President – Chief Strategy & Sustainability Officer

Christian J. Gianni
Senior Vice President & Chief Technology Officer

John T. Gordon
Senior Vice President, Raw Materials & Sustainable Resources

Jessica T. Graziano
Senior Vice President & Chief Financial Officer

Manpreet S. Grewal
Vice President & Controller

Duane D. Holloway
Senior Vice President, General Counsel & Chief Ethics & Compliance Officer

Kenneth E. Jaycox
Senior Vice President & Chief Commercial Officer

Board of Directors

Tracy A. Atkinson
Retired Executive Vice President & Chief Administrative Officer, State Street Corporation

Andrea J. Ayers
Retired President & CEO, Convergys Corporation

David B. Burritt
President & Chief Executive Officer, United States Steel Corporation

Alicia J. Davis
Chief Strategy Officer, Lear Corporation

Terry L. Dunlap
Principal, Sweetwater LLC

John J. Engel
Chairman & President, CEO, WESCO International, Inc.

John V. Faraci
Retired Chairman & Chief Executive Officer, International Paper

Murry S. Gerber
Retired Chairman & CEO, EQT Corporation

Jeh C. Johnson
Partner, Paul, Weiss, Rifkind, Wharton & Garrison

Paul A. Mascarenas
Retired Chief Technical Officer & Vice President, Ford Motor Company

Michael H. McGarry
Executive Chairman, PPG

David S. Sutherland
Retired President and CEO, IPSCO, Inc.

Patricia A. Tracey
Retired Vice President, Homeland Security & Defense Services, HP



Corporate Information

Corporate Headquarters

600 Grant Street, Pittsburgh, PA 15219

Transfer Agent

EQ Shareowner Services, 1110 Centre Point Curve
Suite 101, Mendota Heights, MN 55120-4100
Phone: (866) 443-4801, shareowneronline.com

Independent Registered Public Accounting Firm

PricewaterhouseCoopers LLP, Pittsburgh, PA

Stock Exchange Information

United States Steel Corporation's stock
Symbol is "X." The stock is listed on the
New York Stock Exchange (Principal Exchange)
And the Chicago Stock Exchange

Investor Relations

Kevin Lewis, Vice President – Finance
Phone: (412) 433-6935, Email: klewis@uss.com

Eric Linn, Director – Investor Relations
Phone: (412) 433-2385, Email: eplinn@uss.com

Corporate Communication

Tara Carraro, Senior Vice President & Chief Communications Officer Email: tcarraro@uss.com

Amanda Malkowski, Lead, Media Relations
Phone: (412) 433-2512, Email: almalkowski@uss.com

Annual Meeting Information

The 2023 Annual Meeting of Stockholders
Will be held virtually beginning at 8:00 a.m.
Eastern Time on Tuesday, April 25, 2023

Legal Disclaimer: We present earnings before interest, income taxes, depreciation and amortization (EBITDA) and adjusted EBITDA, which are non-GAAP measures, as additional measurements to enhance the understanding of our operating performance. We believe that EBITDA and adjusted EBITDA, considered along with net earnings, are relevant indicators of trends relating to our operating performance and provide management and investors with additional information for comparison of our operating results to the operating results of other companies. Adjusted EBITDA is a non-GAAP measure that excludes the effects of items that include: restructuring and other charges, asset impairment charges, losses (gains) on asset sold and previously held investments, gain on sale of Transtar, (gains) losses on debt extinguishment, tax impact of adjusted items, and other charges, net. We also present free cash flow, a non-GAAP measure of cash generated from operations, after any investing activity and dividends paid to stockholders. We believe that free cash flow provides further insight into the Company's overall utilization of cash. Please refer to the Forward-looking Statements and the non-GAAP Financial Measures section of our 4Q 2022 Earnings Release, dated February 2, 2023 for the reconciliations of adjusted EBITDA and free cash flow. The inclusion of information in this presentation should not be construed as a characterization regarding the materiality or financial impact (or potential impact) of that information or confirmation or other expectation that the actions described in this presentation (or related capital investments) will be taken within the time frame described, or at all.

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2022

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549
FORM 10-K

(Mark One)

☒ **ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the Fiscal Year Ended December 31, 2022
Or

☐ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**

For the transition period from to .

Commission file number 1-16811



United States Steel Corporation
(Exact name of registrant as specified in its charter)

Delaware	**25-1897152**
(State of Incorporation)	(I.R.S. Employer Identification No.)

600 Grant Street, Pittsburgh, PA 15219-2800
(Address of principal executive offices)
Tel. No. (412) 433-1121

Securities registered pursuant to Section 12 (b) of the Act:

Title of Each Class	Trading Symbol	Name of Exchange on which Registered
United States Steel Corporation Common Stock, par value $1.00	X	New York Stock Exchange
United States Steel Corporation Common Stock, par value $1.00	X	Chicago Stock Exchange

Securities registered pursuant to Section 12(g) of the Act: None

Indicate by check mark whether the registrant is a well-known seasoned issuer, as defined in Rule 405 of the Securities Act. Yes ☑ No ☐

Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or Section 15(d) of the Act. Yes ☐ No ☑

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15 (d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for at least the past 90 days. Yes ☑ No ☐

Indicate by check mark whether the registrant has submitted electronically every Interactive Data File required to be submitted pursuant to Rule 405 of Regulation S-T (§232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit such files). Yes ☑ No ☐

Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, a smaller reporting company, or emerging growth company. See the definition of “large accelerated filer,” “accelerated filer," “smaller reporting company” and "emerging growth company" in Rule 12b-2 of the Exchange Act.

Large accelerated filer ☒ Accelerated filer ☐ Non-accelerated filer ☐ Smaller reporting company ☐ Emerging growth company ☐

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Indicate by check mark whether the registrant has filed a report on and attestation to its management’s assessment of the effectiveness of its internal control over financial reporting under Section 404(b) of the Sarbanes-Oxley Act (15 U.S.C. 7262(b)) by the registered public accounting firm that prepared or issued its audit report. Yes ☑ No ☐

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Act). Yes ☐ No ☒

Aggregate market value of Common Stock held by non-affiliates as of June 30, 2022 (the last business day of the registrant’s most recently completed second fiscal quarter): $4.3 billion. The amount shown is based on the closing price of the registrant’s Common Stock on the New York Stock Exchange composite tape on that date. Shares of Common Stock held by executive officers and directors of the registrant are not included in the computation. However, the registrant has made no determination that such individuals are “affiliates” within the meaning of Rule 405 under the Securities Act of 1933.

There were 226,603,781 shares of United States Steel Corporation Common Stock outstanding as of January 30, 2023.

Documents Incorporated By Reference:

Portions of the Proxy Statement for the 2023 Annual Meeting of Stockholders are incorporated into Part III.

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FORWARD-LOOKING STATEMENTS

This report contains information that may constitute “forward-looking statements” within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. We intend the forward-looking statements to be covered by the safe harbor provisions for forward-looking statements in those sections. Generally, we have identified such forward-looking statements by using the words “believe,” “expect,” “intend,” “estimate,” “anticipate,” “project,” “target,” “forecast,” “aim,” “should,” "plan," "goal," "future," “will,” "may" and similar expressions or by using future dates in connection with any discussion of, among other things, the construction or operation of new or existing facilities or operating capabilities, the timing, size and form of share repurchase transactions, operating or financial performance, trends, events or developments that we expect or anticipate will occur in the future, statements relating to volume changes, share of sales and earnings per share changes, anticipated cost savings, potential capital and operational cash improvements, changes in the global economic environment, including supply and demand conditions, inflation, interest rates, supply chain disruptions and changes in prices for our products, international trade duties and other aspects of international trade policy, statements regarding our future strategies, products and innovations, statements regarding our greenhouse gas emissions reduction goals, statements regarding existing or new regulations and statements expressing general views about future operating results. However, the absence of these words or similar expressions does not mean that a statement is not forward-looking. Forward-looking statements are not historical facts, but instead represent only the Company’s beliefs regarding future events, many of which, by their nature, are inherently uncertain and outside of the Company’s control. It is possible that the Company’s actual results and financial condition may differ, possibly materially, from the anticipated results and financial condition indicated in these forward-looking statements. Management believes that these forward-looking statements are reasonable as of the time made. However, caution should be taken not to place undue reliance on any such forward-looking statements because such statements speak only as of the date when made. Our Company undertakes no obligation to publicly update or revise any forward-looking statements, whether as a result of new information, future events or otherwise, except as required by law. In addition, forward-looking statements are subject to certain risks and uncertainties that could cause actual results to differ materially from our Company's historical experience and our present expectations or projections. These risks and uncertainties include, but are not limited to the risks and uncertainties described in this report in “Item 1A. Risk Factors” and those described from time to time in our future reports filed with the Securities and Exchange Commission.

References in this Annual Report on Form 10-K to (i) "U. S. Steel," "the Company," "we," "us" and "our" refer to United States Steel Corporation and its consolidated subsidiaries unless otherwise indicated by the context, (ii) "Big River Steel" refers to Big River Steel Holdings LLC and its direct and indirect subsidiaries unless otherwise indicated by the context and (iii) "Transtar" refers to Transtar LLC and its direct and indirect subsidiaries unless otherwise indicated by the context.

Non-Generally Accepted Accounting Principles (non-GAAP) Financial Measures

This report contains the non-GAAP financial measure cash conversion cycle. We believe the cash conversion cycle is a useful measure in providing investors with information regarding our cash management performance and is a widely accepted measure of working capital management efficiency. The cash conversion cycle should not be considered in isolation or as an alternative to other GAAP metrics as an indicator of performance.

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PART I

Item 1. BUSINESS

United States Steel Corporation, with operations in the United States of America (U.S.) and Central Europe, is transforming itself into a customer-centric, world-competitive, Best for All® steelmaker by investing in the competitive advantages that differentiate us in our customers' eyes. We are executing on our strategy by investing where we have distinct cost and capability advantages so that we are a superior steel solutions provider for our customers. By offering the new steels that our customers are increasingly demanding, we aim to achieve world-competitive positioning in strategic, high-margin end markets and deliver high-quality, value-added products and innovative solutions utilizing a lower carbon footprint than previously available through our traditional integrated steelmaking model.

During 2022, U. S. Steel had annual raw steel production capability of 22.4 million net tons (17.4 million tons in North America and 5.0 million tons in Europe). U. S. Steel performs a wide range of applied research, development and technical support functions at facilities in Pennsylvania, Michigan, Texas and Slovakia. U. S. Steel supplies customers throughout the world primarily in the automotive, construction, consumer (packaging and appliance), electrical, industrial equipment, service center/ distribution, structural tubing and energy (oil country tubular goods (OCTG) and line pipe) markets. According to the worldsteel Association’s latest published statistics, U. S. Steel is the second largest U.S. based steel producer and the twenty-fourth largest steel producer in the world. U. S. Steel is a Delaware corporation established in 1901.

Segments

U. S. Steel has four reportable segments: North American Flat-Rolled (Flat-Rolled), Mini Mill, U. S. Steel Europe (USSE) and Tubular Products (Tubular). The Mini Mill segment reflects the full ownership of Big River Steel after January 15, 2021, when U. S. Steel purchased the remaining equity interest in Big River Steel that it did not previously own, and a second mini mill currently under construction in Osceola, Arkansas. Prior to the acquisition, the minority interest equity earnings of Big River Steel were included in the Other category. The Tubular segment includes the electric arc furnace at our Fairfield Tubular Operations in Fairfield, Alabama. The Other category includes results of our real estate business, the previously held equity method investment in Big River Steel, and our former Transtar business. On July 28, 2021, the Company sold 100% of the equity interests in Transtar, its short-line railroad business.

Flat-Rolled

The Flat-Rolled segment includes the operating results of U. S. Steel’s integrated steel plants and equity investees in North America involved in the production of slabs, strip mill plates, sheets and tin mill products, as well as all iron ore and coke production facilities in the United States. These operations primarily serve North American customers in the automotive, appliance, construction, container, pipe and tube, sheet converter, industrial equipment and service center markets.

During 2022, Flat-Rolled had aggregate annual raw steel production capability of 13.2 million tons at our Gary Works, Mon Valley Works, and Granite City Works facilities. In December 2021, U. S. Steel permanently idled the steelmaking operations at Great Lakes Works which reduced the Company's overall annual raw steel production capability by 3.8 million net tons. Raw steel production was 8.8 million tons in 2022, 9.9 million tons in 2021 and 9.3 million tons in 2020. Raw steel production averaged 67 percent of capability in 2022, 58 percent of capability in 2021 and 55 percent of capability in 2020.

Mini Mill

The Mini Mill segment includes the operating results of U. S. Steel's Big River Steel facility in North America and a second mini mill currently under construction in Osceola, Arkansas. The Mini Mill segment produces hot-rolled, cold-rolled and coated sheets and electrical steels. This operation primarily serves North American customers in the automotive, appliance, construction, container, pipe and tube, sheet converter, electrical, industrial equipment and service center markets.

Mini Mill has aggregate annual raw steel production capability of 3.3 million tons at our Big River Steel facility. Raw steel production was 2.7 million tons in 2022 and 2.7 million tons in 2021. Raw steel production averaged 80 percent of capability in 2022 and 81 percent of capability in 2021.

European Operations

The USSE segment includes the operating results of U. S. Steel Košice (USSK), U. S. Steel’s integrated steel plant and coke production facilities in Slovakia, and its subsidiaries. USSE conducts its business mainly in Central and Western Europe and primarily serves customers in the European transportation (including automotive), construction, container, appliance, electrical, service center, conversion and oil, gas and petrochemical markets. USSE produces and sells slabs, strip mill plate, sheet, tin mill products and spiral welded pipe.

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USSE has annual raw steel production capability of 5.0 million tons. USSE's raw steel production was 3.8 million tons in 2022, 4.9 million tons in 2021 and 3.4 million tons in 2020. USSE's raw steel production averaged 77 percent of capability in 2022, 99 percent of capability in 2021 and 67 percent of capability in 2020.

Tubular

The Tubular segment includes the operating results of U. S. Steel's tubular production facilities and an equity investee in the United States. These operations can produce and sell rounds, seamless and electric resistance welded (ERW) steel casing and tubing (commonly known as OCTG), and standard and line pipe and mechanical tubing and primarily serve customers in the oil, gas and petrochemical markets. The Tubular segment has annual raw steel production capability of 900 thousand tons. Raw steel production was 634 thousand tons in 2022, 464 thousand tons in 2021 and 16 thousand tons in 2020. Raw steel production averaged 70 percent of capability in 2022, 52 percent of capability in 2021 and 7 percent of capability in 2020. Tubular has total production capability of 1.9 million tons. In 2020, Tubular indefinitely idled the Lone Star Tubular Operations and Lorain Tubular Operations thereby effectively reducing on-line tubular production capacity by 790 thousand and 380 thousand tons, respectively. U. S. Steel Tubular Products LLC (USSTP), a wholly owned subsidiary of U. S. Steel, continues to design and develop a range of premium and semi-premium connections to address our customers' needs.

For further information, see "Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations" and Note 4 to the Consolidated Financial Statements.

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Steel Shipments by Market and Segment

The following table, except as noted in Footnote 1 below, does not include shipments to end customers by joint ventures and other equity investees of U. S. Steel. Shipments of materials to these entities are included in the "Further Conversion – Joint Ventures" market classification. No single customer accounted for more than 10 percent of gross annual revenue for the three consecutive years ended December 31, 2022.

(Thousands of Tons)	Flat-Rolled	Mini Mill	USSE	Tubular	Total
Major Market – 2022					
Steel Service Centers	**1,128**	**1,080**	**839**	**—**	**3,047**
Further Conversion – Trade Customers	**2,163**	**772**	**289**	**—**	**3,224**
– Joint Ventures [1]	**256**	**—**	**—**	**—**	**256**
Transportation and Automotive [1]	**2,611**	**20**	**619**	**—**	**3,250**
Construction and Construction Products	**922**	**310**	**1,052**	**30**	**2,314**
Containers and Packaging	**693**	**13**	**423**	**—**	**1,129**
Appliances and Electrical Equipment	**416**	**93**	**225**	**—**	**734**
Oil, Gas and Petrochemicals	**—**	**—**	**3**	**494**	**497**
All Other	**183**	**—**	**309**	**—**	**492**
TOTAL	**8,372**	**2,288**	**3,759**	**524**	**14,943**
Major Market – 2021					
Steel Service Centers	1,539	1,121	995	—	3,655
Further Conversion – Trade Customers	1,701	684	314	—	2,699
– Joint Ventures [1]	490	—	—	—	490
Transportation and Automotive [1]	2,355	17	590	—	2,962
Construction and Construction Products	1,224	282	1,346	18	2,870
Containers and Packaging	942	17	449	—	1,408
Appliances and Electrical Equipment	570	109	266	—	945
Oil, Gas and Petrochemicals	—	—	8	426	434
All Other	197	—	334	—	531
TOTAL	9,018	2,230	4,302	444	15,994
Major Market – 2020					
Steel Service Centers	1,450	—	690	—	2,140
Further Conversion – Trade Customers	2,063	—	202	—	2,265
– Joint Ventures [1]	415	—	—	—	415
Transportation and Automotive [1]	2,012	—	517	—	2,529
Construction and Construction Products	1,261	—	775	34	2,070
Containers and Packaging	913	—	435	—	1,348
Appliances and Electrical Equipment	497	—	194	—	691
Oil, Gas and Petrochemicals	—	—	5	430	435
All Other	100	—	223	—	323
TOTAL	8,711	—	3,041	464	12,216

[1] PRO-TEC automotive substrate shipments are included in the Transportation and Automotive category.

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Steel Industry Background and Competition

The global steel industry is cyclical, highly competitive and has historically been characterized by global overcapacity.

U. S. Steel's competitive position may be affected by, among other things, differences among U. S. Steel's and its competitors' cost structure, labor costs, environmental remediation and compliance costs, global capacity, achievement of innovations in new technologies and sustainable products and the existence and magnitude of government support.

U. S. Steel competes with many North American and international steel producers. Competitors include 1) integrated producers, which use iron ore and coke as the primary raw materials for steel production, 2) Electric Arc Furnace (EAF) producers, which primarily use steel scrap and other iron-bearing feedstocks as raw materials and 3) slab re-rollers, who purchase mostly imported, but some domestic, semi-finished products and convert them into sheet products. In addition, other materials, such as aluminum, plastics and composites, compete with steel in several applications. According to worldsteel Association, global steel production in 2022 declined compared to 2021, decreasing by 4 percent, or approximately 80 million metric tons, to 1.88 billion metric tons. Steel production generally decreased across the world, with the global decline primarily being driven by the top five steel producing countries and Ukraine, which collectively represents approximately 60 percent of the total global decline. Among the top five steel producing countries, production decreased in China by 22 million metric tons, or 2 percent; Japan by 7 million metric tons, or 7 percent; the U.S. by 5 million metric tons, or 6 percent; and Russia by 6 million metric tons, or 7 percent. These declines were partially offset however by India, which increased crude steel production by 7 million metric tons, or 5 percent, from 2021. Steel production in Ukraine decreased by 15 million metric tons, or 71 percent, from 2021 as a result of the Russian invasion and the impact of the ongoing conflict. The top five steel producing countries accounted for 73 percent of the world's steel production in 2022.

See "International Trade" below for a discussion of global overcapacity and the Company's efforts to mitigate the competitive impact.

EAF producers typically require lower capital expenditures for construction and operation of facilities and may have lower total employment costs. Some EAF producers utilize thin slab casting technology to produce flat-rolled products and are increasingly able to compete directly with integrated producers in many flat-rolled product applications previously produced only by integrated steelmakers. Slab re-rollers do not incur the cost of melting steel; their input costs are largely driven by the market price of slabs.

U. S. Steel provides defined benefit pension and/or other post-employment benefits to approximately 65,000 current employees, retirees and their beneficiaries. Many of our competitors do not have comparable retiree obligations. Participation in U. S. Steel's main defined benefit pension plan was closed to new entrants on July 1, 2003 and benefit accruals for all non-represented participants were frozen effective December 31, 2015. Participation in U. S. Steel’s retiree medical and life insurance programs for United Steelworkers (USW)-represented employees were closed to employees hired or rehired (except in limited circumstances) on or after January 1, 2016. For non-represented employees, retiree medical benefits were eliminated December 31, 2017, and retiree life insurance benefits for non-represented employees were eliminated for those who retired after December 31, 2017.

We believe that our major North American and many European integrated steel competitors are confronted with substantially similar environmental regulatory conditions and therefore do not believe that our relative position with regard to such competitors will be materially affected by the impact of environmental laws and regulations. However, if future regulations do not recognize that the integrated steel process involves a series of chemical reactions involving carbon that create carbon dioxide (CO_2) emissions without linking these emissions to steel scrap as well, the competitive position of our integrated operations will be adversely impacted compared to mini mills. Our competitive position compared to producers in developing nations such as China, Russia, Brazil and India will be harmed unless such nations require commensurate reductions in CO_2 emissions or there are policies to adjust for the carbon emissions disparities. Competing materials such as plastics may not be similarly impacted. The specific impact on each competitor will vary depending on a number of factors, including the age and location of its operating facilities and its production methods. U. S. Steel is also responsible for remediation costs related to former and present operating locations and disposal of environmentally sensitive materials. Many of our competitors, including North American producers, or their successors, that have been the subject of bankruptcy relief have no or substantially lower liabilities for such environmental remediation matters.

In 2023, we expect additional steelmaking capacity will enter the domestic steel market as competitors' growth projects come on-line or ramp up to full production in North America throughout the year.

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Business Strategy

We are executing on our customer-centric Best for All® strategy to provide customers with profitable steel solutions for people and planet. Our strategy is focused on developing quality products and customer process solutions by investing where we have distinct cost or capability competitive advantages. We are expanding our competitive advantages in low-cost iron ore, mini mill steelmaking, and best-in-class finishing assets with innovative solutions and commercial acumen. These competitive advantages are built on a foundation of research, innovation and deep customer relationships. In executing our strategy, we aim to enhance our earnings profile, deliver long-term cash flow through industry cycles and reduce our cost, capital, and carbon intensity. By offering the product capabilities, including the more sustainable steels (steels made with lower greenhouse gas emissions) our customers are increasingly demanding, we can achieve more competitive positioning in strategic, high-margin end markets, and deliver high-quality, sustainable, value-added products and innovative solutions.

Our strategy is informed by our critical success factors, which are the bedrock of the Best for All® strategy: (1) Win in Strategic Markets; (2) Move Up the Talent Curve; and (3) Move Down the Cost Curve. We are enhancing our competitive advantage in low-cost iron ore by expanding this advantage to serve our growing fleet of EAF producers (EAFs). We are currently investing in pig iron capability to enhance the efficiencies of our blast furnace operations as well as reduce the cost structure and reduce the global supply chain risk of our EAFs by increasingly feeding them with internally-produced pig iron. In the future, we may plan to further expand our low-cost iron ore advantage by incorporating in direct reduced iron (DRI) or hot briquetted iron (HBI) capabilities into our internal supply chain. We recently took an important step in this direction by investing in direct reduced (DR)-grade pellet capabilities to produce the feedstock for a potential future investment in DRI/HBI. We are also investing in new technologies to improve our cost position and increase our capabilities, including our mini mill steelmaking and best-in-class finishing capabilities. We will focus on strategic markets, where there is the greatest opportunity to provide differentiated, innovative and value-added solutions that will help our customers succeed. We know that to accomplish our objectives, we also need to continue to move up the talent curve. We are investing in our employees and providing the training and resources they need to succeed. This will help us reinforce a culture of caring, where accountability, fairness and respect are foundational, and high performance and inclusion in all its forms are valued and celebrated. See "Human Capital Management" below for additional information on our talent attraction, development, and retention initiatives.

U. S. Steel will continue to evaluate potential strategic and organizational opportunities, which may include the acquisition, divestiture or consolidation of assets. Given the cyclicality of our industry, we are focused on strategically deploying our capital, in-line with our capital allocation framework, in order to invest in areas consistent with the execution of our Best for All strategy and are considering various possibilities, including exiting lines of business and the sale of certain assets, that we believe would ultimately result in greater stockholder value. The Company will pursue opportunities based on its long-term strategy that is aligned with what is in the best interests of the Company's stockholders.

Strategic Projects, Technology Investments and Operating Configuration Adjustments

Throughout 2022, the Company continued to advance its Best for All strategy. On January 11, 2022, the Company announced Osceola, Arkansas as the site of a new sustainable and technologically advanced steel mill. The planned mini mill is expected to have about 3 million tons per year of steelmaking capability, and will combine two state-of-the-art EAFs with differentiated steelmaking and finishing technology, including endless casting and rolling equipment and a planned advanced high-strength steel (AHSS) finishing line. The Company is working with the same technical advisors and engineers who were instrumental in the successful construction of the adjacent Big River Steel facilities. Upon completion, we expect that this project will apply to become LEED® certified. We believe that the continued adoption of mini mill technology will expand our ability to produce the next generation of proprietary sustainable steel solutions, including AHSS. The project is expected to be completed in 2024.

In the second quarter 2022, the Company began the construction of a pig iron caster at our Gary Works facility. The approximately $60 million capital investment will produce up to 500,000 tons of pig iron annually and provide a critical raw material input for the Company's EAFs. The Gary Works pig iron project is expected to provide nearly 50 percent of Big River Steel’s ore-based metallics needs and deliver an internal rate of return in excess of 30 percent. Pig iron production at Gary Works and shipments to Big River Steel began in the fourth quarter 2022.

In the third quarter 2022, the Company began construction of a DR grade pellet facility at its Keetac ore operations. The approximately $150 million investment is expected to be operational in 2024. In addition to producing DR-grade pellets to ultimately feed EAFs with DRI or HBI, the production facility will maintain flexibility to continue producing blast furnace grade pellets. Upon completion, the Company could also sell the DR-grade pellets to third-party DRI or HBI producers. The DR-grade pellets produced will be a new product line for U. S. Steel.

In August 2021, the Company commenced construction on a non-grain oriented (NGO) electrical steel line at Big River Steel. The Company expects this $450 million investment to make Big River Steel a leader in NGO electrical steels by delivering product capabilities in this growing market. The 200 thousand ton NGO electrical steel line is expected to deliver first coil in September 2023 and be available to meet the growing electric vehicle demand expected in North America over the coming years.

In the third quarter 2021, the Company also began construction on a 325 thousand ton galvanize/Galvalume® line at Big River Steel. This $280 million investment is expected to grow the Company’s best-in-class finishing capabilities, by expanding the

Company's presence in value-added construction applications and enhancing Big River Steel's product mix. This finishing line is expected to begin production in second quarter 2024.

As the Company advances and expands its mini mill capability, it seeks to become better, not bigger and will adjust its footprint accordingly by re-evaluating cost and capability advantages within its evolving footprint. In December 2021 and June 2022, the Company permanently idled the steelmaking and ironmaking operations, respectively, at its Great Lakes Works facility. In addition, in March 2022, the Company permanently idled the finishing facilities at its East Chicago Tin operations, which had been idled on an indefinite basis during 2019. The coil finishing process at Great Lakes Works continues to operate and remains a component of the Company's operating plans. In December 2022, we the Company indefinitely idled the majority of tin operations at our Gary Works facility.

Commercial Strategy

Our commercial strategy is focused on providing customer-centric solutions with differentiated and value-added steel products, which includes advanced high strength steels such as our newer grades of generation 3 (GEN3) steel, coated sheets for the automotive and appliance industries, electrical steel sheets for the manufacture of motors and electrical equipment, both bare and prepainted galvanized and Galvalume® sheets for construction, heavy gauge hot rolled coils used in the production of construction and agricultural-related heavy machinery as well as skelp for line pipe used for energy transmission as well as extraction, tin mill products for the packaging industry and OCTG pipe, connections, accessories and rig site services for use in drilling for oil and gas. In addition, our portfolio of customers serves a variety of different traditional and emerging industries meeting the needs of numerous markets.

U. S. Steel is committed to leveraging our Best for All strategy to develop and commercialize our low-carbon footprint and advanced high-strength steels for our current and future customers. Over the next five years, U. S. Steel plans to develop and commercialize numerous differentiated grades of low-carbon footprint, high rate of recycled-content steels, providing compelling new options for customers in automotive, appliance, industrial equipment, construction, renewable energy and other markets to enhance the sustainability of their products. For example, in April 2021, we announced a new sustainable steel product line, verdeX™, which is made with up to 90% recycled steel content and a reduced carbon footprint - as much as 70-80% smaller than traditional integrated steelmaking methods. After launching our verdeX™ brand of sustainable steel products in 2021, we worked closely with customers on their own sustainability goals. In 2022, we reached agreements with multiple customers on the sale of verdeX™ products moving forward in industries such as automotive, construction, and distribution, setting the stage for increased sales of verdeX™ in these and other industries in 2023 and beyond. In addition, we continue to work with customers in numerous industries to help them implement AHSS solutions in the products they manufacture. While the automotive industry has been most active in the application of these products in new vehicle platforms, and it continues to accelerate the deployment of AHSS solutions in new vehicle launches, U. S. Steel is successfully introducing AHSS in other industries as well. Our collaboration with Greenbrier and Norfolk-Southern generated new AHSS sales into the railcar market in 2022, and we also commenced new projects in other industries such as appliance, construction, and in the renewable energy sector to create stronger, lightweight, cost-effective AHSS applications.

We are responsive to our customers' changing needs by developing new steel products and uses for steel that meet their evolving markets and regulatory demands. We have research centers in Munhall, Pennsylvania, Košice, Slovakia, and Houston, Texas, as well as a technology center in Troy, Michigan. The focus of these centers is to engineer new products and to co-create innovative solutions that meet our customers' toughest challenges to reduce carbon emissions, increase strength, improve longevity and serve the needs of their customers. In the fourth quarter 2022, we continued to invest in our talent by hiring a Chief Technology Officer to provide overall enterprise leadership, focusing on driving innovation and product development, as well as enhancing our manufacturing capability.

For automotive customers leveraging advanced high strength steels, we commissioned a first of its kind GEN3 hot dipped galvanize line at our PRO-TEC Coating Company (PRO-TEC) joint venture in 2020, and have embedded application engineers at original equipment manufacturers (OEMs) to demonstrate how to best utilize the high strength, highly formable, cost effective material in body design to meet passenger safety requirements while significantly reducing weight to meet future vehicle fuel efficiency standards.

In our tubular markets, we continue development of premium and semi-premium tubular connections designed for our customers that operate in challenging drilling environments. These connections optimize well construction activities and provide outstanding sealing capabilities for onshore and offshore oil and gas drilling in North America. An example is the USS-TALON HTQ™, which was introduced in 2020 for customers that are constructing onshore natural gas and oil wells with long laterals requiring best-in-class torque capacity and optimized well-bore clearances.

Commercial Sales of Product

U. S. Steel characterizes sales as contract sales if sold pursuant to an agreement with a defined volume and pricing and a duration of longer than three months, and as spot if sold without a defined volume and pricing agreement, typically three months or less. In 2022, approximately 76 percent, 61 percent, 48 percent and 78 percent of sales by Flat-Rolled, Mini Mill, USSE and Tubular, respectively, were contract sales. Some contract pricing agreements include fixed prices while others are adjusted periodically based upon published prices of steel products or cost components.

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Human Capital Management

At U. S. Steel, we are focused on attracting and retaining the top talent needed to support our strategic transformation and meet our customers' evolving needs as a sustainable steel solutions provider. The support and development of our people is foundational to achieving our Best for All strategy. We refer to this strategic talent pillar as "Moving Up the Talent Curve."

Our focus on people extends to our current and future employees. We aim to have an engaged and diverse workforce to promote new ideas and innovation, reflect the communities where we operate, and deliver exceptional customer service. We seek to build an inclusive environment where people feel free to bring their professional selves to work. To achieve the Best for All strategy, we must have the "Best from All."

Active Employees as of December 31, 2022	
North America	14,487
Slovakia	8,253
Total	22,740

Ethics & Compliance

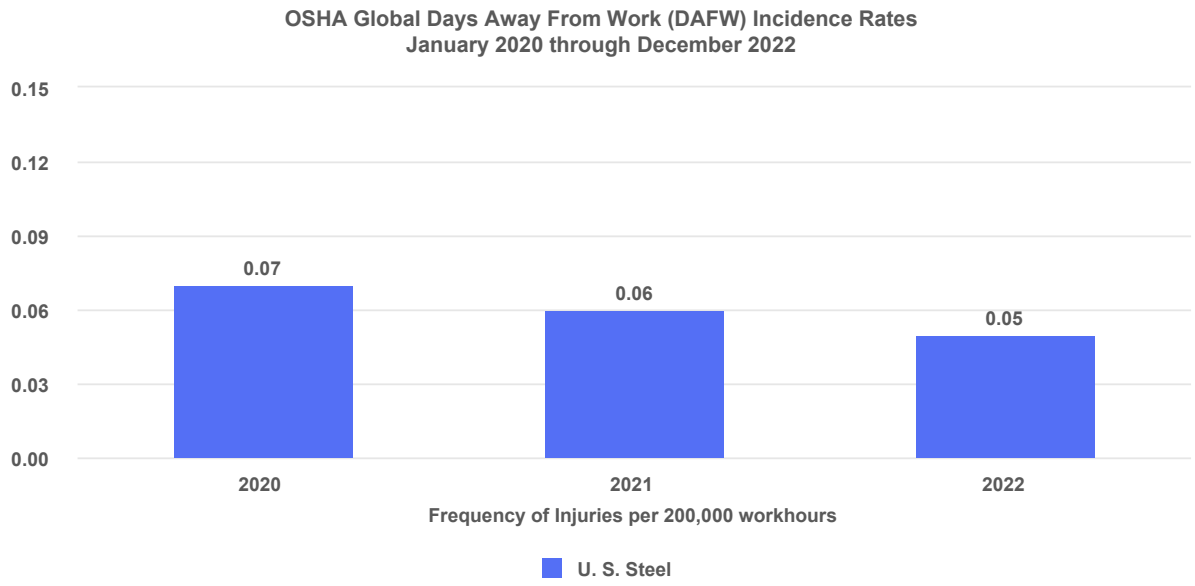
Our culture is based on our S.T.E.E.L. Principles: **S**afety First; **T**rust and Respect; **E**nvironmental Stewardship; **E**xcellence and Accountability; and **L**awful and Ethical Conduct. We expect our employees and members of our board of directors to take personal responsibility to "do what's right," and our Code of Ethical Business Conduct serves as the foundation for the actions of our employees and directors. To further ensure that employees understand the Company's expectations and all applicable rules, we provide annual formal ethics and compliance training to our employees and have frequent communications with information about key compliance topics, which include messages from senior management underscoring the importance of doing business with integrity. Employees also receive summaries of current events that demonstrate the need to do business lawfully and ethically that include reminders of the company's expectations for all employees. In addition, through our annual policy certification process, employees of USSK, non-represented employees in the United States, and members of our board of directors certify their ongoing compliance with our Code of Ethical Business Conduct.

Employee Health & Safety

At U. S. Steel, we have a long-standing commitment to the safety and health of every person who works in our facilities. Every employee deserves to return home safely at the end of every day, and we are working to eliminate all injuries and incidents. In addition, the psychological safety of all employees is important to us. We have combined physical safety and psychological safety into the construct of 360° safety. Ensuring a safe workplace also improves productivity, quality, reliability and financial performance. By making safety and health a personal responsibility, our employees are making a daily commitment to follow safe work practices, look out for the safety of co-workers and ensure safe working conditions for everyone. A "Safety First" mindset is as essential to our success as the tools and technologies we rely on to do business.

Our objective is to attain a sustainable zero harm culture supported by leadership and owned by an engaged and highly skilled workforce, empowered with the capabilities and resources needed to assess, reduce and eliminate workplace risks and hazards. In support of these objectives, we have developed an enhanced Safety Management System, initiated new safety communication methods and enhanced contractor safety processes. One of our most important safety protocols is our fatality prevention audit program. These proactive assessments of the processes and protocols we have in place, and adherence to them, to avoid fatalities and severe injuries are conducted annually at the enterprise level and more frequently at each of our facilities. We assess our safety performance through a variety of lagging and leading indicators, including OSHA Days Away From Work (DAFW). This measurement allows us to evaluate the frequency of injuries sustained at our facilities requiring an employee to stay at home for more than one day. U. S. Steel has achieved record-safety performance in this measurement in the last several years, routinely achieving performance better than industry benchmarks.

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For 2022, we had a corporate DAFW rate of 0.05, which is 18 times better than the U.S. Bureau of Labor Statistics' Iron and Steel benchmark DAFW rate of 0.90.

Diversity, Equity, & Inclusion

Attracting, developing, and retaining a workforce of talented, diverse people is essential to having high-performing teams that drive results for our Company's stakeholders. As part of our commitment to cultivating a culture of caring, we have inclusive benefits available for our U.S. non-represented workforce, including expanded parental leave, back-up dependent care, infertility coverage, gender reassignment coverage and healthcare continuation for the families of employees who suffered work-related or military service fatalities. We also support several employee resource groups (ERGs) to enhance employee engagement, promote a culture of belonging, foster diversity in the workplace, and raise awareness related to issues of identity and intersectionality. Our ERGs also provide training and education, mentorship and networking opportunities for their members.

Talent Attraction, Development and Retention

We believe that attraction, development and retention of talent is essential to our success, especially in today's competitive labor market. We offer internship programs, partner with universities, community colleges and technical schools, and collaborate with community employment centers and economic development nonprofit organizations to build strong and diverse internal and external sources of potential employees and opportunities for our existing employee's growth and development.

Once at U. S. Steel, we seek to provide opportunities for continuous learning and development. All of our employees at a director-level and above have a formal professional development plan that is assessed at least annually. In addition, we proactively monitor our attrition rates and take targeted actions to ensure our highest potential and performing employees are motivated to remain with the Company. Over the past five years, our regrettable voluntary turnover rate has been at or below 5 percent.

We offer a competitive total rewards package of compensation and benefits that we regularly evaluate and benchmark across the manufacturing industry to ensure that we position U. S. Steel as an employer of choice.

At the onset of the pandemic in early 2020, we quickly transitioned our corporate and administrative employees, approximately 10% of our workforce, to a work-from-home environment. We've invested in technology to maintain this virtual community and found that our employees are more productive and have more flexibility and autonomy in managing their workload in a way that best fits their situation. We plan to maintain a virtual / hybrid working option for these employees in order to promote workplace flexibility and attract and retain highly qualified employees across the country.

Labor Relations

Approximately 80% of our employees in North America and Slovakia are covered by collective bargaining agreements. We work closely with union representatives to provide safe and productive workplaces that enable our employees to deliver high-quality products and meet the needs of our customers. Our relationship with the United Steelworkers (USW) includes not only a

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commitment to safety programs, but also a common approach to combating the unfairly traded imports that threaten our industry, our company and ultimately the jobs of our employees.

Certain hourly employees of U. S. Steel's flat-rolled, tubular, cokemaking and iron ore operations in the United States are covered by collective bargaining agreements with the USW entered into effective September 1, 2022, (the 2022 Labor Agreements) that expire on September 1, 2026. The 2022 Labor Agreements include a signing bonus for each eligible USW-represented employee and annual 5% wage increases effective September 1, 2022, 2023, 2024 and 2025. The 2022 Labor Agreements also provide for certain increases to pension and retirement benefits, including increases in our defined benefit pension plan, retiree healthcare contributions, and to the contribution rate to the Steelworkers Pension Trust from $3.50 to $4.00 per hour, effective January 1, 2023. During the fourth quarter of 2022, U. S. Steel recorded a charge of approximately $67 million for the 2022 Labor Agreements signing bonus and related costs.

In addition, as part of the collective bargaining process, U. S. Steel and the USW agreed to leverage the overfunded OPEB plans to support the benefits provided to active represented employees. The OPEB plans were modified to allow the Company to utilize a certain amount of surplus assets to pay additional legally permissible benefits previously paid by the Company. The arrangement permits the Company to utilize a target of $75 million annually for active and retiree employee benefits, with an annual minimum of $50 million, beginning in 2023 and continuing through December 31, 2026. For additional information, see Note 18 to the Consolidated Financial Statements in Part II Item 8 of this Form 10-K.

Capital Structure, Liquidity and Capital Allocation

Our Best for All strategy's primary financial goal is to enhance stockholder value by utilizing our capital structure, liquidity and enhanced capital allocation priorities to advance the Company's strategic objectives, generate long-term value and reward stockholders. Our cash deployment strategy is aligned with our corporate strategy and includes: executing on strategic projects and portfolio moves; maintaining a strong balance sheet and a healthy pension plan; and delivering sustainable growth with a focus on core values such as safety and environmental stewardship and rewarding stockholders for the continued progress we make. Cash deployment is also performed with a customer-centric focus on improving safety, our environment, quality, delivery and cost.

Our liquidity supports our ability to satisfy short-term obligations, fund working capital requirements and provides a foundation to execute key strategic priorities. We are focused on maintaining a strong balance sheet and may proactively refinance or repay our debt from time to time to protect our capital structure from unforeseen external events and re-financing risks.

On May 27, 2022, U. S. Steel entered into the Sixth Amended and Restated Credit Facility Agreement (Credit Facility Agreement) to replace the existing Fifth Amended and Restated Credit Facility Agreement (Fifth Credit Facility Agreement). The Credit Facility Agreement has substantially the same terms as the Fifth Credit Facility Agreement, except the Credit Facility Agreement references the Secured Overnight Financing Rate instead of the London Interbank Offered Rate, adjusts the individual lenders' commitments, and renews the five-year maturity to May 27, 2027, and the financial impact from replacing the Fifth Credit Facility Agreement was immaterial. The Credit Facility Agreement also adjusts the threshold for the fixed charge coverage ratio. The total availability under the facility remained the same at $1,750 million. Consistent with the Fifth Credit Facility Agreement, the Credit Facility Agreement is secured by first-priority liens on certain accounts receivable and inventory and includes targets related to greenhouse gas emissions intensity reduction, safety performance and facility certification by ResponsibleSteel™.

On September 6, 2022, U. S. Steel closed on an offering of $290 million aggregate principal amount of 5.450% Environmental Improvement Revenue Bonds due 2052 (2052 ADFA Green Bonds). U. S. Steel received net proceeds of approximately $287 million after fees of approximately $3 million related to the underwriting and third-party expenses. The net proceeds from the issuance of the 2052 ADFA Green Bonds will be used to partially fund work related to U. S. Steel's solid waste disposal facilities, including two EAFs and other equipment facilities at its new technologically-advanced flat rolled steel making facility, BR2, currently under construction near Osceola, Arkansas.

In 2022, we repurchased approximately $365 million in debt, and we ended the year with $5.9 billion of total liquidity.

On July 25, 2022, following the completion of previously authorized $800 million share repurchase programs, the Board of Directors authorized a new share repurchase program for the repurchase of up to $500 million of the Company's outstanding common stock from time to time in the open market or privately negotiated transactions at the discretion of management. The Company's share repurchase program does not obligate it to acquire any specific number of shares.

U. S. Steel repurchased 37.6 million shares of common stock for approximately $849 million under these programs during the year ended December 31, 2022, and there is approximately $301 million remaining under the current stock repurchase authorization. In addition, the Board of Directors declared quarterly dividends of five cents per common share for each of the quarters in 2022.

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Facilities and Locations as of December 31, 2022

Location Overview

Flat-Rolled Segment

1. Gary Works
2. Great Lakes Works
3. 4. Mon Valley Works
5. Granite City Works
6. Fairfield Sheet
7. Minntac
7. Keetac
7. Hibbing Taconite
8. USS-UPI, LLC
9. PRO-TEC Coating Company
10. Double G Coatings Company
2. 11. Worthington Specialty Processing
1. Chrome Deposit*
2. Automotive Center

Mini Mill Segment

18. Big River Steel

Tubular Segment

6. Fairfield Tubular
15. Lorain Tubular
16. Offshore Operations Houston
17. Lone Star Tubular
12. 17. Wheeling Machine Products
13. Patriot Premium Threading Services

USSE Segment

14. U. S. Steel Košice

Administrative and Research

3. Corporate Headquarters
3. Research and Technology Center
16. U. S. Steel Tubular Products Innovation
14. USSE Research



*Chrome Deposit locations are near major steel mills and are not all reflected on the map above.

Map of Europe not drawn to scale

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Flat-Rolled

The operating results of all U. S. Steel's domestic-integrated steel and sheet plants, coke and iron ore operations and ore and sheet production joint ventures are included in Flat-Rolled. Also, included within Flat-Rolled is a research and technology center located in Munhall, Pennsylvania (near Pittsburgh) and a technology center in Troy, Michigan. The research and technology center carries out a wide range of applied research, development and technical support functions. The technology center brings automotive sales, service, distribution and logistics services, product technology and applications research into one location and much of U. S. Steel's work in developing new grades of steel to meet the demands of automakers for high-strength, light-weight and formable materials is carried out at this location.

Flat-Rolled Operations Table

Operations, (Property Location)	Annual Production Capability	Principal Products and/or Services
Gary Works, (Gary, Indiana)[a]	7.5 million tons of raw steel	strip mill plate in coil; hot-rolled, cold-rolled and coated sheets; and tin mill products
Midwest, (Portage, Indiana)	finishing facility	hot-rolled, cold-rolled and coated sheets; and tin mill products
Great Lakes Works [b], (Ecorse, River Rouge and Dearborn, Michigan)	finishing facility	cold-rolled and coated sheets
Mon Valley Works [c]: Edgar Thompson, (Braddock, Pennsylvania), Irvin, (West Mifflin, Pennsylvania), Fairless, (Fairless Hills, Pennsylvania), and Clairton, (Clairton, Pennsylvania)	2.9 million tons of raw steel and 4.3 million tons of coke	hot-rolled, cold-rolled and coated sheets; and coke and coke by-products
Granite City Works [d], (Granite City, Illinois)	2.8 million tons of raw steel	slabs and hot-rolled, cold-rolled and coated sheets
Granite City Works, (Granite City, Illinois); Gateway Energy and Coke Company LLC (Gateway)	coke supply agreement	not applicable
USS-UPI, LLC (UPI)[e], (Pittsburg, California)	finishing facility	cold-rolled and coated sheets; tin mill products
Fairfield Works, (Fairfield, Alabama)	finishing facility	coated sheets
Minnesota Ore Operations: Minntac, (Mt. Iron, Minnesota) and Keetac, (Keewatin, Minnesota)	22.4 million tons of iron ore pellets	iron ore pellets

[a] The majority of tin operations were indefinitely idled as of December 31, 2022.

[b] The steel and ironmaking production facilities were permanently idled in December of 2021 and June of 2022, respectively. Great Lakes Works' pickle line, cold mill and CGL continue to operate, while the DESCO and electrolytic galvanizing lines are indefinitely idled.

[c] From time to time, we may swap coke with other domestic steel producers or sell on the open market. Coke by-products are sold to the chemicals and raw materials industries.

[d] In March 2020, one of the blast furnaces at Granite City Works was indefinitely idled.

[e] In February 2020, UPI was added with the purchase of the remaining 50% ownership interest from POSCO.

Joint Ventures Within Flat-Rolled

U. S. Steel participates in a number of joint ventures that are included in Flat-Rolled, most of which are conducted through subsidiaries. All of these joint ventures are accounted for under the equity method. The significant joint ventures and other investments are described below.

Joint Ventures [a] Within Flat-Rolled Table

Joint Venture, (Property Location)	U. S. Steel's Ownership Percentage	Annual Production Capability
Hibbing Taconite Company (Hibbing); (Hibbing, Minnesota)	14.7%	9 million tons of which U. S. Steel's share is 1.3 million tons
PRO-TEC Coating Company (PRO-TEC), (Leipsic, Ohio)	50.0%	2.0 million tons [b]
Double G Coatings Company (Double G) [c]; Jackson, Mississippi	50.0%	315 thousand tons
Worthington Specialty Processing (Worthington) [d]	49.0%	not applicable
Chrome Deposit Corporation (CDC), (six locations near major steel plants)	50.0%	not applicable

[a] See further information about our equity investees in Note 12 to the Consolidated Financial Statements.

[b] U. S. Steel's domestic production facilities supply PRO-TEC with cold-rolled sheets and U. S. Steel markets all of PRO-TEC's products.

[c] Each partner supplies its own steel to Double G and markets what is processed by Double G.

[d] In 2022, Worthington Specialty Processing sold its remaining manufacturing facilities. The joint venture is expected to be dissolved in 2023.

Mini Mill

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The operations of Big River Steel are included in Mini Mill. Big River Steel, located in Osceola, Arkansas, is an EAF sheet steel production facility.

Mini Mill Operations Table

Operations, (Property Location)	Annual Production Capability	Principal Products and/or Services
Big River Steel, (Osceola, Arkansas)	3.3 million tons of raw steel	hot-rolled, cold-rolled and coated sheets; and electrical steels

USSE

USSE operates in Košice, Slovakia an integrated facility and a research laboratory, which, in conjunction with our Research and Technology Center, supports efforts in coke making, electrical steels, and design and instrumentation.

USSE Operations Table

Operations, (Property Location)	Annual Production Capability	Principal Products and/or Services
U. S. Steel Košice, (Košice, Slovakia)	5.0 million tons of raw steel	coke; slabs; strip mill plate: hot, cold and coated sheets; tin mill products; and spiral welded pipe

Tubular

Tubular manufactures seamless and welded OCTG, standard pipe, line pipe and mechanical tubing.

Tubular Operations Table

Operations, (Property Location)	Production Capability	Principal Products and Services
Fairfield Tubular Operations, (Fairfield, Alabama)	0.9 million tons of raw steel [(a)] and 750 thousand tons of tubular	seamless tubular pipe
Lorain Tubular Operations [(b)], (Lorain, Ohio)	380 thousand tons of tubular	seamless tubular pipe
Lone Star Tubular [(b)], (Lone Star, Texas)	#1 electric-weld pipe mill (EWPM) 400 thousand tons and #2 EWPM 380 thousand tons of tubular	welded tubular pipe
Wheeling Machine Products [(c)], (Pine Bluff, Arkansas and Hughes Springs, Texas)	not applicable	tubular couplings
Offshore Operations, (Houston, Texas)	not applicable	tubular threading, inspection, accessories and storage services and premium connections
Tubular Processing [(d)], (Houston, Texas)	not applicable	tubular processing

[(a)] Based on the rounds caster capacity which is its constraining production unit.

[(b)] In April 2020, the Lorain Tubular and Lone Star Tubular operations were temporarily idled for an indefinite period of time.

[(c)] In April 2020, the Wheeling Machine Products at Hughes Springs, Texas was temporarily idled for an indefinite period of time.

[(d)] Tubular Processing has been temporarily idled since 2015.

Joint Ventures [(a)] Within Tubular Table

Operations, (Property Location)	U. S. Steel's Ownership Percentage	Production Capability	Principal Products and/or Services
Patriot Premium Threading Services, (Midland, Texas)	50%	not applicable	Tubular threading, accessories and premium connections

[(a)] See further information about our equity investees in Note 12 to the Consolidated Financial Statements.

Other

U. S. Steel's Other category includes the operating results relating to our real estate operations, the previously held equity method investment in Big River Steel, and our former railroad business. The Company owns approximately 45,000 acres of real estate assets, either held for development or managed, in Alabama, Illinois, Michigan, Minnesota and Pennsylvania.

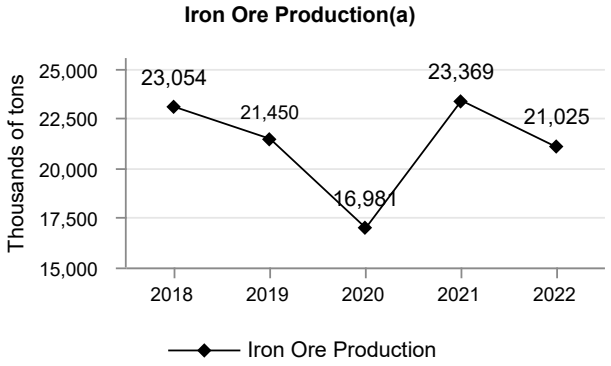
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Raw Materials and Energy

As a predominantly integrated producer, U. S. Steel's primary raw materials are iron units in the form of iron ore pellets and sinter ore, carbon units in the form of coal and coke (which is produced from coking coal) and steel scrap. For our EAF production, our primary raw material is scrap. U. S. Steel's raw materials supply strategy consists of acquiring and expanding captive sources of certain primary raw materials and entering into flexible supply contracts for certain other raw materials at competitive market prices that are subject to fluctuations based on market conditions at the time.

The amounts of such raw materials needed to produce a ton of steel will fluctuate based upon the specifications of the final steel products, the quality of raw materials and, to a lesser extent, differences among steel producing equipment. In broad terms, the Company's integrated steel process consumes approximately 1.4 tons of coal to produce one ton of coke and then it consumes approximately 0.3 tons of coke, 0.3 tons of steel scrap (approximately 60 percent of which is internally generated) and 1.3 tons of iron ore pellets to produce one ton of raw steel. In addition, we consume approximately 10 mmbtu's of natural gas per ton produced. Generally, the Company's mini mill operations consumes approximately 0.8 tons of steel scrap, 0.3 tons of pig iron, and 0.1 tons of HBI to produce one ton of raw steel. In addition, the mini mill operations consume approximately 0.6 MKWH of electricity per ton of raw steel produced. While we believe that these estimated consumption amounts are useful for planning purposes, and are presented to give a general sense of raw material and energy consumption related to steel production, substantial variations may occur.

Iron Ore



(a) Includes our share of production from Hibbing through December 31, 2022.

The iron ore facilities at Minntac and Keetac contain approximately 900 million short tons of indicated resources and probable reserves and our share of recoverable reserves at the Hibbing joint venture is approximately 4 million short tons. Refer to Mining Properties in Item 2 of this Form 10-K for additional information. Recoverable reserves are defined as the tons of product that can be used internally or delivered to a customer after considering mining and beneficiation or preparation losses. Minntac and Keetac's annual capability and our share of annual capability for the Hibbing joint venture total approximately 23 million tons. We have iron ore pellet production capability that exceeds our steelmaking capability in the U.S.

We historically have sold iron ore pellets to third parties, including in 2022, 2021 and 2020. The Company has agreements to supply iron ore pellets to third-party customers over the next several years.

Substantially all of USSE's iron ore requirements are purchased from outside sources, primarily Ukrainian and Brazilian mining companies. Prices are determined in long-term contracts with strategic suppliers or as spot prices negotiated monthly or quarterly. USSE also has received iron ore from U. S. Steel's iron ore facilities in North America. We believe that supplies of iron ore adequate to meet USSE's needs are available at competitive market prices.

Coking Coal

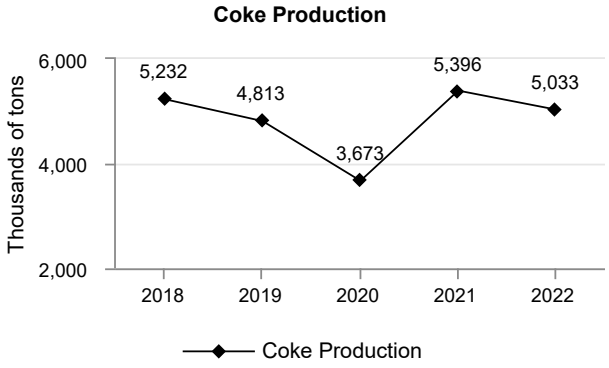
All of U. S. Steel's coal requirements for our cokemaking facilities are purchased from outside sources. Pricing for Flat-Rolled's coking coal contracts are typically negotiated on a yearly basis, and from time to time we have entered into multi-year agreements for a portion of our coking coal requirements.

Prices for European contracts are negotiated quarterly, annually or determined as index-based prices.

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We believe that supplies of coking coal adequate to meet our needs are available from outside sources at competitive market prices. The main source of coking coal for Flat-Rolled is the United States, and sources for USSE include Poland, Ukraine, Canada, Australia and the United States.

Coke



In North America, the Flat-Rolled segment operates a cokemaking facility at the Clairton Plant of Mon Valley Works. At our Granite City Works, we have a 15-year coke supply agreement with Gateway that expires on December 31, 2024. Blast furnace injection of coal, and self-generated coke oven gas is also used to reduce coke usage.

With Flat-Rolled's cokemaking facilities and the Gateway long-term supply agreement, it has the capability to be nearly self-sufficient with respect to its annual coke requirements at normal operating levels. Coke from time to time has been purchased from, sold to, or swapped with suppliers and other end-users to adjust for production needs and reduce transportation costs.

In Europe, the USSE segment operates cokemaking facilities at USSK. While USSE is self-sufficient for coke at normal operating levels, it periodically purchases coke from Polish and Czech coke producers to meet production needs. Volume and price are negotiated quarterly.

Steel Scrap and Other Materials

We believe that supplies of steel scrap and alloys that are adequate to meet our needs are readily available from outside sources at competitive market prices for the Flat-Rolled, Mini Mill and USSE segments. Generally, approximately 38 percent of our steel scrap requirements were internally generated through normal operations for these segments.

Limestone

All of Flat-Rolled's limestone requirements and USSE's lime and limestone requirements are purchased from outside sources. We believe that supplies of limestone and lime adequate to meet our needs are readily available from outside sources at competitive market prices.

Zinc and Tin

We believe that supplies of zinc and tin required to fulfill the requirements for Flat-Rolled, Mini Mill and USSE are available from outside sources at competitive market prices. For Flat-Rolled and Mini Mill the main sources of zinc are Canada, Mexico and the United States and the main sources of tin are Bolivia, Brazil and Peru. For USSE, the main sources of zinc are Finland, Poland, the Netherlands, Germany and Slovakia and the main sources of tin are Peru, Indonesia, China and Bolivia.

During 2022, Flat-Rolled protected approximately 40 percent and 75 percent of its operation's zinc and tin purchases, respectively, with financial swap derivatives to manage exposure to zinc and tin price fluctuations. During 2022, USSE protected approximately 16 percent of its operation's zinc purchases with forward physical contracts to manage our exposure to zinc price fluctuations and protected approximately 68 percent of its operation's tin purchases with financial swaps to manage our exposure to tin price fluctuations. For further information, see Note 16 to the Consolidated Financial Statements.

Natural Gas

All of U. S. Steel's natural gas requirements are purchased from outside sources.

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We believe that adequate supplies to meet Flat-Rolled's, Mini Mill's and Tubular's needs are available at competitive market prices. For 2022, approximately 70 percent of our natural gas purchases in Flat-Rolled were based on bids solicited on a monthly basis from various vendors; the remainder were made daily or with term agreements.

We believe that adequate natural gas supplies to meet USSE's needs are available at competitive market prices. During 2022, we routinely executed fixed-price forward physical purchase contracts for natural gas to partially manage our exposure to natural gas price increases. For 2022, approximately 48 percent of our natural gas purchases in USSE were made with fixed-price forward physical purchase contracts; the remainder were based on bids solicited on a quarterly or monthly basis.

Flat-Rolled and USSE use self-generated coke oven and blast furnace gas to reduce consumption of natural gas. USSE uses self-generated coke oven, converter and blast furnace gas to reduce consumption of natural gas and steam coal that results in lower CO_2 emissions production.

Additionally, Russian supply of natural gas to Europe has decreased significantly in response to enacted sanctions. However, Slovakia has natural gas storage and access to additional supply from countries including Norway, the U.S. and Africa. Together, these sources are enough to support the country's expected consumption through the 2023 winter season, which includes demand for natural gas for our USSE segment operations.

Industrial Gases

U. S. Steel purchases industrial gas in the U.S. under long-term contracts with various suppliers. USSE owns and operates its own industrial gas facility, but also may purchase industrial gases from time to time from third parties.

International Trade

U. S. Steel continues to face import competition, much of which is unfairly traded and fueled by massive global steel overcapacity, currently estimated to be over 500 million metric tons per year—more than five times the entire U.S. steel market and over seventeen times total U.S. steel imports. These imports and overcapacity negatively impact the Company's operational and financial performance. U. S. Steel continues to lead efforts to address these challenges that threaten the Company, our workers, our stockholders and our country's national and economic security.

As of the date of this filing, pursuant to a series of Presidential Proclamations issued in accordance with Section 232 of the Trade Expansion Act of 1962, U.S. imports of certain steel products are subject to a 25 percent tariff, except imports from: (1) Argentina, Brazil, and South Korea, which are subject to restrictive quotas; (2) the European Union (EU), Japan and the United Kingdom (UK) that are melted and poured in the EU/Japan/UK, within quarterly tariff-rate quota (TRQ) limits; (3) Canada and Mexico, which are not subject to tariffs or quotas, but tariffs could be re-imposed on surging product groups after consultations; (4) Ukraine, which are exempt from tariffs until June 1, 2023; and (5) Australia, which are not subject to tariffs, quotas or an anti-surge mechanism.

The U.S. Department of Commerce (DOC) is managing a process in which U.S. companies may request and/or oppose temporary product exclusions from the Section 232 tariffs and quotas. U. S. Steel opposes exclusion requests for imported products that are the same as, or substitutes for, products manufactured by U. S. Steel.

Multiple legal challenges to the Section 232 action continue before the U.S. Court of International Trade (CIT) and the U.S. Court of Appeals for the Federal Circuit (CAFC), the latter which has consistently rejected constitutional and statutory challenges to the Section 232 action.

Since its implementation in March 2018, the Section 232 action has supported the U.S. steel industry's and U. S. Steel's investments in advanced steel production capabilities, technology and skills, strengthening U.S. national and economic security. The Company continues to actively defend the Section 232 action.

In February 2019, the European Commission (EC) implemented a definitive safeguard on global steel imports in the form of TRQs that impose 25 percent tariffs on steel imports that exceed the TRQ limit, effective through June 2024. In December 2022, the EC initiated a fourth review of the safeguard.

Antidumping duties (AD) and countervailing duties (CVD or antisubsidy duties) apply in addition to the Section 232 tariffs, quotas, TRQs and the EC's safeguard, and AD/CVD orders may continue beyond the Section 232 action and the EC's safeguard. U. S. Steel continues to actively defend and maintain the 61 U.S. AD/CVD orders and 14 EU AD/CVD orders covering U. S. Steel products in multiple proceedings before the DOC, U.S. International Trade Commission (ITC), CIT, CAFC, the EC and European courts, and the World Trade Organization (WTO).

In July 2022, the ITC voted to continue the AD/CVD orders on corrosion-resistant steel from China, India, Italy, South Korea and Taiwan and cold-rolled steel from China, India, Japan, South Korea and the UK for another five years, but voted to revoke the AD/CVD orders on cold-rolled steel from Brazil. In October 2022, the ITC voted to continue the AD/CVD orders on hot-rolled

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steel from Australia, Japan, Korea, Netherlands, Russia, Turkey and the United Kingdom for another five years, but voted to revoke the AD/CVD orders on hot-rolled steel from Brazil. Also, in October 2022, the ITC voted to impose new AD/CVD orders on imports of OCTG from Argentina, Mexico, Korea and Russia.

In August 2022, the EC imposed definitive AD measures on imports of hot-dipped galvanized steel from Russia and Turkey and announced the continuation of AD measures on imports of cold-rolled steel from China and Russia for another five years. The EC is conducting five-year reviews of the AD/CVD orders on hot-rolled steel from five countries with a decision expected in 2023.

In April 2022, the U.S. suspended normal trade relations with Russia and Belarus, resulting in higher than normal tariffs on imports from Russia and Belarus, including steel and raw materials. In June, President Biden announced additional tariff increases on certain products from Russia, including certain steel products and ferroalloys, effective August 1, 2022.

Additional tariffs of 7.5 to 25 percent continue to apply to certain U.S. imports from China, including certain raw materials used in steel production, semi-finished and finished steel products, and downstream steel-intensive products, pursuant to Section 301 of the Trade Act of 1974. The Office of the United States Trade Representative (USTR) is currently conducting a statutory review of the Section 301 tariffs.

The United States and EU are currently negotiating a global sustainable steel arrangement to restore market-oriented conditions and address carbon intensity that is targeted for completion by the end of 2023.

U. S. Steel will continue to execute a broad, global strategy to maximize opportunities and navigate challenges presented by imports, global steel overcapacity, and international trade law and policy developments.

Environmental Stewardship

U. S. Steel is committed to effective environmental stewardship. We have implemented and continue to develop business practices that are designed to reduce negative environmental impacts. We believe part of being a good corporate citizen requires a dedicated focus on how our industry affects the environment. We have taken the actions described below in furtherance of that goal. U. S. Steel's environmental expenditures totaled $334 million in 2022, $302 million in 2021 and $278 million in 2020. Overall, environmental compliance expenditures represent approximately 2 percent of U. S. Steel’s total costs and expenses in 2022, 2021 and 2020. For further information, see “Item 7. Management’s Discussion and Analysis of Financial Condition and Results of Operations – Environmental Matters.”

We continue to work on the promotion of cost-effective environmental strategies by supporting the development of appropriate air, water and waste laws and regulations at the local, state, national and international levels. We are committed to reducing our emissions and are investigating, creating and implementing innovative, best practice solutions throughout our operations to improve our environmental performance and to manage and reduce energy consumption.

U. S. Steel’s North America operations recycled 4.8 million tons of purchased and produced steel scrap annually in 2022 and in 2021. USSK recycled approximately 754 thousand tons and 970 thousand tons of produced steel scrap in 2022 and 2021, respectively. Because of steel’s physical properties, our products can be recycled at the end of their useful life without loss of quality, contributing to steel’s high recycling rate and affordability. North America operations recycled approximately 2.2 million tons of blast furnace slag, 58 thousand tons of Basic Oxygen Process steel slag, and 75 thousand tons of electric arc furnace slag by selling it for use as aggregate and in highway construction. In 2022, USSK recycled approximately 1.1 million tons of blast furnace slag, and 168 thousand tons of Basic Oxygen Process steel slag.

Many of our major production facilities have Environmental Management Systems that are certified to the ISO 14001 Standard. This standard, published by the International Organization for Standardization (ISO), provides the framework for the measurement and improvement of environmental impacts of the certified facility.

In 2019, and in each succeeding year since, we published the Clairton Operating and Environmental Report related to our Clairton Plant of Mon Valley Works. While U. S. Steel agreed to publish an annual report as part of the 2019 Allegheny County Health Department Settlement Order and Agreement, we took the opportunity to enhance the report by including detailed descriptions of our operations, our safety and environmental performance and community involvement in order to provide easily accessible information for the public. The Report details battery combustion stack and fugitive emission performance at Clairton and Clairton's continued commitment to environmental stewardship. In 2021, we published a similar report for the Edgar Thomson facility.

Reduction of Greenhouse Gas Emissions

In 2019, the Company announced its commitment to reduce greenhouse gas emissions intensity across its global footprint by 20 percent, as measured by the rate of CO_2 equivalents emitted per ton of finished steel shipped, by 2030 based on 2018 baseline levels. Then, in 2021, the Company announced its goal to achieve net-zero emissions by 2050, as measured by the rate of CO_2

equivalents emitted per ton of finished steel shipped. The Company has provided information on paths to achieve this goal on its website. These targets apply to U. S. Steel's global operations.

U. S. Steel plans to achieve its greenhouse gas emissions intensity reduction goals through the execution of multiple initiatives. These include the use of EAF steelmaking technology at U. S. Steel's Fairfield Works and at Big River Steel, the first LEED-certified steel mill in the United States and the first steel mill in North America to receive ResponsibleSteel™ site certification. EAF steelmaking primarily relies on recycled scrap, rather than iron ore, to produce new steel products, which is a less carbon intensive process and leverages the ability to continuously recycle steel. Further carbon intensity reductions are expected to come from the implementation of ongoing energy efficiency measures, continued use of renewable energy sources and other process improvements to be developed.

The carbon reduction targets reflect our continued commitment to improvement in production efficiency and the manufacture of products that are environmentally friendly. In addition to a commitment to reduce its own greenhouse gas emissions intensity, U. S. Steel is committed to helping its customers achieve their environmental goals. Our industry-leading XG3™ advanced high-strength steel enables automakers to manufacture lighter weight vehicles that meet federal Corporate Average Fuel Economy (CAFE) standards with reduced carbon emissions. As part of our innovation efforts, we continue to look at new steelmaking technologies so that we can produce green steels and further reduce carbon emissions.

Environmental Matters, Litigation and Contingencies

Some of U. S. Steel's facilities were in operation before 1900. Although the Company believes that its environmental practices have either led the industry or at least been consistent with prevailing industry practices, hazardous materials have been and may continue to be released at current or former operating sites or delivered to sites operated by third parties.

Our U.S. facilities are subject to environmental laws applicable in the U.S., including the Clean Air Act (CAA), the Clean Water Act (CWA), the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as well as state and local laws and regulations.

U. S. Steel has incurred and will continue to incur substantial capital, operating and maintenance and remediation expenditures as a result of environmental laws and regulations, related to release of hazardous materials, which in recent years have been mainly for process changes to meet CAA obligations and similar obligations in Europe.

EU Environmental Requirements and Slovak Operations

Phase IV of the EU Emissions Trading System (EU ETS) commenced on January 1, 2021, and will finish on December 31, 2030. The European Commission issued final approval of the updated 2021-2025 Slovak National Allocation table in February 2022. Subsequently, the Slovak Ministry of Environment allocated the full amount of 2022 free allowances totaling 6.3 million European Union Emission Allowances (EUA) to USSE in February and April 2022. As of December 31, 2022, we have pre-purchased approximately 2.1 million EUA totaling €147 million (approximately $157 million) to cover the expected 2022 and 2023 shortfall of emission allowances.

The EU's Industrial Emissions Directive requires implementation of EU determined best available techniques (BAT) for Iron and Steel production to reduce environmental impacts as well as compliance with BAT associated emission levels. Total capital expenditures for projects to comply with or go beyond BAT requirements were €138 million (approximately $147 million). These costs were partially offset by the EU funding received and may be mitigated over the next measurement periods if USSK complies with certain financial covenants, which are assessed annually. USSK complied with these covenants as of December 31, 2022. If we are unable to meet these covenants in the future, USSK might be required to provide additional collateral (e.g., bank guarantee) to secure 50 percent of the EU funding received.

For further discussion of laws applicable in Slovakia and the EU and their impact on USSE, see Note 26 to the Consolidated Financial Statements, "Contingencies and Commitments, Environmental Matters, EU Environmental Requirements."

Minnesota Mining Operations - Water

The State of Minnesota has a sulfate wild rice water quality standard (WQS) set at 10mg/L. This sulfate WQS was established in 1973, since this time industry has been working with the legislature and the Minnesota Pollution Control Agency (MPCA) to reevaluate the environmental protection and science behind the 10 mg/L standard. In 2011, the legislature passed a law requiring MPCA to revise the sulfate standard. MPCA started the process to revise the rulemaking for the sulfate WQS, but it was never completed. During the interim the Keetac National Pollutant Discharge Elimination System (NPDES) permit was issued in November 2011 with a sulfate standard of 14 mg/L and a compliance schedule. Then in 2015, the Minnesota legislature passed a law that MPCA could not require businesses to expend funds to comply with the sulfate limit until the rulemaking was revised by MPCA as directed by the legislature in 2011. To date the sulfate WQS rulemaking has not been revised. During this time Minntac has also received a NPDES permit with a sulfate limit and compliance schedule.

Both Minntac and Keetac have been working to determine the best options to address sulfate. One of the options in process is that both sites have submitted and even renewed site-specific standard (SSS) requests to MPCA. The SSS present plans specific to each location and explain the actual impact on sulfate from the facilities. To date MPCA has not taken any action on

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the SSS plans. The United States Environmental Protection Agency (the U.S. EPA) partially rejected the CWA 303(d) list for impaired waters submitted by MPCA for 2021. The MPCA's impaired waters list was in part rejected to add Hay Lake as being impaired for wild rice sulfate. In February 2022, the U.S. EPA Region V sent a letter to MPCA recognizing the conflict between state law and the CWA.

U. S. Steel is continuing to work to determine the most efficient and effective options to meet the sulfate standard. However, if MPCA does not revise the sulfate standard of 10mg/L or approve the SSS it is likely to have an impact on mining operations as it will require extensive changes to water collection and treatment.

New and Emerging Environmental Regulations

United States and European Greenhouse Gas Emissions Regulations

The Phase IV EU ETS period spans 2021-2030 and began on January 1, 2021.The Phase IV period is divided into two sub periods (2021-2025 and 2026-2030), rules for the first subperiod are finalized, however we expect that rules for the second subperiod may be more stringent than those for the first one. Once approved, the rules may impact subperiod 2026-2030. Currently, the overall EU ETS target is a 40 percent reduction of 1990 emissions by 2030. Free allocation of CO_2 allowances is based on reduced benchmark values which have been published in the first quarter of 2021 and historical levels of production from 2014-2018. Allocations to individual installations may be adjusted annually to reflect relevant increases and decreases in production. The threshold for adjustments is set at 15 percent and will be assessed on the basis of a rolling average of two precedent years. Production data verified by an external auditor shows that USSE rolling average for 2020-2021 returned to base limit for hot metal production resulting in increase of the free allocation for 2022 compared to 2021, however 2022 free allocation was still slightly reduced due to missing the 15 percent threshold for sinter production. Additionally, lower production in 2019 through 2021 will have an impact on the future free allocation for 2026-2030, where the historical production average for years 2019-2023 will be assessed. Based on actual production data for 2022, we expect that free allocation for hot metal will remain unchanged for 2023, however allocations for sinter will be lower.

In order to achieve the EU political goal of carbon emissions neutrality by 2050, on July 14, 2021, the European Commission released a package of legislative proposals called Fit for 55. The proposals contain significant changes to current EU ETS functions and requirements, including: a new carbon border adjustment mechanism to impose carbon fees on EU imports, further reduction of free CO_2 allowance allocation to heavy industry and measures to strengthen the supply of carbon allowances. The legislative process is being impacted by the ongoing Russia-Ukraine crisis. The proposals are subject to the EU legislative process, and we cannot predict their future impact.

United States - Air

The CAA imposes stringent limits on air emissions with a federally mandated operating permit program and civil and criminal enforcement sanctions. The CAA requires, among other things, the regulation of hazardous air pollutants through the development and promulgation of National Emission Standards for Hazardous Air Pollutants (NESHAP) and Maximum Achievable Control Technology (MACT) Standards. The U.S. EPA has developed various industry-specific MACT standards pursuant to this requirement. The CAA requires the U.S. EPA to promulgate regulations establishing emission standards for each category of Hazardous Air Pollutants. The U.S. EPA also must conduct risk assessments on each source category that is already subject to MACT standards and determine if additional standards are needed to reduce residual risks.

While our operations are subject to several different categories of NESHAP and MACT standards, the principal impact of these standards on U. S. Steel's operations includes those that are specific to coke making, iron making, steel making and iron ore processing.

On July 13, 2020, the U.S. EPA published a Residual Risk and Technology Review rule for the Integrated Iron and Steel MACT category in the Federal Register. Based on the results of the U.S. EPA's risk review, the agency determined that risks due to emissions of air toxics from the Integrated Iron and Steel category are acceptable and that the current regulations provided an ample margin of safety to protect public health. Under the technology review, the U.S. EPA determined that there are no developments in practices, processes or control technologies that necessitate revision of the standards. In September 2020, several petitions for review of the rule, including those filed by the Company, the American Iron and Steel Institute (the AISI), Clean Air Council and others, were filed with the United States Court of Appeals for the D.C. Circuit. The cases were consolidated and are being held in abeyance until the U.S. EPA reviews and responds to administrative petitions for review. The U.S. EPA is required by court order to issue a final rule by October 26, 2023. Because the U.S. EPA has yet to propose a revised iron and steel rule, any impacts are not estimable at this time.

For the Taconite Iron Ore Processing category, based on the results of the U.S. EPA's risk review, the agency promulgated a final rule on July 28, 2020, in which the U.S. EPA determined that risks from emissions of air toxics from this source category are acceptable and that the existing standards provide an ample margin of safety. Furthermore, under the technology review, the agency identified no cost-effective developments in controls, practices, or processes to achieve further emissions reductions. Petitions for review of the rule were filed in the United States Court of Appeals for the D.C. Circuit, in which the Company and the

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AISI intervened. The U.S. EPA is required by court order to issue a final rule by November 16, 2023. Because the U.S. EPA has yet to propose a revised taconite rule, any impacts are not estimable at this time.

The U.S. EPA is in the process of conducting its statutorily obligated residual risk and technology review of coke oven standards. Because the U.S. EPA has not completed its review of the Coke MACT regulations, any impacts related to the U.S. EPA's review of the coke standards cannot be estimated at this time. The U.S. EPA is under a court-ordered deadline to complete the residual risk and technology rulemaking by May 23, 2024.

In response to Court orders that invalidated prior U.S. EPA determinations regarding ozone attainment interference, on April 6, 2022, the U.S. EPA proposed a Federal Implementation Plan (that would replace several pending or disapproved State Implementation Plans) for Regional Ozone Transport for the 2015 Ozone National Ambient Air Quality Standard. The proposed rule would affect electric generating units (EGUs) in 26 states and certain non-EGU industries, including, among several others, coke ovens, taconite production kilns, boilers, blast furnaces, basic oxygen furnaces, reheating furnaces, and annealing furnaces in 23 states, including those where U. S. Steel has operations. The impacts of the rule, if promulgated as proposed, could be material. U. S. Steel submitted comments on the proposed rule on June 21, 2022. Based upon the U.S. EPA agreements with non-governmental organizations the rule is likely to be published as final by the U.S. EPA during the first quarter 2023. Once the rule is final, U. S. Steel will further evaluate the potential impacts to operations.

The CAA also requires the U.S. EPA to develop and implement National Ambient Air Quality Standards (NAAQS) for criteria pollutants, which include, among others, particulate matter (PM) - consisting of PM_{10} and $PM_{2.5}$, lead, carbon monoxide, nitrogen dioxide, sulfur dioxide (SO_2) and ozone.

In October 2015, the U.S. EPA lowered the NAAQS for ozone from 75 parts per billion (ppb) to 70 ppb. On November 6, 2017, the U.S. EPA designated most areas in which we operate as attainment with the 2015 standard. In a separate ruling, on June 4, 2018, the U.S. EPA designated other areas in which we operate as "marginal nonattainment" with the 2015 ozone standard. On December 6, 2018, the U.S. EPA published a final rule regarding implementation of the 2015 ozone standard. Because no state regulatory or permitting actions to bring the ozone nonattainment areas into attainment have yet to be proposed or developed for U. S. Steel facilities, the operational and financial impact of the ozone NAAQS cannot be reasonably estimated at this time. On December 31, 2020, the U.S. EPA published a final rule pursuant to its statutorily required review of NAAQS that retains the ozone NAAQS at 70 ppb. In January 2021, New York, along with several states and non-governmental organizations filed petitions for judicial review of the action with the United States Court of Appeals for the D.C. Circuit. Several other states and industry trade groups intervened in support of the U. S. EPA's action. The case remains in abeyance before the court until December 15, 2023, as the U.S. EPA voluntarily reconsiders the ozone NAAQS. Because the U.S. EPA has yet to complete its reconsideration and propose a revised ozone NAAQS, any impacts are not estimable at this time.

On December 18, 2020, the U.S. EPA published a final rule pursuant to its statutorily required review of NAAQS that retains the existing $PM_{2.5}$ standards without revision. In early 2021, several states and non-governmental organizations filed petitions for judicial review of the action with the United States Court of Appeals for the D.C. Circuit. Several industry trade groups intervened in support of the U.S. EPA's action. The case remains in abeyance before the court until March 1, 2023, as the U.S. EPA voluntarily reconsiders the $PM_{2.5}$ NAAQS. On January 6, 2023, the U.S. EPA proposed to lower the annual $PM_{2.5}$ NAAQS from the current 12 ug/m^3 standard to within the range of 9.0 to 10.0 ug/m^3. U. S. Steel is currently reviewing the proposal to determine the impacts and evaluate any need to comment. Because the U.S. EPA has very recently proposed the rule without specificity, any impacts are inestimable at this time.

For calendar year 2022, all Allegheny County ambient air quality monitors met all U.S. EPA health based National Ambient Air Quality Standards for the second consecutive year. On March 16, 2022, the U.S. EPA published a final rule, a clean data determination, showing that Allegheny County has attained the 2012 annual $PM_{2.5}$ NAAQS based on the 2018 – 2020 ambient air quality data. Based on these and other data, ACHD submitted a Redesignation Request and Maintenance Plan to the U.S. EPA requesting that the U.S. EPA redesignate all of Allegheny County in attainment with the current $PM_{2.5}$ NAAQS.

United States – Water

The U.S. EPA issued the final rule redefining the Waters of the United States (WOTUS), set to become effective March 1, 2023. The definition of WOTUS has had many changes and legal challenges over the last several years. The new WOTUS rule expands the definition of what all waters will be considered to be a waters of the United States. The expansion of the WOTUS definition is likely to lead to additional legal challenges. It is also possible that the ruling in the U. S. Supreme court case Sackett v. EPA would impact the WOTUS definition as it relates to wetlands. The Sackett case was heard by the Court in the Fall 2022 term and decision is expected early in 2023. U. S. Steel will continue to review the final WOTUS definition and its potential impact on the Company.

Environmental Remediation

For further discussion of relevant environmental matters, including environmental remediation obligations, see "Item 3. Legal Proceedings, Environmental Proceedings."

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Property, Plant and Equipment Additions

For property, plant and equipment additions, including finance leases, see “Item 7. Management’s Discussion and Analysis of Financial Condition and Results of Operations – Financial Condition, Liquidity and Capital Resources” and Note 13 to the Consolidated Financial Statements.

Available Information

U. S. Steel’s Internet address is ***www.ussteel.com***. We post our Annual Report on Form 10-K, our quarterly reports on Form 10-Q, our proxy statement, our current reports on Form 8-K, amendments to those reports and our interactive data files to our website free of charge as soon as reasonably practicable after such reports are filed, or furnished to, with the Securities and Exchange Commission (SEC). We also post all press releases and earnings releases to our website.

All other filings with the SEC are available via a direct link on the U. S. Steel website to the SEC’s website, *www.sec.gov*.

Also available on the U. S. Steel website are U. S. Steel’s Corporate Governance Principles, Code of Ethical Business Conduct and the charters of the Audit Committee, the Compensation & Organization Committee and the Corporate Governance & Sustainability Committee of the Board of Directors. These documents and the Annual Report on Form 10-K and proxy statement are also available in print to any stockholder who requests them. Such requests should be sent to the Office of the Corporate Secretary, United States Steel Corporation, 600 Grant Street, Suite 1844, Pittsburgh, Pennsylvania, 15219-2800 (telephone: 412-433-1121).

U. S. Steel does not incorporate into this document the contents of any website or the documents referred to in the immediately preceding paragraphs.

Other Information

Information on net sales, depreciation, capital expenditures, earnings (loss) before interest and income taxes and assets by reportable segment and for business in the Other category and on net sales and assets by geographic area are set forth in Note 4 to the Consolidated Financial Statements.

For significant operating data for U. S. Steel for each of the last five years, see “Five-Year Operating Summary (Unaudited)” within this document.

Item 1A. RISK FACTORS

Economic and Market Risk Factors

The changing global economic climate is having adverse impacts on our business, which may create new risks and exacerbate certain other risks set forth below.

Changes in the global economic environment, inflation, rising interest rates, recessions or prolonged periods of slow economic growth, and global instability and actual and threatened geopolitical conflict, could have an adverse effect on our industry and business, as well as those of our customers and suppliers.

Overall economic conditions in the U.S. and globally, including in Europe, including adverse factors such as inflation, rising interest rates, supply chain disruptions and the impacts of the war in Ukraine, significantly impact our business. Periods of economic downturn or continued uncertainty could result in difficulty increasing or maintaining our level of sales or profitability and we may experience an adverse effect on our business, results of operations, financial condition and cash flows.

Our U.S. operations are subject to economic conditions, including credit and capital market conditions, inflation, prevailing interest rates, and political factors, which if changed could negatively affect our results of operations, cash flows and liquidity. Political factors include, but are not limited to, changes to tax laws and regulations resulting in increased income tax liability, increased regulation, such as carbon emissions limitations or trading mechanisms, limitations on exports of energy and raw materials, and trade remedies. Actions taken by the U.S. government could affect our results of operations, cash flows and liquidity.

USSE is subject to economic conditions and political factors associated with the EU, Slovakia and neighboring countries, and the euro currency. Changes in any of these economic conditions or political factors could negatively affect our results of operations, cash flows and liquidity. Political factors include, but are not limited to, taxation, nationalization, inflation, government instability, regional conflict, civil unrest, increased regulation and quotas, tariffs, sanctions and other market-distorting measures. The ongoing war in Ukraine has had a broad range of adverse impacts on global economic conditions, some of which have had and are likely to continue to have adverse impacts on our business, including increased raw material and energy costs, softer

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customer demand and lower steel prices. USSE purchases a significant portion of its iron ore and coal from suppliers based in Ukraine.

Additionally, we are also exposed to risks associated with the business success and creditworthiness of our suppliers and customers. If our customers or suppliers are negatively impacted by a slowdown in economic markets, we may face the reduction, delay or cancellation of customer orders, delays or interruptions of the supply of raw materials, and increased risk of insolvency and other credit related issues of customers or suppliers, which could delay payments from customers, result in increased customer defaults and cause our suppliers to delay filling, or to be unable to fill, our needs at all or on a timely or cost-effective basis. The occurrence of any of these events may adversely affect our business, results of operations, financial condition and cash flows.

The steel industry, as well as the industries of our customers and suppliers upon whom we are reliant, is highly cyclical, which may have an adverse effect on our customer demand and results of operations.

Steel consumption is highly cyclical and generally follows economic and industrial conditions both worldwide and in regional markets. Price fluctuations are impacted by the timing, magnitude and duration of these cycles, and are difficult to predict. This volatility makes it difficult to balance the procurement of raw materials and energy with global steel prices, our steel production and customer product demand. U. S. Steel has implemented strategic initiatives to produce more stable and consistent results, even during periods of economic and market downturns, but this may not be enough to mitigate the effect that the volatility inherent in the steel industry has on our results of operations.

Additionally, our business is reliant on certain other industries that are cyclical in nature. We sell to the automotive, service center, converter, energy and appliance and construction-related industries. Some of these industries are highly sensitive to general economic conditions and may also face meaningful fluctuations in demand based on a number of factors outside of our control, including regulatory factors, supply chain disruptions, changing customer demand, economic conditions and raw material and energy costs. As a result, downturns or volatility in any of the markets we serve could adversely affect our financial position, results of operations and cash flows.

U. S. Steel has been and continues to be adversely affected by unfairly traded imports and global overcapacity, which may cause downward pricing pressure, lost sales and revenue, market share, decreased production, investment, and profitability.

Currently, global steel production capacity significantly exceeds global steel demand, which adversely affects U.S. and global steel prices. Global overcapacity continues to result in high levels of dumped and subsidized steel imports into the markets we serve. Domestic and international trade laws provide mechanisms to address the injury caused by such imports to domestic industries. Excessive steel imports have resulted and may continue to result in downward pricing pressure and lost sales and revenue, which adversely impacts our business, operations, financial condition and cash flows.

Although U. S. Steel currently benefits from 61 U.S. AD and CVD or anti-subsidy duty orders and 14 EU AD/CVD orders, petitions for trade relief are not always successful or effective. When implemented, such relief is generally subject to periodic reviews and challenges, which can result in revocation of AD/CVD orders or reduction of effective duty rates. There can be no assurance that any relief will be obtained or continued in the future or that such relief will adequately combat unfairly traded imports.

As of the date of this filing, pursuant to a series of Presidential Proclamations issued in accordance with Section 232 of the Trade Expansion Act of 1962, U.S. imports of certain steel products are subject to a 25 percent tariff, except imports from: (1) Argentina, Brazil, and South Korea, which are subject to restrictive quotas; (2) the EU, Japan, and UK that are melted and poured in the EU/Japan/UK, within quarterly TRQ limits; (3) Canada and Mexico, which are not subject to tariffs or quotas, but tariffs could be re-imposed on surging product groups after consultations; (4) Ukraine, which are exempt from tariffs until June 1, 2023; and (5) Australia, which are not subject to tariffs, quotas, or an anti-surge mechanism. The Section 232 national security action on steel imports currently provides U. S. Steel and other domestic steel producers critical relief from imports. With no scheduled end date, the future coverage and duration of the Section 232 action is not known. Further, the U.S. government may negotiate alternatives to the Section 232 tariffs for certain countries, similar to TRQ agreements with the EU, Japan, and the UK.

USTR's review of additional imports tariffs of 7.5 to 25 percent on certain U.S. imports from China, including certain raw materials used in steel production, semi-finished and finished steel products, and downstream steel-intensive products, pursuant to Section 301 of the Trade Act of 1974 could change the coverage and levels of such tariffs.

In February 2019, the EC implemented a definitive safeguard on global steel imports in the form of TRQs. The TRQs, which impose 25 percent tariffs on steel imports that exceed the TRQ limit, are currently effective through June 2024. In December 2022, the EC initiated its fourth periodic review of this safeguard, which may result in adjustments to the safeguard TRQ limits.

All of the above factors present a degree of uncertainty to our financial and operational performance, our customers, and overall economic conditions, all of which could impact steel demand and our performance. Faced with significant import competition and

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overcapacity in various markets, we will continue to evaluate potential strategic and organizational opportunities, which may include exiting lines of business and the sale of certain assets, temporary shutdowns or closures of facilities.

Shortages of skilled labor, increased labor costs or our failure to attract and retain other highly qualified personnel in the future could disrupt our operations and adversely affect our financial results.

We depend on skilled labor for the manufacture of our products. Some of our facilities are located in areas where demand for skilled labor often exceeds supply. Shortages of some types of skilled labor, such as electricians and qualified maintenance technicians, could restrict our ability to maintain or increase production rates, lead to production inefficiencies and increase our labor costs. Our shift to the Best for All strategy will also require a set of job skills that is different from our prior needs. Our continued success depends on the active participation of our key employees. We have recently observed an overall tightening and increasingly competitive labor market. The competitive nature of the labor markets in which we operate, the cyclical nature of the steel industry and our resulting needs for skilled employees increase our risk of not being able to recruit, train and retain the employees we require at efficient costs and on reasonable terms, and could lead to increased costs, such as increased overtime to meet demand and increased wage rates to attract and retain employees. In addition, many companies, including U. S. Steel, have had employee layoffs as a result of reduced business activities during industry downturns. The loss of our key people or our inability to attract new key employees could adversely affect our operations. Additionally, layoffs or other adverse actions could result in an adverse relationship with our workforce or third-party labor providers. If we are unable to recruit, train and retain adequate numbers of qualified employees and third-party labor providers on a timely basis or at a reasonable cost or on reasonable terms, our business and results of operations could be adversely affected. Additionally, an overall labor shortage, lack of skilled labor, increased turnover or labor inflation as a result of general macroeconomic factors that affect our customers or suppliers could have a material adverse impact on the company's operations, results of operations, liquidity or cash flows.

Strategic Risk Factors

Our investments in new technologies and products may not be fully successful.

Execution of our Best for All® strategy depends, in part, on the success of a number of investments we have made and plan to make in new facilities, technologies and products and successfully transitioning our footprint to a lower-cost, carbon and capital intensive model. Our Best for All strategy is centered around expanding our competitive advantages in low-cost iron ore mini mill steelmaking, and best-in-class finishing capabilities. These competitive advantages are built on a foundation of research, innovation and deep customer relationships. We are expanding our low-cost iron ore competitive advantage by investing in ways to translate the advantage to feed our growing EAF footprint. This includes investments in a pig iron caster at the Gary Works facility and DR-grade pellet capabilities in Keetac, Minnesota. We are expanding our mini mill steelmaking capabilities through the construction of a second mini mill facility in Osceola, Arkansas. We are also expanding our best-in-class finishing capabilities through investments in a non-grain oriented electrical steel line and galvanizing construction line at Big River Steel. In executing our strategy, we aim to enhance our earnings profile, deliver long-term cash flow through industry cycles and reduce our cost, capital, and carbon intensity. By offering the product capabilities, including the more sustainable steels (steels made with lower greenhouse gas emissions) our customers are increasingly demanding, we believe that we can achieve more competitive positioning in strategic, high-margin end markets, and deliver high-quality, sustainable, value-added products and innovative solutions.

Construction of our strategic projects is subject to changing market conditions and demand for our completed projects, delays, inflation and cost overruns, work stoppages, labor shortages, engineering issues, weather interferences, supply chain delays, changes required by governmental authorities, delays or the inability to acquire required permits or licenses, changes in the ability to finance the projects or disruption of existing operations, any of which could have an adverse impact on our operational and financial results. Furthermore, new product development or modification is costly, may be restricted by regulatory requirements, involves significant research, development, time, expense and human capital and may not necessarily result in the successful commercialization of new products, customer adoption of new technologies or products or new technologies may not perform as intended or expected. Unsuccessful execution of these strategic projects, underperformance of any of these assets or failure of new products to gain market acceptance could adversely affect our business, results of operations and financial condition and may limit the benefits of our stockholder value creation strategy.

From time to time, we engage in acquisitions, divestitures and joint ventures and may encounter difficulties in integrating and separating these businesses and therefore we may not realize the anticipated benefits.

As we pursue our Best for All® strategy, we may seek growth opportunities through strategic acquisitions as well as evaluate our portfolio for potential divestitures to optimize our business footprint and portfolio. The success of these transactions will depend on our ability to integrate or separate, as applicable, assets and personnel in these transactions and to cooperate with our strategic partners. We may encounter difficulties in integrating acquisitions with our operations as well as separating divested businesses, and in managing strategic investments. Furthermore, we may not realize the degree, or timing, of benefits we anticipate when we first enter into a transaction.

Additionally, we seek opportunities to monetize non-core and excess iron assets, including through real estate sales, third party agreements and option agreements. These opportunities may not materialize or generate the financial benefits expected. For

example, Stelco Inc. holds an option (Option) to acquire an undivided 25 percent interest in a to-be-formed entity that will own the Company's current iron ore mine located in Mt. Iron, Minnesota. There is a possibility that Stelco may not exercise its Option in the anticipated timeframe or at all. If the proposed joint venture with Stelco is not successful, fails to provide the benefits we expect, or is not created at all, we may in the future have more iron ore than we need to support the business. Additionally, the existence of the Option may deter future potential opportunities to monetize the iron ore assets. Any of the foregoing could adversely affect our business and results of operations.

Operational and Commercial Risk Factors

Our operational footprint, unplanned equipment outages and other unforeseen disruptions may adversely impact our results of operations or result in idle facility costs or impairment charges.

U. S. Steel has adjusted its operating configuration to advance its Best for All® strategy, in response to market conditions, including global economic volatility, declining steel prices, oil and gas industry disruption, global overcapacity and unfairly traded imports, and to optimize capability and cost performance, by idling and restarting production at certain facilities. Due to our existing operational footprint, the Company may not be able to respond in an efficient manner to fully realize the benefits from changing market conditions that are favorable to integrated steel producers or most efficiently mitigate the negative impacts of such changes. Our decisions concerning which facilities to operate and at what levels are made based upon execution of our Best for All strategy, market conditions, our customers' orders for products as well as the capabilities and cost performance of our locations. We may concentrate production operations at several plant locations and not operate others, and as a result we may incur idle facility costs or impairment charges.

Our steel production depends on the operation of critical structures and pieces of equipment, such as blast furnaces, electric arc furnaces, steel shops, casters, hot strip mills and various structures and operations, including information technology systems, that support them, as well as finishing lines at our facilities and certain of our joint ventures. While we invested in operational and reliability enhancements to our assets through the asset revitalization program, launched in 2017, and continue to implement initiatives focused on proactive maintenance of key machinery and equipment at our production facilities, we may experience prolonged periods of reduced production and increased maintenance and repair costs due to equipment failures at our facilities or those of our key suppliers.

It is also possible that operations may be disrupted due to other unforeseen circumstances such as power outages, explosions, fires, floods, pandemics, terrorism, accidents, severe weather conditions, and changes in U.S., European Union and other foreign tariffs, free trade agreements, trade regulations, laws and policies. We are also exposed to similar risks involving major customers and suppliers such as force majeure events of raw materials suppliers that have occurred and may occur in the future. Availability of raw materials and delivery of products to customers could be affected by logistical disruptions, such as shortages of barges, ocean vessels, rail cars or trucks or unavailability of rail lines or of the locks on the Great Lakes or other bodies of water. To the extent that lost production could not be compensated for at unaffected facilities and depending on the length of the outage, our sales and our unit production costs could be adversely affected.

We are subject to risks related to the global COVID-19 pandemic, which has had adverse impacts on economic and market conditions and our business. COVID-19 has created significant volatility, uncertainty and economic disruption in the regions in which we operate. We expect that certain parts of our operations will continue to be impacted by the continuing effects of COVID-19, including resurgences and variants of the virus. It remains difficult to predict the full impact of the COVID-19 pandemic on the broader economy, and whether such change is temporary or permanent.

The physical impacts of climate change may also have a material adverse effect on our results of operations. Climate change may be associated with increased occurrence of extreme weather conditions, which could include, among other things, increased risk of flooding, potential heat stress at facilities and other natural disasters that may lead our customers to curtail or shut down production or to supply chain and operational disruptions.

We face increased competition within our industry and from alternative materials and risks concerning innovation, new technologies, products and increasing customer demand for lower-carbon products.

As a result of increasingly stringent regulatory requirements and increased market and technological changes driven by broader trends such as decarbonization and electrification efforts in response to climate change, designers, engineers and industrial manufacturers, especially those in the automotive industry, are increasing their use of lighter weight, less carbon intense and alternative materials, such as aluminum, composites, plastics and carbon fiber. Use of such materials could reduce the demand for our steel products or steel products generally, which may reduce our profitability and cash flow. Additionally, the trend toward light weighting in the automotive industry, which requires lighter gauges of steel at higher strengths, could result in lower steel volumes required by that industry over time.

Additionally, technologies such as direct iron reduction, oxygen-coal injection and experimental technologies such as molten oxide electrolysis and hydrogen flash smelting may be more cost effective than our current production methods. However, we may not have sufficient capital to invest in such technologies and may incur difficulties adapting and fully integrating these

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technologies into our existing operations. We may also encounter production restrictions, or not realize the cost benefit from such capital intensive technology adaptations to our current production processes.

Limited availability, or volatility in prices of raw materials, scrap and energy may constrain operating levels and reduce profit margins.

U. S. Steel and other steel producers have periodically faced problems obtaining sufficient raw materials and energy in a timely manner due to delays, defaults, severe weather conditions, or force majeure events, shortages or transportation problems (such as shortages of barges, ore vessels, rail cars or trucks, or disruption of rail lines, waterways, or natural gas transmission lines), resulting in production curtailments. As a result, we may be exposed to risks concerning pricing and availability of raw materials and energy resources from third parties as well as logistics constraints moving our own raw materials and scrap to our plants. USSE purchases substantially all of its iron ore and coking coal requirements from outside sources. Any curtailments or escalated costs may further reduce profit margins.

U. S. Steel has agreed, and may continue to agree, to purchase raw materials and energy at prices that have been, and may be, above future market prices or in greater volumes than required in the future. Additionally, any future decreases in iron ore, scrap, natural gas, electricity and oil prices may place downward pressure on steel prices. If steel prices decline, our profit margins on indexed contracts and spot business could be reduced.

A failure of our information technology infrastructure and cybersecurity threats may adversely affect our business operations.

Despite efforts to protect confidential business information, personal data of employees and contractors, and the control systems of manufacturing plants, U. S. Steel systems and those of our third-party service providers have been and may be subject to cyber-attacks or system breaches. System breaches can lead to theft, unauthorized disclosure, modification or destruction of proprietary business data, personally identifiable information (PII), or other sensitive information, to defective products, production downtime and damage to production assets, and the inaccessibility of key systems, with a resulting impact to our reputation, competitiveness and operations. We have experienced cybersecurity attacks that have resulted in unauthorized persons gaining access to our information technology systems and networks, and we could in the future experience similar attacks. To date, no cybersecurity attack has had a material impact on our financial condition, results of operations or liquidity.

While the Company continually works to safeguard our systems and mitigate potential risks, there can be no assurance that such actions will be sufficient to prevent cyber-attacks or security breaches or mitigate all potential risks to our systems, networks and data, particularly with the recent proliferation and sophistication of ransomware attacks around the world. The potential consequences of a material cybersecurity attack include reputational damage, investigations and/or adverse proceedings with government regulators or enforcement agencies, litigation with third parties, disruption to our systems, including production capabilities, unauthorized release of confidential, personally identifiable or otherwise protected information, corruption of data, diminution in the value of our investment in research, development and engineering and increased cybersecurity protection and remediation costs, which in turn could adversely affect our competitiveness, results of operations and financial condition. The amount of insurance coverage we maintain may be inadequate to cover claims or liabilities resulting from a cybersecurity attack.

We depend on third parties for transportation services and increases in costs or the availability of transportation may adversely affect our business and operations.

Our business depends on the transportation of a large number of products, both domestically and internationally. We rely primarily on third parties, including the recently divested Transtar business, for transportation of the products we manufacture as well as delivery of our raw materials. Any increase in the cost of the transportation of our raw materials or products, as a result of increases in fuel or labor costs, higher demand for logistics services, consolidation in the transportation industry or otherwise, may adversely affect our results of operations as we may not be able to pass such cost increases on to our customers.

Our transportation service providers may face disruptions due to weather conditions or events, strikes, labor shortages or other constraints. If any of these providers were to fail to deliver raw materials to us or deliver our products in a timely manner, we may be unable to manufacture and deliver our products in response to customer demand. In addition, if any of these third parties were to cease operations or cease doing business with us, we may be unable to replace them at a reasonable cost. Such failure of a third-party transportation provider could harm our reputation, negatively affect our customer relationships and have a material adverse effect on our financial position and results of operations.

Our 2022 Labor Agreements with the USW contain provisions that may impact certain business activities.

Our 2022 Labor Agreements with the USW contain provisions that grant the USW a limited right to bid on the Company's sale of a facility (or sale of a controlling interest in an entity owning a facility) covered by the 2022 Labor Agreements, excluding public equity offerings and/or the transfer of assets between U. S. Steel and its wholly owned subsidiaries. These agreements also require a minimum level of capital expenditures (subject to approval of the Board of Directors) to maintain the competitive status

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of the covered facilities, and place certain limited restrictions on our ability to replace product produced at a covered facility with product produced at other than Company facilities or affiliates or U.S. or Canadian facilities with employee protections similar to the protections found in the 2022 Labor Agreements when the Company is operating covered facilities below capacity. The provisions in the 2022 Labor Agreements, as well as current or future proposed labor legislation or regulations, could unfavorably impact certain business activities including pricing, operating costs, margins and/or our competitiveness in the marketplace.

Financial Risk Factors

Our business and execution of our strategy require substantial expenditures for capital investments, debt service obligations, operating leases and maintenance that we may be unable to fund, which may require other actions to satisfy our obligations under our debt.

We have approximately $3.9 billion of total debt (see Note 17 to the Consolidated Financial Statements). If our cash flows and capital resources are insufficient to fund our planned capital expenditures or debt service obligations, we may face substantial liquidity problems and may be forced to reduce or delay investments and capital expenditures, terminate strategic projects, or to dispose of material assets or operations or issue additional debt or equity. We may not be able to take such actions, if necessary, on commercially reasonable terms or at all. The Credit Facility Agreement, the documents governing the USSK Credit Facility, the documents governing the Big River Steel ABL Facility and Big River Steel notes, and the indentures governing our existing senior unsecured notes may restrict our ability to dispose of assets and may also restrict our ability to raise debt or equity capital to be used to repay other debt when it becomes due. We may not be able to consummate those dispositions or to obtain proceeds in an amount sufficient to meet any debt service obligations then due. Our inability to generate sufficient cash flows to satisfy our debt obligations, or to refinance our indebtedness on commercially reasonable terms or at all, would materially and adversely affect our financial position and results or operations and may place us at a competitive disadvantage with competitors who may have less indebtedness and other obligations or greater access to financing. In addition, the availability under our Credit Facility Agreement and Big River ABL Facility may be reduced if we have insufficient collateral, or if we do not meet a fixed charge coverage ratio test. Availability under the USSK Credit Agreement could be limited if USSK does not meet certain financial covenants.

Our ability to service or refinance our debt or fund investments and capital expenditures required to maintain or expand our business operations depends on our financial condition and operating performance, which are subject to prevailing economic and competitive conditions and to certain financial, business, legislative, regulatory and other factors beyond our control, such as inflation, rising interest rates, supply chain disruptions and the impacts of the war in Ukraine. We may not be able to maintain a level of cash flows from operating activities sufficient to permit us to satisfy our liquidity needs. In addition, the availability under certain of our debt instruments may be limited if we do not meet certain financial covenants. Furthermore, the agreements governing the BRS ABL Facility and other outstanding indebtedness of Big River Steel LLC and its subsidiaries limit their ability, subject to certain exceptions, to pay dividends or distributions or make other restricted payments, such that we may not be able to access the cash generated by these subsidiaries to fund our other expenditures.

If we cannot make scheduled payments on our debt, we will be in default and holders of our senior unsecured notes could declare all outstanding principal and interest to be due and payable, the lenders under the Sixth Amended and Restated Credit Agreement, the USSK Credit Facility and the Export Credit Facility could terminate their commitments to loan money, accelerate full repayment of any or all amounts outstanding (which may result in the cross acceleration of certain of our other debt obligations) and the lenders could foreclose against the assets securing their borrowings and we could be forced into bankruptcy or liquidation. All of these events would materially and adversely affect our financial position and results of operations.

Furthermore, ratings agencies could downgrade our ratings either due to factors specific to our business, a prolonged cyclical downturn in the steel industry, macroeconomic trends such as global or regional recessions and trends in credit and capital markets more generally. Ratings agencies also may lower, suspend or withdraw ratings on the outstanding securities of U. S. Steel or Big River Steel. Any lowering, suspension or withdrawal of such ratings may have an adverse effect on the market prices of such securities.

Any decline in our operating results or downgrades in our credit ratings may make raising capital or entering into any business transaction more difficult, lead to reductions in the availability of credit or increased cost of credit, adversely affect the terms of future borrowings, may limit our ability to take advantage of potential business opportunities, may have an adverse effect on the terms under which we purchase goods and services, and lead to reductions in the availability of credit.

We have significant retiree health care, retiree life insurance and pension plan costs, which may negatively affect our results of operations and cash flows.

We maintain retiree health care and life insurance and defined benefit pension plans covering many of our domestic employees and former employees upon their retirement. Some of these benefit plans are not fully funded, and thus will require cash funding in future years. Minimum contributions to domestic qualified pension plans (other than contributions to the Steelworkers Pension Trust (SPT) described below) are regulated under the Employee Retirement Income Security Act of 1974 (ERISA) and the Pension Protection Act of 2006 (PPA).

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The level of cash funding for our defined benefit pension plans in future years depends upon various factors, including voluntary contributions that we may make, future pension plan asset performance, actual interest rates under the law, the impact of business acquisitions or divestitures, union negotiated benefit changes and future government regulations, many of which are not within our control. In addition, assets held by the trusts for our pension plan and our trust for retiree health care and life insurance benefits are subject to the risks, uncertainties and variability of the financial markets. Future funding requirements could also be materially affected by differences between expected and actual returns on plan assets, actuarial data and assumptions relating to plan participants, the discount rate used to measure the pension obligations and changes to regulatory funding requirements. See "Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations" and Note 18 to the Consolidated Financial Statements for a discussion of assumptions and further information associated with these benefit plans.

U. S. Steel contributes to a domestic multiemployer defined benefit pension plan, the SPT, for USW-represented employees formerly employed by National Steel and represented employees hired after May 2003. We have legal requirements for future funding of this plan should the SPT become significantly underfunded or we decide to withdraw from the plan. Either of these scenarios may negatively impact our future cash flows. The 2022 Labor Agreements increased the contribution rate for most steelworker employees. Collectively bargained company contributions to the plan could increase further as a result of future changes agreed to by the Company and the USW.

The accounting treatment of goodwill, equity method investments and other long-lived assets could result in future asset impairments, which would reduce our earnings.

We periodically test our goodwill, equity method investments and other long-lived assets to determine whether their estimated fair value is less than their value recorded on our balance sheet. The results of this testing for potential impairment may be adversely affected by uncertain market conditions for the global steel industry and general economic conditions. If we determine that the fair value of any of these assets is less than the value recorded on our balance sheet, and, in the case of equity method investments the decline is other than temporary, we would likely incur a non-cash impairment loss that would negatively impact our results of operations. We have incurred asset impairment charges in recent years, including during the year ended December 31, 2022, and there can be no assurances that continued market dynamics or other factors may not result in future impairment charges.

We are subject to foreign currency risks, which may negatively impact our profitability and cash flows.

The financial condition and results of operations of USSE are reported in euros and then translated into U.S. dollars at the applicable exchange rate for inclusion in our financial statements. The appreciation of the U.S. dollar against the euro negatively affects our Consolidated Results of Operations. International cash requirements have been and in the future may be funded by intercompany loans, which may create intercompany monetary assets and liabilities in currencies other than the functional currencies of the entities involved, which can have a non-cash impact on income when they are remeasured at the end of each period. Procurement of equipment of announced strategic projects may be denominated in foreign currencies, which could adversely affect the costs of these projects.

In addition, foreign producers, including foreign producers of subsidized or unfairly traded steel with foreign currency denominated costs may gain additional competitive advantages or target our home markets if the U.S. dollar or euro exchange rates strengthen relative to those producers' currencies. Volatility in the markets and exchange rates for foreign currencies and contracts in foreign currencies could have a significant impact on our reported financial results and condition.

Financial regulatory frameworks introduced by U.S. and EU regulators may limit our financial flexibility or increase our costs.

We use swaps, forward contracts and similar agreements to mitigate our exposure to volatility, which entails a variety of risks. The Commodity Future Trading Commission’s Dodd Frank and the EU’s European Market Infrastructure Regulation and other government agencies' regulatory frameworks can limit the Company’s ability to hedge interest rate, foreign exchange (FX), or commodity pricing exposures, which could expose us to increased economic risk. These frameworks may introduce additional compliance costs or liquidity requirements. Some counterparties may cease hedging as a result of increased regulatory cost burdens, which in turn may reduce U. S. Steel’s ability to hedge its interest rate, FX or commodity exposures.

We are a party to various legal proceedings, the resolution of which could negatively affect our profitability and cash flows in a particular period.

We are involved at any given time in various litigation matters, including administrative and regulatory proceedings, governmental investigations, environmental matters and commercial disputes. Our profitability and cash flows in a particular period could be negatively affected by an adverse ruling or settlement in any legal proceeding or investigation. While we believe that we have taken appropriate actions to mitigate and effectively manage these risks, due to the nature of our operations, these risks will continue to exist and additional legal proceedings or investigations may arise from time to time.

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Additionally, we may be subject to product liability claims that may have an adverse effect on our financial position, results of operations and cash flows. Events such as well failures, line pipe leaks, blowouts, bursts, fires and product recalls could result in claims that our products or services were defective and caused death, personal injury, property damage or environmental pollution. The insurance we maintain may not be adequate, available to protect us in the event of a claim, or its coverage may be limited, canceled or otherwise terminated, or the amount of our insurance may be less than the related impact on our enterprise value after a loss. We establish reserves based on our assessment of contingencies, including contingencies for claims asserted against us in connection with litigation, arbitrations and environmental issues. Adverse developments in litigation, arbitrations, environmental issues or other legal proceedings may affect our assessment and estimates of the loss contingency recorded as a reserve and require us to make payments in excess of our reserves, which could negatively affect our operations, financial results and cash flows. See "Item 3. Legal Proceedings" and Note 26 to the Consolidated Financial Statements for further details.

Regulatory Risk Factors

Compliance with existing and new environmental regulations, environmental permitting and approval requirements may result in delays or other adverse impacts on planned projects, our results of operations and cash flows.

Steel producers in the U.S., along with their customers and suppliers, are subject to numerous federal, state and local laws and regulations relating to the protection of the environment. These laws and regulations concern the generation, storage, transportation, disposal, emission or discharge of pollutants, contaminants and hazardous substances into the environment, the reporting of such matters, and the general protection of public health and safety, natural resources, wildlife and the environment. Steel producers in the EU are subject to similar laws. These laws and regulations continue to evolve and are becoming increasingly stringent. The ultimate impact of complying with such laws and regulations is not always clearly known or determinable because regulations under some of these laws have not yet been promulgated or are undergoing revision. Additionally, compliance with certain of these laws and regulations, such as the CAA and similar state and local requirements, governing air emissions, could result in substantially increased capital requirements and operating costs and could change the equipment or facilities we operate. Compliance with current or future regulations could entail substantial costs for emission-based systems and could have a negative impact on our results of operations and cash flows. Failure to comply with the requirements may result in administrative, civil and criminal penalties, revocation of permits to conduct business or construct certain facilities, substantial fines or sanctions, enforcement actions (including orders limiting our operations or requiring corrective measures), natural resource damages claims, cleanup and closure costs, and third-party claims for property damage and personal injury as a result of violations of, or liabilities under, environmental laws, regulations, codes and common law. The amount and timing of environmental expenditures is difficult to predict, and, in some cases, liability may be imposed without regard to contribution or to whether we knew of, or caused, the release of hazardous substances.

In addition, the Company must obtain, maintain and comply with numerous permits, leases, approvals, consents and certificates from various governmental authorities in connection with the construction and operation of new production facilities or modifications to existing facilities. In connection with such activities, the Company may need to make significant capital and operating expenditures to detect, repair and/or control air emissions, to control water discharges or to perform certain corrective actions to meet the conditions of the permits issued pursuant to applicable environmental laws and regulations.

There can be no assurance that future approvals, licenses and permits will be granted or that we will be able to maintain and renew the approvals, licenses and permits we currently hold. Failure to do so could have a material adverse effect on our results of operations and cash flows. Furthermore, compliance with the environmental permitting and approval requirements may be costly and time consuming and could result in delays or other adverse impacts on planned projects, our results of operations and cash flows.

We have significant environmental remediation costs that negatively affect our results of operations and cash flows.

Some of U. S. Steel's current and former facilities were in operation before many federal and state environmental regulations were in place. Hazardous materials associated with those facilities have been and may continue to be encountered at current or former operating sites or delivered to sites operated by third parties.

U. S. Steel is involved in numerous remediation projects at currently operating facilities, facilities that have been closed or sold to unrelated parties and other sites where material generated by U. S. Steel was deposited. In addition, there are numerous other former operating or disposal sites that could become subject to remediation, which may negatively affect our results of operations and cash flows.

Reducing greenhouse gas (GHG) emissions from steelmaking operations to meet corporate targets or comply with new regulations as well as stakeholder expectations and mitigate potential physical impacts of climate change could significantly increase costs to manufacture future materials or reduce the amount of materials being manufactured.

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Iron and steel producers around the world are facing mounting pressure to reduce greenhouse gas emissions from operations. The majority of greenhouse gas emissions from the production of iron and steel are caused by the combustion of fossil fuels, the use of electrical energy, and the use of coal, lime, and iron ore as feedstock. The two main production processes are the integrated route of blast furnace ironmaking in combination with basic oxygen furnace steelmaking (BOF) and the alternative route of electric arc furnace steelmaking. Both routes generate greenhouse gas emissions with the latter process, involving the electric arc melting of a majority of steel scrap, generating less than half that of the traditional integrated steelmaking process.

Federal, state and local governmental agencies within the United States may introduce regulatory changes in response to the potential impacts of climate change, including the introduction of carbon emissions limitations or trading mechanisms. Any such regulation regarding climate change and GHG emissions could impose significant costs on our operations and on the operations of our customers and suppliers, including increased energy, capital equipment, emissions controls, environmental monitoring and reporting and other costs in order to comply with current or future laws or regulations concerning climate change and GHG emissions. Any adopted future climate change and GHG regulations could negatively impact our ability, and that of our customers and suppliers, to compete with companies situated in areas not subject to or not complying with such limitations. Inconsistency of regulations may also change the attractiveness of the locations of some of the Company's assets and investments. In addition, changes in certain environmental regulations, including those that may impose output limitations or higher costs associated with climate change or greenhouse gas emissions, could substantially increase the cost of manufacturing and raw materials to us and other steel producers. For additional details, see “Part I – Item 1, Business – New and Emerging Environmental Regulations – United States and European Greenhouse Gas Emissions Regulations” above.

Additionally, the European Union has established aggressive CO_2 reduction targets of 40 percent by 2030, against a 1990 baseline, and full carbon neutrality by 2050. As part of the European Green Deal the Commission proposed in September 2020 to raise the 2030 reduction target to at least 55 percent compared to 1990. The new target has yet to be endorsed by the European Parliament. An emission trading system (ETS) was established to encourage compliance with set emissions reduction targets. These aggressive targets require drastic measures within the steel industry to comply. The transition to EAF technology, as well as incremental gains in energy reduction, use of renewable energy, hydrogen-based steelmaking and continued asset and process improvements are expected to reduce our GHG footprint. However, the development of breakthrough technologies is likely required to continue the path of low to no carbon footprint in the steel industry. Implementation of new technologies will most likely require significant amounts of capital and an abundant source of low-cost hydrogen and/or green power, most likely leading to an increase in the cost of future steelmaking. In addition, the cost of emission allowances is forecast to increase, along with the number of allowances decreasing in the next several years. The price of CO_2 emission allowances was 81 euro per metric ton as of December 31, 2022 and forecasts call for potential prices exceeding 100 euro per metric ton in future years.

Environmental, social and governance matters may impact our business and reputation.

In addition to the changing rules and regulations related to environmental, social and governance (ESG) matters imposed by governmental and self-regulatory organizations such as the SEC and the New York Stock Exchange, a variety of third-party organizations and institutional investors evaluate the performance of companies on ESG topics, and the results of these assessments are widely publicized. These changing rules, regulations and stakeholder expectations have resulted in, and are likely to continue to result in, increased general and administrative expenses and increased management time and attention spent complying with or meeting such regulations and expectations. Reduced access to or increased cost of capital may occur as financial institutions and investors increase expectations related to ESG matters.

Developing and acting on initiatives within the scope of ESG, and collecting, measuring and reporting ESG-related information and metrics can be costly, difficult and time consuming and is subject to evolving reporting standards. We may also communicate certain initiatives and goals, regarding environmental matters, diversity, social investments and other ESG-related matters, in our SEC filings or in other public disclosures. These initiatives and goals within the scope of ESG could be difficult and expensive to implement, the technologies needed to implement them may not be cost effective and may not advance at a sufficient pace, and we could be criticized for the accuracy, adequacy or completeness of the disclosure. Furthermore, statements about our ESG-related initiatives and goals, and progress against those goals, may be based on standards for measuring progress that are still developing, internal controls and processes that continue to evolve and assumptions that are subject to change in the future. In addition, we could be criticized for the scope or nature of such initiatives or goals, or for any revisions to these goals. If our ESG-related data, processes and reporting are incomplete or inaccurate, or if we fail to achieve progress with respect to our goals, including our previously announced commitments to reduce greenhouse gas emissions, within the scope of ESG on a timely basis, or at all, our reputation, business, financial performance and growth could be adversely affected.

New and changing data privacy laws and cross-border transfer requirements could have a negative impact on our business and operations.

Our business depends on the processing and transfer of data between our affiliated entities, to and from our business partners, and with third-party service providers, and of our employees, which may be subject to data privacy laws and/or cross-border transfer restrictions. In North America and Europe, new legislation and changes to the requirements or applicability of existing laws, as well as evolving standards and judicial and regulatory interpretations of such laws, may impact U. S. Steel’s ability to effectively process and transfer data both within the United States and across borders in support of our business operations and/or keep pace with specific requirements regarding safeguarding and handling personal information. While U. S. Steel takes steps to comply with these legal requirements, non-compliance could lead to possible administrative, civil, or criminal liability, as well as

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reputational harm to the Company and its employees. The costs of compliance with privacy laws and the potential for fines and penalties in the event of a breach may have a negative impact on our business and operations.

Item 1B. UNRESOLVED STAFF COMMENTS

None.

Item 2. PROPERTIES

See Item 1. Business, Facilities and Locations for listings of U. S. Steel's main properties, their locations and their products and services.

U. S. Steel and its predecessors have owned their properties for many years with no material adverse title claims asserted. In the case of Great Lakes Works, Granite City Works, the Midwest Plant and Keetac iron ore operations, U. S. Steel or its subsidiaries are the beneficiaries of bankruptcy laws and orders providing that properties are held free and clear of past liens and liabilities. In addition, U. S. Steel or its predecessors obtained title insurance, local counsel opinions or similar protections when significant properties were initially acquired or since acquisition.

At the Midwest Plant in Indiana, U. S. Steel has a supply agreement for various utility services with a company that owns a cogeneration facility located on U. S. Steel property. The Midwest Plant agreement expires in 2028.

U. S. Steel leases its headquarters office space in Pittsburgh, Pennsylvania.

For property, plant and equipment additions, including finance leases, see "Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations, Liquidity and Capital Resources" and Note 13 to the Consolidated Financial Statements.

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Mining Properties

Summary Overview of Mining Operations

U. S. Steel operates two surface iron ore mining complexes in Minnesota consisting of the Minntac Mine and Pellet Plant and the Keetac Mine and Pellet Plant, which are wholly owned by the Company. As of December 31, 2022, U. S. Steel owns a minority interest in the iron ore mining assets of Hibbing Taconite Company.

The following table provides a summary of the net book value of the land and PP&E at the Minntac and Keetac mines as of December 31, 2022:

(in millions)	Gross Value	Accumulated Depreciation	Net Book Value
Minntac Mine and Pellet Plant			
Land	$ 30	$ —	$ 30
Other property, plant and equipment	1,558	1,232	326
Total	**$ 1,588**	**$ 1,232**	**$ 356**
Keetac Mine and Pellet Plant			
Land	$ 7	$ —	$ 7
Other property, plant and equipment	298	177	121
Total	**$ 305**	**$ 177**	**$ 128**

The following table provides a summary of our mineral production by mining complex for each reportable period:

Iron Ore Pellets	**Production**		
(Millions of short tons)	**2022**	**2021**	**2020**
Iron Ore Pellets			
Minntac Mine and Pellet Plant	**15.1**	16.1	14.1
Keetac Mine and Pellet Plant	**5.9**	6.0	2.0
Hibbing Taconite Company [(1)]	**0.9**	1.3	0.9
Total	**21.9**	23.4	17.0

[(1)] Represents U. S. Steel's proportionate share of production as these investments are unconsolidated equity affiliates.

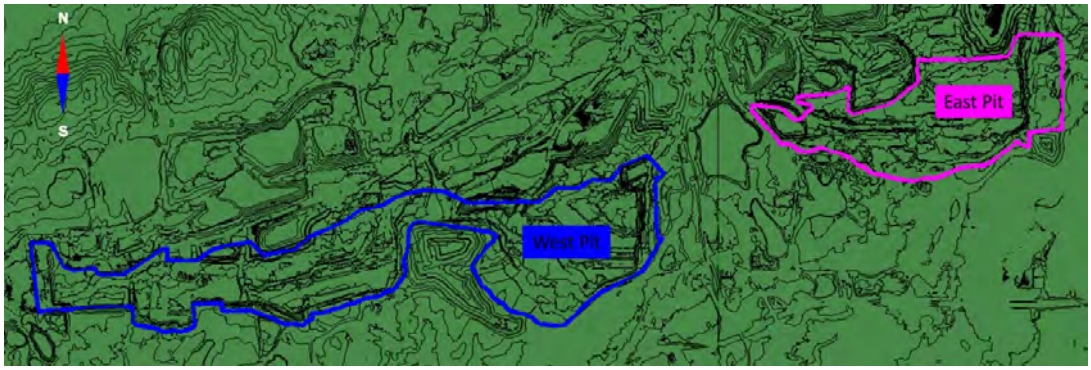
In accordance with Regulation S-K, Items 1300-1305, we engaged DRA Global and Barr Engineering Co. to provide feasibility studies and technical report summaries for our material mining operations at Minntac and Keetac in 2021. The majority shareholders of the Hibbing Taconite Company separately engaged qualified persons to perform the same procedures at the Hibbing Taconite Mine in 2021. Accordingly, the figures below for the Hibbing Taconite Mine were provided by the majority shareholders using the reports provided by the qualified persons. The tables showing resources and reserves by mining property were prepared using the results of the procedures performed by the qualified persons designated by each organization, which have no affiliation with or interest in our material mining properties.

Regulation S-K, Item 1302, requires registrants to file the technical report summary as an exhibit to the Form 10-K filing when disclosing for the first time mineral reserves or resources or when there has been a material change in the mineral reserves or resources since the last technical report summary filed for the properties. The Company did not have any material changes to its reserves or resources during 2022, nor is it disclosing any mineral reserves or resources for the first time. Accordingly, the technical report summary is not filed as an exhibit with the 2022 Form 10-K.

Minntac Mine and Pellet Plant

The Minntac Mine and Pellet Plant is located in Mountain Iron, Minnesota and is wholly owned and operated by U. S. Steel. On April 30, 2020, the Company granted Stelco Inc. (Stelco) a purchase option to acquire a 25 percent interest in the Minntac mining operations. The option can be exercised at any time before January 31, 2027. For more information regarding the purchase option, please see Note 20 to the Consolidated Financial Statements. The Minntac Mine has 25,420 acres of surface rights. The surface mine in the production stage whereby taconite iron ore is mined using the Truck-Shovel method. The mine is approximately 55 years old and has been operated by U. S. Steel since 1967. For discussions regarding encumbrances, violations, fines, etc. related to the Minntac Mine, see Item 3. Legal Proceedings.

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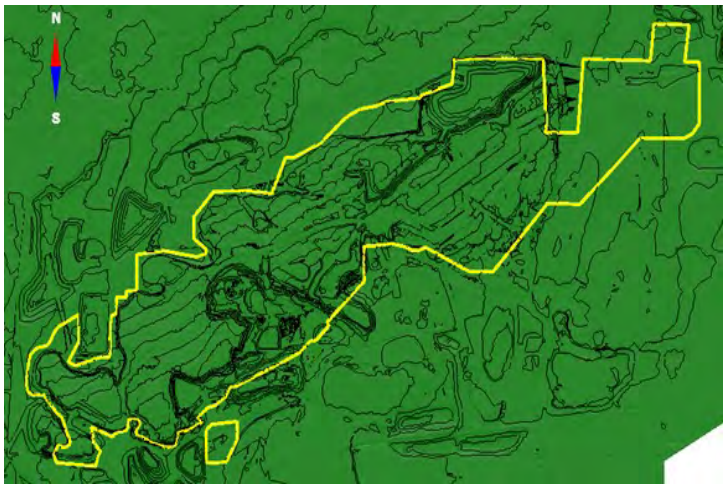
The following table provides details of our iron ore resources and reserves at Minntac for the year ended December 31, 2022. Resources below are stated exclusive of reserves.

Minntac Mine and Pellet Plant

	Amount			Grades/Qualities		Cut-off Grades		Metallurgical Recovery
(Millions of short tons)	2022	2021	Change (%)	MagFe%	Concentrate Silica %	Min MagFe %	Max Concentrate Silica %	Weight Recovery %
Measured mineral resources	—	—	— %	—	—	—	—	—
Indicated mineral resources	251.00	251.00	— %	18.20	5.51	14.00	10.00	23.65
Measured + indicated mineral resources	**251.00**	**251.00**	**— %**	**18.20**	**5.51**	**14.00**	**10.00**	**23.65**
Inferred mineral resources	149.10	149.10	— %	18.05	6.27	14.00	10.00	22.50
Proven mineral reserves	—	—	— %	—	—	—	—	—
Probable mineral reserves	266.10	281.20	(5)%	19.29	5.59	14.00	10.00	25.11
Total mineral reserves	**266.10**	**281.20**	**(5)%**	**19.29**	**5.59**	**14.00**	**10.00**	**25.11**

Keetac Mine and Pellet Plant

The Keetac Mine and Pellet Plant is located in Keewatin, Minnesota and is wholly owned and operated by U. S. Steel. The Keetac Mine has 18,020 acres of surface rights. The surface mine is in the production stage whereby taconite iron ore is mined using the Truck-Shovel method. The mine is approximately 55 years old and has been operated by U. S. Steel since 2003, when it was acquired as part of the Company's purchase of National Steel Corporation. For discussions regarding encumbrances, violations, fines, etc. related to the Keetac Mine, see Item 3. Legal Proceedings.



The following table provides details of our iron ore resources and reserves at Keetac for the year ended December 31, 2022. Resources below are stated exclusive of reserves.

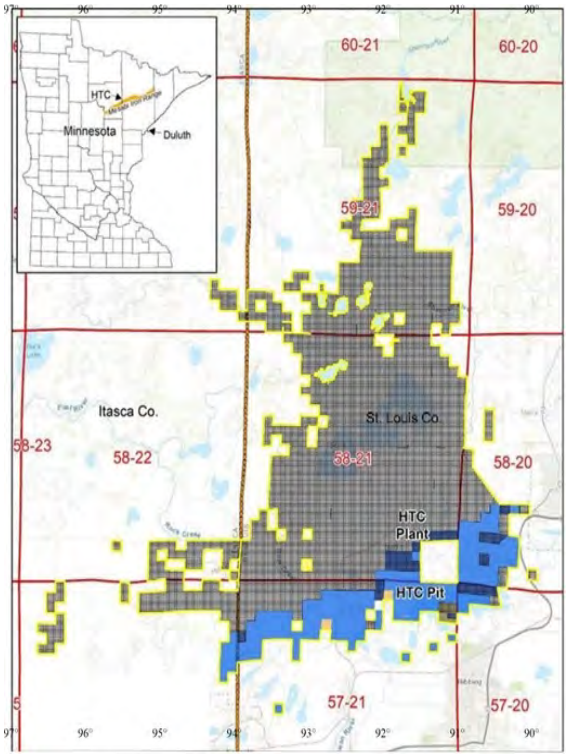
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Keetac Mine and Pellet Plant

	Amount			Grades/Qualities		Cut-off Grades		Metallurgical Recovery
(Millions of short tons)	2022	2021	Change (%)	MagFe%	Concentrate Silica %	Min MagFe %	Max Concentrate Silica %	Weight Recovery %
Measured mineral resources	—	—	— %	—	—	—	—	—
Indicated mineral resources	192.90	192.90	— %	18.93	3.40	14.00	9.00	27.34
Measured + indicated mineral resources	**192.90**	**192.90**	**— %**	**18.93**	**3.40**	**14.00**	**9.00**	**27.34**
Inferred mineral resources	160.50	160.50	— %	18.83	3.81	14.00	9.00	27.30
Proven mineral reserves	—	—	— %	—	—	—	—	—
Probable mineral reserves	179.30	185.20	(3)%	19.29	3.57	14.00	9.00	20.97
Total mineral reserves	**179.30**	**185.20**	**(3)%**	**19.29**	**3.57**	**14.00**	**9.00**	**20.97**

Hibbing Taconite Mine

U. S. Steel maintains a minority interest in the Hibbing Taconite Mine, which is majority-owned by Cleveland-Cliffs, Inc. and located in Hibbing, Minnesota. The Hibbing Mine has 30,760 acres of surface rights, of which 1,150 acres are associated with mineral leases. The majority of the mineral rights are leased. 6,640 acres of mineral leases are expiring between 2023 and 2056. The taconite iron ore mine is currently in the production stage.



The following table provides details of our proportionate share of iron ore resources and reserves at Hibbing for the year ended December 31, 2022. Resources below are stated exclusive of reserves.

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Hibbing Taconite Company [1]

	Amount			Grades/Qualities
(Millions of short tons)	**2022**	**2021**	**Change (%)**	**MagFe%**
Measured mineral resources	0.40	0.40	— %	19.20
Indicated mineral resources	—	—	— %	18.70
Measured + indicated mineral resources	**0.40**	**0.40**	**— %**	**19.20**
Inferred mineral resources	—	—	— %	—
Proven mineral reserves	3.30	4.20	(21.43)%	18.70
Probable mineral reserves	0.40	0.40	— %	18.70
Total mineral reserves	**3.70**	**4.60**	**(19.57)%**	**18.70**

[1] Represents U. S. Steel's proportionate share of proven and probable reserves and production as these investments are unconsolidated equity affiliates.

Internal Controls

U. S. Steel estimates its iron ore resources and reserves using exploration drill holes, physical inspections, sampling, laboratory testing, 3-D computer models, economic pit analysis and fully-developed pit designs for its operating mines. Estimates for our share of unconsolidated equity affiliates are based upon information supplied by the joint ventures. Refer to sections 2 and 3 of the technical report summaries filed as Exhibit 96.1 to our 2021 Form 10-K for further details.

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Item 3. LEGAL PROCEEDINGS

General Litigation

On June 8, 2021, JSW Steel (USA) Inc. and JSW Steel USA Ohio, Inc. (collectively, JSW), U.S. based subsidiaries of Indian steelmaker JSW Steel, filed suit in the United States District Court for the Southern District of Texas against Nucor, U. S. Steel, AK Steel Holding Group and Cleveland-Cliffs (collectively, the JSW Defendants) alleging that the Defendants operated as a cartel and formed a conspiracy to boycott JSW from obtaining semi-finished steel slabs. JSW alleges that the JSW Defendants acted in violation of Section 1 of the Sherman Act and the Clayton Act (federal antitrust), and violation of the Texas Free Enterprise and Antitrust Act. JSW also alleges that the JSW Defendants formed a civil conspiracy in violation of Texas common law, and that the JSW Defendants tortiously interfered with JSW's business relationships. The basis for JSW's allegations relate to the JSW Defendants participation in the DOC's Section 232 process, including the JSW Defendants' support of the enactment of the President's Section 232 proclamation, statements made by the JSW Defendants after the enactment of Section 232, and the JSW Defendants' participation in the Section 232 exclusion process. Plaintiffs seek monetary damages including $45 million for payment of Section 232 tariffs and unspecified amounts for financial penalties, termination fees and lost profits as well as other damages. U. S. Steel, along with the other JSW Defendants, filed a Motion to Dismiss the case on August 17, 2021. On February 17, 2022, the Court issued an opinion dismissing JSW's antitrust complaint with prejudice. JSW filed a timely notice of appeal with the United States Court of Appeals for the Fifth Circuit. The matter is fully briefed and is scheduled for oral argument at the Fifth Circuit in first quarter 2023. The Company continues to vigorously defend the matter.

On October 2, 2017, an Amended Shareholder Class Action Complaint was filed in the United States District Court for the Western District of Pennsylvania consolidating previously-filed actions. Separately, five related shareholder derivative lawsuits were filed in state and federal courts in Pittsburgh, Pennsylvania and the Delaware Court of Chancery. The underlying consolidated class action lawsuit alleges that U. S. Steel, certain current and former officers, an upper-level manager of the Company and the financial underwriters who participated in the August 2016 secondary public offering of the Company's common stock (collectively, the "Class Action Defendants") violated federal securities laws in making false statements and/or failing to discover and disclose material information regarding the financial condition of the Company. The lawsuit claims that this conduct caused a prospective class of plaintiffs to sustain damages during the period from January 27, 2016 to April 25, 2017 as a result of the prospective class purchasing the Company's common stock at artificially inflated prices and/or suffering losses when the price of the common stock dropped. The derivative lawsuits generally make the same allegations against the same officers and also allege that certain current and former members of the Board of Directors failed to exercise appropriate control and oversight over the Company and were unjustly compensated. The plaintiffs seek to recover losses that were allegedly sustained. The Class Action Defendants moved to dismiss plaintiffs' claims. On September 29, 2018 the Court ruled on those motions granting them in part and denying them in part. On March 18, 2019, the plaintiffs withdrew the claims against the Class Action Defendants related to the 2016 secondary offering. As a result, the underwriters are no longer parties to the case. On December 31, 2019, the court granted the Plaintiffs' motion to certify the proceeding as a class action. The Company's appeal of that decision was denied. Discovery followed and concluded. On May 20, 2022, the Plaintiffs and Class Action Defendants agreed to settle the Shareholder Class Action in the amount of $40 million to be fully funded by the Company's insurers. Court approval of the class action settlement is currently pending with a Final Approval Hearing set for March 20, 2023. The related derivative cases, which were previously stayed, are now proceeding and the Company will vigorously defend against the derivative lawsuits.

On December 24, 2018, U. S. Steel's Clairton Plant experienced a fire, affecting portions of the facility involved in desulfurization of the coke oven gas generated during the coking process. With the desulfurization process out of operation as a result of the fire, U. S. Steel was not able to certify compliance with Clairton Plant's Title V permit levels for sulfur emissions. U. S. Steel promptly notified ACHD, which has regulatory jurisdiction for the Title V permit, and updated the ACHD regularly on efforts to mitigate any potential environmental impacts until the desulfurization process was returned to normal operations. Of the approximately 2,400 hours between the date of the fire and April 4, 2019, when the Company resumed desulfurization, there were ten intermittent hours where average SO_2 emissions exceeded the hourly NAAQS for SO_2 at the Allegheny County regional air quality monitors located in Liberty and North Braddock boroughs, which are near U. S. Steel's Mon Valley Works facilities. On April 29, 2019, PennEnvironment and Clean Air Council, both environmental, non-governmental organizations filed a Complaint in Federal Court in the Western District of Pennsylvania. The ACHD was subsequently granted intervenor status. Collectively the parties seek injunctive relief and civil penalties regarding the alleged Permit violations following the fire. Discovery has concluded. The court denied the parties' respective Motions for Summary Judgment. A non-jury trial is currently scheduled to take place in April and May of 2023. The Company will continue to vigorously defend against the matter.

Asbestos Litigation

See Note 26 to our Consolidated Financial Statements, Contingencies and Commitments for a description of our asbestos litigation.

ENVIRONMENTAL PROCEEDINGS

The following is a summary of the proceedings of U. S. Steel that were pending or contemplated as of December 31, 2022, under federal and state environmental laws, and which U. S. Steel reasonably believes may result in monetary sanctions of at

least $1 million (the threshold chosen by U. S. Steel as permitted by Item 103 of Regulation S-K promulgated under the Securities Exchange Act of 1934, as amended). Information about specific sites where U. S. Steel is or has been engaged in significant clean up or remediation activities is also summarized below. Except as described herein, it is not possible to accurately predict the ultimate outcome of these matters.

CERCLA Remediation Sites

Claims under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) have been raised with respect to the cleanup of various waste disposal and other sites. Under CERCLA, potentially responsible parties (each, a PRP) for a site include current owners and operators, past owners and operators at the time of disposal, persons who arranged for disposal of a hazardous substance at a site and persons who transported a hazardous substance to a site. CERCLA imposes strict and joint and several liabilities. Because of various factors, including the ambiguity of the regulations, the difficulty of identifying the responsible parties for any particular site, the complexity of determining the relative liability among them, the uncertainty as to the most desirable remediation techniques, and the amount of damages and cleanup costs and the time period during which such costs may be incurred, we are unable to reasonably estimate U. S. Steel's ultimate liabilities under CERCLA.

As of December 31, 2022, U. S. Steel has received information requests or been identified as a PRP at a total of four CERCLA sites, three of which have liabilities that have not been resolved. Based on currently available information, which is in many cases preliminary and incomplete, management believes that U. S. Steel's liability for CERCLA cleanup and remediation costs at the other site will be over $5 million as described below.

Duluth Works

The former U. S. Steel Duluth Works site was placed on the National Priorities List under CERCLA in 1983 and on the State of Minnesota's Superfund list in 1984. Liability for environmental remediation at the site is governed by a Response Order by Consent executed with the MPCA in 1985 and a Record of Decision signed by MPCA in 1989. U. S. Steel has partnered with the Great Lakes National Program Office (GLNPO) of the U.S. EPA Region 5 to address contaminated sediments in the St. Louis River Estuary and several other operable units that could impact the estuary if not addressed. An amendment to the Project Agreement between U. S. Steel and GLNPO was executed during the second quarter of 2018 to recognize the initial costs associated with implementing the first two phases of the proposed remedial plan at the site.

Remediation contracts were issued by both USS and GLNPO for the first phase of the remedial work at the site during the fourth quarter of 2020. USS and GLNPO have completed the second phase of work at the site which extended through early 2022. The final phase of the remedial design has been defined and another amendment to the Project Agreement between U.S. Steel and GLNPO was executed in December 2021. Execution of this final phase is in progress and is expected to extend through 2023. USS' portion of additional, design, oversight costs and implementation of all three phases of the preferred remedial alternative on the upland property and Estuary are currently estimated as of December 31, 2022 at approximately $22 million.

Resource Conservation Recovery Act (RCRA) and Other Remediation Sites

U. S. Steel may be liable for remediation costs under other environmental statutes, both federal and state, or where private parties are seeking to impose liability on U. S. Steel for remediation costs through discussions or litigation. There are nine such sites where remediation is being sought involving amounts in excess of $1 million. Based on currently available information, which is in many cases preliminary and incomplete, management believes that liability for cleanup and remediation costs in connection with five sites may involve remediation costs between $1 million and $5 million per site and four sites are estimated to, or could have, costs for remediation, investigation, restoration or compensation in excess of $5 million per site.

For more information on the status of remediation activities at U. S. Steel's significant sites, see the discussions below.

Gary Works

On October 23, 1998, the U.S. EPA issued a final Administrative Order on Consent (Order) addressing Corrective Action for Solid Waste Management Units (SWMU) throughout Gary Works. This Order requires U. S. Steel to perform a RCRA Facility Investigation (RFI), a Corrective Measures Study (CMS) and Corrective Measure Implementation. Evaluations are underway at six groundwater areas on the east side of the facility. A remedial groundwater treatment system has been operating at one of the six areas since 2021. An Interim Stabilization Measure work plan was recently approved by the U.S. EPA for a second area and a contractor has begun installation of the remedial system. Until the remaining Phase I work and Phase II field investigations are completed, it is not possible to assess what additional expenditures will be necessary for Corrective Action projects at Gary Works. In total, the accrued liability for Corrective Action projects is approximately $28 million as of December 31, 2022, based on our current estimate of known remaining costs.

Geneva Works

At U. S. Steel's former Geneva Works, liability for environmental remediation, including the closure of three hazardous waste impoundments and facility-wide corrective action, has been allocated between U. S. Steel and the current property owner pursuant to an agreement and a permit issued by the Utah Department of Environmental Quality (UDEQ). Having completed the

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investigation on a majority of the remaining areas identified in the permit, U. S. Steel had determined the most effective means to address the majority of impacted materials was to manage those materials in a previously approved on-site Corrective Action Management Unit (CAMU). U. S. Steel awarded a contract for the implementation of the CAMU project during the fourth quarter of 2018. Construction, waste stabilization and placement along with closure of the CAMU were substantially completed in the fourth quarter of 2020. U. S. Steel has an accrued liability of approximately $19 million as of December 31, 2022, for our estimated share of the remaining costs of remediation at the site.

USS-UPI LLC (UPI)

In February 2020, U. S. Steel purchased the remaining 50 percent interest in USS-POSCO Industries, a former joint venture that is located in Pittsburg, California between subsidiaries of U. S. Steel and POSCO, now known as USS-UPI, LLC. Prior to formation of the joint venture, UPI's facilities were previously owned and operated solely by U. S. Steel, which assumed responsibility for the existing environmental conditions. U. S. Steel continues to monitor the impacts of the remedial plan implemented in 2016 to address groundwater impacts from trichloroethylene at SWMU 4. Evaluations continue for the SWMUs, known as the Northern Boundary Group, and it is likely that corrective measures will be required, but it is not possible at this time to define a scope or estimate costs for what may be required by the California Department of Toxic Substances Control. As such, there has been no material change in the status of the project during the twelve months ended December 31, 2022. As of December 31, 2022, approximately $1 million has been accrued for ongoing environmental studies, investigations and remedy monitoring. Significant additional costs associated with this site are possible and are referenced in Note 26 to the Consolidated Financial Statements, Contingencies and Commitments, Environmental Matters, Remediation Projects, Projects with Ongoing Study and Scope Development. See Note 5 to the Consolidated Financial Statements for further details regarding U. S. Steel's purchase of UPI.

Cherryvale, KS Zinc

In April 2003, U. S. Steel and Salomon Smith Barney Holdings, Inc. entered into a Consent Order with the Kansas Department of Health & Environment (KDHE) concerning a former zinc smelting operation in Cherryvale, Kansas. Remediation of the site proper was essentially completed in 2007. The Consent Order was amended on May 3, 2013 to require investigation (but not remediation) of potential contamination beyond the boundary of the former zinc smelting operation. On November 22, 2016, KDHE approved a State Cooperative Final Agency Decision Statement that identified the remedy selected to address potential contamination beyond the boundary of the former zinc smelting site. The Removal Action Design Plan was approved during the second quarter of 2018. The Waste Deposition Area design and the Interim Risk Management Plan (which includes institutional controls) were approved by KDHE during the fourth quarter of 2018. An amended consent order for remediation was signed in May 2019 and a remediation contract was executed in June 2019. Remediation work was substantially completed in the 4th quarter of 2022. U. S. Steel has an accrued liability of approximately $908,000 as of December 31, 2022, for our estimated share of the remaining cost of remediation.

Fairfield Works

A consent decree was signed by U. S. Steel, the U.S EPA and the U.S. Department of Justice and filed with the United States District Court for the Northern District of Alabama (United States of America v. USX Corporation) in December 1997. In accordance with the consent decree, U. S. Steel initiated a RCRA corrective action program at the Fairfield Works facility. The Alabama Department of Environmental Management, with the approval of the U.S. EPA, assumed primary responsibility for regulation and oversight of the RCRA corrective action program at Fairfield Works. While work continues on different aspects of the program, there has been no material change in the status of the project during the year ended December 31, 2022. In total, the accrued liability for remaining work under the Corrective Action Program, was approximately $377,000 at December 31, 2022. Significant additional costs associated with this site are possible and are referenced in Note 26 to the Consolidated Financial Statements “Contingencies and Commitments, Environmental Matters, Remediation Projects, Projects with Ongoing Study and Scope Development.”

Air Related Matters

Granite City Works

In October 2015, Granite City Works received a Violation Notice from Illinois Environmental Protection Agency (IEPA) in which the IEPA alleges that U. S. Steel violated the emission limits for nitrogen oxides (NOx) and volatile organic compounds from the Basic Oxygen Furnace Electrostatic Precipitator Stack. In addition, the IEPA alleges that U. S. Steel exceeded its natural gas usage limit at its CoGeneration Boiler. U. S. Steel responded to the notice and is currently discussing resolution of the matter with IEPA.

Although discussions with IEPA regarding the foregoing alleged violations are ongoing and the resolution of these matters is uncertain at this time, it is not anticipated that the result of those discussions will be material to U. S. Steel.

Minnesota Ore Operations

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On February 6, 2013, the U.S. EPA published a FIP that applies to taconite facilities in Minnesota. The FIP establishes and requires emission limits and the use of low NOx reduction technology on indurating furnaces as Best Available Retrofit Technology (BART). While U. S. Steel installed low NOx burners on three furnaces at Minntac and is currently obligated to install low NOx burners on the two other furnaces at Minntac pursuant to existing agreements and permits, the rule would require the installation of a low NOx burner on the one furnace at Keetac for which U. S. Steel did not have an otherwise existing obligation. U. S. Steel estimates expenditures associated with the installation of low NOx burners of as much as $25 million to $30 million. In 2013, U. S. Steel filed a petition for administrative reconsideration to the U.S. EPA and a petition for judicial review of the 2013 FIP and denial of the Minnesota State Implementation Plan (SIP) to the Eighth Circuit. In April 2016, the U.S. EPA promulgated a revised FIP with the same substantive requirements for U. S. Steel. In June 2016, U. S. Steel filed a petition for administrative reconsideration of the 2016 FIP to the U.S. EPA and a petition for judicial review of the 2016 FIP before the Eighth Circuit Court of Appeals. While the proceedings regarding the petition for judicial review of the 2013 FIP remained stayed, oral arguments regarding the petition for judicial review of the 2016 FIP were heard by the Eighth Circuit Court of Appeals on November 15, 2017. Thus, both petitions for judicial review remain with the Eighth Circuit. On December 4, 2017, the U.S. EPA published a notification in the Federal Register in which the U.S. EPA denied U. S. Steel's administrative petitions for reconsideration and stay of the 2013 FIP and 2016 FIP. On February 1, 2018, U. S. Steel filed a petition for judicial review of the U.S. EPA's denial of the administrative petitions for reconsideration to the Eighth Circuit Court of Appeals. The U.S. EPA and U. S. Steel reached a settlement regarding the five indurating lines at Minntac. After proposing a revised FIP and responding to public comments, on March 2, 2021, the U.S. EPA promulgated a final revised FIP incorporating the conditions and limits for Minntac to which the parties agreed. U. S. Steel and the U.S. EPA continue to negotiate resolution for Keetac.

Mon Valley Works

On November 9, 2017, the U.S. EPA Region III and ACHD jointly issued a Notice of Violation (NOV) regarding the Company's Edgar Thomson facility in Braddock, Pennsylvania. In addition, on November 20, 2017, ACHD issued a separate, but related, NOV to the Company regarding the Edgar Thomson facility. In the NOVs, based upon their inspections and review of documents collected, the agencies allege that the Company has violated the CAA by exceeding the allowable visible emission standards from certain operations during isolated events. In addition, the agencies allege that the Company has violated certain maintenance, reporting, and recordkeeping requirements. U. S. Steel met with the U.S. EPA Region III and ACHD several times. On May 17, 2022, the United States Department of Justice (the DOJ), the U.S. EPA Region III and the ACHD filed a Complaint in the United States District Court for the Western District of Pennsylvania and lodged a proposed Consent Decree negotiated in good faith between U. S. Steel, DOJ, the U.S. EPA Region III and ACHD that will resolve this matter. On December 16, 2022, the Court approved the Consent Decree and it is currently in effect.

On March 2, 2022, the Company received a stipulated penalty demand for $0.9 million from the Allegheny County Health Department (ACHD) pursuant to the June 2019 Settlement Agreement and Order (SAO) between the Company and ACHD. In the demand notice, ACHD alleges that based upon daily visible emission observation inspections occurring April 1, 2021 through December 31, 2021, the Company's Clairton plant violated applicable opacity standards from coke battery fugitive emission sources. The Company disagrees with the bases for the demand. The Company has initiated dispute resolution in accordance with the SAO and is attempting to reach a negotiated resolution of the matter.

On March 7, 2022, the Company received an enforcement order from the ACHD that includes a civil penalty demand for $1.8 million. In the Order, the ACHD alleges that the Company's Clairton plant is solely and entirely culpable for 153 alleged exceedances of the Pennsylvania hydrogen sulfide ambient air standard that are reported to have occurred during January 1, 2020 through March 1, 2022. The Company disagrees with the bases for the demand. On April 5, 2022, the Company appealed the Order and is vigorously defending the matter. On September 1, 2022, after conferring with ACHD and the Company, the ACHD Hearing Officer issued an order requiring discovery to be completed by June 1, 2023 with a hearing date of September 18, 2023.

On March 24, 2022, the Company received an enforcement order from the ACHD that includes a civil penalty demand for $4.6 million for alleged air permit violations occurring between January 1, 2020 through March 15, 2022 regarding the Company's Clairton plant's coke oven pushing emission control systems. The Company disagrees with the bases for the demand and has appealed the Order. On September 1, 2022, after conferring with ACHD and the Company, the ACHD Hearing Officer issued an order requiring discovery to be completed by June 1, 2023 with a hearing date of September 25, 2023.

Item 4. MINE SAFETY DISCLOSURE

The information concerning mine safety violations and other regulatory matters required by Section 1503(a) of the Dodd-Frank Wall Street Reform and Consumer Protection Act and Item 104 of Regulation S-K is included in Exhibit 95 to this Form 10-K.

INFORMATION ABOUT OUR EXECUTIVE OFFICERS

The executive officers of U. S. Steel and their ages as of February 1, 2023, are as follows:

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Name	Age	Title	Executive Officer Since
Daniel R. Brown	50	Senior Vice President - Advanced Technology Steelmaking & Chief Operating Officer, Big River Steel Works	February 1, 2022
James E. Bruno	57	Senior Vice President - European Solutions and President USSK	December 1, 2014
Scott D. Buckiso	55	Senior Vice President and Chief Manufacturing Officer North American Flat-Rolled	May 31, 2015
David B. Burritt	67	President & Chief Executive Officer	September 1, 2013
Richard L. Fruehauf	55	Senior Vice President - Chief Strategy & Sustainability Officer	March 1, 2019
Jessica T. Graziano	49	Senior Vice President & Chief Financial Officer	August 8, 2022
Manpreet S. Grewal	43	Vice President, Controller & Chief Accounting Officer	March 30, 2020
Duane D. Holloway	50	Senior Vice President, General Counsel and Chief Ethics & Compliance Officer	April 16, 2018
Kenneth E. Jaycox	55	Senior Vice President and Chief Commercial Officer	September 28, 2020

Messrs. Brown, Bruno, Buckiso, Burritt and Fruehauf have held responsible management or professional positions with U. S. Steel or its subsidiaries for more than the past five years. Prior to joining U. S. Steel in 2022, Ms. Graziano spent eight years with United Rentals, Inc, culminating in her position as Executive Vice President and Chief Financial Officer. Prior to her work with United Rentals, Ms. Graziano spent five years at Revlon, Inc. where she advanced through positions of increasing responsibility culminating in her being named Senior Vice President, Chief Accounting Officer and Corporate Controller. Prior to joining U. S. Steel in 2020, Mr. Jaycox served as Vice President, Transformation at Sysco Corporation where during his seven-year tenure, he progressed through a series of executive responsibilities including transformation, sales development and support, and revenue management. Prior to joining U. S. Steel in 2020, Mr. Grewal served as vice president, business finance, controller and chief accounting officer at Covanta since February 2017. Prior to Covanta, Mr. Grewal spent fourteen years at Johnson Controls Incorporated (formerly Tyco International) in increasingly responsible roles, including internal audit, accounting, controllership, and financial planning and analysis. Prior to joining U. S. Steel in 2018, Mr. Holloway served as executive vice president and general counsel at Ascena Retail Group Inc. During his time at Ascena, Mr. Holloway served as global chief legal, compliance, sustainability and diversity officer. Prior to his work at Ascena, Mr. Holloway served as vice president and deputy general counsel for CoreLogic Inc., the leading global residential property information, analytics and data-enabled solutions provider.

PART II

Item 5. MARKET FOR REGISTRANT'S COMMON EQUITY, RELATED STOCKHOLDER MATTERS AND ISSUER PURCHASES OF EQUITY SECURITIES

Common Stock Information

The principal market on which United States Steel Corporation (U. S. Steel) common stock is traded is the New York Stock Exchange, where the common stock trades under trading symbol "X". U. S. Steel common stock is also traded on the Chicago Stock Exchange under the symbol "X".

As of January 30, 2023, there were 10,657 registered holders of U. S. Steel common stock.

The Board of Directors currently intends to declare and pay dividends on shares of U. S. Steel common stock based on the financial condition and results of operations of U. S. Steel out of legally available funds and in accordance with the requirements set forth by applicable law. Quarterly dividends were declared by U. S. Steel in 2022 in the amount of five cents per share. Quarterly dividends were declared by U. S. Steel in 2021 in the amount of one cent per share in the first, second and third quarters and five cents per share in the fourth quarter.

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Purchases of Equity Securities by the Issuer and the Affiliated Purchasers

On October 25, 2021, the Board of Directors authorized a share repurchase program that allowed for the repurchase of up to $300 million of its outstanding common stock from time to time in the open market or privately negotiated transactions. On January 24, 2022 the Board of Directors authorized an additional $500 million under the share repurchase program.

On July 25, 2022, following the completion of the previously authorized $800 million share repurchase programs, the Board of Directors authorized a new share repurchase program that allows for the repurchase of up to $500 million of its outstanding common stock from time to time in the open market or privately negotiated transactions at the discretion of management. The Company's share repurchase program does not obligate it to acquire any specific number of shares.

Approximately $50 million of common stock was repurchased in January 2023, and there is currently approximately $251 million remaining under the current authorizations.

Share repurchase activity under the Company's stock repurchase authorization during the three months ended December 31, 2022 was as follows:

Period	Total Number of Shares Purchased	Average Price Paid per Share	Total Number of Shares Purchased as Part of Publicly Announced Plans or Programs	Approximate Dollar Value of Shares that May Yet Be Purchased Under the Plans or Programs in effect at December 31, 2022 [(a)]
October 1 - 31, 2022	—	$ —	—	$ 451,000,800
November 1 - 30, 2022	2,243,200	$ 24.61	2,243,200	$ 395,788,300
December 1 - 31, 2022	3,673,509	$ 25.80	3,673,509	$ 301,000,800
Quarter ended December 31, 2022	5,916,709	$ 25.35	5,916,709	$ 301,000,800

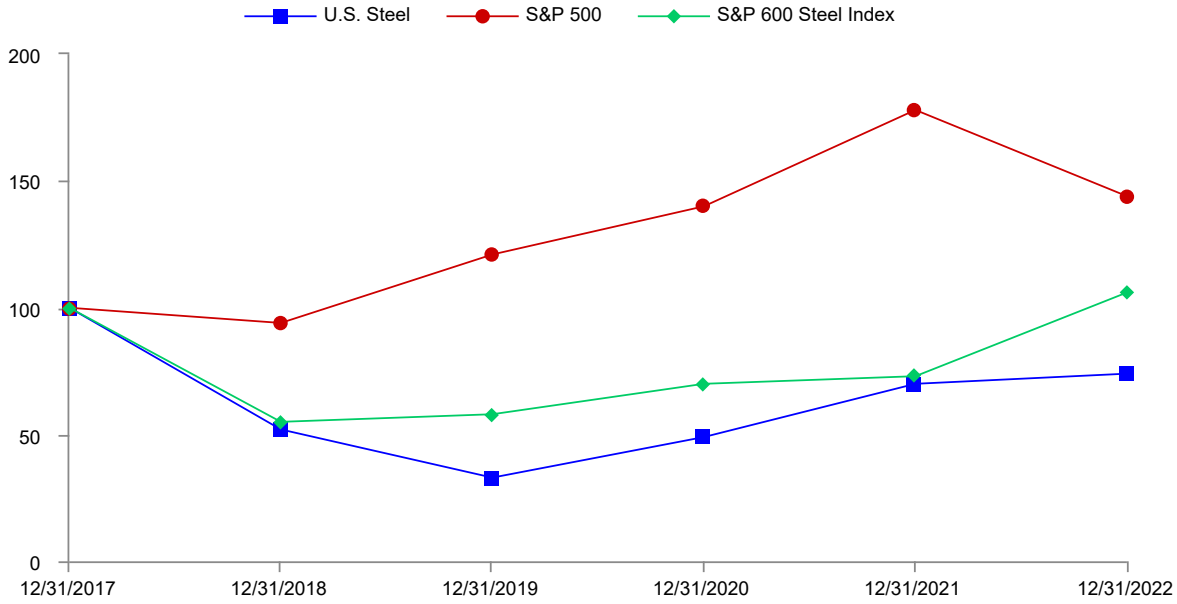
[(a)] On October 25, 2021, the Board of Directors authorized a share repurchase program to repurchase up to $300 million of our outstanding common stock at the discretion of management. On January 24, 2022 the Board of Directors authorized an additional $500 million under the share repurchase program. Each of the repurchase programs have no expiration date. On July 25, 2022, following the completion of the previously authorized $800 million share repurchase programs, the Board of Directors authorized a new share repurchase program that allows for the repurchase of up to $500 million of its outstanding common stock. The Company's share repurchase program does not obligate it to acquire any specific number of shares. Under this program, the shares will be purchased from time to time at prevailing market prices, through open market or privately negotiated transactions, depending upon market conditions. The repurchase program has no expiration date.

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Stockholder Return Performance

The graph below assumes $100 invested on December 31, 2017 and compares the yearly change in cumulative total stockholder return of our common stock with the cumulative total return of the Standard & Poor's (S&P) 500 Stock Index and the S&P 600 Steel Index, and assumes that all dividends were reinvested.

Comparison of Cumulative Total Return
on $100 Invested in U. S. Steel Stock on December 31, 2017
vs
S&P 500 and S&P 600 Steel Index



For information on securities authorized for issuance under our equity compensation plans, see "Item 12. Security Ownership of Certain Beneficial Owners and Management and Related Stockholder Matters."

Unregistered Sales of Equity Securities

U. S. Steel had no sales of unregistered equity securities during the period covered by this report.

Item 6. RESERVED

Item 7. MANAGEMENT'S DISCUSSION AND ANALYSIS OF FINANCIAL CONDITION AND RESULTS OF OPERATIONS

The following discussion should be read in conjunction with the Consolidated Financial Statements and the related Notes that appear elsewhere in this document. Please refer to Item 7 of our 2021 Form 10-K for further discussion and analysis of our 2020 financial condition and results of operations.

Overview

2022 marked our second-best financial year in the Company's history with continued execution of our strategy. Each of our operating segments contributed meaningfully to 2022's success, while delivering record safety performance and strong operational excellence, quality, and reliability for our customers. We continued to invest in our future by progressing on key strategic projects and we also rewarded stockholders in 2022 with direct returns, including a quarterly dividend and share repurchases. In the second half of 2022, we quickly responded to changing market dynamics by temporarily idling certain operations to better balance steel supply with customer demand.

U. S. Steel's results in 2022 compared to the previous year for the four reportable segments, except for Tubular Products (Tubular), generally declined from challenging business conditions:

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- **North American Flat-Rolled (Flat-Rolled):** Flat-Rolled results declined primarily due to lower sales volume across most consumer and manufacturing industries and increased material, energy and operating costs, partially offset by higher sales price.

- **Mini Mill:** Mini Mill results declined primarily due to lower sales prices and higher raw material costs.

- **U. S. Steel Europe (USSE):** USSE results declined primarily due to lower sales volume, increased raw material and energy costs and the weakening euro exchange rate, partially offset by higher sales price.

- **Tubular:** Tubular results improved primarily due to increased volume, higher sales price and improved premium product mix, driven by the steady increase of drilling activity, partially offset by continued high levels of imports.

Fluctuations in the market price of raw materials and other inflationary impacts have affected the results of each of our reportable segments, and fluctuations going-forward are reasonably likely to have a material impact on future results. We could experience inflation related headwinds in 2023 for certain raw materials and other costs.

In February 2022, Russia invaded Ukraine and active conflict continues in the country. The war in Ukraine will likely continue to cause disruption and instability in Russia, Ukraine, as well as the markets in which we operate. The Company is constantly monitoring the situation for impacts and risks to the business and is implementing risk mitigating strategies where possible.

As a result of the invasion, governments around the world, including the European Union (EU) and the United States of America (U.S.), have enacted sanctions against Russia and Russian interests. We are complying with all applicable sanctions that impact our business.

USSE purchases certain raw materials from sources that procure supply from Russia, including natural gas and iron ore. Since the onset of the war, and before, USSE has been building its inventory of iron ore and coal and procuring them through alternate sources. Current levels of iron ore and coal are sufficient to serve customer demand through the end of the first quarter 2023.

With the EU prohibiting purchases of coal from suppliers in Russia, new purchases of coal originating from Russia have stopped. The Company has built up sufficient inventory on site or in-transit to meet current customer demand. Efforts to secure alternate sources of supply are underway to continue meeting demand.

Additionally, Russian supply of natural gas to Europe has decreased significantly in response to enacted sanctions. However, Slovakia has natural gas storage and access to additional supply from countries including Norway, the U.S. and Africa. Together, these sources are enough to support the country's expected consumption through the 2023 winter season, which includes demand for natural gas for our USSE segment operations.

Critical Accounting Estimates

Management’s discussion and analysis of U. S. Steel’s financial condition and results of operations is based upon U. S. Steel’s financial statements, which have been prepared in accordance with accounting standards generally accepted in the United States (U.S. GAAP). The preparation of these financial statements requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities, the disclosure of contingent assets and liabilities at year-end and the reported amount of revenues and expenses during the year. Management regularly evaluates these estimates, including those related to employee benefits liabilities and assets held in trust relating to such liabilities; the carrying value of property, plant and equipment; intangible assets; valuation allowances for receivables, inventories and deferred income tax assets; liabilities for deferred income taxes; potential tax deficiencies; environmental obligations; potential litigation claims and settlements and put and call option assets and liabilities. Management’s estimates are based on historical experience, current business and market conditions, and various other assumptions that are believed to be reasonable under the circumstances, the results of which form the basis for making judgments about the carrying values of assets and liabilities that are not readily apparent from other sources. Actual results may differ materially from current expectations under different assumptions or conditions.

Management believes that the following are the more significant judgments and estimates used in the preparation of the financial statements.

Goodwill and intangible assets – Goodwill represents the excess of the cost over the fair value of acquired identifiable tangible and intangible assets and liabilities assumed from businesses acquired. Goodwill and intangible assets deemed to have indefinite lives are not amortized, but are subject to impairment testing annually, or more frequently if events or changes in circumstances indicate the asset might be impaired. We perform our annual goodwill impairment test as of October 1 and monitor for interim triggering events on an ongoing basis.

We review goodwill for impairment utilizing either a qualitative assessment or a quantitative goodwill impairment test. If we choose to perform a qualitative assessment and we determine that the fair value of the reporting unit more likely than not exceeds the carrying value, no further evaluation is necessary. For reporting units where we perform the quantitative goodwill impairment test, we compare the fair value of each reporting unit, which we primarily determine using an income approach based

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on the present value of discounted cash flows, to the respective carrying value, which includes goodwill. If the fair value of the reporting unit exceeds its carrying value, we do not consider the goodwill impaired. If the carrying value is higher than the fair value, we recognize the difference as an impairment loss.

A quantitative goodwill impairment testing process requires valuation of the respective reporting unit, which we primarily determine using an income approach based on a discounted five year forecasted cash flow including a terminal value. We compute the terminal value using the constant growth method, which values the forecasted cash flows in perpetuity. The assumptions about future cash flows and growth rates are based on the respective reporting unit's long-term forecast and are subject to review and approval by senior management. A reporting unit's discount rate is a significant assumption and is a risk-adjusted weighted average cost of capital, which we believe approximates the rate from a market participant's perspective. The estimated fair value could be impacted by changes in market conditions, interest rates, growth rates, tax rates, costs, pricing and capital expenditures. We categorize the fair value determination as Level 3 in the fair value hierarchy due to its use of internal projections and unobservable measurement inputs.

Our Mini Mill reporting unit holds the goodwill recognized as a result of the Company's acquisition of Big River Steel and currently is our only reporting unit that has a significant amount of goodwill. This goodwill is primarily attributable to Big River Steel's operational abilities, workforce and the anticipated benefits from their recent expansion. U. S. Steel completed its annual goodwill impairment test using a quantitative analysis during the fourth quarter of 2022 and determined there was no impairment of goodwill.

Intangible assets with indefinite lives are also subject to at least annual impairment testing, which compares the fair value of the intangible assets with their carrying amounts. U. S. Steel has determined that certain of its acquired intangible assets have indefinite useful lives. These assets are also reviewed for impairment annually in the fourth quarter and whenever events or circumstances indicate the carrying value may not be recoverable. U. S. Steel completed its annual evaluation of its indefinite-lived water rights using a qualitative assessment and determined there was no indication of impairment. Key assumptions included in this test relate to the relevant market rate of an acre foot of water.

If business conditions deteriorate or other factors have an adverse effect on our qualitative and quantitative estimates, inclusive of discounted future cash flows or assumed growth rates, or if we experience a sustained decline in our market capitalization, future assessments of goodwill for impairment may result in impairment charges.

Finite-lived intangible assets are amortized on a straight-line basis over their estimated useful lives and are tested for impairment when events occur that indicate that the net book value will not be recovered over future cash flows.

Business combinations – We account for business combinations under the acquisition method of accounting in accordance with ASC Topic 805, *Business Combinations,* which requires an allocation of the consideration we paid to the identifiable assets, intangible assets and liabilities based on the estimated fair values as of the closing date of the acquisition. The excess of the fair value of the purchase price over the fair values of these identifiable assets, intangible assets and liabilities is recorded as goodwill.

Purchased intangibles are initially recognized at fair value and amortized over their useful lives unless those lives are determined to be indefinite. The valuation of acquired assets will impact future operating results. The fair value of identifiable intangible assets is determined using an income approach on an individual asset basis. Specifically, we use the multi-period excess earnings method to estimate the fair value of the customer relationships intangible asset. Determining the fair value of the customer relationships intangible asset involves significant judgements and assumptions, including expected realized price, base year metallic costs, contributory asset charges, and customer attrition rate.

Inventories – Inventories are carried at the lower of cost or market for last-in, first-out (LIFO), moving average and first-in, first-out (FIFO) method inventories. The predominant method of inventory costing for Flat-Rolled and Tubular is LIFO. The Mini Mill segment uses FIFO for raw materials and a moving average costing method to account for semi-finished and finished products. FIFO is the predominant inventory costing method used by the USSE segment. The LIFO method of inventory costing was used on 43 percent and 46 percent of consolidated inventories at December 31, 2022 and 2021, respectively. Since the LIFO inventory valuation methodology is an annual calculation, interim estimates of the annual LIFO valuation are required. We recognize the effects of the LIFO inventory valuation method on an interim basis by estimating the year-end inventory amounts. The projections of annual LIFO inventory amounts are updated quarterly. Changes in U.S. GAAP rules or tax law, such as the elimination of the LIFO method of accounting for inventories, could negatively affect our profitability and cash flow.

Pensions and Other Benefits – The recording of net periodic benefit costs for defined benefit pensions and Other Benefits is based on, among other things, assumptions of the expected annual return on plan assets, discount rate, mortality, escalation or other changes in retiree health care costs and plan participation levels. Changes in the assumptions or differences between actual and expected changes in the present value of liabilities or assets of U. S. Steel’s plans could cause net periodic benefit costs to increase or decrease materially from year to year as discussed below.

U. S. Steel’s investment strategy for its U.S. pension and Other Benefits plan assets provides for a diversified mix of high-quality bonds, public equities and selected smaller investments in private equities, private credit, timber and mineral interests. For its

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U.S. pension, U. S. Steel has a target allocation for plan assets of 50 percent in fixed income investments. The balance is invested in equity securities, timber, private equity and real estate partnerships. U. S. Steel believes that returns on equities over the long term will be higher than returns from fixed-income securities as actual historical returns from U. S. Steel's trusts have shown. Returns on bonds tend to offset some of the short-term volatility of stocks. Both equity and fixed-income investments are made across a broad range of industries and companies (both domestic and foreign) to provide protection against the impact of volatility in any single industry as well as company specific developments. U. S. Steel will use a 6.90 percent assumed rate of return on assets for the development of net periodic cost for the main defined benefit pension plan in 2023. Actual returns since the inception of the plan have exceeded this 6.90 percent rate and while recent annual returns have been volatile, it is U. S. Steel's expectation that rates will achieve this level in future periods.

For its Other Benefits plan, U. S. Steel is employing a liability driven investment strategy. The plan assets are allocated to match the plan cash flows with maturing investments. To achieve this strategy, U. S. Steel has a target allocation for plan assets of 88 percent in fixed income and private credit. The balance is primarily invested in equity securities, timber, private equity and real estate partnerships. U. S. Steel will use a 4.50 percent assumed rate of return on assets for the development of net periodic cost for its Other Benefit plans for 2023. The 2023 assumed rate of return was updated after a review of capital market forecasted returns based on target allocations. The expected asset return for 2023 will continue to be 4.50 percent.

The expected long-term rate of return on plan assets is applied to the market value of assets as of the beginning of the period less expected benefit payments and considering any planned contributions.

To determine the discount rate used to measure our pension and Other Benefit obligations for U.S. plans we utilize a bond matching approach to select specific bonds that would satisfy our projected benefit payments. At December 31, 2022, the weighted average discount rate used for our pension and Other Benefit obligations was determined to be 5.55 percent and 5.66 percent, respectively, compared to the weighted average discount rate used of 3.01 percent and 3.11 percent, respectively, at December 31, 2021. The discount rate reflects the current rate at which we estimate the pension and Other Benefits liabilities could be effectively settled at the measurement date.

U. S. Steel reviews its actual historical rate experience and expectations of future health care cost trends to determine the escalation of per capita health care costs under U. S. Steel's benefit plans. Approximately 75 percent of our costs for the domestic United Steelworkers (USW) participants' retiree health benefits in the Company's main domestic benefit plan are limited to a per capita dollar maximum calculation based on 2006 base year actual costs incurred under the main U. S. Steel benefit plan for USW participants (cost cap). The full effect of the cost cap is expected to be realized around 2030. After 2030, the Company's costs for a majority of USW retirees and their dependents are expected to remain fixed and as a result, the cost impact of health care escalation for the Company is projected to be limited for this group (see Note 18 to the Consolidated Financial Statements). For measurement of its domestic retiree medical plans where health care cost escalation is applicable, U. S. Steel has assumed an initial escalation rate of 6.00 percent for 2023. This rate is assumed to decrease gradually to an ultimate rate of 4.50 percent in 2038 and remain at that level thereafter.

Net periodic pension benefit cost (credit), including multiemployer plans, is expected to total approximately $39 million in 2023 compared to $6 million in 2022. Excluding settlement and special termination losses totaling $12 million in 2022, the increase in net periodic pension benefit cost in 2023 is primarily due to 2022 asset performance and an increase in prior service cost. Net periodic other benefit (credit) in 2023 is expected to be approximately $(83) million, compared to $(108) million in 2022. The expected decrease in the 2023 net periodic other benefit (credit) is primarily due to the transfer of $595 million in surplus funds from the Post Retirement Benefit Trust (VEBA) assets to be used for active insurance benefits. See Note 18 to the Consolidated Financial Statements, "Pensions and Other Benefits."

The table below projects the incremental effect of a hypothetical one percentage point change in significant assumptions used in determining the funded status and net periodic benefit cost for pension and other benefits:

	Hypothetical Rate Change Increase (Decrease)	
(In millions)	1%	(1)%
Expected return on plan assets		
Incremental (decrease) increase in:		
Net periodic pension and other benefits costs for 2023	$ (60)	$ 60
Discount rate		
Incremental (decrease) increase in:		
Net periodic pension and other benefits costs for 2023	$ (4)	$ 11
Pension & other benefits obligations at December 31, 2022	$ (411)	$ 474

Changes in the assumptions for expected annual return on plan assets and the discount rate used for accounting purposes do not impact the funding calculations used to derive minimum funding requirements for the pension plan. However, the discount rate required for minimum funding purposes is also based on corporate bond related indices and as such, the same general

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sensitivity concepts as above can be applied to increases or decreases to the funding obligations of the plans assuming the same hypothetical rate changes. See Note 18 to the Consolidated Financial Statements for a discussion regarding legislation enacted in March of 2021 that impacts the discount rate used for funding purposes. For further cash flow discussion see “Item 7. Management’s Discussion and Analysis of Financial Condition and Results of Operations, Liquidity and Capital Resources.”

Long-lived assets – U. S. Steel evaluates long-lived assets, primarily property, plant and equipment for impairment whenever changes in circumstances indicate that the carrying amounts of those productive assets exceed their recoverable amount as determined by the asset group's projected undiscounted cash flows. We evaluate the impairment of long-lived assets at the asset group level. Our primary asset groups are Flat-Rolled, Mini Mill, USSE, welded tubular and seamless tubular.

In the second quarter of 2022, the Company recognized charges of $151 million for the write-off of the blast furnaces and related fixed assets for the permanent idling of the iron making process at our Great Lakes Works facility, which had been idled on an indefinite basis during 2020. There were no other triggering events that required an impairment evaluation of our long-lived asset groups during the year-ended December 31, 2022.

In the fourth quarter of 2021, U. S. Steel decided to permanently idle the steelmaking assets at Great Lakes Works, which had been indefinitely idled since 2020, resulting in an impairment of $128 million for property, plant and equipment.

Taxes - U. S. Steel records a valuation allowance, related to certain state net operating losses, state tax credits and unused capital losses, to reduce deferred tax assets to the amount that is more likely than not to be realized. A valuation allowance is recorded if, based on the weight of all available positive and negative evidence, it is more likely than not that some portion, or all, of a deferred tax asset will not be realized. Each quarter U. S. Steel analyzes the likelihood that our deferred tax assets will be realized. In the future, if we determine that it is more likely than not that we will be able to realize all or a portion of our deferred tax assets, the valuation allowance will be reduced, and we will record a non-cash net benefit to earnings.

In 2021, U. S. Steel determined, based upon weighing all positive and negative evidence, that a full valuation allowance for the domestic deferred tax assets was no longer required. Accordingly, we reversed all of the domestic valuation allowance except for a portion of the domestic valuation allowance related to certain state net operating losses and state tax credits. During the year ended December 31, 2021, we realized a non-cash net benefit of $715 million related to the valuation allowance release, which was partially offset by the addition of a valuation allowance of $82 million, the majority of which relates to an unused capital loss generated in the fourth quarter of 2021.

At the end of both 2022 and 2021, U. S. Steel did not have any undistributed foreign earnings and profits for which U.S. deferred taxes have not been provided.

For further information on income taxes see Note 11 to the Consolidated Financial Statements.

Environmental remediation – U. S. Steel has been identified as a PRP at four sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as of December 31, 2022. Of these, there are three sites where information requests have been received or there are other indications that U. S. Steel may be a PRP under CERCLA, but where sufficient information is not presently available to confirm the existence of liability or to make a reasonable estimate with respect to any potential liabilities. There are also nine additional sites where U. S. Steel may be liable for remediation costs in excess of $1 million under other environmental statutes, both federal and state, or where private parties are seeking to impose liability on U. S. Steel for remediation costs through discussions or litigation. At many of these sites, U. S. Steel is one of a number of parties involved and the total cost of remediation, as well as U. S. Steel’s share, is frequently dependent upon the outcome of ongoing investigations and remedial studies. U. S. Steel accrues for environmental remediation activities when the responsibility to remediate is probable and the amount of associated costs is reasonably determinable. As environmental remediation matters proceed toward ultimate resolution or as remediation obligations arise, charges in excess of those previously accrued may be required.

U. S. Steel's accrual for environmental liabilities for U.S. and international facilities as of December 31, 2022 and 2021 was $126 million and $158 million, respectively. These amounts exclude liabilities related to asset retirement obligations, disclosed in Note 19 to the Consolidated Financial Statements.

U. S. Steel is the subject of, or a party to, a number of pending or threatened legal actions, contingencies and commitments involving a variety of matters, including laws and regulations relating to the environment. The ultimate resolution of these contingencies could, individually or in the aggregate, be material to the Consolidated Financial Statements.

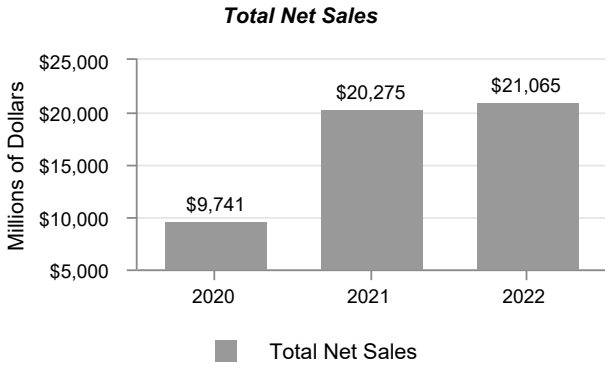
For discussion of relevant environmental items, see “Part I. Item 3. Legal Proceedings—Environmental Proceedings.”

Segments

U. S. Steel has four reportable segments: North American Flat-Rolled, Mini Mill, USSE and Tubular Products. For further description of segment operations and information see Item 1 Segments and Note 4 to the Consolidated Financial Statements, respectively.

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Net Sales



Net Sales by Segment

Net sales by segment for the years ended December 31, 2022 and 2021 are set forth in the following table:

(Dollars in millions, excluding intersegment sales)	Years Ended December 31, 2022	2021	% Change
Flat-Rolled	**$ 12,522**	$ 12,180	3 %
Mini Mill [(a)]	**2,681**	3,008	(11)%
USSE	**4,243**	4,262	— %
Tubular	**1,611**	789	104 %
Total sales from reportable segments	**21,057**	20,239	4 %
Other	**8**	36	(78)%
Net Sales	**$ 21,065**	$ 20,275	4 %

[(a)] Mini Mill segment added after January 15, 2021 with the purchase of the remaining equity interest in BRS.

Management's analysis of the percentage change in net sales for U. S. Steel's reportable business segments is set forth in the following table:

Year Ended December 31, 2022 versus Year Ended December 31, 2021	Steel Products[(a)] Volume	Price	Mix	Acquisition Variance	FX[(b)]	Other[(c)]	Net Change
Flat-Rolled	(6)%	7 %	— %	n/a	— %	2 %	3 %
Mini Mill [(d)]	(2)%	(11)%	— %	2 %	— %	— %	(11)%
USSE	(13)%	22 %	1 %	n/a	(11)%	1 %	— %
Tubular	17 %	87 %	(1)%	n/a	— %	— %	103 %

[(a)] Excludes intersegment sales.

[(b)] Foreign currency translation effects.

[(c)] Primarily consists of sales of raw material and coke making by-products

[(d)] Mini Mill segment added after January 15, 2021 with the purchase of the remaining equity interest in BRS.

Net sales for the twelve months ended December 31, 2022 compared to the same period in 2021 were $21,065 million and $20,275 million, respectively.

- For the Flat-Rolled segment the increase in sales primarily resulted from higher average realized prices ($89 per ton) primarily from higher value-added products, partially offset by decreased shipments (645 thousand tons) across most products.
- For the Mini Mill segment the decrease in sales primarily resulted from lower average realized prices ($180 per ton) primarily from lower value-added products partially offset by increased shipments (57 thousand tons), including the partial period of the Company's controlling interest in Big River Steel in January of 2021.
- For the USSE segment the consistent sales primarily resulted from higher average realized prices ($124 per net ton) across most products, offset by decreased shipments (543 thousand tons) across most products.

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- For the Tubular segment the increase in sales primarily resulted from higher average realized prices ($1,282 per net ton) and increased shipments (79 thousand tons).

Operating Expenses

Union profit-sharing costs

	Year Ended December 31,	
(Dollars in millions)	**2022**	**2021**
Allocated to segment results	**$ 442**	**$ 430**

The amounts above represent profit-sharing amounts paid to active USW-represented employees and are included in cost of sales on the Consolidated Statement of Operations.

Profit-based amounts are calculated and paid on a quarterly basis as a percentage of consolidated earnings (loss) before interest and income taxes based on 7.5 percent of profit between $10 and $50 per ton and 15 percent of profit above $50 per ton. There were no changes to the calculation of profit-based amounts in the 2022 Labor Agreements.

Net periodic pension and other benefits costs

Pension and other benefit costs (other than service cost) are reflected within net interest and other financial costs and the service cost component is reflected within cost of sales in the Consolidated Statements of Operations.

Defined benefit and multiemployer pension plan costs included in cost of sales totaled $119 million in 2022 and $128 million in 2021.

Other benefit service cost included in cost of sales totaled $9 million in 2022 and $11 million in 2021.

Costs related to defined contribution plans totaled $47 million in 2022 and $45 million in 2021.

Selling, general and administrative expenses

Selling, general and administrative expenses were consistent for the years ended December 31, 2022 and December 31, 2021 at $422 million and $426 million, respectively.

Operating configuration adjustments

The Company adjusted its operating configuration in response to global overcapacity, unfair trade practices, market conditions and decreased customer demand by indefinitely and temporarily idling certain of its facilities. U. S. Steel will continue to adjust its operating configuration in order to ensure its order book and production footprint are balanced.

Idled Operations

In the second half of 2022, we took actions to adjust our footprint by temporarily idling certain operations to better align production with market conditions. The operations that were idled in the second half of 2022 and remained idled as of December 31, 2022, along with their carrying values included:

- Blast furnace #8 at Gary Works, $30 million
- Blast furnace #3 at Mon Valley Works, $45 million (restarted in January 2023)
- Blast furnace #2 at USSE, $25 million (restarted in January 2023)

The following operations were initially idled in 2020 and remained idle as of December 31, 2022. These facilities and their respective carrying values as of December 31, 2022 included:

- Blast Furnace A at Granite City Works, $55 million
- Lone Star Tubular Operations, $5 million
- Lorain Tubular Operations, $60 million
- Wheeling Machine Products coupling production facility at Hughes Springs, Texas, immaterial

In the fourth quarter of 2022, U. S. Steel indefinitely idled the majority of the tin mill operations at Gary Works. This included the Tin Line #5, which was previously temporarily idled in the third quarter of 2022, and the Tin Line #6 indefinitely idled the fourth quarter of 2022. As of December 31, 2022, the carrying value of the indefinitely idled tin mill operations assets at Gary Works is $80 million.

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At Great Lakes Works, the Company permanently idled the steelmaking operations in 2021 and ironmaking operations in 2022 which resulted in non-cash impairments of $128 million and $151 million, respectively. The coil finishing process at Great Lakes Works continues to operate and remains a component of the Company's operating plans.

Depreciation, depletion and amortization

Depreciation, depletion and amortization expenses were $791 million in both years ended December 31, 2022 and December 31, 2021.

Earnings from investees

Earnings from investees were $243 million in 2022 versus earnings from investees of $170 million in 2021. The increase in 2022 from the prior year is primarily due to current year earnings from our PRO-TEC joint venture from higher realized prices.

Restructuring and Other Charges

During 2022, the Company recorded restructuring and other charges of $48 million, which consists of charges of $30 million related to the planned disposition of a component within the Flat-Rolled segment, severance-related charges at domestic facilities of $4 million, charges under the Company's voluntary retirement programs at U. S. Steel Košice (USSK) of $23 million and a $9 million favorable adjustment to the expected exit costs of indefinitely idled facilities.

Charges for restructuring and ongoing cost reduction initiatives are recorded in the period U. S. Steel commits to a restructuring or cost reduction plan, or executes specific actions contemplated by the plan and all criteria for liability recognition have been met. Charges related to restructuring and cost reductions are reported in Restructuring and other charges in the Consolidated Statements of Operations.

Earnings (loss) before interest and income taxes by segment [(a)]	**Year Ended December 31,**	
(Dollars in Millions)	**2022**	**2021**
Flat-Rolled	**$ 1,951**	$ 2,630
Mini Mill	**481**	1,206
USSE	**444**	975
Tubular	**544**	1
Total earnings from reportable segments	**3,420**	4,812
Other	**$ 22**	(11)
Segment earnings before interest and income taxes	**3,442**	4,801
Other items not allocated to segments:		
Restructuring and other charges [(b)]	**(48)**	(128)
Asset impairment charges [(c)]	**(163)**	(273)
United Steelworkers labor agreement signing bonus and related costs	**(64)**	—
Gains on assets sold & previously held investments	**6**	118
Gain on sale of Transtar [(d)]	**—**	506
Environmental remediation charge	**—**	(43)
Other items, net	**(13)**	(35)
Total earnings before interest and income taxes	**$ 3,160**	$ 4,946

[(a)] See Note 4 to the Consolidated Financial Statements for reconciliations and other details.

[(b)] Included in restructuring and other charges on the Consolidated Statements of Operations. See Note 25 to the Consolidated Financial Statements for further details.

[(c)] See Note 1 to the Consolidated Financial Statements for further details.

[(d)] See Note 5 to the Consolidated Financial Statements for further details.

Segment results for Flat-Rolled

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	Year Ended December 31, 2022	2021	% Change
Earnings before interest and taxes ($ in millions)	**$ 1,951**	$ 2,630	(26)%
Gross margin	**20 %**	27 %	(7)%
Raw steel production (mnt)	**8,846**	9,881	(10)%
Capability utilization	**67 %**	58 %	9 %
Steel shipments (mnt)	**8,373**	9,018	(7)%
Average realized steel price per ton	**1,261**	1,172	8 %

The decrease in Flat-Rolled results for 2022 compared to 2021 was primarily due to:

- decreased shipments, including volume inefficiencies (approximately $290 million)
- decreased non-prime sales (approximately $95 million)
- higher raw material costs, primarily coal and alloys (approximately $680 million)
- higher energy costs (approximately $365 million)
- increased costs primarily for purchased products and services, including costs at our mining operations (approximately $515 million),

these changes were partially offset by:

- increased average realized prices, including mix (approximately $960 million)
- increased coke, iron ore and other non-steel sales (approximately $55 million)
- favorable equity investees income (approximately $60 million)
- lower other costs, primarily commodity derivatives and variable compensation (approximately $190 million).

Gross margin for 2022 as compared to 2021 decreased primarily as a result of lower sales volume and increased input costs, partially offset by higher average realized prices.

Segment results for Mini Mill [(a)]

	Year Ended December 31, 2022	2021	% Change
Earnings before interest and taxes ($ in millions)	**$ 481**	$ 1,206	(60)%
Gross margin	**25 %**	47 %	(22)%
Raw steel production (mnt)	**2,650**	2,688	(1)%
Capability utilization	**80 %**	81 %	(1)%
Steel shipments (mnt)	**2,287**	2,230	3 %
Average realized steel price per ton	**1,134**	1,314	(14)%

[(a)] Mini Mill segment added after January 15, 2021 with the purchase of the remaining equity interest in BRS.

The decrease in Mini Mill results for 2022 compared to 2021 was primarily due to:

- decreased average realized prices (approximately $440 million)
- decreased shipments (approximately $35 million)
- higher raw material costs (approximately $275 million),

these changes were partially offset by:

- lower other costs, primarily variable compensation (approximately $25 million).

Gross margin for 2022 as compared to 2021 decreased primarily as a result of lower average realized sales price and increased raw material costs, partially offset by the partial period of the Company's controlling interest in Big River Steel in January of 2021.

Segment results for USSE

	Year Ended December 31, 2022	2021	% Change
Earnings before interest and taxes ($ in millions)	**$ 444**	$ 975	(54)%
Gross margin	**13 %**	26 %	(13)%
Raw steel production (mnt)	**3,839**	4,931	(22)%
Capability utilization	**77 %**	99 %	(22)%
Steel shipments (mnt)	**3,759**	4,302	(13)%
Average realized steel price per ton	**1,090**	966	13 %

The decrease in USSE results for 2022 compared to 2021 was primarily due to:

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- decreased shipments, including volume inefficiencies (approximately $160 million)
- higher raw material costs, primarily coal and coke (approximately $760 million)
- increased operating costs (approximately $125 million)
- higher energy costs (approximately $200 million)
- weakening of the euro versus the U.S. dollar (approximately $160 million),

these changes were partially offset by:

- increased average realized prices, including mix (approximately $845 million)
- increased non-steel sales (approximately $10 million)
- lower other costs, primarily variable compensation (approximately $20 million).

Gross margin for 2022 as compared to 2021 decreased primarily as a result of lower sales volume, higher raw material and energy costs and negative impacts from the weakening of the euro versus the U.S. dollar, partially offset by higher average realized prices.

Segment results for Tubular

	Year ended December 31, 2022	2021	% Change
Earnings before interest and taxes ($ in millions)	**$ 544**	$ 1	NM
Gross margin	**37 %**	7 %	30 %
Raw steel production (mnt)	**634**	464	37 %
Capability utilization	**70 %**	52 %	18 %
Steel shipments (mnt)	**523**	444	18 %
Average realized steel price per ton	**2,978**	1,696	76 %

The increase in Tubular results for 2022 compared to 2021 was primarily due to:

- increased average realized prices (approximately $580 million)
- increased shipments (approximately $40 million),

these changes were partially offset by:

- higher raw material costs (approximately $15 million)
- increased operating costs (approximately $10 million)
- higher energy costs (approximately $10 million)
- higher other costs, primarily variable compensation (approximately $40 million).

Gross margin for 2022 as compared to 2021 increased primarily as a result of higher average realized prices and sales volume.

Results for Other

The Other category had earnings of $22 million for the year ended December 31, 2022 compared to losses of $11 million for the year ended December 31, 2021.

Net Interest and Other Financial Costs

(Dollars in millions)	Year Ended December 31, 2022	2021
Interest expense	**159**	313
Interest income	**(44)**	(4)
Loss on debt extinguishment	**—**	292
Other financial costs	**32**	46
Net periodic benefit income	**(246)**	(45)
Net interest and other financial (benefits) costs	**$ (99)**	$ 602

Net interest and other financial (benefits) costs improved in 2022 compared to 2021 primarily due to the absence of current year debt retirement losses; reduced interest expense from a reduced level of debt and increased capitalized interest; and an increase in net periodic benefit income, primarily due to lower amortization of actuarial losses and the absence of current year de-risking settlement charges. For additional information on U. S. Steel indebtedness see Note 17 to the Consolidated Financial Statements.

For additional information on U. S. Steel's foreign currency exchange activity see Note 16 to the Consolidated Financial Statements and Item 7A**.** "Quantitative and Qualitative Disclosures about Market Risk – Foreign Currency Exchange Rate Risk."

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Income Tax

The income tax expense for the year ended December 31, 2022 was $735 million compared to an income tax expense of $170 million in 2021. The change from the prior year period was primarily due to the tax benefit in the prior year period resulting from the release of the valuation allowance on domestic deferred tax assets.

In the third quarter of 2022, Pennsylvania House Bill 1342 was enacted, which in part phased in a corporate net income tax (CNIT) rate reduction over nine years. The CNIT rate for the 2022 tax year is 9.99%. The CNIT rate will be reduced to 8.99% for the 2023 tax year. Starting with the 2024 tax year, the rate is reduced by 0.5% annually until it reaches 4.99% for the 2031 tax year and each year thereafter. The Company assessed the impact of the law change and recorded an additional expense for it of $13 million in 2022 on its Consolidated Financial Statements.

On August 16, 2022, H.R. 5376 (commonly called the Inflation Reduction Act of 2022) was signed into law, which, among other things, implemented a corporate alternative minimum tax (CAMT) of 15 percent on book income of certain large corporations. The CAMT imposes a minimum tax on net income adjusted for certain items prescribed by the legislation and is effective for tax years beginning after December 31, 2022. Although management is currently assessing the impact of the law change and awaiting guidance from the Department of Treasury, the Company anticipates being subject to the new CAMT but does not believe that it will have a material impact on its Consolidated Financial Statements.

For further information on income taxes see Note 11 to the Consolidated Financial Statements.

Net earnings attributable to U. S. Steel

Net earnings attributable to U. S. Steel in 2022 was $2,524 million compared to net earnings of $4,174 million in 2021. The changes primarily reflected the factors discussed above.

Liquidity and Capital Resources

Cash Flows and Capital Requirements

Net Cash Provided by Operating Activities

Net cash provided by operating activities was $3,505 million in 2022 compared to $4,090 million in 2021. The decrease in 2022 compared to 2021 was primarily due to decreased net earnings, losses on debt extinguishments and income taxes and pension and other post-retirement benefits payables, partially offset by changes in working capital, deferred taxes payable and gains on sale of assets. Changes in working capital can vary significantly depending on factors such as the timing of inventory production and purchases, which is affected by the length of our business cycles as well as our captive raw materials position, customer payments of accounts receivable and payments to vendors in the regular course of business.

Our cash conversion cycle increased by 6 days in the fourth quarter of 2022 from the fourth quarter of 2021 as shown below:

Cash Conversion Cycle	2022		2021	
	$ millions	Days	$ millions	Days
Accounts receivable, net [(a)]	$ 1,634	39	$ 2,089	37
+ Inventories [(b)]	$ 2,359	60	$ 2,210	51
- Accounts Payable and Other Accrued Liabilities [(c)]	$ 2,831	70	$ 2,684	65
= Cash Conversion Cycle [(d)]		29		23

[(a)] Calculated as Average Accounts Receivable, net divided by total Net Sales multiplied by the number of days in the period.
[(b)] Calculated as Average Inventory divided by total Cost of Sales multiplied by the number of days in the period.
[(c)] Calculated as Average Accounts Payable and Other Accrued Liabilities less bank checks outstanding and other current liabilities divided by total Cost of Sales multiplied by the number of days in the period.
[(d)] Calculated as Accounts Receivable Days plus Inventory Days less Accounts Payable Days.

The cash conversion cycle is a non-GAAP financial measure. We believe the cash conversion cycle is a useful measure in providing investors with information regarding our cash management performance and is a widely accepted measure of working capital management efficiency. The cash conversion cycle should not be considered in isolation or as an alternative to other GAAP metrics as an indicator of performance.

The LIFO inventory method is the predominant method of inventory costing for our Flat-Rolled and Tubular segments. The first-in, first-out FIFO and moving average methods are the predominant inventory costing methods for our Mini Mill segment and the

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FIFO method is the predominant inventory costing method for our USSE segment. In the U.S., management monitors the inventory realizability by comparing the LIFO cost of inventory with the replacement cost of inventory. To the extent the replacement cost (i.e., market value) of inventory is lower than the LIFO cost of inventory, management will write the inventory down. As of December 31, 2022 and 2021, the replacement cost of the LIFO inventory was higher by approximately $1,154 million and $896 million, respectively.

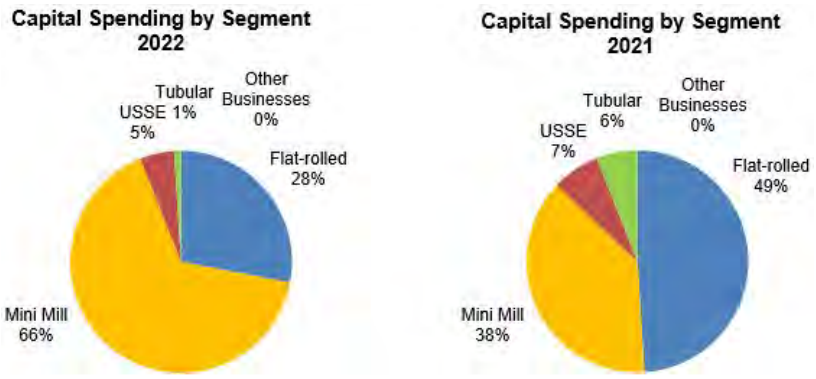
Net cash provided by operating activities for 2022 and 2021 reflects employee benefits payments as shown in the following table.

Benefits Payments for Employees	**Year Ended December 31,**	
(Dollars in millions)	**2022**	**2021**
Other employee benefits payments not funded by trusts	**$ 32**	$ 46
Payments to a multiemployer pension plan	**74**	75
Pension related payments not funded by trusts	**2**	11
Reductions in cash flows from operating activities	**$ 108**	$ 132

Net Cash Used in Investing Activities

Net cash used in investing activities was $1,679 million in 2022 compared to $840 million in 2021. The increase in net cash used in investing activities was primarily due to increased capital expenditures (discussed in more detail below) and receipt of $627 million in the prior year for the sale of Transtar, partially offset by the payment of $625 million in the prior year period for the purchase of the remaining equity interest in Big River Steel and proceeds of $54 million in the current year period from government grants.

Capital expenditures in 2022 were $1,769 million compared to $863 million in 2021.



Total capital expenditures for 2022 were $1,769 million. Flat-Rolled capital expenditures were $503 million and included spending for the construction of a pig iron facility at Gary Works, Keetac DR-grade pellet capability, as well as mining equipment, infrastructure and environmental projects across the Flat-Rolled footprint. Mini Mill capital expenditures were $1,159 million and included $780 million, exclusive of the air separation unit, for the new Big River 2 (BR2) 3 million ton per year facility being built in Osceola, Arkansas, as well as spending for the new continuous galvanizing line (CGL) and non-grain oriented electrical steel facility being built at the existing Big River Steel facility. USSE capital expenditures were $90 million and included spending for the blast furnace stoves, 5-stand control system upgrades, wastewater quality improvements, rail bridge upgrades and various other projects. Tubular capital expenditures were $17 million and included spending to support steelmaking, infrastructure and environmental projects within the Tubular footprint.

Net Cash used in Financing Activities

Net cash used in financing activities was $868 million for the twelve months ended December 31, 2022 compared to net cash used by financing activities of $2,747 million for the same period in 2021. The period over period decrease in cash used in financing activities was primarily due to higher debt repayments made during the prior year, partially offset by the cash received from common stock issuances in the prior year period and repurchases of common stock made in the current year period.

Debt Financing

In 2022, U. S. Steel made payments of debt and redemption premiums of approximately $382 million. The following is a summary of debt repayments for our Senior Secured Notes, Senior Notes and other debt obligations made during the twelve months ended December 31, 2022:

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Debt Instrument (in millions)	Date	Year Ended December 31, 2022 Debt Extinguished
2037 Senior Notes [a]	Third quarter 2022	76
2029 Senior Notes [b]	Third quarter 2022	225
Hoover, AL Environmental Revenue Bonds	Second quarter 2022	14
2029 Senior Notes [b]	Second quarter 2022	48
2029 Senior Notes [b]	First quarter 2022	2
Total		$ 365

[a] There were redemption discounts and unamortized debt issuance cost write-offs of $6 million and $1 million , respectively, included in (gain) loss on debt extinguishment on the Consolidated Statement of Operations related to the repayment.
[b] During the twelve months ended December 31, 2022, there were no redemption premiums paid and a net loss of $4 million for the write-off of unamortized discounts and debt issuance costs, included in (gain) loss on debt extinguishment on the Consolidated Statement of Operations, as a result of these debt repayments.

Certain of our credit facilities, including the Credit Facility Agreement, the Big River Steel ABL Facility, the USSK Credit Agreement and the Export Credit Agreement, contain standard terms and conditions including customary material adverse change clauses. If a material adverse change was to occur, our ability to fund future operating and capital requirements could be negatively impacted. The €300 million USSK Credit Agreement contains certain USSK specific financial covenants. There are currently no amounts outstanding under the facility. The USSK Credit Agreement requires USSK to maintain a net debt to earnings before interest, taxes, depreciation and amortization (EBITDA) ratio of less than 3.50:1 for the rolling twelve months ending June 30, 2023. The Company has determined that it may not be able to comply with this covenant at June 30, 2023 based on the currently forecasted EBITDA for the twelve-month period ending June 30, 2023. This could partially or fully limit USSK's ability to borrow under the USSK Credit Agreement. Any amendment or waiver may lead to additional lender protections, including a reduction of loan commitments or less favorable terms, and there can be no assurance that USSK can obtain waivers or amendments in timely fashion, or on acceptable terms or at all. The Company believes that USSK will have adequate cash on hand as of June 30, 2023, and will not need to borrow under the USSK Credit Agreement.

We assumed additional indebtedness in connection with the acquisition of Big River Steel on January 15, 2021. Most of Big River Steel's prior financing arrangements were secured transactions, with many of the assets of BRS Intermediate Holdings LLC, Big River Steel LLC and BRS Finance Corp. secured as collateral. Until we repay, refinance or otherwise amend the debt arrangements, we remain subject to the restrictive terms of the indentures.

We use surety bonds, trusts and letters of credit to provide financial assurance for certain transactions and business activities. The use of some forms of financial assurance and cash collateral have a negative impact on liquidity. U. S. Steel has committed $178 million of liquidity sources for financial assurance purposes as of December 31, 2022. Increases in certain of these commitments which use collateral are reflected within cash, cash equivalents and restricted cash on the Consolidated Statement of Cash Flows.

The maximum guarantees of the indebtedness of unconsolidated entities of U. S. Steel totaled $7 million at December 31, 2022. If any default related to the guaranteed indebtedness occurs, U. S. Steel has access to its interest in the assets of the investees to reduce its potential losses under the guarantees.

We may from time to time seek to retire or repurchase our outstanding long-term debt through open market purchases, privately negotiated transactions, exchange transactions, redemptions or otherwise. Such purchases or exchanges, if any, will depend on prevailing market conditions, our liquidity requirements and other factors and may be commenced or suspended at any time. The amounts involved may be material. See Note 17 to the Consolidated Financial Statements for further details regarding U. S. Steel's debt.

Share Repurchases

In the third quarter of 2022, following the completion of the previously authorized $800 million share repurchase programs, the Board of Directors authorized a new share repurchase program that allows for the repurchase of up to $500 million of its outstanding common stock from time to time in the open market or privately negotiated transactions at the discretion of management. The Company's share repurchase program does not obligate it to acquire any specific number of shares. Common stock repurchased under our share repurchase programs totaled 37.6 million shares and approximately $849 million in the twelve months ended December 31, 2022. See Note 27 to the Consolidated Financial Statements, "Common Stock Issued and Repurchased" for further details.

Capital Requirements

Our major cash requirements in 2023 are expected to be for capital expenditures, including strategic priorities, employee benefits and operating costs, which includes purchases of raw materials. We ended 2022 with $3,504 million of cash and cash

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equivalents and $5,925 million of total liquidity. Available cash is left on deposit with financial institutions or invested in highly liquid securities with parties we believe to be creditworthy.

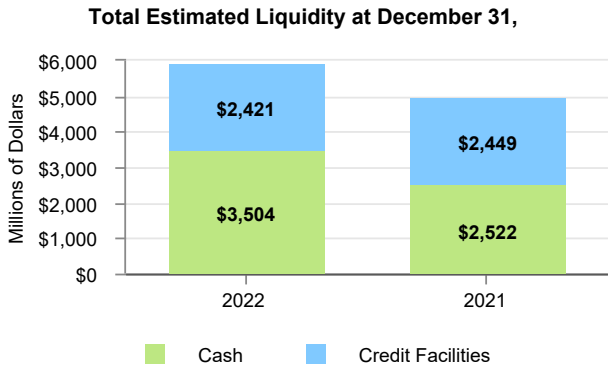
Capital expenditures for 2023 are expected to total approximately $2.5 billion which are focused largely on strategic projects, as we work to increase our capacity and raw material and finishing capabilities by focusing on investments in our Mini Mill and Flat-Rolled segments.

U. S. Steel's contractual commitments to acquire property, plant and equipment at December 31, 2022 totaled $2,235 million.

Liquidity

The following table summarizes U. S. Steel's liquidity as of December 31, 2022:

(Dollars in millions)		
Cash and cash equivalents	$	3,504
Amount available under Credit Facility Agreement		1,746
Amount available under Big River Steel - Revolving Line of Credit		350
Amounts available under USSK Credit Agreement and USSK Credit Facility		325
Total estimated liquidity	$	5,925



As of December 31, 2022, $405 million of the total cash and cash equivalents was held by our foreign subsidiaries. Substantially all of the liquidity attributable to our foreign subsidiaries can be accessed without the imposition of income taxes as a result of the election effective December 31, 2013 to liquidate for U.S. income tax purposes a foreign subsidiary that holds most of our international operations.

We expect that our estimated liquidity requirements will consist primarily of our 2023 planned strategic capital expenditures, working capital requirements, interest expense, and operating costs and employee benefits for our operations after taking into account the footprint actions and cost reductions at our plants and headquarters. Our available liquidity at December 31, 2022 consists principally of our cash and cash equivalents and available borrowings under the Credit Facility Agreement, Big River Steel ABL Facility, USSK Credit Agreement and the USSK Credit Facility. Management continues to evaluate market conditions in our industry and our global liquidity position, and may consider additional actions to further strengthen our balance sheet and optimize liquidity, including but not limited to the repayment or refinancing of outstanding debt and the incurrence of additional debt to opportunistically finance strategic projects. The Company may also return excess liquidity to shareholders through share repurchases and dividends from time to time.

U. S. Steel management believes that U. S. Steel's liquidity will be adequate to satisfy our obligations for the foreseeable future, including obligations to complete currently authorized capital spending programs. Future requirements for U. S. Steel's business needs, including the funding of acquisitions and capital expenditures, scheduled debt maturities, repurchase of debt, share buybacks, dividends, contributions to employee benefit plans and any amounts that may ultimately be paid in connection with contingencies, are expected to be funded by a combination of internally generated funds (including asset sales), proceeds from the sale of stock, borrowings, refinancings and other external financing sources. The following table summarizes the Company's contractual obligations at December 31, 2022, and the effect such obligations are expected to have on our liquidity and cash flows in future periods.

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(Dollars in millions)

Contractual Obligations	Total	2023	Payments Due by Period 2024 through 2025	2026 through 2027	Beyond 2027
Debt (including interest) and finance leases[(a)]	$ 6,940	$ 297	$ 628	$ 1,029	$ 4,986
Operating leases[(b)]	177	58	74	35	10
Contractual purchase commitments[(c)]	6,262	4,707	610	552	393
Capital commitments[(d)]	2,235	1,683	552	—	—
Environmental commitments[(d)]	126	32	—	—	94
Steelworkers Pension Trust[(e)]	430	84	170	176	—
Employee related benefits[(f)]	177	38	71	68	—
Total contractual obligations	$ 16,347	$ 6,899	$ 2,105	$ 1,860	$ 5,483

(a) See Note 17 to the Consolidated Financial Statements.
(b) See Note 24 to the Consolidated Financial Statements.
(c) Reflects estimated contractual purchase commitments under purchase orders and “take or pay” arrangements. “Take or pay” arrangements are primarily for purchases of gases and certain energy and utility services.
(d) See Note 26 to the Consolidated Financial Statements.
(e) While it is difficult to make a prediction of cash requirements beyond the term of the 2022 Labor Agreements with the USW, which expire on September 1, 2026, projected amounts shown through 2027 assume the contribution rate per hour included in the 2022 Labor Agreements of $4.00 per hour worked.
(f) The amounts reflect corporate cash outlays for expected benefit payments to be paid by the Company. (See Note 18 to the Consolidated Financial Statements.) The accuracy of this forecast of future cash flows depends on future medical health care escalation rates and restrictions related to our trusts for retiree healthcare and life insurance (VEBA) that impact the timing of the use of trust assets. Projected amounts have been reduced to reflect withdrawals from the USW VEBA trust available under its agreements with the USW. Due to these factors, it is not possible to reliably estimate cash requirements beyond five years and actual amounts experienced may differ significantly from those shown.

Other Commercial Commitments

The following table summarizes U. S. Steel’s commercial commitments at December 31, 2022, and the effect such commitments could have on our liquidity and cash flows in future periods.

(Dollars in millions)

Commercial Commitments	Total	Scheduled Reductions by Period 2023	2024 through 2025	2026 through 2027	Beyond 2027	
Standby letters of credit[(a)]	$ 53	$ 32	$ 1	$ —	$ 20	[(b)]
Surety bonds[(a)]	95	—	—	—	95	[(b)]
Funded Trusts[(a)]	31	—	—	—	31	[(b)]
Total commercial commitments	$ 179	$ 32	$ 1	$ —	$ 146	

(a) Reflects a commitment or guarantee for which future cash outflow is not considered likely.
(b) Timing of potential cash outflows is not determinable.

Off-Balance Sheet Arrangements

U. S. Steel has invested in several joint ventures that are reported as equity investments. Several of these investments involved a transfer of assets in exchange for an equity interest. U. S. Steel has supply arrangements with several of these joint ventures.

U. S. Steel’s other off-balance sheet arrangements include guarantees, indemnifications, unconditional purchase obligations, surety bonds, trusts and letters of credit disclosed in Note 26 to the Consolidated Financial Statements.

Derivative Instruments

See “Item 7A. Quantitative and Qualitative Disclosures About Market Risk” for discussion of derivative instruments and associated market risk for U. S. Steel.

Environmental Matters

U. S. Steel’s environmental expenditures were as follows:

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(Dollars in millions)	2022	2021	2020
North America:			
Capital	**$ 38**	$ 27	$ 36
Compliance			
Operating & maintenance	**255**	201	188
Remediation[(a)]	**18**	57	37
Total North America	**$ 311**	$ 285	$ 261
USSE:			
Capital	**$ 6**	$ —	$ 6
Compliance			
Operating & maintenance	**11**	10	6
Remediation[(a)]	**6**	7	5
Total USSE	**$ 23**	$ 17	$ 17
Total U. S. Steel	**$ 334**	$ 302	$ 278

[(a)] These amounts include spending charged against remediation reserves, net of recoveries where permissible, but do not include non-cash provisions recorded for environmental remediation.

U. S. Steel's environmental capital expenditures accounted for 2 percent of total capital expenditures in 2022 and 3 percent in 2021 and 6 percent in 2020.

Environmental compliance expenditures represented 2 percent of U. S. Steel's total costs and expenses in 2022, 2021 and 2020. Remediation spending during 2020 through 2022 was mainly related to remediation activities at former and present operating locations.

For discussion of other relevant environmental items see "Part I, Item 3. Legal Proceedings – Environmental Proceedings."

The following table shows activity with respect to environmental remediation liabilities for the years ended December 31, 2022 and December 31, 2021. These amounts exclude liabilities related to asset retirement obligations accounted for in accordance with ASC Topic 410. See Note 19 to the Consolidated Financial Statements.

(Dollars in millions)	2022	2021
Beginning Balance	**$ 158**	$ 146
Plus: Additions	**20**	43
Adjustments for changes in estimates	**3**	—
Less: Obligations settled	**(55)**	(31)
Ending Balance	**$ 126**	$ 158

New or expanded environmental requirements, which could increase U. S. Steel's environmental costs, may arise in the future. U. S. Steel intends to comply with all legal requirements regarding the environment, but since many of them are not fixed or presently determinable (even under existing legislation) and may be affected by future legislation, it is not possible to predict accurately the ultimate cost of compliance, including remediation costs which may be incurred and penalties which may be imposed. U. S. Steel's environmental capital expenditures are expected to be approximately $84 million in 2023, $15 million of which is related to projects at USSE. U. S. Steel's environmental expenditures for 2023 for operating and maintenance and for remediation projects are expected to be approximately $232 million and $42 million, respectively, of which approximately $13 million and $5 million for operating and maintenance and remediation, respectively, is related to USSE. Although, the outcome of pending environmental matters is not estimable at this time, it is reasonably possible that U. S. Steel's environmental capital and operating and maintenance expenditures could materially increase as a result of the future resolution of these matters. Predictions of future environmental expenditures beyond 2023 can only be broad-based estimates, which have varied, and will continue to vary, due to the ongoing evolution of specific regulatory requirements, the possible imposition of more stringent requirements and the availability of new technologies to remediate sites, among other factors.

Accounting Standards

See Notes 2 and 3 to the Consolidated Financial Statements in Part II Item 8 of this Form 10-K.

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Item 7A. QUANTITATIVE AND QUALITATIVE DISCLOSURES ABOUT MARKET RISK

U. S. Steel is exposed to certain risks related to its ongoing business operations, including financial, market, political, and economic risks. The following discussion provides information regarding U. S. Steel's exposure to the risks of changing foreign currency exchange rates, commodity prices and interest rates.

U. S. Steel may enter into derivative financial instrument transactions in order to manage or reduce these market risks. The use of derivative instruments is subject to our corporate governance policies. These instruments are used solely to mitigate market exposure and are not used for trading or speculative purposes.

U. S. Steel may elect to use hedge accounting for certain commodity or currency transactions. For those transactions, the impact of the hedging instrument will be recognized in other comprehensive income until the transaction is settled. Once the transaction is settled, the effect of the hedged item will be recognized in income. For further information regarding derivative instruments see Notes 1 and 16 to the Consolidated Financial Statements.

Foreign Currency Exchange Rate Risk

U. S. Steel is subject to the risk of price fluctuations due to the effects of exchange rates on revenues and operating costs, firm commitments for capital expenditures and existing assets or liabilities denominated in currencies other than the U.S. dollar, particularly the euro. U. S. Steel historically has made limited use of forward currency contracts to manage exposure to certain currency price fluctuations. U. S. Steel elected cash flow hedge accounting for foreign exchange forwards and had no material open forward exchange contracts that were subject to mark-to-market accounting as of December 31, 2022.

The fair value of our derivatives is determined using Level 2 inputs, which are defined as "significant other observable" inputs. The inputs used include quotes from counterparties that are corroborated with market sources.

Volatility in the foreign currency markets could have significant implications for U. S. Steel as a result of foreign currency transaction effects. Future foreign currency impacts will depend upon changes in currencies and the extent to which we engage in derivatives transactions. For additional information on U. S. Steel's foreign currency exchange activity, see Note 16 to the Consolidated Financial Statements.

Commodity Price Risk and Related Risks

In the normal course of our business, U. S. Steel is exposed to market risk or price fluctuations related to the purchase, production or sale of steel products. U. S. Steel is also exposed to price risk related to the purchase, production or sale of coal, coke, natural gas, steel scrap, iron ore and pellets, and zinc, tin and other nonferrous metals used as raw materials. U. S. Steel is also subject to market price risk for the purchase of a portion of its electricity at certain facilities. See Note 16 to the Consolidated Financial Statements for further details on U. S. Steel's derivatives.

U. S. Steel's market risk strategy has generally been to obtain competitive prices for our products and services and allow operating results to reflect market price movements dictated by supply and demand; however, from time to time U. S. Steel has made forward physical purchases to manage exposure to price risk related to the purchases of natural gas and certain non-ferrous metals used in the production process. As of December 31, 2022, U. S. Steel, through U. S. Steel Europe, had $12 million forward buy contracts for zinc. There were no forward buy contracts for natural gas or any of the other significant raw materials used in the domestic production process.

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Interest Rate Risk

U. S. Steel is subject to the effects of interest rate fluctuations on the fair value of certain of our non-derivative financial instruments. A sensitivity analysis of the projected incremental effect of a hypothetical 10 percent increase/decrease in year-end 2022 and 2021 interest rates on the fair value of U. S. Steel's non-derivative financial instruments is provided in the following table:

(Dollars in millions)	2022		2021	
Non-Derivative Financial Instruments[a]	**Fair Value[b]**	**Change in Fair Value[c]**	Fair Value[b]	Change in Fair Value[c]
Financial liabilities:				
Debt[d][e]	**$ 3,815**	**$ 116**	$ 4,379	$ 143

(a) Fair values of cash and cash equivalents, current accounts and notes receivable, accounts payable, bank checks outstanding and accrued interest approximate carrying value and are relatively insensitive to changes in interest rates due to the short-term maturity of the instruments. Accordingly, these instruments are excluded from the table.
(b) See Note 20 to the Consolidated Financial Statements for carrying value of instruments.
(c) Reflects, by class of financial instrument, the estimated incremental effect of a hypothetical 10 percent change in interest rates at December 31, 2022, and 2021, on the fair value of U. S. Steel's non-derivative financial instruments. For financial liabilities, this assumes a 10 percent decrease in the weighted average yield to maturity of U. S. Steel's long-term debt at December 31, 2022 and December 31, 2021.
(d) Excludes finance lease obligations.
(e) Fair value was determined using Level 2 inputs which were derived from quoted market prices and is based on the yield on public debt where available or current borrowing rates available for financings with similar terms and maturities.

U. S. Steel's sensitivity to interest rate declines and corresponding increases in the fair value of our debt portfolio would unfavorably affect our results and cash flows only to the extent that we elected to repurchase or otherwise retire all or a portion of our fixed-rate debt portfolio at prices above carrying value.

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Item 8. CONSOLIDATED FINANCIAL STATEMENTS AND SUPPLEMENTARY DATA

The information required by this item is set forth in our Consolidated Financial Statement contained in this Annual Report on Form 10-K. Specific financial statements can be found at the page listed below:

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MANAGEMENT'S REPORT TO STOCKHOLDERS

February 3, 2023

To the Stockholders of United States Steel Corporation:

Financial Statements and Practices

The accompanying consolidated financial statements of United States Steel Corporation are the responsibility of and have been prepared by United States Steel Corporation in conformity with accounting principles generally accepted in the United States of America. They necessarily include some amounts that are based on our best judgments and estimates. United States Steel Corporation's financial information displayed in other sections of this report is consistent with these financial statements.

United States Steel Corporation seeks to assure the objectivity and integrity of its financial records by careful selection of its managers, by organizational arrangements that provide an appropriate division of responsibility and by communication programs aimed at assuring that its policies, procedures and methods are understood throughout the organization.

United States Steel Corporation has a comprehensive, formalized system of internal controls designed to provide reasonable assurance that assets are safeguarded, that financial records are reliable and that information required to be disclosed in reports filed with or submitted to the Securities and Exchange Commission is recorded, processed, summarized and reported within the required time limits. Appropriate management monitors the system for compliance and evaluates it for effectiveness, and the independent registered public accounting firm measures its effectiveness and recommends possible improvements thereto.

The Board of Directors exercises its oversight role in the area of financial reporting and internal control over financial reporting through its Audit Committee. This committee, composed solely of independent directors, regularly meets (jointly and separately) with the independent registered public accounting firm, management, internal audit and other executives to monitor the proper discharge by each of their responsibilities relative to internal control over financial reporting and United States Steel Corporation's financial statements.

Internal Control Over Financial Reporting

United States Steel Corporation's management is responsible for establishing and maintaining adequate internal control over financial reporting, as defined in Exchange Act Rule 13a-15(f). Under the supervision and with the participation of United States Steel Corporation's management, including the Chief Executive Officer and Chief Financial Officer, United States Steel Corporation conducted an evaluation of the effectiveness of its internal control over financial reporting based on the framework in *Internal Control – Integrated Framework (2013)* issued by the Committee of Sponsoring Organizations of the Treadway Commission.

Based on this evaluation, United States Steel Corporation's management concluded that United States Steel Corporation's internal control over financial reporting was effective as of December 31, 2022.

The effectiveness of United States Steel Corporation's internal control over financial reporting as of December 31, 2022, has been audited by PricewaterhouseCoopers LLP, an independent registered public accounting firm, as stated in their report which is included herein.

/S/ DAVID B. BURRITT	/S/ JESSICA T. GRAZIANO
David B. Burritt	Jessica T. Graziano
President and Chief Executive Officer	Senior Vice President and Chief Financial Officer

/S/ MANPREET S. GREWAL
Manpreet S. Grewal
Vice President, Controller & Chief Accounting Officer

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Report of Independent Registered Public Accounting Firm

To the Board of Directors and Stockholders of United States Steel Corporation

Opinions on the Financial Statements and Internal Control over Financial Reporting

We have audited the accompanying consolidated balance sheets of United States Steel Corporation and its subsidiaries (the "Company") as of December 31, 2022 and 2021, and the related consolidated statements of operations, of comprehensive income (loss), of stockholders' equity and of cash flows for each of the three years in the period ended December 31, 2022, including the related notes and financial statement schedule listed in the index appearing under Item 15(a)(2) (collectively referred to as the "consolidated financial statements"). We also have audited the Company's internal control over financial reporting as of December 31, 2022, based on criteria established in *Internal Control - Integrated Framework* (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission (COSO).

In our opinion, the consolidated financial statements referred to above present fairly, in all material respects, the financial position of the Company as of December 31, 2022 and 2021, and the results of its operations and its cash flows for each of the three years in the period ended December 31, 2022 in conformity with accounting principles generally accepted in the United States of America. Also in our opinion, the Company maintained, in all material respects, effective internal control over financial reporting as of December 31, 2022, based on criteria established in *Internal Control - Integrated Framework* (2013) issued by the COSO.

Basis for Opinions

The Company's management is responsible for these consolidated financial statements, for maintaining effective internal control over financial reporting, and for its assessment of the effectiveness of internal control over financial reporting, included in the accompanying Management's Report to Stockholders on Internal Control Over Financial Reporting. Our responsibility is to express opinions on the Company's consolidated financial statements and on the Company's internal control over financial reporting based on our audits. We are a public accounting firm registered with the Public Company Accounting Oversight Board (United States) (PCAOB) and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audits to obtain reasonable assurance about whether the consolidated financial statements are free of material misstatement, whether due to error or fraud, and whether effective internal control over financial reporting was maintained in all material respects.

Our audits of the consolidated financial statements included performing procedures to assess the risks of material misstatement of the consolidated financial statements, whether due to error or fraud, and performing procedures that respond to those risks. Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the consolidated financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the consolidated financial statements. Our audit of internal control over financial reporting included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, and testing and evaluating the design and operating effectiveness of internal control based on the assessed risk. Our audits also included performing such other procedures as we considered necessary in the circumstances. We believe that our audits provide a reasonable basis for our opinions.

Definition and Limitations of Internal Control over Financial Reporting

A company's internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company's internal control over financial reporting includes those policies and procedures that (i) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company; (ii) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (iii) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company's assets that could have a material effect on the financial statements.

Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

Critical Audit Matters

The critical audit matter communicated below is a matter arising from the current period audit of the consolidated financial statements that was communicated or required to be communicated to the audit committee and that (i) relates to accounts or

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disclosures that are material to the consolidated financial statements and (ii) involved our especially challenging, subjective, or complex judgments. The communication of critical audit matters does not alter in any way our opinion on the consolidated financial statements, taken as a whole, and we are not, by communicating the critical audit matter below, providing a separate opinion on the critical audit matter or on the accounts or disclosures to which it relates.

Goodwill Impairment Test – Mini Mill Reporting Unit

As described in Notes 1 and 14 to the consolidated financial statements, the Company's consolidated goodwill balance was $920 million as of December 31, 2022, which included $916 million relating to the Mini Mill reporting unit. Goodwill is deemed to have an indefinite life and is not amortized, but is subject to impairment testing annually, or more frequently if events or changes in circumstances indicate the asset might be impaired. Management performs an annual goodwill impairment test as of October 1 and monitors for interim triggering events on an ongoing basis. Fair value is determined by management using an income approach based on a discounted five year forecasted cash flow including a terminal value. The assumptions about future cash flows and growth rates are based on the respective reporting unit's long-term forecast. The Mini Mill reporting unit's discount rate is a significant assumption and is a risk-adjusted weighted average cost of capital, which management believes approximates the rate from a market participant's perspective.

The principal considerations for our determination that performing procedures relating to the goodwill impairment test of the Mini Mill reporting unit is a critical audit matter are (i) the significant judgment by management when developing the fair value estimate of the Mini Mill reporting unit; (ii) a high degree of auditor judgment, subjectivity, and effort in performing procedures and evaluating management's significant assumption related to the discount rate; and (iii) the audit effort involved the use of professionals with specialized skill and knowledge.

Addressing the matter involved performing procedures and evaluating audit evidence in connection with forming our overall opinion on the consolidated financial statements. These procedures included testing the effectiveness of controls relating to management's goodwill impairment test, including controls over the valuation of the Mini Mill reporting unit. These procedures also included, among others (i) testing management's process for developing the fair value estimate; (ii) evaluating the appropriateness of the discounted cash flow model; (iii) testing the completeness and accuracy of underlying data used in the discounted cash flow model; and (iv) evaluating the reasonableness of the significant assumption used by management related to the discount rate. Evaluating management's assumption related to the discount rate involved evaluating whether the significant assumption used by management was reasonable considering the consistency with external market and industry data. Professionals with specialized skill and knowledge were used to assist in evaluating (i) the appropriateness of the Company's discounted cash flow model and (ii) the reasonableness of the discount rate assumption.

/s/ PricewaterhouseCoopers LLP
Pittsburgh, Pennsylvania
February 3, 2023

We have served as the Company's auditor since 1903.

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UNITED STATES STEEL CORPORATION
CONSOLIDATED STATEMENTS OF OPERATIONS

(Dollars in millions, except per share amounts)	Year Ended December 31, 2022	2021	2020
Net sales:			
Net sales	**$ 19,123**	$ 18,964	$ 8,765
Net sales to related parties (Note 23)	**1,942**	1,311	976
Total (Note 6)	**21,065**	20,275	9,741
Operating expenses (income):			
Cost of sales (excludes items shown below)	**16,777**	14,533	9,555
Selling, general and administrative expenses	**422**	426	277
Depreciation, depletion and amortization (Notes 13 and 14)	**791**	791	643
(Earnings) loss from investees (Note 12)	**(243)**	(170)	117
Gain on sale of Transtar (Note 5)	**—**	(506)	—
Asset impairment charges (Note 1)	**163**	273	263
Restructuring and other charges (Note 25)	**48**	128	138
Gain on equity investee transactions (Note 12)	**(6)**	(111)	(31)
Net gains on sale of assets	**(12)**	(7)	(149)
Other (gains) losses, net	**(35)**	(28)	3
Total	**17,905**	15,329	10,816
Earnings (loss) before interest and income taxes	**3,160**	4,946	(1,075)
Interest expense	**159**	313	280
Interest income	**(44)**	(4)	(7)
Loss on debt extinguishment (Note 7)	**—**	292	—
Other financial costs (benefits)	**32**	46	(16)
Net periodic benefit income	**(246)**	(45)	(25)
Net interest and other financial (benefits) costs (Note 7)	**(99)**	602	232
Earnings (loss) before income taxes	**3,259**	4,344	(1,307)
Income tax expense (benefit) (Note 11)	**735**	170	(142)
Net earnings (loss)	**2,524**	4,174	(1,165)
Less: Net earnings attributable to noncontrolling interests	**—**	—	—
Net earnings (loss) attributable to United States Steel Corporation	**$ 2,524**	$ 4,174	$ (1,165)
Earnings (loss) per common share (Note 8)			
Earnings (loss) per share attributable to United States Steel Corporation stockholders:			
— Basic	**$ 10.22**	$ 15.77	$ (5.92)
— Diluted	**$ 9.16**	$ 14.88	$ (5.92)

The accompanying notes are an integral part of these Consolidated Financial Statements.

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UNITED STATES STEEL CORPORATION
CONSOLIDATED STATEMENTS OF COMPREHENSIVE INCOME (LOSS)

(Dollars in millions)	Year Ended December 31, 2022	2021	2020
Net earnings (loss)	**$ 2,524**	$ 4,174	$ (1,165)
Other comprehensive income (loss), net of tax:			
Changes in foreign currency translation adjustments [(a)]	**(91)**	(78)	68
Changes in pension and other employee benefit accounts [(a)]	**(297)**	433	385
Changes in derivative financial instruments [(a)]	**(28)**	23	(22)
Total other comprehensive (loss) income, net of tax	**(416)**	378	431
Comprehensive income (loss) including noncontrolling interest	**2,108**	4,552	(734)
Comprehensive income (loss) attributable to noncontrolling interest	**—**	—	—
Comprehensive income (loss) attributable to United States Steel Corporation	**$ 2,108**	$ 4,552	$ (734)

[(a)] Related income tax benefit (expense)

Foreign currency translation adjustments	**$ 24**	$ 32	$ (16)
Pension and other benefits adjustments	**95**	(147)	(123)
Derivative adjustments	**9**	(6)	4

The accompanying notes are an integral part of these Consolidated Financial Statements.

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UNITED STATES STEEL CORPORATION
CONSOLIDATED BALANCE SHEETS

(Dollars in millions)	December 31, 2022	2021
Assets		
Current assets:		
Cash and cash equivalents (Note 9)	**$ 3,504**	$ 2,522
Receivables, less allowance of $38 and $44	**1,485**	1,968
Receivables from related parties (Note 23)	**150**	121
Inventories (Note 10)	**2,359**	2,210
Other current assets	**368**	331
Total current assets	**7,866**	7,152
Long-term restricted cash (Note 9)	**31**	76
Investments and long-term receivables, less allowance of $4 in both periods (Note 12)	**840**	694
Operating lease assets (Note 24)	**146**	185
Property, plant and equipment, net (Note 13)	**8,492**	7,254
Intangibles, net (Note 14)	**478**	519
Deferred income tax benefits (Note 11)	**10**	32
Goodwill (Note 14)	**920**	920
Other noncurrent assets	**675**	984
Total assets	**$ 19,458**	$ 17,816
Liabilities		
Current liabilities:		
Accounts payable and other accrued liabilities	**$ 2,873**	$ 2,809
Accounts payable to related parties (Note 23)	**143**	99
Payroll and benefits payable	**493**	425
Accrued taxes	**271**	365
Accrued interest	**67**	68
Current operating lease liabilities (Note 24)	**49**	58
Short-term debt and current maturities of long-term debt (Note 17)	**63**	28
Total current liabilities	**3,959**	3,852
Noncurrent operating lease liabilities (Note 24)	**105**	136
Long-term debt, less unamortized discount and debt issuance costs (Note 17)	**3,914**	3,863
Employee benefits (Note 18)	**209**	235
Deferred income tax liabilities (Note 11)	**456**	122
Deferred credits and other noncurrent liabilities	**504**	505
Total liabilities	**9,147**	8,713
Contingencies and commitments (Note 26)		
Stockholders' Equity		
Common stock issued — 282,487,412 and 279,522,227 shares issued (par value $1 per share, authorized 400,000,000 shares) (Note 8)	**283**	280
Treasury stock, at cost (54,089,559 shares and 15,708,839 shares)	**(1,204)**	(334)
Additional paid-in capital	**5,194**	5,199
Retained earnings	**6,030**	3,534
Accumulated other comprehensive (loss) income (Note 21)	**(85)**	331
Total United States Steel Corporation stockholders' equity	**10,218**	9,010
Noncontrolling interests	**93**	93
Total liabilities and stockholders' equity	**$ 19,458**	$ 17,816

The accompanying notes are an integral part of these Consolidated Financial Statements.

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UNITED STATES STEEL CORPORATION
CONSOLIDATED STATEMENTS OF CASH FLOWS

(Dollars in millions)	Year Ended December 31, 2022	2021	2020
Increase (decrease) in cash and cash equivalents			
Operating activities:			
Net earnings (loss)	**$ 2,524**	$ 4,174	$ (1,165)
Adjustments to reconcile net cash provided by operating activities:			
Depreciation, depletion and amortization (Notes 13 and 14)	**791**	791	643
Gain on sale of Transtar (Note 5)	**—**	(506)	—
Asset impairment charges (Note 1)	**163**	273	263
Gain on equity investee transactions (Note 12)	**(6)**	(111)	(31)
Restructuring and other charges (Note 25)	**48**	128	138
Loss on debt extinguishment (Note 7)	**—**	292	—
Pensions and other post-employment benefits	**(213)**	15	(21)
Deferred income taxes (Note 11)	**501**	(52)	(130)
Net gain on sale of assets	**(12)**	(7)	(149)
Equity investees (earnings) loss, net of distributions received	**(215)**	(168)	117
Changes in:			
Current receivables	**370**	(955)	98
Inventories	**(222)**	(677)	506
Current accounts payable and accrued expenses	**(180)**	783	(29)
Income taxes receivable/payable	**(15)**	161	20
All other, net	**(29)**	(51)	(122)
Net cash provided by operating activities	**3,505**	4,090	138
Investing activities:			
Capital expenditures	**(1,769)**	(863)	(725)
Acquisition of Big River Steel, net of cash acquired (Note 5)	**—**	(625)	—
Investment in Big River Steel	**—**	—	(9)
Proceeds from sale of Transtar (Note 5)	**—**	627	—
Proceeds from cost reimbursement government grants (Note 26)	**54**	—	—
Proceeds from sale of assets	**32**	26	167
Proceeds from sale of ownership interests in equity investees (Note 12)	**12**	—	8
Other investing activities	**(8)**	(5)	(4)
Net cash used in investing activities	**(1,679)**	(840)	(563)
Financing activities:			
Issuance of short-term debt, net of financing costs (Note 17)	**—**	—	240
Repayment of short-term debt (Note 17)	**—**	(180)	(70)
Revolving credit facilities - borrowings, net of financing costs (Note 17)	**—**	50	1,402
Revolving credit facilities - repayments (Note 17)	**—**	(911)	(1,621)
Issuance of long-term debt, net of financing costs (Note 17)	**343**	864	1,148
Repayment of long-term debt (Note 17)	**(382)**	(3,183)	(13)
Net proceeds from public offering of common stock (Note 27)	**—**	790	410
Proceeds from Stelco Option Agreement, net of financing costs (Note 20)	**—**	—	94
Common stock repurchased (Note 27)	**(849)**	(150)	—
Proceeds from government incentives (Note 26)	**82**	—	—
Other financing activities	**(62)**	(27)	(9)
Net cash (used in) provided by financing activities	**(868)**	(2,747)	1,581
Effect of exchange rate changes on cash	**(19)**	(21)	23
Net increase in cash, cash equivalents and restricted cash	**939**	482	1,179
Cash, cash equivalents and restricted cash at beginning of year (Note 9)	**2,600**	2,118	939
Cash, cash equivalents and restricted cash at end of year (Note 9)	**$ 3,539**	$ 2,600	$ 2,118

See Note 22 for supplemental cash flow information.

The accompanying notes are an integral part of these Consolidated Financial Statements.

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UNITED STATES STEEL CORPORATION
CONSOLIDATED STATEMENTS OF STOCKHOLDERS' EQUITY

	Dollars in Millions			Shares in Thousands		
	2022	**2021**	**2020**	**2022**	**2021**	**2020**
Common stock:						
Balance at beginning of year	**$ 280**	$ 229	$ 179	**279,522**	229,106	178,555
Common stock issued	**3**	51	50	**2,965**	50,416	50,551
Balance at end of year	**$ 283**	$ 280	$ 229	**282,487**	279,522	229,106
Treasury stock:						
Balance at beginning of year	**$ (334)**	$ (175)	$ (173)	**(15,709)**	(8,673)	(8,509)
Common stock repurchased	**(849)**	(150)	—	**(37,559)**	(6,557)	—
Common stock (repurchased) reissued for employee/non-employee director stock plans	**(21)**	(9)	(2)	**(822)**	(479)	(164)
Balance at end of year	**$ (1,204)**	$ (334)	$ (175)	**(54,090)**	(15,709)	(8,673)
Additional paid-in capital:						
Balance at beginning of year	**$ 5,199**	$ 4,402	$ 4,020			
Dividends on common stock	**—**	(5)	(6)			
Common stock issued	**—**	742	360			
Employee stock plans	**72**	60	28			
Cumulative effect upon adoption of Accounting Standards Update 2020-06	**(77)**	—	—			
Balance at end of year	**$ 5,194**	$ 5,199	$ 4,402			

The accompanying notes are an integral part of these Consolidated Financial Statements.

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UNITED STATES STEEL CORPORATION
CONSOLIDATED STATEMENTS OF STOCKHOLDERS' EQUITY

(Continued)

(Dollars in millions)	2022	2021	2020	Comprehensive Income (Loss) 2022	2021	2020
Retained earnings:						
Balance at beginning of year	**$ 3,534**	$ (623)	$ 544			
Net earnings (loss) attributable to United States Steel Corporation	**2,524**	4,174	(1,165)	**$ 2,524**	$ 4,174	$ (1,165)
Dividends on common stock	**(50)**	(18)	(2)			
Cumulative effect upon adoption of Accounting Standards Update 2020-06	**22**	—	—			
Other	**—**	1	—			
Balance at end of year	**$ 6,030**	$ 3,534	$ (623)			
Accumulated other comprehensive (loss) income:						
Pension and other benefit adjustments (Note 18):						
Balance at beginning of year	**$ (25)**	$ (458)	$ (843)			
Changes during year, net of taxes [(a)]	**(304)**	433	360	**(304)**	433	360
Changes during year, equity investee net of taxes [(a)]	**7**	—	25	**7**	—	25
Balance at end of year	**$ (322)**	$ (25)	$ (458)			
Foreign currency translation adjustments:						
Balance at beginning of year	**$ 371**	$ 449	$ 381			
Changes during year, net of taxes [(a)]	**(91)**	(78)	68	**(91)**	(78)	68
Balance at end of year	**$ 280**	$ 371	$ 449			
Derivative financial instruments:						
Balance at beginning of year	**$ (15)**	$ (38)	$ (16)			
Changes during year, net of taxes [(a)]	**(28)**	23	(22)	**(28)**	23	(22)
Balance at end of year	**$ (43)**	$ (15)	$ (38)			
Total balances at end of year	**$ (85)**	$ 331	$ (47)			
Total stockholders' equity	**$ 10,218**	$ 9,010	$ 3,786			
Noncontrolling interests:						
Balance at beginning of year	**$ 93**	$ 93	$ 1			
Stelco Option Agreement	**—**	—	93			
Other	**—**	—	(1)			
Net loss	**—**	—	—	**—**	—	—
Balance at end of year	**$ 93**	$ 93	$ 93			
Total comprehensive income (loss)				**$ 2,108**	$ 4,552	$ (734)

[(a)] Related income tax benefit (expense):

Foreign currency translation adjustments	**$ 24**	$ 32	$ (16)
Pension and other benefits adjustments	**95**	(147)	(123)
Derivative adjustments	**9**	(6)	4

The accompanying notes are an integral part of these Consolidated Financial Statements.

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1. Nature of Business and Significant Accounting Policies

Nature of Business

U. S. Steel produces and sells steel products, including flat-rolled and tubular products, in North America and Europe. Operations in the United States also include iron ore and coke production facilities and real estate operations. Operations in Europe also include coke production facilities.

Significant Accounting Policies

Principles applied in consolidation

These financial statements include the accounts of U. S. Steel and its majority-owned subsidiaries. Additionally, variable interest entities for which U. S. Steel is the primary beneficiary are included in the Consolidated Financial Statements, and their impacts are either partially or completely offset by noncontrolling interests. Intercompany accounts, transactions and profits have been eliminated in consolidation.

Investments in entities over which U. S. Steel has significant influence are accounted for using the equity method of accounting and are carried at U. S. Steel's share of net assets plus loans, advances and our share of earnings less distributions.

Earnings or loss from investees includes U. S. Steel's share of earnings or loss from equity method investments (and any amortization of basis differences), which are generally recorded a month in arrears.

Use of estimates

Generally accepted accounting principles require management to make estimates and assumptions that affect the reported amounts of assets and liabilities, the disclosure of contingent assets and liabilities at year-end and the reported amounts of revenues and expenses during the year. Significant items subject to such estimates and assumptions include the carrying value of property, plant and equipment; intangible assets; the fair value of assets or liabilities acquired in a business combination; valuation allowances for receivables, inventories and deferred income tax assets and liabilities; environmental liabilities; liabilities for potential tax deficiencies; potential litigation claims and settlements; assets and obligations related to employee benefits; put and call option and contingent forward purchase commitment assets and liabilities; and restructuring and other charges. Actual results could differ materially from the estimates and assumptions used.

The preparation of the financial statements includes an assessment of certain accounting matters using all available information including consideration of forecasted financial information in context with other information reasonably available to us. However, our future assessment of current expectations could result in material impacts to our consolidated financial statements in future reporting periods. All such adjustments are of a normal recurring nature unless disclosed otherwise.

Sales recognition

Sales are recognized when U. S. Steel's performance obligations are satisfied. Generally, U. S. Steel's performance obligations are satisfied, control of our products is transferred, and revenue is recognized at a single point in time, when title transfers to our customer for product shipped or when services are provided. Revenues are recorded net of any sales incentives. Shipping and other transportation costs charged to customers are treated as fulfillment activities and are recorded in both revenue and cost of sales at the time control is transferred to the customer. See Note 6 for further details on U. S. Steel's revenue.

Inventories

Inventories are carried at the lower of cost or net realizable value. Fixed costs related to abnormal production capacity are expensed in the period incurred rather than capitalized into inventory.

LIFO is the predominant method of inventory costing for inventories held by the Flat-Rolled and Tubular segments. The Mini Mill segment uses a moving average costing method to account for semi-finished and finished products and FIFO to account for raw materials. FIFO is the predominant method used by the USSE segment. The LIFO method of inventory costing was used on 43 percent and 46 percent of consolidated inventories at December 31, 2022, and 2021, respectively.

Derivative instruments

From time to time, U. S. Steel may use fixed price forward physical purchase contracts to partially manage our exposure to price risk. Generally, forward physical purchase contracts qualify for the normal purchase normal sales exclusion in Accounting Standards Codification (ASC) 815, *Derivatives and Hedging*, and are not subject to mark-to-market accounting. U. S. Steel also uses derivatives such as commodity-based financial swaps and foreign currency exchange forward contracts to manage its exposure to purchase and sale price fluctuations and foreign currency exchange rate risk. The USSE and Flat-Rolled segments elect hedge accounting for some of their derivatives. Under hedge accounting, fluctuations in the value of the derivative are recognized in Accumulated other comprehensive (loss) income (AOCI) until

the associated underlying is recognized in earnings. When the associated underlying is recognized in earnings, the value of the derivative is reclassified to earnings from AOCI. The Mini Mill segment has not elected hedge accounting. Therefore, the changes in fair value of the Mini Mill segment's foreign exchange forwards, as well as fair value changes for other derivatives where hedge accounting has not been elected, are recognized immediately in earnings. In accordance with the guidance in ASC Topic 820 on fair value measurements and disclosures, the fair value of our foreign exchange forwards, commodity purchase swaps and sales swaps was determined using Level 2 inputs, which are defined as "significant other observable" inputs. The inputs used are from market sources that aggregate data based upon market transactions. See Note 16 for further details on U. S. Steel's derivatives.

Property, plant and equipment
Property, plant and equipment is carried at cost less accumulated depreciation and is depreciated on a straight-line basis over the estimated useful lives of the assets.

Depletion of mineral properties is based on rates which are expected to amortize cost over the estimated tonnage of minerals to be removed.

When property, plant and equipment is sold or otherwise disposed of, any gains or losses are reflected in income. If a loss on disposal is expected, such losses are recognized when the assets are reclassified as assets held for sale or when impaired as part of an asset group's impairment.

Asset Impairment
U. S. Steel evaluates impairment of its property, plant and equipment whenever circumstances indicate that the carrying value may not be recoverable. We evaluate the impairment of long-lived assets at the asset group level. Our asset groups are flat-rolled, mini mill, welded tubular, seamless tubular and USSE. Asset impairments are recognized when the carrying value of an asset group exceeds its recoverable amount as determined by the asset group's aggregate projected undiscounted cash flows.

In the second quarter 2022, the Company recognized charges of approximately $151 million for the write-off of the blast furnaces and related fixed assets for the permanent idling of the iron making process at the Company's Great Lakes Works facility, which had been idled on an indefinite basis during 2020. The coil finishing process at Great Lakes Works continues to operate and remains a component of the Company's operating plans.

In December 2021, the Company permanently idled the steel making process at Great Lakes Works, which had been idled on an indefinite basis during 2020. As a result of this decision, the Company recognized charges of approximately $128 million for the write-off of the BOP, steel casting and hot strip mill related fixed assets. In addition, in October 2021, equipment at Gary Works related to steel production intended for petroleum conveying pipe were written-off resulting in a charge of approximately $88 million.

In May 2019, U. S. Steel announced that it planned to construct a new endless casting and rolling facility at its Edgar Thomson Plant in Braddock, Pennsylvania, and a cogeneration facility at its Clairton Plant in Clairton, Pennsylvania, both part of the Company's Mon Valley Works. The Company purchased certain equipment for this project before delaying groundbreaking in March 2020 in response to COVID-19. In April 2021, the Company determined not to pursue this project, re-evaluated the use of the already purchased equipment, and subsequently transferred suitable equipment to the Mini Mill segment to be used on the planned, three-million-ton mini mill flat-rolled facility to be constructed. Total impairments of $56 million were recognized for this project in 2021.

For the period ended March 31, 2020, the steep decline in oil prices that resulted from market oversupply and declining demand was considered a triggering event for the welded tubular and seamless tubular asset groups. A quantitative analysis was completed for both asset groups and a $263 million impairment, consisting of an impairment of $196 million for property, plant and equipment and $67 million for intangible assets was recorded for the welded tubular asset group while no impairment was indicated for the seamless tubular asset group. There were no other triggering events that required an impairment evaluation of our long-lived asset groups during the years-ended December 31, 2022 and 2021.

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Goodwill and identifiable intangible assets
Goodwill represents the excess of the cost over the fair value of acquired identifiable tangible and intangible assets and liabilities assumed from businesses acquired. Goodwill and intangible assets deemed to have indefinite lives are not amortized, but are subject to impairment testing annually, or more frequently if events or changes in circumstances indicate the asset might be impaired. We perform our annual goodwill impairment test as of October 1 and monitor for interim triggering events on an ongoing basis.

We review goodwill for impairment utilizing either a qualitative assessment or a quantitative goodwill impairment test. If we choose to perform a qualitative assessment and we determine that the fair value of the reporting unit more likely than not exceeds the carrying value, no further evaluation is necessary. For reporting units where we perform the quantitative goodwill impairment test, we compare the fair value of each reporting unit, which we primarily determine using an income approach based on the present value of discounted cash flows, to the respective carrying value, which includes goodwill. If the fair value of the reporting unit exceeds its carrying value, we do not consider the goodwill impaired. If the carrying value is higher than the fair value, we recognize the difference as an impairment loss.

A quantitative goodwill impairment testing process requires valuation of the respective reporting unit, which we primarily determine using an income approach based on a discounted five year forecasted cash flow including a terminal value. We compute the terminal value using the constant growth method, which values the forecasted cash flows in perpetuity. The assumptions about future cash flows and growth rates are based on the respective reporting unit's long-term forecast and are subject to review and approval by senior management. A reporting unit's discount rate is a significant assumption and is a risk-adjusted weighted average cost of capital, which we believe approximates the rate from a market participant's perspective. The estimated fair value could be impacted by changes in market conditions, interest rates, growth rates, tax rates, costs, pricing and capital expenditures. We categorize the fair value determination as Level 3 in the fair value hierarchy due to its use of internal projections and unobservable measurement inputs.

Our Mini Mill reporting unit holds the goodwill recognized as a result of the Company's acquisition of Big River Steel and currently is our only reporting unit that has a significant amount of goodwill. This goodwill is primarily attributable to Big River Steel's operational abilities, workforce and the anticipated benefits from their recent expansion. U. S. Steel completed its annual goodwill impairment test using a quantitative analysis during the fourth quarter of 2022 and determined there was no impairment of goodwill.

Intangible assets with indefinite lives are also subject to at least annual impairment testing, which compares the fair value of the intangible assets with their carrying amounts. U. S. Steel has determined that certain of its acquired intangible assets have indefinite useful lives. These assets are also reviewed for impairment annually in the fourth quarter and whenever events or circumstances indicate the carrying value may not be recoverable. U. S. Steel completed its annual evaluation of its indefinite-lived water rights using a qualitative assessment and determined there was no indication of impairment.

Finite-lived intangible assets are amortized on a straight-line basis over their estimated useful lives and are tested for impairment when events occur that indicate that the net book value will not be recovered over future cash flows.

Environmental remediation
Environmental expenditures are capitalized if the costs mitigate or prevent future contamination or if the costs improve existing assets' environmental safety or efficiency. U. S. Steel provides for remediation costs and penalties when the responsibility to remediate is probable and the amount of associated costs is reasonably estimable. The timing of remediation accruals typically coincides with completion of studies defining the scope of work to be undertaken or when it is probable that a formal plan of action will be approved by the oversight agency. Remediation liabilities are accrued based on estimates of believed environmental exposure and are discounted if the amount and timing of the cash disbursements are readily determinable.

Asset retirement obligations
Asset retirement obligations (AROs) are initially recorded at fair value and are capitalized as part of the cost of the related long-lived asset and depreciated in accordance with U. S. Steel's depreciation policies for property, plant and equipment. The fair value of the obligation is determined as the discounted value of expected future cash flows. Accretion expense is recorded each month to increase this discounted obligation over time. Certain AROs related to disposal costs of the majority of assets at our integrated steel facilities are not recorded because they have an indeterminate settlement date. These AROs will be initially recognized in the period in which sufficient information exists to estimate their fair value. See Note 19 for further details on U. S. Steel's AROs.

Pensions and other post-employment benefits
U. S. Steel has defined contribution or multiemployer arrangements for pension benefits for more than 80 percent of its employees in the United States and defined benefit pension plans covering the remaining employees. For hires before January 1, 2016, U. S. Steel has defined benefit retiree health care and life insurance plans (Other Benefits) that cover its represented employees in North America upon their retirement. Government-sponsored programs into which U. S. Steel

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makes required contributions cover U. S. Steel's European employees. For more details regarding pension and other post-employment benefits see Note 18 of the Consolidated Financial Statements.

The pension and Other Benefits obligations and the related net periodic benefit costs are based on, among other things, assumptions regarding the discount rate, estimated return on plan assets, salary increases, the projected mortality of participants and the current level and future escalation of health care costs. Additionally, U. S. Steel recognizes an obligation to provide post-employment benefits for disability-related claims covering indemnity and medical payments for certain employees in North America. The obligation for these claims and the related periodic costs are measured using actuarial techniques and assumptions. Actuarial gains and losses occur when actual experience differs from any of the many assumptions used to value the benefit plans, or when assumptions change. For pension and Other Benefits, the Company recognizes into income on an annual basis a portion of unrecognized actuarial net gains or losses that exceed 10 percent of the larger of projected benefit obligations or plan assets (the corridor). These unrecognized amounts in excess of the corridor are amortized over the plan participants' average life expectancy or average future service, depending on the demographics of the plan. Unrecognized actuarial net gains and losses for disability-related claims are immediately recognized into income.

Deferred taxes
Deferred tax assets and liabilities are recognized for the estimated future tax consequences attributable to differences between the financial statement carrying amounts of existing assets and liabilities and their respective tax basis. The realization of deferred tax assets is assessed quarterly based on several interrelated factors. These factors include U. S. Steel's expectation to generate sufficient future taxable income and the projected time period over which these deferred tax assets will be realized. U. S. Steel records a valuation allowance when necessary to reduce deferred tax assets to the amount that will more likely than not be realized. See Note 11 for further details of deferred taxes.

2. New Accounting Standards

In October 2021, the FASB issued Accounting Standards Update 2021-08, *Accounting for Contract Assets and Contract Liabilities from Contracts with Customers* (ASU 2021-08). ASU 2021-08 requires that an entity recognize and measure contract assets and contract liabilities acquired in a business combination in accordance with Topic 606, *Revenue from Contracts with Customers*. ASU 2021-08 is effective to public companies for fiscal years beginning after December 15, 2022, and interim periods within those fiscal years, with early adoption of all amendments in the same period permitted. The Company will apply the guidance prescribed by ASU 2021-08 to business combinations, if any, that take place subsequent to the effective date.

In September 2022, the FASB issued Accounting Standards Update 2022-04, *Disclosure of Supplier Finance Program Obligations* (ASU 2022-04). ASU 2022-04 requires that an entity disclose certain information about supplier finance programs used in connection with the purchase of goods and services. ASU 2022-04 is effective for all entities with fiscal years beginning after December 15, 2022, and interim periods within those fiscal years, except for the amendment on roll forward information, which is effective for fiscal years beginning after December 15, 2023. Early adoption of all amendments is permitted. The Company will adopt the interim disclosure requirements as applicable during the first quarter 2023 and the annual disclosure requirements except for the annual rollforward in the 2023 Form 10-K. The Company will adopt the annual rollforward disclosure requirement in the 2024 Form 10-K.

3. Recently Adopted Accounting Standards

In August 2020, the FASB issued Accounting Standards Update 2020-06, *Accounting for Convertible Instruments and Contracts in an Entity's Own Equity* (ASU 2020-06). ASU 2020-06 simplifies the accounting for certain financial instruments with characteristics of liabilities and equity, including convertible instruments and contracts on an entity's own equity. ASU 2020-06 also requires entities to provide expanded disclosures about the terms and features of convertible instruments and amends certain guidance in ASC 260 on the computation of earnings per share (EPS) for convertible instruments and contracts on an entity's own equity. The update requires entities to use the If-Converted Method for calculating diluted EPS, retiring the previous alternative calculation of the Treasury Stock Method for calculating diluted EPS for convertible instruments.

U. S. Steel has adopted this guidance using the modified retrospective implementation method as of January 1, 2022. The cumulative effect of the changes made to our consolidated January 1, 2022, balance sheet for the adoption of ASU 2020-06 was as follows:

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(in millions)	Balance as of December 31, 2021	Adjustments due to ASU 2020-06	Balance as of January 1, 2022
Consolidated Balance Sheet			
Assets			
Deferred income tax benefits	$32	$4	$36
Liabilities			
Long-term debt, less unamortized discount and debt issuance costs	$3,863	$74	$3,937
Deferred income tax liabilities	$122	$(15)	$107
Equity			
Additional paid-in capital	$5,199	$(78)	$5,121
Retained Earnings	$3,534	$22	$3,556

In November 2021, the FASB issued Accounting Standards Update 2021-10, *Disclosures by Business Entities about Government Assistance* (ASU 2021-10). ASU 2021-10 provides expanded disclosure requirements for business entities that account for a transaction with a government by applying a grant or contribution accounting model by analogy. The Company adopted this guidance effective January 1, 2022. The adoption of this guidance did not have a material impact on the Company's Consolidated Financial Statements.

In December 2019, the FASB issued Accounting Standards Update 2019-12, *Income Taxes (Topic 740) - Simplifying the Accounting for Income Taxes* (ASU 2019-12). ASU 2019-12 simplifies accounting for income taxes by removing certain exceptions from the general principles in Topic 740 including elimination of the exception to the incremental approach for intraperiod tax allocation when there is a loss from continuing operations and income or a gain from other items such as other comprehensive income. U. S. Steel adopted this guidance on January 1, 2021. The adoption of this guidance did not have a material impact on the Company's Consolidated Financial Statements.

In March 2020, the FASB issued Accounting Standards Update 2020-04, *Facilitation of the Effects of Reference Rate Reform on Financial Reporting* (ASU 2020-04). ASU 2020-04 provides optional exceptions for applying generally accepted accounting principles to modifications of contracts, hedging relationships, and other transactions that reference LIBOR or another rate that will be discontinued by reference rate reform if certain criteria are met. The guidance was effective beginning on March 12, 2020 and the amendments were applied prospectively through December 31, 2022. U. S. Steel adopted this guidance during 2020. The adoption of this guidance did not have a material impact on the Company's Consolidated Financial Statements.

In June 2016, the FASB issued ASU 2016-13, *Financial Instruments - Credit Losses (Topic 326): Measurement of Credit Losses on Financial Instruments* (ASU 2016-13), which adds an impairment model that is based on expected losses rather than incurred losses. U. S. Steel's significant financial instruments which are valued at cost are trade receivables (receivables). U. S. Steel's receivables carry standard industry terms and are categorized in two receivable pools, U.S. and USSE. Both pools use customer specific risk ratings based on customer financial metrics, past payment experience and other factors and qualitatively consider economic conditions to assess the level of allowance for doubtful accounts. USSE mitigates credit risk for approximately 76 percent of its receivables balance using credit insurance, letters of credit, bank guarantees, prepayments or other collateral. ASU 2016-13 was effective for public companies for fiscal years beginning after December 15, 2019, including interim reporting periods. U. S. Steel adopted this standard effective January 1, 2020. The impact of adoption was not material to the Consolidated Financial Statements.

4. Segment Information

U. S. Steel has four reportable segments: North American Flat-Rolled, Mini Mill, USSE and Tubular Products. The results of our real estate business, the previously held equity method investment in Big River Steel, and of our former railroad businesses are combined and disclosed in the Other category. The majority of U. S. Steel's customers are located in North America and Europe. No single customer accounted for more than 10 percent of gross annual revenues.

The Flat-Rolled segment includes the operating results of U. S. Steel’s integrated steel plants and equity investees in the United States involved in the production of slabs, strip mill plates, sheets and tin mill products, as well as all pig iron, iron ore and coke production facilities in the United States. These operations primarily serve North American customers in the service center, conversion, transportation (including automotive), construction, container and appliance and electrical markets.

The Mini Mill segment reflects the acquisition of Big River Steel after the purchase of the remaining equity interest on January 15, 2021 (see Note 5 for further details) and BR2 facility, which is under construction in Osceola, Arkansas. As of December 31, 2021, the Mini Mill segment includes the operating results of U. S. Steel’s two electric arc furnace steel

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plant in Osceola, Arkansas involved in the production of sheets and electrical products. These operations primarily serve North American customers in the service center, conversion, transportation (including automotive), construction, container and appliance and electrical markets.

The USSE segment includes the operating results of USSK, U. S. Steel's integrated steel plant and coke production facilities in Slovakia, and its subsidiaries. USSE conducts its business mainly in Central and Western Europe and primarily serves customers in the European transportation (including automotive), construction, container, appliance, electrical, service center, conversion and oil, gas and petrochemical markets. USSE produces and sells slabs, strip mill plate, sheet, tin mill products and spiral welded pipe.

The Tubular segment includes the operating results of U. S. Steel's tubular production facilities and an equity investee in the United States. These operations produce and sell rounds, seamless and electric resistance welded (welded) steel casing and tubing (commonly known as oil country tubular goods or OCTG), standard and line pipe and mechanical tubing and primarily serve customers in the oil, gas and petrochemical markets. The Tubular segment includes the electric arc furnace at our Fairfield Tubular Operations in Fairfield, Alabama.

The chief operating decision maker evaluates performance and determines resource allocations based on a number of factors, the primary measure being earnings (loss) before interest and income taxes. Earnings (loss) before interest and income taxes for reportable segments and the Other category does not include net interest and other financial costs (income), income taxes, and certain other items that management believes are not indicative of future results.

The accounting principles applied at the operating segment level in determining earnings (loss) before interest and income taxes are generally the same as those applied at the consolidated financial statement level. Intersegment sales and transfers are accounted for at market-based prices and are eliminated at the corporate consolidation level. Corporate-level selling, general and administrative expenses and costs related to certain former businesses are allocated to the reportable segments and Other based on measures of activity that management believes are reasonable.

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The results of segment operations are as follows:

(In millions)	Customer Sales	Intersegment Sales	Net Sales	Earnings (loss) from investees	Earnings (loss) before Interest and Income Taxes	Depreciation, depletion & amortization	Capital expenditures
2022							
Flat-Rolled	**$ 12,522**	**$ 350**	**$ 12,872**	**$ 220**	**$ 1,951**	**$ 499**	**$ 503**
Mini Mill [a]	**2,681**	**366**	**3,047**	**—**	**481**	**158**	**1,159**
USSE	**4,243**	**13**	**4,256**	**—**	**444**	**85**	**90**
Tubular	**1,611**	**5**	**1,616**	**23**	**544**	**48**	**17**
Total reportable segments	**21,057**	**734**	**21,791**	**243**	**3,420**	**790**	**1,769**
Other	**8**	**1**	**9**	**—**	**22**	**1**	**—**
Reconciling Items and Eliminations	**—**	**(735)**	**(735)**	**—**	**(282)**	**—**	**—**
Total	**$ 21,065**	**$ —**	**$ 21,065**	**$ 243**	**$ 3,160**	**$ 791**	**$ 1,769**
2021							
Flat-Rolled	$ 12,180	$ 178	$ 12,358	$ 150	$ 2,630	$ 491	$ 422
Mini Mill [a]	3,008	508	3,516	—	1,206	151	331
USSE	4,262	4	4,266	—	975	98	57
Tubular	789	20	809	14	1	46	51
Total reportable segments	20,239	710	20,949	164	4,812	786	861
Other	36	65	101	6	(11)	5	2
Reconciling Items and Eliminations	—	(775)	(775)	—	145	—	—
Total	$ 20,275	$ —	$ 20,275	$ 170	$ 4,946	$ 791	$ 863
2020							
Flat-Rolled	$ 7,071	$ 208	$ 7,279	$ (9)	$ (596)	$ 496	$ 484
USSE	1,967	3	1,970	—	9	97	79
Tubular	639	7	646	4	(179)	39	159
Total reportable segments	9,677	218	9,895	(5)	(766)	632	722
Other	64	98	162	(94)	(39)	11	3
Reconciling Items and Eliminations	—	(316)	(316)	(18)	(270)	—	—
Total	$ 9,741	$ —	$ 9,741	$ (117)	$ (1,075)	$ 643	$ 725

[a] Includes capital expenditures related to BR2 of $796 million and $144 million in 2022 and 2021, respectively.

A summary of total assets by segment is as follows:

	December 31,	
(In millions)	**2022**	**2021**
Flat-Rolled	**$ 7,936**	$ 7,337
Mini Mill [a]	**5,787**	4,715
USSE	**5,823**	6,111
Tubular	**1,140**	1,054
Total reportable segments	**$ 20,686**	$ 19,217
Other	**$ 141**	$ 88
Corporate, reconciling items, and eliminations [b]	**(1,369)**	(1,489)
Total assets	**$ 19,458**	$ 17,816

[a] Includes assets related to BR2 of $1.4 billion and $0.3 billion in 2022 and 2021, respectively.
[b] The majority of Corporate, reconciling items, and eliminations total assets is comprised of cash and the elimination of intersegment amounts.

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The detail of reconciling items to consolidated earnings (loss) before interest and income taxes is as follows:

(In millions)	2022	2021	2020
Items not allocated to segments:			
Restructuring and other charges (Note 25)	**$ (48)**	$ (128)	$ (138)
Asset impairment charges	**(163)**	(273)	(287)
United Steelworkers labor agreement signing bonus and related costs	**(64)**	—	—
Gains on assets sold & previously held investments	**6**	118	170
Gain on sale of Transtar (Note 5)	**—**	506	—
Environmental remediation charges	**—**	(43)	—
Other charges, net	**(13)**	(35)	(15)
Total reconciling items	**$ (282)**	$ 145	$ (270)

Geographic Area:
The information below summarizes external sales, property, plant and equipment and equity method investments based on the location of the operating segment to which they relate.

(In millions)	Year	External Sales	Assets
North America	**2022**	**$ 16,822**	**$ 8,459** [(a)]
	2021	16,013	7,034 [(a)]
	2020	7,774	5,590 [(a)]
Europe	**2022**	**4,243**	**843**
	2021	4,262	880
	2020	1,967	993
Total	**2022**	**21,065**	**9,302**
	2021	20,275	7,914
	2020	9,741	6,583

[(a)] Assets with a book value of $8,459 million, $7,034 million and $5,590 million were located in the United States at December 31, 2022, 2021 and 2020, respectively.

5. Acquisitions and Dispositions

Big River Steel Acquisition
On January 15, 2021, U. S. Steel purchased the remaining equity interest in Big River Steel for approximately $625 million in cash net of $36 million and $62 million in cash and restricted cash received, respectively, and the assumption of liabilities of approximately $50 million. There were acquisition related costs of approximately $9 million during the twelve months ended December 31, 2021.

Prior to the closing of the acquisition on January 15, 2021, U. S. Steel accounted for its 49.9% equity interest in Big River Steel under the equity method as control and risk of loss were shared among the joint venture members. Using step acquisition accounting the Company increased the value of its previously held equity investment to its fair value of $770 million which resulted in a gain of approximately $111 million. The fair value of the previously held equity investment was determined using Level 3 valuation techniques, including the significant factors and assumptions used to value Big River Steel disclosed below. The gain was recorded in gain on equity investee transactions in the Consolidated Statement of Operations.

The acquisition has been accounted for in accordance with ASC 805, *Business combinations*. There were step-ups to fair value of approximately $308 million, $194 million and $24 million for property, plant and equipment, debt and inventory, respectively. An intangible asset for customer relationships and goodwill of approximately $413 million and $916 million were also recorded, respectively. Goodwill represents the excess of purchase price over the fair market value of the net assets. Goodwill is primarily attributable to Big River Steel's operational abilities, workforce and the anticipated benefits from their recent expansion and is expected to be tax deductible. The inventory step-up was fully amortized as of March 31, 2021, the intangible asset will be amortized over a 22-year period, and the debt step-up will be amortized over the contractual life of the underlying debt.

The value of Big River Steel was determined using Level 3 valuation techniques. Level 3 valuation techniques include inputs to the valuation methodology that are considered unobservable and significant to the fair value measurement. A significant factor in determining the equity value was the discounted forecasted cash flows of Big River Steel. Forecasted cash flows are primarily impacted by the forecasted market price of steel and metallic inputs as well as the expected timing of significant capital expenditures. The model utilized a risk adjusted discount rate of 11.0% and a terminal growth rate of 2%.

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The following table presents the allocation of the aggregate purchase price based on estimated fair values:

		(in millions)
Assets Acquired:		
Receivables	$	166
Receivables with U. S. Steel [1]		99
Inventories		184
Other current assets		16
Property, plant and equipment		2,188
Intangibles		413
Goodwill		916
Other noncurrent assets		19
Total Assets Acquired	$	4,001
Liabilities Assumed:		
Accounts payable and accrued liabilities	$	224
Payroll and benefits payable		27
Accrued taxes		9
Accrued interest		33
Short-term debt and current maturities of long-term debt		29
Long-term debt		1,997
Deferred income tax liabilities		26
Deferred credits and other long-term liabilities		211
Total Liabilities Assumed	$	2,556
Fair value of previously held investment in Big River Steel	$	770
Purchase price, including assumed liabilities and net of cash acquired		675
Difference in assets acquired and liabilities assumed	$	1,445

[1] The transaction to purchase Big River Steel included receivables for payments made by Big River Steel on behalf of U. S. Steel for retention bonuses of $22 million that impacted the previously held equity investment and for U. S. Steel liabilities assumed in the purchase of approximately $50 million. In addition, there were assumed receivables of approximately $27 million for steel substrate sales from Big River Steel to U. S. Steel. The receivables with U. S. Steel eliminate in consolidation with offsetting intercompany payables from U. S. Steel.

The following unaudited pro forma information for U. S. Steel includes the results of the Big River Steel acquisition as if it had been consummated on January 1, 2020. The unaudited pro forma information is based on historical information and is adjusted for amortization of the intangible asset, property, plant and equipment and debt fair value step-ups discussed above. Non-recurring acquisition related items included in the 2020 period include $111 million for the gain on previously held equity investment, $9 million in acquisition related costs and $24 million in inventory step-up amortization related to the purchase of the remaining interest in Big River Steel. In addition, costs for non-recurring retention bonuses of $44 million that occurred in January 2021 prior to the purchase of the remaining equity interest are included in the 2020 period. The pro forma information does not include any anticipated cost savings or other effects of the integration of Big River Steel. Accordingly, the unaudited pro forma information does not necessarily reflect the actual results that would have occurred, nor is it necessarily indicative of future results of operations. Pro forma adjustments were not tax-effected in 2020 as U. S. Steel had a full valuation allowance on its domestic deferred tax assets.

	Years Ended December 31,	
(in millions)	**2021**	**2020**
Net sales	$ 20,347	$ 10,694
Net earnings (loss)	$ 4,103	$ (1,260)

Transtar Disposition

On July 28, 2021, U. S. Steel completed the sale of 100 percent of its equity interests in its wholly-owned short-line railroad, Transtar, LLC (Transtar) to an affiliate of Fortress Transportation and Infrastructure Investors, LLC. The Company received net cash proceeds of $627 million, subject to certain customary adjustments as set forth in the Membership Interest Purchase Agreement, and recognized a pretax gain of approximately $506 million in 2021. In connection with the closing of the transaction, the Company entered into certain ancillary agreements including a railway services agreement, providing for continued rail services for its Gary Works and Mon Valley Works facilities, and a transition services agreement. Because Transtar does not represent a significant component of U. S. Steel's business and does not

constitute a reportable business segment, its results through the date of disposition are reported in the Other category. See Note 4 for further details.

Other Transactions
As of December 31, 2022, the Company intends to pursue the disposition of certain assets related to a component of its flat-roll business. As a result, the Company has recognized a total of $119 million in restructuring-related charges, $89 million during the fourth quarter 2021 and $30 million during the year ended December 31, 2022. These charges are expected to be paid out on a long-term basis.

USS-UPI, LLC (UPI) (formerly known as USS-POSCO Industries)
On February 29, 2020, U. S. Steel purchased the remaining 50% ownership interest in USS-POSCO Industries, (now USS-UPI, LLC), (UPI) for $3 million, net of cash received of $2 million. There was an assumption of accounts payable owed to U. S. Steel for prior sales of steel substrate of $135 million associated with the purchase that was reflected as a reduction in receivables from related parties on the Company's Consolidated Balance Sheet as of December 31, 2020.

Using step acquisition accounting U. S. Steel increased the value of the Company's previously held equity investment to its fair value of $5 million which resulted in a gain of approximately $25 million. The gain was recorded in gain on equity investee transactions in the Consolidated Statement of Operations.

Receivables of $44 million, inventories of $96 million, accounts payable and accrued liabilities of $19 million, current portion of long-term debt of $55 million and payroll and employee benefits liabilities of $78 million were recorded with the acquisition. Property, plant and equipment of $97 million which included a fair value step-up of $47 million and an intangible asset of $54 million were also recorded on the Company's Consolidated Balance Sheet. The intangible asset, which will be amortized over ten years, arises from a land lease contract, under which a certain portion of payment owed to UPI is realized in the form of deductions from electricity costs.

6. Revenue

Revenue is generated primarily from contracts to produce, ship and deliver steel products, and to a lesser extent, raw materials sales such as iron ore pellets and coke by-products and real estate sales. Generally, U. S. Steel's performance obligations are satisfied and revenue is recognized when title transfers to our customer for product shipped or services are provided. Revenues are recorded net of any sales incentives. Shipping and other transportation costs charged to customers are treated as fulfillment activities and are recorded in both revenue and cost of sales at the time control is transferred to the customer. Costs related to obtaining sales contracts are incidental and are expensed when incurred. Because customers are invoiced at the time title transfers and U. S. Steel's right to consideration is unconditional at that time, U. S. Steel does not maintain contract asset balances. Additionally, U. S. Steel does not maintain contract liability balances, as performance obligations are satisfied prior to customer payment for product. U. S. Steel offers industry standard payment terms.

The following tables disaggregates our revenue by product for each of our reportable business segments for the years ended December 31, 2022, 2021 and 2020, respectively (Net Sales by Product, in millions, excluding intersegment sales):

Year Ended December 31, 2022	Flat-Rolled	Mini Mill	USSE	Tubular	Other	Total
Semi-finished	$ 193	$ —	$ 103	$ —	$ —	$ 296
Hot-rolled sheets	2,338	1,570	1,919	—	—	5,827
Cold-rolled sheets	3,898	356	385	—	—	4,639
Coated sheets	4,461	745	1,622	—	—	6,828
Tubular products	—	—	68	1,594	—	1,662
All other [(a)]	1,632	10	146	17	8	1,813
Total	$ 12,522	$ 2,681	$ 4,243	$ 1,611	$ 8	$ 21,065

[(a)] Consists primarily of sales of raw materials and coke making by-products

Year Ended December 31, 2021	Flat-Rolled	Mini Mill [(b)]	USSE	Tubular	Other	Total
Semi-finished	$ 12	$ —	$ 126	$ —	$ —	$ 138
Hot-rolled sheets	2,592	1,744	2,149	—	—	6,485
Cold-rolled sheets	3,785	526	448	—	—	4,759
Coated sheets	4,408	732	1,376	—	—	6,516
Tubular products	—	—	58	781	—	839
All other [(a)]	1,383	6	105	8	36	1,538
Total	$ 12,180	$ 3,008	$ 4,262	$ 789	$ 36	$ 20,275

[(a)] Consists primarily of sales of raw materials and coke making by-products.

[(b)] Mini Mill segment added after January 15, 2021 with the purchase of the remaining equity interest in Big River Steel.

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Year Ended December 31, 2020	Flat-Rolled	USSE	Tubular	Other	Total
Semi-finished	$ 94	$ 2	$ —	$ —	$ 96
Hot-rolled sheets	1,273	793	—	—	2,066
Cold-rolled sheets	2,102	164	—	—	2,266
Coated sheets	2,990	904	—	—	3,894
Tubular products	—	40	621	—	661
All other [b]	612	64	18	64	758
Total	$ 7,071	$ 1,967	$ 639	$ 64	$ 9,741

[a] Consists primarily of sales of raw materials and coke making by-products.

7. Net Interest and Other Financial Costs

(In millions)	2022	2021	2020
Interest income:			
Interest income	**$ (44)**	$ (4)	$ (7)
Interest expense and other financial costs:			
Interest incurred	**218**	342	306
Less interest capitalized	**59**	29	26
Total interest expense	**159**	313	280
Loss on debt extinguishment [a]	**—**	292	—
Net periodic benefit (income) costs (other than service cost)	**(246)**	(45)	(25)
Foreign currency net loss (gain) [b]	**11**	17	(15)
Financial costs on:			
Amended Credit Agreement	**5**	6	3
USSK Credit Facility	**3**	4	2
Other [c]	**4**	5	(21)
Amortization of discounts and deferred financing costs	**9**	14	15
Total other financial costs (benefits)	**32**	46	(16)
Net interest and other financial (benefits) costs	**$ (99)**	$ 602	$ 232

[a] Represents a net pretax charge of $292 million during 2021 related to the repayments of the Export-Import Credit Agreement, 2025 Senior Secured Notes, 2025 Senior Notes, 2026 Senior Notes, 2029 Senior Secured Notes, Credit Facility Agreement and Environmental Revenue Bonds.

[b] The functional currency for USSE is the euro. Foreign currency net loss (gain) is a result of transactions denominated in currencies other than the euro.

[c] 2020 includes a gain of $39 million for the change in fair value of certain call and put options related to U. S. Steel's previously held 49.9% ownership interest in Big River Steel.

8. Earnings (Loss) and Dividends Per Common Share

Earnings (Loss) per Share Attributable to United States Steel Corporation Stockholders
Basic earnings (loss) per common share is based on the weighted average number of common shares outstanding during the period.

Diluted earnings (loss) per common share assumes the exercise of stock options, the vesting of restricted stock units and performance awards, provided in each case the effect is dilutive. In 2022, the "if-converted" method is used to calculate the dilutive effect of the Senior Convertible Notes due in 2026 as a result of ASU 2020-06. In 2021 and 2020, the "treasury stock" method was used to calculate the dilutive effect of the Senior Convertible Notes due in 2026 (due to our intent and policy, among other factors, to settle the principal amount of the 2026 Senior Convertible Notes in cash upon conversion).

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The computations for basic and diluted earnings (loss) per common share from continuing operations are as follows:

(Dollars in millions, except per share amounts)	2022	2021	2020
Net earnings (loss) attributable to United States Steel Corporation stockholders			
Basic	**$ 2,524**	$ 4,174	$ (1,165)
Interest expense on Senior Convertible Notes, net of tax	**13**	—	—
Diluted	**$ 2,537**	$ 4,174	$ (1,165)
Weighted-average shares outstanding (in thousands):			
Basic	**246,986**	264,667	196,721
Effect of Senior Convertible notes	**26,194**	11,126	—
Effect of stock options, restricted stock units and performance awards	**3,783**	4,651	—
Diluted	**276,963**	280,444	196,721
Net earnings (loss) per share attributable to United States Steel Corporation stockholders:			
Basic	**$ 10.22**	$ 15.77	$ (5.92)
Diluted	**$ 9.16**	$ 14.88	$ (5.92)

The following table summarizes the securities that were antidilutive, and therefore, were not included in the computation of diluted earnings (loss) per common share:

(In thousands)	2022	2021	2020
Securities granted under the 2016 Omnibus Incentive Compensation Plan, as amended and restated	**960**	1,185	6,780

Dividends Paid per Share
Quarterly dividends on common stock were five cents per share for each quarter in 2022. Quarterly dividends on common stock were one cent per share in the first, second and third quarters and five cents per share in the fourth quarter of 2021. Quarterly dividends on common stock were one cent per share for each quarter in 2020.

9. Cash, Cash Equivalents and Restricted Cash

The following table provides a reconciliation of cash, cash equivalents and restricted cash reported within U. S. Steel's Consolidated Balance Sheets that sum to the total of the same amounts shown in the Consolidated Statement of Cash Flows:

	December 31,		
(In millions)	2022	2021	2020
Cash and cash equivalents	**$ 3,504**	$ 2,522	$ 1,985
Restricted cash in other current assets	**4**	2	3
Long-term restricted cash	**31**	76	130
Total cash, cash equivalents and restricted cash	**$ 3,539**	$ 2,600	$ 2,118

Amounts included in restricted cash represent cash balances which are legally or contractually restricted, primarily for electric arc furnace construction, environmental liabilities and other capital projects and insurance purposes.

10. Inventories

(In millions)	December 31, 2022	December 31, 2021
Raw materials	**$ 1,098**	$ 713
Semi-finished products	**811**	1,056
Finished products	**398**	388
Supplies and sundry items	**52**	53
Total	**$ 2,359**	$ 2,210

Current acquisition costs for LIFO inventories were estimated to exceed the above inventory values at December 31 by $1,154 million in 2022 and $896 million in 2021. As a result of the liquidation of LIFO inventories, cost of sales decreased and earnings before interest and income taxes increased by $44 million, $11 million and $5 million in 2022, 2021 and 2020, respectively.

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11. Income Taxes

Components of earnings (loss) before income taxes:

(In millions)	2022	2021	2020
United States	**$ 2,847**	$ 3,400	$ (1,303)
Foreign	**412**	944	(4)
Earnings (loss) before income taxes	**$ 3,259**	$ 4,344	$ (1,307)

At the end of both 2022 and 2021, U. S. Steel does not have any undistributed foreign earnings and profits for which U.S. deferred taxes have not been provided.

Income tax provision (benefit):

	2022			2021			2020		
(In millions)	Current	Deferred	Total	Current	Deferred	Total	Current	Deferred	Total
Federal	**$ 101**	**$ 451**	**$ 552**	$ (7)	$ 8	$ 1	$ (10)	$ (95)	$ (105)
State and local	**54**	**43**	**97**	50	(71)	(21)	(3)	(24)	(27)
Foreign	**79**	**7**	**86**	179	11	190	1	(11)	(10)
Total	**$ 234**	**$ 501**	**$ 735**	$ 222	$ (52)	$ 170	$ (12)	$ (130)	$ (142)

A reconciliation of the federal statutory tax rate of 21 percent to total provision (benefit) follows:

(In millions)	2022	2021	2020
Statutory rate applied to earnings (loss) before income taxes	**$ 684**	$ 912	$ (275)
Valuation allowance	**(38)**	(633)	367
Tax accounting benefit related to increase in OCI	**—**	—	(138)
Excess percentage depletion	**(48)**	(66)	(31)
Capital loss generated	**—**	(139)	—
State and local income taxes after federal income tax effects	**97**	83	(47)
Effects of foreign operations	**85**	191	(10)
U.S. impact of foreign operations	**6**	4	1
Impact of tax credits	**(83)**	(173)	(18)
Adjustment of prior years' federal income taxes	**40**	(5)	12
Other	**(8)**	(4)	(3)
Total provision (benefit)	**$ 735**	$ 170	$ (142)

In March 2022, the Company and the Arkansas Economic Development Commission entered into the Recycling Tax Credit Incentive Agreement, whereby the Company may earn state income tax credits in an amount equal to 30 percent of the cost of waste reduction, reuse, or recycling equipment, subject to meeting the requirements of the Arkansas Code Ann. Section 26-51-506, for BR2 which is under construction in Osceola, Arkansas. Documentation supporting the Company's investment in qualifying equipment must be submitted as part of an application for certification expected to be completed on or before 2025. In March 2022, the Company received a lump-sum payment of approximately $82 million as proceeds from the sale of a portion of expected future tax credits to be earned by the Company (see Note 26 for additional information). The Company estimates that it could earn tax credits in excess of $700 million, exclusive of the amount sold in March 2022, which the Company will recognize in the year the assets are placed into service and meet the requirements of Arkansas Code Ann. Section 26-51-506. Any unused tax credit that cannot be claimed in a tax year may be carried forward indefinitely by the Company and applied to its future state tax liability.

On August 16, 2022, H.R. 5376 (commonly called the Inflation Reduction Act of 2022) was signed into law, which, among other things, implemented a CAMT of 15 percent on book income of certain large corporations, a one percent excise tax on net stock repurchases and several tax incentives to promote clean energy. The provision pertaining to an excise tax on corporate stock repurchases imposes a nondeductible one percent excise tax on a publicly traded corporation for the net value of certain stock that the corporation repurchases. The value of the repurchases subject to the tax is reduced by the value of any stock issued by the corporation during the tax year, including stock issued or provided to the employees. The CAMT imposes a minimum tax on net income adjusted for certain items prescribed by the legislation. Both the CAMT and the excise tax provisions of this legislation are effective for tax years beginning after December 31, 2022. Although management is currently assessing the impact of the law change and awaiting guidance from the Department of Treasury,

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the Company anticipates being subject to the new CAMT but does not believe that it will have a material impact on its Consolidated Financial Statements.

Included in the 2021 provision is a benefit of $715 million related to the reversal of a portion of the valuation allowance recorded against the Company's net domestic deferred tax asset, partially offset by the addition of a valuation allowance of $82 million, the majority of which relates to an unused capital loss carryforward.

The 2020 tax benefit includes a $138 million benefit related to recording a loss from continuing operations and income from other comprehensive income categories and expense of $13 million for an updated estimate to tax reserves related to an unrecognized tax benefit. Due to the full valuation allowance on our domestic deferred tax assets, the tax benefit in 2020 does not reflect any additional tax benefit for domestic pretax losses.

Deferred taxes
Deferred tax assets and liabilities resulted from the following:

	December 31,	
(In millions)	**2022**	**2021**
Deferred tax assets:		
Federal tax loss carryforwards (no expiration)	**$ 1**	$ 20
Federal tax loss carryforwards (expiring in 2037)	**1**	—
Federal capital loss carryforwards (expiring in 2026)	**69**	66
State tax credit carryforwards (expiring in 2024 through 2031)	**10**	11
State tax loss carryforwards (expiring in 2023 through 2043)	**77**	150
State capital loss carryforwards (expiring in 2026 through 2036)	**28**	16
General business credit carryforwards	**—**	94
Foreign tax loss and credit carryforwards (expiring in 2023 through 2031)	**67**	244
Contingencies and accrued liabilities	**64**	78
Operating lease liabilities	**37**	47
Capitalized research and development	**35**	15
Receivables, payables and debt	**13**	33
Inventory	**14**	—
Other temporary differences	**53**	34
Valuation allowance	**(119)**	(162)
Total deferred tax assets	**$ 350**	$ 646
Deferred tax liabilities:		
Property, plant and equipment	**$ 589**	$ 379
Operating right-of-use assets	**35**	45
Investments in subsidiaries and equity investees	**141**	121
Inventory	**—**	112
Employee benefits	**31**	70
Receivables, payables and debt	**—**	6
Other temporary differences	**—**	3
Total deferred tax liabilities	**$ 796**	$ 736
Net deferred tax (liability) asset	**$ (446)**	$ (90)

U. S. Steel recognizes deferred tax assets and liabilities for the estimated future tax consequences attributable to differences between the financial statement carrying amounts of existing assets and liabilities and their respective tax basis. The realization of deferred tax assets is assessed quarterly based on several interrelated factors. These factors include U. S. Steel's expectation to generate sufficient future taxable income and the projected time period over which these deferred tax assets will be realized.

Each quarter U. S. Steel analyzes the likelihood that our deferred tax assets will be realized. A valuation allowance is recorded if, based on the weight of all available positive and negative evidence, it is more likely than not that some portion, or all, of a deferred tax asset will not be realized.

At June 30, 2021, U. S. Steel determined, based upon weighing all positive and negative evidence, that a full valuation allowance for the domestic deferred tax assets was no longer required. Accordingly, we reversed all of the domestic valuation allowance except for a portion of the domestic valuation allowance related to certain state net operating losses and state tax credits.

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During the year ended December 31, 2021, U. S. Steel realized a non-cash net benefit of $715 million related to the valuation allowance release, which was partially offset by the addition of a valuation allowance of $82 million, the majority of which relates to an unused capital loss generated in the fourth quarter of 2021.

At December 31, 2022, the net domestic deferred tax liability was $437 million, net of an established valuation allowance of $116 million. At December 31, 2021, the net domestic deferred tax liability was $88 million, net of an established valuation allowance of $159 million.

At December 31, 2022, the net foreign deferred tax liability was $9 million, net of an established valuation allowance of $3 million. At December 31, 2021, the net foreign deferred tax liability was $2 million, net of an established valuation allowance of $3 million. The net foreign deferred tax asset will fluctuate as the value of the U.S. dollar changes with respect to the euro.

U. S. Steel will continue to monitor the realizability of its deferred tax assets on a quarterly basis. In the future, if we determine that realization is more likely than not for a deferred tax asset with a valuation allowance, the related valuation allowance will be reduced, and we will record a non-cash benefit to earnings.

Unrecognized tax benefits
Unrecognized tax benefits are the differences between a tax position taken, or expected to be taken, in a tax return and the benefit recognized for accounting purposes pursuant to the guidance in ASC Topic 740 on income taxes. The total amount of unrecognized tax benefits was $2 million, $3 million and $16 million as of December 31, 2022, 2021 and 2020, respectively.

The total amount of unrecognized tax benefits that, if recognized, would affect the effective tax rate was $2 million as of both December 31, 2022 and 2021.

U. S. Steel records interest related to uncertain tax positions as a part of net interest and other financial costs in the Consolidated Statements of Operations. Any penalties are recognized as part of selling, general and administrative expenses. U. S. Steel had accrued liabilities of $2 million for interest and penalties related to uncertain tax positions as of both December 31, 2022, and 2021.

A tabular reconciliation of unrecognized tax benefits follows:

(In millions)	2022	2021	2020
Unrecognized tax benefits, beginning of year	**$ 3**	$ 16	$ 3
Increases – tax positions taken in prior years	**—**	—	13
Decreases – tax positions taken in prior years	**—**	(13)	—
Settlements	**—**	—	—
Lapse of statute of limitations	**(1)**	—	—
Unrecognized tax benefits, end of year	**$ 2**	$ 3	$ 16

Tax years subject to examination
Below is a summary of the tax years open to examination by major tax jurisdiction:

U.S. Federal – 2017 and forward
U.S. States – 2015 and forward
Slovakia – 2011 and forward

Status of Internal Revenue Service (IRS) examinations
The IRS audit of U. S. Steel's 2017-2018 federal consolidated tax returns began in 2020 and is ongoing. The IRS completed its audit of the Company's 2014-2016 tax returns in 2020.

12. Investments, Long-Term Receivables and Equity Investee Transactions

	December 31,	
(In millions)	2022	2021
Equity method investments	**$ 810**	$ 660
Receivables due after one year, less allowance of $4 in both periods	**22**	31
Other	**8**	3
Total	**$ 840**	$ 694

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Summarized financial information of all investees accounted for by the equity method of accounting is as follows (amounts represent 100% of investee financial information):

(In millions)	2022	2021	2020
Income data – year ended December 31:			
Net Sales	**$ 3,222**	$ 2,229	$ 2,485
Operating income	**492**	376	12
Net earnings	**462**	346	(124)
Balance sheet date – December 31:			
Current Assets	**$ 1,085**	$ 744	$ 960
Noncurrent Assets	**974**	1,084	3,101
Current liabilities	**314**	293	419
Noncurrent Liabilities	**513**	529	3,063

U. S. Steel's portion of the income (loss) from investees reflected on the Consolidated Statements of Operations was $243 million, $170 million and $(117) million for the years ended December 31, 2022, 2021 and 2020, respectively.

All of our significant investees are located in the U.S. Investees accounted for using the equity method include:

Investee	December 31, 2022 Interest
Chrome Deposit Corporation	50 %
Daniel Ross Bridge, LLC	50 %
Double G Coatings Company, Inc.	50 %
Hibbing Development Company	24.1 %
Hibbing Taconite Company[(a)]	14.7 %
Patriot Premium Threading Services, LLC	50 %
PRO-TEC Coating Company, LLC	50 %
Strategic Investment Fund Partners II[(b)]	5.2 %
Worthington Specialty Processing	49.0 %

[(a)] Hibbing Taconite Company (Hibbing) is an unincorporated joint venture that is owned, in part, by Hibbing Development Company (HDC), which is accounted for using the equity method. Through HDC we are able to influence the activities of HTC, and as such, its activities are accounted for using the equity method.

[(b)] Strategic Investment Fund Partners II is a limited partnership and in accordance with ASC Topic 323, the financial activities are accounted for using the equity method.

In 2020, we recognized pre-tax gains on equity investee transactions of approximately $6 million on the sale of our 49 percent ownership interest in Feralloy Processing Company and $25 million for the step-up to fair value of our previously held investment in UPI.

In 2022, we recognized pre-tax gains on equity investee transactions of approximately $6 million from Worthington Specialty Processing pertaining to the sale of the joint venture's facilities and subsequent distribution to the investors. The joint venture is expected to be dissolved in 2023 and is expected to result in an immaterial distribution to the Company.

Dividends or partnership distributions received from equity investees were $28 million in 2022 and $2 million in 2021, respectively. There were none received in 2020.

U. S. Steel evaluates impairment of its equity method investments whenever circumstances indicate that a decline in value below carrying value is other than temporary. Under these circumstances, we would adjust the investment down to its estimated fair value, which then becomes its new carrying value.

We supply substrate to certain of our equity method investees and from time to time will extend the payment terms for their trade receivables. For discussion of transactions and related receivable and payable balances between U. S. Steel and its investees, see Note 23.

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13. Property, Plant and Equipment

(In millions)	Useful Lives	December 31, 2022	2021
Land and depletable property	—	**$ 210**	$ 213
Buildings	35-40 years	**1,530**	1,558
Machinery and equipment			
Steel producing	2-30 years	**15,900**	15,968
Other	5-30 years	**95**	94
Information technology	5-6 years	**805**	798
Assets under finance lease	5-15 years	**212**	160
Construction in process	—	**2,470**	885
Total		**21,222**	19,676
Less accumulated depreciation and depletion		**12,730**	12,422
Net		**$ 8,492**	$ 7,254

Amounts in accumulated depreciation and depletion for assets acquired under finance leases were $86 million and $59 million at December 31, 2022 and 2021, respectively.

14. Goodwill and Intangible Assets

Intangible assets are being amortized on a straight-line basis over their estimated useful lives and are detailed below:

		As of December 31, 2022			As of December 31, 2021		
(In millions)	Useful Lives	Gross Carrying Amount	Accumulated Amortization	Net Amount	Gross Carrying Amount	Accumulated Amortization	Net Amount
Customer relationships	22 Years	**$ 413**	**$ 37**	**$ 376**	$ 413	$ 18	$ 395
Patents	5-15 Years	**17**	**12**	**5**	17	11	6
Energy Contract	2 Years	**54**	**32**	**22**	54	11	43
Total amortizable intangible assets		**$ 484**	**$ 81**	**$ 403**	$ 484	$ 40	$ 444

Amortization expense was $42 million and $26 million for years ended December 31, 2022 and December 31, 2021, respectively. We expect approximately $120 million in total amortization expense from 2023 through 2027 and approximately $283 million in remaining amortization expense thereafter.

The carrying amount of acquired water rights with indefinite lives as of December 31, 2022 and December 31, 2021 totaled $75 million.

Below is a summary of goodwill by segment for the twelve months ended December 31, 2022:

(In millions)	Flat-Rolled	Mini Mill	USSE	Tubular	Total
Balance at December 31, 2021	$ —	$ 916	$ 4	$ —	$ 920
Additions	**—**	**—**	**—**	**—**	**—**
Balance at December 31, 2022	**$ —**	**$ 916**	**$ 4**	**$ —**	**$ 920**

15. Stock-Based Compensation Plans

U. S. Steel has outstanding stock-based compensation awards that were granted by the Compensation & Organization Committee of the Board of Directors (the Committee), or its designee, under the 2005 Stock Incentive Plan (the 2005 Plan) and the 2016 Omnibus Incentive Compensation Plan, as amended and restated (the Omnibus Plan) (collectively the Plans). On April 26, 2016, the Company's stockholders approved the Omnibus Plan and authorized the Company to issue up to 7,200,000 shares of U. S. Steel common stock under the Omnibus Plan. The Company's stockholders authorized the issuance of an additional 6,300,000 shares under the Omnibus Plan on April 25, 2017, an additional 4,700,000 shares under the Omnibus Plan on April 28, 2020 and an additional 14,500,000 shares under the Omnibus Plan on April 27, 2021. While awards that were previously granted under the 2005 Plan remain outstanding, all future awards will be granted under the Omnibus Plan. As of December 31, 2022, there were 9,080,478 shares available for future grants under the Omnibus Plan.

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Generally, a share issued under the Omnibus Plan pursuant to an award other than a stock option will reduce the number of shares available under the Stock Plan by 1.78 shares. Shares related to awards under either plan (i) that are forfeited, (ii) that terminate without shares having been issued or (iii) for which payment is made in cash or property other than shares, are again available for awards under the Omnibus Plan. Shares delivered to U. S. Steel or withheld for purposes of satisfying the exercise price or tax withholding obligations are not available for future awards. The purpose of the Plans is to attract, reward and retain employees and non-employee directors who create long-term value for our stockholders by delivering on objectives that support our long-term strategy. The Committee administers the Plans, and under the Omnibus Plan may make grants of stock options, restricted stock units (RSUs), performance awards, and other stock-based awards.

The following table summarizes the total stock-based compensation awards granted during the years 2022, 2021 and 2020:

	Stock Options	Restricted Stock Units	TSR Performance Awards	ROCE Performance Awards [a]	Performance-Based Restricted Stock Units
2022	**—**	**1,249,830**	**236,520**	**408,870**	**83,951**
2021	171,000	1,891,481	306,930	485,900	676,954
2020	—	2,640,690	671,390	—	—

[a] The ROCE awards granted in 2020 are not shown in the table because they were granted in cash.

Stock-based compensation expense
The following table summarizes the total compensation expense recognized for stock-based compensation awards:

(In millions, except per share amounts)	Year Ended December 31, 2022	Year Ended December 31, 2021	Year Ended December 31, 2020
Stock-based compensation expense recognized:			
Cost of sales	**$ 15**	$ 14	$ 8
Selling, general and administrative expenses	**42**	41	18
Total	**57**	55	26
Related deferred income tax benefit [a]	**14**	14	—
Decrease in net income	**43**	41	26
Decrease in basic earnings per share	**0.18**	0.16	0.13
Decrease in diluted earnings per share	**0.16**	0.15	0.13

[a] Amounts for 2020 do not reflect a tax benefit as a result of a full valuation allowance on our domestic deferred tax assets.

As of December 31, 2022, total future compensation cost related to nonvested stock-based compensation arrangements was $45 million and the average period over which this cost is expected to be recognized is approximately 16 months.

Stock options
Compensation expense for stock options is recorded over the vesting period based on the fair value on the date of grant, as calculated by U. S. Steel using the Black-Scholes model and the assumptions listed below. Awards generally vest ratably over a three-year service period and have a term of ten years. Stock options are generally issued at the average market price of the underlying stock on the date of the grant. Upon exercise of stock options, shares of U. S. Steel stock are issued from treasury stock or from authorized, but unissued common stock. There were 171,000 performance-based stock options granted in 2021. There were no stock options granted in 2022 and 2020.

The expected annual dividends per share are based on the latest annualized dividend rate at the date of grant; the expected life in years is determined primarily from historical stock option exercise data; the expected volatility is based on the historical volatility of U. S. Steel stock; and the risk-free interest rate is based on the U.S. Treasury strip rate for the expected life of the option.

The 171,000 performance-based stock options granted in December 2021 do not become vested and exercisable until the Company's 20-trading day average closing stock price meets or exceeds the following stock price hurdles during the seven-year period beginning on the grant date, as follows:

20-trading day Average Closing Stock Price Achievement During 7-Year Period Beginning on Grant Date [a]	Percentage of Performance-Based Stock Options Exercisable
$ 35.00	33.33 %
$ 45.00	33.33 %
$ 55.00	33.34 %

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[a] The $35.00 tranche vested in April 2022.

The following table shows a summary of the status and activity of stock options for the year ended December 31, 2022:

	Shares	Weighted-Average Exercise Price (per share)	Weighted-Average Remaining Contractual Term (in years)	Aggregate Intrinsic Value (in millions)
Outstanding at January 1, 2022	1,659,764	$ 25.31		
Granted	—	$ —		
Exercised	(408,760)	$ 20.29		
Forfeited or expired	(40,789)	$ 29.08		
Outstanding at December 31, 2022	1,210,215	$ 26.88	2.97	$ 3
Exercisable at December 31, 2022	1,096,215	$ 27.24	2.65	$ 2
Exercisable and expected to vest at December 31, 2022	1,210,215	$ 26.88	2.97	$ 3

The aggregate intrinsic value in the table above represents the total pretax intrinsic value (difference between our closing stock price on the last trading day of 2022 and the exercise price, multiplied by the number of in-the-money options). Intrinsic value changes are a function of the fair market value of our stock.

The total intrinsic value of stock options exercised (i.e., the difference between the market price at exercise and the price paid by the employee to exercise the option) was $5 million and $3 million during the years ended December 31, 2022 and December 31, 2021, respectively, and immaterial during the year ended December 31, 2020. The total amount of cash received by U. S. Steel from the exercise of options was $8 million and $7 million during the years ended December 31, 2022 and December 31, 2021, respectively. The related net tax benefit realized from the exercise of these options was immaterial in 2022 and 2021.

Stock awards
Compensation expense for nonvested stock awards is recorded over the vesting period based on the fair value at the date of grant.

RSUs awarded as part of annual grants generally vest ratably over three years. Their fair value is the average market price of the underlying common stock on the date of grant. RSUs granted in connection with new-hire or retention awards generally cliff vest three years from the date of the grant.

Total shareholder return (TSR) performance awards may vest at varying levels at the end of a three-year performance period if U. S. Steel's total shareholder return compared to the total shareholder return of a peer group of companies meets performance criteria during the three-year performance period. TSR is calculated as follows: 20 percent for each year in the three-year performance period and 40 percent for the full three-year period. TSR performance awards may vest and payout 50 percent at the threshold level, 100 percent at the target level and 200 percent at the maximum level for payouts. Payment for performance in between the threshold percentages will be interpolated. The fair value of the performance awards is calculated using a Monte-Carlo simulation.

Performance awards based on the return on capital employed (ROCE) metric were granted in equity in 2022 and 2021, and in cash in 2020. ROCE awards granted will be measured on a weighted average basis of the Company's consolidated worldwide earnings (loss) before interest and income taxes, as adjusted, divided by consolidated worldwide capital employed, as adjusted, over a three year period.

For outstanding 2020 and 2021 ROCE-based equity awards, weighted average ROCE is calculated based on the ROCE achieved in the first, second and third years of the performance period, weighted at 20 percent, 30 percent and 50 percent, respectively. For outstanding 2022 ROCE-based equity awards, weighted average ROCE is calculated based on the ROCE achieved in the first, second and third years of the performance period, weighted at 20 percent for each year in the three-year performance period and 40 percent for the full three-year period. The ROCE awards will payout 50 percent at the threshold level, 100 percent at the target level and 200 percent at the maximum level. Payouts for performance in between the threshold percentages will be interpolated.

Compensation expense associated with the ROCE awards will be contingent based upon the achievement of the specified ROCE performance goals and will be adjusted on a quarterly basis to reflect the probability of achieving the ROCE metric.

ROCE performance awards may vest at the end of a three-year performance period contingent upon meeting ROCE performance goals approved by the Committee. The fair value of the ROCE performance awards is the average market price of the underlying common stock on the date of grant.

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In December 2021 and August 2022, special performance-based restricted stock unit awards (PSUs) were granted to members of the Company's executive leadership team. Shares are earned based on the achievement of certain pre-set quantitative performance criteria during the four-year performance period, January 1, 2022 through December 31, 2025. Shares may vest following the expiration of the Performance Period if the Company satisfies the performance criteria.

The Chief Executive Officer was granted PSUs that vest with the following, equally weighted, performance metrics: (i) EBITDA margin expansion, (ii) greenhouse gas emissions intensity reduction, (iii) asset portfolio optimization, (iv) leverage metrics and (v) corporate relative valuation. Other members of the executive leadership team were granted PSUs that vest with performance criteria related to: (i) on time and on budget completion of the second mini mill (30% of the grant), (ii) EBITDA margin expansion (40% of the grant) and (iii) greenhouse gas emissions intensity reduction (30% of the grant).

For the PSU awards, a payout is achievable at threshold (50% of target), target (100% of target) or maximum (200% of target) performance achievement. Payout amounts will be interpolated between the threshold, target and maximum amounts.

The following table shows a summary of the performance awards outstanding as of December 31, 2022, and their fair market value on the respective grant date:

Performance Period	Fair Value (in millions)	Minimum Shares	Target Shares	Maximum Shares
2022 - 2024	$ 17	—	641,773	1,283,546
2021 - 2023	$ 31	—	1,475,765	2,951,530
2020 - 2022	$ 5	—	641,005	1,282,010

The following table shows a summary of the status and activity of nonvested stock awards for the year ended December 31, 2022:

	Restricted Stock Units	TSR Performance Awards [a]	ROCE Performance Awards [a]	Performance-Based Restricted Stock Units [a]	Total	Weighted-Average Grant-Date Fair Value
Nonvested at January 1, 2022	3,699,689	1,121,703	915,969	676,954	6,414,315	$ 16.85
Granted	1,249,830	236,520	408,870	83,951	1,979,171	24.52
Vested	(1,547,733)	(69,508)	(881,878)	—	(2,499,119)	18.10
Performance adjustment factor [b]	—	(104,260)	440,939	—	336,679	22.26
Forfeited or expired	(76,039)	—	(7,297)	(63,420)	(146,756)	21.21
Nonvested at December 31, 2022	3,325,747	1,184,455	876,603	697,485	6,084,290	$ 19.02

[a] The number of shares shown for the performance awards is based on the target number of share awards.
[b] Consists of adjustments to vested performance awards to reflect actual performance.

The following table presents information on RSUs and performance awards granted:

	2022	2021	2020
Number of awards granted	**1,979,171**	3,361,265	3,312,080
Weighted-average grant-date fair value per share	**$ 24.52**	$ 20.24	$ 8.69

During the years ended December 31, 2022, 2021, and 2020, the total fair value of shares vested was $45 million, $29 million, and $16 million, respectively.

16. Derivative Instruments

U. S. Steel is exposed to foreign currency exchange rate risks in our European operations. USSE's revenues are primarily in euros and costs are primarily in euros and U.S. dollars. U. S. Steel uses foreign exchange forward sales contracts (foreign exchange forwards) with maturities up to 23 months to manage our currency requirements and exposure to foreign currency exchange rate fluctuations. Derivative instruments are required to be recognized at fair value in the Consolidated Balance Sheet. The USSE and Flat-Rolled segments use hedge accounting for their foreign exchange forwards. The Mini Mill segment has foreign exchange forwards for which hedge accounting has not been elected; therefore, the changes in the fair value of their foreign exchange forwards are recognized immediately in the Consolidated Statements of Operations (mark-to-market accounting).

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U. S. Steel also uses financial swaps to protect from the commodity price risk associated with purchases of natural gas, zinc, tin, electricity, and iron ore pellets (commodity purchase swaps). We elected cash flow hedge accounting for commodity purchase swaps for natural gas, zinc, tin, and iron ore pellets and use mark-to-market accounting for electricity swaps. The commodity purchase swaps where hedge accounting was elected have maturities up to 12 months. The commodity purchase swaps where hedge accounting was not elected have maturities up to 12 months.

U. S. Steel has entered into financial derivatives that are used to partially manage the sales price risk of certain hot-rolled coil sales (sales swaps) and iron ore pellet sales (sales swaps and zero cost collars). The sales swaps and the zero cost collars are all accounted for using hedge accounting. The hot-rolled coil sales swaps and the iron ore zero cost collars have reached maturity, and the iron ore sales swaps have maturities up to 13 months.

Generally, forward physical purchase contracts qualify for the normal purchase and normal sales exceptions described in ASC Topic 815 and are not subject to mark-to-market accounting. In accordance with the guidance in ASC Topic 820 on fair value measurements and disclosures, the fair value of our foreign exchange forwards, commodity purchase swaps and sales swaps was determined using Level 2 inputs, which are defined as "significant other observable" inputs. The inputs used are from market sources that aggregate data based upon market transactions.

The table below shows the outstanding swap quantities used to hedge forecasted purchases and sales as of December 31, 2022, and December 31, 2021:

Hedge Contracts	Classification	December 31, 2022	December 31, 2021
Natural gas (in mmbtus)	Commodity purchase swaps	**45,174,000**	40,498,000
Tin (in metric tons)	Commodity purchase swaps	**738**	1,648
Zinc (in metric tons)	Commodity purchase swaps	**5,222**	7,167
Electricity (in megawatt hours)	Commodity purchase swaps	**460,320**	810,720
Iron ore pellets (in metric tons)	Commodity purchase swaps	**280,000**	30,000
Iron ore pellets (in metric tons)	Zero cost collars	**108,000**	1,296,000
Iron ore pellets (in metric tons)	Sales swaps	**1,087,500**	—
Hot-rolled coils (in tons)	Sales swaps	**11,000**	157,120
Foreign currency (in millions of euros)	Foreign exchange forwards	**€266**	€308
Foreign currency (in millions of dollars)	Foreign exchange forwards	**$90**	$2
Foreign currency (in millions of CAD)	Foreign exchange forwards	**$1**	$0

The following summarizes the fair value amounts included in our Consolidated Balance Sheets as of December 31, 2022, and December 31, 2021:

(In millions)	Balance Sheet Location	December 31, 2022	December 31, 2021
Designated as Hedging Instruments			
Sales swaps	Accounts receivable	**$ 3**	$ 10
Sales swaps	Accounts payable	**8**	30
Sales swaps	Investments and long-term receivables	**—**	1
Sales swaps	Other long-term liabilities	**1**	—
Commodity purchase swaps	Accounts receivable	**14**	17
Commodity purchase swaps	Accounts payable	**51**	29
Commodity purchase swaps	Investments and long-term receivables	**—**	1
Commodity purchase swaps	Other long-term liabilities	**11**	4
Foreign exchange forwards	Accounts receivable	**3**	15
Foreign exchange forwards	Accounts payable	**9**	—
Foreign exchange forwards	Other long-term liabilities	**3**	—
Not Designated as Hedging Instruments			
Commodity purchase swaps	Accounts receivable	**13**	5
Commodity purchase swaps	Investments and long-term receivables	**1**	5

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The table below summarizes the effect of hedge accounting on AOCI and amounts reclassified from AOCI into earnings for 2022, 2021, and 2020:

	(Loss) Gain on Derivatives in AOCI				Amount of (Loss) Gain Recognized in Income		
(In millions)	2022	2021	2020	Location of Reclassification from AOCI [a]	2022	2021	2020
Sales swaps	**$ 14**	$ 7	$ (26)	Net sales	**$ (18)**	$ (170)	$ —
Commodity purchase swaps	**(35)**	(11)	17	Cost of sales [b]	**103**	57	(24)
Foreign exchange forwards	**(16)**	33	(17)	Cost of sales	**44**	(3)	(7)

[a] The earnings impact of our hedging instruments substantially offsets the earnings impact of the related hedged items resulting in immaterial ineffectiveness.
[b] Costs for commodity purchase swaps are recognized in cost of sales as products are sold.

The table below summarizes the impact of derivative activity where hedge accounting has not been elected on our Consolidated Statements of Operations for 2022, 2021 and 2020:

		Amount of (Loss) Gain Recognized in Income		
(In millions)	Consolidated Statement of Operations Location	2022	2021	2020
Commodity purchase swaps	Cost of sales	**$ 18**	$ 19	$ (1)
Foreign exchange forwards	Other financial costs	**(7)**	2	—

At current contract values, $43 million in AOCI as of December 31, 2022, will be recognized as an increase in cost of sales over the next year, and $5 million in AOCI as of December 31, 2022, will be recognized as a decrease in net sales over the next year.

17. Debt

				December 31,	
(In millions)	Issuer/Borrower	Interest Rates %	Maturity	2022	2021
2037 Senior Notes	U. S. Steel	6.650	2037	**$ 274**	$ 350
2029 Senior Secured Notes	Big River Steel	6.625	2029	**720**	720
2029 Senior Notes	U. S. Steel	6.875	2029	**475**	750
2026 Senior Convertible Notes	U. S. Steel	5.000	2026	**350**	350
Environmental Revenue Bonds	U. S. Steel	4.125 - 6.750	2024 - 2052	**924**	647
Environmental Revenue Bonds	Big River Steel	4.500 - 4.750	2049	**752**	752
Finance leases and all other obligations	U. S. Steel	Various	2023-2029	**100**	67
Finance leases and all other obligations	Big River Steel	Various	2023-2031	**176**	122
ECA Credit Agreement	Big River Steel	Variable	2031	**136**	136
Credit Facility Agreement	U. S. Steel	Variable	2027	**—**	—
Big River Steel ABL Facility	Big River Steel	Variable	2026	**—**	—
USSK Credit Agreement	U. S. Steel Kosice	Variable	2026	**—**	—
USSK Credit Facility	U. S. Steel Kosice	Variable	2024	**—**	—
Total debt				**3,907**	3,894
Less unamortized discount, premium and debt issuance costs				**(70)**	3
Less short-term debt, long-term debt due within one year, and short-term issuance costs				**63**	28
Long-term debt				**$ 3,914**	$ 3,863

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The following is a summary of debt repayments for our Senior notes and environmental revenue bonds made during the twelve months ended December 31, 2022:

		Year Ended December 31, 2022
Debt Instrument (in millions)	Date	Debt Extinguished
2037 Senior Notes[(a)]	Third quarter 2022	$ 76
2029 Senior Notes[(b)]	Third quarter 2022	225
Hoover, AL Environmental Revenue Bonds	Second quarter 2022	14
2029 Senior Notes[(b)]	Second quarter 2022	48
2029 Senior Notes[(b)]	First quarter 2022	2
Total		**$ 365**

[(a)] There were redemption discounts and unamortized debt issuance cost write-offs of $6 million and $1 million, respectively, included in (gain) loss on debt extinguishment on the Consolidated Statement of Operations related to the repayment.
[(b)] During the twelve months ended December 31, 2022, there were no redemption premiums paid and a net loss of $4 million for the write-off of unamortized discounts and debt issuance costs, included in (gain) loss on debt extinguishment on the Consolidated Statement of Operations, as a result of these debt repayments.

Arkansas Development Finance Authority Environmental Improvement Revenue Bonds, Series 2022 (United States Steel Corporation Project) (Green Bonds)
On September 6, 2022, U. S. Steel closed on an offering of $290 million aggregate principal amount of 5.450% Environmental Improvement Revenue Bonds due 2052 (2052 ADFA Green Bonds). U. S. Steel received net proceeds of approximately $287 million after fees of approximately $3 million related to the underwriting and third-party expenses. The net proceeds from the issuance of the 2052 ADFA Green Bonds will be used to partially fund work related to U. S. Steel's solid waste disposal facilities, including two EAFs and other equipment facilities at its new technologically-advanced flat rolled steel making facility, BR2, currently under construction near Osceola, Arkansas.

On and after September 1, 2025, the Company may redeem the 2052 ADFA Green Bonds at its option, at any time in whole or from time to time in part at the redemption prices (expressed in percentages of principal amount) listed below, plus accrued and unpaid interest on the 2052 ADFA Green Bonds, if any, to, but excluding, the applicable redemption date, if redeemed during the twelve-month period beginning on September 1 of each of the years indicated below.

Year	Redemption Price
2025	105.000 %
2026	104.000 %
2027	103.000 %
2028	102.000 %
2029	101.000 %
2030 and thereafter	100.000 %

At any time prior to September 1, 2025, U. S. Steel may also redeem the 2052 ADFA Green Bonds, at our option, in whole or in part, or from time to time, at a price equal to the greater of 100 percent of the principal amount of the 2052 ADFA Green Bonds plus accrued and unpaid interest, if any, or the sum of the present value of the redemption price of the 2052 ADFA Green Bonds if they were redeemed on September 1, 2025, plus interest payments due through September 1, 2025, discounted to the date of redemption on a semi-annual basis at the applicable tax-exempt municipal bond rate, plus accrued and unpaid interest, if any.

2026 Senior Convertible Notes
In October 2019, U. S. Steel issued $350 million of 5.00% Senior Convertible Notes due November 1, 2026 (2026 Senior Convertible Notes). Interest on the 2026 Senior Convertible Notes is payable semi-annually on May 1 and November 1 of each year. The initial conversion rate for the 2026 Senior Convertible Notes is 74.8391 shares of U. S. Steel common stock per $1,000 principal amount, equivalent to an initial conversion price of approximately $13.36 per share of common stock, subject to adjustment pursuant to the 2026 Senior Convertible Notes indenture. Based on the initial conversion rate, the 2026 Senior Convertible Notes are convertible into 26,193,685 shares of U. S. Steel common stock and we reserved for the possible issuance of 33,396,930 shares, which is the maximum amount that could be issued upon conversion. Prior to August 1, 2026, holders of notes may convert all or a portion of their notes at their option only upon the satisfaction of specified conditions and during certain periods. On or after August 1, 2026, holders may convert all or a portion of their notes prior to the maturity date. Upon conversion, we will satisfy the obligation with cash, common stock, or a combination thereof, at our election. U. S. Steel may not redeem the 2026 Senior Convertible Notes prior to November 5, 2023. On or after November 5, 2023, and prior to August 1, 2026, if the price per share of U. S. Steel's common stock has been at least 130% of the conversion price for specified periods, U. S. Steel may redeem all or a portion of the 2026 Senior Convertible Notes at a cash redemption price of 100% of the principal amount, plus accrued and unpaid interest.

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If U. S. Steel undergoes a fundamental change, as defined in the 2026 Senior Convertible Notes, holders may require us to repurchase the 2026 Senior Convertible Notes in whole or in part for cash at a price equal to 100% of the principal amount of the 2026 Senior Convertible Notes to be purchased plus any accrued and unpaid interest up to, but excluding the repurchase date.

Big River Steel — Sustainability Linked ABL Facility
Big River Steel's amended senior secured asset-based revolving credit facility (Big River Steel ABL Facility) matures on July 23, 2026. The facility is secured by first-priority liens on accounts receivable and inventory and certain other assets and second priority liens on most tangible and intangible assets of Big River Steel in each case subject to permitted liens. Additionally, the amendment includes sustainability targets related to greenhouse gas emissions intensity reduction, safety performance and facility certification by ResponsibleSteel™.

The Big River Steel ABL Facility provides for borrowings for working capital and general corporate purposes in an amount equal up to the lesser of (a) $350 million and (b) a borrowing base calculated based on specified percentages of eligible accounts receivables and inventory, subject to certain adjustments and reserves.

Big River Steel LLC must maintain a fixed charge coverage ratio of at least 1.00 to 1.00 for the most recent twelve consecutive months when availability under the Big River Steel ABL Facility is less than the greater of ten percent of the borrowing base availability and $13 million. Based on the most recent four quarters as of December 31, 2022, Big River Steel would have met the fixed charge coverage ratio test. The facility includes affirmative and negative covenants and events of default that are customary for facilities of this type.

There were no loans outstanding under the Big River Steel ABL Facility at December 31, 2022.

U. S. Steel — Sustainability Linked Credit Facility Agreement
On May 27, 2022, U. S. Steel entered into the Sixth Amended and Restated Credit Facility Agreement (Credit Facility Agreement) to replace the existing Fifth Amended and Restated Credit Facility Agreement (Fifth Credit Facility Agreement). The Credit Facility Agreement has substantially the same terms as the Fifth Credit Facility Agreement, except the Credit Facility Agreement references the Secured Overnight Financing Rate instead of the London Interbank Offered Rate, adjusts the individual lenders' commitments, and renews the five-year maturity to May 27, 2027. The Credit Facility Agreement also adjusts the threshold for the fixed charge coverage ratio. The total availability under the facility remained the same at $1,750 million, and the financial impact from replacing the Fifth Credit Facility Agreement was immaterial. Consistent with the Fifth Credit Facility Agreement, the Credit Facility Agreement is secured by first-priority liens on certain accounts receivable and inventory and includes targets related to greenhouse gas emissions intensity reduction, safety performance and facility certification by ResponsibleSteel™.

The Credit Facility Agreement provides for borrowings for working capital and general corporate purchases in an amount equal to the lesser of (a) $1,750 million or (b) a borrowing base calculated based on specified percentages of eligible accounts receivable and inventory, subject to certain adjustments and reserves. As of December 31, 2022, there were approximately $4 million of letters of credit issued and no loans drawn under the Credit Facility Agreement. U. S. Steel must maintain a fixed charge coverage ratio of at least 1.00 to 1.00 for the most recent four consecutive quarters when availability under the Credit Facility Agreement is less than the greater of ten percent of the maximum facility availability and $140 million. Based on the most recent four quarters as of December 31, 2022, the Company would have met the fixed charge coverage ratio test.

USSK Credit Facilities
On September 29, 2021, USSK entered into a €300 million (approximately $320 million) unsecured sustainability linked credit agreement (USSK Credit Agreement). The USSK Credit Agreement matures in 2026 and contains specific financial covenants as well as sustainability targets related to greenhouse gas emissions intensity reduction, safety performance and facility certification by ResponsibleSteel™. At December 31, 2022, USSK had no borrowings under the USSK Credit Agreement.

Under the USSK Credit Agreement, USSK is required to maintain a net debt to EBITDA ratio of less than 3.50:1.00 for the rolling twelve months ending June 30, 2023. The Company has determined that it may not be able to comply with the EBITDA ratio covenant at June 30, 2023, based on the currently forecasted EBITDA for the twelve-month period ending June 30, 2023. This could partially or fully limit USSK’s ability to borrow under the USSK Credit Agreement.

Any amendment or waiver may lead to additional lender protections, including a reduction of loan commitments or less favorable terms, and there can be no assurance that USSK can obtain waivers or amendments in timely fashion, or on acceptable terms or at all. The Company believes that USSK will have adequate cash on hand as of June 30, 2023, and will not need to borrow under the USSK Credit Agreement.

At December 31, 2022, USSK had no borrowings under its €20 million credit facility (approximately $21 million) (USSK Credit Facility) and the availability was approximately $5 million due to approximately $16 million of customs and other guarantees outstanding.

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Debt Maturities – Aggregate maturities of debt are as follows (in millions):

2023	2024	2025	2026	2027	Later Years	Total
$ 65	$ 132	$ 44	$ 520	$ 99	$ 3,046	$ 3,906

18. Pensions and Other Benefits

U. S. Steel has defined contribution or multiemployer retirement benefits for more than 80 percent of its employees in the United States and non-contributory defined benefit pension plans covering the remaining employees. Benefits under the defined benefit pension plans are based upon years of service and final average pensionable earnings, with a minimum benefit based upon years of service. In addition, pension benefits for most non-represented employees under these plans are based upon a percent of total career pensionable earnings. Effective December 31, 2015, non-represented participants in the defined benefit plan no longer accrue additional benefits under the plan. For those non-represented employees without defined benefit coverage (defined benefit pension plan was closed to new participants in 2003) and those for which the defined benefit plan was frozen, the Company also provides in the defined contribution plans (401(k) plans) a retirement account benefit based on salary and attained age. Most non-represented employees also participate in the 401(k) plans whereby the Company matches a certain percentage of salary based on the amount contributed by the participant. As of December 31, 2022, more than 75 percent of U. S. Steel's represented employees in the United States are covered by the SPT, a multiemployer pension plan, to which U. S. Steel contributes on the basis of a fixed dollar amount for each hour worked.

Certain hourly employees of U. S. Steel's flat-rolled, tubular, cokemaking and iron ore operations in the United States are covered by collective bargaining agreements with the USW entered into effective September 1, 2022 (the 2022 Labor Agreements) that expire on September 1, 2026. The 2022 Labor Agreements include a signing bonus for each eligible USW-represented employee and annual 5% wage increases effective September 1, 2022, 2023, 2024 and 2025. Additionally, the 2022 Labor Agreements provide for increases to our pension and retirement benefits, including increases to our defined benefit pension plan, retiree healthcare contributions, and to the contribution rate to the SPT from $3.50 to $4.00 per hour effective January 1, 2023. During the fourth quarter of 2022, U. S. Steel recorded a charge of approximately $67 million for the 2022 Labor Agreements signing bonus and related costs which was recognized primarily as a component of Cost of sales on the Consolidated Statements of Operations.

In addition, as part of the collective bargaining process, U. S. Steel and the USW agreed to leverage the overfunded OPEB plans to support the benefits provided to active represented employees. Beginning January 1, 2023, this agreement allows the Company to use a certain amount of surplus VEBA assets (the surplus amount) to pay for legally permissible benefits under Section 501(c)(9) of the Internal Revenue Code for active employees and retirees of the USW. The surplus amount will represent a one-time transfer of VEBA assets to a subaccount to be used for these employees and retirees, which will take place in the first quarter 2023. The surplus amount of $595 million was determined as of December 31, 2022 (after merger of the UPI VEBA) and is the balance of VEBA assets in excess of 135% of the retiree obligation. The Company will be permitted to withdraw a target of $75 million annually, with a guaranteed annual minimum of $50 million, on a quarterly pro rata basis, from the subaccount to cover the cost of the permissible benefits for active USW employees and USW retirees. As a result of its designation for this purpose, the surplus amount is presented as $75 million in Other current assets and $520 million in Other noncurrent assets on the Consolidated Balance Sheet as of December 31, 2022. Pursuant to the agreement with the USW, the Company merged the United States Steel Corporation Plan for Active Employee Insurance Benefits with and into the United States Steel Corporation Plan for Retiree Insurance Benefits effective January 1, 2023. Upon the one-time transfer from the VEBA to the subaccount, the surplus assets will no longer be accounted for under ASC 715, *Compensation-Retirement Benefits* and is instead expected to be accounted for primarily under the provisions of ASC 825 *Financial Instruments,* which is likely to result in the portfolio being accounted for on a fair value basis, with gains and losses recognized in earnings, and reported as activity in Other financial costs (benefits) on the Company's Consolidated Statements of Operations.

On November 8, 2021, U. S. Steel entered into a commitment agreement with Banner Life Insurance Company and William Penn Life Insurance Company of New York (the "Insurers") and State Street Global Advisors Trust Company, as independent fiduciary to the United States Steel Corporation Plan for Employee Pension Benefits (Revision of 2003), for the plan to purchase group annuity contracts and transfer approximately $284 million of its pension plan obligations to the Insurers. The purchase of the group annuity contracts was funded directly by the assets of the pension plan. The purchase resulted in the transfer of administrative and benefit-paying responsibilities for approximately 17,800 U.S. retirees and beneficiaries to the Insurers. The Insurers began paying benefits for certain retirees and beneficiaries in the Plan on January 1, 2022. There was no change to the pension benefits for any retirees and beneficiaries as a result of the transaction. As a result of the transaction, the Corporation recognized a non-cash pension settlement charge of approximately $93 million. This amount was reclassified to earnings through Net interest and other financial costs from Accumulated other comprehensive loss.

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In addition during 2021, the Company recorded termination charges of approximately $34 million in pensions and $17 million in other benefits related to the planned disposition of a component within the flat-roll segment. These charges were recognized as Restructuring and other charges on the Consolidated Statements of Operations.

In February of 2020, U. S. Steel acquired the remaining 50% ownership of its joint venture with UPI and its associated benefit plans. Upon acquisition, UPI's defined benefit pension and other benefit liability was estimated on a net basis at $8 million and $55 million, respectively.

On October 26, 2022, U. S. Steel entered into an agreement with Pacific Life Insurance Company (the Insurer) and State Street Global Advisors Trust Company, as independent fiduciary to the UPI Pension Plan, for the plan to purchase group annuity contracts and transfer approximately $115 million of its pension plan obligations to the Insurer. The purchase of the group annuity contracts was completed on November 1, 2022 and funded directly by the assets of the pension plan. The purchase resulted in the transfer of the administrative and benefit-paying responsibilities for approximately 850 U.S. retirees and beneficiaries to the Insurer. The Insurer began paying benefits for certain retirees and beneficiaries in the Plan on January 1, 2023. There was no change to the pension benefits for any retirees and beneficiaries as a result of the transaction. As a result of the transaction, the Corporation recognized a non-cash pension settlement credit of approximately $3 million. This amount was reclassified to earnings through Net interest and other financial costs from accumulated other comprehensive loss.

Effective as of December 15, 2022, the UPI Pension Plan was merged into the U. S. Steel pension plan.

U. S. Steel’s defined benefit retiree health care and life insurance plans (Other Benefits) cover the majority of its represented employees in the United States upon their retirement. Health care benefits are provided for Medicare and pre-Medicare retirees, with Medicare retirees largely enrolled in Medicare Advantage Plans. Both are subject to various cost sharing features, and in most cases domestically, an employer cap on total costs. The Other Benefits plan was closed to represented employees hired or rehired under certain conditions on or after January 1, 2016.

The retiree medical and retiree life insurance plans, for non-represented employees were amended to eliminate retiree medical benefits effective December 31, 2017, and to eliminate retiree life insurance benefits for employees who retired after December 31, 2017.

The majority of U. S. Steel’s European employees are covered by government-sponsored programs into which U. S. Steel makes required contributions. Also, U. S. Steel sponsors defined benefit plans for most European employees covering benefit payments due to employees upon their retirement, some of which are government mandated. These same employees receive service awards throughout their careers based on stipulated service and, in some cases, age and service.

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U. S. Steel uses a December 31 measurement date for its plans and may have an interim measurement date if significant events occur. Details relating to pension benefits and Other Benefits are below.

	Pension Benefits		Other Benefits	
(In millions)	**2022**	**2021**	**2022**	**2021**
Change in benefit obligations				
Benefit obligations at January 1	**$ 5,422**	$ 6,186	**$ 1,620**	$ 1,841
Service cost	**45**	53	**9**	11
Interest cost	**157**	163	**49**	50
Plan amendments	**120**	—	**10**	—
Actuarial losses (gains)	**(1,011)**	(202)	**(332)**	(171)
Exchange rate gain	**(1)**	(3)	**—**	—
Settlements, curtailments and termination benefits	**(108)**	(358)	**2**	19
Benefits paid	**(438)**	(417)	**(122)**	(130)
Benefit obligations at December 31	**$ 4,186**	$ 5,422	**$ 1,236**	$ 1,620
Change in plan assets				
Fair value of plan at January 1	**$ 5,632**	$ 6,035	**$ 2,094**	$ 2,111
Actual return on plan assets	**(904)**	394	**(258)**	70
Plan Spin-Offs and Mergers	**—**	—	**(595)**	—
Asset reversion	**—**	—	**—**	(4)
Employer contributions	**—**	—	**2**	2
Settlements	**(121)**	**(380)**	**—**	**—**
Benefits paid from plan assets	**(437)**	(417)	**(92)**	(85)
Fair value of plan assets at December 31	**$ 4,170**	$ 5,632	**$ 1,151**	$ 2,094
Funded status of plans at December 31	**(16)**	210	**(85)**	474

For pension benefits, the largest contributor to the actuarial gain in 2022 was the increase in the discount rate from 3.01% at December 31, 2021 to 5.55% at December 31, 2022. In 2021, the largest contributor of actuarial gain was the increase in the discount rate from 2.72% at December 31, 2020 to 3.01% at December 31, 2021.

For Other Benefits, the largest contributor to the actuarial gain in 2022 was the increase in the discount rate from 3.11% at December 31, 2021 to 5.66% at December 31, 2022. There were also gains at December 31, 2022 attributable to reductions in future health care costs. In 2021, the largest contributor of actuarial gain was attributable to reductions in future health care costs and the increase in the discount rate from 2.80% at December 31, 2020 to 3.11% at December 31, 2021.

Amounts recognized in accumulated other comprehensive loss:

		2022		
(In millions)	**12/31/2021**	**Amortization**	**Activity**	**12/31/2022**
Pensions				
Prior Service Cost	$ 12	$ (2)	$ 120	**$ 130**
Actuarial Losses	1,296	(70)	250	**1,476**
Other Benefits				
Prior Service Credit	(74)	24	9	**(41)**
Actuarial Gains	(693)	53	18	**(622)**

As of December 31, 2022 and 2021, the following amounts were recognized in the Consolidated Balance Sheet:

	Pension Benefits		Other Benefits	
(In millions)	**2022**	**2021**	**2022**	**2021**
Noncurrent assets	**$ 10**	$ 252	**$ —**	$ 535
Current liabilities	**(2)**	(1)	**(37)**	(3)
Noncurrent liabilities	**(24)**	(41)	**(48)**	(59)
Accumulated other comprehensive loss [(a)]	**1,606**	1,308	**(663)**	(767)
Net amount recognized	**$ 1,590**	$ 1,518	**$ (748)**	$ (294)

[(a)] Accumulated other comprehensive loss effects associated with accounting for pensions and other benefits in accordance with ASC Topic 715 at December 31, 2022 and December 31, 2021, respectively, are reflected net of tax of $626 million and $531 million respectively, on the Consolidated Statements of Stockholders' Equity.

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The Accumulated Benefit Obligation (ABO) for all defined benefit pension plans was $4,103 million and $5,274 million at December 31, 2022 and 2021, respectively.

(In millions)	December 31, 2022	2021
Information for pension plans with an accumulated benefit obligation in excess of plan assets:		
Aggregate accumulated benefit obligations (ABO)	**$ (19)**	$ (294)
Aggregate projected benefit obligations (PBO)	**(26)**	(309)
Aggregate fair value of plan assets	**—**	268

The aggregate PBO in excess of plan assets reflected above is included in the payroll and benefits payable and employee benefits lines on the Consolidated Balance Sheet.

Following are the details of net periodic benefit costs related to Pension and Other Benefits:

	Pension Benefits			Other Benefits		
(In millions)	**2022**	**2021**	**2020**	**2022**	**2021**	**2020**
Components of net periodic benefit cost (credits):						
Service cost	**$ 45**	$ 53	$ 51	**$ 9**	$ 11	$ 12
Interest cost	**157**	163	193	**49**	50	63
Expected return on plan assets	**(357)**	(361)	(333)	**(91)**	(81)	(80)
Amortization - prior service costs (credits)	**2**	2	2	**(24)**	(29)	(6)
- actuarial losses (gains)	**73**	132	145	**(53)**	(23)	(16)
Net periodic benefit cost, excluding below	**(80)**	(11)	58	**(110)**	(72)	(27)
Multiemployer plans [(a)]	**74**	75	76	**—**	—	—
Settlement, termination and curtailment losses	**12**	135	11	**2**	19	4
Net periodic benefit cost (credits)	**$ 6**	$ 199	$ 145	**$ (108)**	$ (53)	$ (23)

(a) Primarily represents pension expense for the SPT covering USW employees hired from National Steel Corporation and new USW employees hired after May 21, 2003.

Net periodic benefit expense (credits) for pensions and Other Benefits is projected to be approximately $39 million and approximately $(83) million, respectively, in 2023. The pension cost projection includes approximately $84 million of contributions to the SPT.

Weighted average assumptions used to determine the benefit obligation at December 31 and net periodic benefit cost for the year ended December 31 are detailed below.

	Pension Benefits		Other Benefits	
	2022	**2021**	**2022**	**2021**
	U.S. and Europe	**U.S. and Europe**	**U.S.**	**U.S.**
Actuarial assumptions used to determine benefit obligations at December 31:				
Discount rate	**5.55 %**	3.01 %	**5.66 %**	3.11 %
Increase in compensation rate	**3.15 %**	2.60 %	**N/A**	N/A

	Pension Benefits			Other Benefits		
	2022	**2021**	**2020**	**2022**	**2021**	**2020**
	U.S. and Europe	**U.S. and Europe**	**U.S. and Europe**	**U.S.**	**U.S.**	**U.S.**
Actuarial assumptions used to determine net periodic benefit cost for the year ended December 31:						
Discount rate	**3.01 %**	2.72 %	3.35 %	**3.11 %**	2.80 %	3.42 %
Expected annual return on plan assets	**6.82 %**	6.82 %	6.47 %	**4.50 %**	4.25 %	4.25 %
Increase in compensation rate	**2.60 %**	2.60 %	2.62 %	**N/A**	N/A	N/A

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The discount rate reflects the current rate at which the pension and Other Benefit liabilities could be effectively settled at the measurement date. In 2017, we refined our discount rate determination process for our U.S. plans by using a bond matching approach to select specific bonds that would satisfy our projected benefit payments. We believe the bond matching approach more closely reflects the process we would employ to settle our pension and other benefits obligations. For our European pension plan, the discount rate is determined using data published by European Central Bank and underlying data provided by EuroMTS Ltd. The discount rate assumptions are updated annually.

	2022	2021
Assumed health care cost trend rates at December 31:	**U.S.**	**U.S.**
Health care cost trend rate assumed for next year	**6.00%**	5.75%
Rate to which the cost trend rate is assumed to decline (the ultimate trend rate)	**4.50%**	4.50%
Year that the rate reaches the ultimate trend rate	**2038**	2029

U. S. Steel reviews its actual historical rate experience and expectations of future health care cost trends to determine the escalation of per capita health care costs under U. S. Steel's benefit plans. About 75 percent of our costs for the domestic USW participants' retiree health benefits in the Company's main domestic benefit plan are limited to a per capita dollar maximum calculation based on 2006 base year actual costs incurred under the main U. S. Steel benefit plan for USW participants (cost cap). The full effect of the cost cap is expected to be realized around 2030. After 2030, the Company's costs for a majority of USW retirees and their dependents are expected to remain fixed and as a result, the cost impact of health care escalation for the Company is projected to be limited for this group.

Plan Assets

ASC Topic 820 establishes a single definition of fair value, creates a three-tier hierarchy as a framework for measuring fair value based on inputs used to value the Plan's investments, and requires additional disclosure about fair value. The hierarchy gives the highest priority to unadjusted quoted prices in active markets for identical assets or liabilities (level 1) and the lowest priority to unobservable inputs (level 3). The three levels of the fair value hierarchy are summarized below:

- Level 1 – Inputs to the valuation methodology are unadjusted quoted prices for identical assets or liabilities in active markets that the Plan has the ability to access.
- Level 2 – Inputs to the valuation methodology include:
  - Quoted prices for similar assets or liabilities in active markets;
  - Quoted prices for identical or similar assets or liabilities in inactive markets;
  - Inputs other than quoted prices that are observable for the asset or liability;
  - Inputs that are derived principally from or corroborated by observable market data by correlation or other means

  If the asset or liability has a specified (contractual) term, the level 2 input must be observable for substantially the full term of the asset or liability.

- Level 3 – Inputs to the valuation methodology are unobservable and significant to the fair value measurement.

An instrument's level is based on the lowest level of any input that is significant to the fair value measurement. Valuation techniques maximize the use of relevant observable inputs and minimize the use of unobservable inputs. The following is a description of the valuation methodologies used for assets measured at fair value. There have been no changes in the methodologies used at December 31, 2022 and 2021.

Short-term investments are valued at amortized cost which approximates fair value due to the short-term maturity of the instruments. Equity securities - U.S. & International are valued at the closing price reported on the active exchange on which the individual securities are traded. U.S. and Non U.S. government bonds are valued using pricing models maximizing the use of observable inputs for similar securities. Corporate U.S. & Non U.S. bonds are also valued using pricing models maximizing the use of observable inputs for similar securities, which includes basing value on yields currently available on comparable securities of issuers with similar credit ratings. When quoted prices are not available for identical or similar bonds, the bond is valued under a discounted cash flow approach that maximizes observable inputs, such as current yields of similar instruments, but includes adjustments for certain risks that may not be observable, such as credit and liquidity risks. Mortgage and asset-backed securities are valued using quotes from a broker dealer. Private equities and real estate are valued using information provided by external managers for each individual investment held in the fund or using NAV (net asset value) as a practical expedient. Timberland investments are valued at their appraised value. Mineral Interests and other alternatives are valued at the present value of estimated future cash flows discounted at estimated market rates for assets of similar quality and duration.

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The fair value of U. S. Steel's pension plan assets by asset category at December 31 were as follows (in millions):

	2022					2021				
	Level 1	Level 2	Level 3	measured at NAV [a]	Total	Level 1	Level 2	Level 3	measured at NAV [a]	Total
Asset Category										
Equity										
U. S. companies	$ 273	$ —	$ —	$ —	$ 273	$ 433	$ —	$ —	$ —	$ 433
International companies	366	—	—	—	366	183	—	—	—	183
Total equity	639	—	—	—	639	616	—	—	—	616
Fixed Income										
Corporate Bonds - U.S.	—	989	—	—	989	—	1,405	—	—	1,405
Corporate Bonds - Non-U.S.	—	206	—	—	206	—	251	—	—	251
U.S. government and agencies	—	244	—	—	244	—	426	—	—	426
Non-U.S. government	—	51	—	—	51	—	78	—	—	78
Mortgage and asset-backed securities	—	10	—	—	10	—	1	—	—	1
Derivative financial instruments	(7)	7	—	—	—	—	—	—	—	—
Total fixed income	(7)	1,507	—	—	1,500	—	2,161	—	—	2,161
Alternatives										
Timberlands	—	—	—	19	19	—	—	—	268	268
Mineral Interests and other alternatives	—	—	54	125	179	—	—	22	9	31
Private equity	—	—		251	251	—	—	—	259	259
Real estate	—	—	35	193	228	—	—	32	187	219
Total alternatives	—	—	89	588	677	—	—	54	723	777
Commingled Funds	—	—	—	1,176	1,176	—	—	—	1,964	1,964
Short-Term Investments	116	39	—	—	155	117	—	—	—	117
Other [b]	23	—	—	—	23	(3)	—	—	—	(3)
Total assets at fair value	$ 771	$ 1,546	$ 89	$ 1,764	$ 4,170	$ 730	$ 2,161	$ 54	$ 2,687	$ 5,632

[a] In accordance with ASC Topic 820, certain investments that were measured at net asset value per share (or its equivalent) have not been classified in the fair value hierarchy.
[b] Includes cash, accrued income, and miscellaneous payables.

The following table sets forth a summary of changes in the fair value of U. S. Steel's Pension plan Level 3 assets for the years ended December 31, 2022 and 2021:

	Level 3 assets only	
(In millions)	2022	2021
Balance at beginning of period	$ 54	$ 324
Transfers in and/or out of Level 3	—	(269)
Actual return on plan assets:		
Realized gain	1	3
Net unrealized gain	6	2
Purchases, sales, issuances and settlements:		
Purchases	33	24
Sales	(5)	(30)
Balance at end of period	$ 89	$ 54

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The fair value of U. S. Steel's Other Benefits plan assets by asset category at December 31 were as follows (in millions):

	2022					2021				
	Level 1	Level 2	Level 3	measured at NAV [a]	Total	Level 1	Level 2	Level 3	measured at NAV [a]	Total
Asset Category										
Equity										
U. S. companies	$ 50	$ —	$ —	$ —	$ 50	$ 186	$ —	$ —	$ —	$ 186
International companies	19	—	—	—	19	97	—	—	—	97
Total equity	69	—	—	—	69	283	—	—	—	283
Fixed Income										
Corporate Bonds - U.S.	—	479	—	—	479	—	718	—	—	718
Corporate Bonds - Non-U.S.	—	112	—	—	112	—	191	—	—	191
U.S. government and agencies	—	26	—	—	26	—	198	—	—	198
Non-U.S. government	—	5	—	—	5	—	17	—	—	17
Mortgage and asset-backed securities	—	4	—	—	4	—	9	—	—	9
Total fixed income	—	626	—	—	626	—	1,133	—	—	1,133
Alternatives										
Timberlands	—	—	—	2	2	—	—	—	35	35
Other alternatives	—	—	47	29	76	—	—	39	2	41
Private equity	—	—	—	39	39	—	—	—	59	59
Real estate	—	—	—	17	17	—	—	—	26	26
Total alternatives	—	—	47	87	134	—	—	39	122	161
Commingled Funds	—	—	—	262	262	—	—	—	434	434
Short-Term Investments	33	9	—	—	42	71	—	—	—	71
Other [b]	18	—	—	—	18	12	—	—	—	12
Total assets at fair value [c]	$ 120	$ 635	$ 47	$ 349	$ 1,151	$ 366	$ 1,133	$ 39	$ 556	$ 2,094

[a] In accordance with ASC Topic 820, certain investments that were measured at net asset value per share (or its equivalent) have not been classified in the fair value hierarchy.
[b] Includes cash, accrued income, and miscellaneous payables.
[c] The classification within the fair value hierarchy and the composition of the asset categories for the VEBA assets surplus amount of $595 million are the same as the Other Benefits plan assets as of December 31, 2022.

The following table sets forth a summary of changes in the fair value of U. S. Steel's Other Benefits plan Level 3 assets for the years ended December 31, 2022 and 2021:

	Level 3 assets only	
(In millions)	**2022**	**2021**
Balance at beginning of period	$ 39	$ 35
Transfers in and/or out of Level 3	(25)	(35)
Actual return on plan assets:		
Realized gain	—	—
Net unrealized loss	(2)	1
Purchases, sales, issuances and settlements:		
Purchases	35	39
Sales	—	(1)
Balance at end of period	$ 47	$ 39

U. S. Steel's investment strategy for its U.S. pension and Other Benefits plan assets provides for a diversified mix of high quality bonds, public equities and selected smaller investments in private equities, private credit, timber and mineral interests. For its U.S. pension, U. S. Steel has a target allocation for plan assets of 50 percent in corporate bonds, government bonds and mortgage, private credit, and asset-backed securities. The balance is invested in equity securities, timber, private equity and real estate partnerships. U. S. Steel believes that returns on equities over the long term will be higher than returns from fixed-income securities as actual historical returns from U. S. Steel's trusts have shown. Returns on bonds tend to offset some of the short-term volatility of stocks. Both equity and fixed-income investments are made across a broad range of industries and companies (both domestic and foreign) to provide protection against the impact of volatility in any single industry as well as company specific developments. U. S. Steel will use a 6.90 percent assumed rate of return on assets for the development of net periodic cost for the main defined benefit pension plan in 2023. Actual

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returns since the inception of the plan have exceeded this 6.90 percent rate and while recent annual returns have been volatile, it is U. S. Steel's expectation that rates will achieve this level in future periods.

For its Other Benefits plan, U. S. Steel is employing a liability driven investment strategy. The plan assets are allocated to match the plan cash flows with maturing investments. To achieve this strategy, U. S. Steel has a target allocation for plan assets of 88 percent in fixed income and private credit. The balance is primarily invested in equity securities, timber, private equity and real estate partnerships. U. S. Steel will use a 4.50 percent assumed rate of return on assets for the development of net periodic cost for its Other Benefit plans for 2023.

Steelworkers Pension Trust

For most bargaining unit employees participating in the SPT, U. S. Steel contributed to the SPT a fixed dollar amount for each hour worked of $3.50 through December 31, 2022. SPT contributions per hour worked increased to $4.00 effective January 1, 2023. U. S. Steel's contributions to the SPT represented greater than 30% of the total combined contributions of all employers participating in the plan for the years ended December 31, 2022, 2021 and 2020.

Participation in a multi-employer pension plan agreed to under the terms of a collective bargaining agreement differ from a traditional qualified single employer defined benefit pension plan. The SPT shares risks associated with the plan in the following respects:

a. Contributions to the SPT by U. S. Steel may be used to provide benefits to employees of other participating employers;

b. If a participating employer stops contributing to the SPT, the unfunded obligations of the plan may be borne by the remaining participating employers;

c. If U. S. Steel chooses to stop participating in the SPT, U. S. Steel may be required to pay an amount based on the underfunded status of the plan, referred to as a withdrawal liability.

On March 21, 2011 the Board of Trustees of the SPT elected funding relief which has the effect of decreasing the amount of required minimum contributions in near-term years, but will increase the minimum funding requirements during later plan years. As a result of the election of funding relief, the SPT's zone funding under the Pension Protection Act may be impacted.

In addition to the funding relief election, the Board of Trustees also elected a special amortization rule, which allows the SPT to separately amortize investment losses incurred during the SPT's December 31, 2008 plan year-end over a 29 year period, whereas they were previously required to be amortized over a 15 year period.

U. S. Steel's participation in the SPT for the annual periods ended December 31, 2022, 2021 and 2020 is outlined in the table below.

Pension Fund	Employer Identification Number/ Pension Plan Number	Pension Protection Act Zone Status as of December 31 [a]		FIP/RP Status Pending/ Implemented[b]	U.S. Steel Contributions (in millions)			Surcharge Imposed[c]		Expiration Date of Collective Bargaining Agreement
		2022	2021		2022	2021	2020	2022	2021	
Steelworkers Pension Trust	23-6648508/499	Green	Green	No	$ 74	$ 75	$ 76	No	No	September 1, 2022

[a] The zone status is based on information that U. S. Steel received from the plan and is certified by the plan's actuary. Among other factors, plans in the green zone are at least 80 percent funded, while plans in the yellow zone are less than 80 percent funded and plans in the red zone are less than 65 percent funded.
[b] Indicates if a financial improvement plan (FIP) or a rehabilitation plan (RP) is either pending or has been implemented.
[c] Indicates whether there were charges to U. S. Steel from the plan.

Cash Flows

The following information is in addition to the contributions to the SPT noted in the table above.

Employer Contributions **–** U. S. Steel did not make any voluntary or mandatory contributions to the U. S. Steel Retirement Plan Trust in 2022 or 2021. The U. S. Steel Retirement Plan Trust is the funding vehicle for the Company's main defined benefit pension plan.

For pension plans not funded by trusts, U. S. Steel made $2 million, $11 million and $7 million of pension payments not funded by trusts in 2022, 2021 and 2020, respectively.

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Cash payments totaling $32 million, $46 million and $46 million were made for other post-employment benefit payments not funded by trusts in 2022, 2021 and 2020, respectively. In 2022, 2021 and 2020, U. S. Steel continued to use assets from our VEBA trust for represented retiree health care and life insurance benefits to pay USW post-employment benefit claims.

Estimated Future Benefit Payments – The following benefit payments, which reflect expected future service as appropriate, are expected to be paid from U. S. Steel's defined benefit plans:

(In millions)	Pension Benefits	Other Benefits
2023	$ 427	$ 118
2024	408	114
2025	364	109
2026	357	121
2027	352	122
Years 2028 - 2030	1,619	543

Defined contribution plans
U. S. Steel also contributes to several defined contribution plans for its salaried employees. Effective January 1, 2016, all non-represented salaried employees in North America receive pension benefits in the form of a separate retirement account through a defined contribution plan with contribution percentages based upon age, for which company contributions totaled $21 million, $20 million and $10 million in 2022, 2021 and 2020, respectively. U. S. Steel's matching contributions to salaried employees' defined contribution plans, which are 100 percent of the employees' contributions up to six percent of their eligible salary, totaled $19 million, $18 million and $8 million in 2022, 2021 and 2020, respectively. U. S. Steel also maintains non-qualified defined contribution plans to provide benefits which are otherwise limited by the Internal Revenue Code for qualified plans. U. S. Steel's contributions under these defined contribution plans were less than $1 million in 2022 and totaled $1 million for both 2021 and 2020.

Most represented employees are eligible to participate in a defined contribution plan where there is no company match on savings except for certain Tubular hourly employees. Effective with the 2015 Labor Agreement, represented hires on or after January 1, 2016 are eligible for a $0.50 per hour savings account contribution. As a result of the 2018 Labor Agreements, the savings account contribution for each hour worked increased to $0.55 effective January 1, 2019, $0.60 effective January 1, 2020, and $0.65 effective January 1, 2021. As a result of the 2022 Labor Agreements, it will be increased to $0.75 effective January 1, 2023. These Company contributions for represented employees totaled $5 million, $4 million and $4 million in 2022, 2021 and 2020, respectively.

Other post-employment benefits
The Company provides benefits to former or inactive employees after employment but before retirement. Certain benefits including workers' compensation and black lung benefits represent material obligations to the Company and under the guidance for nonretirement post-employment benefits, have historically been treated as accrued benefit obligations. Liabilities for these benefits recorded at December 31, 2022, totaled $88 million as compared to $110 million at December 31, 2021. Liability amounts were developed assuming a discount rate of 5.65% and 2.87% at December 31, 2022 and 2021. Net periodic benefit cost for these benefits is projected to be $16 million in 2023 compared to $(1) million in 2022 and $17 million in 2021.

Pension Funding

In March 2021, the American Rescue Plan Act (ARPA - H.R. 1319) further extended the pension relief interest rate corridor used to measure defined benefit pension obligations for calculating minimum annual contributions. The new interest rate formula results in higher interest rates for minimum funding calculations as compared to prior law over the next few years, which will improve the funded status of our main defined benefit pension plan and reduce minimum required contributions.

U. S. Steel will monitor the funded status of the plan to determine when voluntary contributions may be prudent in order to mitigate potentially larger mandatory contributions in later years.

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19. Asset Retirement Obligations

U. S. Steel's asset retirement obligations (AROs) primarily relate to mine, landfill closure and post-closure costs. The following table reflects changes in the carrying values of AROs for the years ended December 31, 2022 and 2021:

	December 31,	
(In millions)	2022	2021
Balance at beginning of year	$ 66	$ 60
Additional obligations incurred	13	3
Obligations settled	(12)	(7)
Change in estimate of obligations	(5)	(1)
Foreign currency translation effects	—	(1)
Accretion expense	4	12
Balance at end of period	$ 66	$ 66

Certain AROs related to disposal costs of the majority of fixed assets at our integrated steel facilities have not been recorded because they have an indeterminate settlement date. These AROs will be initially recognized in the period in which sufficient information exists to estimate their fair value.

20. Fair Value of Financial Instruments

The carrying value of cash and cash equivalents, current accounts and notes receivable, accounts payable and accrued interest included in the Consolidated Balance Sheet approximate fair value. See Note 16 for disclosure of U. S. Steel's derivative instruments, which are accounted for at fair value on a recurring basis.

Stelco Option for Minntac Mine Interest
On April 30, 2020, the Company entered into an Option Agreement with Stelco, that grants Stelco the option to purchase a 25 percent interest (the Option Interest) in a to-be-formed entity (the Joint Venture) that will own the Company's current iron ore mine located in Mt. Iron, Minnesota (the Minntac Mine). As consideration for the option, Stelco paid the Company an aggregate amount of $100 million in five $20 million installments during the year-ended December 31, 2020 which are recorded net of transaction costs in the Consolidated Balance Sheet. In the event Stelco exercises the option, Stelco will contribute an additional $500 million to the Joint Venture, which amount shall be remitted solely to U. S. Steel in the form of a one-time special distribution, and the parties will engage in good faith negotiations to finalize the master agreement (pursuant to which Stelco will acquire the Option Interest) and the limited liability company agreement of the Joint Venture.

The following table summarizes U. S. Steel's financial assets and liabilities that were not carried at fair value at December 31, 2022 and 2021.

	December 31, 2022		December 31, 2021	
(In millions)	Fair Value	Carrying Amount	Fair Value	Carrying Amount
Financial liabilities:				
Long-term debt [(a)]	$ 3,815	$ 3,701	$ 4,379	$ 3,702

[(a)] Excludes finance lease obligations.

The fair value of long-term debt was determined using Level 2 inputs which were derived from quoted market prices.

Fair value of the financial assets and liabilities disclosed herein is not necessarily representative of the amount that could be realized or settled, nor does the fair value amount consider the tax consequences of realization or settlement.

Financial guarantees are U. S. Steel's only unrecognized financial instrument. For details relating to financial guarantees see Note 26.

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21. Reclassifications from Accumulated Other Comprehensive Income (AOCI)

(In millions)	Pension and Other Benefit Items	Foreign Currency Items	Unrealized Gain (Loss) on Derivatives	Total
Balance at December 31, 2020	$ (458)	$ 449	$ (38)	$ (47)
Other comprehensive income (loss) before reclassifications	297	(78)	(56)	163
Amounts reclassified from AOCI [(a)]	136	—	79	215
Net current-period other comprehensive income (loss)	433	(78)	23	378
Balance at December 31, 2021	$ (25)	$ 371	$ (15)	$ 331
Other comprehensive (loss) income before reclassifications	**(292)**	**(91)**	**74**	**(309)**
Amounts reclassified from AOCI [(a)]	**(5)**	**—**	**(102)**	**(107)**
Net current-period other comprehensive loss	**(297)**	**(91)**	**(28)**	**(416)**
Balance at December 31, 2022	**$ (322)**	**$ 280**	**$ (43)**	**$ (85)**

[(a)] See table below for further details.

Details about AOCI components [(a)]	**Amount reclassified from AOCI**		
(In millions)	**2022**	**2021**	**2020**
Amortization of pension and other benefit items			
Prior service credits [(a)]	**$ (23)**	$ (27)	$ (4)
Actuarial losses [(a)]	**20**	109	129
Settlements, termination and curtailment (gains) losses [(a)]	**(3)**	100	2
UPI purchase accounting adjustment	**—**	—	23
Total pensions and other benefits items	**(6)**	182	150
Derivative reclassifications to Consolidated Statements of Operations	**(133)**	105	32
Total before tax	**(139)**	287	182
Tax provision (benefit)	**32**	(72)	(41)
Net of tax	**$ (107)**	$ 215	$ 141

[(a)] These AOCI components are included in the computation of net periodic benefit cost (see Note 18 for additional details).

22. Supplemental Cash Flow Information

(In millions)	Year Ended December 31, 2022	2021	2020
Net cash (used in) provided by operating activities included:			
Interest and other financial costs paid (net of amount capitalized)	**$ (161)**	$ (319)	$ (248)
Income taxes (paid) refunded	**$ (242)**	$ (75)	$ 45
Non-cash investing and financing activities:			
Change in accrued capital expenditures	**$ 351**	$ 40	$ (121)
U. S. Steel common stock issued for employee/non-employee director stock plans	**$ 46**	$ 28	$ 19
Capital expenditures funded by finance lease borrowings	**$ 52**	$ 18	$ 31
Export Credit Agreement (ECA) financing	**$ —**	$ 23	$ 34

23. Transactions with Related Parties

Related party sales and service transactions are primarily related to equity investees and were $1,942 million, $1,311 million and $976 million in 2022, 2021 and 2020, respectively.

Accounts payable to related parties include balances due to PRO-TEC Coating Company (PRO-TEC) of $142 million and $98 million at December 31, 2022 and 2021, respectively for invoicing and receivables collection services provided by U. S. Steel on PRO-TEC's behalf. U. S. Steel, as PRO-TEC's exclusive sales agent, is responsible for credit risk related to

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those receivables. U. S. Steel also provides PRO-TEC marketing, selling and customer service functions. Payables to other related parties totaled $1 million for both periods ending December 31, 2022 and 2021, respectively.

Purchases from related parties for outside processing services provided by equity investees amounted to $27 million, $38 million and $90 million during 2022, 2021 and 2020, respectively. Purchases of iron ore pellets from related parties amounted to $131 million, $111 million and $78 million for the years ended December 31, 2022, 2021 and 2020, respectively.

Upon the acquisition of Big River Steel on January 15, 2021, there were related party payables of approximately $27 million for steel substrate sales from Big River Steel to U. S. Steel. After the acquisition, the related party payables became intercompany payables that are eliminated in consolidation.

Upon the acquisition of UPI on February 29, 2020 there were $135 million of related party receivables for prior sales of steel substrate from U. S. Steel to UPI. After the acquisition, the related party receivables became intercompany receivables that are eliminated in consolidation.

24. Leases

Operating lease assets consist primarily of office space, heavy mobile equipment used in our mining operations and facilities and equipment under operating service agreements for electricity generation and scrap processing. We also have operating lease assets for light mobile equipment and information technology assets. The Company also has short term leases related to transportation services for which we apply the short-term lease exception. Significant finance leases primarily consist of heavy mobile equipment used in our mining operations. Variable lease payments are primarily related to operating service agreements where payment is solely dependent on consumption of certain services, such as raw material and by-product processing. Most long-term leases include renewal options and, in certain leases, purchase options. Generally, we are not reasonably certain that these options will be exercised. We have residual value guarantees under certain light mobile equipment leases. There is no impact to our leased assets for residual value guarantees as the potential loss is not probable (see “Other Contingencies” in Note 26 for further details). We do not have material restrictive covenants associated with our leases or material amounts of sublease income. From time to time, U. S. Steel may enter into arrangements for the construction or purchase of an asset and then enter into a financing arrangement to lease the asset. U. S. Steel recognizes leased assets and liabilities under these arrangements when it obtains control of the asset.

The following table summarizes the lease amounts included in our Consolidated Balance Sheet as of December 31, 2022.

(In millions)	Balance Sheet Location	December 31, 2022	December 31, 2021
Assets			
Operating	Operating lease assets [(a)]	**$ 146**	$ 185
Finance	Property, plant and equipment [(b)]	**126**	101
Total Lease Assets		**$ 272**	$ 286
Liabilities			
Current			
Operating	Current operating lease liabilities	**$ 49**	$ 58
Finance	Current portion of long-term debt	**25**	16
Non-Current			
Operating	Noncurrent operating lease liabilities	**105**	136
Finance	Long-term debt less unamortized discount and issue costs	**98**	76
Total Lease Liabilities		**$ 277**	$ 286

[(a)] Operating lease assets are recorded net of accumulated amortization of $142 million and $128 million as of December 31, 2022, and December 31, 2021, respectively.
[(b)] Finance lease assets are recorded net of accumulated depreciation of $86 million and $59 million as of December 31, 2022, and December 31, 2021, respectively.

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The following table summarizes lease costs included in our Consolidated Statement of Operations for the years ended December 31, 2022, December 31, 2021, and December 31, 2020.

(In millions)	Classification	Year Ended December 31, 2022	Year Ended December 31, 2021	Year Ended December 31, 2020
Operating Lease Cost [(a)]	Cost of sales	**$ 65**	$ 69	$ 67
Operating Lease Cost	Selling, general and administrative expenses	**14**	14	14
Finance Lease Cost				
Amortization	Depreciation, depletion and amortization	**26**	21	14
Interest	Interest expense	**9**	9	4
Total Lease Cost		**$ 114**	$ 113	$ 99

[(a)] Operating lease cost recorded in cost of sales includes $12 million, $11 million and $7 million of variable lease cost for the years ended December 31, 2022, December 31, 2021 and December 31, 2020, respectively. Operating lease cost recorded in selling, general and administrative expenses includes $1 million of variable lease cost for the year ended December 31, 2022. An immaterial amount of variable lease cost was included in cost of sales and selling, general and administrative expenses for each of the years ended December 31, 2021, and December 31, 2020. $1 million of short-term lease cost is included in cost of sales and selling, general and administrative expenses for the years ended December 31, 2022, December 31, 2021, and December 31, 2020.

Lease liability maturities as of December 31, 2022, are shown below.

(In millions)	Operating	Finance	Total
2023	$ 58	$ 37	$ 95
2024	43	35	78
2025	31	33	64
2026	21	28	49
2027	14	13	27
After 2027	10	3	13
Total Lease Payments	**$ 177**	**$ 149**	**$ 326**
Less: Interest	23	26	49
Present value of lease liabilities	**$ 154**	**$ 123**	**$ 277**

Lease terms and discount rates are shown below.

	December 31, 2022
Weighted average lease term	
Finance	4 years
Operating	4 years
Weighted average discount rate	
Finance	5.79 %
Operating	6.73 %

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Supplemental cash flow information related to leases is as follows:

(In millions)	Year Ended December 31, 2022	Year Ended December 31, 2021	Year Ended December 31, 2020
Cash paid for amounts included in the measurement of lease liabilities:			
Operating cash flows from operating leases	**$ 66**	$ 70	$ 71
Operating cash flows from finance leases	**9**	9	4
Financing cash flows from finance leases	**20**	30	13
Right-of-use assets exchanged for lease liabilities:			
Operating leases	**20**	40	41
Finance leases	**52**	18	31

25. Restructuring and Other Charges

During 2022, the Company recorded restructuring and other charges of $48 million, which consists of charges of $30 million related to the planned disposition of a component within the Flat-Rolled segment, $23 million related to headcount reductions under a voluntary early retirement program (VERP) offered at USSK, a $9 million favorable adjustment to the expected exit costs of indefinitely idled facilities, and $4 million of severance-related charges at other facilities. Cash payments were made related to severance and exit costs of approximately $95 million.

During 2021, the Company recorded restructuring and other charges of $128 million, which consists of charges of $29 million for Great Lakes Works, charges of approximately $89 million related to the planned disposition of a component within the Flat-Rolled segment, and environmental-related charges at other facilities of $10 million. Cash payments were made related to severance and exit costs of approximately $58 million.

During 2020, the Company recorded restructuring and other charges of $138 million, which consists of charges of $66 million for the indefinite idling of a significant portion of Great Lakes Works, and our Keetac mining operations which was restarted in the fourth quarter, $25 million for the indefinite idling of Lorain Tubular Operations and Lone Star Tubular Operations, and $15 million and $32 million for employee benefit costs related to Company-wide headcount reductions and headcount reductions under a VERP offered at USSK, respectively. Cash payments were made related to severance and exit costs of approximately $169 million. A portion of these cash payments, approximately $38 million, were funded by the postretirement benefit trust (VEBA) per an agreement with the United Steelworkers of America.

Charges for restructuring and ongoing cost reduction initiatives are recorded in the period U. S. Steel commits to a restructuring or cost reduction plan, or executes specific actions contemplated by the plan and all criteria for liability recognition have been met. Charges related to the restructuring and cost reductions are reported in restructuring and other charges in the Consolidated Statements of Operations.

The activity in the accrued balances incurred in relation to restructuring during the years ended December 31, 2022, and December 31, 2021, were as follows:

(in millions)	Employee Related Costs	Exit Costs	Non-cash Charges	Total
Balance at December 31, 2020	$ 51	$ 126	$ —	$ 177
Additional charges	76	51	1	$ 128
Cash payments/utilization	(36)	(28)	(1)	(65)
Balance at December 31, 2021	**$ 91**	**$ 149**	**$ —**	**$ 240**
Additional charges	**58**	**(10)**	**—**	**48**
Cash payments/utilization[(a)]	**(17)**	**(89)**	**—**	**(106)**
Balance at December 31, 2022	**$ 132**	**$ 50**	**$ —**	**$ 182**

[(a)] $7 million and $11 million of payments were made from the pension fund trust assets in the Employee Related Cost column during the years ended December 31, 2021, and December 31, 2022, respectively.

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Accrued liabilities for restructuring and other cost reduction programs are included in the following balance sheet lines:

(in millions)	December 31, 2022	December 31, 2021
Accounts payable	**$ 33**	$ 34
Payroll and benefits payable	**—**	2
Employee benefits	**131**	88
Deferred credits and other noncurrent liabilities	**18**	116
Total	**$ 182**	$ 240

26. Contingencies and Commitments

U. S. Steel is the subject of, or party to, a number of pending or threatened legal actions, contingencies and commitments involving a variety of matters, including laws and regulations relating to the environment. Certain of these matters are discussed below. The ultimate resolution of these contingencies could, individually or in the aggregate, be material to the Consolidated Financial Statements. However, management believes that U. S. Steel will remain a viable and competitive enterprise even though it is possible that these contingencies could be resolved unfavorably.

U. S. Steel accrues for estimated costs related to existing lawsuits, claims and proceedings when it is probable that it will incur these costs in the future and the costs are reasonably estimable.

Asbestos matters – As of December 31, 2022, U. S. Steel was a defendant in approximately 920 active cases involving approximately 2,510 plaintiffs. The vast majority of these cases involve multiple defendants. About 1,545, or approximately 62 percent, of these plaintiff claims are currently pending in jurisdictions which permit filings with massive numbers of plaintiffs. At December 31, 2021, U. S. Steel was a defendant in approximately 915 cases involving approximately 2,505 plaintiffs. Based upon U. S. Steel's experience in such cases, it believes that the actual number of plaintiffs who ultimately assert claims against U. S. Steel will likely be a small fraction of the total number of plaintiffs.

The following table shows the number of asbestos claims in the current year and the prior two years:

Period ended	Opening Number of Claims	Claims Dismissed, Settled and Resolved	New Claims	Closing Number of Claims
December 31, 2020	2,390	240	295	2,445
December 31, 2021	2,445	200	260	2,505
December 31, 2022	2,505	230	235	2,510

The amount U. S. Steel accrues for pending asbestos claims is not material to U. S. Steel's financial condition. However, U. S. Steel is unable to estimate the ultimate outcome of asbestos-related claims due to a number of uncertainties, including: (1) the rates at which new claims are filed, (2) the number of and effect of bankruptcies of other companies traditionally defending asbestos claims, (3) uncertainties associated with the variations in the litigation process from jurisdiction to jurisdiction, (4) uncertainties regarding the facts, circumstances and disease process with each claim, and (5) any new legislation enacted to address asbestos-related claims.

Further, U. S. Steel does not believe that an accrual for unasserted claims is required. At any given reporting date, it is probable that there are unasserted claims that will be filed against the Company in the future. The Company engages an outside valuation consultant to assist in assessing its ability to estimate an accrual for unasserted claims. This assessment is based on the Company's settlement experience, including recent claims trends. This analysis focuses on settlements made over the last several years as these claims are likely to best represent future claim characteristics. After review by the valuation consultant and U. S. Steel management, it was determined that the Company could not estimate an accrual for unasserted claims.

Despite these uncertainties, management believes that the ultimate resolution of these matters will not have a material adverse effect on U. S. Steel's financial condition.

Environmental Matters – U. S. Steel is subject to federal, state, local and foreign laws and regulations relating to the environment. These laws generally provide for control of pollutants released into the environment and require responsible parties to undertake remediation of hazardous waste disposal sites. Penalties may be imposed for noncompliance. Changes in accrued liabilities for remediation activities where U. S. Steel is identified as a named party are summarized in the following table:

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(In millions)	Year Ended December 31, 2022	2021
Beginning of period	**$ 158**	$ 146
Accruals for environmental remediation deemed probable and reasonably estimable	**20**	43
Adjustments for changes in estimates	**3**	—
Obligations settled	**(55)**	(31)
End of period	**$ 126**	$ 158

Accrued liabilities for remediation activities are included in the following Consolidated Balance Sheet lines:

(In millions)	December 31, 2022	December 31, 2021
Accounts payable	**$ 32**	$ 65
Deferred credits and other noncurrent liabilities	**94**	93
Total	**$ 126**	$ 158

Expenses related to remediation are recorded in cost of sales and were $21 million and $47 million for the years ended December 31, 2022 and December 31, 2021, respectively. It is not currently possible to estimate the ultimate amount of all remediation costs that might be incurred or the penalties that may be imposed. Due to uncertainties inherent in remediation projects and the associated liabilities, it is reasonably possible that total remediation costs for active matters may exceed the accrued liabilities by as much as 20 to 35 percent.

Remediation Projects
U. S. Steel is involved in environmental remediation projects at or adjacent to several current and former U. S. Steel facilities and other locations that are in various stages of completion ranging from initial characterization through post-closure monitoring. Based on the anticipated scope and degree of uncertainty of projects, we categorize projects as follows:

(1) *Projects with Ongoing Study and Scope Development* – Projects which are still in the development phase. For these projects, the extent of remediation that may be required is not yet known, the remediation methods and plans are not yet developed, and/or cost estimates cannot be determined. Therefore, significant costs, in addition to the accrued liabilities for these projects, are reasonably possible. There are four environmental remediation projects where additional costs for completion are not currently estimable, but could be material. These projects are at Fairfield Works, Lorain Tubular, USS-UPI LLC (UPI) formerly known as USS-POSCO Industries and the former steelmaking plant at Joliet, Illinois. As of December 31, 2022, accrued liabilities for these projects totaled $1 million for the costs of studies, investigations, interim measures, design and/or remediation. It is reasonably possible that additional liabilities associated with future requirements regarding studies, investigations, design and remediation for these projects could be as much as $22 million to $36 million.

(2) *Significant Projects with Defined Scope* – Projects with significant accrued liabilities with a defined scope. As of December 31, 2022, there are three significant projects with defined scope greater than or equal to $5 million each, with a total accrued liability of $69 million. These projects are: Gary Resource Conservation and Recovery Act (RCRA) (accrued liability of $28 million), Duluth Works (accrued liability of $22 million) and the former Geneva facility (accrued liability of $19 million).

(3) *Other Projects with a Defined Scope* – Projects with relatively small accrued liabilities for which we believe that, while additional costs are possible, they are not likely to be significant, and also include those projects for which we do not yet possess sufficient information to estimate potential costs to U. S. Steel. There are three other environmental remediation projects which each had an accrued liability of between $1 million and $5 million. The total accrued liability for these projects at December 31, 2022 was $4 million. These projects have progressed through a significant portion of the design phase and material additional costs are not expected.

The remaining environmental remediation projects each have an accrued liability of less than $1 million each. The total accrued liability for these projects at December 31, 2022 was approximately $6 million. The Company does not foresee material additional liabilities for any of these sites.

Post-Closure Costs – Accrued liabilities for post-closure site monitoring and other costs at various closed landfills totaled $24 million at December 31, 2022 and were based on known scopes of work.

Administrative and Legal Costs – As of December 31, 2022, U. S. Steel had an accrued liability of $10 million for administrative and legal costs related to environmental remediation projects. These accrued liabilities were based on projected administrative and legal costs for the next three years and do not change significantly from year to year.

Capital Expenditures – For a number of years, U. S. Steel has made substantial capital expenditures to comply with various regulations, laws, and other requirements relating to the environment. Such capital expenditures totaled $43 million and $27 million In 2022 and 2021, respectively. U. S. Steel anticipates making additional such expenditures in the future, which may be material; however, the exact amounts and timing of such expenditures are uncertain because of the continuing evolution of specific regulatory requirements.

European Union (the EU) Environmental Requirements - Phase IV of the EU Emissions Trading System (the EU ETS) commenced on January 1, 2021 and will finish on December 31, 2030. The European Commission issued final approval of the updated 2021-2025 Slovak National Allocation table in February 2022. Subsequently, the Slovak Ministry of Environment allocated the full amount of 2022 free allowances totaling 6.3 million EUA to USSE in February and April 2022. As of December 31, 2022, we have pre-purchased approximately 2.1 million EUA totaling €147 million (approximately $157 million) to cover the expected 2022 and 2023 shortfall of emission allowances.

The EU's Industrial Emissions Directive requires implementation of EU-determined best available techniques (BAT) for Iron and Steel production to reduce environmental impacts as well as compliance with BAT associated emission levels. Total capital expenditures for projects to comply with or go beyond BAT requirements were €138 million (approximately $147 million). These costs were partially offset by the EU funding received and may be mitigated over the next measurement periods if USSK complies with certain financial covenants, which are assessed annually. USSK complied with these covenants as of December 31, 2022. If we are unable to meet these covenants in the future, USSK might be required to provide additional collateral (e.g., bank guarantee) to secure 50 percent of the EU funding received.

Environmental indemnifications – Throughout its history, U. S. Steel has sold numerous properties and businesses and many of these sales included indemnifications and cost sharing agreements related to the assets that were divested. The amount of potential environmental liability associated with these transactions and properties is not estimable due to the nature and extent of the unknown conditions related to the properties divested and deconsolidated. Aside from the environmental liabilities already recorded as a result of these transactions due to specific environmental remediation activities and cases (included in the $126 million of accrued liabilities for remediation discussed above), there are no other known probable and estimable environmental liabilities related to these transactions.

Guarantees – The maximum guarantees of the indebtedness of unconsolidated entities of U. S. Steel totaled $7 million at December 31, 2022.

Other contingencies – Under certain operating lease agreements covering various equipment, U. S. Steel has the option to renew the lease or to purchase the equipment at the end of the lease term. If U. S. Steel does not exercise the purchase option by the end of the lease term, U. S. Steel guarantees a residual value of the equipment as determined at the lease inception date (totaling approximately $13 million at December 31, 2022). No liability has been recorded for these guarantees as the potential loss is not probable.

The Company's BR2 project in Osceola, Arkansas qualifies for financing and related economic incentives associated with the acquisition, development, construction and operation of the facility. These incentives consist of advance lump-sum payments which are included in deferred credits and other noncurrent liabilities on the Consolidated Balance Sheet. In March 2022, the Company received a lump-sum payment of approximately $82 million as proceeds from the sale of a portion of expected future tax credits to be earned by the Company under the State of Arkansas's Recycling Tax Credit program. These funds are to be used primarily for the acquisition of project related equipment, however they may also be used for the training and development of new employees hired for the project. The Company is contingently liable for certain repayment penalties if the Company fails to meet certain employment requirements in any given period. In April 2022, the Company received a $3 million grant from Mississippi County, Arkansas, and in May 2022, the Company received a $50 million grant from the State of Arkansas Quick Action Closing Fund. Both grants pertain to the reimbursement of qualifying project costs. For each of these incentives and grants, the balance of deferred income will be recognized into Other gains, net in the accompanying Consolidated Statements of Operations on a systematic basis over the periods in which the Company earns the granted funds by complying with the investment and employment requirements of the grant programs.

Insurance – U. S. Steel maintains insurance for certain property damage, equipment, business interruption and general liability exposures; however, insurance is applicable only after certain deductibles and retainages. U. S. Steel is self-insured for certain other exposures including workers' compensation (where permitted by law) and auto liability. Liabilities are recorded for workers' compensation and personal injury obligations. Other costs resulting from losses under deductible or retainage amounts or not otherwise covered by insurance are charged against income upon occurrence.

U. S. Steel uses surety bonds, trusts and letters of credit to provide whole or partial financial assurance for certain obligations such as workers' compensation. The total amount of active surety bonds, trusts and letters of credit being used for financial assurance purposes was approximately $178 million as of December 31, 2022, which reflects U. S. Steel's maximum exposure under these financial guarantees, but not its total exposure for the underlying obligations. A significant portion of our trust arrangements and letters of credit are collateralized by the Credit Facility Agreement. The remaining trust arrangements and letters of credit are collateralized by restricted cash. Restricted cash, which is recorded in other

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current and noncurrent assets, totaled $35 million and $78 million at December 31, 2022 and December 31, 2021 respectively.

Capital Commitments – At December 31, 2022, U. S. Steel's contractual commitments to acquire property, plant and equipment totaled $2.235 billion.

Contractual Purchase Commitments – U. S. Steel is obligated to make payments under contractual purchase commitments, including unconditional purchase obligations. Payments for contracts with remaining terms in excess of one year are summarized below (in millions):

2023	2024	2025	2026	2027	Later years	Total
$477	$258	$352	$285	$267	$394	$2,033

The majority of U. S. Steel's unconditional purchase obligations relate to the supply of industrial gases, and certain energy and utility services with terms ranging from two to 13 years. Unconditional purchase obligations also include coke and steam purchase commitments related to a coke supply agreement with Gateway Energy & Coke Company LLC (Gateway) under which Gateway is obligated to supply a minimum volume of the expected targeted annual production of the heat recovery coke plant, and U. S. Steel is obligated to purchase the coke from Gateway at the contract price. As of December 31, 2022, if U. S. Steel were to terminate the agreement, it may be obligated to pay in excess of $24 million.

Total payments relating to unconditional purchase obligations were approximately $850 million in 2022, $767 million in 2021 and $553 million in 2020.

27. Common Stock Issued and Repurchased

On October 25, 2021, the Board of Directors authorized a share repurchase program that allowed for the repurchase of up to $300 million of its outstanding common stock from time to time in the open market or privately negotiated transactions. On January 24, 2022 the Board of Directors authorized an additional $500 million under the share repurchase program.

On July 25, 2022, following the completion of the previously authorized $800 million share repurchase programs, the Board of Directors authorized a new share repurchase program that allows for the repurchase of up to $500 million of its outstanding common stock from time to time in the open market or privately negotiated transactions at the discretion of management. The Company's share repurchase program does not obligate it to acquire any specific number of shares.

U. S. Steel repurchased 37.6 million shares and 6.6 million shares of common stock for approximately $849 million and $150 million under these programs during 2022 and 2021, respectively.

In February 2021, U. S. Steel issued 48.3 million shares of common stock for net proceeds of approximately $790 million.

In June 2020, U. S. Steel issued 50 million shares of common stock for net proceeds of approximately $410 million.

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FIVE-YEAR OPERATING SUMMARY (Unaudited)

(Thousands of tons, unless otherwise noted)	2022	2021	2020	2019	2018
Raw Steel Production					
Gary, IN	**5,326**	5,664	4,675	4,974	5,958
Great Lakes, MI	**—**	—	328	1,964	2,369
Mon Valley, PA	**2,161**	2,668	2,552	2,331	2,640
Granite City, IL	**1,359**	1,549	1,758	2,140	926
Total Flat-Rolled facilities	**8,846**	9,881	9,313	11,409	11,893
Mini Mill facility	**2,650**	2,688	—	—	—
U. S. Steel Košice	**3,839**	4,931	3,366	3,903	5,023
Tubular facility	**634**	464	16	—	—
Total	**15,969**	17,964	12,695	15,312	16,916
Raw Steel Capability					
Flat-Rolled	**13,200**	13,200	17,000	17,000	17,000
Mini Mill	**3,300**	3,300	—	—	—
USSE	**5,000**	5,000	5,000	5,000	5,000
Tubular [(c)]	**900**	900	900	—	—
Total	**22,400**	22,400	22,900	22,000	22,000
Production as % of total capability:					
Flat-Rolled	**67 %**	58 %	55 %	67 %	70 %
Mini Mill	**80 %**	81 %	— %	— %	— %
USSE	**77 %**	99 %	67 %	78 %	100 %
Tubular [(c)]	**70 %**	52 %	7 %	— %	— %
Coke Production					
Flat-Rolled	**3,627**	3,848	2,557	3,485	3,718
USSE	**1,407**	1,548	1,116	1,328	1,514
Total	**5,034**	5,396	3,673	4,813	5,232
Iron Ore Pellet Production [(a)]					
Total	**22,059**	23,369	16,981	21,450	23,054
Steel Shipments by Segment [(b)]					
Flat-Rolled	**8,373**	9,018	8,711	10,700	10,510
Mini Mill	**2,287**	2,230	—	—	—
USSE	**3,759**	4,302	3,041	3,590	4,457
Tubular	**523**	444	464	769	780
Total steel shipments	**14,942**	15,994	12,216	15,059	15,747
Average Realized Price (dollars per net ton)					
Flat-Rolled	**$ 1,261**	$ 1,172	$ 718	$ 753	$ 811
Mini Mill	**$ 1,134**	$ 1,314	$ —	$ —	$ —
USSE	**$ 1,090**	$ 966	$ 626	$ 652	$ 693
Tubular	**$ 2,978**	$ 1,696	$ 1,271	$ 1,450	$ 1,483

[(a)] Includes our share of production from Hibbing.

[(b)] Does not include intersegment shipments or shipments by joint ventures and other equity investees of U. S. Steel. Includes shipments from U. S. Steel to joint ventures and equity investees of substrate materials, primarily hot-rolled and cold-rolled sheets.

[(c)] The Fairfield Electric Arc Furnace commenced operation in October 2020. The 2020 production as a % of total capability amount is based on an October 1, 2020 start date.

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FIVE-YEAR OPERATING SUMMARY (Unaudited) (Continued)

(Thousands of net tons)	2022	2021	2020	2019	2018
Steel Shipments by Market - North American Facilities [a] [c]					
Steel service centers	**2,208**	2,660	1,450	1,902	1,904
Further conversion:					
Trade customers	**2,935**	2,385	2,063	2,823	2,273
Joint ventures [b]	**256**	490	415	819	810
Transportation and automotive [b]	**2,631**	2,372	2,012	2,620	2,874
Construction and construction products	**1,261**	1,524	1,295	1,120	991
Containers and packaging	**706**	959	913	652	768
Appliances and electrical equipment	**509**	679	497	570	599
Oil, gas and petrochemicals	**494**	426	430	725	742
All other	**183**	197	100	238	329
Total	**11,183**	11,692	9,175	11,469	11,290
Steel Shipments by Market - USSE					
Steel service centers	**839**	995	690	740	799
Further conversion:					
Trade customers	**289**	314	202	214	287
Transportation and automotive	**619**	590	517	676	728
Construction and construction products	**1,052**	1,346	775	1,048	1,637
Containers and packaging	**423**	449	435	440	439
Appliances and electrical equipment	**225**	266	194	220	261
Oil, gas and petrochemicals	**3**	8	5	—	11
All other	**309**	334	223	252	295
Total	**3,759**	4,302	3,041	3,590	4,457

[a] Does not include shipments by joint ventures and other equity investees of U. S. Steel, but instead reflects the shipments of substrate materials, primarily hot-rolled and cold-rolled sheets, to those entities.
[b] PRO-TEC automotive substrate shipments are included in the Transportation and Automotive category.
[c] Shipments previously reported in 2018 as Exports have been reclassified to one of the other categories to which they relate.

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FIVE-YEAR FINANCIAL SUMMARY (Unaudited) (Continued)

(Dollars in millions, except per share amounts)	2022	2021	2020	2019	2018
Net sales by segment:					
Flat-Rolled	**$ 12,872**	$ 12,358	$ 7,279	$ 9,560	$ 9,912
Mini Mill	**3,047**	3,516	—	—	—
USSE	**4,256**	4,266	1,970	2,420	3,228
Tubular	**1,616**	809	646	1,191	1,236
Total reportable segments	**$ 21,791**	$ 20,949	$ 9,895	$ 13,171	$ 14,376
Other	**9**	101	162	168	186
Intersegment sales	**(735)**	(775)	(316)	(402)	(384)
Total	**$ 21,065**	$ 20,275	$ 9,741	$ 12,937	$ 14,178
Segment earnings (loss) before interest and income taxes:					
Flat-Rolled	**$ 1,951**	$ 2,630	$ (596)	$ 196	$ 883
Mini Mill	**481**	1,206	—	—	—
USSE	**444**	975	9	(57)	359
Tubular	**544**	1	(179)	(67)	(58)
Total reportable segments	**$ 3,420**	$ 4,812	$ (766)	$ 72	$ 1,184
Other	**22**	(11)	(39)	23	55
Items not allocated to segments [(a)]	**(282)**	145	(270)	(325)	(115)
Total earnings (loss) before interest and income taxes	**$ 3,160**	$ 4,946	$ (1,075)	$ (230)	$ 1,124
Net interest and other financial costs	**(99)**	602	232	222	312
Income tax expense (benefit)	**735**	170	(142)	178	(303)
Net earnings (loss) attributable to United States Steel Corporation	**$ 2,524**	$ 4,174	$ (1,165)	$ (630)	$ 1,115
Per common share:					
- Basic	**$ 10.22**	$ 15.77	$ (5.92)	$ (3.67)	$ 6.31
- Diluted	**$ 9.16**	$ 14.88	$ (5.92)	$ (3.67)	$ 6.25

[(a)] See Note 4 to the Consolidated Financial Statements.

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Item 9. CHANGES IN AND DISAGREEMENTS WITH ACCOUNTANTS ON ACCOUNTING AND FINANCIAL DISCLOSURE

None.

Item 9A. CONTROLS AND PROCEDURES

Conclusions Regarding the Effectiveness of Disclosure Controls and Procedures

Under the supervision and with the participation of U. S. Steel's management, including the chief executive officer and chief financial officer, U. S. Steel conducted an evaluation of our disclosure controls and procedures, as such term is defined under Rule 13a-15(e) promulgated under the Securities Exchange Act of 1934, as amended (the Exchange Act). Based on this evaluation, U. S. Steel's chief executive officer and chief financial officer concluded that U. S. Steel's disclosure controls and procedures were effective as of the end of the period covered by this annual report.

Management's Report on Internal Control Over Financial Reporting

See "Item 8. Financial Statements and Supplementary Data – Management's Reports to Stockholders – Internal Control Over Financial Reporting."

Attestation Report of Independent Registered Public Accounting Firm

See "Item 8. Financial Statements and Supplementary Data – Report of Independent Registered Public Accounting Firm."

Changes in Internal Control Over Financial Reporting

There have not been any changes in U. S. Steel's internal control over financial reporting that occurred during the fourth quarter of 2022 which have materially affected, or are reasonably likely to materially affect, U. S. Steel's internal control over financial reporting.

Item 9B. OTHER INFORMATION

None.

Item 9C. DISCLOSURE REGARDING FOREIGN JURISDICTIONS THAT PREVENT INSPECTIONS

Not Applicable.

PART III

Item 10. DIRECTORS, EXECUTIVE OFFICERS AND CORPORATE GOVERNANCE

Information concerning the directors of U. S. Steel required by this item is incorporated and made part hereof by reference to the material appearing under the heading "Election of Directors" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders, which will be filed with the Securities and Exchange Commission, pursuant to Regulation 14A, no later than 120 days after the end of the fiscal year. Information concerning the Audit Committee and its financial expert required by this item is incorporated and made part hereof by reference to the material appearing under the heading "Corporate Governance - Board Committees – Audit" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders. Information regarding the Nominating Committee required by this item is incorporated and made part hereof by reference to the material appearing under the heading "Corporate Governance - Board Committees – Corporate Governance & Sustainability" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders. Information regarding the ability of stockholders to communicate with the Board of Directors is incorporated and made part hereof by reference to the material appearing under the heading "Corporate Governance - Commitment to Stockholder Engagement - Communications from Stockholders and Interested Parties" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders. Information regarding compliance with Section 16(a) of the Exchange Act required by this item is incorporated and made part hereof by reference to the material appearing under the heading "Delinquent Section 16(a) Reports" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders. Information concerning the executive officers of U. S. Steel is contained in Part I of this Form 10-K under the caption "Information about our Executive Officers."

U. S. Steel has adopted a Code of Ethical Business Conduct that applies to all of our directors and officers, including our principal executive officer, principal financial officer, principal accounting officer or controller, or persons performing similar functions. U. S. Steel will provide a copy of this code free of charge upon request. To obtain a copy, contact the Office of the Corporate Secretary, United States Steel Corporation, 600 Grant Street, Pittsburgh, Pennsylvania, 15219-2800 (telephone: 412-433-1121). The Code of Ethical Business Conduct is also available through the Company's website at ***www.ussteel.com.*** U. S. Steel does not intend to incorporate the contents of our website into this Annual Report on Form 10-K.

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Item 11. EXECUTIVE COMPENSATION

Information required by this item is incorporated and made part hereof by reference to the material appearing under the heading "Compensation & Organization Committee Report" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders.

Item 12. SECURITY OWNERSHIP OF CERTAIN BENEFICIAL OWNERS AND MANAGEMENT AND RELATED STOCKHOLDER MATTERS

Equity Compensation Plan Information

Plan Category	(1) Number of securities to be issued upon exercise of outstanding options, warrants and rights	(2) Weighted-average exercise price of outstanding options, warrants and rights	(3) Number of securities remaining available for future issuance under equity compensation plans excluding securities reflected in Column (1) [(b)]
Equity compensation plans approved by security holders [(a)]	10,700,781	$26.88	9,080,478
Equity compensation plans not approved by security holders[(c)]	—	(one for one)	—
Total	10,700,781	—	9,080,478

(a) The numbers in columns (1) and (2) of this row contemplate all shares that could potentially be issued as a result of outstanding grants under the 2005 Stock Incentive Plan and the 2016 Omnibus Incentive Compensation Plan, as amended and restated as of December 31, 2022. (For more information, see Note 15 to the Consolidated Financial Statements). Column (1) includes (i) 647,733 shares of common stock that could be issued for the Common Stock Units outstanding under the Deferred Compensation Program for Non-Employee Directors and (ii) 5,517,086 shares that could be issued for the 2,758,543 performance awards outstanding under the Long-Term Incentive Compensation Program (a program under the 2016 Omnibus Incentive Compensation Plan, as amended and restated). The calculation in column (2) does not include the Common Stock Units since the weighted average exercise price for Common Stock Units is one for one; that is, one share of common stock will be given in exchange for each unit of such phantom stock accumulated through the date of the director's retirement. Also, the calculation in column (2) does not include the performance awards since the shares issued for performance awards can range from zero for one to two for one; that is, performance awards may result in up to 5,517,086 of common stock being issued (two for one), or some lesser number of shares (including zero shares of common stock issued), depending upon the Corporation's common stock performance versus that of a peer group of companies or the Corporation's return on capital employed performance over a performance period.

(b) Represents shares available under the 2016 Omnibus Incentive Compensation Plan, as amended and restated.

(c) At December 31, 2022, U. S. Steel had no securities remaining for future issuance under equity compensation plans that had not been approved by security holders. Column (1) represents Common Stock Units that were issued pursuant to the Deferred Compensation Plan for Non-Employee Directors prior to its being amended to make it a program under the 2005 Stock Incentive Plan and 2016 Omnibus Incentive Compensation Plan, as amended and restated. The weighted average exercise price for Common Stock Units in column (2) is one for one; that is, one share of common stock will be given in exchange for each unit of phantom stock upon the director's retirement from the Board of Directors. All future grants under this amended plan/program will count as shares issued under to the 2016 Omnibus Incentive Compensation Plan, as amended and restated, a stockholder approved plan.

Other information required by this item is incorporated and made part hereof by reference to the material appearing under the headings "Stock Ownership of Directors and Executive Officers" and "Stock Ownership of Certain Beneficial Owners" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders.

Item 13. CERTAIN RELATIONSHIPS AND RELATED TRANSACTIONS, AND DIRECTOR INDEPENDENCE

Information required by this item is incorporated and made part hereof by reference to the material appearing under the headings "Corporate Governance - Related Person Transactions Policy" and "Corporate Governance – Director Independence" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders.

Item 14. PRINCIPAL ACCOUNTANT FEES AND SERVICES

Information required by this item is incorporated and made part hereof by reference to the material appearing under the heading "Audit Fees" in U. S. Steel's Proxy Statement for the 2023 Annual Meeting of Stockholders.

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PART IV

Item 15. EXHIBITS AND FINANCIAL STATEMENT SCHEDULE

A. Documents Filed as Part of the Report

1. **Financial Statements and Supplementary Data**
Financial Statements filed as part of this report are included in “Item 8 – Financial Statements and Supplementary Data”.

2. **Financial Statement Schedules**
See “Schedule II – Valuation and Qualifying Accounts and Reserves" for years ended December 31, 2022, 2021, and 2020. All other schedules are omitted because they are not applicable or the required information is contained in the applicable financial statements or notes thereto.

B. Exhibits

Exhibit No.

2. Plan of acquisition, reorganization, arrangement, liquidation or succession

(a)	Call Option Equity Purchase Agreement, by and among U. S. Steel Holdco LLC, Big River Steel Holdings LLC, Pinnacle Mountain Holding Company III, LLC and Consolidated Steel Equity Investors, LLC, dated as of December 15, 2020.	Incorporated by reference to Exhibit 2.1 to United States Steel Corporation's Form 8-K filed on December 18, 2020, Commission File Number 1-16811.

3. Articles of Incorporation and By-Laws

(a)	Amended and Restated Certificate of Incorporation of United States Steel Corporation, dated April 25, 2017	Incorporated by reference to Exhibit 3.1 to United States Steel Corporation's Form 8-K filed on April 28, 2017, Commission File Number 1-16811.
(b)	Amended and Restated By-Laws of United States Steel Corporation, dated as of January 31, 2023.	Incorporated by reference to Exhibit 3.1 to United States Steel Corporation's Form 8-K filed on February 2, 2023, Commission File Number 1-16811.

4. Instruments Defining the Rights of Security Holders, Including Indentures

(a)	Indenture between United States Steel Corporation and The Bank of New York Mellon (f/k/a The Bank of New York, dated as of May 21, 2007.	Incorporated by reference to Exhibit 4.1 to United States Steel Corporation’s Form 8-K filed on May 22, 2007, Commission File Number 1-16811.
(b)	First Supplemental Indenture between United States Steel Corporation and The Bank of New York Mellon(f/k/a The Bank of New York, dated as of May 21, 2007).	Incorporated by reference to Exhibit 4.2 to United States Steel Corporation’s Form 8-K filed on May 22, 2007, Commission File Number 1-16811.
(c)	Tenth Supplemental Indenture between United States Steel Corporation and The Bank of New York Mellon, dated as of February 11, 2021.	Incorporated by reference to Exhibit 4.1 to United States Steel Corporation’s Form 8-K filed on February 11, 2021, Commission File Number 1-16811.
(d)	Indenture by and between United States Steel Corporation and The Bank of New York Mellon, dated as of October 21, 2019.	Incorporated by reference to Exhibit 4.1 to United States Steel Corporation’s Form 8-K filed on October 21, 2019, Commission File Number 1-16811.
(e)	Indenture among Big River Steel LLC, BRS Finance Corp., BRS Intermediate Holdings LLC, each Guarantor that may become party thereto and U.S. Bank National Association, dated as of September 18, 2020.	Incorporated by reference to Exhibit 4.1 to United States Steel Corporation’s Form 8-K filed on January 19, 2021, Commission File Number 1-16811.
(f)	Description of Securities.	Incorporated by reference to Exhibit 4.1 to United States Steel Corporation’s Form 10-K filed on February 14, 2020, Commission File Number 1-16811.

Certain long-term debt instruments are omitted pursuant to Item 601(b)(4)(iii) of Regulation S-K. U. S. Steel agrees to furnish to the Commission on request a copy of any instrument defining the rights of holders of long-term debt of U. S. Steel and of any subsidiary for which consolidated or unconsolidated financial statements are required to be filed.

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10. Material Contracts

(a)	Recapitalization and Equity Purchase Agreement by and among U. S. Steel Holdco LLC, BRS Stock Holdco LLC, Big River Steel Holdings LLC, the Equityholders of Big River Steel Corp. and Big River Steel Holdings LLC and United States Steel Corporation, dated as of September 30, 2019.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on October 1, 2019, Commission File Number 1-16811.
(b)	Purchase and Sale Agreement by and among U. S. Steel Holdco LLC, United States Steel Corporation and TPG Growth II BDH, L.P, dated as of September 30, 2019.	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 8-K filed on October 1, 2019, Commission File Number 1-16811.
(c)	Option Agreement by and between United States Steel Corporation and Stelco Inc., dated as of April 30, 2020. on and Stelco.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on April 30, 2020, Commission File Number 1-16811.
(d)	Underwriting Agreement by and between United States Steel Corporation and Credit Suisse Securities (USA) LLC on behalf of the several Underwriters, dated February 8, 2021.	Incorporated by reference to Exhibit 1.1 to United States Steel Corporation's Form 8-K filed on February 11, 2021, Commission File Number 1-16811.
(e)	Membership Interest Purchase Agreement by and between United States Steel Corporation and Percy Acquisition LLC, dated June 7, 2021.**	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on June 8, 2021, Commission File Number 1-16811.
(f)	Commitment Agreement by and among United States Steel Corporation, Banner Life Insurance Company, William Penn Life Insurance Company of New York and State Street Global Advisors Trust Company, dated November 9, 2021.**	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(g)	Sixth Amended and Restated Credit Agreement, dated as of May 27, 2022, among United States Steel Corporation, the Subsidiary Guarantors from time to time party thereto, the Lenders party thereto, the LC Issuing Banks party thereto, and JPMorgan Chase Bank, N.A., as Administrative and Collateral Agent.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on June 3, 2022, Commission File Number 1-16811.
(h)	Third Amended and Restated Borrower Security Agreement, dated as of May 27, 2022, between United States Steel Corporation and JPMorgan Chase Bank, N.A., as Collateral Agent.	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 8-K filed on June 3, 2022, Commission File Number 1-16811.
(i)	Third Amended and Restated Subsidiary Security Agreement, dated as of May 27, 2022, between the Subsidiary Guarantors and JPMorgan Chase Bank, N.A., as Collateral Agent.	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 8-K filed on June 3, 2022, Commission File Number 1-16811.
(j)	Second Amended and Restated Borrower Canadian Security Agreement, dated as of May 27, 2022, between United States Steel Corporation and JPMorgan Chase Bank, N.A., as Collateral Agent.	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 8-K filed on June 3, 2022, Commission File Number 1-16811.
(k)	Agreement of Sale between United States Steel Corporation and The Industrial Development Board of the City of Hoover, dated as of October 1, 2019.	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 8-K filed on October 28, 2019, Commission File Number 1-16811.
(l)	Loan Agreement between United States Steel Corporation and the Allegheny County Industrial Development Authority, dated as of October 1, 2019.	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 8-K filed on October 28, 2019, Commission File Number 1-16811.
(m)	Credit Agreement, dated December 10, 2019, by and among United States Steel Corporation, KfW IPEX-Bank GMBH, as Mandated Lead Arranger and ECA Structuring Bank, KfW IPEX-Bank as Facility Agent, KfW IPEX-Bank as ECA Agent, and the financial institutions listed therein as lenders, and other parties party thereto from time to time	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-K filed on February 14, 2020, Commission File Number 1-16811.
(n)	First Amendment to the Credit Agreement among United States Steel Corporation and KFW IPEX-BANK GMBH, dated as of November 17, 2020.	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-K filed on February 12, 2021, Commission File Number 1-16811.
(o)	Agreement of Sale between United States Steel Corporation and The Industrial Development Board of the City of Hoover regarding $63,400,000 million 6.375% Environmental Improvement Revenue Bonds, Series 2020 (United States Steel Corporation Project), dated as of November 1, 2020.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on November 24, 2020, Commission File Number 1-16811.

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(p)	Loan Agreement dated between United States Steel Corporation and the Indiana Finance Authority regarding $33,300,000 Indiana Finance Authority Environmental Improvement Revenue Bonds, Series 2020A (United States Steel Corporation Project) and Indiana Finance Authority Environmental Improvement Revenue Refunding Bonds, Series 2020B (United States Steel Corporation Project), dated as of November 1, 2020.	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 8-K filed on November 24, 2020, Commission File Number 1-16811.
(q)	ABL Credit Agreement by and among Big River Steel LLC, BRS Intermediate Holdings LLC, Goldman Sachs Bank USA and each lender party thereto, dated as of August 23, 2017.**	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(r)	First Amendment to ABL Credit Agreement by and among Big River Steel LLC, BRS Intermediate Holdings LLC, Goldman Sachs Bank USA and each lender party thereto, dated as of September 10, 2020.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on January 19, 2021, Commission File Number 1-16811.
(s)	Second Amendment to ABL Credit Agreement by and among Big River Steel LLC, BRS Intermediate Holdings LLC, Goldman Sachs Bank USA and each lender party thereto, dated as of July 23, 2021.	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-Q filed on July 30, 2021, Commission File Number 1-16811.
(t)	Bond Financing Agreement between Arkansas Development Finance Authority and each of Big River Steel LLC, BRS Finance Corp. and BRS Intermediate Holdings LLC relating to $265 million Arkansas Development Finance Authority Industrial Development Revenue Bonds (Big River Steel Project), Tax-Exempt Series 2020 (Green Bonds), dated as of September 10, 2020.	Incorporated by reference to Exhibit 10.2.1 to United States Steel Corporation's Form 8-K filed on January 19, 2021, Commission File Number 1-16811.
(u)	Definitions Annex relating to Arkansas Development Finance Authority Industrial Development Revenue Bonds (Big River Steel Project), Tax-Exempt Series 2020 (Green Bonds), dated as of September 10, 2020.	Incorporated by reference to Exhibit 10.2.2 to United States Steel Corporation's Form 8-K filed on January 19, 2021, Commission File Number 1-16811.
(v)	Bond Financing Agreement between Arkansas Development Finance Authority and each of Big River Steel LLC, BRS Finance Corp. and BRS Intermediate Holdings LLC relating to $487 million Arkansas Development Finance Authority Industrial Development Revenue Bonds (Big River Steel Project), Series 2019, dated as of May 31, 2019.	Incorporated by reference to Exhibit 10.3.1 to United States Steel Corporation's Form 8-K filed on January 19, 2021, Commission File Number 1-16811.
(w)	Definitions Annex relating to Arkansas Development Finance Authority Industrial Development Revenue Bonds (Big River Steel Project), Series 2019, dated as of May 31, 2019.	Incorporated by reference to Exhibit 10.3.2 to United States Steel Corporation's Form 8-K filed on January 19, 2021, Commission File Number 1-16811.
(x)	Loan Agreement between Arkansas Development Finance Authority and each of United States Steel Corporation and Exploratory Ventures, LLC relating to $290,000,000 Arkansas Development Finance Authority Environmental Improvement Revenue Bonds, Series 2022 (United States Steel Corporation Project) (Green Bonds), dated as of September 1, 2022.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on October 28, 2022, Commission File Number 1-16811.
(y)	EUR 300,000,000 Unsecured Sustainability Linked Revolving Credit Facility Agreement among U. S. Steel Košice, s.r.o., and ING Bank N.V., Komerèní banka, a.s., Slovenská sporiteľňa, a.s., UniCredit Bank Czech Republic and Slovakia , a.s., Československá Obchodná banka, a.s., and Citibank Europe plc, dated September 29, 2021.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on October 1, 2021, Commission File Number 1-16811.
(z)	Supplemental Agreement No. 9 between U. S. Steel Košice, s.r.o. and ING Bank N.V., dated December 3, 2021.	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(aa)	United States Steel Corporation 2005 Stock Incentive Plan, Effective April 26, 2005.*	Incorporated by reference to Appendix B to United States Steel Corporation's Definitive Proxy Statement on Schedule 14A filed on March 11, 2005, Commission File Number 1-16811.
(bb)	United States Steel Corporation 2005 Stock Incentive Plan, Amended and Restated Effective April 27, 2010.*	Incorporated by reference to Appendix A to United States Steel Corporation's Definitive Proxy Statement on Schedule 14A filed on March 12, 2010, Commission File Number 1-16811.

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(cc)	United States Steel Corporation 2005 Stock Incentive Plan, Amended and Restated Effective April 29, 2014.*	Incorporated by reference to Appendix A to United States Steel Corporation's Definitive Proxy Statement on Schedule 14A filed on March 14, 2014, Commission File Number 1-16811.
(dd)	Form of Stock Option Grant under the Long-Term Incentive Compensation Program, a program under the United States Steel Corporation 2005 Stock Incentive Plan.*	Incorporated by reference to Exhibit 10(x) to United States Steel Corporation's Form 10-K filed on February 27, 2007, Commission File Number 1-16811.
(ee)	Form of Performance Award Grant Agreement under the Long-Term Incentive Compensation Program, a program under the United States Steel Corporation 2005 Stock Incentive Plan.*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on April 26, 2011, Commission File Number 1-16811.
(ff)	Form of Stock Option Grant Agreement under the Long-Term Incentive Compensation Program, a program under the United States Steel Corporation 2005 Stock Incentive Plan.*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on April 26, 2011, Commission File Number 1-16811.
(gg)	Form of Restricted Stock Unit Retention Grant Agreement under the Long-Term Incentive Compensation Program, a program under the United States Steel Corporation 2005 Stock Incentive Plan.*	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 10-Q filed on April 26, 2011, Commission File Number 1-16811
(hh)	Form of Restricted Stock Unit Annual Grant Agreement under the Long-Term Incentive Compensation Program, a program under the United States Steel Corporation 2005 Stock Incentive Plan.*	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-Q filed on April 26, 2011, Commission File Number 1-16811.
(ii)	Form of Retention Performance Award Grant Agreement under the Long-Term Incentive Compensation Program, a program under the United States Steel Corporation 2005 Stock Incentive Plan.*	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 8-K filed on July 2, 2012, Commission File Number 1-16811.
(jj)	Form of Non-Qualified Stock Option Grant Agreement under the Long-Term Incentive Compensation Program, a program under the United States Steel Corporation 2005 Stock Incentive Plan.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on April 29, 2015, Commission File Number 1-16811.
(kk)	Administrative Regulations for the Long-Term Incentive Compensation Program under the United States Steel Corporation 2005 Stock Incentive Plan, Amended and Restated Effective May 28, 2013.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on May 30, 2013, Commission File Number 1-16811.
(ll)	Administrative Regulations for the Long-Term Incentive Compensation Program under the United States Steel Corporation 2005 Stock Incentive Plan, Amended and Restated Effective February 25, 2014.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on March 3, 2014, Commission File Number 1-16811.
(mm)	Administrative Procedures for the Long-Term Incentive Compensation Program under the United States Steel Corporation 2005 Stock Incentive Plan, as Amended and Restated, and under the United States Steel Corporation 2010 Annual Incentive Compensation Plan, as amended February 24, 2015.*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on April 29, 2015, Commission File Number 1-16811.
(nn)	Administrative Procedures for the Long-Term Incentive Compensation Program under the United States Steel Corporation 2005 Stock Incentive Plan, as Amended and Restated, and under the United States Steel Corporation Annual Incentive Compensation Plan, Effective February 22, 2016.*	Incorporated by reference to Exhibit 10(kk) to United States Steel Corporation's Form 10-K filed on February 29, 2016, Commission File Number 1-16811.
(oo)	United States Steel Corporation Deferred Compensation Program for Non-Employee Directors, a program under the 2005 Stock Incentive Plan, effective as of November 29, 2005.*	Incorporated by reference to Exhibit 10(d) to United States Steel Corporation's Form 10-K filed on February 28, 2012, Commission File Number 1-16811.
(pp)	United States Steel Corporation 2010 Annual Incentive Compensation Plan, Effective April 27, 2010.*	Incorporated by reference to Appendix B to United States Steel Corporation's Definitive Proxy Statement on Schedule 14A filed on March 12, 2010, Commission File Number 1-16811.
(qq)	Form of Incentive Award Agreement under the United States Steel Corporation 2010 Annual Incentive Compensation Plan.*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on April 29, 2015, Commission File Number 1-16811.

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(rr)	Administrative Regulations for the Executive Management Annual Incentive Compensation Program under the United States Steel Corporation 2010 Annual Incentive Compensation Plan, as amended January 27, 2014.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on January 31, 2014, Commission File Number 1-16811.
(ss)	Administrative Procedures for the Executive Management Annual Incentive Compensation Program under the United States Steel Corporation 2010 Annual Incentive Compensation Plan, as amended January 27, 2015*	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-Q filed on April 29, 2015, Commission File Number 1-16811.
(tt)	Administrative Procedures for the Executive Management Annual Incentive Compensation Program under the United States Steel Corporation 2010 Annual Incentive Compensation Plan, as amended February 22, 2016.*	Incorporated by reference to Exhibit 10(ll) to United States Steel Corporation's Form 10-K filed on February 29, 2016, Commission File Number 1-16811.
(uu)	Administrative Procedures for the Executive Management Annual Incentive Compensation Program under the United States Steel Corporation 2010 Annual Incentive Compensation Plan, as amended November 1, 2016.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on November 2, 2016, Commission File Number 1-16811.
(vv)	United States Steel Corporation Supplemental Thrift Program, Amended and Restated Effective July 31, 2013.*	Incorporated by reference to Exhibit 10.7 to United States Steel Corporation's Form 10-Q filed on October 29, 2013, Commission File Number 1-16811.
(ww)	United States Steel Corporation Supplemental Thrift Program, Amended and Restated Effective November 1, 2016.*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on November 2, 2016, Commission File Number 1-16811.
(xx)	United States Steel Corporation Supplemental Thrift Program, Amended and Restated Effective January 1, 2019.*	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-Q filed on May 3, 2019, Commission File Number 1-16811.
(yy)	United States Steel Corporation Non Tax-Qualified Retirement Account Program, Amended and Restated Effective November 13, 2013.	Incorporated by reference to Exhibit 10(dd) to United States Steel Corporation's Form 10-K filed on February 25, 2014, Commission File Number 1-16811.
(zz)	United States Steel Corporation Non Tax-Qualified Retirement Account Program, Amended and Restated Effective January 1, 2016.*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on November 2, 2016, Commission File Number 1-16811.
(aaa)	United States Steel Corporation Non Tax-Qualified Retirement Account Program, Amended and Restated Effective January 1, 2019.*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on May 3, 2019, Commission File Number 1-16811.
(bbb)	United States Steel Corporation Non Tax-Qualified Pension Plan, Amended and Restated Effective December 31, 2015.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on August 21, 2015, Commission File Number 1-16811.
(ccc)	United States Steel Corporation Executive Management Supplemental Pension Program, Amended and Restated Effective December 31, 2015.*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 8-K filed on August 21, 2015, Commission File Number 1-16811.
(ddd)	United States Steel Corporation Supplemental Retirement Account Program, Amended and Restated Effective January 1, 2016.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on November 4, 2015, Commission File Number 1-16811.
(eee)	United States Steel Corporation Supplemental Retirement Account Program, Amended and Restated Effective January 1, 2019.*	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 10-Q filed on May 3, 2019, Commission File Number 1-16811.
(fff)	United States Steel Corporation Change in Control Severance Plan, Effective January 1, 2016.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on November 6, 2015, Commission File Number 1-16811.
(ggg)	United States Steel Corporation Change in Control Severance Plan, Amended and Restated Effective July 28, 2020*.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on July 30, 2020, Commission File Number 1-16811.
(hhh)	United States Steel Corporation Executive Severance Plan, Effective December 14, 2021.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on December 20, 2021, Commission File Number 1-16811.
(iii)	United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Effective April 26, 2016.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on April 27, 2016, Commission File Number 1-16811.

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(jjj)	First Amendment to United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Effective February 28, 2017.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on April 26, 2017, Commission File Number 1-16811.
(kkk)	United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Amended and Restated Effective April 28, 2020*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 8-K filed on May 1, 2020, Commission File Number 1-16811.
(lll)	United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Amended and Restated Effective April 27, 2021.*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on April 30, 2021, Commission File Number 1-16811.
(mmm)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Restricted Stock Unit Grant Agreement (Retention Grant)*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on July 27, 2016, Commission File Number 1-16811.
(nnn)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Restricted Stock Unit Grant Agreement (Annual Grant)*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on July 27, 2016, Commission File Number 1-16811
(ooo)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan (Stock Option Grant).*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on July 27, 2016, Commission File Number 1-16811.
(ppp)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Restricted Stock Unit Grant Agreement (Annual Grant).*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on April 27, 2018, Commission File Number 1-16811.
(qqq)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Restricted Stock Unit Grant Agreement (Retention Grant).*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on April 27, 2018, Commission File Number 1-16811.
(rrr)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Share Award Grant Agreement (TSR Grant).*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on April 27, 2018, Commission File Number 1-16811.
(sss)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Share Award Grant Agreement (ROCE Grant).*	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-Q filed on April 27, 2018, Commission File Number 1-16811.
(ttt)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Share Award Grant Agreement (TSR Grant).*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on May 3, 2019, Commission File Number 1-16811.
(uuu)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Cash Award Grant Agreement (ROCE Grant).*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on May 1, 2020, Commission File Number 1-16811.
(vvv)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Restricted Stock Unit Grant Agreement (Retention Grant).*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on May 1, 2020, Commission File Number 1-16811.
(www)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Share Award Grant Agreement (2021 Grants).*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on April 30, 2021, Commission File Number 1-16811.
(xxx)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Cash Award Grant Agreement (2021 Grants).*	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 10-Q filed on April 30, 2021, Commission File Number 1-16811.
(yyy)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Restricted Stock Unit Grant Agreement (2021 Grants).*	Incorporated by reference to Exhibit 10.6 to United States Steel Corporation's Form 10-Q filed on April 30, 2021, Commission File Number 1-16811.
(zzz)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Retention Restricted Stock Unit Grant Agreement (2021 Grants).*	Incorporated by reference to Exhibit 10.7 to United States Steel Corporation's Form 10-Q filed on April 30, 2021, Commission File Number 1-16811.
(yyy)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan TSR Performance Share Award Grant Agreement (2021 Grants).*	Incorporated by reference to Exhibit 10.8 to United States Steel Corporation's Form 10-Q filed on April 30, 2021, Commission File Number 1-16811.
(aaaa)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Share Award Grant Agreement (2021 SVP Performance Awards)* **	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(bbbb)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Share Award Grant Agreement (2021 CEO Performance Award)* **	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.

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(cccc)	Form of United States Steel Corporation 2016 Omnibus Incentive Compensation Plan Performance Non-Qualified Stock Option Grant Agreement (2021 CEO PSO)* **	Incorporated by reference to Exhibit 10.6 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(dddd)	Form of United States Steel Corporation 2016 Omnibus Incentive Plan Performance Share Award Grant Agreement (ROCE Grant)*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on April 29, 2022, Commission File Number 1-16811.
(eeee)	Form of United States Steel Corporation 2016 Omnibus Incentive Plan Performance Share Award Grant Agreement (TSR Grant)*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on April 29, 2022, Commission File Number 1-16811.
(ffff)	Administrative Procedures for the Executive Management Annual Compensation Incentive Program under the United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Effective February 27, 2018.*	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 10-Q filed on April 27, 2018, Commission File Number 1-16811.
(gggg)	Administrative Procedures for the Executive Management Annual Incentive Compensation Plan under the United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Effective February 26, 2019.*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-Q filed on May 3, 2019, Commission File Number 1-16811.
(hhhh)	Administrative Procedures for the Executive Management Annual Incentive Compensation Plan under the United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Effective February 25, 2020.*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-Q filed on May 1, 2020, Commission File Number 1-16811.
(iiii)	Administrative Procedures for the Executive Management Annual Incentive Compensation Plan under the United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Effective February 23, 2021.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on April 30, 2021, Commission File Number 1-16811.
(jjjj)	United States Steel Corporation Deferred Compensation Program for Non-Employee Directors, a program under the United States Steel Corporation 2016 Omnibus Incentive Plan, effective as of July 26, 2016, as amended on October 30, 2018.*	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-K filed on February 15, 2019, Commission File Number 1-16811.
(kkkk)	United States Steel Corporation Deferred Compensation Program for Non-Employee Directors, a program under the United States Steel Corporation 2016 Omnibus Incentive Plan, effective as of July 26, 2016, as amended on October 28, 2019.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-K filed on February 14, 2020, Commission File Number 1-16811.
(llll)	United States Steel Corporation Deferred Compensation Program for Non-Employee Directors, a program under the United States Steel Corporation 2016 Omnibus Incentive Compensation Plan, Effective January 1, 2022.*	Incorporated by reference to Exhibit 10.7 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(mmmm)	United States Steel Corporation Non-Employee Director Stock Program of the 2016 Omnibus Incentive Compensation Plan, Effective November 1, 2019.*	Incorporated by reference to Exhibit 10.2 to United States Steel Corporation's Form 10-K filed on February 14, 2020, Commission File Number 1-16811.
(nnnn)	United States Steel Corporation Non-Employee Director Compensation Policy, Effective as of January 1, 2022.*	Incorporated by reference to Exhibit 10.8 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(oooo)	Letter Agreement between Scott D. Buckiso and United States Steel Corporation, dated July 30, 2020.*	Incorporated by reference to Exhibit 10.4 to United States Steel Corporation's Form 10-K filed on February 12, 2021, Commission File Number 1-16811.
(pppp)	Separation Agreement and Release by and between Kevin P. Bradley and United Stated Steel Corporation, dated October 7, 2019.*	Incorporated by reference to Exhibit 10.3 to United States Steel Corporation's Form 10-K filed on February 14, 2020, Commission File Number 1-16811.
(qqqq)	Separation Agreement and Release by and between Douglas R. Matthews and United States Steel Corporation, dated December 24, 2020.*	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-K filed on February 12, 2021, Commission File Number 1-16811.
(rrrr)	Form of Offer Letter to Kenneth E. Jaycox Jr., dated September 19, 2020.*	Incorporated by reference to Exhibit 10.9 to United States Steel Corporation's Form 10-K filed on February 11, 2022, Commission File Number 1-16811.
(ssss)	Special Transition Agreement and Release by and between Christine S. Breves and United States Steel Corporation, dated February 15, 2022.	Incorporated by reference to Exhibit 10.1 to United States Steel Corporation's Form 10-Q filed on April 29, 2022, Commission File Number 1-16811.

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(tttt)	Form of Offer Letter to Jessica T. Graziano, dated June 6, 2022.**	Incorporated by reference to Exhibit 10.5 to United States Steel Corporation's Form 10-Q filed on July 29, 2022, Commission File Number 1-16811.

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10.1	**Amendment No. 1 to Sixth Amended and Restated Credit Agreement, dated as of December 19, 2022, among United States Steel Corporation, the Subsidiary Guarantors from time to time party thereto, the Lenders party thereto, the LC Issuing Banks party thereto, and JPMorgan Chase Bank, N.A., as Administrative and Collateral Agent.****
10.2	**Third Amendment to ABL Credit Agreement by and among Big River Steel LLC, BRS Intermediate Holdings LLC, Goldman Sachs Bank USA and each lender party thereto, dated as of December 19, 2022.****
10.3	**First Supplemental Agreement, dated December 15, 2022, between U. S. Steel Košice, s.r.o., and ING Bank N.V., as Facility Agent, relating to an up to EUR 300,000,000 credit agreement dated September 29, 2021.****
21	**List of Subsidiaries**
23	**Consent of PricewaterhouseCoopers LLP**
24	**Powers of Attorney**
31.1	**Certification of Chief Executive Officer required by Rules 13a-14(a) or 15d-14(a) of the Securities Exchange Act of 1934, as promulgated by the Securities and Exchange Commission pursuant to Section 302 of the Sarbanes-Oxley Act of 2002**
31.2	**Certification of Chief Financial Officer required by Rules 13a-14(a) or 15d-14(a) of the Securities Exchange Act of 1934, as promulgated by the Securities and Exchange Commission pursuant to Section 302 of the Sarbanes-Oxley Act of 2002**
32.1	**Certification of Chief Executive Officer Pursuant to 18 U.S.C. Section 1350, as Adopted Pursuant to Section 906 of the Sarbanes-Oxley Act of 2002**
32.2	**Certification of Chief Financial Officer Pursuant to 18 U.S.C. Section 1350, as Adopted Pursuant to Section 906 of the Sarbanes-Oxley Act of 2002**
95	**Mine Safety Disclosure required under Section 1503 of the Dodd-Frank Wall Street Reform and Consumer Protection Act**
101	**The following financial information from United States Steel Corporation's Annual Report on Form 10-K for the year ended December 31, 2022 formatted in Inline XBRL (Extensible Business Reporting Language) includes: (i) the Consolidated Statement of Operations, (ii) the Consolidated Statement of Comprehensive Income (Loss), (iii) the Consolidated Balance Sheet, (iv) the Consolidated Statement of Cash Flows, and (v) Notes to the Consolidated Financial Statements.**
104	**Cover Page Interactive Data File (formatted as Inline XBRL and contained in Exhibit 101)**

* Indicates management contract or compensatory plan or arrangement.
** Schedules and exhibits have been omitted pursuant to Item 601(b)(2) of Regulation S-K. The Corporation hereby undertakes to furnish supplemental copies of the omitted schedules and exhibits upon request by the U.S. Securities and Exchange Commission.

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SCHEDULE II – VALUATION AND QUALIFYING ACCOUNTS AND RESERVES
YEARS ENDED DECEMBER 31, 2022, 2021 AND 2020
(millions of dollars)

Description	Balance at Beginning of Period	Additions: Charged to Costs and Expenses	Additions: Charged to Other Accounts	Deductions: Charged to Costs and Expenses	Deductions: Charged to Other Accounts	Balance at End of Period
Year ended December 31, 2022:						
Reserves deducted in the balance sheet from the assets to which they apply:						
Allowance for doubtful accounts	**$ 44**	**$ 17**	**$ —**	**$ —**	**$ 23**	**$ 38**
Investments and long-term receivables reserve	**4**	**—**	**—**	**—**	**—**	**4**
Deferred tax valuation allowance:						
Domestic	**159**	**18**	**—**	**61**	**—**	**116**
Foreign	**3**	**—**	**—**	**—**	**—**	**3**
Year ended December 31, 2021:						
Reserves deducted in the balance sheet from the assets to which they apply:						
Allowance for doubtful accounts	$ 34	$ 16	$ 4	$ —	$ 10	$ 44
Investments and long-term receivables reserve	5	—	—	—	1	4
Deferred tax valuation allowance:						
Domestic	793	86	25	745	—	159
Foreign	3	—	—	—	—	3
Year ended December 31, 2020:						
Reserves deducted in the balance sheet from the assets to which they apply:						
Allowance for doubtful accounts	$ 28	$ 6	$ 2	$ —	$ 2	$ 34
Investments and long-term receivables reserve	5	—	3	—	3	5
Deferred tax valuation allowance:						
Domestic	560	240	2	—	9	793
Foreign	3	—	—	—	—	3

Item 16. FORM 10-K SUMMARY

None.

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SIGNATURES

Pursuant to the requirements of Section 13 or 15(d) of the Securities Exchange Act of 1934, the Registrant has duly caused this report to be signed on its behalf by the undersigned, thereunto duly authorized.

Date: February 3, 2023

UNITED STATES STEEL CORPORATION

By: */s/ Manpreet S. Grewal*
Manpreet S. Grewal
Vice President, Controller & Chief Accounting Officer

Signature	Title
/s/ David B. Burritt **David B. Burritt**	President & Chief Executive Officer & Director (Principal Executive Officer)
/s/ Jessica T. Graziano **Jessica T. Graziano**	Senior Vice President & Chief Financial Officer (Principal Financial Officer)
/s/ Manpreet S. Grewal **Manpreet S. Grewal**	Vice President, Controller & Chief Accounting Officer (Principal Accounting Officer)
* **Tracy A. Atkinson**	Director
* **Andrea J. Ayers**	Director
* **Terry L. Dunlap**	Director
* **John J. Engel**	Director
* **John V. Faraci**	Director
* **Murry S. Gerber**	Director
* **Jeh C. Johnson**	Director
* **Paul A. Mascarenas**	Director
* **Michael H. McGarry**	Director
* **David S. Sutherland**	Board Chair
* **Patricia A. Tracey**	Director

* **BY:** */s/ Manpreet S. Grewal*
Manpreet S. Grewal
Attorney-in-Fact

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GLOSSARY OF CERTAIN DEFINED TERMS

The following definitions apply to terms used in this document:

2026 Senior Convertible Notes	Senior Convertible Notes due November 1, 2026
2052 ADFA Green Bonds	Arkansas Development Finance Authority Environmental Improvement Revenue Bonds due 2052
401(k) plans	defined contribution plans
ABL	Asset-Based Loan
ABO	Accumulated Benefit Obligation
ACHD	Allegheny County Health Department
AD	antidumping
AD/CVD	antidumping and countervailing duty
ADFA	Arkansas Development Finance Authority
AHSS	advanced high-strength steel
AISI	American Iron and Steel Institute
AOCI	Accumulated Other Comprehensive Income
ARO	Asset Retirement Obligation
ARPA	American Rescue Plan Act
ASC	Accounting Standards Codification
ASU	Accounting Standards Update
BART	Best Available Retrofit Technology
BAT	Best Available Technique
Big River Steel ABL Facility	Big River Steel amended senior secured asset-based revolving credit facility
BOF	Basic Oxygen Furnace Steelmaking
BOP	Basic Oxygen Process
BR2	Big River 2
BRS	Big River Steel
CAA	Clean Air Act
CAFC	U.S. Court of Appeals for the Federal Circuit
CAFE	Corporate Average Fuel Economy
CAMT	corporate alternative minimum tax
CAMU	Corrective Action Management Unit
CDC	Chrome Deposit Corporation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CIT	U.S. Court of International Trade
CMS	Corrective Measures Study
CNIT	corporate net income tax
CO2	carbon dioxide
commodity purchase swaps	financial swaps associated with purchases of natural gas, zinc, tin and electricity
COSO	Committee of Sponsoring Organizations of the Treadway Commission
cost cap	Steel benefit plan
Credit Facility Agreement	Sixth Amended and Restated Credit Facility Agreement
CVD	countervailing duties
CWA	Clean Water Act
DAFW	OSHA Days Away From Work
DOC	U.S. Department of Commerce
DOJ	The United States Department of Justice
Double G	Double G Coatings Company LLC
DR	direct reduced
DRI	direct reduced iron
EAF	Electric Arc Furnace
EBITDA	earnings before interest, taxes, depreciation and amortization
EC	European Commission
ECA	Export Credit Agreement
EGU	electric generating unit
EPS	earnings per share
ERGs	employee resource groups
ERISA	Employee Retirement Income Security Act of 1974
ERW	electric resistance welded

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ESG	environmental, social and governance
ETS	Emissions Trading System
EU	European Union
EU ETS	EU Emissions Trading System
EUA	European Union Emission Allowances
EWPM	electric-weld pipe mil
Agreement	Export-Import Transaction Specific Loan and Security Agreement
FASB	Financial Accounting Standards Board
FIFO	first in, first out
FIP	Federal Implementation Plan
Agreement	Fifth Amended and Restated Credit Facility Agreement
Flat-Rolled	North American Flat-Rolled segment
foreign exchange forwards	foreign exchange forward sales contracts
FX	foreign exchange
GAAP	Generally Accepted Accounting Principles
Gateway	Gateway Energy and Coke Company LLC
GEN3	generation 3
GHG	greenhouse gas
GLNPO	Great Lakes National Program Office
Green Steels	steels made with low greenhouse gas emissions intensity
HBI	hot briquetted iron
HDC	Hibbing Development Company
Hibbing	Hibbing Taconite Company
IEPA	Illinois Environmental Protection Agency
IRS	Internal Revenue Service
ISO	International Organization for Standardization
ITC	U.S. International Trade Commission
KDHE	Kansas Department of Health & Environment
Keetac	U. S. Steel's iron ore operations at Keewatin, Minnesota
LIFO	last in, first out
MACT	Maximum Achievable Control Technology
Midwest	Midwest Plant
Minntac	U. S. Steel's iron ore operations at Mt. Iron, Minnesota
mmbtus	Metric Million British Thermal Units
mnt	thousand net tons
MPCA	Minnesota Pollution Control Agency
NAAQS	National Ambient Air Quality Standards
NAV	net asset value
NESHAP	National Emission Standards for Hazardous Air Pollutants
NGO	non-grain oriented
NOV	Notice of Violation
NOx	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
OCTG	oil country tubular goods
OEM	original equipment manufacturer
Order	Administrative Order on Consent
Other Benefits	defined benefit retiree health care and life insurance plans
Patriot	Patriot Premium Threading Services, LLC
PCAOB	Public Company Accounting Oversight Board (United States)
PII	Personally Identifiable Information
PM	Particulate Matter
PPA	Pension Protection Act of 2006
ppb	parts per billion
PRO-TEC	PRO-TEC Coating Company, U. S. Steel and Kobe Steel Ltd. joint venture
PRP	potentially responsible party
PSU	Performance-based restricted Stock Unit
RCRA	Resource Conservation and Recovery Act

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RFI	RCRA Facility Investigation
ROCE	Return On Capital Employed
RP	Rehabilitation plan
RSU	Restricted Stock Unit
S&P	Standard & Poor’s
sales swaps	financial swaps hot-rolled coil and iron ore pellet sales
SAO	Settlement Agreement and Order
SEC	Securities and Exchange Commission
SIP	State Implementation Plan
SO2	Sulfur dioxide
SPT	Steelworkers Pension Trust
SSS	site-specific standard
Stelco	Stelco Inc.
sustainable steels	steels made with low greenhouse gas emissions
SWMU	Solid Waste Management Units
the 2005 Plan	2005 Stock Incentive Plan
the 2022 Labor Agreements	collective bargaining agreements with United Steelworkers effective September 1, 2022
the Committee	the Compensation & Organization Committee of the Board of Directors
the "Company"	United States Steel Corporation and its subsidiaries
the Exchange Act	the Securities Exchange Act of 1934
the "Insurers"	Banner Life Insurance Company and William Penn Life Insurance Company of New York
the insurer	Pacific Life Insurance Company
the Minntac Mine	iron ore mine located in Mt. Iron, Minnesota
the Omnibus Plan	2016 Omnibus Incentive Compensation Plan, as amended and restated
USSK Credit Agreement	USSK €300 million unsecured sustainability linked credit agreement
TRQ	tariff rate quotas
Transtar	Transtar LLC and its direct and indirect subsidiaries
TSR	Total Shareholder Return
Tubular	Tubular Products segment
U. S. Steel	United States Steel Corporation
U.S. EPA	United States Environmental Protection Agency
U.S. GAAP	accounting standards generally accepted in the United States
UDEQ	Utah Department of Environmental Quality
ug/m3	micrograms per cubic meter
UK	United Kingdom
UPI	USS-POSCO Industries
USSE	U. S. Steel Europe segment
USSK	U. S. Steel Košice
USSTP	U. S. Steel Tubular Products LLC
USTR	United States Trade Representative
USW	United Steelworkers
USX	United States Steel Corporation
VEBA	trusts for retiree healthcare and life insurance
VERP	voluntary early retirement program
welded	seamless and electric resistance welded
Worthington	Worthington Specialty Processing, U. S. Steel and Worthington Industries, Inc. joint venture
WOTUS	Waters of the United States
WTO	World Trade Organization
WQS	water quality standard

Project - City of Hermantown

I WANT TO ▾ RESIDENTS ▾ COMMUNITY ▾ BUSINESS ▾ GOVERNMENT ▾ DEPARTMENTS ▾

Information Regarding Potential Google Data Center | LEARN MORE

TOWN Minnesota

/

PROJECT

With the potential for a Google data center project in Hermantown under evaluation, the City has created the following webpage to provide information throughout the process. This page will be updated at times, so please check back for new information.

Questions and Answers (and Updates)

+ Why am I just learning about this?
+ What is the potential project?
+ Why this location?
− What about jobs?

Job creation is an important part of this project. Construction on this multi-building proposal would occur steadily over an 8-10 year window and employ hundreds of construction workers. As noted by local labor groups at a recent City Council meeting, they have the local workforce and are excited about this possibility, both the project and the timeframe.

There will also be skilled technical roles associated with the long-term operation of this communication services facility. There will be at least 40 full-time positions associated with the initial building, all paying wages higher than the current county average. There may be 100 or more roles at full build out.

Additionally, local suppliers and vendors will also see benefits through the selection of construction, operational contracts, and complementary capabilities that aid in this prospective project. To note; traditionally the data center industry supports more than six jobs for every single job at the data center itself.

+ What about water usage?
+ What about energy usage?
+ What about noise?
+ What about traffic?
+ What about wetlands?
+ What is an AUAR and why was it used?
+ What about taxes?

Page Updated: October 22, 2026

Update: As part of the October 20, 2026, Hermantown Planning & Zoning Commission meeting, an in-depth presentation was given for Google's requested Special Use Permit (SUP). The full video from that presentation is found below. The Planning & Zoning Commission voted to recommend the project to be approved by the Hermantown City Council.

Special Use Permit Presentation – October 20

Additionally, video from the October 19, 2026, City Council meeting regarding the updated agreements – including a first-of-its-kind decommissioning agreement – and Google's announcement that it will no longer seek abatement is also available below.

Agreement Updates – October 19, City Council Video

Update: At the October 19, 2026, Hermantown City Council meeting, Google announced it was no longer seeking abatement for this proposed data center project, as well as a first-of-its-kind decommissioning agreement. This followed a previous announcement by Google and the City of Hermantown on October 14, 2026.

Without an abatement agreement, Google will pay 100 percent of its property taxes, estimated at more than $210 million in City and St. Louis County taxes over the first 20 years after project completion. Specifically, in Hermantown, the project will generate just shy of $3 million annually in taxes upon completion, more than the City's entire current commercial tax base.

Google also committed to a Decommissioning Agreement that protects the City if the project is no longer used as a data center.

Additional updates to the Development Agreement were outlined, including protections for neighboring wells.

The full outline presented at the City Council Meeting on October 19 can be viewed below.

Agreement Updates – October 19, City Council Presentation Slides

Update: At the October 5, 2026, Hermantown City Council meeting, the 2026 Final Alternative Urban Areawide Review (AUAR) was adopted by the Hermantown City Council. This AUAR can be found in the agenda for the October 5 meeting, as well as at the link below.

AUAR – October 5 City Council Agenda

Update: At the September 21, 2026, Hermantown City Council Meeting, Google provided an update on changes to the project based on public feedback. Additionally, Google provided updates on planned community giving in the region beyond its commitments to the City of Hermantown and Hermantown Community Schools. The slides and video from that presentation can be found below.

September 21 – Google Update Presentation

September 21 – Google Update Slides

Additionally, information from the Environmental Quality Board (EQB) website regarding Minnesota Power's proposed 230-kilovolt transmission lines is now available.

Environmental Quality Board – 230 kV Transmission Line Project

Update: The Minnesota Department of Natural Resources (MNDNR) submitted letters as part of the AUAR process – in April, as part of the comment period, as well as in August, during what is called the objection period. The August comment letter, however, clearly states that the MNDNR submittal was not a formal objection.

Project - City of Hermantown

MNDNR – Updated Hermantown AUAR

– MNDNR – Hermantown AUAR Follow-Up

ber 4 – MNDNR – City of Hermantown AUAR Response to MNDNR

September 10 – MNDNR – City of Hermantown Response Follow-Up

Update: The final Google presentation from the week of August 17 is available below. The video and slides are from the Thursday, August 20, City Council work session.

City Council Work Session Video – August 20

City Council Work Session Presentation Slides – August 20

Update: During the week of August 17, Google held a series of informational updates regarding the proposed data center project. The first was at the Monday, August 17, City Council Meeting, followed by the Tuesday, August 18, Planning and Zoning Commission Meeting. The Monday presentation also included updates on the public infrastructure improvements.

Materials from those meetings, as well as the video of the Planning and Zoning presentation, are available below.

Planning and Zoning Presentation Video – August 18

Planning and Zoning Presentation Slides – August 18

City Council Presentation Slides – August 17

City Council Public Infrastructure Slides – August 17

Update: On August 12, the City of Hermantown posted updated project application materials for the proposed Google data center. These materials are being made available to the public in advance of any consideration of potential action by the Planning & Zoning Commission or City Council. Upcoming August meetings for both the City Council and Planning & Zoning Commission will feature presentations and work sessions associated with the proposed project, but the meetings do not have actions on the respective agendas. No actions will be taken regarding this proposed project without completion of the environmental review.

Application – Special Use Permit

Architectural Elevations – Mechanical Building

Architectural Elevations – Office Building

Architectural Elevations – Primary Building

Landscape – Street Section

Photometric Plans

Site Development Plans

Stormwater Management Plans

Traffic Memo – Construction

Traffic Memo – Operations

Acoustic Memorandum

Photometric Overlay

Update: On August 4, the City of Hermantown submitted the updated AUAR to the Environmental Quality Board (EQB). That document and associated appendices can be viewed in the links below. It will also be posted to the EQB Monitor on August 11. A link to the EQB website can be found below in the July 27 update.

Final – Hermantown Industrial AUAR

Appendices A-C

Appendix D

Appendix E

Appendix F

Appendix G

Appendices H-I

Appendix J

Appendix K

Update: On July 27, the City of Hermantown held a City Council Work Session focused on the AUAR itself, the AUAR process, as well as water uses for Google's proposed data center project. That meeting and materials can be viewed at the link below.

July 27, 2026 – City Council Work Session

July 27, 2026 – Presentation

Additionally, access to the documents and appendices of the 2025 and 2026 AUAR processes can be found on the Environmental Quality Board website below.

Environmental Quality Board – Hermantown AUAR

Update: On July 14, Appendix F was updated at the request of the State Historic Preservation Office because portions of the information were deemed non-public data.

Update: In alignment with the June 11, 2026, posting of the Draft AUAR and Mitigation Plan, the City of Hermantown has also opened the public comment period associated with those documents. The comment period runs through July 16, 2026. More information on the process can be found in the following press release.

City of Hermantown – Press Release

Update: The City of Hermantown has prepared a Draft AUAR and Mitigation Plan for the Updated Hermantown Industrial project. The AUAR document is available below for viewing as of June 11, 2026. Due to the document's size, it is divided into several links.

Public comments for the Draft AUAR and Mitigation Plan will be received until 4 p.m. on July 16, 2026. Written comments and project questions should be submitted to AUARComments@hermantownmn.com

Draft AUAR – Main Body

Draft AUAR – Appendix A

Project - City of Hermantown

– Appendix E, F, G, H, I*

and K, which focus on comments, are pending.

s part of the agenda for the May 18, 2026, the Hermantown City Council will consider a resolution accepting the scoping document for the Alternative Urban Areawide Review (AUAR) and moving forward with the preparation of the Draft AUAR.

Information about the action, including the scoping document and public comments, is available in the May 18, 2026, agenda packet.

May 18 – City Council Agenda Packet

Update: As part of the May 4, 2026, Hermantown City Council Meeting, there was a trio of presentations regarding the proposed development agreement and tax abatement agreement. Those three presentations can be viewed at the links below. The City Council chose to table the resolution regarding the agreements after the conclusion of the May 4, 2026, public hearing.

City of Hermantown Agreements Presentation

Ehlers Tax Abatement Presentation

Google's Hermantown Data Center Presentation

Update: On April 29, 2026, The City updated the proposed development agreement and tax abatement agreements with Google based on the discussion at the April 20 City Council Work Sessions. The updated agreements can be found at the links below.

Update: On April 23, 2026, a notice was included in the Hermantown Star regarding a public hearing scheduled for May 4, 2026, as part of the City Council Meeting. The hearing will focus on a potential abatement agreement and development agreement for this project. The notice and agreements are available at the links below.

The proposed agreements are also included on the City Council Work Session Agenda for April 27, 2026.

Notice of Public Hearing

Proposed Abatement Agreement – Updated Final Language

Proposed Development Agreement – Updated Final Language

Update: On April 20, 2026, the City of Hermantown presented on an economic impact analysis performed by UMD's Bureau of Business and Economic Research (BBER). The study outlined five real-life development scenarios that explored our region, but did not happen due to the lack of large, available sites with city water and sewer.

This study did not include any data center analysis, as that is an in-progress possibility for the region at this time.

Key findings from all five scenarios included the creation of more than 1,500 jobs, an addition of nearly $110 million in labor income annually to the county, approximately $5 million in annual county and local tax revenues, and more than $600 million in annual economic output.

The presentation can be found below, along with a link to the study itself.

City of Hermantown Presentation

UMD's Bureau of Business and Economic Research Analysis

Update: On March 31, 2026, the comment period for the scoping document of an updated AUAR began. The AUAR study area includes 26 parcels totaling 278 acres in Hermantown's southwest corner. This study has a smaller geographic footprint and scale than the initial AUAR study adopted in October of 2025. The City of Hermantown and Google jointly agreed to an updated AUAR study with current information and greater specificity.

The AUAR scoping document and City of Hermantown press release can be found below.

AUAR Scoping Document

City of Hermantown Press Release

Update: On March 12, 2026, Mayor Wayne Boucher announced the restart of the AUAR environmental review process, in partnership with Google, to provide greater clarity and transparency regarding the potential project. Hermantown's City Council took an initial step forward in that process on Monday, March 16, 2026, by approving a contract with Braun Intertec Corporation to provide third-party technical review associated with the AUAR.

Additionally, Minnesota Power presented at the March 16, 2026, pre-agenda meeting regarding its efforts to create an electric service agreement with Google. The presentation included process information and the protections in place for Minnesota Power's current residents and business customers.

Minnesota Power – March 16 Presentation

Agendas and minutes for all City Council Meetings are available on Hermantown's Public Portal.

Update: On March 3, 2026, Google announced plans for a data center project in Hermantown. Information regarding that announcement is available below.

City of Hermantown Press Release

Minnesota Power Press Release

Hermantown Chamber of Commerce Press Release

Process Update: On November 10, the City received an update from Mortenson removing any upcoming applications from the Planning & Zoning Commission and City Council agendas to allow for further public engagement.

The letter can be read here.

The City of Hermantown received a lawsuit regarding this project on November 5. At this time, the city will conduct the appropriate review and due diligence and follow the legal process.

The Environmental Quality Board (EQB) received a petition on October 17, 2025, requesting that an Environmental Assessment Worksheet (EAW) be prepared for the data center project proposed in Hermantown.

On December 3, 2025, the City responded to the petition received by the Environmental Quality Board (EQB) in October.

That response can be found here.

It is appropriate for Hermantown to pause the consideration of the previously scheduled Special Use Permit (SUP) and Commercial Industrial Development Permit (CIDP) by the City's Planning and Zoning Commission at its October 21 meeting.

Traditionally, the inclusion of a permit in the Planning and Zoning commission agenda is the point at which people first learn about a project – but this unique project has followed a different public path.

The current pause to perform this important environmental step allows time for the public to review the proposal, as well as for the potential scheduling of more informational meetings. Please review the information below from the application and past meetings, and check back for updates as more information becomes available.

- View Fox 21 Discussion regarding the EQB pause, process, and project
- View WDIO full interview regarding the possible data center project
- SUP & CIDP Applications/Information
    - *The above is the original Planning & Zoning Agenda before the items were removed*

Information Regarding Potential Google Data Center | LEARN MORE

udy elements from the proposed project are available below.

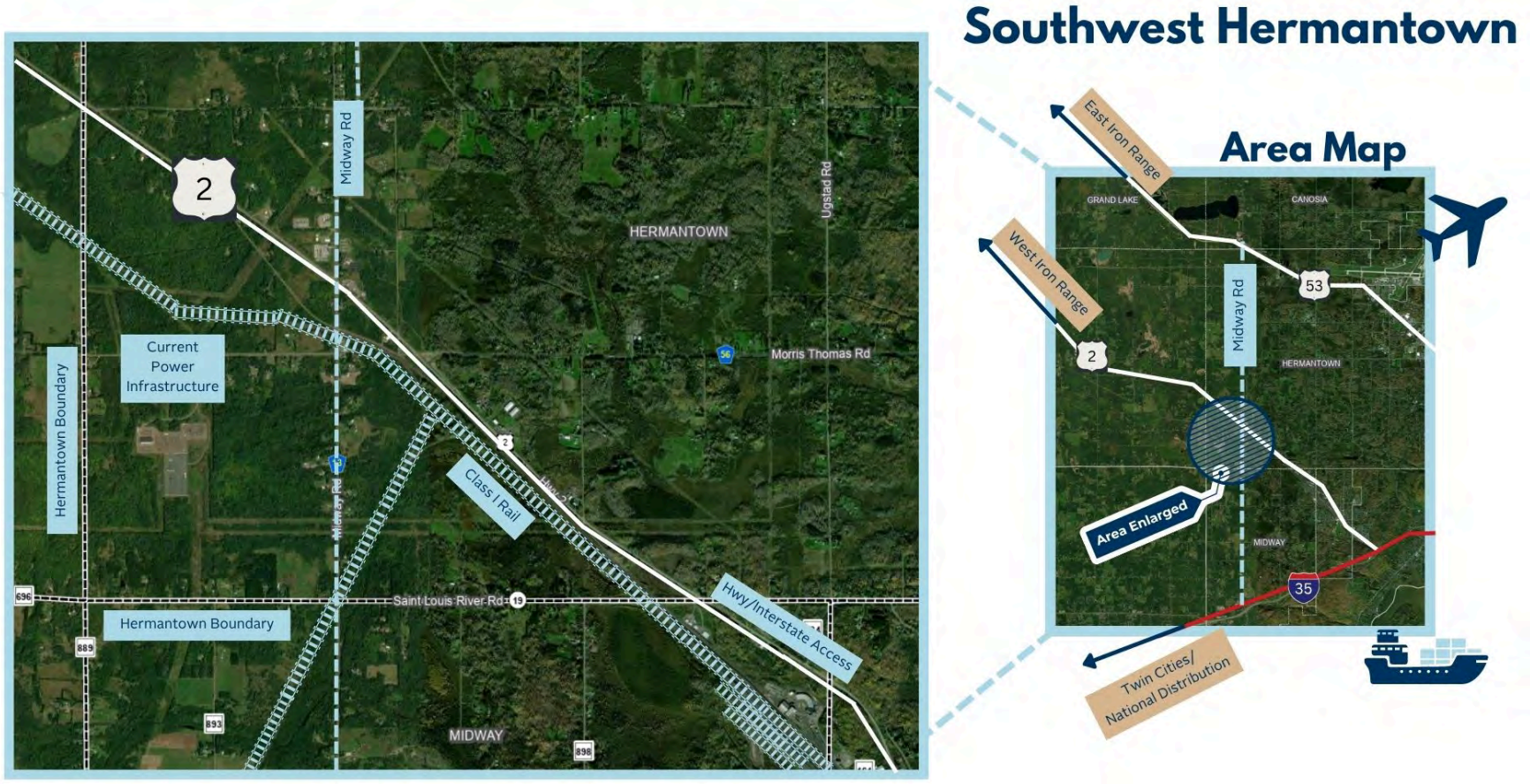
- oustic Study
- Stormwater Management Report
- Traffic Analysis
- Architectural Narrative
- Site Development Plan
- Landscape Rendering
- Landscape Sections

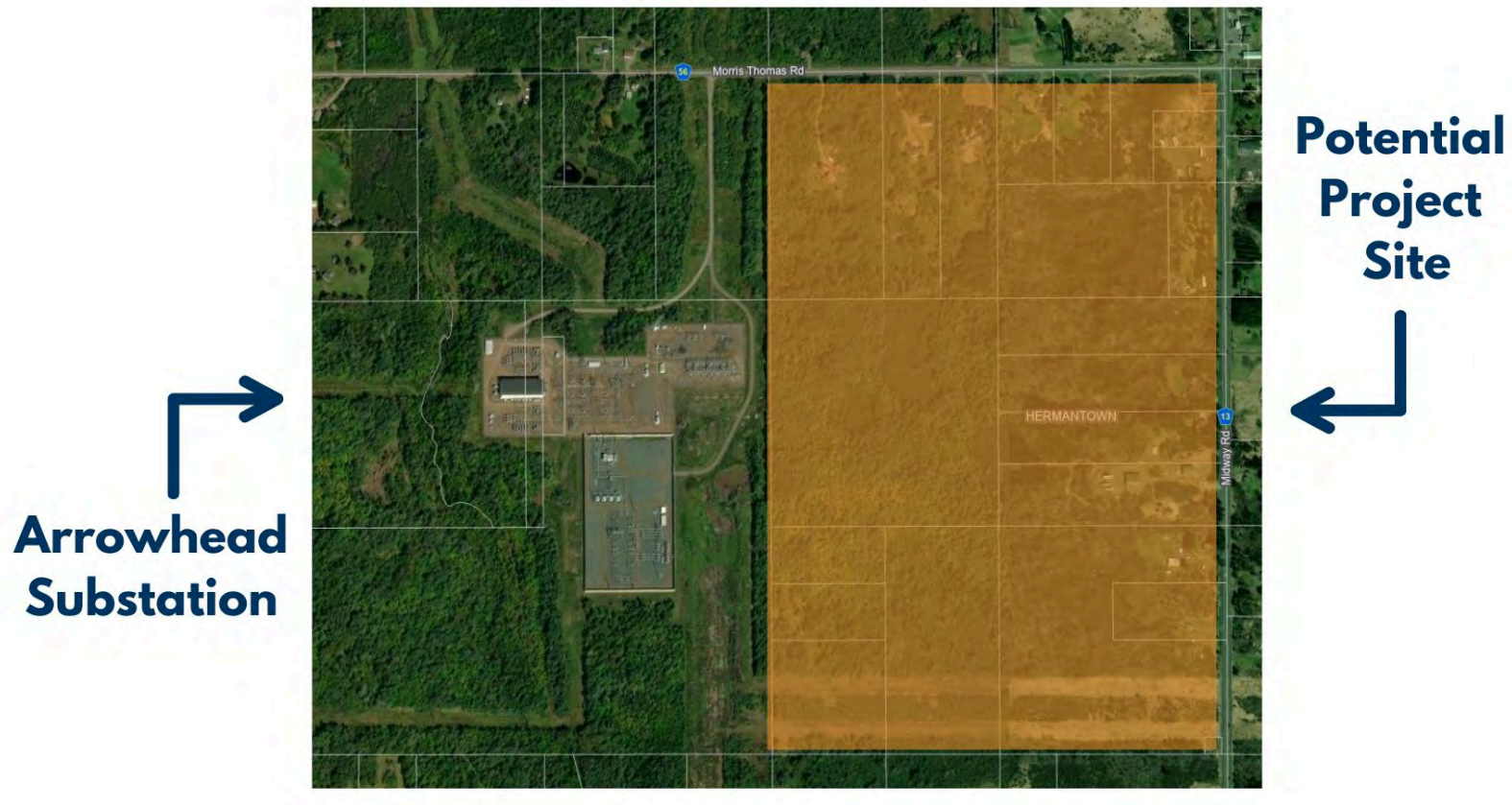
Read Western Lake Superior Sanitary District's recent blog regarding data centers and wastewater.

- WLSSD Resource Renew October 22 Blog

View Minnesota Power's information regarding data centers.

- Minnesota Power Information Fact Sheet
- Minnesota Power Official Letter to Elected and Appointed Officials





Project - City of Hermantown

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Schedule 7 – Minnesota Power Retail Operations MWh Sales Commission Approved Test Year vs. 2025 Actual Sales

	2024 MPUC Approved Test Year	2025 Sales	Difference (MWh)	% Difference
Residential	1,046,133	1,022,157	(23,976)	-2.3%
Commercial	1,199,709	1,163,861	(35,848)	-3.0%
Industrial				
Mining and Metals	5,012,543	4,049,405	(963,138)	-19.2%
Forest Products	723,330	723,531	201	0.0%
Pipelines	310,455	320,046	9,591	3.1%
Other Industrial	285,349	265,765	(19,584)	-6.9%
Total Industrial	6,331,677	5,358,747	(972,930)	-15.4%
Public Authorities & Lighting	50,166	51,521	1,355	2.7%
Total Retail	**8,627,685**	**7,596,286**	**(1,031,399)**	**-12.0%**
Municipals	468,779	481,489	12,710	2.7%
SWLP	994,294	1,085,972	91,678	9.2%
Total Retail and Wholesale	**10,090,758**	**9,163,747**	**(927,011)**	**-9.2%**

Schedule 1 – Minnesota Power Retail Operations
MWh Sales and Customer Counts 2027 Test Year.

	2027 Forecast (2026 AFR)	2027 Test Year	Difference (MWh)	% Difference
Residential	1,027,912	1,027,912	-	0.0%
Commercial	1,177,148	1,177,148	-	0.0%
Industrial		-		
Mining and Metals	4,046,994	4,036,704	(10,290)	-0.3%
Forest Products	701,977	729,435	27,458	3.9%
Pipelines	338,901	319,723	(19,178)	-5.7%
Other Industrial	266,280	259,848	(6,432)	-2.4%
Total Industrial	5,354,152	5,345,710	(8,442)	-0.2%
Public Authorities & Lighting	51,604	51,604	-	0.0%
Total Retail	**7,610,816**	**7,602,374**	**(8,442)**	**-0.1%**
Municipals	481,776	761,560	279,785	58.1%
SWLP	1,091,713	1,082,570	(9,143)	-0.8%
Total Retail and Wholesale	**9,184,305**	**9,446,504**	**262,199**	**2.9%**

DEPARTMENT OF REVENUE

Production Tax

2025 Taconite Production Tonnage by Product Type

Producer	Pellets			Chips and Fines			DRI/Iron Nuggets	Total Tons by Mine
	Acid	Fluxed	Partial Fluxed	Acid	Fluxed/ Partial Fluxed	Concentrate	Nuggets	
Hibbing Taconite	---	---	2,666,318	---	---	---	---	2,666,318
Keewatin Taconite	---	---	4,976,048	---	0	12,221	---	4,988,269
Northshore	---	---	3,129,891	---	58,289	0	---	3,188,180
Minntac	0	12,441,857	0	---	0	---	---	12,441,857
Minorca	0	544,878	0	---	0	---	---	544,878
United Taconite	---	1,317,893	3,377,708	---	0	0	---	4,695,601
Total Tons	**0**	**14,304,628**	**14,149,965**	**0**	**58,289**	**12,221**	**0**	**28,525,103**

Notes:
Partially fluxed pellets contain less than 2 percent flux.

1/27/26 • Investors

Vale's Production and Sales in 4Q25 and 2025

Vale delivered strong operational results in 2025 across all business segments, exceeding its production guidances set at the beginning of the year. Iron ore and copper output reached their highest levels since 2018, at 336 Mt and 382 kt, respectively, and nickel production was the strongest since 2022, at 177 kt, supported by the ramp-up of key projects and continued operational stability.

Iron ore production totaled 90.4 Mt in Q4, 6% (5.1 Mt) higher y/y, driven by Brucutu's robust performance and the continued ramp-up of the Capanema and VGR1 projects. Pellets output totaled 8.3 Mt in Q4, 9% (0.8 Mt) lower y/y, reflecting market conditions. Iron ore sales reached 84.9 Mt in Q4, up 5% (3.7 Mt) y/y, consistent with higher production volumes.

Copper production totaled 108.1 kt in Q4, 6% (6.3 kt) higher y/y, the highest quarterly production since 2018. This increase reflects the all-time-high production at Salobo and consistent operational performance at Sossego and Canadian polymetallic assets.

Nickel production totaled 46.2 kt in Q4, 2% (0.7 kt) higher y/y, driven by the successful commissioning of Onça Puma's 2nd furnace and Voisey's Bay underground mines ramp-up.

Production Summary

000' metric tons	4Q25	4Q24	Δ y/y	3Q25	Δ q/q	2025	2024	Δ y/y	2025 original guidance[3]	2025 current guidance	2026 guidance
Iron ore[1]	90,403	85,279	6.0%	94,403	-4.2%	336,075	327,675	2.6%	325-335 Mt	~335 Mt	335-345 Mt
Pellets	8,325	9,167	-9.2%	7,997	4.1%	31,356	36,891	-15.0%	38-42 Mt[2]	~31 Mt[2]	30-34 Mt[2]
Copper	108.1	101.8	6.2%	90.8	19.1%	382.4	348.2	9.8%	340-370 kt	~370 kt	350-380 kt
Nickel	46.2	45.5	1.5%	46.8	-1.3%	177.2	159.9	10.8%	160-175 kt	~175 kt	175-200 kt

[1] Including third-party purchases, run-of-mine and feed for pelletizing plants. [2] Iron ore agglomerates guidance, including iron ore pellets and briquettes. [3] Guidance released on December 3, 2024, no longer applicable.

Sales Summary

000' metric tons	4Q25	4Q24	Δ y/y	3Q25	Δ q/q	2025	2024	Δ y/y
Iron ore	84,874	81,196	4.5%	85,997	-1.3%	314,358	306,652	2.5%
Fines[1]	73,566	69,912	5.2%	75,020	-1.9%	273,027	260,314	4.9%
Pellets	9,056	10,067	-10.0%	8,769	3.3%	32,801	38,300	-14.4%
ROM	2,251	1,216	85.1%	2,208	1.9%	8,530	8,038	6.1%
Copper	106.9	99.0	8.0%	90.0	18.8%	367.8	327.2	12.4%
Nickel	49.6	47.1	5.3%	42.9	15.6%	172.8	155.2	11.3%

[1] Including third-party purchases.

Price Realization Summary

US$/t	4Q25	4Q24	Δ y/y	3Q25	Δ q/q	2025	2024	Δ y/y
Iron ore fines (CFR/FOB, wmt)	95.4	93.0	2.6%	94.4	1.1%	91.6	95.3	-3.9%
Iron ore pellets (CFR/FOB, wmt)	131.4	143.0	-8.1%	130.8	0.5%	134.0	154.6	-13.3%
Copper[1]	11,003	9,187	19.8%	9,818	12.1%	9,763	8,811	10.8%
Nickel	15,015	16,163	-7.1%	15,445	-2.8%	15,556	17,078	-8.9%

[1] Average realized price for copper operations only (Salobo and Sossego). Average realized copper price for all operations, including copper sales originated from nickel operations was US$ 11,025/t in 4Q25 and US$ 9,653/t in 2025.

Iron ore all-in premium

US$/t	4Q25	4Q24	Δ y/y	3Q25	Δ q/q	2025	2024	Δ y/y
All-in premium - Total	0.9	4.6	-80.4%	2.1	-57.1%	1.5	2.1	-28.6%
Iron ore fines quality and premiums	(0.3)	1.0	n.a.	0.7	n.a.	(0.4)	(1.4)	-71.4%
Pellets business' contribution[1]	1.1	3.6	-69.4%	1.4	-21.4%	1.9	3.5	-45.7%

[1] Weighted average contribution.

Click here for full report

Media Relations Office – Vale
imprensa@vale.com

Press

Innovation
Vale opens model plant in Itabira with AI applied to operations and enhances safety and efficiency

Investors
Financial Results 1Q26

Investors
Vale's production and sales in 1Q26

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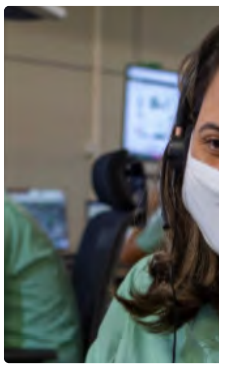
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IRON AND STEEL[1]

(Data in million metric tons, metal, unless otherwise specified)

Domestic Production and Use: The U.S. iron and steel industry produced 82 million tons of raw steel in 2025 with an estimated sales value of about $149 billion, a slight decrease from $150 billion in 2024. At the beginning of 2025, pig iron and raw steel were produced by two companies operating integrated steel mills in eight active locations. Multiple integrated steel mills were fully or partially idled over the last 3 years, and prior reporting of locations previously differentiated multiple facilities at the same location. Raw steel from electric arc furnaces was produced by 47 companies at 102 minimills. Combined raw steel production capacity was about 105 million tons per year, a slight decrease from 107 million tons in 2024. Indiana accounted for an estimated 19% of total raw steel production, followed by Ohio, 8%; Texas, 5%; and Pennsylvania, 4%; no other individual State accounted for more than 4% of total domestic raw steel production. Construction accounted for an estimated 31% of net shipments by market classification, followed by steel service centers and distributors, 26%; automotive, 15%; and steel for converting and processing, 11%; all other applications accounted for 17% of net shipments.

Salient Statistics—United States:	2021	2022	2023	2024	2025[e]
Pig iron production	22.2	20.0	22.5	20.6	21
Raw steel production	85.8	80.5	81.4	79.5	82
Continuously cast steel, percent	99.8	99.7	99.7	99.7	99.7
Shipments, steel mill products	85.9	81.2	81.0	78.7	82
Imports, steel mill products:					
Finished	20.6	22.9	19.7	20.4	19
Semifinished	7.9	5.1	5.9	5.8	5
Total	28.5	28.0	25.6	26.2	24
Exports, steel mill products:					
Finished	7.4	7.5	7.9	7.9	6
Semifinished	0.1	0.1	0.3	0.1	0.1
Total	7.5	7.6	8.2	8.0	7
Stocks, service centers, yearend[2]	7.0	6.7	6.5	6.5	6.7
Consumption, apparent (steel mill products)[3]	100	96.2	92.4	91.1	95
Producer price index, steel mill products (1982=100)[4]	351	382	320	291	290
Employment, average, number:					
Iron and steel mills[4]	78,300	80,800	84,000	84,900	86,000
Steel product manufacturing[4]	52,700	55,400	58,500	59,600	61,000
Net import reliance[5] as a percentage of apparent consumption	14	16	12	14	13

Recycling: See the Iron and Steel Scrap and the Iron and Steel Slag chapters.

Import Sources (2021–24): Canada, 23%; Mexico, 15%; Brazil, 13%; Republic of Korea, 9%; and other, 40%.

Tariff: Item	Number	Normal Trade Relations 12–31–25
Carbon steel:		
Semifinished	7207.00.0000	Free.
Flat, hot-rolled	7208.00.0000	Free.
Flat, cold-rolled	7209.00.0000	Free.
Galvanized	7210.00.0000	Free.
Bars and rods, hot-rolled	7213.00.0000	Free.
Structural shapes	7216.00.0000	Free.
Stainless steel:		
Semifinished	7218.00.0000	Free.
Flat-rolled sheets	7219.00.0000	Free.
Bars and rods	7222.00.0000	Free.

Depletion Allowance: Not applicable.

Government Stockpile:[6]

	FY 2025		FY 2026	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Grain-oriented electrical steel	3,200	—	NA	NA
Tire cord steel[7]	2,370	—	NA	NA

Prepared by **Candice C. Tuck [(703) 648–4912, ctuck@usgs.gov]**

IRON AND STEEL

Events, Trends, and Issues: Under section 232 of the Trade Expansion Act, tariffs increased to a rate of 25% for all countries in March 2025, removing prior exceptions granted since the tariffs were implemented in 2018. In June, tariffs on steel products imported to the United States were increased to 50% for all countries. Various extensions, exclusions, and reciprocal clauses were introduced throughout 2025. In November, Proclamation 10993 granted a 2-year regulatory relief period from Clean Air Act standards set in 2024 affecting coke oven facilities, which manufacture metallurgical coke used in the production of steel in integrated steel mills that account for approximately 28% of domestic steel production.

In March, one company began construction on a new minimill in southern California with a production capacity of 450,000 tons per year of rebar steel. In June, a domestic steel manufacturer completed a deal to be acquired by a Japan-based steel company. The deal was approved by the U.S. Government with stipulations and was expected to generate $11 billion in domestic steelmaking investments through 2028. In September, that company also halted production at one mill in Illinois with a production capacity of 2.7 million tons per year of raw steel but was expected to keep the mill in an operational state with the possibility of resuming production. Citing strategic capacity adjustments to account for product-specific market conditions, another company indefinitely idled multiple facilities, including an Illinois basic oxygen furnace and mill with a production capacity of 700,000 tons per year of hot-rolled coil products; a Michigan basic oxygen furnace and continuous casting facilities with a production capacity of 1.99 million tons per year of pig iron and 2.40 million tons per year of carbon slabs, advanced high-strength steels, and other products; and a Pennsylvania minimill with a production capacity of 300,000 tons per year of rail and other products. That company also restarted a blast furnace in Ohio with a production capacity of 1.37 million tons per year of pig iron.

The World Steel Association[7] estimated global finished steel demand to remain unchanged in 2025 owing to declining steel demand in China offset by growth in developing economies including Egypt, India, Saudi Arabia, and Vietnam. Globally, the manufacturing sector was expected to be affected by affordability pressures on consumers and elevated production costs. Countries with economies reliant on the export of steel-intensive goods were negatively affected by trade tensions.

World Production:

	Pig iron		Raw steel	
	2024	2025[e]	2024	2025[e]
United States	20.6	21	79.5	82
Brazil	27	28	34	35
China	852	830	1,010	980
Germany	24	25	37	38
India	90	98	150	160
Iran	4	4	31	32
Japan	61	59	84	81
Korea, Republic of	44	41	64	60
Russia	51	47	71	65
Turkey	10	10	37	37
Vietnam	14	14	22	23
Other countries	78	93	269	280
World total (rounded)	1,280	1,300	1,880	1,900

World Resources: Not applicable. See the Iron Ore chapter for steelmaking raw-material resources.

Substitutes: Iron is the least expensive and most widely used metal. In most applications, iron and steel compete either with less expensive nonmetallic materials or with more expensive materials that have a performance advantage. Iron and steel compete with lighter materials, such as aluminum and plastics in the automotive industry; aluminum, concrete, and wood in construction; and aluminum, glass, paper, and plastics in containers.

[e]Estimated. NA Not available. — Zero.

[1]U.S. production and shipments data source is the American Iron and Steel Institute; see also the Iron and Steel Scrap and the Iron Ore chapters.

[2]Steel mill products. Source: Metals Service Center Institute, September 2025.

[3]Defined as steel mill product shipments + imports of finished steel mill products – exports of steel mill products ± adjustments for stock changes.

[4]Source: U.S. Department of Labor, Bureau of Labor Statistics, North American Industry Classification System Code 331100 and 332100.

[5]Defined as imports of finished steel mill products – total exports ± adjustments for industry stock changes.

[6]See Appendix B for definitions. Reported in metric tons. For fiscal year 2026, the Annual Materials Plan was not released.

[7]Source: World Steel Association, 2025, worldsteel Short Range Outlook October 2025: Brussels, Belgium, World Steel Association press release, October 13, 3 p. (Accessed November 18, 2025, at https://worldsteel.org/media/press-releases/2025/worldsteel-short-range-outlook-october-2025/.)


FIRST QUARTER 2023
EARNINGS CALL
David Burritt
President and Chief Executive Officer
Jessica Graziano
SVP and Chief Financial Officer
Rich Fruehauf
SVP, Chief Strategy
and Sustainability Officer
Kevin Lewis
VP, Finance

FORWARD-LOOKING STATEMENTS

These slides are being provided to assist readers in understanding the results of operations, financial condition and cash flows of United States Steel Corporation as of and for the first quarter 2023. Financial results as of and for the periods ended March 31, 2023 provided herein are preliminary unaudited results based on current information available to management. They should be read in conjunction with the consolidated financial statements and Notes to the Consolidated Financial Statements contained in our Annual Report on Form 10-K and Quarterly Reports on Form 10-Q filed with the Securities and Exchange Commission.

This presentation contains information that may constitute “forward-looking statements” within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. We intend the forward-looking statements to be covered by the safe harbor provisions for forward-looking statements in those sections. Generally, we have identified such forward-looking statements by using the words “believe,” “expect,” “intend,” “estimate,” “anticipate,” “project,” “target,” “forecast,” “aim,” “should,” “plan,” “goal,” “future,” “will,” “may,” and similar expressions or by using future dates in connection with any discussion of, among other things, the construction or operation of new or existing facilities or operating capabilities, the timing, size and form of share repurchase transactions, operating or financial performance, trends, events or developments that we expect or anticipate will occur in the future, statements relating to volume changes, share of sales and earnings per share changes, anticipated cost savings, potential capital and operational cash improvements, changes in the global economic environment, including supply and demand conditions, inflation, interest rates, supply chain disruptions and changes in prices for our products, international trade duties and other aspects of international trade policy, statements regarding our future strategies, products and innovations, statements regarding our greenhouse gas emissions reduction goals, statements regarding existing or new regulations and statements expressing general views about future operating results. However, the absence of these words or similar expressions does not mean that a statement is not forward-looking. Forward-looking statements are not historical facts, but instead represent only the Company’s beliefs regarding future events, many of which, by their nature, are inherently uncertain and outside of the Company’s control. It is possible that the Company’s actual results and financial condition may differ, possibly materially, from the anticipated results and financial condition indicated in these forward-looking statements. Management believes that these forward-looking statements are reasonable as of the time made. However, caution should be taken not to place undue reliance on any such forward-looking statements because such statements speak only as of the date when made. Our Company undertakes no obligation to publicly update or revise any forward-looking statements, whether as a result of new information, future events or otherwise, except as required by law. In addition, forward-looking statements are subject to certain risks and uncertainties that could cause actual results to differ materially from our Company's historical experience and our present expectations or projections. These risks and uncertainties include, but are not limited to, the risks and uncertainties described in “Item 1A. Risk Factors” in our Annual report on Form 10-K for the year ended December 31, 2022 and those described from time to time in our future reports filed with the Securities and Exchange Commission.

References to "we," "us," "our," the "Company," and "U. S. Steel," refer to United States Steel Corporation and its consolidated subsidiaries, references to “Big River Steel” refer to Big River Steel Holdings LLC and its direct and indirect subsidiaries unless otherwise indicated by the context.

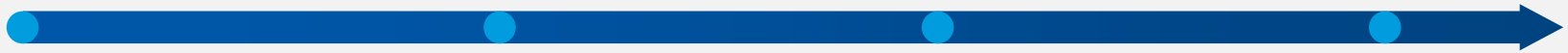
EXPLANATION OF USE OF NON-GAAP MEASURES

We present adjusted net earnings, earnings before interest, income taxes, depreciation and amortization (EBITDA) and adjusted EBITDA, which are non-GAAP measures, as additional measurements to enhance the understanding of our operating performance. We believe that EBITDA, considered along with net earnings, is a relevant indicator of trends relating to our operating performance and provides management and investors with additional information for comparison of our operating results to the operating results of other companies.

Adjusted net earnings is a non-GAAP measure that excludes the effects of items that include: debt extinguishment, asset impairment charges, restructuring and other charges, stock-based compensation expense, VEBA asset surplus adjustment, gains on assets sold and previously held investments, pension de-risking, United Steelworkers labor agreement signing bonus and related costs, tax impact of adjusted items and other charges, net (Adjustment Items). We present adjusted net earnings and adjusted EBITDA to enhance the understanding of our ongoing operating performance and established trends affecting our core operations by excluding the effects of events that can obscure underlying trends. U. S. Steel's management considers adjusted net earnings and adjusted EBITDA as alternative measures of operating performance and not alternative measures of the Company's liquidity. U. S. Steel's management considers adjusted net earnings and adjusted EBITDA useful to investors by facilitating a comparison of our operating performance to the operating performance of our competitors. Additionally, the presentation of adjusted net earnings and adjusted EBITDA provides insight into management's view and assessment of the Company's ongoing operating performance because management does not consider the Adjustment Items when evaluating the Company's financial performance. Adjusted net earnings and adjusted EBITDA should not be considered a substitute for net earnings or other financial measures as computed in accordance with U.S. GAAP and is not necessarily comparable to similarly titled measures used by other companies.

We present free cash flow, a non-GAAP measure of cash generated from operations after any investing activity and investable free cash flow, a non-GAAP measure of cash generated from operations, after any investing activity adjusted for strategic capital expenditures. We believe that free and investable cash flow provides further insight into the Company's overall utilization of cash. We also present net debt, a non-GAAP measure calculated as total debt less cash and cash equivalents. We believe net debt is a useful measure in calculating enterprise value. A condensed consolidated statement of operations (unaudited), condensed consolidated cash flow statement (unaudited), condensed consolidated balance sheet (unaudited) and preliminary supplemental statistics (unaudited) for U. S. Steel are attached.

ADVANCING TOWARDS OUR BEST FOR ALL® FUTURE



Current Landscape

Confident in our ability to execute our Best for All strategy, SAFELY

Bullish on U. S. Steel's future

Challenges

Transitioning to a less cost- / capital- and carbon- intensive business model while becoming the best steel competitor

Solution

Expanding existing competitive advantages

Balanced capital allocation framework

Maintaining strong trade enforcement

Path Forward

Delivering on Best for All

TODAY'S DISCUSSION

Progressing on our Best for All® strategy

Providing a strategic update

Healthy market backdrop

Supporting strategy execution

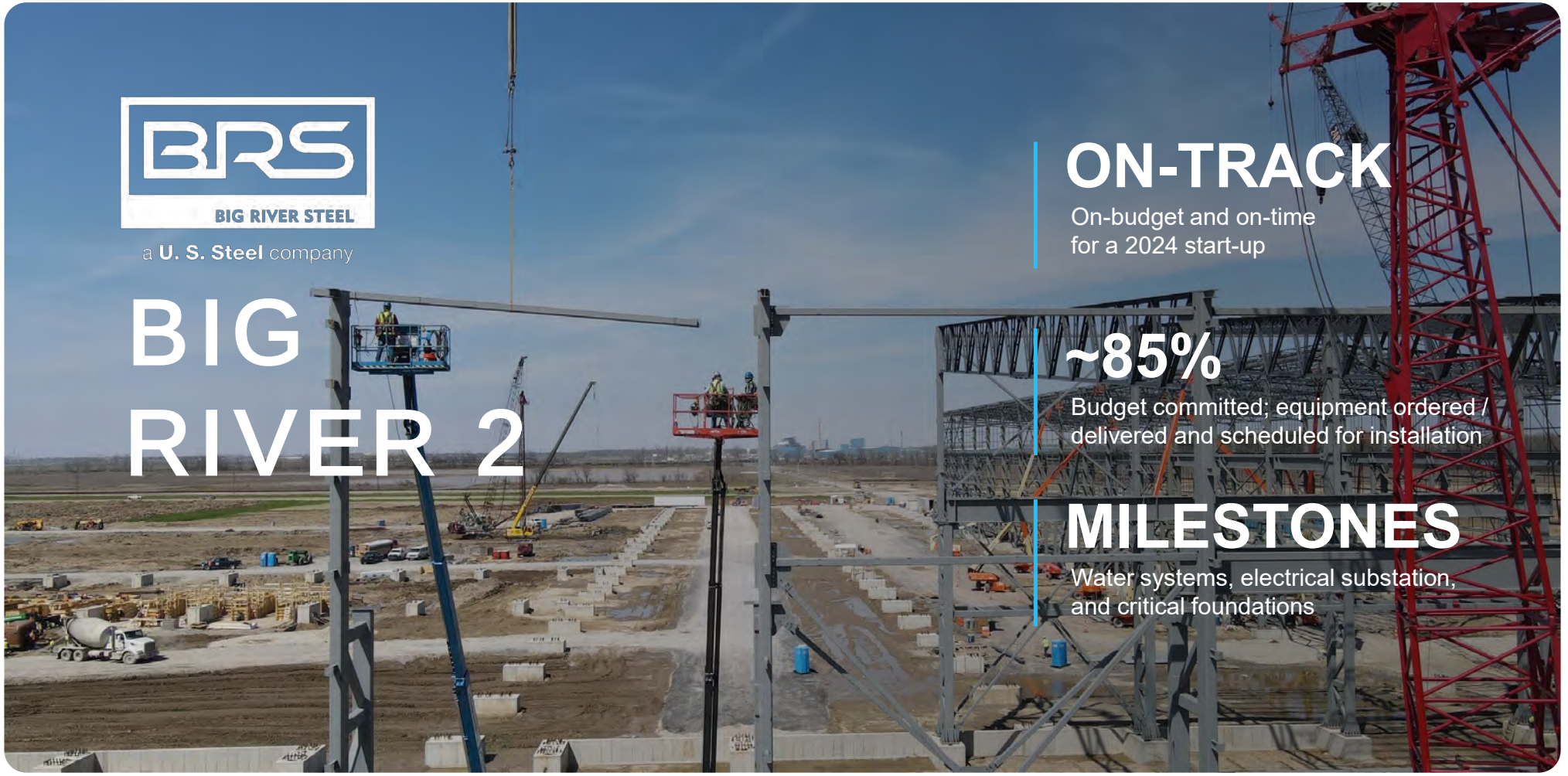
Balanced and diverse order book

Serving end-market demand across industries





PROGRESSING ON OUR BEST FOR ALL STRATEGY



PROGRESSING ON OUR BEST FOR ALL STRATEGY





PROGRESSING ON OUR BEST FOR ALL STRATEGY

BIG RIVER 2

ECR[1] Foundations



[1]Endless casting and rolling

PROGRESSING ON OUR BEST FOR ALL STRATEGY



PROGRESSING ON OUR BEST FOR ALL STRATEGY





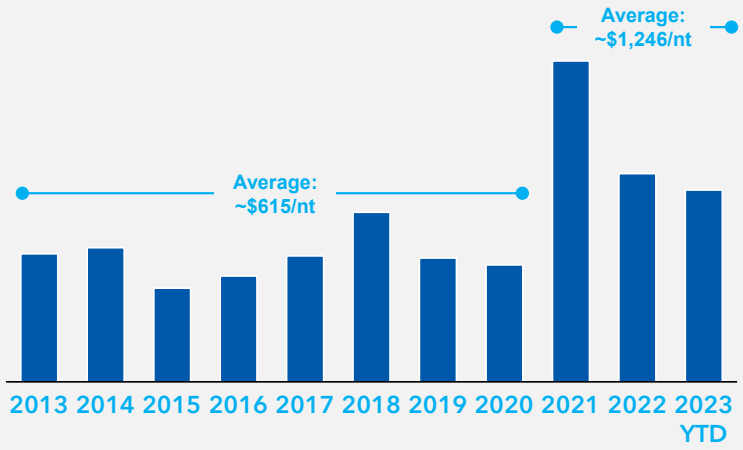
PROGRESSING ON OUR BEST FOR ALL STRATEGY



HEALTHY MARKET BACKDROP

~$1,168/nt
Current spot HRC price[1]

+76%
Increase in HRC prices vs. year-end '22



HOT ROLLED COIL PRICES

[1] CRU

Improved market dynamics

Increased prices supported by raw material input costs & healthy customer demand

Stronger domestic steel market

Diverse capabilities; strong bi-partisan support for manufacturing

Diverse U. S. Steel order book

Diverse end-market exposure provides flexibility in a dynamic demand environment

BALANCED ORDER BOOK

Automotive

Light vehicle sales SAAR
in millions of units



Stable pull rates

USS gaining market share

Appliance

AHAM6 shipments
in millions of units



Record 2021 / 2022 industry shipments

Stable shipments expected in ‘23

Energy

Rig count
Quarter-end United States rigs



Resilient rig count

Continued strong oil and gas demand

Service Centers

MSCI shipments
in millions of tons



Highest per day shipments since Jan. ’20;

Indicative of healthy end-user demand

Q1 2023 FINANCIAL PERFORMANCE

$427M

Adjusted EBITDA Performance

Delivering 10% EBITDA margin

$25M

Investable Free Cash Flow

Supporting $582 million of strategic capex in the quarter

~$5.3B

Strong Liquidity

Including ~$2.8B of cash

Rewarding shareholders with continued direct returns

Note: For reconciliation of non-GAAP amounts see Appendix.

MINI MILL SEGMENT: VALUE CREATION FRAMEWORK

Value creation framework



~$15/ton
sustaining capex per year
(vs. ~$30/ton for legacy assets)

70-80%
fewer scope 1 and 2 GHG emissions vs. BFs

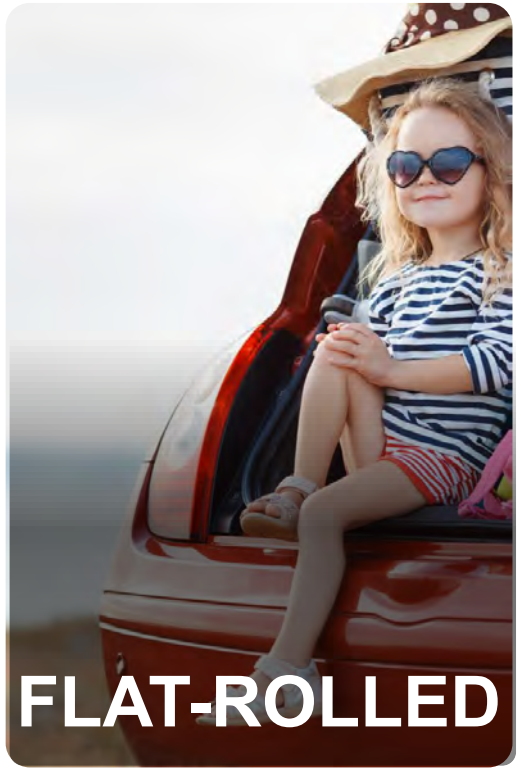
20%+
Differentiated EBITDA margins expected

$1.3B
Expected through-cycle annual EBITDA generation
(assuming historical ~$615/nt HRC price environment)

$1B+
Free Cash Flow generation expected by 2026

Creating a platform for growth & returns

OPERATING SEGMENT OVERVIEW









RECAP

Progressing on our Best for All strategy

Best for All footprint is taking shape

Healthy market backdrop

Further financial upside expected in Q2 2023

Balanced order book

Supported by strategic end-market


CLOSING
REMARKS

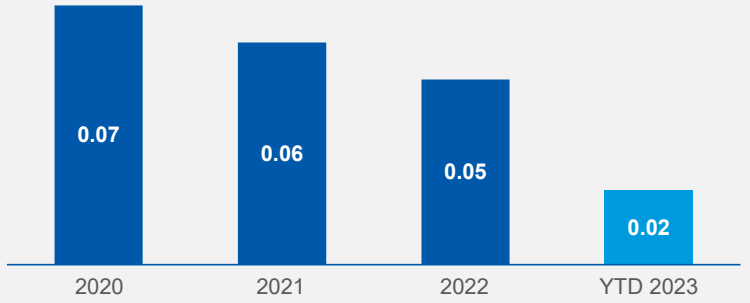

U. S. STEEL DELIVERS STRONG FIRST QUARTER 2023;
BEST FOR ALL STRATEGY ON-TRACK
FIRST QUARTER
2023
UPDATE

IMPROVING ON RECORD SAFETY PERFORMANCE



Benchmark[1]:
BLS - Iron & Steel: 0.90

Multiple years of record-setting performance



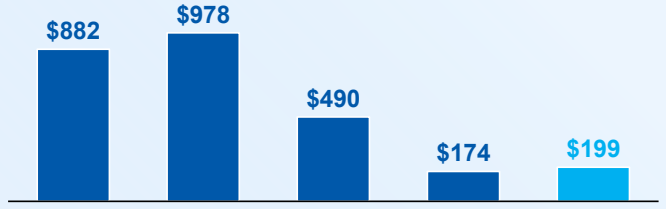
OSHA Days Away from Work[2]

[1] Bureau of Labor Statistics – Iron & Steel 2021 data.
[2] Occupational Safety and Health Administration (OSHA) Days Away from Work is defined as number of days away cases x 200,000 / hours worked. **YTD as of April 27, 2023.**

FINANCIAL UPDATES

Reported Net Earnings

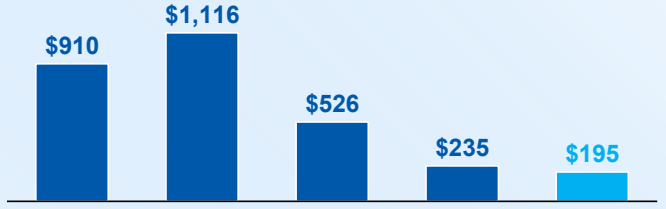
$ Millions



Profit Margin:	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
	17%	16%	9%	4%	4%

Adjusted Net Earnings

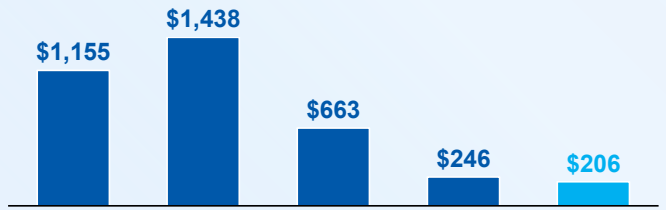
$ Millions



Adjusted Profit Margin:	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
	17%	18%	10%	5%	4%

Segment EBIT[1]

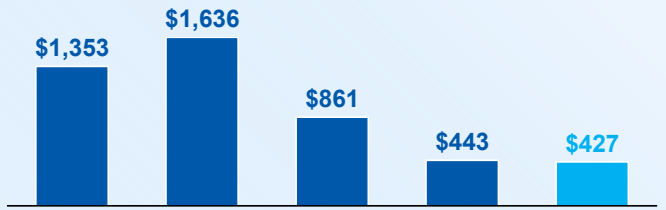
$ Millions



Adjusted Profit Margin[1]:	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
	22%	23%	13%	6%	5%

Adjusted EBITDA[2]

$ Millions



Adjusted Profit Margin[2]:	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
	26%	26%	17%	10%	10%

Note: For reconciliation of non-GAAP amounts see Appendix.
[1] Earnings (loss) before interest and income taxes. [2] Earnings (loss) before interest, income taxes, depreciation and amortization, and excluding adjustment items.

KEY OPERATING STATISTICS TRENDS BY SEGMENT

Flat-Rolled Operating Statistics

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Shipments: in 000s, net tons	1,947	2,365	2,176	1,885	**2,278**
Production: in 000s, net tons	2,205	2,424	2,265	1,952	**2,393**
Average Selling Price $ / net ton	$1,368	$1,339	$1,232	$1,086	**$1,012**

Mini Mill Operating Statistics

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Shipments: in 000s, net tons	507	615	529	636	**659**
Production: in 000s, net tons	601	750	616	683	**759**
Average Selling Price $ / net ton	$1,372	$,1,331	$1,096	$786	**$794**

USSE Operating Statistics

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Shipments: in 000s, net tons	1,110	1,067	867	715	**883**
Production: in 000s, net tons	1,088	1,216	946	589	**1,092**
Average Selling Price $ / net ton	$1,109	$1,217	$1,021	$957	**$909**

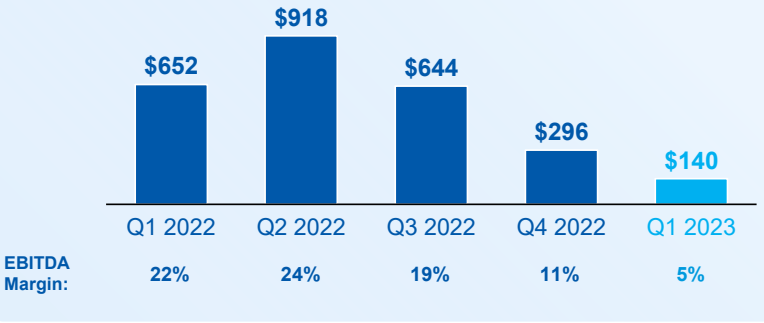
Tubular Operating Statistics

	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Shipments: in 000s, net tons	128	136	126	133	**131**
Production: in 000s, net tons	156	168	173	137	**171**
Average Selling Price $ / net ton	$2,349	$,2,727	$3,217	$3,616	**$3,757**

EBITDA TRENDS BY SEGMENT

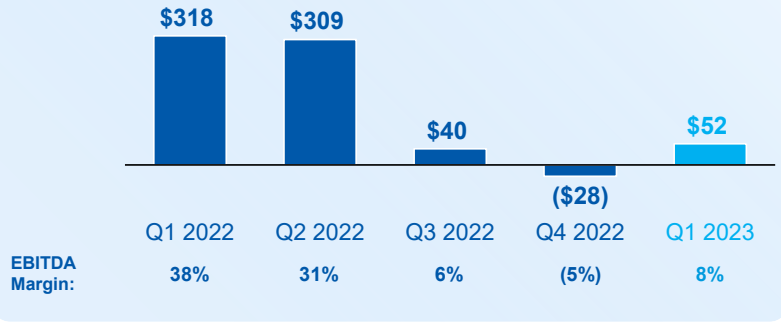
Flat-Rolled Segment EBITDA

$ Millions



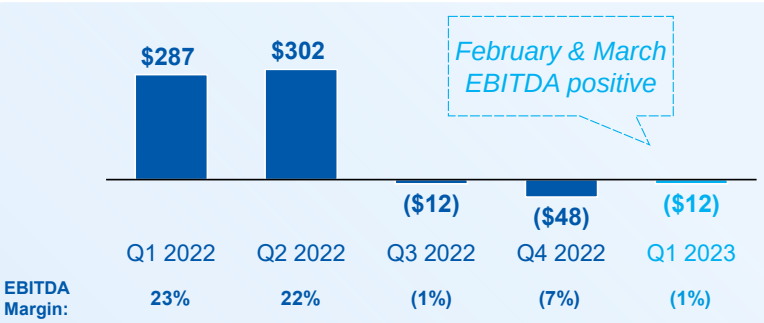
Mini Mill Segment EBITDA

$ Millions



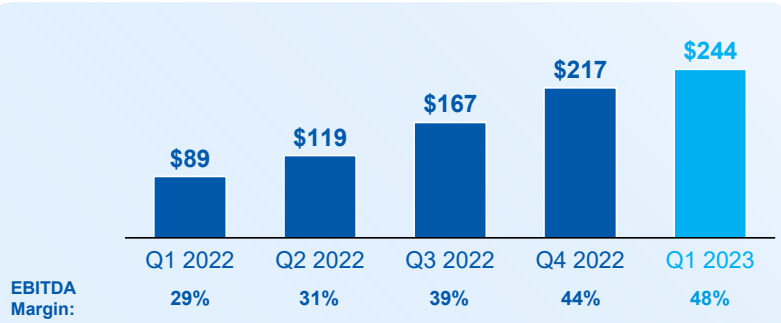
USSE Segment EBITDA

$ Millions



Tubular Segment EBITDA

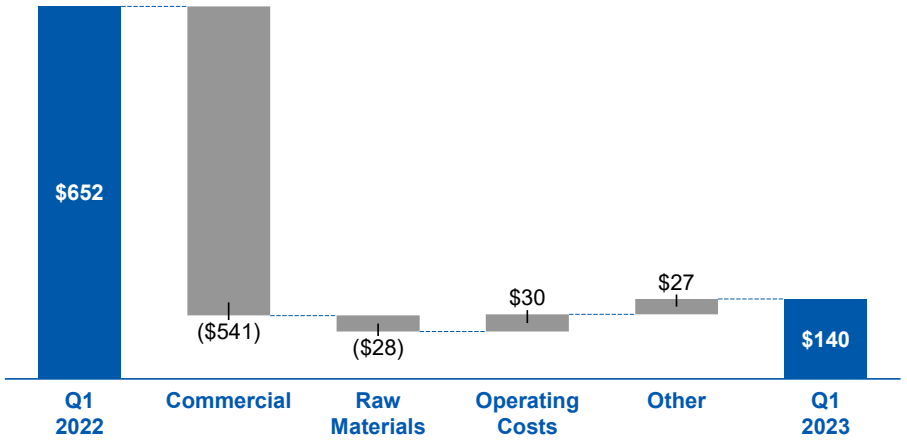
$ Millions



Note: For reconciliation of non-GAAP amounts see Appendix.

EBITDA CHANGE ANALYSIS – FLAT-ROLLED SEGMENT

$ Millions, Q1 2022 vs. Q1 2023



Commercial:

The unfavorable impact is primarily the result of lower average realized prices partially offset by higher shipment volumes.

Raw Materials:

The unfavorable impact is primarily the result of higher coal costs.

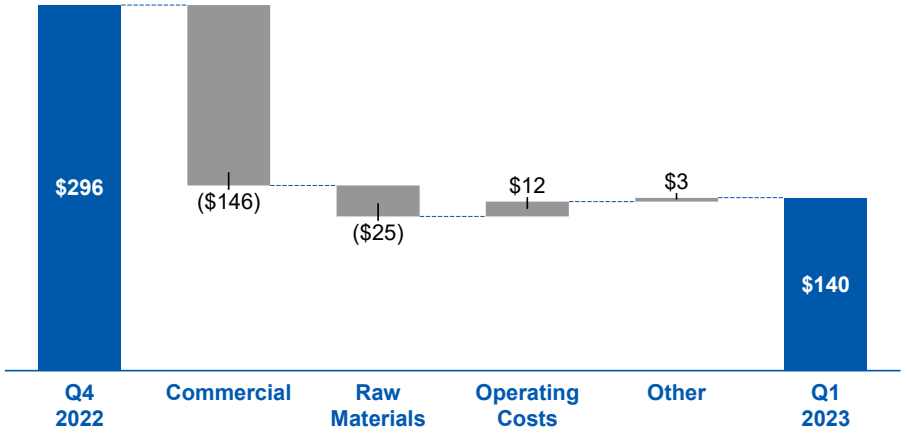
Operating Costs:

The favorable impact is primarily the result of lower outage spending.

Other:

The favorable impact is primarily the result of lower variable compensation.

$ Millions, Q4 2022 vs. Q1 2023



Commercial:

The unfavorable impact is primarily the result of lower average realized prices and seasonal impacts of iron ore shipments partially offset by higher shipment volumes.

Raw Materials:

The unfavorable impact is primarily the result of higher coal costs.

Operating Costs:

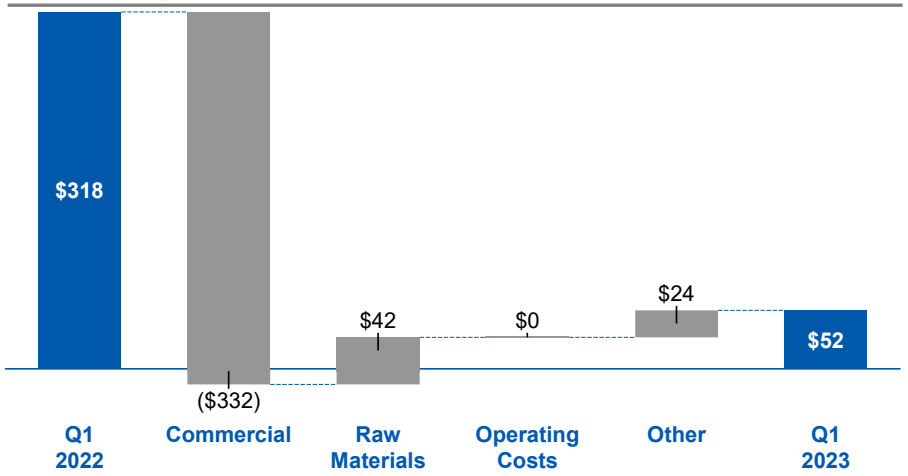
The favorable impact is primarily the result of lower outage spending.

Other:

The change is not material.

EBITDA CHANGE ANALYSIS – MINI MILL SEGMENT

$ Millions, Q1 2022 vs. Q1 2023



Commercial:

The unfavorable impact is primarily the result of lower average realized prices partially offset by higher shipment volumes.

Raw Materials:

The favorable impact is primarily the result of lower metallics costs.

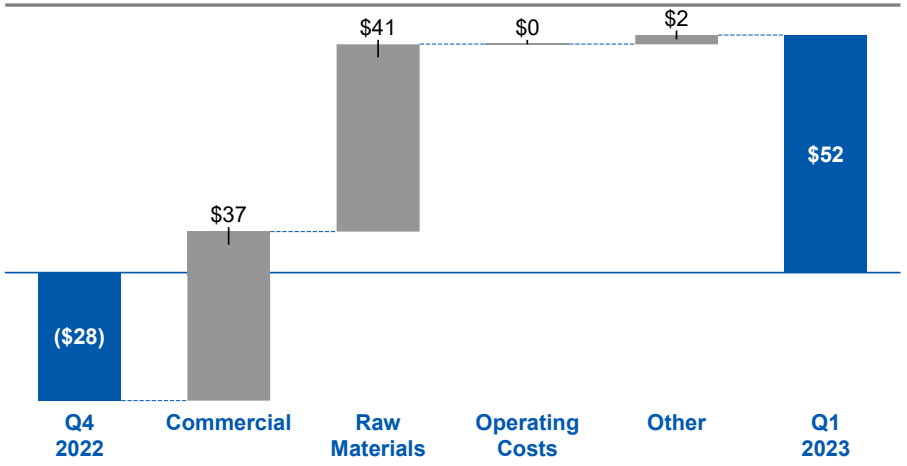
Operating Costs:

No change.

Other:

The favorable impact is primarily the result of lower variable compensation.

$ Millions, Q4 2022 vs. Q1 2023



Commercial:

The favorable impact is primarily the result of higher shipment volumes and higher average realized prices.

Raw Materials:

The favorable impact is primarily the result of lower metallics costs.

Operating Costs:

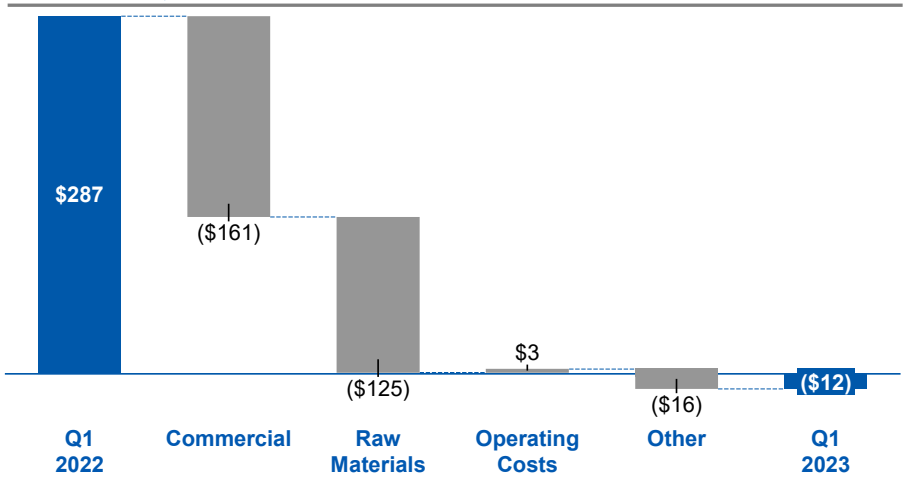
No change.

Other:

The change is not material.

EBITDA CHANGE ANALYSIS – U. S. STEEL EUROPE SEGMENT

$ Millions, Q1 2022 vs. Q1 2023



Commercial:

The unfavorable impact is primarily the result of lower average realized prices.

Raw Materials:

The unfavorable impact is primarily the result of inventory revaluation.

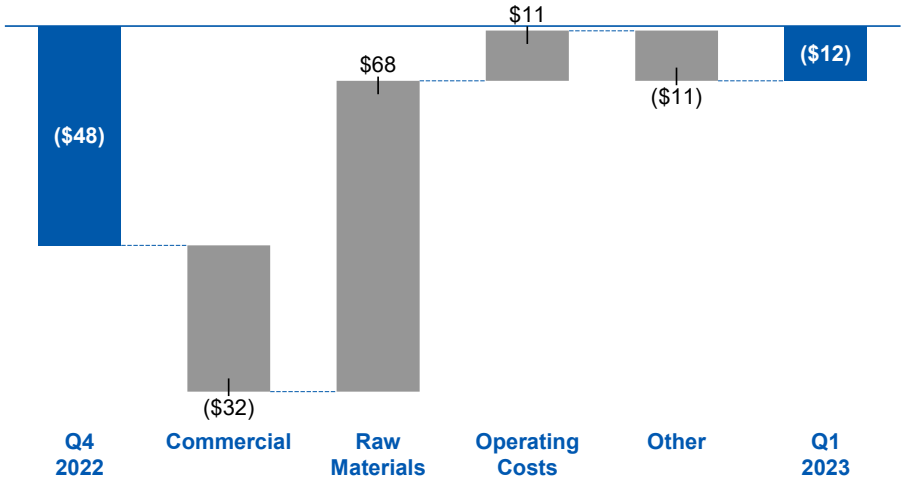
Operating Costs:

The change is not material.

Other:

The unfavorable impact is primarily the result of increased energy costs and the weakening of the Euro vs. the U.S. dollar.

$ Millions, Q4 2022 vs. Q1 2023



Commercial:

The unfavorable impact is primarily the result of lower average realized prices partially offset by higher shipment volumes.

Raw Materials:

The favorable impact is primarily the result of lower costs for iron ore.

Operating Costs:

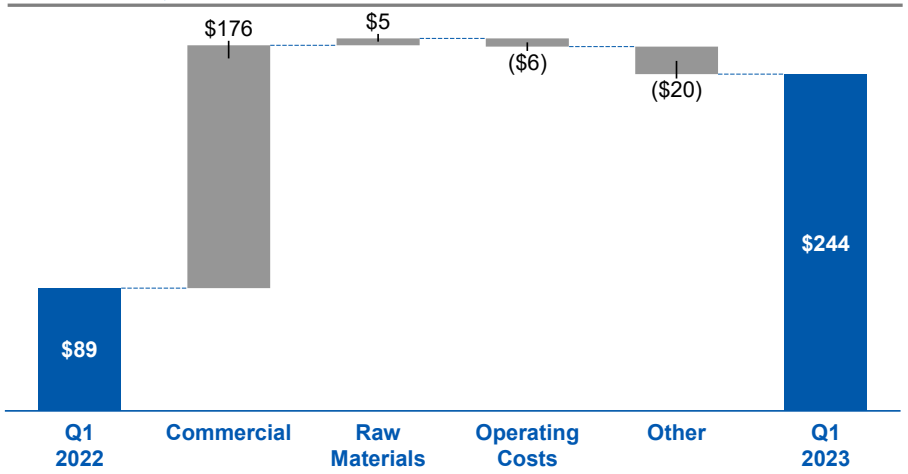
The favorable impact is primarily the result of lower spending and labor costs.

Other:

The unfavorable impact is primarily the result of the absence of an annual electricity compensation rebate received in fourth quarter 2022.

EBITDA CHANGE ANALYSIS – TUBULAR SEGMENT

$ Millions, Q1 2022 vs. Q1 2023



Commercial:

The favorable impact is primarily the result of higher average realized prices.

Raw Materials:

The favorable impact is primarily the result of lower scrap costs.

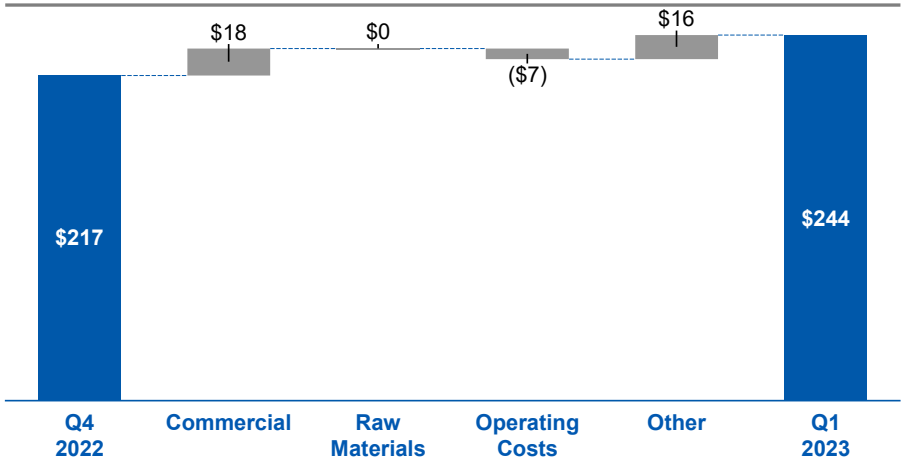
Operating Costs:

The unfavorable impact is primarily the result of increased costs for purchased products and services.

Other:

The unfavorable impact is primarily the result of higher variable compensation.

$ Millions, Q4 2022 vs. Q1 2023



Commercial:

The favorable impact is primarily the result of higher average realized prices.

Raw Materials:

No change.

Operating Costs:

The unfavorable impact is primarily the result of increased costs for purchased products and services.

Other:

The favorable impact is primarily the result of lower United Steelworker variable compensation.

GLOBAL OPERATING FOOTPRINT

Operating

Indefinitely Idled

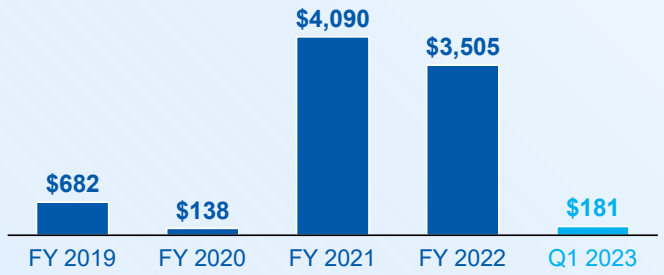
						Idled	Total Capability[1]
NORTH AMERICAN FLAT-ROLLED	Iron Ore Pellets	Minntac		Keetac		-	22.4
	Cokemaking	Clairton				-	3.6
	Gary	BF #4	BF #6	BF #8	BF #14	-	7.5
	Granite City	BF 'A'		BF 'B'		1.4	2.8
	Mon Valley	BF #1		BF #3		-	2.9
MINI MILL	Big River Steel	EAF #1		EAF #2		-	3.3
EUROPE	Košice	BF #1	BF #2	BF #3		-	5.0
TUBULAR	Fairfield	EAF Steelmaking / Seamless Pipe				-	0.90
	Lorain	Seamless Pipe				0.38	0.38
	Lone Star	#1 ERW		#2 ERW		0.79	0.79

[1] Raw steel capability, except at Minntac and Keetac (iron ore pellet capability), Clairton (coke capability), Lorain, and Lone Star (pipe capability). All amounts shown are in millions.

CASH AND LIQUIDITY

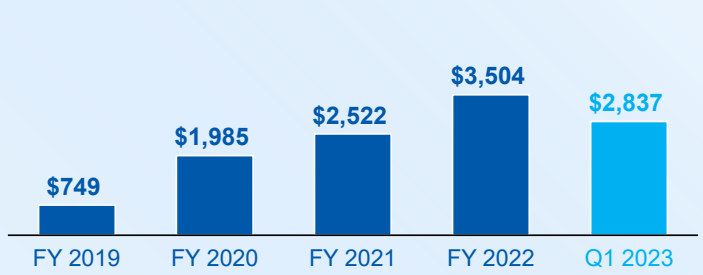
Cash from Operations

$ Millions



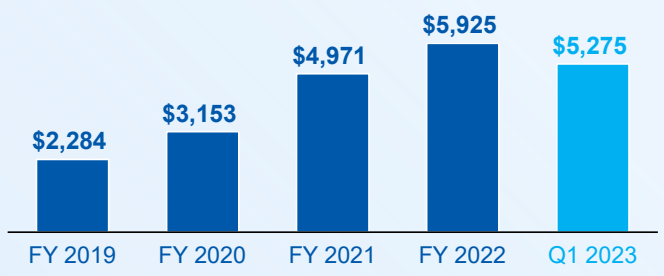
Cash and Cash Equivalents

$ Millions



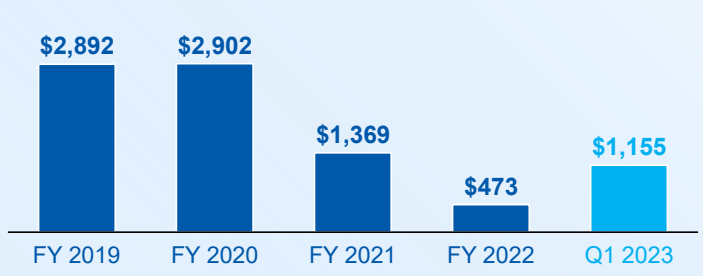
Total Estimated Liquidity

$ Millions



Net Debt

$ Millions



Note: For reconciliation of non-GAAP amounts see Appendix.

RECONCILIATION TABLE

Segment EBITDA

Flat-Rolled ($ millions)	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Segment earnings (loss) before interest and income taxes	$529	$793	$518	$171	($7)
Depreciation	123	125	126	125	147
Flat-Rolled Segment EBITDA	**$652**	**$918**	**$644**	**$296**	**$140**

Mini Mill ($ millions)	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Segment earnings (loss) before interest and income taxes	$278	$270	$1	($68)	$12
Depreciation	40	39	39	40	40
Mini Mill Segment EBITDA	**$318**	**$309**	**$40**	**(28)**	**$52**

U. S. Steel Europe ($ millions)	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Segment earnings (loss) before interest and income taxes	$264	$280	($32)	($68)	($34)
Depreciation	23	22	20	20	22
U. S. Steel Europe Segment EBITDA	**$287**	**$302**	**($12)**	**($48)**	**($12)**

Tubular ($ millions)	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Segment earnings (loss) before interest and income taxes	$77	$107	$155	$205	$232
Depreciation	12	12	12	12	12
Tubular Segment EBITDA	**$89**	**$119**	**$167**	**$217**	**$244**

Other ($ millions)	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Segment earnings (loss) before interest and income taxes	7	($12)	$21	$6	$3
Depreciation	0	0	1	0	0
Other Segment EBITDA	**$7**	**($12)**	**$22**	**$6**	**$3**

RECONCILIATION TABLE

Big River Steel LLC[1] Summary Table

Income Statement $ Millions	Q1 2023
Customer Sales	$554M
Intersegment Sales	$69M
Net Sales	**$623M**
EBIT[2]	$14M
Balance Sheet	
Cash and cash equivalents	$245M
Total Assets	$3,531M
2029 Senior secured notes	$720M
Environmental revenue bonds	$752M
Financial leases and all other obligations	$23M
Fair value step up[3]	$117M
Total Debt[3]	$1,612M
Cash Flow	
Depreciation and Amortization	$35M
Capital Expenditures[4]	$128M

[1] Unless otherwise noted, amounts shown are reflected in Big River Steel LLC, the operating unit of the Big River Steel companies that reside within the Mini Mill segment. [2] Earnings before interest and income taxes. [3] The debt amounts reflect aggregate principal amounts. The fair value step up represents the excess of fair value over book value when Big River Steel was purchased. The fair value step-up is recorded in Big River Steel Holdings LLC. The fair value step up is shown as it is related to the debt amounts in Big River Steel LLC. [4] Excludes capital expenditures for BR2 and air separation unit.

RECONCILIATION TABLE

Net Debt

Net Debt $ millions	YE 2019	YE 2020	YE 2021	YE 2022	Q1 2023
Short-term debt and current maturities of long-term debt	$14	$192	$28	$63	$91
Long-term debt, less unamortized discount and debt issuance costs	$3,627	$4,695	$3,863	$3,914	$3,901
Total Debt	**$3,641**	**$4,887**	**$3,891**	**$3,977**	**$3,992**
Less: Cash and cash equivalents	749	1,985	2,522	3,504	2,837
Net Debt	**$2,892**	**$2,902**	**$1,369**	**$473**	**$1,155**

RECONCILIATION TABLE

Free Cash Flow / Investable Free Cash Flow

Investable free cash flow $ millions	**Q1 2023**
Net cash provided by operating activities	$181
Net cash used in investing activities	(738)
Free cash flow	**($557)**
Strategic capital expenditures	582
Investable free cash flow	**$25**

RECONCILIATION TABLE

Net Earnings

$ Millions	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Reported net earnings attributable to U. S. Steel	$882	$978	$490	$174	$199
Debt extinguishment	-	-	(2)	-	-
Asset impairment charges	6	151	-	6	-
Restructuring and other charges	17	17	23	(9)	1
Stock-based compensation expense[1]	16	16	13	12	11
VEBA asset surplus adjustment	-	-	-	-	(22)
Gains on assets sold and previously held investments	-	-	-	(6)	-
Pension de-risking	-	-	-	(3)	-
United Steelworkers labor agreement signing bonus and related costs[2]	-	-	-	67	-
Other charges, net	(2)	-	13	13	5
Tax impact of adjusted items[3]	(9)	(46)	(11)	(19)	1
Adjusted net earnings	**$910**	**$1,116**	**$526**	**$235**	**$195**

[1] The prior year was retroactively adjusted to reflect the reclassification of stock-based compensation expense. The adjustment net of taxes was $12 million, $12 million, $10 million, $9 million and $8 million for the three months ended March 31, June 30, September 30 and December 31 of 2022 and March 31, 2023, respectively.

[2] The 2022 Labor Agreements include retroactive wage increases. A charge of $3 million pertaining to wages for the month of September 2022 was recognized during the three months ended December 31, 2022. This charge is included as an adjustment to net earnings for the three months ended December 31, 2022, however this amount is not included as an adjustment to net earnings for the year ended December 31, 2022.

[3] The tax impact of adjusted items in 2022 is calculated for U.S. domestic items using a blended tax rate of 25% for Q1, Q2 and Q3 and 24% for Q4 and for USSE items 21%. The tax impact of adjusted items in 2023 is calculated using a blended tax rate of 24%.

Note: The reported net earnings attributable to U. S. Steel for the three months ended March 31, 2022 includes an income tax benefit of $7 million from the reversal of net valuation allowances. The item was presented as an adjustment to arrive at adjusted net earnings attributable to U. S. Steel in the prior period presentation. The reconciliation for the three months ended March 31, 2022 presented above has been recast to reflect the removal of the adjustment in accordance with Securities and Exchange Commission guidance.

RECONCILIATION TABLE

Adjusted EBITDA

$ Millions	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Reported net earnings attributable to U. S. Steel	$882	$978	$490	$174	$199
Income tax expense	246	284	154	51	51
Net interest and other financial costs	(10)	(8)	(30)	(51)	(61)
Reported earning before interest and income taxes	$1,118	$1,254	$614	$174	$189
Depreciation, depletion and amortization expense	198	198	198	197	221
EBITDA	$1,316	$1,452	$812	$371	$410
Asset impairment charges	6	151	-	6	-
Restructuring and other charges	17	17	23	(9)	1
Losses (gains) on assets sold & previously held investments	-	-	-	(6)	-
Stock-based compensation expense[1]	16	16	13	12	11
United Steelworkers labor agreement signing bonus and related costs[2]	-	-	-	67	
Environmental remediation charges	-	-	-	-	
Other charges, net	(2)	-	13	2	5
Adjusted EBITDA	**$1,353**	**$1,636**	**$861**	**$443**	**$427**

[1] The prior year was retroactively adjusted to reflect the reclassification of stock-based compensation expense.

[2] The 2022 Labor Agreements include retroactive wage increases. A charge of $3 million pertaining to wages for the month of September 2022 was recognized during the three months ended December 31, 2022. This charge is included as an adjustment to net earnings for the three months ended December 31, 2022, however this amount is not included as an adjustment to net earnings for the year ended December 31, 2022.

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United States Steel Corporation

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INSIGHT

Section 232 Tariffs on Steel and Aluminum

Updated May 18, 2026

In 2025, President Trump expanded and increased existing steel and aluminum tariffs, imposed since 2018 under Section 232 of the Trade Expansion Act of 1962 (19 U.S.C. §1862). Section 232 authorizes the President to impose trade restrictions if the Secretary of Commerce determines that imports of a good "threaten to impair the U.S. national security." The United States imposes tariffs on steel, aluminum, and products containing steel and aluminum ("derivatives") from nearly all trading partners. Congress may consider whether to exercise its legislative prerogatives related to trade policy and/or monitor potential effects of steel and aluminum tariffs on the U.S. economy.

Background

In 2018, President Trump proclaimed a 25% tariff on steel and a 10% tariff on aluminum imports from most trading partners following a Commerce Department investigation. In 2020, President Trump expanded the tariffs to include 13 new product codes for steel and aluminum derivatives. The Biden Administration largely maintained these tariffs and, in 2023, increased tariffs on imports of Russian aluminum to 200% in response to Russia's war on Ukraine. From 2018 to 2022, the United States negotiated country exemptions from the tariffs and granted entity-specific exclusions as well as General Approved Exclusions (GAEs) applicable to any importer.

Modifications During the Second Trump Administration

February 2025. President Trump modified the Section 232 steel and aluminum tariffs, including to

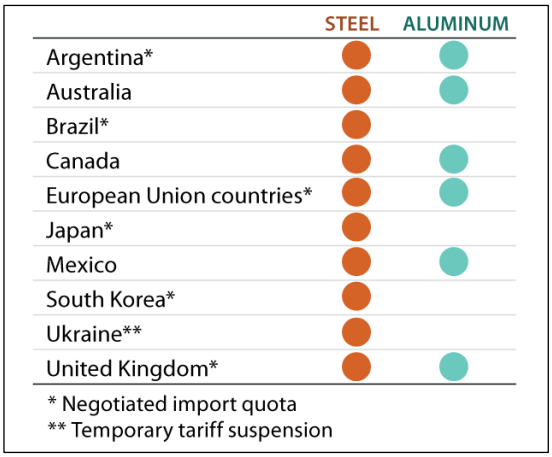
- increase aluminum tariffs to 25%, eliminate all country exemptions (see **Error! Reference source not found.**), and terminate all existing GAEs effective March 2025;
- prohibit new product exclusions (entity-specific product exclusions to "remain effective until their expiration date or until excluded product volume is imported, whichever occurs first");
- expand the scope of derivatives covered; and
- direct the Commerce Secretary to establish an "inclusions" process to allow U.S. stakeholders to request the addition of derivatives to the scope of tariffs.

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IN12519

President Trump stated that he terminated country exemptions and product exclusions because they "undermine" the tariffs' objectives, such as increasing U.S. production.

Figure 1. Section 232 Steel and Aluminum Country Exemptions Terminated in March 2025

Eliminated by Proclamations 10895 and 10896



Source: CRS, from various presidential proclamations. With the exception of Ukraine, country exemptions terminated in March 2025 were granted between 2018 to 2022.

June 2025. President Trump increased both steel and aluminum tariffs to 50%, except for imports from the United Kingdom (UK), which faced a 25% tariff pursuant to the U.S.-UK Economic Prosperity Deal. For most derivatives, Section 232 tariffs applied only to the steel or aluminum content and did not apply to derivatives containing only U.S.-sourced steel or aluminum.

August 2025. Following the first-ever inclusions process, the Commerce Department added more than 400 product codes within the scope of tariffs.

April 2026. President Trump made significant changes to the tariffs, including imposing tariffs on the full value of goods (not just the metal content), lowering/eliminating tariffs for certain derivatives, imposing a 10% tariff on derivatives containing primarily U.S.-sourced steel and aluminum, and eliminating the inclusions process (see **Table 1**). The White House stated that a reduced tariff rate of 15% on certain industrial and electrical grid equipment through 2027 was aimed at supporting companies' investments in new or expanded U.S. production. The White House asserted that the April 2026 changes strengthen the tariffs and more effectively protect U.S. national security. At a House Ways and Means hearing, U.S. Trade Representative Jamieson Greer stated that the exclusion of some derivatives from tariffs and simplified compliance requirements in the April 2026 proclamation could benefit some U.S. manufacturers that may have been negatively affected by tariffs. Other analyses found that some products may face higher tariffs under the new rules.

Relation to Other Tariffs. Goods subject to Section 232 automotive tariffs are exempt from steel and aluminum tariffs. Temporary global 10% tariffs implemented under Section 122 of the Trade Act of 1974 do not apply to products covered by Section 232 tariffs. Section 232 steel and aluminum tariffs apply in addition to

- most-favored nation (MFN) tariffs imposed on goods from most trading partners without a U.S. free trade agreement (FTA) or which do not meet FTA rules (also called Column 1 duties);
- trade remedies; and
- tariffs under Section 301 of the Trade Act of 1974.

Potential Implications for the U.S. Economy

In 2025, the United States imported $25 billion worth of steel articles—20% less than 2024—and $18 billion worth of aluminum—5% less than 2024 (see **Table 2**), excluding derivatives. Some U.S. steel and aluminum producers assert that tariffs are critical for boosting U.S. production. Other groups assert that the 2025 tariff expansion has negatively affected U.S. manufacturers. Some groups are seeking further expansion of the tariffs. Some groups support the tariff actions while also emphasizing policy alignment in North America through the U.S.-Mexico-Canada Agreement (USMCA). Currently, Section 232 steel and aluminum tariffs apply to USMCA-compliant goods. Since September 2025, Canada has imposed 25% tariffs on C$15.6 billion (approximately $11 billion) worth of U.S. steel and aluminum imports. Except for the abovementioned U.S.-UK deal and limited exceptions for aircraft-related goods, U.S. bilateral framework agreements have not addressed steel and aluminum tariffs.

Issues for Congress

Some Members support the tariffs and advocate for expanding the President's tariff authorities, including under Section 232 (e.g., H.R. 735). Others argue that Congress should play a stronger role in overseeing U.S. trade actions (e.g., S. 348, H.R. 1903). Some Members have called for more targeted tariffs or tariff exemptions to mitigate potential adverse impacts on the U.S. economy. Other Members have called for imposing tariffs on additional steel and aluminum products.

Some Members have called for commissioning reports on the potential economic effects of tariffs (e.g., H.R. 2287, H.R. 4326). In 2023, at the direction of Congress, the U.S. International Trade Commission analyzed the effects of the Section 232 steel and aluminum tariffs on the U.S. economy.

Members also may consider the extent to which Congress should exercise oversight of executive branch-led trade negotiations or whether Section 232 tariffs violate U.S. international trade obligations. For example, Section 232 tariffs were a key issue during the first Trump Administration's negotiation of USMCA, which is scheduled to undergo a review in July 2026. As part of USMCA oversight, Members may assess whether the United States should maintain or eliminate Section 232 steel and aluminum tariffs on Canada and Mexico or exempt USMCA-compliant products.

Table 1. Section 232 Tariffs on Steel and Aluminum

April 2026 Revisions

Annex I-A (steel and aluminum articles, certain copper articles, certain steel/aluminum derivatives)	• 50% tariff on full value • 25% tariff on full value of steel and aluminum articles and derivatives from the United Kingdom (UK) composed of at least 95% UK-sourced steel/aluminum (UK-origin steel articles made by Tata Steel UK may count steel from the Netherlands towards the 95% until January 2028) • 10% tariff on full value of derivatives composed of at least 95% U.S.-sourced steel, aluminum, and copper
Annex I-B (certain steel/aluminum derivatives, certain copper articles)	• 25% tariff on full value • 15% tariff on full value of steel and aluminum derivatives from the UK composed of at least 95% UK-sourced steel/aluminum (UK-origin steel articles made by Tata Steel UK may count steel from the Netherlands towards the 95% until January 2028) • 10% tariff on full value of derivatives composed of at least 95% U.S.-sourced steel, aluminum, and copper

Annex I-A (steel and aluminum articles, certain copper articles, certain steel/aluminum derivatives)	• 50% tariff on full value • 25% tariff on full value of steel and aluminum articles and derivatives from the United Kingdom (UK) composed of at least 95% UK-sourced steel/aluminum (UK-origin steel articles made by Tata Steel UK may count steel from the Netherlands towards the 95% until January 2028) • 10% tariff on full value of derivatives composed of at least 95% U.S.-sourced steel, aluminum, and copper
Annex II (items not subject to tariffs)	• No Sec. 232 tariff • Goods not subject to Sec. 232 duties may no longer be exempt from other tariffs (e.g., those imposed under Sec. 122 of the Trade Act of 1974)
Annex III (items with reduced tariffs until December 31, 2027)	• Column 1 duty rate ≥15% 0% Sec. 232 tariff • Column 1 duty rate <15% Column 1 duty rate + Sec. 232 tariff = 15% • 25% tariff on products from trading partners with whom the United States does not maintain normal trading relations (i.e., Cuba, North Korea, Russia, Belarus) • For products composed of at least 95% U.S.-sourced steel/aluminum: • Column 1 duty rate ≥10% 0% Sec. 232 tariff • Column 1 duty rate <10% Column 1 duty rate + Sec. 232 tariff = 10%
Annex IV (items not subject to tariffs)	• Goods in Annex I-B or Annex III that do not contain any aluminum, steel, or copper content are not subject to Sec. 232 duties • Goods in Annex I-B or Annex III (except those in HTS chapter 72, 73, 74, or 76) are not subject to Sec. 232 duties if the weight of aluminum, steel, and/or copper is less than 15% of the weight of the imported article • Goods not subject to Sec. 232 duties may no longer be exempt from other tariffs (e.g., those imposed under Sec. 122 of the Trade Act of 1974)
Other provisions	• 0% tariff on certain parts listed in Annex I-B imported for use in motorcycle manufacturing; continued exemption for certain trading partners related to certain civil aircraft and aircraft parts • Inclusions processes terminated for steel, aluminum, and copper. The Commerce Secretary and U.S. Trade Representative may jointly determine to add products within the scope of tariffs • Russia-specific tariff codes (10%-50% for steel, copper; continued 200% tariff on aluminum)

Source: CRS, summary of key provisions from annexes in Proclamation 11021 of April 2, 2026; U.S. Customs and Border Protection Cargo Systems Messaging Service (CSMS) #68253075, April 3, 2026; and U.S. Department of Commerce, Bureau of Industry and Security, "Notice of Technical Corrections to the Harmonized Tariff Schedule of the United States for Duties Imposed by Presidential Proclamation 11021," 91 *FR* 23056, April 29, 2026.

Notes: In the same proclamation, President Trump also modified copper tariffs. See CRS Insight IN12614, *Section 232 National Security Tariffs on Copper Imports*.

Table 2. U.S. Steel and Aluminum Imports, 2024 and 2025

Millions of U.S. Dollars

	2024		2025	
Partner	**Value**	**% Share Total Imports**	**Value**	**% Share Total Imports**
		Steel		
Canada	$7,177.9	23%	$4,560.1	18%
European Union	$6,804.2	22%	$5,831.2	23%
Mexico	$3,530.3	11%	$2,238.0	9%
South Korea	$2,938.3	9%	$2,448.8	10%
Brazil	$2,910.4	9%	$2,259.0	9%
All Other	$8,168.5	26%	$7,581.2	30%
Total Steel Imports	$31,529.7	100%	$24,918.3	100%
		Aluminum		
Canada	$9,440.1	51%	$7,535.4	43%
European Union	$1,540.4	8%	$1,618.3	9%
United Arab Emirates	$1,147.3	6%	$1,512.3	9%
China	$827.1	4%	$528.9	3%
South Korea	$797.8	4%	$1,062.2	6%
Bahrain	$605.7	3%	$671.7	4%
All Other	$4,214.1	23%	$4,568.4	26%
Total Aluminum Imports	$18,572.4	100%	$17,566.0	100%

Source: CRS. General imports data from the U.S. Census Bureau (accessed via Trade Data Monitor, April 23, 2026) using U.S. Harmonized Tariff Schedule (HTS) product codes for "articles of aluminum" and "articles of steel" attached to U.S. Customs and Border Protection CSMS #68253075.

Notes: Table sorted by top import sources in 2024. This table *excludes* derivative articles. Columns may not sum due to rounding.

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NEWS RELEASE

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FOR IMMEDIATE RELEASE

U. S. STEEL ANNOUNCES SUCCESSFUL START-UP OF NEW ELECTRIC ARC FURNACE AT ITS ALABAMA FACILITY

PITTSBURGH, October 26, 2020 – Today, U. S. Steel announced the successful start-up of its newly constructed, technologically advanced electric arc furnace (EAF) steelmaking facility at its Fairfield, Alabama, operations. The EAF start-up is the latest milestone providing customer value through the company's "Best of Both" integrated and mini-mill technology strategy.

Commenting on the start-up, U. S. Steel President and Chief Executive Officer David B. Burritt said, "The EAF significantly enhances our ability to deliver customer-centric solutions and results. We made a commitment to add electric arc steelmaking to our operating footprint as part of our 'Best of Both' strategy. This successful start-up delivers on that promise, and I am very pleased with the way our people safely accomplished this while navigating the disruptive influences of the COVID-19 pandemic. We had the added benefit of using this project as a tool for technical collaboration with the EAF experts at our 'Best of Both' partner, Big River Steel. Fairfield EAF #1 adds significantly more sustainable steelmaking technology to our portfolio."

Of the announcement, U. S. Steel Senior Vice President – Tubular Products Doug Matthews said, "I am proud of the Fairfield team for their perseverance and continued focus throughout the construction and start-up processes, especially on our core value of safety. We are excited to provide our customers with more sustainable tubular solutions, including our technically advanced proprietary connections, to support their efforts to safely extract and transport the resources necessary to power our daily lives."

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The EAF method of steelmaking utilizes electrical energy to melt a heat of steel. This process charges recycled steel scrap into the furnace, which is then heated by electric arcs; melting the scrap into liquid steel. In the start-up process, Fairfield EAF #1 commenced its first arc, charged and melted steel scrap, and on October 20, tapped its first heat of liquid steel.

The EAF will have an annual steelmaking capacity of 1.6 million tons. Video footage of the startup is available on U. S. Steel's YouTube page at http://www.youtube.com/c/USSteelCorp or here.

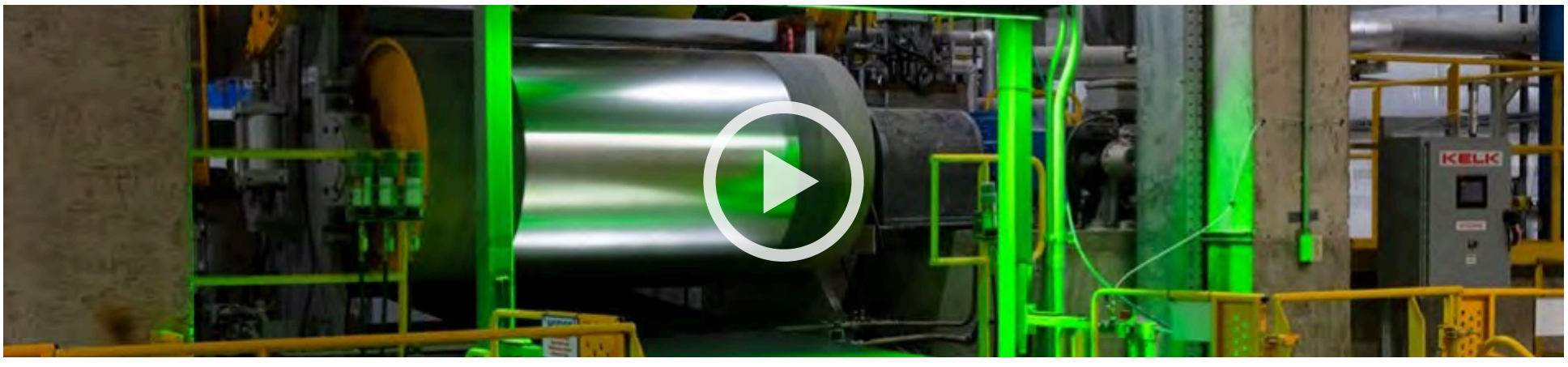
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Founded in 1901, the United States Steel Corporation is a Fortune 250 company and leading integrated steel producer. With extensive iron ore production and an annual raw steelmaking capability of 22 million net tons, U. S. Steel produces high value-added steel products for the automotive, infrastructure, appliance, container, and energy industries. The company's "Best of Both" integrated and mini-mill technology strategy is advancing a more secure, sustainable future for U. S. Steel and its stakeholders. With renewed emphasis on innovation and customer focus, the company produces cutting-edge products such as U. S. Steel's proprietary XG3™ advanced high-strength steel. U. S. Steel is headquartered in Pittsburgh, Pennsylvania, with world-class operations across the United States and in Central Europe. For more information, please visit www.ussteel.com.

Source: United States Steel Corporation

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The Next Generation of American Steelmaking is BIG and Well Underway

by Dan Brown, Executive Vice President, Advanced Technology Steelmaking at U. S. Steel and Chief Operating Officer, U. S. Steel's Big River Steel Works
DEC 15 , 2025

The completion of the Big River 2 (BR2) expansion at U. S. Steel's Big River Steel Works facility in Osceola, Arkansas, marks **a transformative milestone in American steelmaking,** setting new standards in both scale and innovation.

U. S. Steel's multi-billion-dollar investment in Big River Steel Works since 2019 has nearly doubled Big River Steel's production capacity from three to six million tons annually. Combined, both complexes can now make just about **every single steel product in coil form imaginable.** These highly engineered, sustainably made products are ready to supply to our customers – both current and potential.

An expanded offering for growing markets

The increased production capacity and technological advances brought by the BR2 expansion will expand our customer base.

Heading into 2026, we're targeting the automotive, appliance, solar and construction markets. On-site finishing capabilities such as our three highly advanced continuous galvanizing lines, our non-grain oriented (NGO) electrical steel line, a paint line, and more make ordering from Big River Steel even more convenient, attractive, and value-added.

Sustainability also remains central to Big River Steel Works' identity and a differentiator for our customers. As the first steel mill in North America to earn ResponsibleSteel™ certification, Big River Steel continues to set the pace for lower-emissions, high-performance steelmaking. And our innovative mix of sustainably produced steels such as verdeX® steel and InduX™ electrical steel demonstrate how world-class steel can be produced responsibly while meeting the evolving expectations of customers, communities and global supply chains.

A one-of-kind ESP line to meet technical demands

Steel is no longer the commodity it was years ago. Today, steel is a highly engineered material made to order to meet our customers' specialized needs. And chief among those needs: **stronger, lighter, more ductile, and more durable steel** with tight tolerances. Customers are also increasingly looking for a reliable, resilient supply chain and they prefer coils that are finished right off the line – no additional processing needed.

The expanded Big River Steel Works campus meets those needs thanks in part to **the only endless steel processing (ESP) line in North America.** The ESP is a caster and hot rolling mill combined, capable of taking a 200-ton batch of steel from red-hot liquid form to cooled, rolled coil ready for customer use in as little as 25 to 30 minutes.

Because of the ESP we're able to produce **hot-rolled steel at lighter gauges with exceptionally uniform properties.** In fact, customers are telling us that the steel from the ESP is some of best product they've ever seen.

A partnership that advances our vision

U. S. Steel's partnership with Nippon Steel has the potential to transform our company and the American steel industry, and the team at Big River Steel Works is already seeing some of those opportunities become realities. Nippon Steel's team is helping us get further ahead in non-grain-oriented electrical steel production and are also supporting automotive-grade development with better chemistries and operational improvements. And while one of Nippon Steel's areas of expertise lies in the blast furnace operations at the heart of much of our company's steelmaking footprint, their **deep bench of highly knowledgeable and experienced engineers** is already identifying ways for Big River Steel Works to improve – from electric arc furnace steelmaking to finishing.

A more complete footprint across North America

Looking more broadly, **the expanded Big River Steel Works truly rounds out the entire U. S. Steel portfolio.** Our integrated plants continue to offer an enduring legacy of high-quality steelmaking, producing critical grades still only capable through the blast furnace process. And now with a more complete footprint in one location, our mini mill segment can serve a broader range of customers in more complete ways while also giving our company added flexibility when a situation calls for it. Finally, with its DRI-ready capabilities, the expanded Big River Steel Works will support our commitment to Mined, Melted and Made in America by making even greater use of the vital iron ore resources controlled by our Minnesota Ore Operations facilities.

Local investment, enduring impact

Finally, we can't forget the positive impact the Big River Steel expansion is having on Mississippi County and surrounding areas of northeast Arkansas. Our **$3 billion investment in BR2 is the largest in state history.** In addition to thousands of construction jobs over a two-and-a-half-year period, the project is creating and supporting permanent jobs, growing the local tax base, employing local suppliers and drawing additional companies to invest in the region. U. S. Steel has also contributed $2.6 million to schools, health care infrastructure and first responders. Employee giving and volunteerism will continue to be central to our commitment to the region because as we say here: Big River Cares!

An exciting time for steel

If you think back to 30 or 40 years ago, it's fair to say that steel was a commodity-type industry. But the recently completed expansion at Big River Steel Works is proof that **steelmaking belongs in the larger, global conversation about industrial innovation.** As we invite our customers to discover what we can do for their business, we also encourage the nation to stay tuned for what the next generation of American steel has to offer.

ABOUT THE AUTHOR



Dan Brown serves as Executive Vice President of Advanced Technology Steelmaking for U. S. Steel and is Chief Operating Officer for U. S. Steel's Big River Steel Works.

Forward-Looking Statements:

This webpage contains information that may constitute "forward-looking statements" within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. We intend the forward-looking statements to be covered by the safe harbor provisions for forward-looking statements in those sections. Generally, we have identified such forward-looking statements by using the words "believe," "expect," "intend," "estimate," "anticipate," "project," "target," "forecast," "aim," "should," "will," "may" and similar expressions or by using future dates in connection with any discussion of, among other things, the construction or operation of new or existing facilities or operating capabilities, the timing, size and form of share repurchase transactions, operating or financial performance, trends, events or developments that we expect or anticipate will occur in the future, statements relating to volume changes, share of sales and earnings per share changes, anticipated cost savings, potential capital and operational cash improvements, changes in the global economic environment, including supply and demand conditions, inflation, interest rates, supply chain disruptions and changes in prices for our products, international trade duties and other aspects of international trade policy, statements regarding our future strategies, products and innovations, statements regarding our greenhouse gas emissions reduction goals, statements regarding existing or new regulations and statements expressing general views about future operating results. However, the absence of these words or similar expressions does not mean that a statement is not forward-looking. Forward-looking statements are not historical facts, but instead represent only the Company's beliefs regarding future events, many of which, by their nature, are inherently uncertain and outside of the Company's control. It is possible that the Company's actual results may differ, possibly materially, from the anticipated results indicated in these forward-looking statements. Management believes that these forward-looking statements are reasonable as of the time made. However, caution should be taken not to place undue reliance on any such forward-looking statements because such statements speak only as of the date when made. Our Company undertakes no obligation to publicly update or revise any forward-looking statements, whether as a result of new information, future events or otherwise, except as required by law. In addition, forward-looking statements are subject to certain risks and uncertainties that could cause actual results to

differ materially from our Company's historical experience and our present expectations or projections. These risks and uncertainties include, but are not limited to, the risks and uncertainties described on this webpage and in "Item 1A. Risk Factors" in our Annual Report on Form 10-K and those described from time to time in our reports filed with the Securities and Exchange Commission.

United States Steel Corporation
Corporate Headquarters
600 Grant Street
Pittsburgh, PA 15219

For general inquiries,
contact the U. S. Steel Operator.
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8 a.m. - 5 p.m. Eastern
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December 9, 2020

Cleveland-Cliffs Inc. Completes Acquisition of ArcelorMittal USA

CLEVELAND--(BUSINESS WIRE)-- Cleveland-Cliffs Inc. **(NYSE: CLF)** today announced that it has successfully completed the acquisition of substantially all of the operations of ArcelorMittal USA LLC and its subsidiaries ("ArcelorMittal USA"), forming the largest flat-rolled steel producer in North America. On a full-year 2019 basis, the combined Company generated pro-forma revenues of approximately $17 billion and combined adjusted EBITDA of approximately $1.7 billion, including previously disclosed expected synergies.

In connection with the acquisition of ArcelorMittal USA, which includes the interests of ArcelorMittal USA of 60% in I/N Tek L.P. and 50% in I/N Kote L.P., Cleveland-Cliffs also acquired Nippon Steel Corporation's remaining interests of 50% in I/N Kote and 40% in I/N Tek, for a total consideration of approximately $183 million. With this additional transaction, Cleveland-Cliffs becomes the sole owner of 100% of I/N Tek and I/N Kote, which generated a combined $121 million of adjusted EBITDA in 2019.

Lourenco Goncalves, Chairman, President and Chief Executive Officer said, "The acquisition by Cleveland-Cliffs of ArcelorMittal USA, boosted by our buyout of Nippon Steel from the I/N Tek and I/N Kote joint ventures, opens a new chapter in the history of the steel business in the United States. The assets we have acquired will be combined with our existing footprint, including AK Steel, Precision Partners, AK Tube, several mining and pelletizing facilities, our Research & Development Center, and the most modern Direct Reduction plant in the world, which we have just started to operate in Toledo, OH. Our new footprint expands our technological capability and enhances our operational flexibility, elevating Cleveland-Cliffs to a prominent role as a major player in supporting American manufacturing, American future investments in infrastructure, and the prosperity of the American people through good paying middle-class jobs."

Mr. Goncalves added, "We are also excited with the addition of the re-rolling plant co-owned by ArcelorMittal and Nippon Steel in Alabama as a very important long-term client of Cleveland-Cliffs for automotive grade slabs."

Mr. Goncalves concluded, "We recognize our leadership role both domestically and globally as a major steel company, and pledge to operate our business in a disciplined, environmentally responsible, and socially conscious manner. The potential of operating this set of assets under one roof is immense, and will be carried out to the benefit of our employees, their families, and the communities in which we operate."

Goldman Sachs & Co. LLC acted as financial advisor and Jones Day served as legal counsel to Cleveland-Cliffs. BofA Securities acted as lead arranger for the Company's amended and upsized Asset Based Lending facility.

About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847

as a mine operator, Cliffs is also the largest producer of iron ore pellets in North America. In 2020, Cliffs acquired two major steelmakers, AK Steel and ArcelorMittal USA, vertically integrating its legacy iron ore business with quality-focused steel production and emphasis on the automotive end market. Cliffs' fully integrated portfolio includes custom-made pellets and, by the end of 2020, Hot Briquetted Iron (HBI); flat-rolled carbon steel, stainless, electrical, plate, tin and long steel products; as well as carbon and stainless steel tubing, hot and cold stamping and tooling. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs more than 25,000 people across its mining, steel and downstream manufacturing operations in the United States and Canada. For more information, visit www.clevelandcliffs.com.

Forward-Looking Statements

This release contains statements that constitute "forward-looking statements" within the meaning of the federal securities laws. As a general matter, forward-looking statements relate to anticipated trends and expectations rather than historical matters. Forward-looking statements are subject to uncertainties and factors relating to our operations and business environment that are difficult to predict and may be beyond our control. Such uncertainties and factors may cause actual results to differ materially from those expressed or implied by the forward-looking statements. These statements speak only as of the date of this release, and we undertake no ongoing obligation, other than that imposed by law, to update these statements. Uncertainties and risk factors that could affect our future performance and cause results to differ from the forward-looking statements in this release include, but are not limited to: severe financial hardship, bankruptcy, temporary or permanent shutdowns or operational challenges, due to the ongoing COVID-19 pandemic or otherwise, of one or more of our major customers, including customers in the automotive market, key suppliers or contractors, which, among other adverse effects, could lead to reduced demand for our products, increased difficulty collecting receivables, and customers and/or suppliers asserting force majeure or other reasons for not performing their contractual obligations to us; uncertainty and weaknesses in global economic conditions, including downward pressure on prices caused by the COVID-19 pandemic, oversupply of imported products, reduced market demand and risks related to U.S. government actions with respect to Section 232, the USMCA and/or other trade agreements, treaties or policies; uncertainties associated with the highly competitive and highly cyclical steel industry and reliance on the demand for steel from the automotive industry; continued volatility of steel and iron ore prices and other trends, which may impact the price-adjustment calculations under certain of our sales contracts; our ability to cost-effectively achieve planned production rates or levels, including at our HBI production plant; our ability to successfully identify and consummate any strategic investments or development projects, including our HBI production plant; the impact of our steelmaking customers reducing their steel production due to the COVID-19 pandemic, or increased market share of steel produced using methods other than those used by our customers, or increased market share of lighter-weight steel alternatives, including aluminum; our ability to maintain adequate liquidity, our level of indebtedness and the availability of capital could limit cash flow available to fund working capital, planned capital expenditures, acquisitions, and other general corporate purposes or ongoing needs of our business; our actual economic iron ore reserves or reductions in current mineral estimates, including whether any mineralized material qualifies as a reserve; our ability to successfully diversify our product mix and add new customers; the outcome of any contractual disputes with our customers, joint venture partners or significant energy, material or service providers or any other litigation or arbitration; problems or uncertainties with sales

volume or mix, productivity, transportation, environmental liabilities, employee-benefit costs and other risks of the steel and mining industries; impacts of existing and increasing governmental regulation and related costs and liabilities, including failure to receive or maintain required operating and environmental permits, approvals, modifications or other authorization of, or from, any governmental or regulatory entity and costs related to implementing improvements to ensure compliance with regulatory changes; our ability to maintain appropriate relations with unions and employees; the ability of our customers, joint venture partners and third-party service providers to meet their obligations to us on a timely basis or at all; events or circumstances that could impair or adversely impact the viability of a production plant or mine and the carrying value of associated assets, as well as any resulting impairment charges; uncertainties associated with natural disasters, weather conditions, unanticipated geological conditions, supply or price of energy, equipment failures, infectious disease outbreaks and other unexpected events; adverse changes in interest rates, foreign currency rates and tax laws; the potential existence of significant deficiencies or material weakness in our internal control over financial reporting; our ability to realize the anticipated benefits of the merger with AK Steel and to successfully integrate the businesses of AK Steel into our existing businesses, including uncertainties associated with maintaining relationships with customers, vendors and employees, as well as realizing additional future synergies; additional debt we assumed or issued in connection with the merger with AK Steel, as well as additional debt we incurred in connection with enhancing our liquidity during the COVID-19 pandemic, may negatively impact our credit profile and limit our financial flexibility; changes in the cost of raw materials and supplies; supply chain disruptions or poor quality of raw materials or supplies, including scrap, coal, coke and alloys; disruptions in, or failures of, our information technology systems, including those related to cybersecurity; unanticipated costs associated with healthcare, pension and OPEB obligations; our ability to integrate ArcelorMittal USA's businesses and our existing businesses successfully and to achieve anticipated synergies; business and management strategies for the maintenance, expansion and growth of the combined company's operations; potential litigation relating to the acquisition of ArcelorMittal USA that could be instituted against us or our officers and directors; disruptions from the acquisition that have the potential to harm our or ArcelorMittal USA's businesses, including current plans and operations; our ability to retain and hire key personnel, including within the ArcelorMittal USA businesses; potential adverse reactions or changes to business relationships resulting from the completion of the acquisition of ArcelorMittal USA; and additional debt we incur, or other proposed financing transactions we may enter into, in connection with the acquisition may negatively impact our credit profile and limit our financial flexibility.

For additional factors affecting the business of Cliffs, refer to “Risk Factors” in Cliffs’ Quarterly Report on Form 10-Q for the quarterly period ended September 30, 2020.

You are urged to carefully consider these risk factors.

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Source: Cleveland-Cliffs Inc.

February 21, 2022

Cleveland-Cliffs Announces Indefinite Idle of Indiana Harbor #4 Blast Furnace and Notifies of Flat-Rolled Price Increase

CLEVELAND--(BUSINESS WIRE)-- Cleveland-Cliffs Inc. announced today that it will indefinitely idle its Indiana Harbor #4 blast furnace (IH#4). This action is a result of the successful implementation of operational improvements, particularly the addition of significant amounts of HBI to the burden of blast furnaces and the maximization of scrap usage in BOFs. The employees allocated to IH#4 will be reassigned to other positions within Indiana Harbor Works, as the number of available job openings at the Indiana Harbor complex exceeds the amount of jobs associated with IH#4. The Company will continue normal operations of the entire Indiana Harbor Works, including its two steel shops, the hot strip mill and all its finishing facilities, as well as the nearby Riverdale Works. With both Indiana Harbor blast furnaces #3 and #4 now indefinitely idled, going forward, all downstream operations including Riverdale Works will be supplied exclusively by the Company's flagship high-productivity IH#7 blast furnace.

The IH#4 furnace, which has a production capacity of 2.1 million net tons of hot metal per year, is expected to cease production within the next two months. This action will reduce the number of operational blast furnaces in Cliffs' footprint from 8 to 7. The Company does not expect any change to full-year 2022 steel shipment volumes as a result of the indefinite idle of IH#4.

Separately, the Company will also notify its customers that, based on a stronger inflow of new orders, it is increasing current spot market base prices for all April orders of carbon hot rolled, cold rolled and coated steel products by a minimum of $50 per net ton.

Lourenco Goncalves, Cliffs' Chairman, President and Chief Executive Officer said, "Our strategy of increasing productivity at our ironmaking and steelmaking facilities through the use of both in-house produced HBI and additional scrap has allowed us to reduce coke rate and consequently reduce CO_2 emissions, as well as to stretch hot metal utilization and still be able to produce similar amounts of crude steel with fewer blast furnaces. Said another way, by concentrating the operation and maximizing productivity at IH#7 we are improving our carbon footprint and, at the same time, lowering our cost structure for the same level of steel production and shipments. Most importantly, as we have enough job openings on site for all impacted employees, we are now able to fill several available job openings at Indiana Harbor Works with the current workforce of IH#4."

About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials, direct reduced iron, and ferrous scrap to primary steelmaking and downstream finishing, stamping, tooling,

and tubing. We are the largest supplier of steel to the automotive industry in North America and serve a diverse range of other markets due to our comprehensive offering of flat-rolled steel products. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs approximately 26,000 people across its operations in the United States and Canada.

Forward-Looking Statements

This release contains statements that constitute "forward-looking statements" within the meaning of the federal securities laws. All statements other than historical facts, including, without limitation, statements regarding our current expectations, estimates and projections about our industry or our businesses, are forward-looking statements. We caution investors that any forward-looking statements are subject to risks and uncertainties that may cause actual results and future trends to differ materially from those matters expressed in or implied by such forward-looking statements. Investors are cautioned not to place undue reliance on forward-looking statements. Among the risks and uncertainties that could cause actual results to differ from those described in forward-looking statements are the following: disruptions to our operations relating to the ongoing COVID-19 pandemic, including the heightened risk that a significant portion of our workforce or on-site contractors may suffer illness or otherwise be unable to perform their ordinary work functions; continued volatility of steel, iron ore and scrap metal market prices, which directly and indirectly impact the prices of the products that we sell to our customers; uncertainties associated with the highly competitive and cyclical steel industry and our reliance on the demand for steel from the automotive industry, which has been experiencing a trend toward light weighting and supply chain disruptions, such as the semiconductor shortage, that could result in lower steel volumes being consumed; potential weaknesses and uncertainties in global economic conditions, excess global steelmaking capacity, oversupply of iron ore, prevalence of steel imports and reduced market demand, including as a result of the prolonged COVID-19 pandemic; severe financial hardship, bankruptcy, temporary or permanent shutdowns or operational challenges, due to the ongoing COVID-19 pandemic or otherwise, of one or more of our major customers, including customers in the automotive market, key suppliers or contractors, which, among other adverse effects, could lead to reduced demand for our products, increased difficulty collecting receivables, and customers and/or suppliers asserting force majeure or other reasons for not performing their contractual obligations to us; risks related to U.S. government actions with respect to Section 232 of the Trade Expansion Act of 1962 (as amended by the Trade Act of 1974), the United States-Mexico-Canada Agreement and/or other trade agreements, tariffs, treaties or policies, as well as the uncertainty of obtaining and maintaining effective antidumping and countervailing duty orders to counteract the harmful effects of unfairly traded imports; impacts of existing and increasing governmental regulation, including potential environmental regulations relating to climate change and carbon emissions, and related costs and liabilities, including failure to receive or maintain required operating and environmental permits, approvals, modifications or other authorizations of, or from, any governmental or regulatory authority and costs related to implementing improvements to ensure compliance with regulatory changes, including potential financial assurance requirements; potential impacts to the environment or exposure to hazardous substances resulting from our operations; our ability to maintain adequate liquidity, our level of indebtedness and the availability of capital could limit our financial flexibility and cash flow necessary to fund working capital, planned capital expenditures, acquisitions, and other general corporate purposes or ongoing needs of our business; our ability to reduce our indebtedness or return capital to shareholders within the

currently expected timeframes or at all; adverse changes in credit ratings, interest rates, foreign currency rates and tax laws; the outcome of, and costs incurred in connection with, lawsuits, claims, arbitrations or governmental proceedings relating to commercial and business disputes, environmental matters, government investigations, occupational or personal injury claims, property damage, labor and employment matters, or suits involving legacy operations and other matters; supply chain disruptions or changes in the cost or quality of energy sources, including electricity, natural gas and diesel fuel, or critical raw materials and supplies, including iron ore, industrial gases, graphite electrodes, scrap metal, chrome, zinc, coke and metallurgical coal; problems or disruptions associated with transporting products to our customers, moving manufacturing inputs or products internally among our facilities, or suppliers transporting raw materials to us; uncertainties associated with natural or human-caused disasters, adverse weather conditions, unanticipated geological conditions, critical equipment failures, infectious disease outbreaks, tailings dam failures and other unexpected events; disruptions in, or failures of, our information technology systems, including those related to cybersecurity; liabilities and costs arising in connection with any business decisions to temporarily idle or permanently close an operating facility or mine, which could adversely impact the carrying value of associated assets and give rise to impairment charges or closure and reclamation obligations, as well as uncertainties associated with restarting any previously idled operating facility or mine; our ability to realize the anticipated synergies and benefits of our recent acquisition transactions and to successfully integrate the acquired businesses into our existing businesses, including uncertainties associated with maintaining relationships with customers, vendors and employees and known and unknown liabilities we assumed in connection with the acquisitions; our level of self-insurance and our ability to obtain sufficient third-party insurance to adequately cover potential adverse events and business risks; challenges to maintaining our social license to operate with our stakeholders, including the impacts of our operations on local communities, reputational impacts of operating in a carbon-intensive industry that produces greenhouse gas emissions, and our ability to foster a consistent operational and safety track record; our ability to successfully identify and consummate any strategic capital investments or development projects, cost-effectively achieve planned production rates or levels, and diversify our product mix and add new customers; our actual economic mineral reserves or reductions in current mineral reserve estimates, and any title defect or loss of any lease, license, easement or other possessory interest for any mining property; availability of workers to fill critical operational positions and potential labor shortages caused by the ongoing COVID-19 pandemic, as well as our ability to attract, hire, develop and retain key personnel; our ability to maintain satisfactory labor relations with unions and employees; unanticipated or higher costs associated with pension and OPEB obligations resulting from changes in the value of plan assets or contribution increases required for unfunded obligations; the amount and timing of any repurchases of our common shares; and potential significant deficiencies or material weaknesses in our internal control over financial reporting.

For additional factors affecting the business of Cliffs, refer to Part I – Item 1A. Risk Factors of our Annual Report on Form 10-K for the year ended December 31, 2021, and other filings with the U.S. Securities and Exchange Commission.

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Source: Cleveland-Cliffs Inc.

United States Steel Corporation Completes Big River Steel Acquisition

JANUARY 15, 2021

5 Minute Read

- **Enables profitable growth through sustainable production of the most advanced high strength steels from the only LEED-certified steel mill**
- **Creates North America's only customer-centric "Best of Both" steelmaker, combining world-competitive integrated and mini mill technologies to improve through-cycle stockholder returns**
- **Aligns superior workforce around more innovative and entrepreneurial "Best of Both" strategy**

PITTSBURGH--(BUSINESS WIRE)-- United States Steel Corporation (NYSE: X) ("U. S. Steel") announced today it closed its acquisition of the remaining equity of Big River Steel ("Big River Steel") for approximately $774 million from cash on hand. The transaction met customary closing conditions, including antitrust approval from the United States Department of Justice.

"We are creating the first 'Best of Both' integrated and mini mill steel company. Taking a page from the Big River Steel playbook, we are closing on this world competitive green steel asset purchase under budget and ahead of schedule," said U. S. Steel President and Chief Executive Officer David Burritt. "Our customers now have access to a truly sustainable source of the most advanced high strength steels. Our customer-centric organization will provide customers, employees, communities and investors with the world competitive advantages from the most advanced process technology and the intellectual capital necessary to produce the most advanced products."

"The innovative and entrepreneurial collaboration we are already seeing has us even more enthused about the potential for our people and our 'Best of Both' company. This is not an either/or initiative where you compromise the competitive advantage of one versus the other. Instead, we are dedicated to encouraging and sharing the best attributes of both, to the benefit of our customers. We fully expect to generate profitable growth quickly in 2021 and enable a more nimble, innovative, and cost-effective company across the business cycle."

U. S. Steel's management team will provide additional detail on the Big River Steel acquisition during the company's fourth quarter 2020 earnings conference call scheduled on January 29, 2021, at 8:30 a.m. EST. The call will be available via the U. S. Steel website. To access the webcast, visit the website at www.ussteel.com and click "Investors." Replays of the conference call will be available on the website after 10:30 a.m. EST on January 29, 2021.

Barclays served as exclusive M&A financial advisor, while PJT Partners and Rothschild & Co. served as financing advisors to U. S. Steel on the acquisition, and Milbank LLP provided legal counsel.

Big River Steel is a LEED-certified Flex Mill™ in northeast Arkansas that is believed to be the newest and most advanced flat rolled mill in North America. Big River Steel's advanced manufacturing technology and skilled operators combined with U. S. Steel's product development capabilities and intellectual property have allowed Big River Steel to produce 14 advanced U. S. Steel grades, including substrate for its XG3™ grade of Generation 3 advanced high-strength steel (AHSS). Big River Steel offers high-quality products and services

to discerning customers in the automotive, energy, construction, and agricultural industries. Big River Steel's Phase II-A expansion doubled the mill's hot-rolled steel production capacity to 3.3 million tons annually, establishing it as one of the largest electric arc furnace-oriented flat-rolled mills in North America. The Phase II-A expansion was completed in November 2020, ahead of schedule and below budget.

FORWARD-LOOKING STATEMENTS

This release contains information that may constitute "forward-looking statements" within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. We intend the forward-looking statements to be covered by the safe harbor provisions for forward-looking statements in those sections. Generally, we have identified such forward-looking statements by using the words "believe," "expect," "intend," "estimate," "anticipate," "project," "target," "forecast," "aim," "should," "will," "may" and similar expressions or by using future dates in connection with any discussion of, among other things, operating performance, trends, events or developments that we expect or anticipate will occur in the future, statements relating to volume changes, share of sales and earnings per share changes, anticipated cost savings, potential capital and operational cash improvements, anticipated disruptions to our operations and industry due to the COVID-19 pandemic, changes in global supply and demand conditions and prices for our products, international trade duties and other aspects of international trade policy, the integration of Big River Steel in our existing business, business strategies related to the combined business and statements expressing general views about future operating results. However, the absence of these words or similar expressions does not mean that a statement is not forward-looking. Forward-looking statements are not historical facts, but instead represent only the Company's beliefs regarding future events, many of which, by their nature, are inherently uncertain and outside of the Company's control. It is possible that the Company's actual results and financial condition may differ, possibly materially, from the anticipated results and financial condition indicated in these forward-looking statements. Management believes that these forward-looking statements are reasonable as of the time made. However, caution should be taken not to place undue reliance on any such forward-looking statements because such statements speak only as of the date when made. Our Company undertakes no obligation to publicly update or revise any forward-looking statements, whether as a result of new information, future events or otherwise, except as required by law. In addition, forward-looking statements are subject to certain risks and uncertainties that could cause actual results to differ materially from our Company's historical experience and our present expectations or projections. These risks and uncertainties include, but are not limited to our ability to realize the level of cost savings, productivity improvement, growth or other anticipated benefits and additional future synergies, including in the time period anticipated, of the acquisition of Big River Steel; our ability to successfully integrate the businesses of Big River Steel into our existing businesses, including uncertainties associated with maintaining relationships with customers, vendors and employees, as well as differences in operating technologies, cultures, and management philosophies that may delay successful integration; additional debt, which we assumed in connection with the acquisition of Big River Steel and incurred to enhance our liquidity during the COVID-19 pandemic, may negatively impact our credit profile and limit our financial flexibility; business strategies for the combined company's operations; the diversion of management's attention from ongoing business operations; our ability to retain and hire key personnel, including within the Big River Steel business, and to access our distribution channels, including the availability of workforce and subcontractors; potential adverse reactions or changes to business relationships resulting from the completion of the acquisition of Big River Steel; unknown or underestimated liabilities and unforeseen increased expenses or delays associated with the acquisition and integration beyond current estimates; and the risks and uncertainties described in "Item 1A. Risk Factors" of our Annual report on Form 10-K, quarterly reports on Form 10-Q and those described from time to time in our future reports filed with the Securities and Exchange Commission.

Founded in 1901, the United States Steel Corporation is a Fortune 250 company and a leading steel producer. Together with its subsidiary Big River Steel and an unwavering focus on safety, the company's customer-centric "Best of Both" world-competitive integrated and mini mill technology strategy is advancing a more secure, sustainable future for U. S. Steel and its stakeholders. With a renewed emphasis on innovation, U. S. Steel serves the automotive, construction, appliance, energy, containers and packaging industries with high value-added steel products such as U. S. Steel's proprietary XG3™ advanced high- strength steel. The company also maintains competitively advantaged iron ore production and has an annual raw steelmaking capability of 26.2 million net tons. U. S. Steel is headquartered in Pittsburgh, Pennsylvania, with world-class operations across the United States and in Central Europe. For more information, please visit www.ussteel.com.

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8 a.m. - 5 p.m. Eastern
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Nippon Steel Corporation and U. S. Steel Finalize Historic Partnership

JUNE 18, 2025

7 Minute Read

U. S. Steel to Retain Its Iconic Name and Headquarters in Pittsburgh, Pennsylvania

and Continue to Be Mined, Melted, and Made in America

Partnership Expected to Protect and Create More Than 100,000 Jobs

Moving Forward Together as the 'Best Steelmaker with World-Leading Capabilities'

Tokyo and Pittsburgh – June 18, 2025 – Nippon Steel Corporation (TSE: 5401) ("Nippon Steel"), together with its wholly owned subsidiary Nippon Steel North America, Inc. and United States Steel Corporation ("U. S. Steel") (collectively, the "Companies"), today announced they have finalized their historic partnership.

Together, Nippon Steel and U. S. Steel will be a world-leading steelmaker, with best-in-class technologies and manufacturing capabilities. The partnership will protect and create more than 100,000 jobs through unprecedented massive investments in steelmaking in the United States that will be unleashed across U. S. Steel's footprints, including in Pennsylvania, Indiana, Arkansas, Minnesota and Alabama. This partnership ensures that U. S. Steel will retain its iconic name and headquarters in Pittsburgh, Pennsylvania, and that it will continue to be Mined, Melted, and Made in America for generations to come.

Eiji Hashimoto, Nippon Steel's Representative Director, Chairman and CEO, said, "I am very pleased that the partnership between Nippon Steel and U. S. Steel has been realized thanks to President Trump's historic and visionary decision. I would like to thank the wide range of stakeholders in the United States and Japan, including U. S. Steel employees, local communities, government officials, elected officials, and business leaders, for their endorsement and support of this partnership. Nippon Steel is excited about opening a new chapter of U. S. Steel's storied history. Building on our investment, the transfer of our advanced technologies, and the unwavering efforts of management and the employees of both companies, Nippon Steel is committed, together with U. S. Steel, to solidifying its position as the world's leading steelmaker."

Takahiro Mori, Nippon Steel's Representative Director and Vice Chairman, and who will serve as Chairman of the Board of U. S. Steel said, "Since announcing our deal, I have engaged in extensive dialogue with many stakeholders, including the employees of U. S. Steel, government officials and community leaders, and I would like to express my sincere gratitude to all of them for their tremendous cooperation and support for this partnership. I am delighted that we have made this day a reality. We share President Trump's commitment to protect the future of the American steel industry, American workers, and American national security, and we look forward to building a stronger and brighter future for U. S. Steel."

U. S. Steel's CEO Dave Burritt stated: "This is a momentous day for our country, our communities, and the American steel industry. Thanks to President Trump's bold leadership, American workers secured the best possible deal. U. S. Steel will remain rooted in the United States and continue

to call Pittsburgh home. Through our partnership with Nippon Steel, we are poised to grow better and bigger, with transformative investment, cutting-edge technology, and the creation of good-paying jobs across the United States."

The Companies have now completed the transaction as contemplated by their merger agreement. The Companies have also entered into a National Security Agreement ("NSA") with the U.S Government, and U. S. Steel will issue a Golden Share to the U.S. Government.

Under the NSA, the U.S. Government and the Companies have agreed to measures to protect U.S. national security, including, among others, the following commitments by the Companies:

- **Investment -** Nippon Steel will make approximately $11 billion in new investments in U. S. Steel by 2028, which includes an initial investment in a greenfield project that will be completed after 2028;

- **U.S. Headquarters -** U. S. Steel will remain a U.S.-incorporated entity and will maintain its headquarters in Pittsburgh, Pennsylvania;

- **U.S. Board -** A majority of the members of U. S. Steel's board of directors will be U.S. citizens;

- **U.S. Management -** U. S. Steel's key management personnel, including its CEO, will be U.S. citizens;

- **U.S. Production -** U. S. Steel will maintain capacity to produce and supply steel from its U.S. production locations to meet market demand in the U.S.; and

- **U. S. Steel Autonomous Trade -** Nippon Steel will not prevent, prohibit, or otherwise interfere with U. S. Steel's ability to pursue trade action under U.S. law

Pursuant to the NSA and through the ownership of the Golden Share, the U.S. Government will have certain rights, including, among others:

- The right to appoint one independent director; and

- Consent rights of the President of the United States, or his designee, on specific matters, including:

  - Reductions in the committed capital investments under the NSA;
  - Changing U. S. Steel's name and headquarters;
  - Redomiciling U. S. Steel outside of the United States;
  - Transfer of production or jobs outside of the United States;
  - Material acquisitions of competing businesses in the United States; and
  - Certain decisions on closure or idling of U. S. Steel's existing U.S. manufacturing facilities, trade, labor, and sourcing outside of the United States.

This framework will enable Nippon Steel to secure management flexibility and profitability at U. S. Steel while protecting U.S. national security.

With this partnership, the Nippon Steel Group's annual crude steel production capacity is expected to reach 86 million tons, bringing it closer to Nippon Steel's global strategic goal of 100 million tons of global crude steel production capacity.

The total number of jobs that will be created and is referenced above is based on a study done by Parker Strategy Group, commissioned by U. S. Steel. Total jobs figure includes direct, indirect and induced jobs.

Advisors

Citi acted as financial advisor to Nippon Steel. Ropes & Gray LLP acted as legal advisor to Nippon Steel. PJT Partners and Akin Gump Strauss Hauer & Feld LLP acted as strategic advisors to Nippon Steel. Barclays Capital Inc., Goldman Sachs & Co. LLC and Evercore acted as financial advisors to U. S. Steel. Milbank LLP, Covington & Burling LLP and Wachtell, Lipton, Rosen & Katz acted as legal advisors to U. S. Steel.

About Nippon Steel

Nippon Steel is one of the world's leading steelmakers and Japan's largest steelmaker. Nippon Steel has a global crude steel production capacity of approximately 86 million tonnes and employs around 136,000 people in the world. Nippon Steel's manufacturing base encompasses more than 15 countries including: Japan, the United States, India, Thailand, Indonesia, Vietnam, Brazil, Mexico, Sweden and others. Nippon Steel established a manufacturing base in the United States around 40 years ago and has focused on building cooperative and good relationships with employees, labor unions, suppliers, customers, and communities. As the 'Best Steelmaker with World-Leading Capabilities,' Nippon Steel pursues world-leading technologies and manufacturing capabilities and contributes to society by providing excellent products and services. For more information, please visit: https://www.nipponsteel.com.

About U. S. Steel

Founded in 1901, U. S. Steel delivers profitable and sustainable steel solutions. Propelled by its talented employees and an unwavering focus on safety, U. S. Steel serves the automotive, construction, appliance, energy, containers, and packaging industries with high value-added steel products. Steel production begins with our competitively advantaged iron ore production capabilities which fuel our integrated steelmaking facilities and investments in electric arc furnaces. To help our customers create the best products with the fewest emissions, we are committed to reaching net-zero greenhouse gas emissions by 2050. U. S. Steel is at the forefront of creating steels that are stronger, lighter, and better for the environment. This includes our proprietary XG3® advanced high-strength steel, verdeX® steel produced with 70-80% lower CO2 emissions with a recycled content of up to 90%, and ultra-thin lightweight InduX™ steel for electric vehicles, generators, and transformers. U. S. Steel maintains operations across the United States and in Central Europe and is headquartered in Pittsburgh, Pennsylvania. For more information, please visit www.ussteel.com and follow U. S. Steel on LinkedIn, Instagram, Facebook, and X.

CAUTIONARY NOTE REGARDING FORWARD-LOOKING STATEMENTS

This press release contains information regarding U. S. Steel and Nippon Steel that may constitute "forward-looking statements," as that term is defined under the Private Securities Litigation Reform Act of 1995 and other securities laws, that are subject to risks and uncertainties. We intend the forward-looking statements to be covered by the safe harbor provisions for forward-looking statements in those sections. Generally, we have identified such forward-looking statements by using the words "believe," "expect," "intend," "estimate," "anticipate," "project," "target," "forecast," "aim," "should," "plan," "goal," "future," "will," "may" and similar expressions or by using future dates in connection with any discussion of, among other things, statements expressing general views about trends, events or developments that we expect or anticipate will occur in the future, potential changes in the global economic environment, anticipated capital expenditures, the construction or operation of new or existing facilities or capabilities and the costs associated with such matters, as well as statements regarding the transaction. However, the absence of these words or similar expressions does not mean that a statement is not forward-looking. Forward-looking statements include all statements that are not historical facts, but instead represent only U. S. Steel's and Nippon Steel's beliefs regarding future goals, plans and expectations about our prospects for the future and other events, many of which, by their nature, are inherently uncertain and outside of U. S. Steel's or Nippon Steel's control and may differ, possibly materially, from the anticipated events indicated in these forward-looking statements. Management of U. S. Steel or Nippon Steel, as applicable, believes that these forward-looking statements are reasonable as of the time made. However, caution should be taken not to place undue reliance on any such forward-looking statements because such statements speak only as of the date when made. In addition, forward looking statements are subject to certain risks and uncertainties that could cause actual results to differ materially from U. S. Steel's or Nippon Steel's historical experience and our present expectations or projections. Risks and uncertainties include

without limitation: the risk that any announcements relating to the transaction could have adverse effects on the market price of Nippon Steel's common stock or American Depositary Receipts; the risk of any unexpected costs or expenses resulting from the transaction; and the risk that the transaction could have an adverse effect on the ability of U. S. Steel or Nippon Steel to retain customers and retain and hire key personnel and maintain relationships with customers, suppliers, employees, stockholders and other business relationships and on its operating results and business generally. U. S. Steel directs readers to its Form 10-K for the year ended December 31, 2024 and Quarterly Report on Form 10-Q for the quarter ended March 31, 2025, and the other documents it files with the SEC for other risks associated with U. S. Steel's future performance. These documents contain and identify important factors that could cause actual results to differ materially from those contained in the forward-looking statements.

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U. S. STEEL MAKES STRATEGIC PROGRESS ON INDIANA PROJECTS BACKED BY NIPPON STEEL PARTNERSHIP

DECEMBER 22, 2025

A Minute Read

PITTSBURGH, DECEMBER 22, 2025 – At its final meeting of the year, U. S. Steel's Board of Directors approved the funding for the full $350 million Gary Works blast furnace reline project. Relining Blast Furnace #14 is critical maintenance needed to allow Gary Works to continue to meet customer commitments and ensures the long-term iron making capabilities and capacities at Gary Works. Blast Furnace #14, the largest of four at Gary Works, produces iron for high-strength steel used in everything from cars to buildings, using iron ore pellets from its Minnesota Ore facilities.

Major investments in upgrades at the hot strip mill, where steel slabs are converted to coils, and the steel shop, where iron is converted to steel, continue to advance. Those upgrades are expected to cost roughly $200 million.
U. S. Steel is working with the Indiana Department of Environmental Management to secure necessary permits for those upgrades, submitting its air permit and stormwater construction plans in December. These projects and collection of investments, once operational, will enhance steelmaking capabilities, improve competitiveness, and increase capacity.

"Each milestone represents tangible progress on our mission to invest billions in the future of American steelmaking," said David B. Burritt, President and CEO of U. S. Steel. "These Gary Works projects will fuel American manufacturing and expand opportunities for Hoosiers. From the iron range to the finishing lines, these projects are the definition of investing in steel mined, melted and made in America."

These advancements build on strong momentum across U. S. Steel, supported by Nippon Steel's advanced technology and commitment to invest $11 billion by the end of 2028. Shared technical expertise is accelerating key upgrades and reinforcing capabilities that customers rely on nationwide.

About U. S. Steel

Founded in 1901, U. S. Steel delivers profitable and sustainable steel solutions. Propelled by its talented employees and an unwavering focus on safety, U. S. Steel serves the automotive, construction, appliance, energy, containers, and packaging industries with high value-added steel products. Steel production begins with our competitively advantaged iron ore production capabilities which fuel our integrated steelmaking facilities and investments in electric arc furnaces. To help our customers create the best products with the fewest emissions, we are committed to reaching net-zero greenhouse gas emissions by 2050. U. S. Steel is at the forefront of creating steels that are stronger, lighter, and better for the environment. This includes our proprietary XG3® advanced high-strength steel, verdeX® steel produced with 70-80% lower CO2 emissions with a recycled content of up to 90%, and ultra-thin lightweight InduX™ steel for electric vehicles,

generators, and transformers. U. S. Steel maintains operations across the United States and in Central Europe and is headquartered in Pittsburgh, Pennsylvania. For more information, please visit www.ussteel.com and follow U. S. Steel on LinkedIn, Instagram, Facebook, and X.

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United States Steel Celebrates Opening of DR-Grade Pellet Production Facility in Minnesota

MAY 23, 2024

A Minute Read

The $150 million investment expands on the Company's existing competitive advantage in low-cost iron ore

KEEWATIN, Minn.--(BUSINESS WIRE)-- U. S. Steel (NYSE: X) ("U. S. Steel") today celebrated the launch and operational readiness of its direct reduced (DR)-grade pellet production facility at its Minnesota Ore Operations-Keetac Plant. Having already confirmed the first shipment of DR-grade pellets, the Keetac facility is on track to deliver approximately four million tons of pellets annually. The $150 million investment marks a step forward in U. S. Steel's metallics strategy by supplying the increasingly tight DR-grade pellet market with low-cost iron ore and building on the company's ability to meet customer needs.

This press release features multimedia. View the full release here: https://www.businesswire.com/news/home/20240523633782/en/

Minnesota Governor Tim Walz; David B. Burritt, President and CEO of U. S. Steel; Kristen Vake, Executive Director, Iron Mining Association of Minnesota; and Travis Kolari, Head of Operations, U. S. Steel Minnesota Ore Operations cut the ribbon on U. S. Steel's new DR-Grade pellet plant. (Photo: Business Wire)

Minnesota Governor Tim Walz; David B. Burritt, President and CEO of U. S. Steel; Kristen Vake, Executive Director, Iron Mining Association of Minnesota; and Travis Kolari, Head of Operations, U. S. Steel Minnesota Ore Operations cut the ribbon on U. S. Steel's new DR-Grade pellet plant. (Photo: Business Wire)

The new production facility will maintain optionality, able to produce either DR-grade iron ore pellets or blast furnace iron ore pellets, allowing the Company to adjust to changing market conditions. Minnesota Governor Tim Walz and other elected officials joined the celebration, along with U. S. Steel President and CEO David B. Burritt, Senior Vice President - Raw Materials and Sustainable Resources John Gordon, employees, and members of the community.

"This project was completed ahead of time, under budget, and most importantly, safely. Plus, it created 250 construction jobs and 33 full-time union and management jobs," said Burritt. "This is an incredible achievement for our team at Keetac and for U. S. Steel, as we continue to produce the highest quality products: mined, melted, and made right here in the USA."

"U. S. Steel's new pellet facility is a smart investment in the people and potential of the Iron Range," said Governor Walz. "This project is a win-win. We're creating jobs, lowering emissions, and ensuring Minnesota's iron ore industry remains strong for generations."

Construction on the DR-grade pellet facility began in August of 2022 and was completed in December of 2023. U. S. Steel's Minnesota Ore Operations directly employs nearly 2,000 workers.

About U. S. Steel

Founded in 1901, United States Steel Corporation is a leading steel producer. With an unwavering focus on safety, the Company's customer-centric Best for All® strategy is advancing a more secure, sustainable future for U. S. Steel and its stakeholders. With a renewed emphasis on innovation, U. S. Steel serves the automotive, construction, appliance, energy, containers, and packaging industries with high value-added steel products such as U. S. Steel's proprietary XG3® advanced high-strength steel. The Company also maintains competitively advantaged iron ore production and has an annual raw steelmaking capability of 22.4 million net tons. U. S. Steel is headquartered in Pittsburgh, Pennsylvania, with world-class operations across the United States and in Central Europe. For more information, please visit www.ussteel.com.

View source version on businesswire.com:
https://www.businesswire.com/news/home/20240523633782/en/

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UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

FORM 8-K

CURRENT REPORT

Pursuant to Section 13 or 15(d) of the
Securities Exchange Act of 1934

Date of report (Date of earliest event reported): **June 9, 2020**

VERSO CORPORATION

(Exact name of registrant as specified in its charter)

Delaware	**001-34056**	**75-3217389**
(State or other jurisdiction of incorporation)	(Commission File Number)	(IRS Employer Identification Number)

8540 Gander Creek Drive
Miamisburg, Ohio 45342
(Address, including zip code, of principal executive offices)

(877) 855-7243
(Registrants' telephone number, including area code**)**

Check the appropriate box below if the Form 8-K filing is intended to simultaneously satisfy the filing obligation of the registrant under any of the following provisions:

☐ Written communications pursuant to Rule 425 under the Securities Act (17 CFR 230.425)

☐ Soliciting material pursuant to Rule 14a-12 under the Exchange Act (17 CFR 240.14a-12)

☐ Pre-commencement communications pursuant to Rule 14d-2(b) under the Exchange Act (17 CFR 240.14d-2(b))

☐ Pre-commencement communications pursuant to Rule 13e-4(c) under the Exchange Act (17 CFR 240.13e-4(c))

Securities registered pursuant to Section 12(b) of the Act:

Title of each class	Trading Symbol(s)	Name of each exchange on which registered
Class A common stock, par value $0.01 per share	VRS	New York Stock Exchange

Indicate by check mark whether the registrant is an emerging growth company as defined in Rule 405 of the Securities Act of 1933 (§230.405 of this chapter) or Rule 12b-2 of the Securities Exchange Act of 1934 (§240.12b-2 of this chapter).

Emerging growth company ☐

If an emerging growth company, indicate by check mark if the registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ☐

Item 7.01 Regulation FD Disclosure.

On June 9, 2020, Verso Corporation ("Verso") issued a press release announcing that it plans to indefinitely idle its mills in Duluth, Minnesota and Wisconsin Rapids, Wisconsin as discussed below in Item 8.01. A copy of the press release is furnished as Exhibit 99.1 to this Current Report on Form 8-K and is incorporated herein by reference.

In addition, Verso is furnishing as Exhibit 99.2 to this Current Report on Form 8-K certain supplemental info for the three months ended March 31, 2020, which such supplemental information is incorporated herein by reference.

The information in this Item 7.01, including Exhibit 99.1 and Exhibit 99.2 attached hereto, are not to be considered "filed" under the Securities Exchange Act of 1934, as amended, and shall not be incorporated by reference into any of Verso's previous or future filings.

Item 8.01. Other Events.

On June 9, 2020, Verso announced that it plans to indefinitely idle its mills in Duluth, Minnesota and Wisconsin Rapids, Wisconsin, while exploring viable and sustainable alternatives for both mills. Those alternatives could include restarting if market conditions improve, marketing for sale or closing permanently.

Verso's decision to reduce its production capacity was driven by the accelerated decline in printing and writing paper demand resulting from the COVID-19 pandemic. The stay-at-home orders have significantly reduced the use of print advertising in various industries, including retail, sports, entertainment and tourism.

The production capacity of the Duluth mill is approximately 270,000 tons of supercalendered paper and the production capacity of the Wisconsin Rapids mill is approximately 540,000 tons of coated and packaging papers.

Item 9.01 Financial Statements and Exhibits.

(d) Exhibits

Exhibit Number	Description of Exhibit
99.1	Press Release issued by Verso on June 9, 2020.
99.2	Supplemental information, dated June 9, 2020.
104	Cover Page Interactive Data File (embedded within the Inline XBRL document).

vrs-8k_20200609.htm

SIGNATURE

Pursuant to the requirements of the Securities Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned hereunto duly authorized.

Date: June 9, 2020

VERSO CORPORATION

By: /s/ Allen J. Campbell
Allen J. Campbell
Senior Vice President and Chief Financial Officer

Exhibit 99.

Verso Announces Necessary Actions to Offset Unprecedented Market Decline Due to COVID-19

MIAMISBURG, Ohio, June 9, 2020 /PRNewswire/ -- Verso Corporation (NYSE: VRS) today announced that it is taking immediate actions to offset unprecedented market decline due to the COVID-19 pandemic and to reposition the company for future success.

Verso will indefinitely idle paper mills in Duluth, Minnesota, and Wisconsin Rapids, Wisconsin, while exploring viable and sustainable alternatives for both mills, including restarting if market conditions improve, marketing for sale or closing permanently. The decision to reduce production capacity is driven by the accelerated decline in graphic paper demand resulting from the COVID-19 pandemic. The stay-at-home orders have significantly reduced the use of print advertising in various industries, including retail, sports, entertainment and tourism. According to Fastmarkets RISI, North American printing & writing demand fell by 38% year-over-year in April, and operating rates are expected to drop well below 70% during the second quarter.

"It is critical that we maintain a healthy balance sheet and focus on cash flow, while balancing our supply of products and our customers' demand," said President and Chief Executive Officer Adam St. John. "After a comprehensive review of post-pandemic demand forecasts and capacity, we made the difficult decision to idle the Duluth and Wisconsin Rapids mills. We expect the idling of these facilities to improve our free cash flow. The sell through of inventory is expected to offset the cash costs of idling the mills."

Verso expects to idle the Duluth Mill by the end of June 2020, and the Wisconsin Rapids Mill by the end of July 2020, resulting in the layoff of approximately 1,000 employees. Verso will continue to supply graphic and specialty papers in roll and sheet form, as well as packaging papers and pulp.

"Decisions to idle facilities are always difficult because they impact employees, their families, and communities," said St. John. "Verso is committed to treating all of our affected employees with fairness and respect. As always, safety is our highest priority and will be our primary focus during this difficult time."

About Verso
Verso Corporation is the turn-to company for those looking to successfully navigate the complexities of paper sourcing and performance. A leading North American producer of graphic and specialty papers, packaging and pulp, Verso provides insightful solutions that help drive improved customer efficiency, productivity, brand awareness and business results. Verso's long-standing reputation for quality and reliability is directly tied to our vision to be a company with passion that is respected and trusted by all. Verso's passion is rooted in ethical business practices that demand safe workplaces for our employees and sustainable wood sourcing for our products. This passion, combined with our flexible manufacturing capabilities and an unmatched commitment to product performance, delivery and service, make Verso a preferred choice among commercial printers, paper merchants and brokers, converters, publishers and other end users. For more information, visit us online at versoco.com.

Forward-Looking Statements
In this press release, all statements that are not purely historical facts are forward-looking statements within the meaning of Section 27A of the Securities Act of 1933 and Section 21E of the Securities Exchange Act of 1934. Forward-looking statements may be identified by the words "believe," "expect," "anticipate," "project," "plan," "estimate," "intend," "potential" and other similar expressions. Forward-looking statements are based on currently available business, economic, financial, and other information and reflect management's current beliefs, expectations, and views with respect to future developments and their potential effects on Verso. Actual results could vary materially depending on risks and uncertainties that may affect Verso and its business. Verso's actual actions and results may differ materially from what is expressed or implied by these statements due to a variety of factors, including: uncertainties regarding the duration and severity of the COVID-19 pandemic and measures intended to reduce its spread; the long-term structural decline and general softening of demand facing the paper industry; adverse developments in general business and economic conditions; developments in alternative media, which are expected to adversely affect the demand for some of Verso's key products, and the effectiveness of Verso's responses to these developments; intense competition in the paper manufacturing industry; Verso's ability to compete with respect to certain specialty paper products for a period of two years after the closing of the Pixelle Sale; Verso's business being less diversified following the sale of two mills after the closing of the Pixelle Sale; Verso's dependence on a small number of customers for a significant portion of its business; Verso's limited ability to control the pricing of its products or pass through increases in its costs to its customers; changes in the costs of raw materials and purchased energy; negative publicity, even if unjustified; any failure to comply with environmental or other laws or regulations, even if inadvertent; legal proceedings or disputes; any labor disputes; and the potential those risks and uncertainties listed under the caption "Risk Factors" in Verso's Form 10-K for the fiscal year ended December 31, 2019 and Quarterly Report on Form 10-Q for the fiscal quarter ended March 31, 2020, and from time to time in Verso's other

filings with the Securities and Exchange Commission. Verso assumes no obligation to update any forward-looking statement made in this press release to reflect subsequent events or circumstances or actual outcomes.



CONTACT: Investors, investor.relations@versoco.com, 937-528-3220 or Media, Shawn Hall, Director, Communications, 937-528-3700, shawn.hall@versoco.com

Exhibit 99.2

Supplemental Information for Q1 2020

	Q1 '19	Q1 '20	Δ	Δ %
Shipments (000 tons)				
- Paper	499	439	(60)	-12%
- Pulp	45	56	11	24%
Total	544	495	(49)	-9%
NSP ($/ton)				
- Paper	$ 956	$ 879	$ (77)	-8%
- Pulp	$ 687	$ 460	$ (227)	-33%

Table represents Verso Consolidated data excluding Androscoggin and Stevens Point Mills for all periods provided.

Q1 2020 Selected Supplemental Data ($M)	Androscoggin, Stevens Point[1]	Luke	Duluth, Wisc. Rapids	Escanaba Quinnesec	Total Q1 2019	Total Q1 2020[1]
Net sales	$ 59	$ 8	$ 156	$ 248	$ 639	$ 471
Cost of Products Sold	$ 52	$ 12	$ 156	$ 207	$ 549	$ 427
Gross Margin	$ 7	$ (4)	$ -	$ 41	$ 90	$ 44
Cash CapEx	$ (3)	$ -	$ (7)	$ (12)	$ (18)	$ (22)

[1] Includes data for Androscoggin and Stevens Point Mills through 2/9/20



American Forest & Paper Association

MAY 29, 2026 | PRESS RELEASE

AF&PA Releases 66th Annual Paper Industry Capacity and Fiber Consumption Survey

New survey data highlights production capacity and fiber trends across major grades

WASHINGTON – The American Forest & Paper Association (AF&PA) today released the 66th Annual Paper Industry Capacity and Fiber Consumption Survey. The report provides detailed data on U.S. paper industry capacity and production compiled by the AF&PA statistics team.

> "This year's survey underscores the scale of the U.S. paper manufacturing industry and the essential role it plays in the economy," said Heidi Brock, President and CEO of the American Forest & Paper Association. "Even as some grades face market pressure, manufacturers are investing and aligning capacity with demand, maintaining solid operating performance and continuing to compete."

Though U.S. paper and paperboard production declined 3.7% in 2025, to 66.3 million tons, several sectors showed continued resilience. Containerboard operating rates held firm at 91.9%, while printing-writing operating rates improved to 82.8%, reflecting continued capacity adaptation to demand changes. Packaging paper production increased 1.7%, boxboard production was essentially flat at 12.4 million tons and tissue production remained near 7.8 million tons.

Overall fiber consumption used to make paper and paperboard products in 2025 decreased by 3.5% compared to 2024. Wood pulp decreased by 3.2% and recovered fiber decreased by 4.0%.

"U.S. mills continue to produce the packaging, tissue and other paper products that people and businesses rely on every day," said Brock. "The data shows an industry that continues to operate at significant scale, adapt to changing market conditions and serve strong demand for fiber-based products."

U.S. Paper-Based Packaging Capacity

Containerboard production fell 4.4% to 36.1 million tons, and containerboard capacity declined 5.1% in 2025. Despite that

reduction, containerboard continued to account for more than half of total U.S. paper and paperboard capacity, and mills maintained a 91.9% operating rate.

U.S. Printing-Writing and Tissue Capacity

Printing-writing capacity fell 13.9% in 2025 to 7.7 million tons. Capacity has fallen from nearly 18 million tons in 2015, reflecting a long-term adjustment in this segment. However, operating rates for Printing-Writing increased from 76.8% in 2024 to 82.8% in 2025.

Tissue production declined 0.8% in 2025 to 7.8 million tons, underscoring the essential role tissue continues to play in the industry's product mix. Over time, tissue has also represented a growing share of total U.S. paper and paperboard capacity.

What is Capacity?

Capacity is the tonnage of paper, paperboard or pulp that could be produced with full use of equipment and adequate supplies of raw materials and labor, assuming full demand.

AF&PA's Capacity Survey details U.S. industry capacity data for 2025 and 2026 for all major grades of paper, paperboard and pulp, as well as fiber consumption. It is based on a comprehensive survey of U.S. pulp and paper mills. It includes production data for 2025.

AF&PA data represent about 87% of U.S. paper and paperboard industry capacity, with estimates completing the data set.

How to Purchase the AF&PA Capacity Survey?

The complete Survey is available for purchase online. Please visit our website afandpa.org/statistics-resources/reports or contact

statistics_publications@afandpa.org or 202-463-4716 for this report and other industry reports.

STATISTICS

The American Forest & Paper Association (AF&PA) serves to advance public policies that foster economic growth, job creation and global competitiveness for a vital sector that makes the essential paper and packaging products Americans use every day. The U.S. forest products industry employs more than 925,000 people, largely in rural America, and is among the top 10 manufacturing sector employers in 44 states. Our industry accounts for approximately 4.7% of the total U.S. manufacturing GDP, manufacturing more than $435 billion in products annually. AF&PA member companies are significant producers and users of renewable biomass energy and are committed to making sustainable products for a sustainable future through the industry's decades-long initiative —
Better Practices, Better Planet 2030.

RELATED **NEWS**

STATISTICS

AF&PA Releases May 2026 Packaging Papers Monthly Report

Total packaging papers & specialty packaging shipments in May increased 12% compared to May 2025. They were up 6% when compared to the same 5 months of 2025.

STATISTICS

AF&PA Releases May 2026 Printing-Writing Monthly Report

According to the report, total printing-writing paper shipments decreased 14% in May compared to May 2025.

STATISTICS

AF&PA Releases April 2026 Packaging Papers Monthly Report

Total packaging papers & specialty packaging shipments in April increased 5.5% compared to April 2025. They were up 4.8% when compared to the same 4 months of 2025.

VIEW ALL NEWS

American Forest & Paper Association

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Paper Meets LIVE! 2026

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Minnesota Power
Docket No. E015/GR-26-199

MP Exhibit___(Forsman)
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Volume 2
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WORLD BANK GROUP

Minerals for Climate Action:
The Mineral Intensity of the Clean Energy Transition

CLIMATE-SMART MINING FACILITY
Kirsten Hund, Daniele La Porta, Thao P. Fabregas, Tim Laing, John Drexhage

Climate **Smart** Mining

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Foreword

The data presented in this report speak for themselves: Ambitious climate action will bring significant demand for minerals. Limiting global warming to at or below 1.5°C–2°C, to realize a low-carbon future, requires a large-scale transition to clean energy. Manufacturing solar panels, wind turbines, and batteries will shape the supply and demand for critical minerals for the foreseeable future. Doing so will have significant implications for a wide variety of industries and for mineral-rich developing countries. These countries stand to benefit from the rise in demand for minerals but also need to manage the material and climate footprints associated with increased mining activities.

This report's findings make it clear that all stakeholders along the mineral and renewable energy supply chains have a vital role to play in the transition to a cleaner energy system to achieve Sustainable Development Goal 7 (Affordable and Clean Energy for All), while ensuring that it does not come at the cost of the climate, the environment, and people, particularly communities directly affected by mining activities.

In 2017, the World Bank published *The Growing Role of Minerals and Metals for a Low Carbon Future*, concluding that a low-carbon future will not be possible without minerals. This report makes that case even stronger, but with a new emphasis on how technology improvements and recycling could impact mineral demand up to 2050. For the first time, the global warming potential of different low-carbon technologies were analyzed in comparison with fossil-fuel-based energy systems. We also present a new framework to capture the risks associated with the demand for specific critical minerals.

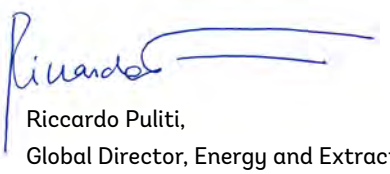
This report intends to provide policy makers, mineral producers, renewable energy developers, climate negotiators, and civil society organizations with a data-driven understanding of how the shift to a cleaner energy system could impact mineral demand. It also provides a forward-looking outlook on the actions each stakeholder can take to minimize the carbon and material footprints of such a significant shift.

The mineral intensity of low-carbon technologies should not be overlooked. We know that to date, the mining industry consumes up to 11 percent of the global energy use, while 70 percent of mining projects from the six largest mining companies operate in water-stressed regions. Increasing demand for minerals and metals would only push these figures higher unless we adopt a radically different, climate-smart approach. Understanding these new, climate-related risks will be critical for all stakeholders involved in renewable energy and battery technology supply chains—from extraction to the end use of any given mineral or metal.

While the mineral intensity of renewable energy has its challenges, our research shows that, even if low-carbon technologies are more mineral intensive, they only account for a fraction (6 percent) of emissions generated by fossil fuel technologies. This means that the deployment of renewable energy is essential in helping us meet the Paris Agreement, even if it means that more minerals will be needed to get there.

To address these challenges, the World Bank launched the Climate-Smart Mining Initiative to ensure that minerals for the clean energy transition are produced and supplied sustainably and responsibly, while enabling developing countries to benefit from this seismic shift. The goal is to ensure that mineral-rich developing countries are well prepared to meet this growing demand with the smallest possible carbon footprint, while safeguarding the environment and people.

I am confident that, with the adoption of climate-smart mining, we can make the clean energy transition possible without endangering the climate and the environment. By working together to reduce the carbon and material footprints of minerals, we can support the large-scale deployment of renewable energy and battery storage technologies required to meet ambitious climate targets and achieve a low-carbon future that benefits everyone.



Riccardo Puliti,
Global Director, Energy and Extractive Industries
World Bank

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The report's model was built from the original publication *The Growing Role of Minerals and Metals for a Low Carbon Future* and benefited from insight, feedback and data from a number of other esteemed colleagues. Our sincerest thanks go to all of them.

Lastly, the team greatly appreciates the input and guidance from Christopher Sheldon and Riccardo Puliti.

Abbreviations

2DS	2-degree scenario (IEA)
4DS	4-degree scenario (IEA)
B2DS	beyond 2-degree scenario (IEA)
CCS	carbon capture and storage
CdTe	cadmium telluride
CIGS	copper indium gallium selenide
CSP	concentrated solar power
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EOL	end of life
GHG	greenhouse gas
Gt	gigatons
GW	gigawatts
GWh	gigawatt-hours
GWP	global warming potential
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LCOE	levelized cost of energy
Li-ion	lithium-ion
Mt	million tons
MW	megawatts
NDC	Nationally Determined Contribution
NMC	nickel manganese cobalt oxide
OECD	Organisation for Economic Co-operation and Development
PV	photovoltaic
RC	recycled content
Ref	reference scenario (IRENA)
REmap	renewable energy roadmap scenario (IRENA)
RTS	reference technology scenario (IEA)
SDG	Sustainable Development Goal

All dollars are U.S. dollars unless otherwise indicated.

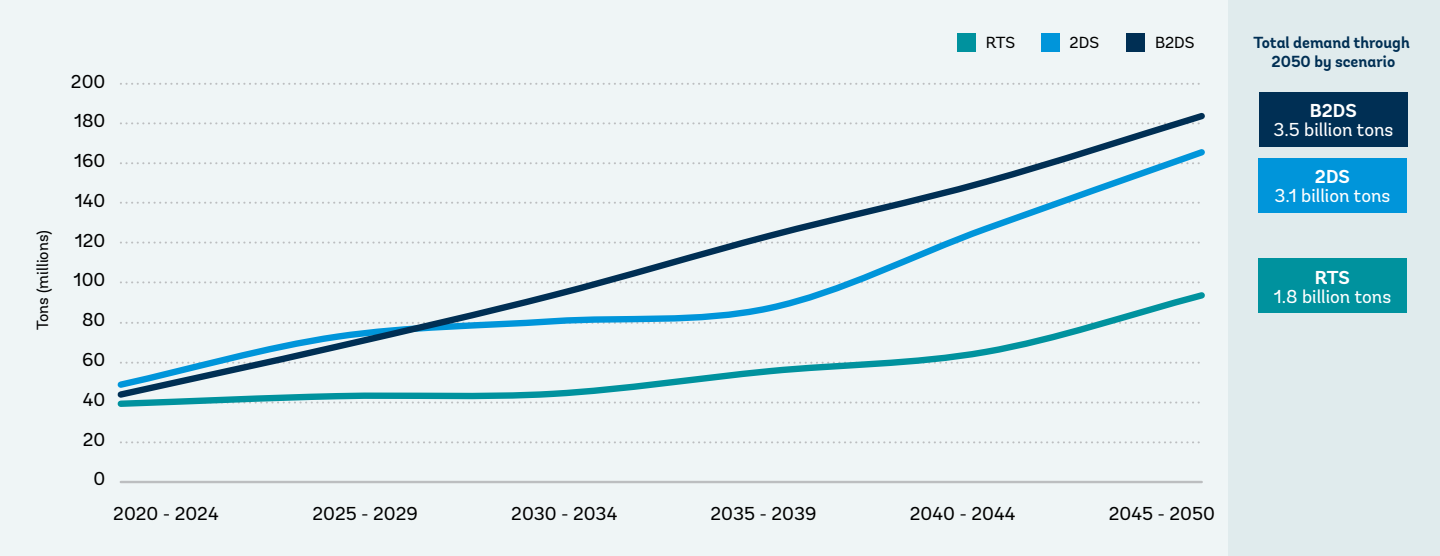


Executive Summary

1. A low-carbon future will be very mineral intensive because clean energy technologies need more materials than fossil-fuel-based electricity generation technologies. Greater ambition on climate change goals (1.5°C–2°C or below), as outlined by the Paris Agreement, requires installing more of these technologies and will therefore lead to a larger material footprint.[1]

Low-carbon technologies, particularly solar photovoltaic (PV), wind, and geothermal, are more mineral intensive relative to fossil fuel technologies. For example, about 3,000 solar panels are needed for 1 megawatt (MW) of capacity of solar PV; this means that a 200 MW solar PV project could be as big as 550 American football fields (Mathis and Eckhouse 2020). Under a 2-degree scenario (2DS),[2] production of graphite, lithium, and cobalt will need to be significantly ramped up by more than 450 percent by 2050—from 2018 levels—to meet demand from energy storage technologies.[3] Though demand for some base minerals, like aluminum and copper, appears to be smaller in percentage terms, their absolute production figures are significant, at 103 million tons and 29 million tons by 2050, respectively. These projections do not include the associated infrastructure needed to support the deployment of these technologies (for example, transmission lines) or the physical parts (like the chassis[4] of newly built electric vehicles).[5] Because of the material intensity of low-carbon technologies, any potential shortages in mineral supply could impact the speed and scale at which certain technologies may be deployed globally.

Figure ES.1 Projected Annual Average Demand of Minerals up to 2050 Under the IEA Energy Technology Perspective Scenarios



Note: "Minerals" refers to the 17 minerals included in this analysis plus steel, but excluding concrete. Steel has been included because of the size of demand for the alloy from energy technologies. Average annual demand is the mean demand for minerals across the time periods given. The higher mineral demand under the 2DS than the B2DS before 2030 can be explained by the higher overall generation capacity projected by the IEA to be needed in the 2DS compared with the B2DS. This is especially true of solar photovoltaic in the 2DS in these time periods. Subsequently, the plateau in mineral demand in the 2DS is caused by a relatively slower penetration of renewable generation, followed by a rapid increase in storage capacity from 2035 onward. 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, RTS = reference technology scenario.

1 This report does not intend to forecast what will happen, but instead provide a range of scenarios to explore the future global energy system and how different policy choices and technology improvements could affect overall mineral demand up to 2050.
2 2DS—along with B2DS (beyond 2-degree scenario) and RTS (reference technology scenario)—refers to one of the scenarios developed in the International Energy Agency (IEA) *Energy Technology Perspectives 2017*. Please refer to chapter 1 for additional information.
3 These projections may be conservative and will most likely be larger in a 1.5°C-degree scenario, which demands solutions to be implemented faster, and at a larger scale.
4 "Chassis" refers to the frame of car and associated components.
5 Steel figures have not been included in this analysis because of potential double counting issues.

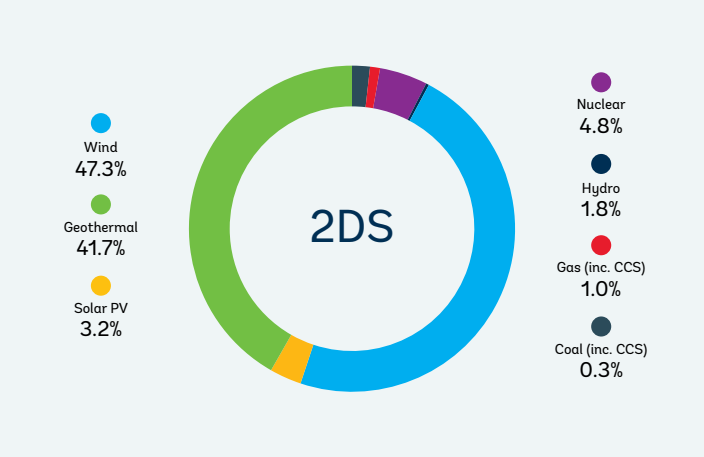
2. Each mineral carries a different demand risk depending on whether it is cross-cutting (needed across a range of low-carbon technologies) or concentrated (needed in one specific technology). Absolute production numbers and relative increases in demand for each mineral may also play a role in their ability to meet supply as well as have climate and environmental implications.

Cross-cutting minerals, such as copper, chromium, and molybdenum, are used across a wide variety of clean energy generation and storage technologies and have stable demand conditions. This is because these minerals do not depend on the deployment of any one specific technology within the clean energy transition. Molybdenum and copper, for instance, are used in more than eight clean energy generation and storage technologies; thus, even if technological improvements, costs reductions, and deployment of new emerging technologies were to take place, these changes would have little impact on the overall demand for them. For copper, the greatest share of demand comes from solar PV and wind, but demand may be underestimated as it does not include the transmission infrastructure needed to connect these new technologies to electricity grids.

Concentrated minerals, such as lithium, graphite, and cobalt, are needed only for one or two technologies and therefore possess higher demand uncertainty as technological disruption and deployment could significantly impact their demand. These minerals are primarily used in energy storage and have the highest demand figures relative to 2018 production levels. With energy storage having the highest level of uncertainty post-2030 given the number of energy storage subtechnologies currently at the research and development (R&D) and pilot stages, as well as different policy choices and market forces, concentrated minerals have the highest level of demand risk, particularly for producers of these minerals.

Beyond cross-cutting versus concentrated, some minerals face higher levels of changes in demand from the shift to a low-carbon future. Graphite and lithium demand are so high that current production would need to ramp up by nearly 500 percent by 2050 under a 2DS just to meet demand. Demand for aluminum for energy technologies in 2050, on the other hand, makes up only 9 percent of current production levels, but aluminum is used across a broad range of technologies, making it less susceptible to changes in technology deployment, and it has the highest absolute levels of demand from any of the minerals in this analysis. Understanding these different demand risks is crucial for mining and energy industries that must be adaptive to rapidly evolving energy technologies. To facilitate the understanding of the relationship between cross-cutting and concentrated minerals, as well as the different levels of demand, this report has developed a demand risk matrix (figure 4.7) that can be used by stakeholders and policy makers, allowing minerals to be categorized based on their demand risk profile.

Figure ES.2 Total Molybdenum Demand by Energy Technology Through 2050 Under 2DS



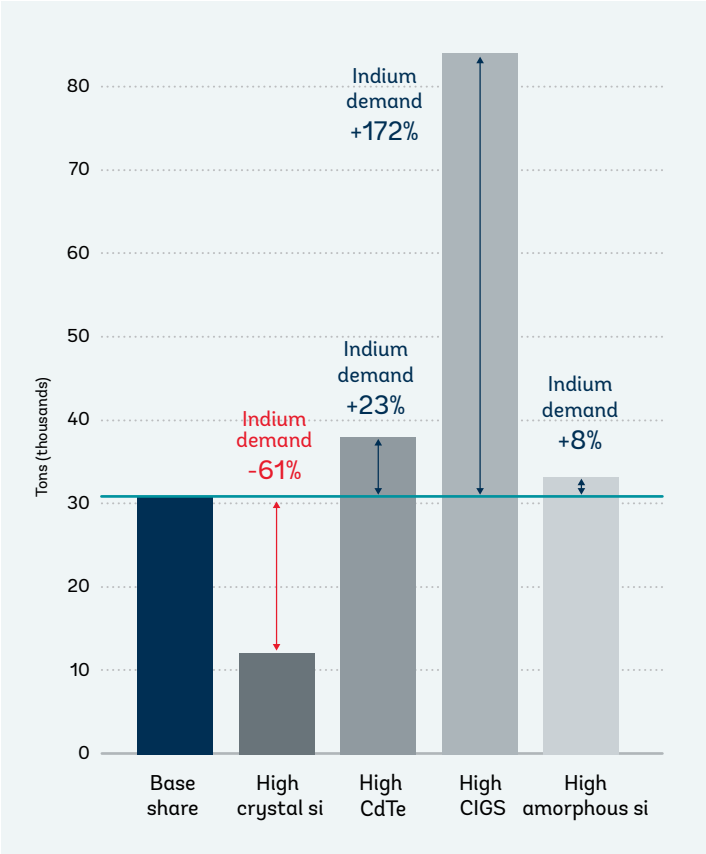
Note: 2DS = 2-degree scenario, CCS = carbon capture and storage, CSP = concentrated solar power, PV = photovoltaic.

3. Technology and subtechnology choice, material substitution, and technological improvements will shift the demand for individual minerals under different low-carbon scenarios. Still, any lower-carbon pathway will increase the overall demand of minerals.

Under a 2DS, solar PV will account for the majority of aluminum demand from energy technologies (87 percent), while wind and geothermal will account for most zinc and titanium demand, at 98 percent and 64 percent, respectively. Solar PV and wind, combined, account for 74.2 percent of all copper demand, while battery storage accounts for all graphite and lithium demand in this analysis. Each energy technology has different mineral compositions, leading to demand features that can vary significantly from one technology to another.

Substitution effects, such as efficiency improvements, could have strong impacts on the demand for individual minerals, like indium, based on which subtechnology within a technology ends up being most widely deployed up to 2050. Factors that could drive substitution effects include market dynamics, availability of minerals, technological improvements, and costs. The technology pathway that will emerge to decarbonize electricity production will shape the minerals that will experience the largest increases in demand. It is possible that new technologies such as floating offshore wind, green hydrogen, or solid-state batteries may change the shape of the future energy system. These technologies require different minerals and carry different mineral demand implications, but given that they are generally more material intensive than their fossil-fuel-based counterparts, overall demand for minerals will still increase.

Figure ES.3 Cumulative Demand for Indium from Solar PV Subtechnologies Compared to Base Share Under 2DS Through 2050

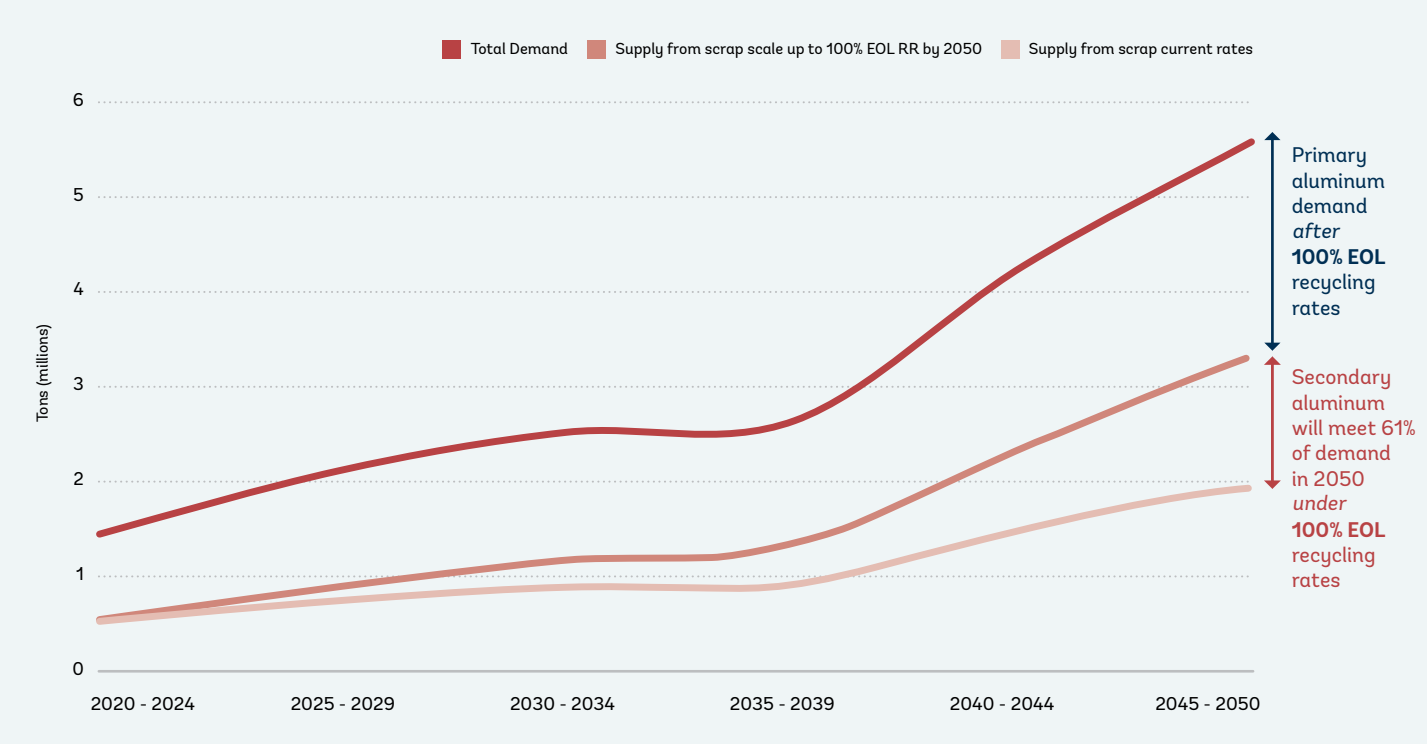


Note: 2DS = 2-degree scenario, amorphous Si = amorphous silicon, CdTe = cadmium telluride, CIGS = copper indium gallium selenide, crystal Si = crystalline silicon, PV = photovoltaic.

4. While the recycling and reuse of minerals can play a key role in reducing emissions, mining will still be required to supply the critical minerals needed to produce these low-carbon technologies, even with large future increases in recycling rates.

Recycling and reuse will have a role in meeting future mineral demand, but primary mineral demand from mining will still be needed. Recycling rates vary greatly for all minerals due to costs and technical issues. The challenge with meeting most of the demand from recycling is partly due to lack of existing material to recycle and reuse, along with costs and technological barriers (for example, some technologies may not be easily recyclable due to design). Facilitating recycling and reuse is a vital part of the low-carbon transition, but policy measures will need to incentivize action in this area while promoting awareness of the economic and environmental challenges associated with the processes of recycling. Future increases in recycling rates can play an important role in mitigating increases in demand for raw materials, as can reuse of components for energy storage technologies, such as lithium-ion batteries, and refurbishment of equipment, such as wind turbines. Even if these challenges in the mineral recycling sector can be overcome, there is still a need to meet remaining primary demand in the most effective and environmentally and socially responsible manner. It will be crucial for importers of these critical minerals with ambitious climate targets, particularly in developed countries, to work closely with mineral producers in developing countries to decarbonize and reduce the material impacts associated with increased extractive activities.

Figure ES.4 Aluminum Recycling Projections Relative to Annual Aluminum Demand Under 2DS Through 2050

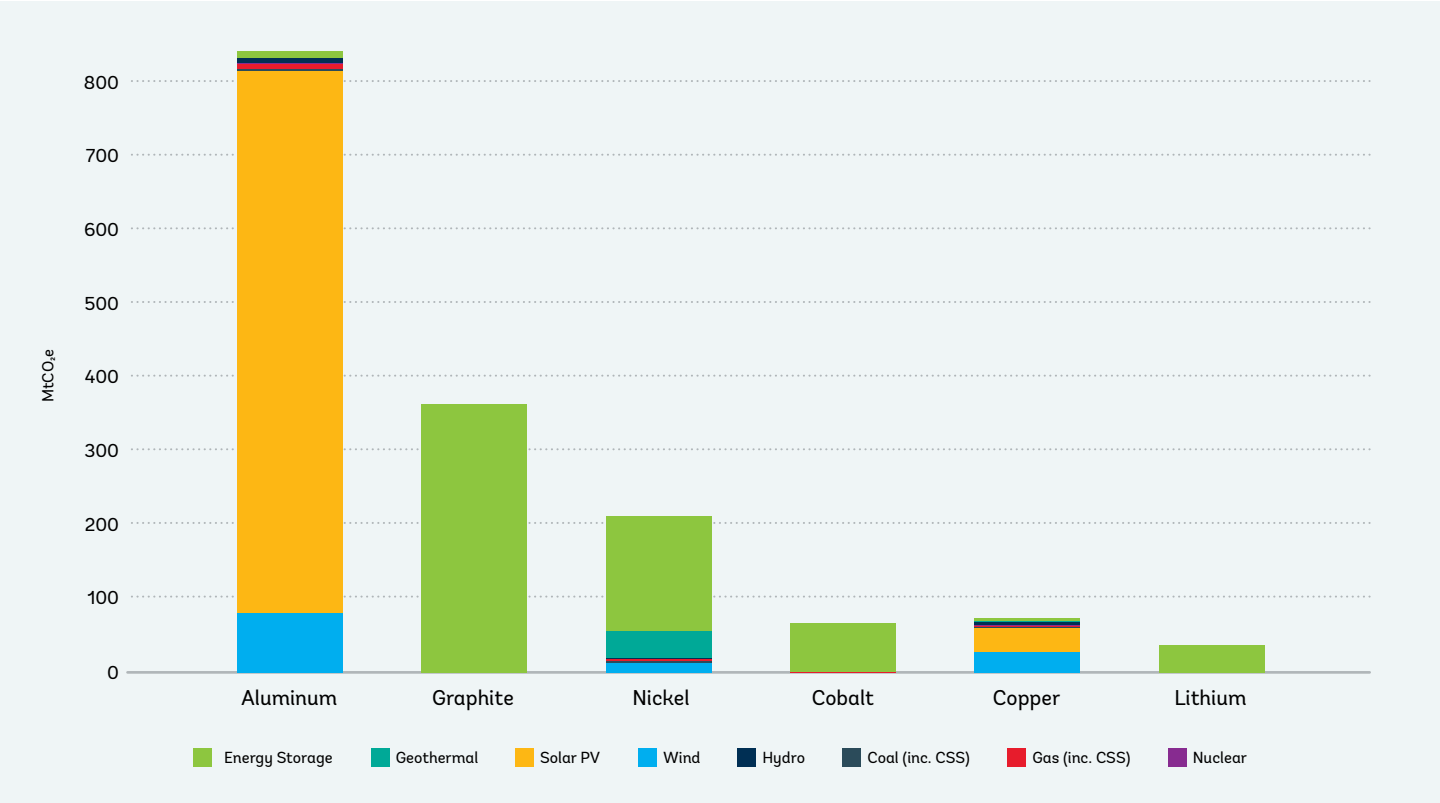


Note: EOL recycling rates are assumed to increase annually to meet 100 percent EOL by 2050. This means that secondary aluminum meets an increasing amount of aluminum demand over time. 2DS = 2-degree scenario, EOL = end of life, RR = recycling rates.

5. Despite the higher mineral intensity of renewable energy technologies, the scale of associated greenhouse gas emissions is a fraction of that of fossil fuel technologies. However, the carbon and material footprints cannot be overlooked.

While increasing the share of renewable energy is one of the most effective ways of decarbonizing the electricity sector, the countries who have committed to the Paris Agreement need to address the mineral intensity of clean energy technologies. Emissions from the production and operation of renewable energy and storage technologies are just 6 percent of coal and gas generation under a 2DS. They account, however, for about 16 gigatons of carbon dioxide equivalent (GtCO2e) emissions up to 2050—similar to the 2018 emissions of the United States and China—without factoring in the emissions from transporting minerals between processing and manufacturing facilities. Together, aluminum, graphite, and nickel production for energy technologies account for a cumulative 1.4 $GtCO_2e$ up to 2050, nearly equivalent to the total 2018 carbon dioxide emissions from France, Germany, and the United Kingdom combined.[6] Greening the power sector and battery production requires that upstream and downstream emissions-related challenges from clean energy technologies be meaningfully addressed through policy and innovation while integrating these emissions reductions into countries' Nationally Determined Contributions under the Paris Agreement.

Figure ES.5 Cumulative Global Warming Potential from Extraction and Processing of Minerals, Not Including Operations, Using Cradle-to-Gate Through 2050 Under 2DS



Note: 2DS = 2-degree scenario, CCS = carbon capture and storage, CSP = concentrated solar power, $MtCO_2e$ = million tons of carbon dioxide equivalent.

6 Data retrieved from the 2019 Global Carbon Atlas: http://www.globalcarbonatlas.org/en/CO2-emissions.

6. Limiting the carbon footprint of minerals needed for the clean energy transition may offer double wins, helping to boost economic growth and reduce environmental risks in resource-rich developing countries. It will also enable the transition to a 1.5°C–2°C pathway, in line with the Paris Agreement, Sustainable Development Goal (SDG) 7, "access to affordable, reliable, sustainable and modern energy for all," and SDG 13, taking "urgent action to combat climate change and its impacts."

Taking a holistic approach toward increasing climate ambition in developed, emerging, and developing countries, as well as in producers and consumers of minerals, involves understanding and analyzing the full supply chain of low-carbon technologies, from mineral extraction to the end of life of these technologies. Thus, upstream and end-of-life activities of clean energy technologies must be taken into account to ensure that (1) the mining industry can meet increasing demand up to 2050 using sustainable and responsible practices; (2) governments and the private sector address the emissions associated with increased mineral production while ensuring a continued, stable, and affordable supply of these minerals to support a low-carbon transition; and (3) innovation across the whole supply chain is leveraged to ensure low-carbon technologies can be easily disassembled and safely disposed of, and the mineral contents recycled to partially meet this new demand.

Limiting greenhouse gas emissions throughout the clean energy technology supply chain could offer double wins, helping boost economic growth as well as reducing climate and environmental risks in resource-rich developing countries that are positioned to supply these minerals. If, however, the mitigation of emissions and other potentially harmful environmental and social effects are not achieved from increased mineral production, there is a risk that clean energy technologies may not maintain the same level of support they have today for climate action. Therefore, it is vital that the production and disposal of these technologies do not come at the expense of people and the environment. The mining sector has an important role in the clean energy transition, contributing to SDG 7, and can play a crucial role in the global fight against climate change (SDG 13, Paris Agreement). Ensuring that innovation takes a center stage in decarbonizing and encouraging responsible mineral production would equally contribute to SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production).



7. The **Climate-Smart Mining** Initiative addresses these challenges by working together with governments, development partners, industries, and civil society to minimize the new emissions from a low-carbon transition and work closely with resource-rich developing countries to responsibly supply these strategic minerals for clean energy technologies.

Combining climate-smart mining with an overview of the different demand risks of minerals, via the demand risk matrix, provides a framework for climate, energy, and mining stakeholders to understand and mitigate risks associated with providing a stable supply of minerals while limiting the carbon and material footprints of increased climate ambition. Each stakeholder along the supply chain has a role to play:

- **Climate stakeholders:** With minerals playing a vital role in enabling the clean energy transition, it will be crucial for members of the climate community to work closely with producers of those minerals—including resource-rich developing countries and the mining industry—to ensure that these emissions are mitigated. Mineral-rich countries that make it a priority to reduce emissions from mineral production, through ***climate-smart mining*** practices, could assess options to integrate their decarbonization efforts in their Nationally Determined Contributions under the Paris Agreement.
- **Clean energy stakeholders:** The energy sector also has an important role to play in ensuring that the low-carbon technologies they are deploying are being produced sustainably and responsibly while taking into account the waste management of these technologies once they reach end of life, in 10, 20, or 30 years from today. The mining sector accounts for 2–11 percent of the world's total energy consumption, so it will be important for the energy sector to work closely with mineral producing countries and miners to ensure that minerals are produced using clean sources of energy and ***climate-smart mining*** practices.



- **Mining stakeholders:** The mining community should position itself as a contributor to SDG 7 by ensuring that the carbon and material footprints associated with the minerals they supply are minimized. Innovation is necessary to reduce the amount of energy, water, and land needed to extract these minerals and reduce the sector's carbon and environmental footprints. Without putting into place measures that address these challenges, such as adapting ***climate-smart mining*** practices, it will be difficult for the mining sector to position itself as a champion and enabler of the clean energy transition.



Methodology
Estimating Mineral Demand

The methodology in this report is based on a spreadsheet-based model that derives the total global demand of relevant minerals and metals (together referred to as "**minerals**") from electricity generation and energy storage up to 2050.[7] The electricity generation and energy storage scenarios (together referred to as "**technology-based mitigation scenarios**") use data from the International Energy Agency's (IEA) *Energy Technology Perspectives 2016* and *Energy Technology Perspectives 2017* and the International Renewable Energy Agency's (IRENA) 2019 *Global Energy Transformation: A Roadmap to 2050*, to identify the amount of minerals that would be required under each scenario to supply clean energy technologies.

While the analysis estimates mineral demand from energy storage as well as geothermal, solar, wind, and conventional energy technologies, it does not take into account the global supply of minerals available to date to meet demand, nor the new mineral demand that will come from new global transmission infrastructure needed to electrify a low-carbon world (for example, connecting renewable energy projects to existing transmission infrastructure and creating new charging stations for electric vehicles). It also does not consider the current and future price of energy technologies, nor the price of minerals required for the energy transition. In other words, this report exclusively analyzes the amount of minerals that will be needed to supply a specific subset of clean energy technologies (listed below) regardless of price and whether today's mineral supply worldwide would be able to meet this new demand up to 2050.

Overall Methodology

The methodology was developed using primary and secondary research to build a robust model to determine potential mineral demand stemming from the clean energy transition. A literature scoping study and interviews with clean energy experts were conducted to review mineral use in electricity generation and energy storage technologies for clean and conventional energy. This information was then used to develop the assumptions used in the model to estimate annual mineral demand. These annual demands were then aggregated into cumulative demand up to 2050. Key assumptions in the model included technology-based mitigation scenarios based on IEA and IRENA outlooks; technology and subtechnologies required to reach those scenarios; assumed life spans of those technologies; and the minerals required to supply a megawatt of electricity or a megawatt-hour of energy storage from each technology included in the model. The model has static and dynamic elements. The capacity required for each energy technology and subtechnology varies from year to year, depending on the relevant technology-based mitigation scenarios. Other aspects, such as the minerals required to supply a megawatt or megawatt-hour or electricity or energy storage, and the life spans of the technologies, remain static in the model, although the sensitivity of results to altering the first of these assumptions is tested.

Literature Scoping Study

The approach included identifying the subtechnologies within each energy technology necessary to include in the analysis to derive mineral demand (see table 1.1). For example, many variants of solar PV panels exist on the market today, and each has slightly different mineral requirements. Wind turbines can come in a number of different models, too, and onshore and offshore wind turbines require different amounts of minerals. *Subtechnologies* are these different types of solar panels, wind turbines, or batteries.

The report then identified a list of 17 minerals for inclusion in the analysis (see table 1.2).

7 This report builds on the World Bank's previous report, *The Growing Role of Minerals and Metals for a Low Carbon Future* (June 2017), and adopts a similar methodology. The analysis covers 17 elements and minerals: Sixteen are produced and used after various amounts of extraction and processing, while one, graphite, is a particular form of carbon.

Table 1.1 Energy Technologies Included in This Study

Energy technologies							
Clean energy (electricity generation)	**Technology**	**Subtechnology**	Energy storage	**Technology**	**Subtechnology**	Conventional energy (electricity generation)	**Technology**	**Subtechnology**
	Concentrated solar power	n.a.		**Battery: Automotive**	Split between Li-ion, lead acid, and other		**Coal**	Coal-fired electricity generation
	Hydro-electricity	n.a.		**Battery: Decentralized**	Split between Li-ion, lead acid, and other			Coal-fired electricity generation + CCS
	Geothermal	n.a.		**Battery: Grid-scale**	Split between Li-ion, lead acid, redox flow, and other		**Gas**	Gas-fired electricity generation
	Nuclear	n.a.						Gas-fired electricity generation + CCS
	Solar PV	Solar PV – CdTe						
		Solar PV – crystal silicon						
		Solar PV – CIGS						
		Solar PV – amorphous silicon						
	Wind	Offshore						
		Onshore						

Note: The mineral demand for the technologies listed here have been included in the overall mineral demand results for this study. CCS = carbon capture and storage, CdTe = cadmium telluride, CIGS = copper indium gallium selenide, Li-ion = lithium-ion, n.a. = not applicable, PV = photovoltaic.

Data collected from the literature review also included the amount of elements and minerals (henceforth referred to as minerals) needed (see table 1.2) to build a megawatt of capacity of a particular subtechnology; this has been typically expressed by the mineral's weight, in kilograms, of installed megawatt (kg/installed MW). For example, one data source may report the zinc required to build a 3 MW wind turbine, while another source gives the zinc needed for a 5 MW turbine. These numbers have been standardized to give the amount of zinc needed to produce 1 MW of a wind turbine.

Different estimates were collected, and for each mineral-subtechnology pairing—such as zinc for offshore wind or lithium for Li-ion batteries—a low, median, and high value were chosen. These different values were used in the model to produce an estimated range of mineral demand. The midpoint of this range is reported in this analysis.

Table 1.2 Minerals Identified in the Literature Review for Inclusion in the Scenario Study

1	Aluminum	10	Manganese
2	Chromium	11	Molybdenum
3	Cobalt	12	Neodymium
4	Copper	13	Nickel
5	Graphite	14	Silver
6	Indium	15	Titanium
7	Iron	16	Vanadium
8	Lead	17	Zinc
9	Lithium		

Technology-Based Mitigation Scenarios

As mentioned above, "**technology-based mitigation scenarios**" refers to the electricity generation and energy storage scenarios up to 2050 that were drawn from the IEA and IRENA. More specifically, this report uses six technology-based mitigation scenarios to estimate mineral demand (table 1.3).

An important distinction to make about the IEA and IRENA scenarios is that the 2017 IEA scenarios include outlook on both electricity generation and energy battery storage penetration, while the IRENA scenarios and the IEA 4DS exclusively focus on electricity generation. In other words, the IRENA scenarios and IEA 4DS do not report the penetration of energy storage in the clean energy transition.

While the 4DS is not used in the models for the IEA's 2017 ETP scenarios or in IRENA's 2019 scenarios, it has been retained here as the base scenario, which is defined as the state of affairs where there is marginal progress toward a low-carbon transition. This is done not because a 4DS is likely or normative, but to compare the relative demand for relevant minerals between a future with and without low-carbon technology penetration in the global energy system.

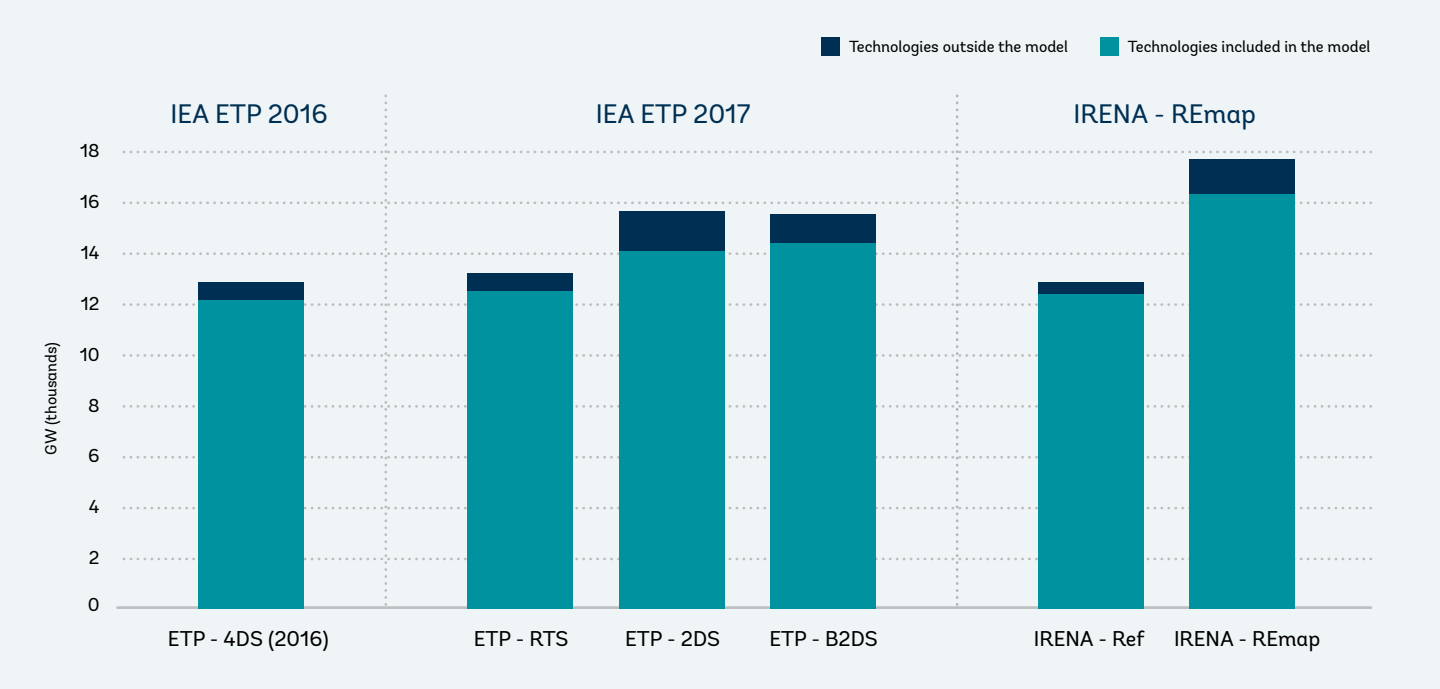
The IEA and IRENA also hold the view that the state of technology capacity is already sufficient to meet even the most ambitious of the global temperature scenarios. That said, neither agency speculates on the relative availability of the materials required to actually implement that scale of low-carbon technology penetration.

Table 1.3 Technology-Based Mitigation Scenarios

Technology-Based Mitigation Scenarios			
	Scenario acronym	**Source**	**Scenario description**
1	**4DS** (Base scenario)	4-degree scenario from the IEA ETP (2016) report	**Base scenario**, where the world carries on a current trajectory, makes minor improvements in shifting energy system away from fossil fuel sources
2	**RTS**	Reference technology scenario from the IEA ETP (2017) report	Assumes all countries will implement their Nationally Determined Contributions (NDCs), as proscribed under the Paris Agreement, resulting in an average temperature increase of **2.7°C by 2100**
3	**2DS**	2-degree scenario from the IEA ETP (2017) report	Scenario with at least a 50% chance of limiting the average global temperature increase to **2°C by 2100**
4	**B2DS** (Most ambitious scenario in the IEA report)	Beyond 2-degree scenario from the IEA ETP (2017) report	Scenario with a 50% chance of limiting average future temperature increases to **1.75°C by 2100**
5	**Ref**	Reference scenario from IRENA (2019a)	Similar to the IEA's RTS, it accounts for actions, commitments made under current/planned policies, including NDCs. Rise in temperatures would be at least **2.6°C by 2100**
6	**REmap** (Most ambitious scenario in IRENA)	Renewable energy roadmap scenario from IRENA (2019a)	Ambitious scenario that limits the rise in global temperature to **"well below" 2°C** above preindustrial levels by **2100**

Note: IEA = International Energy Agency, IRENA = International Renewable Energy Agency, ETP = Energy Technology Perspectives.

Figure 1.1 Technology Coverage in the Model



Source: IEA 2016, 2017; IRENA 2019a.
Note: 2DS = 2-degree scenario, 4DS = 4-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, ETP = Energy Technology Perspectives, GW = gigawatt, Ref = reference scenario, REmap = renewable energy roadmap scenario.

The electricity generation technologies included in the model—clean and conventional—account for the vast majority of future generated electricity in both the IEA and IRENA scenarios (figure 1.1). A very small share of electricity generation is not included, mainly electricity generated from oil-based power stations, biomass power plants, and wave and ocean electricity-generating facilities. These technologies were excluded owing to the lack of publicly available data on the minerals needed for them.

The majority of clean energy technologies, particularly solar PV but also wind (onshore and offshore), are expected to be deployed in developing countries because of large projected increases in electricity demand and accompanying increasing economic development, coupled with significant renewable energy resources, particular solar, in many of these countries. For example, in the IEA's 2DS, installed capacity of solar PV and wind is 117 percent higher in non-Organisation for Economic Co-operation and Development (OECD) countries than in OECD countries by 2050.

For solar PV specifically, the picture is even more striking, with solar PV in non-OECD countries being 208 percent of that in OECD countries.

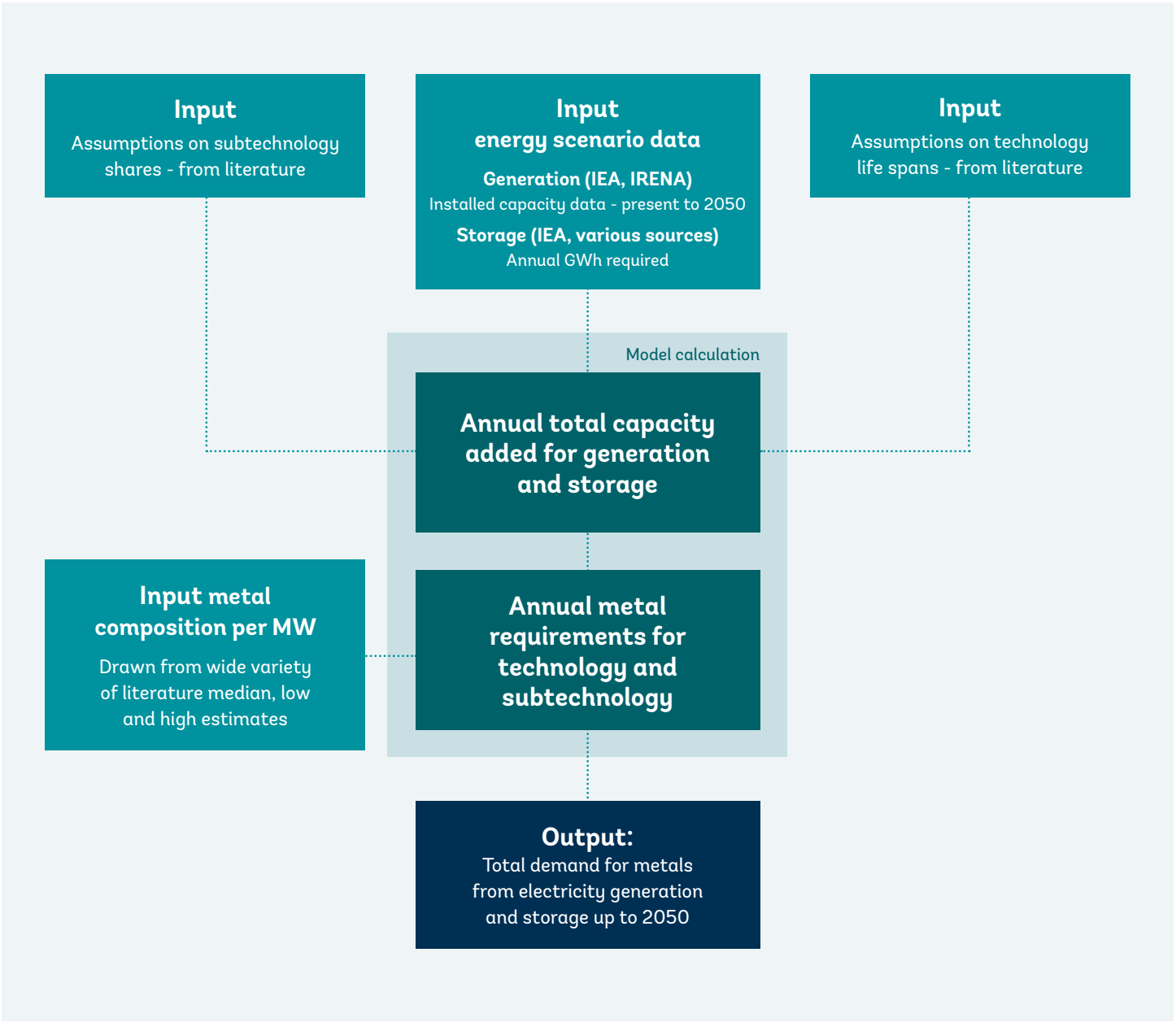
Modeling Inputs

The model approach is shown in figure 1.2. The core inputs are fourfold:

- Technology-based mitigation scenarios developed by the IEA and IRENA
- Technology and subtechnology shares required to meet those scenarios
- Assumed life spans on relevant technologies
- A range of estimates minerals required to supply a megawatt of electricity

Figure 1.2 breaks down the steps used in estimating mineral demand under a range of climate scenarios based on the IEA data.

Figure 1.2 Methodology for Estimating Demand of Minerals for 2050 Energy Technology Scenarios



These four inputs were combined into the model to create two more comprehensive categories of data:

I. Estimated capacity additions for electricity generation and energy storage technologies by 2050.

II. Estimated annual mineral requirements in supplying these technologies, which were then summed through 2050 to derive the final calculations of total demand for minerals from electricity generation and energy storage.

Table 1.4 lays out the penetration of different subtechnologies to 2050 that form the model's base scenario.

Table 1.4 Assumed Subtechnology Shares in 2050

Technology	Subtechnology	2050 Penetration
Energy storage (Automotive)	Lithium-ion	100%
Energy storage (Grid scale)	Lead acid	2.5% – 5% *(depending on scenario)*
Energy storage (Grid scale)	Lithium-ion	70% - 84% *(depending on scenario)*
Energy storage (Grid scale)	Redox Flow	2.8 % - 3.7% *(depending on scenario)*
Energy storage (Grid scale)	Other [a]	9.8% - 25%
Energy storage (Decentralized)	Lithium-ion	33%
Energy storage (Decentralized)	Lead Acid	33%
Energy storage (Decentralized)	Other [a]	33%
Solar PV	Crystalline silicon	50%
Solar PV	Cadmium telluride	16.7%
Solar PV	Copper indium gallium selenide	16.7%
Solar PV	Amorphous silicon	16.7%
Wind	Direct drive	25%
Wind	Geared	75%

Note: In the breakdown of battery composition, the refurbishment of car batteries to grid/decentralized energy has not been accounted for in the estimated mineral demand under the various scenarios. It is discussed, however, in the section on reuse in chapter 4.
a. This category represents all other forms of grid-based and decentralized energy storage, such as pumped storage. As this represents a composite basket of technologies, there are no estimates on mineral requirements of this category.

The relative demand for minerals is also driven by the expected longevity of energy technologies. Table 1.5 breaks down the assumptions behind the expected life span of key zero-carbon technologies. In particular, the expected and shorter life span of 10 years for energy storage highlights the critical role it will play in determining the future minerals market. The life span for many of these technologies is likely to vary between subtechnologies and is also uncertain given that some of these technologies have not yet reached full-scale commercial deployment, yet alone the end of their projected life span. Should the life spans of the technologies be longer than projected, or be extended through refurbishment, then less of these technologies will need to be deployed over the time period of the model—for example, although the analysis conservatively assumes a life span of 20 years for wind, offshore wind is often designed with a lifetime of 25 years and some turbines have been in operation for more than 40 years. Should life spans be longer than anticipated, mineral demand from these technologies will be lower than estimated in this report's projections.

Table 1.5 Assumed Lifetime of Technologies

Technology	Assumed life span (years)
Concentrated solar power	30
Energy storage (all battery types)	10
Geothermal	30
Hydroelectricity	25
Nuclear	50
Solar photovoltaic	30
Wind	20
Coal	40
Coal + carbon capture and storage	40
Gas	30
Gas + carbon capture and storage	30

While the model relied on primary and secondary research, most of the model's assumptions are primarily based on publicly available data. The data are thus limited in a number of facets, not least that the data are obtained from a variety of different studies with different methodologies and scopes, and crucially different ages. Where possible, the data have been drawn from consistent sources, but this comes at the expense of some of the data being more recently dated. Additional assumptions made are outlined and discussed in annex B.

Recycling, Reuse

To build off the model described above to estimate mineral demand up to 2050 under the IEA and IRENA scenarios, additional analysis has been conducted on if and how mineral recycling and reuse could potentially affect estimated mineral demand. In its current form, the results generated provide estimates for the demand for end-use minerals in low-carbon energy technologies without considering whether those minerals come from primary or secondary minerals. A brief analysis was conducted on five minerals—aluminum, cobalt, copper, nickel, and lithium—to examine the impact of recycling on primary mineral demand, while the impact of reuse was examined for lithium only.

Primary mineral is considered to be newly mined material, while secondary mineral is considered to be recycled material. There are two commonly reported rates for recycling: (1) ***end of life (EOL)***, which gives how much of a mineral is recycled at the end of its use in a product; and (2) ***recycled content (RC)***, which gives the percentage of secondary material that goes into end-use demand for a mineral.

EOL and RC rates are not equal, and the former is higher than the latter (see table 1.6). The primary reason for this difference is the availability of scrap. Take the example of aluminum: Between 42 and 70 percent of aluminum is recycled at the end of its life, with rates as high as 90 percent in some countries;[8] the industry is also well developed in recycling the scrap that it obtains. Yet the recycled content of new aluminum products has been estimated at between 34 and 36 percent. This is because the availability of scrap is simply not enough to meet the growing demand for aluminum. In addition, some recycling processes cause losses in the material itself and it may not be technically or economically feasible to recover material suitable for recycling from some applications. This is especially the case now with Li-ion batteries (Church and Wuennenberg 2019), helping explain the low recycling rates for lithium (table 1.6). RC rates are also an average across all industries, and with certain minerals, recycled material provides a suboptimal performance. For example, the cobalt used in batteries needs to be extremely pure, limiting the use of recycled material for that particular use (Bomgardner and Scott 2018), while it is extremely difficult to recycle the fiberglass used in wind turbine blades (Martin 2020). These reasons imply that even if EOL rates could reach 100 percent (implying that all possible scrap was captured, recycled, and could be reused), RC rates are unlikely to reach 100 percent without significant reductions in overall demand for these minerals.

Table 1.6 End-of-Life Recycling Rates and Recycled Content Rates

Mineral	End-of-life recycling rates	Recycled content rates
Aluminum	42%–70%	34%–36%
Cobalt	68%	32%
Copper	43%–53%	20%–37%
Lithium	<1%	<1%
Nickel	57%–63%	29%–41%

Source: UNEP 2011.

To estimate the impact of current and potential future recycling rates on the demand for primary minerals, a two-step methodology is adopted. First, it is assumed that current EOL and RC recycling rates persist to 2050. Given these levels of recycled content, the balance between primary and secondary mineral production is estimated using the RC rates and the overall level of demand for the mineral estimated in the model. The implicit assumption here is that the minerals used in energy technologies had the same balance between primary and secondary production as minerals used across all applications.

8 See "Quality and Value," (webpage), Aluminum for Future Generation, for more information: http://recycling.world-aluminium.org/review/quality-value/

The impact that increasing future recycling rates have on primary demand is then examined. Estimates of future recycling rates are sparse, both for EOL and RC. To understand the scale of a large future increase in recycling efforts, the following assumptions are made for four of the minerals studied (aluminum, cobalt, copper, and nickel):

- ***Current recycling rates:*** Estimates of current EOL and RC rates are drawn from the literature, taken as the midpoint of the range of values collected.
- ***New scenario – scaling up EOL recycling rates:*** EOL recycling rates are scaled up to 100 percent by 2050. This is likely to be unrealistic because of some losses remaining in the system, but it demonstrates an ambitious increase in recycling efforts.
- ***Availability of scrap material:*** The same ratio of scrap material availability to overall mineral demand remains the same.
- ***Impact on RC rates:*** RC rates therefore follow the same ratio to EOL rates, as demonstrated today, and RC rates for 2050 are estimated using the same ratios.
- ***Determining primary, secondary mineral production:*** RC rates are used to estimate the balance between primary and secondary mineral production in each year.

This process is not possible to do for lithium given the mineral's negligible current estimated EOL and RC rates. Thus, scenarios of future lithium recycling rates are drawn from the literature.[9]

As for the estimates for mineral reuse, whereby components of the energy system are reused, this has the potential of, again, creating a difference between end-use and primary mineral demand. For example, there is discussion on repurposing Li-ion batteries from electric vehicles for stationary applications, such as the electricity grid. This impact of reuse is thus examined in the report to understand the impact of increasing reuse patterns on the model's estimated mineral demand from energy technologies.

Although this additional analysis does not intend to provide a complete picture of mineral recycling rates, it is an important area to explore to estimate whether current and future mineral recycling and reuse would be sufficient to meet the demand for minerals of clean energy technologies to achieve a low-carbon future. A key aspect not covered in this analysis is the role of refurbishment—for example, where all or component parts of energy technologies, such as wind turbines, are refurbished to extend their life span. The implications of this are, however, discussed in the section on reuse in chapter 4.

Global Warming Potential

This section focuses on the global warming potential (GWP) of clean energy technologies compared with fossil fuel technologies, partly using a life-cycle analysis. While the data are incomplete,[10] initial results confirm that the additional extraction and processing of minerals will be appreciably less greenhouse gas (GHG)-intensive than a base scenario with the continued strong reliance on fossil fuels, with an estimated 615 gigatons of carbon dioxide ($GtCO_2$) being produced in the base scenario up to 2050, while moving to a 2DS involves an extra 6 $GtCO_2$ from building and operating renewable technologies, but it reduces emissions from fossil fuel generation by over 350 $GtCO_2$.

This GWP analysis does not cover the full life cycle of renewable electricity generation and energy storage technologies; it is limited to the operation of each technology. In other words, the GWP does not take into account the emissions associated with replacing and disposing energy technologies once they reach their end of life, nor does it take into account the transportation of renewable energy technologies, such as wind turbines, or the shipping of coal and gas. The intent of the GWP analysis is to produce an estimate of the GWP of shifting to a new and low-carbon energy system.

The basic approach is to examine the GWP in the extraction and processing of relevant minerals found in low-carbon technologies and then compare that with the GWP of the traditional fossil fuel-based electricity generation sources—namely, coal and gas. GWP refers to the relative amount of GHG emissions (the vast majority of which is carbon) used in the extraction, production, and processing of minerals, as well as the operation of these technologies. Nuclear

9 For example, Ziemann et al. (2018) provides projections for lithium recycling rates that are used in the analysis on recycling in chapter 4.
10 Calculations on the greenhouse gas (GHG) impact in the manufacturing of clean technologies in this study does not cover, for example, steel or cement; the GHG emissions associated with the production of infrastructure associated with the fossil fuel industry are also not examined.



energy has been excluded from this GWP analysis to focus on the issue of renewable energy versus fossil fuel production.

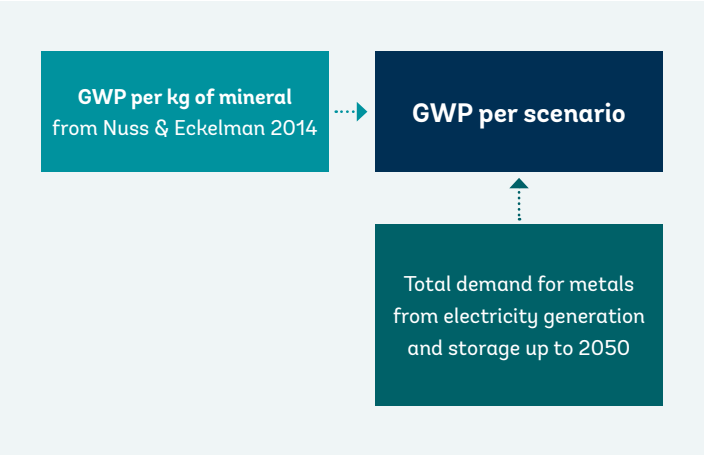
With respect to the specific minerals and metals covered in this study, the model draws on data from a paper by Nuss and Eckelman (2014). This paper gives consistent estimates of the amount of GWP of minerals in terms of carbon dioxide equivalent (CO_2e) from the direct and indirect emissions (for example, the emissions from the extraction and processing and estimates of the emissions associated with the type of electricity used in those processes). The authors estimate the relative GWP of these materials using a "**cradle-to-gate**" scope, thereby excluding transportation of the minerals and any emissions associated with their disposal.

There is little literature on the carbon footprint of energy technologies, and the data among the available sources vary vastly because of the different assumptions around extraction, processing, and operational emissions. For this analysis, the underlying data come from the period around 2008 and are thus not fully reflective of the situation today, and not for 2050. What has changed and is likely to further change, impacting the GWP per kilogram for the minerals in different ways, includes shifting electricity mix, reducing ore grades, relative prices of commodities,[11] and changing mining and production techniques.

The direction, and scale, of these changes will differ from mineral to mineral.[12] For example, iron will always have a relatively high GWP so long as it relies on coking ovens. Aluminum's GWP, on the other hand, is very much predicated on the electricity source needed for its production. For example, its GWP is much smaller when the energy source for the aluminum production is hydroelectricity rather than electricity from coal power stations.

To produce the estimates, the total demand for minerals from the various energy technologies in the model are combined with the estimates of GWP per kilogram of mineral (figure 1.3). This then provides an estimate of the different GWPs arising from the minerals used in the technologies in the IEA 2DS.

Figure 1.3 Schematic of Global Warming Potential Component of Model



Note: GWP = global warming potential.

A range for each estimate was produced stemming from the range of the GWP per kilogram of mineral and the projected range of mineral demand. The numbers reported in this analysis are the midpoint of the range. This is discussed in more detail in annex B.

Model Uncertainty

Like many projections, there are uncertainties regarding future mineral demand from energy technologies, as it relies on a variety of different sources with different methodologies to derive forward-looking projections. These include the mineral composition of the energy technologies themselves; the share, and scale, of energy technologies that will be deployed in the future; which subtechnologies will actually be deployed within each energy technology; and the life span of technologies and future paths of recycling and reuse.

The model captures uncertainty around two of these elements: (1) mineral composition and (2) share, and scale, of energy technology penetration. It produces a range of demand for each mineral, and all results of this analysis are midpoints of the range of estimated mineral demand. The ranges of some of the minerals

11 Relative prices are important because of the methodological choice of economic allocation rather than mass allocation for the GWP of production processes that produce two or more final metal products. For example, some forms of copper refining yield copper, silver, selenium, and tellurium. The question then becomes how to allocate the GWP from the copper refining process between the four minerals. Economic allocation, adopted by Nuss and Eckelman (2014), allocates the GWP on the basis of the revenue earned from the four minerals. Mass allocation allocates on the mass of the products obtained. Under the economic allocation methodology, large shifts in relative prices would shift the allocation of the GWP between the end-use metals.

12 These issues have been explored in depth for seven specific metals in van der Voet et al. (2019). A further discussion of issues relating to the GWP sources can be found in annex B.

are considerable. For example, aluminum is used in solar PV for the frames; however, this service could be provided by synthetic or composite materials—and if or when aluminum is replaced, demand for that mineral could fall considerably.

The second aspect of uncertainty relating to the share and scale of energy technology penetration is captured by the use of various scenarios. Different scenarios from the IEA are used to capture the impact of wider deployment of low-carbon energy technologies. The four IEA scenarios are used to highlight the impact of greater climate ambition, demonstrating a clear trend that higher ambition leads to higher demand for minerals.

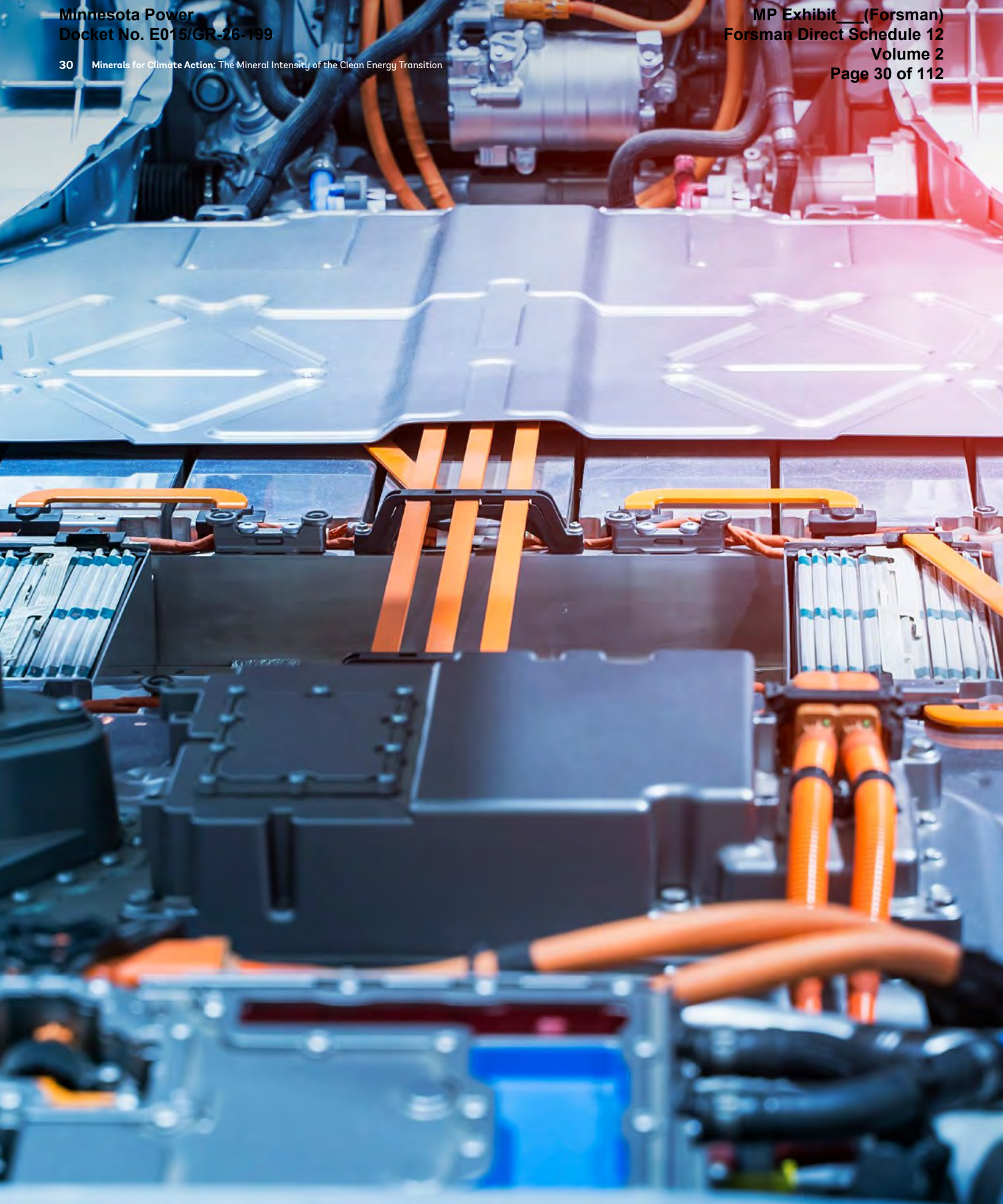
Within this greater ambition, however, are a number of potential technology pathways to meet the same level of emissions reductions. More focus could be placed on fossil fuel generation with carbon capture and storage, or on renewable deployment. Even within this second choice, there are options for more wind deployment, or more solar PV, higher rates of geothermal, or concentrated solar power. These choices do not necessarily mean higher or lower levels of overall demand for minerals, but they do imply demand for different minerals. This uncertainty is partially captured by the inclusion of scenarios from two different sources: the IEA and IRENA. The IEA scenarios see a greater role for carbon capture and storage, while the IRENA scenarios see greater renewable deployment. Comparing the results of these different groups of scenarios therefore highlights an aspect of this uncertainty.

The uncertainty over the emergence of new subtechnologies is also not captured in the model. The uncertainty over this element is likely to be much greater post-2030 than in the next decade, especially in the realm of energy storage, where a number of new technologies are emerging fast, such as solid-state Li-ion batteries as well as other types of flow batteries (for example, iron-based), and new developments in thermal electric and mechanical storage. Each of these technologies will have differing mineral compositions. Predicting which, if any, of these technologies will emerge is impossible, implying that post-2030 both the scale of storage and the mineral composition of energy storage is highly uncertain. This creates uncertainty over not only the amount of demand of minerals but the actual minerals themselves that will be needed for the low-carbon transition. These different demand risks are addressed in the report through a demand risk matrix.

The potential implications for mineral demand from a range of emerging new technologies, including some of these new emerging storage technologies, are discussed in the Emerging Energy Technologies section in chapter 3. For additional information on uncertainty ranges, please refer to annex B.







The Role of Minerals in the Clean Energy Transition

The penetration of renewable energy in the energy sector will be crucial to achieve a low-carbon future. The energy sector today accounts for 41 percent of carbon emissions worldwide, or 13.6 $GtCO_2e$ (IEA 2019a), and is expected to rise further as the global population grows, particularly in developing countries, and energy consumption rises because of this new demand.[13] With renewable energy costs falling rapidly from clean energy technologies, such as solar PV and onshore wind at 0.08/kWh and 0.05/kWh in 2018 (IRENA 2019d), respectively, it is expected that these technologies will play a significant role in decarbonizing electricity production. However, the rapid deployment of these low-carbon technologies needed to reach a 2°C pathway, or below, will also mean that the demand for minerals needed to produce these technologies will rise.

The implications of rising mineral demand can be examined through multiple lens. On one hand, increasing extractive and processing activities *could* have serious environmental and social implications *if* these activities are not managed responsibly to meet this new demand from the increased deployment of renewable energy. As of today, the mining sector accounts for approximately 2–11 percent of total global energy consumption (Guilbaud 2016; CCSI 2018), while 70 percent of mining operations from the six largest mining companies are located in water-stressed countries (IFC and ICCM 2017). On the other hand, new demand for these "strategic" minerals could also provide new opportunities for resource-rich developing countries and enable them to meaningfully contribute to the clean energy transition.

Adopting climate-smart mining (World Bank 2019) practices would enable the mining sector to transform its current practices—through innovation and new partnerships with downstream companies and civil society organizations—to further reduce the overall sector's carbon and environmental footprints. Providing adaptation measures (for example, water efficiency) and the incorporation of desalination can contribute to operational independence while improving relationships with the communities (Campero and Harris 2019). Integrating renewable energy into mining operations, for example, as well as employing energy efficiency measures could reduce at least 40 percent of total energy use in the crushing and grinding of minerals (Australia 2018). Providing demand estimates for a variety of minerals can illustrate the implications of various lower carbon pathways, and it is a crucial exercise to undertake as it provides a framework to ensure that the decarbonization of electricity generation does not end up shifting greenhouse gas (GHG) emissions from electricity production to upstream (extraction and processing) and EOL (disposal of energy technologies) activities.

This analysis estimates the amount of minerals that may be needed per clean energy technology—including their subtechnologies—to provide policy makers, private sector entities, and civil society organizations with the latest information available to support the low-carbon transition through a holistic approach. This includes estimating potential mineral demand under six technology-based mitigation scenarios from the IEA and IRENA while taking into account the role that recycling *could* have in meeting this new mineral demand. It does not intend to forecast what will happen, but instead provide a range of scenarios to explore the future global energy system and how different policy choices and technology improvements could affect overall mineral demand up to 2050. Failing to address concerns on materials use intensity and its relationship to increasing environmental and social impacts may cause a backlash that will question the appropriateness of some of these technologies in comparison to those that are conventional (Bloomberg 2019; Wade 2016).

13 Energy sector in this context refers to electricity and heat generation only. This category is further broken down by sector on the IEA website.

Renewable Energy and Storage Forecast

Renewable energy has been one of the largest growing sources of installed electricity generating capacity, growing from 1,058 GW in 2008 to 2,179 GW in 2018 (IRENA 2018), largely driven by government policies, regulations, and incentives as a means to decarbonize the energy sector and limit the negative impacts of a changing climate. Demand-side interventions, as well as economies of scale and technological developments on the supply side, have enabled renewable energy to become competitive with fossil-fuel-based technologies. For example, some countries have already begun transitioning away from support schemes (for example, feed-in-tariffs, or FiTs) to support renewable energy growth, to competitive auctions for long-term power purchase agreements (IEA 2019d, 154).

Policy choices, technology improvements, and these latest pricing trends combined indicate that the growth of renewable energy in the global electricity mix is here to stay, making renewable energy and storage forecasts a central point in this report's analysis to estimate mineral demand up to 2050. The IEA and IRENA scenarios for electricity generation and battery storage, including the subtechnology shares in those scenarios, also highlight the energy technology coverage in the model and break down key inputs used to better understand the minerals' role in the clean energy transition.

Technology-Based Mitigation Scenarios

As this report relies heavily on the IEA and IRENA **technology-based mitigation scenarios**, the six scenarios have been captured again in table 2.1 to provide a reference point for each assumption used to derive estimated mineral demand up to 2050.

Table 2.1 Shortened Technology-Based Mitigation Scenarios from IEA and IRENA

Technology-based mitigation scenarios			
	Scenario	**Source**	**Scenario description**
1	**4DS** (Base scenario)	**IEA**	**Base scenario**, where the world carries on a current trajectory and makes little improvement in shifting the energy system away from fossil fuel sources
2	**RTS**	**IEA**	Assumes all countries will implement their NDCs under the Paris Agreement, resulting in an average temperature increase of **2.7°C by 2100**
3	**2DS**	**IEA**	Scenario with at least a 50% chance of limiting the average global temperature increase to **2°C by 2100**
4	**B2DS**	**IEA**	Scenario with a 50% chance of limiting average future temperature increases to **1.75°C by 2100**
5	**Ref**	**IRENA**	Accounts for actions, commitments made under current/planned policies, including NDCs. Rise in temperatures would be at least **2.6°C by 2100**
6	**REmap**	**IRENA**	Ambitious scenario that limits the rise in global temperature to "well below" **2°C above preindustrial levels by 2100**

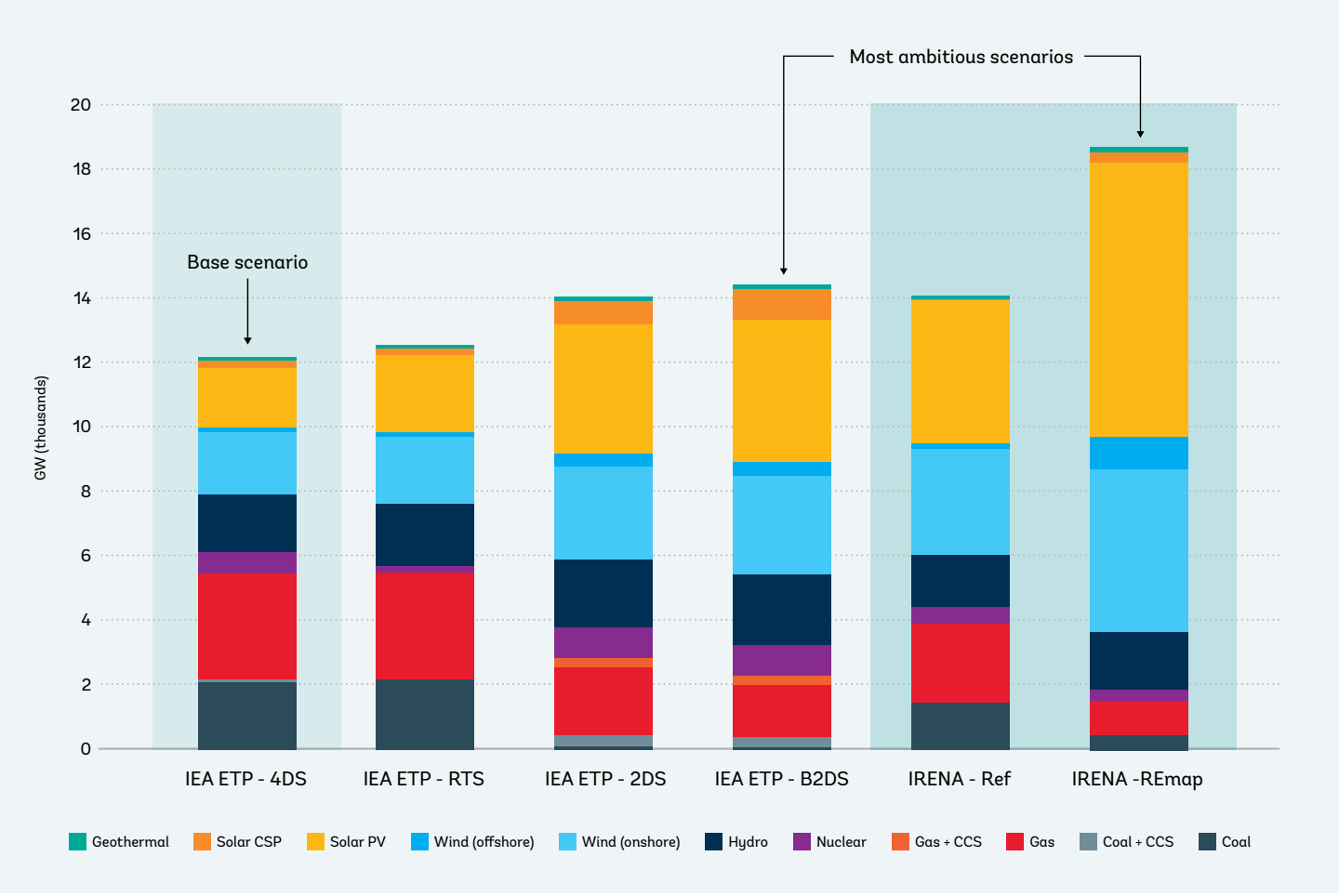
Note: 2DS = 2-degree scenario, 4DS = 4-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, NDC = Nationally Determined Contribution, Ref = reference scenario, REmap = renewable energy roadmap scenario.

Electricity Generation: Installed Electrical Capacity in 2050

The IEA and IRENA use different assumptions about renewable energy penetration in their technology-based mitigation scenarios. For example, IRENA's REmap projections on renewable electricity penetration up to 2050 are higher than IEA's 2DS and B2DS, at 64 percent and 51 percent, respectively. These differences are due to a number of factors, including different global economic growth assumptions—IRENA assumes an annual global GDP growth of 3.2 percent; the IEA assumes 2.9 percent—and different assumptions about the emergence of other low-carbon technologies such as carbon capture and storage (CCS).

The type of energy technology penetration in the global energy mix is relevant for minerals because they are required to supply transportation and nontransportation-related energy storage and renewable energy technologies. Figure 2.1 provides an overview of the relevant energy technologies expected to play a role in the global electricity production in the future; however, three technologies are excluded from this model—oil, biomass, and tidal—owing to the lack of data on their mineral composition.

Figure 2.1 Estimated Installed Capacity in 2050 Across the Technology-Based Mitigation Scenarios



Source: IEA 2016, 2017; IRENA 2019a.
Note: 2DS = 2-degree scenario, 4DS = 4-degree scenario, B2DS = beyond 2-degree scenario, CCS = carbon capture and storage, CSP = concentrated solar power, ETP = Energy Technology Perspectives, IRENA = International Renewable Energy Agency, PV = photovoltaic, Ref = reference scenario, REmap = renewable energy roadmap scenario.





Under the base scenario (4DS), coal and gas with some CCS dominate the electricity sector, while the share of conventional energy gradually diminishes as the world becomes increasingly ambitious in its climate targets. Geothermal is seen to play a larger role under the base scenario than other reference scenarios (RTS and Ref), mainly because it was produced before the other scenarios. In the intervening period, the costs of variable renewable energy, such as solar PV and wind, have fallen dramatically, as have the costs of integrating these technologies into the grid, albeit not as dramatically as the latter. This has meant that in the later RTS and Ref scenarios, other renewables have become more attractive than geothermal energy.

From the base scenario, a decrease in coal is observed once the model moves toward the IEA's 2DS and B2DS, and away from the RTS and the 4DS. While coal decreases in the 2DS and B2DS, the share of CCS for gas and coal starts to appear in the electricity mix, albeit a very small share, whereas in the IRENA scenario, those technologies are not expected to materialize.

Renewables—particularly solar PV and wind—rise dramatically under those same IEA scenarios, but again, the IRENA models assume a much higher penetration of those two technologies than do the IEA models, which also assume increasing contributions from other nonemitting sources, including hydroelectricity and nuclear energy. The IRENA Ref scenario has higher levels of wind penetration than the IEA 2DS and B2DS. One of the key takeaways is the following: the more ambitious the scenario, the higher the penetration of renewable energy in the electricity mix for both the IEA and IRENA scenarios.

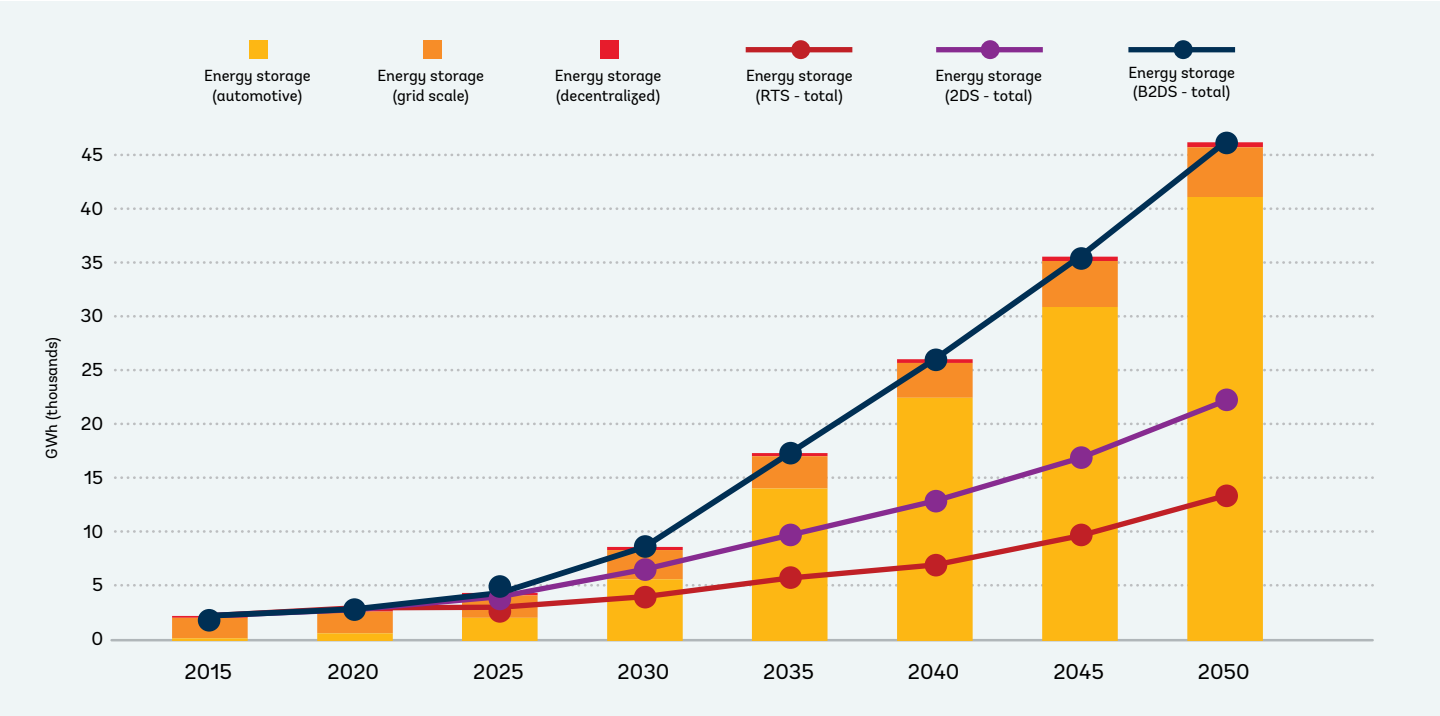
Energy Storage Projections

Unlike electricity generation, mineral demand estimates for energy storage technology were solely derived from the IEA,[14] as data on energy storage under the IRENA scenarios were not available. The IEA 4DS (base scenario) also does not include the penetration of energy storage in the electricity mix. Energy storage predictions up to 2050 were extrapolated from data provided by the IEA on energy storage requirements for automotive and nontransportation-related energy storage up to 2040 and 2060. The average of the storage requirements from 2040 and 2060 was taken to give an estimate of the required storage in 2050, and then combined with data from a wide variety of sources on other key aspects of the storage sector.

As seen in figure 2.2, all three IEA scenarios demonstrate that the relative demand for energy storage, particularly with respect to energy storage for transportation, is expected to rise dramatically by 2050. In the 2DS, for example, demand for storage rises from 4,108 gigawatt-hours (GWh) in 2025 to 22,270 GWh in 2050. The demand for energy storage technology rises exponentially as each scenario increases in climate ambition, with a difference of 32,792 GWh from the RTS (in light red) to B2DS (in dark blue) in 2050.

The energy storage market penetration is split between transportation (covering electric and hybrid vehicles) and nontransportation (covering storage from electricity generation), with the latter again split between grid scale (for regulation of grid voltage and storage from intermittent electricity generation, such as renewables) and decentralized (storage from individual, small-scale renewable energy installations). Redox-flow batteries are only used in grid-scale applications.

Figure 2.2 Expected Growth in Energy Storage Through 2050



Source: Based on IEA ETP 2017.
Note: 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, GWh = gigawatt-hours, RTS = reference technology scenario.

14 IRENA's scenarios only provide data for electricity generation and not energy storage.

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Mineral Intensity of Clean Energy Technologies

The clean energy transition is expected to be much more mineral intensive than fossil-fuel-based electricity generation. It is important to understand the extent to which mineral demand will grow globally to supply renewable energy and storage technologies. Table 3.1 provides an overview of the minerals covered in this analysis and their relevance to each technology identified in the technology-based mitigation scenarios.

Copper, aluminum, chromium, manganese, molybdenum, and nickel are required for a range of low-carbon technologies, making them critical elements for realizing a low-carbon future. The mapping of relevant minerals to energy technologies found in the technology-based mitigation scenarios is by no means an exhaustive list, as it focuses exclusively on certain electricity generation and energy storage technologies—and a range of other minerals are also needed, but they have not been included in the model owing to data constraints.

These minerals include, but are not limited to, dysprosium for direct-drive wind turbines; cadmium, tellurium, selenium, and gallium for various types of solar PV panels; and platinum in other forms of energy storage (such as fuel cells, discussed in the Emerging Energy Technologies section in chapter 3). The exclusion of these minerals from this analysis should not, however, be interpreted as a commentary on their lack of criticality for individual technologies, or the low-carbon transition. Some technologies may also use small amounts of minerals in components, such as the use of carbon brushes in the motors of wind turbines; however, no data were available on such use and thus they were excluded from the model.

As mentioned in chapter 1, the new infrastructure required to support a low-carbon transition has not been addressed, nor have other clean energy options, such as hydrogen-based vehicles, where platinum would play a key role. The need to connect some 840 million people without electricity access today as well as build the motors and chassis to electrify 135 million electric vehicles that are expected to come online in the next 10 years to decarbonize the transportation sector (IEA 2019b) are examples of new energy infrastructure that also have not been captured in this analysis. Additionally, the materials needed to install these low-carbon technologies, such as cement to stabilize wind turbines' installation, have not been addressed in this analysis.

Table 3.1 Mapping Minerals with Relevant Low-Carbon Technologies

	Wind	Solar photovoltaic	Concentrated solar power	Hydro	Geothermal	Energy Storage	Nuclear	Coal	Gas	Carbon capture and storage
Aluminum	■	■				■	■	■	■	
Chromium	■			■	■	■	■	■	■	■
Cobalt						■		■	■	■
Copper	■	■	■	■	■	■	■	■	■	■
Graphite						■				
Indium		■					■			
Iron	■					■				
Lead	■	■		■		■	■			
Lithium						■				
Manganese	■			■	■	■		■	■	■
Molybdenum	■	■		■	■		■	■	■	■
Neodymium	■									
Nickel	■	■		■	■	■	■	■	■	■
Silver		■	■				■			
Titanium				■	■		■	■	■	
Vanadium						■	■	■		
Zinc	■	■		■		■	■			
Total	10	8	2	8	6	11	11	9	8	6

Solar Photovoltaic

Solar photovoltaic (PV) has been the most rapidly deployed renewable energy technology globally, with installed capacity reaching 485 GW in 2018 (IRENA 2019b), outpacing all other technologies in growth between 2017 and 2018, growing by 24 percent. The high learning rate[15] of solar PV (22–40 percent) has resulted in dramatic cost reductions, with the global-weighted average levelized cost of energy (LCOE) falling by 77 percent between 2010 and 2018 (IRENA 2019c), making it one of the most attractive technologies for renewable energy investors worldwide.

This trend can be reflected with installed capacity of solar PV expected to reach up to 8,519 GW (IRENA 2019c) by 2050 in Africa, Asia, and Europe owing to continued cost decreases, where the technology is expected to reach price parity with fossil fuel technologies. Solar PV's relative growth in Africa, for example, is likely to be huge, with the IEA's *World Energy Outlook 2019* projecting solar PV deployments in the region to grow by more than 3,000 percent between 2018 and 2040. By 2050, most solar PV deployments are expected to take place in non-OECD countries, especially in China and India.

Four widely used solar PV subtechnologies are represented in this analysis:

1. **Crystalline silicon (crystal Si)** cells make up about 85 percent of the current market. They can either be manufactured as single crystalline, polycrystalline, or amorphous silicon.
2. **Copper indium gallium selenide (CIGS)** is a "thin film" solar technology. It can be made into thinner cells than crystal Si, which may reduce material and manufacturing costs while allowing for flexible cells.
3. **Cadmium telluride (CdTe)** is another thin film technology. It is cost competitive with crystal Si and has good efficiency. However, the toxicity of cadmium and the future supply of tellurium make the future of this technology uncertain.
4. **Amorphous silicon (amorphous Si)** solar cells are the final thin film technology. They suffer from lower performance than crystal Si but are able to be printed on flexible materials.



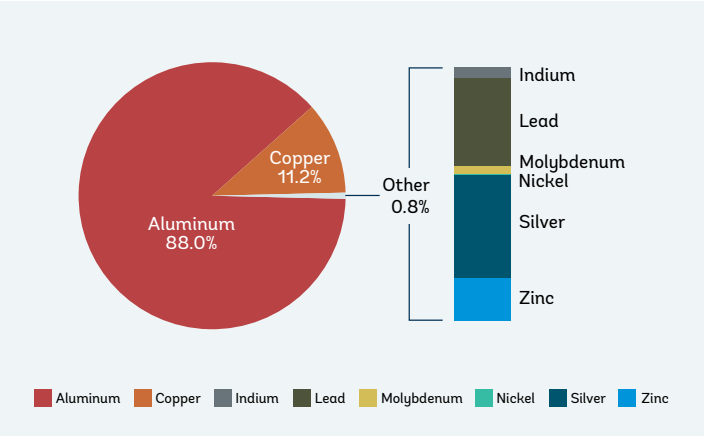
15 The learning rate is defined as the fractional reduction in cost for each doubling of cumulative production.





Solar PV technologies are primarily made up of aluminum, copper, and silver—with various minerals also playing a role in each of the different technologies, some of which are included in this analysis, such as indium in CIGS, and some that are not, such as cadmium for CdTe. Figure 3.1 shows the major mineral demand used to supply solar PV through 2050. Aluminum accounts for more than 85 percent of most solar PV components, being used for the frames of the panels, and copper following suit at about 11 percent. While silver accounts for a smaller share of mineral composition in a 2DS, less than 0.05 percent, it accounted for nearly 7 percent of total silver demand in 2015 owing to the rapid deployment of solar PV worldwide (Sanderson 2016).

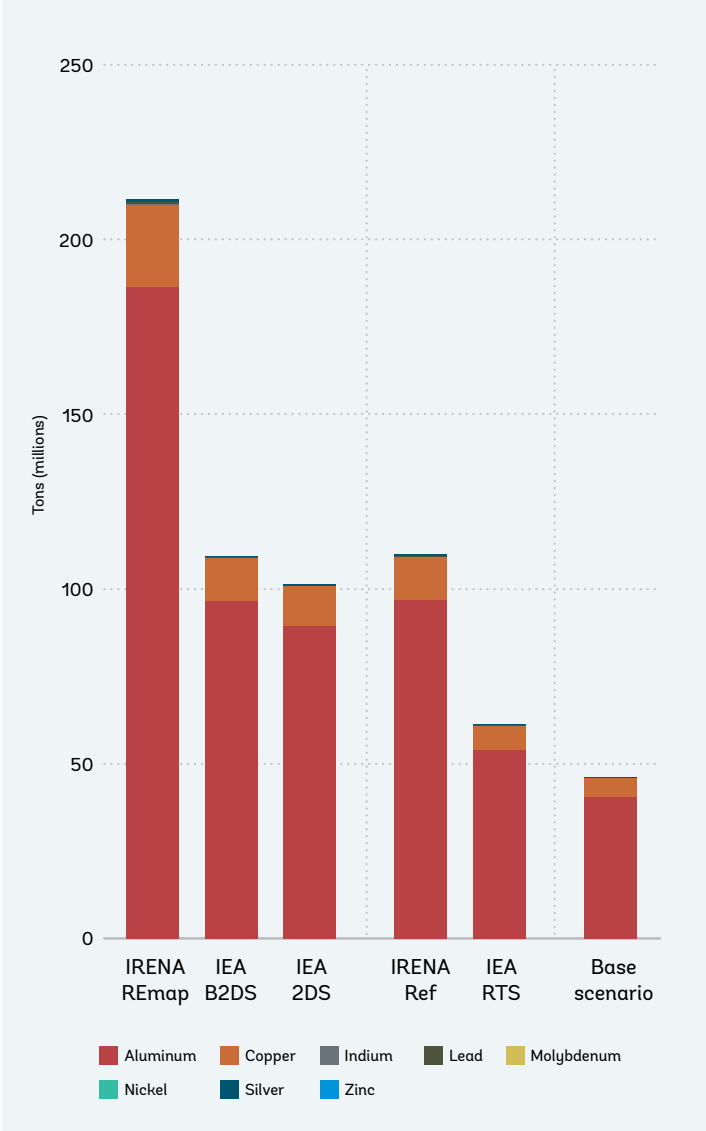
Figure 3.1 Share of Mineral Demand from Solar Photovoltaic Under the IEA 2DS Through 2050



Note: 2DS = 2-degree scenario, IEA = International Energy Agency.

Between the scenarios, IRENA's REmap scenario is by far the most materially intensive, owing to its higher installed capacity of solar PV, with 160 million tons of aluminum and 20 million tons of copper required by 2050 (figure 3.2). Compared with the base scenario, the demand for both minerals grow by more than 350 percent.

Figure 3.2 Cumulative Demand for Minerals Needed for Solar Photovoltaic Through 2050

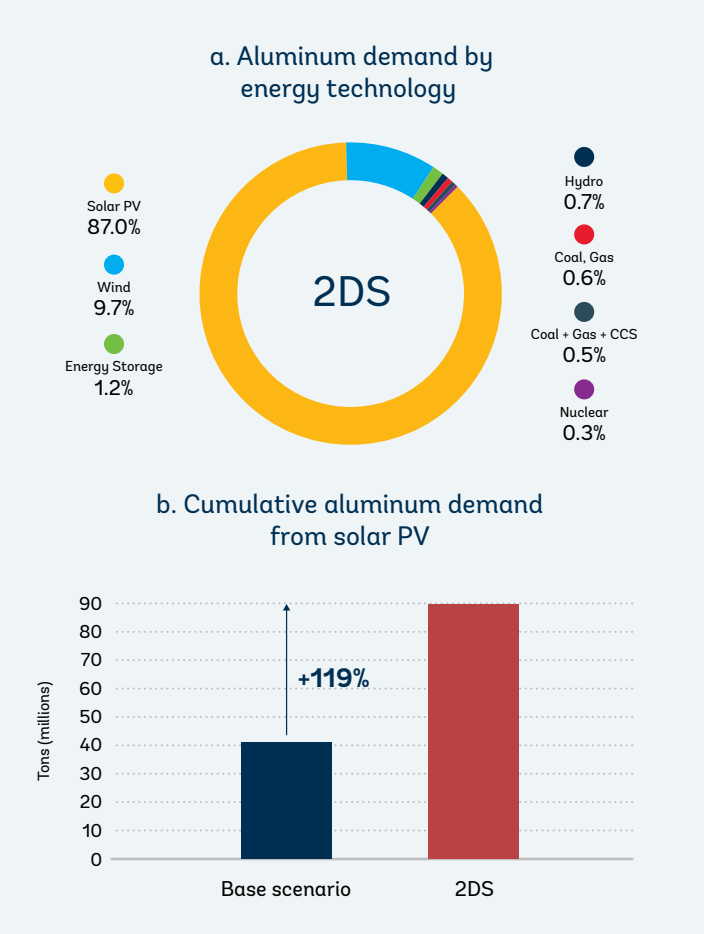


Note: 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, Ref = reference scenario, REmap = renewable energy roadmap scenario, RTS = reference technology scenario.

While aluminum is a major contributor to solar PV technologies, it is also used in most other low-carbon technologies, such as wind, energy storage, and hydroelectricity. Figure 3.3 shows that the vast majority of growth in demand for aluminum is tied to solar PV used both in the cells themselves and in the frame and attachments. Its greatest use is with crystal-Si cells as these are still assumed to represent the greatest share of the solar market by 2050. Greater ambition to combat climate change is associated with greater penetration of solar PV and therefore greater demand for aluminum—cumulative demand for aluminum is 119 percent greater in the 2DS than in the base scenario.

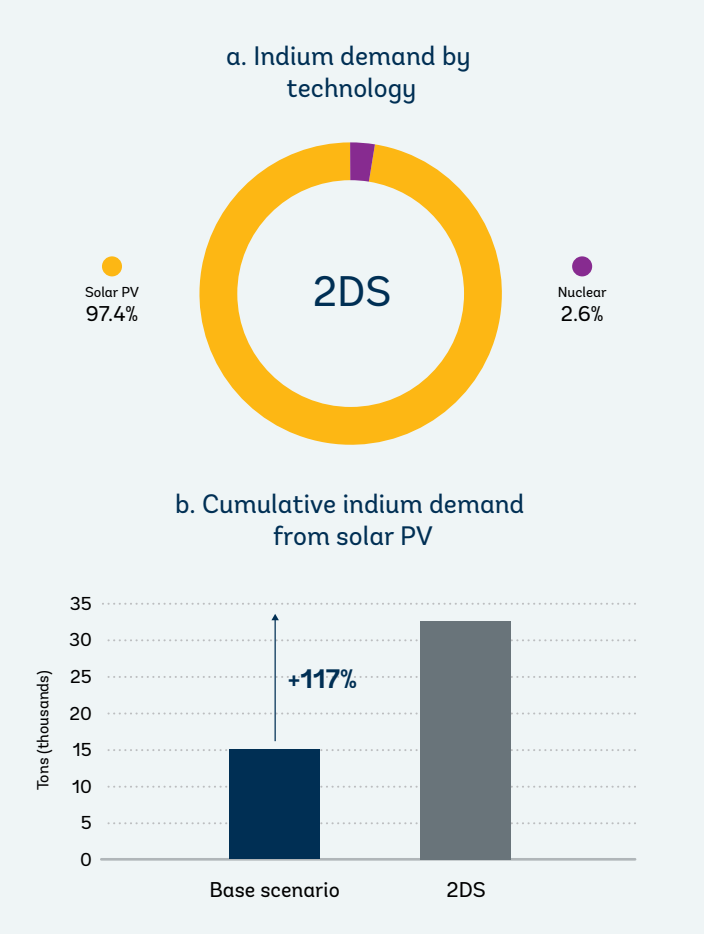
Indium is another critical element that is used almost exclusively for solar PV. Figure 3.4 shows the cumulative demand for indium by technology. The vast majority of indium (97 percent) is used in solar PV, predominantly in CIGS solar cells, with the remaining 3 percent used in nuclear power. The relative share in a solar PV is small but critical to a key type of solar PV subtechnology: thin film. The current literature expects this subtechnology to grow, and in the model, the three thin film subtechnologies—CIGS, CdTe, and amorphous silicon—are assumed to grow from 20 percent to 50 percent of solar panels.

Figure 3.3 Total Aluminum Demand by Energy Technology Through 2050 (2DS, Base Scenario)



Note: 2DS = 2-degree scenario, CCS = carbon capture and storage, PV = photovoltaic.

Figure 3.4 Total Indium Demand by Energy Technology Through 2050 (2DS, Base Scenario)



Note: 2DS = 2-degree scenario, PV = photovoltaic.

Trade-Offs in Solar PV Subtechnologies

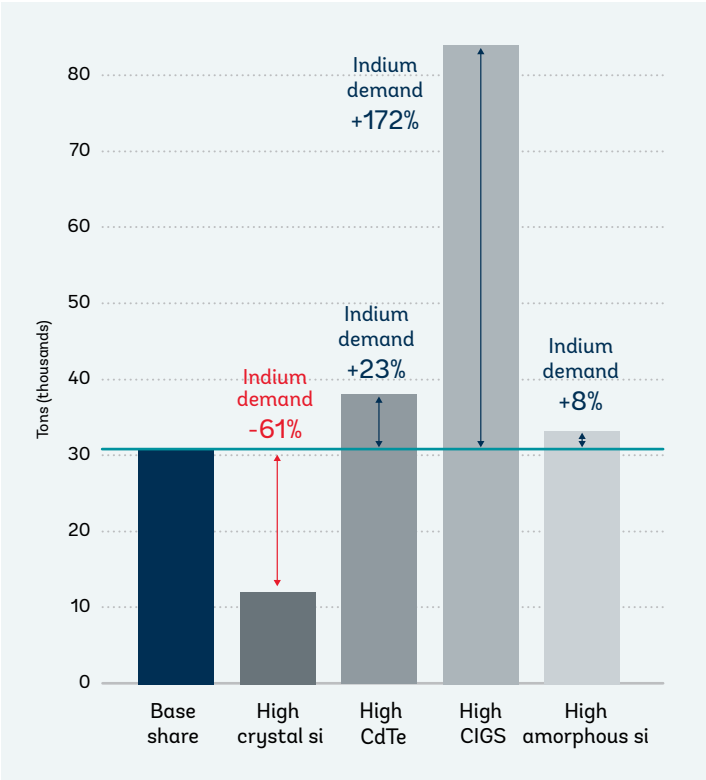
There are trade-offs in mineral demand from solar PV technology, depending on which subtechnologies end up being deployed most through 2050. Each technology for constructing solar PV cells has distinct advantages and disadvantages, as well as differing mineral content.

Since indium is the most affected by potential changes in the subtechnologies solar PV market share, figure 3.5 presents how indium demand could increase or decrease, depending on various outcomes. Table 3.2 breaks down the penetration of different subtechnologies relative to the base share to demonstrate how the demand for indium would change.

In the base share scenario, the share of crystal Si declines in use with gradual increases in share from the other three emerging technologies. The high crystal Si scenario keeps the subtechnology's share at 2017 levels, with static shares for the other three subtechnologies. The high CdTe, CIGS, and amorphous Si scenarios have the relevant technologies growing to half the market by 2050, with crystal Si declining in importance and small increases for the other two subtechnologies.

Indium is the key mineral affected by changes in subtechnology market share in solar PV; minerals such as silicon, gallium, and tellurium would also be affected, but these are not included in the model. Demand for indium is greatest in the high CIGS scenario, and smallest in the high crystal Si scenario, as seen in figure 3.5. These changes are potentially significant, with indium demand increasing by more than 170 percent, compared to the base share, when penetration of CIGS is highest. In contrast, if crystal Si remains the dominant subtechnology, then indium demand would be more than 60 percent lower than in the base share scenario.

Figure 3.5 Cumulative Demand for Indium from Solar PV Subtechnologies Compared to Base Share Under 2DS Through 2050



Note: 2DS = 2-degree scenario, amorphous Si = amorphous silicon, CdTe = cadmium telluride, CIGS = copper indium gallium selenide, crystal Si = crystalline silicon, PV = photovoltaic.

Table 3.2 Share of Subtechnology Penetration in Solar PV Market Compared with Base Share Under 2DS

2050 share	Crystal Si	CdTe	CIGS	Amorphous Si
Base share (2DS)	**50%**	16.7%	16.7%	16.7%
High share: **Crystal Si**	**80%**	6.7%	6.7%	6.7%
High share: **CdTe**	16.7%	**50%**	16.7%	16.7%
High share: **CIGS**	16.7%	16.7%	**50%**	16.7%
High share: **Amorphous Si**	16.7%	16.7%	16.7%	**50%**

Note: 2DS = 2-degree scenario, amorphous Si = amorphous silicon, CdTe = cadmium telluride, CIGS = copper indium gallium selenide, crystal Si = crystalline silicon, PV = photovoltaic.





Wind

Similar to solar PV, wind energy has also been one of the fastest growing renewables, with installed capacity reaching 566 GW in 2018 (IEA 2019c). Increases in wind turbine size, higher efficiency, lower cost of capital, and economies of scale have lowered wind electricity generation prices to the point where it is competitive with fossil fuel generation in many areas, and, according to Citibank, is even "approaching the average wholesale electricity price in a number of large markets—including Italy, Spain, the United Kingdom, and China—and has already attained and surpassed parity in Brazil" (Savvantidou et al. 2013). Onshore wind costs are frequently below $40 per megawatt-hour in developed markets. Offshore wind has seen even more dramatic cost reductions, falling from a range of $150–$200 per megawatt-hour in 2015 to under $50 per megawatt-hour in the United Kingdom in late 2019 (ESMAP 2019).

Under the IEA and IRENA scenarios, the bulk of onshore wind growth is expected to take place in emerging markets with strong wind resources and consistent policy support. Offshore wind is expected to expand its current footprint in Europe and China before moving into emerging markets over the next few years. A recent study by the World Bank found over 3.1 terawatts of offshore wind technical potential in only eight emerging markets.

Simply put, wind turbines convert the kinetic energy of wind into electricity. The largest onshore wind turbines now exceed 6 MW of peak generation capacity, enough to power more than 5,000 homes in the United States. The largest offshore wind turbines are twice that size (12 MW) and have blades as long as 107 meters (indeed, they are the largest pieces of rotating machinery that humans have ever invented). The next generation of wind turbines are expected to reach generation capacity up to 15 MW or even 20 MW soon (AIP 2019).

Figure 3.6 Evolution of the Wind Turbine

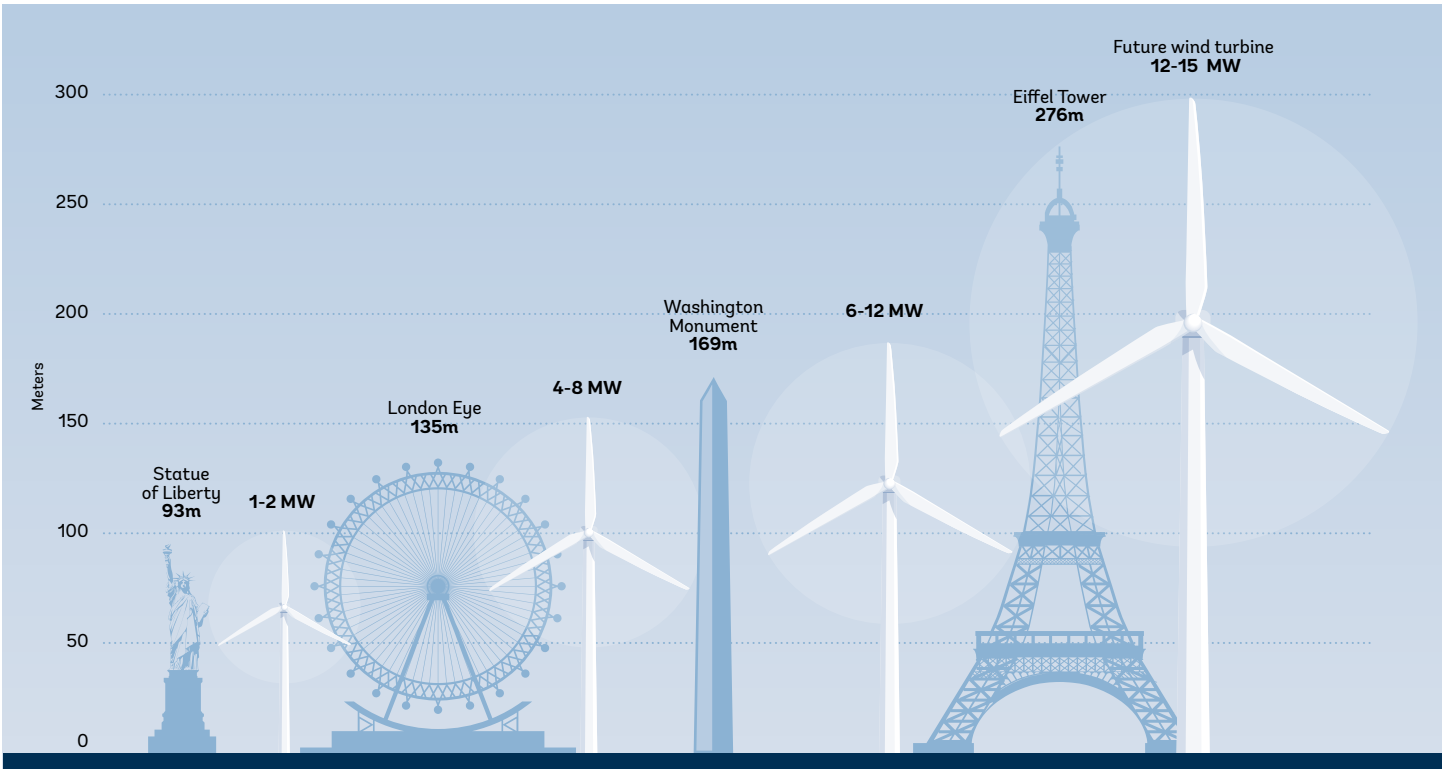


Illustration adapted from various sources (for example, https://www.researchgate.net/figure/Evolution-of-wind-turbine-size-and-output-Liebreich-2017_fig3_331249559; Power Technology, https://www.power-technology.com/features/haliade-x-look-ges-supersized-new-wind-turbine/attachment/ge-infographic-1-haliade-x/).

Onshore and offshore wind turbines share many commonalities, but they also have significant differences in design, technology, and required materials, both in the turbines themselves and in the balance of plant. Offshore wind turbines encounter harsher conditions than their onshore counterparts and thus need to be more resistant to corrosion, higher winds, and extreme weather.

Offshore wind farms also require greater material inputs in their foundations (mainly steel) and in the cabling required to transmit the electricity onshore (for example, copper). Offshore wind farms do, however, offer greater capacity factors than their onshore counterparts (ESMAP 2019).

Modern utility-scale wind turbines can be divided into two categories: geared or direct drive.

1. **Geared turbines** make up roughly 80 percent of global installed capacity. These "Danish design" machines use a gearbox to convert the relatively low rotational speed of the turbine rotor (12–18 rpm) to a much higher speed (1,500 rpm) for input to a generator. The vast majority of these generators are double-fed induction generators, which use significant amounts of copper and iron. Geared turbines have achieved a very low cost with a high level of reliability, although they generally require more frequent maintenance because of the higher number of moving parts relative to their direct-drive counterparts.

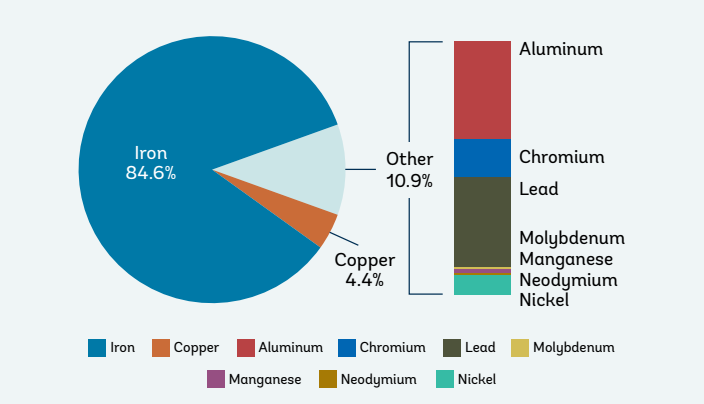
2. **Direct drive wind turbines** feature generators that are fixed directly to the rotor and therefore turn at the same speed. Certain models (for example, those produced by Goldwind) employ a generator with permanent magnets consisting of rare earth minerals such as neodymium and dysprosium. Other models (for example, those produced by Enercon) use an electrically excited rotor utilizing significant amounts of copper. Direct-drive turbines tend to be initially more expensive per megawatt, although this can be offset by lower maintenance during the turbine's operation.

In general terms, geared turbines tend to dominate onshore installations, where maintenance is relatively straightforward. Conversely, direct-drive turbines are preferred in offshore wind applications, where maintenance is much more challenging. The difference in how these subtechnologies are deployed between onshore and offshore wind has implications in how the model derives mineral demand from wind technologies.

The main components of turbines (towers, castings, nacelle, shafts, and so on) are primarily made up of steel. The blades are a composite of fiberglass, resins, balsa wood, and adhesives (some use carbon fiber, although this increases the cost significantly). Modern wind turbines can be anywhere from 150 to 250 meters in height from base to blade tip, nearly the height of the Eiffel Tower. Steel figures have been excluded from the analysis because of potential double counting issues, with minerals included in the analysis such as chromium being used in the steel needed for wind turbines. Steel is primarily manufactured using a mix of iron ore, carbon, and other elements. Other elements also could be used for steel production, including nickel, molybdenum, titanium, manganese, vanadium, or cobalt, depending on the type and quality of steel required for industrial applications.

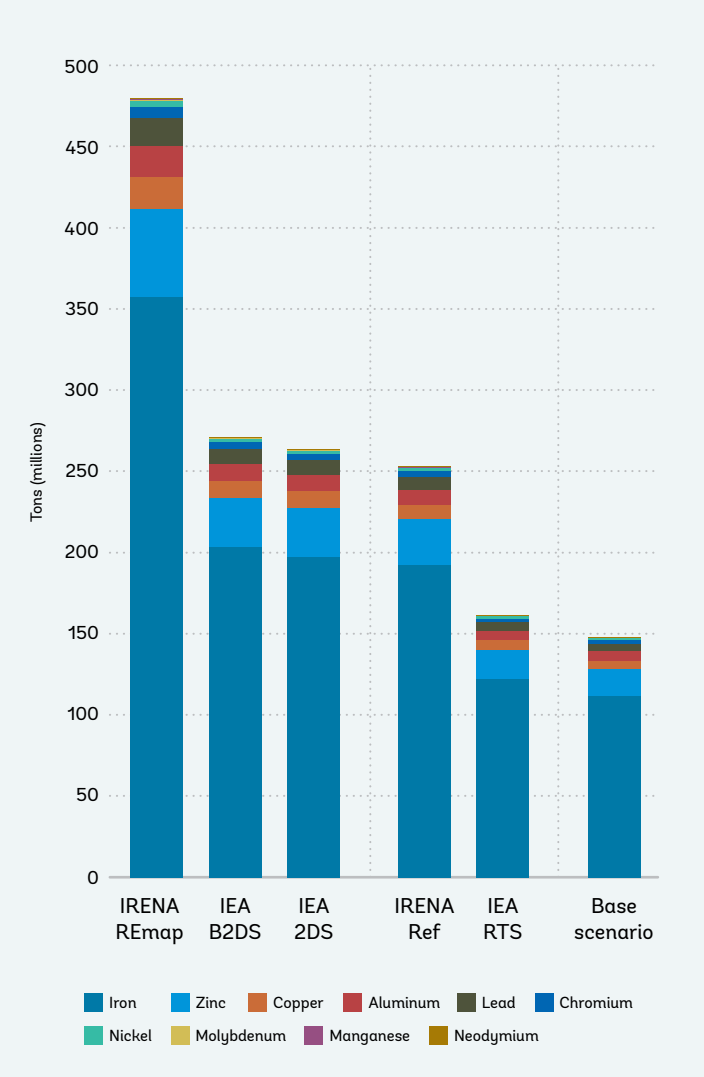
Figure 3.7 shows the major minerals used to supply wind installations through 2050, with iron accounting for 84.6 percent of demand and copper 4.4 percent. Note, the iron reported here is that which is used directly in the turbine, in either the generator core, the mainframe, or the rotor hubs; it does not include the iron needed for the steel components. All other minerals combined represent nearly 11 percent of demand, primarily for the permanent magnets (neodymium), gearboxes (nickel), or cabling (aluminum). Minerals not included in this analysis include dysprosium, which is used in permanent magnet direct-drive turbines.

Figure 3.7 Share of Mineral Demand from Wind Under IEA 2DS Through 2050



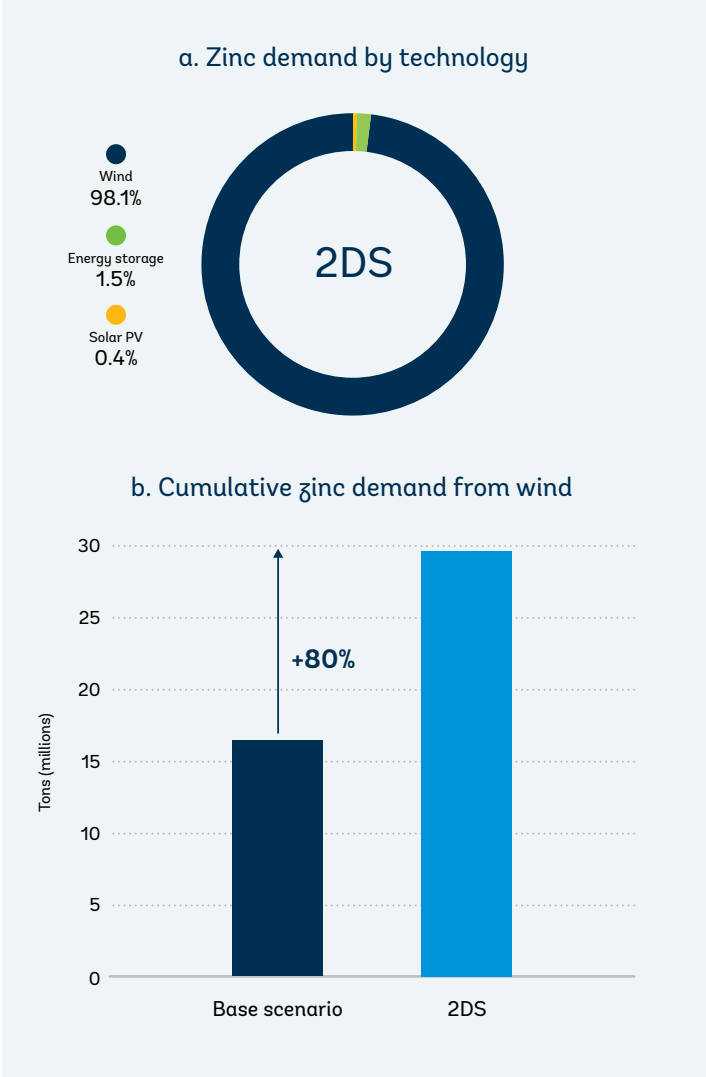
Note: 2DS = 2-degree scenario, IEA = International Energy Agency.

Figure 3.8 Cumulative Demand for Minerals Needed for Wind Through 2050



Note: 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, Ref = reference scenario, REmap = renewable energy roadmap scenario, RTS = reference technology scenario.

Figure 3.9 Total Zinc Demand by Energy Technology Through 2050 (2DS, Base Scenario)



Note: 2DS = 2-degree scenario, PV = photovoltaic.

As seen in figure 3.8, the strongest demand for these minerals come from the IRENA REmap scenario, representing a 78 percent increase from the IEA B2DS, as there is a higher installed capacity of wind in comparison to the IEA scenarios. The slight variations across the minerals across the technology-based mitigation scenarios are due to slightly differing mixes of offshore and onshore wind that have different mineral compositions.

With the exception of zinc, all the minerals used to construct wind turbines are also needed to build other clean energy technologies. As seen in figure 3.9, 98.1 percent of zinc demand from energy technologies comes from the wind industry, as the mineral is predominantly used for protecting wind turbines from corrosion.

Trade-Offs in Wind Subtechnologies

Similar to solar PV, there are trade-offs in mineral demand for wind depending on which subtechnology—geared or direct drive—ends up being the most widely deployed. Currently, the most widely deployed wind technology is geared, as it is often used for onshore wind applications; direct drive is primarily targeted for the deployment of offshore wind, given its lower maintenance requirements. While onshore wind makes up the majority of wind energy deployment across all scenarios, the share of offshore wind is expected to increase with technology improvements and expected falling costs (LCOE).

Neodymium, which is only used in permanent magnet direct-drive turbines, is a key mineral affected by the balance between these technologies. Two alternative scenarios are constructed to highlight how shifts in the balance between geared and direct-drive turbines may affect the demand for neodymium.

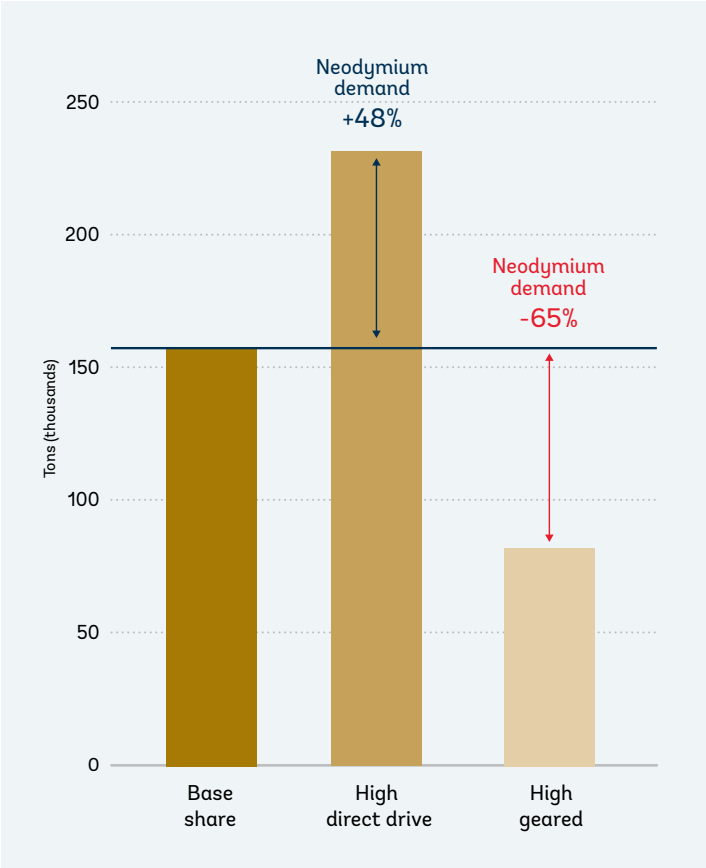
The first scenario has a higher share of direct-drive turbines,[16] rising to 40 percent of onshore turbines and 90 percent of offshore turbines by 2050, compared with 25 percent and 75 percent in the mixed base scenario. The second scenario has higher shares of geared turbines, accounting for 90 percent of onshore turbines and 40 percent of offshore (table 3.3).

The greatest demand for neodymium comes in the high share direct drive scenario (see figure 3.10), with cumulative demand almost 50 percent higher than the base share scenario. In contrast, demand for neodymium in the high share geared scenario is 65 percent lower than the base share scenario.

Table 3.3 Share of Subtechnology Penetration in Wind Market Compared with Base Share

2050 share	Onshore Geared	Onshore Direct drive	Offshore Greared	Offshore Direct drive
Base share (2DS)	75%	25%	25%	75%
High share: **Geared**	**90%**	10%	**40%**	60%
High share: **Direct drive**	60%	**40%**	10%	**90%**

Figure 3.10 Cumulative Demand for Neodymium from Wind Subtechnologies Compared to Base Share Under 2DS Through 2050



Note: 2DS = 2-degree scenario.

16 It should be noted that not all direct-drive turbines use permanent magnets and thus demand neodymium. Data on the neodymium concentration in direct-drive turbines are drawn from a number of sources in the literature and a central point was used. The substitution between different direct-drive turbines is a scale of resolution beyond the scope of the model.

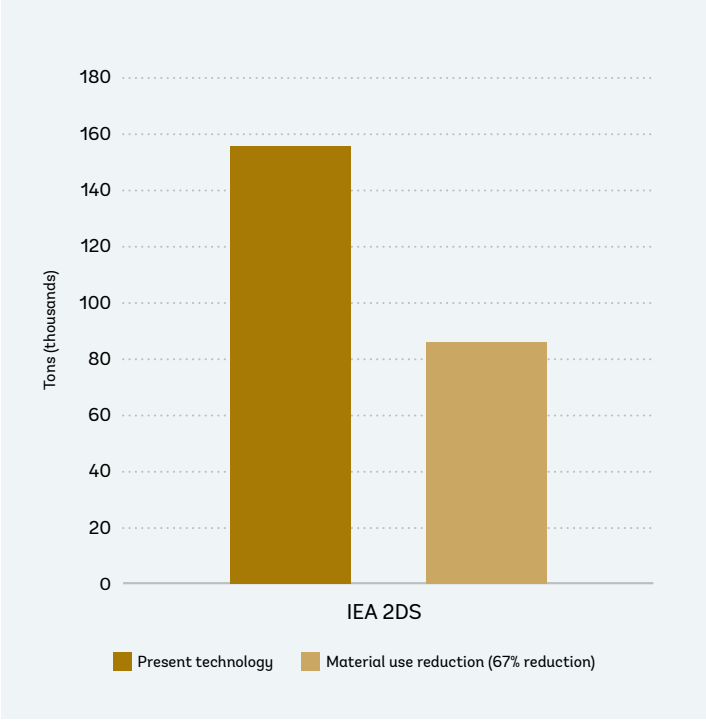


Material Use Improvements in Wind Turbines

Material improvements in direct-drive onshore and offshore wind turbines could lead to potential efficiency gains in the use of neodymium in the turbines. Such improvements could include (1) the decreased use of permanent magnets through alternative designs (for example, air core axial flux), and/or (2) the increased use of hybrid turbines using a medium-speed gearbox and permanent magnet generator.

To estimate the efficiency gains from the reduction of materials in wind turbines, a 67 percent mineral reduction is assumed through 2050 under a 2DS, a figure derived from the lowest figure for neodymium use in direct-drive turbines in the literature. As noted in figure 3.11, if material improvements were to take place, cumulative demand of neodymium would fall by 45 percent, compared with the present mineral composition of current wind technology.

Figure 3.11 Cumulative Demand for Neodymium from Wind Technologies Under Present Technology and Material Use Reduction Under 2DS Through 2050



Note: 2DS = 2-degree scenario, IEA = International Energy Agency.



Geothermal

Geothermal energy currently accounts for less than 1 percent of global electricity generation capacity (IEA 2019c) and is actively being used in more than 20 countries;[17] the United States is the world's largest producer, at about 2.5 GW in 2018.[18] Geothermal energy can be used for electricity generation, direct or indirect use, or co-generation. There are limitations with the use of geothermal energy since electricity can only be generated in locations with high or medium temperatures, typically close to tectonically active regions.[19] Countries such as Indonesia, Iceland, the Philippines, and New Zealand—countries in tectonically active regions—actively use geothermal to meet their electricity needs. Indonesia recently announced a plan to build 7.2 GW of geothermal by 2025 given its comparative advantage in this resource to meet its growing energy demand.[20]

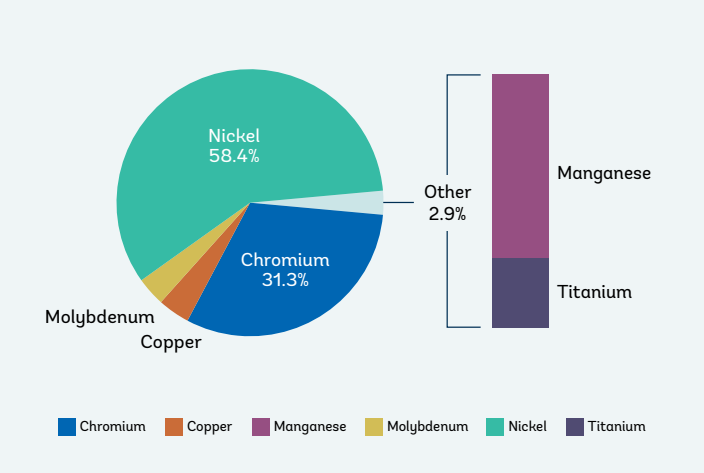
Geothermal generates electricity from thermal energy located below the earth's surface, whether in liquid, trapped steam, or rock. Therefore, geothermal requires a very high level of quality steel to be able to carry reservoirs of steam and hot water for electricity generation. Corrosion-resistant alloys, for example, are needed in the geothermal plants, requiring minerals such as titanium and molybdenum. The demand for these minerals from specific geothermal plants will vary from location to location based on the number and depth of wells needed to access the thermal energy.[21]

Geothermal uses relatively more steel than wind, approximately 6–10 times as much per megawatt of capacity. Unlike wind—which also requires a large amount of steel, primarily manufactured from a mix of nickel and iron ore—geothermal requires steel alloys with a large quantity of titanium to cope with the high heat and pressure in geothermal power generation. Literature on geothermal production is more limited than for wind and solar PV, and given that a large share of mineral demand for the technology comes from the use of elements to create various alloys of steel, steel has, again, been excluded from this analysis to avoid double-counting.

Figure 3.12 shows the major minerals required for supplying geothermal through 2050. In addition to being used in wind, chromium represents a key mineral for geothermal technologies, with 36 percent of its demand from all energy technologies going toward geothermal.

The highest capacity of geothermal is found in the REmap and B2DS scenarios, with overall mineral demand of relevant minerals increasing by 78 percent and 71 percent from the Ref and RTS scenarios, respectively (figure 3.13).

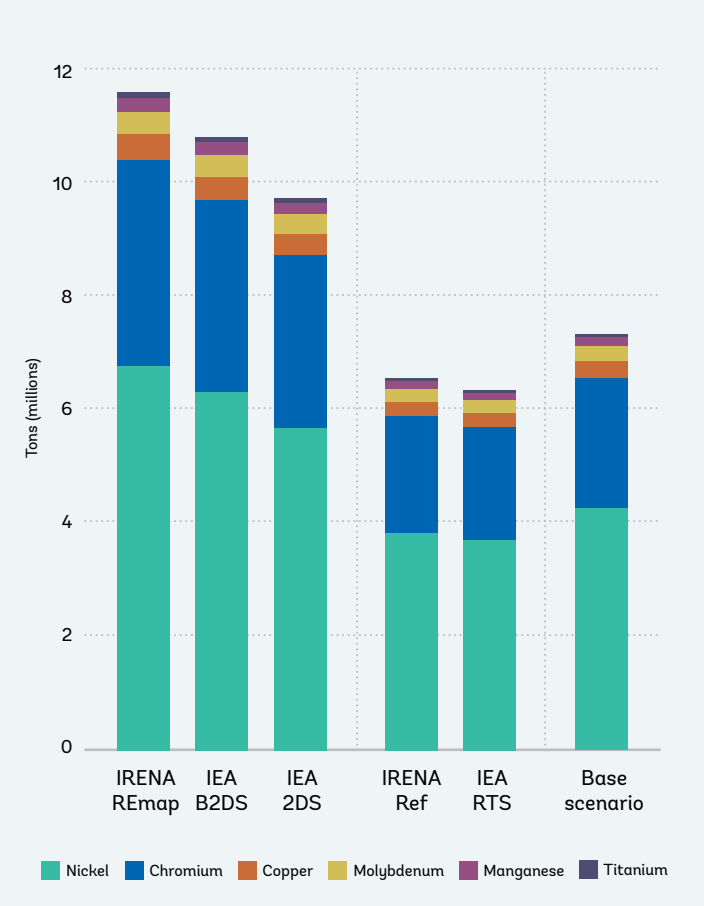
Figure 3.12 Share of Mineral Demand from Geothermal Under 2DS Through 2050



Note: 2DS = 2-degree scenario.

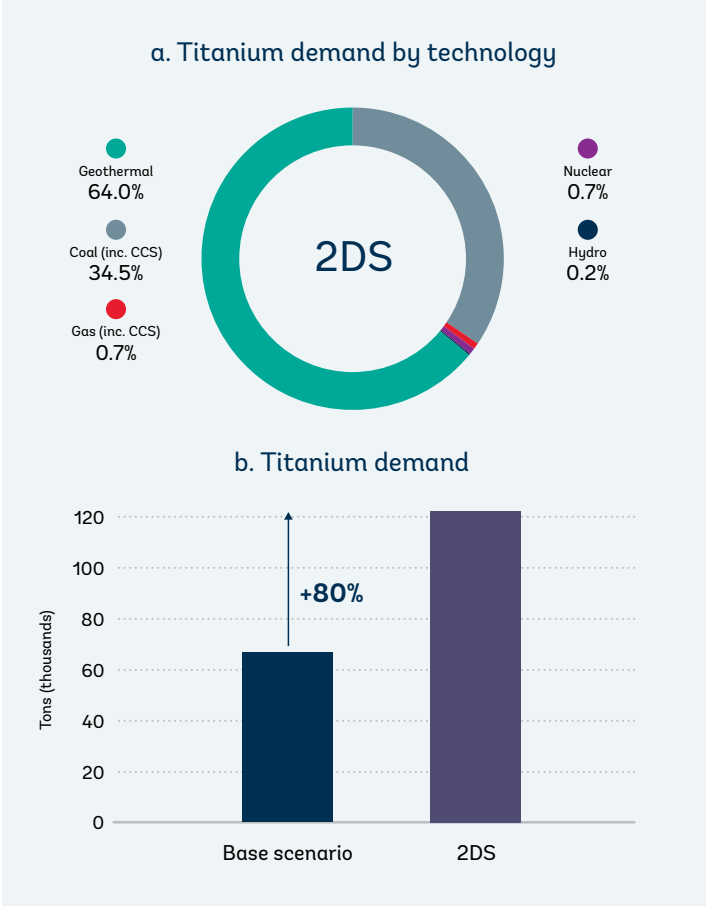
17 "Geothermal Energy," National Geographic, https://www.nationalgeographic.com/environment/global-warming/geothermal-energy/.
18 "Geothermal Energy," International Renewable Energy Agency, https://www.irena.org/geothermal.
19 Ibid.
20 "Indonesia Needs $15 Billion Investment to Meet Geothermal Target by 2025," Reuters, August 13, 2019, https://www.reuters.com/article/us-indonesia-geothermal/indonesia-needs-15-billion-investment-to-meet-geothermal-target-by-2025-idUSKCN1V30R0.
21 Data used in the model is an average of three plants—a 50 MW facility with 25 wells at depth of 5 kilometers; a 10 MW facility with 5 wells 1.5 kilometers deep, and 48.4 MW facility with 22 wells 2.5 kilometers deep—and covers both plant facilities and well pipes (Moss et al. 2013).

Figure 3.13 Cumulative Demand for Minerals Needed for Geothermal Through 2050



Note: 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, Ref = reference scenario, REmap =renewable energy roadmap scenario, RTS = reference technology scenario.

Figure 3.14 Total Titanium Demand by Energy Technology Through 2050 (2DS, Base Scenario)



Note: 2DS = 2-degree scenario, CCS = carbon capture and storage.

Contrary to solar PV and wind mineral demand trends, figure 3.13 illustrates that the overall demand for geothermal minerals in the base scenario is slightly higher than in both the RTS and Ref scenarios because of different assumptions around geothermal deployment up to 2050. In the base scenario, a higher share of geothermal capacity is expected. This reflects changes in assumptions about the projected costs of geothermal energy over time, relative to other renewable technologies. Because the costs of solar PV and wind have plummeted in recent years, these technologies are now seen as more attractive over other renewable technologies. Therefore, the most up-to-date projections from IRENA and the IEA now project lower levels of geothermal capacity than the slightly older IEA data from which the base scenario is drawn.

Titanium is one of the relevant minerals that are affected by the assumptions around both geothermal and coal and CCS deployment. As seen in figure 3.14, under a 2DS, geothermal accounts for 64 percent of titanium demand, while coal and CCS account for 34.5 percent. With titanium being heavily used in both technologies, its demand will grow regardless of whether the world moves toward a more fossil fuel intensive or lower-carbon energy pathway.





Concentrated Solar Power

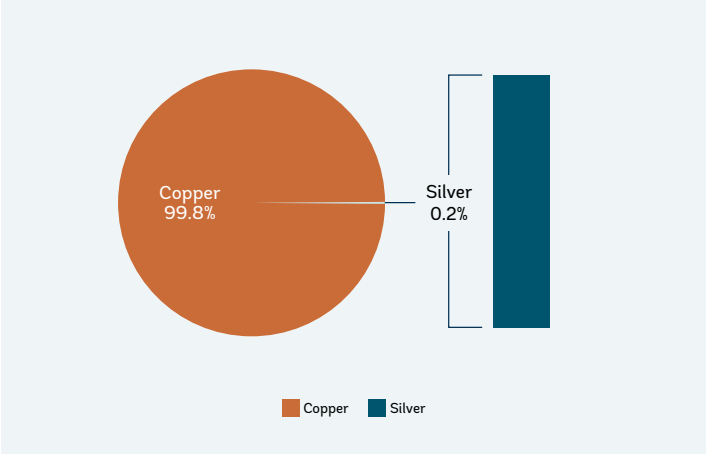
Concentrated solar power (CSP) produces electricity by concentrating the sun's heat using mirrors to heat water and drive steam turbines. A variety of CSP plant sizes exist, ranging from 1 MW to 400 MW. One of the main advantages of CSP, compared with solar PV, is that it can be equipped with molten salts to store heat, which can then be released in the evening, making it an ideal renewable energy source for large-scale applications. Despite its advantages, CSP only accounted for 5.5 GW of installed capacity globally in 2018, compared with 480 GW of solar PV,[22] because of its high costs relative to other renewables and geographic constraints. CSP can only be deployed in locations with excellent direct normal irradiation, which is typically found in desert regions, so currently CSP is most found in countries such as Chile, Spain, and the United States.

Regions such as North Africa and the Middle East are expected to take the lead in developing their CSP capacity, even though CSP deployment will remain small relative to solar PV and wind. There is potential for the technology to be further scaled up given continued falling prices and technological improvements. Growth rates may still be large; the IEA's *World Energy Outlook 2019* projects growth in Africa-deployed CSP at more than 900 percent by 2040. This growth is most likely to occur in developing countries, with the IEA projecting that, under the 2DS, almost 80 percent of all CSP installed capacity will be in non-OECD countries by 2050. CSP's storage capacity also makes it an attractive renewable source for developing countries endowed with high direct normal irradiation.

Given the niche aspect of the technology, there are considerable fewer studies on the material inputs required for CSP systems. Bulk materials such as glass, steel, and aluminum are needed for the support structures for the mirrors, but no data were available in the literature for these materials, or the minerals identified were outside the model. Data were available, however, for the use of copper (for wiring, pumps, electric motors, and the generator) and silver (used for coating the glass for the mirrors). Various types of CSP plants are emerging—including parabolic trough systems, linear fresnel systems, and central receivers—with each using varying amounts of silver. There was insufficient data on both installed capacity and material composition to model these types separately, but the model does capture variations in silver demand from the various types.

Figure 3.15 shows the balance between copper and silver for which data were available under a 2DS, with copper representing a much greater share of modeled demand because of its wider spread use across CSP facilities.

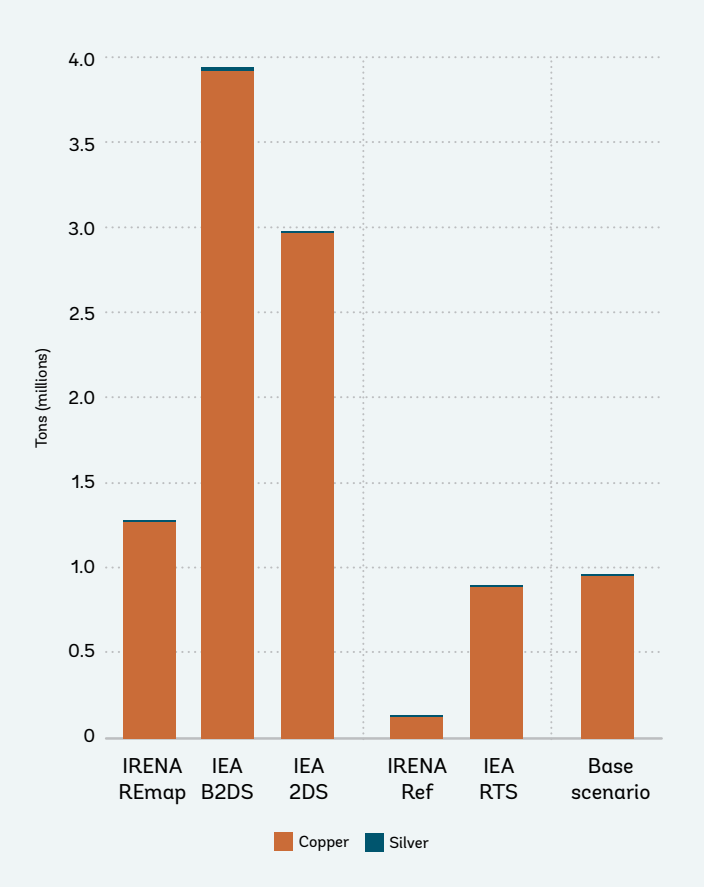
Figure 3.15 Share of Mineral Demand from Concentrated Solar Power Under IEA 2DS Through 2050



Note: 2DS = 2-degree scenario, IEA = International Energy Agency.

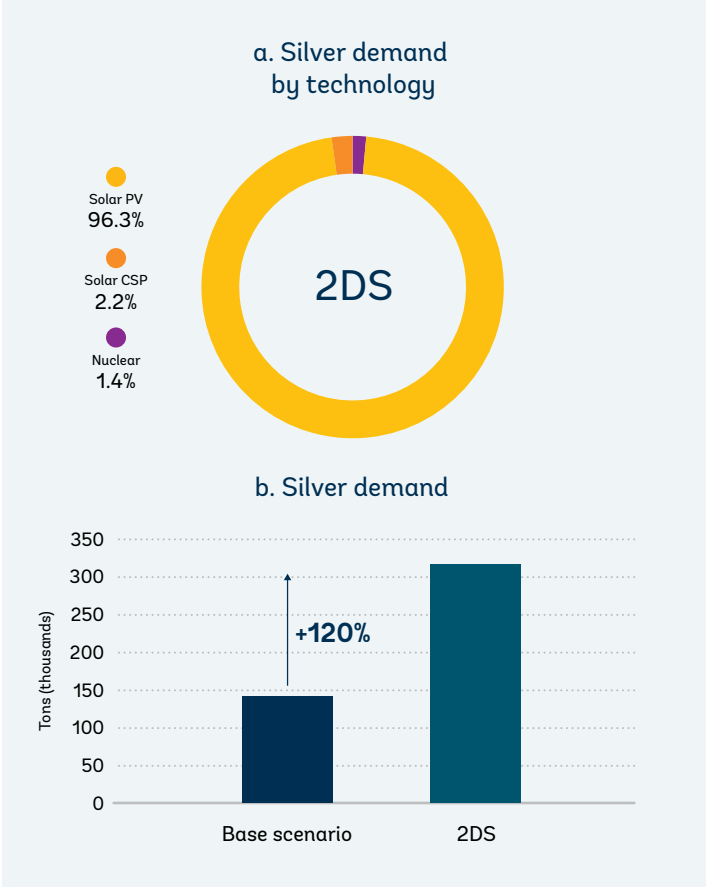
22 "Solar Energy," IRENA, https://www.irena.org/solar.

Figure 3.16 Cumulative Demand for Minerals Needed for Concentrated Solar Power Through 2050



Note: 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, Ref = reference scenario, REmap = renewable energy roadmap scenario, RTS = reference technology scenario.

Figure 3.17 Total Silver Demand by Technology Through 2050 (2DS, Base Scenario)



Note: 2DS = 2-degree scenario, CSP = concentrated solar power, PV = photovoltaic.

Mineral demand is strongest in the B2DS, as seen in figure 3.16, where it is expected that CSP capacity will be the highest. Both of the IRENA scenarios, Ref and REmap, are bearish on CSP's share in the global electricity mix through 2050, explaining the lower demand for copper and silver. This reflects different assumptions on the projected costs of the technology against other renewable technologies, such as solar PV. The base scenario also projects a higher share of CSP than the later RTS one, reflecting changing beliefs on the balance between CSP and solar PV, with cost reductions in the latter causing it to be projected as an even greater share of renewable capacity compared with CSP in the more recent IEA projections.

While the projected figures for both copper and silver appear to grow dramatically in the more ambitious scenarios, they pale in comparison to the minerals' use in solar PV. For example, figure 3.17 shows the demand for silver by technology through 2050 under a 2DS. The vast majority of demand for silver, at 96.3 percent, is linked to solar PV growth, predominantly from solar PV's subtechnology, crystal Si, with only 2.2 percent of silver demand linked to CSP and 1.4 percent to nuclear. Under a 2DS, demand for silver is expected to double, growing from 1.4 thousand tons in 2017 to nearly 3.2 thousand tons in 2050.





Energy Storage

Energy storage technology stores electricity when it is generated and can then later dispatch it as needed.[23] It is a very important technology for renewable energy, particularly for variable ones such as solar PV and wind, which are nondispatchable, as electricity is only generated when the sun is shining or when the wind is blowing. Energy storage can provide a solution and act as an ancillary service for these specific technologies by storing electricity in a battery and then releasing it during peak hours, usually in the evening. Given this high potential, the World Bank launched the Energy Storage Program to scale up 17.5 GWh of battery storage by 2025 in developing countries.[24]

While energy storage can play a major role in stabilizing the grid from variable renewable energy, its costs are still too high for it to be deployed more widely. Relative to solar PV and wind technologies that have an average LCOE of 0.05/kWh, battery storage has LCOE costs averaging 250/kWh, making it too expensive for most applications today. Despite the high costs, the increased use of batteries in electric vehicles has been the primary reason why battery costs have fallen quickly, from 288/kWh in 2016 to 157/kWh today, representing a 46 percent decrease in price.

Energy storage is crucial for the low-carbon transition for two main reasons: (1) It is used to power electric vehicles, and (2) it is needed to store power from intermittent electricity generation from solar PV and wind farms, including grid and decentralized operations. Both applications of energy storage are included in the model from the IEA's technology-based mitigation scenarios since data on energy storage were not available for the IRENA and base scenarios. Battery electric vehicles are expected to account for approximately 90 percent of deployments in the IEA scenarios, with stationary and decentralized applications making up the other 10 percent; the mineral demand follows this sectorial split.

Mobile Energy Storage

The energy storage landscape for automobiles (and other wheeled ground vehicles, including buses, vans, and trucks) is changing very rapidly. All vehicles today have some battery energy storage, almost always a lead-acid battery, to help start the engine and to power vehicle electronics. There are two primary batteries used in the automotive sector and covered in this analysis:

- **Lead-acid batteries** have dominated the early stages of electric vehicle operation because they are a mature technology and are inexpensive, but they are limited by their weight and their range. They are being gradually replaced by Li-ion batteries, initially developed for use in laptops and other electronics.
- **Li-ion batteries** offer a much higher energy density than previous generations of batteries, meaning more energy can be stored for the weight of battery. They also require less maintenance and offer a range of flexibility since they can be manufactured with a variety of different minerals, and are tailored for different functions. They do, however, come at a higher cost, require protective circuits, and are a potential fire risk.

The model assumes that initially a mix of lead-acid and Li-ion batteries are used in electric vehicles, with Li-ion quickly taking over the entire market.

Stationary Energy Storage

Stationary energy storage has different desirable features from the use of batteries in electric vehicles. Weight, for example, is less of a concern, and different applications of stationary storage have different needs. Some batteries need a lot of power to be stored for short durations, whereas others need less power but a longer storage time. Different batteries may therefore play a role in mineral demand:

- **Li-ion batteries** are the dominant technology at the moment in stationary energy storage, although lead-acid batteries still play a small role in some applications.

23 In this section, energy storage refers to battery technologies specifically, not other forms of energy storage, such as pumped hydroelectricity, nor thermal storage (such as the molten salts used in CSP). Batteries are also a crucial component of electric vehicles, vital for storing and carrying the electricity needed to run the motors of these vehicles.

24 For more information, see the World Bank's Energy Sector Management Assistance Program's "Energy Storage Program" webpage: https://www.esmap.org/energystorage.

- **Redox flow batteries** are an emerging technology in stationary energy storage. They are heavy and large, and thus unsuitable for vehicles, but they can be built with extremely large capacities (up to 200 MW, compared with 100 MW for Li-ion) and have a long life span.

In the model, Li-ion batteries provide the largest amount of stationary storage, with a declining role for lead-acid batteries and an emerging role for vanadium-based redox flow batteries.

Battery Technology Post-2030

The battery space is emerging rapidly, and many new options are under development. This uncertainty is much greater post-2030 owing to the huge scale of innovation and experimentation occurring in the sector. The assumption that Li-ion batteries dominate both the mobile and stationary market for the next decade is conservative. Post-2030, the scale of uncertainty is much greater, with a wide range of options in both markets.

Within mobile storage, options such as solid-state Li-ion batteries could enter the market. However, the automotive market itself could pivot, with hydrogen fuel cell vehicles entering the market at scale. Within the stationary space, there will be increasing demand for longer-duration batteries. Some of this demand could be met by vanadium redox flow batteries, but other options are also emerging rapidly, including iron-based flow batteries, thermal-electric options that involve storing energy as heat in a variety of different media from molten salts (also used in CSP to store energy) or rocks. There is even concrete and mechanical storage, which stores energy as mechanical energy and discharges it by dropping weights.[25]

Predicting which, if any, of these technologies emerges to commercial scale is impossible, but each could affect the demand for minerals generally, and especially the minerals used heavily in the types of stationary storage assumed in the model, such as lithium, cobalt, nickel, manganese, and vanadium. The impacts of some of these technologies are discussed in the Emerging Energy Technologies section later in this chapter.

Battery Composition

Batteries generally have three main elements: a cathode, an anode, and an electrolyte that sits between the two materials to enable electricity to be collected and discharged at different times. The minerals used for these elements differs between and within battery technologies.

Redox flow batteries differ in that they operate by pumping a liquid electrolyte (usually sulfuric acid, mixed with vanadium salts—in vanadium redox flow batteries), through a core consisting of a positive and negative electrode, separated by a membrane.[26]

Examples of the different types of batteries covered in the model are given in table 3.4.

As the climate scenarios become more ambitious, 12 of the 17 minerals in this analysis show much larger increases in demand because of their use in energy storage, particularly those minerals used in Li-ion batteries (figure 3.19). Lead, vanadium, and iron show smaller increases: They are not used in Li-ion batteries, but rather in lead-acid or redox flow batteries, whose deployment do not vary as significantly across the 2DS and B2DS.

Figure 3.18 Li-ion Battery

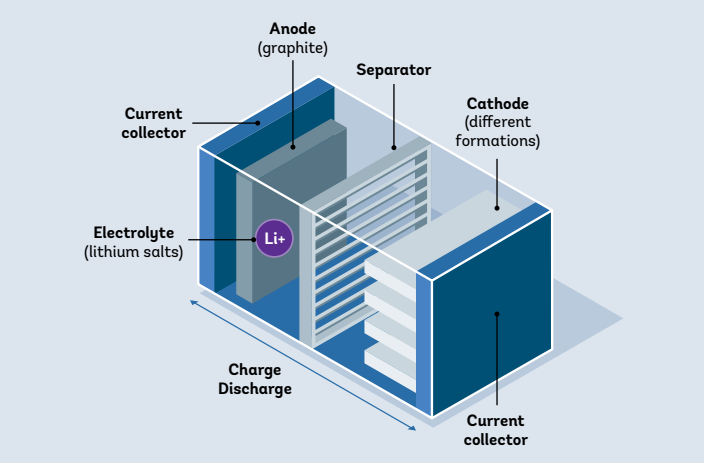


Illustration adapted from the World Bank's Minerals for Climate Action Infographic, https://www.worldbank.org/en/news/infographic/2019/02/26/climate-smart-mining.

25 One example of mechanical storage includes a technology that uses abandoned mine shafts. Energy is stored by lifting weights to the top of the shaft and discharged by dropping the weights to the bottom of the shaft.
26 A number of different chemistries are possible, but batteries using vanadium are the most mature and thus are the main type of redox flow battery included in the model.

Table 3.4 Batteries and Their Subtechnologies Covered in the Ref, 2DS, and B2DS

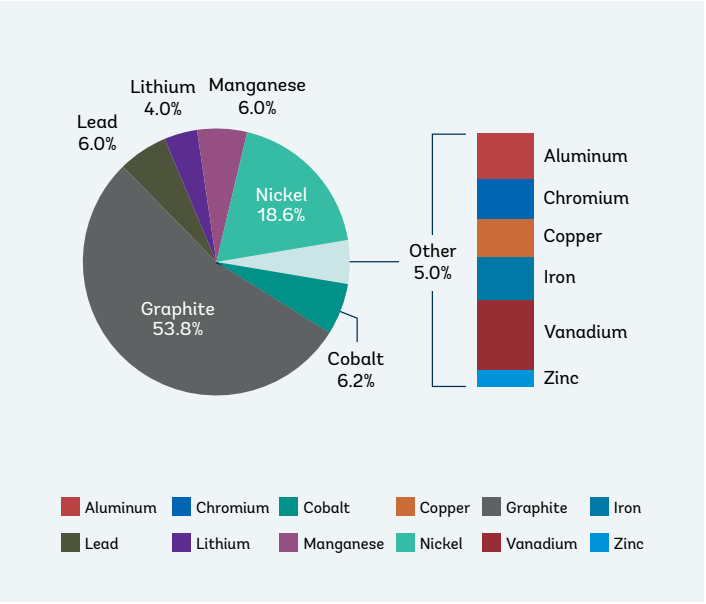
	Cathode	Anode	Electrolyte	Uses
Lithium-ion	Various: • Nickel manganese cobalt **(NMC)** oxide • Nickel manganese cobalt **(NMC)** oxide • Nickel cobalt aluminum **(NCA)** oxide • Lithium cobalt oxide **(LCO)** • Lithium manganese oxide **(LMO)** • Lithium iron phosphate **(LFP)**	Graphite	Lithium salt	• Electric vehicles, stationary storage, medical devices, e-bikes • Electric vehicles, stationary storage, medical devices, e-bikes • Portable electronics • Power tools, medical devices • Electric vehicles, electric buses, stationary storage
Lead-acid	Lead-dioxide	Lead	Sulfuric acid	Vehicles, backup power systems, stationary storage
Redox flow	n.a.	n.a.	Vanadium-based	Stationary storage

Note: 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, n.a. = not applicable, Ref = reference scenario.

While cobalt and lithium are probably best known for being used in energy storage, batteries generally use a wide variety of minerals for the cathode, as covered in figure 3.19, including aluminum, lead, and manganese. Graphite, used for the anode, accounts for nearly 53.8 percent of mineral demand. Nickel, needed for cathode production in NMC (nickel manganese cobalt oxide) and NCA (nickel cobalt aluminum oxide) batteries, accounts for the second highest level of demand, at 18.6 percent. Cobalt, another battery mineral, is expected to account for 6.2 percent of total demand up to 2050 under a 2DS. Lithium, accounting for 4 percent of total demand, is used across all Li-ion batteries, regardless of the cathode composition.

It should be noted that this analysis does not take into account the implications of mineral supply to achieve a low-carbon future, but for demand for energy storage minerals specifically. Supply has been minimally highlighted owing to the fact that some battery minerals, namely cobalt and graphite, are primarily (more than 50 percent) produced in one country, albeit not the same one.[27]

Figure 3.19 Share of Mineral Demand from Energy Storage Under IEA 2DS Through 2050



Note: 2DS = 2-degree scenario, IEA = International Energy Agency.

27 China produces nearly 70 percent of the world's natural graphite, while the Democratic Republic of Congo produces more than 60 percent of the world's cobalt (EC 2018)

Compared to the IEA RTS, mineral demand increases by 107 percent in the B2DS because of the large-scale deployment of battery electric vehicles (figure 3.20). The uncertainty regarding battery storage deployment is high, particularly as battery storage technologies are expected to be in greatest demand post-2030. Still, the storyline remains the same as that for energy generation technologies: Greater climate ambition leads to greater overall mineral demand. However, as demand levels grow, the types of technology that might meet that demand become uncertain, as more space is available for new battery technologies, with different mineral requirements, to enter the market.

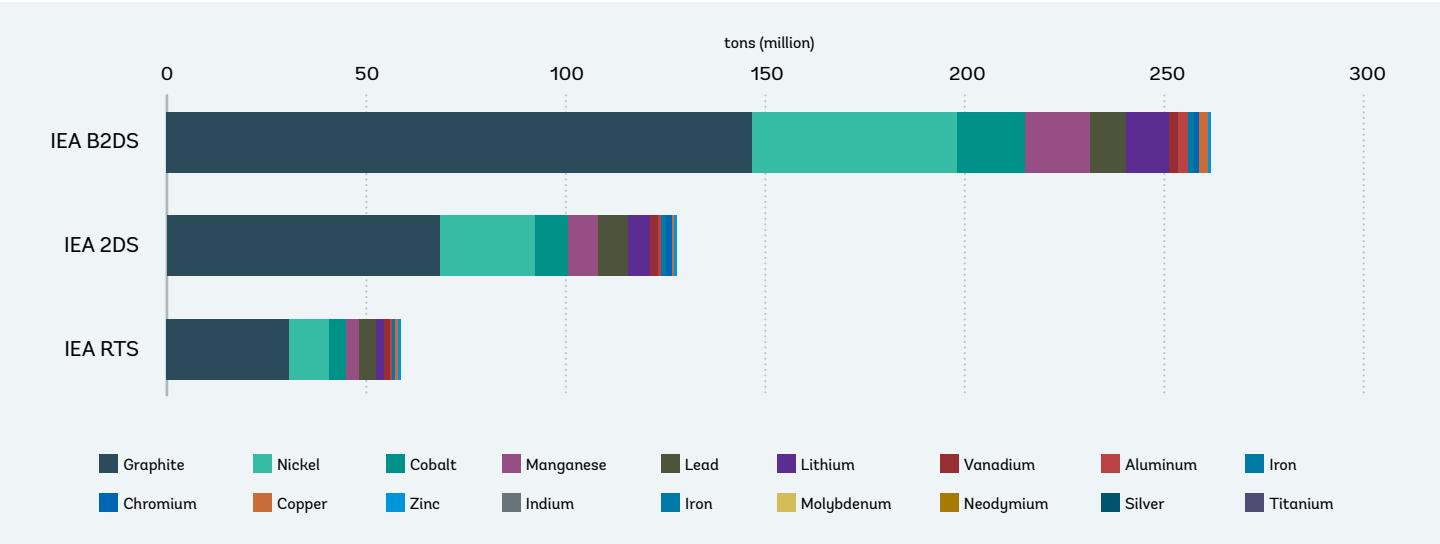
The only use of both graphite and lithium in energy technologies included in the model is linked to energy storage in Li-ion batteries for the anode and electrolyte, respectively.[28] As these two minerals are not used in other energy technologies, their overall demand cannot be compared to other technologies.

Trade-Offs in Battery Subtechnologies

Within some battery technologies, trade-offs exist between component minerals, and thus the choice of subtechnology or even specific types of subtechnology can have implications for the demand for not just one mineral, but a grouping of minerals. With battery manufacturers concerned about mineral supply chains, especially for cobalt, the battery industry has been spearheading efforts to reduce the amount of cobalt needed in batteries, to reduce supply chain risks, while maintaining the efficiency level in battery technology. Mainstream media and nongovernment organizations reporting on the labor and environmental issues surrounding cobalt extraction have put pressure on downstream companies to become more responsible in where and how they source cobalt for battery technologies.

With the battery sector changing the most rapidly among all technologies, being able to forecast which subtechnology will be the most used up to 2050 is nearly impossible. The scarcity of available data on, for example, the different shares of the different battery chemistries in the Li-ion market, both now and in the

Figure 3.20 Cumulative Demand for Minerals Needed for Energy Storage Through 2050



Note: Demand in the 4DS scenario is not presented because energy storage is not modeled in that scenario. 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, RTS = reference technology scenario.

28 Graphite has some niche uses in other energy technologies, such as the use of carbon brushes in the motors of wind turbines, but no data were available for these uses and their scale is likely to be very small compared with the use of graphite in battery technologies.

future, has been a challenge. In the model, data have been drawn from across the various chemistries, and, using the methodology described above, have modeled the "average" Li-ion battery. However, to illustrate how changes in the types of Li-ion battery that may dominate the future market may impact mineral demand, two illustrative scenarios have been developed.

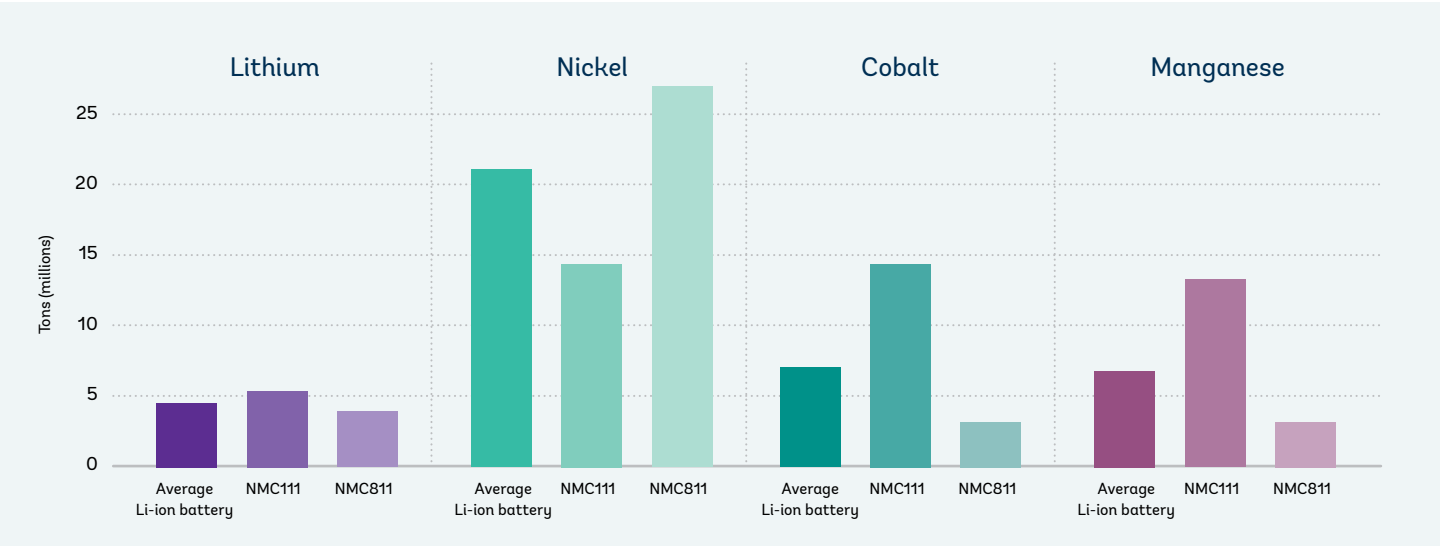
In the battery sector, the Li-ion battery compositions are described by their mineral content ratio. In a NMC811 design, for example, the 8, 1, and 1 represent the nickel (80 percent), manganese (10 percent), and cobalt (10 percent), respectively, used in the cathode, while in the NMC111 design, nickel, manganese, and cobalt are used in equal proportions. The latter has been the main chemistry used in NMC batteries to date, but there is increasing interest in the new NMC811 design, which is potentially cheaper, lighter, and offers longer range to electric vehicles—along with reducing the amount of cobalt required.

To demonstrate the impact of shifts in demand within the Li-ion battery market, two alternative scenarios are compared to the "average" Li-ion battery, which is the base in the model (see figure 3.21). In the first scenario, every Li-ion battery is assumed to be an NMC811, while in the second one, all batteries are assumed to be an NMC111.[29]

Lithium demand varies by almost 20 percent from the base share depending on the battery choice. Figure 3.21 shows that the higher levels of lithium demand with NMC111 are also associated with much greater levels of cobalt and manganese demand, approximately 100 percent more than the base share. However, with NMC111, nickel demand is much lower, over 35 percent lower.

There a clear trade-off between nickel, cobalt, and manganese (and to a lesser extent lithium), depending on which battery subtechnology emerges. Shortages (and thus higher prices) of minerals such as cobalt could incentivize shifts to different Li-ion battery types—either NMC811 or non-cobalt types like lithium-iron phosphate. On the other hand, shortages in lithium could shift battery types to NMC811, increasing the demand for nickel.

Figure 3.21 Cumulative Demand for Minerals from Li-ion Battery Scenarios Under 2DS Through 2050



Note: 2DS = 2-degree scenario, Li-ion = lithium-ion.

29 These are extreme scenarios, but they demonstrate potential directions and scales of impact on demand for particular minerals.

Material Use Improvements in Li-ion Batteries

Many of the technologies needed for a low-carbon future are being deployed rapidly while cost-reductions are occurring.[30] These cost reductions stem from many sources, including decreasing concentration of minerals such as cobalt. In 2018, the minerals needed to build cathodes and anodes (battery cell) accounted for approximately 70 percent of the total cost of a battery (Goldie-Scot 2019).

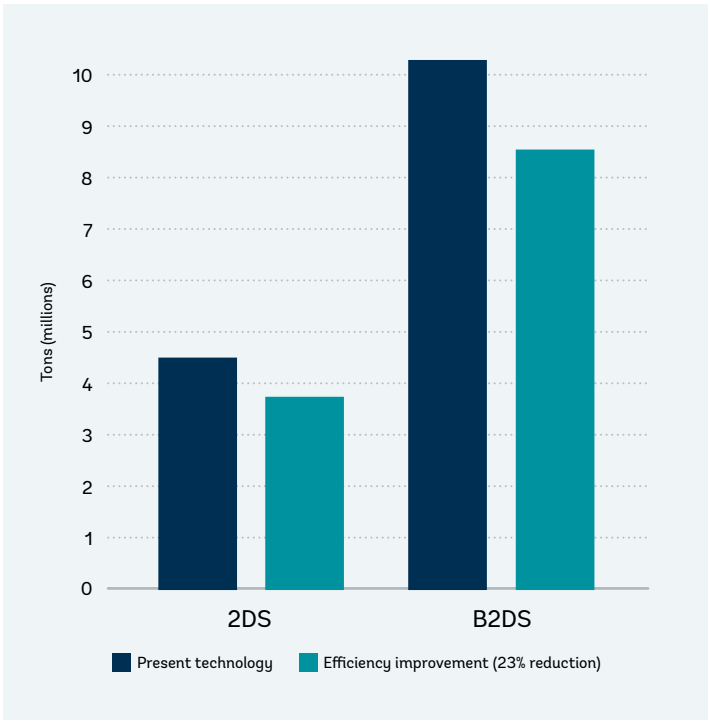
Although not all technologies show a clear pattern of reduction (depending on how subtechnology choice is assumed to occur), there are patterns of change. For example, various sources in the literature show a reduction in the estimated composition of lithium in Li-ion batteries over recent years.[31] In 2016 Teske et al. estimated a composition of 0.24 tons per megawatt-hour for a Li-ion (NCA) battery. By 2018, the IEA estimated a composition of 0.1 tons per megawatt-hour for a similar battery (IEA 2018).

To capture this effect, the model was extended using the assumption that all Li-ion batteries would keep improving their use of lithium, with all batteries moving to the most efficient type seen in the literature today. This shift led to a 23 percent reduction in the use of lithium in Li-ion batteries by 2050. Figure 3.22 shows the effect of these material improvements in Li-ion batteries on the demand for lithium under a 2DS and B2DS. The impact of this result would reduce the demand for lithium by between 16 and 17 percent, with the largest absolute difference seen under a B2DS.

Improvements in the energy density of Li-ion batteries, such as the amount of energy batteries can store per kilogram, as well as their cycle life, how many times a battery can be charged and discharged before its capacity starts to fall below 80 percent of its original capacity, will also have important implications for demand for minerals such as lithium, graphite, and cobalt. Should density and cycle life increase sharply, then the demand for new batteries and the minerals they require will fall.



Figure 3.22 Cumulative Demand for Lithium from Energy Storage Under Present Technology and Material Use Reduction Through 2050 Under 2DS, B2DS



Note: 2DS = 2-degree scenario, B2DS = beyond 2-degree scenario.

30 See, for example, figure 5.1 of IEA's 2018 report *Global Electric Vehicle Outlook*.
31 See, for example, Teske et al. (2016) and IEA (2018).

Emerging Energy Technologies

This section discusses the various emerging technologies that are considered potential game changers in the transformation of the energy system globally. Other than carbon capture and storage, these specific technologies have not been included in the model to estimate demand across the 17 minerals analyzed in the model, but they are included here because their potential commercialization in the near term could have implications on overall mineral demand. This analysis remains technology agnostic with regard to which energy technology could become more prominent to achieve a low-carbon future, but as the emerging technologies are also mineral intensive, they are addressed in the report.

Carbon Capture Storage

Carbon capture and storage (CCS) is one of the key technologies that is expected to be deployed under the IEA scenarios, albeit with great uncertainty, and it has been partially captured in the model. However, it has been included in the Emerging Energy Technologies section because the technology is still at relatively early stages of development compared to solar PV, wind, geothermal, CSP, and energy storage.

CCS involves the capture of CO_2 from three sources:

- Combustion of coal and gas
- Transportation of the CO_2 from source site to long-term storage
- Long-term storage of the CO_2

Figure 3.23 Carbon Capture Storage

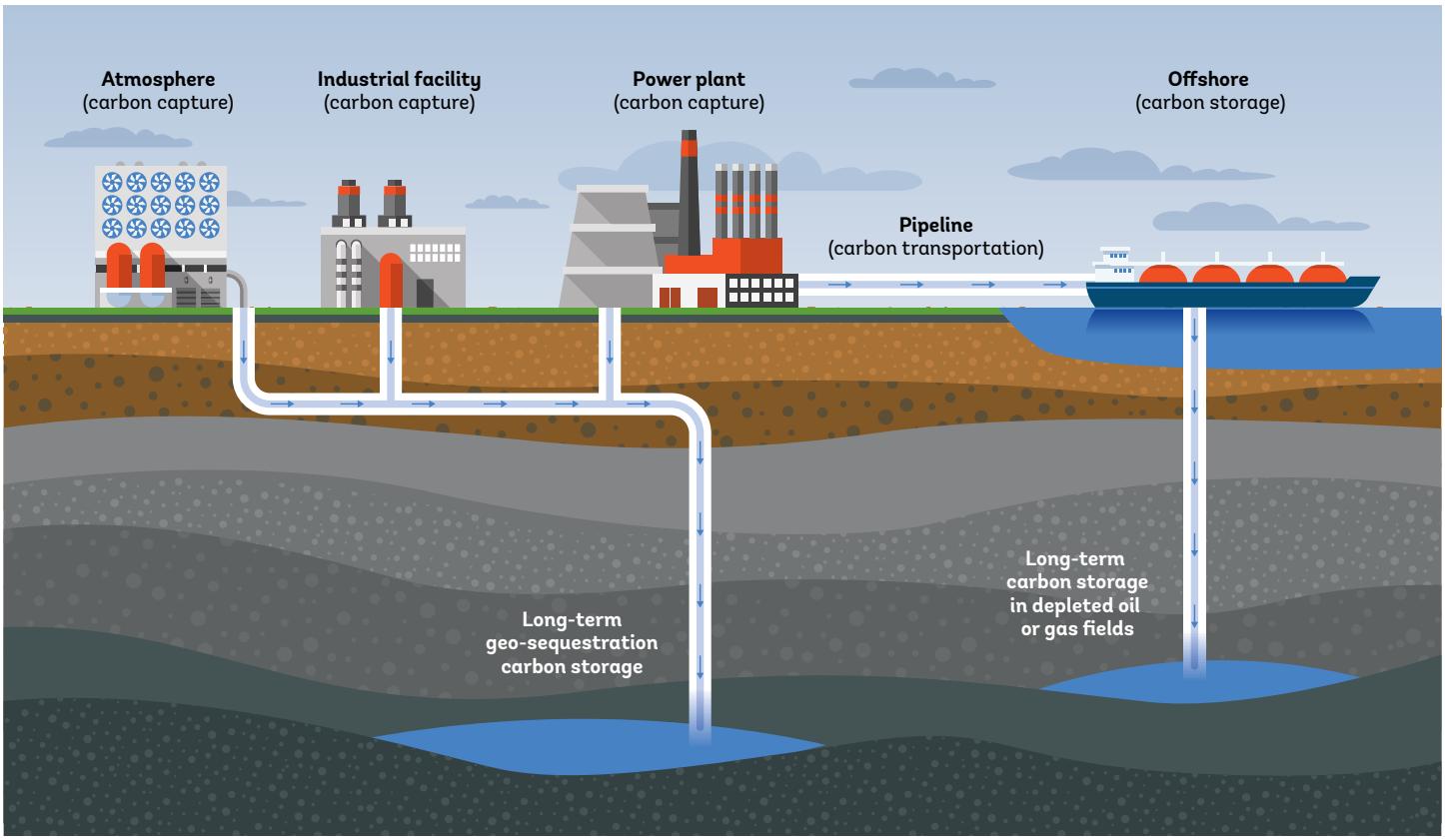


Illustration adapted from various sources (for example, Shell Sustainability Report 2016, https://reports.shell.com/sustainability-report/2016/energy-transition/our-work-to-address-climate-change/carbon-capture-and-storage.html; Carbon Capture and Storage Association, http://www.ccsassociation.org/what-is-ccs/).

Widespread commercial-scale CCS has yet to emerge and there is great uncertainty over how large a role it will play in the future. CCS's role in technology-based mitigation scenarios varies widely. The IEA sees an increasing role for the technology in the 2DS and B2DS scenarios; it projects that under the 2DS, 350 GW of coal plants with CCS attached will be in operation, representing 74 percent of all coal facilities. IRENA, on the other hand, sees the technology differently and does not include CCS in their scenarios.

Crucial to the scale at which CCS may be deployed are costs, including the size of a carbon price, which is vital for ensuring that CCS is commercially viable; regulatory and legal factors relating to the storage of carbon, and any liabilities that may result from this process; and availability of suitable geological formations to store the CO_2 underground.

These factors have limited the widespread adoption of CCS, resulting in its slow acceptance. In 2018, there were 43 large-scale facilities at various stages of operation, with 20 operating commercially (GCCSI 2019). The technology itself, however, is not entirely new—capturing CO_2 and injecting it into oil wells to improve recovery has been going on for over 45 years. Projects are emerging that involve capturing CO_2 from electricity plants, as well as from iron and steel facilities.

The sparsity of large-scale operating CCS plants makes projecting the mineral composition of the technology in the future challenging. Work in this area has identified chromium, cobalt, copper, manganese, molybdenum, and nickel as the key minerals involved in the technology. These minerals are used in a variety of ways in CCS, either in capturing the CO_2 (such as manganese and nickel) or in the steel alloys needed for the CCS plant, transportation pipes, and other changes needed for the generation plant. A critical factor is the length of the pipelines needed to transport the CO_2 to the storage sites; this will vary between facilities and would alter the overall scale of demand for minerals from the technology.

Batteries: Next Generation

Among many battery experts, the view is that Li-ion batteries will dominate the battery sector in the next decade,[32] similar to projections made under the model used in this analysis. However, a number of rapidly emerging new battery technologies could potentially challenge the proposed future dominance of Li-ion batteries. Great uncertainty exists about when, or if, these new batteries will reach widespread market deployment. However, many of these new technologies offer substantial benefits over Li-ion batteries should they become viable; thus, they could play a large role in providing energy storage options, both mobile and stationary, post-2030. Two groups of these technologies, solid-state Li-ion batteries and zinc-air batteries, are examined to give understanding on the potential impact of such breakthrough technologies on demand for minerals.

Figure 3.24 Solid-State Battery

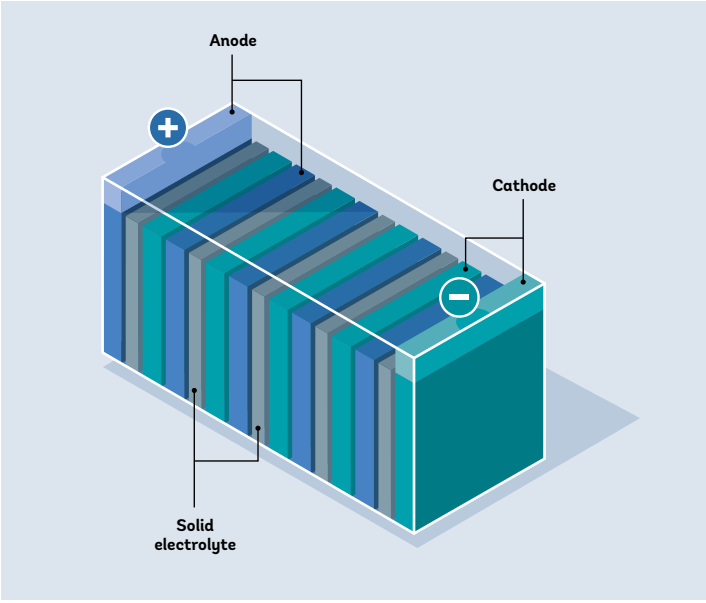


Illustration adapted from various sources (for example, Electronics-Lab.com, https://www.electronics-lab.com/solid-state-li-ion-batteries-high-energy-dense-batteries-closer/).

32 See, for example, Tsiropoulos, Tarvydas, and Lebedeva (2018).

Solid-State Batteries

Solid-state batteries differ from their more common liquid counterparts by replacing the liquid electrolyte in conventional Li-ion batteries with a solid alternative such as a polymer or ceramic. This structure enables engineers to replace the graphite anode with a lithium mineral anode, which greatly increases the storage potential of the battery. Solid-state batteries, theoretically, offer greater storage, faster charging, improved safety, and a reduced fire risk because they use nonflammable ceramic electrodes. This structure also reduces the need for cooling systems, allowing space for larger batteries in applications such as electric vehicles. The batteries are, however, hindered by costs, design safety, and production techniques. They have been proposed for use in electric vehicles—especially because of their fast charging, higher storage, and reduced fire risk—and stationary storage applications. Projections, however, place them 5 to 10 years away from market deployment.[33]

Should solid-state batteries play a major role from 2030 onward, there may be implications for the demand of some minerals used in energy storage applications. Lithium demand would likely remain strong, as the mineral would still be required for the anode. Graphite demand could fall as the graphite anode is replaced by lithium.[34] The greatest uncertainty lies in the composition of the solid electrolyte; the wide variety of different options being proposed use a range of additional minerals, including tin, aluminum, silver, and boron (Varzi et al. 2016). Therefore, great uncertainty exists not only on the potential scale of future market deployment of solid-state batteries, but also on the implications of such deployment on demand for minerals.

Zinc-Air Batteries

Zinc-air batteries have become more prominent in the emerging storage sector because of their high specific energy density compared to other storage options, such as Li-ion batteries. Zinc-air batteries have emerged as the leading mineral-air battery type because they are safe, environmentally friendly, and potentially cheap and simple. The potential advantages of the technology can be seen in a comparison of the practical energy density of different battery technologies. Lithium-air batteries are possible and have even higher energy densities, but zinc is more attractive for a number of reasons, including safety, ease of recyclability, and greater global availability. Zinc-air batteries could potentially be used in both electric vehicles—either solely or, potentially more practically, as a range extender in combination with a Li-ion battery—and stationary storage (Sherman et al. 2018). For example, New York Urban Electric Power is working with a number of public sector partners to deploy a 1 MWh grid-connected zinc-air battery for demand response and peak shaving.

Should zinc-air batteries reach large-scale deployment in electric vehicles, or in stationary storage, they could dampen the demand for the minerals used in Li-ion batteries (for example, lithium, graphite, nickel, manganese, and cobalt). Demand could then shift to nickel, manganese, and zinc itself, but also potentially to lanthanum or silver as well. Large-scale deployment, however, is only likely to be post-2030, with the timing, the scale, and the composition of the batteries highly uncertain.

33 See, for example, Meeus (2018).
34 Lead-acid batteries offer 40 watt-hours (Wh)/kg; Li-ion batteries, 160 Wh/kg; and zinc-air batteries, approximately 350 Wh/kg (Caramia and Bozzini 2014).

Floating Offshore Wind

Offshore wind has experienced rapid growth in recent years, especially in the North Sea and China. The vast majority of projects are installed on fixed foundations (usually monopiles) in water less than 60 meters deep. For deeper waters (up to 1,000 meters), floating foundations may be used. Although the floating wind technology is still at a nascent stage, it offers great future potential to rapidly increase the scale and the geographic scope of offshore wind. At the same time, it could also increase the mineral demand for steel because floating platforms tend to be much heavier than their fixed counterparts. An October 2019 report by ESMAP estimated that eight developing countries—Brazil, India, Morocco, the Philippines, South Africa, Sri Lanka, Turkey, and Vietnam—have the technical potential for more than 3,000 GW of offshore wind, two-thirds of which would require floating turbines (ESMAP 2019).

Floating turbines are just starting to enter commercialization. A 30 MW demonstration project, Hywind, has been operating in the United Kingdom since 2017. And a number of pilot projects have begun elsewhere, with different models of floating foundations emerging, such as spar-buoy, spar-submersible, and tension-leg platform. Many of these models draw on existing applications of floating foundations within the offshore oil industry. Each model has different advantages and disadvantages and varying implications for mineral demand. Costs are also falling rapidly, declining 86 percent since 2009 (ESMAP 2019).

Beyond steel, demand for other minerals from floating offshore wind turbines could be similar or different from other wind options. The biggest difference in mineral demand relates to the length of transmission cabling required. Where floating offshore turbines will be deployed is not just a function of distance from the shore but also depth to the seabed. In areas where floating turbines are deployed a relatively short distance from the shore, then cabling will not necessarily be longer, and demand for copper may not be greater. Should floating offshore turbines be deployed at greater distances, however, then demand for copper could rise.[35]

Figure 3.25 Floating Offshore Wind

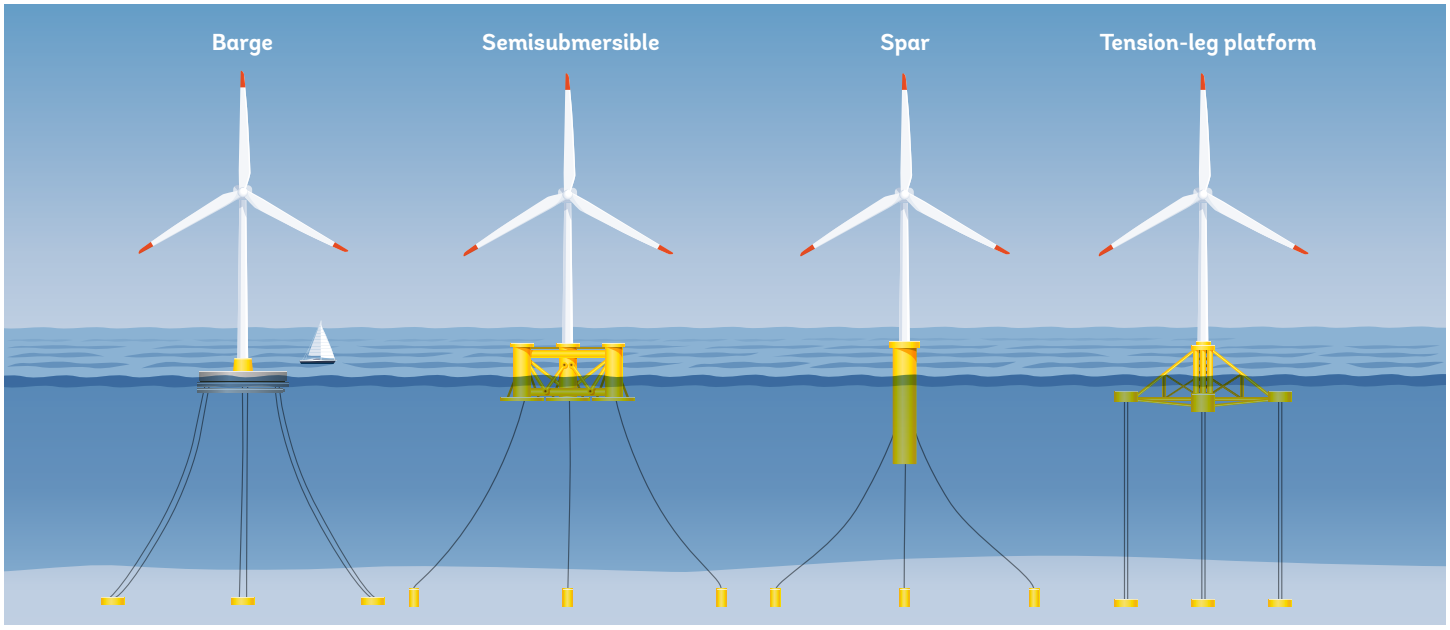


Illustration adapted from ESMAP (2019) and various other sources.

35 These factors are discussed in more depth in life-cycle assessments of floating turbines, such as in Tsai et al. (2016) and Chipindula et al. (2018).

Fuel Cells and Hydrogen

A key potential low-carbon technology not included in this analysis is the use of fuel cells and hydrogen in the clean energy transition, for providing space heating and powering various industrial processes as well as transportation. The use of fuel cells and hydrogen to provide a power source for low-carbon transportation has been explored for some time now because of its potential to lower carbon emissions (assuming green hydrogen is used) and the potential for hydrogen to be used as an energy carrier. Despite this promise, hydrogen deployment has been limited by high costs barriers in providing the fuel cells and the required hydrogen needed to power those cells, along with infrastructure constraints.

Figure 3.26 Hydrogen Fuel Cell

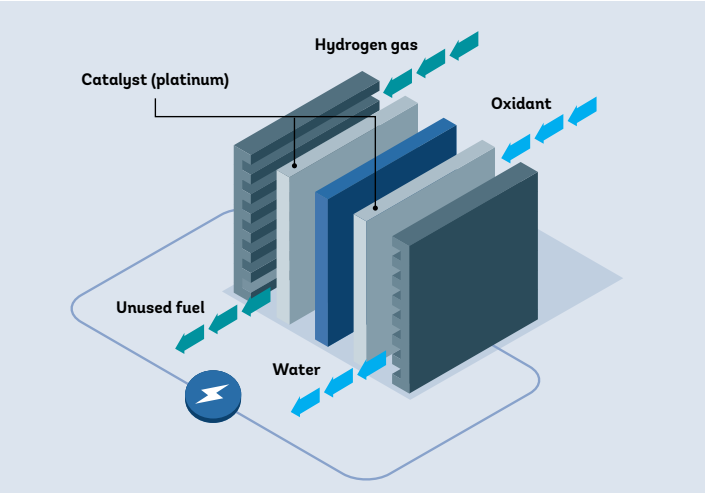


Illustration adapted from various sources (for example, Setra, https://www.setra.com/blog/what-is-a-hydrogen-fuel-cell-and-how-does-it-work).

Fuel cell transportation has specific features that give it a comparative advantage over batteries and other low-carbon technologies. Fuel cells offer a higher energy density per weight than batteries, allowing for longer distance travel and improved performance in vehicles, such as buses and heavy freight. The point-to-point nature of this form of transportation also helps overcome some of the infrastructure constraints associated with needing to electrify all electric vehicles with transmission infrastructure. All these features combined explain why fuel cells have been emerging predominantly in buses, and medium to heavy freight transportation.

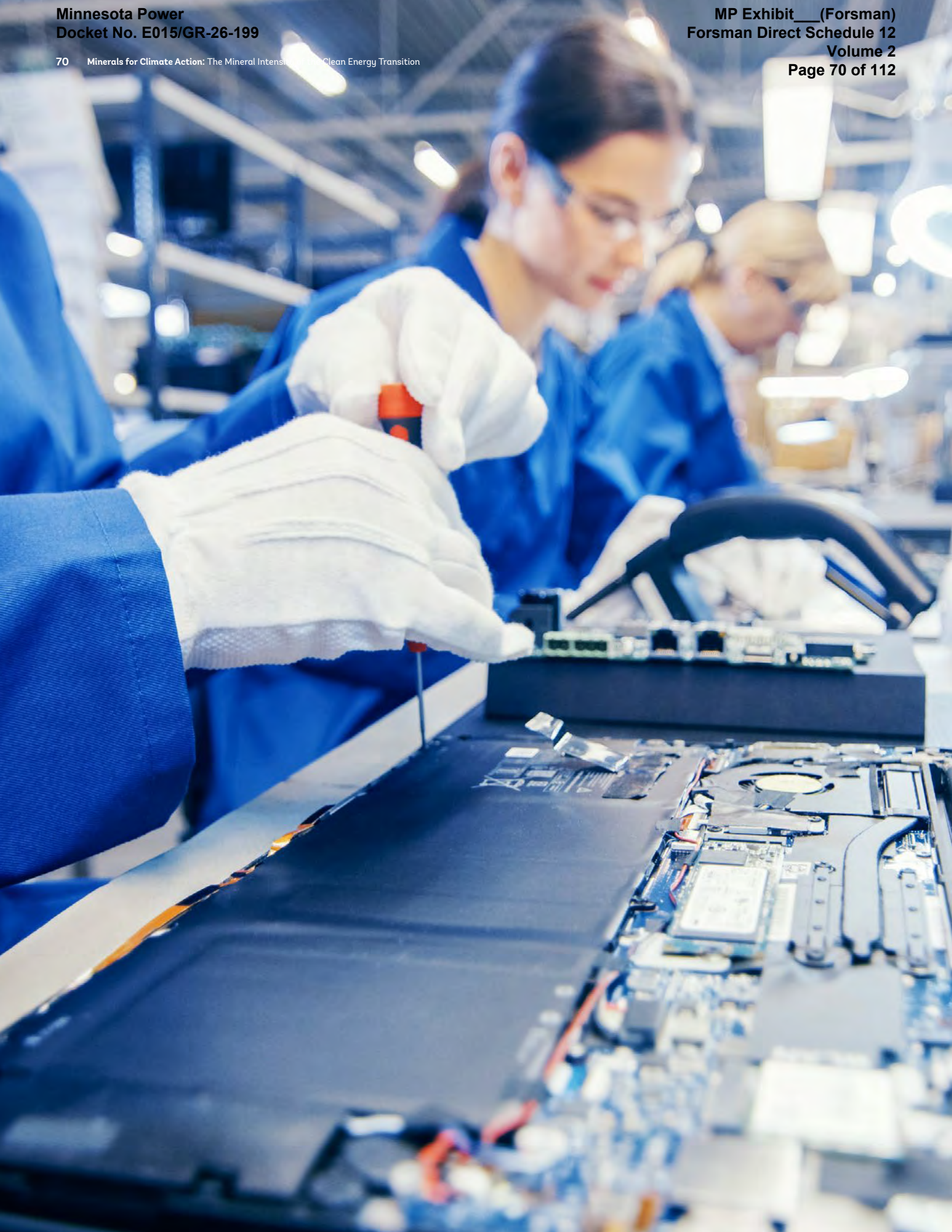
Fuel cells have various subtechnologies, including ones that use a catalyst prominently made out of platinum or ruthenium, but there are two main subtechnologies:

- **Proton exchange membrane fuel cells** are the most commonly used hydrogen subtechnology because of their low weight. These fuel cells operate at low temperatures and require a catalyst usually made out of platinum to split the hydrogen and oxygen molecules. This subtechnology also utilizes chromium steel, composed of 18 percent chromium and 8 percent nickel.[36]
- **Solid oxide fuel cells** do not require a catalyst. These fuel cells operate at very high temperatures and are thus not suitable for transportation; they are predominantly used for stationary power generation. Although the solid oxide fuel cell does not need platinum as a catalyst, it uses other minerals such as yttrium, zirconium, lanthanum, and samarium in the anodes, cathodes, and electrolytes.

The platinum market as a whole showed a surplus in 2018, in part attributable to a decline in consumption of diesel cars, in which platinum is used in the catalytic converter (Johnson Matthey 2019). This trend is likely to continue, and whether it will be offset by sufficient demand from fuel cells depends on their speed and scale of deployment. Platinum may also play further roles in future energy systems, as it is important component not just of the fuel cells but also in the electrolysis production of hydrogen. Should hydrogen grow as an energy carrier for uses beyond fuel cells, such as space heating, platinum demand could rise strongly.

Recycling will also play an important role in platinum demand from hydrogen. Platinum group minerals are highly recyclable, with potential recovery rates of 95 percent possible (Hagelüken 2012). The scale at which platinum group minerals could be recycled from fuel cell applications, especially within transportation, remains to be seen, but it could have a large impact on overall demand for primary platinum.[37]

36 Estimates have highlighted potential future efficiency gains, reducing the share of steel to 0.02 kg/KW by 2025—down from 0.1 kg/KW in 2008 (Moss et al. 2013).
37 The current use of six platinum group metals as catalysts in fine chemical production demonstrates recycling rates of 80–90 percent. Recycling rates in automotive applications are lower, but still around 50–60 percent. Recycling from electrical applications have proved trickier, with rates below 10 percent.



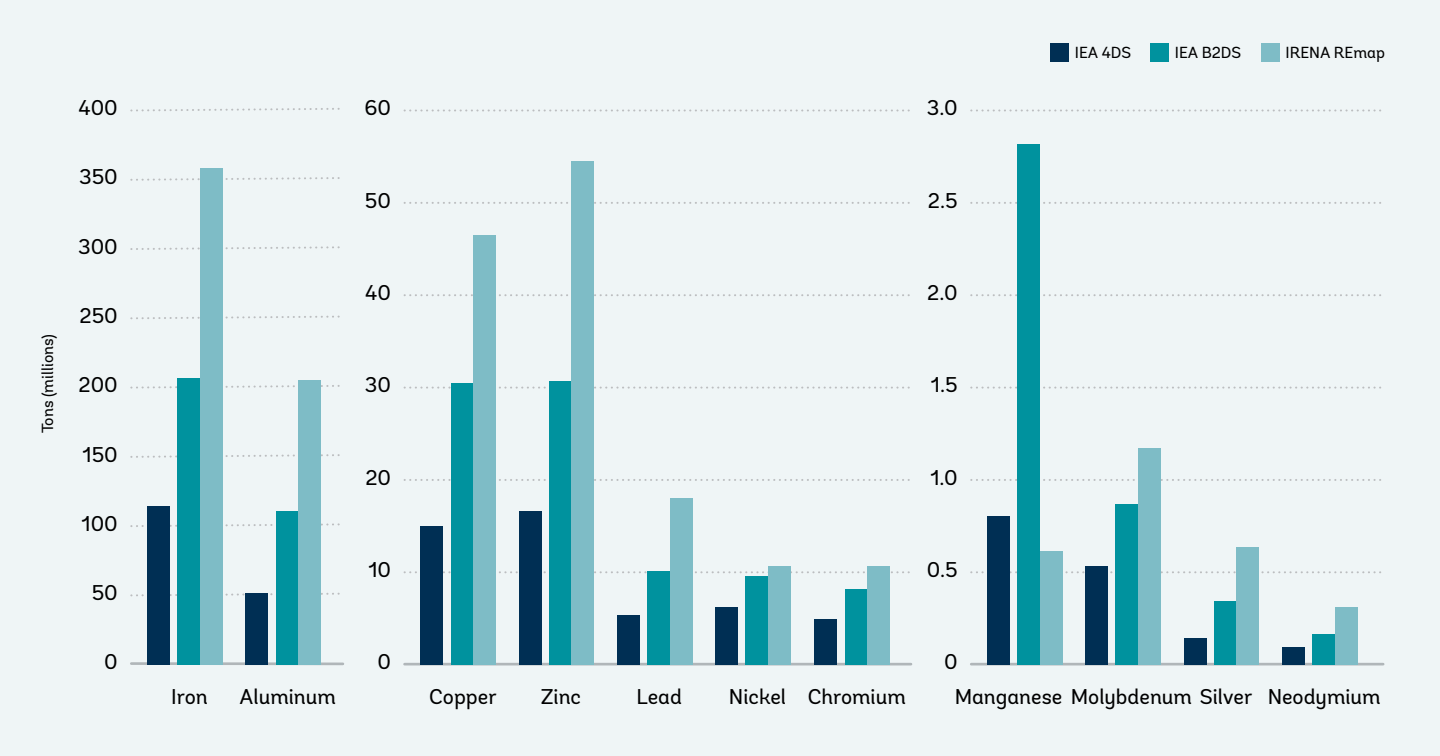
Overall Mineral Demand up to 2050

This chapter illustrates the overall demand across all 17 minerals from the six technology-based mitigation scenarios to show the impact that the clean energy transition will have on minerals in comparison with the base scenario. Figure 4.1 shows the total cumulative demand for minerals through 2050 from **electricity generation** technologies only under IRENA's REmap and the IEA's base scenario (4DS) and B2DS (again, energy storage figures are not provided because the data were unavailable for the base and IRENA scenarios).

The figures demonstrate an overall increase in demand for as many as 11 minerals used across a variety of energy technologies, with iron and aluminum showing the highest absolute increase, followed by copper and zinc. These trends indicate a relative increase in mineral demand with the relative ambitiousness of each technology-based mitigation scenario. This confirms one of the critical conclusions of previous findings: Not only is low-carbon energy transition materially intensive, but that intensity increases with the level of decarbonization.

Most minerals show the highest levels of demand under the IRENA scenario, when compared with their IEA counterparts, owing to the IRENA scenario's greater reliance on wind and solar PV technologies. The key exception is manganese, which shows much higher levels of demand under the 4DS and B2DS scenarios because of its use in CCS, which the IEA considers more likely than IRENA.

Figure 4.1 Cumulative Demand for Minerals for Energy Technologies (Without Storage) Through 2050 Only Under 4DS, B2DS, and REmap



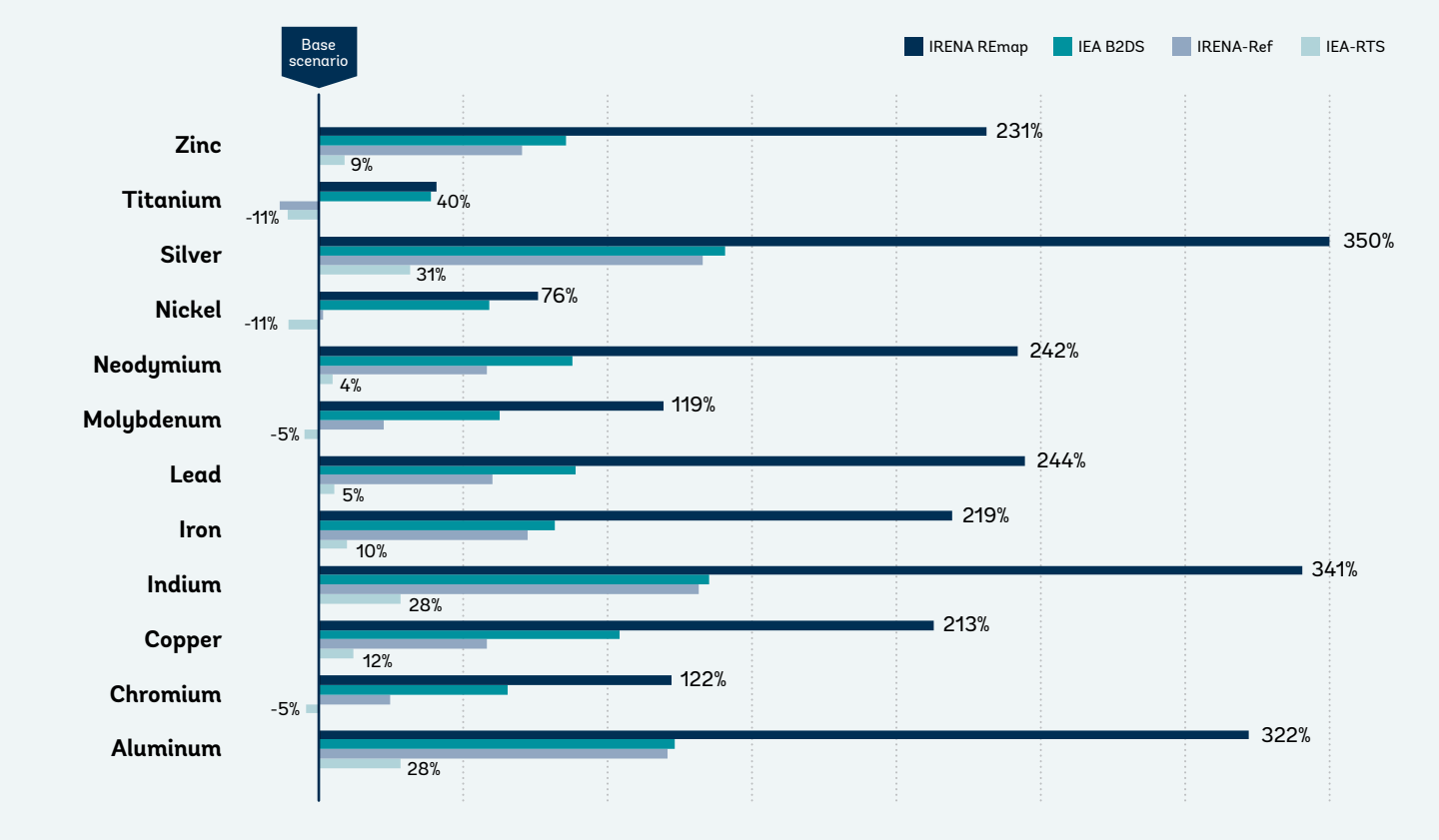
Note: Base scenario = 4-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, REmap = renewable energy roadmap scenario.

Figure 4.2 provides another way of looking at the scenarios and implications for minerals demand: the percentage of expected change from the base scenario in supplying electricity generation technologies only. In the REmap scenario, demand for aluminum, indium, and silver are expected to increase by more than 300 percent by 2050 from the base scenario, while the demand for copper, iron, lead, neodymium, and zinc is expected to increase by more than 200 percent. In comparison, in the most ambitious scenario under the IEA (B2DS), the demand for more than five minerals is expected to double by 2050, from the base scenario.

Annual Demand

The results presented to date have highlighted the cumulative scale of minerals needed to meet the challenge of the low-carbon transition. However, it is important to note the annual pathway that is needed to meet this cumulative scale. It is not simply a one-off investment in a stock of minerals that are needed for the low-carbon transition. Instead, it is a steadily increasing annual requirement that is needed to meet a higher future projected demand for electricity. This evolution can be seen in figure ES.1, which highlights that annual rates of demand are increasing up to 2050. The rate of increase tails off slowly to 2050, but it still reveals a picture whereby annual demand in 2050 is much greater than that in 2020.

Figure 4.2 Relative Change in Demand for Minerals from Energy Technologies (Without Storage) Through 2050 Under RTS, Ref, B2DS, and REmap, Compared to Base Scenario

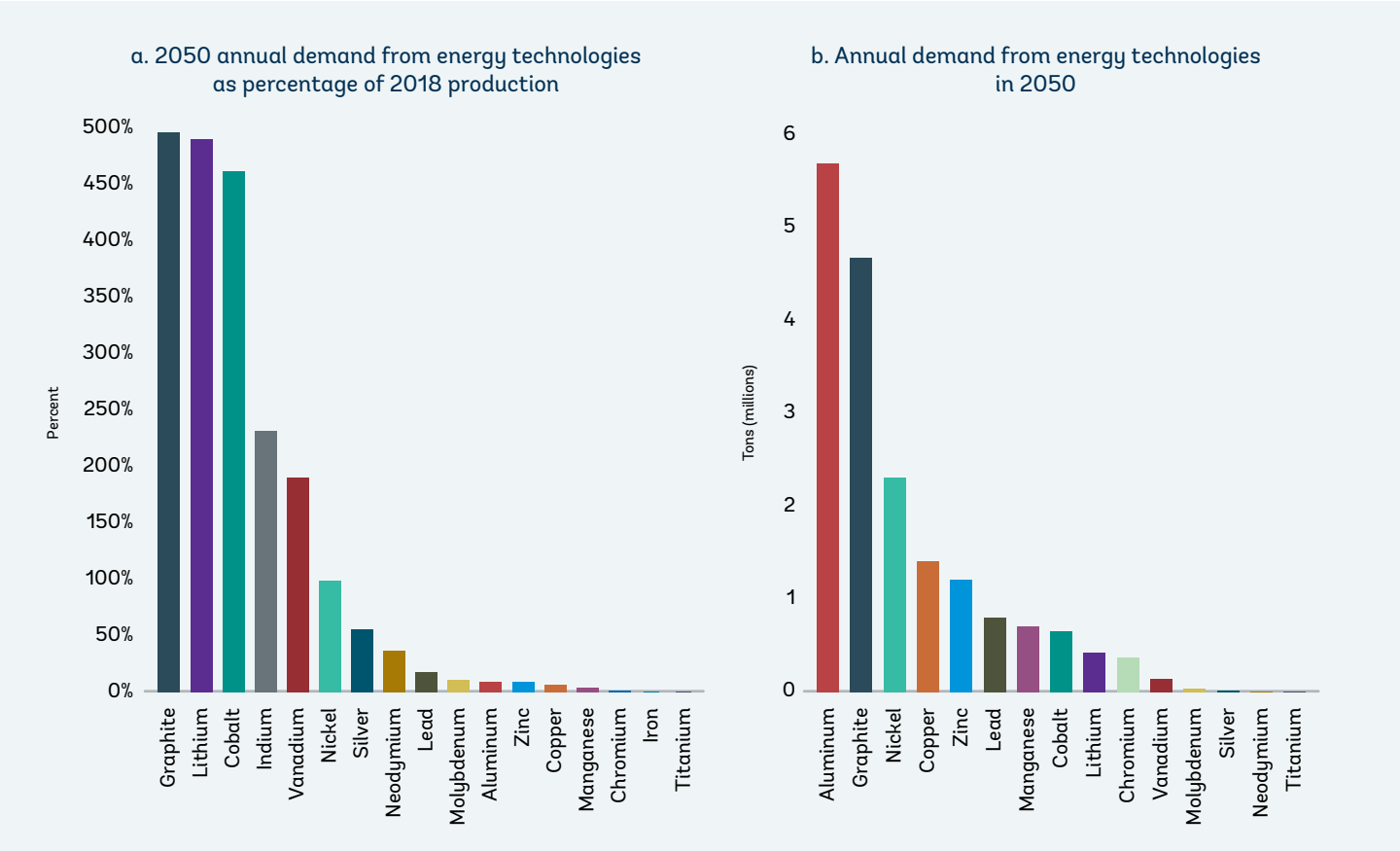


Note: Base scenario = 4-degree scenario, B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, Ref = reference scenario, REmap = renewable energy roadmap scenario; RTS = reference technology scenario.

As all 17 minerals covered in the model are used for different applications outside the energy sector, this analysis compares the mineral demand coming from the 10 energy technologies under the 2DS and compares it with 2018 production figures. Figure 4.3, panel a, provides the percentage increase in mineral demand based on 2018 production figures, with the majority of demand coming from battery minerals, namely graphite, lithium, and cobalt. These minerals will be needed at scales significantly beyond current production levels, by up to as much as five times. Figure 4.3, panel b, illustrates the annual absolute increase in mineral production up to 2050, with production figures being the highest for aluminum, graphite, and nickel.

Graphite demand increases in both absolute and percentage terms since graphite is needed to build the anodes found in the most commonly deployed automotive, grid, and decentralized batteries. About 4.5 million tons of graphite is needed to be produced annually by 2050, or a cumulative of 68 million tons, while graphite demand increases by nearly 500 percent from 2018 production figures, demonstrating the critical role graphite plays in the clean energy transition, being used in Li-ion batteries, the most widely projected deployed battery technology.

Figure 4.3 Projected Annual Mineral Demand Under 2DS Only from Energy Technologies in 2050, Compared to 2018 Production Levels



Note: 2DS = 2-degree scenario.

Market Dynamics and Mineral Demand

The demand estimates produced in this analysis are the demand that would occur assuming that supply can fully adjust to meet that demand and that no substitution or efficiency improvements occur. Higher levels of demand would lead to higher prices, causing increases in supply but also substitution of other minerals, where technically possible, as well as innovation in efficiency improvements. The outlook presented in this section should be seen as the first pillar in understanding the full impact that a low-carbon transition will have on the markets for minerals. These results should be combined with further research on the supply aspects as well as the substitution and technical efficiency possibilities.



Even where future demand from energy technologies does not exceed current production, the share of demand from energy technology in total demand for virtually all these minerals is likely to rise, which carries implications for their relative accessibility over the next few decades.[38] For example, the percent share of aluminum appears to be relatively small, but the mineral's absolute numbers are much greater than lithium (the highest percentage increase)—at about 5.6 million tons in 2050, compared with 0.4 million tons for lithium that same year. Absolute demand may be so high that it could bring pressure on the aluminum industry's capacity to meet the expected demand in servicing the low-carbon future.

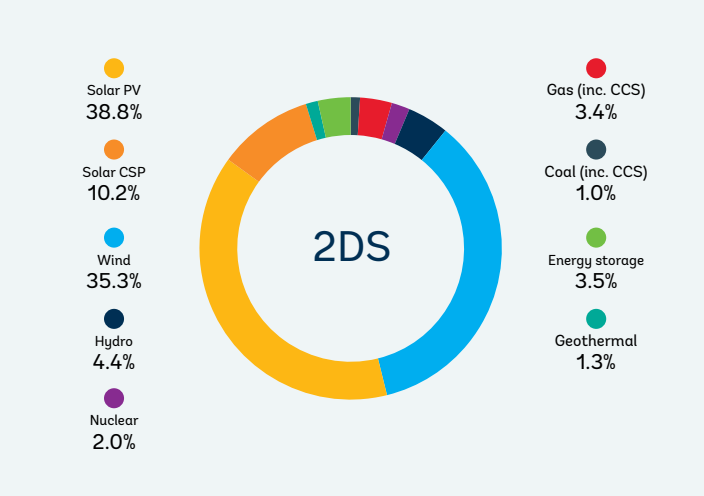
Cross-Cutting Minerals

Cross-cutting minerals refer to minerals that are used across a wide variety of energy generation and storage technologies. Earlier in this report, the demand for minerals such as lithium, graphite, silver, and aluminum was identified as being concentrated in one or two specific energy technologies up to 2050. This section also focuses on the minerals that are used throughout a broader spectrum of energy technologies, as this has implications for the overall demand of minerals regardless of which technology or subtechnology ends up being deployed the most under each technology-based mitigation scenario.

Copper, chromium, and molybdenum are examples of minerals that are used across eight or more technologies, with copper being used in all energy generation and storage technologies covered in the model. It is important to pay attention to cross-cutting minerals since these are a subset of minerals that are not dependent on the deployment of one specific energy technology for the demand to be affected. In other words, changes in technology or subtechnology deployment will most likely have a minimal impact on the overall demand of cross-cutting minerals.

38 As market dynamics were not considered in this analysis, further information on how market dynamics could potentially impact this report's mineral projections, which are based on the IEA and IRENA scenarios, can be found in annex B.

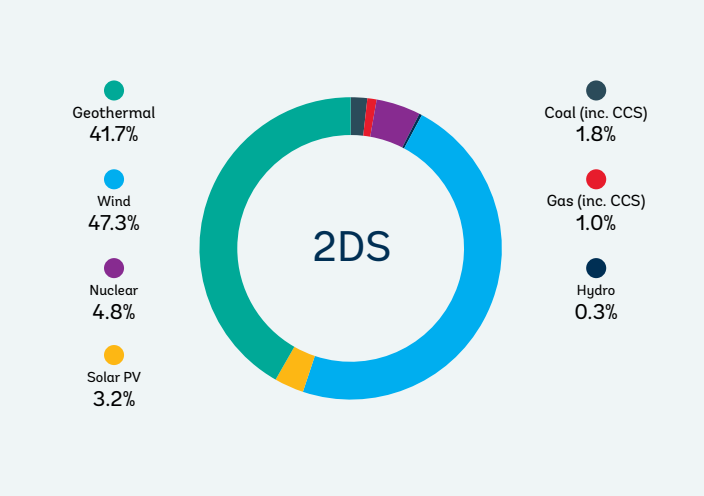
Figure 4.4 Total Copper Demand by Energy Technology Through 2050 Under 2DS



Note: 2DS = 2-degree scenario, CCS = carbon capture and storage, CSP = concentrated solar power, PV = photovoltaic.

Figure 4.4 shows the total cumulative demand for copper from electricity generation and energy storage technologies through 2050. The greatest share of demand comes from solar PV (39 percent) and wind (35 percent), particularly for offshore wind. Together, solar PV and wind represent 74 percent of total copper demand in a 2DS. This is likely a significant underestimation of the demand for copper in servicing the clean energy future since it does not include infrastructure requirements, such as transmission systems. The International Copper Association estimates that more than 60 percent of refined copper is used for supporting electricity and heating systems.[39]

Figure 4.5 Total Molybdenum Demand by Energy Technology Through 2050 Under 2DS

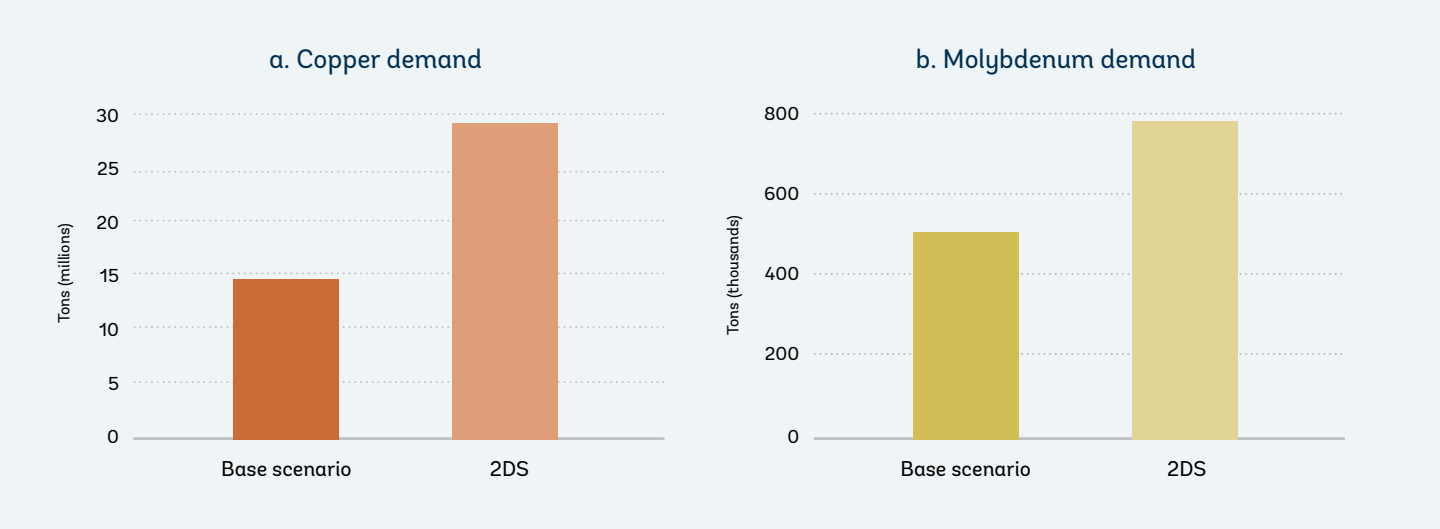


Note: 2DS = 2-degree scenario, CCS = carbon capture and storage, CSP = concentrated solar power, PV = photovoltaic.

Molybdenum is another critical mineral required for a range of low-carbon technologies, especially wind and geothermal. The greatest share of demand for molybdenum from electricity generation and energy storage technologies comes from wind (47.3 percent) and geothermal (41.7 percent), with all the other generation and energy storage technologies together accounting for only a small share (11 percent) (figure 4.5). This is despite the fact that molybdenum typically only makes up 0.15 percent of the mineral composition of a wind turbine. Together, wind and geothermal account for 89 percent of molybdenum demand under a 2DS. There is a lack of clear data allowing for determination of which subtechnology of wind accounts for the greatest demand.

39 For further information, see "Energy and Renewables," Applications, Copper Development Association: https://copperalliance.org.uk/about-copper/applications/energy-and-renewables/.

Figure 4.6 Cumulative Copper and Molybdenum Demand Through 2050 (2DS, Base Scenario)



Note: 2DS = 2-degree scenario.

While copper and molybdenum are both cross-cutting minerals, there is a significant difference between the two: Copper is a base metal that is used across a wide variety of industries,[40] while molybdenum is considered to be a niche mineral that is usually recovered as a byproduct or co-product of copper (figure 4.6).[41] The difference can also be seen in production figures. In 2018, 21 million tons of copper was produced, whereas only 0.3 million tons of molybdenum was extracted—a 20.7-million-ton difference between the two minerals. In other words, 7,000 percent more copper was produced in 2018 relative to molybdenum, even though both minerals are used across a wide variety of energy technologies and will both contribute to a low-carbon future pathway given their importance in solar PV, wind, and geothermal technologies.

As mentioned earlier, the copper figures are most likely vastly underestimated, with copper's demand likely to increase significantly from new transmission infrastructure needed for new transportation infrastructure and energy systems, as well as for a growing global population.

40 In this case, copper is referred to as a base metal since it is commonly used and inexpensive. It is not considered a precious metal such as silver or gold. However, for consistency, all minerals and metals in this report are referred to as minerals.
41 "Molybdenum," Minerals Database, Minerals Education Coalition, accessed 2019, https://mineralseducationcoalition.org/minerals-database/molybdenum/.

Demand Risk Matrix

A key element of this analysis is to understand how overall mineral demand could be affected by the technology concentration of each mineral or the increase in growth from energy technologies compared to current production figures. The relative importance of mineral demand is even more important for minerals that are *cross-cutting*, meaning they do not depend on the deployment of one or two specific technologies to be relevant.

A **demand risk matrix** has been developed under a 2DS to provide an overview of these trends based on technology concentration levels per each mineral relative to 2018 production figures (in absolute and percentage figures). Two indexes, which make up the matrix, have been created, to ease comparisons between minerals:

- **Weighted coverage-concentration index** (technology concentration index): This index captures how cross-cutting or concentrated in a few technologies the minerals are in the model. A value for 1 is given for the most cross-cutting mineral, namely copper, with the scores for all other minerals relative to copper. The index is calculated on an equal weighting of two items: (1) the number of technologies that require one mineral, and (2) the share of demand for minerals that comes from a single technology. The assumptions are described in further detail in annex B.
- **2018-2050 production-demand index** (demand index): This index captures the scale to which production must scale up to meet demand from energy technologies. The index consists of two parts:
  - *Relative demand* is captured by comparing 2050 demand from energy technologies to 2018 total production of the mineral. An index between 0 and 1 is then computed, with the mineral with highest relative demand, graphite, given a score of 1 and each other mineral given a score relative to graphite.
  - *Absolute demand* is captured through the absolute level of demand in 2050 from energy technologies for each mineral. The mineral with the highest level (aluminum) is given a score of 1 and every other mineral is given a score between 0 and 1 relative to aluminum.

The two parts of the index are given an equal weight to compute an overall production-demand index. The two indexes are then plotted together to give four categories, or quadrants. A breakdown of the quadrants and the possible interpretation on mineral demand from ***energy technologies*** is below, as seen in figure 4.7 and annex B.



Figure 4.7 Demand Risk Matrix Under 2DS



1 Quadrant 1 Medium-Impact Minerals:

Minerals that fall in quadrant 1 are the least impacted minerals from demand. These minerals feature in only a small range of energy technologies and the anticipated increases in demand are a small percentage of 2018 production levels. It is important to stress that this matrix only compares minerals demand from energy technologies only and does not consider supply risks, nor the demand from other industries outside the energy sector.

- This is not to say that these minerals are not important to the deployment of particular subtechnologies. Neodymium is a rare earth that is critical for the deployment of offshore wind.

2 Quadrant 2 High-Impact Minerals:

Minerals that fall in quadrant 2 are important because, although they only feature in a small number of technologies, their level of future demand is much greater than 2018 production levels. Changes to the technologies or subtechnologies used may have big implications for overall levels of demand. They are predominantly (but not exclusively) minerals used in energy storage technologies.

- Lithium, which is only used in energy storage under this analysis, is projected to need 488 percent of 2018 production levels to meet its 2050 demand under a 2DS.[42]

3 Quadrant 3 High-Impact, Cross-Cutting Minerals:

Minerals that fall in quadrant 3 are critical because the demand from 2018 production levels increases significantly, yet their use is also widespread across a variety of technologies.

- Aluminum is used widely for both energy generation and storage technologies. The demand for aluminum is therefore expected to be critical regardless of which technology-based mitigation scenario is achieved. While aluminum's overall level of demand from energy technologies is less than 10 percent of its 2018 production levels, it has the highest production levels compared to all other 16 minerals, with cumulative production reaching 102 million tons by 2050 to primarily supply solar PV and then other energy technologies.

4 Quadrant 4 Cross-Cutting Minerals:

The minerals in quadrant 4 are important because while their overall demand from energy technologies relative to production (in percentage) is not as dramatic as that for minerals in quadrants 2 or 3, they are used across a wide variety of technologies and are not dependent on one specific technology. Therefore, the demand for these minerals will exist no matter which technologies or subtechnologies are deployed.

- Copper, for example, represented as an index of 1, is used across all 10 energy technologies covered in the model and therefore is the mineral for which the demand will be the least impacted by significant changes in the technology-based mitigation scenarios.

42 While this report does not address supply, about 71 percent of all rare earths, including neodymium, are produced in China.



Mineral Recycling, Reuse

Recycling could play an increased role in meeting demand for minerals to supply a low-carbon transition. As of today, the most recycled minerals are iron and steel (AGI 2017). Minerals mapped under the demand risk matrix in the previous section could, in theory, shift into different quadrants, depending on whether some of these minerals are partially recycled once energy technologies reach end of life, reducing the amount of minerals that need to be extracted. The opportunities for mineral recycling are important to explore, particularly as mineral demand increases under the most ambitious climate pathways.

Primary minerals refer to minerals that are extracted and processed into a final mineral product before being used to manufacture products, including energy technologies, while secondary minerals refer to minerals that have been recycled from a variety of products. The model's estimated projections for the potential role of recycling do not consider the economics of mineral recycling, nor the technical limitations of recycling. The cost of recycling is a crucial factor in determining how much recycling takes place. If the primary mineral is available much more cheaply than recycled material, then very little recycling will occur. Policy support and technological improvements will play a critical role in how the mineral recycling industry develops to bring down costs and encourage innovation to meet demand from low-carbon technologies.

Recycling

Only five minerals have been selected to analyze the potential impact of recycling on mineral demand, given the limitations of available data on mineral recycling, as well as to provide consistency with other sections. Aluminum is specifically highlighted because it is used across almost all energy generation technologies and storage and has significant demand implications relative to its 2018 production levels (quadrant 3 – high-impact, cross-cutting minerals). Lithium and cobalt are relevant because the demand for these minerals increase by 488 percent and 460 percent, respectively, relative to 2018 production (quadrant 2 – high-impact minerals). Nickel and copper are showcased because both minerals are cross-cutting minerals (quadrant 4 – cross-cutting minerals) and their increase in demand in either absolute or relative numbers is significant, relative to niche minerals, under a 2DS.

As discussed in the Recycling, Reuse section of chapter 1, two recycling rates are important for the analysis:

- **End of life (EOL):** The percentage of material that is recovered at the end of a products life and recycled into new material
- **Recycled content (RC):** The percentage of a new product that is made using secondary (recycled) material

The implications of recycling under a 2DS can be seen in figures 4.8–4.10. In these charts, the end-use demand for the relevant minerals is illustrated, chiefly the amount of minerals that is actually required to go into a wind turbine or solar panels. The figures show the amount of primary mineral that is required if current RC rates remain the same until 2050,[43] along with the situation if EOL rates increase to 100 percent by 2050 (lithium rates are estimated differently, as explained in the Recycling, Reuse section in chapter 1).

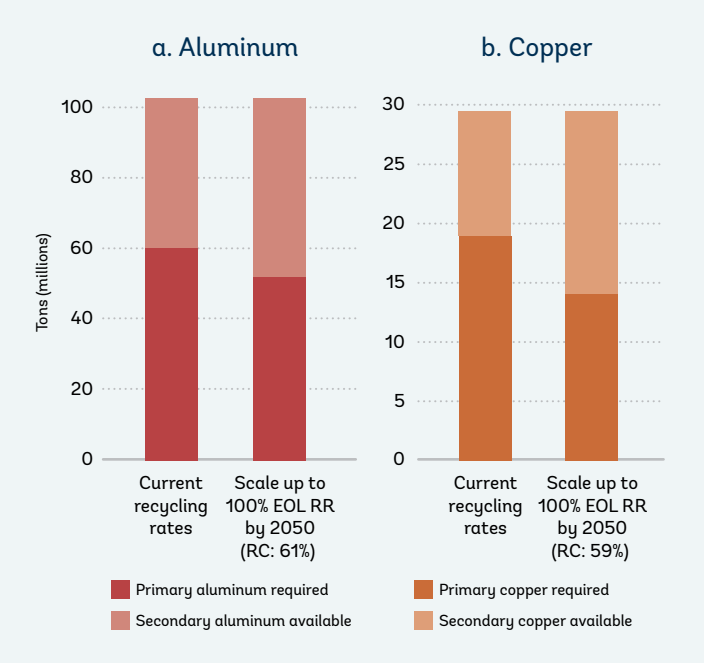
Figure 4.8 presents the impacts for aluminum and copper recycling. Approximately 102.8 million tons of aluminum is required to meet demand from the energy technologies under a 2DS. Should RC rates remain constant at today's levels of 35 percent, then 42.3 million tons would be met by secondary or recycled production, with the remaining 60.5 million tons coming from primary production, from bauxite extraction.

If EOL rates increase to 100 percent by 2050—implying that all aluminum available is recycled—then RC rates rise to 61 percent. The final amount of aluminum needed to supply technologies doesn't change, but the amount met by secondary production rises to 57 million tons, with 24 percent less primary production required.[44] The demand for primary production does not disappear completely even with a 100 percent EOL rate, as the production of secondary aluminum is limited by the supply of scrap available.

Should structural changes to the nature of the economy take place, which means that the ratio of scrap availability to overall mineral demand changes, then the potential to increase RC rates from 100 percent EOL rates exist, reducing primary mineral demand further. Examples of such changes that could increase scrap availability include changes to the design of products to enable better mineral recovery, and large falls in demand for the mineral from other sectors, outside the energy industry.

For copper specifically, current RC rates are assumed to be 28.5 percent (figure 4.8) and an increase to 100 percent EOL by 2050 increases RC rates to 59 percent, reducing the overall cumulative demand for primary copper from energy technologies by 26 percent. While increasing EOL rates to 100 percent has a similar impact on both minerals, primary demand for aluminum still outweighs primary copper demand by more than three times, at over 46 million tons for aluminum and over 14 million tons for copper through 2050. Again, the copper figures may be underestimated given that transmission figures are not included in this analysis.

Figure 4.8 Impact of Recycling on Cumulative Demand for Aluminum and Copper Under 2DS Through 2050

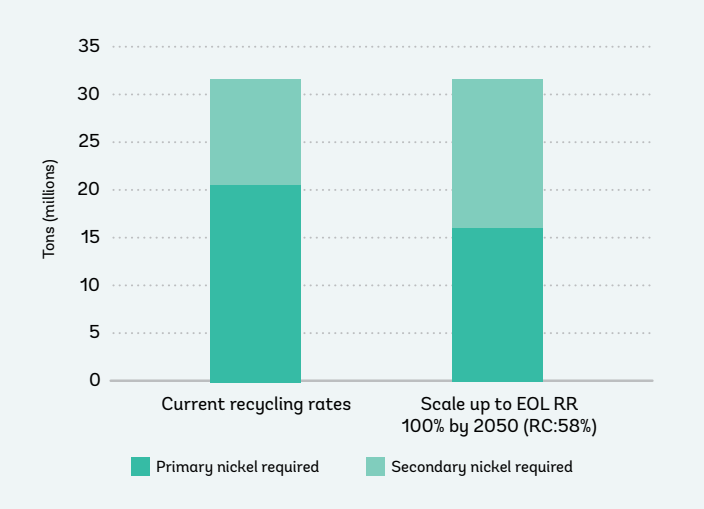


Note: 2DS = 2-degree scenario.

43 Data on global recycling rates for different minerals are patchy and a review of the literature shows a wide range of estimates.

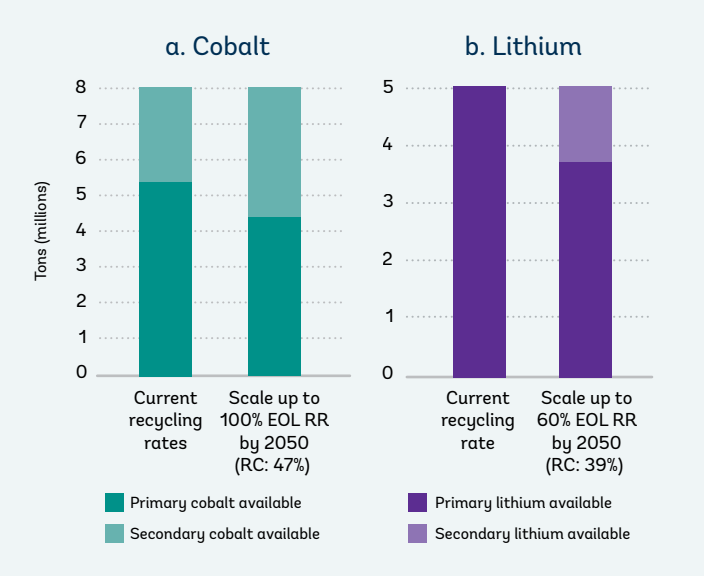
44 The change in primary demand is a function of two factors: the time path of end-use aluminum demand and the time path of recycling rates. Although the results seem trite, they are in fact contingent on how fast recycling rates increase and when the majority of end-use demand occurs. Given that the larger share of end-use demand occurs closer to 2050, should recycling rates scale up more quickly than the linear trend assumed here, then overall primary demand would decrease. Similarly, a slower transition to higher recycling rates will require higher levels of primary aluminum to be supplied.

Figure 4.9 Impact of Recycling on Cumulative Demand for Nickel Under 2DS Through 2050



Note: 2DS = 2-degree scenario, EOL = end of life, RC = recycled content, RR = recycling rate.

Figure 4.10 Impact of Recycling on Cumulative Demand for Cobalt and Lithium Under 2DS Through 2050



Note: 2DS = 2-degree scenario.

Nickel is a crucial metal for the move to a green energy future as it is needed in energy storage, for use in Li-ion batteries, and is also used in a wide range of generation technologies, often being used as a component of the steel required. Rates on the RC of nickel, or scrap nickel, vary, but they center on 35 percent. Should RC rates stay at this level, then primary demand for nickel through 2050 would stand at just over 20 million tons (figure 4.9). Following similar assumptions for copper and aluminum, as well as assuming that EOL rates increase to 100 percent by 2050, then RC rates increase to 58 percent and primary demand for nickel would fall by 23 percent compared to today's RC rates.

The battery minerals cobalt and lithium have very different recycling trajectories. Cobalt currently has an RC of 32 percent, with primary cobalt accounting for 5.4 million tons of demand up to 2050 (figure 4.10). An increase to 100 percent EOL by 2050 increases RC to 47 percent, reducing the overall cumulative demand for primary cobalt from energy technologies by 15 percent, following a similar trajectory as aluminum and copper with regard to decreased demand from primary production. However, the technical challenges of extracting cobalt for use in batteries may make these assumptions less robust than for aluminum and copper, which are easier to recycle.

Lithium, on the other hand, is very different because current lithium recycling rates (both EOL and RC) are close to zero according to a variety of sources.[45] However, some sources have highlighted the high future potential for recycling to grow in this area.[46] For example, they project medium and high recycling scenarios of EOL rates of 40 percent and 80 percent, respectively. In this analysis, a midpoint has been selected, with EOL rising to 60 percent by 2050 implying an estimated 39 percent RC rate.[47] The impact of such recycling is to reduce cumulative demand for lithium by 26 percent.

45 It should be noted that there is a large amount of research and activity investigating the potential to recycle lithium from Li-ion batteries. However, to date little available public data show this is yet happening commercially at any scale. In fact, where there are recent studies, they have highlighted the low cost of lithium and the relatively high cost of recycling as a key barrier to scaling up lithium recycling. See, for example,
46 Ziemann et al. (2018) and Church and Wuennenberg (2019).
47 This is drawn from the analysis in Ziemann et al. (2018).

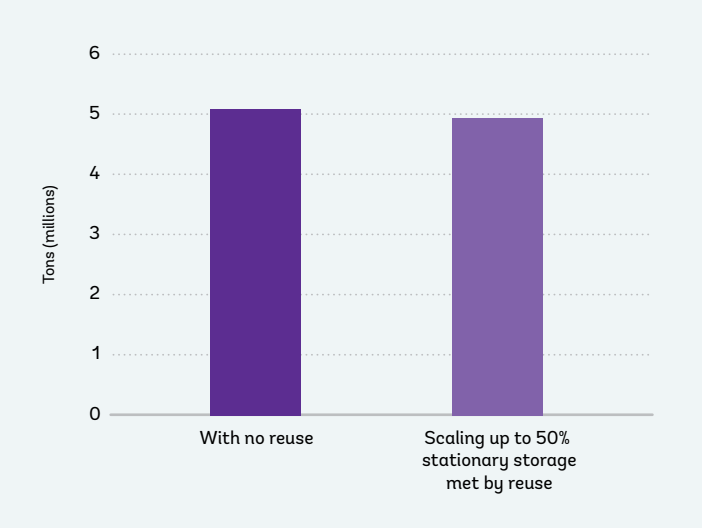
Reuse

Reuse differs from recycling in that recycling involves the breaking down of the material and re-forming it for an alternative use. The term "reuse" in this context is used to mean the reusing of the original component, such as a battery, for another use beyond what was original intended. For example, Li-ion batteries that are used in electric vehicles could potentially be used in other types of energy storage applications.[48] While reuse of batteries could provide opportunities for stationary storage applications, this potential solution to reducing overall mineral demand should be carefully approached from waste and safety perspectives.

This could be the case if, once clean energy technologies reach end of life and can be to some degree repurposed, they do not end up being used as an excuse to dispose these technologies under the guise of a "repurposed" product; this is especially true for developing countries or underserved communities that may end up becoming recipients of these technologies once they reach end of life, resulting in an increased amount of waste.

In this context, reuse has also been termed as repurposing. Conservative assumptions have been applied to the rate of reused Li-ion batteries with the assumption that reused batteries meet 50 percent of the demand for Li-ion batteries in stationary storage by 2050. This reduces the total cumulative demand for lithium by 3 percent (figure 4.11). Should there be a reuse of Li-ion batteries in transport, either between cars or between trucks and buses and cars—through remanufacturing processes—then this could reduce primary demand for lithium substantially.[49] There is, however, little current evidence of these processes occurring at a commercial level, despite much research and interest in the area.

Figure 4.11 Impact of Reuse on Cumulative Demand for Lithium Under 2DS Through 2050



Note: 2DS = 2-degree scenario

Otherwise, with lithium demand only coming from energy storage under the Ref, 2DS, and B2DS, particularly in the automotive sector, the only way to significantly reduce lithium's demand would be by finding ways to reuse Li-ion batteries in the electric vehicle sector, as stationary storage applications only account for a small share of energy storage deployments up to 2050. However, this trend is unlikely as electric vehicles require batteries with the capacity to undertake a large amount of cycling (charging and discharging) and to hold a charge and recharge quickly—features associated with new batteries.

48 See the discussion in Ahmadi et al. (2017).
49 See Strandridge and Hasan (2015) for further details.

Opportunities and Challenges

While the opportunities for recycling minerals could help address demand risks associated with the low-carbon transition, some recyclable minerals may not be suitable for the production of certain energy technologies, as some technologies may require a very high grade of a specific mineral for their application (for example, steel). Moreover, the energy intensiveness of some recycling processes could pose the same issues that have been identified in steel and aluminum production.

Recycling rates vary massively between minerals because of cost and technical issues. Rates for recycling of steel are especially high, with over an estimated 85 percent of it being recycled EOL. Even within minerals, rates vary across products. For example, 95 percent of steel from automobiles is recycled, compared with 70 percent from steel packaging. Recycling rates, however, can be deceptive. Despite 85 percent of steel being recycled, about one-third of steel comes from primary production, as the majority of steel is locked up in long-term, durable structures, limiting the amount of steel that is available for recycling, especially when demand is increasing.

Recycling brings environmental benefits in a number of areas, especially in GHG emissions, with the carbon footprint from the secondary production of minerals, such as aluminum, being a fraction that of primary production. For other minerals, however, recycling comes with additional environmental challenges, such as energy use and water footprints, that need to be weighed against the environmental benefits.

Overall, recycling could present interesting opportunities for countries with advanced recycling technology with reliable low-carbon, electricity production to potentially reduce the pressure of increasing demand for certain minerals, but policy coherence among countries will be needed so that future international recycling practices take into account the environmental, safety, and high costs of mineral recycling.



Refurbishment of structures and equipment to prolong their life spans has not been covered by this analysis, but it is another crucial feature phenomenon that could affect the demand for primary minerals. Recycling of many components of energy technologies may prove to be technically difficult or costly. Refurbishing parts of energy technologies can prolong life spans dramatically, reducing the mineral footprint. For example, old wind turbines at the end of their life span can be refurbished by retaining the tower but replacing some or all of the other components, increasing the capacity of the turbine or retrofitting it with more efficient components such as gearboxes or generators. Estimating the scale of such effects is difficult, but increasing refurbishment would reduce the overall scale of mineral demand, and may impact minerals used in frames and structures more than those minerals used in specific components such as motors or magnets.





Global Warming Potential of Energy Technologies, Minerals

GWP of Energy Technologies

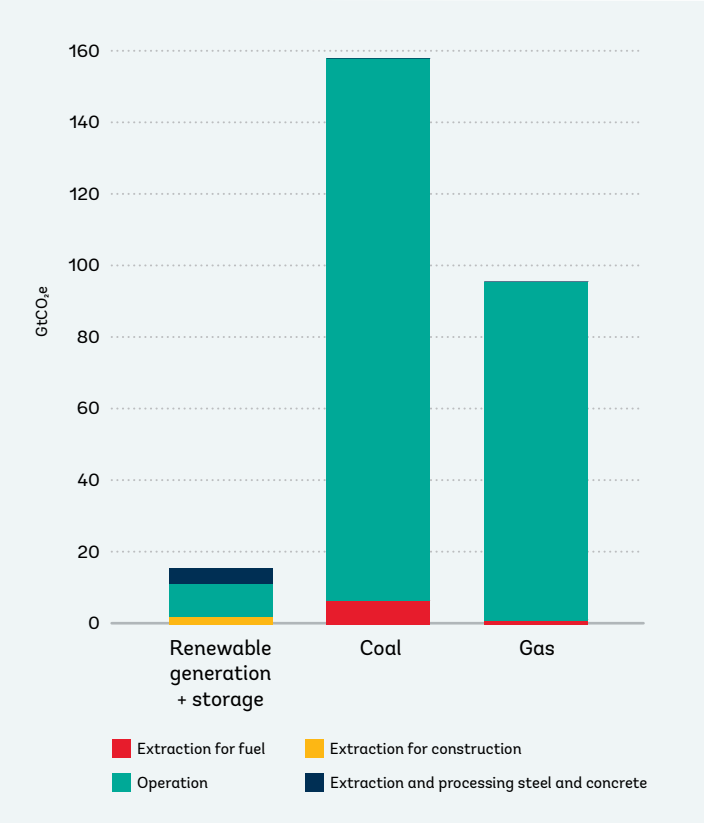
The importance in calculating the GWP of energy technologies is to compare the carbon footprint associated with extracting and recycling more minerals to supply a low-carbon future. The aim is to understand the carbon footprint implications of the clean energy transition, particularly as the previous sections of the analysis have demonstrated that low-carbon technologies, including generation and storage, are extremely mineral intensive. With the Paris Agreement calling for increasing global temperature to not exceed a 2°C scenario, the GWP analysis provides the approximate calculation of the carbon footprint of clean energy technologies compared with fossil fuel ones under the IEA 2DS, mirroring the approach taken in the demand risk matrix to meet mineral demand.

As seen in figure 5.1, there are emissions associated with minerals required for a low-carbon future up to 2050, but clean energy technologies provide a substantially smaller overall GHG footprint than either coal or gas—with renewable energy and storage contributing approximately 16 $GtCO_2e$ through 2050 in the 2DS, compared with almost 160 $GtCO_2e$ from coal and approximately 96 $GtCO_2e$ from gas. In the base scenario, where substantially more electricity is generated from these latter sources, the emissions from coal and gas are much greater, at more than 470 $GtCO_2e$ and 130 $GtCO_2e$, respectively.

The primary difference between clean and conventional energy has to do with the operation of each of those technologies. While the GHG footprint in the extraction and processing of minerals required for the construction of renewable energy technologies is likely to be higher than that for fossil fuel generation, once the emissions that result from extracting coal and gas, and crucially in burning it to generate electricity, are taken into account, fossil fuel generation has a significantly greater footprint. In other words, the relative GWP of "cradle to gate" of renewable energy technologies compared with the GWP of fossil fuel combustion under a 2DS are considerably smaller.

Although steel and cement were not included in the analysis, they have been included in figure 5.1 because of their high contribution to emissions from the construction of both renewable and fossil fuel energy technologies. Steel is currently estimated to account for 7–9 percent of total GHG emissions. Cement accounts for approximately 8 percent (Timperley 2018). Data on the steel and cement needed to build the technologies, and the carbon footprint for steel and cement, were drawn from the literature, with high, median, and low values used to capture the range of estimates in a similar manner as other aspects of the model.

Figure 5.1 Cumulative GWP Through 2050 from "Cradle to Gate" Mineral Extraction and Processing, Operations of Renewable Electricity Generation, and Energy Storage Technologies Compared to Fossil Fuel Technologies Under 2DS



Note: Extraction for construction includes the crade-to-gate emissions from the 17 minerals included in the analysis. Extraction and processing steel and concrete includes crade-to-gate emissions for steel and concrete and are included because of the scale of emissions from these two minerals compared to the 17 minerals included in the analysis. $GtCO_2$ = gigatons of carbon dioxide, GWP = global warming potential.

GHG emissions from just the operation of coal and gas facilities alone are comparable to 2017 GHG emissions[50] of more than 60 years of European Union emissions, at an annual basis. This finding is consistent with the wider literature that have examined the life-cycle footprint of the different energy technologies. It also falls in line with the IEA's estimation of coal combustion contributing to the 0.3°C of the 1°C increase in global average temperature above preindustrial levels, representing about 30 percent of total GHG emissions globally.[51]

The National Renewable Energy Laboratory (NREL) conducted an exercise attempting to harmonize the various life-cycle estimates of different energy technologies. The NREL's scope differs from the GWP estimated above, as this analysis focuses solely on the GWP relating to the mineral extraction and processing, as well as the operation of energy technologies, without considering the end of life of these technologies, but the findings from their work are similar.[52]

The takeaway from this GWP analysis is that, while a more ambitious climate scenario leads to a higher demand for number of minerals, the GWP of clean energy technologies, using a cradle-to-gate approach, is significantly smaller than coal and gas; therefore, the clean energy transition is the preferred means to achieve a 2°C or below pathway that is in line with the Paris Agreement and the Sustainable Development Goals.

GWP of Minerals

Given the material intensity of low-carbon technologies, as well as the implications associated with their disposal, particularly for battery technologies, current and future renewable energy policy should also take into account the emissions associated with these technologies' increased deployment. It should also be noted that the GWP analysis does not consider the environmental and social risks (for example, water, ecosystems, and so on) associated with increased extractive and processing activities, particularly **cross-cutting minerals** (quadrant 4) and **high-impact, cross-cutting minerals** (quadrant 3).

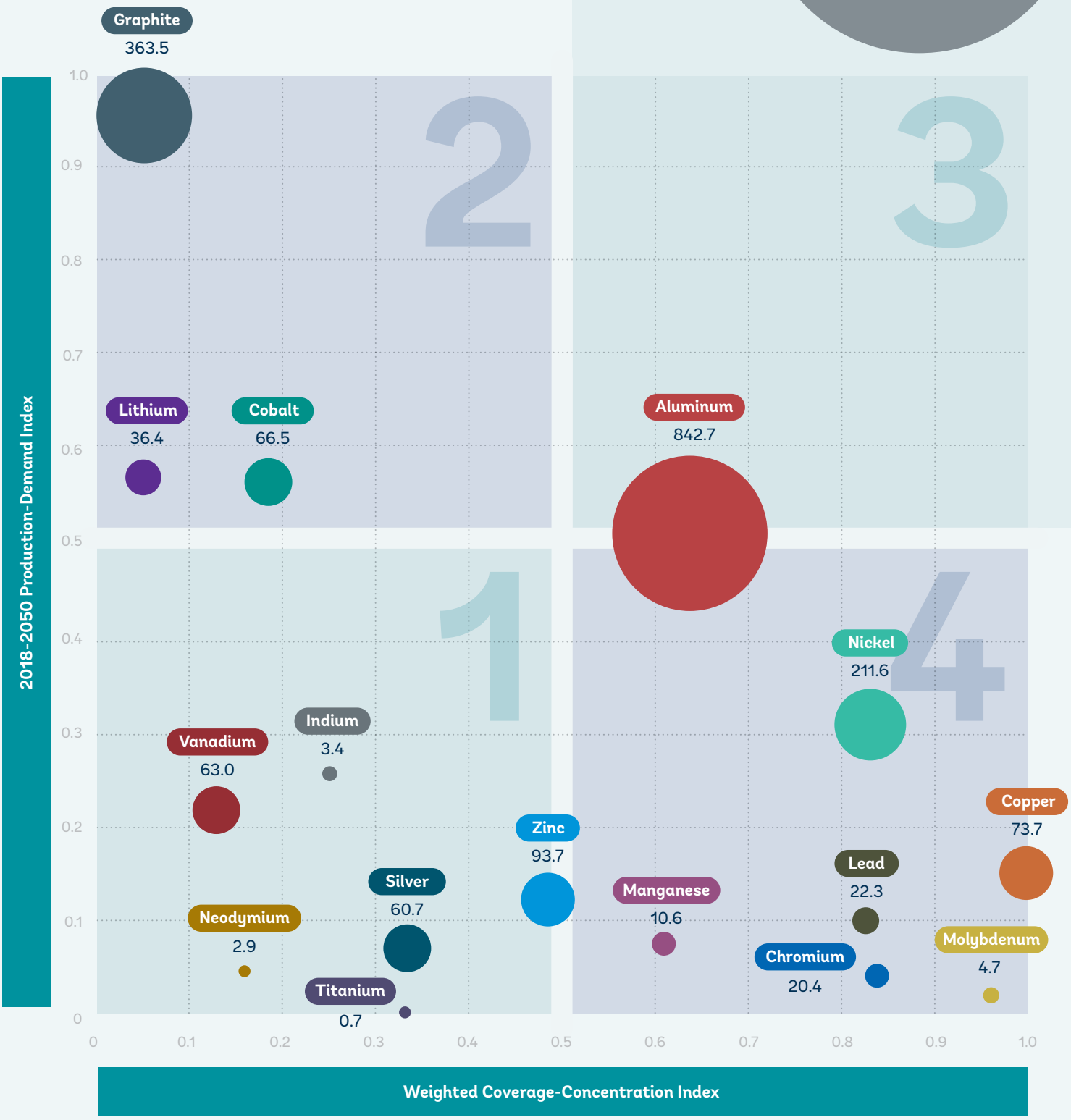
The GWP can also be used to look at the carbon intensiveness for each mineral, relative to the 2DS, to understand which mineral has the lowest and highest carbon footprint. Figure 5.2 shows the balance between the emissions impact of these minerals and their demand importance in the transition to a low-carbon energy system, with circle size representing a mineral's cumulative emissions up to 2050.

Aluminum has the highest cumulative carbon footprint under a 2DS, at 840 $MtCO_2e$, as solar PV is expected to be the most widely deployed renewable energy technology under that scenario, accounting for 87 percent of total aluminum demand; it is also used across a range of other energy technologies. Additionally, aluminum demand is expected to grow by 111 percent, from 48.8 million tons under the base scenario to 102.8 million tons in a 2DS. Aluminum is the highest ranked mineral on the demand index as it is a **high-impact, cross-cutting mineral**; it is used across a wide range of technologies and has the highest annual production levels, reaching 5.6 million tons per year by 2050.

50 Data sourced from Union of Concerned Scientists, "Each Country's Share of CO2 Emissions," published July 16, 2008, updated October 10, 2019, https://www.ucsusa.org/resources/each-countrys-share-co2-emissions.
51 Data available from the IEA Data and Statistics database: https://www.iea.org/data-and-statistics?country=WORLD&fuel=CO2%20emissions&indicator=CO2%20emissions%20by%20energy%20source.
52 The NREL finds that the mean carbon emissions per kilowatt-hour from solar PV is just 6 percent of the same kilowatt-hour produced by a coal plant, and 12 percent of a kilowatt-hour from a gas plant. More information on the project is available at "Life Cycle Assessment Harmonization," NREL: https://www.nrel.gov/analysis/life-cycle-assessment.html.

Figure 5.2 Total Cumulative Emissions from Cradle to Gate for Energy Technologies Through 2050 Under 2DS Compared to the Demand Index ($MtCO_2e$)

Emissions values are $MtCO_2e$.

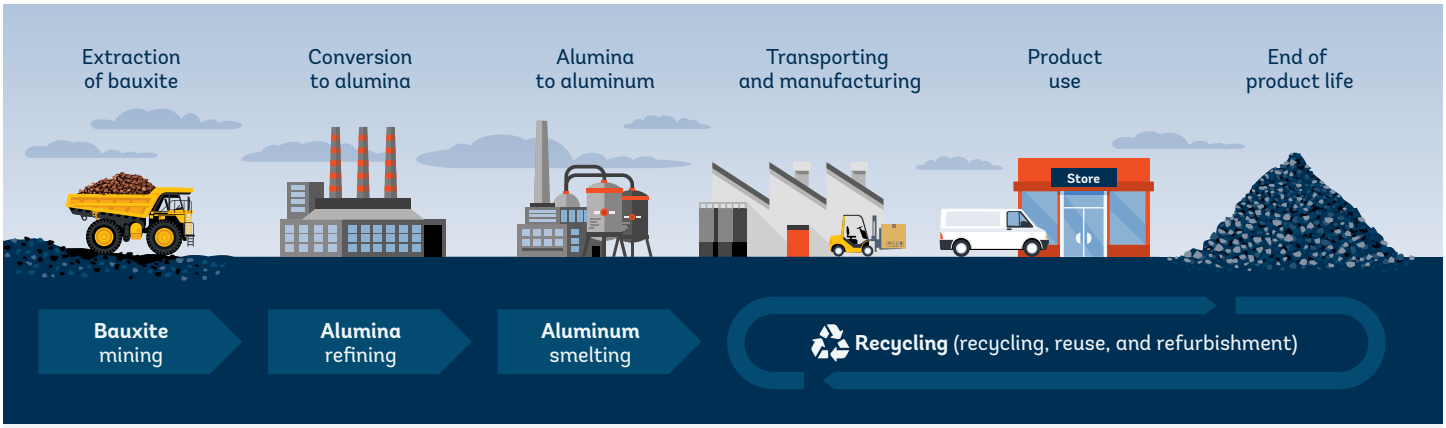


Graphite follows suit as a **high-impact mineral**, accounting for about 360 $MtCO_2e$ up to 2050 because it is exclusively used to manufacture anodes used in most battery technologies. Nickel has the third highest GWP and falls into the **cross-cutting mineral** category; it both has high levels of future demand, nearly doubling production from 2018 levels, and is used across a wide range of technologies.

Together, aluminum, graphite, and nickel production for energy technologies account for a cumulative 1.4 $GtCO_2e$ up to 2050, nearly equivalent to the total 2018 CO_2 emissions from France, Germany, and the United Kingdom combined.[53] Steel has not been included in the GWP analysis to avoid double-counting minerals such as nickel, titanium, iron ore, and chromium, given that these minerals are needed to produce steel. The emissions from steel would be so high, that its cumulative emissions would stand at 3.7 $GtCO_2e$—more than four times higher than the GWP of aluminum.

Six minerals have been selected from three of the four quadrants in the demand risk matrix to understand which energy technology has the highest GWP per mineral under a 2DS. Similar to trends above, aluminum accounts for the largest share of emissions,[54] led

Box 5.1 Reducing Emissions from Aluminum Production

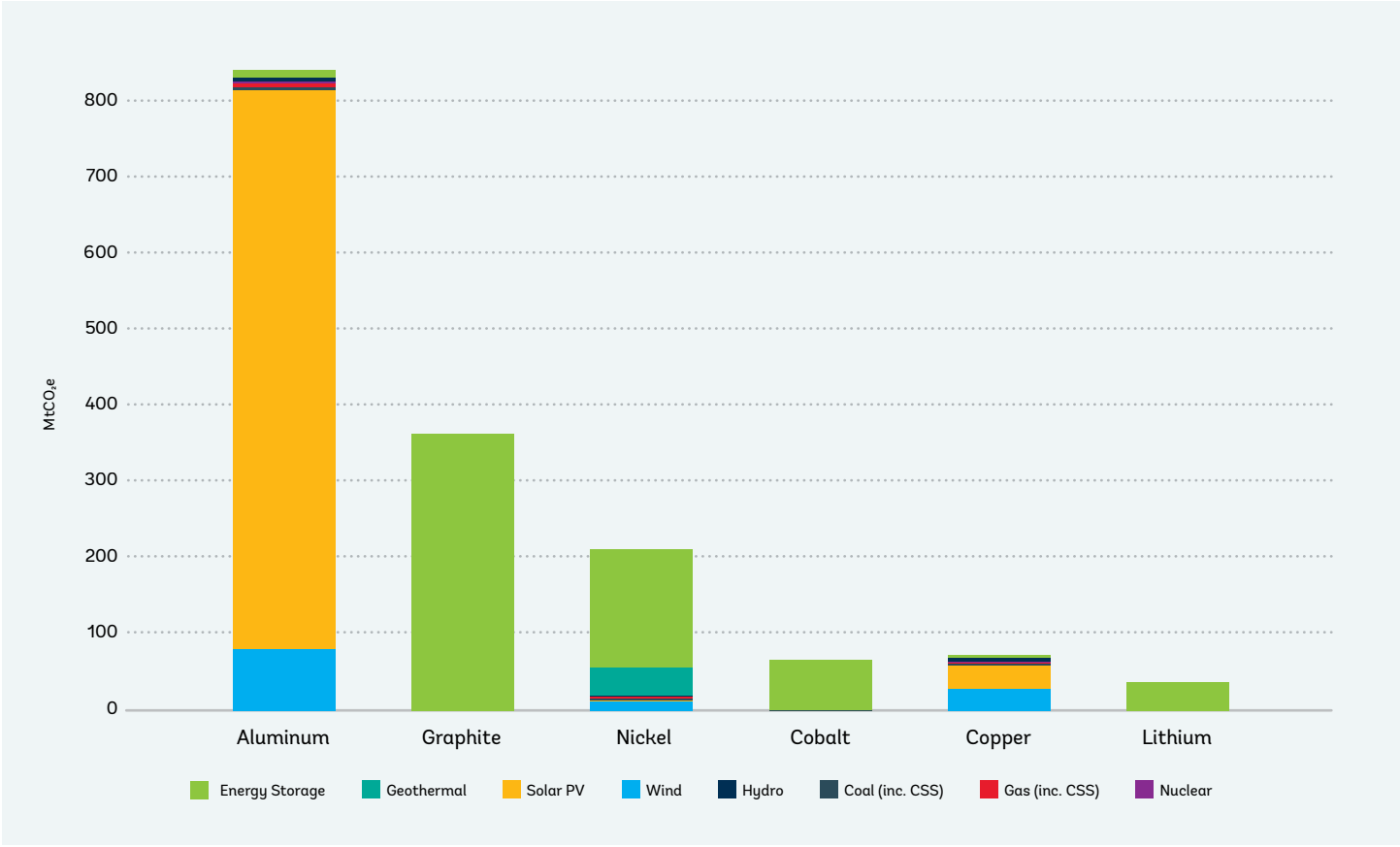


Primary aluminum production is a multistaged process that transforms bauxite that is dug out of the ground into first alumina (aluminum oxide) through crushing, washing, treating, and baking the bauxite (the Bayer process), and then into aluminum via electrolysis (Hall-Héroult process).

Emissions are produced at each stage, with the greatest proportion coming from the final stage because of the large amounts of electricity involved and the CO_2 that directly arises from the process itself. Emissions per ton of aluminum could fall dramatically in the future—especially from this final stage—as a result of the low-carbon transition itself. Increased renewable deployment reduces the carbon intensity of electricity and therefore the emissions from the electrolysis process. Using data from the academic literature, it is estimated that cumulative emissions of 840 $MtCO_2e$ from aluminum from energy technologies only could fall to under 500 $MtCO_2e$ as a result of these changes, and increased recycling. However, as the process of producing aluminum produces direct CO_2 emissions from the process of breaking down aluminum oxide (alumina) into aluminum, other technological advances will be needed to reduce emissions from the electrolysis process.

53 Data from "CO2 Emissions," Global Carbon Atlas: http://www.globalcarbonatlas.org/en/CO2-emissions.
54 A full overview of the aluminum production process and its associated emissions can be found in annex B.

Figure 5.3 Cumulative GWP from Extraction and Processing of Minerals, Not Including Operations, Using Cradle-to-Gate Through 2050 Under 2DS



Note: 2DS = 2-degree scenario, CCS = carbon capture and storage, CSP = concentrated solar power, GWP = global warming potential, $MtCO_2e$ = million tons of carbon dioxide equivalent.

by solar PV (87 percent) and then wind (10 percent) deployments, as seen in figure 5.3. Under a B2DS, total emissions for aluminum production to supply energy technologies increases to 0.9 $GtCO_2e$, representing an 8 percent increase from the 2DS. GHG emissions from cobalt, graphite, lithium, and nickel production primarily come from energy storage technologies specifically, although nickel is also used across a range of other energy technologies. Still, energy storage accounts for a large share of nickel's carbon footprint—154 $MtCO_2e$, representing 73 percent of total nickel emissions from energy technologies—while it accounts for 100 percent of graphite's carbon footprint equivalent (363 $MtCO_2e$).

As a cross-cutting mineral, copper is used across all energy technologies, with a total carbon footprint of 74 $MtCO_2e$ under a 2DS, similar to cobalt and lithium. However, the GWP copper figure may be vastly underestimated because copper is used in a wide variety of industries and crucial for the clean energy transition, from transmission infrastructure to connecting electric vehicles worldwide. Although aluminum's large carbon footprint primarily comes from solar PV, aluminum is also considered a cross-cutting mineral because it is used across six energy technologies, including electricity generation and storage.



Conclusion

Rising Overall Demand for Minerals

The demand for base and niche minerals to help build clean energy technologies are expected to rise substantially up to 2050, increasing in both absolute and percentage terms from 2018 production levels. Although clean energy technologies are distinct, they all share a common feature: Higher material intensity in comparison to fossil-fuel-based electricity generation. Regardless of which technology-based mitigation scenario is achieved to keep global warming under 2 degrees or beyond, the rapid and large-scale deployment of renewable energy will lead to significant increases in mineral demand because of how these technologies produce and store electricity.

Based on the model presented in this report, large relative increases in demand of up to nearly 500 percent are estimated for certain minerals, especially those concentrated in energy storage technologies, such as lithium, graphite, and cobalt. Even those minerals whose relative demand increases are smaller (for example, copper) still face large increases in absolute demand. Different energy technologies require different types of minerals, either to build their structures or frames, or as components in the technology used to generate electricity, such as the PV cells in solar PV and magnets or motors in wind turbines. Therefore, the technology pathway that emerges from the clean energy transition will shape the types of minerals that will experience the largest increases in demand. That said, regardless of which low-carbon technology pathway is selected, overall mineral demand will still increase.

Technologies involved in the clean energy transition are emerging, evolving, and improving rapidly through innovation and increased deployment. Thus, the way in which the low-carbon transition will emerge is very difficult to predict. This analysis relied on the IEA and IRENA scenarios to model the future energy system, but it is highly likely that a very different mix of electricity generation, and especially energy storage technologies, will emerge as a result of policy choices, technological innovation, and market forces. New technologies such as floating offshore wind or hydrogen fuel cells could emerge and dominate the market, or their commercialization could be hindered by costs or policy barriers. The increases in demand for specific minerals from the model should be regarded as a possibility that could emerge and are subject to shifts in policy or technologies. The overarching conclusion—that mineral demand will increase—is agnostic to the exact mix of technologies and subtechnologies that may be deployed up to 2050.

Opportunities and risks are present for both the mining sector and the governments that have low-carbon minerals, particularly in mineral-rich developing countries. For the mining industry and resource-rich economies, there are environmental and social challenges that need to be addressed as a result of mining activities. The use of scarce water resources, for example, can create conflict between mining companies and the communities around which they operate. For developing countries specifically, these environmental and social issues are exacerbated by weak governance. Countries that host these minerals are likely to see an increased demand, which, if well managed, could contribute to economic growth and sustainable development. Understanding how demand patterns for these crucial minerals may shift in the face of a new energy system is crucial to long-term planning for countries that produce these minerals and deploy renewable energy technologies as part of their national climate ambitions.

Mineral Demand Vulnerability and Risks

Meeting the challenge of large-scale deployment of renewable energy requires the steady availability of a variety of key minerals as well as stable prices and minimal market disruptions. This is particularly true in developing countries that need to deliver on SDG 7, *"access to affordable, reliable, sustainable and modern energy for all."* Understanding that each mineral may carry different demand risks is crucial for the mining industry and governments, both of which need to be prepared for changes in low-carbon technology deployments, potentially causing large and volatile shifts in mineral demand. Understanding that minerals can have varying demand risks can also provide insight into potential recycling opportunities and needs.

This report has gone beyond estimating mineral demand under different climate scenarios, specifically by developing a new framework to understand the demand risks that may be associated with a group of specific minerals. Some minerals will face potentially large increases related to only one technology (or subtechnology), while others will face lower but more broad-based increases in absolute demand. Understanding which minerals fall into which demand risk category is crucial for miners, renewable energy developers, and policy makers to build a comprehensive plan for the clean energy transition.

The **demand risk matrix** provides an overview of how 17 minerals identified as key to the low-carbon transition are impacted by different demand profiles.

I. Medium-Impact Minerals

- Medium-impact minerals, such as titanium and neodymium, are still affected by demand increases and may still play an important role in the clean energy transition. Even though medium-impact minerals neither have high levels of relative demand nor are cross-cutting across a range of energy technologies, the markets for these minerals could still be affected. Although their relative demand increases are small in the climate scenarios presented, future changes in technology deployment could cause significant increases in demand for these minerals.
- Medium-impact minerals are not used in a wide range of technologies but are crucial components of specific technologies, such as neodymium for offshore wind and titanium for geothermal. Issues that threaten the ability of the market to meet this demand could severely impact the deployment of these specific technologies as well as change the shape of the low-carbon transition. In some cases, substitution and efficiency may be possible, as demonstrated in the case of neodymium for wind energy, but this may be limited in many instances. While this analysis, again, does not assess mineral supply risk, neodymium is a rare earth, and more than 70 percent of rare earths are currently produced in China.

II. High-Impact Minerals

- The clean energy transition has significant implications for the production of certain minerals. High-impact minerals such as graphite, lithium, and cobalt will, under a 2DS, need to increase their production significantly, up to nearly 500 percent by 2050 from 2018 levels. Most of this demand will come specifically from energy storage technologies; it could also carry supply risks, as more than 60 percent of graphite and cobalt production are concentrated in China and the Democratic Republic of Congo, respectively.
- Demand for high-impact minerals is therefore both potentially high and uncertain, raising opportunities and risks to both the renewable energy industry and those involved in the supply chain of these minerals. Relatively small changes in the amount and type of energy storage technologies and subtechnologies deployed could have large implications for the markets of these minerals. Similarly, any potential challenges in meeting this demand could cause changes within the storage sector, causing industry to change battery chemistry or even battery type.

III. High-Impact, Cross-Cutting Minerals

- High-impact, cross-cutting minerals, such as aluminum, are critical not only because their demand does not depend on one specific technology, but also because they are needed in higher quantities across a wide variety of energy technologies. High-impact, cross-cutting minerals are less susceptible to fluctuating demand risks because the high level of demand for these minerals will always exist no matter what type of energy technology or subtechnology is deployed up to 2050. Additionally, the scale-up in demand required is significant, implying there is a greater trigger from demand to increase supply, compared to minerals that are just cross-cutting. This makes this category of minerals a high risk for both producers and consumers alike, but also a potential opportunity for producers who will supply these minerals to meet this higher demand.
- Demand for high-impact, cross-cutting minerals is likely to be high and fairly certain over time. For aluminum specifically, its future use and production may have significant implications on the clean energy transition because it is used across

most technologies and has absolute demand figures that significantly outweigh all 17 minerals except graphite. Solar PV accounts for 87 percent of total aluminum demand since it is expected to be the most widely deployed clean energy technology as climate scenarios become more ambitious. Aluminum is thus vital to the low-carbon energy future. The challenge is to provide a steady supply of high-impact, cross-cutting minerals, like aluminum, at a cost that allows the renewable energy sector to fulfill its potential.

IV. Cross-Cutting Minerals

- Even without large increases in relative demand, minerals may be greatly impacted by the low-carbon transition. For some minerals, such as copper, future demand from clean energy technologies may not represent a large portion of current production levels.[55] However, the amount of those minerals needed, in absolute terms, outweighs the production of other minerals whose relative increases are much greater; the increase in demand is still large enough to have an impact on the overall market and availability of those minerals. Again, these projected demands only account for energy technologies and do not include the transmission lines needed to integrate these technologies into electricity grids.
- Cross-cutting minerals are also used across a wide range of electricity generation and energy storage technologies, meaning that future increases in demand are less reliant on the fate of any one technology. For these minerals, where relative demand may not be high but the absolute demand may be, this projected demand has a high certainty of occurring. Meeting this demand is also crucial to the entire fate of the low-carbon transition as these minerals are vital in many energy technologies. Even without large triggers from rapidly increasing relative demand, it will be crucial that supply can meet demand.

Role of Recycling and Reuse

Recycling, reuse, and refurbishment have important roles in limiting and meeting future demand for minerals for clean energy technologies, but extraction of mineral resources will still be needed. Recycling rates, both end of life and recycled content, vary greatly across minerals. Current recycling rates could reduce the required primary demand for minerals involved in the low-carbon transition. Future increases in recycling rates can play an important role in mitigating increases in demand for primary minerals, as can reuse of components for energy storage technologies, such as Li-ion batteries, although commercial application of such reuse is currently limited. Incentivizing recycling, reuse, and refurbishment is a vital part of the low-carbon transition. However, more policy measures are needed to scale up action in this area, all the while remaining cognizant of both economic and environmental challenges associated with the recycling processes.

Even with large increases in recycling—including a scenario where 100 percent EOL recycling is achieved—there is still likely to be strong demand for primary minerals. This is especially the case for those minerals with the highest growth in demand, which lack existing material to recycle and reuse. Even if large increases in the mineral recycling sector can be achieved, there will still be a need to meet remaining primary demand. Further work will be needed in this area to ensure that recycling processes are carried out in a responsible way. Policy measures are needed that encourage energy efficiency, environmentally and socially sound practices, and innovation to ensure that clean energy technologies can be safely and efficiently dissembled and recycled.

Emissions Mitigation and Reduction Opportunities

While deploying renewable energy is one of the most effective ways to decarbonize the electricity sector, the mineral intensity of clean energy technologies must be addressed. Even if the emissions from the mineral production and operation of clean energy technologies are just 6 percent that of coal and gas generation, the emissions are not insignificant. Greening the electricity sector will require that upstream- and downstream-related emissions are addressed. Policy and innovation will be needed to *"take urgent action to combat climate change and its*

55 Current production refers to minerals produced in 2018, based on the Mineral Commodity Summaries, U.S. Geological Survey.

impacts" (SDG 13) while integrating these emissions reductions into countries' Nationally Determined Contributions (NDCs).

Deploying renewable energy technologies globally without taking into account the mineral demand risks and the additional carbon emissions from upstream and EOL activities may hinder rather than accelerate progress on SDG 7 and SDG 13. The emission intensity of each mineral has been captured within the **demand risk matrix** to offer insight on potential avenues to maximize emissions reduction and mitigation efforts from clean energy technology production and end use. While providing a steady and cost-effective supply of minerals is vital to enable the global deployment of clean electricity generation and storage, the various demand risk profiles also mean that different mitigation strategies need to be employed to decarbonize the various areas of the clean energy mineral supply chain.

Understanding and analyzing the full mineral supply chain for low-carbon technologies are critical to effectively realize climate ambitions. This means that the clean energy transition must take into account that (1) current and future mineral production, including recycling, meets increasing demand up to 2050; (2) emissions associated with increased mineral production are effectively mitigated or reduced while ensuring a continued, stable, and affordable supply of these minerals to support a low-carbon transition; and (3) innovation is leveraged to ensure that these technologies can be safely disposed, easily dissembled, and the mineral contents recycled, at economically reasonable levels, to partially meet this new demand.

The scale, intensity, and causes of emissions vary from mineral to mineral. Mining silver, for example, is emissions intensive, though silver is not demanded on a large scale. Silver production will rise 15 thousand tons annually by 2050, from the demand of solar PV and CSP technologies alone, compared to 27 thousand tons produced overall in 2018 (USGS 2018b). On the other hand, 5.6 million tons of aluminum, produced from bauxite ore, is needed under a 2DS by 2050 to supply just low-carbon technologies, compared to 60 million tons of total aluminum produced for all uses in 2018 (USGS 2018a). Other minerals, such as copper, have smaller GHG footprints per kilogram, but they are needed at a larger scale relative to silver. Understanding these complexities and tailoring different policy approaches for reducing the carbon footprint of these different minerals are key.

Tailoring strategies to all the different categories of minerals is critical for both helping meet the challenge of supplying strategic minerals and minimizing emissions from the clean energy transition. Aluminum, for example, falls into the high-impact, cross-cutting minerals category and happens to have the largest cumulative emissions under a 2DS or beyond. That makes it crucial for more attention to be focused on the entire aluminum supply chain to ensure steady and affordable supply, all the while decarbonizing primary aluminum production. All stakeholders along these minerals' supply chains should look for strategies that can help reduce emissions and not exacerbate demand risks. These strategies can include government policy support, technological innovation by industry, and end users incentivizing suppliers to reduce their GHG emissions for products they are going to buy.

Some of the interventions to scale up renewable energy may offer double wins, helping both to boost economic growth in resource-rich developing countries and to reduce climate and environmental risks. One example relates to the emissions associated with the transportation of the minerals, as well as to facilitating value-added production in countries where extraction takes place and boosting manufacturing capacity for renewable technologies in areas where demand is strong—for example, solar PV in Africa, given the region's massive solar resources. Although this lies outside the scope of this analysis, these emission reduction and mitigation opportunities may be significant for particular minerals and technologies, depending on where renewables will be deployed and where these minerals will be produced.

GHG emissions from steel and cement production are most likely significantly higher than emissions generated by the majority of the 17 minerals identified in this analysis. Steel production currently accounts for nearly 7–9 percent of total GHG emissions worldwide (WSA 2020), while cement accounts for nearly 8 percent (Rodgers 2018). Thus, for certain clean energy technologies, estimated GHG emissions associated with their production may be vastly underestimated when these are excluded. For technologies such as wind, geothermal, and hydroelectricity, steel and cement are major inputs, but they have

been unaccounted for in this analysis because of potential double-counting issues, as a variety of minerals included in the model are needed to produce steel. Enhanced international cooperation on reducing the GHG footprint of these two industries will be crucial to effectively decarbonize the production of low-carbon technologies, from an upstream perspective.

Recycling some of these low-carbon technologies once they reach end of life could help reduce emissions associated with primary mineral production, but the emissions associated with the energy intensiveness of recycling processes also need to be considered. Recycling alone cannot eliminate all emissions associated with supplying minerals, but it could have a dramatic effect in reducing some of these emissions. For example, secondary aluminum (for example, recycled content) could have a carbon footprint that is about 5–10 percent of that coming from primary aluminum production (Nuss and Eckelman 2014). Increasing recycling therefore can greatly assist in the transition to a cleaner energy system, but challenges relating to the availability of mineral scrap and the need for purity of materials in some applications must be faced, along with reducing the emissions intensity of recycling processes themselves.

Risks Beyond the Model

The model presented here provides key insights to potential future pathways for mineral demand under different levels of ambition on climate change; however, it provides findings on just one part of a complex system. Two crucial areas, supply and wider environmental and social risks, are not covered, but they are important in understanding the wider context of the report.

Supply Risks

Overall, demand for minerals is likely to be high, varied, and in some cases uncertain. It will fluctuate with changes in technology and subtechnology deployments, market conditions, and national and international trends. It is critical to ensure that supply can meet this demand—and in a manner that minimizes the negative consequences of primary mineral production while ensuring that the minerals crucial to either the entire low-carbon transition or key technologies within that transition are supplied to the market consistently. Understanding the supply risk is crucial for developed and developing countries, which are consumers and producers alike, to meet SDGs 7 and 13. This analysis does not address supply, including the material impacts associated with the increased extraction and production of base, precious, and rare minerals.

While this report does not consider potential mineral supply risks, it is on the basis that resource-rich developing countries will be major contributors to the clean energy future by producing a significant part of these strategic minerals and supplying them to the global market. Based on the World Bank's Growing Role of Minerals and Metals for a Low Carbon Future (2017), a number of key developing countries have been identified as having a potentially consequential role in producing these strategic minerals.

Wider Environmental and Social Risks

This report will inform policy makers, private sector actors, and civil society organizations in their quest to help resource-rich developing countries sustainably and responsibly produce the minerals needed to deliver on SDGs 7 and 13. Beyond specific climate-related risks, other environmental and social risks of increased mineral extraction also need to be considered throughout the supply chain. These have not been addressed in this analysis given the focus on GHG emissions.

From a broader environmental perspective, for example, the water intensiveness of the mining sector and the impact of deforestation need to be integrated in how these minerals will need to be produced to sustainably supply clean energy technologies. From a social perspective, understanding issues such as the impact of mining upon local communities is vital to ensure that the transition to a clean energy system is beneficial for all. Given how critical minerals are to the low-carbon transition, a failure to address these wider environmental and social risks could facilitate a backlash against renewable electricity generation and energy storage technologies needed to mitigate GHG emissions.[56]

56 Recent reports such as the World Bank's *Forest-Smart Mining: Identifying Factors Associated with the Impacts of Large-Scale Mining on Forests* (2019) and *Building Resilience: A Green Growth Framework for Mobilizing Mining Investment* (2019), and the IFC and ICMM's *Shared Water, Shared Responsibility, Shared Approach: Water in the Mining Sector* (2017) have shed light on some of these challenges and offered potential solutions. More research will be needed to understand the wider environmental and social risks from increased mineral production.

Next Steps and Actions

The **World Bank Group's Climate-Smart Mining** Initiative supports the sustainable extraction and processing of minerals and metals to secure supply for clean energy technologies while minimizing the climate and material footprints throughout the value chain of those materials by scaling up technical assistance and investments in mineral-rich developing countries. Achieving these objectives would represent a key win-win for climate: It would allow the wide rollout of renewable and storage technologies, required under ambitious climate scenarios, while minimizing the emissions and material footprints associated with those technologies. Being able to understand which minerals are needed for which energy technologies and subtechnologies is crucial to help renewable energy developers, miners, and governments understand where the major risks lie along the clean energy supply chain in order to reduce mineral demand, environmental and climate-related risks.

The **Climate-Smart Mining** Initiative addresses these challenges by working together with governments, development partners, industries, and civil society. Combining climate-smart mining with an understanding of the demand risks can provide actionable insight for climate, energy, and mining stakeholders to identify opportunities to reduce the carbon and material footprints of increased climate ambition while maintaining a stable supply of minerals. Each stakeholder along the supply chain has a role to play:

- ***Climate policy makers:*** With minerals playing a vital role in enabling the clean energy transition, it will be crucial for members of the climate community to work closely with producers of those minerals—including resource-rich developing countries and the mining industry—to ensure that the associated emissions are effectively mitigated. Mineral-rich countries that make it a priority to reduce emissions from mineral production, through **climate-smart mining** practices, could integrate their decarbonization efforts in their NDCs under the Paris Agreement. To address some of these challenges, climate stakeholders can do the following:
  - ✓ Actively support mineral-rich countries that make it a priority to reduce emissions from mineral production, through climate-smart mining practices, while helping them integrate their decarbonization efforts in their NDCs.
  - ✓ Support measures that aim to decarbonize the full supply chain of low-carbon technologies, including emissions from the transportation of minerals between mines and processing facilities, as well as the emissions from manufacturing these technologies.
  - ✓ Leverage new and existing frameworks, such as the demand risk matrix, to focus on minerals that require a more targeted approach for climate mitigation strategies to supply specific clean energy technologies.
- ***Clean energy stakeholders:*** The energy sector also has an important role to play in ensuring that the low-carbon technologies they are developing and deploying are being produced sustainably and responsibly while taking into account the waste management of these technologies once they reach end of life. The energy community can play a role in helping producers of minerals reduce their carbon footprint by engaging with countries and mining companies. With the mining sector accounting for 2–11 percent of the world's total energy consumption, it will be important for the energy sector to work closely with miners to ensure that minerals are produced using clean sources of energy and **climate-smart mining** practices. Specifically, the energy sector should do the following:
  - ✓ Focus on reducing the environmental and carbon footprints of the full supply chain of their technologies, from working with miners by helping them adopt climate-smart mining practices to working on easing decommissioning, reuse, recycling, and refurbishment to increase the lifetimes of these technologies.
  - ✓ Connect with stakeholders across the mining sector as well as those involved in the recycling industry to assist in approaching these challenges from a holistic perspective.
  - ✓ Use frameworks, such as the demand risk matrix, to understand where the greatest demand challenges may lie and where innovation may need to be focused to reduce the use of particular materials.

- ***Mining Stakeholders:*** The mining community should position itself as a contributor to SDG 7 by ensuring that the climate and material footprints associated with the minerals they supply are minimized. Innovation is necessary to reduce the amount of energy, water, and land needed to mine these minerals. Without putting into place measures that address these challenges, by adopting **climate-smart mining** practices, it will be difficult for the mining sector to position itself as a champion and enabler of the clean energy transition. Specific actions recommended for the sector:
  - ✓ Mainstream the use of climate-smart mining practices to reduce the carbon and material footprints of supplying the critical minerals needed for the low-carbon transition.
  - ✓ Build networks with those involved at all stages of low-carbon technology supply chains, to help build understanding of the opportunities, challenges, and risks in supplying the materials needed for the low-carbon transition.
  - ✓ Encourage and advocate for innovation to develop and share new technological developments to green mineral supply chains. This includes developing new methods to reduce water use, increase energy efficiency, deploy clean energy trucks and processing technology, and explore mineral recycling opportunities.
- ***Governments:*** Policies will have a pivotal role to play in ensuring that **climate-smart mining** practices are adopted throughout the entire supply chain of low-carbon technologies, to secure the supply of these minerals through sustainable and responsible means, while integrating a circular approach to these minerals. Most notably, policy makers should consider doing the following:
  - ✓ Encourage, incentivize, and remove economic and technical barriers to recycling, reuse, and refurbishment of the technologies involved in the clean energy transition.
  - ✓ Work with the mining sector and renewable energy developers to understand where the greatest demand risks may occur.
  - ✓ Work with the mining sector and users that produce and consume these minerals to ensure that climate-smart mining practices are encouraged and incentivized, and that economic and technical barriers are removed.





Rio Tinto, Diavik Diamond Mine, Canada



Annex A.
About Climate-Smart Mining

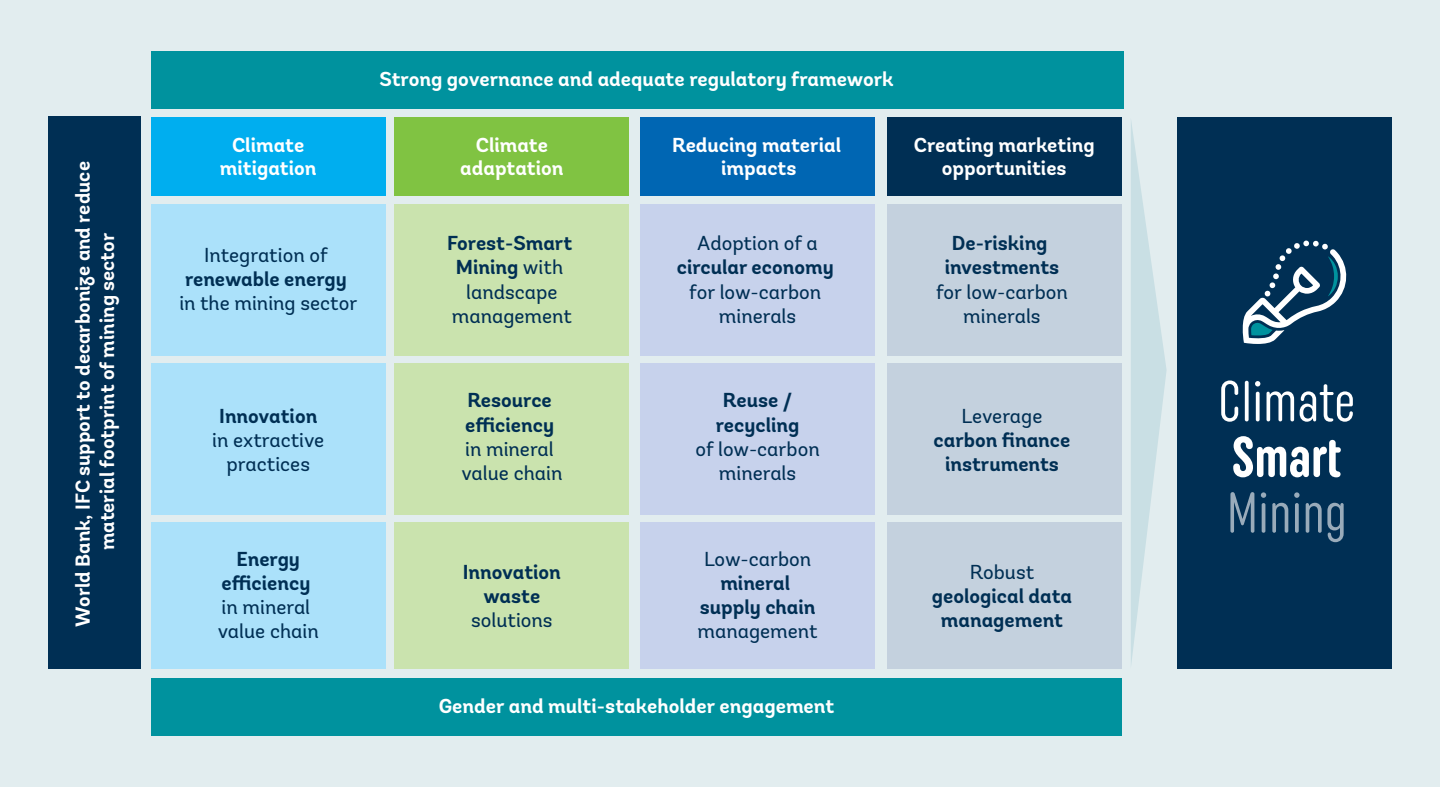
The Climate-Smart Mining Initiative will help resource-rich developing countries benefit from the increasing demand for minerals and metals, while ensuring the mining sector is managed in a way that minimizes its environmental and climate footprints.[57]

The initiative supports the responsible extraction and processing of minerals and metals to secure supply for clean energy technologies by minimizing the social, environmental, and climate footprints throughout the value chain of those materials by scaling up technical assistance and investments in resource-rich developing countries.

While the growing demand for minerals and metals provides economic opportunities for resource-rich developing countries and the industry alike, significant challenges will likely emerge if the climate-driven clean energy transition is not managed responsibly and sustainably. Without climate-smart mining practices, negative impacts from mining activities will increase, affecting already vulnerable communities in developing countries, as well as the environment in which they operate.

The Climate-Smart Mining Initiative has been developed to align with the Sustainable Development Goals and the Paris Agreement to ensure that the decarbonization of the mining and electricity industries also benefits the resource-rich countries that host these strategic minerals and the communities directly impacted by their extraction, as well as the developing countries that are projected to deploy renewable energy technologies to reach their climate ambitions.

Figure A.1 Climate-Smart Mining Building Blocks



57 "Climate-Smart Mining: Minerals for Climate Action" (Brief), Extractive Industries, World Bank, https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action.

Annex B. Methodology

A number of assumptions, data, and methods were utilized in the model. This annex expands on the methodology discussed in the report.

Energy Storage Assumptions

Modeling future energy storage pathways is difficult because of the rapidly emerging nature of the different technologies involved, and the relative lack of publicly available scenarios to draw on. As such, a number of assumptions were made on the basis of a broad reading of the literature and discussions with industry experts.

- **Automotive energy storage assumptions**
  - By 2030, all automotive energy storage is met by li-ion batteries. Up to 2030, the use of lead-acid batteries declines linearly to zero.
- **Automotive energy storage assumptions**
  - By 2030, all automotive energy storage is met by Li-ion batteries. Up to 2030, the use of lead-acid batteries declines linearly to zero.
- **Stationary energy storage assumptions**
  - Energy storage requirements are met by 90 percent grid-scale energy storage and 10 percent decentralized.
  - Decentralized energy storage transitions to an equal mix of lead-acid, Li-ion, and other energy storage technologies by 2050.
  - Grid-scale energy storage is met by a majority of Li-ion batteries (70–84 percent of capacity, depending on scenario) and a small percentage of lead-acid (2.5–5 percent). Other technologies (mostly pumped-energy storage) decline in importance to between 17 and 25 percent, while vanadium redox flow batteries grow at a rate of 5 percent of extra additional capacity per year to account for between 2.8 and 3.7 percent of capacity by 2050, depending on the scenario.

Weighted Coverage-Concentration Index

The weighted coverage-concentration index is calculated on an equal weighting of two items: (1) the number of technologies that require one mineral, and (2) the share of demand for minerals that comes from a single technology. This index is normalized to 1 for copper, with all other minerals rated against that mineral. The two components are calculated in the following way:

- *Number of technologies that require one mineral.* This is calculated by counting how many technologies the mineral plays a role in. Any minerals used in energy storage are given a value based on the overall demand of minerals from energy storage compared to energy generation (6 percent). Those minerals also used in generation technologies are given a score based on the share of total installed capacity in 2050 in the 2DS that the technologies the minerals are used in account for, multiplied by the total amount of minerals used in generation (94 percent). For example, if a mineral was just used in wind, it would receive a score of 0.22 because wind accounts for 23 percent of installed capacity in 2050 and this would be multiplied by 94 percent. The more technologies a mineral is involved in, the higher the value.
- *Share of demand for the mineral that comes from a single technology.* This is calculated by subtracting from 1 the largest percentage share of demand from one technology. For example, if 60 percent of demand from a mineral comes from wind, then this would be calculated as 1 – 0.6 = 0.4. The idea behind this is that the lower the share from any one technology, the more cross-cutting the mineral.

2018–2050 Production-Demand Index

The 2018–2050 production-demand index is calculated on an average of absolute and relative demand, as discussed above. The data used to calculate this index are given in table B.2.

Table B.1 Implication of Clean Energy Transition on Mineral Demand Challenges

Quadrant	Category	Implication
Quadrant 1	**Medium-impact minerals**	Quadrant 1 minerals may appear to be less of a priority, but that may not necessarily be the case. Some of these minerals may be critical to key subtechnologies, and although some substitution may be possible, they may be strategically important to the clean energy transition. Since these minerals may not face the high levels of demand faced by quadrant 2 minerals, nor the stable conditions faced by quadrants 3 and 4, less priority may be given to these minerals, but in turn, this may result in potentially increasing their criticality, if supply constraints exist.
Quadrant 2	**High-impact minerals**	Demand for minerals in quadrant 2 is much higher, but it is much more concentrated in certain technologies or subtechnologies. Demand growth could be substantial, but potentially more varied if shifts in policy, market conditions, or other key factors cause different types of technology or subtechnology to be deployed at greater, or lesser, levels.
Quadrant 3	**High-impact, cross-cutting minerals**	Quadrant 3 minerals encounter the dual challenge of meeting high levels of demand from a broad range of technologies. They do not face the same challenges of technology choice as quadrant 2 minerals, but they face higher levels of relative demand than quadrant 4 minerals. Demand pressures are thus likely to be highest and most stable in these minerals.
Quadrant 4	**Cross-cutting minerals**	Quadrant 4 represents stable and steady levels of demand. Minerals in this area are not so dependent on shifts in energy technology, and greater levels of climate ambition are likely to lead to increases in these minerals across the board. Demand growth is therefore likely to be predictable and steady.

Table B.2 2018 Mineral Production and 2050 Projected Annual Demand from Energy Technologies

Mineral	2018 annual production (Tons, thousands) [a]	2050 projected annual demand from energy technologies (Tons, thousands)	2050 projected annual demand from energy technologies as percent of 2018 annual production
Aluminum	60,000	5,583	9%
Chromium	36,000	366	1%
Cobalt	140	644	460%
Copper	21,000	1,378	7%
Graphite	930	4,590	494%
Indium	0.75	1.73	231%
Iron	1,200,000	7,584	1%
Lead	4,400	781	18%
Lithium	85	415	488%
Manganese	18,000	694	4%
Molybdenum	300	33	11%
Neodymium	23 [b]	8.4	37%
Nickel	2,300	2,268	99%
Silver	27	15	56%
Titanium	6,100	3.44	0%
Vanadium	73	138	189%

a. Data for 2018 annual production sourced from the U.S. Geological Survey.
b. Data sourced from Deetman et al. (2018).



Global Warming Potential

The estimates for the GWP of the minerals used in the clean energy transition presented here come with a number of caveats, and avenues for future research. They are based on GWP per kilogram from historical sources and are static—that is, they do not take into account changes in the composition of relevant low-carbon technologies. Nor do they take into account future changes in electricity mix, declining ore grades, changing technologies, shifts in relative prices, or increases in recycling activities. They also do not take into account wider environmental impacts such as health, water, and ecosystem loss from the extraction of the minerals required to build renewable energy technologies.

To calculate their data, Nuss and Eckelman (2014) drew on a wide variety of data sources, and included various production techniques for each metal, creating a weighted average of GWP per metal on the basis of historical shares of each production technique. The details behind estimate of GWP are vast and based on a wide variety of data, techniques, and assumptions. For example, copper production is based on seven different production techniques, utilizing different ore types.

The estimates of GWP per kilogram are based on a share of primary and secondary production based on historical data. Should recycling of key metals increase significantly, as discussed in the main report, then the GWP of the final demanded metal could change substantially. For example, Nuss and Eckelman (2014) estimated the GWP of primary aluminum from bauxite ore at between 8.7 and 30.5 times the GWP of secondary aluminum (depending on the source of the scrap aluminum used). Therefore, significant increases in secondary aluminum production would reduce the overall GWP of aluminum used in energy technologies—with the caveat of there being a readily available supply of scrap aluminum.

With respect to ore grades, van der Voet et al. (2019) found little evidence for declining ore grades for bauxite, iron, or manganese, but they did find declining long-term trends for copper, zinc, lead, and nickel, which will work to increase their GWP numbers, because of higher energy inputs to extract and process the materials to obtain the same amount of ore. Declining ore grades brings increase in associated environmental impacts—for example, an increase on the volume of waste generated produces larger tailings as well as impacts on local ecosystems. For production techniques, the authors again find differing impacts, with a clear trend in improved process efficiencies reducing energy demand in steel production. No such advances have been made for processing bauxite ore into alumina and only a slow improvement in conversion efficiencies of alumina into aluminum.

The conclusion to be drawn is that there are no consistent patterns of improvement in projected future GWP per kilogram of

metals—pathways will differ from metal to metal depending on the dependence on electricity as an energy source and other factors.[58] More research is needed in this area, extending the work conducted by van der Voet et al. (2019). The model notes these key future changes to the GWP per kilogram but uses the static data from Nuss and Eckelman (2014) as a starting point to conduct analysis, noting the limitations and future changes discussed above.

Shifting Aluminum Emissions

The production of aluminum from bauxite ore is a multistaged process, creating different amounts and types of greenhouse gas emissions at the various stages (figure B.1). The carbon intensity of aluminum production is likely to change in the future because of changes in the carbon intensity of electricity, the efficiency of the technologies involved in the process, and the grade of ore extracted from the ground.

The first stage of the process is the extraction of bauxite from the ground. Emissions from this part of the process account for 0.2 percent of emissions per ton (Tan and Khoo 2005), resulting from the use of fuels to run the machinery needed to clear earth and dig mining pits, and to extract and crush the bauxite.

The next stage of the process is the transformation of bauxite to alumina, or aluminum oxide. This is done by a four-stage "Bayer" process, which involves the digestion of the bauxite with caustic soda, the clarification of liquor streams, the precipitation of alumina hydrate, and the calcination of alumina. This latter stage involves heating the alumina in a kiln to temperatures in excess of 1,000°C. Emissions at this stage account for approximately 13 percent of total emissions (Tan and Khoo 2005), resulting from the combustion of fossil fuels at various stages of the process, such as the heating of the kilns.

The final stage transforms the alumina to aluminum via the Hall-Héroult process. This stage is the most carbon-intensive part of the process, accounting for 60–90 percent of emissions (Carbon Trust 2011). It involves the use of large amounts of electricity and therefore its emissions vary greatly depending on the source of the electricity. The process involves the electrolysis of alumina. The electrolysis process involves carbon anodes, separating the oxygen from the alumina (or aluminum oxide) and attaching it to the carbon in the anode, creating CO_2 (and other greenhouse gases) in the process. Thus, emissions come both from the electricity involved and as a direct result of the process.

Emissions may potentially shift at all three stages of the aluminum production process. The scale of these shifts will depend on the penetration of renewables into the electricity grid along with technology improvements and changes in the ore extracted. These shifts may cause the carbon intensity of aluminum to shift in different directions. Higher penetration of renewables will cause the carbon intensity to reduce, while declining ore grades are likely to increase the carbon intensity.

Estimates of the future path of emissions are scarce in the literature, although van der Voet et al. (2019) do provide estimates under adapted GEO-4 scenarios. Under the equitability first scenario—a sustainable development scenario that the authors link to the WEO 450 scenario—aluminum emissions decline by 43 percent per ton by 2050. Although the scenarios are not completely analogous, the impact of these shifts is illustrated in the estimates of the GWP of aluminum up to 2050 under the 2DS. Total aluminum emissions for use in energy technologies declines from 840 $MtCO_2e$ to 550 $MtCO_2e$ under the 2DS (reducing to 454 $MtCO_2e$ if end-of-life recycling rates increase to 100 percent by 2050). This shift illustrates the scale to which the low-carbon transition itself may help mitigate some of the emissions from minerals required—but not all. Mitigation options are available at various stages of the process, including the use of inert anodes in the Hall-Héroult process and innovation focused on reducing electricity use in the electrolysis phase (IEA 2019e). However, further action is needed to reduce emissions involved in the extraction and processing of minerals—this is a crucial area of work for the Climate-Smart Mining Initiative.

58 Van der Voet et al. (2019) use the GEO-4 scenarios in their estimation of future metal demand. The differential impacts on the carbon footprint of different metals can be seen by comparing their projections of emissions per kilogram of metal under the markets first scenario (which represents a scenario dominated by global markets) with that under the equitability first scenario (representing sustainable development). They project the CO_2 equivalent per kilogram for aluminum falling by 11 percent in the markets scenario and by 49 percent in the equitability scenario. In contrast, the same figure for copper rises by 15 percent in the markets scenario and falls by 24 percent in the equitability scenario, while lead's emissions per kilogram increases by 23 percent in the markets scenarios and by 9 percent in the equitability scenario.

Market Dynamics

The demand estimates produced in this model represent underlying (or latent) demand for minerals. This is the demand that would occur, all other things being equal, crucially without changes in supply or induced substitution and efficiency.

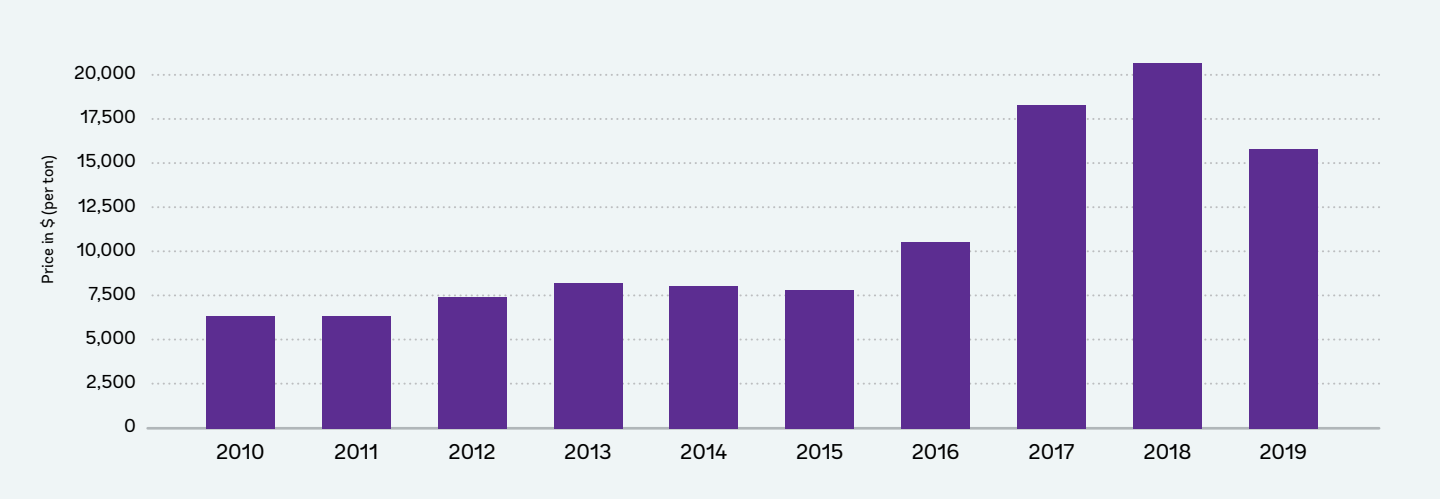
Higher levels of demand for commodities could lead to higher prices, which induce two major effects: (1) Those involved in the extraction and production of commodities increase their supply, and (2) those demanding those minerals are incentivized to reduce their use in their products, either by substituting for other minerals or by improving the efficiency of how the minerals are used.

The demand figures provided in this analysis therefore provide a scale of how far supply needs to adjust if no such substitution or efficiency improvements are possible. To fully gauge the scale at which this demand poses a risk therefore depends on both the supply aspects and the scale at which substitution and efficiency can play a role. The questions related to supply lie beyond the scope of this report, while questions of technology substitution and efficiency vary dramatically from technology to technology, and mineral to mineral. Some of these aspects are explored for lithium, cobalt, nickel, and manganese in Li-ion batteries in the Energy Storage section in chapter 3 of the main report.

Even though technology substitution and supply responses may allow large-scale increases in demand to be met, such rapid scale-ups of demand may cause price spikes and falls, creating instability and uncertainty for both the mining and renewable energy sectors. An example of this can be seen in recent movements in the lithium market. Rapid growth in the demand for Li-ion batteries from a growing electric vehicle market as well as mobile phones, laptops, and tablets has induced large increases in supply over recent years, culminating in a 98 percent increase in global production between 2017 and 2018. This in turn caused a short-term oversupply in the market, causing a drop in lithium prices in 2019.

This reduces the incentives for substitution and technical efficiency in the use of lithium, and also incentives to invest in future lithium supply. This may cause future price spikes, increasing supply. Understanding these dynamics is critical for fully understanding the impact that the low-carbon transition will have on mineral markets. Each commodity and technology has particular specificities, which means that the market dynamics will be unique to each case. Therefore, commodity- and technology-specific research are needed to understand the full picture of mineral demand and market dynamics.

Figure B.1 Lithium Prices, 2010–2019



Source: Garside 2020.

Annex C. Uncertainties

Uncertainty regarding the future mineral demand from energy technologies arises from a number of different sources: the mineral composition of the energy technologies, the amount of these technologies that will be deployed in the future, and which of the technologies will actually be deployed.

Uncertainties over the first two are captured in the model by including a range of metal composition estimates and providing comparisons across a range of scenarios. The estimates presented in the report are effectively a central point of a distribution. These distributions are, in some cases, extremely broad—for example, the use of aluminum in solar PV could be substituted for composite or synthetic alternatives. In cases where the use of the mineral is less substitutable and there is less of a range of estimates in the literature, the distribution is much smaller.

When looking at the GWP of minerals needed for a low-carbon transition, there is another source of uncertainty that is compounded with the uncertainty over future mineral demand levels: the uncertainty in the future GWP per kilogram of metal. A portion of this uncertainty is captured by including the range of estimates for GWP per kilogram from Nuss and Eckelman (2014). It should be acknowledged, however, that this is likely to underestimate the uncertainty, given potential future changes in GWP, as discussed in annex B.

The scale of this potential range can be seen by examining the range of GWP for aluminum. The GWP from the use of aluminum in solar PV varies as a result of uncertainty both in the GWP per kilogram and in the use of aluminum in solar PV panels. The uncertainty in the GWP per kilogram of mineral as given in Nuss and Eckelman (2014) is the result of the wide variation in GWP from primary aluminum and recycled aluminum (much of this is due to difference in the electricity source: because aluminum production is so power intensive, the power source—coal versus gas versus hydro—is a very significant variable).



This uncertainty is multiplied by the uncertainty of the use of aluminum in solar PV, especially in the fittings required for solar panels. An extremely wide range for this is given in the literature. Together, these highlight that although the mean GWP for the use of aluminum in solar PV is large, improvements in aluminum production, moves toward greater use of secondary aluminum, and efficiency improvements in solar PV design could reduce the GWP significantly.

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FEBRUARY 15, 2023

PolyMet closes NewRange Copper Nickel joint venture with Teck Resources

Confirms intention to proceed with previously announced rights offering for proceeds of approximately US$200 million

- PolyMet holds 50% interest in NewRange Copper Nickel, owner of the NorthMet and Mesaba projects, two of the largest undeveloped clean energy mineral resources in the U.S.
- Partnering with Teck Resources on NewRange Copper Nickel combined with Glencore's long-standing interest in PolyMet brings substantial operational, marketing and financial resources
- PolyMet offers investors direct access to NewRange Copper Nickel as PolyMet remains a publicly traded company, dually listed on TSX and NYSE American
- Polymet to launch rights offering of approximately US$200 million to fund PolyMet's share of the initial NewRange Copper Nickel work program and certain other costs and expenses and to repay existing Glencore indebtedness, to be fully backstopped by Glencore

St. Paul, Minn., February 15, 2023 – PolyMet Mining Corp. TSX: POM; NYSE American: PLM, ("PolyMet" or the "company") today announced the closing of its previously announced joint venture with Teck American Inc., a subsidiary of Teck Resources Limited ("Teck"). The joint venture will be named NewRange Copper Nickel LLC ("NewRange Copper Nickel"). As previously announced, under the terms of the transaction, the NorthMet and Mesaba deposits containing high-demand copper, nickel, cobalt and platinum group metals (PGM) are placed under single management with PolyMet and Teck each receiving a 50% interest.

"Successful closing of the joint venture moves NewRange Copper Nickel to the forefront of responsible development of American-sourced critical minerals for the manufacture of clean energy and clean transportation technologies such as battery storage, wind and solar generation and electric vehicles," said Jon Cherry, PolyMet chairman, president and CEO.

The two resources contain Measured and Indicated resources of 702 million tons and 2,207 million tons for NorthMet and Mesaba, respectively, and additional Inferred resources of 441 million tons and 1,423 million tons, respectively.[1] In total, the two assets represent approximately one-half of the known 8-billion-ton Duluth Complex resource in northeastern Minnesota, a globally significant resource.

PolyMet offers investors direct access to the NewRange Copper Nickel joint venture as PolyMet Mining Corp. remains a publicly traded company, dually listed on the TSX and NYSE American.

As previously announced, the NewRange Copper Nickel joint venture links the expertise, experience and financial resources of PolyMet, Teck and Glencore to develop the NorthMet mine when the remaining permit proceedings are complete and study the mine development options for Mesaba.

"We are pleased to have a partner like Teck join us in this transformational venture with its strong balance sheet, exceptional record of community involvement and sustainable mining practices, and world-class technical and mining capabilities," Cherry said. Glencore retains its majority equity interest in PolyMet.

The company also announced the departure of Denton Henkelman, vice president and project director, who will leave PolyMet at the end of February. "We are grateful for Denton's leadership and considerable contributions in advancing our technical and economic understanding of NorthMet. We wish him well in his new pursuits," Cherry said.

NorthMet and Mesaba status

PolyMet successfully navigated the NorthMet Project through the comprehensive federal and state environmental review process and federal land exchange – a process that involved considerable public involvement and tribal consultation. The NorthMet Project, located near the community of Hoyt Lakes in northeastern

Minnesota, earned nearly two dozen state and federal permits necessary to build and operate the 32,000 tons-per-day (29,000 tonnes) mine and processing facility. Three permits are pending final resolution of litigation and regulatory process to achieve final project approval.

The Mesaba Project is making progress on baseline environmental studies, resource definition and mineral processing studies. Further studies and proactive community and tribal consultation will help fully define long-term development potential.

About NewRange Copper Nickel LLC

The closing of the joint venture results in Poly Met Mining, Inc. being renamed NewRange Copper Nickel LLC and all of NorthMet's assets, mineral rights, liabilities, permits and financial assurance obligations continuing under NewRange Copper Nickel. Likewise, all of Teck's interest in Mesaba assets, mineral rights and liabilities transfer to NewRange Copper Nickel.

NewRange Copper Nickel is a stand-alone entity with its own leadership team and staff, overseen by a management committee comprised of an equal number of representatives from Teck and PolyMet. The committee chair rotates on a biannual basis with Mr. Cherry serving as first-term chair.

PolyMet and Teck are responsible for funding their pro rata share of costs related to the NorthMet and Mesaba projects. The owners have committed to an initial work program with an estimated budget of US$170 million to maintain permits, update feasibility cost estimates, and undertake detailed engineering to position NorthMet for a development decision following permit clearances, and to advance Mesaba studies.

Glencore has committed to support PolyMet's respective portion of NewRange Copper Nickel's initial US$170 million work program and certain other costs and expenses in the amount of approximately US$100 million. Pursuant to this commitment, Glencore has agreed to fully backstop a rights offering by PolyMet to raise additional funding. Glencore also committed to either convert outstanding convertible debentures or backstop additional funding under the rights offering to repay these debentures and all other debt (including in all cases any accrued and unpaid interest) owing to Glencore from PolyMet. Assuming that no convertible debentures are converted the

additional funding required under the rights offering to repay such debentures and all other debt owing (including in all cases any accrued and unpaid interest) to Glencore from PolyMet is expected to be approximately US$97 million.

Rights Offering

Further details on the commencement, and other terms of the rights offering will be announced upon PolyMet entering into a standby purchase agreement with Glencore, which is anticipated to occur in the near term.

Finance Agreement

As a condition of the financing commitment associated with the joint venture, PolyMet entered into an Investor Rights and Governance Agreement ("IRA") with Glencore that, among other things, provides Glencore reasonable assurances relating to the development and operations of NewRange Copper Nickel, including having a say in decision-making related to these matters.

The company's independent financial advisor, Paradigm Capital Inc. and the Special Committee's independent financial advisor, Maxit Capital LP, provided an opinion to the Board and the Special Committee, respectively, that as of the date thereof, and subject to the various assumptions, limitations and qualifications set forth therein, the transaction is fair, from a financial point of view, to the company.

PolyMet engaged Farris LLP as its legal advisor in connection with the transaction. The Special Committee engaged Mason Law as its legal advisor in connection with the transaction. Glencore engaged McCarthy Tetrault LLP as its legal advisor in connection with the transaction.

This press release has been reviewed and approved by Herb Welhener, an independent Qualified Person within the meaning of National Instrument 43-101.

* * * * *

About PolyMet

PolyMet is a mine development company holding a 50% interest in NewRange Copper Nickel LLC, a 50:50 joint venture with Teck Resources. NewRange Copper Nickel holds the NorthMet and Mesaba copper, nickel, cobalt and platinum group metal (PGM) deposits, two globally significant clean energy mineral resources located in the Duluth Complex in northeast Minnesota. The Duluth Complex is one of the world's major, undeveloped copper, nickel and PGM metal mining regions. NorthMet is the first large-scale project to have received permits within the Complex.

For more information: www.polymetmining.com (http://www.polymetmining.com)

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PolyMet Disclosures

This news release contains certain forward-looking statements concerning anticipated developments in PolyMet's operations in the future. Forward-looking statements are frequently, but not always, identified by words such as "expects," "anticipates," "believes," "intends," "estimates," "potential," "possible," "projects," "plans," and similar expressions, or statements that events, conditions or results "will,"

"may," "could," or "should" occur or be achieved or their negatives or other comparable words. Forward–looking statements relate to future events or future performance and reflect management's expectations or beliefs regarding future events including, but not limited to, statements with respect to the anticipated benefits of the 50/50 joint venture, the company's expectations with respect to the future development of NorthMet and Mesaba and the timing and completion of the upcoming rights offering. Forward-looking statements address future events and conditions and therefore involve inherent known and unknown risks and uncertainties. Such risks and uncertainties include, but are not limited to, among other things, risks relating to the parties meeting their conditions precedent, receipt of regulatory approvals, timing of closing, the outcome of the development of the NorthMet and Mesaba projects, and the outcome of any financing required to raise the funds for PolyMet's share of the initial work program and Glencore's funding commitment. Actual results may differ materially from those in the forward-looking statements due to risks facing PolyMet or due to actual facts differing from the assumptions underlying its predictions.

PolyMet's forward-looking statements are based on the beliefs, expectations and opinions of management on the date the statements are made, and PolyMet does not assume any obligation to update (except as required by law) forward-looking statements if circumstances or management's beliefs, expectations and opinions should change.

Specific reference is made to risk factors and other considerations underlying forward-looking statements discussed in PolyMet's most recent Annual Report on Form 40-F for the fiscal year ended December 31, 2021, and in our other filings with Canadian securities authorities and the U.S. Securities and Exchange Commission.

The Annual Report on Form 40-F also contains the company's mineral resource and other data as required under National Instrument 43-101.

No regulatory authority has reviewed or accepted responsibility for the adequacy or accuracy of this release.

Resources quoted for NorthMet and Mesaba are sourced from the Technical Report prepared under Canadian National Instrument 43 101— Standards of Disclosure fo Mineral Projects ("NI 43-101") for PolyMet entitled "NorthMet Copper Nickel Projec Feasibility Update," dated December 30, 2022, ("PolyMet Technical Report") as filed

under the Company's SEDAR and EDGAR profiles, and the Technical Report entitled "Mesaba Project Form 43-101F1 Technical Report Mineral Resource Statement" ("Mesaba Technical Report") effective as of November 28, 2022, as filed under the company's SEDAR and EDGAR profiles.

[1] See resource statements in the technical report entitled "Mesaba Project Form NI 43-101F1 Technical Report, Minnesota, USA" dated November 28, 2022, prepared by Independent Mining Consultants, Inc. and JDS Energy & Mining Inc. and the resource statements in the technical report entitled "NorthMet Copper-Nickel Project" dated December 30, 2022, prepared by M3 Engineering & Technology Corp., both found under the company's SEDAR and EDGAR profiles.

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US Army Corps of Engineers

News Release

Corps of Engineers announces NorthMet Mine permit decision

Published June 6, 2023 /
Updated: June 6, 2023

ST. PAUL, Minn. --

The U.S. Army Corps of Engineers, St. Paul District, announced today, June 6, that it is revoking the previously suspended NewRange Copper Nickel Company's permit for the NorthMet mine.

Corps officials revoked the Clean Water Act Section 404 permit because the permit does not ensure compliance with water quality requirements of the Fond du Lac Band of Lake Superior Chippewa. The Corps made this decision after thoroughly considering all information provided to the district at a public hearing hosted in May of 2022 to include the evaluation and recommendations provided by the U.S. Environmental Protection Agency and information provided by the Fond du Lac Band (Band) under their respective water quality authorities granted by the Clean Water Act, as well as information provided by NewRange Copper Nickel Company and the public.

The Corps initially completed its Record of Decision and issued a Section 404 Clean Water Act individual permit for regulated activities at the NorthMet project March 21, 2019. At that time, Corps officials determined the project was compliant with all applicable federal laws and regulations. The Corps subsequently suspended the permit March 17, 2021, at the request of the EPA, while the EPA considered effects from the project under Section 401(a)(2) of the Clean Water Act to water quality downstream in the state of Wisconsin and within the Band's Reservation. The EPA issued a "may affect" determination to the Band and the state of Wisconsin on June 4, 2021. The Band submitted an objection to the permit and its "will affect" determination on Aug. 3, 2021, and requested the Corps hold a public hearing.

The Corps held a public hearing in May 2022, to seek information on whether the permit should be re-issued, revoked, or modified with new conditions to ensure compliance with the Band's applicable water quality requirements. During the hearing, the Band provided information on its determination that the NorthMet project will violate its water quality requirements. The EPA agreed with the Band and recommended the Corps not reinstate the suspended permit. The permittee provided information to support their view that the project would not violate the Band's water quality

and requested the Corps reinstate the suspended permit. The Corps also received verbal and written comments from the public.

Given the Corps' jurisdiction under Section 404 of the Clean Water Act, the Band and EPA's water quality authority provided in the Clean Water Act, and the absence of sufficient permit conditions to ensure compliance with the applicable downstream water quality requirements of the Band as required by Section 401(a)(2) of the Clean Water Act, the Corps must revoke the suspended permit. The decision does not preclude NewRange Copper Nickel LLC from submitting a new permit application that will meet all applicable water quality requirements for its project.

The Corps' decision memo on this action may be found here.

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Contact
Public Affairs

Release no. 23-032

PolyMet; NewRange Copper Nickel LLC regulatory Decision Memo

An official website of the United States government Here's how you know

NorthMet Project

PROJECT WEBSITE: https://www.newrangecoppernickel.com/about/projects/northmet-project/

All dates below are specific to the schedule of the Environmental Review and Permitting processes for this project.

ENVIRONMENTAL REVIEW AND PERMITTING STATUS
IN PROGRESS

ESTIMATED COMPLETION DATE OF ENVIRONMENTAL REVIEW AND PERMITTING
02/09/2028

**0
out of
4**

ENVIRONMENTAL REVIEW AND PERMITTING PROCESSES COMPLETED

SECTOR
Mining

CATEGORY
Project Category FAST-41 Transparency Projects

LEAD AGENCY
Department of the Army, US Army Corps of Engineers - Regulatory

View Postings by Agencies

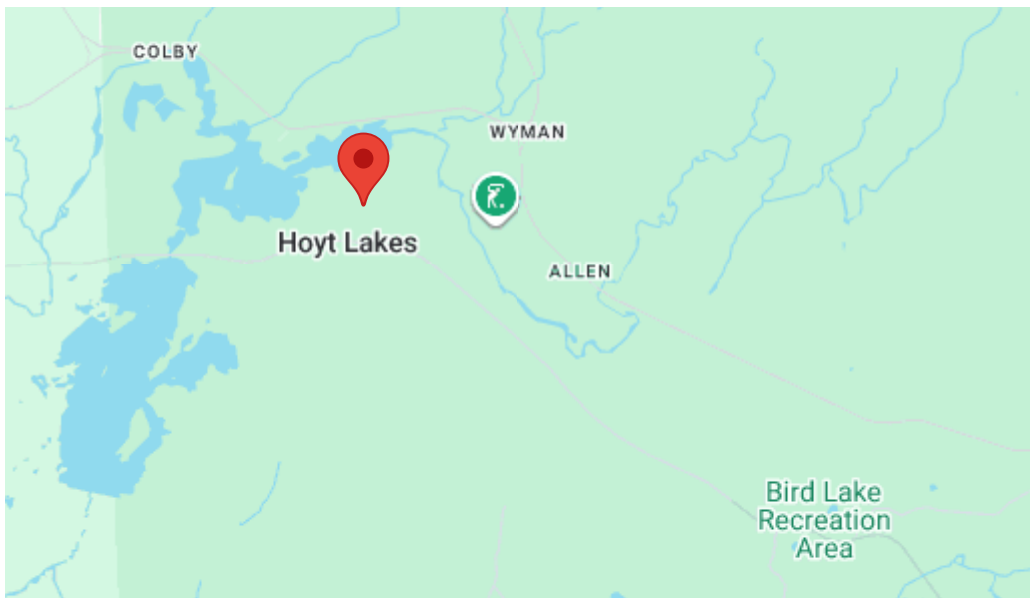
Other Agencies with Actions or Authorizations:

Department of the Interior, Fish and Wildlife Service

Description:

Open pit mining operation to produce copper and nickel-copper concentrates.

This project is posted in the interest of transparency and response to Executive Order 14241.



Project Primary Address
Primary Location
Project Address

6500 Kensington Drive
Hoyt Lakes, MN 55750
United States

Lead Agency Information:

POC Name: Bill Sande
POC Title: Senior Project Manager
POC Email: CEMVP-NorthMet-Review@usace.army.mil
Agency/Department: US Army Corps of Engineers - Regulatory

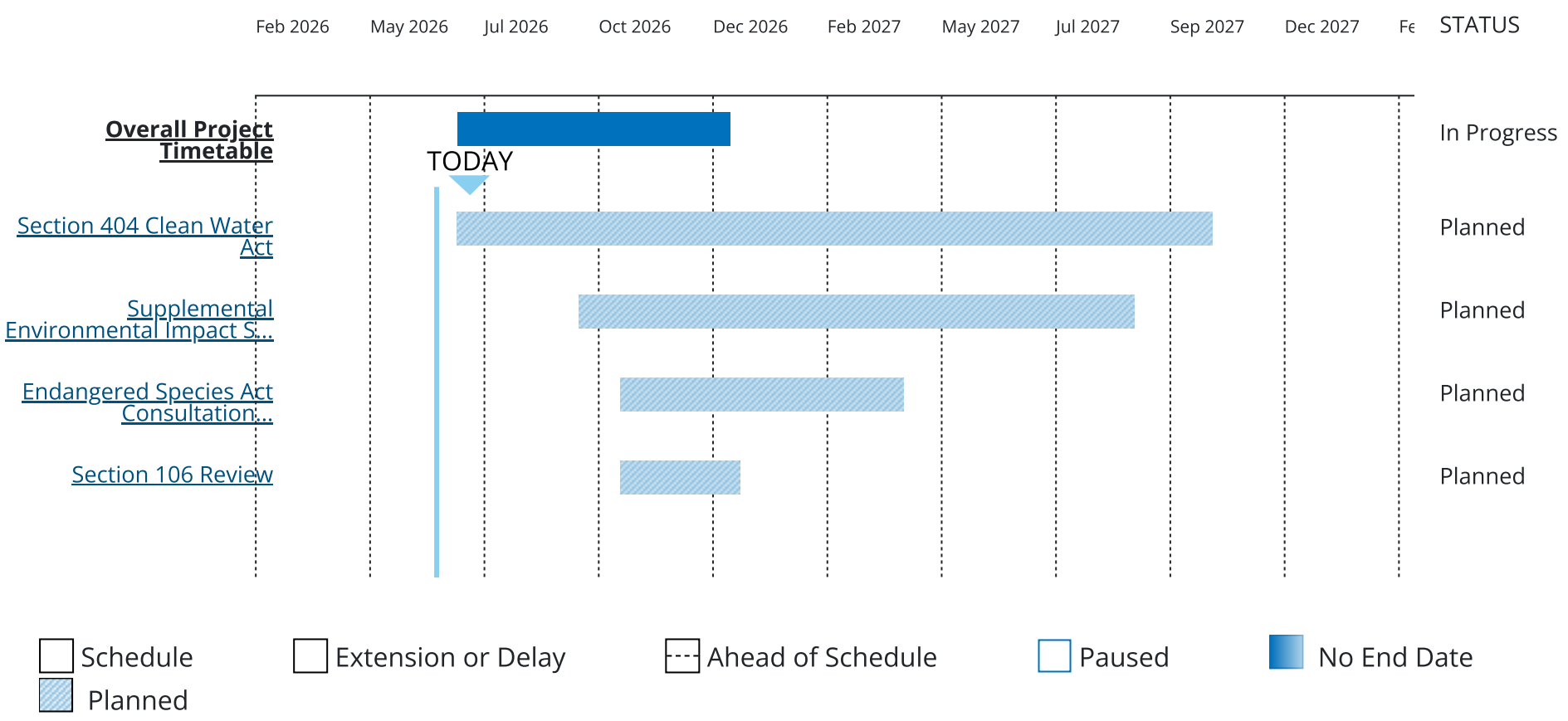
Sponsor Contact Information:

Project Sponsor: NewRange Copper Nickel LLC
POC Name: Christie Kearney
POC Title: Environmental and Permitting Manager
POC Email: Christie.Kearney@NewRangeCopperNickel.com

Permitting Timetable

The permitting timetable below displays data as reported by agencies. Dates for Environmental Review and Permitting processes (Actions) that are in 'Paused' or 'Planned' status are subject to change and are not indicative of a project's final schedule.

- For information about extensions, select an Action from the timetable below and select 'View Action Details' at the bottom of the page.



Action Information

For additional information, please select an Action from the Permitting Timetable above.

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NEWRANGE WRAPS UP MASSIVE SALVAGE, RECYCLE AND CLEANUP PROJECT

MEDIA

$20 million endeavor readies iconic

taconite ore for re-use in copper-nickel processing when the NorthMet Project gets the go-ahead

Download press release

Hoyt Lakes, Minn., December 19, 2024 – NewRange Copper Nickel this week completed one of the largest salvage and recycle projects in Minnesota history, cleaning up the site of the former LTV Steel near Hoyt Lakes, creating a safer, cleaner work environment for the NorthMet copper nickel project.

In the $20 million project, launched in spring 2023, crews removed more than 30,000 tons of structural steel and scrap metal from within the nearly quarter-mile-long concentrator building, more than double the steel used to build US Bank Stadium, home of the Minnesota Vikings. Scrap included

32 pairs of highly recyclable ball and rod mills that once processed taconite ore in the building, rected in the 1950s. An additional 66,000 tons of concrete carved from inside the iconic concentrator was crushed onsite yielding a 55,000-cubic-yard mountain of aggregate, to be returned to beneficial use.

“Skilled union workers accomplished this project on time and within budget, but what we are most proud of is the safe manner in which they performed the work,” said Tannice McCoy, NewRange president and general manager. “While demolition work of this nature carries with it a higher degree of risk, we did not have any lost time due to injury in more than 80,000 work hours of demolition and cleanup.”

In addition to demolition and asbestos abatement, the effort involved removing a 9,000-cubic-yard landfill at the plant site. “This investment reaffirms our commitment to safely and responsibly moving the NorthMet Project forward and visibly demonstrates our promise to leave the property better than we found it,” McCoy said.

Union labor representing locals from the Operating Engineers, Laborers, Electrical Workers, Ironworkers, Millwrights, Pipefitters, and Roofers performed the work – all employed by Minnesota-based contractors Veit, Vic’s Crane & Heavy Haul, Mavo Systems, Hunt Electric, Parsons Electric, and The Jamar Company.

The demolition and cleanup position the now-empty concentrator building to be re-equipped and reused for processing copper-nickel ore when NorthMet is fully permitted and sanctioned for construction.

Separately, NewRange is undergoing a series of recently announced studies to analyze whether new mining technology and sustainability developments can further enhance the project’s environmental safeguards and mining performance. Areas under study for potential improvements are: alternatives to tailings storage, processing rate, ore transport technology, and water science. Delivering a strong project, with special emphasis on protecting water quality, remains the focus. Studies are expected to extend into much of 2025.

As one of the world’s largest undeveloped copper and nickel resources, NewRange could meaningfully support the United States’ global competitiveness and clean energy transition by creating a domestic supply chain of multiple critical minerals – all while limiting new environmental impacts and cleaning up former mine sites. NewRange can develop NorthMet into an environmentally sound, responsibly operated, and modern critical minerals producer in the U.S. to meet near-term demand.

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About NewRange Copper Nickel

NewRange Copper Nickel is a 50:50 joint venture of subsidiaries of Teck Resources Limited and Glencore AG, holding the NorthMet and Mesaba deposits – two large, distinct, and well-defined copper-nickel PGM resources in the established Iron Range mining region of Minnesota. The stand-alone company is working to unlock two new domestic supplies of critical minerals for the low-carbon transition through responsible mining, and delivering significant, multi-generational economic and other benefits to the region and beyond. The company is based in Hoyt Lakes, Minnesota.

or more information about NewRange Copper Nickel and job opportunities, visit our website. For media inquiries, please contact:

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bruce.richardson@www.newrangecoppernickel.com

Get the scoop on everything happening at NewRange Copper Nickel

Stay in touch with our latest updates, news and media releases.

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