Heating and Cooling Innovations for Decarbonization:

AIR SOURCE HEAT PUMPS

Images courtesy of U.S. Department of Energy and RMI

Today, we will cover:

NYS Energy Codes	Looking Back…
	Current Energy Code
	Looking Forward…
ASHP Technology	Heating and Cooling Statistics
	History of ASHPs
	How do they work?
Examples	Types of Air Source Heat Pumps
	What about the winter?
	Successful NYS ASHP Projects

Course Information

This course has been approved by the Department of State for In-Service Training credit as follows:

- 2.0 hours, Topic 3 – Energy Code

Course number: T02-07-3206

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- Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.
- You may always call or email questions. mevans@newportventures.net, 518-377-9410. There is also a way to submit questions on our website.

MATT EVANS

- Building System Analyst and a certified HERS rater conducting energy analysis and rating work for home builders as well as conducting energy ratings and audits on residential as well as commercial buildings.
- 16 years of experience in energy analysis of residential and commercial buildings, building energy codes, consulting, and energy/building science training.
- Provided hundreds of energy code trainings across NY, CT, DE and MD.
- Supports multiple Newport programs with NYSERDA including a state-wide energy code training program, high performance homes project, an LED lighting demonstration and evaluation project, and other technology demonstration projects.
- 30 years of overall experience in the building trades industry including new home construction and remodeling.
- New York State Certified Teacher in Technology Education and Construction Industry and Building Maintenance. (10 years at the Secondary Level)
- Masters Degree in Curriculum Development and Instructional Technology (University of Albany, 2005)
- Bachelors Degree in Vocational Technical Education (Oswego University, 1998)
- Associates Degree in Building Trades (SUNY Delhi, 1995).

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Who do we have in the audience today?

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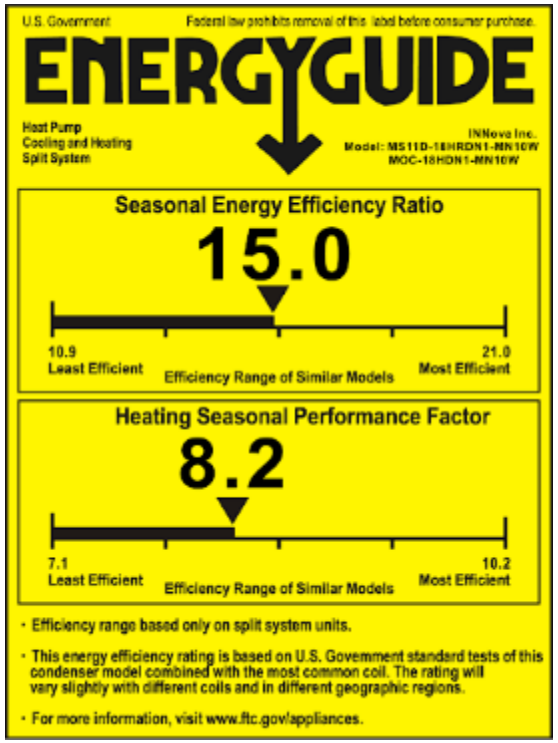
NYS Energy Codes

Looking Back…

Developing Efficiency Ratings



SEER and HSPF for Heat Pump

Efficiency = Energy Out / Energy In

AFUE (heating)	Annual Fuel Utilization Efficiency **annual** heat output / **annual** energy input (BTUs/BTUs) %	Furnaces Boilers Water Heaters
HSPF (heating)	Heating Seasonal Performance Factor **heating season** heat output / **heating season** electric input (BTUs/Watt-hours)	Heat Pumps
SEER (cooling)	Seasonal Energy Efficiency Ratio **cooling season** cooling output / **cooling season** electric input (BTU/h/Watts) Based on summer average temperature of 83°F.	Heat Pumps A/C

Efficiency in NYS

	1992	2007	2017
Air Conditioners			
Split System	10 SEER	13 SEER	13 SEER
Packaged System	9.7 SEER		14 SEER
Heat Pumps			
Split System	10 SEER / 6.8 HSPF	13 SEER / 7.7 HSPF	14 SEER / 8.2 HSPF
Packaged System	9.7 SEER / 6.6 HSPF		14 SEER / 8 HSPF

NYS Energy Codes

Current Energy Code

Current NYS energy code is 2018 IECC

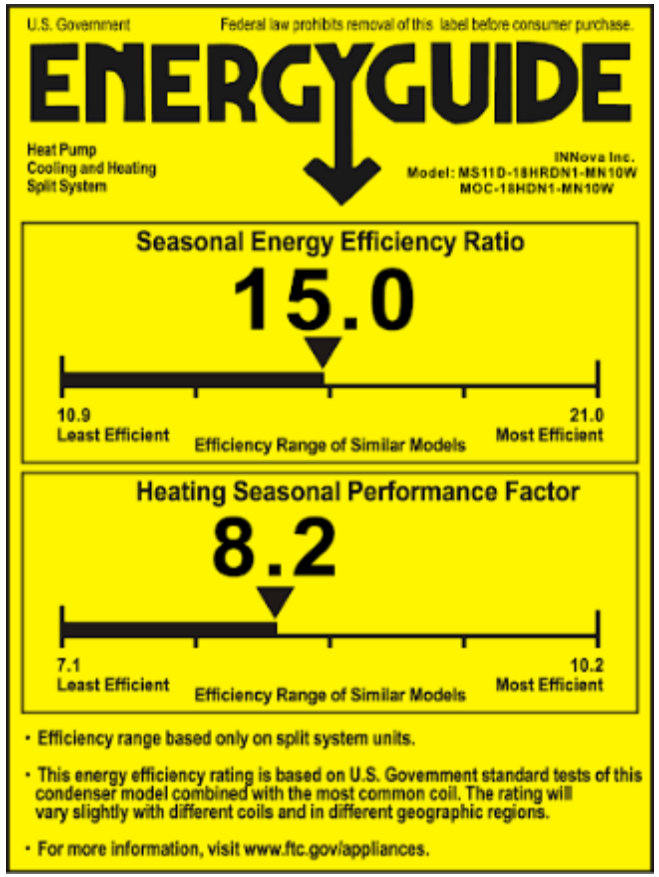
Aligns with the preemptive federal standards

New standards for A/C and ASHPs went into effect on January 1, 2023

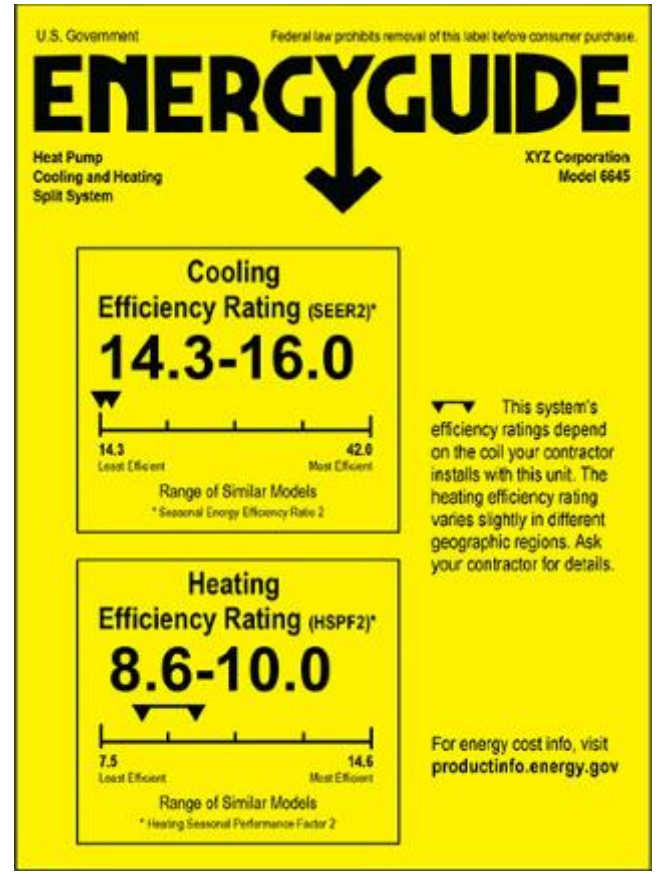
Uses new 'SEER2' and 'HSPF 2' metrics

NYS Energy Codes

Current Energy Code



SEER and HSPF for Heat Pump



SEER2 and HSPF2 for Heat Pump

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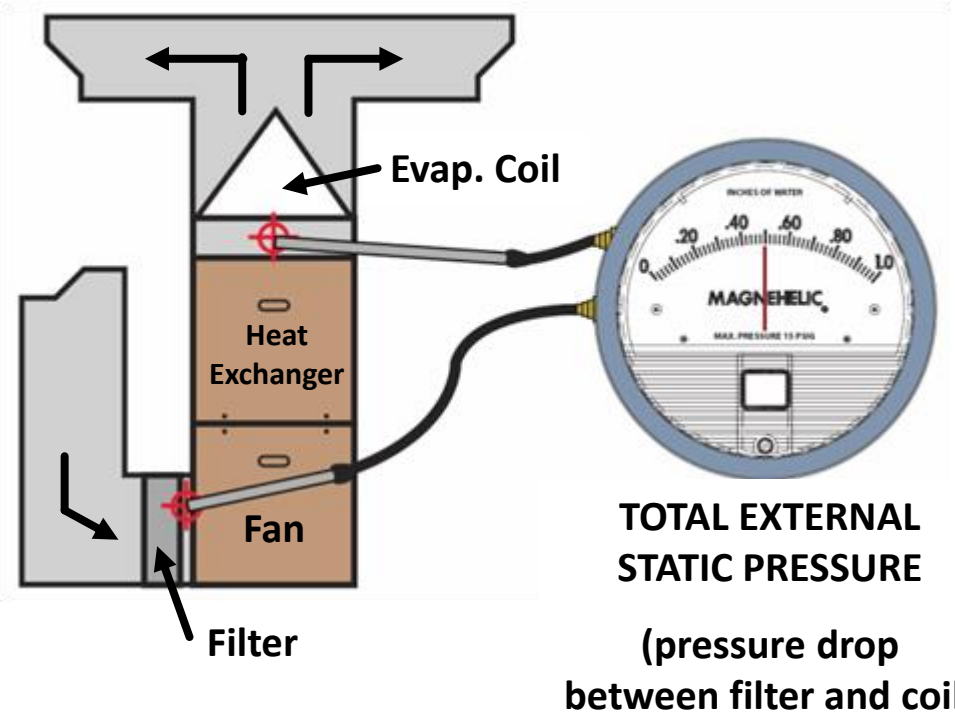
Why SEER2 / HSPF2 ?



- **SEER2 rating is roughly 4.5% lower than the SEER rating.**
- Based on a new testing method "M1"
  - Test increases systems' external static pressure from 0.1 in. to 0.5 in. H_2O
  - More accurately reflects current field conditions
- In the North, phase-in by manufacture date

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How are you currently heating your home in New York State?

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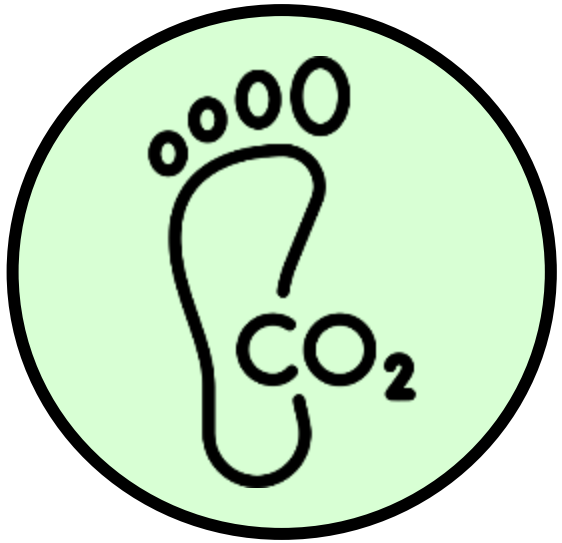
NYS Zero Emissions New Construction (ZENC)
A.K.A. The All-Electric Buildings Act

https://nyassembly.gov/all-electric-buildings/

NYS Zero Emissions New Construction (ZENC)



- Buildings account for 32% of state GHG emissions
- First ZENC law in the nation
- Safe, reliable and resilient future
- Consumer savings

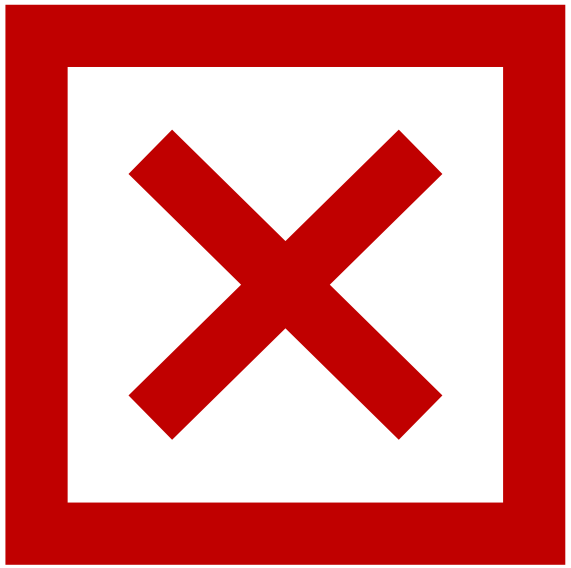
NYS Energy Codes

Looking Forward…

What It Is

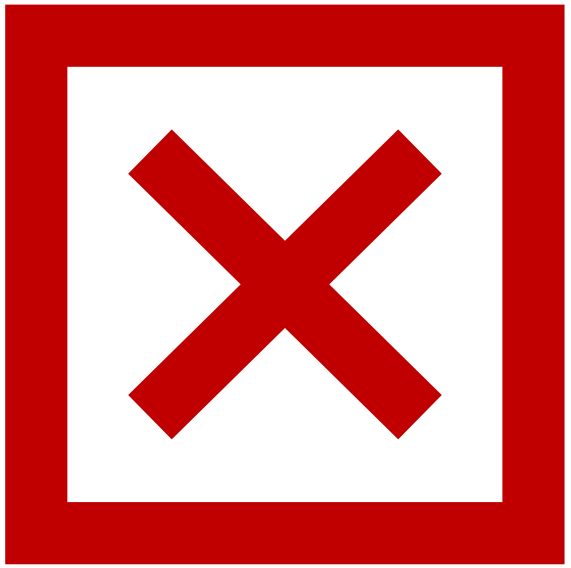
- In 2026, most new NY buildings must use electric heat and appliances:
  - All new buildings 7 stories and under
  - All new commercial and industrial buildings larger than 100,000 ft^2
- Starting in 2029 for all other building types
- Prevents NEW emissions, won't reduce current levels

What It Is Not



- NOT a ban on gas stoves
- NOT a ban on existing gas appliance replacements
- Does NOT apply existing buildings, renovations, repairs, replacements
- Does NOT prohibit alternative fuels (clean hydrogen and renewable natural gas)

Exempt Building Types

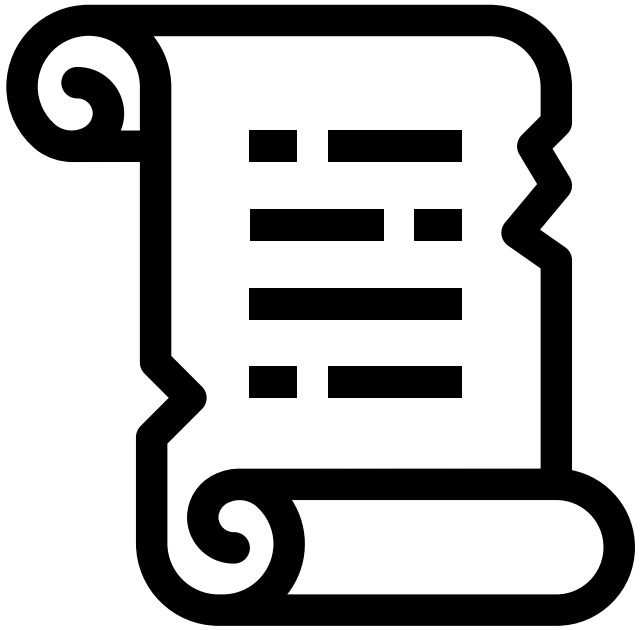


- emergency backup power & standby power
- manufactured homes
- manufacturing facilities
- agricultural buildings
- commercial food establishments
- laboratories
- car washes
- laundromats
- hospitals
- other medical facilities
- critical infrastructure
- fuel cell systems
- crematoriums

NYS Zero Emissions New Construction
Prohibits fossil fuel equipment and building systems

Applies to:	• space heating • water heating • cooking stoves • clothes drying • fireplaces
Does NOT apply to:	• outdoor gas grill with a portable tank or one that uses an alternative fuel • wood burning equipment • renewable natural gas • clean hydrogen

How It Will Be Done: 2022 Advanced Codes And Standards Law



- The Advanced Building Codes, Appliance and Equipment Efficiency Standards Act of 2022 bolsters New York's regulatory and policy environment to support energy efficiency and greenhouse gas reduction strategies in buildings along with expanded appliance standards

ASHP Technology

Heating and Cooling Statistics

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What is the most common energy used to heat a home?

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How old is your current heating system in your home?

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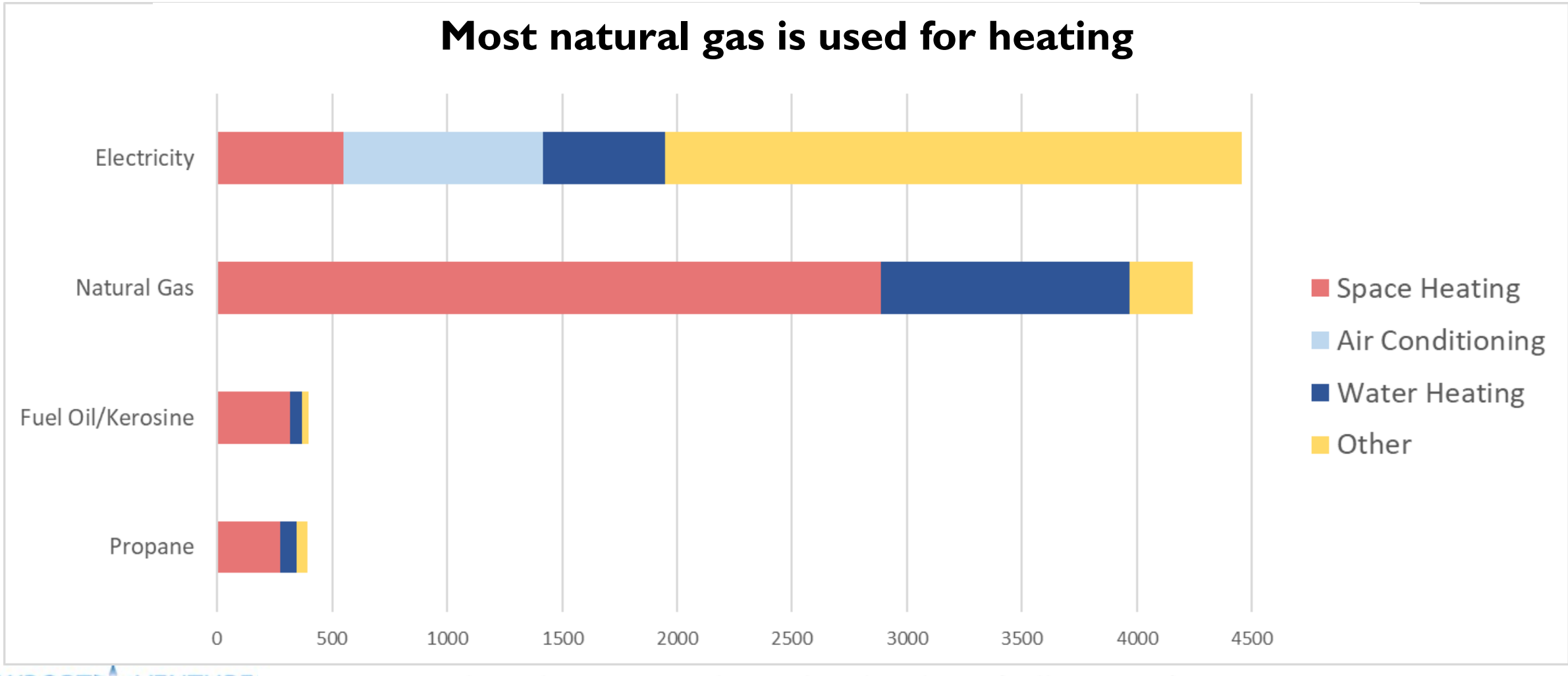
Heating and Cooling Statistics



2020 U.S. Residential Energy Use by Fuel and End Use (trillion BTUs)

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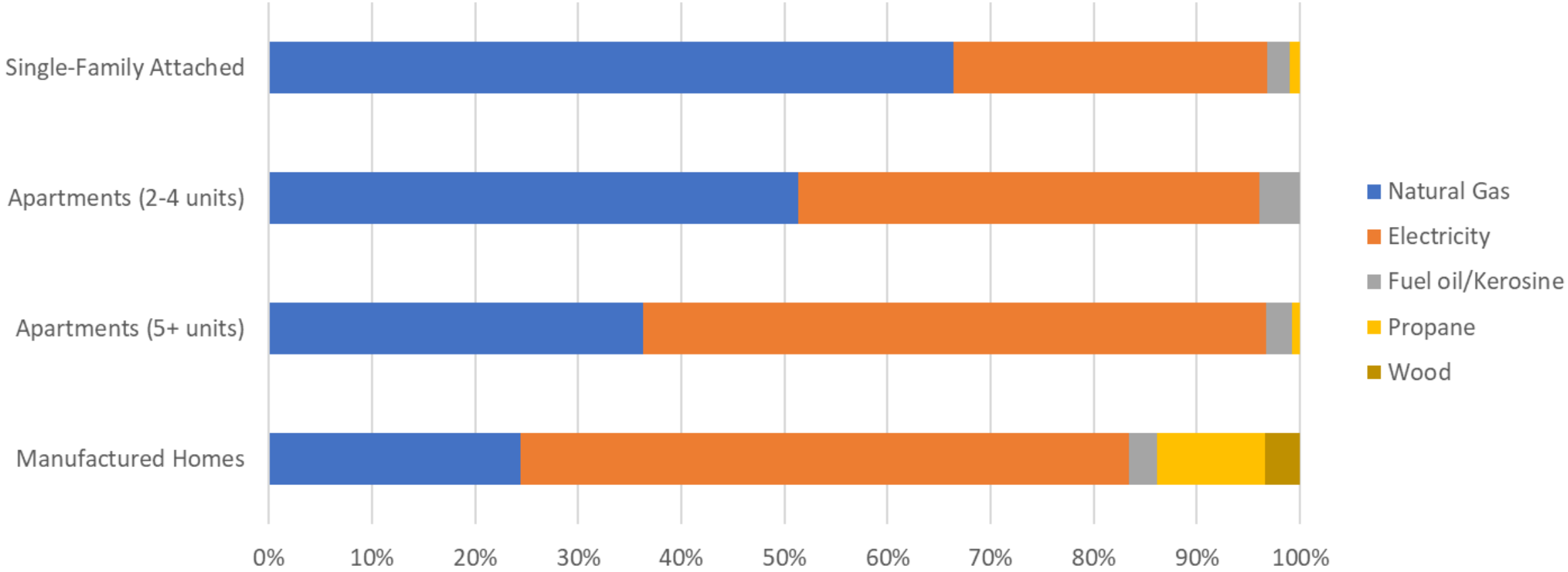
Heating and Cooling Statistics

Does building type make a difference in fuel type used?



Primary Energy Source for Space Heating, by Type of Housing Unit (2020)

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Heating and Cooling Statistics

Location also matters

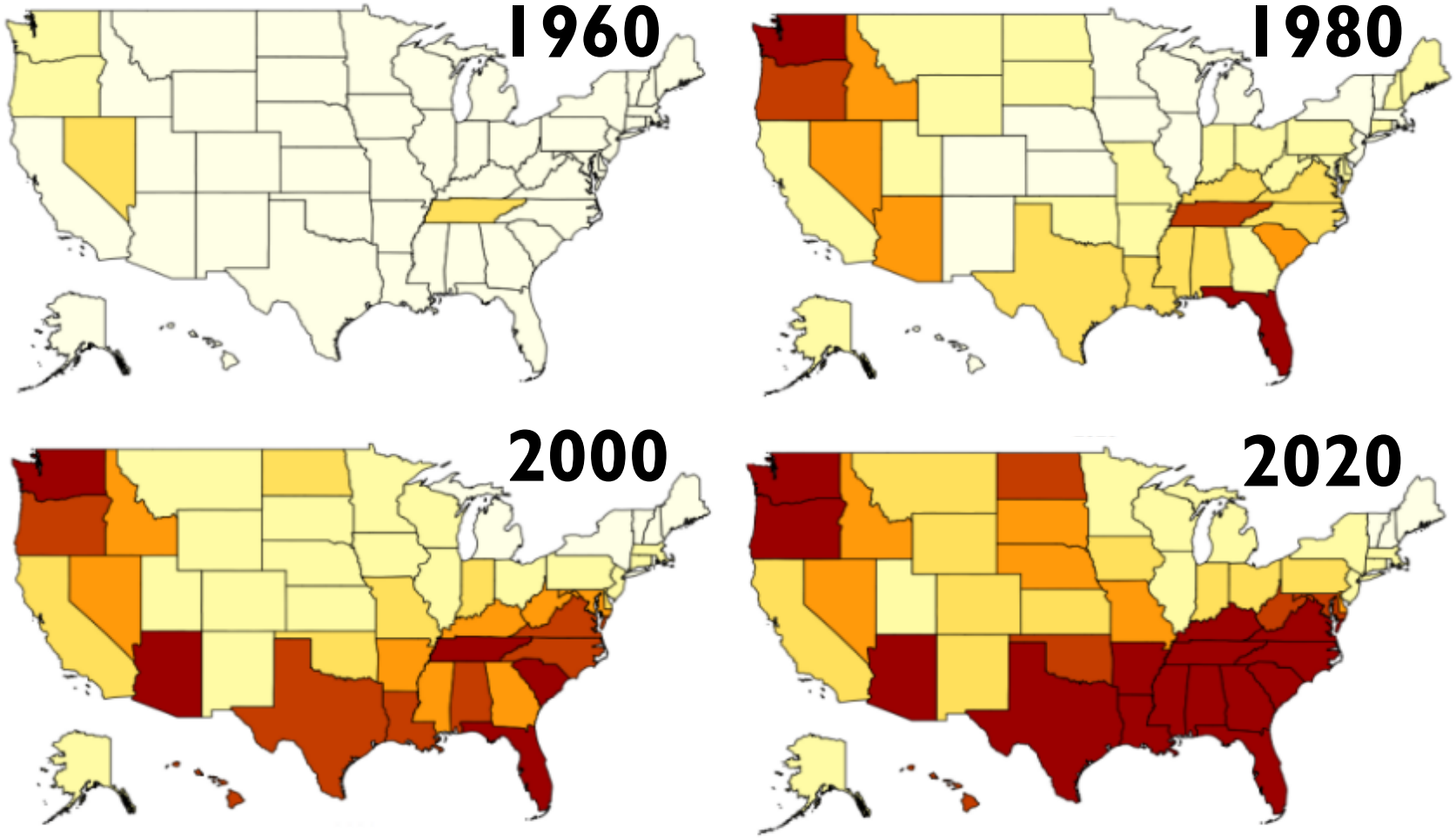

Figure 1. Growth in residential electric heating over the past 60 years (Davis 2022)

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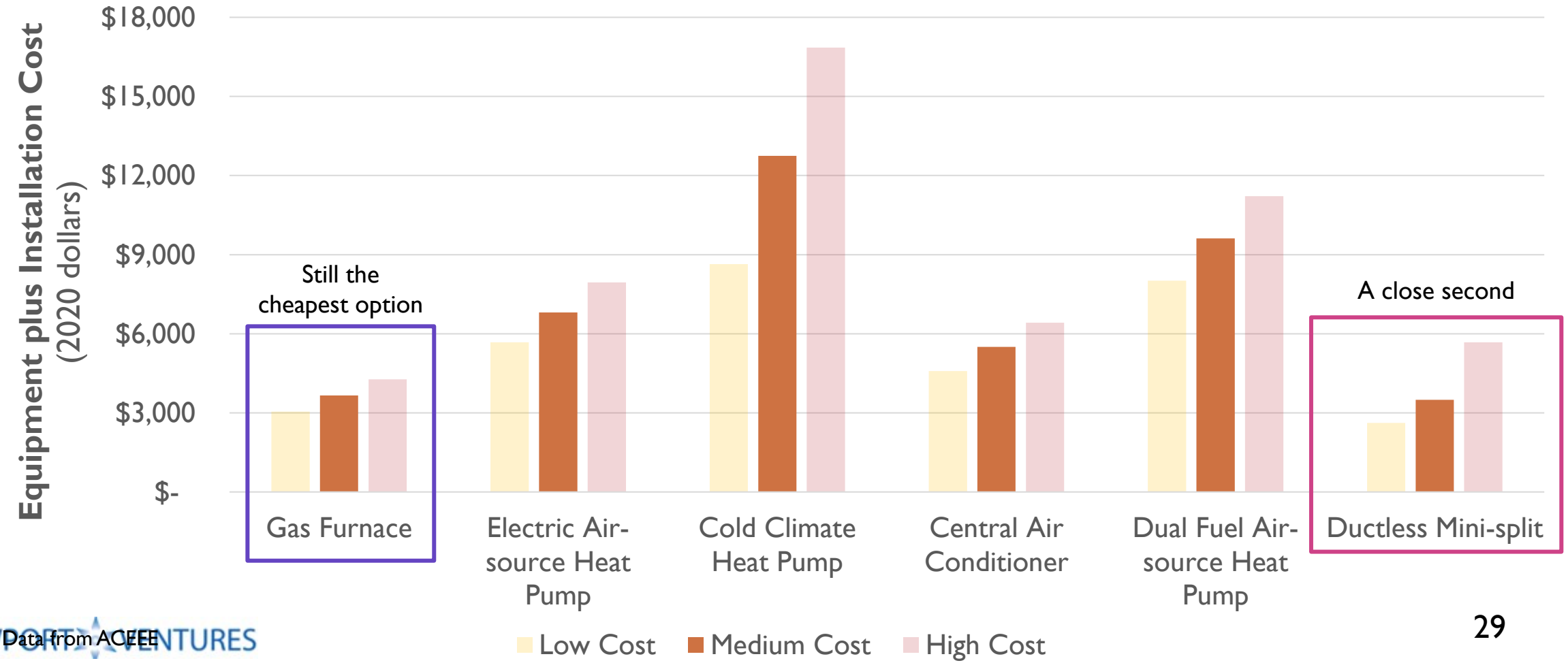
Heating and Cooling Statistics

Isn't it too expensive?



Data from ACEEE

Green financing and incentives can help with costs

NEW YORK STATE | NYSERDA

- "GreenCHOICE" mortgage by Freddie Mac
- National Grid Rebates
- RG&E Incentives
- NYS FlexTech Program
- Federal Tax Credits (IRA)
- And many more!

NEW YORK STATE

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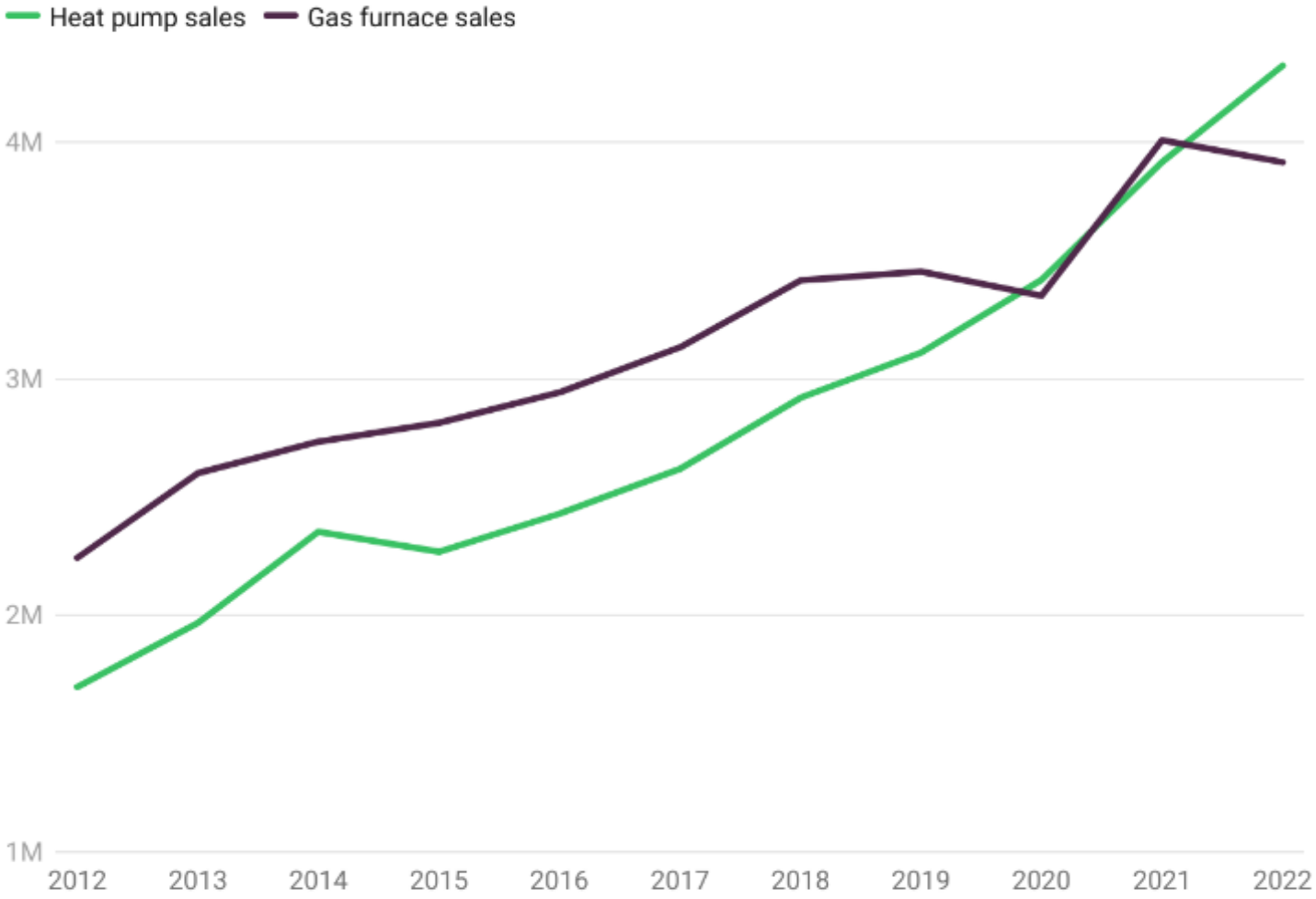
U.S. Heat Pump Sales Surpass Gas Furnaces

Heat pump sales in U.S. surged past gas furnaces in 2022



2022 figures include sales data for Jan–Nov and projected sales for Dec.

Chart: Canary Media • Source: Air-Conditioning, Heating, and Refrigeration Institute

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History of ASHPs

ASHP Technology

History of ASHPs

PIERCE AND TOWNS ICE CUTTING OPERATION, ROBIN HOOD PARK, KEENE, N. H. c.1870

Late 1800s

Natural Ice Shortage = development of refrigeration - basic principles of compression/absorption

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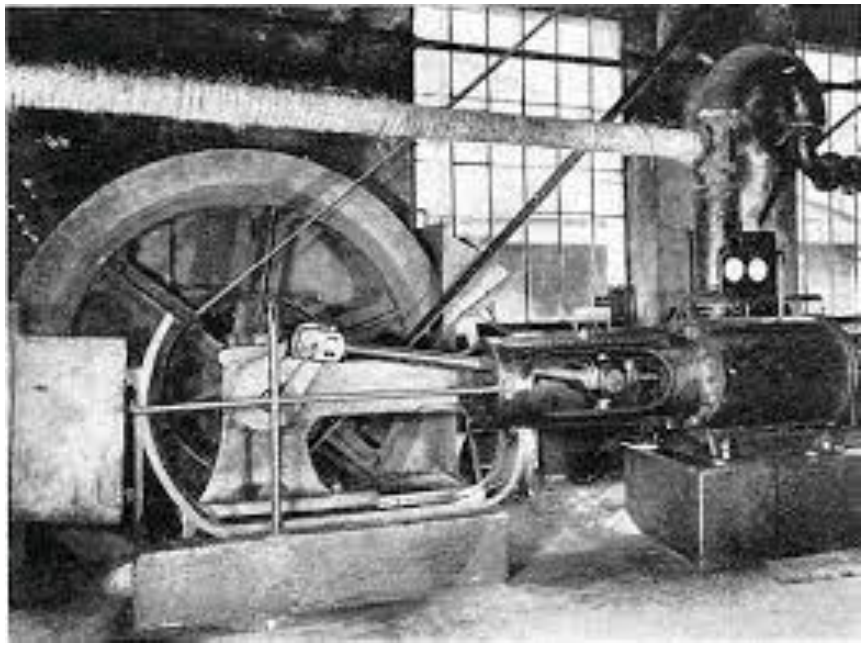
History of ASHPs



1920 – 1950: Reversed refrigeration cycle to make heat. Further development of compression technology.

1930: House in Tucson equipped with a heat pump.

1932: Office building of the Southern California Edison Company in Los Angeles. 10% efficiency

1933: Frigidaire demonstrates air conditioning at the Chicago World's Fair. Still rather poor efficiencies.

1947: Early boom in demand for unitary window air conditioners. 43'000 units sold.

1948: Equitable Building (NYC – 14 floors) installs heat pumps for heating and cooling

1950s and 60s: Oil prices fall continuously, dramatically slowing down all heating only heat pump activities. Stagnation in their development and market penetration.

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History of ASHPs

1973: Oil embargo - OPEC cut back on their exports of petroleum to Western nations. Devastating effect on national economies - global recession and high inflation. Nations rethink their dependence on fossil fuels.

1974: Embargo ends in March 1974. Oil prices had risen by over 300%. Heat pump renaissance.

1976: 1.6 million unitary heat pumps for cooling and heating operating in the U.S.A. and 300,000 new units were manufactured.

1979: Second oil crisis led to a second heat pump boom.

The rapid growth of the heat pump business grew faster than the technology. Too many competitors with not enough know-how.

1982: Oil price beings to decline

Late 1980s: Collapse of heat pump boom

ASHP Technology

History of ASHPs

1992: US passes Environmental Protection Act – promotes heat pump and other efficient technologies

1999: only one manufacturer of unitary absorption air conditioners and heat pumps in the U.S.A. Extensive research activities on absorption heat pumps worldwide.

2008: Cheaper and more efficient vapor compression technology is developed.

ASHP Technology

How do they work?

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Who here has a whole house Air Conditioning unit or Heat Pump installed in your home?

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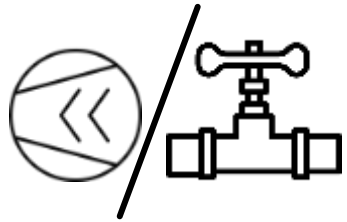
How do they work?

Electricity is used in compressor and fans, not used to create heat directly.



Compressor and expansion valve create pressure changes, causing temperature changes and forcing phase changes.

$$PV = nRT$$

Stay constant

$$\uparrow Pressure \sim \uparrow Temperature$$

$$\downarrow Pressure \sim \downarrow Temperature$$

Heat is released/absorbed during phase changes (latent heat)

Reverse flow of refrigerant to switch between heating and cooling (absorbing heat from inside instead of outside)

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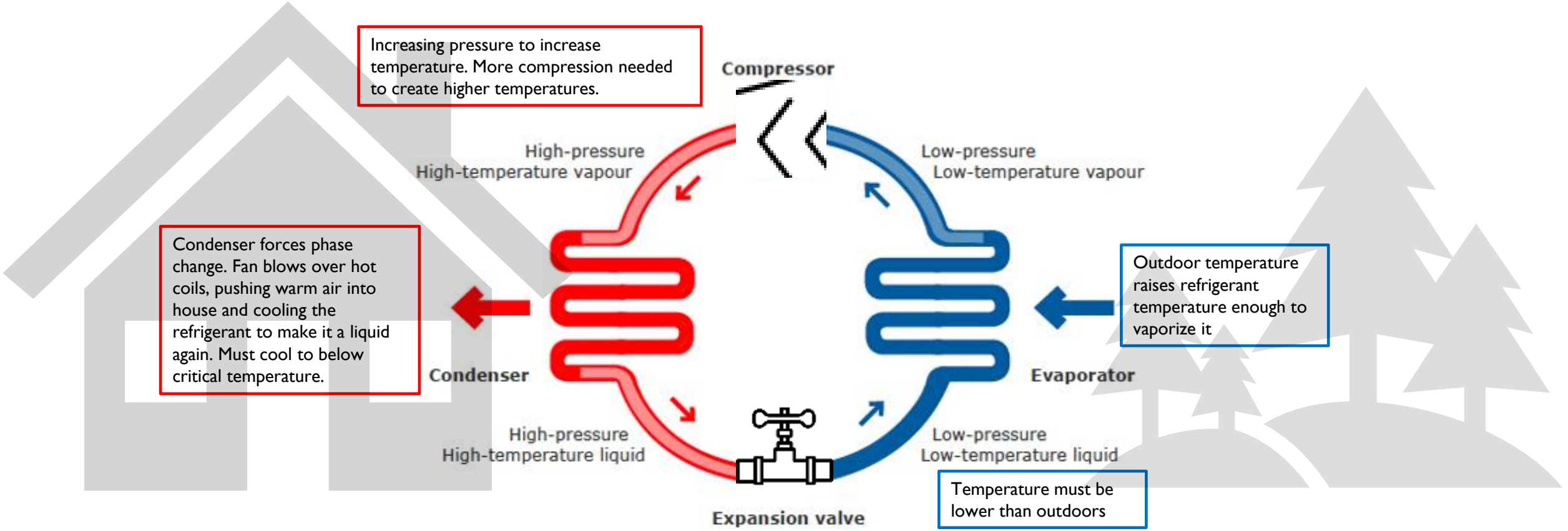
How do they work?

HEAT PUMP BASICS – HEATING MODE



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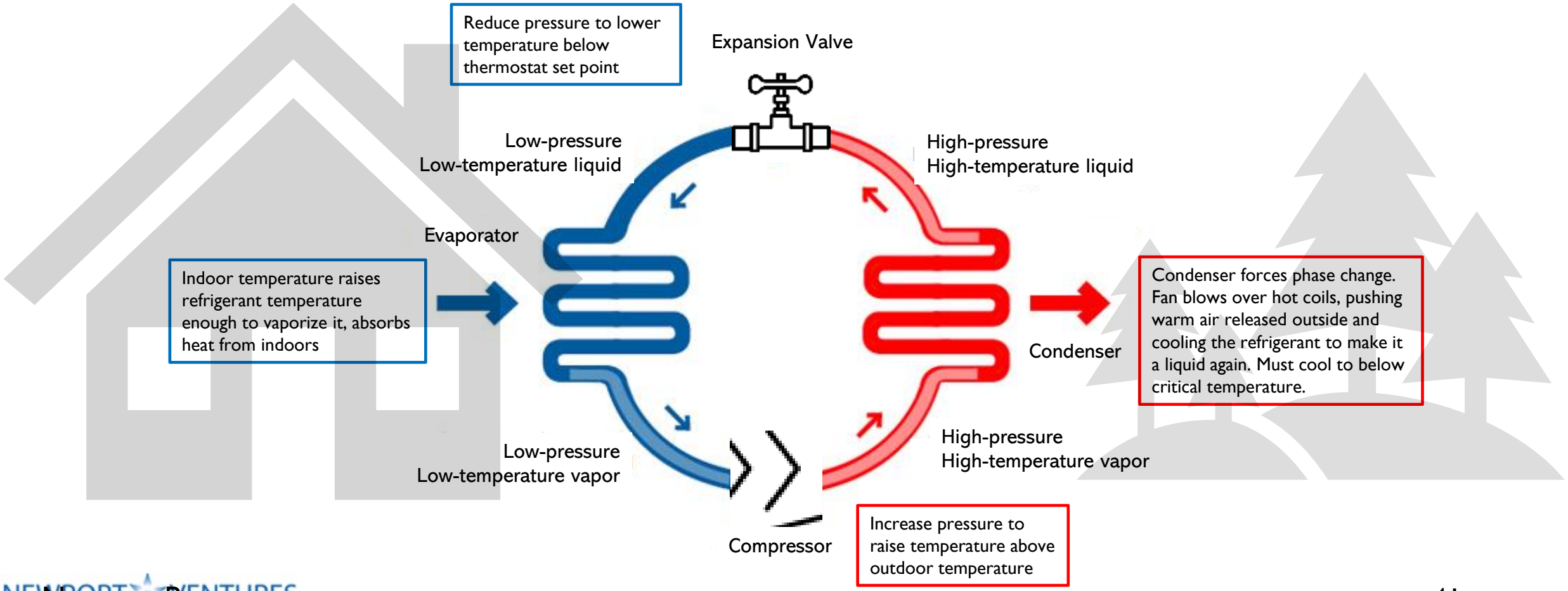
How do they work?

HEAT PUMP BASICS – COOLING MODE



ASHP Technology

How do they work?

TYPICAL HEAT PUMP REFRIGERANTS – ENVIRONMENTAL IMPACT

Refrigerant	GWP	Operating Pressures	Provenance	Problems
R410a (most common)	1,890	130-420 psi	Chemically engineered	Very high GWP
R407c	1,774	50-280 psi	Chemically engineered	Very high GWP
R134a (2nd most common)	1,430	25-65 psi	Chemically engineered	Very high GWP
R32 (replacing 410a)	677	175-375 psi	Chemically engineered	Mildly flammable
R600a	3	60-145 psi	Naturally occurring (Isobutane)	Highly flammable
R744	1	920-2470 psi	Naturally occurring (Carbon Dioxide)	High operating pressure
R717	0	30-145 psi	Naturally occurring (Ammonia)	Toxic
R290	0	130-290 psi	Naturally occurring (Propane)	Highly flammable

Heat pumps help with decarbonization, but need to evolve to eliminate high GWP refrigerants

ASHP Technology

How do they work?

TEMPERATURE SETBACKS

- Inverter driven heat pumps are excellent at maintaining a steady indoor temperature with very little energy.
- Not good at bringing temperatures up suddenly, so fuel backup kicks in when temperature setback ends.
- Therefore, while setbacks can save energy in gas furnace systems, they are not an efficient use of energy for an inverter-driven heat pump system.

Examples

Types of Air Source Heat Pumps

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Examples

Types of Air Source Heat Pumps

- Provide efficient heating and cooling
- Can deliver one-and-a-half to three times more heat energy to a home than the electrical energy it consumes
- Offers a legitimate space heating alternative in colder region

Central ASHPs	Split ASHPs
Variable Capacity	Variable Refrigerant
Cold Climate	Dual Fuel
Mini-Splits	U/Saddle Window
Conditioning ERV	PTACs/PTHPs

Indoors

Outdoors

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Examples

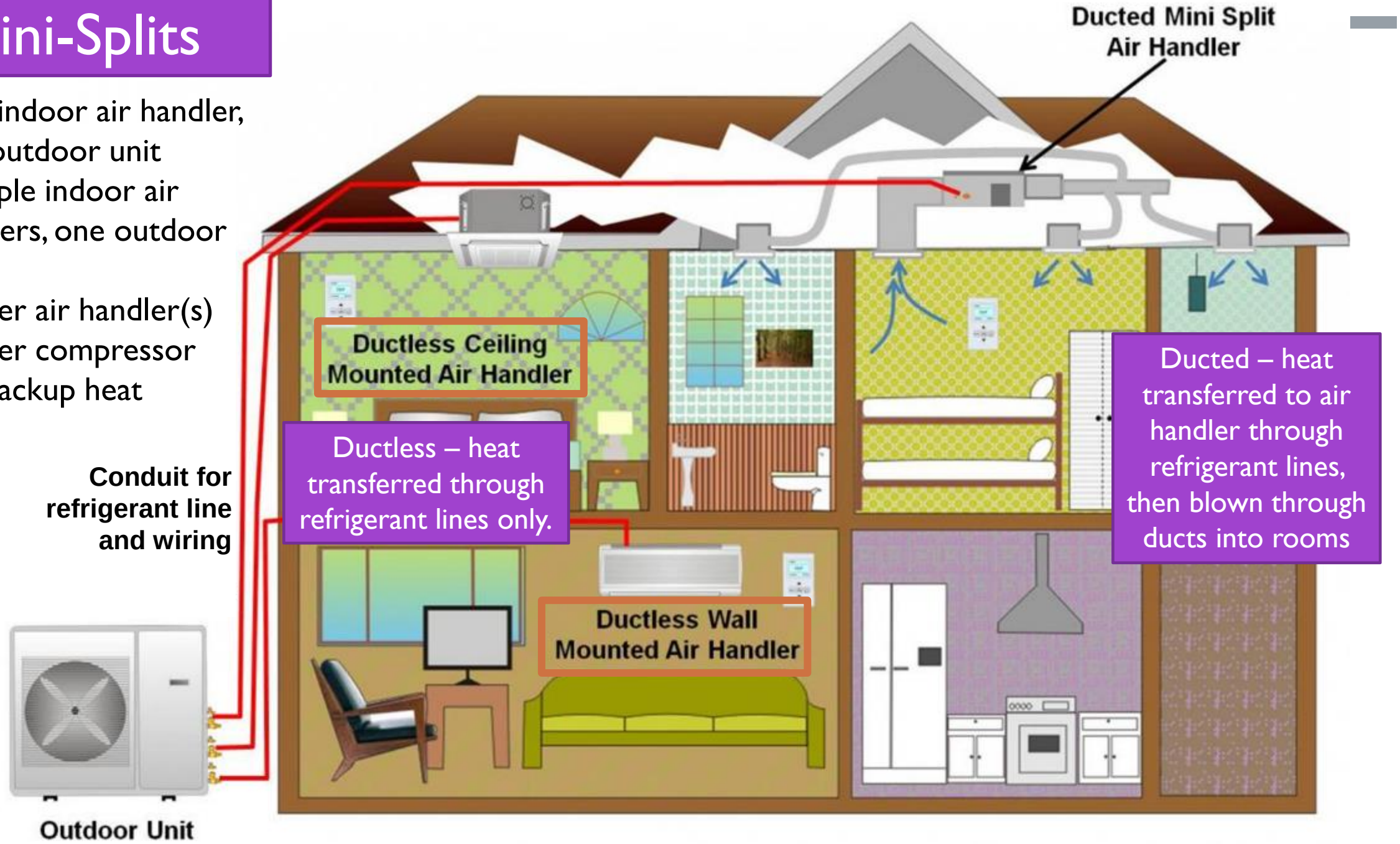
Types of Air Source Heat Pumps

Central Split ASHPs

- Always Ducted
- Most are split systems (except for PTHPs or PTACs)
- Backup electric resistance heat
- Whole-house conditioning
- One air handler conditions the house through ducts

Mini-Splits

- One indoor air handler, one outdoor unit
- Multiple indoor air handlers, one outdoor unit
- Smaller air handler(s)
- Smaller compressor
- No backup heat

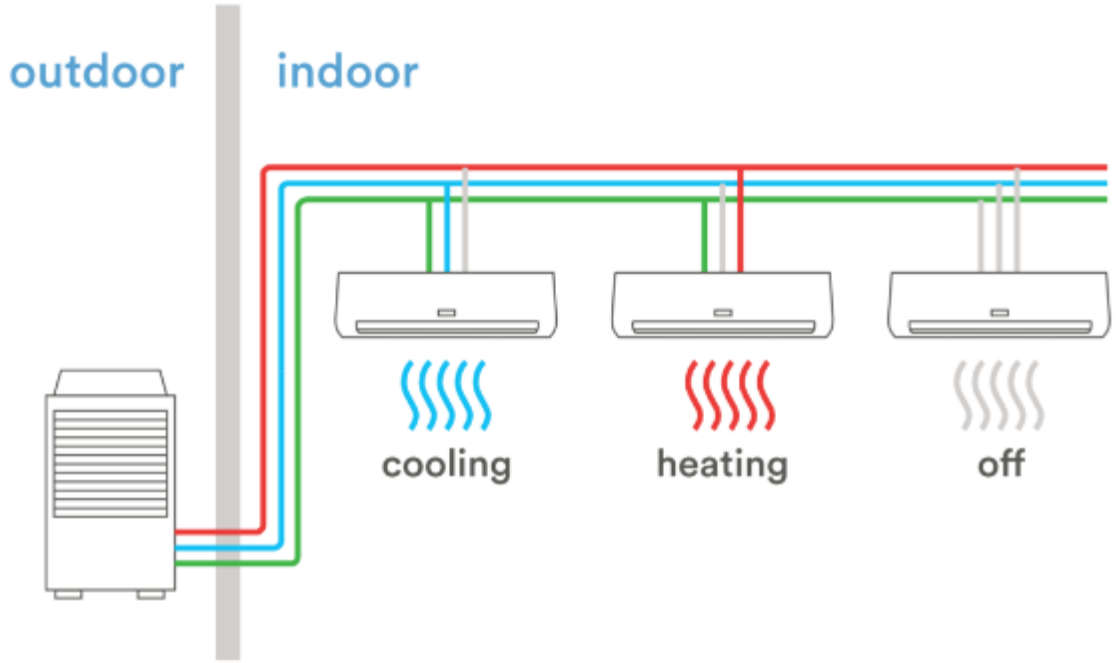


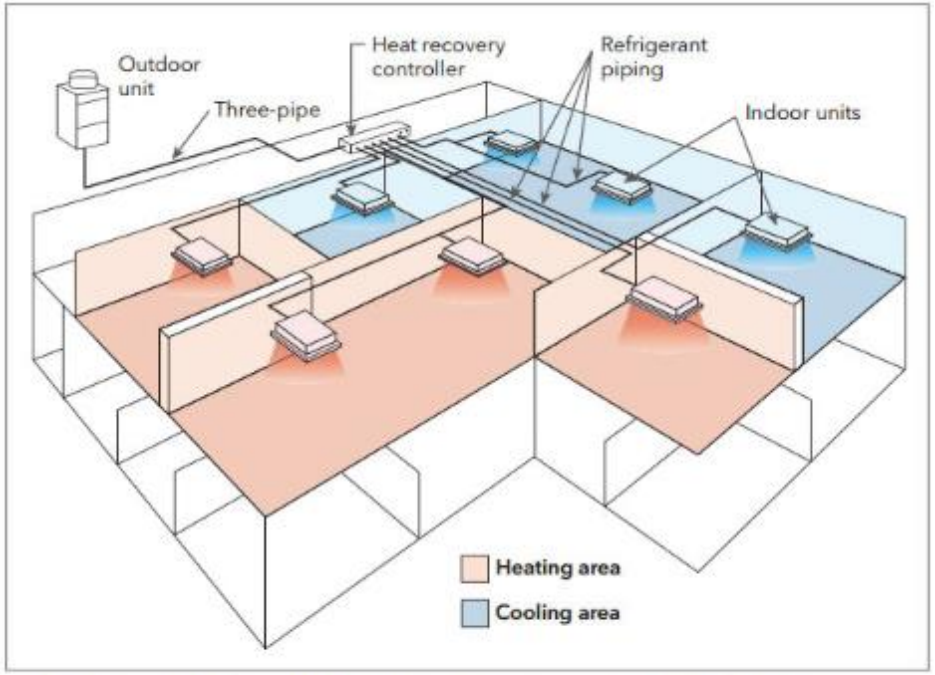
Examples

Types of Air Source Heat Pumps

Variable Refrigerant

- Serve multiple zones in a building, each with different heating and cooling requirements.
- Modulate the amount of refrigerant sent to each zone in accordance with conditioning requirements.





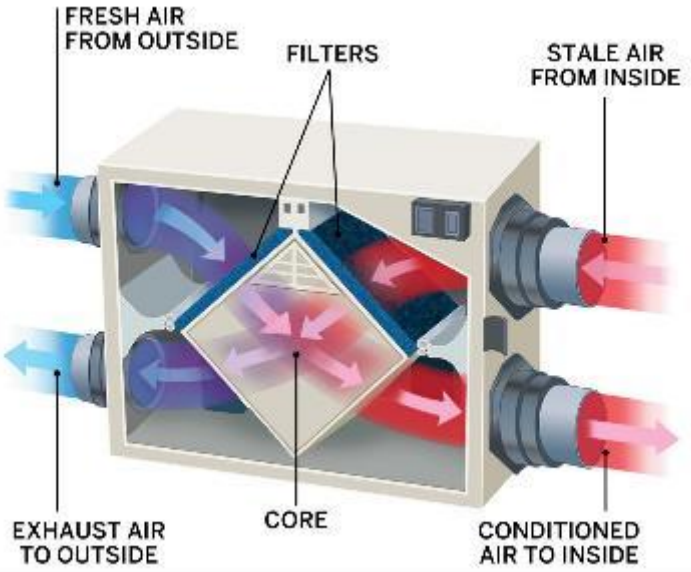
Variable refrigerant flow systems can deliver cooling to some zones and heating to others, with no reheat needed (an air-source system is shown here).

Examples

Types of Air Source Heat Pumps

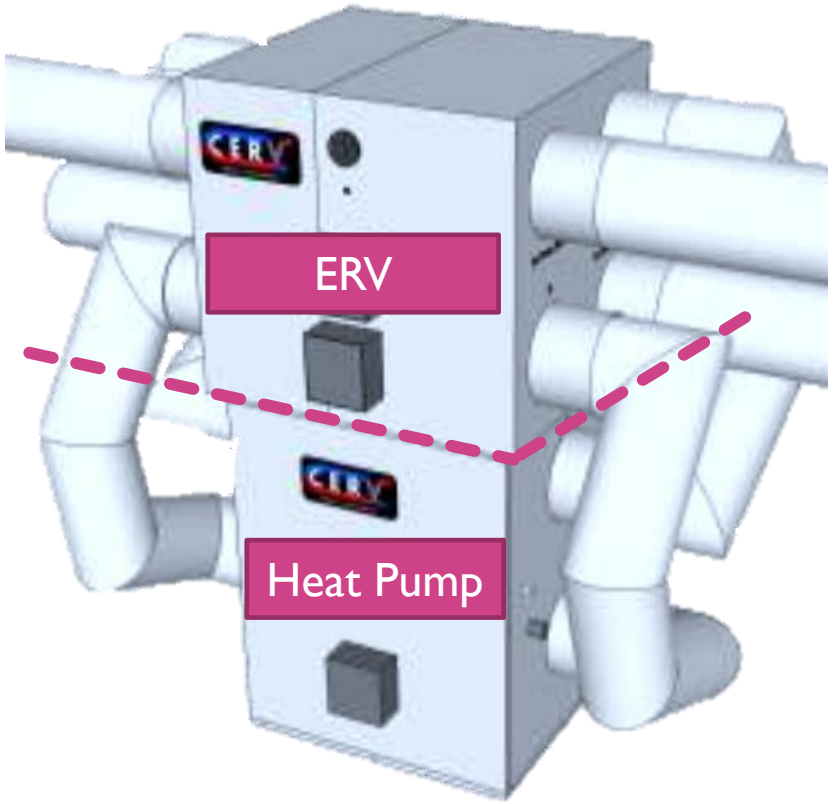
ERV

- Energy Recovery Ventilator reduces load on all HVAC systems.
- Transfers both energy and moisture.
- HRV – transfers only energy



Conditioning ERV

- Energy Recovery Ventilator and Heat Pump combined
- Benefits of ERV directly given to Heat Pump for space conditioning
- Instead of using typical heat exchanger core, CERV exchanges energy through air streams with use of heat pump, which at the same time actively heats or cools the air



Examples

Types of Air Source Heat Pumps

PTACs | PTHPs | U/Saddle Window

Packaged system: both coils are located outside and an outdoor fan pushes air throughout a home.

- Good option for retrofit projects that can't afford a system overhaul – simple, low initial cost
- Newer PTHPs can be installed in windows, like window AC units
- U/Saddle help eliminate leaks around units placed in windows
- Limited fresh air supply – most PTACs do not provide code-required ventilation.
  - PTACs need to work with another ventilation/make-up air source.
- Less efficient than mini-splits

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Examples

What about the winter?

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What are your concerns about Heat Pumps in cold climates?

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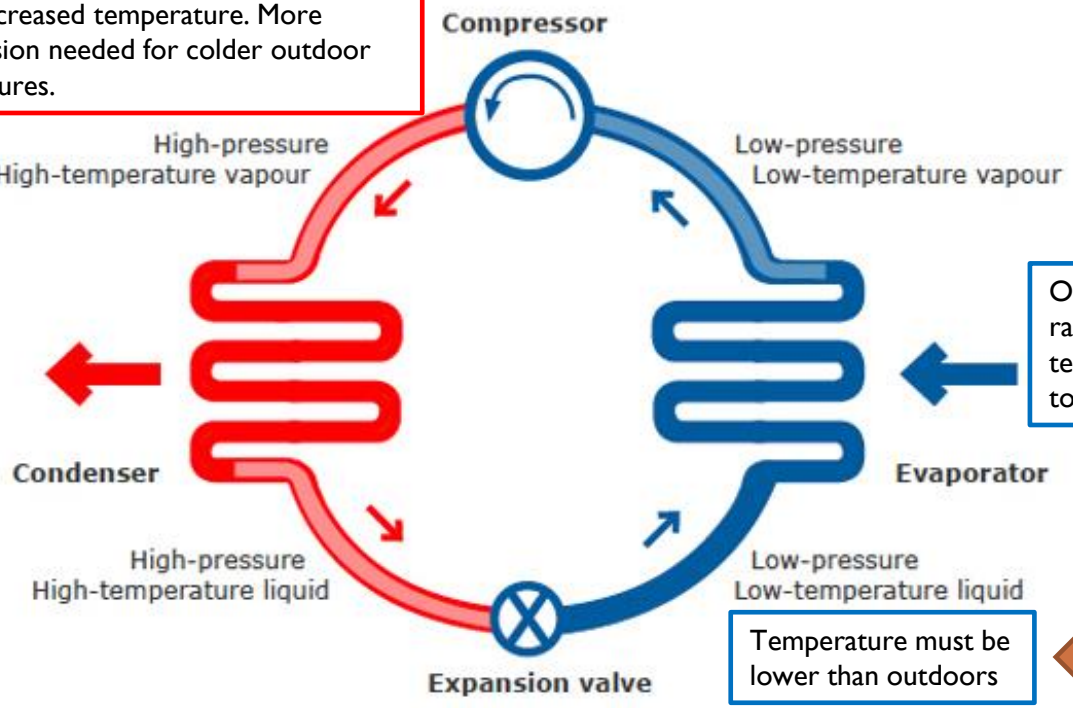
Examples

What about the winter?

Cold climate limitation. Efficiency decrease when more electricity is used for the compressor. Fixed in part by variable-speed compressors.

Electricity used here. Increasing pressure causes increased temperature. More compression needed for colder outdoor temperatures.



Condenser forces phase change. Fan blows over hot coils, pushing warm air into house and cooling the refrigerant to make it a liquid again. Must cool to below critical temperature.

Outdoor temperature raises refrigerant temperature enough to vaporize it

Temperature must be lower than outdoors

Cold climate limitation. How to make temp low enough without too large of a pressure drop? Depending on pressure, these temps can get down to -50 F.

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Examples

What about the winter?

Continuing Barriers

- Bad builder experiences
- Testing standards
- Lower efficiency
- Compressor limitations
- Refrigerant selection
- Frozen coils

Examples

What about the winter?

Recent and Continuing Improvements

- Variable speed compressors
- Improved expansion valves
- Improved coil design
- Efficient and variable speed fans
- Better motors
- Raise off ground, protect from elements

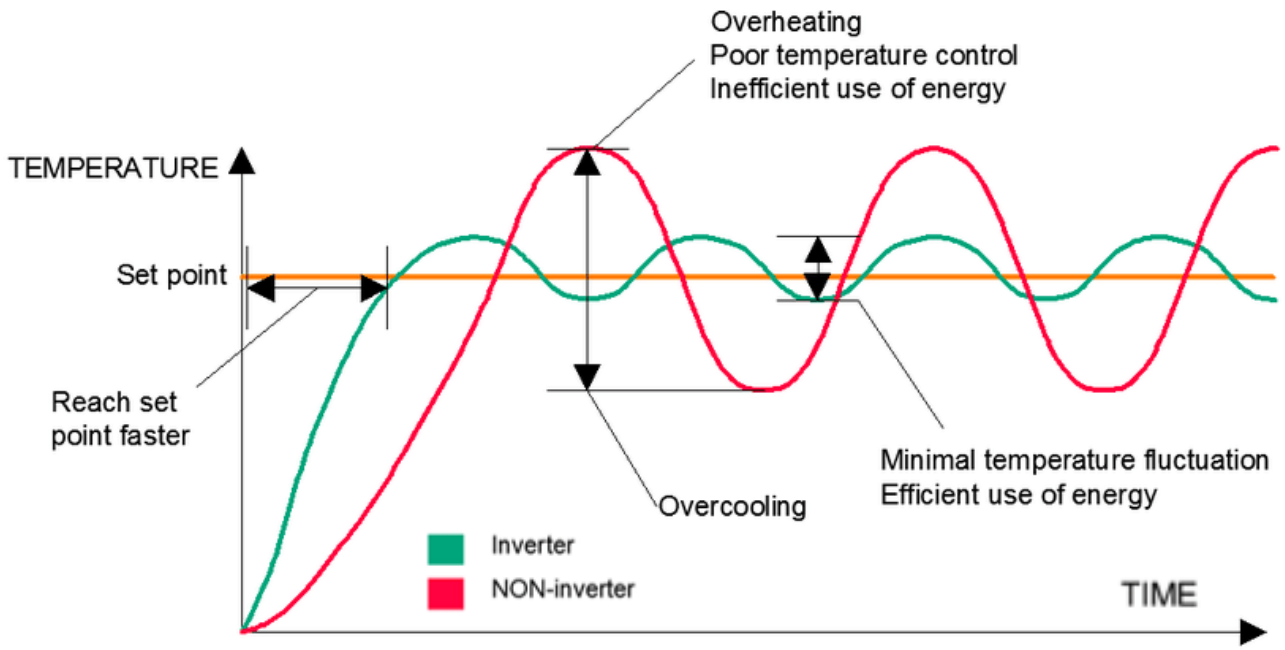
Heat pump in Saxman, Alaska – snow protection

Examples

What about the winter?

Variable Capacity

- **Fixed capacity** ASHPs only run at one capacity, which may be **oversized** for what is needed, **wasting energy**. Turn on and off to meet set point.
- **Inverter:** Part of variable compressor technology that allows variable refrigerant flow/Variable refrigerant volume (coined by Daikin).
- **Efficiency Key:** Can run at the lowest capacity required to deliver the amount of heating or air conditioning needed. Never using more energy than is needed. Can run continuously.
- Well-suited to four-season climates with changing heating and cooling needs.

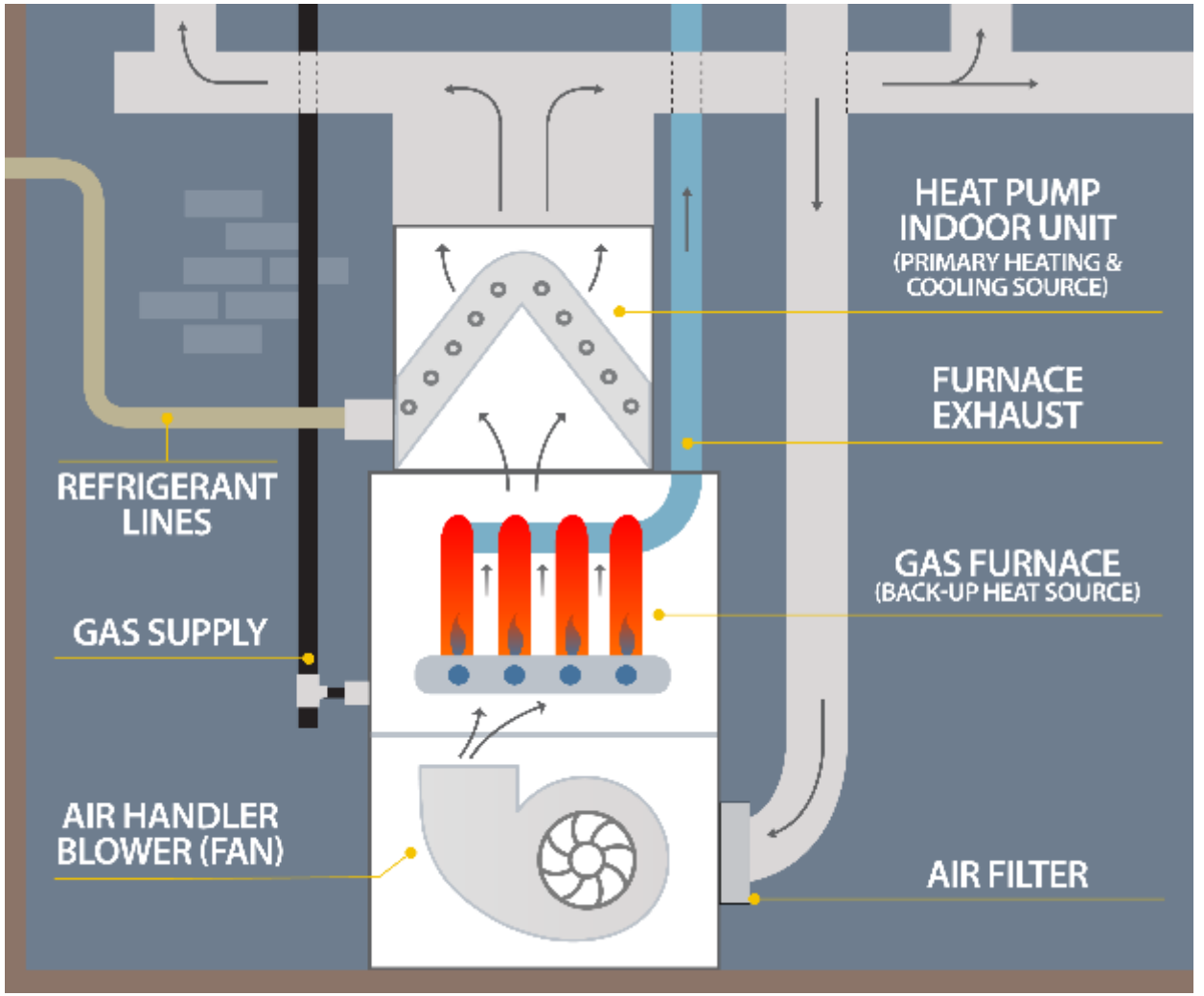


Examples

What about the winter?

Dual Fuel

- Primarily electric heat pump
- Optimized shifts to gas
  - based on temp, needing to catch up, time of use rates – cost of gas/electric
- A dual fuel system capitalizes on the advantages of a heat pump while avoiding its disadvantages by switching to gas when the system decides it is necessary or favorable to do so



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OLD

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Examples

What about the winter?

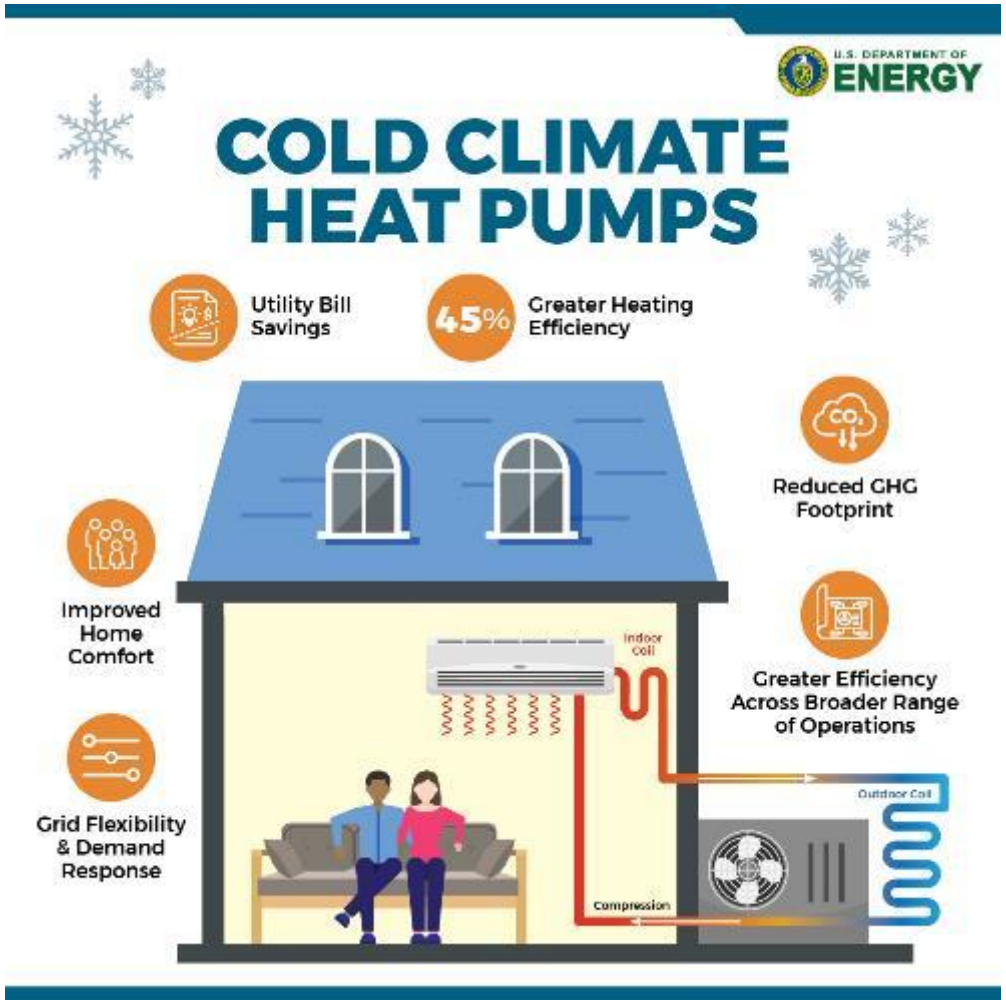
Air to Water Heat Pumps (Hydronic ASHPs)

- Besides outdoor air temperature another big driver for efficiency in **air to water heat pumps** is **supply water temperature**.
- Radiant floor systems can perform very well with lower supply temperatures, resulting in exceptionally high heat pump COPs, even in cold climates

Examples

What about the winter?

- Cold Climate Heat Pump Technology Challenge – sponsored by DOE
- More than 20 utilities, cooperatives, and state agencies have committed to the Challenge.
- Deployment and commercialization are planned for 2024.



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Examples

What about the winter?

ENERGY STAR Cold Climate designation for Heat Pumps manufactured on/after January 1, 2023

- **Performance at 5°F**: COP ≥ 1.75
- **Heating Capacity at 5°F**: ≥ 70% of capacity at 47°F
- Controls verification procedure confirming that these performance metrics are achieved by **native controls** operating as they would in a customer's home
- All values from tests according to M1, where before they could be based on manufacturer data.

ENERGY STAR® Program Requirements
Product Specification for Central Air Conditioner and Heat Pump Equipment

Eligibility Criteria
Version 6.1

Table 3: Energy-Efficiency Criteria for Certified Residential Cold Climate Heat Pumps

Product Type	SEER2	HSPF2
HP Split Systems (Non-Ducted)	≥ 15.2	≥ 8.5
HP Split Systems (Ducted)	≥ 15.2	≥ 8.1
HP Single Package Equipment[1]	≥ 15.2	≥ 8.1

1. Excludes gas/electric package heat pumps, which are not eligible for the Cold Climate designation.

Examples

Successful NYS ASHP Projects

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Examples

Successful NYS ASHP Projects

Dual Fuel Case Study

- Most dual fuel systems decide what fuel to use based on a static switchover temperature.
- Newport's case study tests a more advanced control scheme.
  - Monitors outdoor temperature, heat pump efficiency based on that temperature, and price of electricity at that moment. (Time-varying electric rates are used for load balancing throughout a utility's service area.)
  - Calculates an overall economic efficiency metric to compare with the economic efficiency of the gas furnace. This allows the dual fuel system to choose the system with the highest efficiency per energy cost. System controls are based on **temperature *and* price of electricity**.

TEST SITE

2385 sq. ft, Single-family, 2-story colonial with basement and partial crawlspace

The home is weatherized so it does not have excessive heating loads which could undermine the heat pump. Insulation levels meet recent energy code levels. 3.5 ACH50 infiltration

Location: Capital District of Upstate NY

Climate Zone 5A (6562 HDD, 5129 CDH, Design Winter Heating Temp 4°F, Albany, NY)

Home has a 2019-installed, 2-stage 96 AFUE gas furnace heating system. A/C unit is original, 20+ years old. Ready for retrofit.

NEV

Outdoor unit labels.

OLD

NEW

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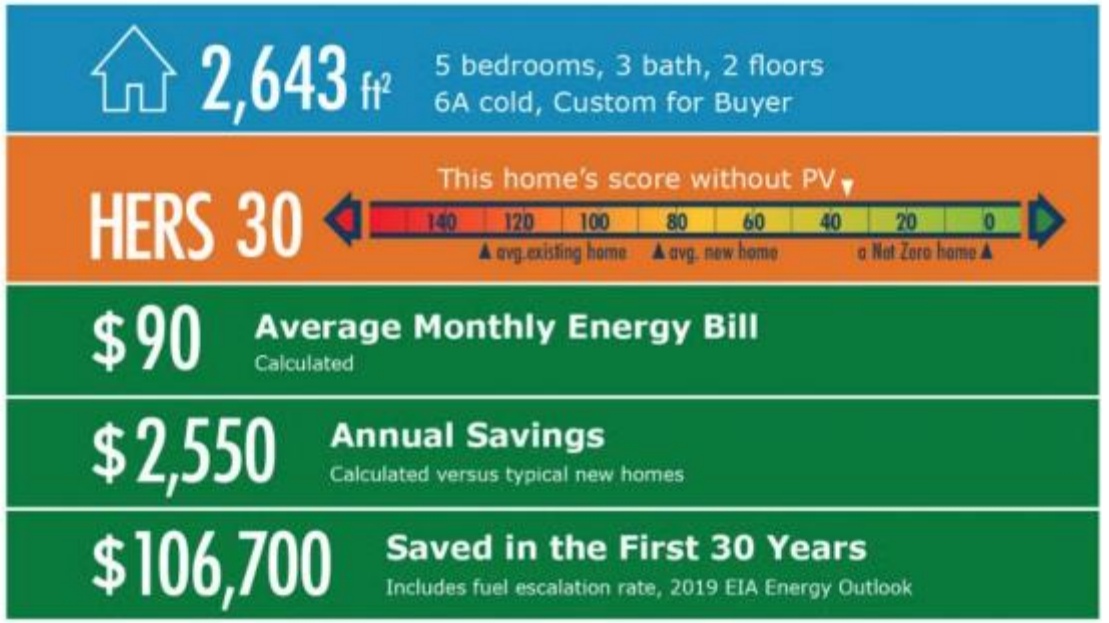
Examples

Successful NYS ASHP Projects



"[In] our old home we were paying about $4,000 a year to heat it. Now we pay … $250."

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

Simple Integrity
Cooperstown , NY
SimpleIntegrityLLC.com
Project: The Haven
Cooperstown, NY

U.S. DOE ZERO ENERGY READY HOME 2020 *Honorable Mention*

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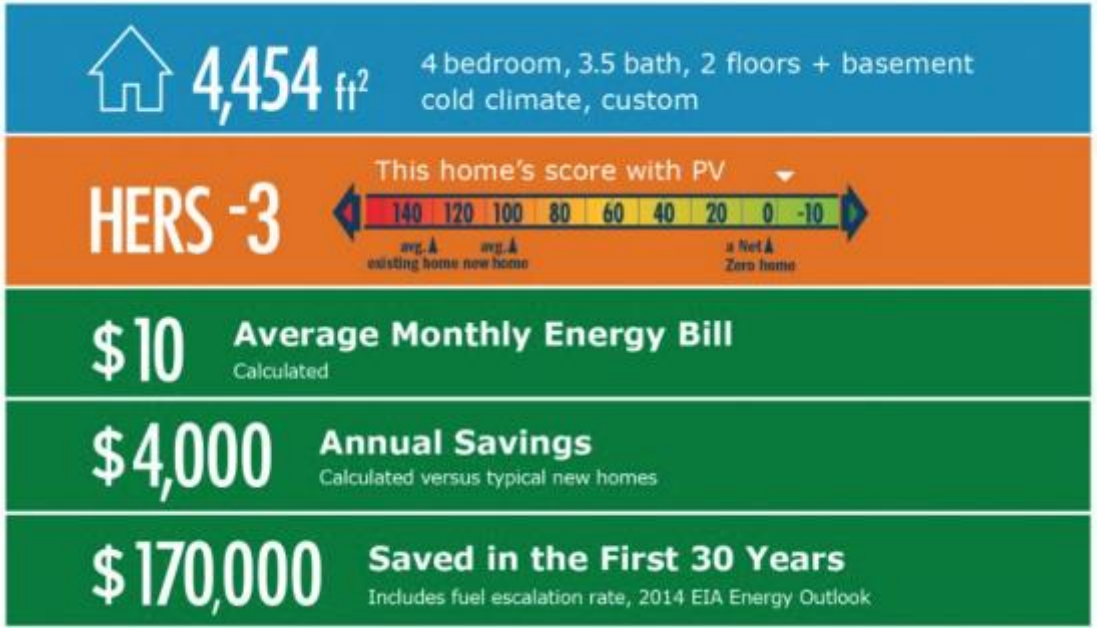
Examples

Successful NYS ASHP Projects



"It is not often that the responsible thing to do for the greater good also turns out to offer immediate personal economic benefits."

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

Greenhill Contracting

Esopus, NY
zeronetnow.com
Project: Green Acres #20

U.S. DOE ZERO ENERGY READY HOME 2015 WINNER Housing Innovation Awards

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Examples

Successful NYS ASHP Projects

467 ft² — 1 bedroom, 1 bath, 1 floor
6A cold climate, multifamily

HERS 26 — This home's score without PV
140 120 100 80 60 40 20 0
avg. existing home | avg. new home | Net Zero home

$50 **Average Monthly Energy Bill**
Calculated

$1,100 **Annual Savings**
Calculated versus typical new homes

$41,000 **Saved in the First 30 Years**
Includes fuel escalation rate, 2015 EIA Energy Outlook

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

AquaZephyr
Ithaca, NY
ecovillageithaca.org
Project: Tree at EcoVillage

U.S. DOE ZERO ENERGY READY HOME 2016 WINNER Housing Innovation Awards

"In most cases, we find building to zero net energy ready levels is not a significant added cost."

Examples

Successful NYS ASHP Projects

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Examples

Successful NYS ASHP Projects

"It's the most comfortable home I've ever lived in."

- Homeowners

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

Under the Sun Building and Remodeling

Greenwich, NY
underthesunbuildgreen.com
Project: Easton Carriage House
Schaghicoke, NY

U.S. DOE ZERO ENERGY READY HOME 2022 WINNER Housing Innovation Awards

RESOURCES

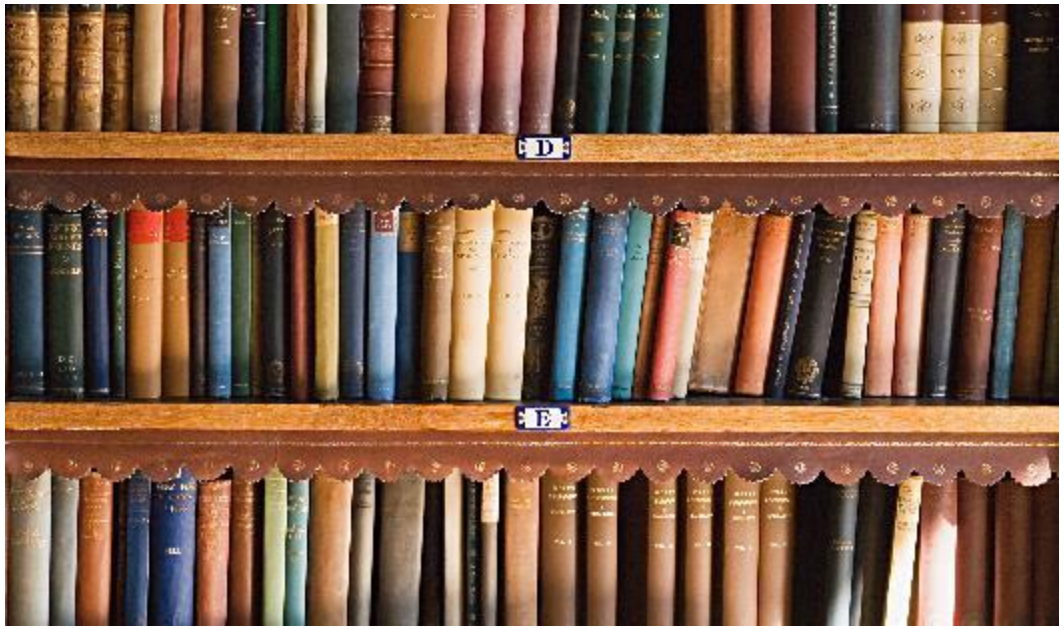
Building America Solution Center

Zero Energy Ready Homes

Net Zero Homes

Newport Partners www.newportpartnersllc.com

Newport Ventures www.newportventures.net



THANK YOU!

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