# Beneficial Electrification

## Advancing Technologies, Efficiency and Comfort for the future with Air Source Heat Pumps

Greg Nahn

February 2020

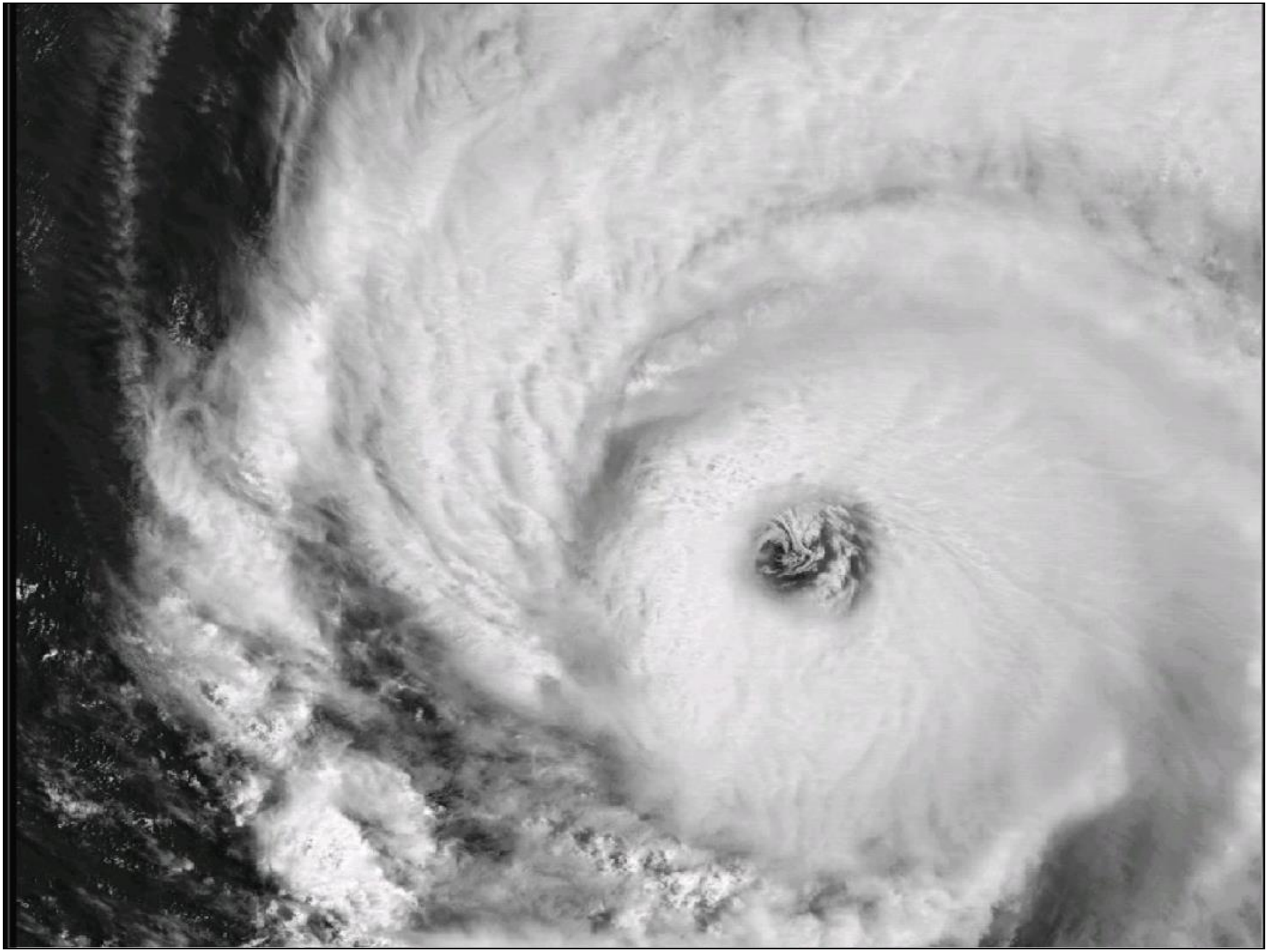
slipstream

**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 hour of credit toward Building Officials and Residential Contractors code /1 hour energy continuing education requirements**

**For additional continuing education approvals, please see your credit tracking card.**

# Headline Here




1928
2004

# We have to stop burning stuff

# Why Buildings Matter

120+ million buildings

66% of 2050 is already here

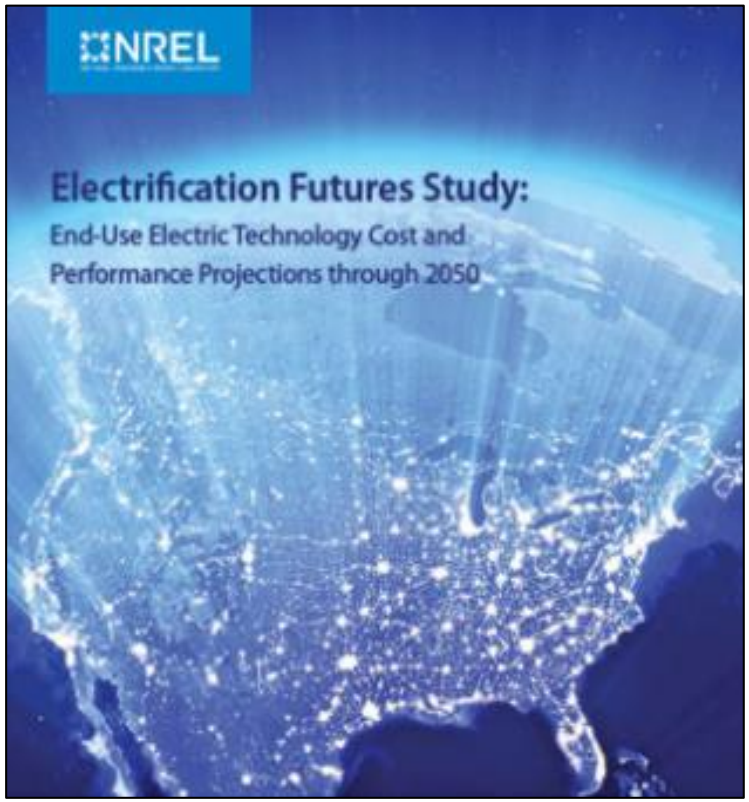
20+ % annual CO2

# What is behind the meter matters most

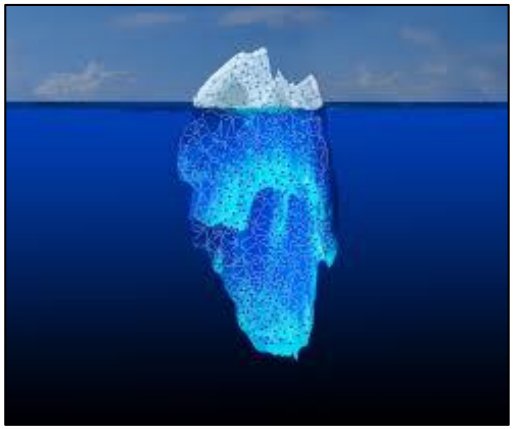
**“We can’t afford to ignore it or be wrong”**

# Advancing Technology

Increasing cleaner, better, safer, enables optimization



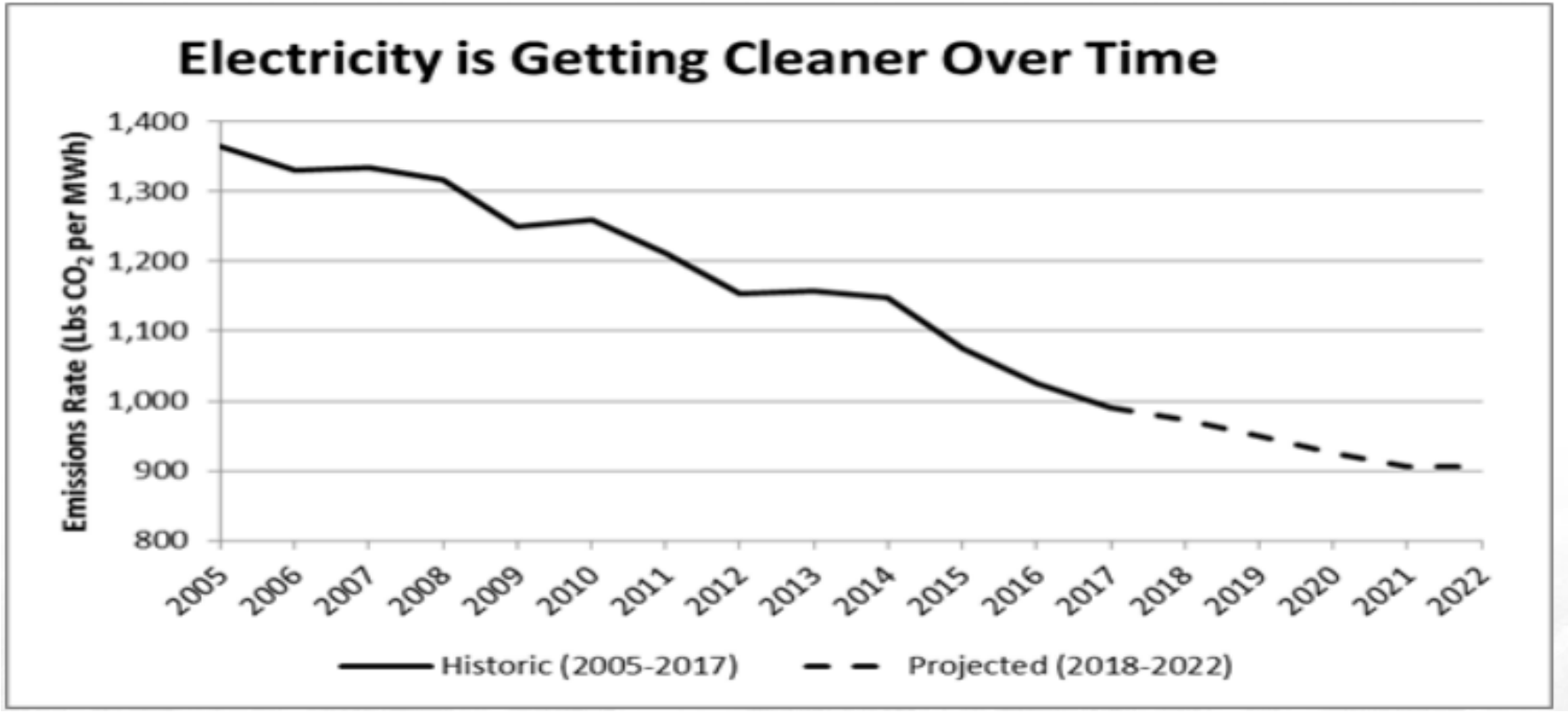




Pathway to Decarbonization

# Advantages of Advanced Electric Heat

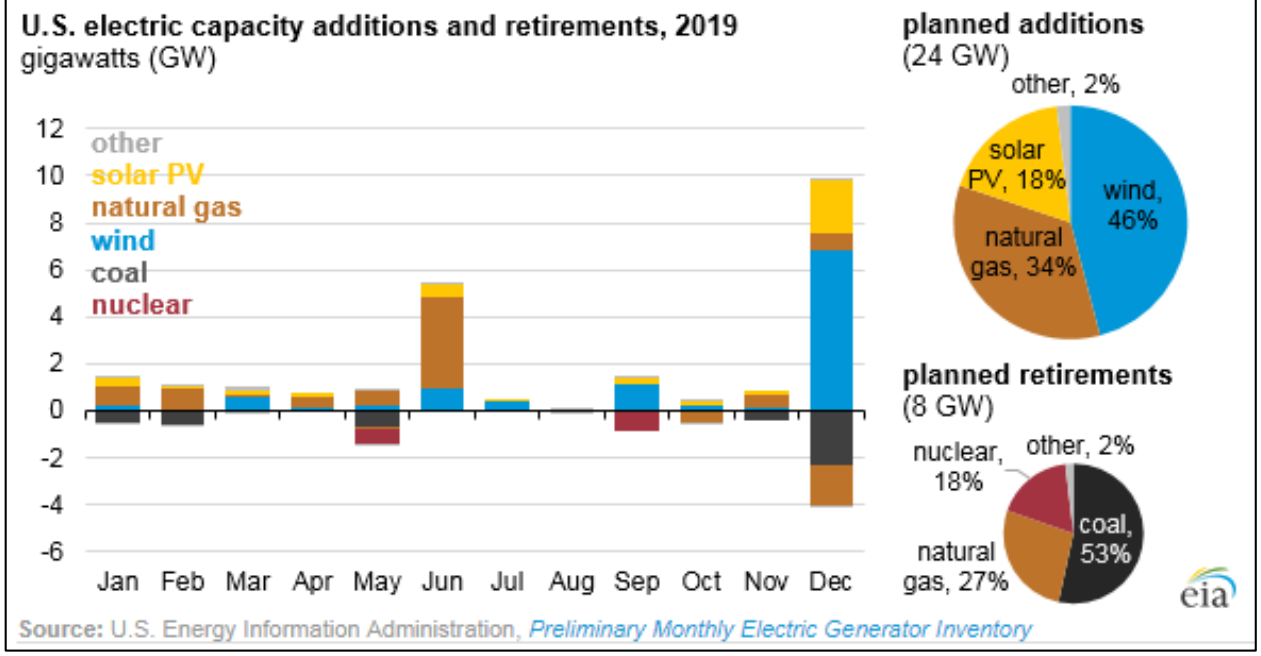
Capitalizes on cleaner electricity:




Credit: Beneficial Electrification League

JANUARY 10, 2019

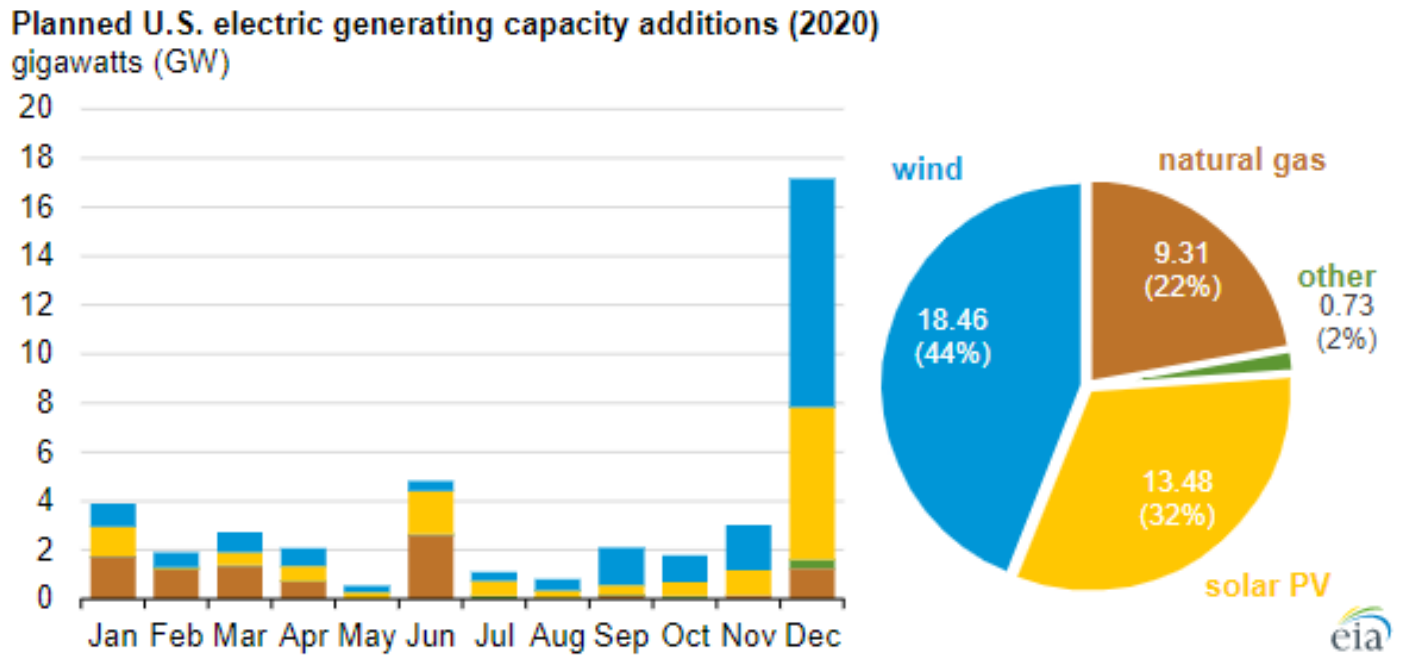
# New electric generating capacity in 2019 will come fro renewables and natural gas




Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

JANUARY 14, 2020

# New electric generating capacity in 2020 will come primarily from wind and solar




Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*

Wind and solar (32 GW)

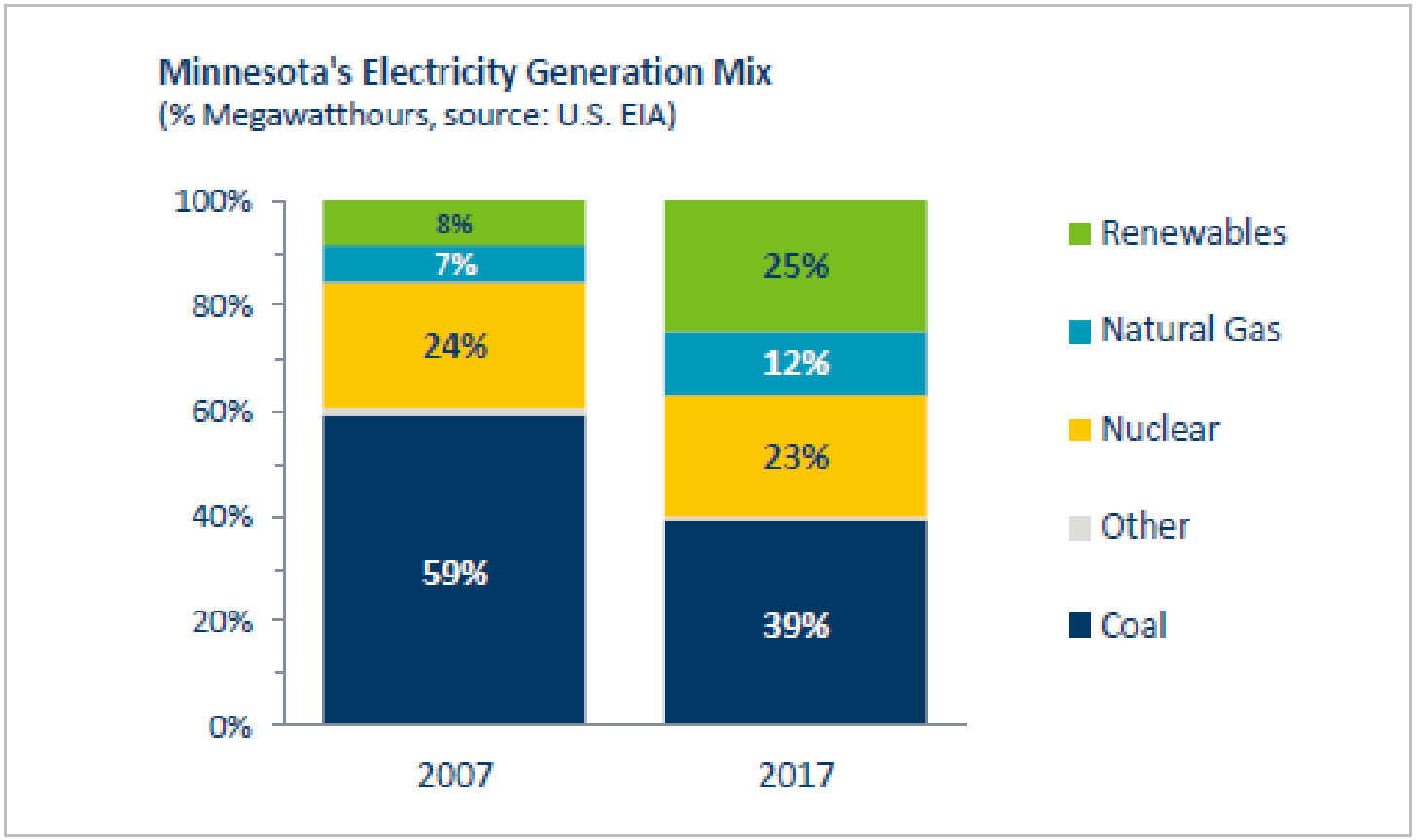
# Minnesota

More breezy than sunny

# Increasingly Cleaner

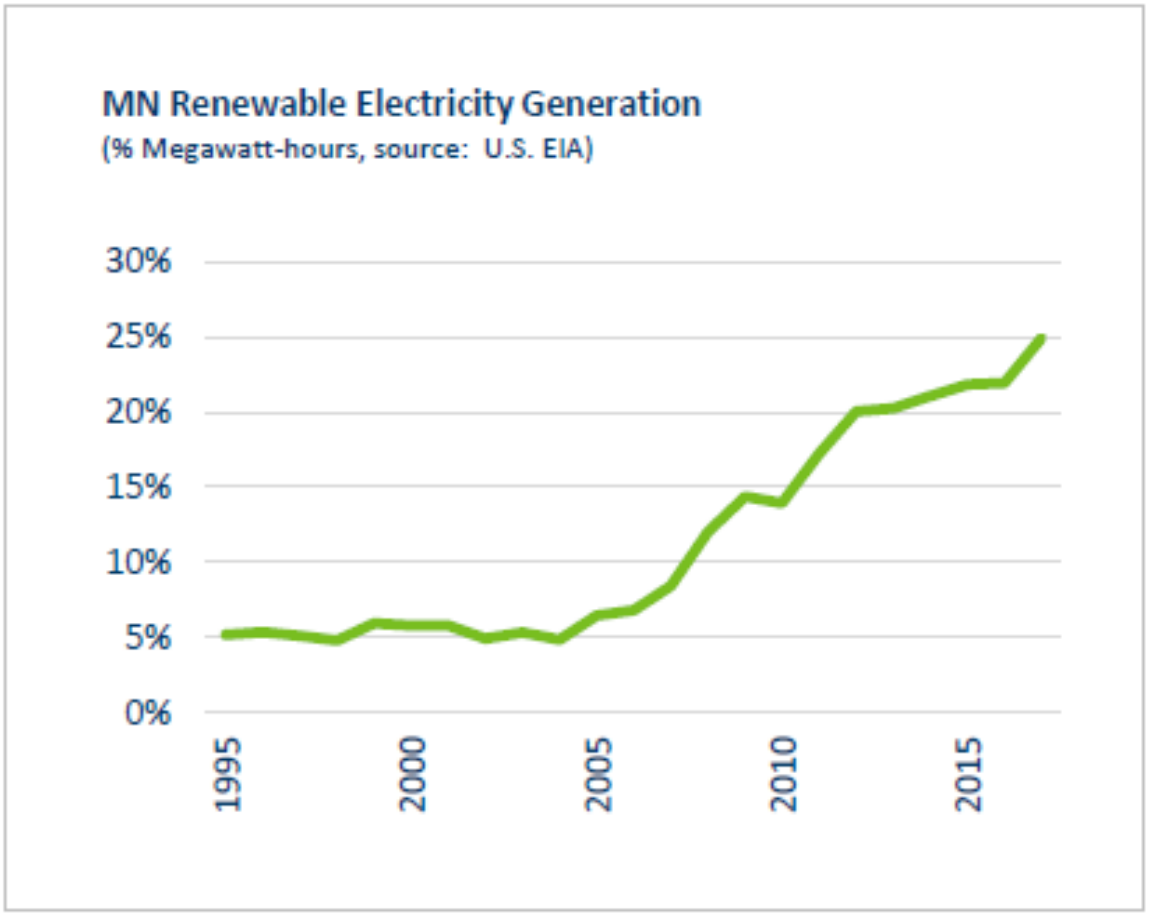
## MN trend in electric generation mix

**Renewables Have Increased Significantly While Coal Has Declined**



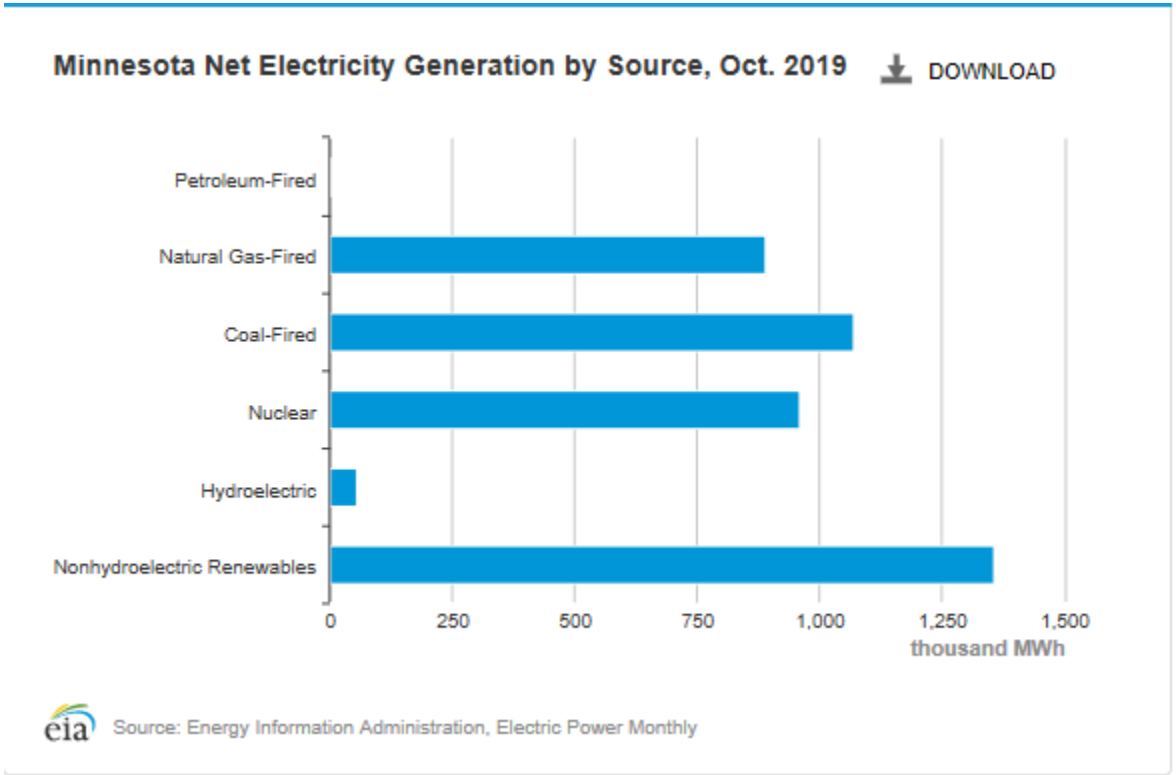
# Generation by Renewables

Minnesota's Renewable Electricity Generation Has Increased Dramatically



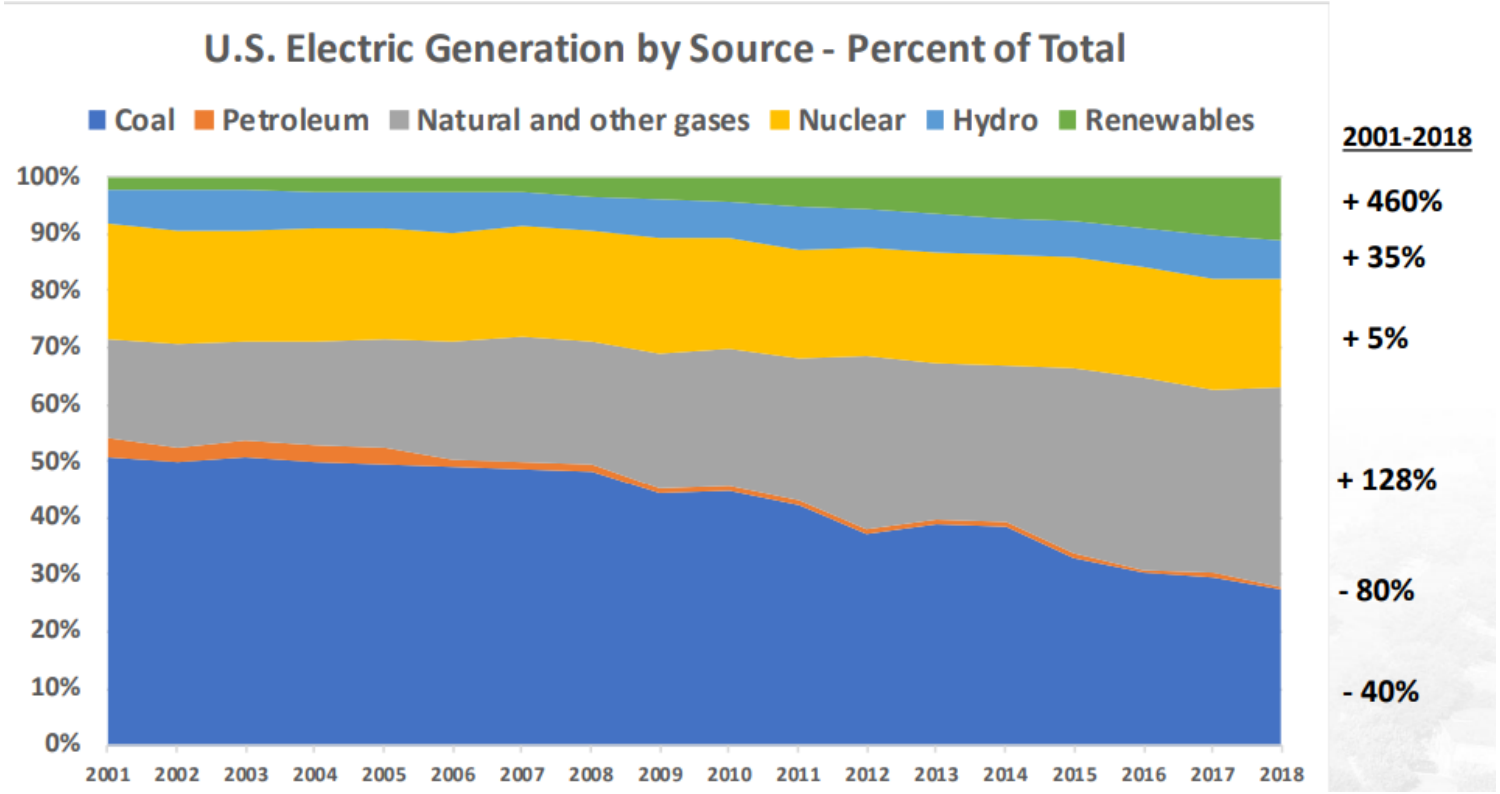
# Generation by Resource

## MN “Snap shot”



# Cleaning the Grid

A process to continue…..



# Momentum is Building

2030

SOLAR

## Alliant Energy Joins Midwestern Utility Peers With a Big Solar Plan

The utility-scale solar market is gathering pace in the industrial Midwest as costs drop and the ITC runs out of road.

EMMA FOEHRINGER MERCHANT | NOVEMBER 04, 2019

2040

ANOTHER VIEW | RACINE JOURNAL TIMES

## We Energies makes turn to 'green energy'

Aug 2, 2018

2050

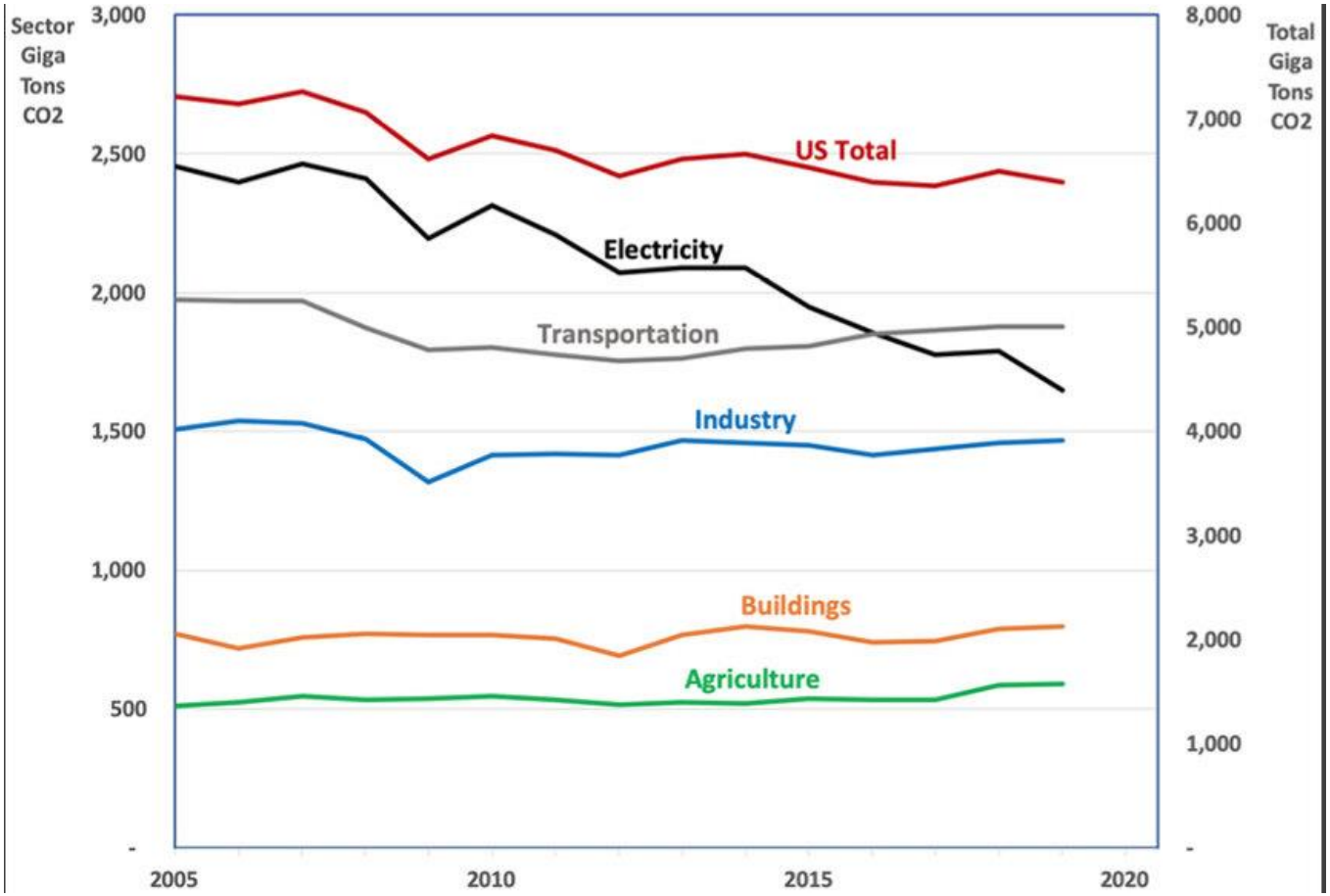
UTILITIES

## Xcel Energy Commits to 100% Carbon-Free Electricity by 2050

The utility's ambitious plan could pre-empt a messy policy battle over renewable energy mandates.

JULIA PYPER | DECEMBER 04, 2018

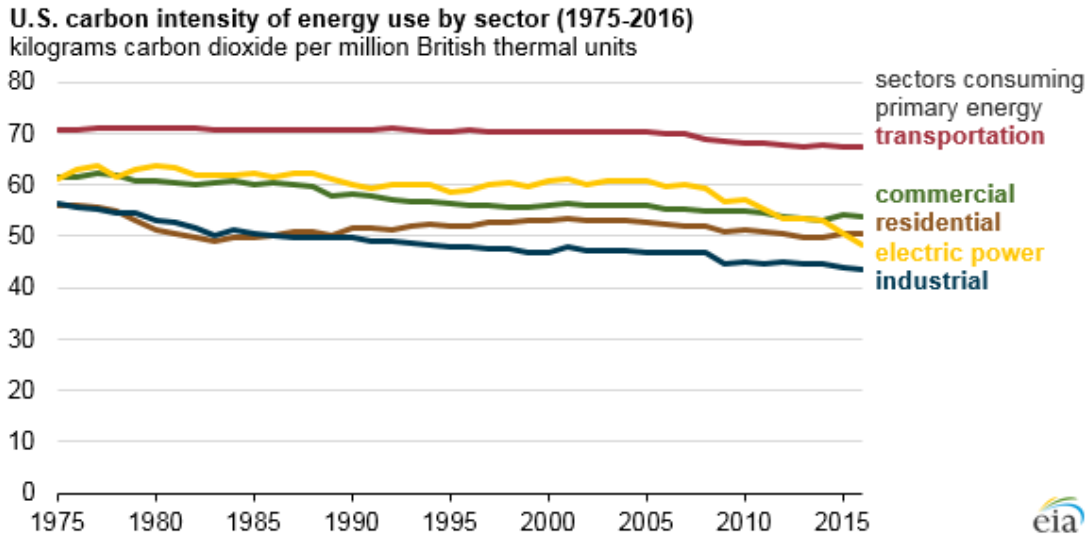
# CO2 Emission by Industry



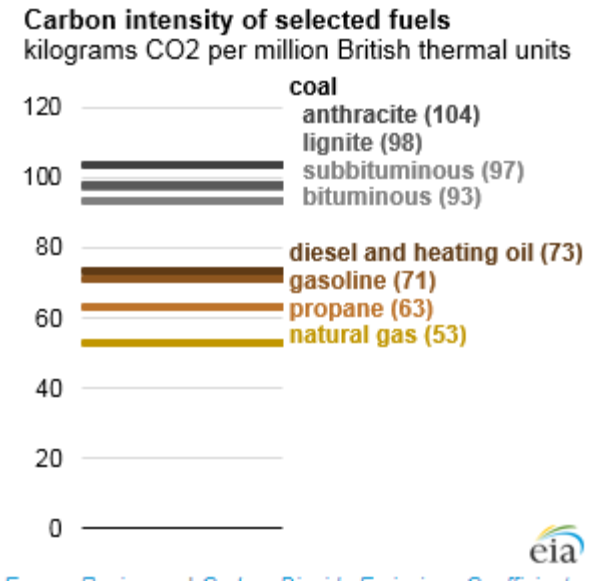
# Carbon Intensity

MAY 1, 2017

## Carbon intensity of energy use is lowest in U.S. industrial and electric power sectors




Source: U.S. Energy Information Administration, *Monthly Energy Review*

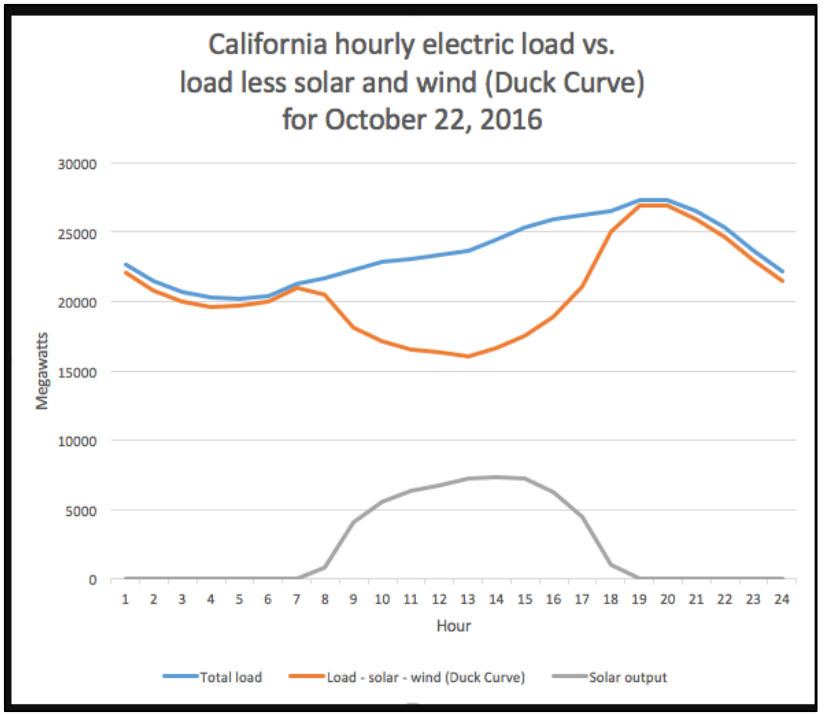


# Advancing Technology:
## Advanced Electric Heat

Allow better grid management

- Flatten “the duck”

Enables large scale integration and utilization




Responsive Supply and Demand

# Advantages of Advancing Technology

Integral to grid interactive and responsive homes

- Load shifting – pre heat or pre charge
- Storage (batteries or **EVs**)
- Rate structure optimization

# Advanced Technologies

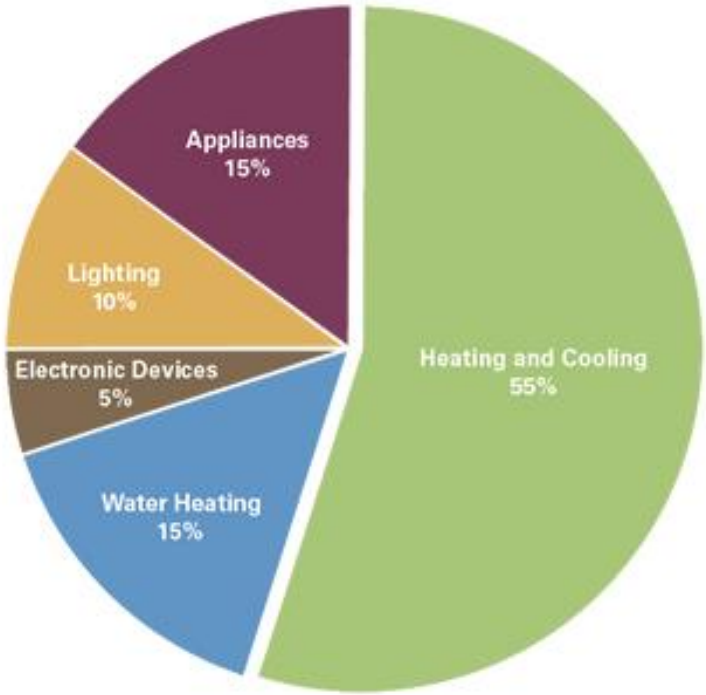
Electrifies end uses that:

- Saves $
- Enables better grid management
- Reduces environmental impact

# Beneficial Electrification

Advancing “targeted” technologies

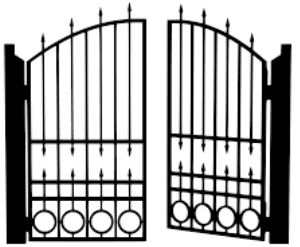
- ASHP (space / water heating)
- Induction cooking
- EV charging stations
- “Connected” devices and/or controls



# Beneficial Electrification

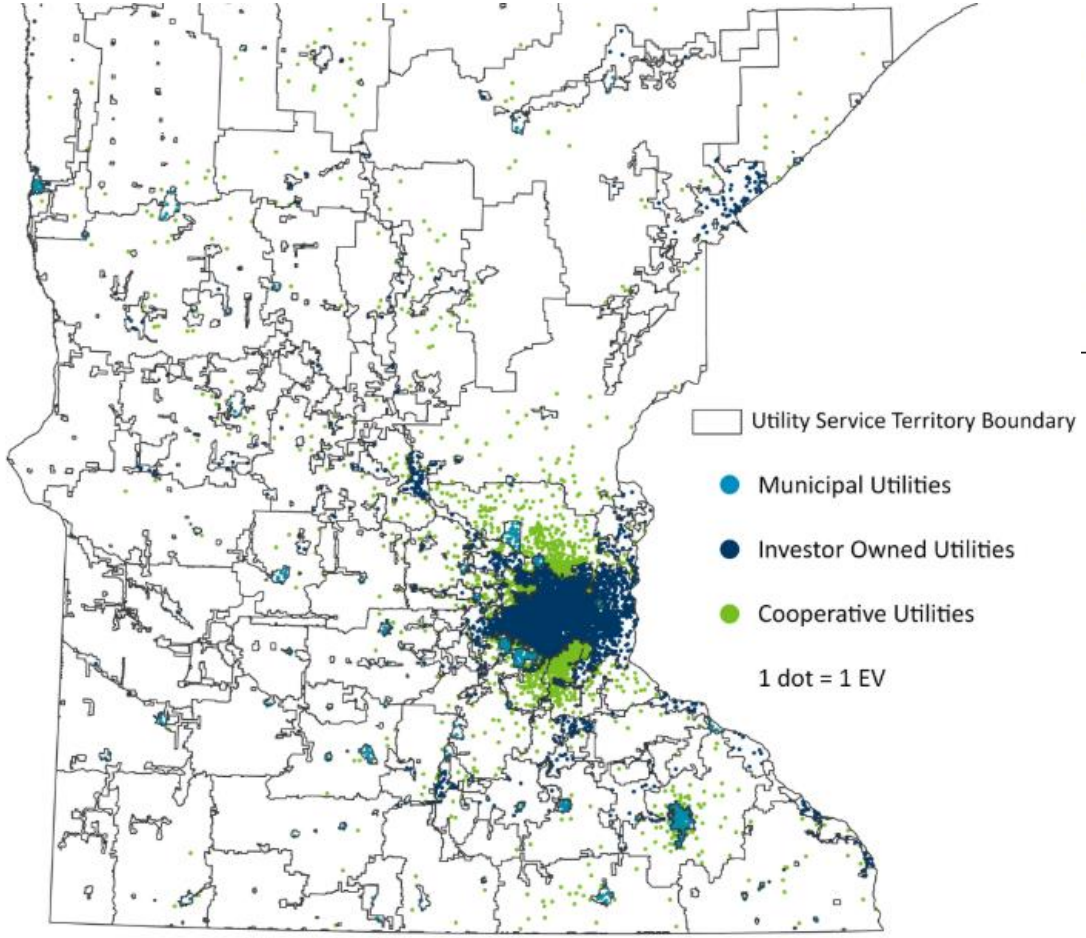
Advancing technologies





# Beneficial Electrification

## Advancing technologies




# Beneficial Electrification

Advancing technologies that can displace the use of fossil fuels

MINNEAPOLIS

## Electric scooters will be available in Minneapolis parks under new agreement

Companies previously weren't allowed to leave vehicles on park property.

By Miguel Otárola Star Tribune | JULY 11, 2019 — 11:02PM


# Advancing Technologies

No gas = No lines = No leaks

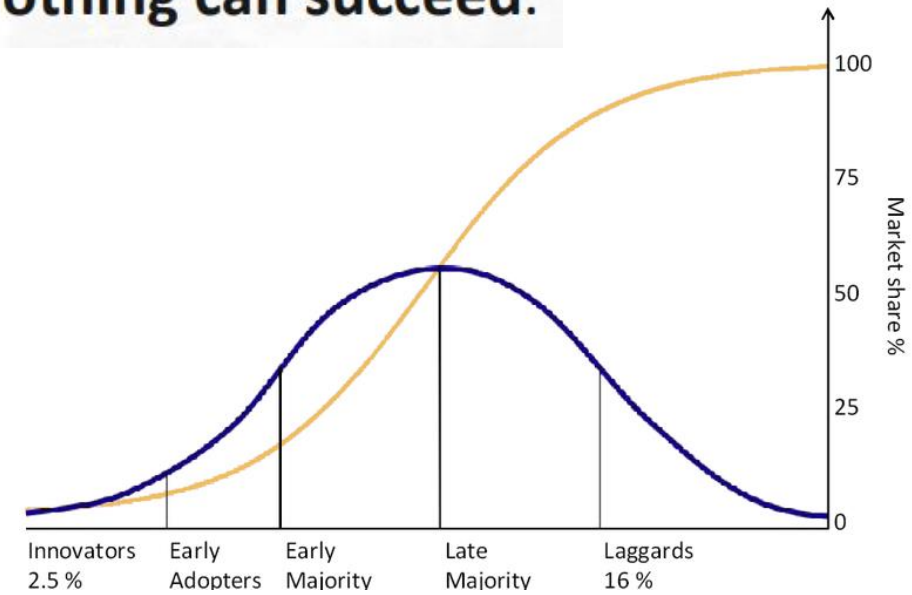
Avoids (infrastructure/installation) costs

# Advancing Technologies

No combustion = No Carbon Monoxide

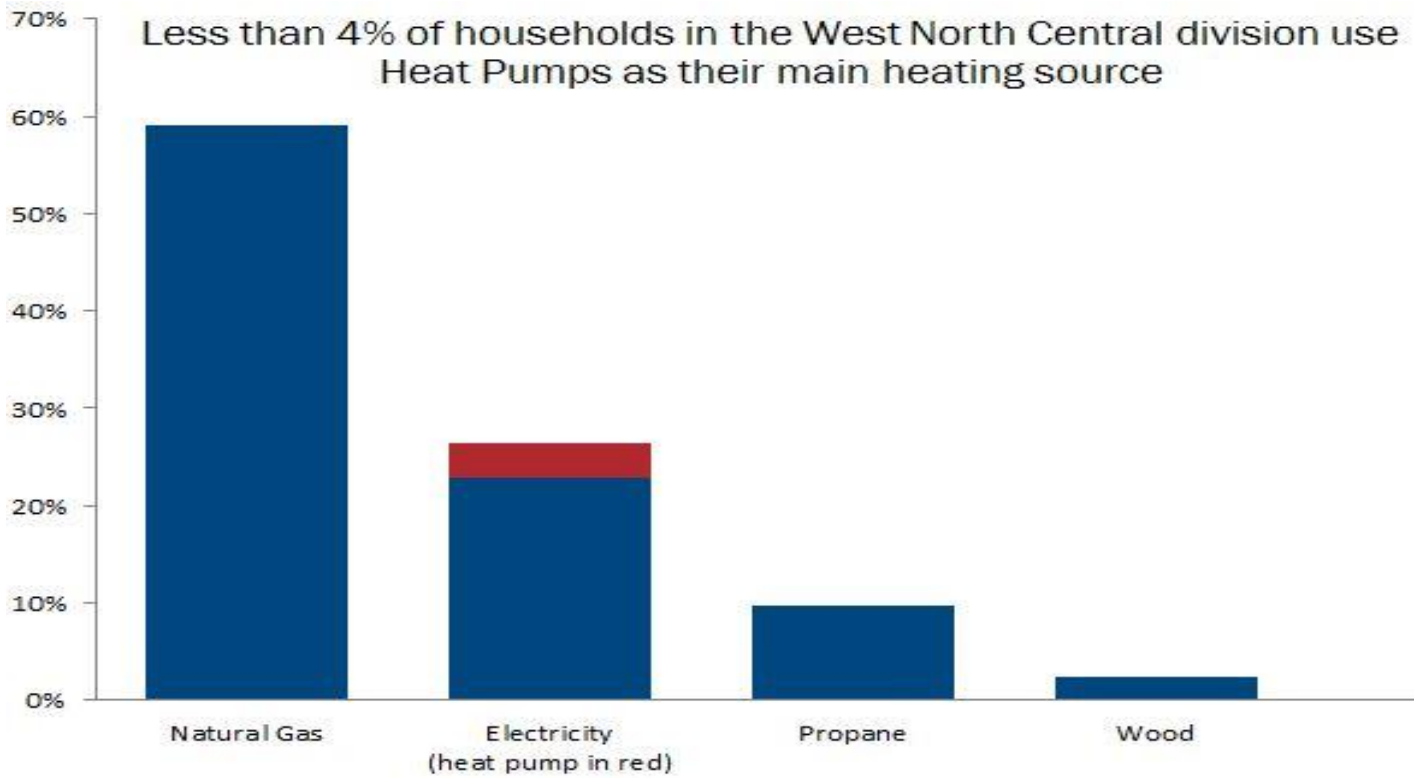

# Making the Case for Air Source Heat pumps

"In this age, in this country, public sentiment is everything. With it, nothing can fail; against it, nothing can succeed.




Credit: Beneficial Electrification League

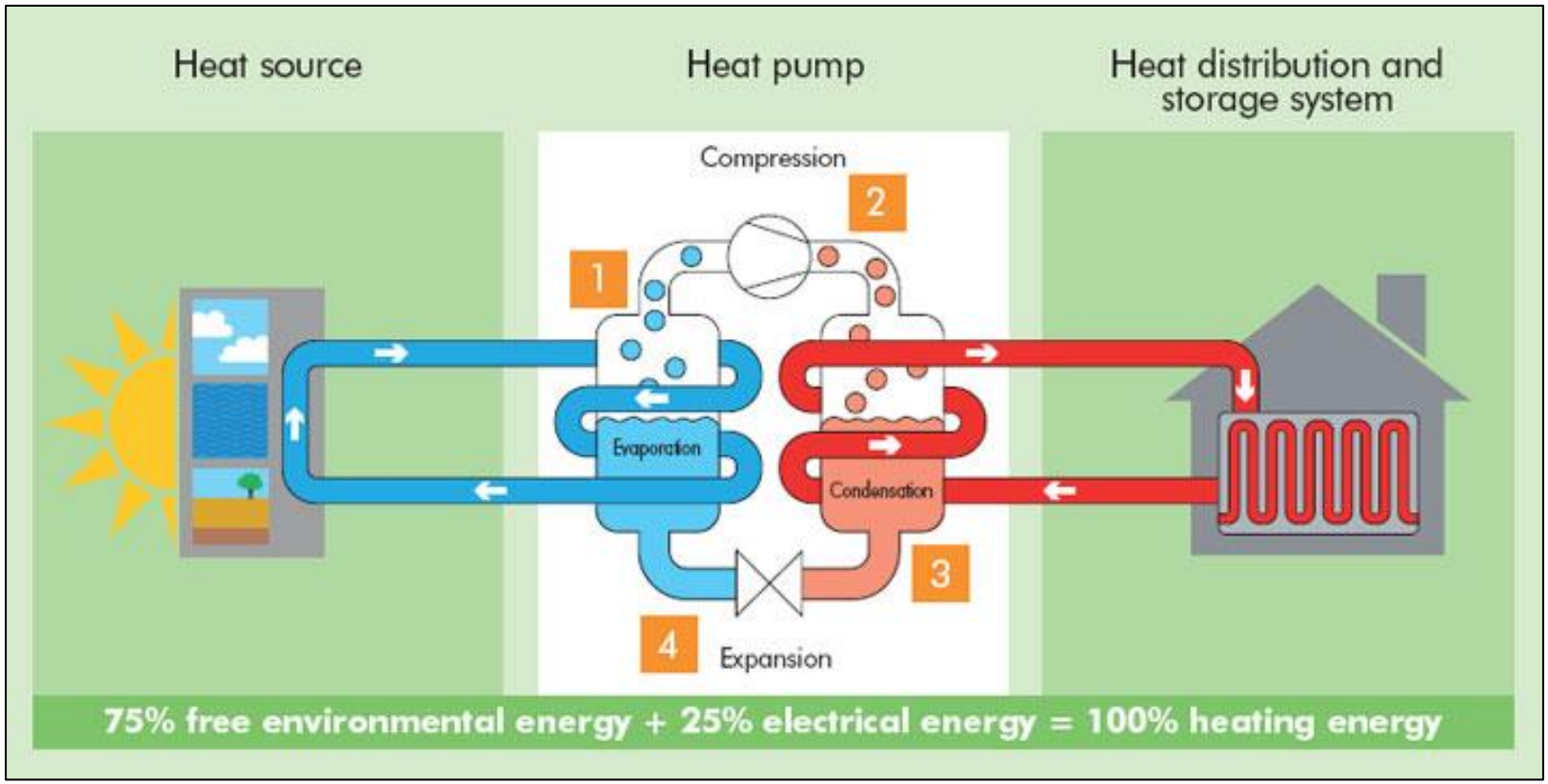
# Breakdown of Heating Types




The West North Central Division includes the states of North Dakota, Minnesota, South Dakota, Nebraska, Iowa, Kansas, and Missouri.

# Heat Pump: Physics

Less energy is required to move heat than to create it



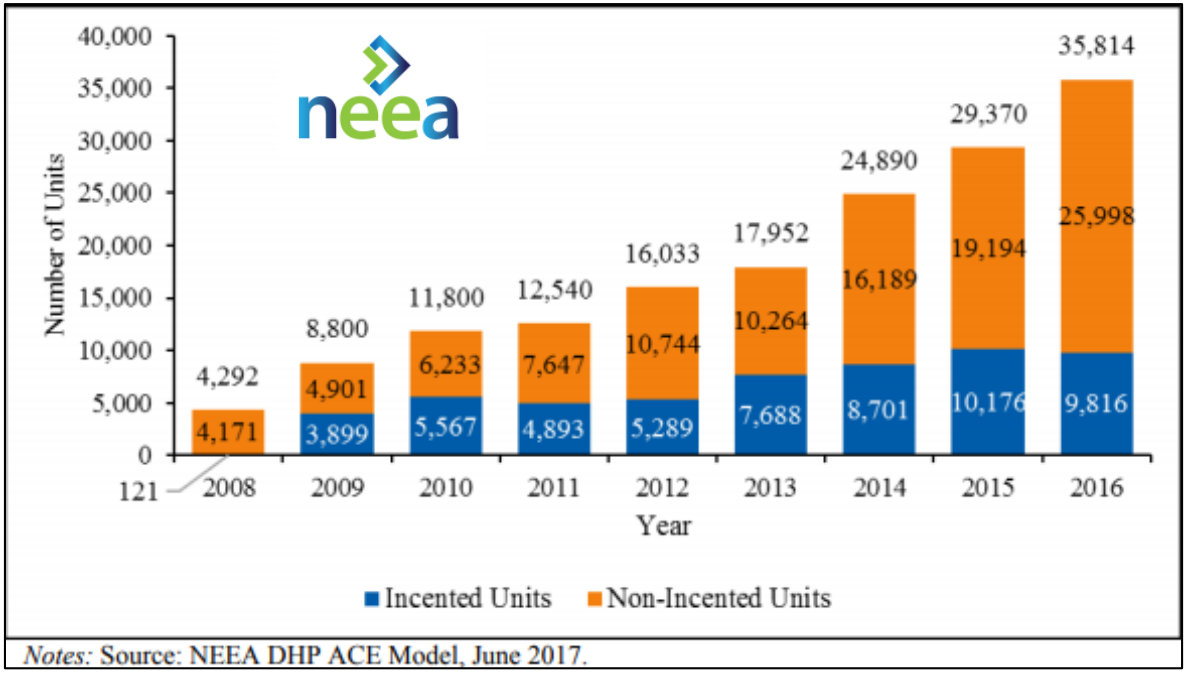

“Refrigerant based heating”

# Heat Pumps

Here to Pump You Up!

# ASHP Objectives

- Recognize increased trends in ASHP installations
- Discuss improvements in ASHP technology
- Identify opportunities to promote ASHPs
- Review types and application tips for ASHP




*Notes:* Source: NEEA DHP ACE Model, June 2017.

# ASHP:  Where it all Started

- Asia / Europe

Ductless ASHP

Mini-Duct ASHP

Centrally ducted ASHP

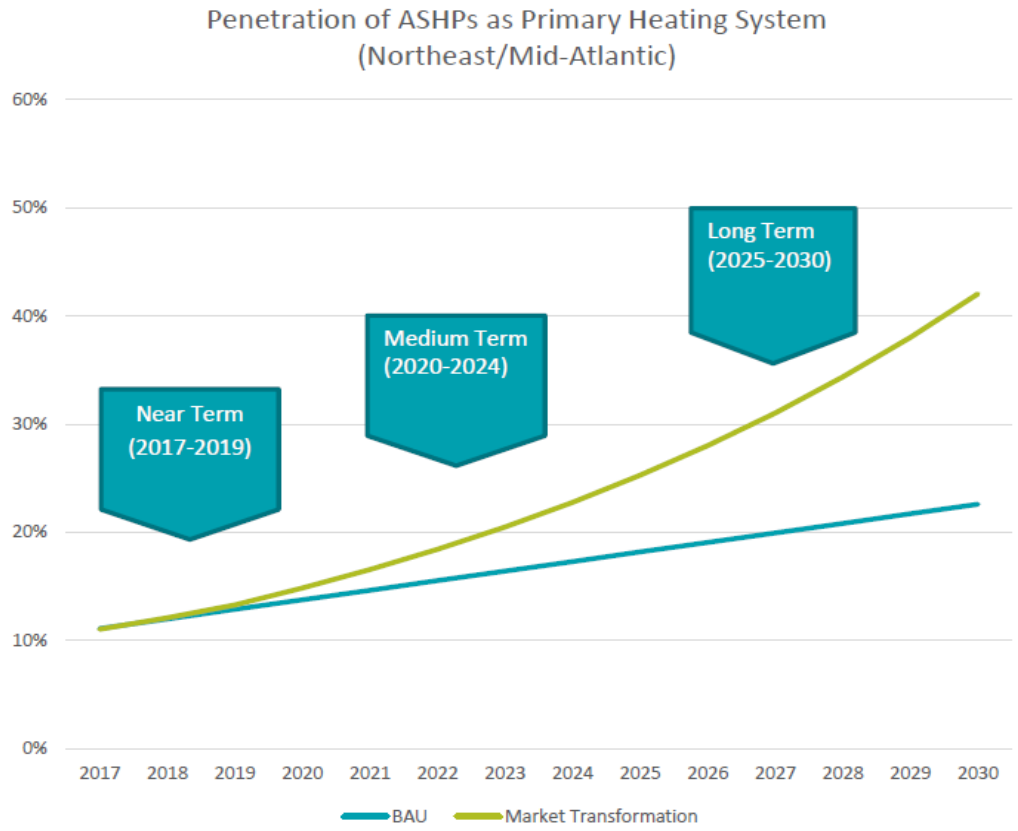
# Trends and Initiatives

Northeast / NEEP

- Targets oil / propane

| | Total 2015 ASHP Sales | 2015 Ductless ASHP Sales | Percent of Total 2015 ASHP Sales (Ductless) | 2015 Ducted ASHP Sales | Percent of Total 2015 ASHP Sales (Ducted) |
|---|---|---|---|---|---|
| **Northeast Region[3]** | 70,144 | 55,905 | 79.7% | 14,239 | 20.3% |
| **Mid-Atlantic Region[4]** | 238,698 | 95,718 | 40.1% | 142,980 | 59.9% |
| **Combined Region** | **308,842** | **151,623** | **49.1%** | **157,219** | **50.9%** |

# ASHP: Projected Trends



# ASHP: Projected Goals

## AIR SOURCE HEAT PUMP

### LONG-TERM MARKET TRANSFORMATION GOALS

*By 2030:*

**40%**

of Northeast homes use high performance ASHPs for heating.

**50%**

of Northeast homes are "energy smart" with at least two "energy smart" systems (HVAC, water heating, plug loads)

**80%**

of Northeast homes with high performance ASHPs are retrofitted to improve thermal efficiency performance.

### INTEGRATED ADVANCED EFFICIENCY SOLUTIONS

- Advanced Power Strips
- Advanced Rooftop Units
- Air Source Heat Pumps
  - Cold Climate Air Source Heat Pump
  - Air-Source Heat Pump Installer Resources
  - Initiative Subscription
- Appliance Efficiency Standards
- Heat Pump Water Heaters

# ASHP: Canada

An Examination of the Opportunity for Residential Heat Pumps in Ontario

Prepared for: Ministry of Energy
Prepared by: IESO

March 6, 2017

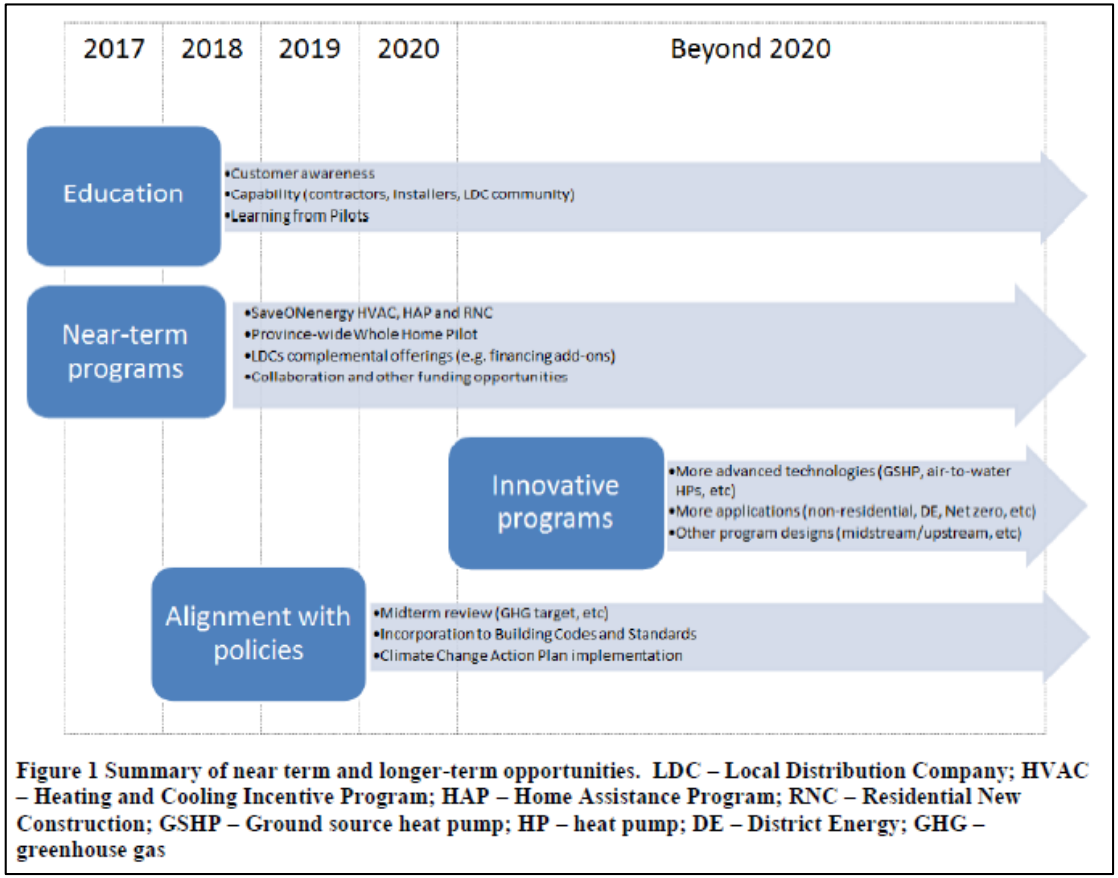
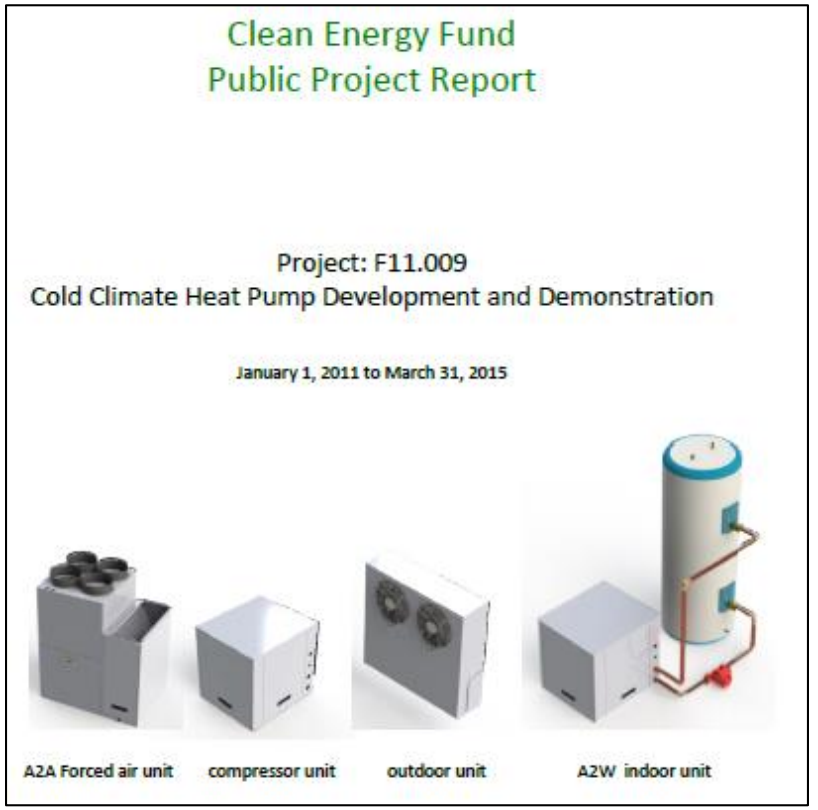



**Figure 1 Summary of near term and longer-term opportunities. LDC – Local Distribution Company; HVAC – Heating and Cooling Incentive Program; HAP – Home Assistance Program; RNC – Residential New Construction; GSHP – Ground source heat pump; HP – heat pump; DE – District Energy; GHG – greenhouse gas**

# Momentum is Building: Canada

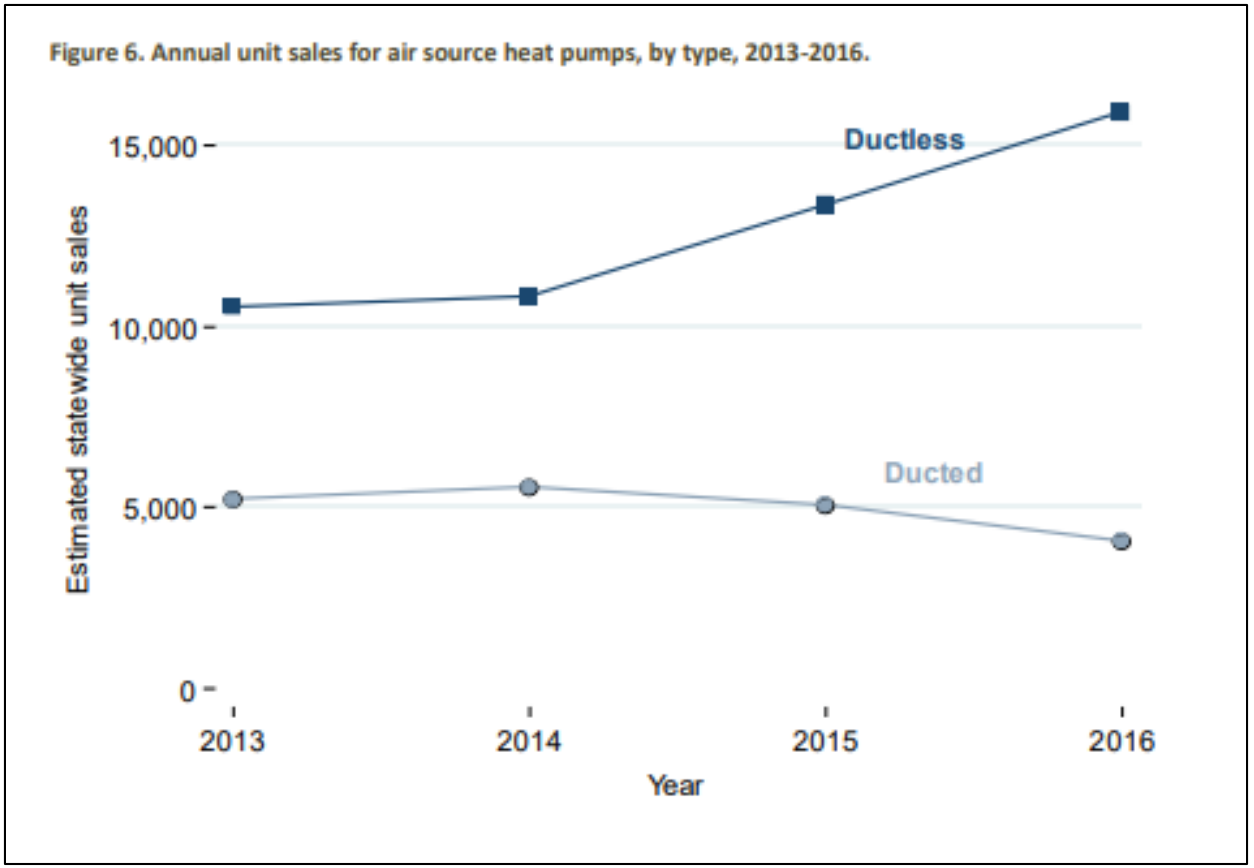
Clean Energy Fund

- De-super
- Multi-family and Air to $H_20$
- Wireless communicating
- Solar assist



# Minnesota

Installation trends for ASHP



# ASHP

NEEP qualifying products list

- Updated web interface

Capacity

- AHRI tested at 47, 17º F
- NEEP listed at 5º F
- Proposal to test at 5º F

AHRI CERTIFIED®
www.ahridirectory.org

This combination qualifies for a Federal Energy Efficiency tax Credit when placed in service between Feb 17,2009 and Dec 31, 2016.

## Certificate of Product Ratings

AHRI Certified Reference Number : 8908615 Date : 01-26-2019 Model Status : Active

AHRI Type : HMSV-A-CB

Outdoor Unit Brand Name : FUJITSU

Outdoor Unit Model Number : AOU36RLXFZH

Indoor Type : Non-Ducted Indoor Units

Rated as follows in accordance with the latest edition of ANSI/AHRI 210/240 with Addenda 1 and 2, Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment and subject to rating accuracy by AHRI-sponsored, independent, third party testing:

Cooling Capacity (95F) : 35200

EER (95F) : 13.00

SEER : 20.00

High Heat (47F) : 36400

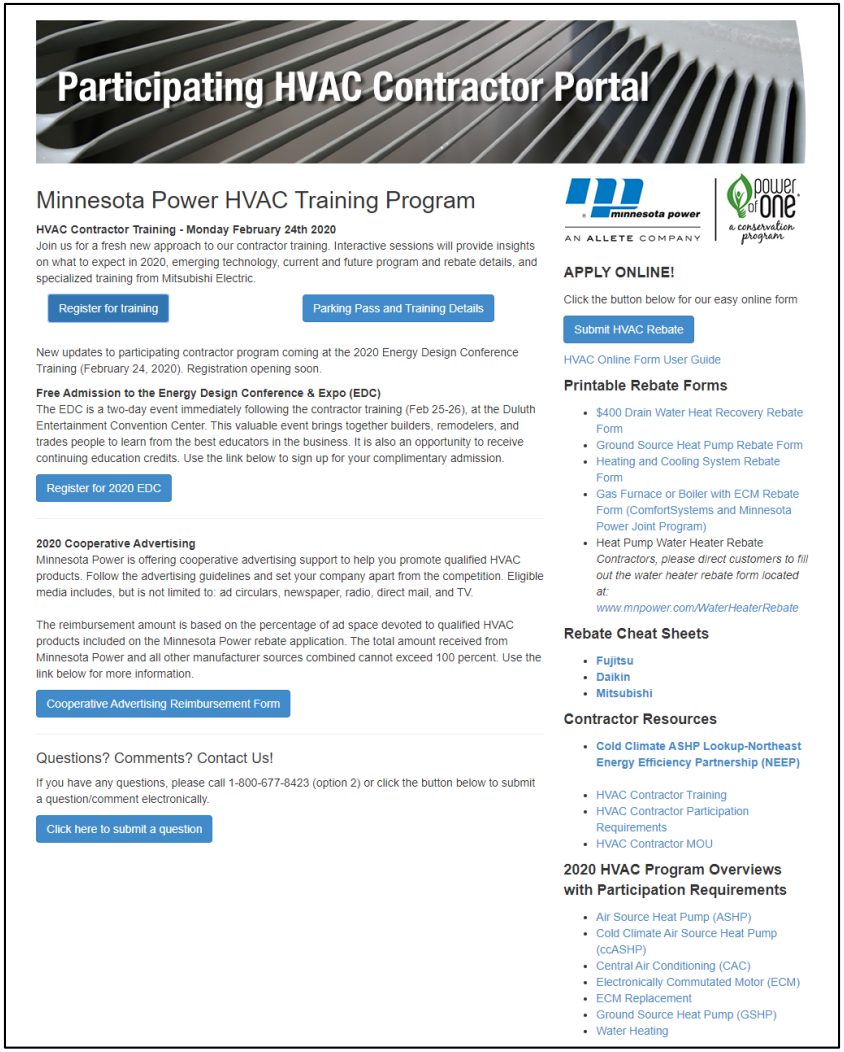
Low Heat (17F) : 21400

HSPF : 10.30

Sold in? : USA, Canada

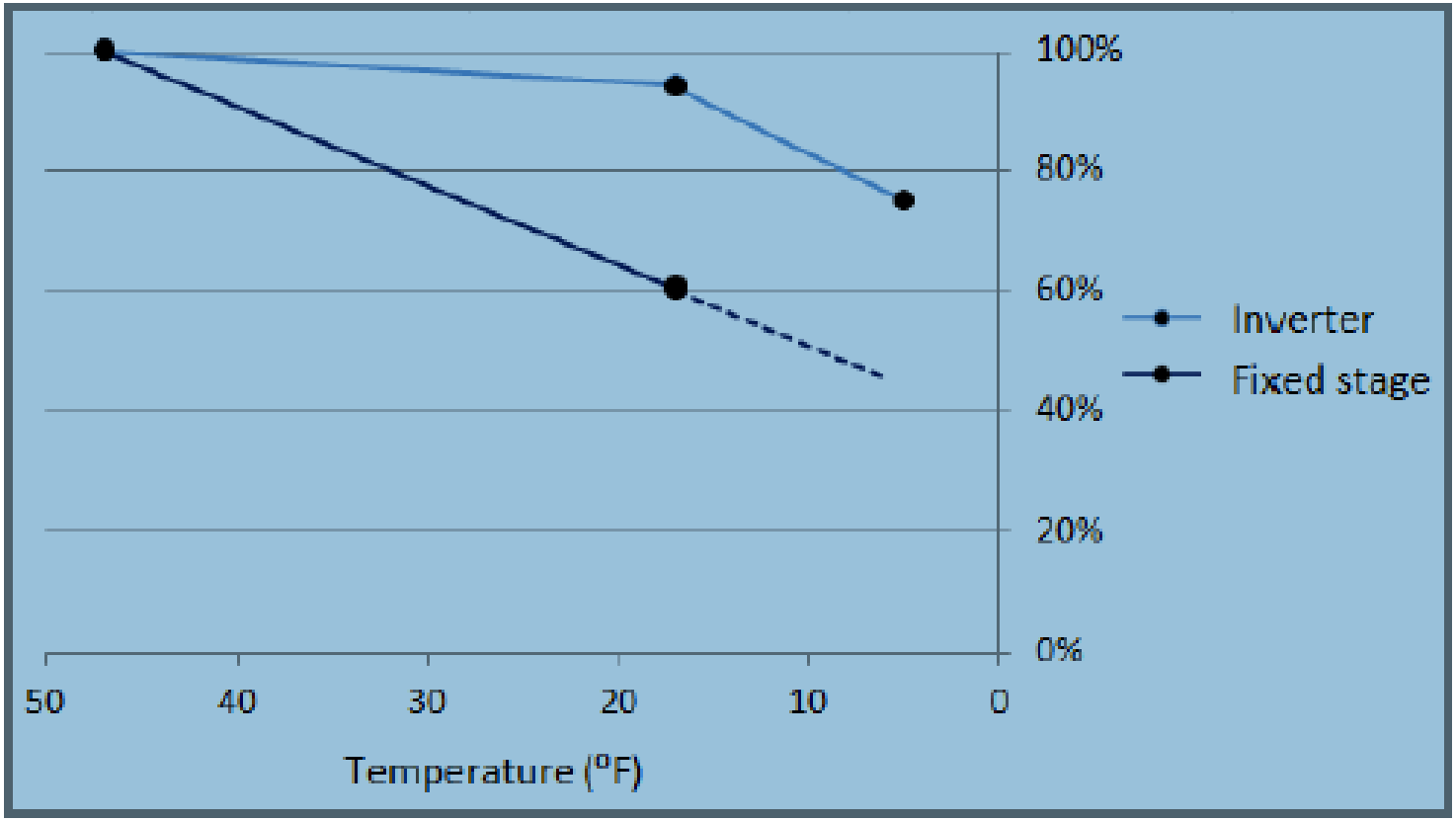
Heating Season Performance Factor (HSPF) Region IV

# ASHP Industry Resource



# ASHP: What we Know

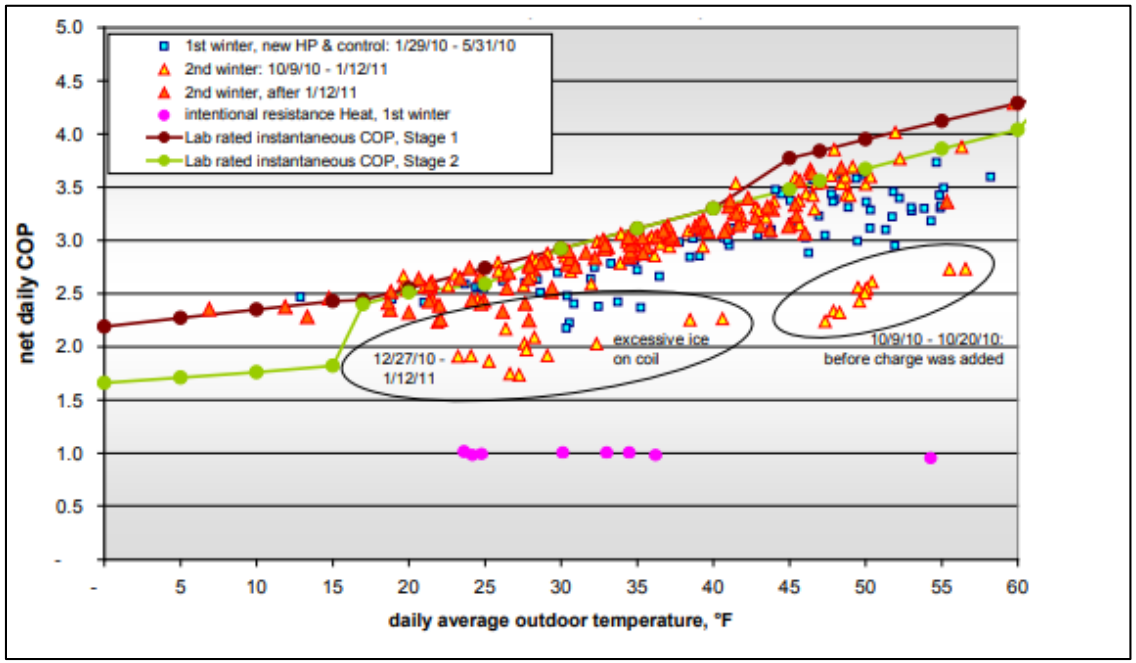
Capacity vs. temp: Range and rate of decline

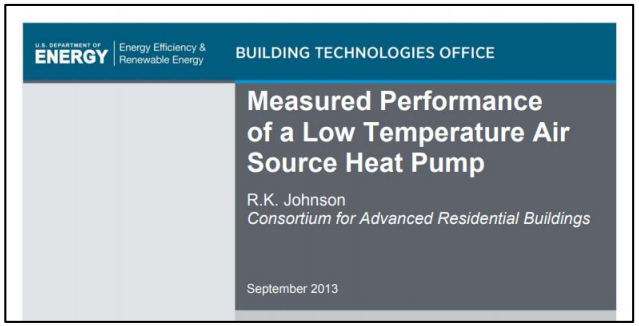


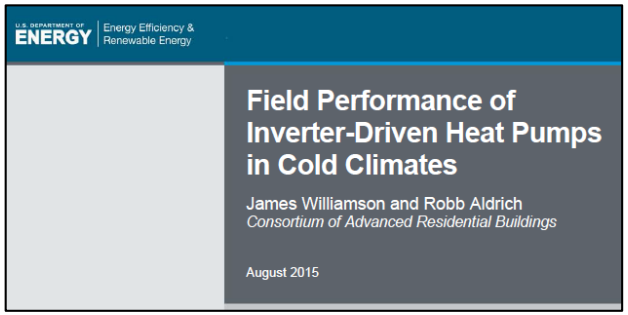
# ccASHP: What we Know

Inverter efficiency vs  temp:

- Coefficient of Performance > 1.75



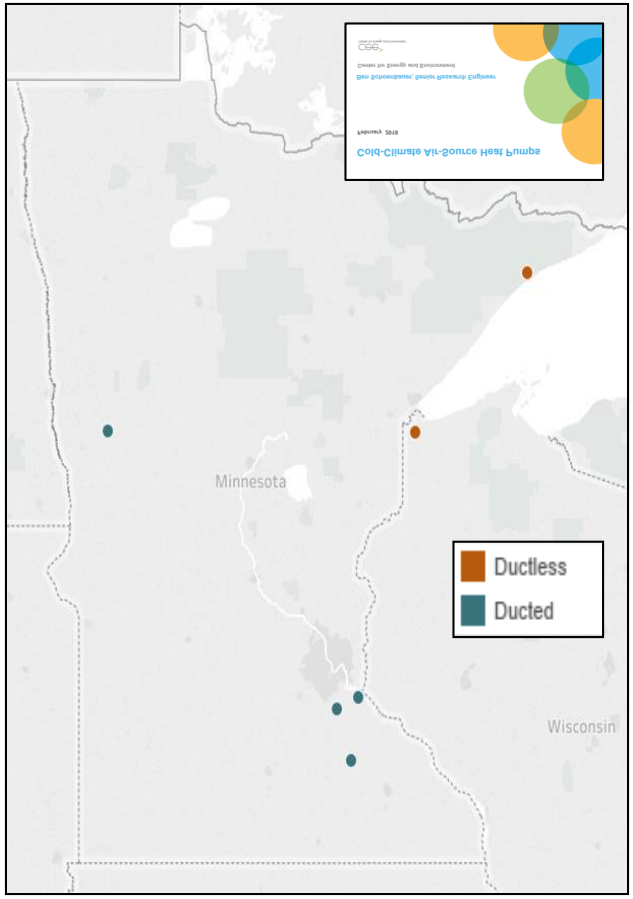



# ASHP: Past Research

MN CEE field study (8 cc ASHP)

- 6 ducted whole house system
  - 4 flex fuel
  - 2 all electric
- 2 ductless mini-split systems



# MN CEE Study - Findings

Site energy:

- 37% to 54%

Total heating costs

- 28% to 54%

Ducted ccASHP

= 84% of heating loads (on average)

## Annual Characteristics and Savings

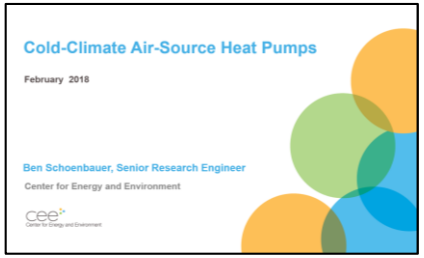
| Site | Heating balance Point [F] | Heating Design Load [Btu/hr] | Site Energy Reduction | Cost Reduction | Propane reduction | Savings [$/yr] |
|---|---|---|---|---|---|---|
| S_1_ducted | 62.6 | 35,468 | **37%** | 28% | 56% | **$469** |
| S_2_ducted | 60.9 | 30,046 | **46%** | 32% | 73% | **$497** |
| S_3_ducted | 66.1 | 24,923 | **49%** | 40% | 67% | **$767** |
| S_4_ducted | 64.5 | 22,778 | **40%** | 30% | 60% | **$358** |
| S_6_ductless | 70.1 | 14,200* | **52%** | 52% | NA | **$610** |
| S_8_ductless | 59.1 | 9,400* | **54%** | 54% | NA | **$349** |
| S_10_elec | 70 | 15,150 | **47%** | 47% | NA | **$496** |
| S_12_elec | 68 | 26,446 | **48%** | 48% | NA | **$833** |

** Design loads for ductless systems are estimated and intended as metric to gauge magnitude of heating load.*

cee Center for Energy and Environment

Pg. 31

# MN CEE Study - Results




Propane consumption down by 64%

- Less than 500 gallons per year at each house

Monitoring confirmed expected performance

- Ducted below 5° F
- Ductless below -13° F

Seasonal COP calculated at 2.5

# Improved ASHP Technology

What makes it possible (circa 2018)

- Efficient compressors
- Inverter driven
- Efficient fan motors
- Communicating controls

Update as to most current information/ advancements in 2020

# Efficient Compressors

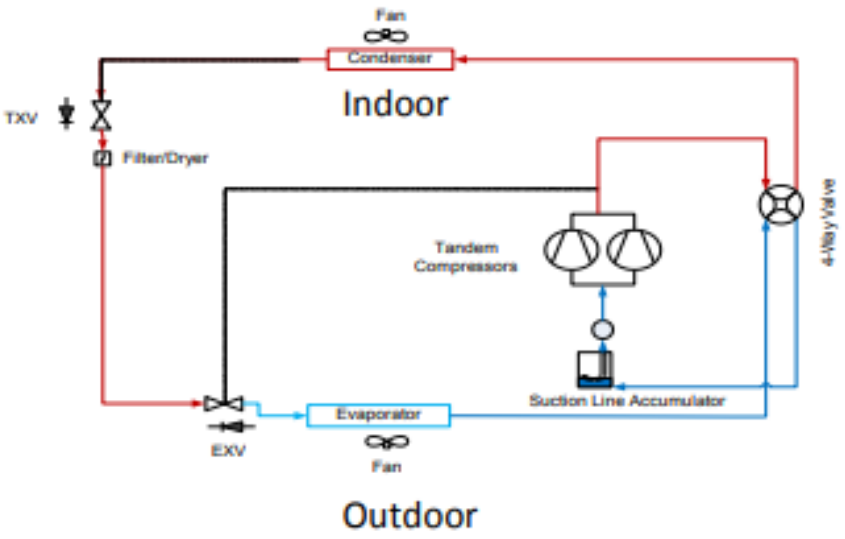
Scroll / rotary compressor

- Longer life
- Reduced noise
- 10-15 degree warmer air
- Multiple stages to fully modulating

# Efficient Compressors in Testing

Tandem compressors (mid-level)

- Single compressor operates for cooling and heating in mild conditions
- Both compressors kick in for low temperature heating



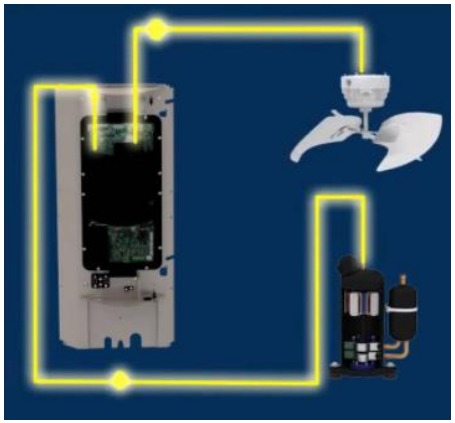
# Efficient Compressors in Testing

Tandem compressors (Sidney, OH)

- Maintained comfortable temps
- 40% energy savings
- Operational at -13° F
- Met demand w/o supplemental heat

# Inverter Driven

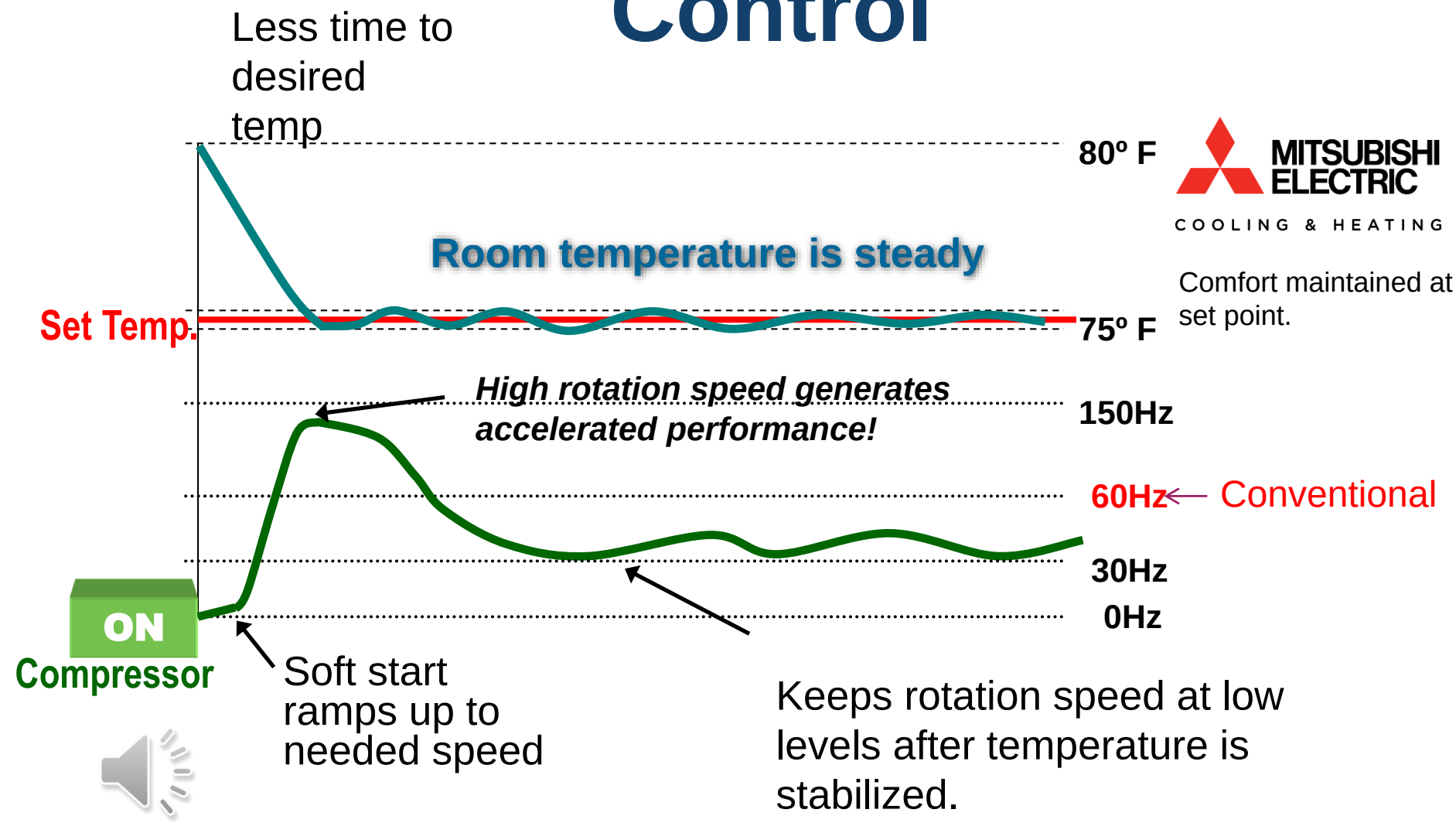
Variable speed device that coverts input voltage into variable frequency / variable voltage output



- May provide variable frequency output to compressor fan motor

- Variable frequency output to compressor controls speed and varies refrigerant flow

# ASHP Inverter Compressor Control




MITSUBISHI ELECTRIC
COOLING & HEATING

Comfort maintained at set point.

# Efficient Fan Motors

ECM motor or brushless DC motors

- In and outdoor units
- Reduced power consumption
- More compact
- Compensates for static pressure

Makes sense!

# Communicating Controls

Internal network/communication across the entire operating system

- Between outdoor and indoor units
- Determines status and system inputs
- Uses information and individual control boards to coordinate  and optimize operation

# Improving (already) Improved ASHP Technology

What makes it more possible now:

- Expanding use of efficient compressors
- New more precise modulation strategies
- Evolution of communicating controls

# Efficiency

Keeps innovating: Heat Pump Dryer

# ASHP Options

Entry level: Single stage

- 14 to15 SEER
- Operable temp 30+
- Designed with significant back-up


Mid level: Two stage

- 16+ SEER
- Operable temp 20+
- Designed with moderate back-up

Inverter driven:

21+ SEER

- Operable temp 5 to -5
- Designed for minimal back-up

# ASHP: Switch Prices

| Enter Seasonal Efficiency of Heating Systems | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COP | 2 | | | | | | | | | | |
| AFUE | 80 | | | | | | | | | | |
| | | Cost per gallon of LP gas | | | | | | | | | Price Point of LPG |
| | | $ 1.00 | $ 1.10 | $ 1.20 | $ 1.30 | $ 1.40 | $ 1.50 | $ 1.60 | $ 1.70 | $ 1.80 | $ 1.90 | $ 2.00 | |
| Cost per kwh of Electricity | $ 0.075 | $ (2.67) | $ (4.04) | $ (5.40) | $ (6.77) | $ (8.14) | $ (9.50) | $ (10.87) | $ (12.23) | $ (13.60) | $ (14.97) | $ (16.33) | $ 0.80 |
| | $ 0.080 | $ (1.94) | $ (3.30) | $ (4.67) | $ (6.04) | $ (7.40) | $ (8.77) | $ (10.13) | $ (11.50) | $ (12.87) | $ (14.23) | $ (15.60) | $ 0.86 |
| | $ 0.085 | $ (1.21) | $ (2.57) | $ (3.94) | $ (5.30) | $ (6.67) | $ (8.04) | $ (9.40) | $ (10.77) | $ (12.13) | $ (13.50) | $ (14.87) | $ 0.91 |
| | $ 0.090 | $ (0.47) | $ (1.84) | $ (3.20) | $ (4.57) | $ (5.94) | $ (7.30) | $ (8.67) | $ (10.04) | $ (11.40) | $ (12.77) | $ (14.13) | $ 0.97 |
| | $ 0.095 | $ 0.26 | $ (1.11) | $ (2.47) | $ (3.84) | $ (5.20) | $ (6.57) | $ (7.94) | $ (9.30) | $ (10.67) | $ (12.03) | $ (13.40) | $ 1.02 |
| | $ 0.100 | $ 0.99 | $ (0.37) | $ (1.74) | $ (3.11) | $ (4.47) | $ (5.84) | $ (7.20) | $ (8.57) | $ (9.94) | $ (11.30) | $ (12.67) | $ 1.07 |
| | $ 0.105 | $ 1.73 | $ 0.36 | $ (1.01) | $ (2.37) | $ (3.74) | $ (5.10) | $ (6.47) | $ (7.84) | $ (9.20) | $ (10.57) | $ (11.94) | $ 1.13 |
| | $ 0.110 | $ 2.46 | $ 1.09 | $ (0.27) | $ (1.64) | $ (3.01) | $ (4.37) | $ (5.74) | $ (7.10) | $ (8.47) | $ (9.84) | $ (11.20) | $ 1.18 |
| | $ 0.115 | $ 3.19 | $ 1.82 | $ 0.46 | $ (0.91) | $ (2.27) | $ (3.64) | $ (5.01) | $ (6.37) | $ (7.74) | $ (9.10) | $ (10.47) | $ 1.23 |
| | $ 0.120 | $ 3.92 | $ 2.56 | $ 1.19 | $ (0.17) | $ (1.54) | $ (2.91) | $ (4.27) | $ (5.64) | $ (7.01) | $ (8.37) | $ (9.74) | $ 1.29 |
| | $ 0.125 | $ 4.66 | $ 3.29 | $ 1.92 | $ 0.56 | $ (0.81) | $ (2.17) | $ (3.54) | $ (4.91) | $ (6.27) | $ (7.64) | $ (9.00) | $ 1.34 |
| | $ 0.130 | $ 5.39 | $ 4.02 | $ 2.66 | $ 1.29 | $ (0.08) | $ (1.44) | $ (2.81) | $ (4.17) | $ (5.54) | $ (6.91) | $ (8.27) | $ 1.39 |
| | $ 0.135 | $ 6.12 | $ 4.76 | $ 3.39 | $ 2.02 | $ 0.66 | $ (0.71) | $ (2.07) | $ (3.44) | $ (4.81) | $ (6.17) | $ (7.54) | $ 1.45 |
| | $ 0.140 | $ 6.85 | $ 5.49 | $ 4.12 | $ 2.76 | $ 1.39 | $ 0.02 | $ (1.34) | $ (2.71) | $ (4.07) | $ (5.44) | $ (6.81) | $ 1.50 |
| | $ 0.145 | $ 7.59 | $ 6.22 | $ 4.86 | $ 3.49 | $ 2.12 | $ 0.76 | $ (0.61) | $ (1.98) | $ (3.34) | $ (4.71) | $ (6.07) | $ 1.56 |
| | $ 0.150 | $ 8.32 | $ 6.95 | $ 5.59 | $ 4.22 | $ 2.86 | $ 1.49 | $ 0.12 | $ (1.24) | $ (2.61) | $ (3.98) | $ (5.34) | $ 1.61 |
| Price Point of Electricity | | $ 0.093 | $ 0.103 | $ 0.112 | $ 0.121 | $ 0.131 | $ 0.140 | $ 0.149 | $ 0.158 | $ 0.168 | $ 0.177 | $ 0.186 | |

Savings per mmBTU

COP varies with temp

| Enter Seasonal Efficiency of Heating Systems | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COP | 2.3 | | | | | | | | | | |
| AFUE | 90 | | | | | | | | | | |
| | | Cost per gallon of LP gas | | | | | | | | | Price Point of LPG |
| | | $ 1.00 | $ 1.10 | $ 1.20 | $ 1.30 | $ 1.40 | $ 1.50 | $ 1.60 | $ 1.70 | $ 1.80 | $ 1.90 | $ 2.00 | |
| Cost per kwh of Electricity | $ 0.075 | $ (2.59) | $ (3.80) | $ (5.01) | $ (6.23) | $ (7.44) | $ (8.66) | $ (9.87) | $ (11.09) | $ (12.30) | $ (13.52) | $ (14.73) | $ 0.79 |
| | $ 0.080 | $ (1.95) | $ (3.16) | $ (4.38) | $ (5.59) | $ (6.81) | $ (8.02) | $ (9.24) | $ (10.45) | $ (11.66) | $ (12.88) | $ (14.09) | $ 0.84 |
| | $ 0.085 | $ (1.31) | $ (2.53) | $ (3.74) | $ (4.95) | $ (6.17) | $ (7.38) | $ (8.60) | $ (9.81) | $ (11.03) | $ (12.24) | $ (13.46) | $ 0.89 |
| | $ 0.090 | $ (0.67) | $ (1.89) | $ (3.10) | $ (4.32) | $ (5.53) | $ (6.75) | $ (7.96) | $ (9.18) | $ (10.39) | $ (11.60) | $ (12.82) | $ 0.94 |
| | $ 0.095 | $ (0.04) | $ (1.25) | $ (2.47) | $ (3.68) | $ (4.89) | $ (6.11) | $ (7.32) | $ (8.54) | $ (9.75) | $ (10.97) | $ (12.18) | $ 1.00 |
| | $ 0.100 | $ 0.60 | $ (0.61) | $ (1.83) | $ (3.04) | $ (4.26) | $ (5.47) | $ (6.69) | $ (7.90) | $ (9.12) | $ (10.33) | $ (11.54) | $ 1.05 |
| | $ 0.105 | $ 1.24 | $ 0.02 | $ (1.19) | $ (2.41) | $ (3.62) | $ (4.84) | $ (6.05) | $ (7.26) | $ (8.48) | $ (9.69) | $ (10.91) | $ 1.10 |
| | $ 0.110 | $ 1.87 | $ 0.66 | $ (0.55) | $ (1.77) | $ (2.98) | $ (4.20) | $ (5.41) | $ (6.63) | $ (7.84) | $ (9.06) | $ (10.27) | $ 1.15 |
| | $ 0.115 | $ 2.51 | $ 1.30 | $ 0.08 | $ (1.13) | $ (2.35) | $ (3.56) | $ (4.78) | $ (5.99) | $ (7.20) | $ (8.42) | $ (9.63) | $ 1.21 |
| | $ 0.120 | $ 3.15 | $ 1.93 | $ 0.72 | $ (0.49) | $ (1.71) | $ (2.92) | $ (4.14) | $ (5.35) | $ (6.57) | $ (7.78) | $ (9.00) | $ 1.26 |
| | $ 0.125 | $ 3.79 | $ 2.57 | $ 1.36 | $ 0.14 | $ (1.07) | $ (2.29) | $ (3.50) | $ (4.72) | $ (5.93) | $ (7.14) | $ (8.36) | $ 1.31 |
| | $ 0.130 | $ 4.42 | $ 3.21 | $ 1.99 | $ 0.78 | $ (0.44) | $ (1.65) | $ (2.86) | $ (4.08) | $ (5.29) | $ (6.51) | $ (7.72) | $ 1.36 |
| | $ 0.135 | $ 5.06 | $ 3.85 | $ 2.63 | $ 1.42 | $ 0.20 | $ (1.01) | $ (2.23) | $ (3.44) | $ (4.66) | $ (5.87) | $ (7.08) | $ 1.42 |
| | $ 0.140 | $ 5.70 | $ 4.48 | $ 3.27 | $ 2.05 | $ 0.84 | $ (0.38) | $ (1.59) | $ (2.80) | $ (4.02) | $ (5.23) | $ (6.45) | $ 1.47 |
| | $ 0.145 | $ 6.33 | $ 5.12 | $ 3.91 | $ 2.69 | $ 1.48 | $ 0.26 | $ (0.95) | $ (2.17) | $ (3.38) | $ (4.60) | $ (5.81) | $ 1.52 |
| | $ 0.150 | $ 6.97 | $ 5.76 | $ 4.54 | $ 3.33 | $ 2.11 | $ 0.90 | $ (0.32) | $ (1.53) | $ (2.74) | $ (3.96) | $ (5.17) | $ 1.57 |
| Price Point of Electricity | | $ 0.095 | $ 0.105 | $ 0.114 | $ 0.124 | $ 0.133 | $ 0.143 | $ 0.152 | $ 0.162 | $ 0.172 | $ 0.181 | $ 0.191 | |

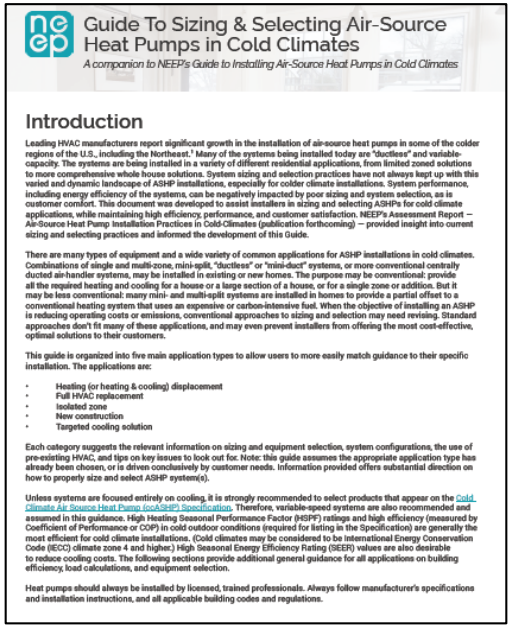

# ASHP Applications

Isolated zone/ addition

Targeted “occupied” zone

Added cooling/system replacement

New construction (NZE) or low load home



Guide To Sizing & Selecting Air-Source Heat Pumps in Cold Climates

*A companion to NEEP's Guide to Installing Air-Source Heat Pumps in Cold Climates*

## Introduction

Leading HVAC manufacturers report significant growth in the installation of air-source heat pumps in some of the colder regions of the U.S., including the Northeast.[1] Many of the systems being installed today are "ductless" and variable-capacity. The systems are being installed in a variety of different residential applications, from limited zoned solutions to more comprehensive whole house solutions. System sizing and selection practices have not always kept up with this varied and dynamic landscape of ASHP installations, especially for colder climate installations. System performance, including energy efficiency of the systems, can be negatively impacted by poor sizing and system selection, as is customer comfort. This document was developed to assist installers in sizing and selecting ASHPs for cold climate applications, while maintaining high efficiency, performance, and customer satisfaction. NEEP's Assessment Report – Air-Source Heat Pump Installation Practices in Cold Climates (publication forthcoming) – provided insight into current sizing and selecting practices and informed the development of this Guide.

There are many types of equipment and a wide variety of common applications for ASHP installations in cold climates. Combinations of single and multi-zone, mini-split, "ductless" or "mini-duct" systems, or more conventional centrally ducted air-handler systems, may be installed in existing or new homes. The purpose may be conventional: provide all the required heating and cooling for a house or a large section of a house, or for a single zone or addition. But it may be less conventional: many mini- and multi-split systems are installed in homes to provide a partial offset to a conventional heating system that uses an expensive or carbon-intensive fuel. When the objective of installing an ASHP is reducing operating costs or emissions, conventional approaches to sizing and selection may need revising. Standard approaches don't fit many of these applications, and may even prevent installers from offering the most cost-effective, optimal solutions to their customers.

This guide is organized into five main application types to allow users to more easily match guidance to their specific installation. The applications are:

- Heating (or heating & cooling) displacement
- Full HVAC replacement
- Isolated zone
- New construction
- Targeted cooling solution

Each category suggests the relevant information on sizing and equipment selection, system configurations, the use of pre-existing HVAC, and tips on key issues to look out for. Note: this guide assumes the appropriate application type has already been chosen, or is driven conclusively by customer needs. Information provided offers substantial direction on how to properly size and select ASHP system(s).

Unless systems are focused entirely on cooling, it is strongly recommended to select products that appear on the Cold Climate Air Source Heat Pump (ccASHP) Specification. Therefore, variable-speed systems are also recommended and assumed in this guidance. High Heating Seasonal Performance Factor (HSPF) ratings and high efficiency (measured by Coefficient of Performance or COP) in cold outdoor conditions (required for listing in the Specification) are generally the most efficient for cold climate installations. (Cold climates may be considered to be International Energy Conservation Code (IECC) climate zone 4 and higher.) High Seasonal Energy Efficiency Rating (SEER) values are also desirable to reduce cooling costs. The following sections provide additional general guidance for all applications on building efficiency, load calculations, and equipment selection.

Heat pumps should always be installed by licensed, trained professionals. Always follow manufacturer's specifications and installation instructions, and all applicable building codes and regulations.

# ASHP Optimization

Targeted zone and Added cooling:

- Replaces or minimizes the operation of less efficient heating
- Reduces dependence on delivered fuels


Ductless ASHP

Centrally ducted ASHP

# ASHP General Guidance

Licensed, **trained** and experienced technicians

Use ccASHP specifications


- Variable speed (3+ or continuous)
- AHRI match w/ COP ≥ 1.75 @ 5º
- 9 ducted ≤ HSPF ≥ 10 ductless
- 15 SEER

# ASHP General Guidance

## Right load calculations

- No padding results
- Accurate inputs
- Use design temps / load calcs
- Be realistic w/ infiltration estimates

# Air Source Heat Pump

Gateway application (Isolated zone)

- Addition / Bonus room
- Comfort issues / Occupant driven

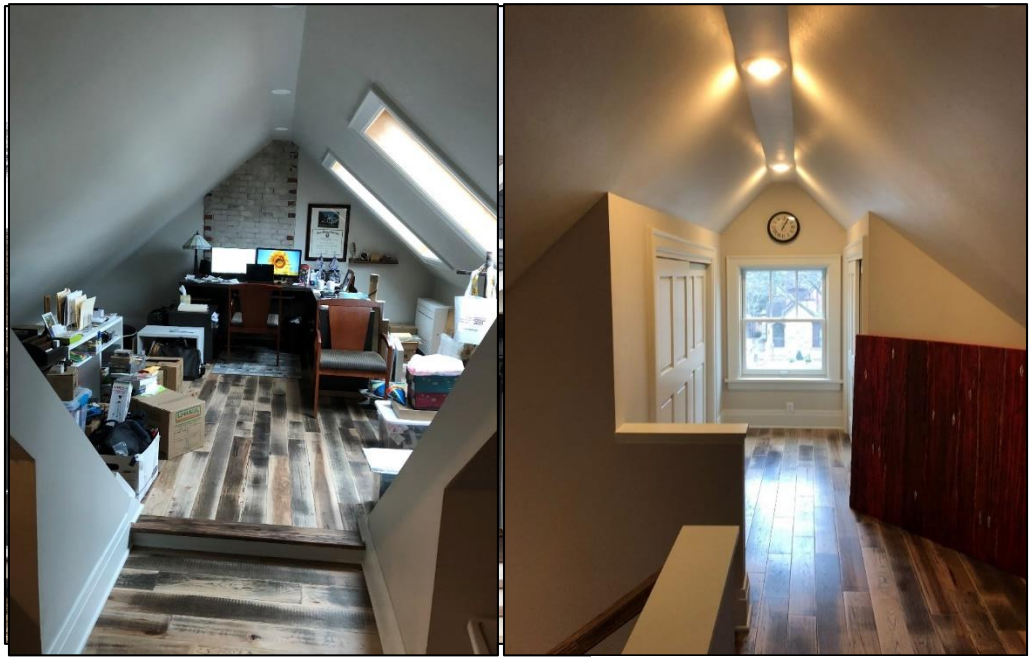


Photo Credit: Cory Chovonec

Ductless ASHP

Mini-Duct ASHP

# Ductless ASHPs

Flexibility

- to add too…. “start small approach”
- to zone and control
- to meet small or customized loads

Ductless ASHP

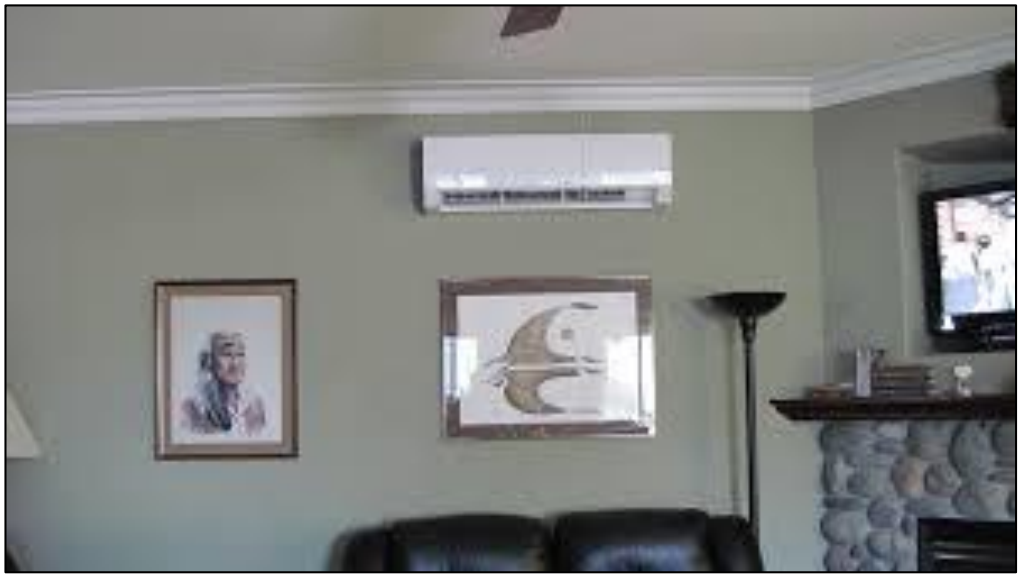
Mini-Duct ASHP

# Ductless ASHPs

"Spot" filtration and dehumidification:

Increased effectiveness where you need it

- Longer (low speed) run time*
- Ability to "Dry" only



NEEP: Buyer's Guide

# Ductless ASHPs

(+) Higher Efficiency (HSPF≥10)

(+) Lower operating temp (-5 to -15 ◦F)

(-) Frost protection

(+/-) Integrated controls

# ASHP Isolated Zone

Tips

Ductless ASHP

- Size for room/block load*
- Account for or disable existing HVAC*
- Use published performance data for adequate capacity

# ASHP Targeted Zone(s)

Operational* HVAC displacement

- Heating and or added cooling
- Offsets more expensive/ less efficient equipment operation (70 up to 90%)
- 1-2 zone ductless to 1-3 room mini-duct in central locations

# Targeted Zone(s)

Trade offs

- Initial cost vs. savings
- Comfort in unserved areas
- Possible freeze mitigation

Ductless ASHP

Mini-Duct ASHP

# Targeted Zone(s)

Tips

- Size for “block” loads
  - Under sizing is optimizing

- Floor mounts for heating

- Fixed t-stat for larger spaces
- Offset existing t-stat four degrees

# System Replacement

Previous system inoperable, antiquated or other*

Decommission/remove

- Size and configured to serve WH
  - Centrally ducted w/caution

    or
  - Multi zone ductless or mini ducted

Use ACCA Manual J

- Size for largest load

# Advantages of Ducted ASHP

Variable “lock-out” temps
or “unrestricted” mode

Credit: NEEP Buyer’s guide

Table 1. Fraction of hours above four potential lockout temperatures.

| Lockout Temperature | Fraction of Hours Above the Lockout Temperature | |
|---|---|---|
| | Grand Rapids | Sault Ste. Marie |
| 10°F | 97% | 91% |
| 20°F | 90% | 80% |
| 30°F | 79% | 70% |
| 40°F | 61% | 51% |

Credit: Slipstream 2019 Dual Fuel Air Source Heat pump Monitoring Report

Centrally ducted ASHP

# Centrally Ducted ASHP

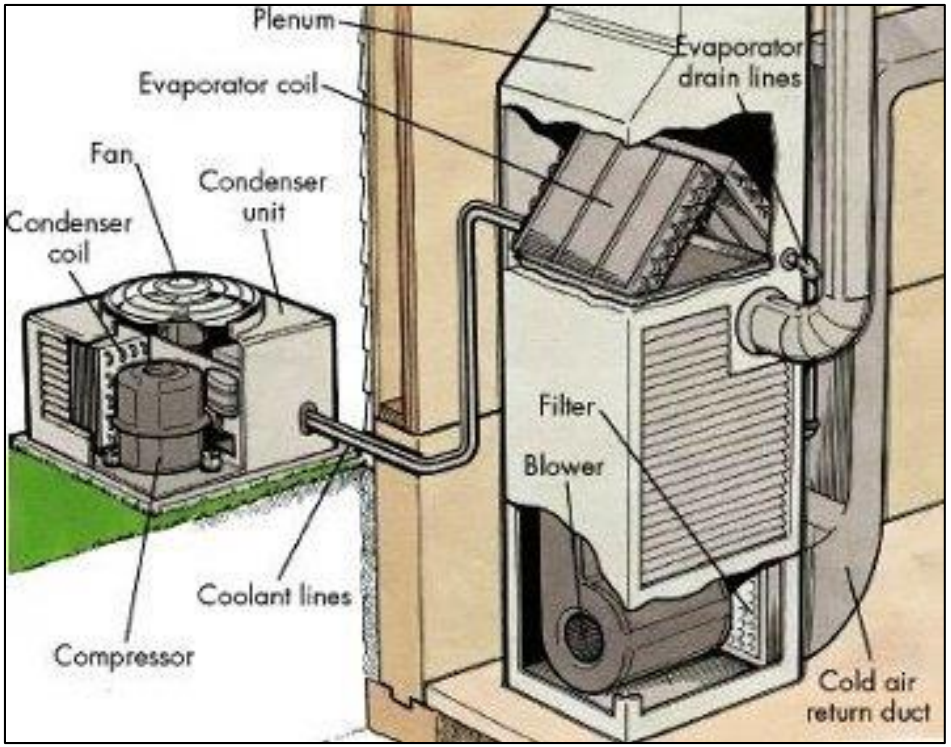
Whole house heating and cooling

Integrates well with existing systems

- Back-up
- Controls

Low opportunity cost when replacing/adding AC

Centrally ducted ASHP



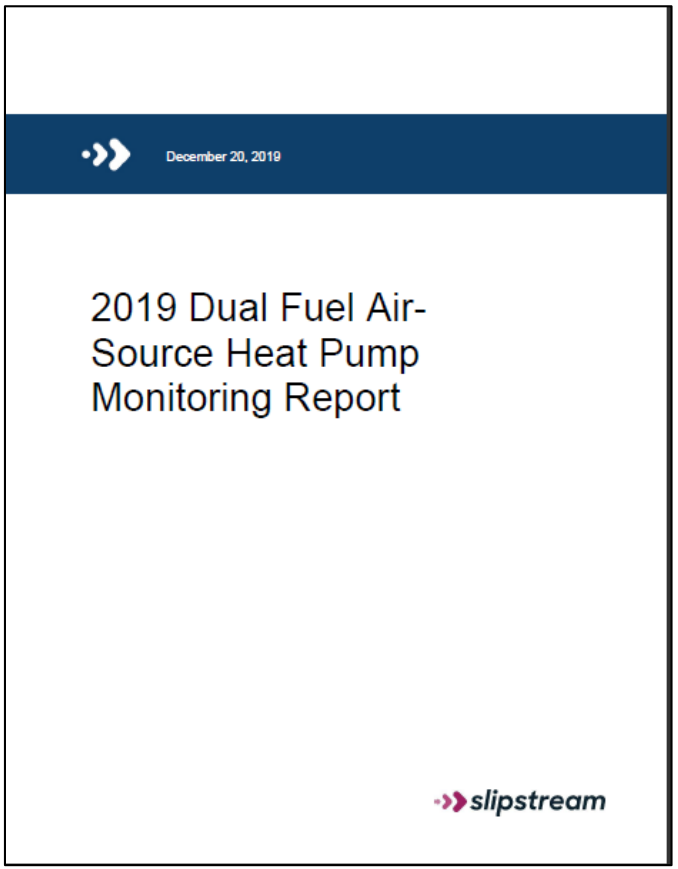
# Centrally Ducted ASHP

Significant cost ($300 to $1000) and emission savings

COPs above 2.5

Displaced propane (35%  to 60%)

Low defrost penalty




Centrally ducted ASHP

# Advantages of Ducted ASHP

Improved performance
(indoor and outdoor units)
- New modulation strategies

Greater product selection
(and price points)
- Multiple fixed vs. variable speed

Centrally ducted ASHP

# System Replacement

Tips

- Match heating capacity at 100-115% heating load or

- Design balance point of 20º F or less (with auxiliary heat)

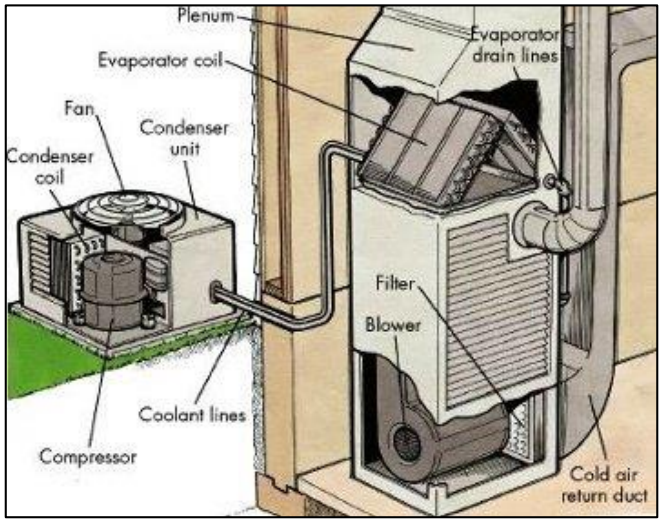
- Investigate enclosure improvements

# System Replacement

Caution

- Address/seal off non-viable ducts

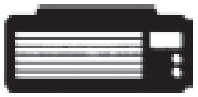
- Ducted ASHP require indoor unit matched with ducts (static pressure) for airflow and velocity



# Low Load Homes

Tight well insulated (new or existing) homes

- 2 ACH50 or less
- Low heating loads
  - ≤ 20 to 40k Btu / hr.



Ductless ASHP

Mini-Duct ASHP

Centrally ducted ASHP

# New System Installation

Tips

- Floor mounts for first, open, large or lower levels
- Mini-ducted for low load rooms
- Central t- stats

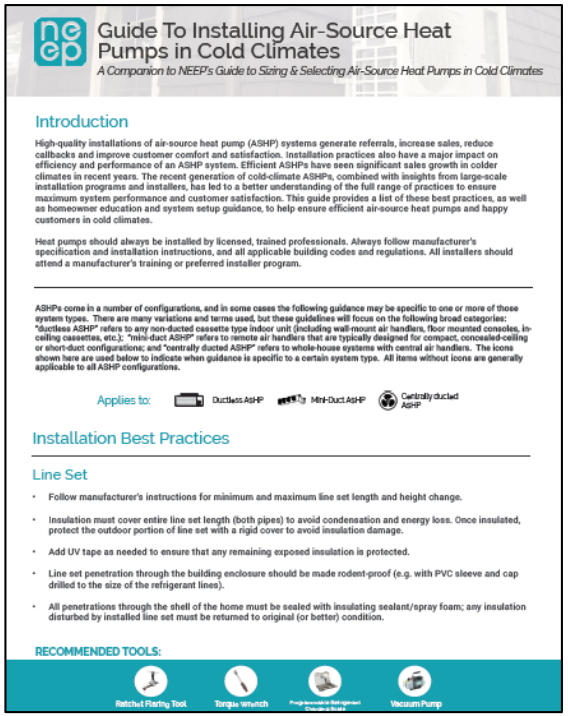
# Low Load Homes

# Low Load Homes

# NEEP Installers Guide

Provides general guidance for:

- **Line sets**
- Refrigerant tubing / charge
- **Outdoor unit placement**
- Settings / homeowner education



Guide To Installing Air-Source Heat Pumps in Cold Climates

*A Companion to NEEP's Guide to Sizing & Selecting Air-Source Heat Pumps in Cold Climates*

Introduction

High-quality installations of air-source heat pump (ASHP) systems generate referrals, increase sales, reduce callbacks and improve customer comfort and satisfaction. Installation practices also have a major impact on efficiency and performance of an ASHP system. Efficient ASHPs have seen significant sales growth in colder climates in recent years. The recent generation of cold-climate ASHPs, combined with insights from large-scale installation programs and installers, has led to a better understanding of the full range of practices to ensure maximum system performance and customer satisfaction. This guide provides a list of these best practices, as well as homeowner education and system setup guidance, to help ensure efficient air-source heat pumps and happy customers in cold climates.

Heat pumps should always be installed by licensed, trained professionals. Always follow manufacturer's specification and installation instructions, and all applicable building codes and regulations. All installers should attend a manufacturer's training or preferred installer program.

ASHPs come in a number of configurations, and in some cases the following guidance may be specific to one or more of those system types. There are many variations and terms used, but these guidelines will focus on the following broad categories: "ductless ASHP" refers to any non-ducted cassette type indoor unit (including wall-mount air handlers, floor mounted consoles, in-ceiling cassettes, etc.); "mini-duct ASHP" refers to remote air handlers that are typically designed for compact, concealed-ceiling or short-duct configurations; and "centrally ducted ASHP" refers to whole-house systems with central air handlers. The icons shown here are used below to indicate when guidance is specific to a certain system type. All items without icons are generally applicable to all ASHP configurations.

Applies to: Ductless AsHP Mini-Duct AsHP Centrally ducted AsHP

Installation Best Practices

Line Set

- Follow manufacturer's instructions for minimum and maximum line set length and height change.
- Insulation must cover entire line set length (both pipes) to avoid condensation and energy loss. Once insulated, protect the outdoor portion of line set with a rigid cover to avoid insulation damage.
- Add UV tape as needed to ensure that any remaining exposed insulation is protected.
- Line set penetration through the building enclosure should be made rodent-proof (e.g. with PVC sleeve and cap drilled to the size of the refrigerant lines).
- All penetrations through the shell of the home must be sealed with insulating sealant/spray foam; any insulation disturbed by installed line set must be returned to original (or better) condition.

RECOMMENDED TOOLS:

Ratchet Flaring Tool Torque Wrench Vacuum Pump

Centrally ducted ASHP

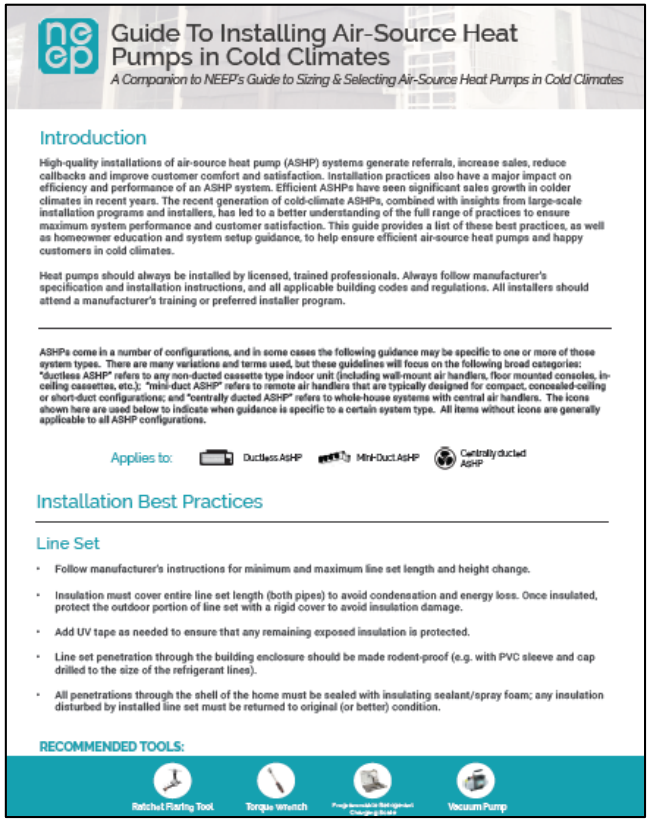
Mini-Duct ASHP

Ductless ASHP

# NEEP Installers Guide

Provides type specific guidance for:

- **Indoor placements**
- Condensate drains
- Ducting considerations
- Thermostat settings



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# Outdoor Placement

Tips:

- Unobstructed and “Customer approved” location
- Level, secure, well drained

# Outdoor Placement

Tips:

- Avoid walkways, drip lines, frost heave
- Consider “buffering” or protecting locations

# Outdoor Placement

Avoid noise transmission

- Not near windows
- 2x6 framing ok
- 2x4 framing use ground mount
- Use remote location if possible

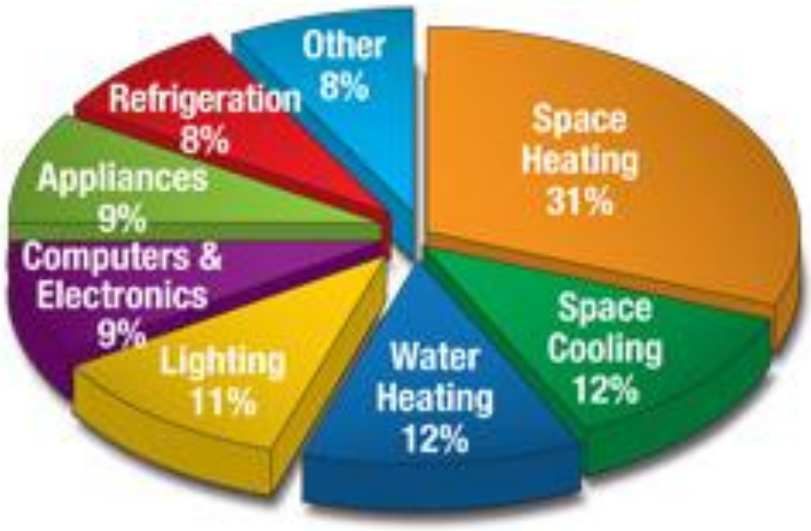
# ASHP

Learn from others….

Video clip: Time permitting

# Advancing Technologies
## Heat Pump Water Heaters

Potential gateway technology:




Water heating

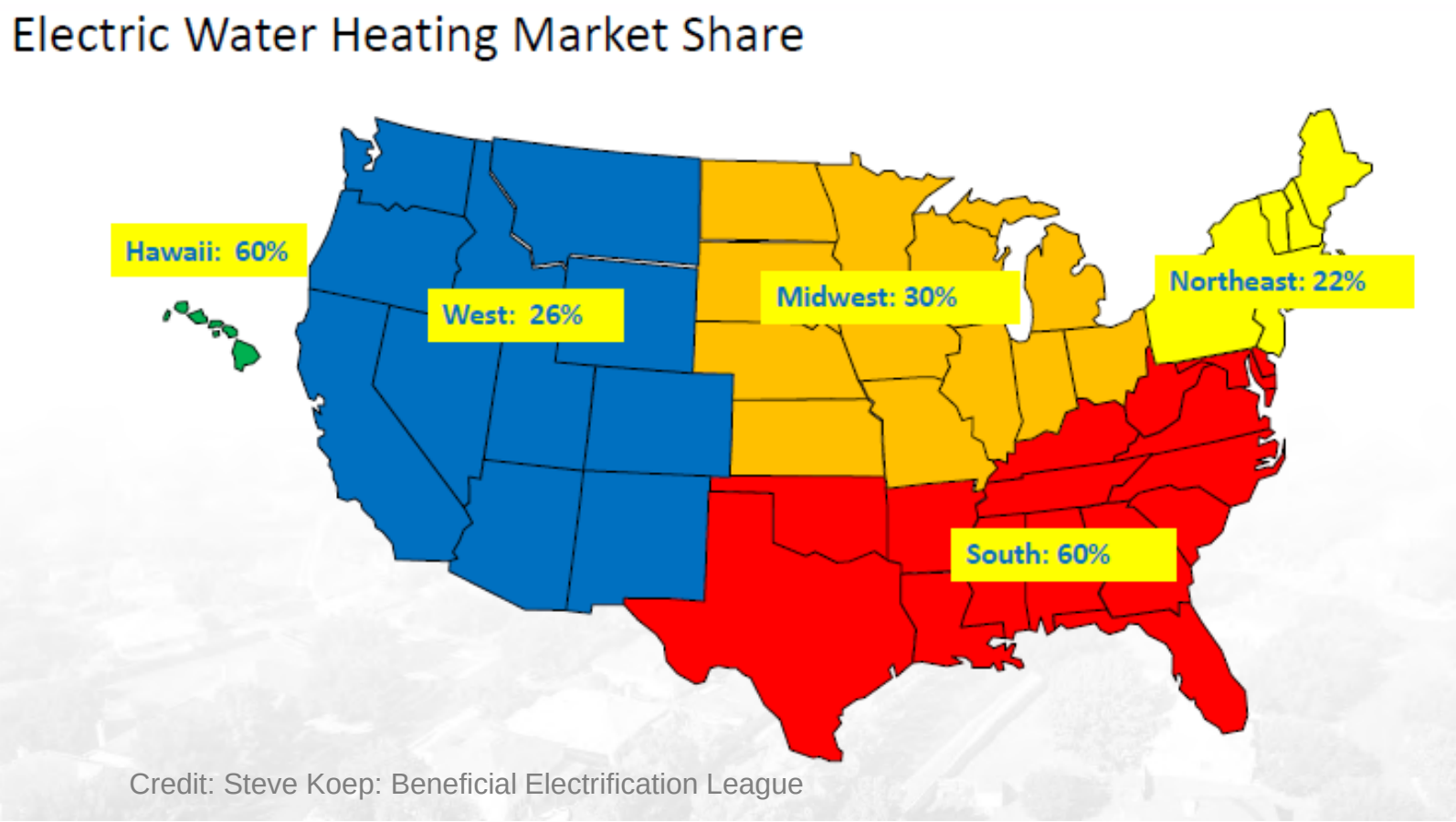
- 2nd largest expense

HPWH significant savings

- vs. propane
- vs. electric resistance

# Heat Pump Water Heaters

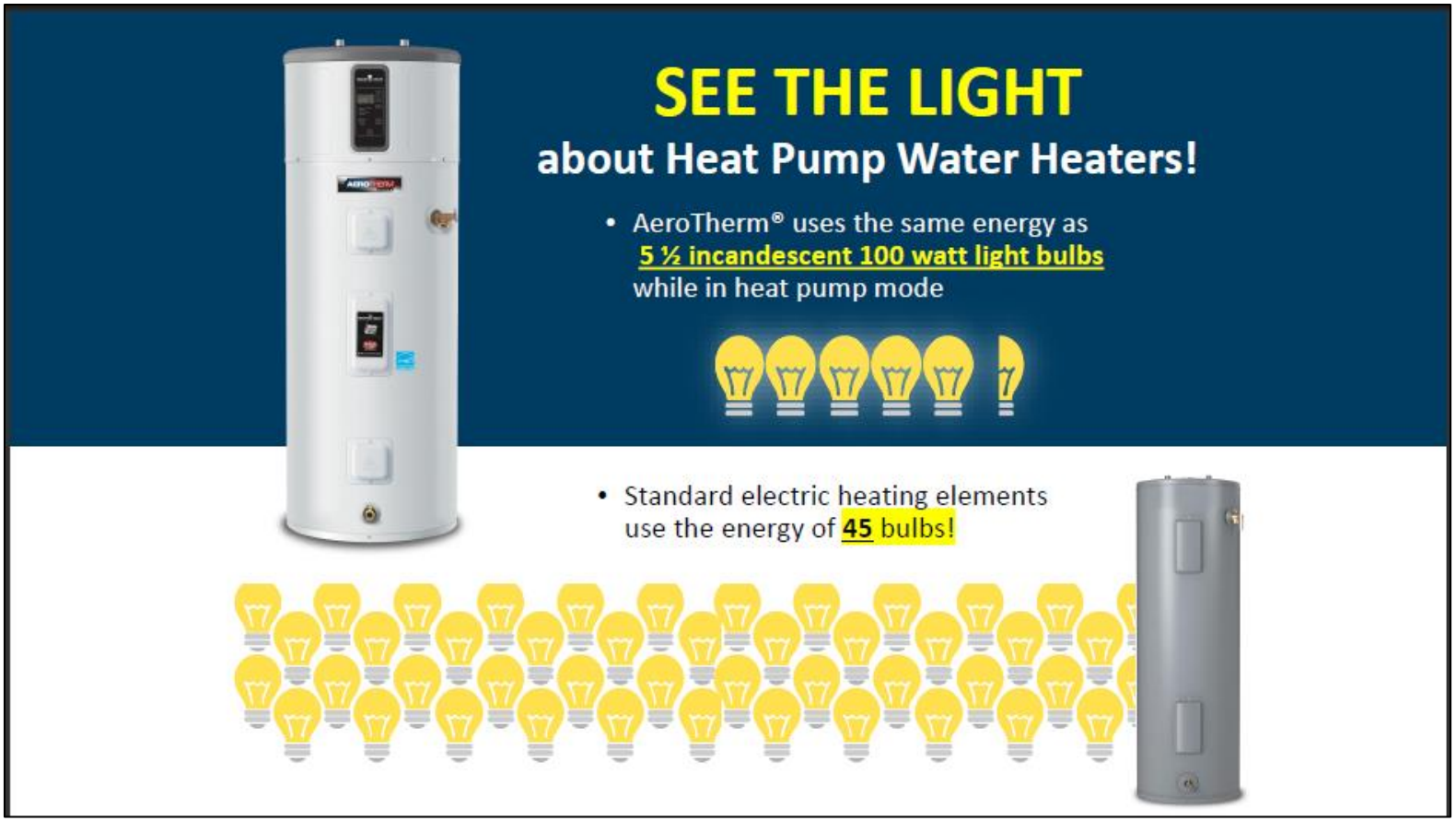
Big opportunity:




Credit: Steve Koep: Beneficial Electrification League

# Heat Pump Water Heaters

## vs electric resistance




Source: Gregg Holladay: Bradford White

# Advancing Technologies
## Heat Pump Water Heaters

Highly Efficient

- (UEF of 2.0 to 3.0+ vs. less ≤ 1)

Multiple modes - flexible

- HP vs Hybrid vs ER mode
- Vacation and timer settings

Equal Recovery Efficiency*

Low to no maintenance*

# Heat Pump Water Heaters

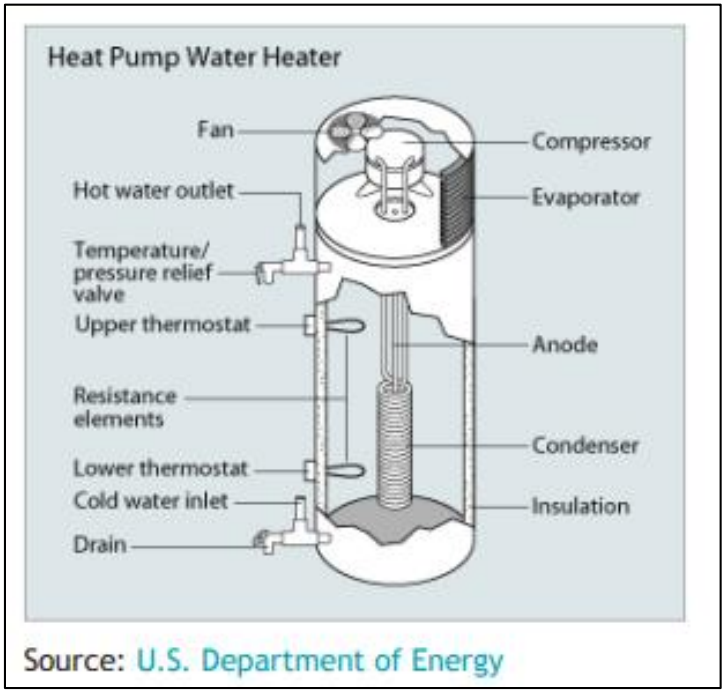
Same performance / less energy

Flexible locations

- Basements work well
- Cools and dehumidifies space

Relatively quiet operation

Relatively easy installation



# Heat Pump Water Heaters

Enable energy storage:

Grid ready/responsive

- Pre-charge units with RE
- Optimize “Time of use” rates

Wi-fi enabled (w App)

- Allows real-time user interface

# Beneficial Electrification

## Advancing Technologies, Efficiency and Comfort for the future with Air Source Heat Pumps

Greg Nahn

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slipstream