Cold Climate Air Source Heat Pumps: A Primer and Launch Pad

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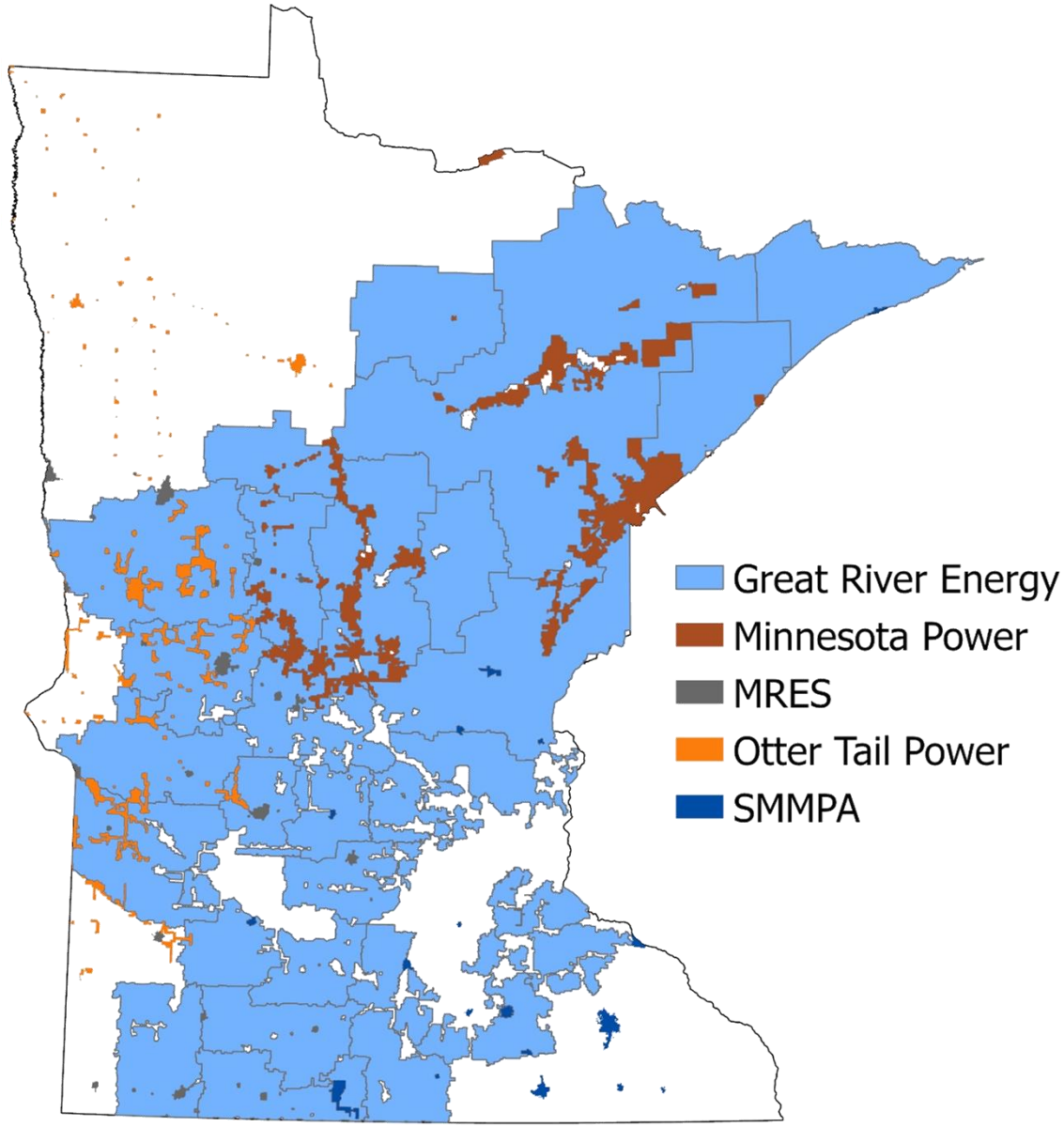
ASHP
air source heat pump collaborative

What are our goals for today?

- Unpack the rising potential for heat pumps
- Learn about the benefits of heat pumps
- Validate the equipment works in cold climates
- Learn where to find more resources

Center for Energy and Environment

MN ASHP Collaborative Members



cee
Center for Energy and Environment

OTTER TAIL POWER COMPANY

minnesota power

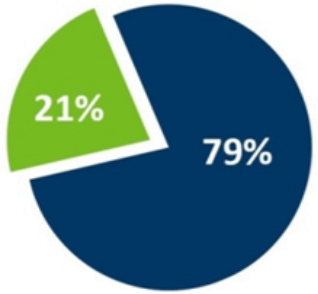
GREAT RIVER ENERGY

MISSOURI RIVER ENERGY SERVICES

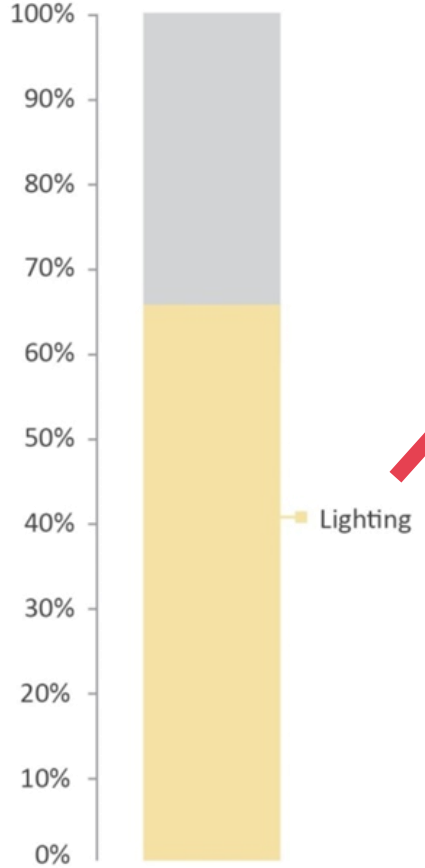
Southern Minnesota Municipal Power Agency

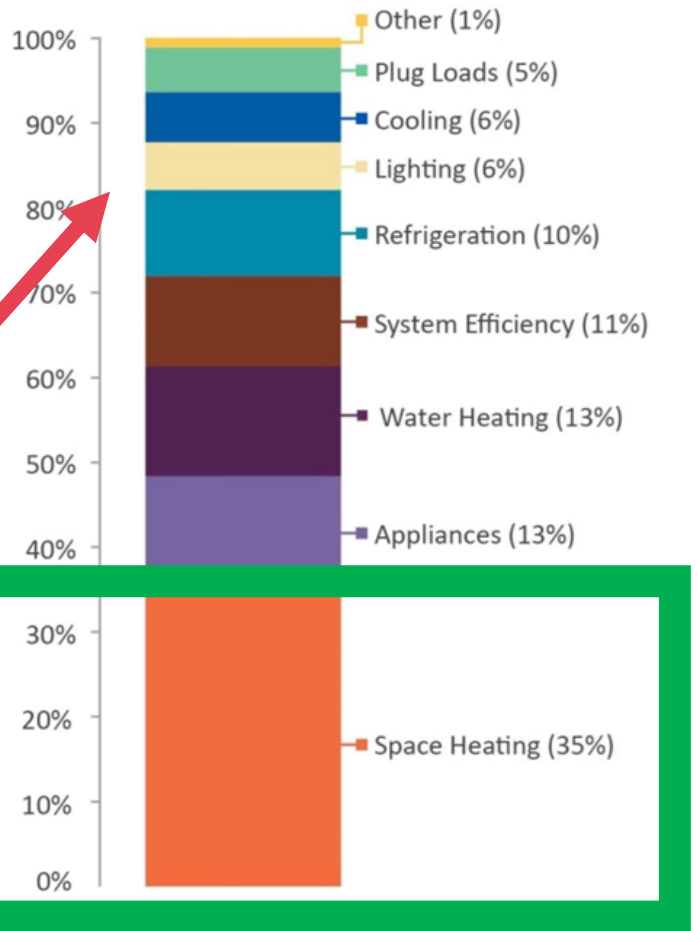
Air source heat pumps have great potential in MN

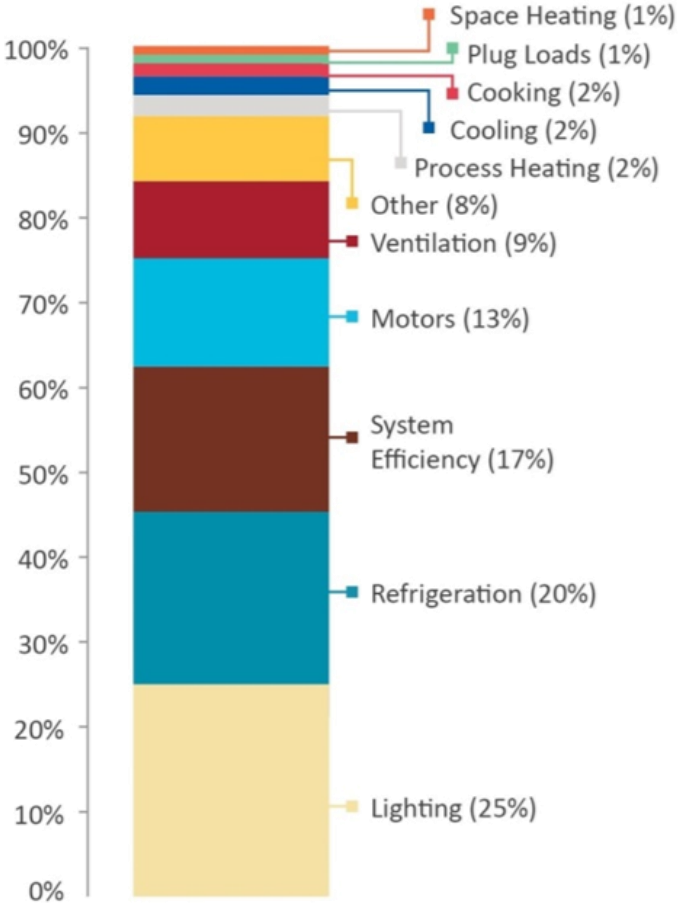
Minnesota Statewide Electric Savings Potential 2020-2029



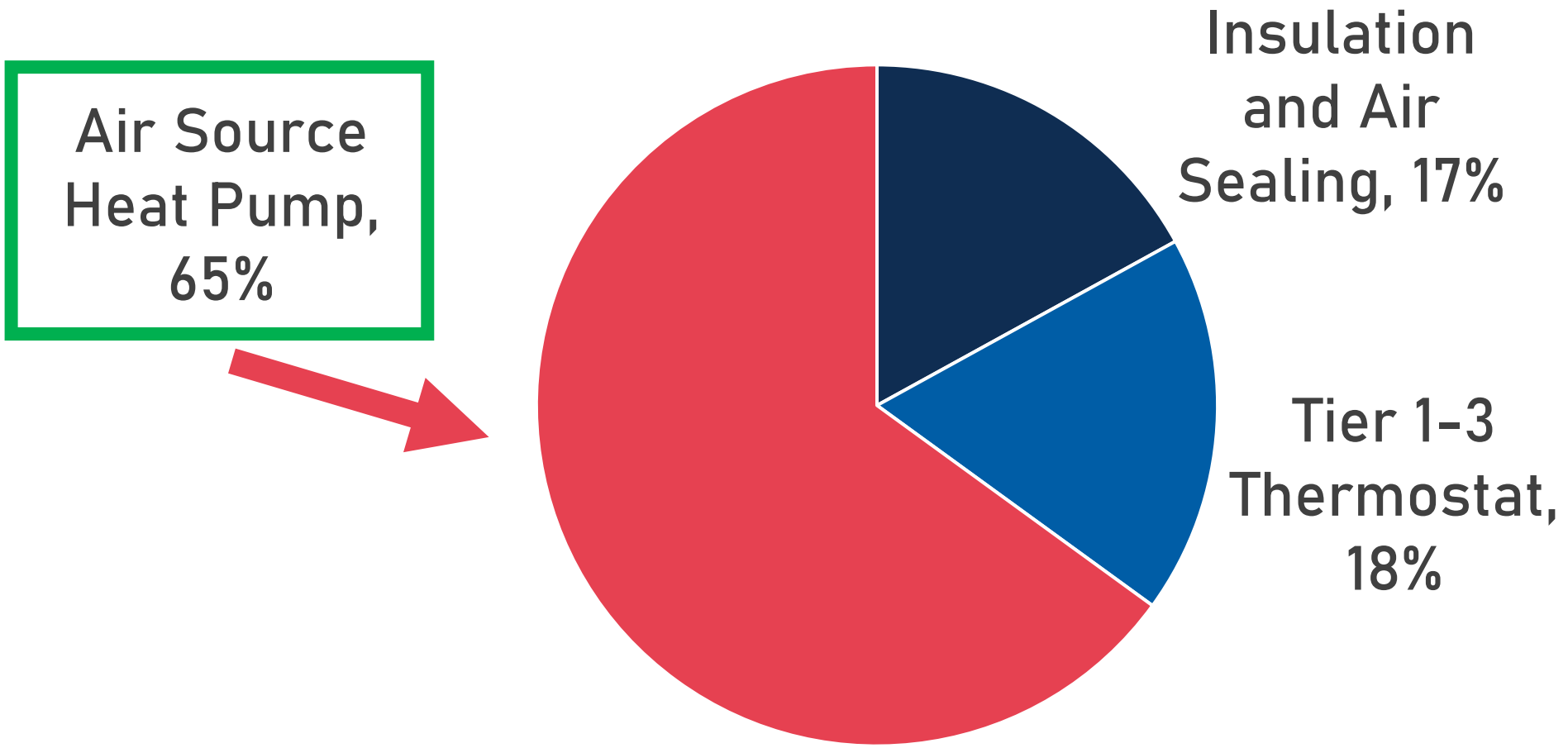
Historical







Estimated residential space heating savings by measure through 2029



Beneficial Electrification

- Goal: transition from carbon intensive fossil fuels to less carbon intensive electric alternative
  - Net reduction in lifetime carbon emissions
  - Net reduction in source energy use
  - Net reduction in fuel-neutral customer energy costs
  - No increase in coincident peak electricity demand

Energy Conservation and Optimization (ECO) Act

- Bi-partisan legislation
- Updates utility energy efficiency programs with a beneficial electrification framework
- New rebates for efficient fuel switching

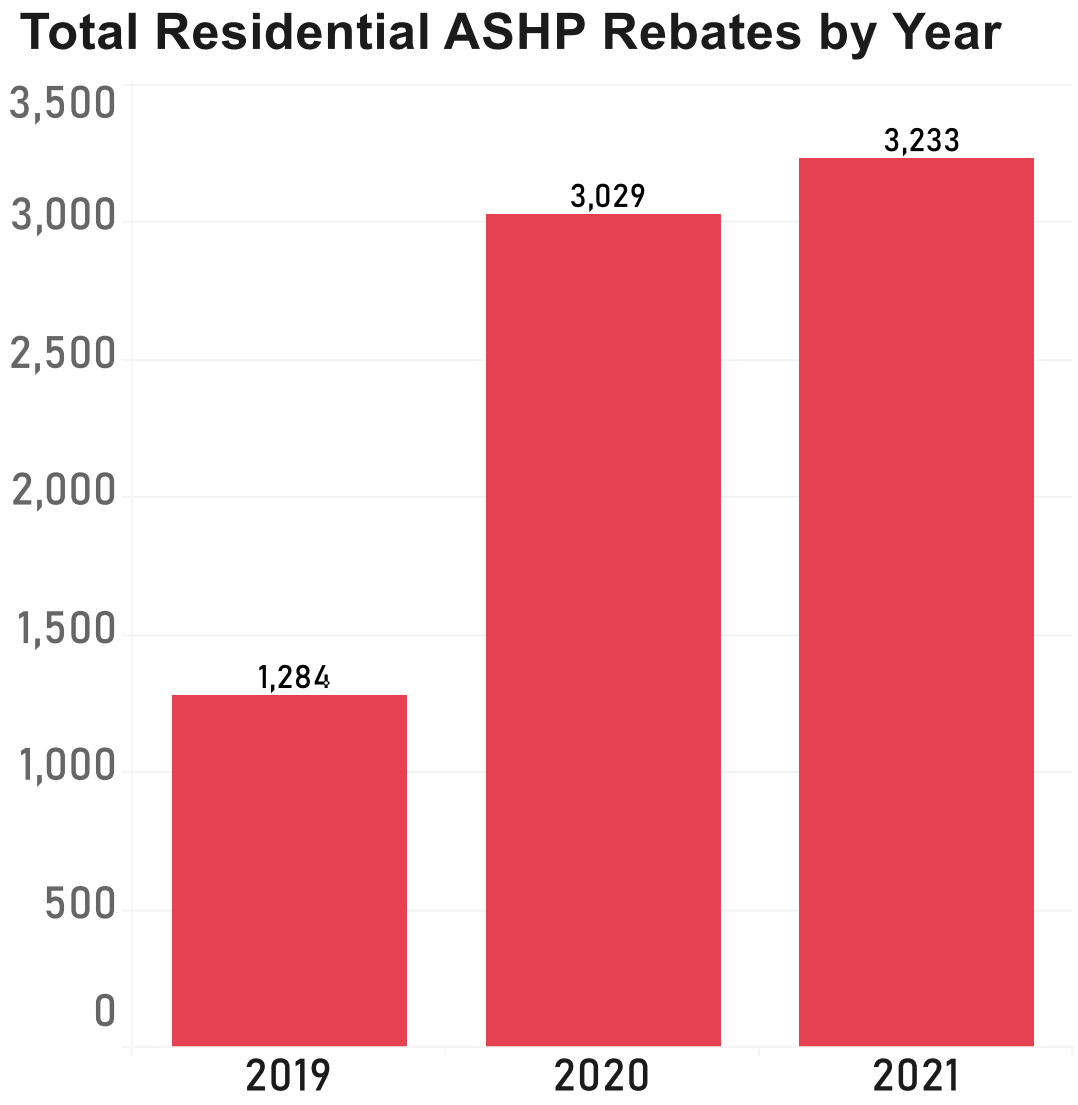
June 2021
Signed into law

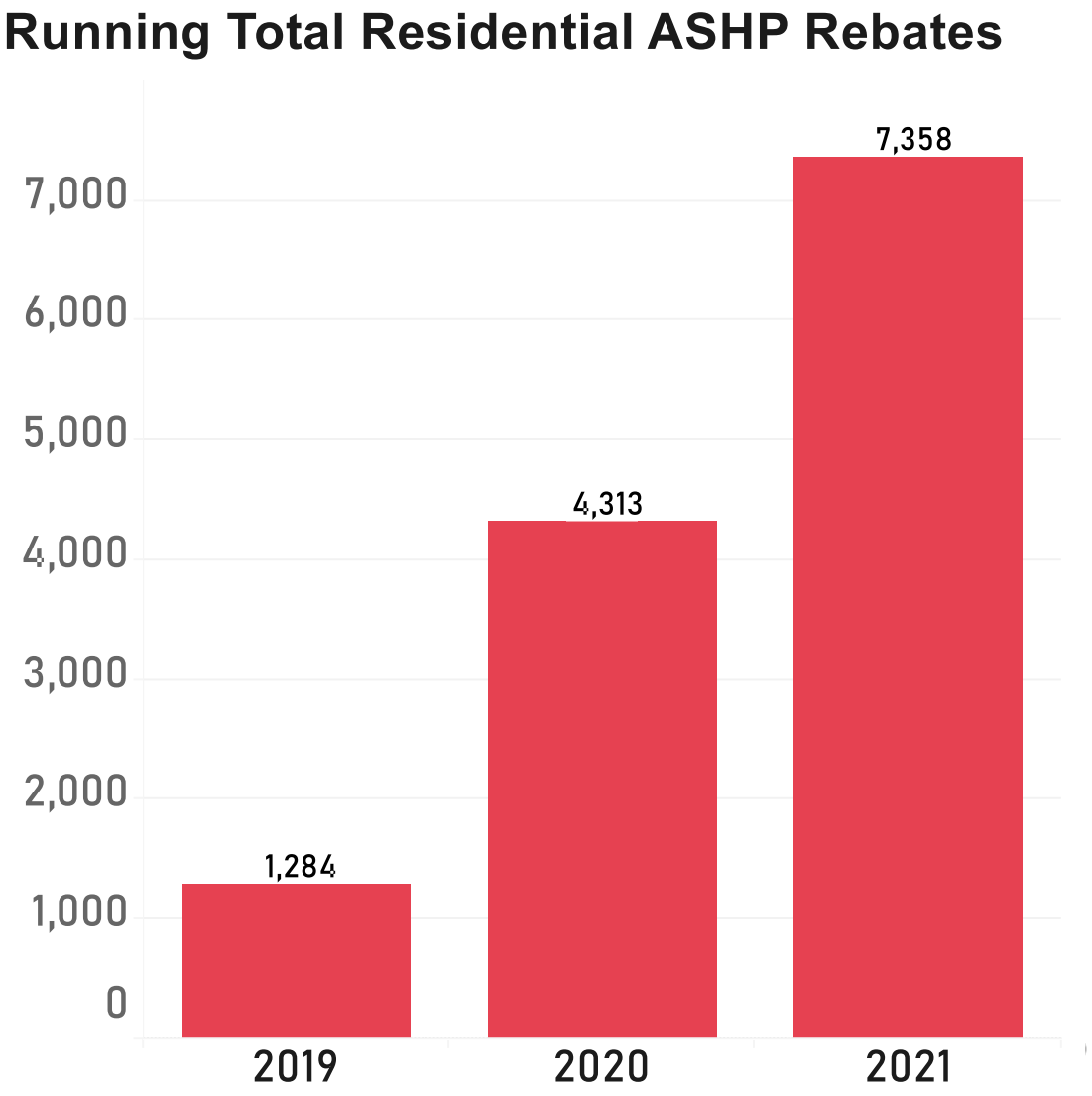
Oct. 2021 – March 2022
EFS stakeholder meetings

March 15, 2022
EFS savings and CBA determined

Jan 2023
EFS programs begin

MN heat pump market growth in utility rebate data through 2021



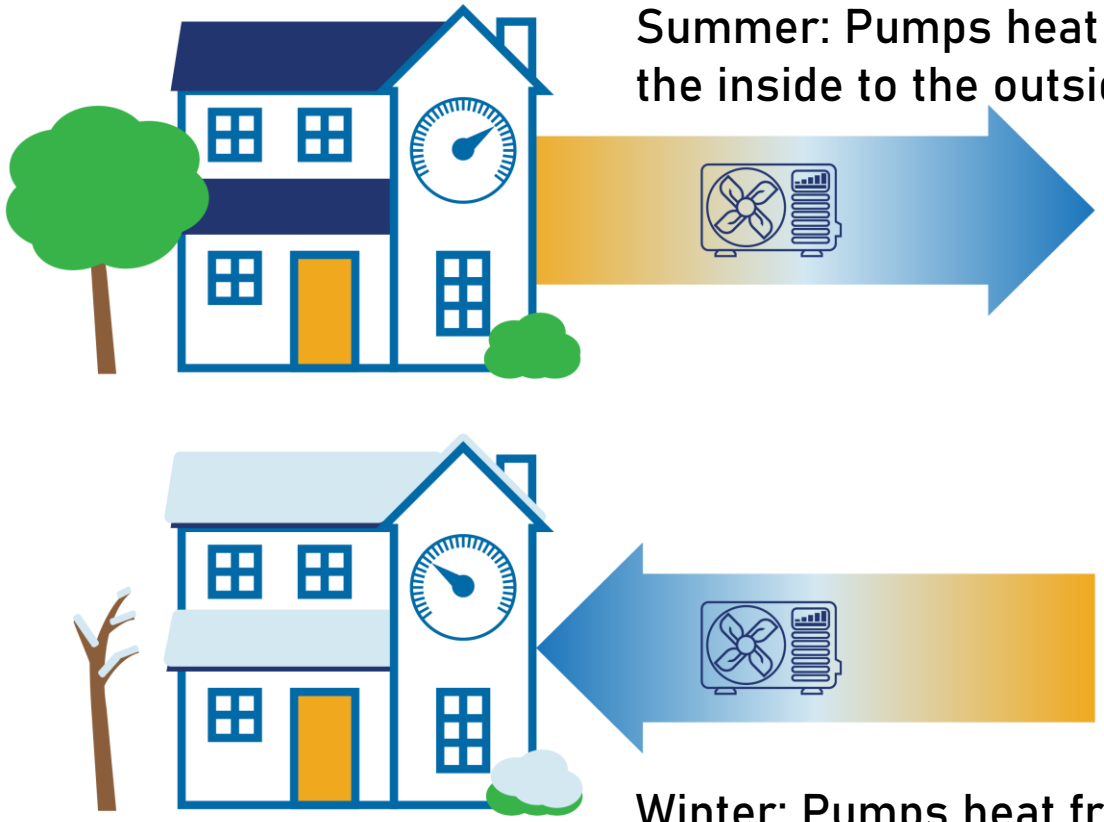


Growing potential

- Rebates shifting from lighting to space heating 2020-2029
- The ECO Act will create additional opportunities for heat pumps
- Utility rebate data show the market is already growing

Level Setting Terminology

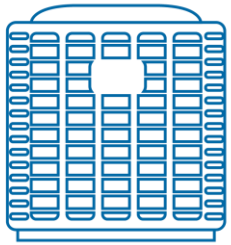
What is a heat pump?



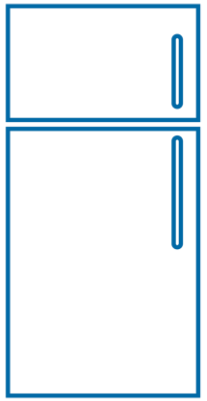
Summer: Pumps heat from the inside to the outside

Winter: Pumps heat from the outside to the inside

<u>Same technology as:</u>



Air Conditioner



Refrigerator

Heat pumps do not generate heat, they **move** it

Where does the heat come from?

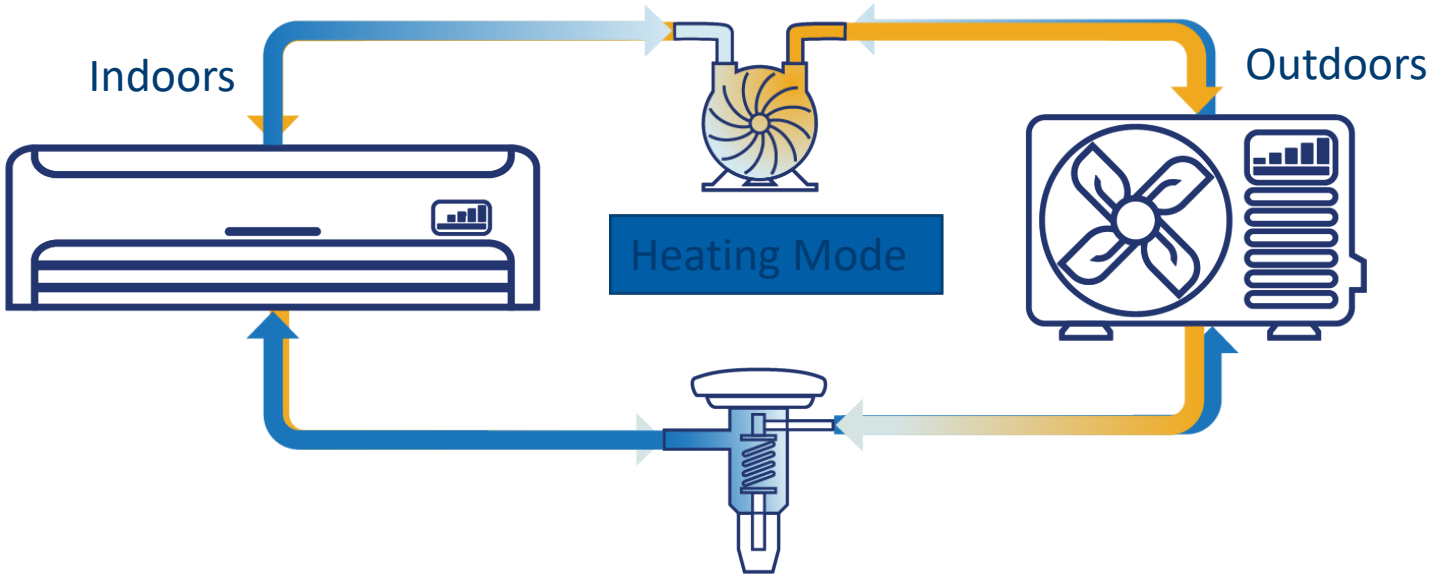
Heating mode: From the outside air, heated by the sun. Even when it is cold outside.

Cooling mode: From the inside air. It is not bringing in cold, it is removing (pumping) heat.

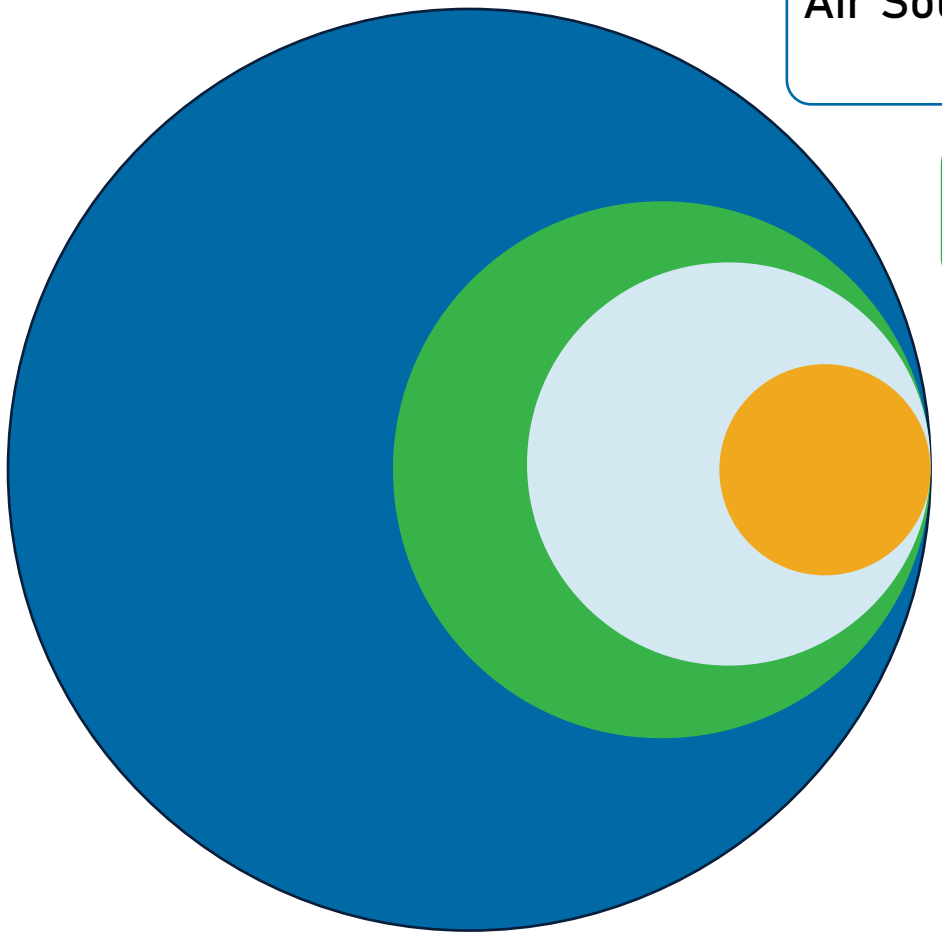
How do heat pumps work?

Vapor Compression Cycle

- Pumped refrigerant
- Pressurized (liquid) delivers heat
- Depressurized (gas) collects heat



The many names of a heat pump



Air Source Heat Pump (ASHP)

Variable Capacity Heat Pump (VCHP)

Cold Climate Air Source Heat Pump (ccASHP)

Cold Climate Ductless Heat Pump (ccDHP)

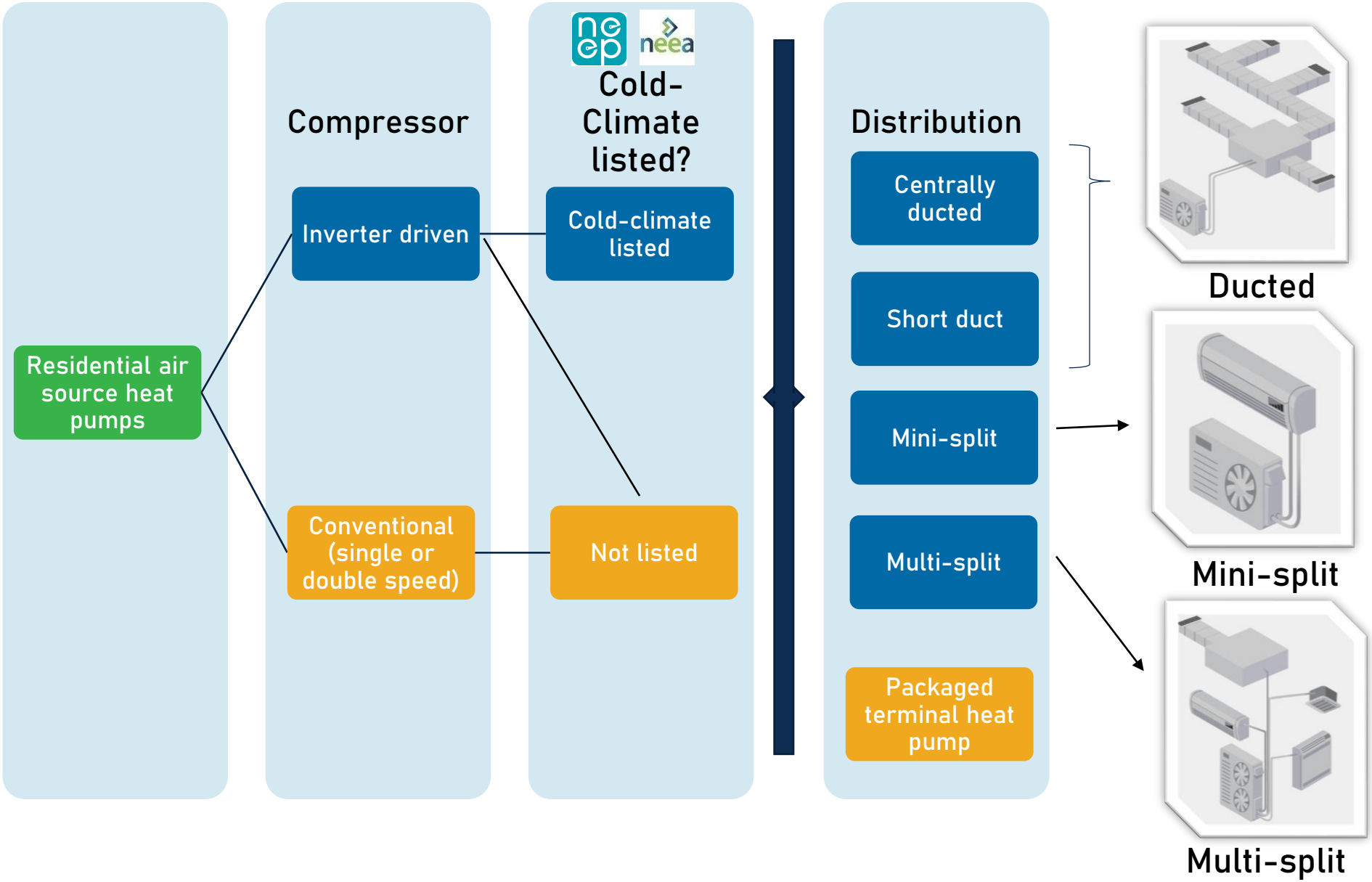
Also Known As:

- Inverter driven
- Extended capacity
- Extra performance
- Extreme climate
- Various branded trade-names:
  Hyper heat®, Aurora ®, Halcyon XLTH ®, Max-Heat ®

Types of Heat Pumps

- Residential Heat Pumps
  - Minisplit heat pumps
  - Multi-split heat pumps
  - Centrally ducted heat pumps
  - Dual-fuel heat pumps
  - Air-to-water heat pumps
  - Ground source heat pumps
- Commercial Heat Pumps
  - VRF heat pumps
  - Ground source heat pumps
  - PTAC heat pumps
  - RTU heat pumps
- Other heat pumps
  - High temperature heat pumps
  - Heat pump water heaters
  - Automotive heat pumps

Heat Pump Taxonomy



Heat Pump Efficiency Ratings Defined

Name	Description	Range
Heating Seasonal Performance Factor (HSPF)	Overall heating efficiency; Heating output (Btu) during a typical heating season divided by total electric energy (watt-hours) used during the same period	7 – 13+
Seasonal Energy Efficiency Ratio (SEER)	Overall cooling efficiency; Cooling output (Btu) during a typical cooling-season divided by the total electric energy (Watt-hours) used during the same period	14 – 25+
Coefficient of Performance (COP)	Instantaneous efficiency (heating or cooling); Units of energy **IN** divided by energy **OUT**	1 – 5+

NEEP's Cold Climate Specification

NEEP'S COLD CLIMATE AIR SOURCE
Heat Pump List

- Variable capacity, residential-scale, air source heat pump. Ducted or ductless
- High rated heating efficiency (≥ 9 HSPF ductless, ≥ 10 HSPF ducted)
- High efficiency even at 5°F (COP ≥ 1.75)
- Highly rated cooling efficiency (≥15 SEER)
- Capacity and efficiency data reported at multiple operating conditions

- Sets and periodically updates the standard
- Maintains a qualifying product list
- Publishes the resultant engineering data

https://ashp.neep.org/#!/

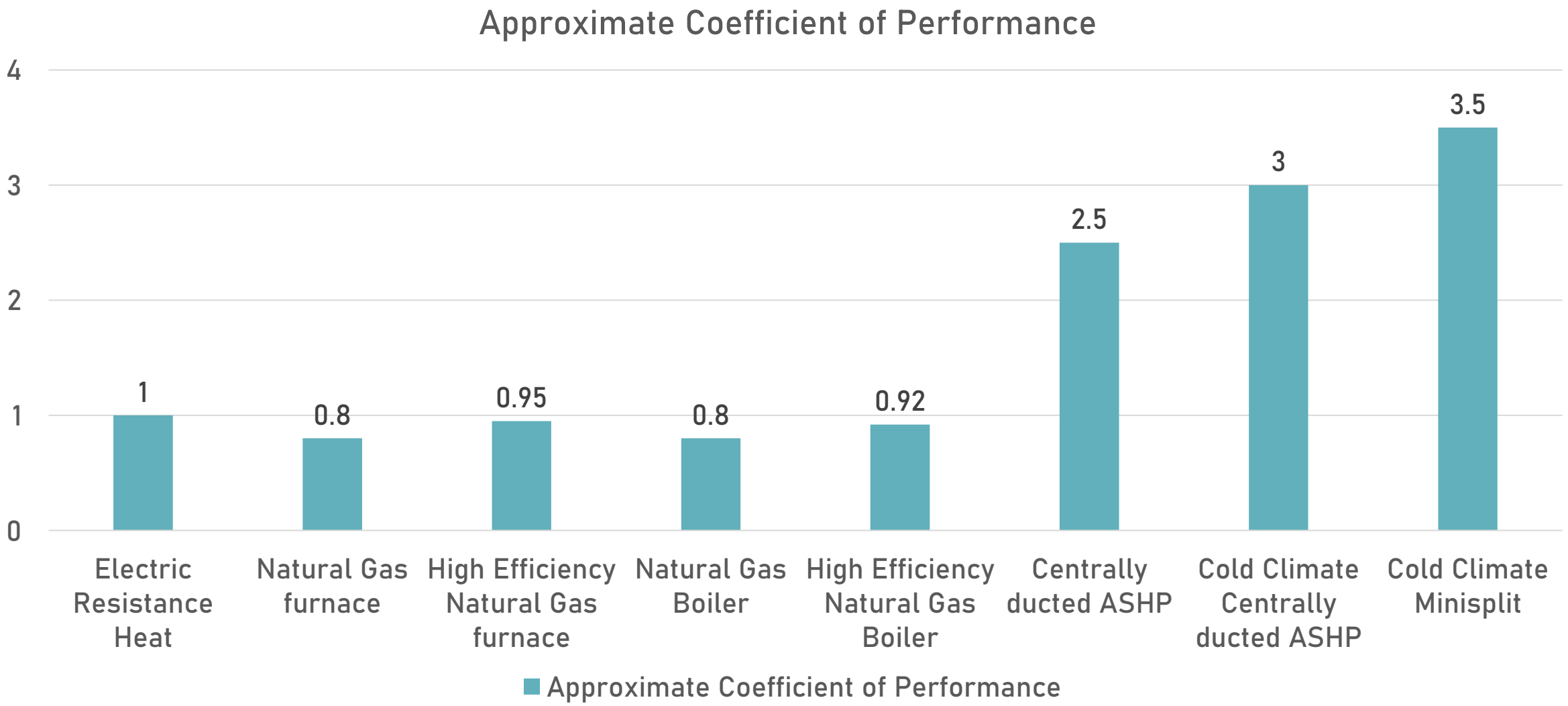
Do ASHPs work well in cold climates?

CEE ccASHP Research

2013	2015	2017	2019	2020	2021
Inverter driven technology comes to market NEEP ccASHP spec.	CARD single family ccASHP field study	Xcel Energy all-electric ASHP projects	MN Potential Study CARD single family ccASHP optimization study CARD multifamily ccASHP study	ComEd ASHP research study NEEA ASHP modeling tool	Heat pumps for AC – multiple projects CARD air to water heat pump study

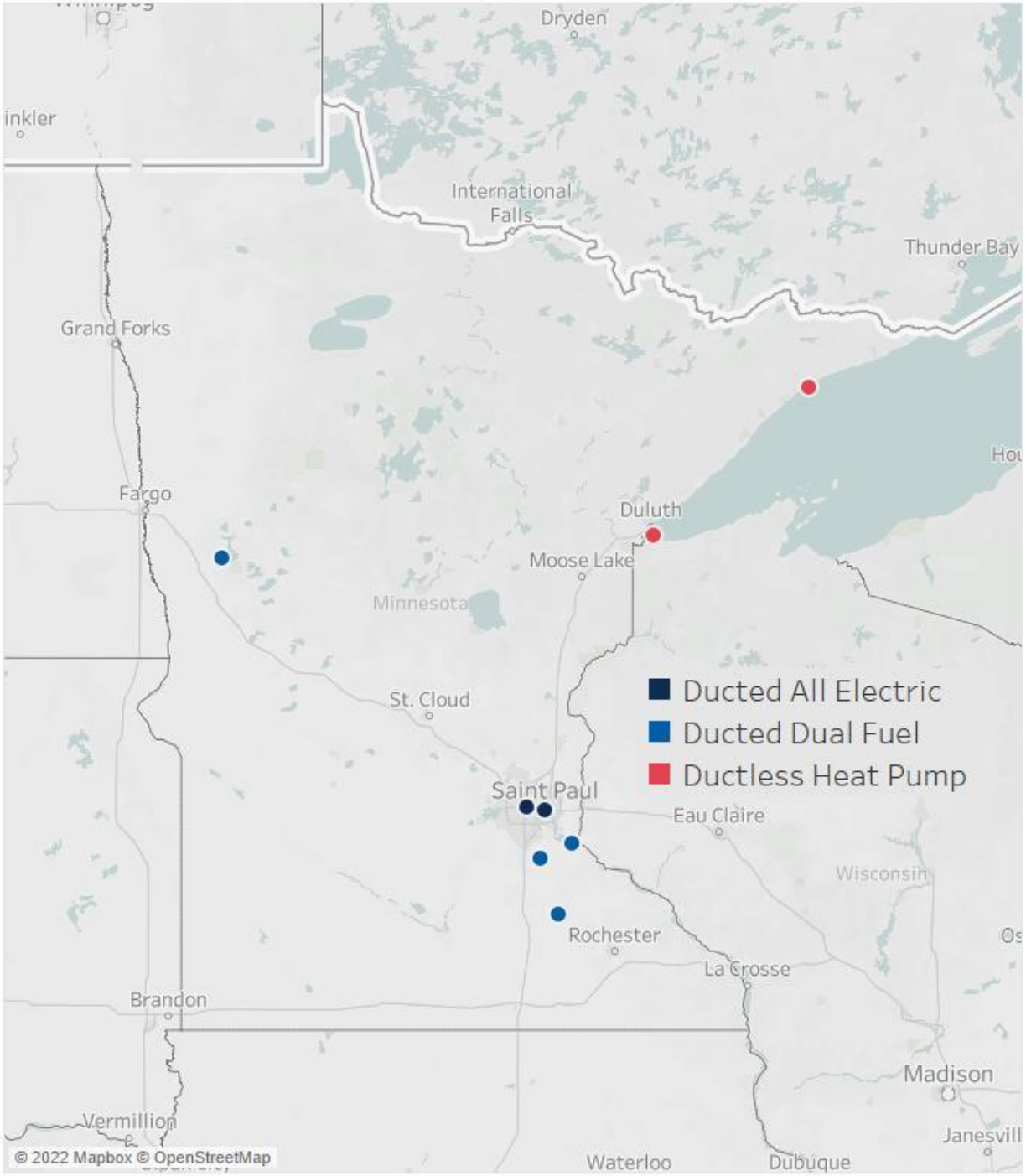
Comparing system types using COP

Coefficient of Performance – For every unit of energy consumed, how many units of heat are produced?

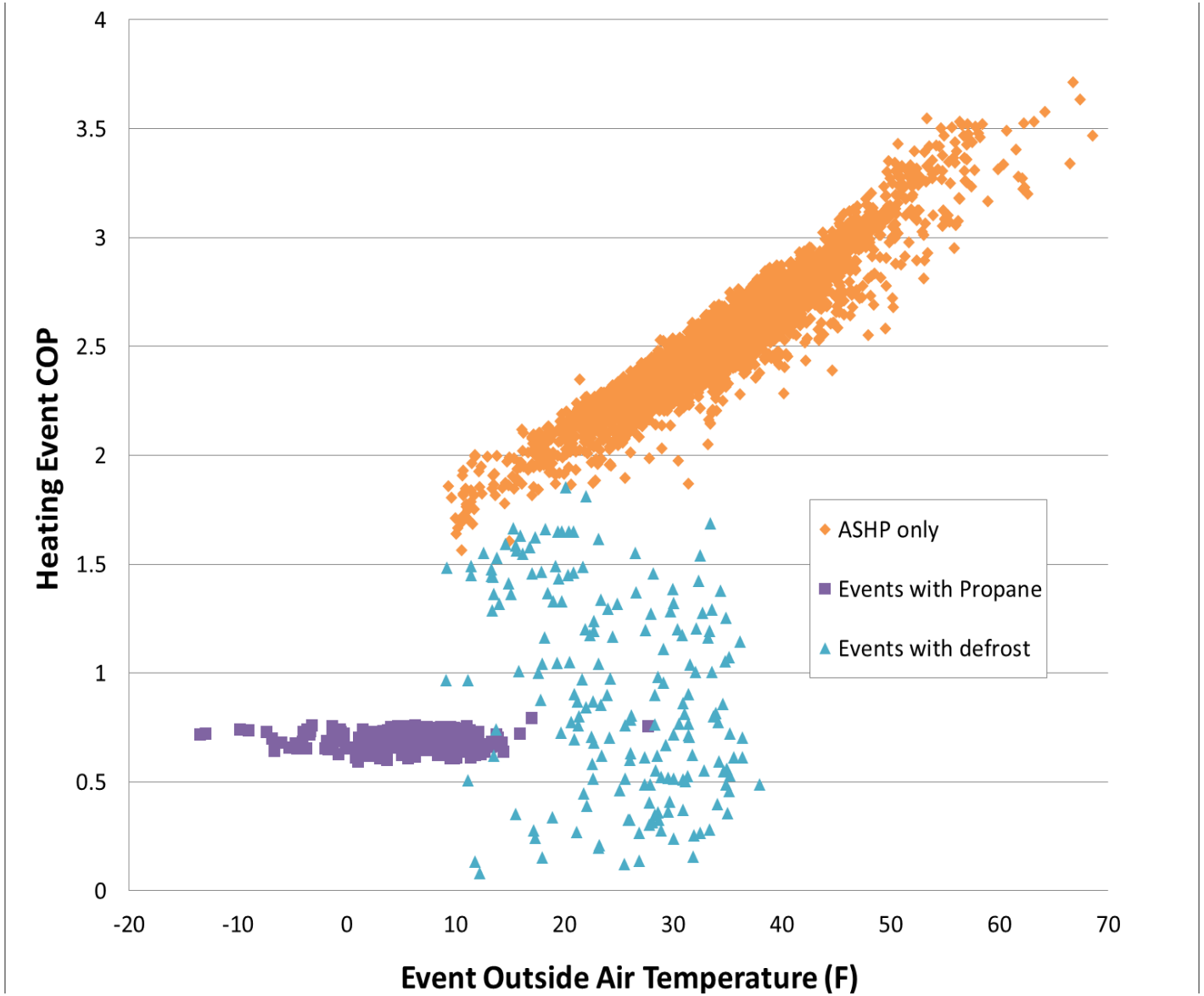


CEE research study overview

- Field Study
  - 8 ccASHP in a variety of MN residences
    - 6 ducted whole house system
    - 2 ductless mini-split systems
  - Monitor installed field performance of ASHP & backup
- Each site had detailed data collection
- Installs in climate zones 6 & 7



Heating Cycle COP of Dual Fuel System



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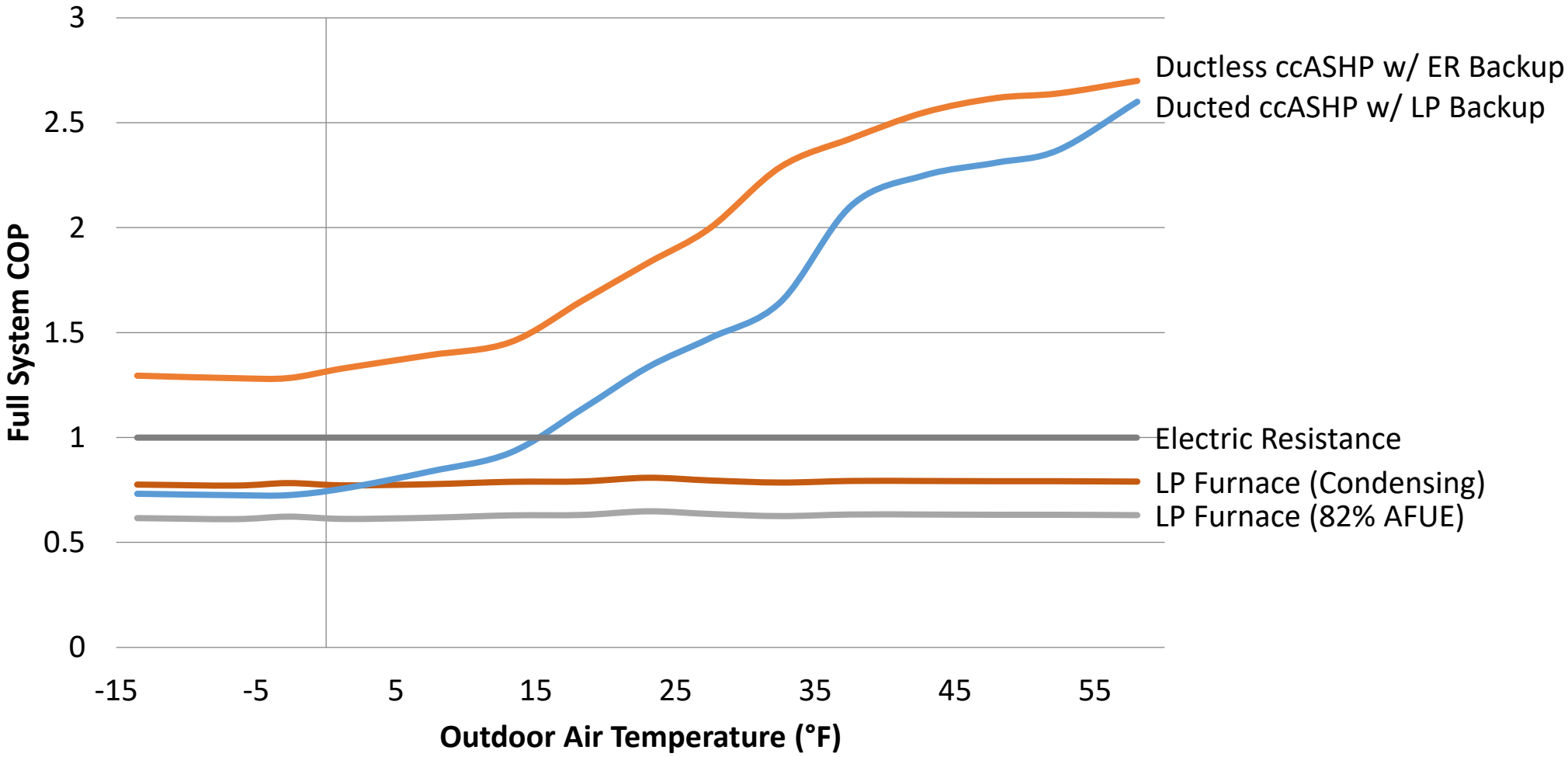
System performance: measured annual

- All-electric, ductless ccASHP **~1.9 to 2.1**
- Dual fuel, ducted ccASHP w/ LP Backup: **~1.2 to 1.3**



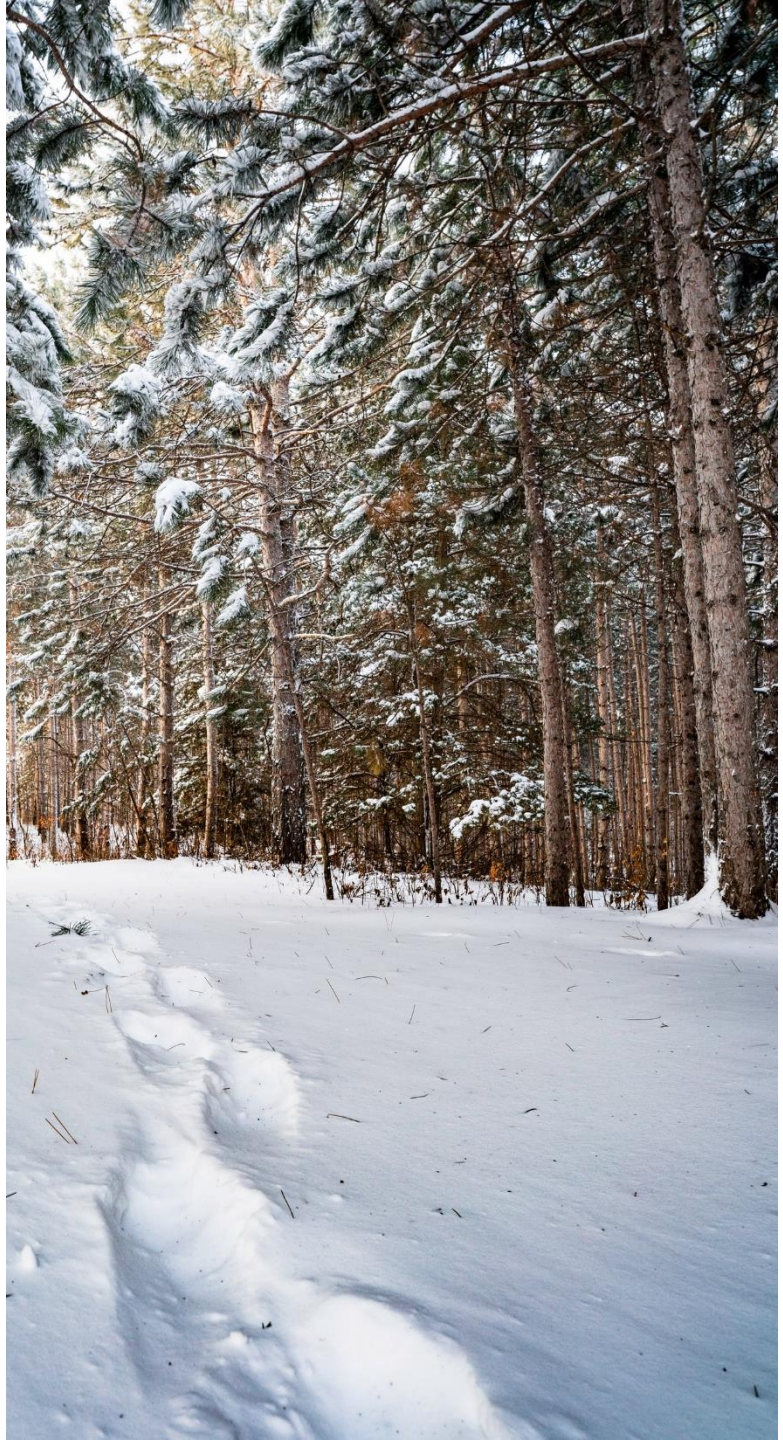
CEE's field research results

✓Significant savings for replacing propane and electric resistance

Percentage Reductions for ccASHPs				
	Site energy	**Source energy**	**Homeowner cost**	**Emissions**
Dual-fuel ASHP vs. propane furnace	40%	10%	30%	5%
All-electric ducted & ductless HP vs. electric resistance	55%	55%	55%	55%

✓Technology continues to improve

- New generation systems can operate as low as -20° (efficiently as low as -13)



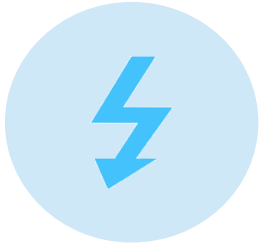
Really…in cold climates?

- Variable capacity advancements have expanded cold climate performance
- Standardization of a cold climate performance specification
- CEE field research studies observed systems delivering heat as cold as -25°F
- Manufacturers claim performance as low as -31°F

What are the benefits of a cold climate ASHP?

ASHP Benefits – Big Picture

Heating and cooling all in one system



Fuel choice flexibility

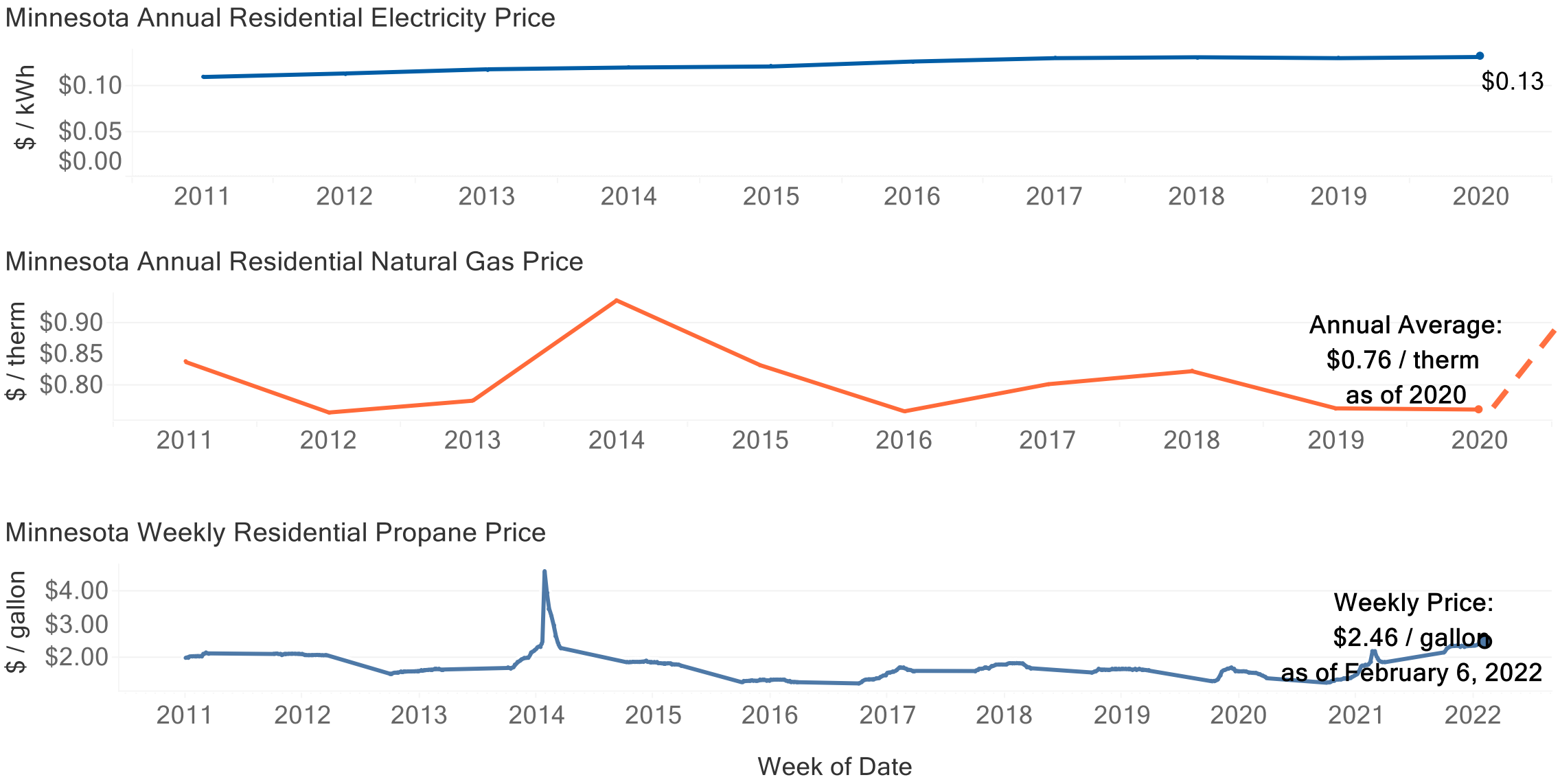
Improved comfort

Heating and cooling operational cost savings

Utility rebates

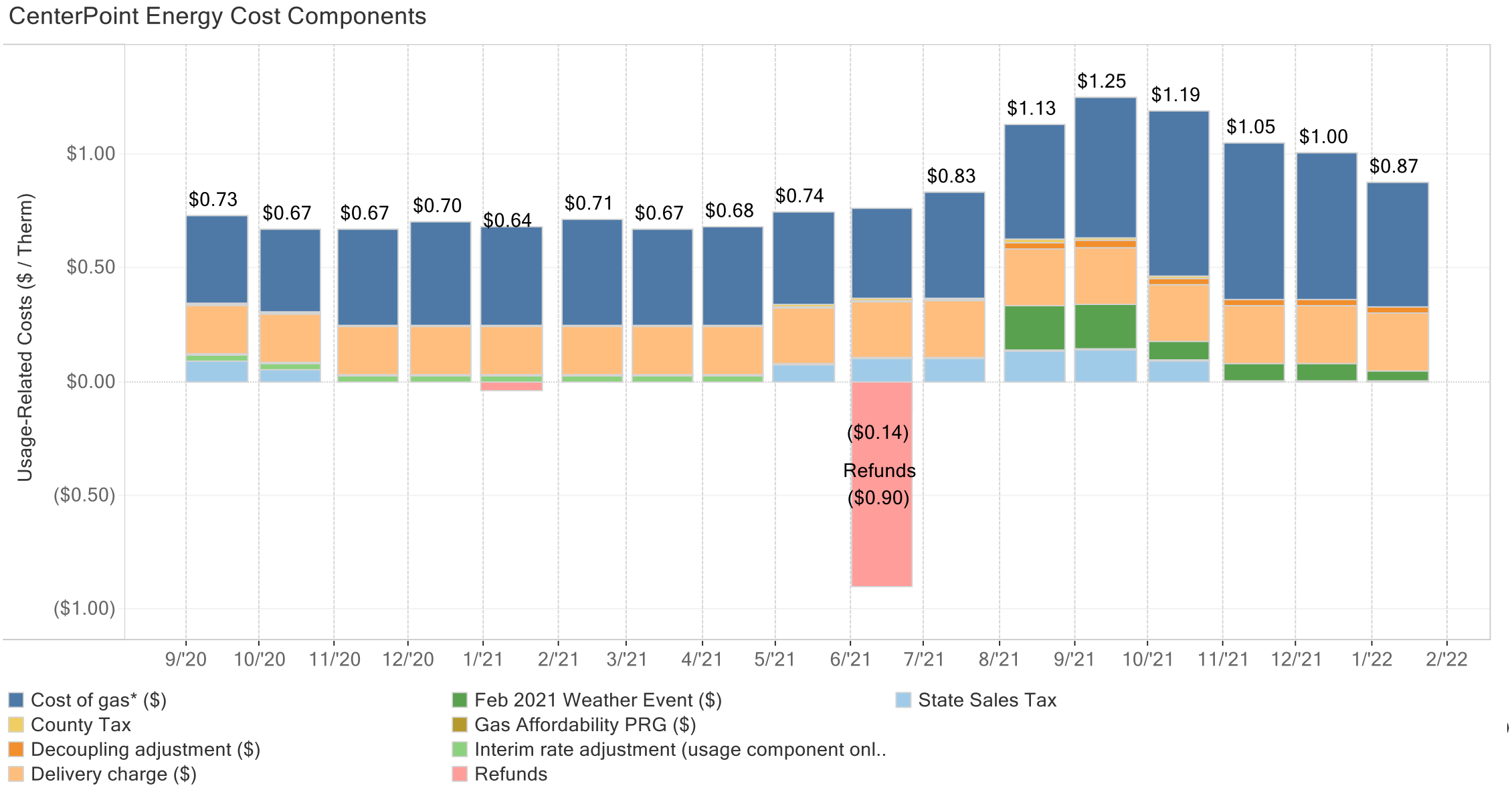
Reduced carbon emissions

Resilience against price volatility

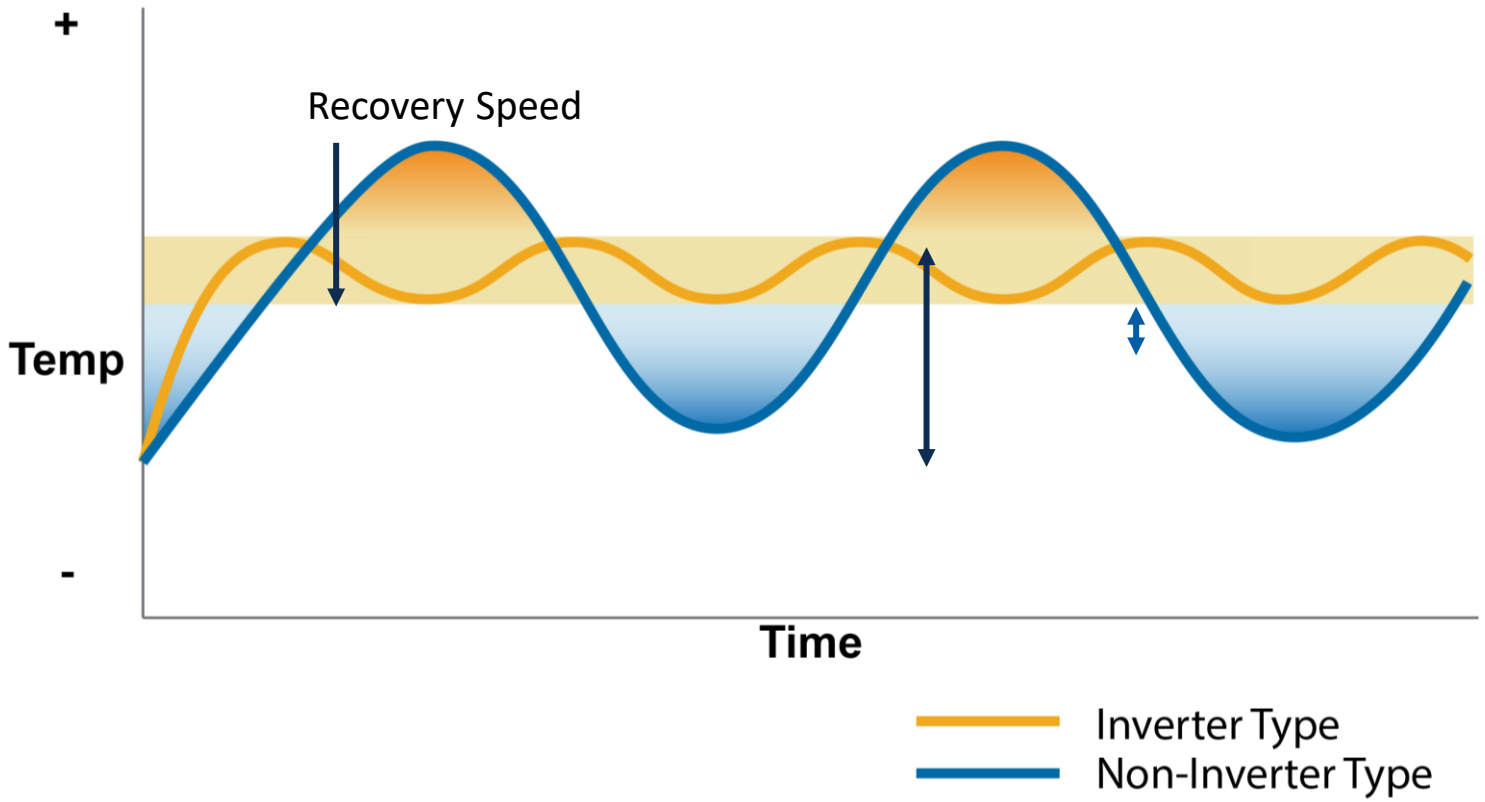


Data source: U.S. Energy Information Administration (EIA)

The cost of natural gas is at an all time high

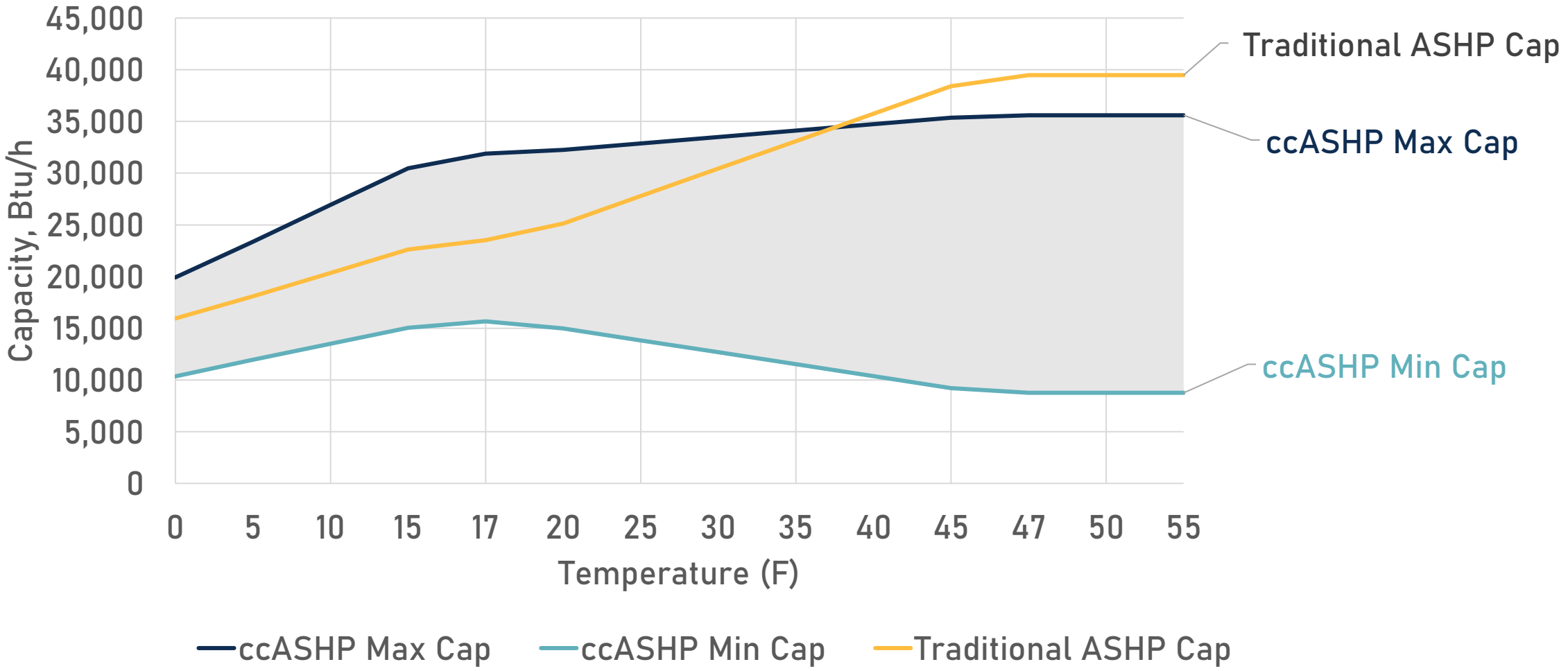


How Modulation Helps - Control



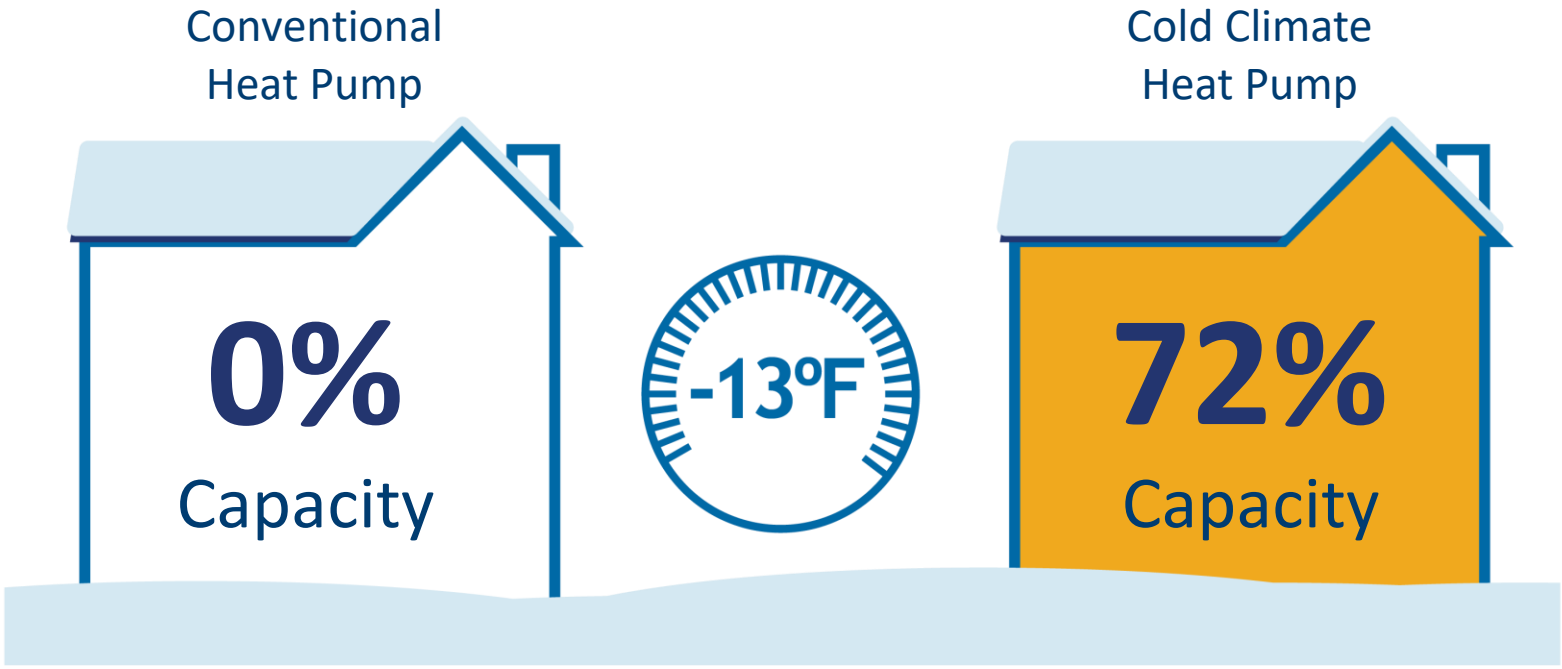
- More control
- Less waste
- Improved comfort

Variable capacity system modulate to load for increased comfort and savings while offering higher capacities at lower temperatures



How Modulation Helps – Capacity

- Traditional heat pumps cannot perform at low temperatures and therefore require supplemental heat
- Cold climate heat pumps require less supplemental heat



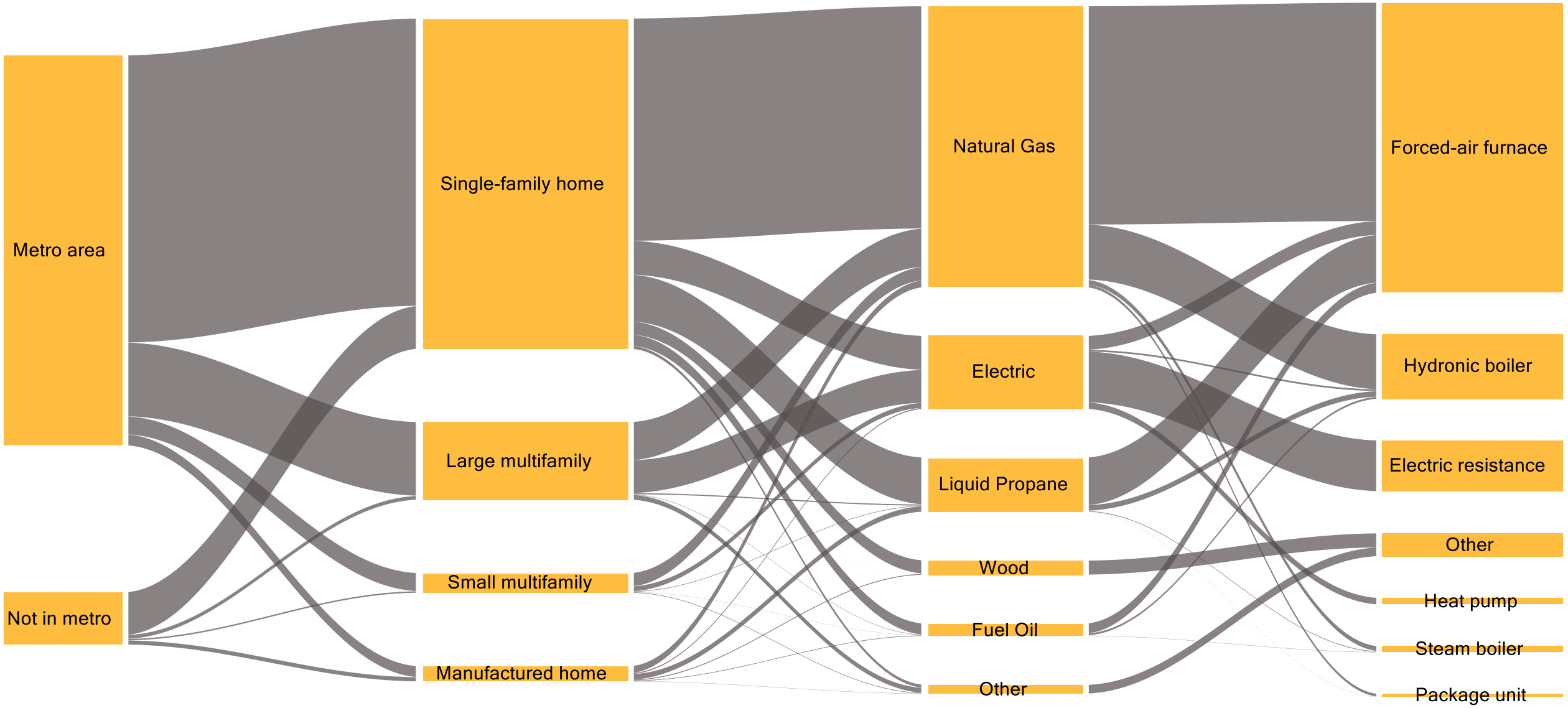
How do benefits stack up by application type?

ASHP Application Types

Existing HVAC	ASHP Options	Considerations	Market Size
AC replacement – with ductwork	Ducted ASHP	Sizing, energy costs, product cost, change over temperature	1,200,000 homes
AC replacement – without ductwork	ccDHP	Sizing, comfort needs, product cost	320,000 homes
Electric baseboard	ccDHP	Sizing, home configuration, number of heads	270,000 homes
Propane furnace	Ducted dual-fuel ccASHP	Sizing and change over temperature	250,000 homes
Electric furnace	Ducted ccASHP	Sizing and electric plenum backup	87,000 homes

Primary Space Heating Types in Minnesota Homes

Total households:
2,358,346



Sources: US Census Bureau and MN Potential Study (CEE 2018)

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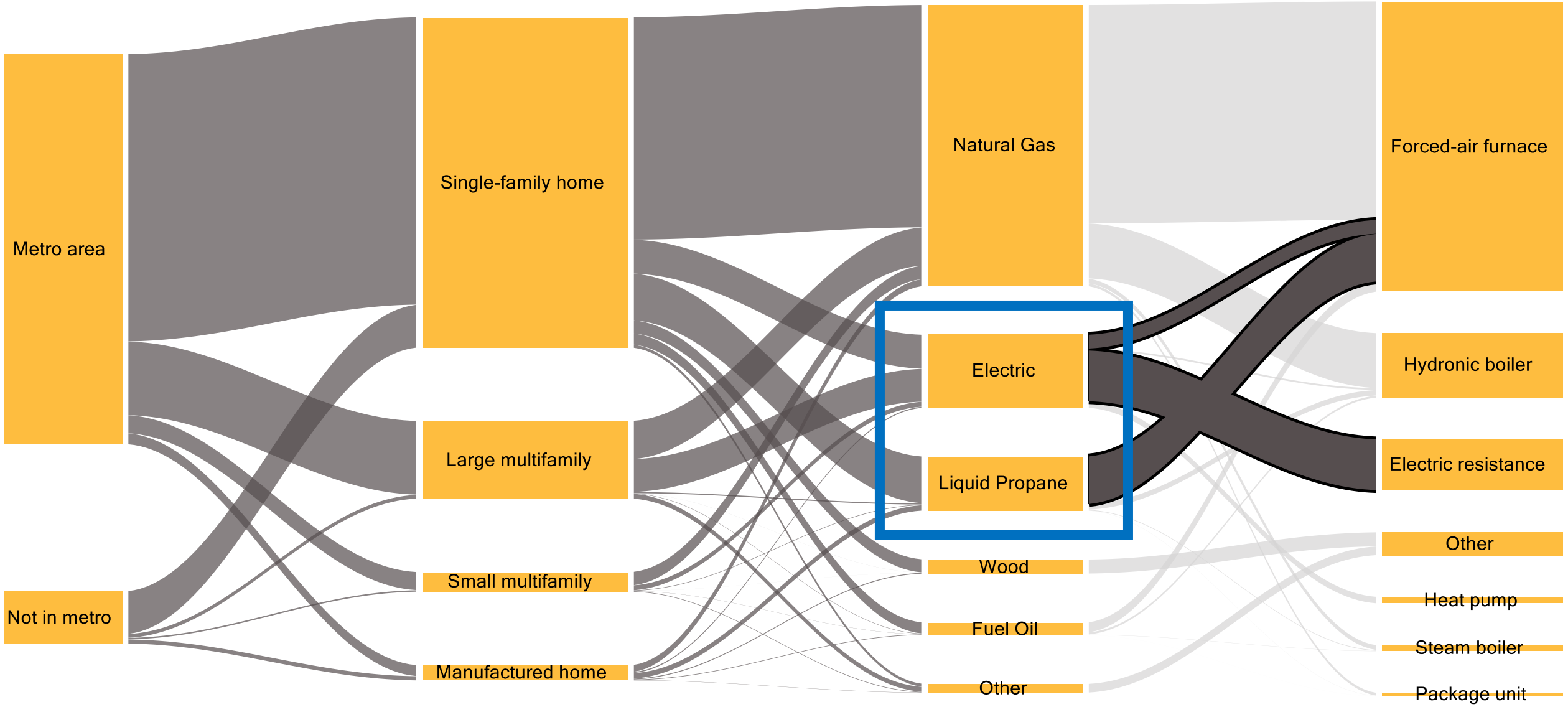


Sources: US Census Bureau and MN Potential Study (CEE 2018)

Focus on three system types

1. Ducted, dual fuel cold-climate air source heat pump (ccASHP) to displace furnace and replace AC

2. Cold-climate ductless heat pump (ccDHP) to displace electric heat or a gas boiler

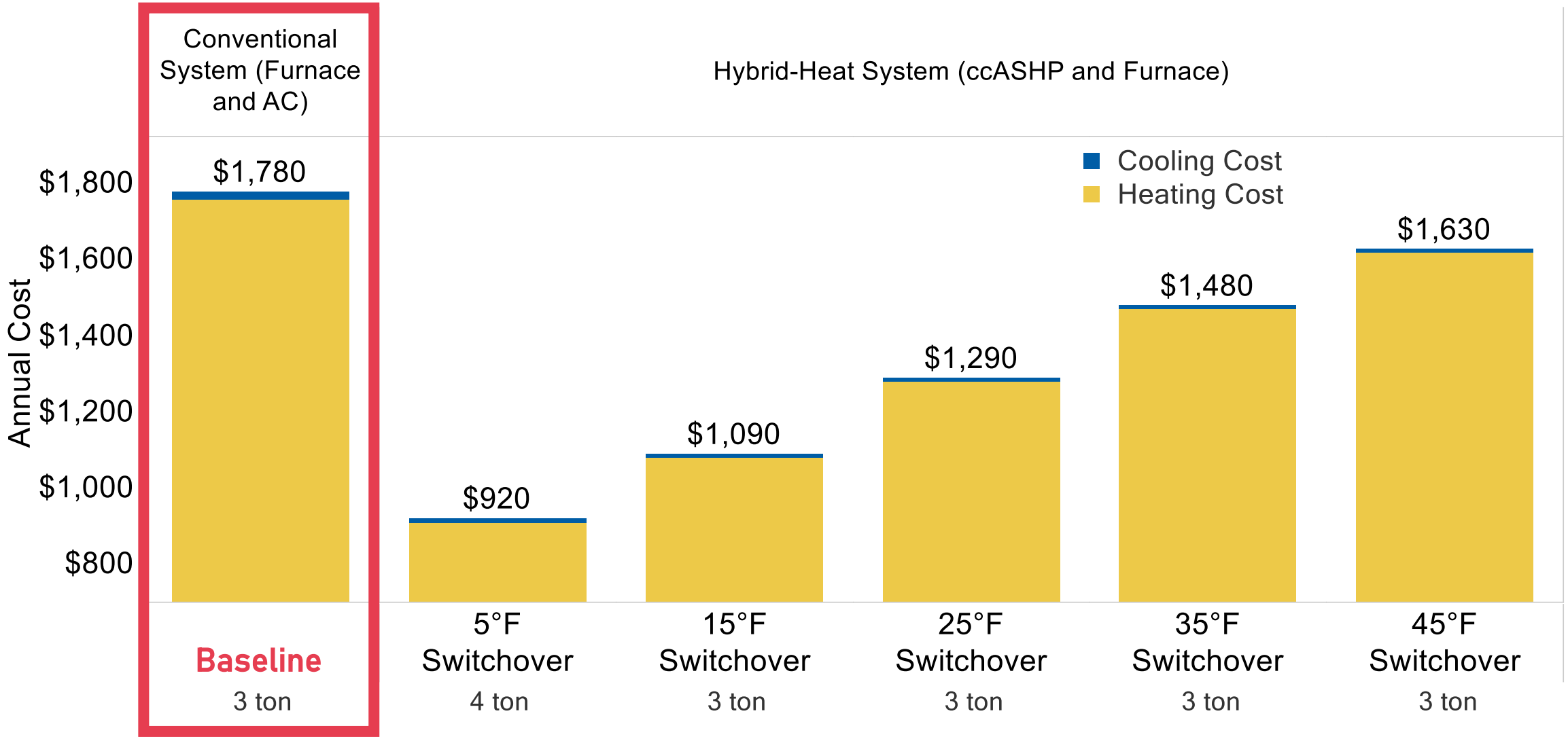
3. All-electric ccASHP to replace AC and displace propane

1. Ducted, dual fuel cold-climate heat pump to displace furnace and replace AC

Benefits

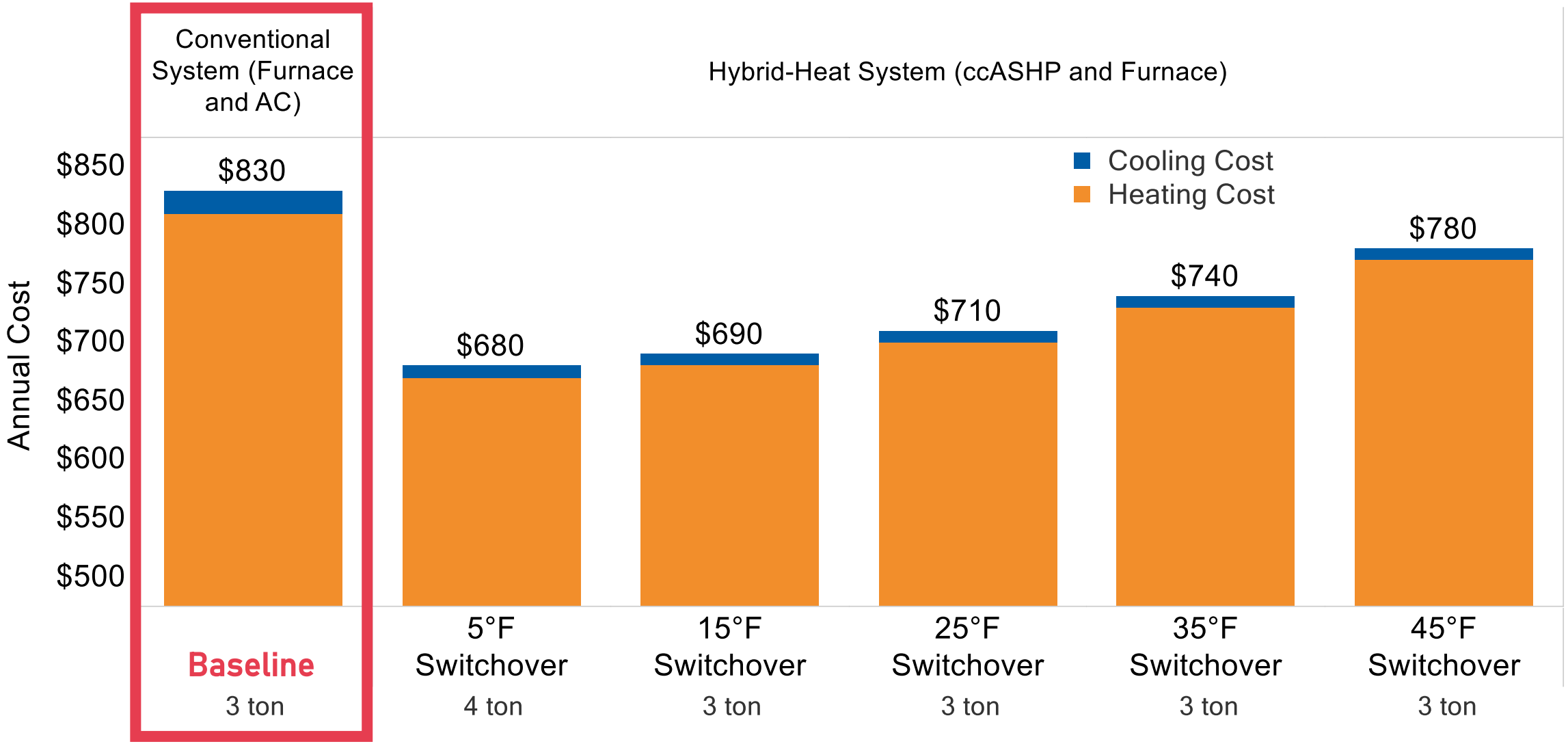
- Ideal for AC replacement
  - If the furnace doesn't have to be replaced, there are units that integrate with any existing furnace
- May have older furnace
  - Opportunity to upgrade entire system
- Resilience and future proof
  - Changing fuel prices
  - Power disruption

Operating costs: dual-fuel ccASHP with propane backup compared with a furnace and AC



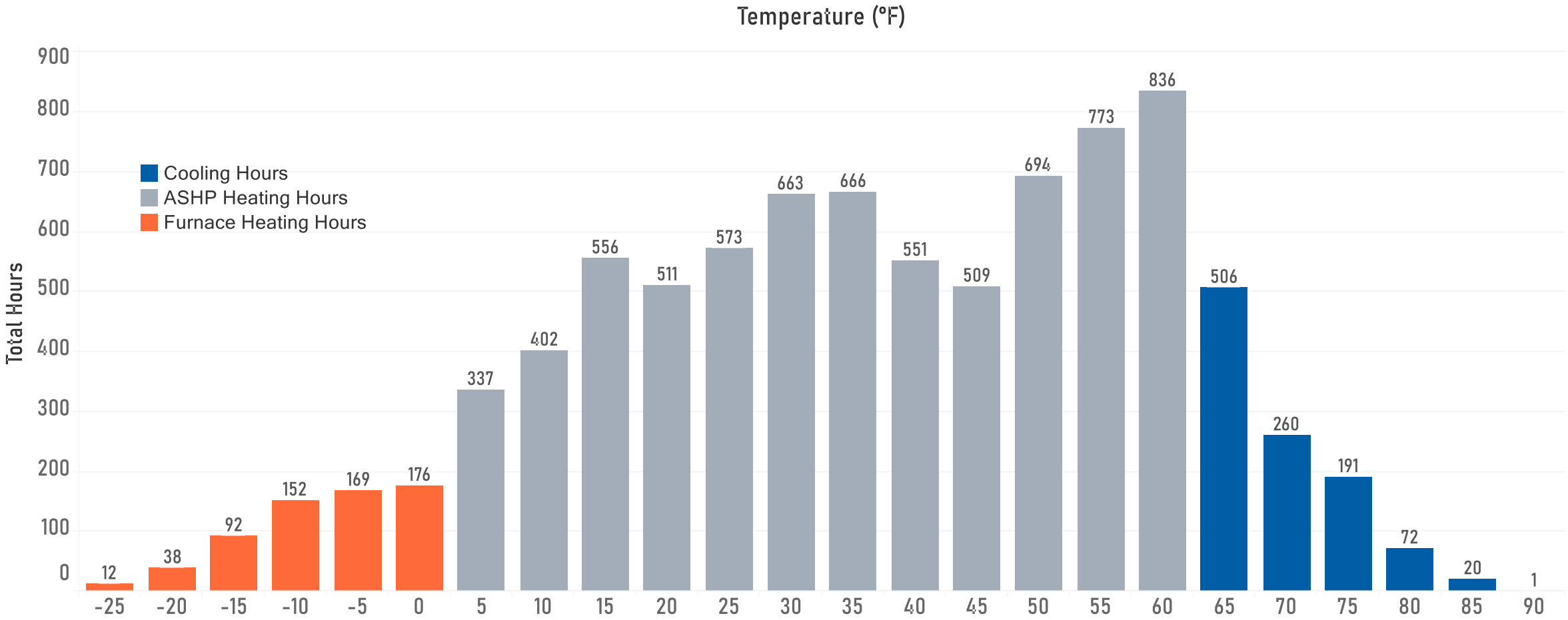
Average NEEP QPL heat pump; Dual fuel electric rate: 6¢/kWh; Propane: $1.60 / gallon; Weather station: Duluth, MN

Operating costs: dual-fuel ccASHP with natural gas backup compared with a furnace and AC



Average NEEP QPL heat pump; Dual fuel electric rate: 6¢/kWh; Natural gas: $8/dtherm; Weather station: Duluth, MN

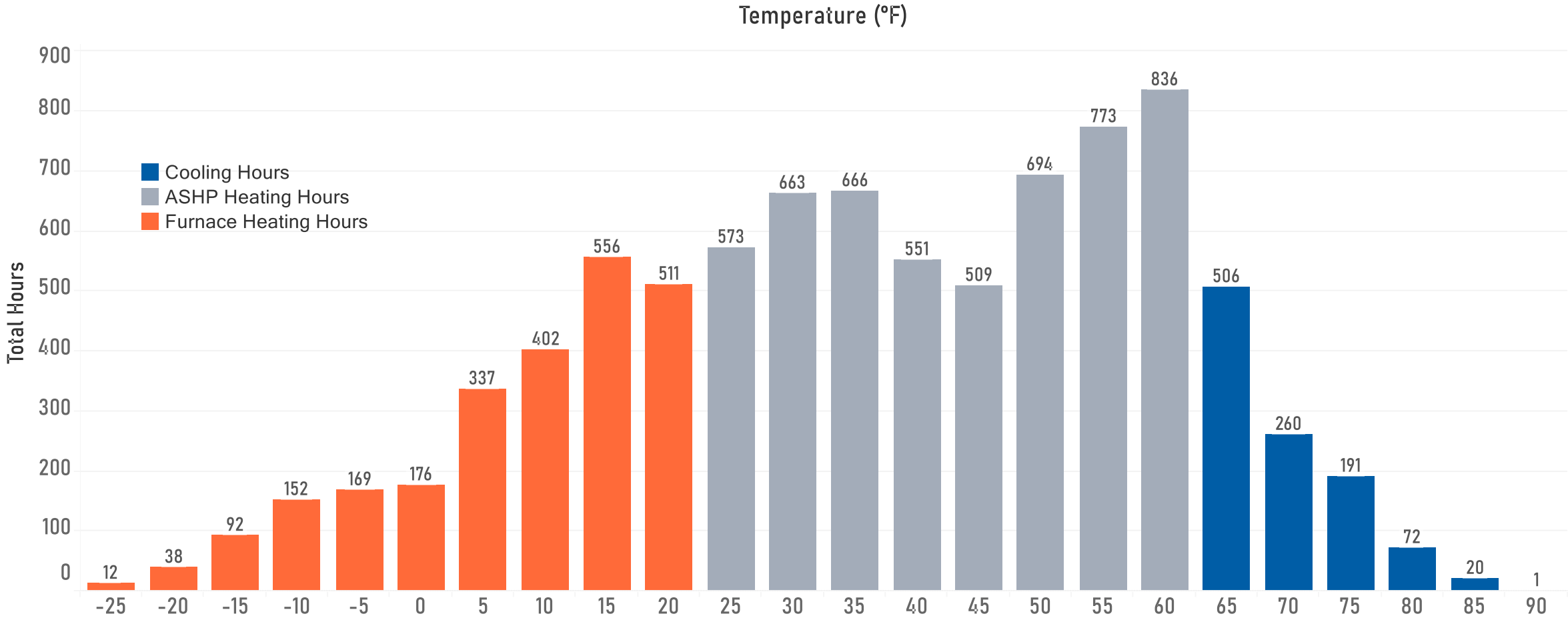
Choosing a switchover temperature of 5°F allows HP to serve ~90% of annual heating hours (Duluth, MN)



Furnace Heating Hours	ASHP Heating Hours	Cooling Hours	Total Hours
639	7,071	1,050	8,760
12%	81%	7%	100%

Filterable TMY3 dashboard for 5 MN regions available at: https://www.mnashp.org/cost-of-heat-comparison

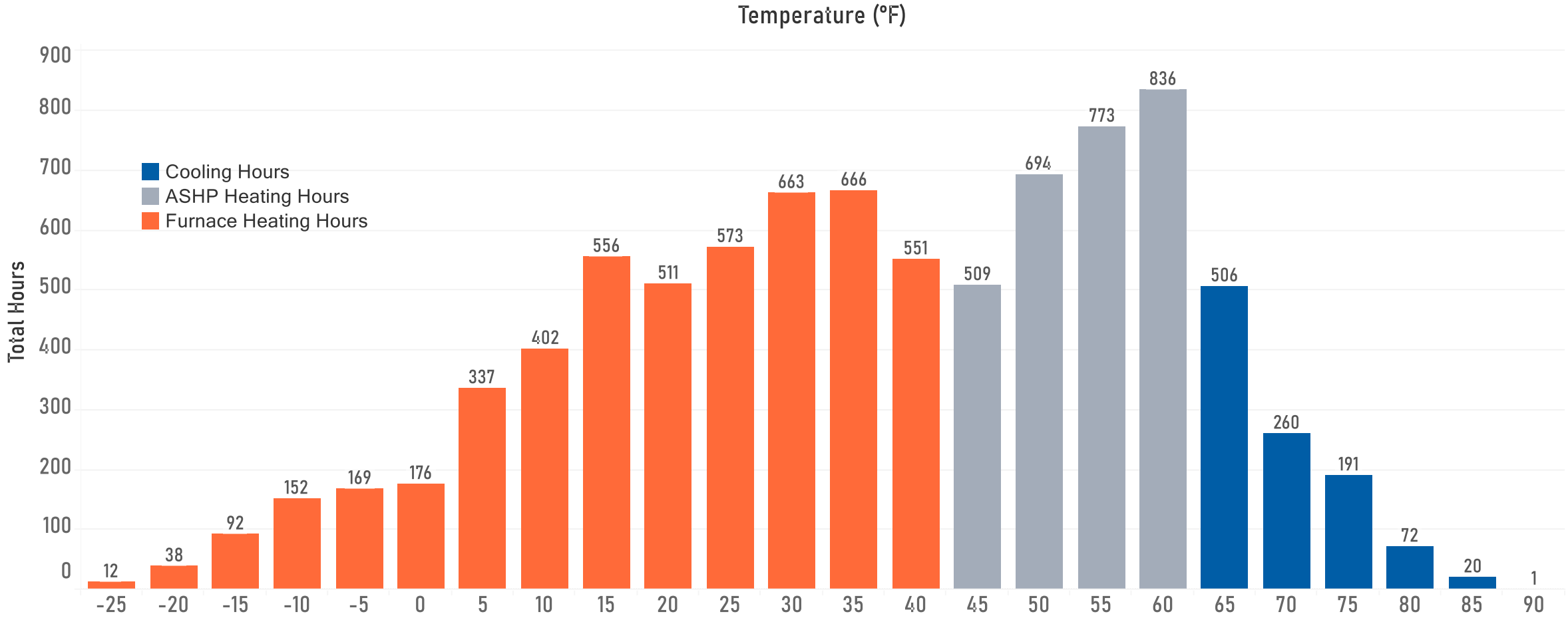
Choosing a switchover temperature of 25°F allows HP to serve ~70% of annual heating hours (Duluth, MN)



Furnace Heating Hours	ASHP Heating Hours	Cooling Hours	Total Hours
2,445	5,265	1,050	8,760
12%	60%	28%	100%

Filterable TMY3 dashboard for 5 MN regions available at: https://www.mnashp.org/cost-of-heat-comparison

Choosing a switchover temperature of 45°F allows HP to serve ~35% of annual heating hours (Duluth, MN)



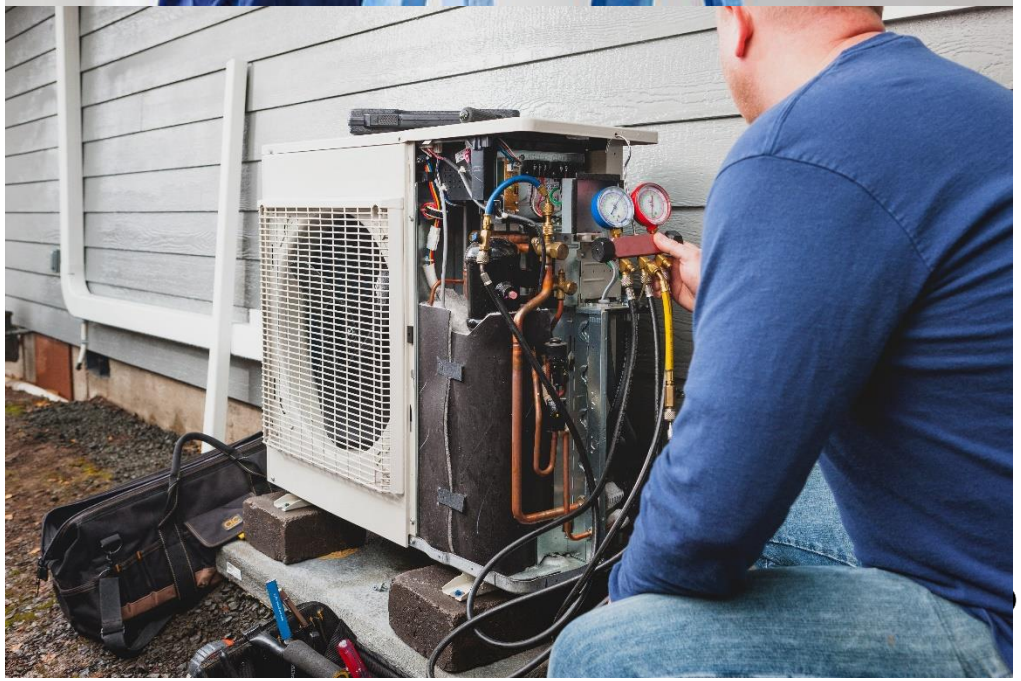
Furnace Heating Hours	ASHP Heating Hours	Cooling Hours	Total Hours
4,898	2,812	1,050	8,760
12%	32%	56%	100%

Filterable TMY3 dashboard for 5 MN regions available at: https://www.mnashp.org/cost-of-heat-comparison

2. Cold-climate ductless heat pumps

Benefits

- Cooling and heating where needed
- Energy savings
- Superior performance
- No ductwork



Ideal applications for ductless heat pumps

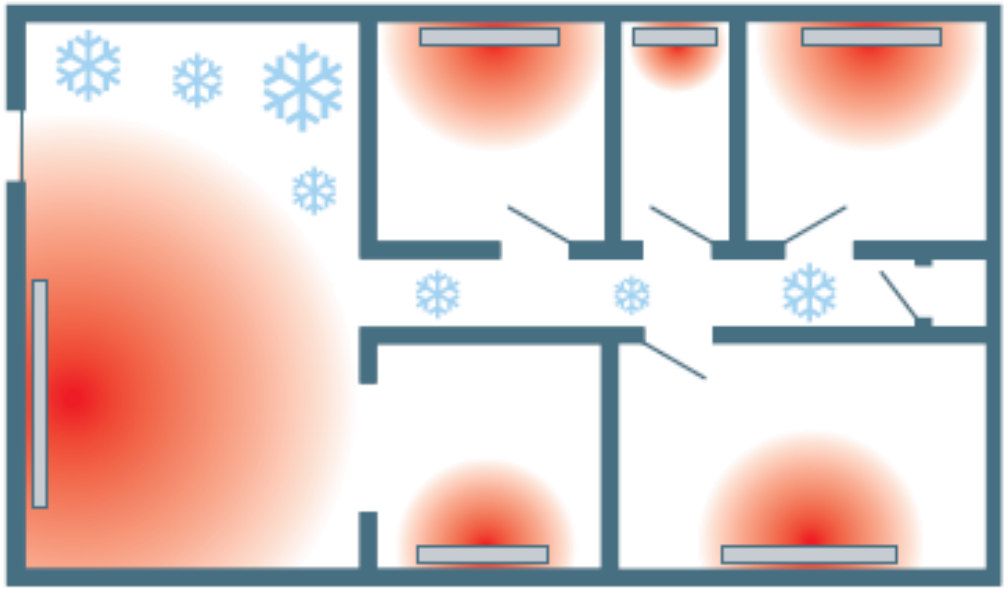
1. Homes with electric baseboard

2. Homes with natural gas boilers

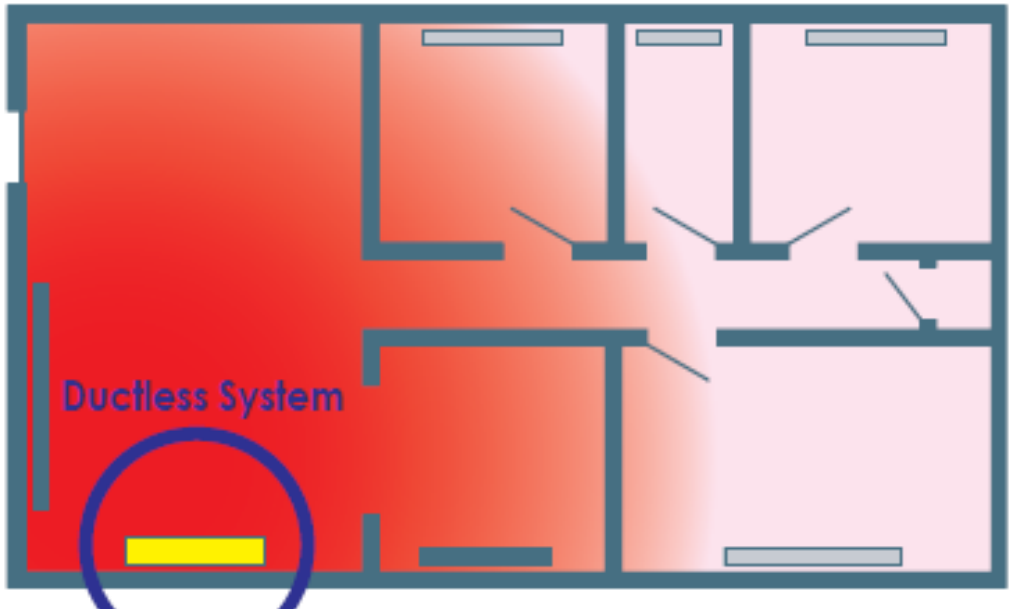
3. Remodel, accessory dwelling units, trouble spots

Cold climate ductless heat pump to displace electric baseboard heat

- Partial loads
- Ideal for open floorplans
- Baseboards remain (backup heating)
- Summer air conditioning
- Half the heating cost
- No ductwork needed



Pre-Existing System
Baseboard heating system



Displacement Heating
Single-head DHP in the main living area

Cold climate ductless heat pump for homes without ductwork

Benefits

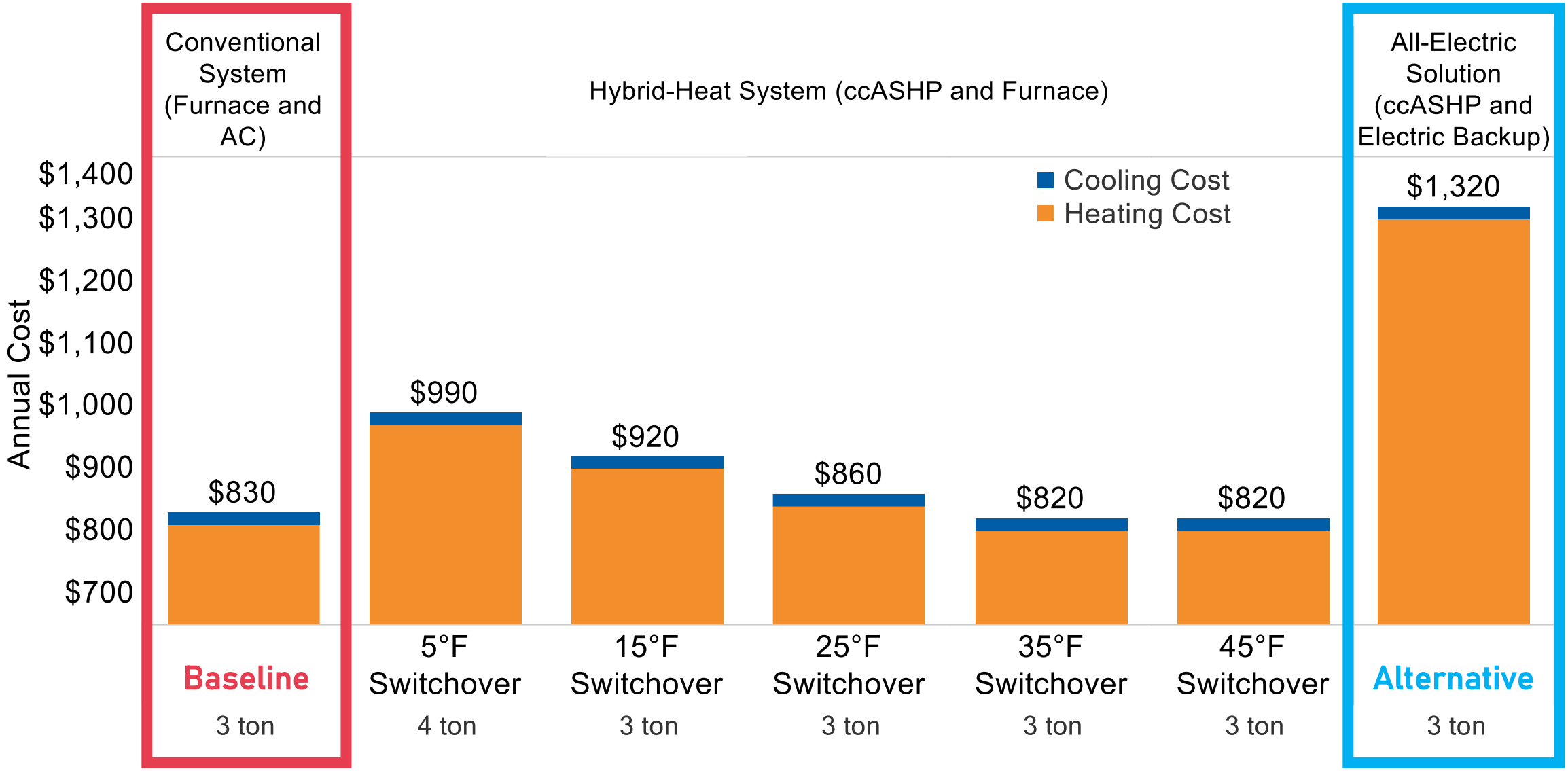
- Improved comfort
- Some heating from the boiler can be supplemented with the heat pump
- Affordable way to add efficient heating and cooling without sacrificing the historic look and feel of the home

3. All electric cold-climate heat pump to replace furnace and AC

Benefits

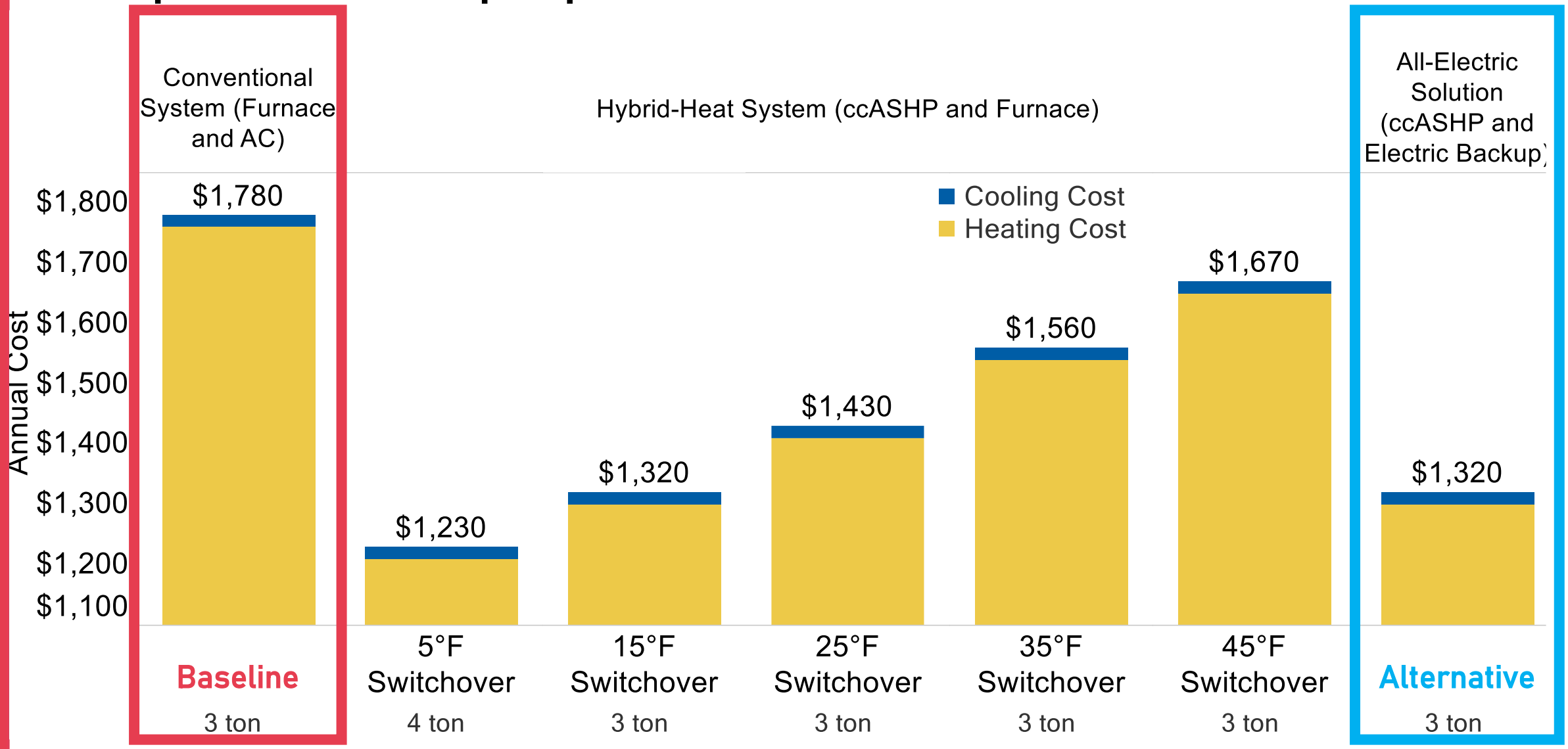
- Both furnace and AC ready to replace
  - Ideal for high performance
- Reduced carbon impact
  - Rooftop solar
  - EV owner

Operating costs: all-electric, cold-climate heat pump compared with a natural gas furnace / AC baseline



Average NEEP QPL heat pump; Standard electric rate: 9.7¢/kWh; Natural gas: $8/dtherm; Weather station: Duluth, MN

Operating costs: all-electric, cold-climate heat pump compared with a propane furnace / AC baseline



Average NEEP QPL heat pump; Standard electric rate: 9.7¢/kWh; Propane: $1.60 / gallon; Weather station: Duluth, MN

A Summary of ASHP Benefits

- Improved comfort
- Resiliency against price volatility
- Operational cost savings for certain application types
- Increased energy efficiency
- Decrease furnace short cycling during shoulder months

Installation Considerations

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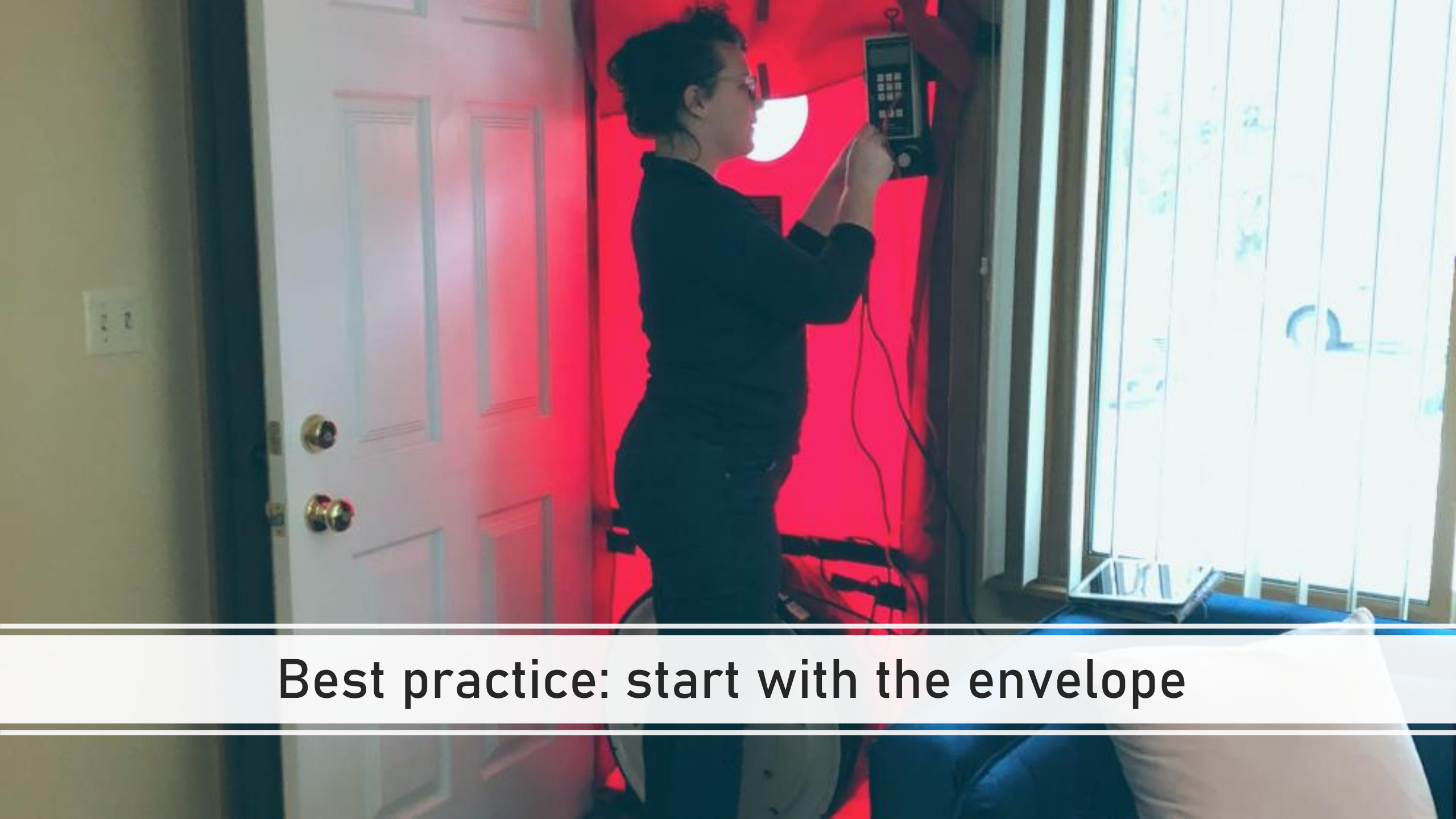


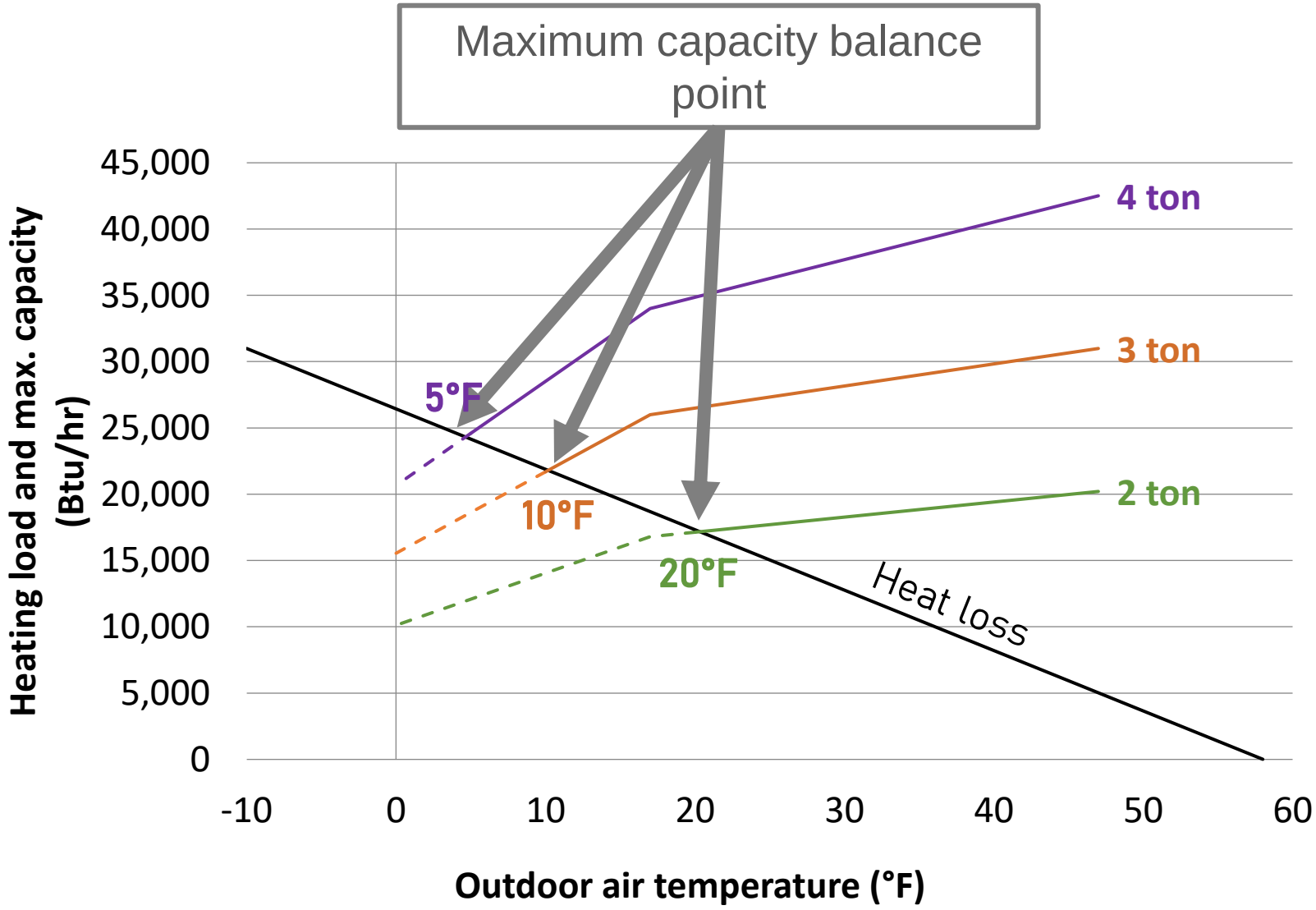
Best practice: start with the envelope

Installation Considerations

- Control and Operation
- Integration with backup
- Sizing

Design & Sizing for Ducted Systems

- Trade-offs between HP size and fraction of heating load meet
- In many scenarios, sizing for heating increases HP size by 1 ton over sizing for cooling when proper sizing practices are followed.
- Percent heating load met by ASHP:
  - **4 ton ~ 86%**
  - **3 ton ~ 77%**
  - **2 ton ~ 60%**



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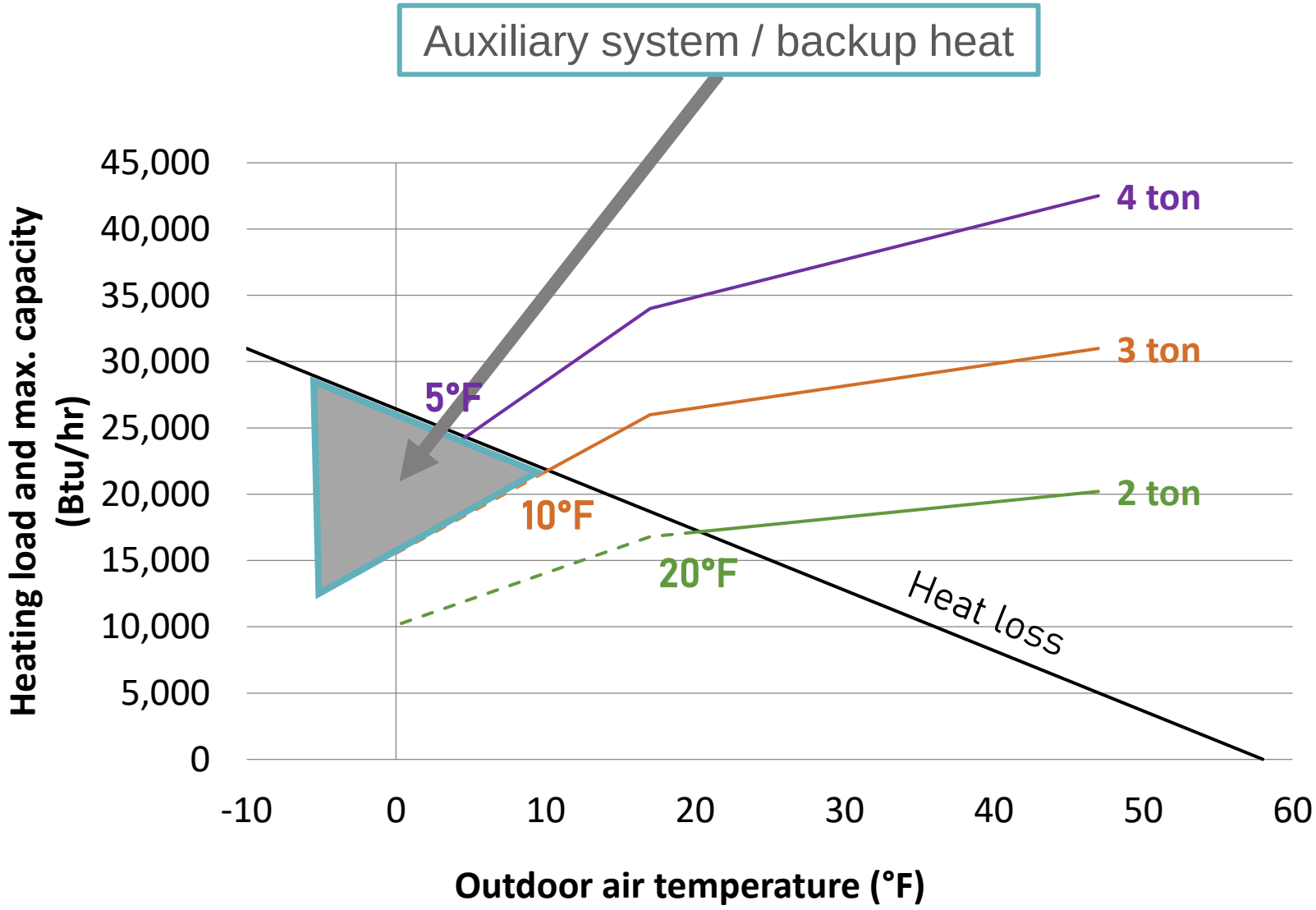
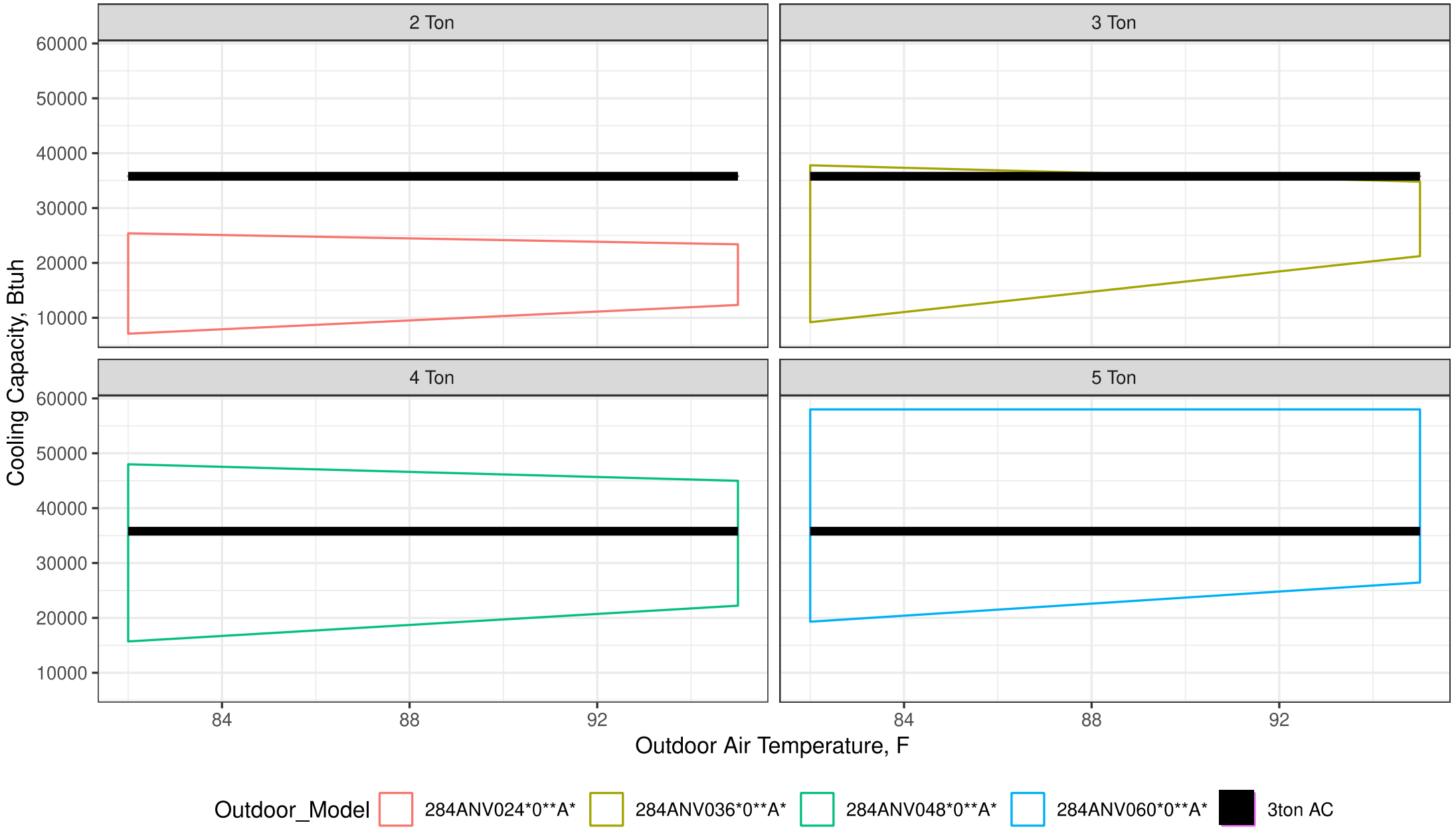


Cooling benefits and impact based on sizing for heating



Ductless installation considerations

- Sizing – heating or cooling load
  - Part load calculations
- Ductless Head Locations
  - Displace maximum load
  - Open space and/or large rooms
- Controls – thermostat setpoints
  - Set backup heat to lower setpoint
  - Backup heat temperature lock out
- Homeowner Education
  - Consistent heating and cooling
  - Temperature controls

Typical Switchover Temps. By Application

Application	Typical switchover temp
ccDHP displacing baseboard heat	0-5° F (or lower depending on sizing)
ccASHP displacing propane furnace	0-15° F (depending on cost of propane and sizing)
ASHP displacing natural gas furnace	25-45° F (depends on gas and electric rate)

Installation take-aways

- Consider ductwork, cooling, and heating load when sizing retrofits
- Size to maximize heating load for propane and electric backup with ccASHPs
- Right sized ccASHPs modulate to a lower capacity during cooling months aiding dehumidification
- Consider fuel prices when selecting switchover temperatures
- Homeowner education goes hand in hand with satisfaction

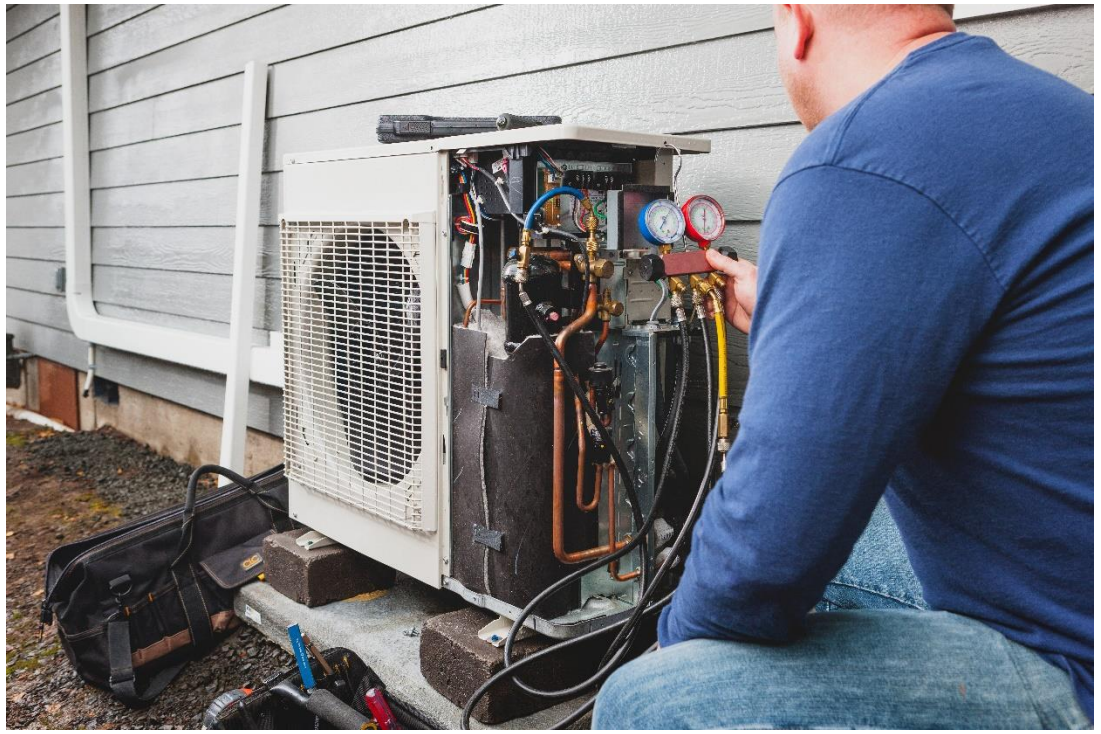
Where can we find more resources on ASHPs?

MN ASHP Collaborative Contractor Resources

- Free training modules
- Best practices guide
- Rebate map lookup tool and downloadable data for all utilities in MN
- Manufacturer promotions
- In person training
- Preferred Contractor Network

Preferred Contractor Network

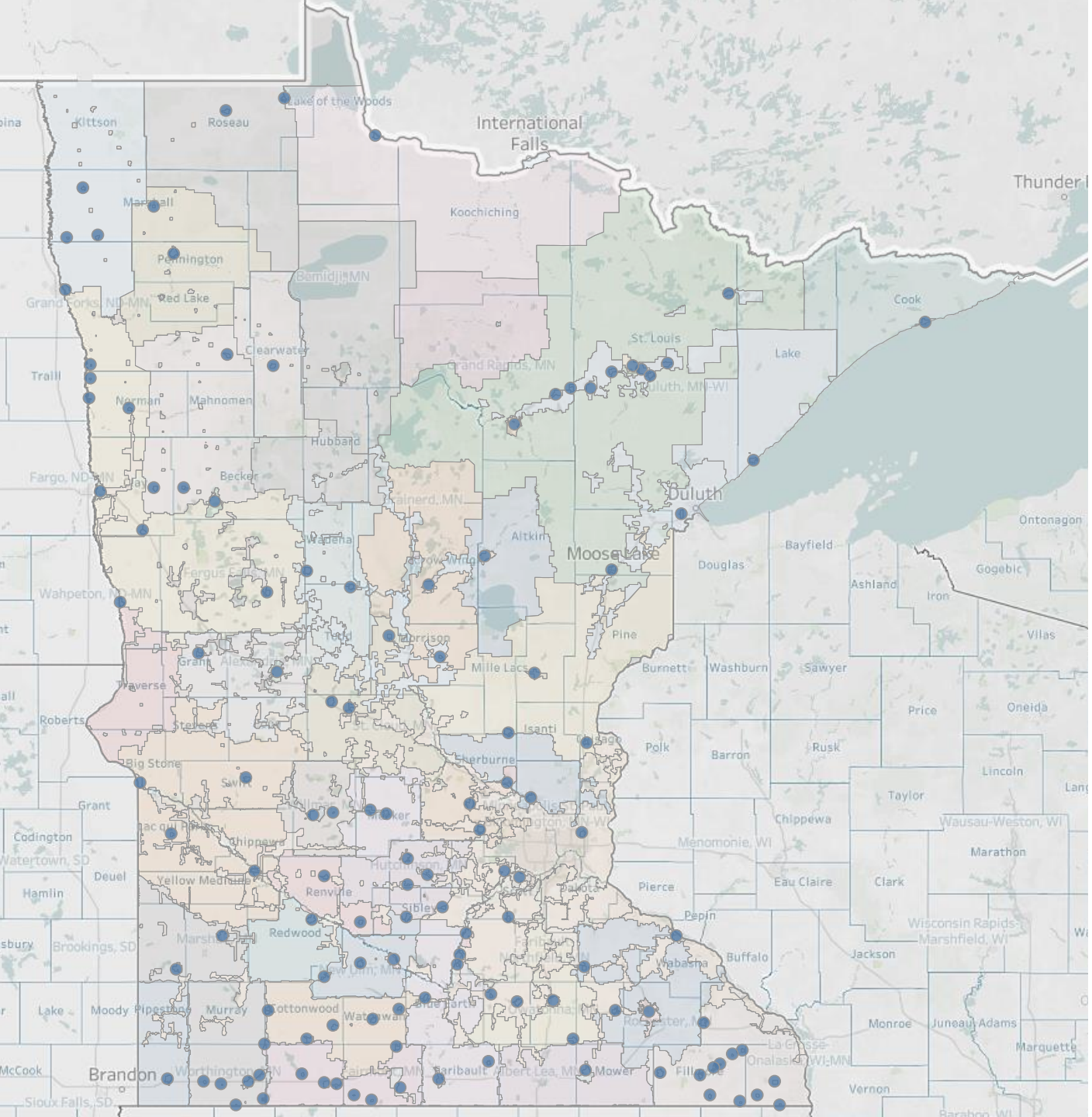
- Gain leads through the ASHP Collaborative website and staff
- Access trainings and the latest heat pump research
- Promote your endorsement from an unbiased, third-party
- Cobrand materials with the ASHP Collaborative
- Complement your inclusion on utility contractor lists



Free Training Opportunities

- Module 1: ASHP Potential and Utility Rebates*
  - Beneficial for business owners, sales staff, and technicians: learn high-level technology information and tools/resources to promote the equipment.
- Module 2: Tips and Tricks for Installing ASHPs*
  - Learn research-based recommendations on installing ccASHP systems for optimized energy performance.
- Module 3: Leads and Marketing for Air Source Heat Pumps
  - Learn how to generate low-cost, high-close-rate leads for air source heat pumps through proven techniques developed by a successful, heat-pump-only business owner.
- Module 4: Sales and Value Proposition for Air Source Heat Pumps
  - Building on concepts outlined in “Leads and Marketing,” learn how to convert leads into sales by using value propositions.

*Prerequisite for Preferred Contractor Network eligibility



Interactive Utility [Rebate Map]

Download the spreadsheet

Newsletter Sign Up

- Learn of limited time manufacturer and rebate opportunities
- Stay up to date with CEE ASHP research
- Get event and conference updates

Current Heat Pump Projects

Heat Pumps for ACs

Air-to-Water Heat Pumps

Best Practices to Residential Cooling Solutions

Cold Climate Heat Pumps for Multifamily

MN ASHP Collaborative Homeowner Resources

- Financing information
- FAQ
- Case studies across MN
- Buying guides
- Product finders
- News articles
- Blog
- Contractor lookup through Preferred Contractor Network

The age of the HP is coming…

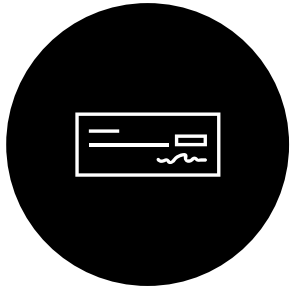
- Multiple value propositions offered through ASHPs
- Opportunity to prepare and take advantage of the market shift
- Electrification is already taking off in other market sectors

Next Steps for Contractors

Practice installations at employee homes to gain experience with the technology

Attend manufacturer training

Attend ASHP Collaborative training



Learn about local utility rebates

Thank You

info@mnashp.org
612-335-5858

ASHP
air source heat pump collaborative