In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 code/energy hours** of credit toward **Building Officials and Residential Contractors** continuing education requirements."

For additional continuing education approvals, please see the continuing education credit section in the conference agenda booklet.

What Matters Most

In Determining ASHP Application Types

Dan Wildenhaus
Rabi Vandergon

ASHP
air source heat pump collaborative

At our core

PROGRAMS

We cut energy waste and improve comfort in homes, buildings, and communities.

RESEARCH

We identify cost-effective, efficient technologies through analysis, modeling, and engagement.

CONSULTING

We help building owners and entire communities achieve long-term, energy-saving solutions.

LENDING

We empower people to make upgrades on energy efficiency and comfort in homes or businesses.

POLICY

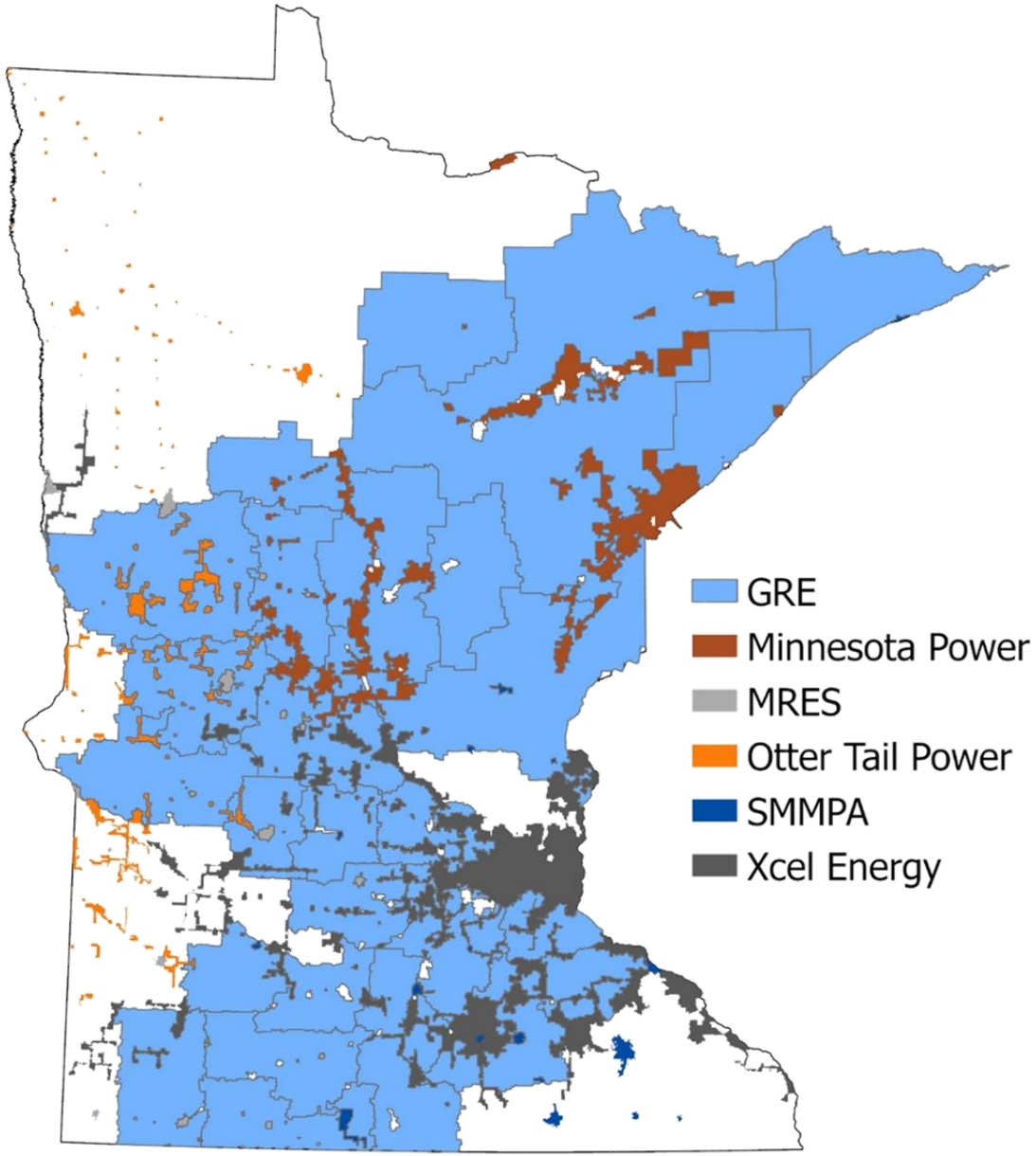
We strive for high-impact, pragmatic solutions guided by a public interest ethic.

MARKET TRANSFORMATION

We accelerate adoption of promising technologies through early market engagement.

cee
Center for Energy and Environment

MN ASHP Collaborative



- Launched by CEE in 2019 to accelerate adoption of ASHPs in MN:
- High opportunity for delivered fuels and electric heat customers in rural MN
- Investor-owned, cooperative, and municipal utilities contribute funding
- Following ECO and ETA legislation, programs are expanding to new application types including dual fuel ASHPS in 2023

Minnesota Energy Resources
CenterPoint Energy
Great River Energy
Missouri River Energy Services
Southern Minnesota Municipal Power Agency
Otter Tail Power Company
Xcel Energy
minnesota power

Goals

Understand features to ensure success:

- Scenario specific considerations and guidance
- Project goals
- Sizing
- System types
- Efficiency ratings
- Performance characteristics of home

Image credit: https://www.deviantart.com/bouzid27/art/Mountain-Everest-Nepal-Himalaya-1-681356456

Quick poll– How many people here do NOT have a heat pump in their home?

Now, how many of you without a heat pump are considering one in the next 5 years?

Research influences

Does sizing really matter? - From research

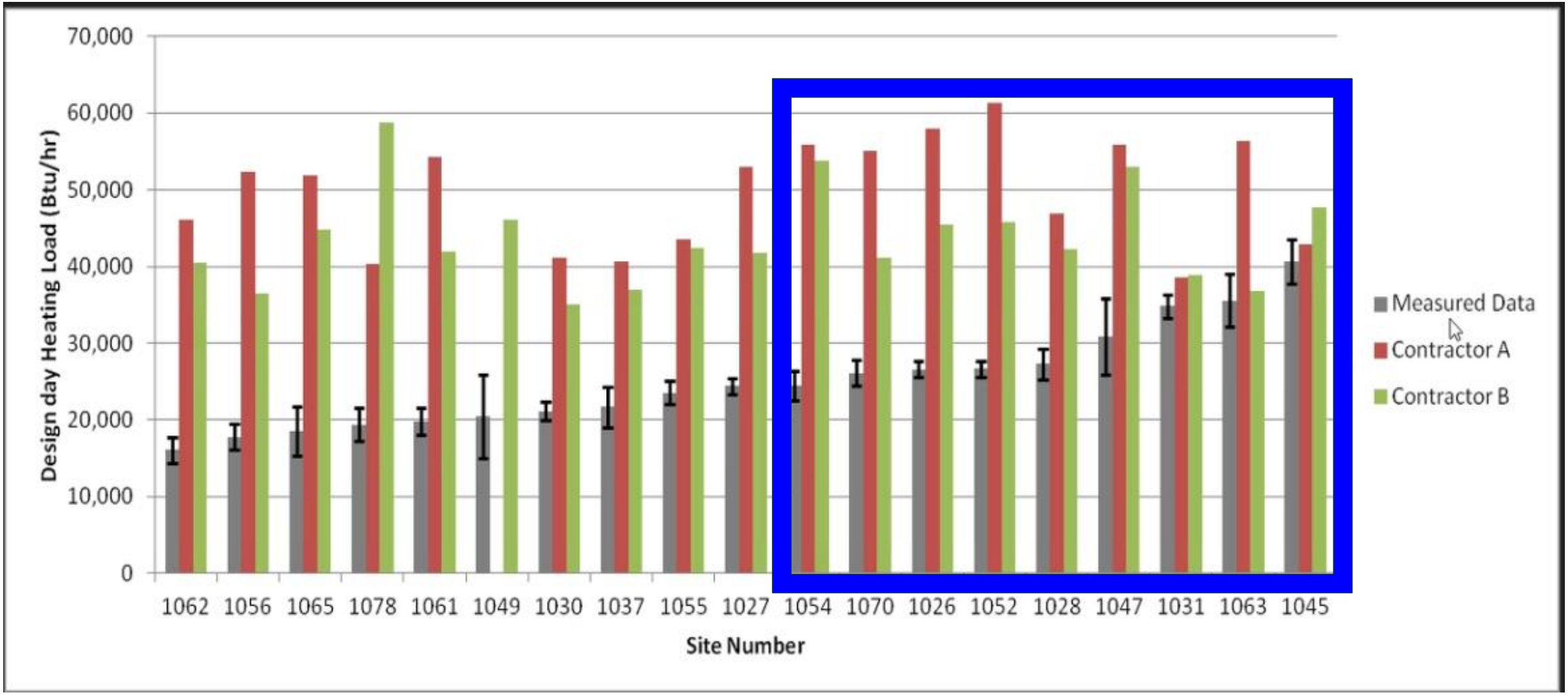
If **oversized for cooling by more than 140%,** energy use/**cost penalty of up to 10%** may be seen (depends on equipment type, brand, algorithms, control strategies and settings, etc..)

If **oversized for heating by more than 150%,** energy use/**cost penalty of 1 to 30%** may be seen (depends on equipment type, brand, algorithms, control strategies and settings, etc..)

Wrong sized for the **ductwork can lead to** much **higher fan watt draw**. An AHRI report showed that adding static pressure to Electrically Commutated Motors only reduced flow from 1 to 3% with increased fan power draw up to 48%!

NIST, NREL, Proctor Engineering, Illinois Institute of Technology, AHRI

CEE research findings



Envelope Improvements? *Acknowledgements*





Lucas Phillips Nick Cindrich Eric Werling Dave Bohac Josh Quinnell

National Renewable Energy Laboratory | U.S. Dept. of Energy | Center for Energy and Environment

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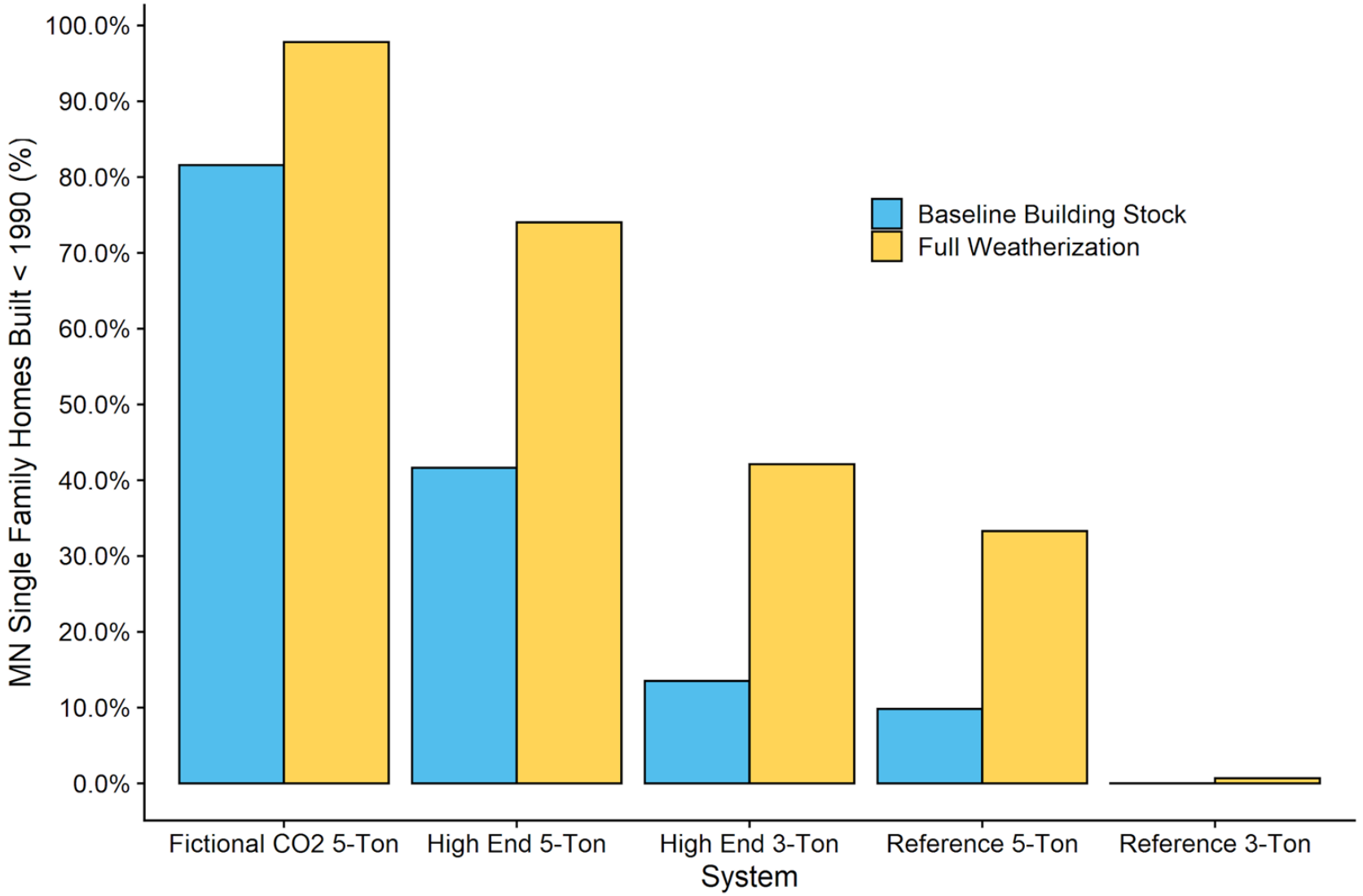
This work was supported in part by the Minnesota Department of Commerce, Division of Energy Resources, through the Conservation Applied Research and Development (CARD) program (Grant Contract #158619).

Envelope Improvements Show Results

- Best system available now can meet load on 75% of <1990 homes
- Even reference 5-ton system meets 33% of homes
- *25% peak load reduction*



Never replace another AC with an AC

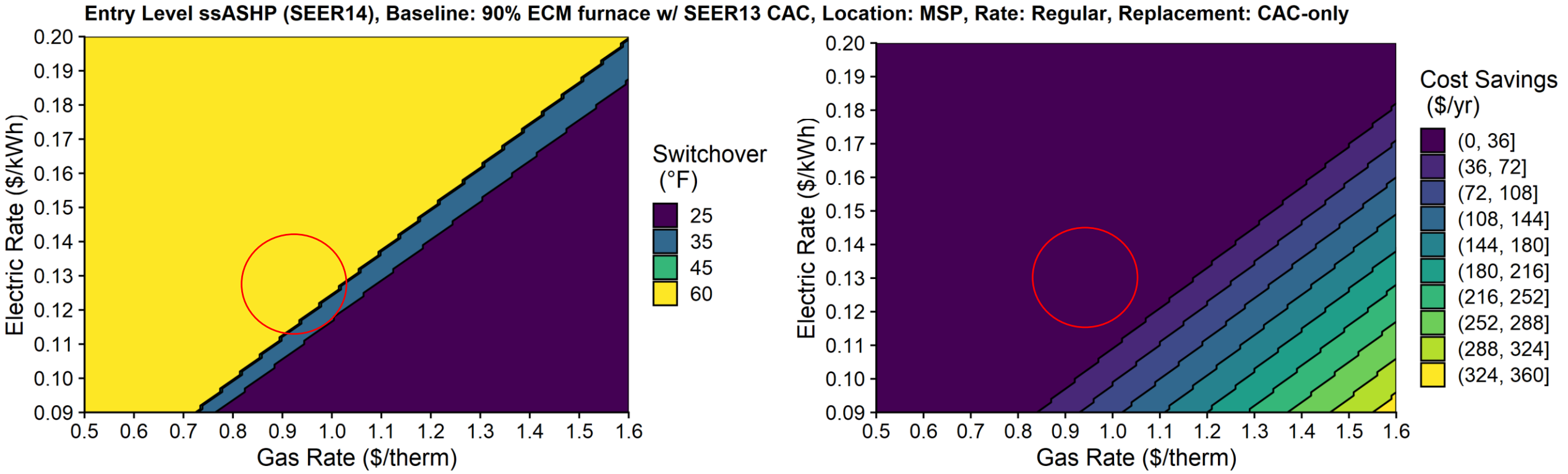
- Research project for ComEd – Strategies for Heat Pump Adoption at the Time of Air Conditioning Replacement
- CARD research project – Market assessment in Minnesota
- CARD research project – Heat Pumps for ACs
- CARD research project – Optimized Installations of Air Source Heat Pumps for Single Family Homes

Cost Savings and Cost-Effectiveness

- All combinations of location, baseline, ASHP, and replacement type have cost-effective outcomes
- ASHP operational cost savings (cost-effectiveness) exhibit extreme sensitivity to electric and gas rates

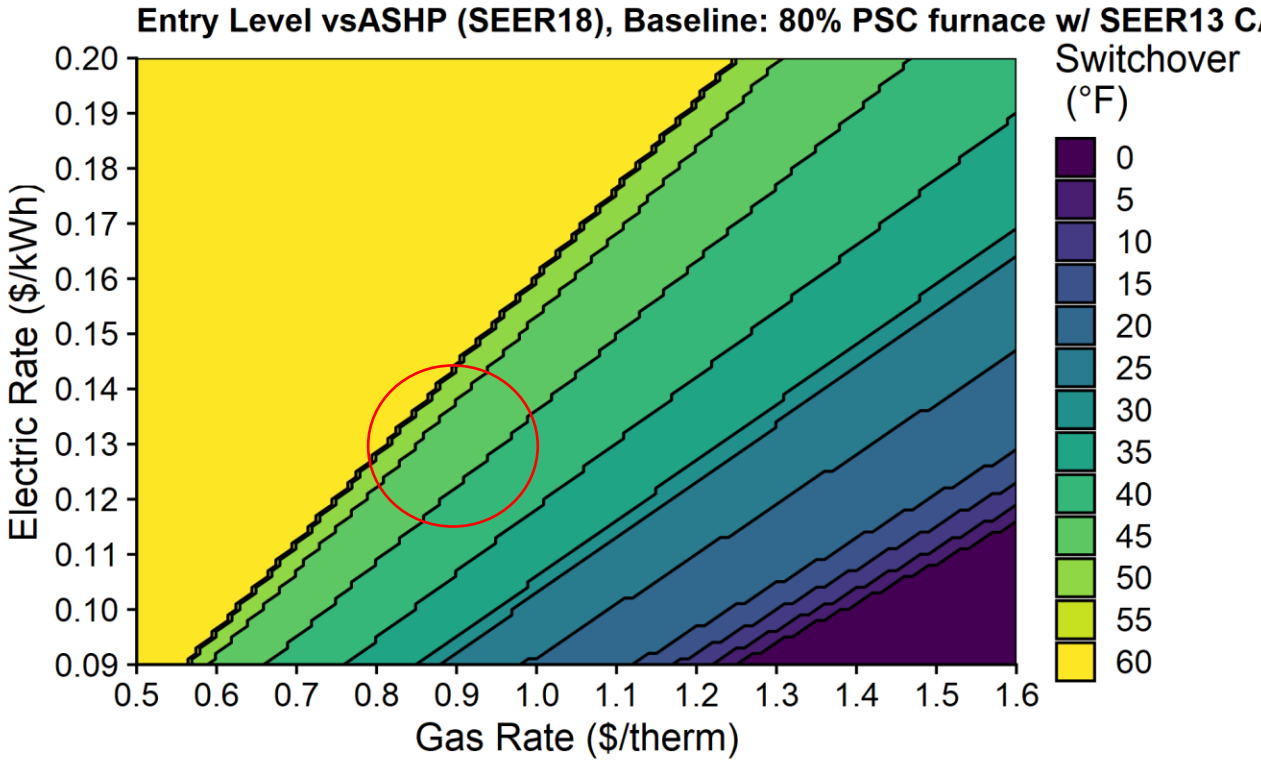
Scenario 1	Scenario 2	Scenario 3
• ssASHP paired with a newer furnace • CAC-only replacement	• Entry-level vsASHP • Full replacement of older furnace	• Entry-level vsASHP • Full replacement of older furnace • Dual fuel space heating rates

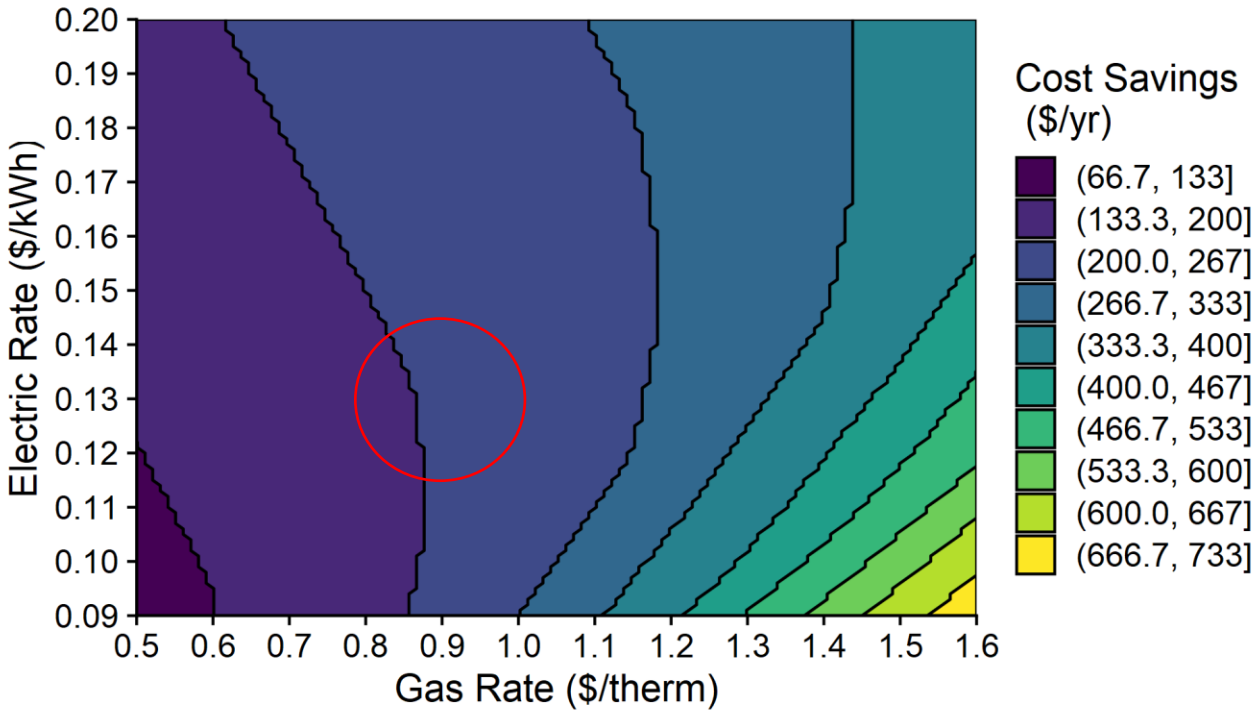
Scenario 1 – Newish existing furnace with entry ssASHP



Scenario 2 – Older existing furnace alongside failed CAC with entry-level vsASHP

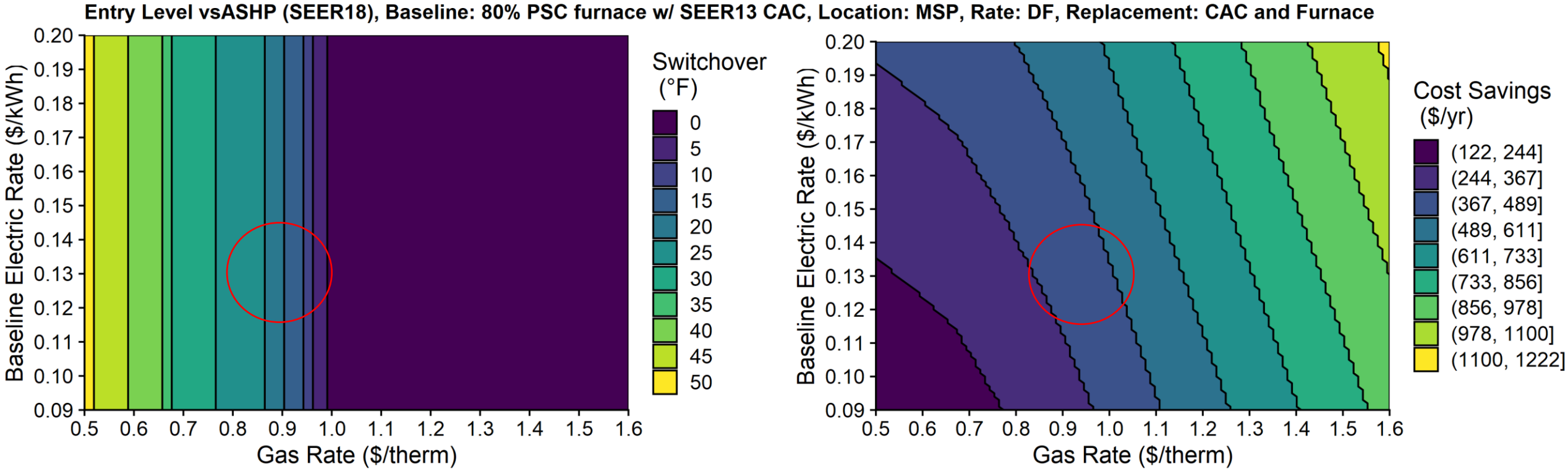
Older existing furnace alongside failed CAC with entry-level vsASHP





Scenario 3 – Older existing furnace alongside failed CAC with entry-level vsASHP with dual fuel rate

Older existing furnace alongside failed CAC with entry-level vsASHP with dual fuel rate



Why is it important to understand ductwork implications?

Several research projects across the country

Increased fan energy use

Capable of delivering the air where it needs to go!

Fan watt draw and pressure

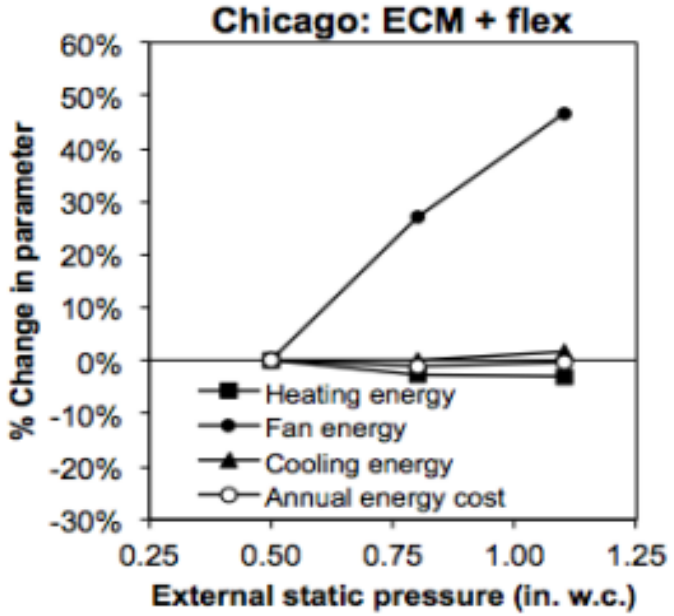


Table 10. Annual energy simulation results for both homes at baseline using the Austin contractor's designs

Home	Duct type	Blower type	Total Pressure (in. w.c.)	Airflow rate (CFM)	Cooling (kWh)	AHU Fans (kWh)	Total Electricity (kWh)	Heating ($\times 10^6$ Btu)	Total Gas Consumption ($\times 10^6$ Btu)
Chicago 3-ton AC Gas furnace 1200 CFM nominal	Flex	PSC	0.50"	1200	619	542	8108	60.95	88.88
			0.80"	964	661	531	8139	60.93	88.85
			1.10"	622	786	600	8331	63.71	91.70
		ECM	0.50"	1200	611	319	7878	61.55	89.51
			0.80"	1162	614	411	7972	60.47	88.39
			1.10"	1103	631	478	8056	60.86	88.78
	Metal	PSC	0.50"	1200	611	531	8086	59.52	87.41
			0.80"	964	656	525	8128	60.25	88.16
			1.10"	622	769	583	8300	62.17	90.12
		ECM	0.50"	1200	603	314	7861	60.10	88.02
			0.80"	1162	611	406	7964	59.89	87.80
			1.10"	1103	625	472	8042	59.90	87.80

Figure 14. Estimated relative change in annual fan, cooling, and heating energy usage and total annual HVAC energy costs for the Chicago home with both types of AHU fans and both rigid and flex duct work at each duct design (using only the Chicago contractor's duct designs).

Industry Alignment

Not alone in this!

- Advanced Heat Pump Coalition
- Consortium for Energy Efficiency – ASHP QI Working Group
- NEEP – Residential Heating Electrification Working Group and Size for Heating Working Group

Advanced Heat Pump Coalition

A "Coalition of the Willing"

Goal

To increase research collaboration among energy efficiency organizations that are working to accelerate market adoption of advanced heat pumps

Membership

- ACTIVE = Fund and Guide collaborative activities
- PASSIVE = attend semi-annual webinars, provide feedback

Committees

- Steering Committee
  (NEEA, NEEP, MEEA, CEC, NRCan, EPA, NYSERDA)
- WG #1 – Improved Test Procedure and QPL
- WG #2 – Roadmap Specification and Mfr Engagement

Brightest heat pump minds
from organizations such as these:

Identify heat pump capabilities and features

Workgroup 2 – Roadmap

Vision

- Heat pump capabilities that enhance in-field performance are well supported by utility programs and provide additional value to the HVAC industry

What is a "Roadmap Specification"

- It is not program specification
- It includes MT fulcrum items
- It leverages industry direction

Desired Outcomes

- Manufacturers have clear understanding of what Utilities need
- Widespread utility program support exists for the features specified

CEE ASHP QI Working Groups

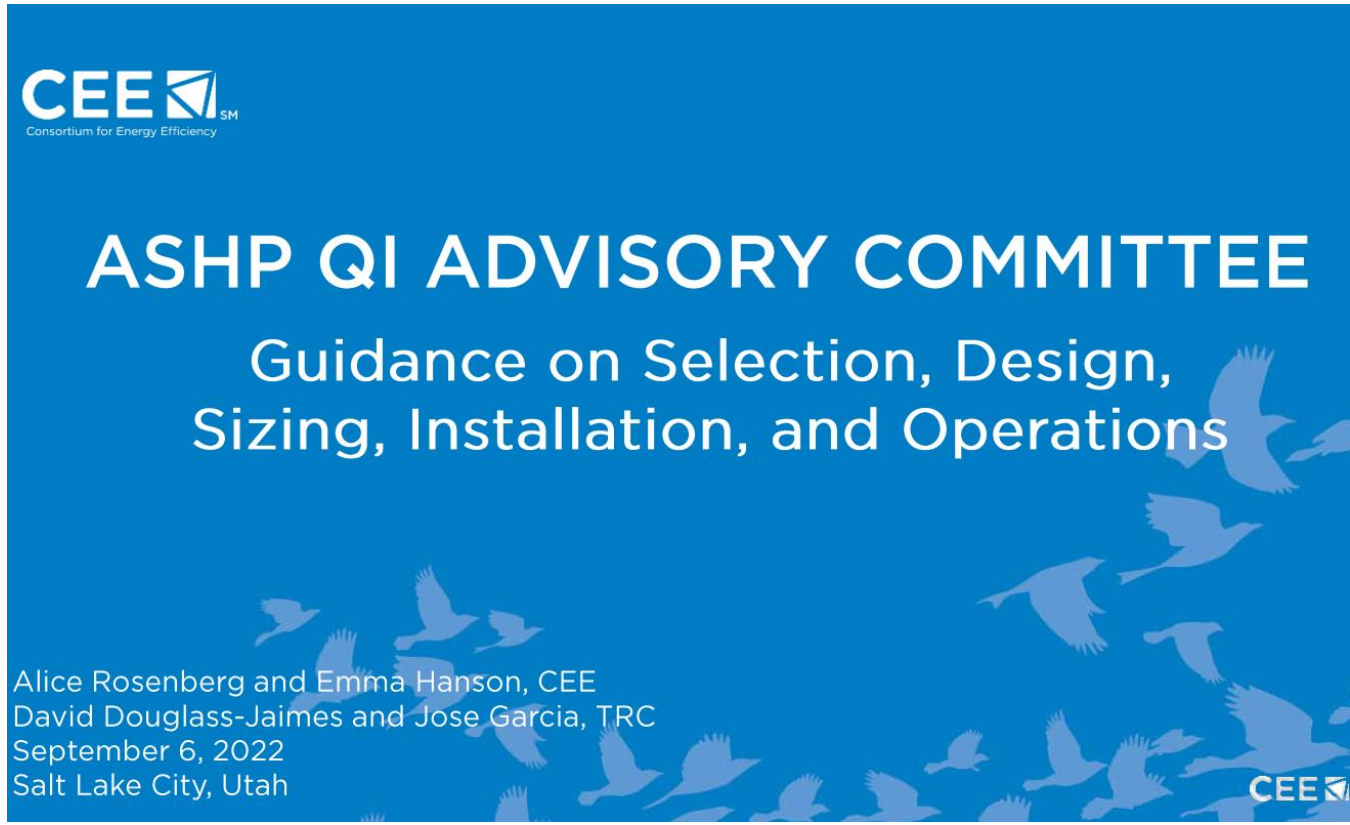
Resource Catalogue

Resource Gaps

- Utility resource gaps
- Contractor resource gaps

Best Practices Identified

- Including application specific practices

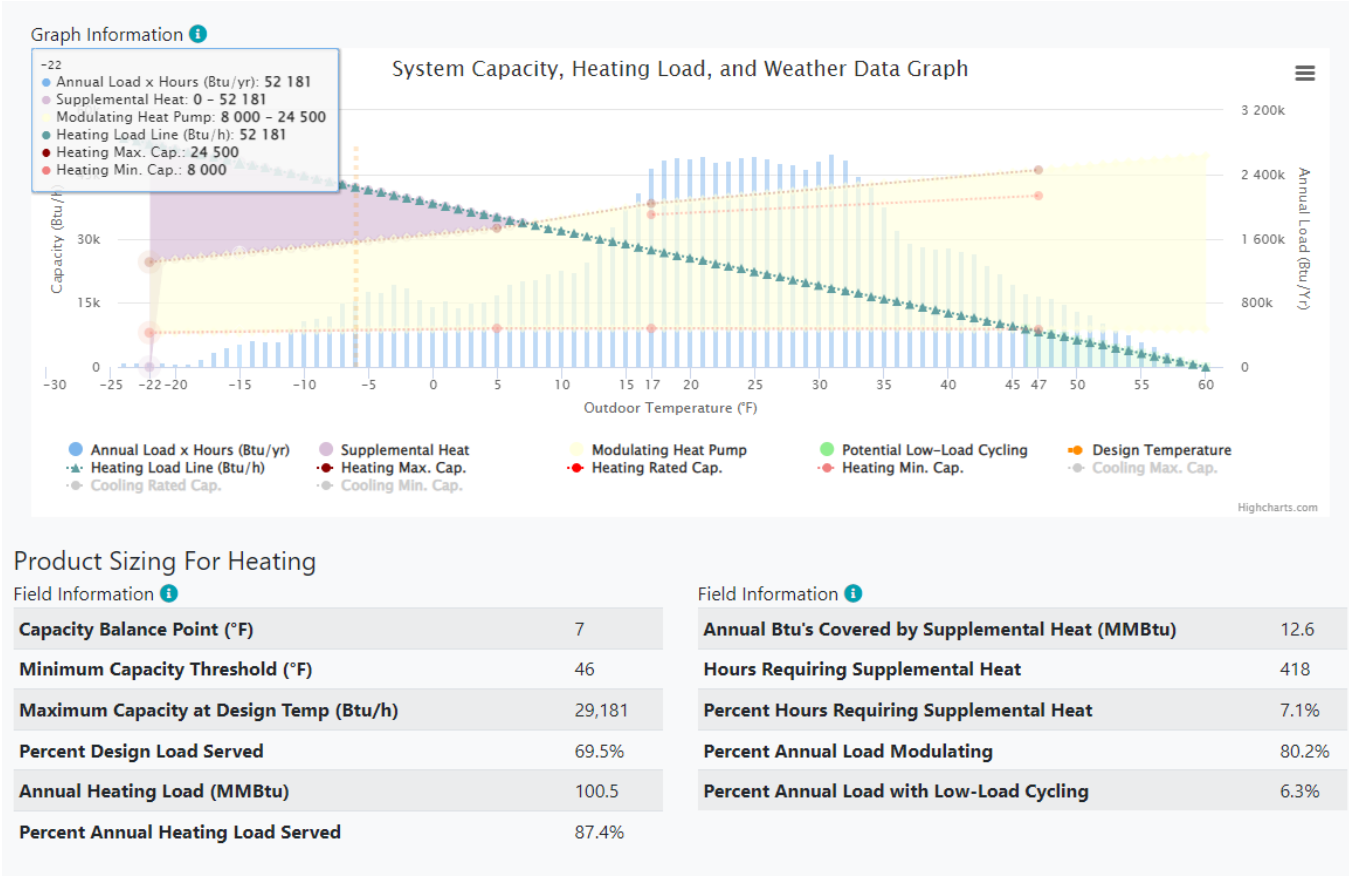


NEEP Size for Heating Working Group

Improve features in the Size for Heating Tool

Vet updated materials from NEEP

Develop and share resources for the Size for Heating Tool



Product Sizing For Heating

Field Information

Capacity Balance Point (°F)	7
Minimum Capacity Threshold (°F)	46
Maximum Capacity at Design Temp (Btu/h)	29,181
Percent Design Load Served	69.5%
Annual Heating Load (MMBtu)	100.5
Percent Annual Heating Load Served	87.4%

Field Information

Annual Btu's Covered by Supplemental Heat (MMBtu)	12.6
Hours Requiring Supplemental Heat	418
Percent Hours Requiring Supplemental Heat	7.1%
Percent Annual Load Modulating	80.2%
Percent Annual Load with Low-Load Cycling	6.3%

Heat Pumps Categorized

By Performance Type

Variable Speed Heat Pump Product Assessment and Analysis

Prepared for NEEA, and led by:

- Christopher Dymond – Sr. Product Manager

Center for Energy and Environment Team:

- Isaac Smith – Project Manger
- Ben Schoenbauer – Lead Research Engineer
- Di Sui – Lead Modeling Tool Developer
- Chidinma Emenike – Lead Analyst

We seek the heat pump “goldilocks zone”

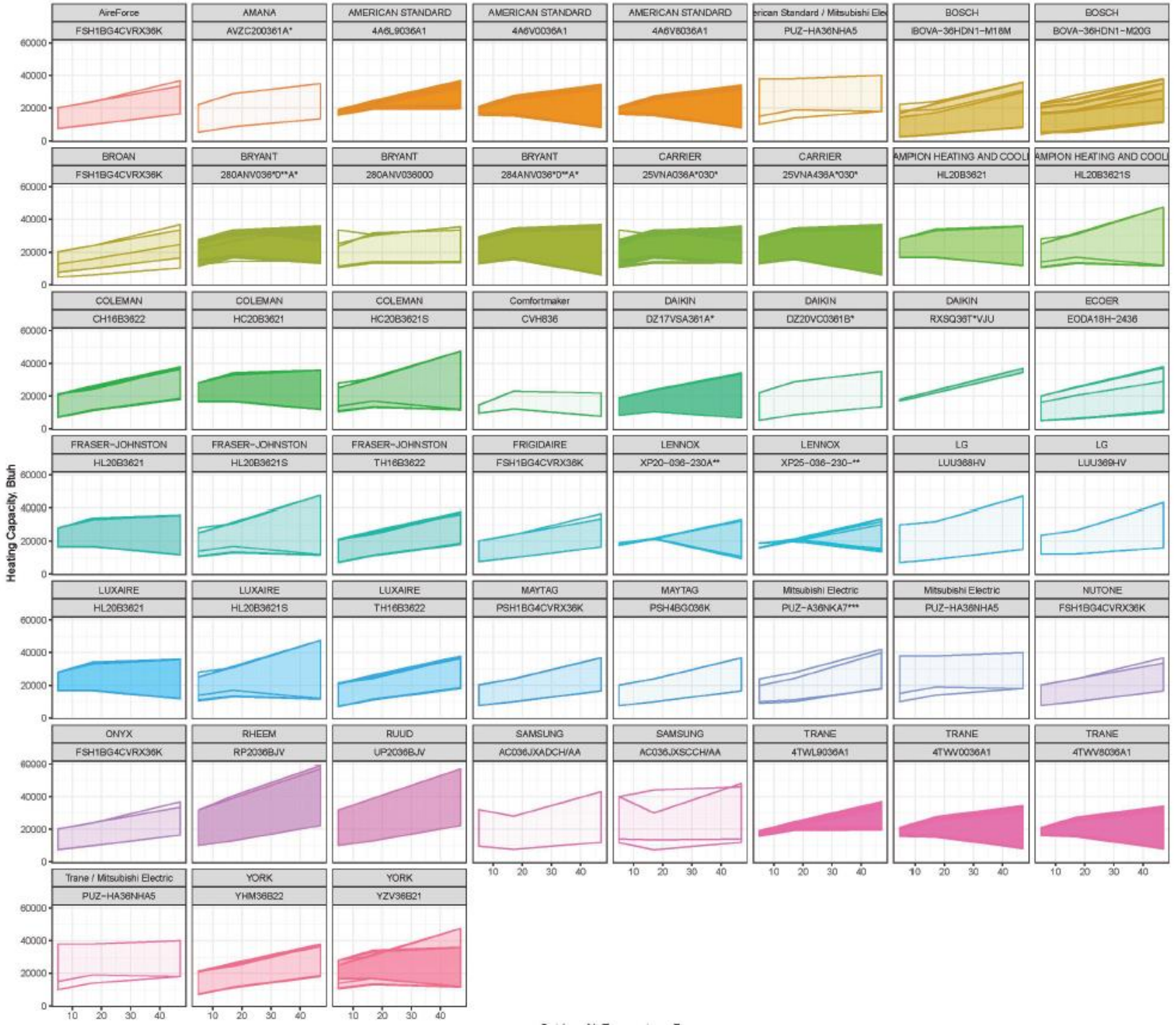
- Christopher Dymond, at project kickoff - July 2020

https://neea.org/resources/variable-speed-heat-pump-product-assessment-and-analysis

Capacity Curves

Nominal 3-Ton units

- AireForce
- AMANA
- AMERICAN STANDARD
- American Standard / Mitsubishi Electric
- BOSCH
- BROAN
- BRYANT
- CARRIER
- CHAMPION HEATING AND COOL
- COLEMAN
- Comfortmaker
- DAIKIN
- ECOER
- FRASER-JOHNSTON
- FRIGIDAIRE
- LENNOX
- LG
- LUXAIRE
- MAYTAG
- Mitsubishi Electric
- NUTONE
- ONYX
- RHEEM
- RUUD
- SAMSUNG
- TRANE
- Trane / Mitsubishi Elec
- YORK



COP Values

Nominal 3-Ton units

- AireFore
- AMANA
- AMERICAN STANDARD
- American Standard / Mitsubishi Electric
- BOSCH
- BROAN
- BRYANT
- CARRIER
- CHAMPION HEATING AND COOLIN
- COLEMAN
- Comfortmaker
- DAIKIN
- ECOER
- FRASER-JOHNSTON
- FRIGIDAIRE
- LENNOX
- LG
- LUXAIRE
- MAYTAG
- Mitsubishi Electric
- NUTONE
- ONYX
- RHEEM
- RUUD
- SAMSUNG
- TRANE
- Trane / Mitsubishi Electric
- YORK

Developing Archetypes – Metric Review

	ModRatio	CapRatio	CapSlope	LowLoadCOP	HighLoadCOP
	Rated @ 95 / Min capacity 47	Capacity Max5 / Rated @ 95	Capacity Max5/Max 17	COP at minimum output @ 47	COP at maximum output @ 17
Excellent: top 10%	4.3	1.0	0.97	5.2	2.8
Good: top 25%	3.60	0.83	0.88	5.0	2.6
Market Mean Value	2.7	0.59	0.79	4.0	2.4
Poor: bottom 25%	2.2	0.54	0.75	3.8	2.1
Worst	1.00	0.50	0.50	3.5	1.0

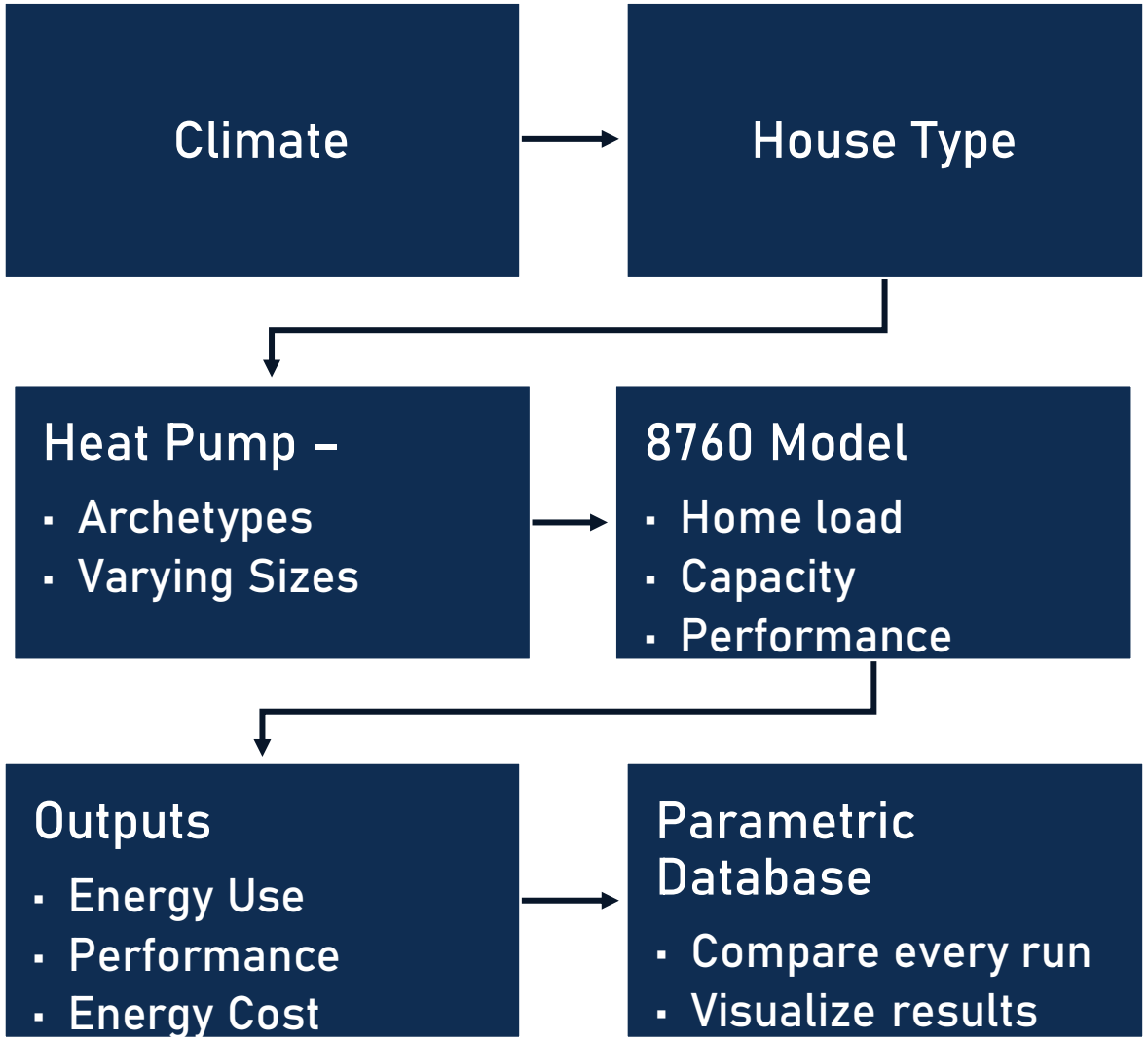
Archetypes

	ModRatio	CapRatio	CapSlope	LowLoadCOP	HighLoadCOP	HSPF
Archetype	Rated @ 95 / Min capacity 47	Capacity Max5 / Rated @ 95	Capacity Max5/Max17	COP at minimum output @ 47	COP at maximum output @ 17	Ave. HSPF for Reference Equipment
Reference VSHP	3.00	0.60	0.80	4.00	2.40	9.70
Capacity Champ	2.50	1.00	1.00	4.00	2.40	10.70
COP King	2.50	0.60	0.80	5.40	2.80	11.40
Modulator	5.00	0.60	0.80	4.00	2.40	10.60
Mild Master	3.50	0.50	0.80	5.00	2.60	11.00
Average Two	1.30	0.50	0.50	3.80	3.00	9.50
Average One	1.00	0.50	0.50	3.60	2.40	8.20

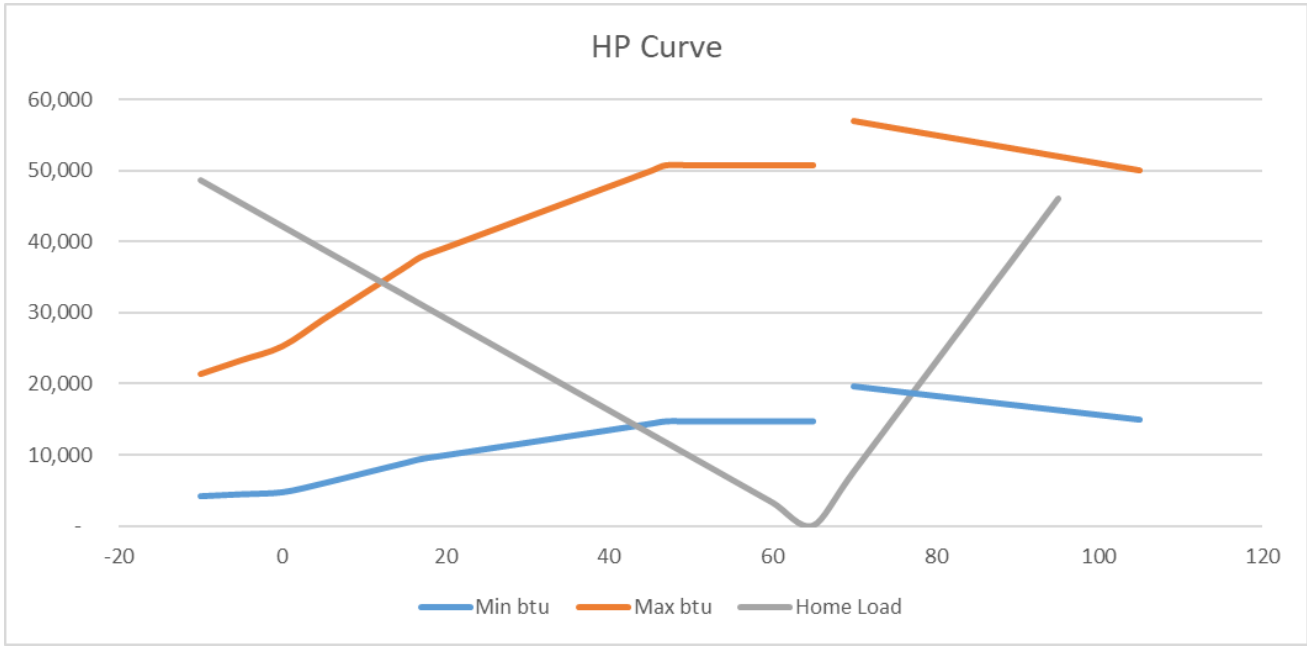
The Variable Capacity Heat Pump Analysis Tool

- Developed by MN CEE guided by NEEA and advisory group
- 8760 hourly energy balance model
- Spreadsheet based
- Key Inputs
  - Climate
  - House load
  - Energy and equipment costs
  - Heat pump COP and Capacity vs T_{amb}
  - Controls and thermostat settings

Model Inputs

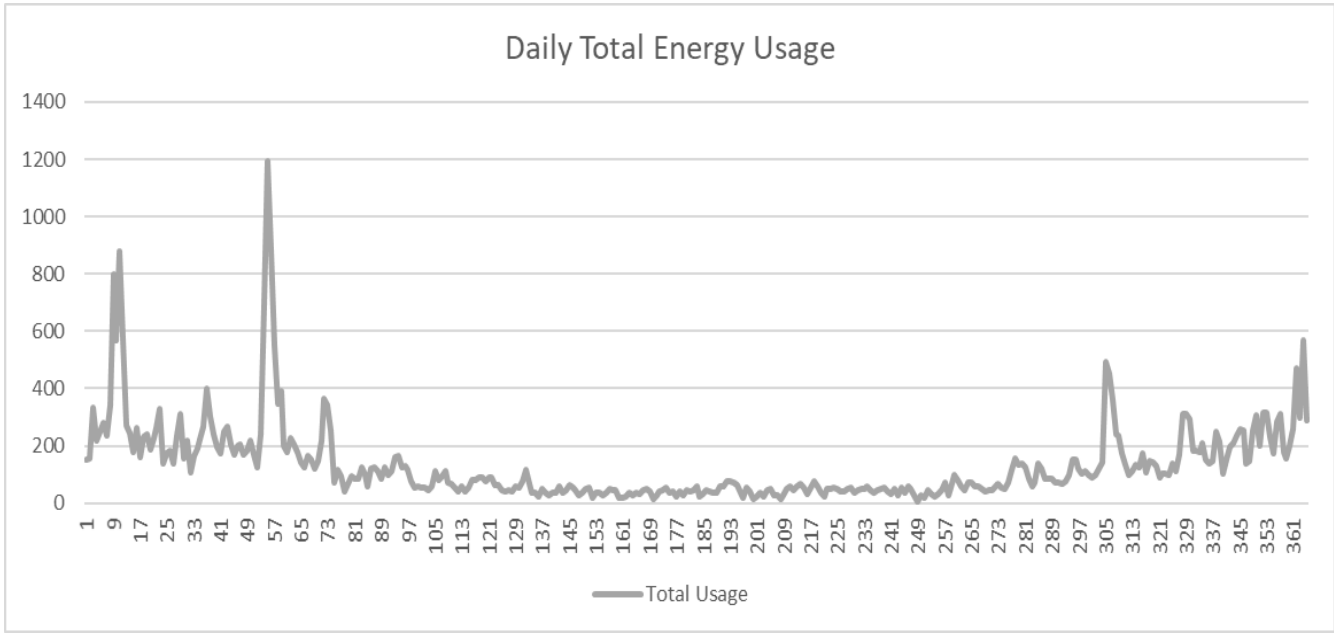


- Home Load: 45,000 Btu/hr @ -5°F
- Same home load curves used across different geographies

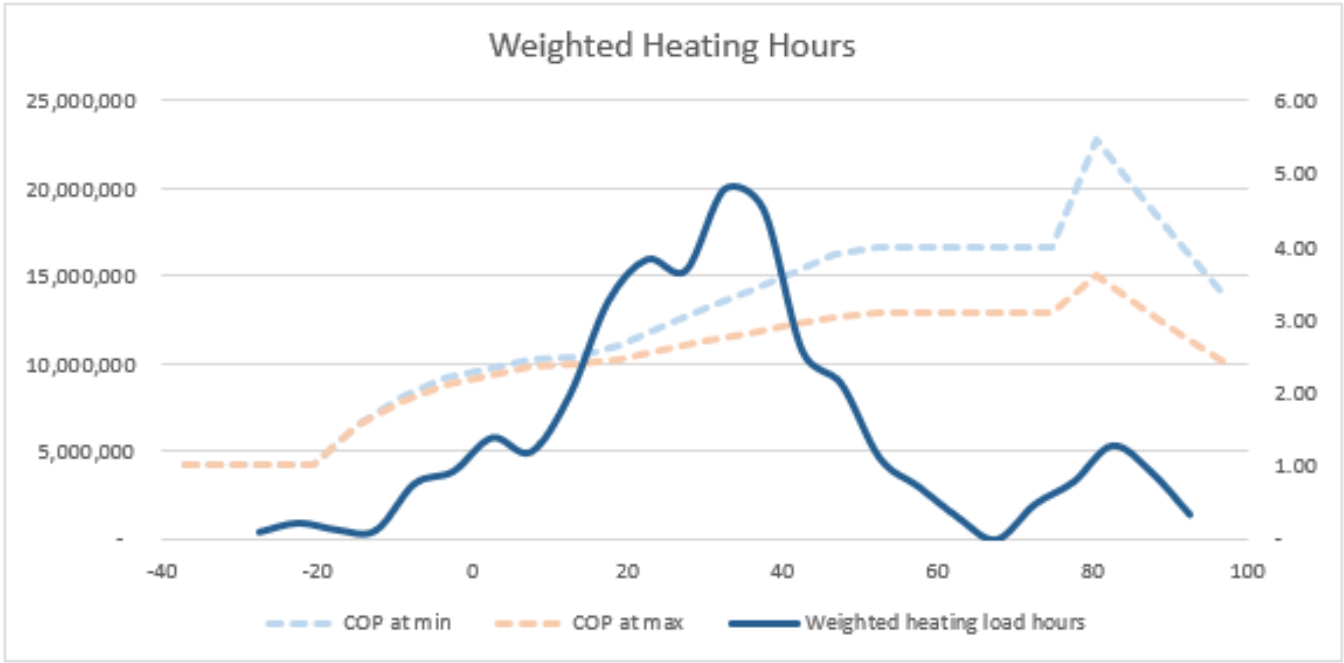


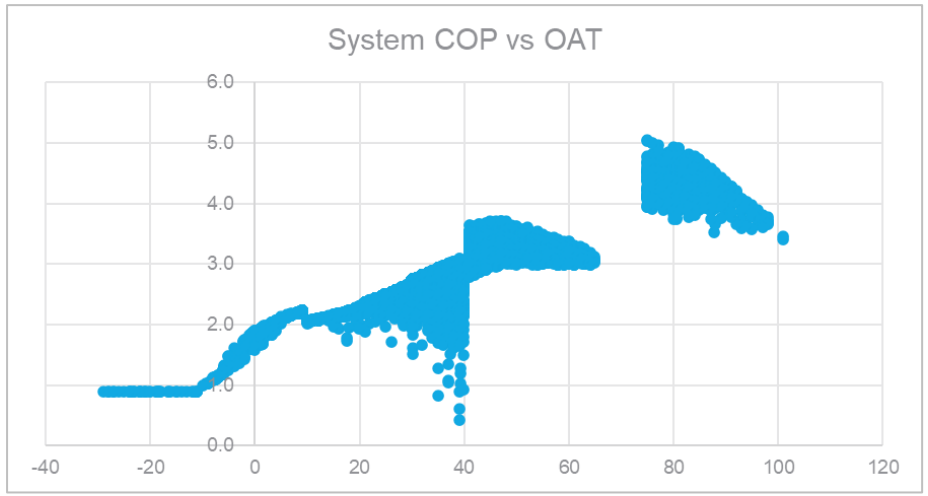
Model Outputs

- Daily Energy
- System COP
- Peak Demand
- Levelized Cost of Heat/Cool
  - Utility perspective
  - Customer perspective



Bozeman



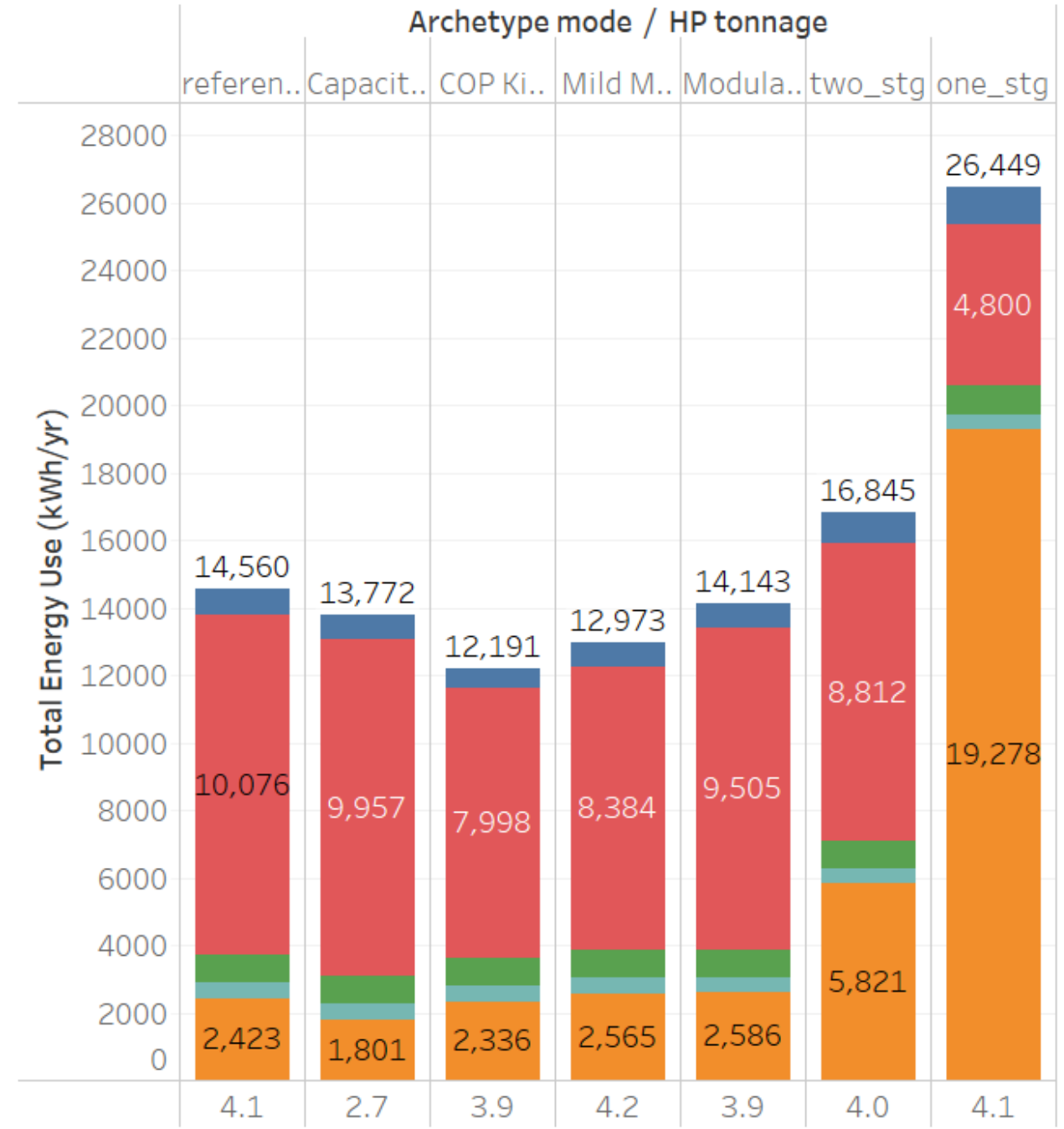


Cold Climate Modeling

- Bozeman, MT
  - Design conditions:
    - Heating load @ design temp (-5.8°F): 46,769 Btu/hr.
    - Cooling load @ design temp (89°F): 27,058 Btu/hr.
- Methodology – model every archetype
  - Vary size by design temperature: -5.8°F, 5°F, 17°F, 30°F
- Evaluate Results
  - Energy use
  - Levelized cost
    - (install cost + maintenance + operation) / lifetime energy delivered
  - Compare results across sizes

Bozeman Results – Energy Use

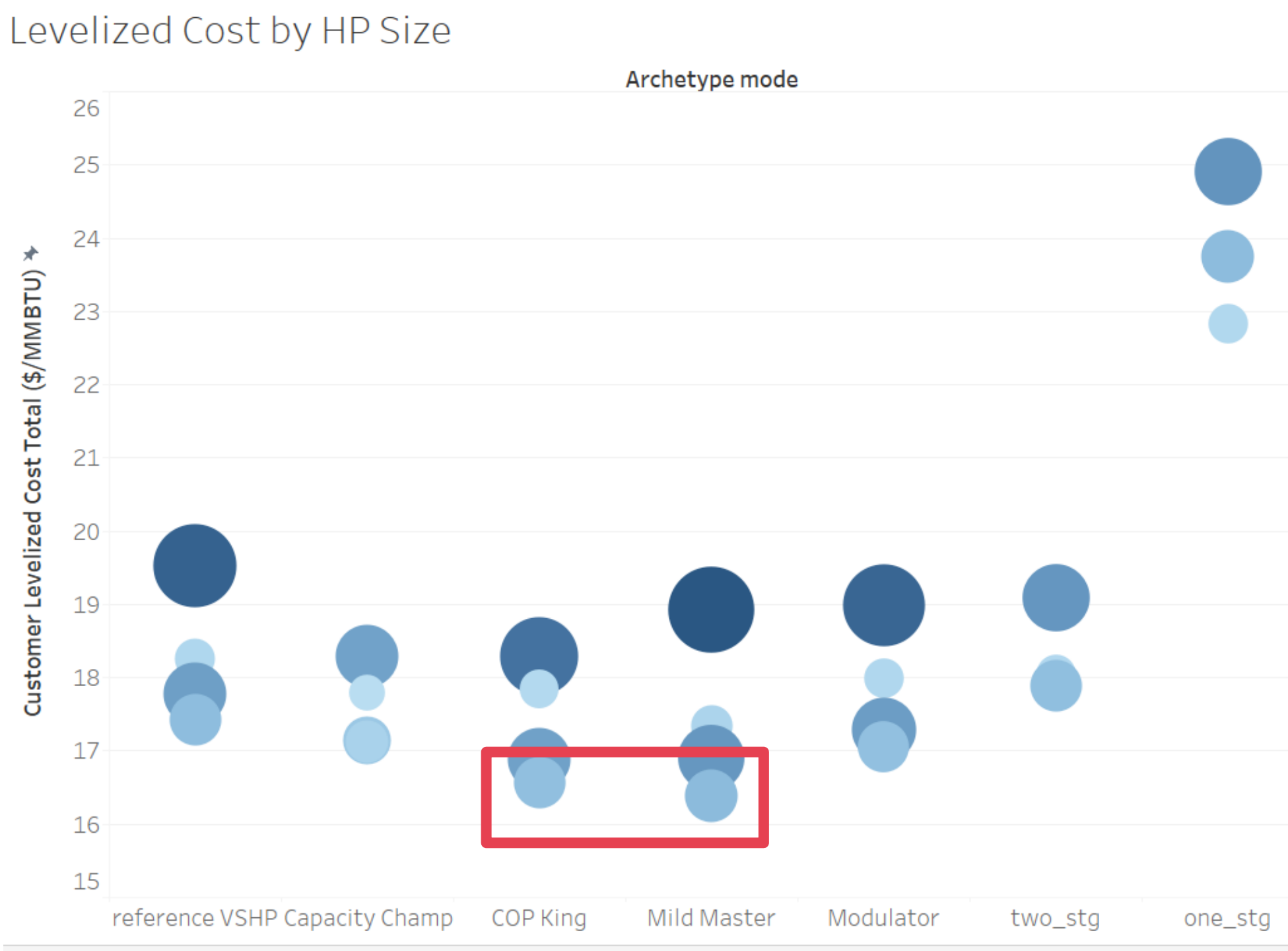
Archetype	Total Energy Use (kWh)	Energy Use Comparison	Percent Difference	Sales Price
Reference VSHP	14,560			$11,344
Capacity Champ	13,772	(788)	-5%	$11,777
COP King	12,191	(2,369)	-16%	$12,688
Mild Master	12,973	(1,587)	-11%	$11,432
Modulator	14,143	(417)	-3%	$11,195
Two-stage	16,845	2,285	16%	$9,432
One-stage	26,449	11,889	82%	$8,247



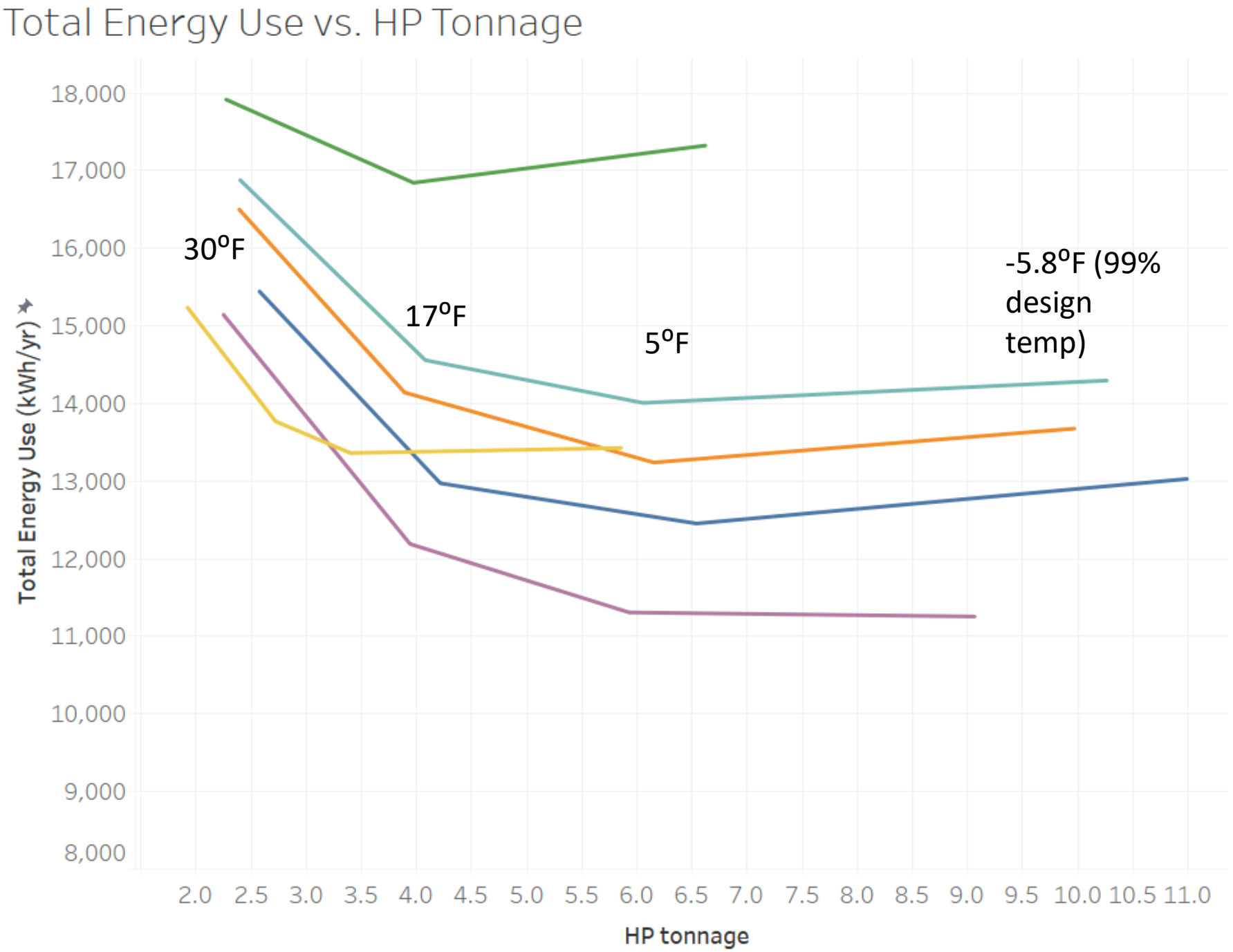
Levelized Cost

HP Key:

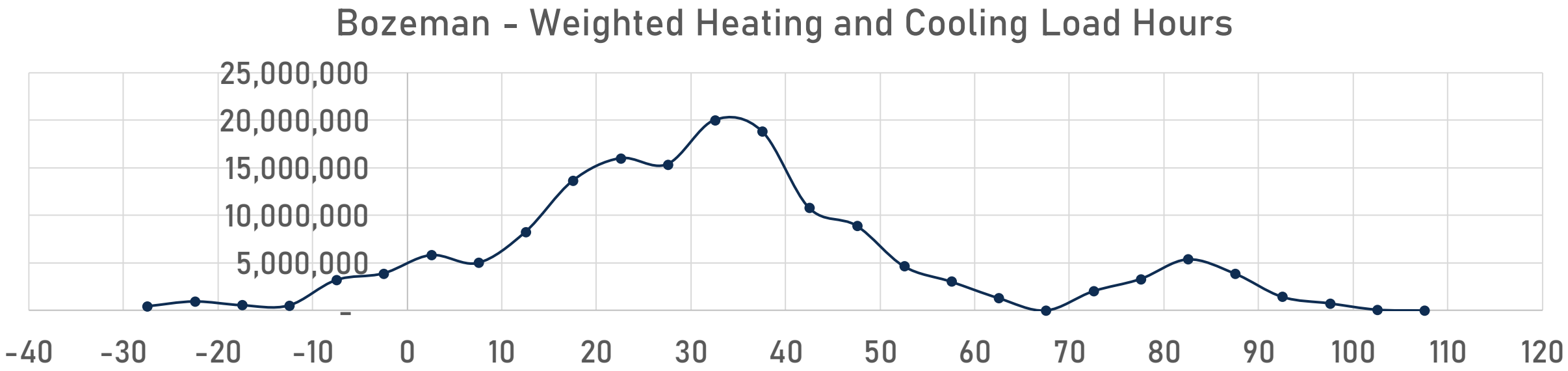
- 7 Ton
- 4 Ton
- 2 Ton

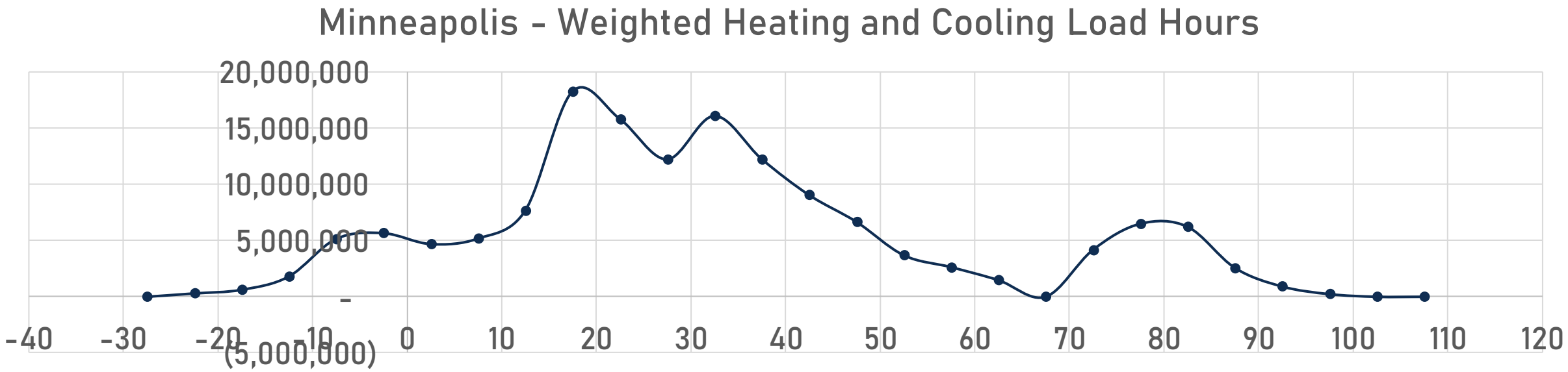


Sizing Example - Bozeman



Comparison of weighted heating hours versus outdoor air temperature





Takeaways

- Equipment cost is a major factor for levelized cost
  - Sizing systems to meet load at 17°F resulted in lowest levelized cost (Capacity Champ either 17°F or 5°F)
  - Bigger system = larger cost
  - SEER remains the largest driver of cost
- Extended capacity and modulation have less impact on performance than expected
- Coefficient of performance, especially low load at 47°F is a key driver to lowest levelized cost
  - COP King and Mild Master w/ good COP at 17°F and 47°F, but capacity ratio of 50% outperform
- Cold-climate sizing—meet the heating load between 5°F and 17°F

Full report: https://neea.org/resources/variable-speed-heat-pump-product-assessment-and-analysis

Heat Pumps Categorized

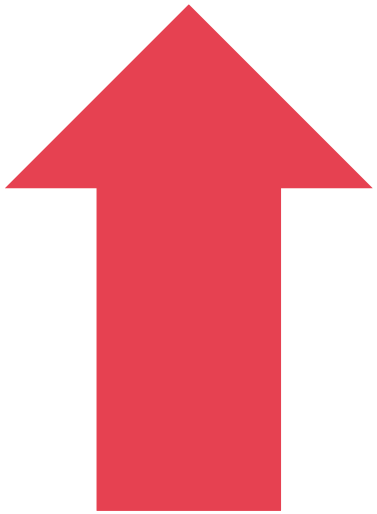
By Efficiency/Rating

Specification and Testing Procedure Changes

Why do we care?

1. Reminder of changes
2. Baseline has changed
3. Compare new and existing equipment
4. Programs updating minimum specification

Federal Minimum Standard and New Ratings



Minimum Efficiency Increasing

Heat Pump Efficiency Increases	
HSPF	~4% increase
SEER	~7% increase

New Rating Procedure = Smaller Numbers

HSPF/SEER to HSPF2/SEER2	
HSPF2	~15% reduced
SEER2	~5% reduced

New Rating Testing Protocol

- Old test procedure

- New test procedure

New Rating Testing Protocol

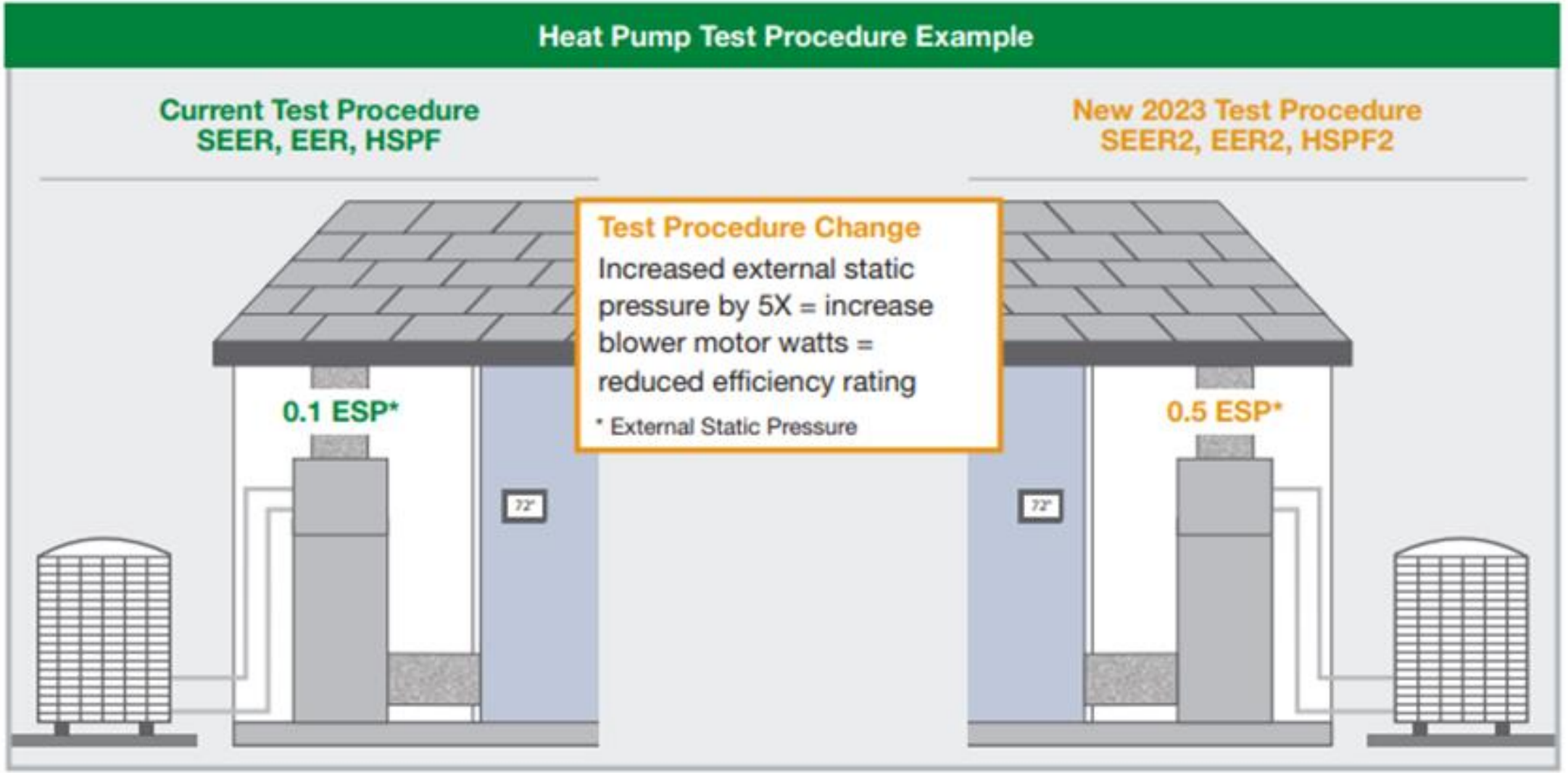


Image from Day and Night Heating and Cooling Products

AHRI conversion factors

HSPF to HSPF2

- Ducted systems = 0.85
- Ductless systems = 0.90

SEER to SEER2 (also EER to EER2)

- Ducted systems = 0.95
- Ductless systems = 1.0

Source: Consortium for Energy Efficiency

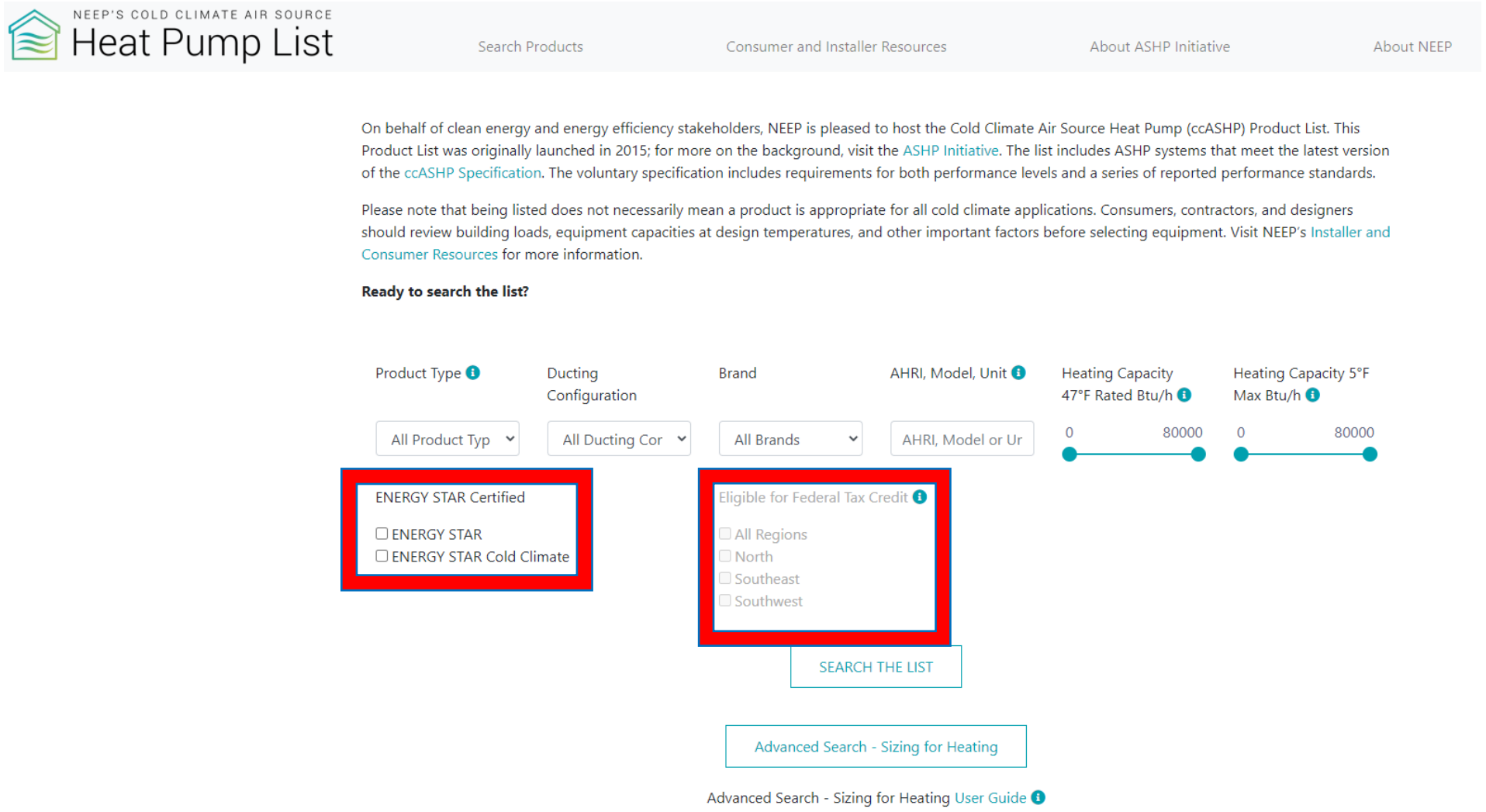
Ducted Specification Comparison

Specification	SEER2	EER2	HSPF2
2023 Federal Minimum Standard (Heat Pump North)	14.3		7.5
ENERGY STAR v6.1	15.2	11.7	7.8
ENERGY STAR v6.1 cold climate	15.2		8.1
25C Tax Credit Levels	15.2	10	8.1

Ductless Specification Comparison

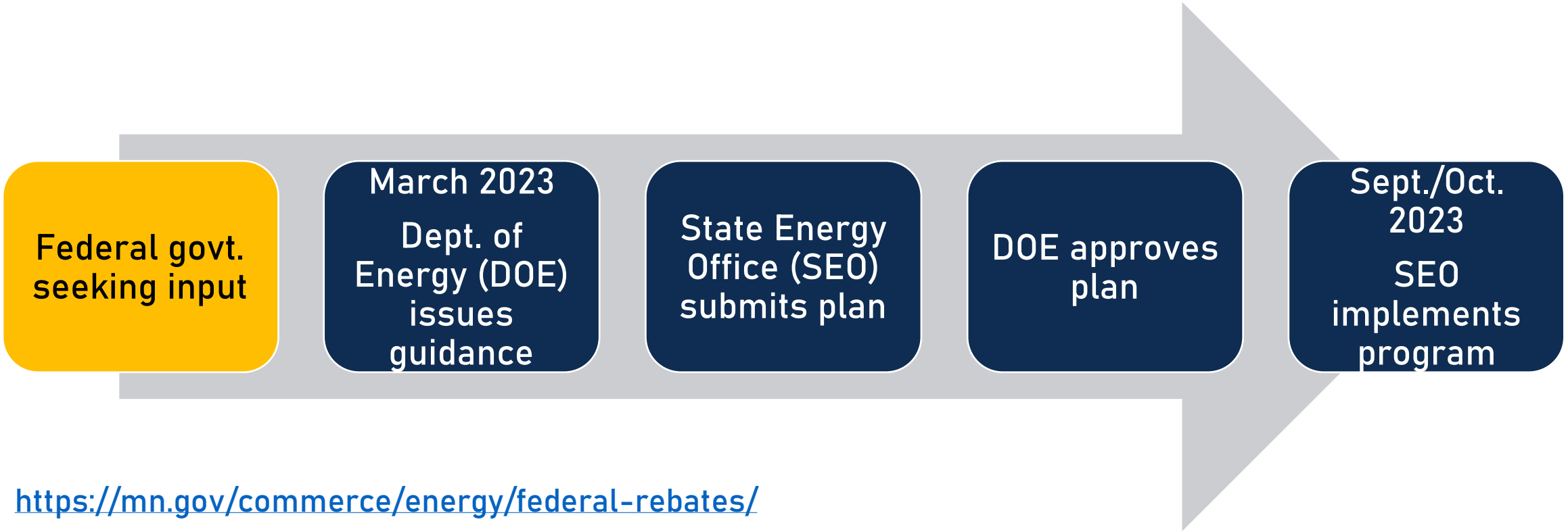
Specification	SEER2	EER2	HSPF2
2023 Federal Minimum Standard (Heat Pump North)	14.3		7.5
ENERGY STAR v6.1	15.2	11.7	7.8
ENERGY STAR v6.1 cold climate	15.2		8.5
25C Tax Credit Levels	16	9	9.5

NEEP cold climate ASHP Product List



Inflation Reduction Act of 2022

- $2,000 Tax Credit for qualifying ASHPs (25C) through 2032
- Statewide home energy rebates (HOMES and HEEHRA)



https://mn.gov/commerce/energy/federal-rebates/

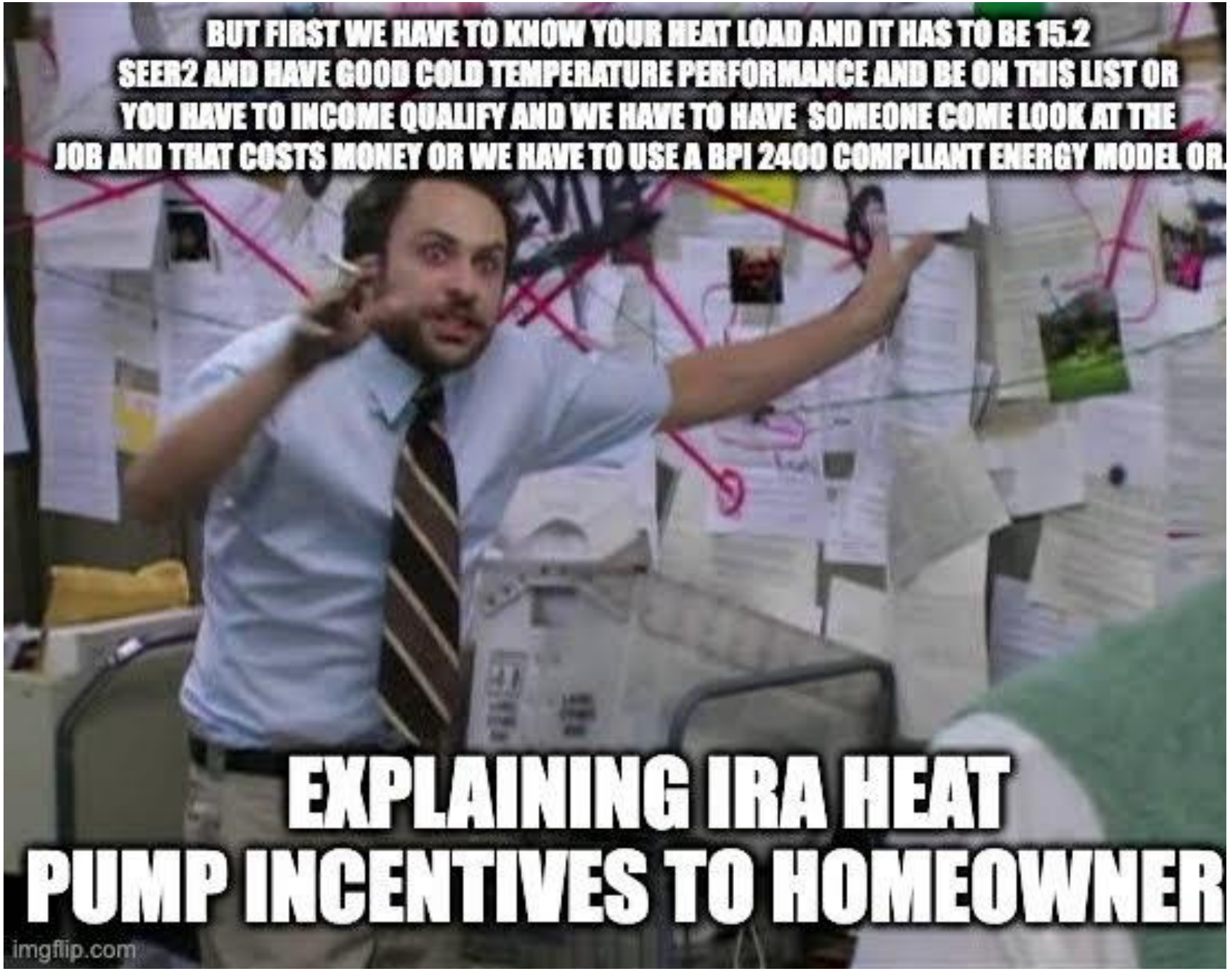
It feels like… because

25C – Must meet CEE highest, non-advanced tier

45L – Regional specific minimums to model against

HOMES – Modeled savings, Federal Minimum Standard

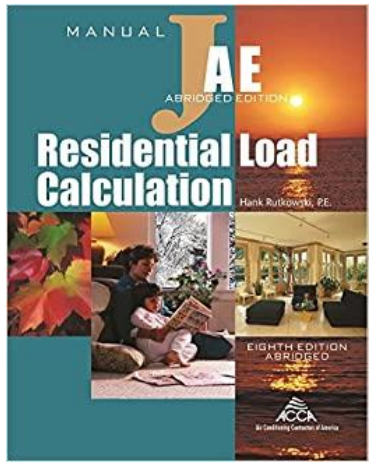
HEEHRA – ENERGY STAR aligned

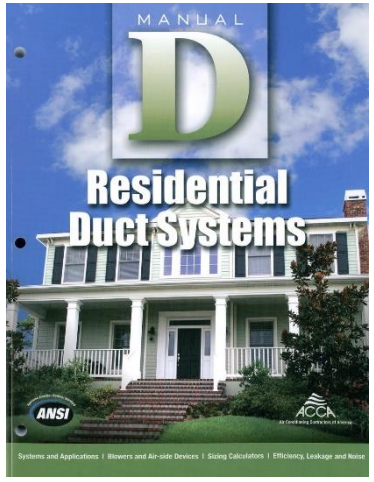


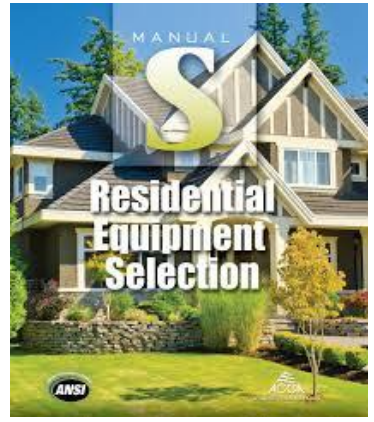
Considerations by Application Type

Design Challenges

- Accurate load calculations
- Determining when to size for heating vs cooling
- Distribution (ductwork) not properly designed for variable speed equipment
- Disbelief heat pumps aren't a viable year-round heating technology in cold climates
- Inaccurate expectations how heat pumps should operate, leading to not use/overuse, or request unnecessary service calls
- Selecting the right heat pump for the use case
- Selecting the best control strategy for the customer and equipment







Actual Use Cases for ASHP

- Central ducted furnace and AC
  - Propane or natural gas (hybrid heat)
  - Electric furnace
- Mini-split displacement
  - Homes with zonal heat
- All electric – full heating system replacement
- Isolated zone
- New construction
  - Gut rehab
  - Deep retrofit

AC and Furnace

Natural gas or propane

ASHP Use Case: Existing Furnace & AC

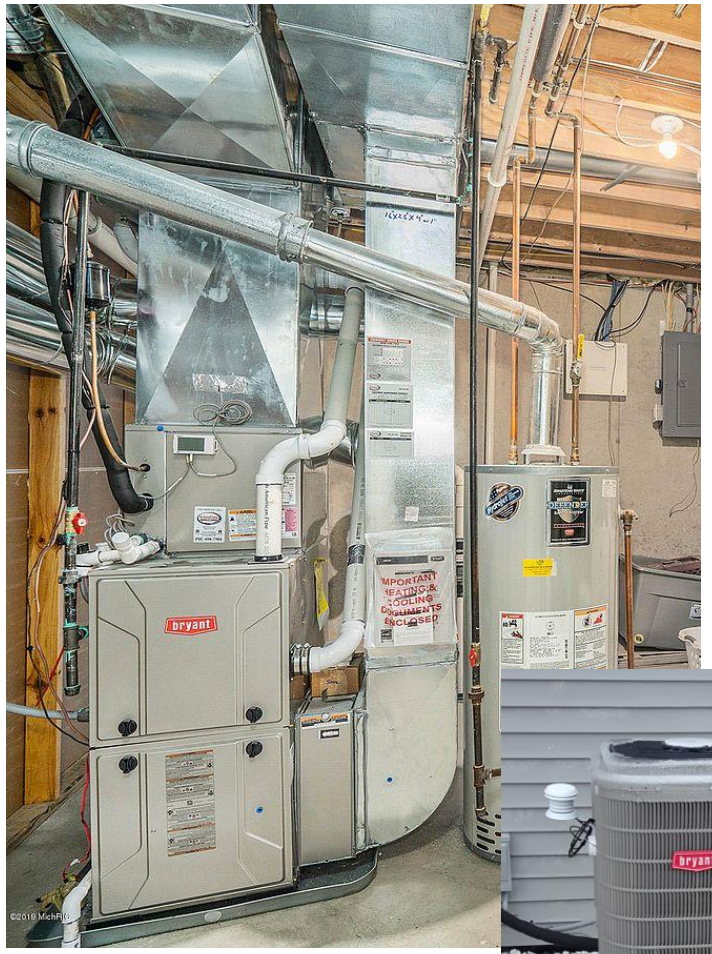
- Typical home attributes
  - 80% efficient furnace
  - 3-ton AC – ≤14 SEER
  - Existing heating fuel natural gas or propane
- General existing conditions to consider
  - Is existing furnace oversized?
  - Comfort complaints about uneven temperatures
  - Are ductwork modifications needed?
  - How much time is spent at home vs away?

ASHP and Furnace

Dual fuel natural gas or propane furnace with single or two stage ASHP

Dual-Fuel – Standard ASHP and Furnace

- How to achieve best cost efficiency for singe and two stage systems.
- Size at the high end of the cooling load
  - Don’t significantly oversize only a ½-1 ton more than cooling need
  - Use maximum capacity at 17 ° F
  - Look for ≥16 SEER
- Furnace replacement or integrate with existing?
  - Replace if near end of life or
  - If inefficient <95 AFUE without ECM blower
- Thermostat and other controls
  - Wherever possible use the manufactures suggested thermostat
  - Enter a customized temperature-based switchover based on findings from customer discussion
- Homeowner education
  - No thermostat setback or very minimal setback no more than 4 degrees
  - Avoid the use of constant fan - utility bill penalty.



ccASHP and Furnace

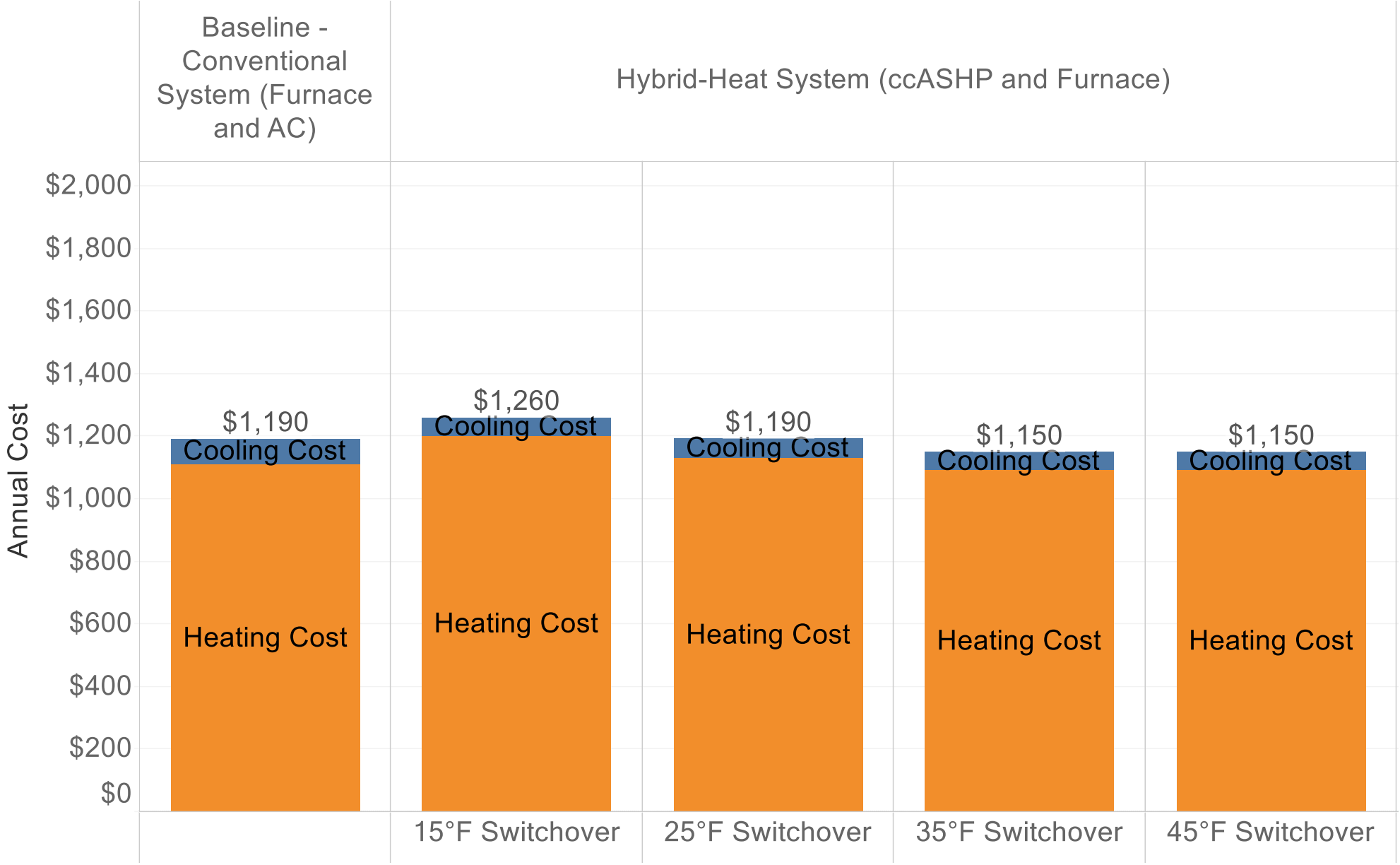
Cold climate heat pump dual fuel natural gas or propane

Dual Fuel - ccASHP and Furnace

- Achieving the best efficiency first cost and operation cost
- Size for heating load
  - Up to 115% of cooling load
  - Use max capacity at 17° F or 5° F
- Furnace replacement or integrate with existing?
  - Replace if near end of life or
  - If inefficient <95 AFUE without ECM blower
- Backup Heat / Controls
  - Thermostat - temperature based switchover*
  - Integrated load-based backup heat
- Homeowner Education
  - No thermostat setbacks
  - When used setbacks typically align operation with peak times
  - No constant fan

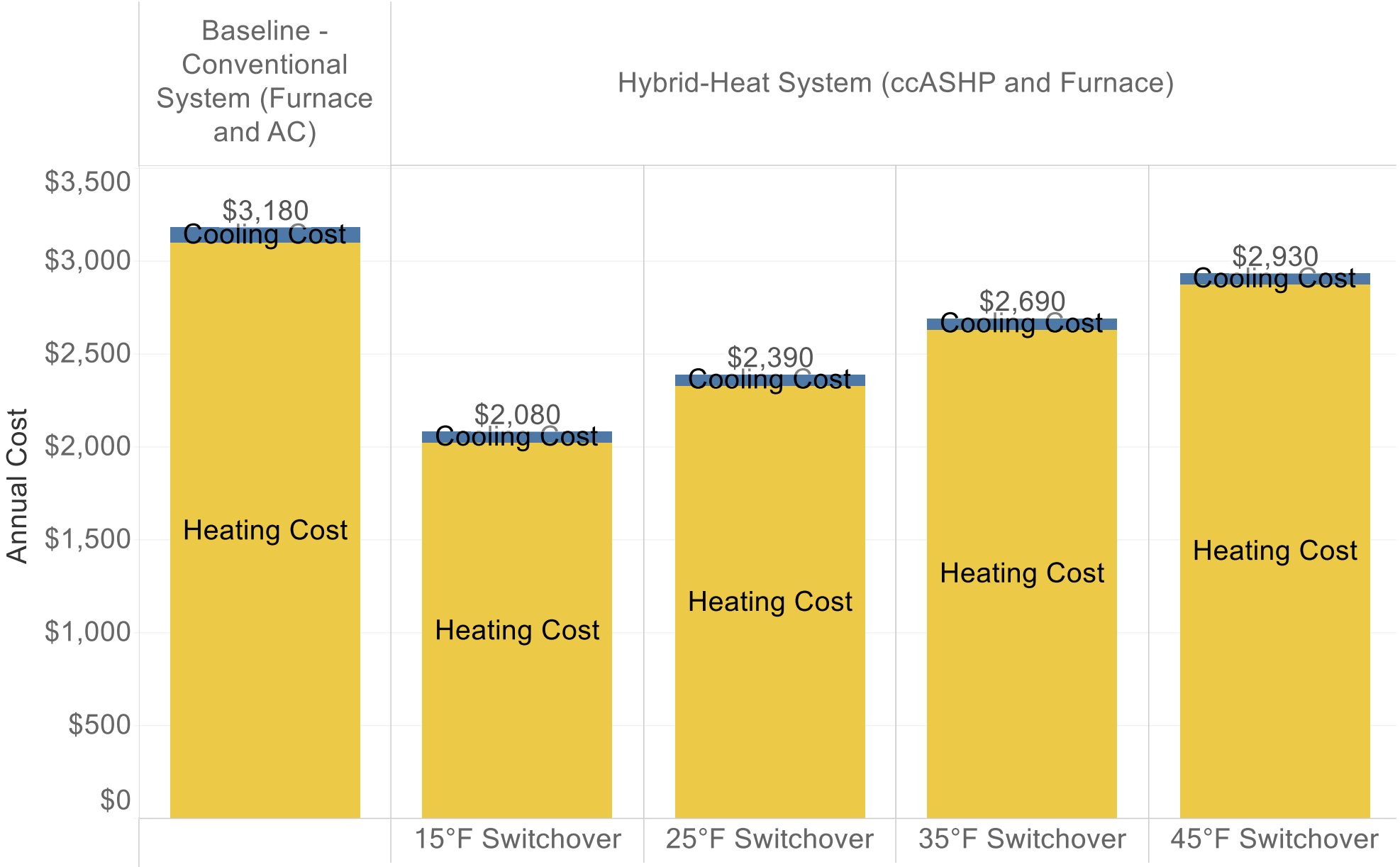
*use balance point or economic switchover temperature

Operational Cost Considerations – Natural Gas



Average NEEP QPL heat pump; Standard electric rate: 10¢/kWh; Natural gas: $82/dtherm; Weather station: Duluth, MN

Operational Cost Considerations – Propane



Average NEEP QPL heat pump; Standard electric rate: 10¢/kWh; Propane: $2.10 / gallon; Weather station: Duluth, MN

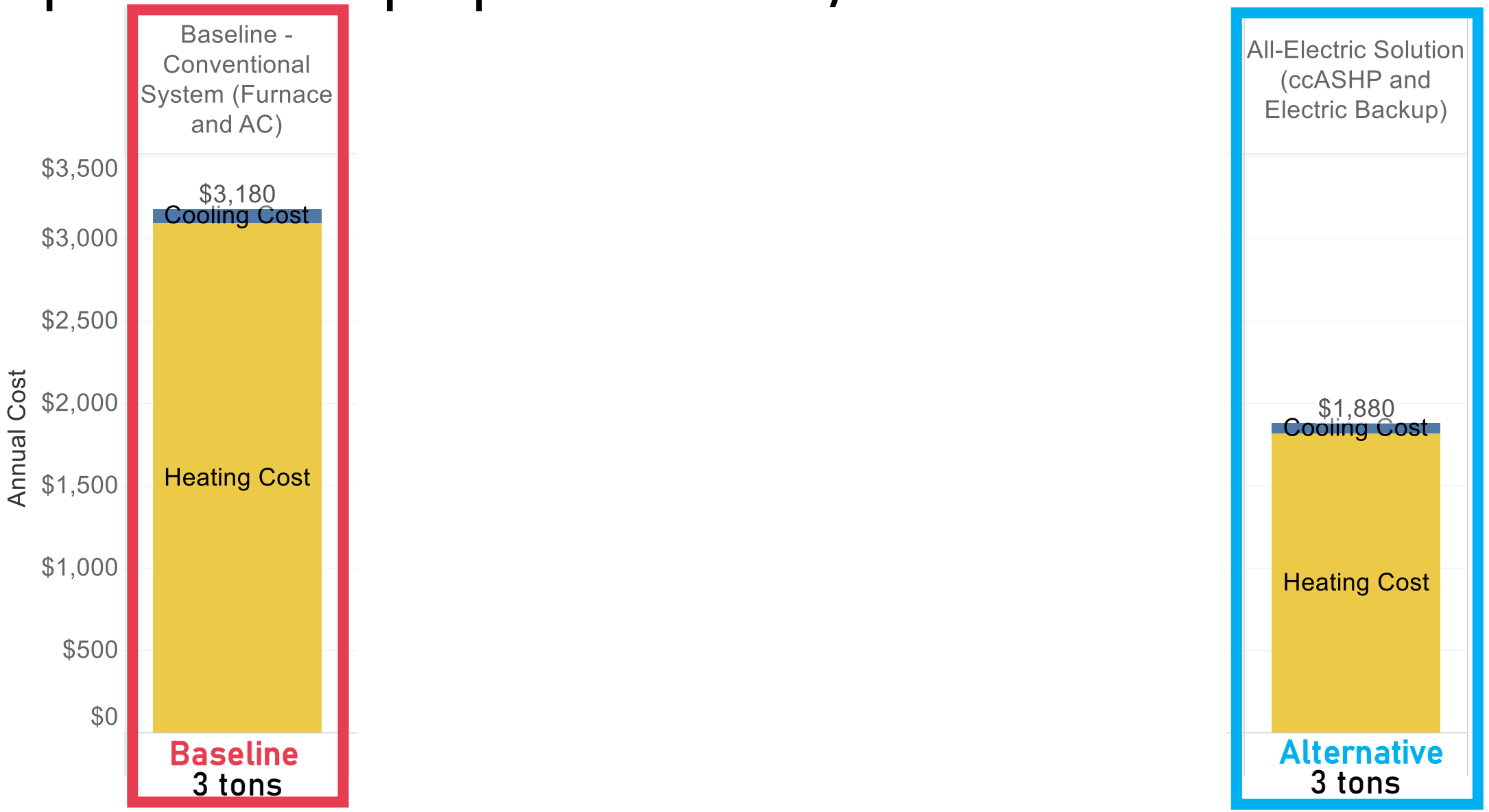
All Electric Furnace

Replacing electric furnace with ccASHP, beneficial electrification

All Electric ccASHP

- How to achieve best cost efficiency with all electric systems.
- Size for heating load
  - Don’t significantly oversize
  - Use maximum capacity at 5 ° F
- Backup heat / controls
  - Use a central thermostat with integrated controls
  - Electric plenum heater meets load when needed
- Homeowner Education
  - No thermostat setback
- When might is this be the right suggestion
  - Already has electric furnace and ac
  - Customer is ready to replace and wants high performance
  - Carbon impact or future driven outlook
- Caution: Possible roadblock could be panel capacity in older homes

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

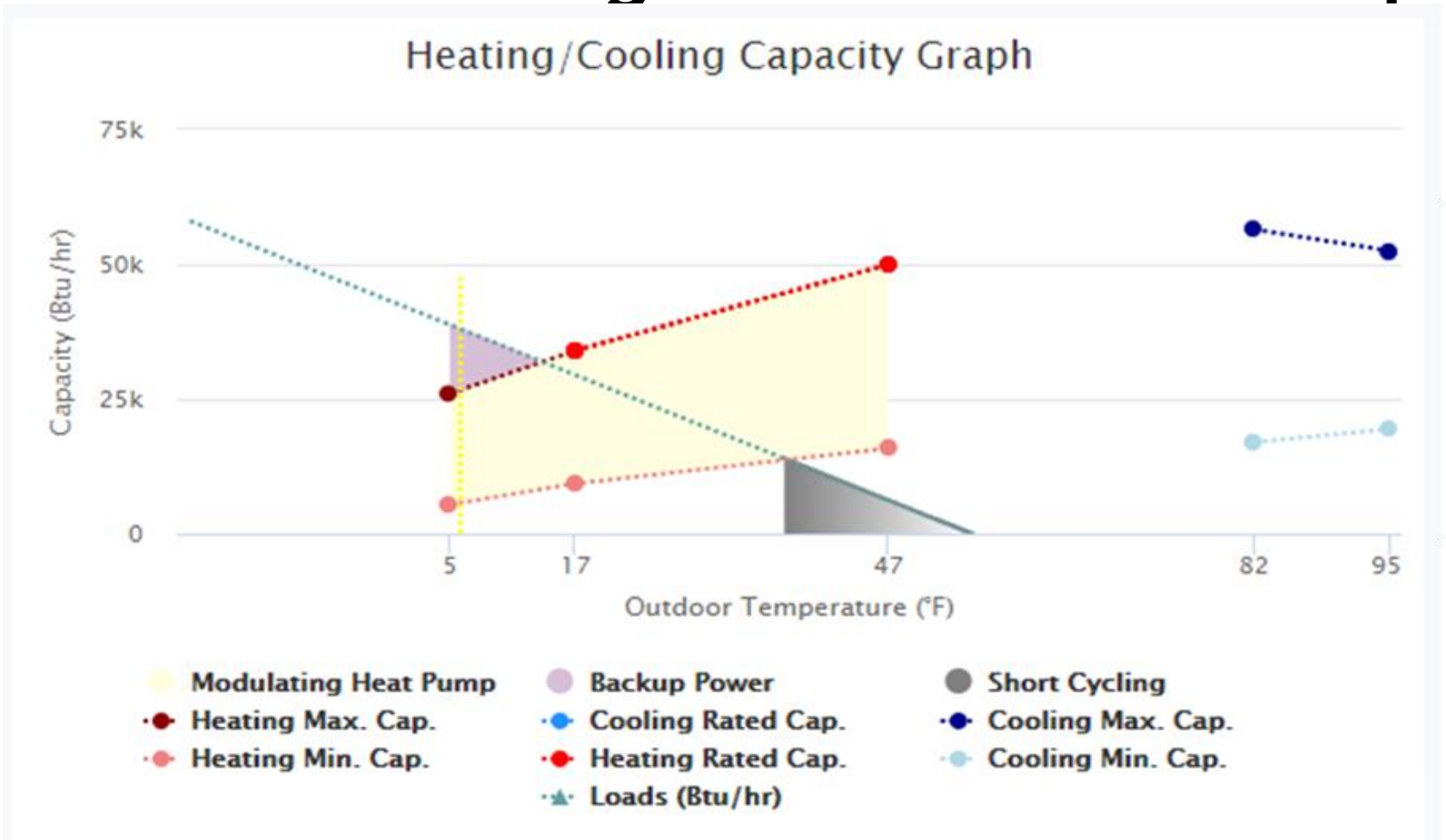


Average NEEP QPL heat pump; Standard electric rate: 10¢/kWh; Propane: $2.10 / gallon; Weather station: Duluth, MN

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

Average NEEP QPL heat pump; Standard electric rate: 10¢/kWh; Natural gas: $82/dtherm; Weather station: Duluth, MN

NEEPs Sizing Guidance Example



Ducted ASHP Summary

- Suggested solutions for AC replacement:
  - Single/two stage ≈ 16 SEER heat pump for cost conscious customers, ccASHP ≈ 18 SEER for those seeking to reduce electric heat and propane or eco minded.
- Advanced solution for comfort concerns:
  - Add a ductless singe zone system to address basement comfort or upstairs bedroom comfort issues. Or offer a central system that can integrate with a ductless unit. (Mitsubishi Intelli-Heat, Carrier Performance Series)
- Existing system treatment:
  - Pre-existing system is kept or upgraded if not an ≥80% AFUE or higher gas/LP furnace. Ducts may be used when in conditioned spaœ, and adequately sized for required heat pump air flow. Existing ducts in unconditioned spaces that remain in use should be sealed and insulated.
- Sizing strategy:
  - Size to meet both the estimated heating and cooling loads. Match system capacity at the design temperature and design for at least 75-85% of the load, utilize existing system for supplemental heat to make up the difference. Lockout backout above 35° F.
- Equipment selection considerations:
  - Use manufacturer published performance at design conditions to identify systems with adequate heating and cooling capacity.
- Oversizing concerns / tradeoffs:
  - when minimum speed cooling capacity is over 115% of design cooling load, look for equipment with a higher ratio of heating to cooling capacity, a lower minimum capacity, or both. Consider existing furnace may be oversized to start with.

Ductless Mini- and Multi-Splits

“Our electric heating bill is at least half. I tell everyone that listens they need to get a ductless heating and cooling system if they want to save and keep warm.”

Doris, Corvallis, Ore.

YEAR-ROUND COMFORT AND LONG-TERM SAVINGS

Your ductless system gives you more control over your home's temperature while heating and cooling at a fraction of the cost of baseboard, wall and ceiling heat or electric furnaces. Follow these guidelines to optimize its efficiency and your comfort.

SET THE SYSTEM OPERATION TO HEAT OR COOL MODE

Use the HEAT or COOL operation mode to meet the temperature needs of the season. Do not use AUTO for the operation mode, as it does not provide efficient or comfortable results in the Northwest. Please note that the operation mode is different from the fan speed.

SET THE FAN SPEED OPTION TO AUTO

Use the AUTO fan speed setting instead of other fixed settings, such as QUIET, LOW, MEDIUM or HIGH. This setting automatically adjusts the fan speed for efficiency and comfort.

PROGRAM YOUR SYSTEM TO YOUR PREFERRED TEMPERATURE

Set your ductless heat pump to a comfortable temperature and let the system self-adjust to meet your needs. Your owner's manual will show you how to program your system.

EXPAND YOUR COMFORT ZONE

Close the windows and leave interior doors open to allow the system to provide conditioned air to the rest of the house.

EXTEND YOUR SYSTEM'S LIFE WITH HOMEOWNER MAINTENANCE

Clean your air filters every two months and replace them per the recommendations in your owner's manual. Keep the outdoor unit clear of leaves, plants or other items that may affect airflow or clog drainage under the unit. Inspect your outdoor unit seasonally to ensure that the outdoor coil is clean, there are no breaks in pipe coverings or insulation and there are no oil stains around the refrigerant line-set connections. Contact your installer if your ductless system needs repair or annual maintenance.

Ductless Mini- and Multi-Splits

- No ductwork
- Comfort and energy savings
- Superior performance
- Cooling and heating where you want it
- Quieter and greater comfort than window AC

Mini Split Displacement

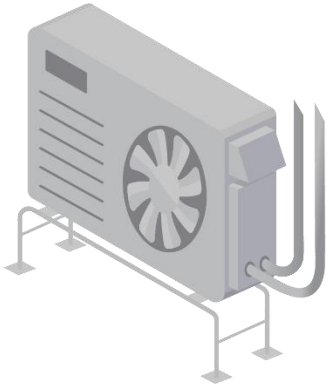
Solutions for zonal electric heat and hydronic systems

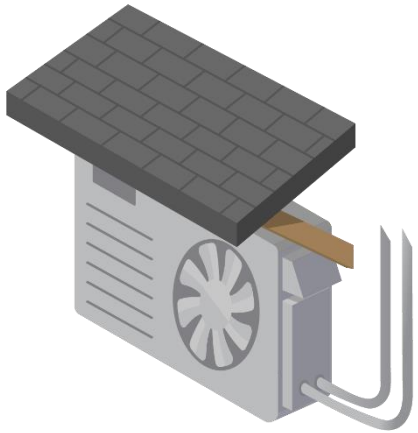
ASHP Use Case: Adding Mini-Splits to Homes with Electric Heat

ASHP Use Case: Adding Mini-Splits to Homes with Boilers

Reminders for Ductless Design

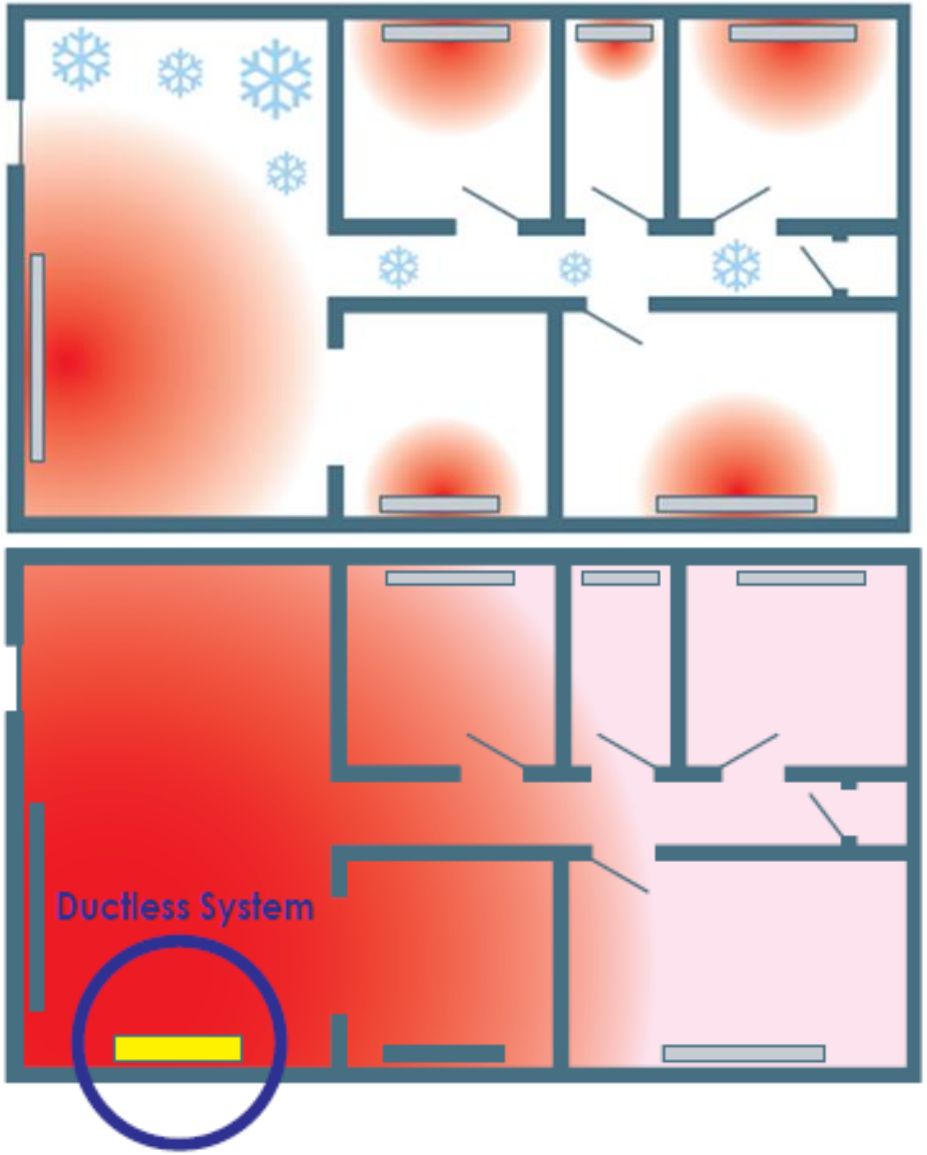
DESIGN LOAD ROUGH ESTIMATOR				
INSULATION TYPE	Climate (Design Temperature F)			
	BELOW -10° F	-10° F to 5° F	5° F to 20° F	ABOVE 20° F
	Btuh/sq.ft.			
No-wall Insulation	47	41	35	Not a Cold Climate
2x4 Construction w/ Insulation	25	22	19	
2x6 Construction w/ Insulation	18	15	13	
New Construction (Post 2012)	16	14	12	





Ductless solution selection

Customer need: Increase comfort, reduce costs

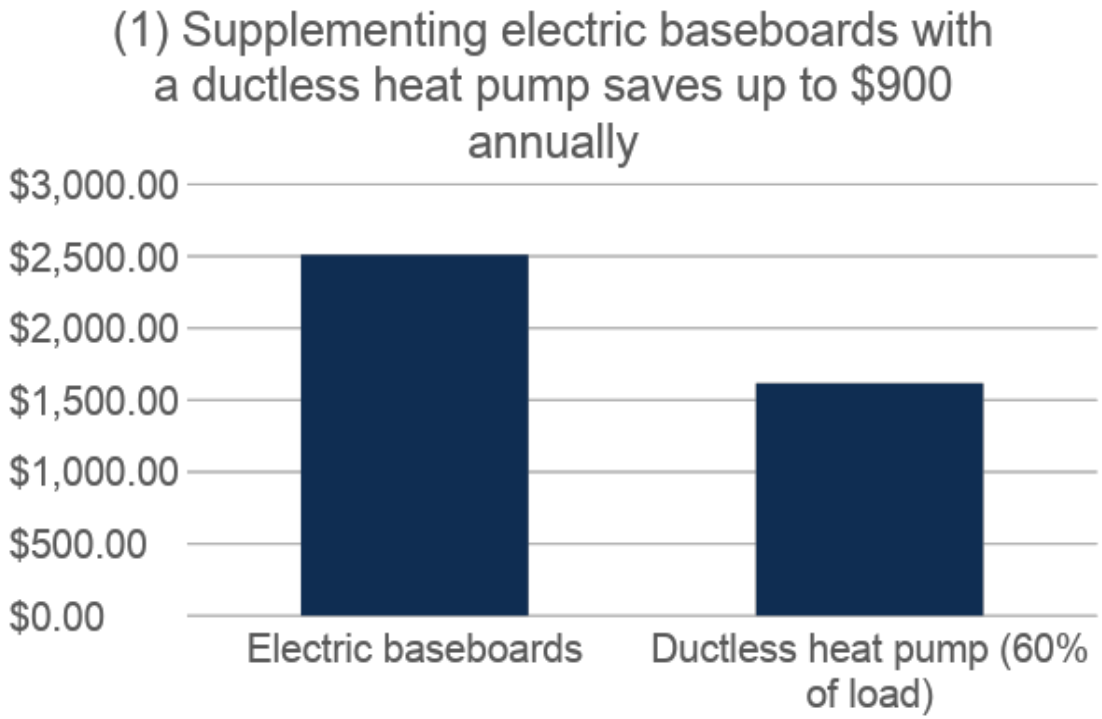


- Simple Solution:
  - Single zone ductless unit or 1-3 room compact-ducted.
  - If compact-ducted set static pressure
- Advanced Solution:
  - 2-5 zone ductless/compact ducted multi split or multiple single zone systems if simultaneous cooling/heating desired
- Sizing Strategy:
  - Locate first/single zone where it will cover most of central living area, establish additional zones as needed based on customer use.
  - Block loads when combined are likely to be less than whole home load
  - Bedrooms are often too small for their own indoor unit
    - Compact ducted or transfer grills and thermostat
- Equipment Selection Considerations:
  - In much of the cold-climate U.S., a ccASHP that covers only 60% of the design load will fulfill over 90% of the home's annual heating load.

Ductless solution placement

- Indoor unit placement:
  - For primary heating applications select floor consoles
  - For bedrooms which can have smaller load than indoor unit size ranges (6k to 36k) consider compact ducted.
  - If using high wall units, a minimum of 6 inches below ceiling and no more than 8 feet up.
  - Be sure that return and supply are not impeded by shelves or other objects below.
- Outdoor unit placement:
  - Elevate out of potential snow fall depth
  - Consider stand vs wall mount to reduce noise transfer
  - Wind baffles, drip caps or custom-made solutions to protect from snow and ice should also be included.
- Existing System Treatment:
  - Evaluate controls for reuse
  - Typical strategy:
    - Set baseboard thermostats back 4 degrees below setpoint of heat pump.
    - Use a centrally located thermostat rather than remote for heat pump.
  - Customer education is the most important step to ensure comfort and savings.

Operational Cost Considerations



Annual Reductions for ccASHPs				
	Site energy	**Source energy**	**Homeowner cost**	**Emissions**
All-electric ducted & ductless HP vs. electric resistance	55%	55%	55%	55%

https://www.mncee.org/cold-climate-air-source-heat-pump-final-report

Other Best Practices

- Check with your distributor and manufacturers!
- NEEP Cold Climate Air Source Heat Pump Specifications and Database
- Minnesota Air Source Heat Pump Collaborative ASHP Installation Best Practices
- NEEA Cold Climate Ductless Heat Pump Specification and Recommendations
- NEEP Guide to Sizing & Selecting Air-Source Heat Pumps in Cold Climates

The big picture

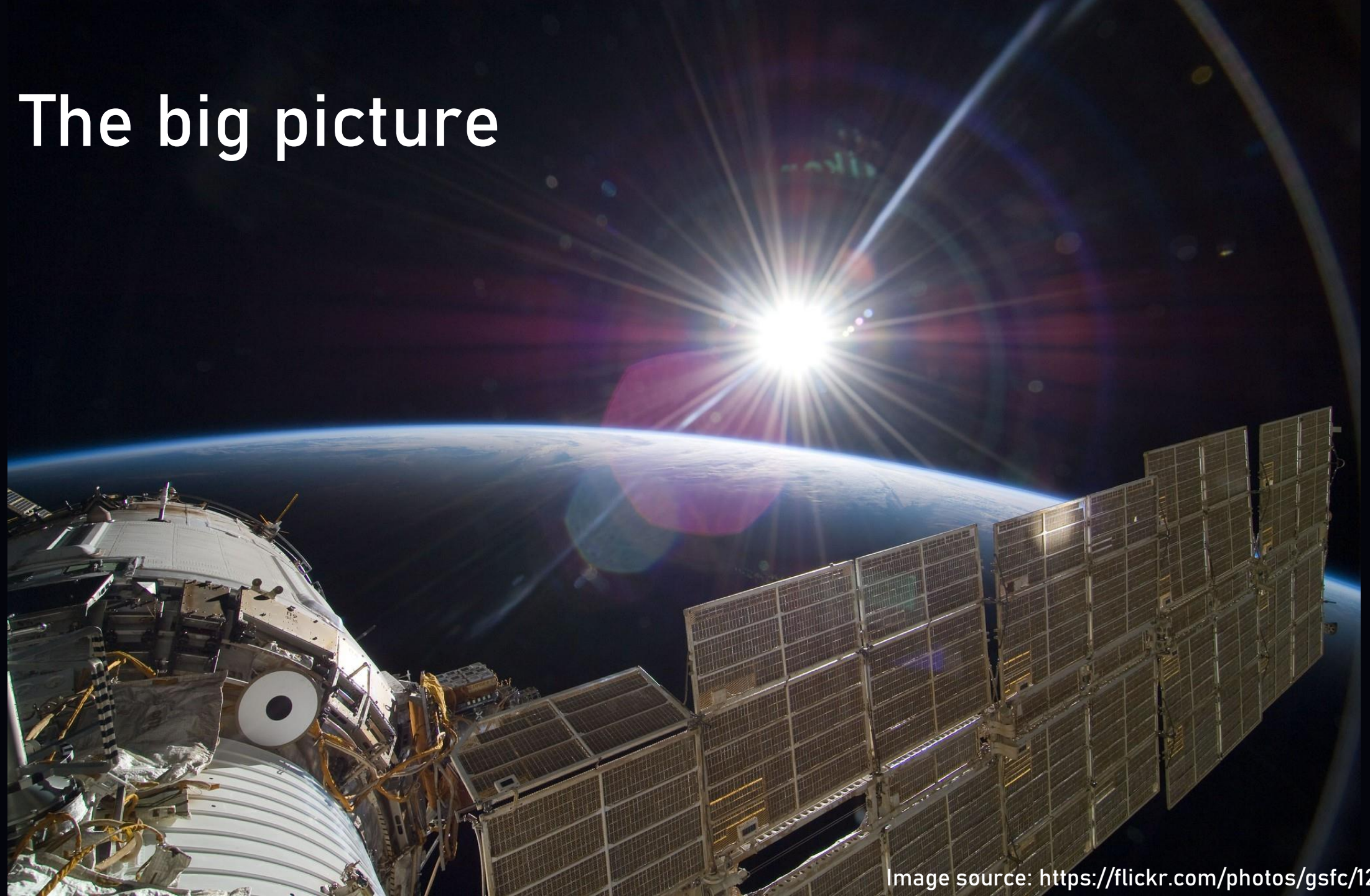


Image source: https://flickr.com/photos/gsfc/12867973205

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