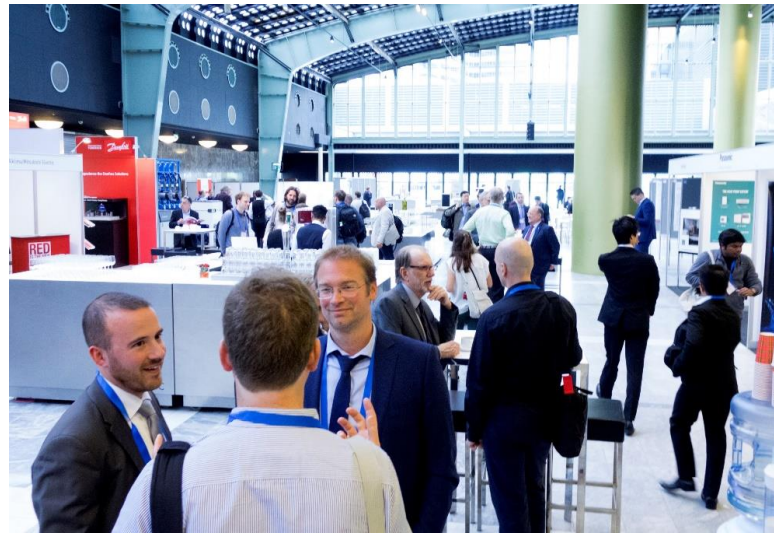


# IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

## US Country Report - 2023



Research, Development, Demonstration, and Deployment of Heat Pumping Technologies

# US Country Report – 2023

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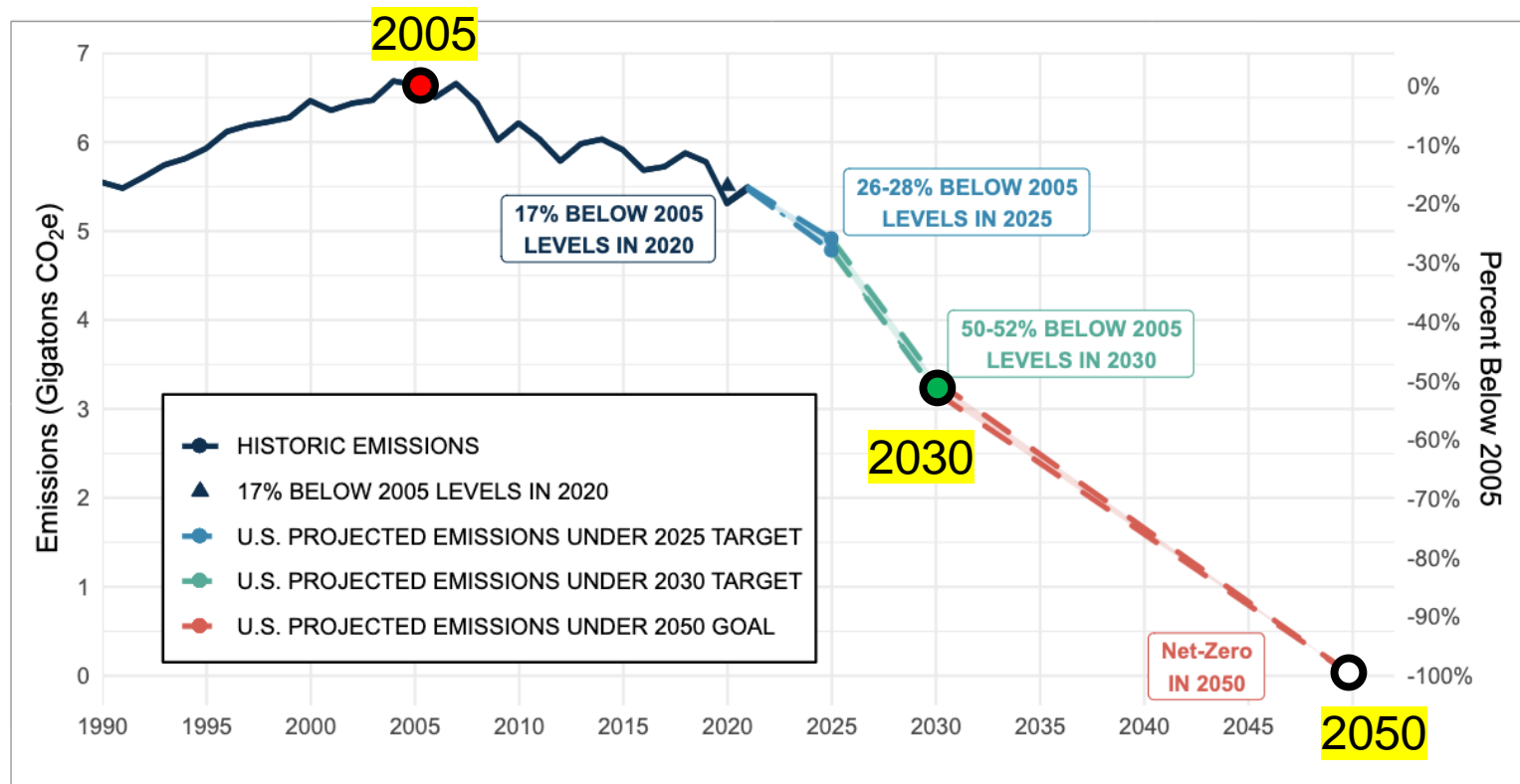
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# Outline

- US Policies and Programs
- Heat Pump Market
- Economic Factors
- Efficiency Standards
- Current R&D Focus
- Summary and Outlook

# US Greenhouse Gas Emission (GHG) Goals

- Reduce GHG emissions by 50%–52% from 2005 levels in 2030
- 100% carbon pollution-free electricity by 2035
- Net-zero emissions economy-wide no later than 2050

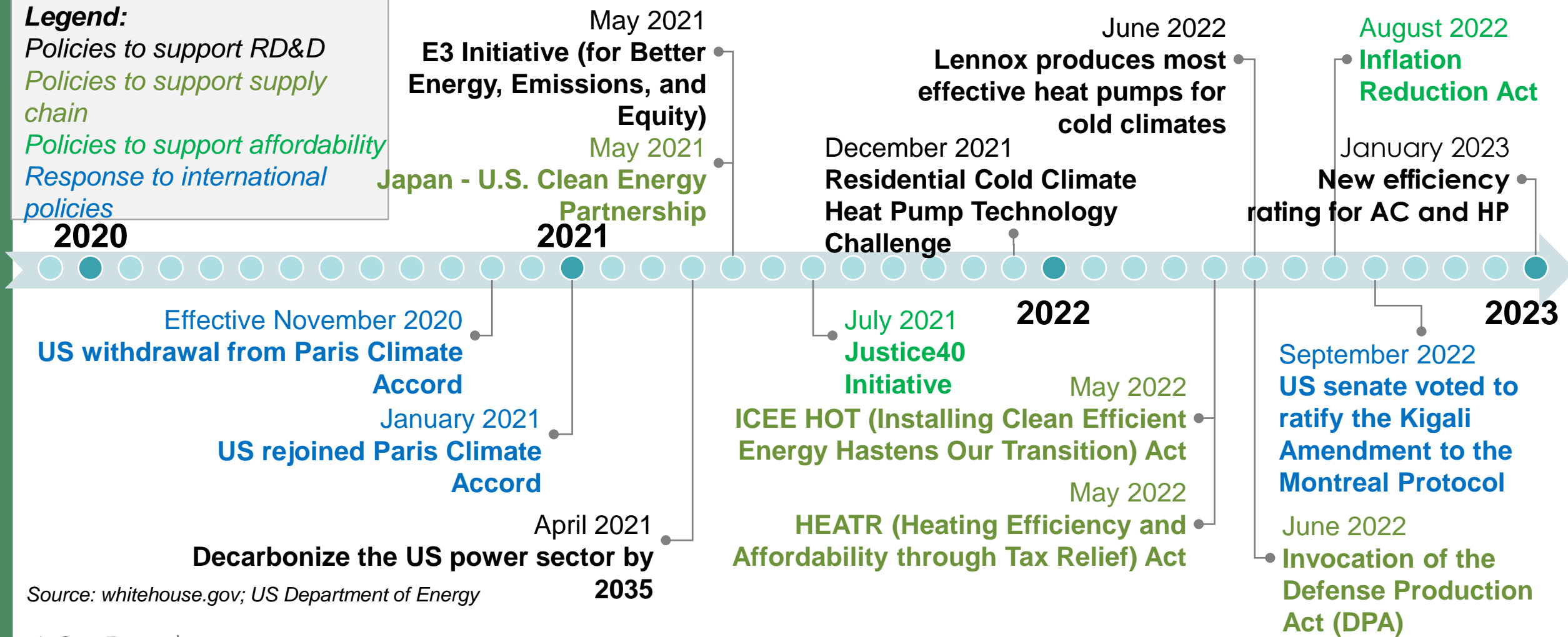


United States historic emissions and projected emissions under the 2050 goal for net-zero.

Source: *The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050*. November 2021. [whitehouse.gov](https://www.whitehouse.gov)

# US Policies and Programs

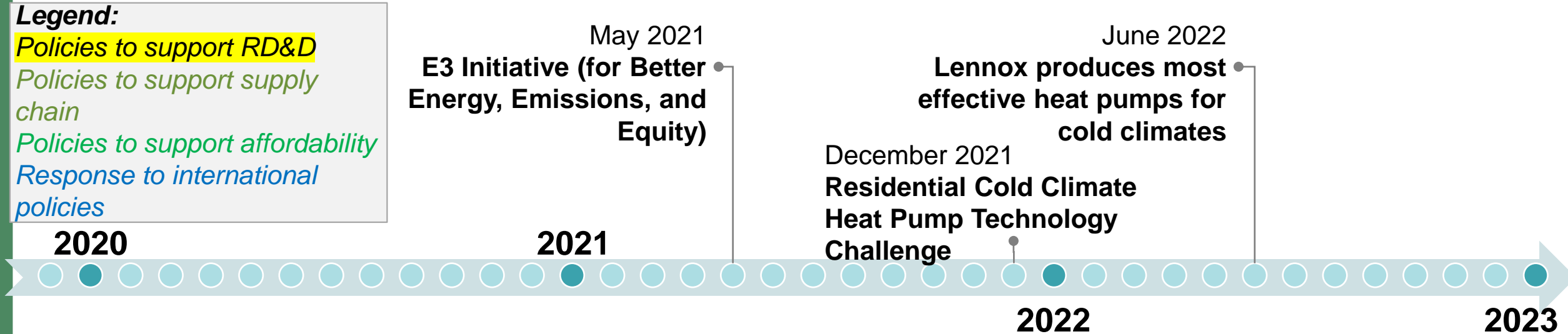
**Legend:**  
*Policies to support RD&D*  
*Policies to support supply chain*  
*Policies to support affordability*  
*Response to international policies*



Source: whitehouse.gov; US Department of Energy

# US Policies and Programs

**Legend:**  
**Policies to support RD&D**  
*Policies to support supply chain*  
*Policies to support affordability*  
*Response to international policies*



- E3 Initiative (Initiative for Better Energy, Emissions, and Equity)**
- Advanced Water Heating Initiative
  - Residential Cold Climate Heat Pump Technology Challenge
  - Collaborative RD&D on low to no-GWP refrigerants
  - Residential HVAC Smart Diagnostic Tools Campaign
  - Better Buildings Low Carbon Pilot

Source: *whitehouse.gov*; *US Department of Energy*

# US Policies and Programs

**Legend:**  
*Policies to support RD&D*  
*Policies to support supply chain*  
*Policies to support affordability*  
*Response to international policies*

May 2021  
**Japan - U.S. Clean Energy Partnership**

2020

2021

2022

2023

**The Defense Production Act (DPA)** allows the president to direct resources to ensure the supply of materials and services necessary for national defense.

DPA was invoked in June 2022 to rapidly expand US manufacturing of five critical clean energy technologies, including heat pumps.

June 2022  
**Invocation of the Defense Production Act (DPA)**

Source: [whitehouse.gov](https://www.whitehouse.gov/); US Department of Energy

# US Policies and Programs

**Legend:**  
*Policies to support RD&D*  
*Policies to support supply chain*  
***Policies to support affordability***  
*Response to international policies*

**Inflation Reduction Act of 2022** aims to curb inflation by

- Lowering health care costs
- Reducing the federal deficit
- Investing into domestic clean energy production and manufacturing

August 2022  
**Inflation Reduction Act**

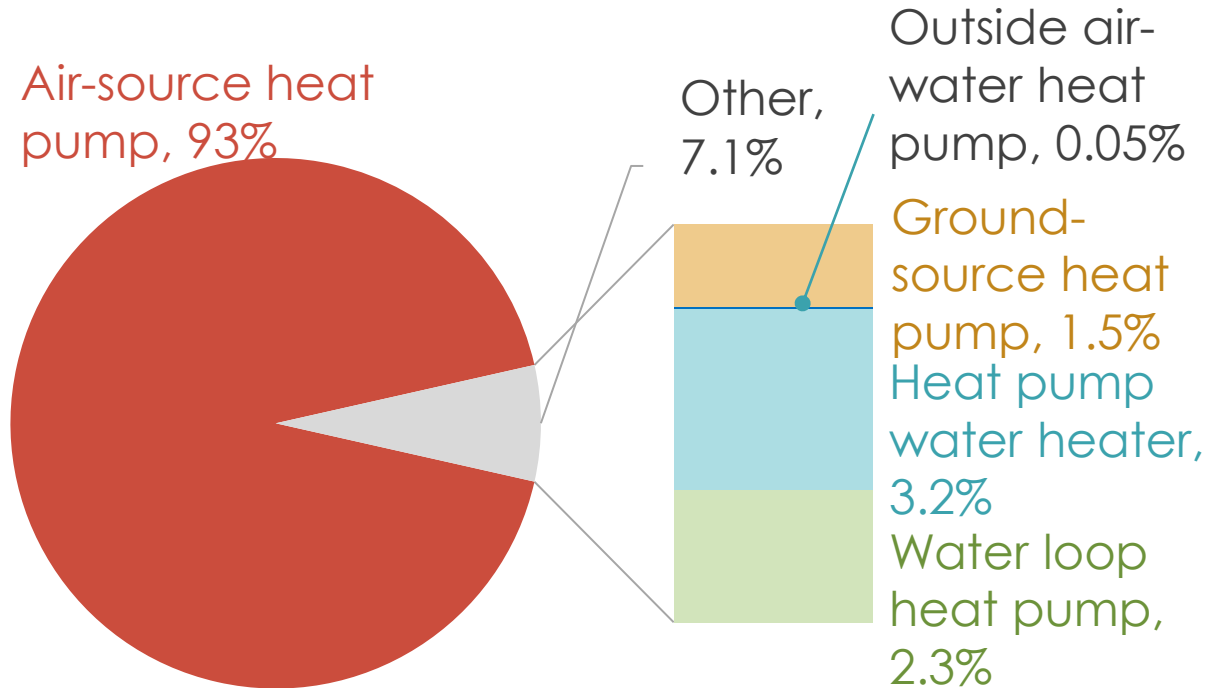
July 2021  
**Justice40**

**Justice40 Initiative** aims to direct 40% of the overall benefits of certain federal investments, including clean energy and energy efficiency, toward disadvantaged communities.



Source: [whitehouse.gov](https://www.whitehouse.gov); US Department of Energy

# US Heat Pump Market

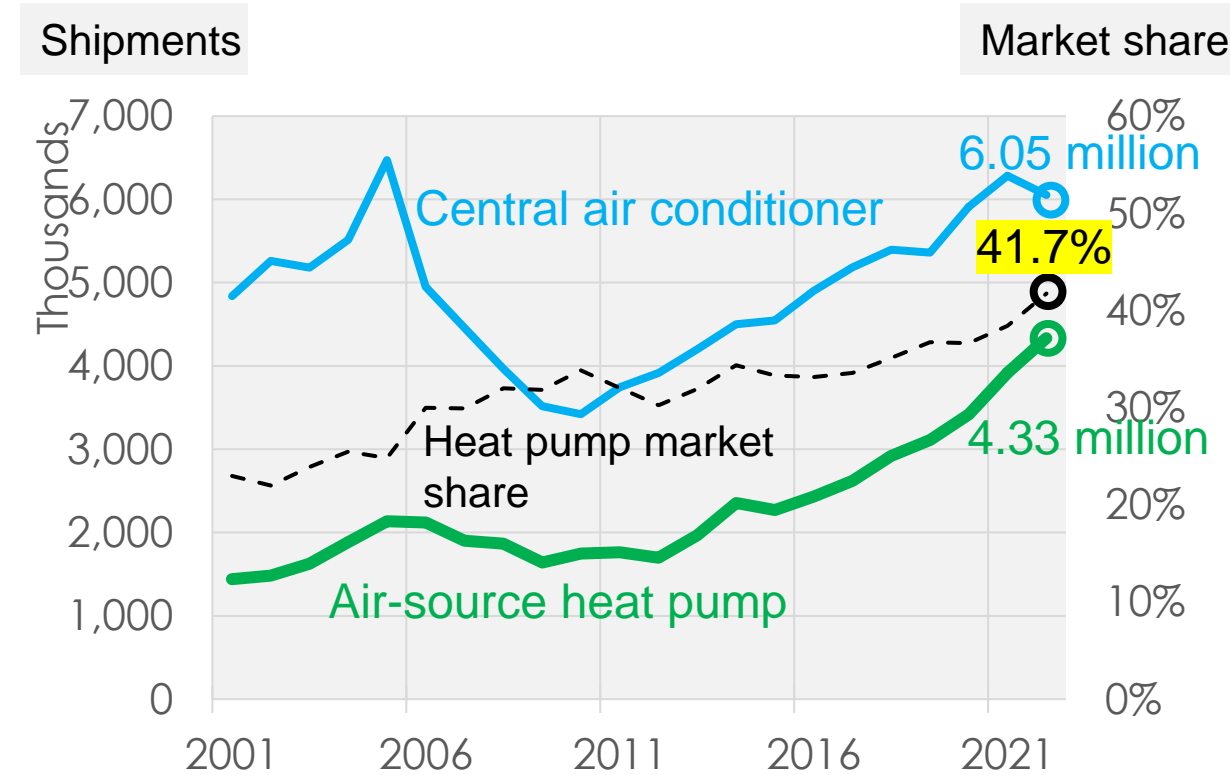
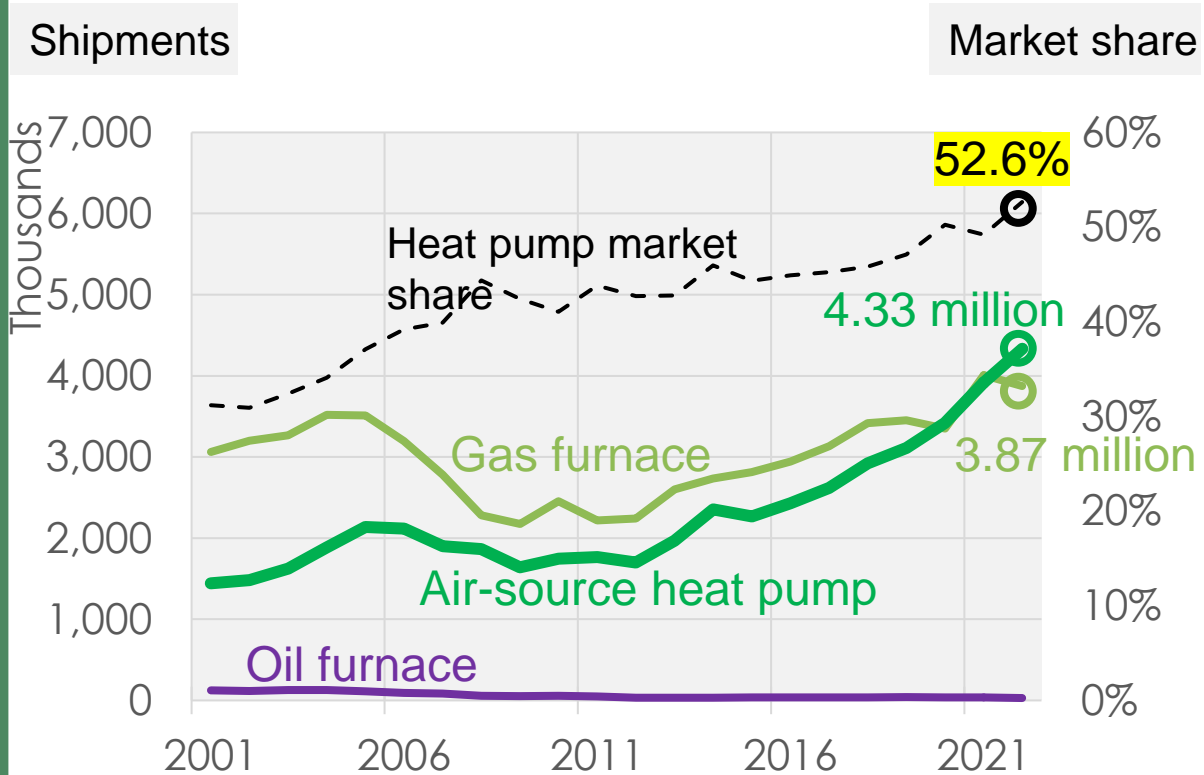


2022 market distribution of heat pump technologies.

Based on data from "The North American Heating & Cooling Product Markets, 2022 Edition," BRG Building Solutions.

- Air-source
  - Air-to-air air-source heat pumps (ASHP); ~93% of US market
  - Air-to-water heat pumps <0.1% of market
  - Air-to-water heat pump water heaters (HPWH); 3.2% of market
- Fluid (water or brine)-source
  - WLHP systems (2.3%)
    - Used in multi-family or office buildings; individual heat pump in each zone tied to central water loop controlled to ~21-32C (~70-90F) temperature range as heat source/sink (aka boiler/tower system)
  - GSHP or geothermal (1.5%)
    - Res. or comm'l applications; based on heat pumps designed for much wider source/sink temperature range (-5 to 35C or wider) (~23-95F or wider)

# Air-Source Heat Pump Shipments 2001-2022



ASHP shipments compared with furnaces and central air conditioners (aka cooling-only heat pump).

Based on data from: The Air-Conditioning, Heating, and Refrigeration Institute (AHRI). Historical Data. <https://www.ahrinet.org/analytics/statistics/historical-data>

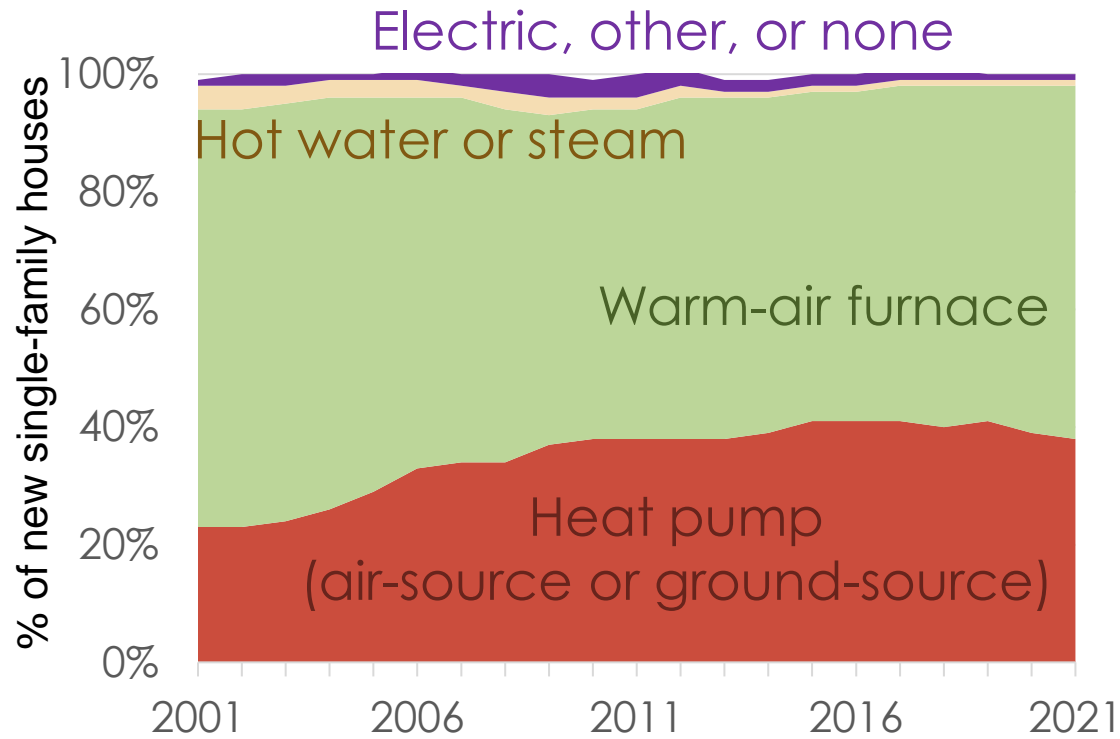
# 2023 Shipments to-date

## Through 1<sup>st</sup> four months, 2023 vs. 2022

- Central AC shipments down **22.9%** (1.586M vs. 2.032M)
- ASHP shipments down **5.9%** (1.263M vs, 1.342M)
- Gas warm air furnace shipments down **21.7%** (1.006M vs. 1.286M)
- ASHP continues trend of gaining central heating system market share at expense of gas furnaces; ~56% for 2023 to-date

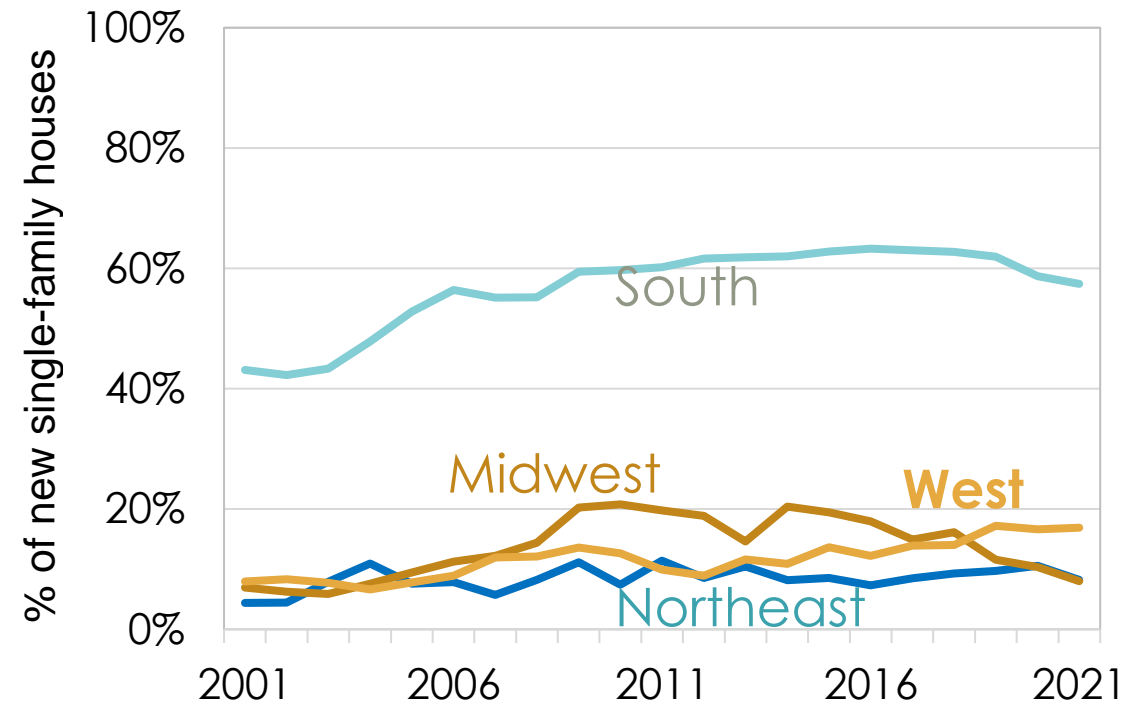
Data source: The Air-Conditioning, Heating, and Refrigeration Institute (AHRI). Historical Data. <https://www.ahrinet.org/analytics/statistics/historical-data>

# Heat Pump Market Share



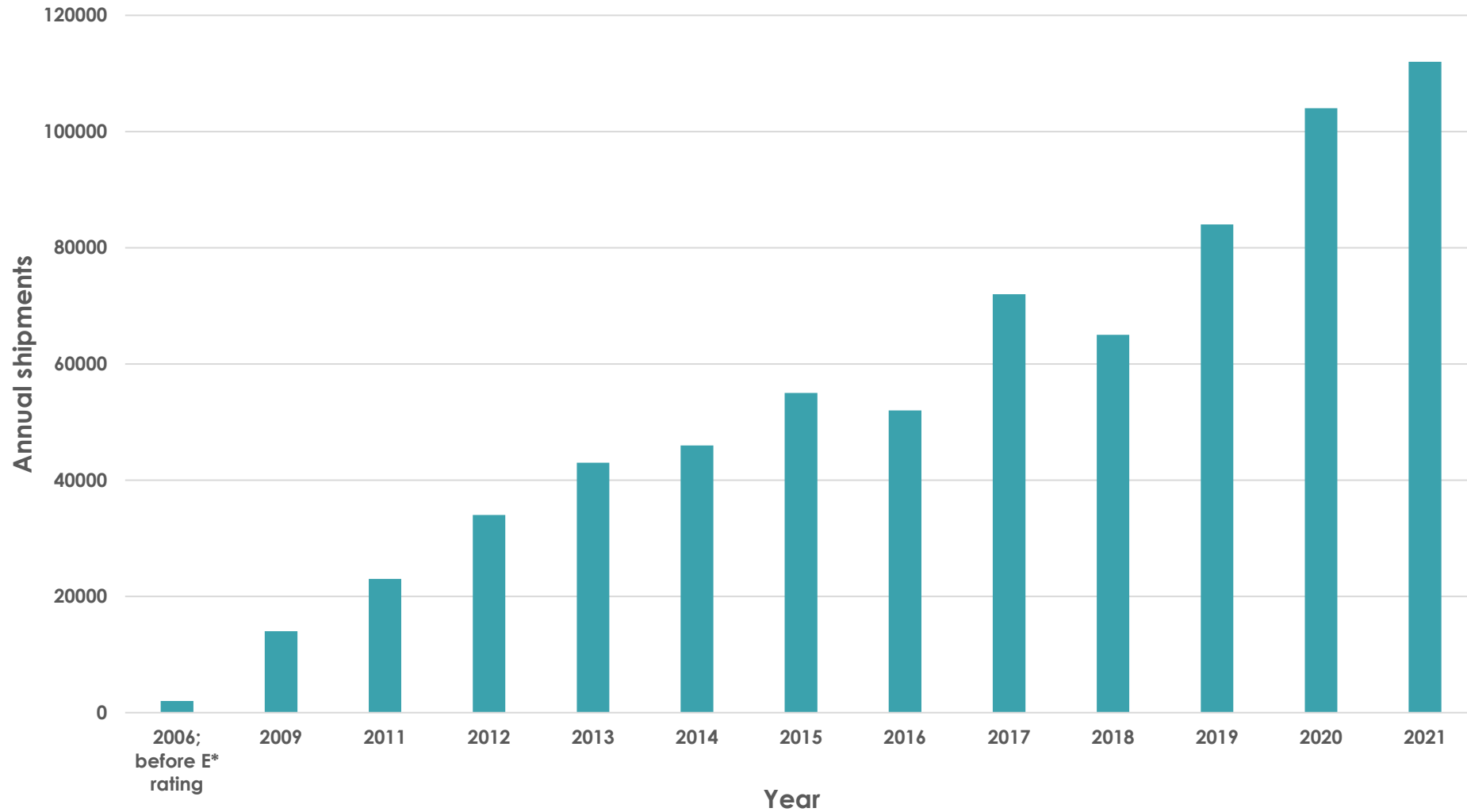
38% of new single-family homes completed in 2021 in the US used a heat pump as their primary heating source.

Based on data from US Census Bureau



Most of these heat pump installations are in the South.

# HPWH shipment history



Data sources: a) Energy Star - [https://www.energystar.gov/partner\\_resources/products\\_partner\\_resources/brand\\_owner\\_resources/unit\\_shipment\\_data](https://www.energystar.gov/partner_resources/products_partner_resources/brand_owner_resources/unit_shipment_data) for 2009-2021;  
b) ORNL estimate for 2006

# GSHP shipment history



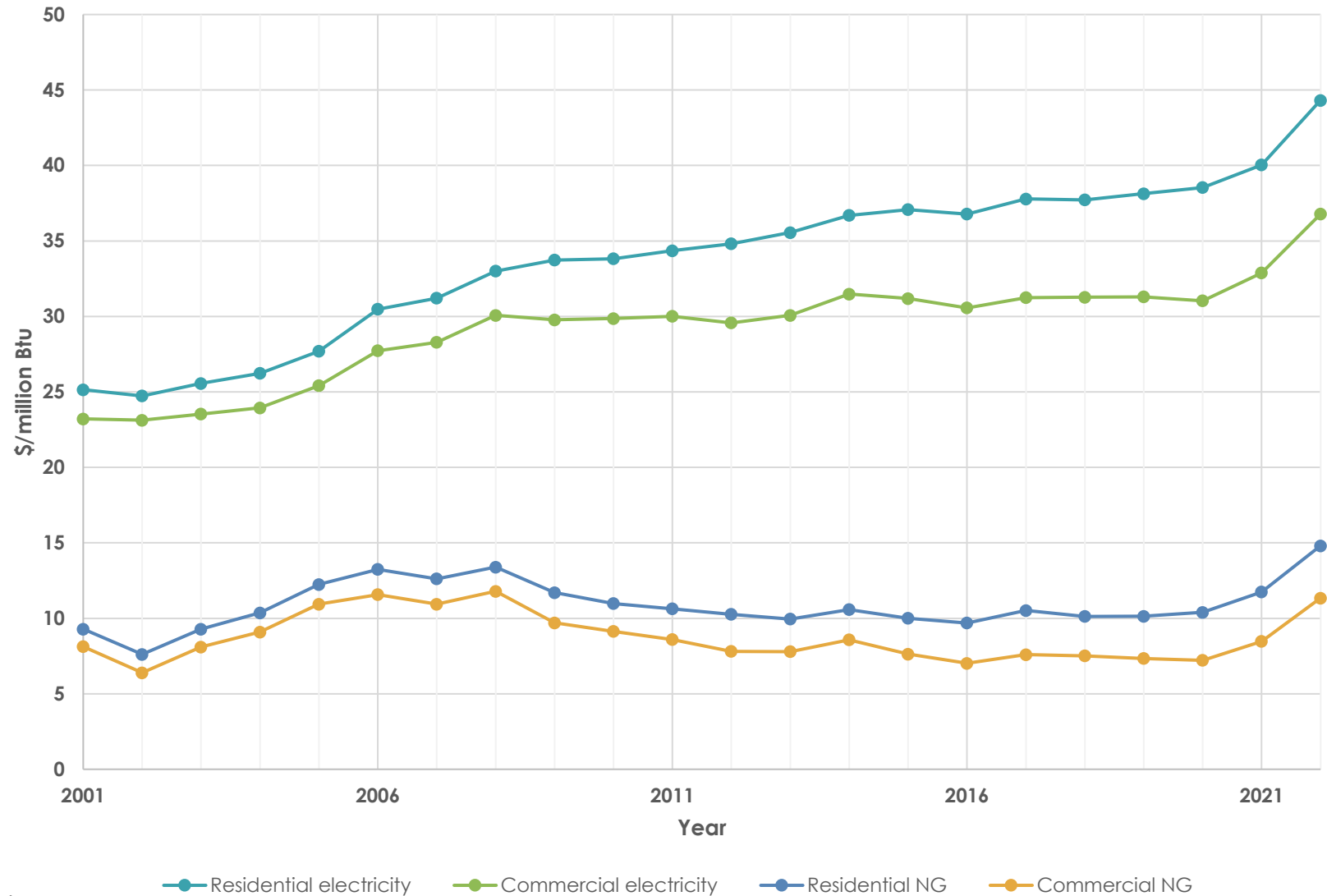
**2006-09 EIA data likely includes data for water-to-air heat pumps intended for both WLHP and GSHP system types**

**NOTE: EIA stopped tracking shipments after 2009**

Based on data from a) DOE Energy Information Administration and b) "The North American Heating & Cooling Product Markets, 2022 Edition," by BRG Building Solutions.

# Average Energy Prices for US Residential and Commercial Customers

- Electric prices generally rose throughout period with sharp increase in 2021 and 2022
- Gas prices rose faster than electricity in early part of period then fell back and plateaued; began increasing again in 2021
- Residential customers pay slightly higher prices on average
- For 2023, Jan-Feb, electric prices are up 10-14% and gas prices up 25-26%

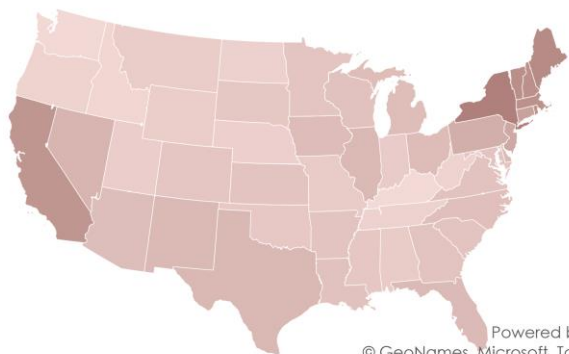


Data source: DOE Energy Information Administration (EIA)

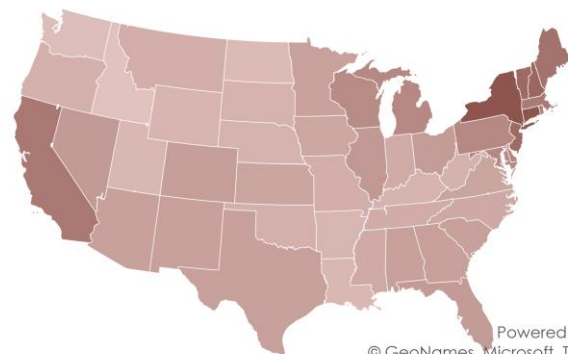
# Residential Energy Prices

## Electricity Price

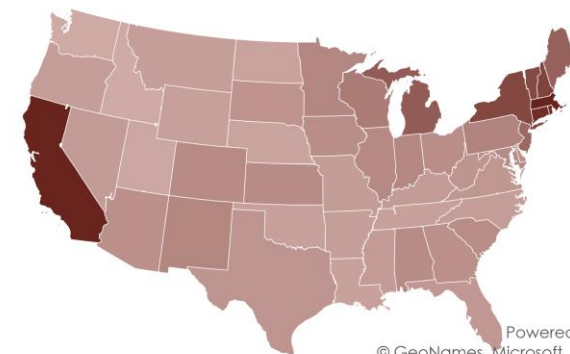
(cents/kWh)



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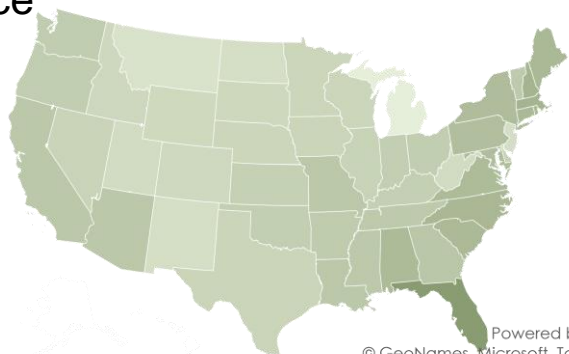
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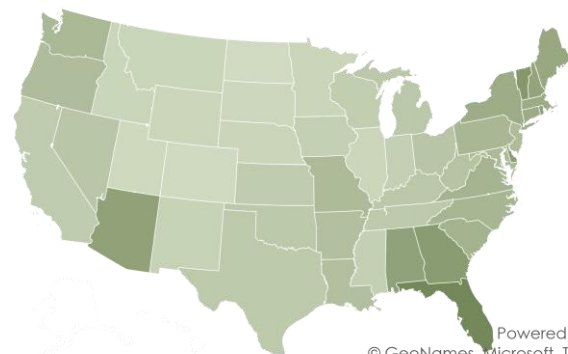
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## Natural Gas Price

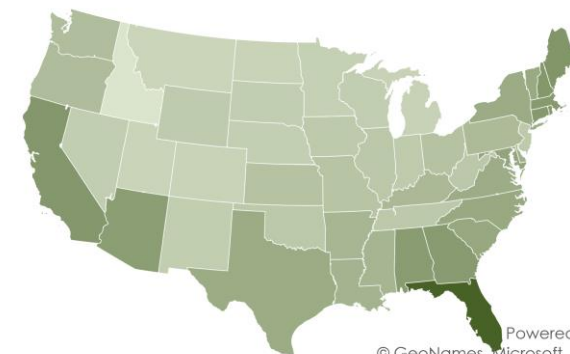
(\$/1000 cuft)



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2001

2011

2021

Regional differences in the heat pump market share can largely be attributed to the milder winters combined with lower electric-to-natural gas price ratios in the southern states.

Data source: US Energy Information Administration

# Financial Incentives

## **Inflation Reduction Act of 2022**

- Tax credits of \$300 for installing ASHP and HPWH in existing homes that meet specified efficiency criteria
- Rebates of 50%–100% up to \$14,000 on electrification measures for low- and moderate-income households

## **Renewable energy tax credits**

- Tax credits of 22%–30% of system cost for GHP installation in existing homes and new construction

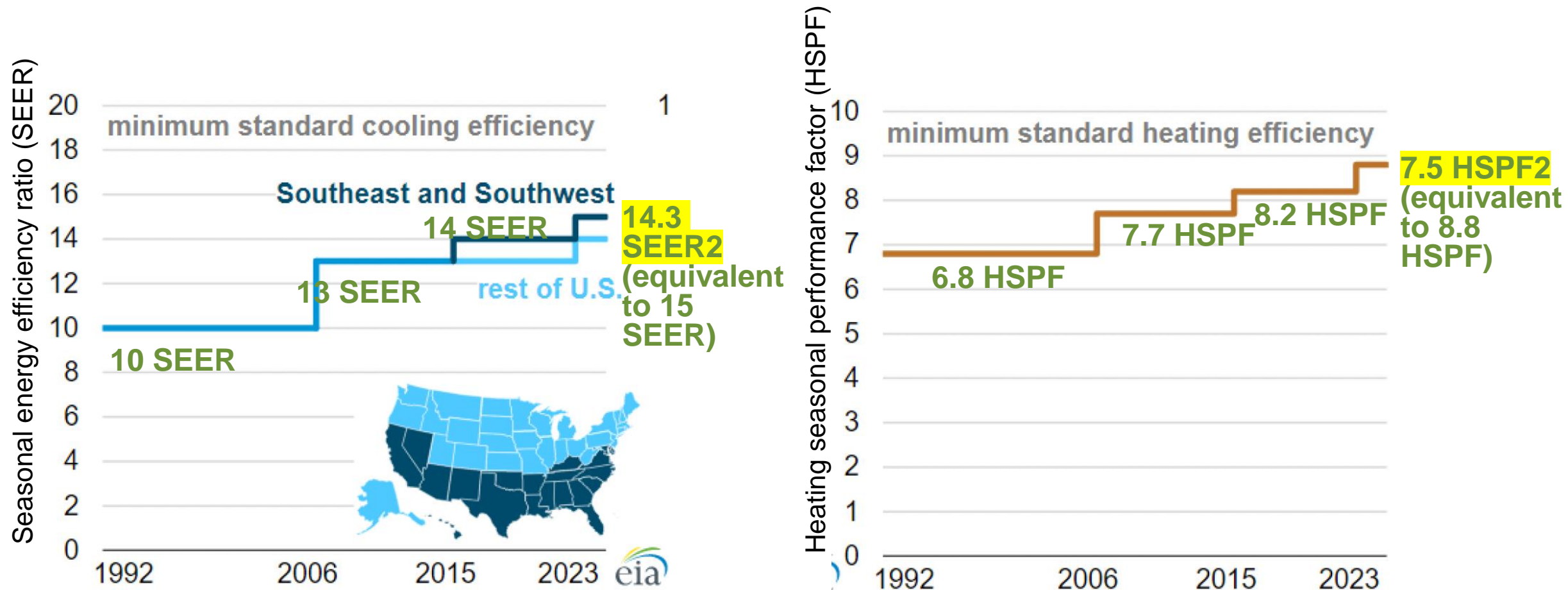
## **Rebate programs by states**

- For ASHP and GHP installation

## **Loan programs, grant programs, and Property-Assessed Clean Energy (PACE) financing**

*Sources: Energy Star; Database of State Incentives for Renewables & Efficiency (DSIRE); US Department of Energy*

# CAC and ASHP Minimum Efficiency Requirements



Performance standards of residential central **air conditioning equipment** and **heat pumps**.

Data source: US Energy Information Administration, <https://www.eia.gov/todayinenergy/detail.php?id=40232#>

# SEER vs. SEER2

- SEER2 is the new cooling efficiency rating for air conditioning equipment that took effect January 1, 2023
- It is calculated the same way as SEER but is based on a revised testing procedure
  - Designed to more accurately reflect installed field conditions for air conditioners and heat pumps
  - One of the main differences in the new test procedure is that higher external air-side pressure drops are required
  - This results in higher fan/blower power use, so an SEER2 rating is a bit lower than SEER calculated at the same temperature conditions

# Research Challenges and Opportunities

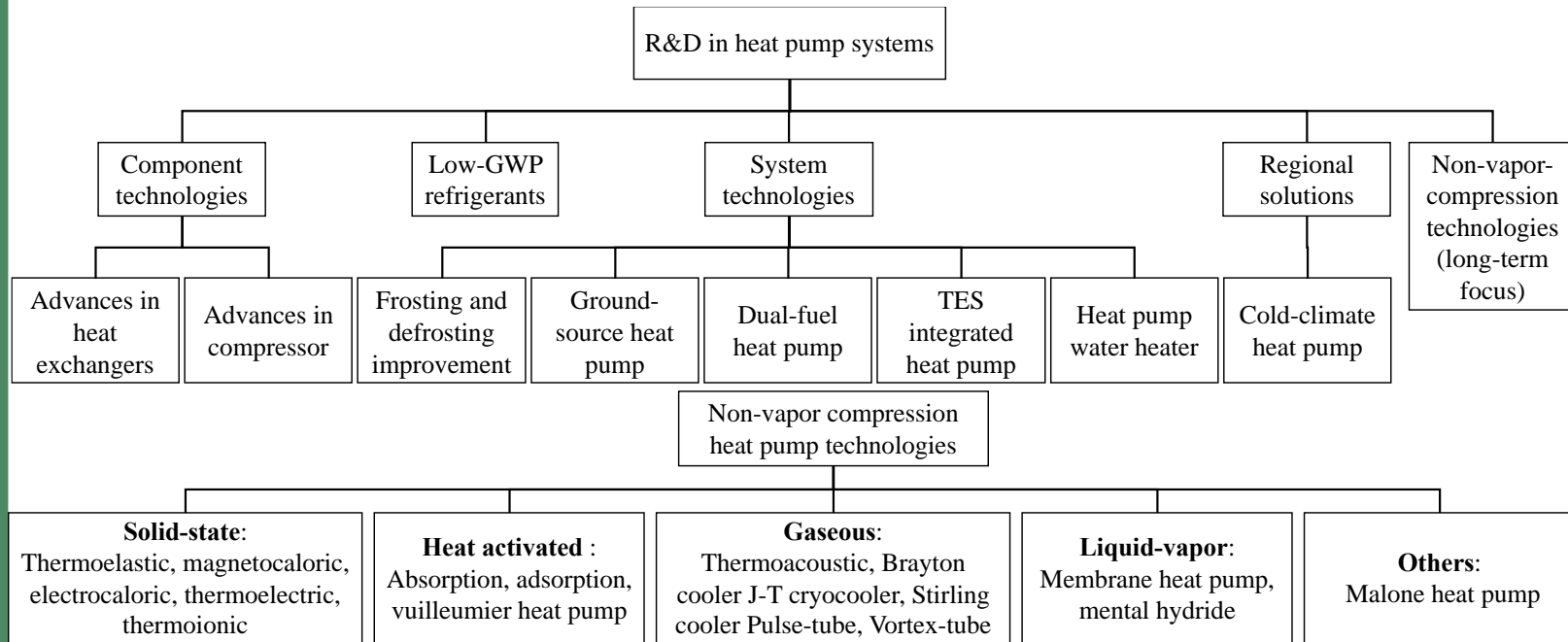
Improve efficiency and capacity of heat pumps for cold climates, and efficiency of systems for warm climates

Reduce installed cost and improve reliability of high-efficiency systems

Develop solutions for problematic heat pump installations, particularly for retrofit and renovation applications

Develop alternative refrigeration technologies and lower-GWP refrigerants to reduce direct emissions

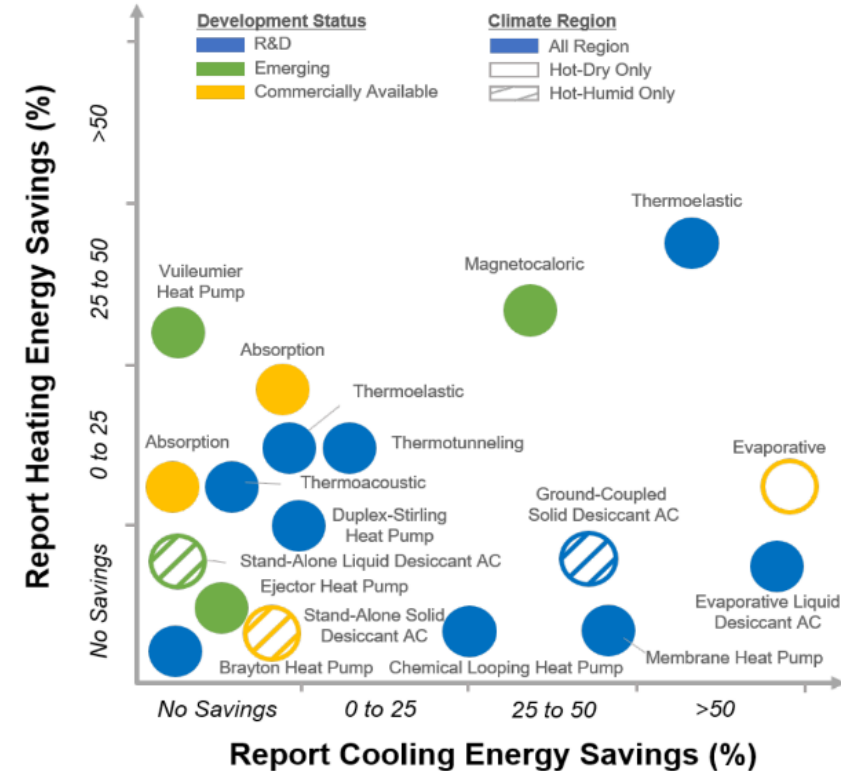
# Current R&D Focus



## E3 Initiative (Initiative for Better Energy, Emissions, and Equity)

- Advanced Water Heating Initiative
- Residential Cold Climate Heat Pump Technology Challenge
- Collaborative RD&D on low to no-GWP refrigerants
- Residential HVAC Smart Diagnostic Tools Campaign
- Better Buildings Low Carbon Pilot

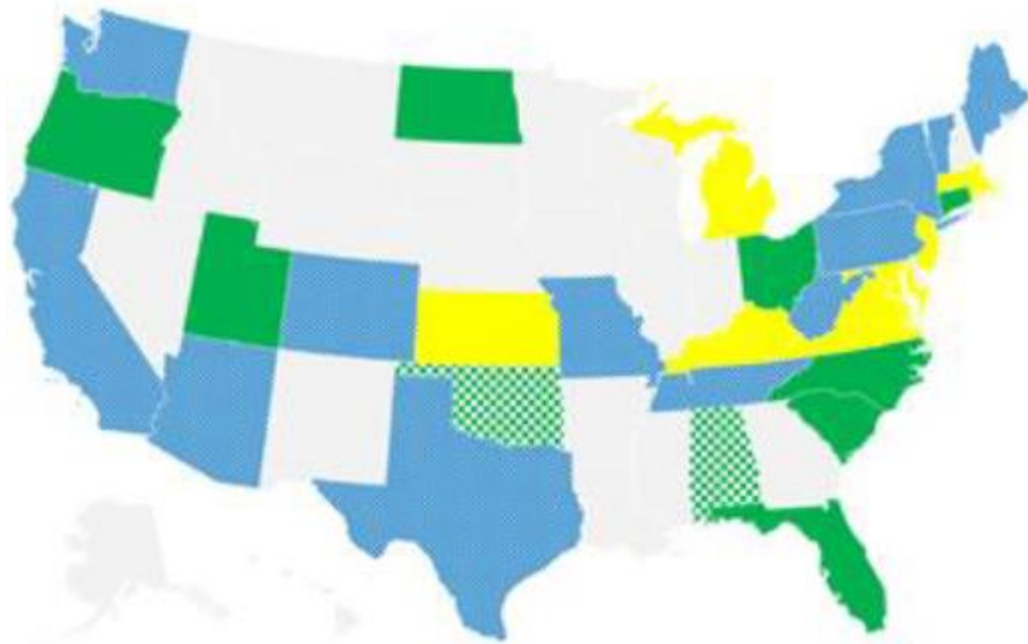
<https://www.energy.gov/eere/buildings/energy-emissions-and-equity-e3-initiative>



Energy saving potential for different non-vapor compression technologies reorganized based on DOE/EE-1703

# Adoption of Low-GWP Refrigerants in Heat Pumps

- Some heat pump OEMs are now selling A2L products in select states that have updated their building codes



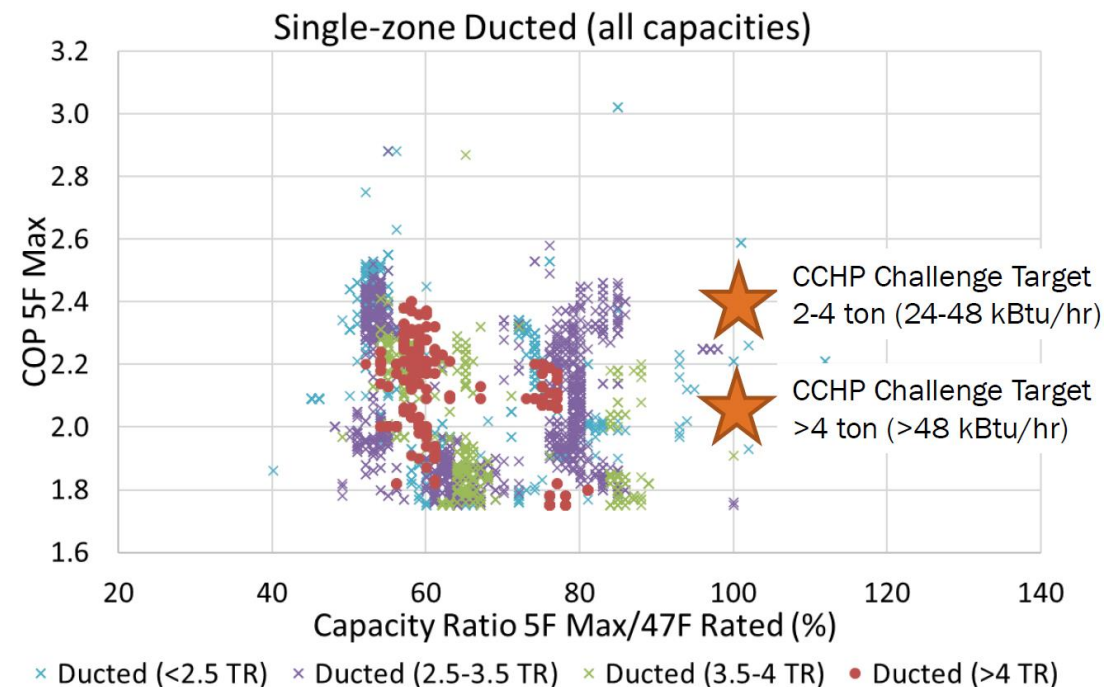
Progress on building code and legislative updates to allow use of A2L refrigerants (Updated November 2022)

*Based on data from 2023 ACEEE Hot Air Forum*

- The blue states allow low GWP A2L refrigerants for both A/C and Refrigeration applications.
- The green states allow A2L refrigerants for A/C application, while green-checked states have partial A/C application allowances.
- States shown in yellow are in progress on building code or legislative to allow low-GWP refrigerants.
- States in light gray have yet to begin the process.

# DOE's Cold Climate Heat Pump (CCHP) Challenge

- Residential, centrally ducted, electric-only HPs that perform better than today's products in cold climates
  - Nominal cooling capacity 24,000 – 65,000 Btu/hr (7-19 kW), strong capacity maintenance (i.e., 100% heating capacity at 5°F, strong performance to below 0°F )
  - Perform efficiently in cold climates: COP lower limit @5 °F [-15C] 2.1 (>4 ton[14 kW]) or 2.4 (2-4 ton[7-14 kW])
  - Employ low-GWP refrigerants (< 750 GWP, AR4 100 year)
  - Incorporate advanced controls and grid-interactive capability to assist with installation, fault detection, demand response, and other activities (AHRI 1380)



Full specification and test procedure for CCHP Challenge:  
<https://www.energy.gov/eere/buildings/residential-cold-climate-heat-pump-challenge>

# Advanced Water Heating Initiative (AWHI)

- A collaborative, market transformation effort that works to catalyze a rapid transition to high-efficiency, grid-connected HPWHs
  - Development of 120 volt HPWH for replacement of existing WHs in homes with limited electricity supply voltage (e.g., homes using gas WHs)
- More than 140 member organizations including manufacturers, utilities, industry associations, and local/state/federal government agencies -  
<https://www.advancedwaterheatinginitiative.org/community>

- Residential HVAC Smart Diagnostic Tools Campaign
- DOE campaign to promote use of smart diagnostic tools to allow HVAC service techs to quickly commission new installations or identify faults in existing systems
  - Estimate that ~9% of residential central AC and ASHP energy use is wasted due to installation faults
- Campaign provides
  - Platform for technical assistance
  - Best practice guidance
  - Independent testing of available smart diagnostic tools
  - Case studies and lessons learned

[https://www.energy.gov/sites/default/files/2022-04/EED\\_1361\\_FLYER\\_EERE-SmartDiagnostic\\_FINAL5.pdf](https://www.energy.gov/sites/default/files/2022-04/EED_1361_FLYER_EERE-SmartDiagnostic_FINAL5.pdf)

- Better Buildings Low Carbon Pilot
- Partner organizations shared experiences, successes and challenges in pursuing low carbon emission strategies
- Key learnings and resources from these partners collected in a “Low Carbon Toolkit”
  - <https://betterbuildingsolutioncenter.energy.gov/low-carbon-pilot-toolkit>
  - Action plan templates, Solutions, Peer exchanges (webinars, etc.)
  - Includes a number based on heat pump and/or cooling system upgrades

# Summary and Outlook

- Uneven **market** growth (i.e., very small market share in cold climates)
- **Hurdles** for heat pump deployment include:
  - High cost of installation; high operational costs in cold climates
  - Supply chain constraints
  - Existing building stock with fossil fuel systems and constraints for fuel-switching
  - Supplemental electric resistance heating at low outdoor temperatures can overstress existing grid
- A large increase in **policies and financial incentives** for advancing heat pump deployment
- As the share of renewables in the energy mix increases, heat pumps can play an important role in electrifying the building sector



**Thank you!**

**Van Baxter**  
**baxtervd@ornl.gov**

# Questions/Discussion

