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."

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Strategies for Heat Pump Adoption at the Time of Air Conditioning Replacement

Energy Design Conference 2023

Samantha Hill

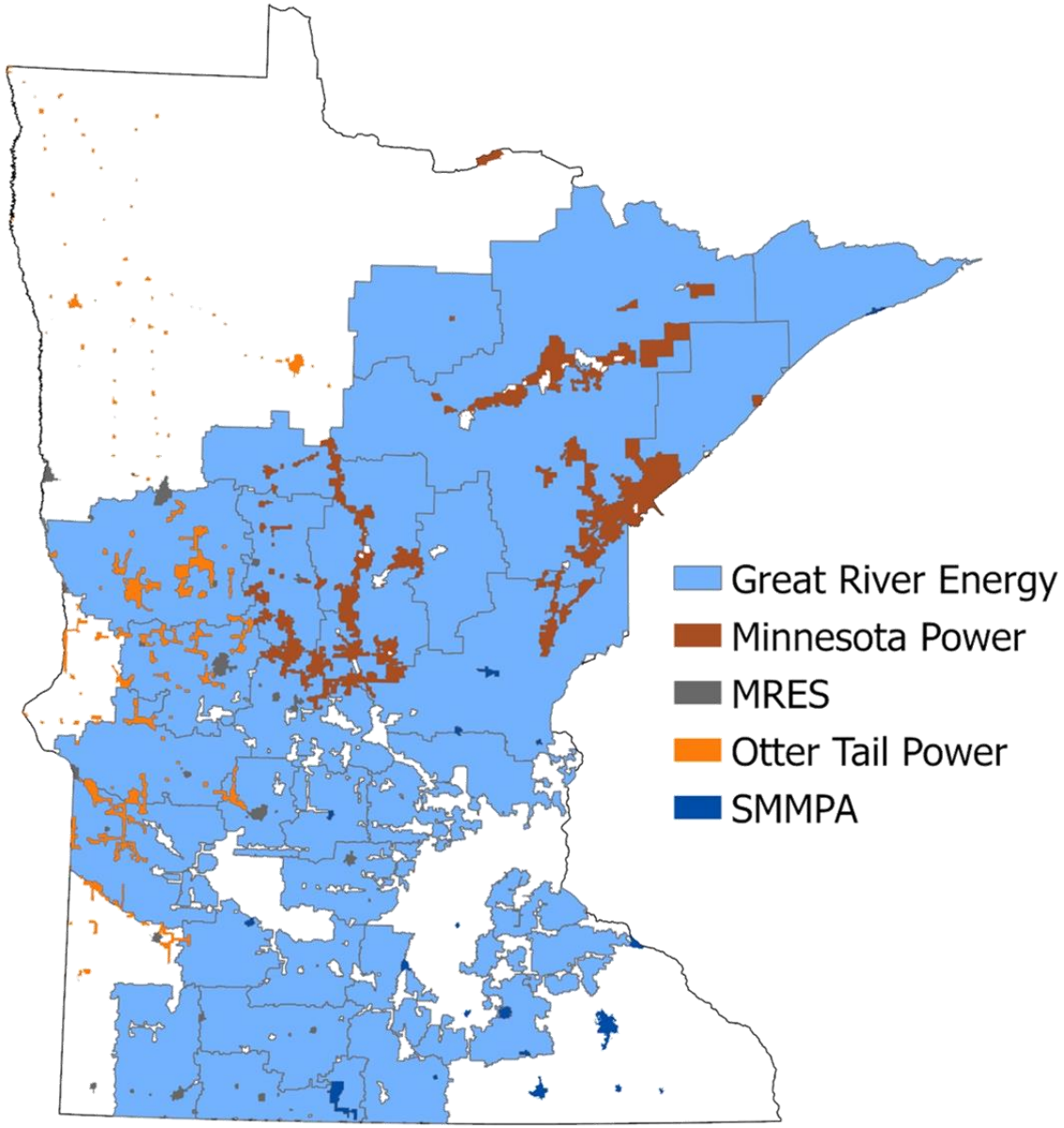
Dan Wildenhaus

ASHP
air source heat pump collaborative

What are our goals for today?

- Recognize AC replacements appropriate for heat pumps
- Explore product options available
- Learn about sizing and design related to comfort and customer economics
- Determine the economic balance point for heat pumps integrated with a natural gas furnace
- Determine cost effective applications for heat pumps as alternatives to air conditioner replacements
- Apply customer decision making when replacing air conditioners to selling heat pumps

MN ASHP Collaborative Members



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POWER COMPANY

minnesota power

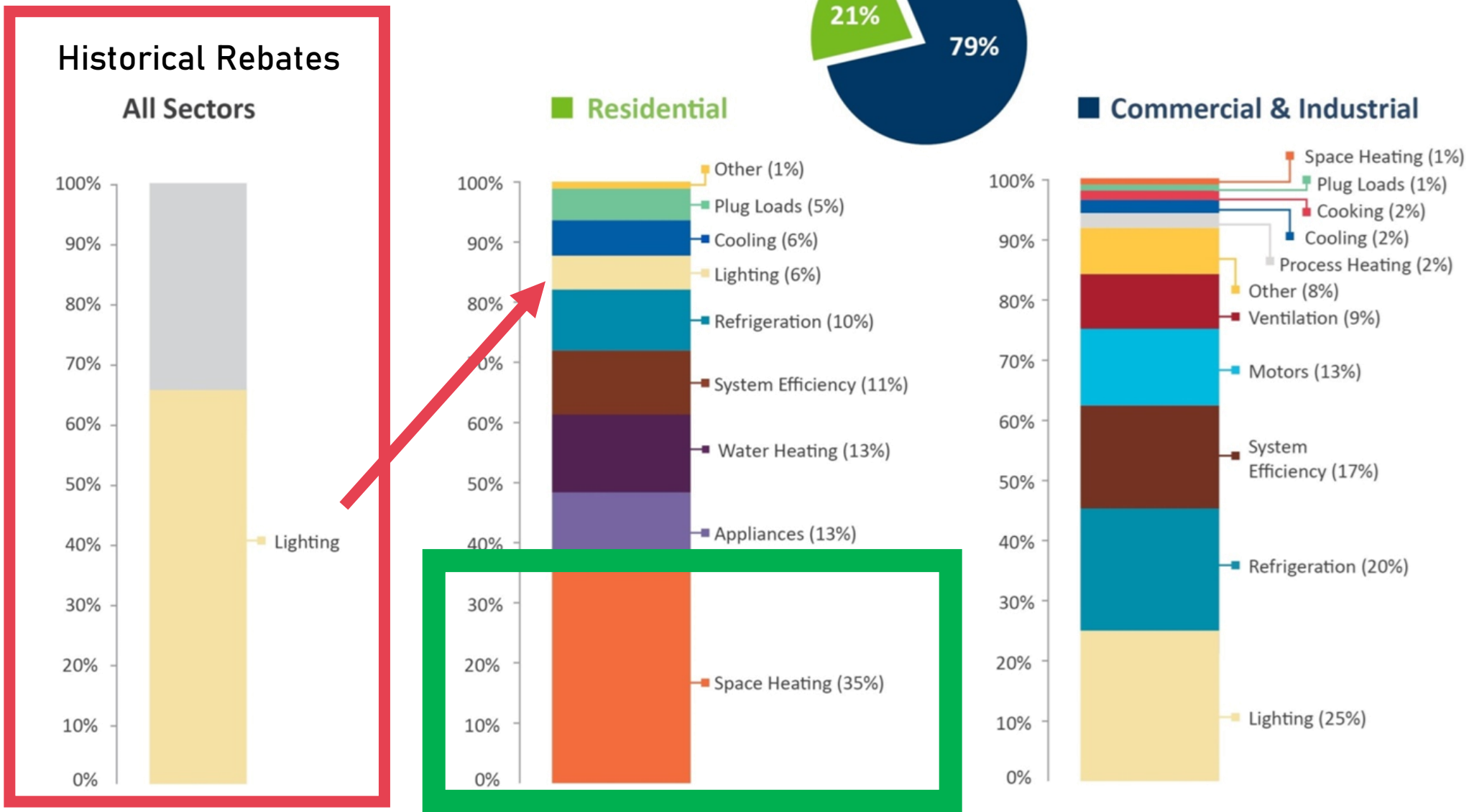
GREAT RIVER ENERGY

MISSOURI RIVER
ENERGY SERVICES

Southern Minnesota
Municipal Power Agency

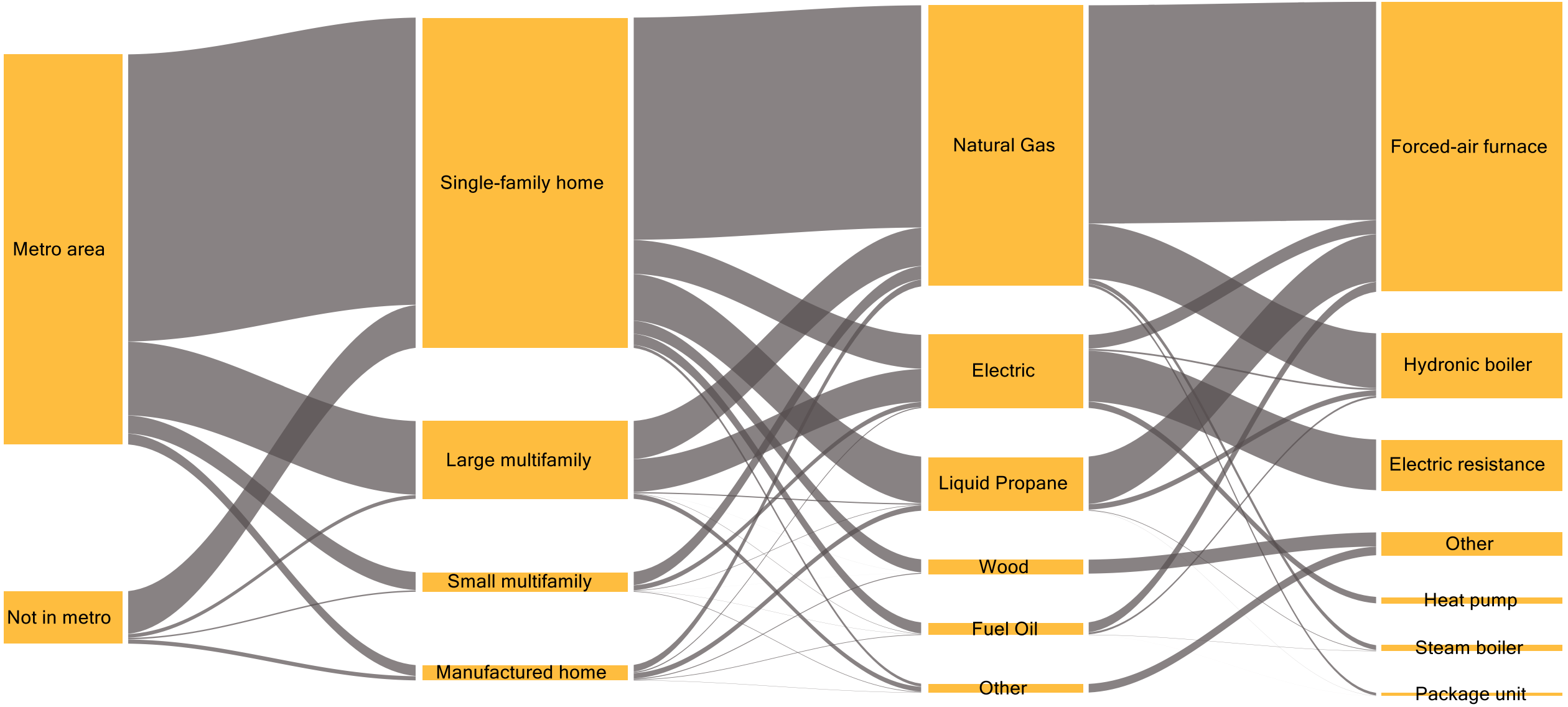
Air source heat pumps have great potential in MN

Minnesota Statewide Electric Savings Potential 2020-2029



Primary Space Heating Types in Minnesota Homes

Total households:
2,358,346

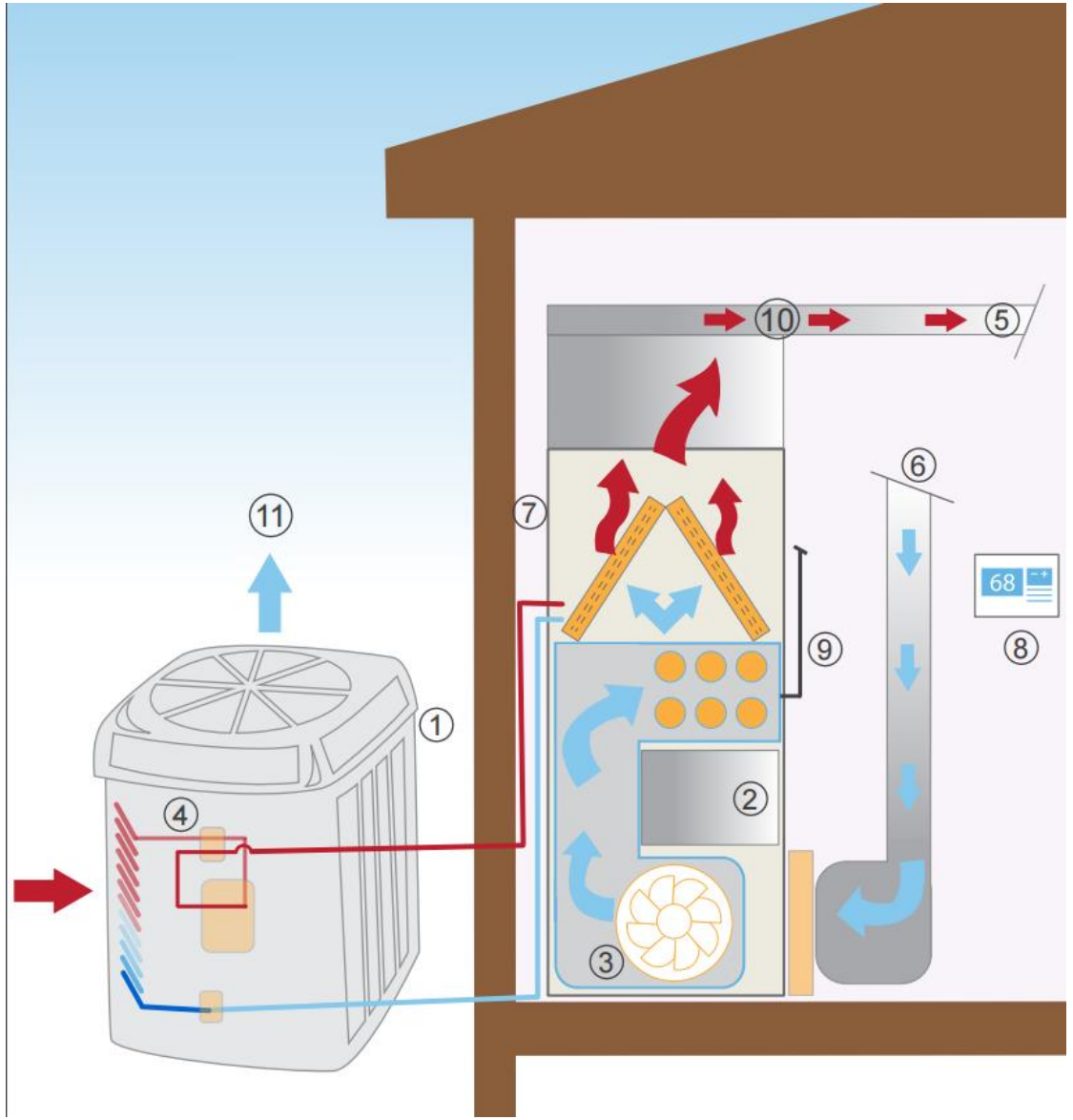


Sources: US Census Bureau and MN Potential Study (CEE 2018)

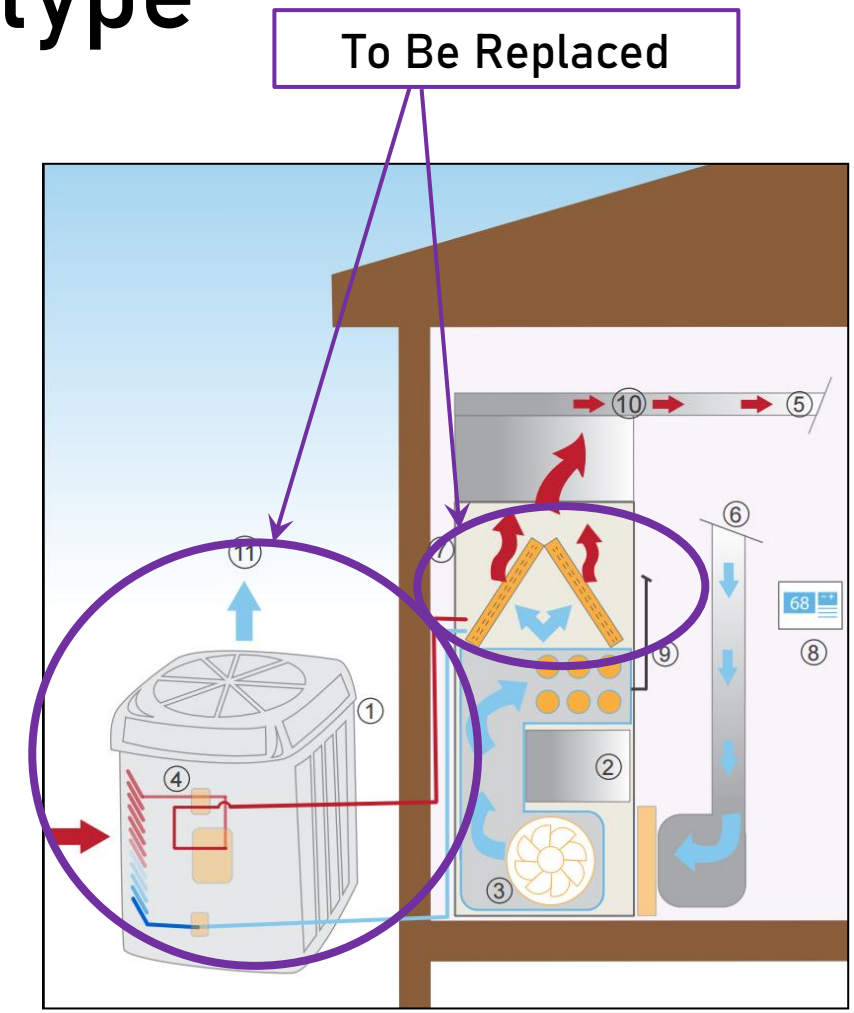
AC Replacement Product Definitions

Definition of AC replacement application type

- Initial VSHP applications require all component package
  - Full replacement
  - New construction
- Full control and communication between all components
  - Optimal performance
  - High cost



Definition of AC replacement application type



- Partial component replacement
  - At AC failure
- Partial control and communication between components
  - ~90+% full optimization
  - Reduced first costs

Product definition for ASHP AC replacement

- Available Product Options:
  - Baseline Options
    - Air Conditioner – majority are min. efficiency (SEER 13) and single stage
  - Upgrade 1
    - Single stage or two stage heat pump
  - Upgrade 2
    - Variable speed heat pump

Any ASHP

VSHP

ccASHP

DOE Challenge

Considering single stage – entry level

- Single (or two stage) heat pumps can not increase compressor speed at cold temperatures
  - Their capacity decreases quicker as it gets cold outside
  - Leads to less operating hours for the HP
- Lower up-front costs
- Good performance at shoulder season air temperatures

Any ASHP

VSHP as AC replacement

- System capacity is more consistent across cold winter temps
- Capable of displacing most of the heating loads
- Less expensive than first gen. ccASHPs, but more costly than ssHPs

Potential Overall Benefits

- Primary driver is decarbonization
- Cooling benefits
- Increased comfort

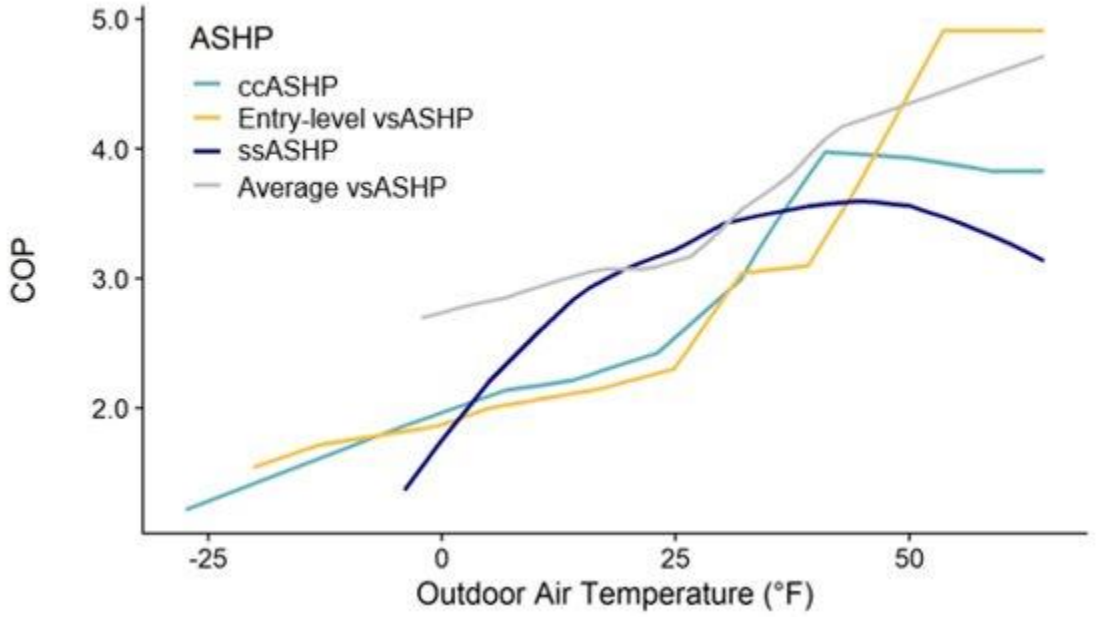
Audience Poll

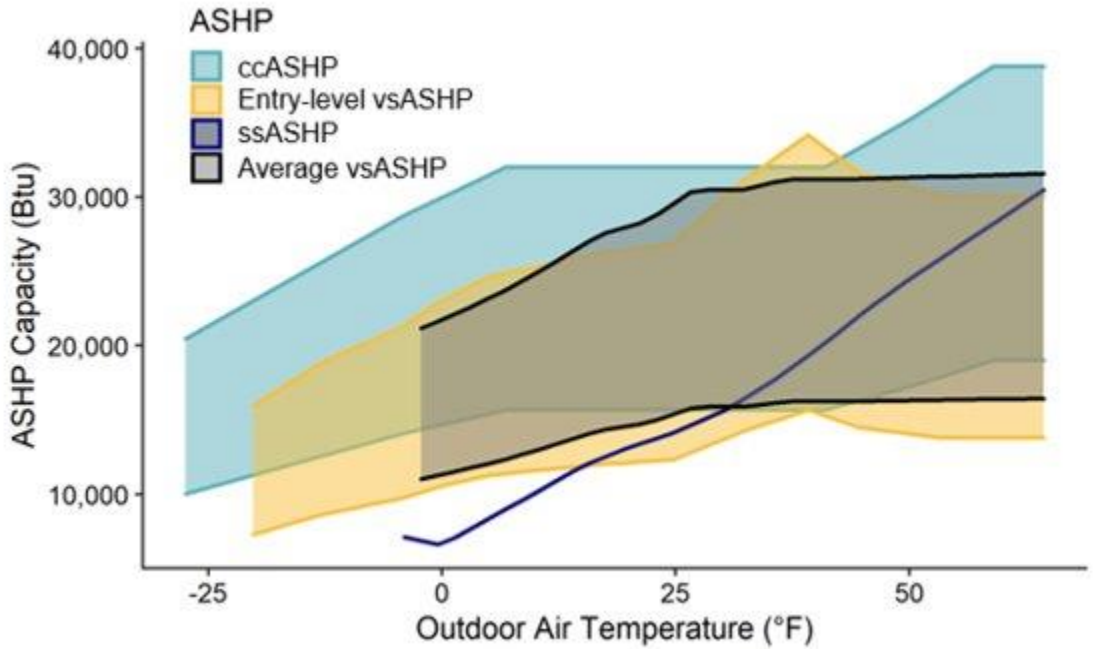
How many people live in a home with a furnace and air conditioner?

How many people think replacing AC with HP is a promising opportunity?

System Design Considerations

A Heat Pump for Every AC Replacement





Choose your HP type based on your application!

AC Replacement Considerations

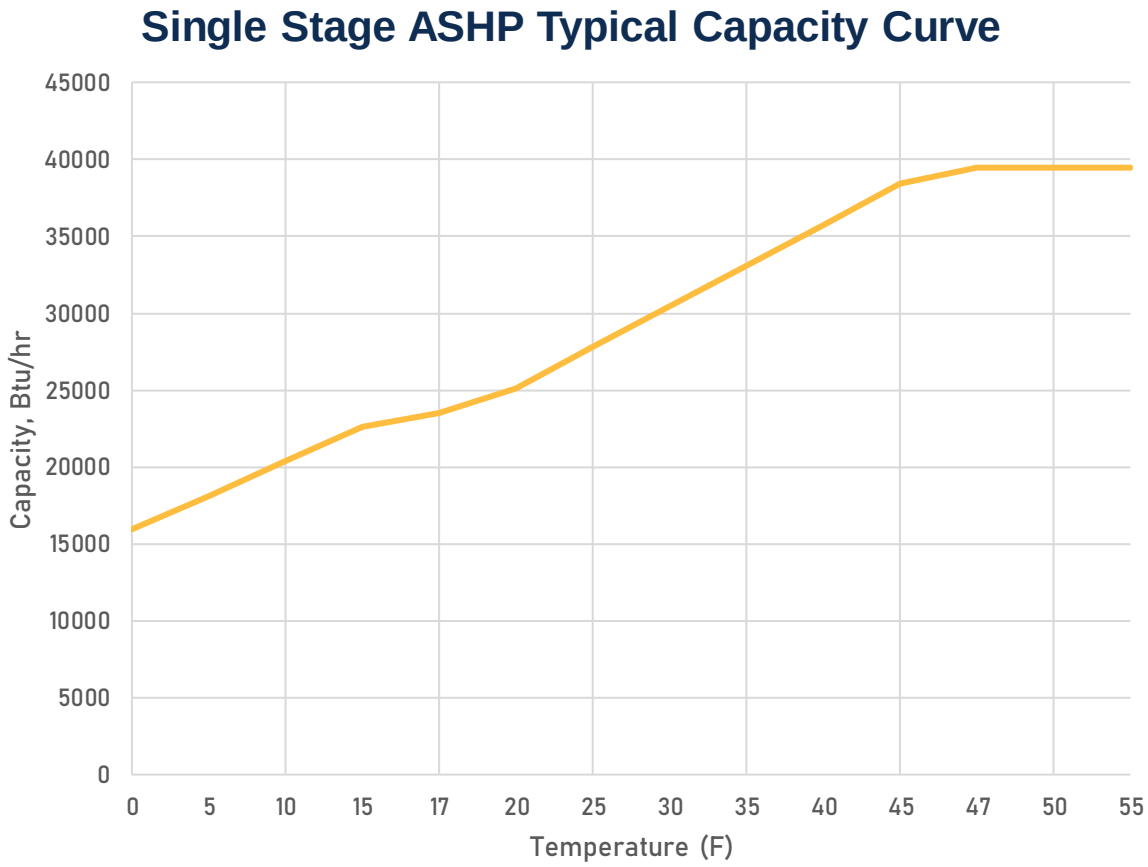
- What is the existing heating fuel type?
  - What are the rates and fuel costs?
- What is the furnace's usable lifetime? And performance specs?
- What is the customer looking for?
  - Comfort
  - Cost savings
  - Emissions reductions
  - Efficiency

Single Stage Heat Pumps (SSHP)

SSHP: Cost Conscious with Natural Gas

- Aligns well with
  - Shoulder season heating only
  - Natural gas furnace backup
  - Low first costs
  - Initial HP market participation

- Avoid for
  - Electric or delivered fuel applications
  - Electrification/Emissions related focus



Coil-only / Non-communicating Variable Speed Heat Pumps (VSHP)

Coil-only VSHP Availability is Growing

- Bosch was first to market with the IDS product lines
- Ducane Lynx launched in 2021 with AHRI-rated coils
- Other manufacturers are planning or are in progress to release AHRI-ratings for coil-only VSHPs

Table 1. Manufacturer VSHP A-Coil Products

Manufacturer	Brand	Product Name	Model #	A-coil Model #
Bosch	Bosch Inverter Ducted Split	IDS 2.0	BOVA20-**	BMAC
Bosch	Bosch Inverter Ducted Split	IDS 1.0	BOVB18-**	BMAC
Carrier	Bryant	Preferred	38MARB	CNPVP
Carrier	Carrier	Performance	38MARB	CNPVP
GREE	KingHome	Ultranixx	KU**UHO	Not available
GREE	GREE	Flexx	FLEXX**HP	FLEXX**C
GREE	MRCOOL	Universal	MDUC0180**	MDUCC150**
Lennox	Lennox	Elite Series	EL18 XPV	Not available
Lennox	Ducane	Lynx	4HP18V	EAC4X
Mitsubishi	Mitsubishi	intelli-Heat	Not available	Not available

Schoenbauer, Ben, and Emily McPherson. "Why We Should Never Install Another Air Conditioner!," *ACEEE Summer Study on Energy Efficiency in Buildings.* 2022

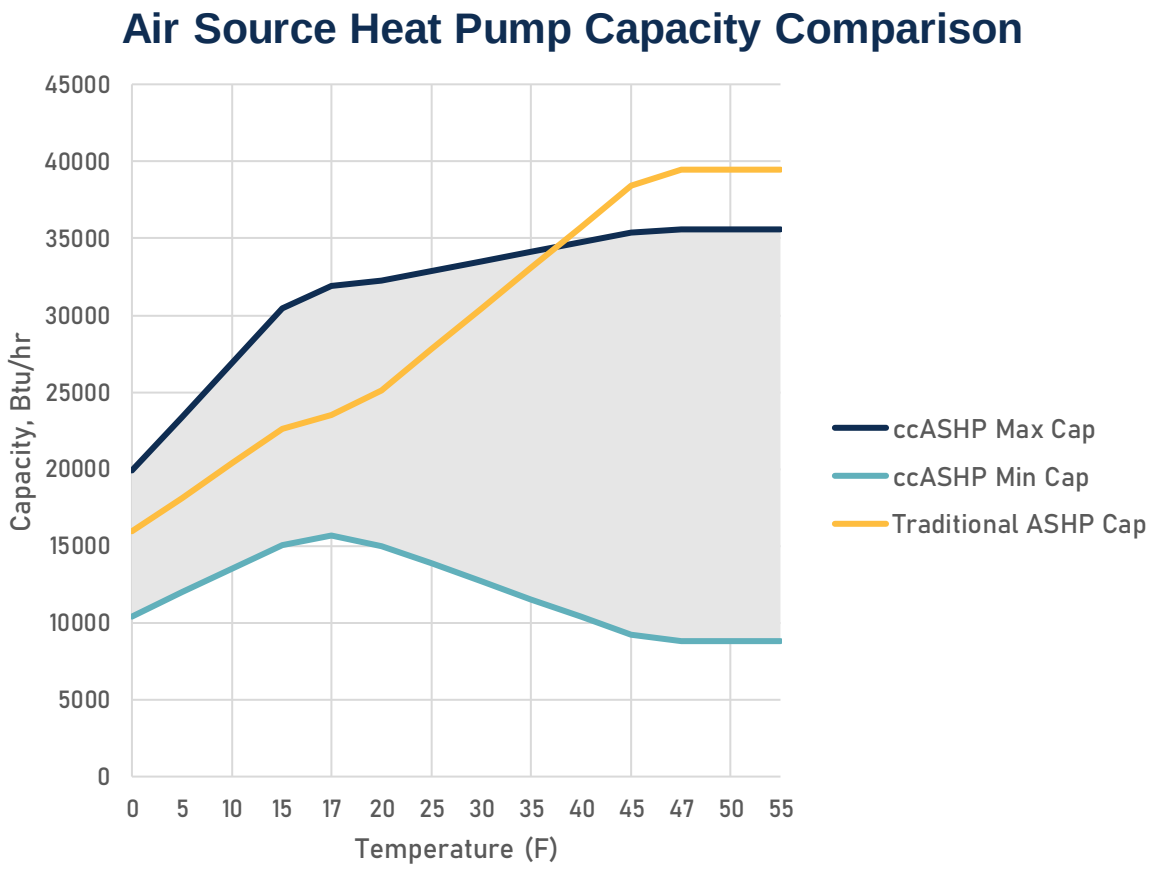
Product Selection

- Cold climate performance
  - HSPF
  - COP at 5F
  - Capacity maintenance at low temperatures
  - QPLs: NEEP ccASHP spec

VSHP: Displace Expensive Heating Fuels, Improve Comfort, Reduce Emissions

- Aligns well with
  - Electric resistance or delivered fuel heat displacement
  - Reducing fuel costs
  - Cooling season savings
  - Increased comfort
  - Electrification & emissions reduction goals

- Avoid for
  - The most cost sensitive customers with natural gas and no dual fuel electric rates



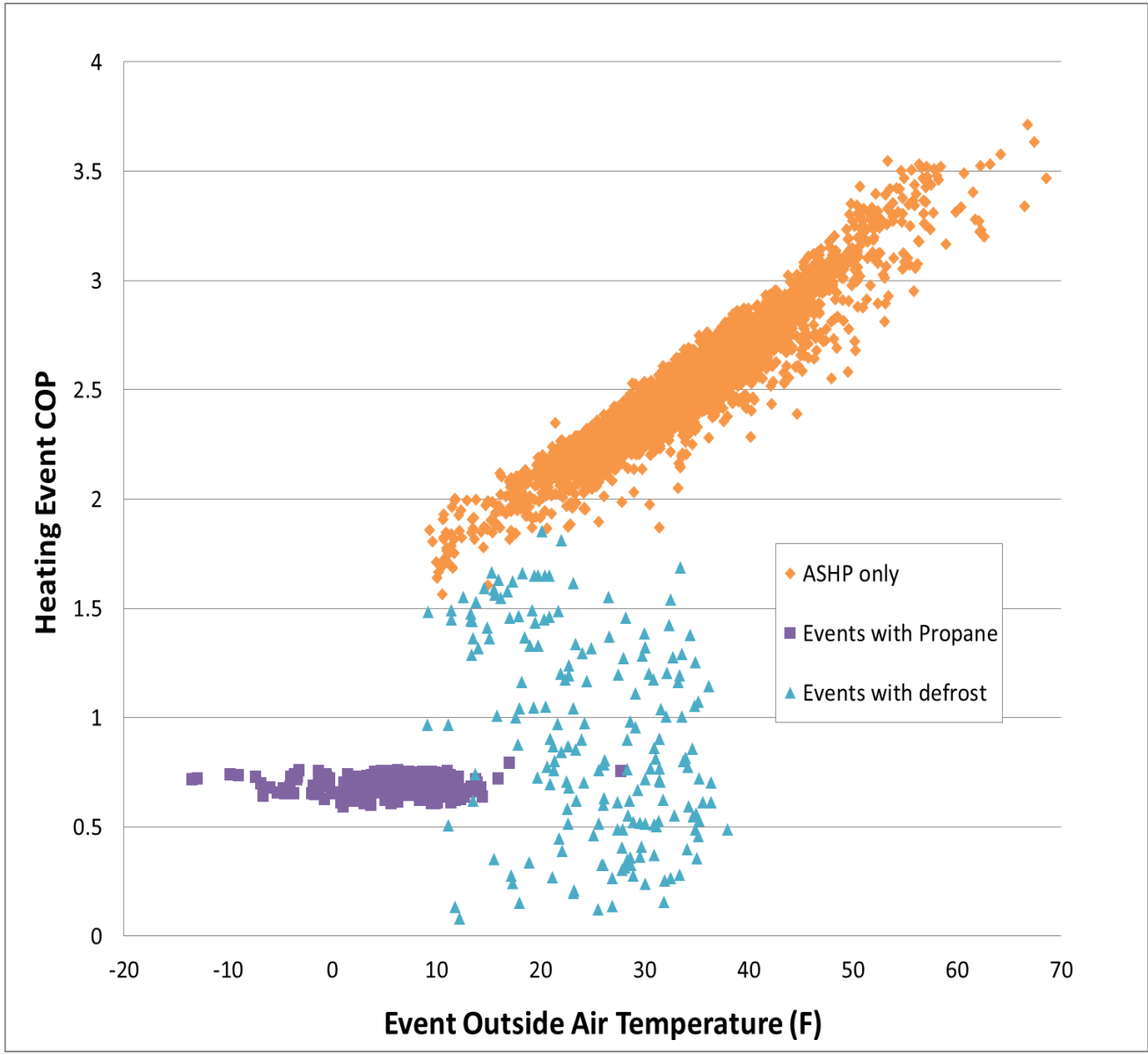
Installation Considerations

Heat Pumps vs. Air Conditioners: Key Differences

- HPs operate in both heating and cooling seasons
- Sizing may be informed by cooling and/or heating loads
- Thermostat upgrades may be needed to control a HP

Choose a Winter Friendly Installation Location

Good Siting May Reduce Defrost Events



Heat Pumps vs. Air Conditioners: Key Differences

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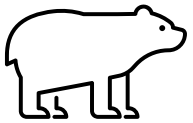
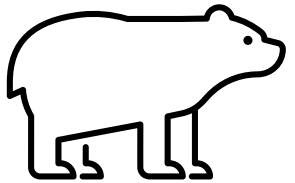
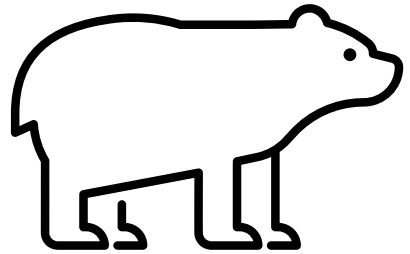
Sizing Matters



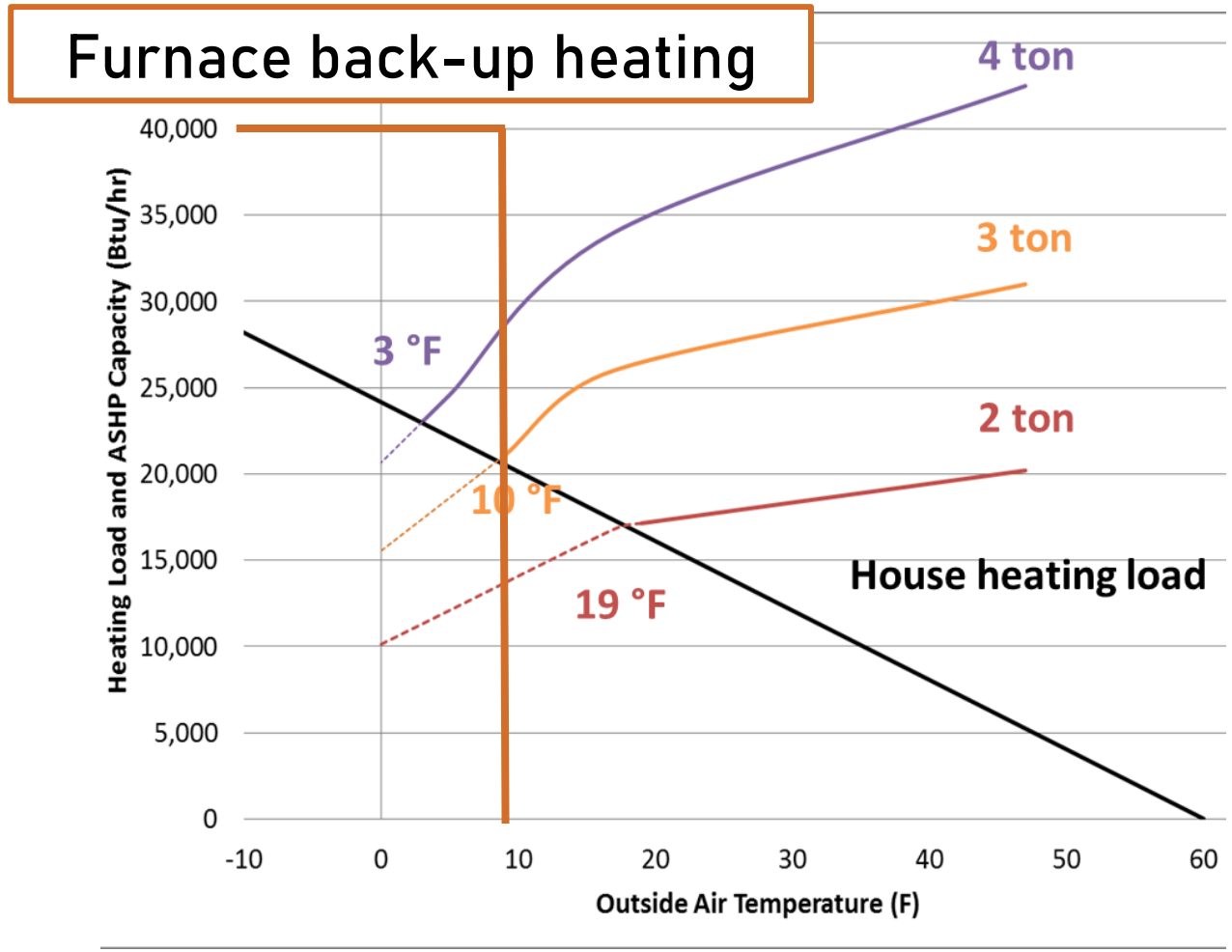




- Existing ACs and furnaces are often oversized
  - Load calculations are always recommended
- **SSHPs should be sized for cooling load**
- Coil-only VSHP models may have fewer offered condenser sizes
  - Manufacturers may offer only 3 and 5 ton condensers
  - Paired coil size and condenser dipswitch settings can scale down the VSHP output for mid-size applications

Sizing VSHPs for Heating

- Trade-offs between HP size and fraction of heating load meet
- Rule of thumb: Sizing for heating increases HP size by 1-ton over sizing for cooling
- Percentage of heating load meet by ASHP:
  - 4 ton ~ 86%,
  - 3 ton ~ 77%
  - 2 ton ~ 60%



Heat Pumps vs. Air Conditioners: Key Differences

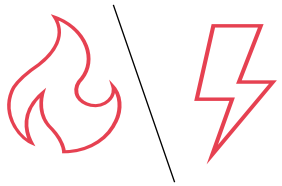
- HPs operate in both heating and cooling seasons
- Sizing may be informed by cooling and/or heating loads
- Thermostat upgrades may be needed to control a HP

Thermostat Selection & Configuration is a Critical Difference between HPs and ACs

NOT ALL THERMOSTATS ARE DUAL FUEL COMPATIBLE

Selecting a heat pump compatible thermostat is NOT enough

Thermostat Features to Look for:

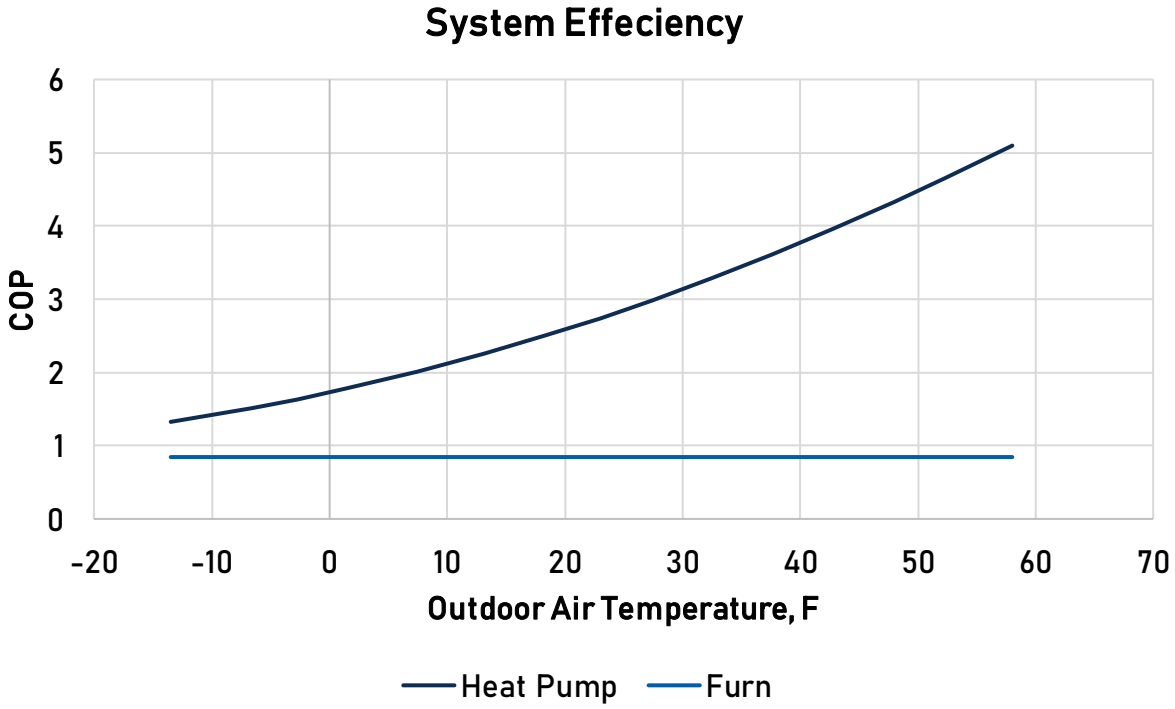


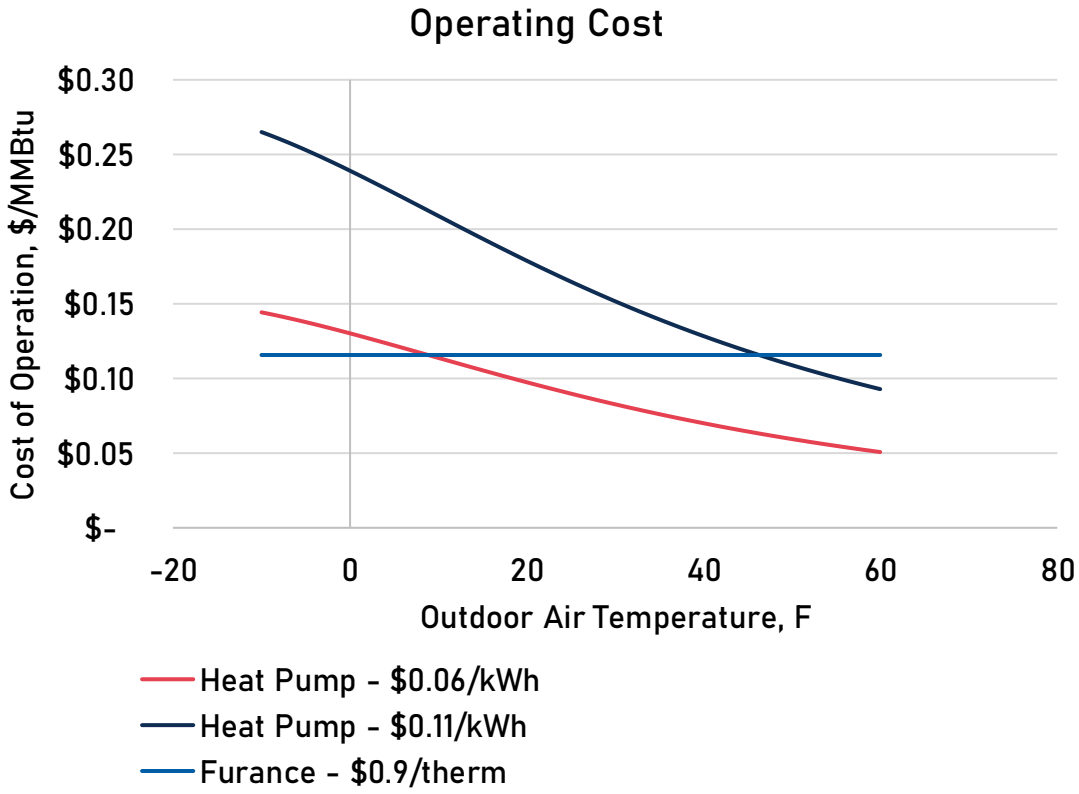
4 or more wires / wireless	▪ Must be able to control the HP reversing valve to operate both heating and cooling modes ▪ Wireless thermostat models exist
Dual fuel controls software	▪ Some thermostats can control a HP but not a HP with a backup heat source
Outdoor air temperature monitoring	▪ Can be a hardwired sensor, wireless sensor, or WiFi connectivity to a local weather station ▪ Required to set a condenser lockout temperature
Multiple stage heating controls	▪ Optional, but may improve comfort or eliminate condenser lockout at low temperatures

Configuring the Thermostat for HPs

- Most HPs activate the reversing valve in heating
  - Bosch IDS is a common VSHP exception to this rule, always check
  - Specific wiring instructions vary by HP model and number of wires from the thermostat
- Some systems can call the backup heat during defrost events
  - Increases the supply air temperature during defrost cycles
- Multi-stage blower speed must be set to the HP coil specs
  - Multi-stage systems should also be configured for appropriate staging and droop settings
- Dual fuel thermostats have a lockout / switchover / balance point temperature to configure
  - Determine when the HP should not be used for heating
  - Select based on economics or the home heat load

Economic Switch Over

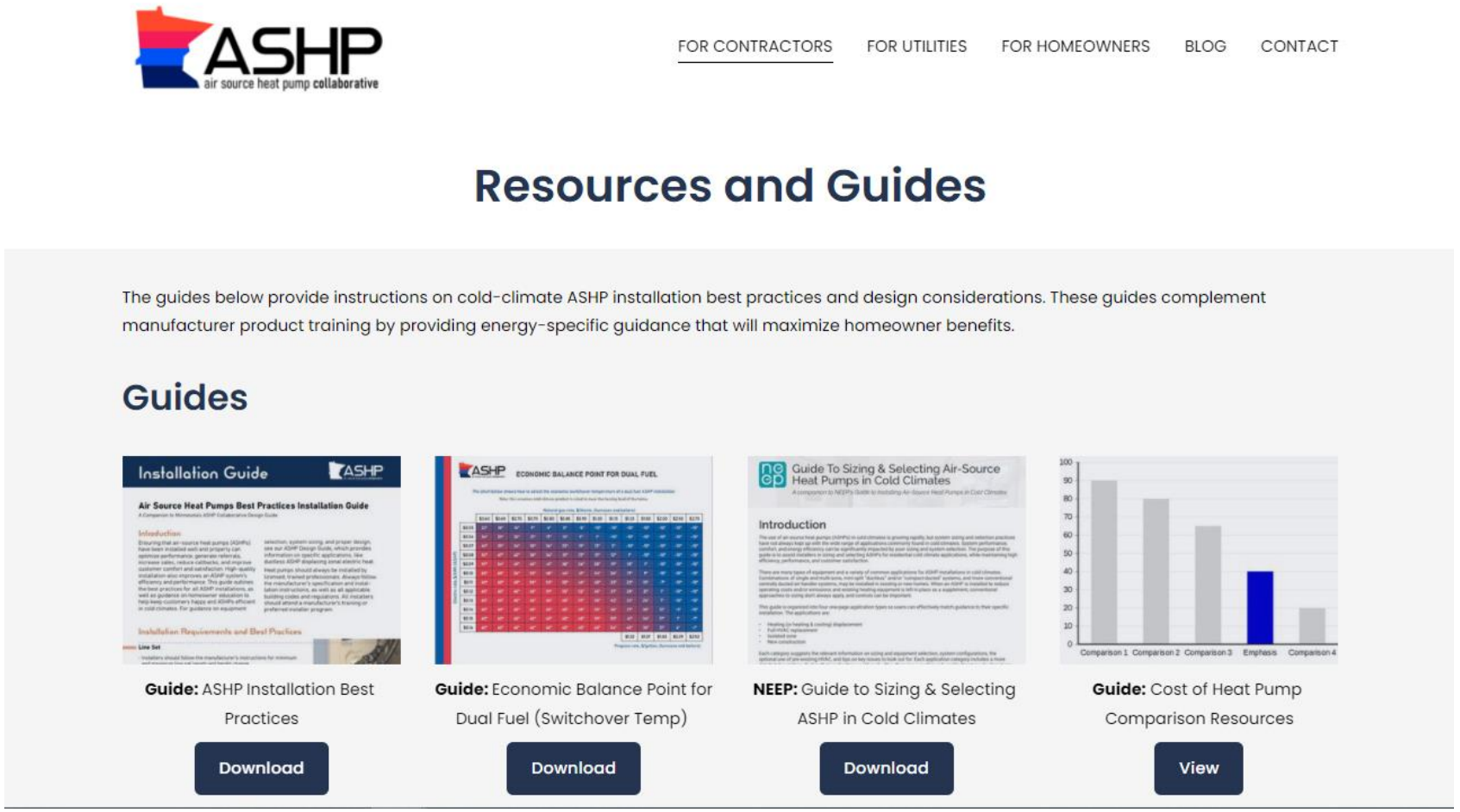




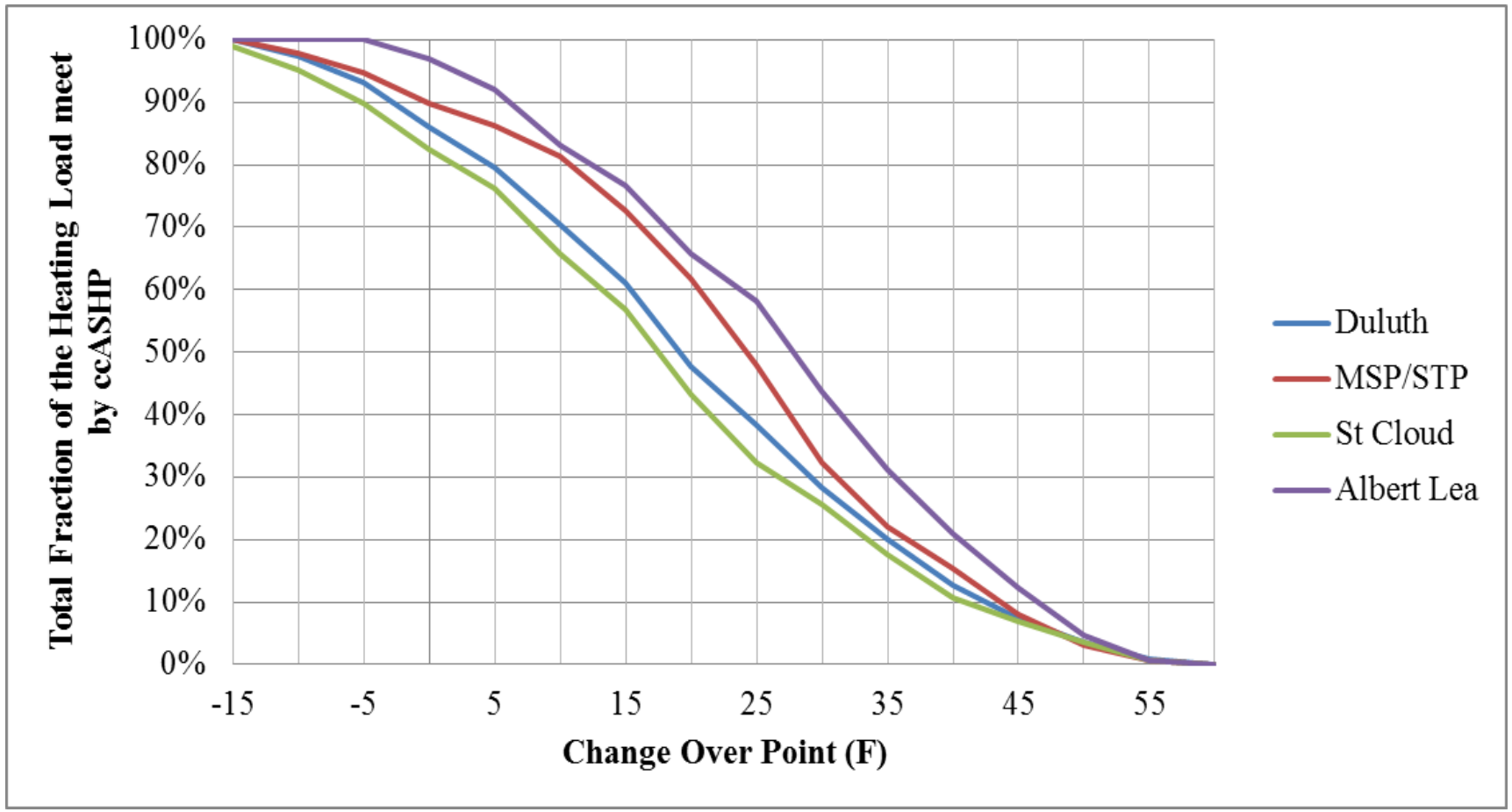
- Economic switchover balances system efficiency with fuel costs to ensure operating costs do not increase

Economic Switch Over Resources

- https://www.mnashp.org/guides



Impact of Switch Over Set Point on % Heating



What if the Switch Over isn't Perfect?

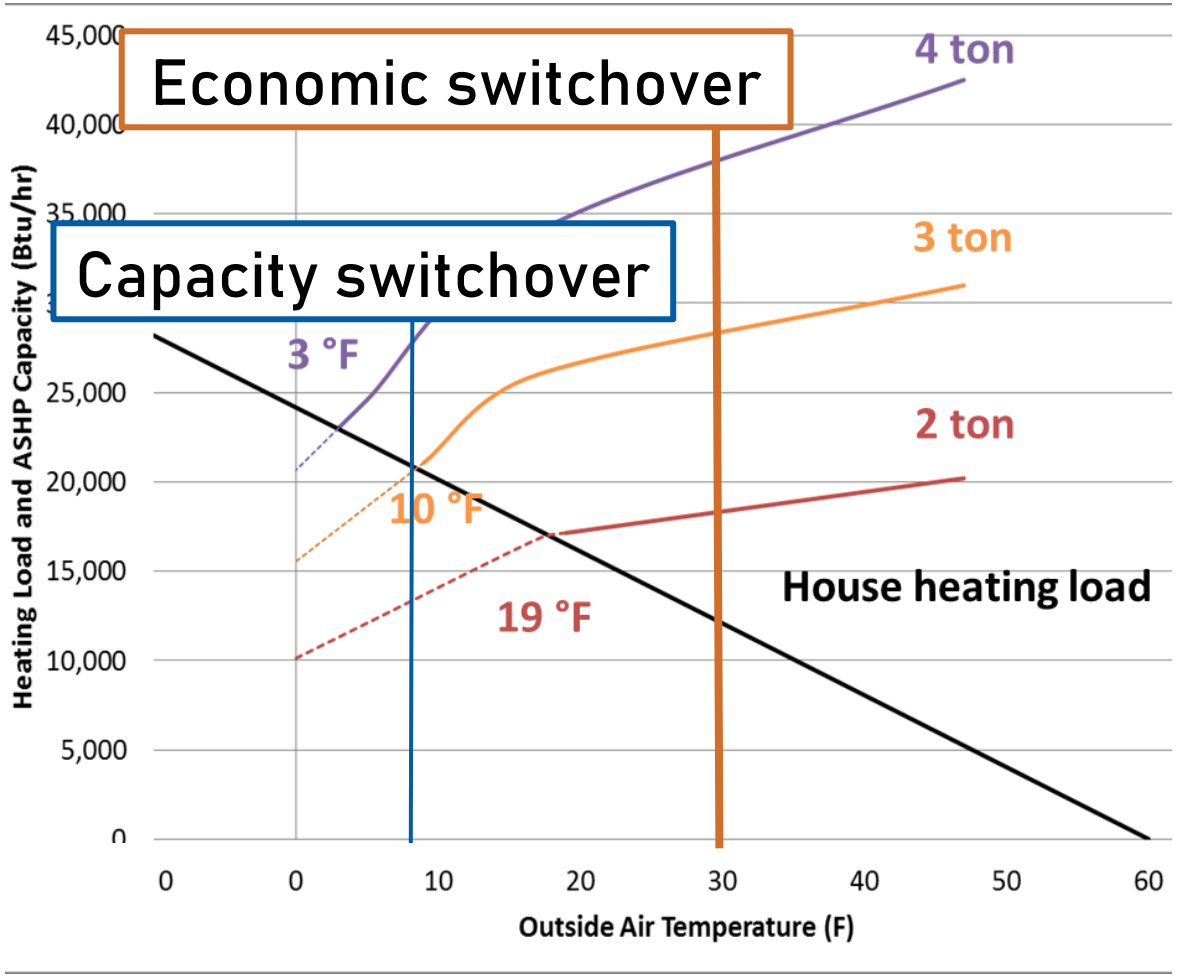
Table 2. Energy Costs and Emissions[2]

HP or AC System	Total Heating and AC Energy Costs	Cost Savings Over Baseline	Carbon emissions (tons)	Carbon savings over baseline (tons)
Baseline - ~13 SEER AC (80% furnace for all)	$1,020		6.6	
VSHP 35°F switchover	$1,020	$ -	5.9	0.7
VSHP 25°F switchover	$1,070	$ (50)	5.3	1.3
VSHP 5°F switchover	$1,190	$ (170)	4.7	1.9
Entry level HP 45°F switchover	$1,010	$ 10	6.3	0.3
Entry level HP 35°F switchover	$1,030	$ (10)	5.9	0.7

Schoenbauer, Ben, and Emily McPherson. "Why We Should Never Install Another Air Conditioner!," *ACEEE Summer Study on Energy Efficiency in Buildings.* 2022

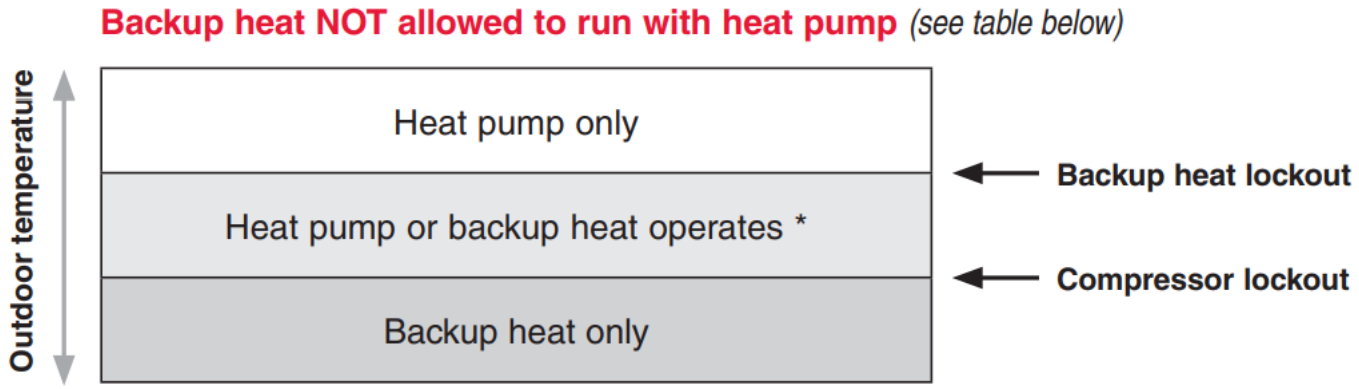
Model assumes Minneapolis, MN weather, $0.11/kWh and $0.80/therm gas energy costs for first year costs

Economic Switch Over ≠ Capacity Switch Over



Staging vs Switch Over (Compressor Lockout)

- Staging controls can be used in conjunction or in place of a switch over setting
  - Choose your staging settings carefully!
  - Staging based on setpoint droop is preferred over maximum runtime
  - Deep overnight setbacks can lead to morning back up heat usage



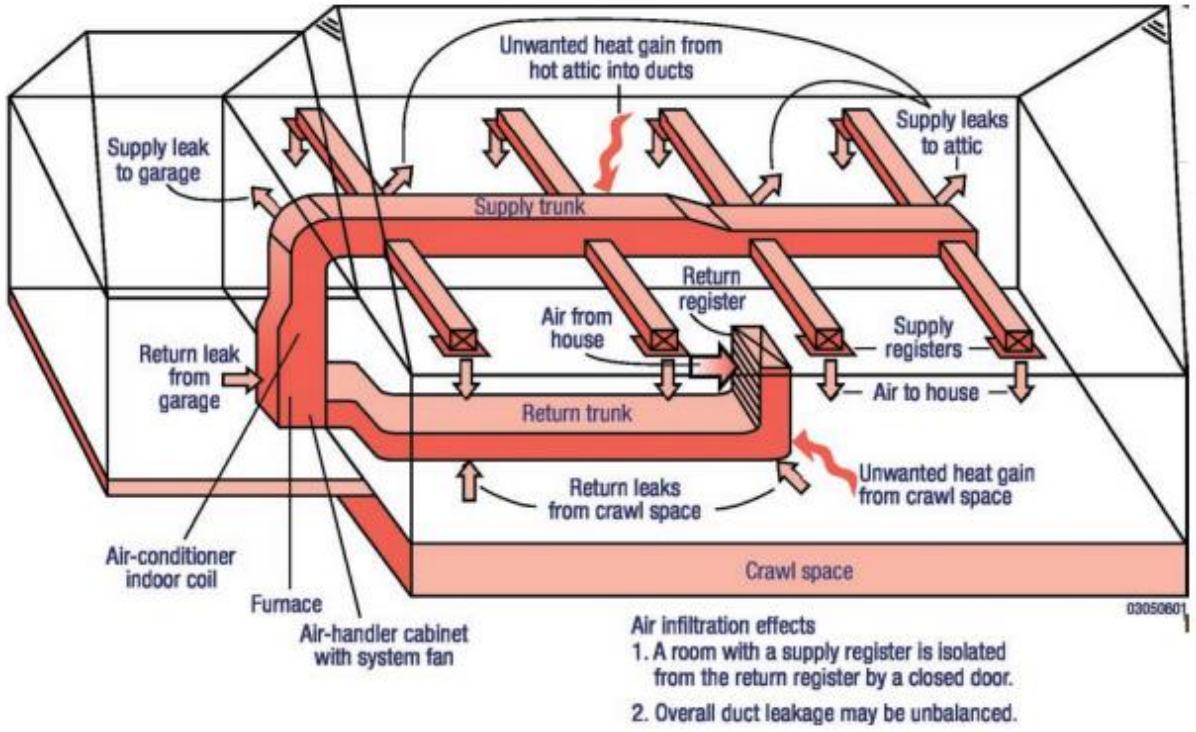
From Honeywell THX9321 Prestige installation guide

Heat Pumps vs. Air Conditioners: Key Differences

- HPs operate in both heating and cooling seasons
- Sizing may be informed by cooling and/or heating loads
- Thermostat upgrades may be needed to control a HP

Considering Ductwork

- VSHP typically have
  - Lower airflows
  - Lower air temperatures
- Comfort impact?
- Quality installation requirements
  - Look for unconditioned spaces
  - Look for existing issues



https://www.nrel.gov/docs/fy05osti/30506.pdf

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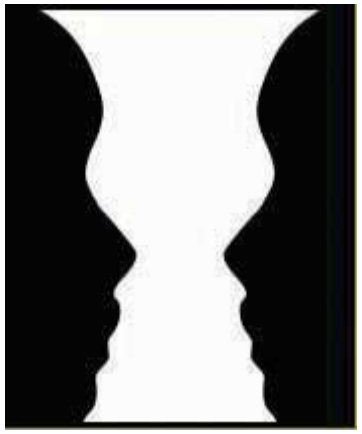
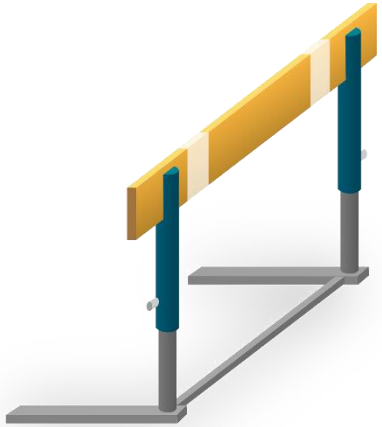
Market Research Findings





- Uncover homeowner perceptions:
  - Find out what customers value (price, features, and benefits)
  - Determine drivers of replacement (e.g., end of life or proactive)
  - Uncover current awareness levels

- Understand contractor, distributor and manufacturer opportunities and barriers

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Market Research Interviews

- 438 Minnesota Households – Online survey
- 30 Installers - In-depth Interviews
- 3 Distributors – In-depth Interviews
- 5 Manufacturers - In-depth Interviews

Acknowledgments

Minnesota Department of Commerce Division of Energy Resources

Leede Research

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Customer Opportunities and Perceptions

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Change or Improve One Thing

Accessing new systems is a key response.

There is strong interest to lower operational costs and efficiency.

Interest in environment

Interest in zoned systems and more even temps,

H2. If you could change or improve one thing about your overall home comfort, relating to heating and AC, what would it be?

N=436

Improvement Responses Include:

Better Insulation, Windows, Doors, Seals (Keep Air Inside) – 12 Responses

Get A New System/Update Current System/Add New Tech. – 63 Responses

Humidity Controls – 35 Responses

Lower The Costs/Costs To Run It/Energy Efficient/Environmentally Friendly – 59 Responses

Misc. Others – 24 Responses

Nothing/No/No Current Issues/Happy With What I Have – 89 Responses

System To Keep Up On Hot Days And Cold Days – 33 Responses

Zoned System/Consistent Temps Throughout House – 118 Responses

Replacement Motivators

Failure of the existing unit is the most significant factor in making changes.

Current AC Unit Fails	65%	6%	3%	3%	0%
Replacement of Furnace or Heating	3%	10%	8%	6%	5%
Ongoing Problems with AC Unit	5%	32%	11%	4%	6%
AC System is Old	4%	6%	12%	7%	6%
Outdoor & Indoor Noise from AC Sys	1%	1%	5%	3%	3%
Size of Footprint for Outdoor AC Unit	1%	1%	2%	1%	2%
New AC is More Efficient	3%	8%	11%	11%	11%
Money Savings on New AC System	2%	7%	13%	13%	8%
Utility Incentives or Rebates for New AC	5%	7%	9%	11%	8%
Contractor Recommends Replacement	3%	3%	4%	3%	4%
Contractor Incentives, Rebates or Financing	2%	3%	3%	7%	6%
New Features or Technology for AC	1%	3%	4%	7%	6%
New Unit has Lower Environmental Impact	2%	3%	8%	6%	8%
General Improvement to Home or Increase Value	2%	4%	3%	5%	9%
Greater Home Comfort Overall	3%	4%	5%	7%	11%

N=438

SP2. The following are a set of items that might impact your consideration to replace your existing air conditioning system. Please select the TOP 5 items that would create the strongest interest in considering a new AC system:

System Replacement Trends – Recent Purchasers

Most customers replaced their furnace at the same time as AC

Still, a significant portion only replaced AC

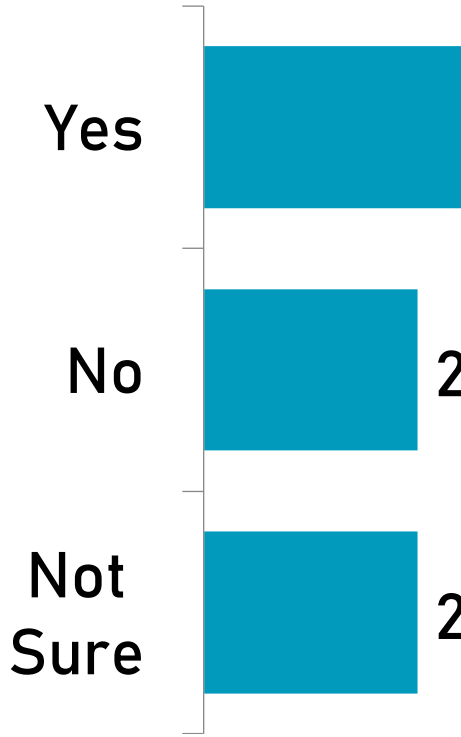
P1a. In the installation process did you replace your heating system at the same time? N=71

Yes: 63%
No: 37%

System Replacement Trends – Intenders

Under half would replace the furnace at the same time,

This is less than the actual purchase group, which may indicate perception differences



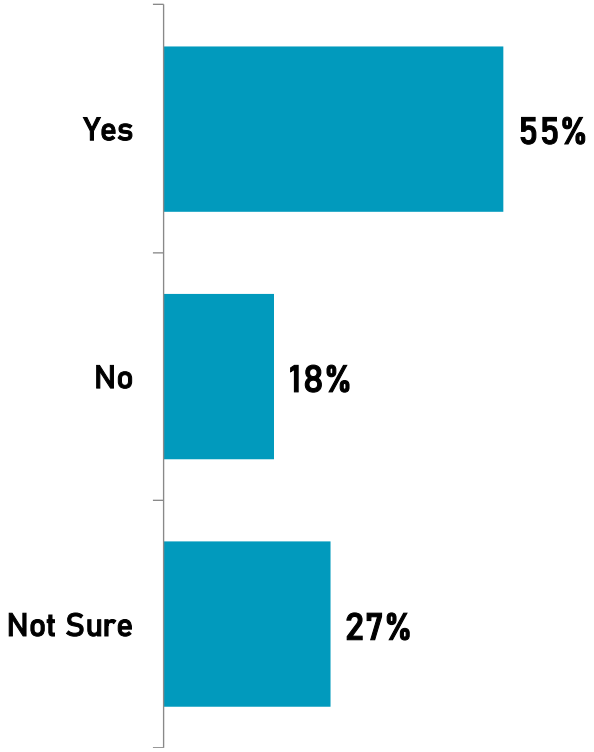
PP1a. In that process would you also replace your furnace at the same time?

N=84

AC Units Upgrades – Recent Purchasers

Over half the respondents are willing to pay more for lower operating costs, showing a mean of 15% premium.

They have an expectation of a six-year payback at that level



P12. Would you be willing to pay more for an air conditioning system that offered a lower cost to operate on an ongoing basis?

N=71

Mean: 14.5% more

If Yes: What percent more would you be willing to pay for a more efficient option?

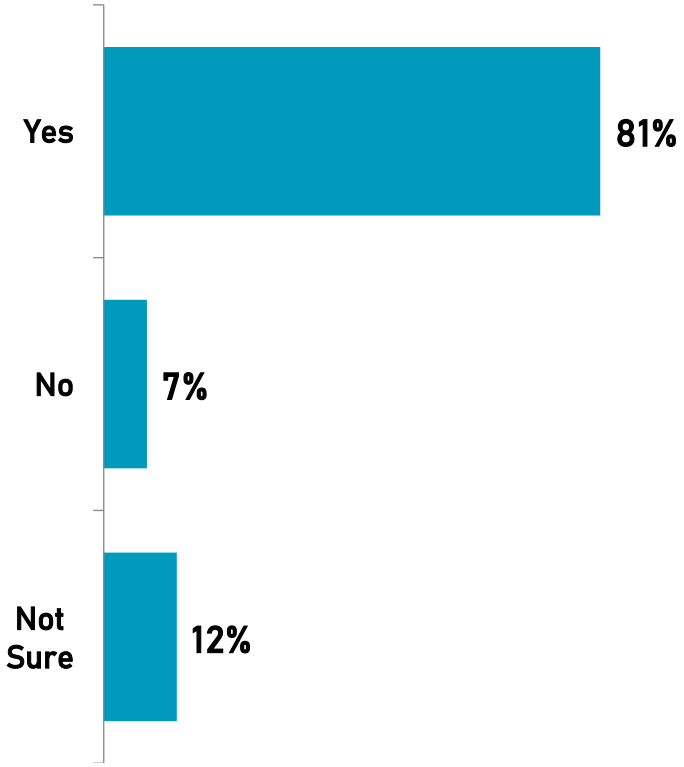
Mean: 6.0 years

How many years would you expect it to take to recoup the difference in cost by savings?

N=39

AC Unit Upgrades - Intenders

Just over 80% would be willing to pay more to save on costs, with a mean of 21%. This is higher than purchasers



Mean: 20.8% more

If Yes: What percent more would you be willing to pay for a more efficient option?

N=68

PP12. Would you be willing to pay more for an air conditioning system that offered a lower cost to operate on an ongoing basis?

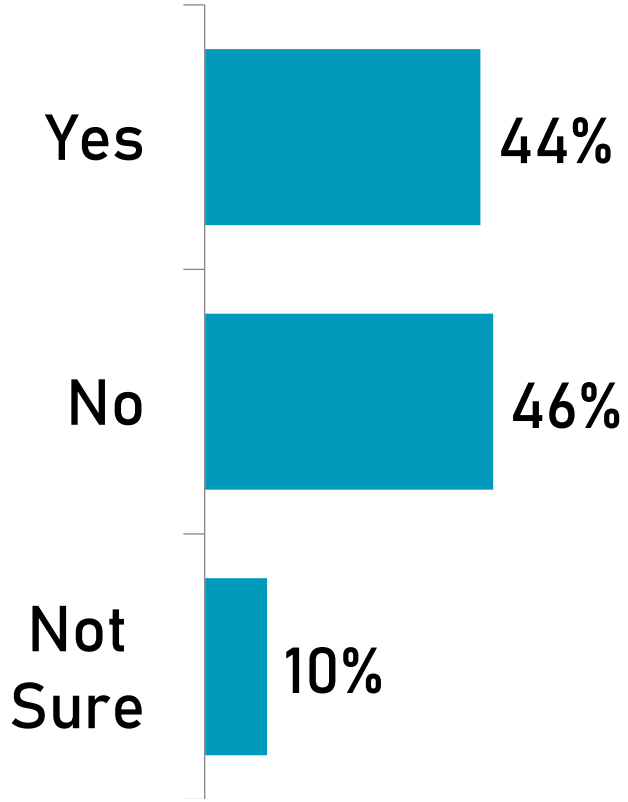
N=84

New Technology & Options

Understanding new technology

Heat Pumps - awareness

There is low to moderate awareness



Do you personally know anyone that has this as their HVAC system?

Yes: 29% N=192
No: 61%
Not Sure: 10%

T1. Have you heard of Heat Pumps as it relates to heating and air conditioning?

N=438

Greatest Advantage

respondents see savings as the biggest advantage,

Open Responses Include:

Cheaper/Cost Savings/Saves Money – 65 Responses

DK/NA/Nothing/Not Sure/Need More Information – 88 Responses

Ductless/Space Savings/Setup Of Unit – 24 Responses

Misc. Others – 19 Responses

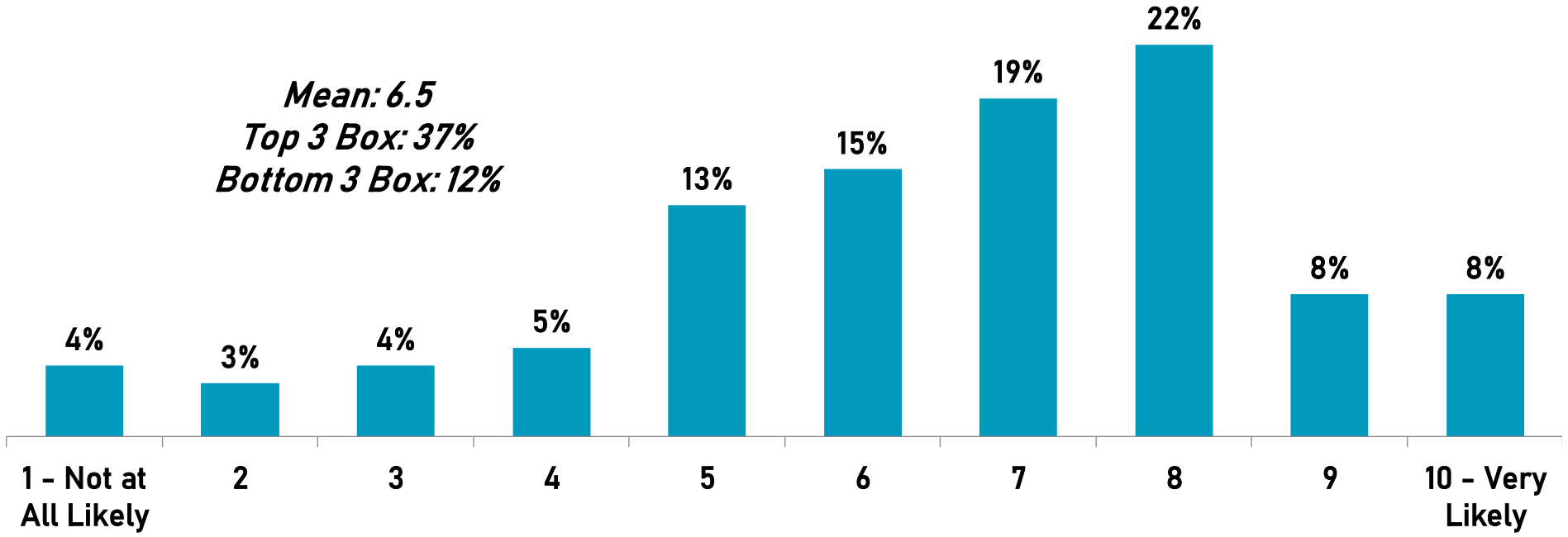
More Efficient/Environment/Dual-purpose Unit – 237 Responses

T2. What would you see as the greatest advantage of this technology in cooling your home?

N=433

Consider vs. Traditional Central Air

Result indicate moderate consideration



T6. how likely would you be to consider this technology as an alternative to AC?

N=438

Information / Learn More

A cost or savings analysis

How it works

Open Responses Include:

Cost Of It/Cost Of Installing/Cost Vs. Savings – 91 Responses

DK/NA/Not Sure/None/Nothing – 136 Responses

Misc. Others – 6 Responses

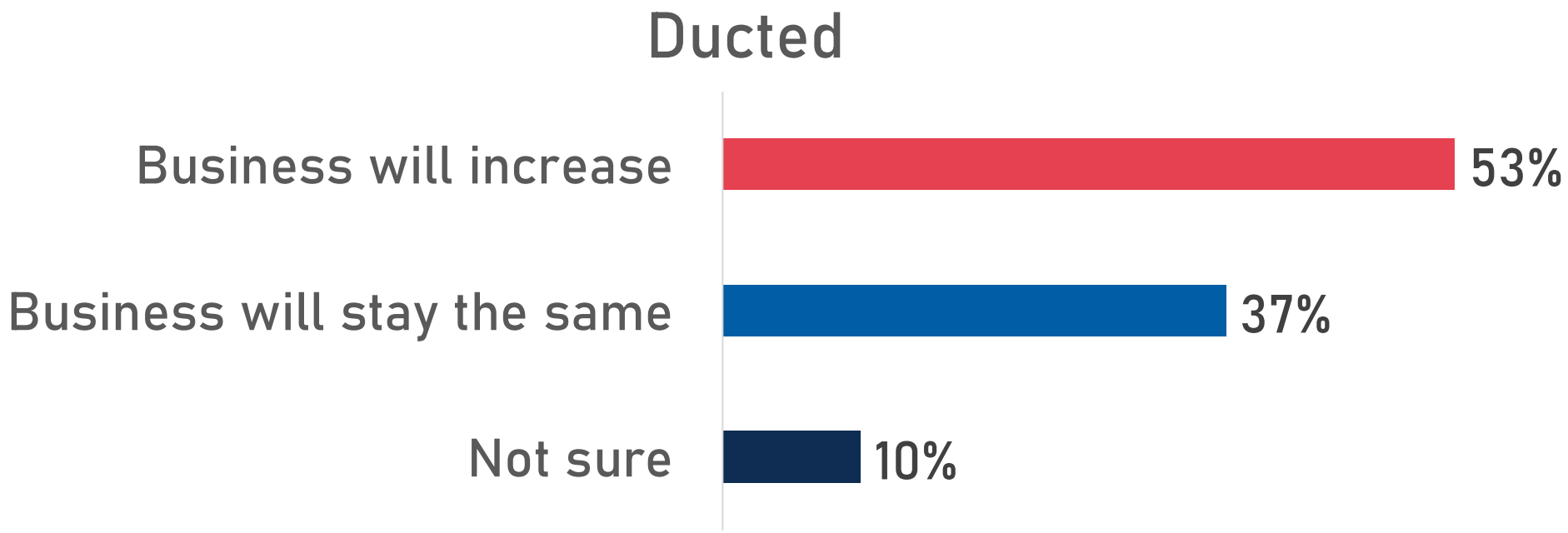
More Information/How Does It Work?/See It In Action/Talk To Others That Have It/Etc. – 200 Responses

T7. What other information would be helpful for you in learning more about this technology?

N=433

Contractor Opportunities and Perceptions

Do you think you will be selling more ASHP's in the future or the same amount as now?



How often do you replace equipment on failure?

How often do you replace both furnace and AC?

Scenario	Average frequency
“How often do you replace an AC when it has failed?”	67% of the time
“When an AC has failed, how often do you also replace the furnace?”	50% of the time
“When a furnace has failed, how often do you also replace the AC?”	51% of the time

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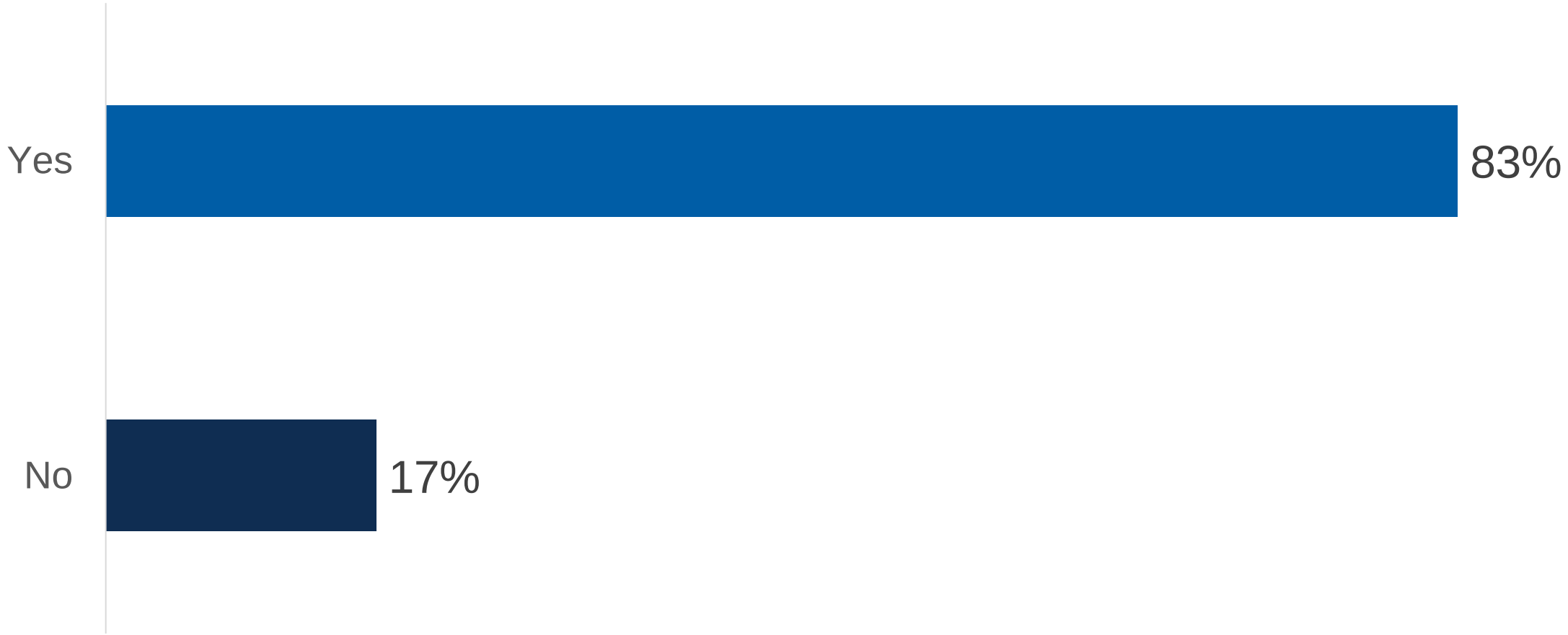
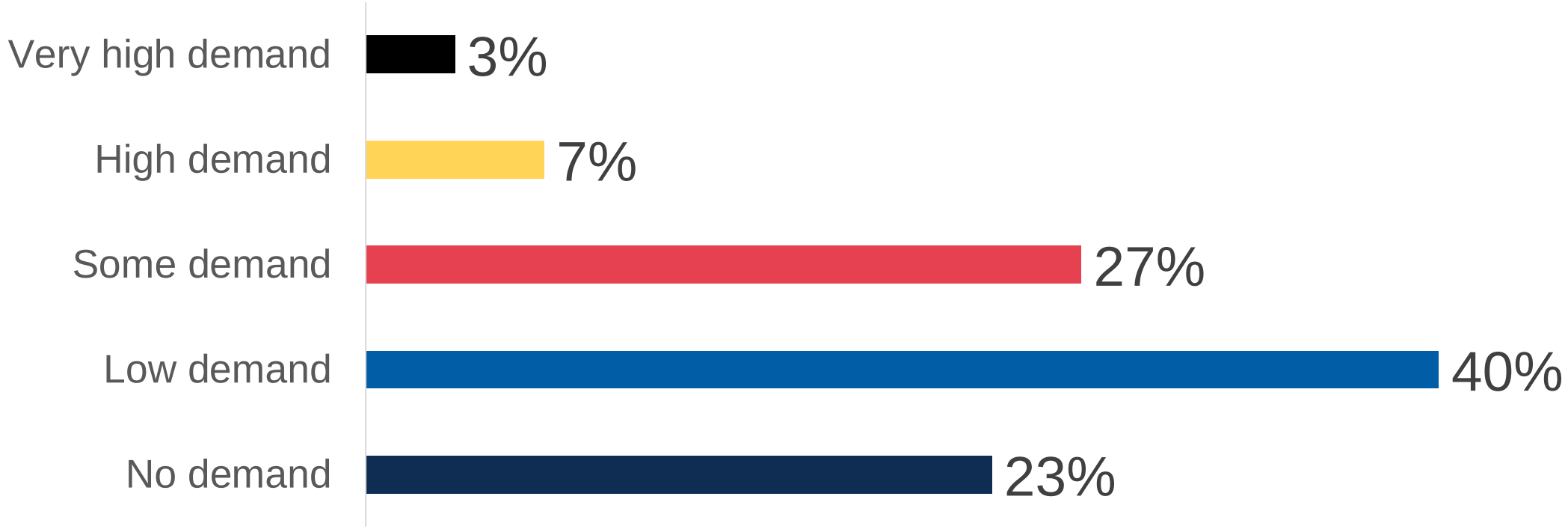
Do you ever recommend a ducted ASHP when replacing a furnace or AC?



What is the customer demand for replacing an AC with an ASHP?



Customer 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

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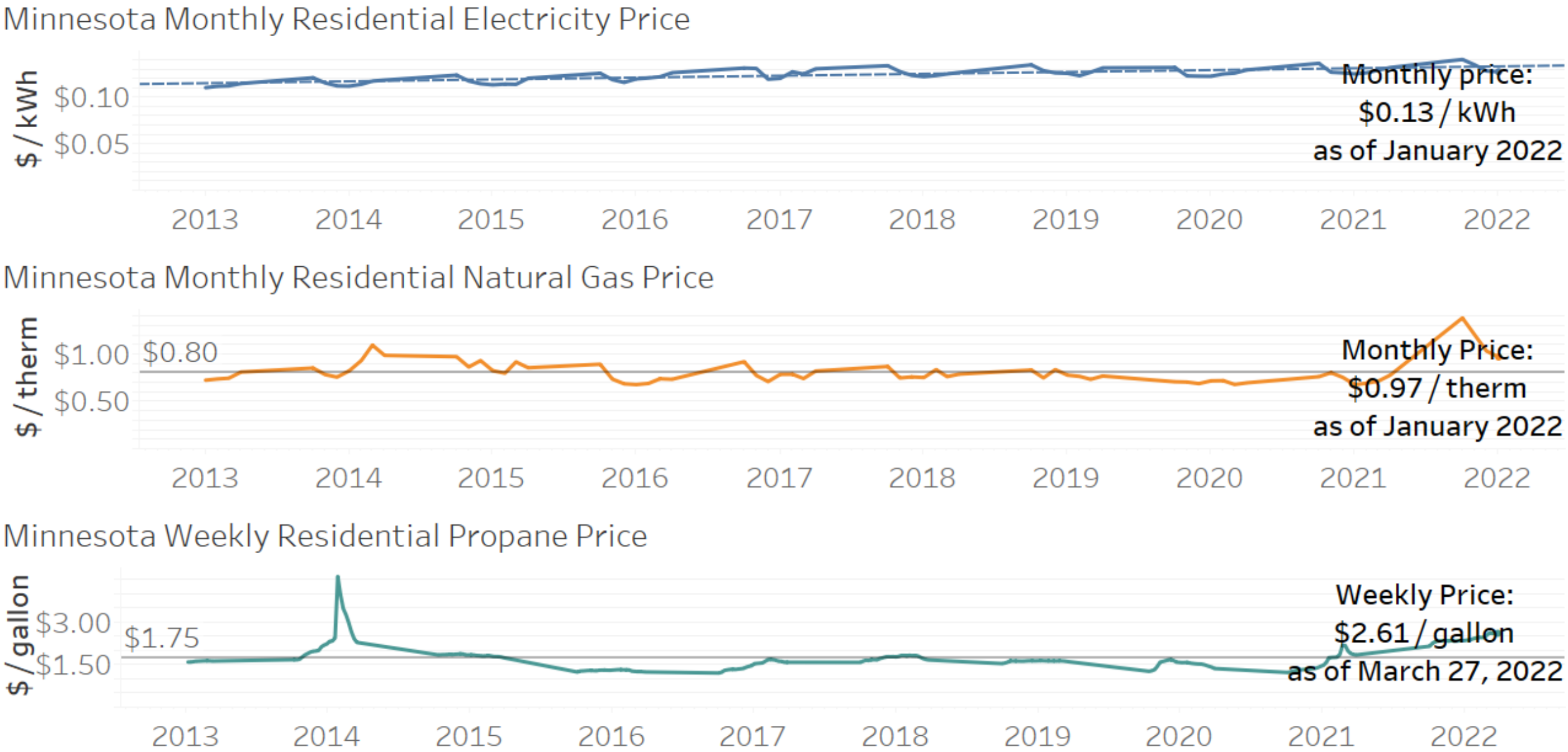
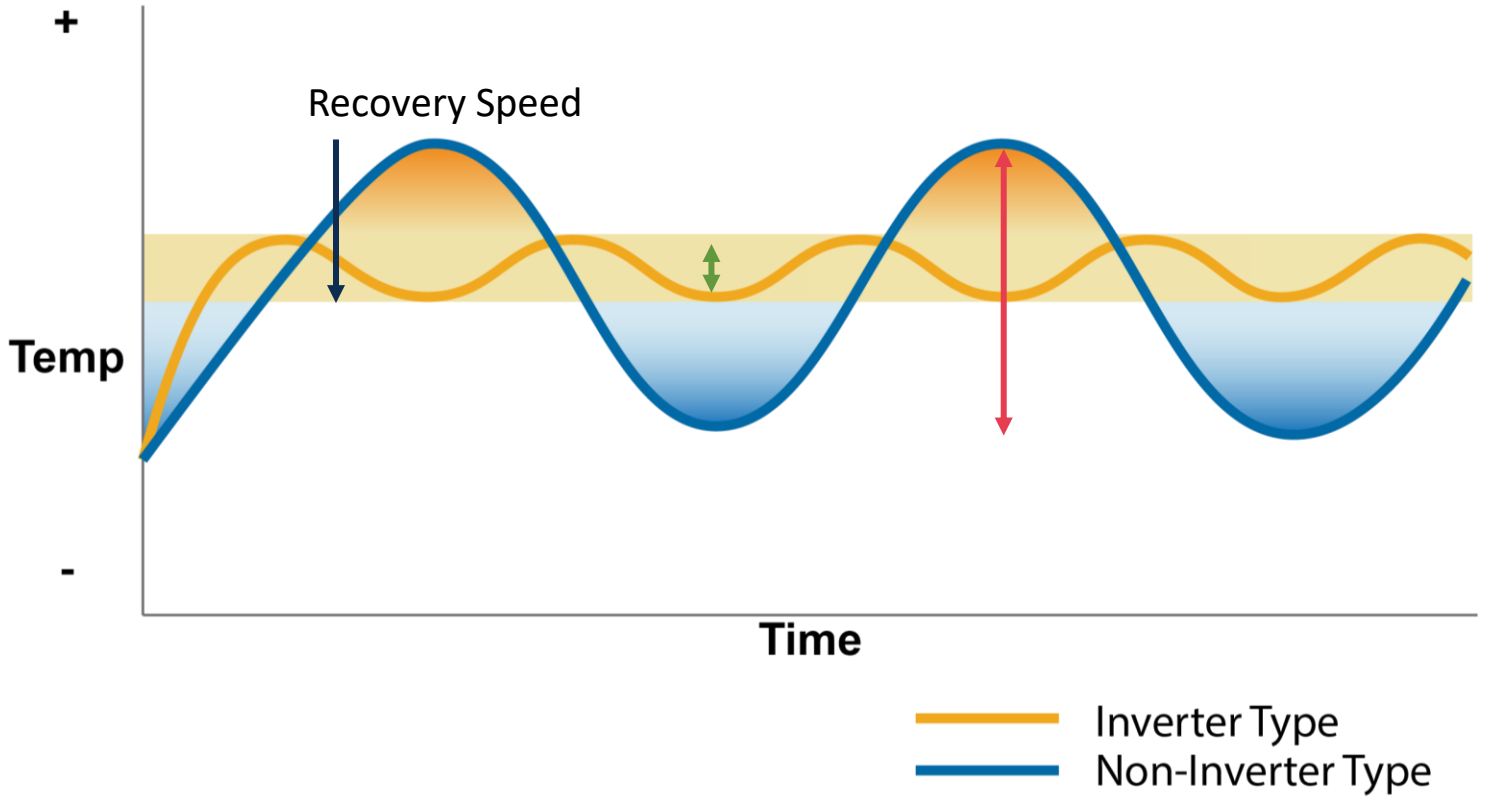
ASHPs Offer Resiliency Against Price Volatility



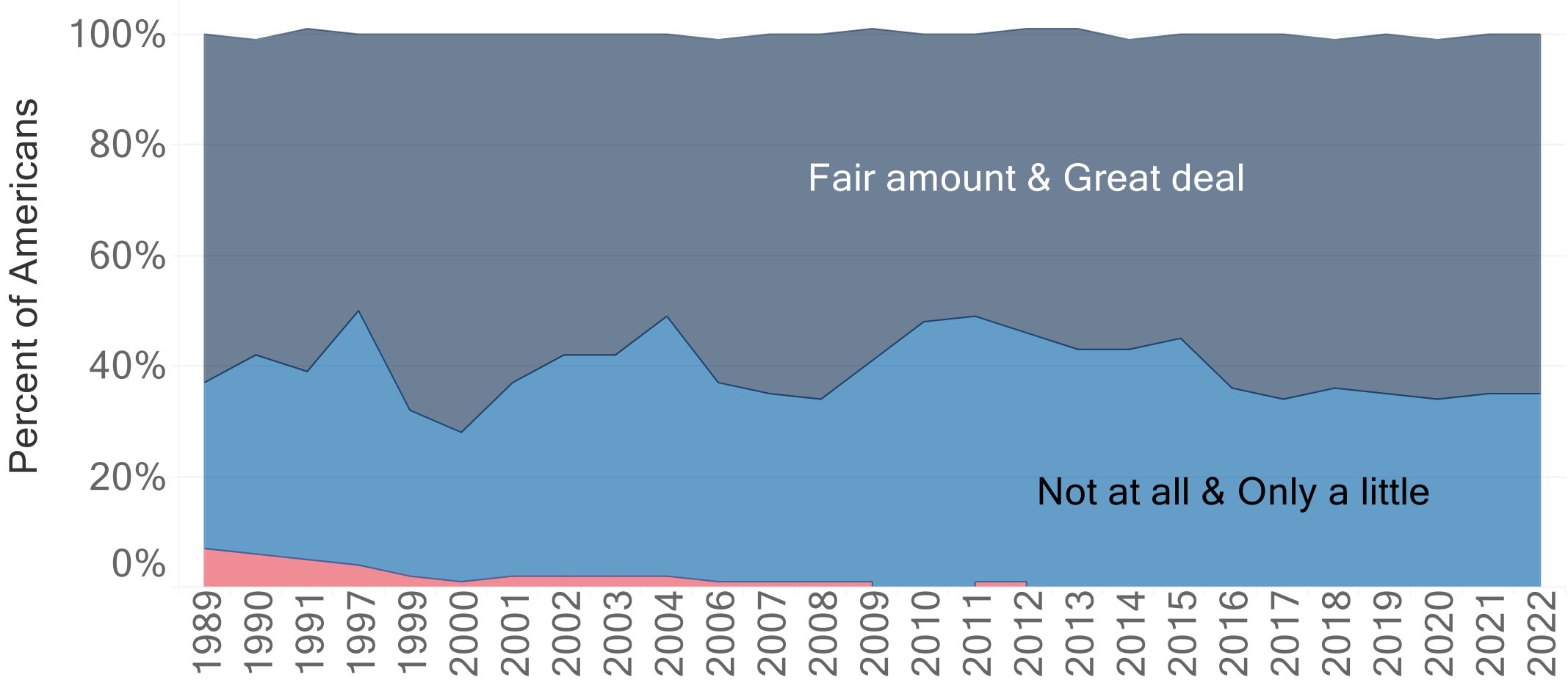
Source: Energy Information Administration (US EIA). All charts exclude April-Sept. months.

How Modulation Helps - Control



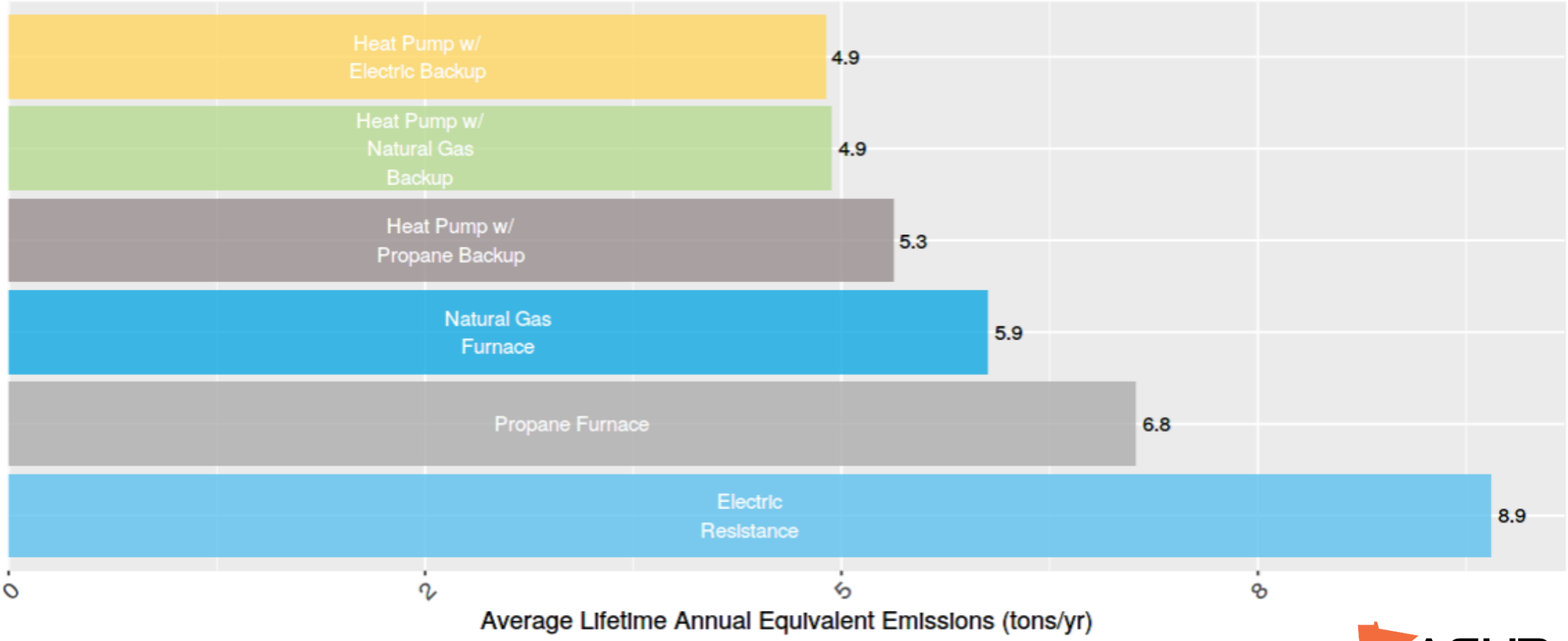
- More control
- Less waste
- Improved comfort

How much do you personally worry about global warming or climate change?



https://news.gallup.com/poll/1615/environment.aspx

All-electric and dual fuel heat pumps will have lower emissions over their lifetime



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Source: https://www.mncee.org/cold-climate-heat-pumps-cost-and-carbon-calculator

The market believes this segment will grow in the future

Customer awareness is moderate; awareness building is needed

An educational sales process is needed

Early adopters are out there and want this solution: never miss the chance to offer it

Upfront cost is critical to customers, leverage rebates, financing

Operational cost matters and customers are willing to pay more upfront for savings

Not all customers want to replace their heating and cooling at the same time: be prepared to offer solutions to these customers

Q&A

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Thank You

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