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# Accelerating Heat Pump Adoption through the Inflation Reduction Act (IRA) and Complementary Policies

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# Executive Summary

We analyze impacts of the Inflation Reduction Act (IRA) on heat pump uptake in the United States and recommend policies that states can use to further increase uptake. The existing literature suggests that the IRA makes a considerable contribution to achieving building decarbonization goals, but that more work is needed.

Building on this literature, we model the effects of two key IRA sections, the High-Efficiency Electric Home Rebate Act (HEEHRA, IRA Section 50122) and the Nonbusiness Energy Property Credit (Section 25C of the Tax Code, IRA Section 13301), on a representative type of home. Specifically, we analyze non-mobile homes that currently use methane gas, propane gas, oil, or electric furnaces as main source of space heating and that have central air conditioning. This type of household numbered 54 million in 2020.

Adapting a decision model developed by the U.S. Department of Energy, we analyze heating decision points (chiefly replacement decisions at the end of life of a current furnace) for these homes. We estimate that the two IRA sections will motivate an additional almost 1 million of these households to switch to heat pumps over the next 10 years, lifting the number of conversions in the decade from 5.1 million (if the IRA hadn't been enacted) to 6 million. In percentage terms, the IRA will increase the number of heating decisions toward heat pumps in this subsector from 10% of decisions to 12%. We look at additional scenarios, including a hypothetical scenario in which the HEEHRA program has no budget cap, which substantially increases the number of conversions.

In short, while the IRA is an important step forward, decarbonization of this type of home, and the building sector more broadly, will require additional policy initiatives. The balance of the paper explores state-level policy and regulatory actions and strategies that can help fill the gap.

**Public Access and Participation**. As they plan for delivering IRA benefits to their citizens, states and local jurisdictions should endeavor to improve their engagement with underserved communities. Improved public access and participation will increase the reach, effectiveness, and equitable decision making of state and local energy programs.

**Clean Heat Standard**. A clean heat standard (CHS) is a performance standard, similar to a renewable energy standard for electric utilities, that applies to wholesale providers of fossil fuels used for heating (such as gas and propane). A CHS requires the provider to deliver a gradually increasing percentage of low-emission "clean heat" resources to customers, promoting the adoption of cleaner and more efficient alternatives such as heat pumps.

**Hybrid Heat**. Hybrid heat is a strategy that exploits the ability of heat pump technology to cool and to heat, while allowing homeowners to retain their existing heating systems. By operating heat pumps at times when they are most efficient and less expensive to operate, this strategy can displace significant amounts of heating load served by dirtier and less efficient heating systems without replacing current systems that may be needed for extreme cold weather.

**Energy Efficiency Programs**. Energy efficiency programs run by utilities or independent administrators can be refocused and expanded to promote heat pumps and associated measures. This may include eliminating fuel-switching prohibitions, creating detailed roadmaps to ramp up program size, ending incentives for gas equipment and setting rules to address missed opportunities.

**Rate Design**. Rate design directly affects the operating costs of electric equipment, including heat pumps. Flat annual kilowatt-hour (kWh) charges may be relatively unfavorable for heat pumps in comparison to methane gas delivered by utilities. The best reforms to improve the economics of heat pump operation are those that improve the cost causation of rates, i.e., rates varying across the day and throughout the year. Time-sensitive rate designs can take advantage of the relative efficiency and flexibility of heat pumps, helping system managers coordinate electric load and saving consumers money.

**Workforce Training and Development**. A shortage of technicians with the expertise to install and maintain heat pumps threatens to hinder their adoption. States will need to focus on improving the skills of their workforce, including the development of training for existing employees and apprentice-based programs.

**Tariffed On-Bill Financing**. Tariffed on-bill financing can overcome an upfront cost barrier faced by customers interested in purchasing clean energy technologies such as heat pumps. Properly designed, an on-bill financing tariff will ensure that a customer's added monthly payments are lower than the monthly amount they are saving on their utility bill due to the investment.

# Part 1: Introduction

## Overview

The Inflation Reduction Act (IRA) became law in August 2022, accelerating U.S. economy-wide greenhouse gas (GHG) emission reductions (see text box below on U.S. climate goals and the IRA[1,2,3]). Heat pumps are a key part of this effort, reducing the emissions associated with building heating. In Part 1 of the paper, we review several IRA programs that incentivize the adoption of these important technologies in American homes.

### U.S. Climate Goals and the IRA

In 2021, the United States pledged to reduce net greenhouse gas emissions by 50-52% in 2030 as part of the country's commitments under the Paris Climate Agreement. The Biden administration also issued a 2050 strategy to reach net-zero emissions. In developing the pledge and strategy, the United States considered reduction pathways that include decarbonization of electricity, electrification of transportation and buildings, greater energy efficiency, and development of very low- and zero-carbon industrial processes and products.

In August 2022, President Biden signed the Inflation Reduction Act into law. The IRA directs $393.7 billion in federal funding to states, local jurisdictions, and others to reduce the nation's carbon emissions by the end of this decade: approximately $250.6 billion for energy, $47.7 billion for manufacturing, $46.4 billion for environment, $23.4 billion for transportation, $20.9 billion for agriculture and $4.7 billion for water.

Mainly taking the form of funding support and other incentives, the IRA is the most significant federal climate and clean energy legislation in U.S. history and will have a significant impact on job creation, energy and energy cost savings, climate goals including emissions reductions, and public health.

[1] U.S. Department of State and Executive Office of the President. (2021, November). *The long-term strategy of the United States: Pathways to net-zero greenhouse gas emissions by 2050*. https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf

[2] Badlam, J., Cox, J., Kumar, A., Mehta, N., O'Rourke, S., & Silvis, J. (2022, October 24). *The Inflation Reduction Act: Here's what's in it*. McKinsey and Co. https://www.mckinsey.com/industries/public-sector/our-insights/the-inflation-reduction-act-heres-whats-in-it

[3] U.S. National Climate Advisor and U.S. Special Presidential Envoy for Climate. (2021, April). *Reducing greenhouse gases in the United States: A 2030 emissions target* [U.S. Nationally Determined Contribution to Paris Agreement]. https://unfccc.int/sites/default/files/NDC/2022-06/United%20States%20NDC%20April%2021%202021%20Final.pdf

In Part 2, we review the literature estimating the number of additional heat pumps that will be installed as a result of these programs. Due to a lack of consensus in the literature, we also conduct our own modeling.

In addition to analyzing effects of federal incentives, the paper also focuses on the application of state policy and program experiences. In Part 3 we review a series of policies and strategies that will further increase familiarity, acceptance and adoption of heat pumps. State and local governments are in a strong position to identify and implement policy and strategy approaches that are suited to their local needs and concerns.

As states and municipalities move forward, they can learn from each other, sharing best practices that will reduce emissions in their housing sectors and make homes safer and more comfortable. The authors hope that this paper encourages state and local governments to build upon the federal support provided by the IRA, and to coordinate their various program offerings to secure the greatest benefits for their states and citizens.

# Heat Pumps and Their Benefits

Over 40% of U.S. households' annual energy consumption is for space heating.[4] Table 1 shows how this heat is delivered. As can be seen, the most common heating fuel in homes is methane gas (46% of homes) and the most common equipment type (58%) is a furnace, which blows warm air through ducts distributed throughout the house.

**Table 1. Share of U.S. households' main heating systems by fuel and system type[5]**

| | Furnace | Boiler | Heat pump | Other | Total |
|---|---|---|---|---|---|
| Methane gas | 38% | 5% | 0% | 2% | **46%** |
| Electricity | 14% | 1% | 15% | 10% | **40%** |
| Propane gas | 3% | 0% | 0% | 1% | **4%** |
| Oil | 2% | 1% | 0% | 0% | **4%** |
| Wood | 0% | 0% | 0% | 2% | **2%** |
| Other | 0% | 0% | 0% | 5% | **5%** |

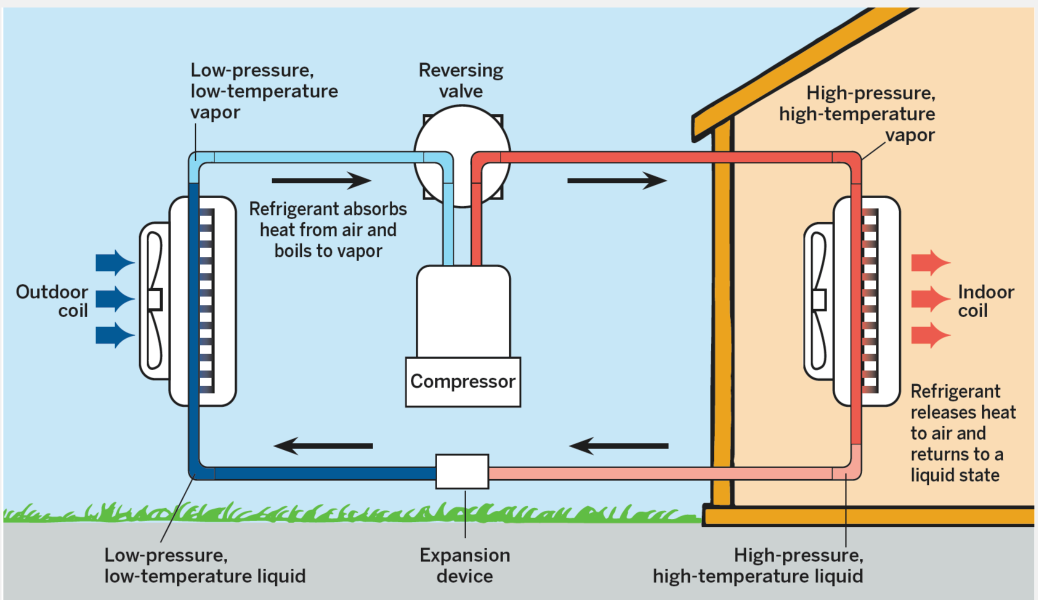
[4] U.S. Energy Information Administration. (2023a, June 13). *2020 Residential Energy Consumption Survey data: CE3.1ST — Annual household site end-use consumption in United States homes by state — totals and averages.* https://www.eia.gov/consumption/residential/data/2020/state/pdf/ce3.1.st.pdf

[5] U.S. Energy Information Administration. (2023b, November). *2020 RECS survey data: Microdata.* https://www.eia.gov/consumption/residential/data/2020/index.php?view=microdata

## Heat Pumps Illustrated

Heat pumps are air conditioners that can operate in both directions: providing cooling in the summer and heating in the winter. They do so by collecting heat, concentrating it and then transferring it either outside or inside the building as needed. This is possible even in especially “cold” or “hot” outdoor temperatures. For example, frigid Norway has the highest heat pump adoption rate of any country at over 60% of households[6] (mostly air-source heat pumps[7]). Heat pumps have been successfully field tested below 0 degrees F in Minnesota and northern Alaska.[8]

**Figure 1. Air-source heat pump heating cycle**[9]




In the United States, heat pumps and air-conditioners are typically air-to-air systems with an outdoor heat exchanger (condenser), a refrigerant loop, and an indoor air handler. The hidden air handler can be installed in a closet, basement, or attic and deliver conditioned air to rooms throughout a home via ducts (this type of system is called a “central” or “ducted” system). Alternatively, the air handler may be mounted on a wall, and serve a single room (“mini-split” or “ductless”). Outside of the United States, air-to-water heat pumps that use radiators for space heating are also common.

[6] Rosenow, J., Gibb, D., Nowak, T., & Lowes, R. (2022, October). Heating up the global heat pump market. *Nature Energy,* 7(10): 901–4. https://doi.org/10.1038/s41560-022-01104-8

[7] European Heat Pump Association. (2023, April 18). *EHPA dashboard*. https://stats.ehpa.org/home/ehpa-dashboard/

[8] Gartman, M. & Shah, A. (2020, December 10). *Heat pumps: a practical solution for cold climates*. RMI. https://rmi.org/heat-pumps-a-practical-solution-for-cold-climates/

[9] U.S. Department of Energy. (n.d.). *Energy saver: Air-source heat pumps*. https://www.energy.gov/energysaver/air-source-heat-pumps

For the United States to reach its energy and climate goals, heating must be electrified and transitioned away from high-emission combustion furnaces and boilers to low-emission technologies.[10] Heat pumps are the key technology necessary to decarbonize heating, as they reduce the total amount of energy needed, and can draw electricity from an increasingly decarbonized grid.[11]

## The High-Efficiency Electric Home Rebate Act (IRA Section 50122)

HEEHRA provides funding for states and Indian tribes to establish rebate programs. Its goal is to enable low-income (earning less than or equal to 80% of area median income, or AMI) and moderate-income (earning 80-150% of AMI) households to electrify their homes. HEEHRA and HOMES — another rebate program for whole-home electrification — make up the Home Energy Rebate Programs authorized under the IRA.[12]

Eligible households will be able to receive up to $14,000 for installing energy efficient electric equipment, including up to $8,000 for heat pumps, $1,750 for heat pump water heaters, $4,000 for an electric load center (panel), and $2,500 for wiring upgrades.[13]

As Table 1 showed, 15% of U.S. households' main heating systems are heat pumps. Of those, the vast majority are ducted (14%) vs. ductless (1%). While the Energy Information Administration (EIA) does not differentiate ground-source vs. air-source heat pumps in its Residential Energy Consumption Survey (RECS), most can be assumed to be air-source, as ground-source shipments were only one-quarter those of air-source systems (1 million[14] versus 4.3 million[15] in 2022). Air-to-water or hydronic systems, which provide heat to a residence by circulating hot water through radiators, are not common in the United States.[16]

When properly installed, an air-source heat pump can deliver roughly three times more heat energy to a home than the electrical energy it consumes, depending on the climate, its efficiency and cold-climate capabilities.[17] This is because a heat pump transfers heat from the air outside rather

[10] U.S. Department of State and Executive Office of the President, 2021.

[11] Pierret, H. (2020, June). *Heat pumps are key to decarbonizing residential heating*. Federation of European Heating, Ventilation and Air Conditioning Associations. https://www.rehva.eu/rehva-journal/chapter/heat-pumps-are-key-to-decarbonizing-residential-heating

[12] U.S. Department of Energy, Office of State and Community Energy Programs. (n.d.). *Home electrification and appliance rebates*. https://www.energy.gov/scep/home-electrification-and-appliance-rebates

[13] U.S. Department of Energy, Office of State and Community Energy Programs. (n.d.). *Blueprint 2C: Building efficiency & electrification campaign*. https://www.energy.gov/scep/blueprint-2c-building-efficiency-electrification-campaign

[14] US Environmental Protection Agency. (2022). *ENERGY STAR® unit shipment and market penetration report, calendar year 2022 summary*, p. 5. https://www.energystar.gov/sites/default/files/2022%20Unit%20Shipment%20Data%20Summary%20Report.pdf

[15] Air-Conditioning, Heating and Refrigeration Institute. (n.d.). *Central air conditioners and air-source heat pumps*. https://www.ahrinet.org/analytics/statistics/historical-data/central-air-conditioners-and-air-source-heat-pumps

[16] Heat pumps can also be used for heating domestic hot water for washing and bathing. This energy use represents 18% of household energy consumption, but is not covered in this paper. See U.S. Energy Information Administration, 2023a.

[17] U.S. Department of Energy. (n.d.). *Energy saver: Air-source heat pumps*. https://www.energy.gov/energysaver/air-source-heat-pumps

than combusting fuel to generate heat directly (see text box on p. 7, "Heat Pumps Illustrated").

Even though heat pumps are roughly three times more efficient than combustion, methane gas is two to six times cheaper than electricity per unit of energy delivered to the home. This makes heat pumps more expensive to run compared to methane systems in many states, especially at lower outdoor temperatures (when heat pump efficiency decreases[18]). However, higher-efficiency and "cold climate" heat pumps, hybrid systems that use the heat pump at peak efficiency, and favorable utility rates (see Part 3) can even the playing field between electricity and gas. For new homes, heat pumps are likely to be more cost-effective than methane gas because builders can avoid the cost of extending gas infrastructure.[19] Also, heat pumps offer significant operating cost savings over propane, oil, and electric resistance, which collectively heat 32% of U.S. homes compared with 46% for methane gas.[20]

Heat pumps can also help reduce indoor air pollution. For example, oxides of nitrogen ($NO_x$), which are produced by burning fossil gas, can lead to irritation to eyes, skin and respiratory systems, aggravating lung conditions such as asthma.[21] Further impacts include lost workdays, emergency room visits and heart attacks. Even partial use of heat pumps in hybrid systems could avoid almost 1,000 premature deaths per year.[22]

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[18] Gibb, D., Rosenow, J., Lowes, R. & Hewitt, N. (2023, September 11). Coming in from the cold: Heat pump efficiency at low temperatures. *Joule, 7*(9), 1939-1942. https://doi.org/10.1016/j.joule.2023.08.005

[19] Billimoria, S., Henchen, M., Guccione, L., & Louis-Prescott, L. (2018). *The economics of electrifying buildings: how electric space and water heating supports decarbonization of residential buildings*. Rocky Mountain Institute. http://www.rmi.org/insights/reports/economics-electrifying-buildings/

[20] US Energy Information Administration, 2023a.

[21] World Health Organization (WHO). (2023). *Air quality and health — type of pollutants*. https://www.who.int/teams/environment-climate-change-and-health/air-quality-and-health/health-impacts/types-of-pollutants

[22] Pantano, S., Malinowski, M., Gard-Murray, A., & Adams, N. (2021, May 26). *3H hybrid heat homes: an incentive program to electrify space heating and reduce energy bills in American homes*. CLASP. https://www.clasp.ngo/research/all/3h-hybrid-heat-homes-an-incentive-program-to-electrify-space-heating-and-reduce-energy-bills-in-american-homes/

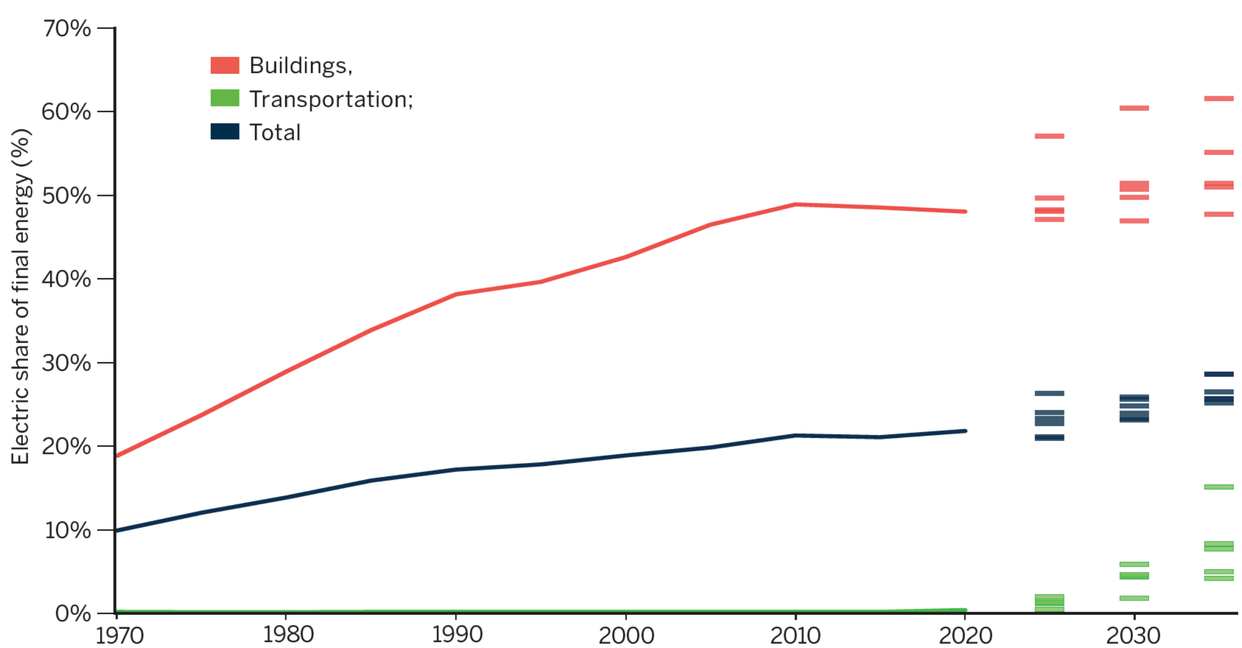
# Part 2: Impacts of the IRA on Heat Pump Deployment

Heat pumps support the IRA goals of energy cost savings, reduced emissions, and improved public health. The next section reviews past studies assessing the impact of the IRA on heat pump deployment. We then summarize our own quantitative analysis on the likely impact of two key sections of the IRA: the High-Efficiency Electric Home Rebate Act (HEEHRA, IRA Section 50122)[23] and the Nonbusiness Energy Property Credit (Section 25C of the Tax Code, IRA Section 13301).

## Literature Review

We reviewed published estimates of the IRA's impacts. The estimates can be categorized into two groups: general and specific. The general estimates try to capture the full breadth of the IRA and report its impact in terms of economy-wide emissions.

**Figure 2. Cross-model comparison of sectoral electrification trends**




Source: Bistline et al., 2023.

[23] We note that the Department of Energy is now referring to this program as the Home Electrification and Appliance Rebates program. For purposes of our discussion, this paper will continue to use HEEHRA.

Bistline et al. survey the various general IRA modeling efforts and find that, including the effects of the IRA, the building sector is on a path toward modestly higher levels of electrification: from 48% electric share of final energy in 2020 to a central estimate of about 55% in 2035 (see Figure 2).[24]

**Non-Business Energy Property Credit (25C) (IRA Section 13301)**

The IRA amended the "credits for energy efficient home improvements" under §25C of the Internal Revenue Code.

Beginning January 1, 2023, and through 2034, the amount of the credit is equal to 30% of the sum of amounts paid by the taxpayer for certain qualified expenditures, including:

1. Qualified energy efficiency improvements installed during the year,
2. Residential energy property expenditures during the year, and
3. Home energy audits during the year.

Heat pumps satisfy the energy efficiency improvement requirement.

25C provides for a $1,200 aggregate yearly tax credit maximum for all building envelope components, home energy audits, and energy property.

Heat pumps and heat pump water heaters have a separate aggregate yearly credit limit of $2,000.

Thus, the maximum total yearly energy efficient home improvement credit amount could reach $3,200.

The EIA estimates that the number of households with heat pumps will grow by 2 percentage points as a result of the IRA.[25] Based on the funding provided by the IRA, Smedick et al. estimate that HEEHRA will lead to 2.4 million electrification upgrades by 2030 (including installations of heat pumps for space heating and heat pump water heaters) in low- to moderate-income households, while the 25C tax credit will incentivize 7.2 million heat pump installations.[26] Assuming that heat pumps for space heating make up half the total installations from both HEEHRA and 25C (for a total of 4.8 million), and that none are replacements for retired heat pumps, the stock of heat pumps for space heating would increase from 17.2 million in 2020[27] to 21.8 million, or from 14% of households to 18%, an increase of 4 percentage points.

[24] Figure based on Bistline, J., et al. (2023). Emissions and energy impacts of the Inflation Reduction Act. *Science,* 380(6652): 1324–1327, Figure S16. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10336889/.

[25] U.S. Energy Information Administration. (2023c, March 16). *Issues in focus: Inflation Reduction Act cases in the AEO2023.* https://www.eia.gov/outlooks/aeo/IIF_IRA/

[26] Smedick, D., Golden, R., & Petersen, A. (2022, August 31). *The Inflation Reduction Act could transform the US buildings sector*. RMI. https://rmi.org/the-inflation-reduction-act-could-transform-the-us-buildings-sector/

[27] Sum of "Heat pump" and "Ductless heat pump (mini-split)". U.S. Energy Information Administration. (2022a, July 6). *2020 Residential Energy Consumption Survey, housing characteristics tables: space heating by housing unit type* (Table HC 6.1). https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%206.1.pdf

In summary, the existing literature suggests that the IRA is a major step forward in decarbonizing the building sector. Our review, however, suggests significant uncertainty as to the extent to which the IRA will drive heat pump installations specifically.

# Modeling

We take a detailed look at the impact of the IRA on heat pump deployment for a key buildings subsector: homes that meet all the following criteria: 1) non-mobile; 2) use fossil gas, electric resistance, or oil furnaces for heating; and 3) have central ducted air-conditioning. In 2020, this represented 54 million households, or 43% of total households and 51% of households that do not use a heat pump as the main space heating equipment.[28] We analyze this subsector because it represents a common type of home in the United States that faces the challenge of making the switch to heat pumps. In addition, this choice of subsector fits the limitations of the model we use (which requires a home to have both a furnace and an air conditioner before calculating the economics of switching to a heat pump).

Table 2 on the following page summarizes the U.S. heating system stock by equipment, main air conditioner type, and housing type. The table does not include the approximately 15% of homes that already use a heat pump as the main space heating equipment. The furnace-central air conditioner cell represents the subsector we analyze in this section.

We consider the impacts of HEEHRA and 25C incentives on converting this subsector of homes to heat pumps at the time of furnace replacement.[29] These conversions may be to a central or ductless heat pump; our conversion estimates include both types and do not differentiate.

We use the model developed by the U.S. Department of Energy (DOE) for its residential furnaces energy conservation standards rulemaking.[30] DOE built the model to estimate the number of homes that would switch to heat pumps and electric furnaces as a result of standards *increasing* the cost of furnaces. Instead of changing the furnace costs, we modified the DOE model to *decrease* the cost of heat pumps to reflect IRA support. The model steps through buildings sampled from the Residential Energy Consumption Survey (RECS), comparing the costs of installing and operating various heating and cooling technologies. The model only switches a home away from a furnace to a heat pump if the home already has central air conditioning and the replacement heat pump has a positive payback within three to four years. (Higher-income households tolerate longer paybacks within this range.) Most decisions occur at furnace failure, but the model also includes new

[28] U.S. Energy Information Administration, 2022a.

[29] We expect additional IRA sections, such as HOMES, the Greenhouse Gas Reduction Fund (GHGRF) and building codes assistance, have an impact on heat pump uptake. However, it is unclear how states will utilize funding from these and other open-ended programs, and if heat pump deployment will be prioritized. See Appendix B for a list of IRA programs that could further benefit heat pumps.

[30] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (2022a, August 24). *Consumer furnace life-cycle cost (LCC) and payback period analysis (NOPR) spreadsheet*. https://www.regulations.gov/document/EERE-2014-BT-STD-0031-0352

construction or major renovations. We next present and discuss the modeling results. Additional details about the model and our assumptions appear in Appendix A.

**Table 2. Share of U.S. households' heating systems by main AC type and main heating system type (excluding homes with a heat pump for heating)**[31]

| | Single-family detached, attached and apartments | | | Mobile homes | | | |
|---|---|---|---|---|---|---|---|
| Main air conditioner type | Furnace | Boiler | Other | Furnace | Boiler | Other | Total |
| Central air conditioner[32] | 51% | 2% | 8% | 2% | 0% | 0% | **63%** |
| Window or wall air conditioner | 6% | 5% | 7% | 1% | 0% | 1% | **20%** |
| Not applicable | 6% | 1% | 5% | 0% | 0% | 0% | **13%** |
| Portable air conditioner | 1% | 0% | 1% | 0% | 0% | 0% | **2%** |
| Evaporative or swamp cooler | 0% | 0% | 0% | 0% | 0% | 0% | **1%** |
| Ductless heat pump, also known as a "mini-split" | 0% | 0% | 0% | 0% | 0% | 0% | **1%** |
| **Total** | 65% | 9% | 21% | 3% | 0% | 1% | **100%** |

Using DOE's model, we find that in the absence of HEEHRA and 25C incentives, 10–12% of furnaces, depending on type, would convert to heat pumps in 2025, resulting in 509,000 heat pump conversions annually, as shown in Table 3. We chose 2025 as our modeling year as that will be the first full year that HEEHRA rebates are likely to be available, but relied on 2022 shipments, the latest year available and the year before the IRA came into effect. Subsequent modeling scenarios exclude these baseline conversions to show the impact of the IRA provisions.

[31] U.S. Energy Information Administration, 2023b.

[32] Includes two-way central ACs not used as main heat source.

**Table 3. Modeled conversion rates from furnaces to heat pumps in 2025 absent IRA incentives**

| | Gas furnace (methane and propane) | Electric furnace | Oil furnace | Total |
|---|---|---|---|---|
| Annual furnace conversions without IRA | 10% | 12% | 11% | **10%** |
| Annual furnace conversions without IRA (thousands) | 421 | 84 | 5 | **509** |

We find that HEEHRA rebates would drive an additional 21% conversions per year, beyond the 10% pre-IRA baseline. We also find that the total potential annual conversions due to HEEHRA would be 1 million per year if the incentive budget were unlimited.

However, HEEHRA's budget is capped at $4.5 billion, a total shared among rebates for all types of equipment, not just heat pumps. As the cost of a heat pump can comprise a maximum of $8,000 of a $14,000 household total, we reduced the total budget available for heat pumps by 8/14, to $2.57 billion. With the average incentive under HEEHRA estimated at approximately $7,000 in 2025 dollars, that would exhaust the program budget after approximately four months, leading to a total of 362,000 heat pump conversions, overwhelmingly from gas furnaces. This result can be seen in the bottom row of Table 4.

**Table 4. Modeling results for HEEHRA conversions**

| | Gas furnace (methane and propane) | Electric furnace | Oil furnace | Total |
|---|---|---|---|---|
| 2025 furnace decisions (thousands) | 4,293 | 690 | 43 | **5,025** |
| Annual furnace conversions due to HEEHRA | 21% | 18% | 23% | **21%** |
| Annual furnace conversions due to HEEHRA (unlimited budget, thousands) | 901 | 122 | 10 | **1,034** |
| Mean HEEHRA incentive (2025 dollars) | $7,123 | $7,032 | $7,199 | **$7,113** |
| Annual HEEHRA budget needed to meet demand (billions of dollars) | $6.4 | $0.9 | $0.1 | **$7.4** |
| Total furnace conversions due to HEEHRA (budget-limited, thousands) | **315** | **43** | **3** | **362** |

Meanwhile, 25C tax credits would drive an additional 1.2% conversions per year, beyond the 10% no-IRA baseline. This would result in 59,000 additional furnace conversions, as shown in Table 5. The 25C tax credit is unlimited in budget, but is limited in time to 10 years, leading to a net total 593,000 conversions over the 10 years of the program.

**Table 5. Modeling results for 25C conversions**

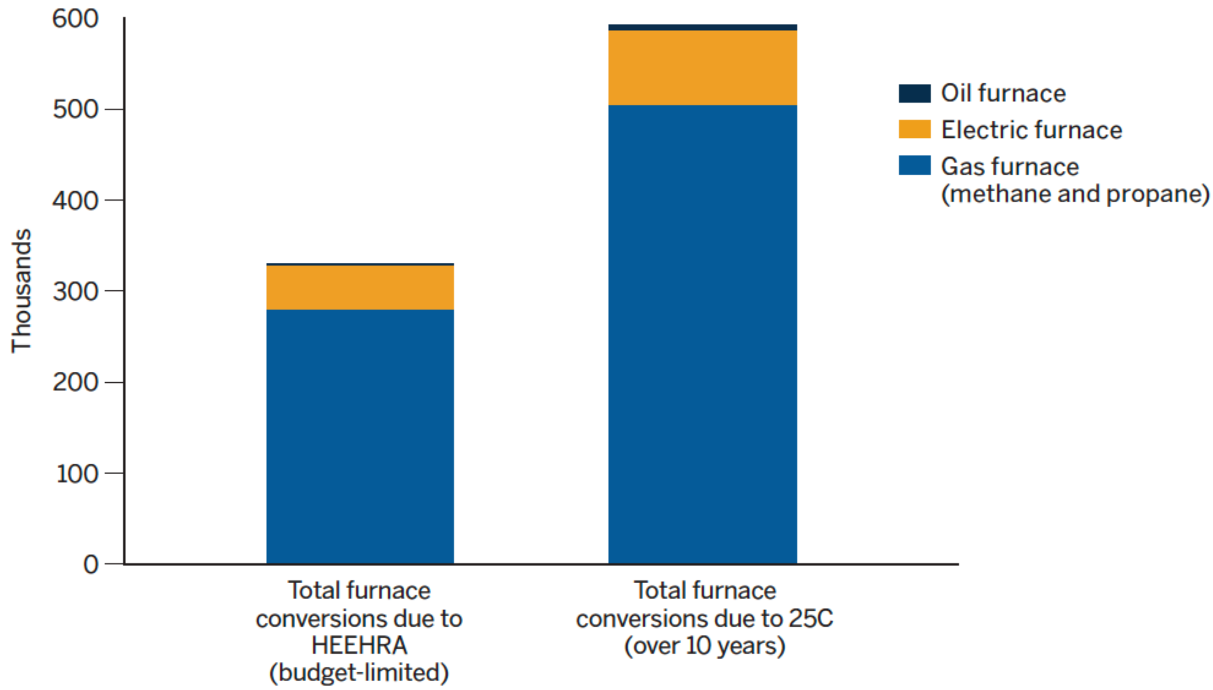
| | Gas furnace (methane and propane) | Electric furnace | Oil furnace | Total |
|---|---|---|---|---|
| 2025 furnace decisions (thousands) | 4,293 | 690 | 43 | **5,025** |
| Annual furnace conversions Due to 25C | 1.2% | 1.0% | 1.5% | **1.2%** |
| Annual furnace conversions Due to 25C (thousands) | 52 | 7 | 1 | **59** |
| Total furnace conversions Due to 25C (thousands) | **515** | **72** | **6** | **593** |

Together the two IRA incentives would drive a grand total of 955,000 additional conversions over 10 years, or an average of 96,000 per year. Put another way, IRA incentives would influence approximately 2% of the approximately 50 million furnace replacements over the decade, converting them to heat pumps. Without a cap on the HEEHRA budget, the impact would be much greater, with IRA incentives influencing 18% of furnace decisions. These results are further summarized in Table 6 below, over the 10 years of the IRA, showing the baseline conversion rate and the impact of the HEEHRA budget cap on the total number of conversions.

**Table 6. Key results: Non-mobile home furnace and central air conditioning to heat pump conversions over 10 years (2023-2032)**

| | Total number of conversions (million) | Weighted average % of decisions |
|---|---|---|
| Baseline scenario (no IRA) | 5.1 | 10% |
| Additional IRA with capped HEEHRA scenario (25C and capped HEEHRA, as in actual law) | 1.0 | 2% |
| Additional IRA with uncapped HEEHRA scenario (25C and uncapped HEEHRA starting in 2025) | 8.9 | 18% |

**Figure 3. Estimate of furnace to heat pump conversions as a result of the two IRA incentives**




# Discussion

Approximately 3.5 times as many conversions would occur in the South as in the North.[33] In the South, a higher proportion of homes already have central air conditioning that can easily be converted to a heat pump, electricity costs are lower, and the warmer climate reduces the necessary capacity, cold-climate performance, and resultant up-front cost of the heat pump.[34]

Also, the vast majority of conversions would be from gas furnaces due to their much higher current installed base. The economics of electric furnace and oil furnace conversions are better long-term, but not sufficiently so to overcome their small market share. Furthermore, electric furnace upfront costs were lower in the model, making it less likely that households would switch to a heat pump within the payback period of three to four years, even with a significant incentive.

[33] The nation is divided into two main regions (North and South) based on the population weighted number of heating degree days (HDD). States with 5,000 HDD or more are considered part of the northern region, while states with less than 5,000 HDD are considered part of the southern region. See U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office. (2014, September). *Explaining central air conditioner & heat pump standards*. https://www.energy.gov/gc/articles/air-conditioner-regional-standards-brochure

[34] Central air conditioning is ducted, and replacing a central air conditioning unit with a heat pump involves minimal effort.

We also ran the HEEHRA and 25C scenarios separately, adding the results of each scenario at the end. In practice, some households may try to "braid" or "stack" the two incentives to further bring down the upfront cost of the heat pump. However, the HEEHRA incentives will be spent so quickly (in less than one year) and the incentives are likely to apply to different populations (LMI vs. households with tax liability that itemize their returns), so we kept the two programs separate in our analysis.

As mentioned at the beginning of this section, we focus only on non-mobile homes with a furnace and central air conditioner (51% of homes without heat pumps). As a result, the total number of homes that could apply for the relevant incentives could be up to two times higher than we modeled. However, including different decision criteria or additional houses would not affect our HEEHRA estimate, as these additional homes would be competing for the same HEEHRA rebate budget. Put another way, increasing the pool of houses analyzed would just use up the rebates faster.

The situation would be different for 25C. Doubling the number of houses eligible for the incentive by including mobile homes and houses without a furnace and air conditioner could result in twice the number of heat pumps installed.

Similarly, the types of heat pumps analyzed could significantly increase the number of conversions.

The IRA states that only heat pumps "which meet or exceed the highest efficiency tier (not including any advanced tier) established by the Consortium for Energy Efficiency"[35] are eligible for the 25C incentive. These highest CEE tier heat pumps are currently uncommon but could become more common in the future. As mentioned in Appendix A, we modeled that heat pump efficiencies are distributed randomly in accordance with the distribution of models currently available on the market. What if 100% of the heat pumps modeled were to qualify for the incentive (reflecting rapid market transformation or 100% households with positive economics seeking out qualifying models)? The result is that the number of conversions due to 25C would roughly double. Together, the additional houses and additional heat pumps could result in a quadrupling of the number of 25C conversions that we estimated.

However, we would expect several effects to temper this increase. First, in the modeled furnace-and-CAC homes, consumers compare the up-front cost of a heat pump against the up-front cost of two separate pieces of equipment: the replacement furnace and central air conditioner. This would not be the case in homes that lack central air conditioning. In these homes heat pumps would be competing with a much cheaper furnace or boiler, with either no air conditioning or window air conditioners.

Secondly, homes with furnaces already have ducts that can be utilized directly by the heat pump. Homes with other heating equipment types may not have ducts, or have ducts sized

[35] Consortium for Energy Efficiency. (n.d.). *CEE tiers and Energy Star*. https://cee1.org/program-resources/tiers-and-energy-star/

for the cooling load, potentially requiring larger ducts or the use of ductless/mini-split heat pumps, which may be more complicated and therefore more costly.

Third, only 60% of households had a tax liability in 2022[36] and only 11% itemized in 2018,[37] further reducing number of households likely to use the 25C tax credit. These factors all limit the total number of installations.

In summary, while there are many factors influencing the uptake of heat pumps, our initial estimate is that the number influenced by IRA will be small, at 955,000 over 10 years or 2% of current shipments over that period. The number of conversions is limited by the total budget amount in the case of HEEHRA and the small size of the incentive in the case of 25C. Further policy measures will be necessary to drive heat pump adoption, discussed next.

[36] Statista. (2023, November 23). *Share of households in the United States that paid no individual income tax in 2022, by income level*. https://www.statista.com/statistics/242138/percentages-of-us-households-that-pay-no-income-tax-by-income-level/

[37] Horan, S. (2021, March 30). *How did the Trump tax bill affect itemized deductions? — 2021 study*. SmartAsset. https://smartasset.com/taxes/how-did-the-trump-tax-bill-affect-itemized-deductions-2021

# Part 3: What States Can Do to Accelerate Heat Pump Benefits of the IRA

As Part 2 illustrated, the literature and our own modeling suggest a range of estimates for the impact of IRA funding and programs on technology deployment and GHG emissions reductions. However, all the estimates agree that the IRA provides a limited boost toward the pace of heat pump deployment necessary to decarbonize buildings to meet economy-wide GHG reduction goals. It is therefore important for state and local policymakers and regulators to recognize their crucial role in supporting and augmenting the heat pump adoption that is likely to occur due to IRA funding and incentives. State and local government actions can help clear barriers to heat pump deployment, create a supportive policy and market environment, give consumers tools and information that they need to make educated choices, and enable more equitable allocation of benefits for citizens. In this section we discuss policies and strategies that jurisdictions can adopt to further support heat pump deployment.

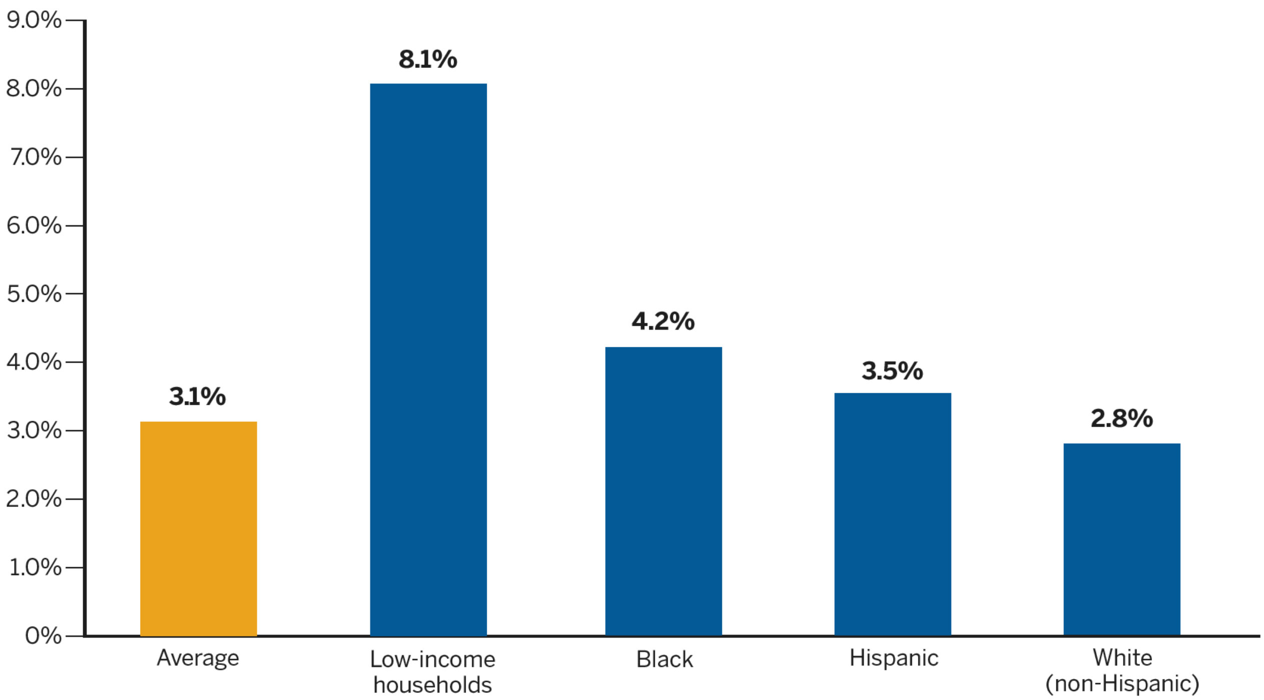
## Public Access and Participation

- As they plan for delivering IRA benefits to their citizens, states and local jurisdictions should endeavor to improve their engagement with underserved communities.
- Hearing from and consulting with marginalized communities is not just a matter of equitable inclusion — it is essential to protecting the public interest and achieving energy policy goals.
- Examples of efforts to improve outreach and public access and participation are being modeled by the states of Colorado and North Carolina, as well as the federal government.

Heating and cooling are essential services, and many communities across our country face higher energy burdens than others. State government agencies are becoming aware that there is more that they can do to reach these communities that may be underserved by state and local programs — communities of color, Indigenous communities, and low-and moderate-income communities.

Today there are 37.9 million Americans living in poverty, accounting for 11.6% of our population.[38,39] As illustrated in Figure 3, due to income discrepancies there are significant differences in the ability of Americans to pay for energy services. As states roll out heat pump and other clean energy programs with the support of the IRA, improved public access and participation will increase the reach, effectiveness, and equitable decision-making of state programs.[40]

**Figure 4. Percent of income spent on energy by household type, U.S.**




Source: ACEEE

State governments are making efforts to be more inclusive of communities that may be unaware and underserved. For example, the governors of Colorado[41] and North Carolina[42] recently issued executive orders directing state agencies to adopt standards of accessibility

[38] U.S. Census Bureau. (2023, January). *National Poverty in America Awareness Month: January 2023* [Press release]. https://www.census.gov/newsroom/stories/poverty-awareness-month.html

[39] Poverty rates for children (under age 18) range from less than 1.0% to 72.7%. See U.S. Census Bureau. (2022, December 8). *New 2017-2021 American Community Survey data show child poverty declined but remained higher than overall rate*. https://www.census.gov/library/stories/2022/12/poverty-rates-by-age-county-region.html

[40] See, e.g., Carley, S. (2023, August 24). *The Utility Energy Efficiency Scorecard* [Presentation]. American Council for an Energy-Efficient Economy (ACEEE). https://www.aceee.org/webinar/2023-utility-energy-efficiency-scorecard

[41] Governor of the State of Colorado, Executive Order D 2020 175 on August 27, 2020, directing the Department of Personnel and Administration to lead state action on equity, diversity and inclusion for the state of Colorado. https://www.colorado.gov/governor/sites/default/files/inline-files/D%202020%20175%20Equity%2C%20Diversity%2C%20and%20Inclusion%20for%20the%20State%20of%20Colorado.pdf

[42] State of North Carolina, Executive Order No. 246 on January 7, 2022, concerning North Carolina's transformation to a clean, equitable economy. https://governor.nc.gov/executive-order-no-246/open

and to improve public participation by communities of color, indigenous communities, and low-and moderate-income communities.

Similarly, Executive Order 14008 (March 2021) makes it the goal of the Biden administration that 40 percent of the overall benefits of certain federal investments flow to communities that are marginalized, underserved, and overburdened by pollution. These Justice40 Initiative[43] categories of investment are broad, including climate change and clean energy. The administration has indicated that existing and new programs supported by the IRA that make investments in any of these categories can also be considered Justice40-covered programs.[44]

As they plan for delivering IRA benefits to their citizens, states and local jurisdictions should make greater efforts to extend their engagement with underserved communities.[45] Hearing from and consulting with marginalized communities isn't just a matter of equitable inclusion — it's essential to protecting the public interest and securing energy policy goals. The IRA envisions programs that can deliver GHG savings in all communities and to all income levels. Greater inclusion in planning will yield better, more comprehensive initiatives, in addition to more equitable program designs and benefits.

# Clean Heat Standard

- A Clean Heat Standard is a *performance standard* for fossil fuel home heating providers that encourages the progressive adoption of *clean heat resources*.
- Different versions of such a policy are being implemented in Vermont and Colorado. State agencies and climate councils in Maryland and Massachusetts are exploring a clean heat standard, and six other states have stated publicly that they will explore such a policy.

A clean heat standard (CHS) is a performance standard, similar to a renewable portfolio standard for electric utilities, applied to providers of fossil fuels used for heating (such as fossil gas, fuel oil and propane). A CHS requires the provider to deliver a gradually increasing percentage of low-emission, clean heat resources to customers. In one version of a CHS, fuel providers demonstrate compliance by acquiring and retiring "clean heat" credits in proportion to their fossil fuel sales.

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[43] The White House, Executive Order 14008 on tackling the climate crisis at home and abroad, January 27, 2021. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

[44] Martinez, C., & Vahlsing, C. (2021, December 2). *Delivering on Justice40*. https:/www.whitehouse.gov/ceq/news-updates/2021/12/02/delivering-on-justice40/

[45] Farnsworth, D., Torre, D., Brutkoski, D. & Hare, R. (2023, January). *Public access and participation plans: a starter kit for state agencies*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/public-access-and-participation-plans-a-starter-kit-for-state-agencies/

# Designing a CHS to Accelerate Heat Pump Deployment

The purpose of a CHS is to reduce the continued use of fossil fuels in buildings, while at the same time promoting the adoption of cleaner and more efficient alternatives such as heat pumps. A CHS not only gives obligated parties compliance choices, but also requires clean heat resources to compete with each other to offer customers options. Policymakers will need to decide what qualifies as a clean heat resource. For example, green hydrogen may be on a state's list of clean heat resources that can generate credits, but it will not necessarily be the most cost-effective or feasible from a safety or functionality standpoint (as it is yet unproven at scale) and thus will not necessarily be relied upon by compliance entities.[46] Being on the list simply means that green hydrogen can compete with other resources on the list — and will ultimately win or lose based on cost, availability, customer preferences and greenhouse gas reduction potential (see text box on following page).

It is also important to note that effects of a CHS on clean heat resource adoption will depend on additional factors such as incorporating equity concerns, consumer education, and availability of equipment and installers. One advantage of a performance standard like the CHS is that provisions to promote equity and environmental sustainability can be built into its design. To ensure that lower-income households and energy-burdened communities are not left behind, a CHS should involve those communities in program development efforts from the start and require that a substantial fraction of clean heat credits each year be secured by delivering services to those customers.

# State Examples

A CHS policy is being implemented in Vermont and Colorado, under significant consideration in Massachusetts and Maryland, and six more states have publicly stated they would explore such a policy.[47]

In May 2023, the state of Vermont passed the Affordable Heat Act (S.5), which launches an administrative CHS implementation process at the Vermont Public Utility Commission which is then to be reviewed by the legislature prior to adoption. The statutory CHS model being considered includes a broad array of resources: weatherization, electric and ground-source heat pumps, renewable fuels (biodiesel, biogas), district heat and advanced wood heat (pellet stoves and wood chip boilers). Under the Vermont CHS, anyone can generate clean heat credits that compliance entities are required to purchase and retire. This can include fuel dealers, HVAC installers, energy efficiency and weatherization providers, utility companies, and pellet stove sellers. The credit system allows fuel providers to comply with the CHS by generating credits or purchasing credits generated by others.

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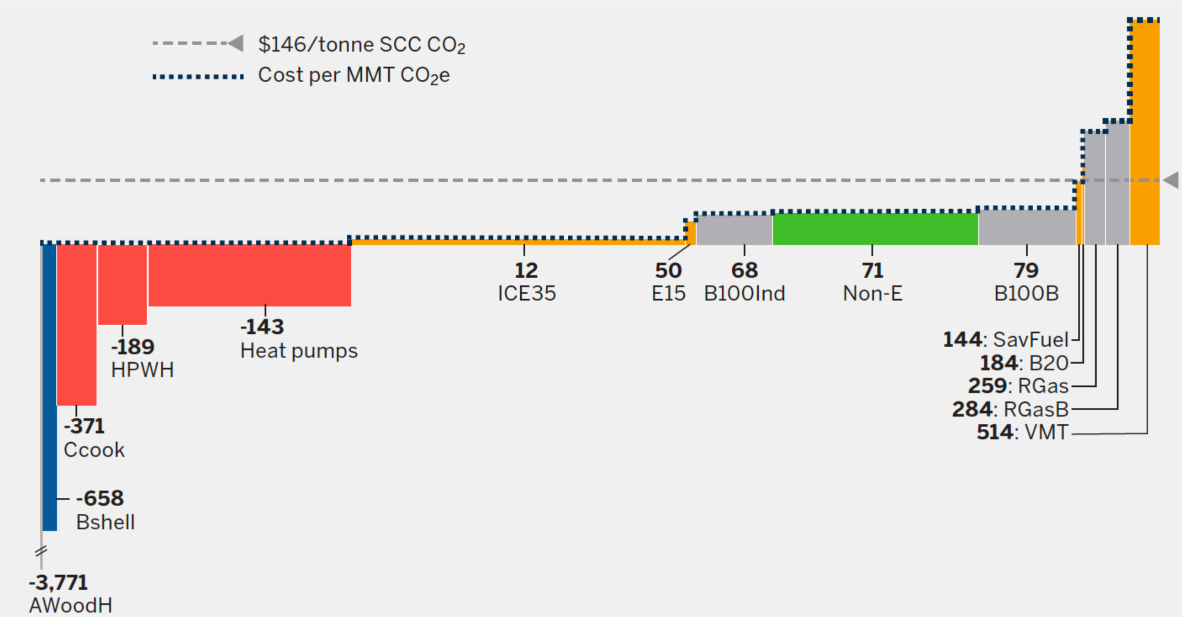
[46] Baldwin, S., Esposito, D., & Tallackson, H. (2022, March). *Assessing the viability of hydrogen proposals: considerations for state utility regulators and policymakers*. Energy Innovation. https://energyinnovation.org/wp-content/uploads/2022/04/Assessing-the-Viability-of-Hydrogen-Proposals.pdf

[47] The additional six states are Connecticut, Hawaii, New Jersey, New York, Pennsylvania and Rhode Island. See U.S. Climate Alliance. (2023, September). U.S. Climate Alliance announces new commitments to decarbonize buildings across America, quadruple heat pump installations by 2030 [Press release]. https://usclimatealliance.org/press-releases/decarbonizing-americas-buildings-sep-2023/

## Assessing the Avoided Emissions of Clean Heat Resources

A key factor informing the competitiveness of any given clean heat resource is its marginal cost per ton of GHG avoided. To illustrate, a study that supported the adoption of a CHS recommendation in Vermont's 2022 Climate Action Plan contained several marginal abatement cost curves that identify a number of potential measures to meet building/thermal climate goals. As illustrated below,[48] the medium-term cost curve (i.e., for measures implemented through 2030) identifies compliance measures with net negative costs, including advanced wood heating, building shell measures (i.e., weatherization), and three electrification measures (clean cooking, heat pump water heaters, and heat pump space conditioning).[49]

**Figure 5. Marginal Abatement Cost Curve of Measures Implemented Through 2030**




When considering the relative costs of clean heat resources to avoid tons of carbon, heat pumps appear very favorably, and are likely to be more economical compliance choices by comparison to alternatives such as biodiesel (B100) or renewable gas (RGas). This illustrates that, in addition to the initial cost of a heat pump and its further discount by the IRA, a CHS can drive greater heat pump adoption.

[48] Hill, D., Bourguet, E., Binnington, T., & Pradhan, S. (2022). *Marginal abatement cost curves – examining the mitigation potential and cost per tonne of emissions reductions of measures in the Vermont pathways analysis*, pp. 7-8. Energy Futures Group. https://outside.vermont.gov/agency/anr/climatecouncil/Shared%20Documents/MAC%20Curve%20Deliverable%20Memo%20Clean%20Version.pdf. Appendices B and C include tabular results for the 2030 (medium-term) and 2050 (long-term) marginal abatement cost curves.

[49] While these resources were identified in Vermont's Climate Action Plan as potential resources for addressing GHG emissions in the state's building sector, a CHS would still subject these resources to an additional screen, a life cycle analysis of related carbon emissions. See Vermont S.5., the Affordable

Unlike the Vermont portfolio standard-based model for animating cleaner resources discussed above, the Colorado Clean Heat Plan, adopted by statute in 2021, takes a planning and programmatic approach, setting GHG reduction goals for 2025 and 2030. To demonstrate compliance, utilities are required to file clean heat plans with the utility commission starting in 2023. Gas utilities are allowed to meet their requirements with electrification, energy efficiency, recovered methane and green hydrogen, with approval from the Colorado Public Utilities Commission based on their filed clean heat plans.[50]

In Massachusetts, a clean heat standard was first recommended in the Massachusetts Clean Energy and Climate Plan for 2025 and 2030,[51] and subsequently endorsed by the Clean Heat Commission in November 2022.[52] Subsequently, the Massachusetts Department of Environmental Protection has commenced a regulatory process with stakeholder workshops.[53] In particular, the CHS under consideration there may award credits "for strategies that reduce GHG emissions, with a strong preference towards pursuing electrification."[54]

In the state of Maryland, the Commission on Climate Change recommended in 2022 to "develop a new climate-aligned, renewable thermal energy program to facilitate the decarbonization of the building sector."[55] Since then, the Maryland Department of the Environment has started to explore the inclusion of a clean heat standard as a regulatory action under Climate Solutions Now Act in conjunction with the Mitigation Working Group of the Commission on Climate Change.[56]

Heat Act, Section 8127(c): "Credit values. Clean heat credits shall be based on the accurate and verifiable lifecycle CO2e emission reductions …." See also Cowart, R., Seidman, N., & LeBel, M. (2022, July). *A clean heat standard for Massachusetts*. Regulatory Assistance Project, prepared for the Massachusetts Executive Office of Energy and Environmental Affairs. Also see Cowart, R., Seidman, N., LeBel, M., & Weston, F. (2023, November). *Meeting the thermal challenge: A clean heat standard for Maryland*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/meeting-thermal-challenge-clean-heat-standard-maryland/

[50] Colorado Public Utilities Commission. (n.d.). *Learn about clean heat plans*. https://puc.colorado.gov/cleanheatplans

[51] Massachusetts Clean Energy and Climate Plan for 2025 and 2030. https://www.mass.gov/doc/clean-energy-and-climate-plan-for-2025-and-2030/download

[52] Massachusetts Executive Office of Energy and Environmental Affairs. (2022, November 30). *Final report of the Massachusetts Commission on Clean Heat*. https://www.mass.gov/info-details/commission-on-clean-heat-issues-final-report

[53] Massachusetts Department of Environmental Protection. (n.d.). *Massachusetts clean heat standard*. https://www.mass.gov/info-details/massachusetts-clean-heat-standard

[54] Massachusetts Department of Environmental Protection. (2023, March). *MassDEP stakeholder discussion document: clean heat standard program design*. https://www.mass.gov/doc/clean-heat-standard-discussion-document/download

[55] Maryland Commission on Climate Change. (2022). *2022 annual report*. https://mde.maryland.gov/programs/air/ClimateChange/MCCC/Documents/2022%20Annual%20Report%20-%20Final%20%284%29.pdf

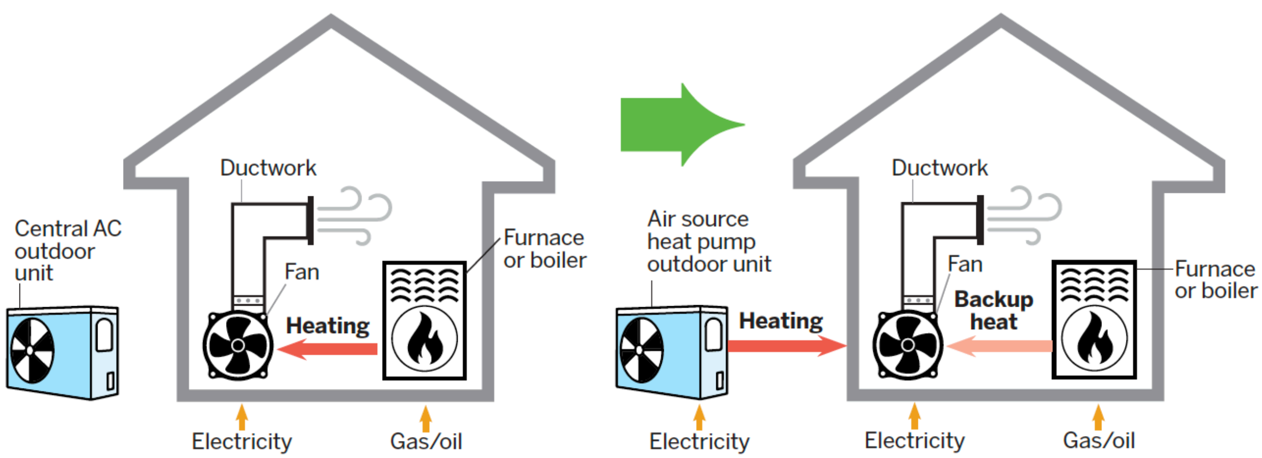
[56] Cowart, Seidman, LeBel & Weston, 2023.

# Hybrid Heat

- If homes with central air conditioning replace their ACs with more efficient “two-way” heat pumps, they can use the heat pumps for both cooling and to meet some of their heating demand, reducing use of existing fossil systems while not requiring them to be fully replaced.
- More than 50 million households could benefit from this flexible, affordable approach, and states should consider incorporating hybrid heating as they design their heat pump programs.

“Hybrid heat” refers to the practice of installing a heat pump without replacing one’s existing fossil heating system. For instance, if homes with central air conditioning (AC) and a separate heating system were to replace their next central air conditioner with a look-alike and more efficient “two-way” heat pump, those homes could not only cool over the summer, but they could also heat at lower cost with the same appliance during other times of the year. Additionally, because the hybrid heat model does not replace the existing heating system, it provides flexibility to low-income and energy-burdened customers who may not be able to afford to fully retrofit their residence.

**Figure 6. Heat pump replacing one-way central air conditioning**




Source: CLASP

Today’s heat pump technology erases the traditional line between cooling and heating appliances, creating significant opportunity. In millions of homes, a typical central AC unit only provides cooling and is currently paired with a fossil-fuel-fired furnace that delivers 100% of a home’s heating needs. This is the case for 1.2 million homes that heat with oil, 2.8 million with propane, 15 million with electric resistance, and 37 million with methane gas.[57]

According to the Air-conditioning, Heating & Refrigeration Institute, 4 million air-source heat pumps are sold each year in the United States, while more than 6 million central ACs are also sold each year.[58] A hybrid heating strategy is an opportunity to displace unnecessary and less efficient home heating with a heat pump that can both cool and heat, can avoid $CO_2$, lower overall heating bills, and produce additional societal benefits, for example, by avoiding on-site fossil combustion and health risks associated with oxides of nitrogen.[59] At the same time, keeping traditional heating sources, although using them less, addresses customer uncertainty and provides back up for hard-to-heat times.

In the fall of 2020, the U.S. EPA put this idea into policy. It determined that two-way heat pumps deserve the agency's coveted Energy Star "Most Efficient" rating, and that one-way air conditioners no longer do. 2023 will be the last year Energy Star recognizes traditional central air conditioners as qualifying for that rating. According to the EPA, "hybrid heating is the logical next step for retrofits in existing homes, given the modest incremental cost to install a heat pump instead of an AC."[60]

Every six seconds, a new residential furnace or air conditioner starts up in the United States. Because the appliance will run for many years, that decarbonization opportunity is lost until 2035-2040. The demand for air conditioning is also increasing, meaning that the opportunity for two-way heat pumps is likely to grow. As they review IRA support for heat pumps or as they develop their own heat pump programs, states should secure the benefits of hybrid heating for the over 50 million households that are ready today to transition from heating with less efficient oil, methane, propane and electric resistance.

# Energy Efficiency Programs

- Energy efficiency programs run by gas utilities, electric utilities, or independent administrators can be refocused and strengthened to promote heat pumps and associated measures.
- To do so, consider eliminating fuel-switching prohibitions, creating detailed roadmaps, ending incentives for gas equipment, and setting rules to address missed opportunities.

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[57] U.S. Energy Information Administration, 2023b.

[58] Air-Conditioning, Heating and Refrigeration Institute. (n.d.). *Central air conditioners and air-source heat pumps*.

[59] U.S. Environmental Protection Agency. (2023, March 20). *Nitrogen dioxide's impact on indoor air quality*. https://www.epa.gov/indoor-air-quality-iaq/nitrogen-dioxides-impact-indoor-air-quality

[60] U.S. Environmental Protection Agency. (2023). *ENERGY STAR® Most Efficient 2023 stakeholder comments & responses — air source heat pumps and central AC*. https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Most%20Efficient%202023%20Stakeholder%20Comment%20Matrix_1.pdf

- Massachusetts is an example of a state that has recently implemented these key elements and has ambitious aims for driving heat pumps under its Mass Save efficiency program.

Energy efficiency programs, run by utilities or independent administrators, have existed in various states for decades — well before the current push for building electrification. Now, these programs can play a major role in promoting IRA goals and promoting building electrification. There are state programs that have significant and growing experience with heat pump measures (such as Efficiency Maine and Mass Save). However, broadly speaking, efficiency programs across the country have historically focused on lighting retrofits (such as supporting switching from incandescent to LED lighting) and other measures that save relatively small amounts of energy. Measures to promote space conditioning and water heating, heat pumps — along with associated building envelope improvements — should become a central focus of energy efficiency programs.[61]

## Bolstering Energy Efficiency Programs to Accelerate Heat Pump Deployment

Several elements can help transform and strengthen efficiency programs to support heat pump deployment.

**Eliminate fuel-switching prohibitions and recognize all fuels**. Efficiency programs are typically governed by a state-level policy — often set out in legislation — referred to as an energy efficiency resource standard (EERS), which sets binding energy savings targets. EERS policies are traditionally designed to require savings of specific energy resources, namely electricity or methane gas in homes or businesses. EERS policies that are set in terms of just one type of fuel, however, constitute a barrier to electrification. Heat pumps, for example, are far more energy efficient than comparable fossil fuel heating technologies. For this reason, EERS policies in Wisconsin, Massachusetts, New York and other states set targets for energy savings not only on a fuel-specific basis, but also on a *fuel-neutral* basis.[62] This approach measures total British thermal units (Btus), GHGs, or some other fuel-neutral unit and captures the benefits of, for example, switching homes from fossil fuel heating to electric air-source heat pumps that may increase electric energy use, but will reduce overall energy use on a total Btu or GHG basis. A fuel-neutral EERS would allow an electric or gas utility to get credit for displacing non-electric fuels, such as a gas heating to heat pump conversion that displaces methane gas.[63]

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[61] Specian, M., & Bell-Pasht, A. (2023). *Energy efficiency in a high renewable energy future*. ACEEE. https://www.aceee.org/research-report/u2303

[62] Molina, M., R. Gold, R., G. Calcagni, G., Belliveau, E., & Cowell, S. (2020). *Implementing fuel-neutral goals: a progress report from Massachusetts and New York*. Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings.

[63] Berg, W., Cooper, E., & Cortez, N. (2020, May). *State policies and rules to enable beneficial electrification in buildings through fuel switching*. ACEEE.

**Create detailed roadmaps.** It is useful to create a detailed state building electrification roadmap to guide utility efficiency programs. The roadmap should model pathways to reach building decarbonization by the target year. It should set annual targets to guide the building sector along a pathway to full building decarbonization. The roadmap should include modeling that considers needed incentives beyond those supplied in the IRA and other policies. Such a roadmap will likely result in aggressive annual targets, such as in the Massachusetts case (see below). This will point the way toward significantly increasing the size and funding of existing programs, including larger targets under the EERS.

**End incentives for gas equipment**. To free up resources for heat pumps, prohibit any new deployment of fossil gas equipment under these programs. This will mean that any program administered by a gas utility will be devoted to electrification.

**Prioritize serving low-income and energy burdened customers.** A detailed roadmap is an opportunity to prioritize providing energy efficiency services to low-income and energy-burdened communities to ensure that they are not left behind.

**Address missed opportunities.** Because a robust roadmap will likely target replacement of nearly all existing heating equipment in the state with heat pumps – and because any given building might only change heating equipment once in twenty years, program administrators should be required to report annual estimates of missed opportunities to switch to electric heat pumps from other types of heating equipment. This could be accompanied by an incentive mechanism to encourage the utility to minimize such missed opportunities.

## State Example

Massachusetts has recently implemented many of the key elements discussed above. In March 2021, the state enacted An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy (the Climate Act).[64] The Climate Act requires economy-wide GHG emissions to reach net zero by 2050 and sets a 2030 limit of at least 50% GHG emissions reductions relative to 1990 levels. It requires the state secretary of energy and environmental affairs to establish GHG sublimits and roadmaps for subsectors of the economy, including for the building sector.[65] It also requires the state to create detailed roadmap documents for meeting these targets, including roadmaps for the building sector.[66]

In response to the Act, the secretary of energy and environmental affairs sets goals every three years for the state's independent energy efficiency program administrator, Mass Save. The goals, as required in the Act, are expressed on a fuel-neutral basis —

https://www.aceee.org/policy-brief/2020/04/state-policies-and-rules-enable-beneficial-electrification-buildings-through. See also discussion of the clean heat standard and clean heat resources available to fossil fuel providers.

[64] 193rd General Court of the Commonwealth of Massachusetts, S. 9, 2021, https://malegislature.gov/Laws/SessionLaws/Acts/2021/Chapter8

[65] More specifically, the Climate Act requires sublimits for sectors including "commercial and industrial heating and cooling" and "residential heating and cooling."

[66] These will build on the state decarbonization roadmaps issued in 2020.

specifically, in tons of carbon dioxide equivalent. Mass Save programs are funded by gas ratepayers and electric ratepayers. Together these sources of funding both go to achieve the GHG target with no prohibition on fuel switching.

In setting the initial three-year goal in 2021, the secretary:[67]

- Designated the goals for Mass Save as a “key policy driver” to meet the overall state GHG target;
- Stated that meeting the goals “will require a significant increase in the scope and scale of building retrofits, through a focus on envelope improvements and efficient electrification”;
- Called for “prioritizing measures consistent with the 2050 Roadmap [i.e., consistent with the goal of net zero GHG emissions] … such as insulation and heat pumps, and reduce support for measures like lighting and fossil-fuel heating incentives;
- Set aggressive targets for the first period, “significantly ramping up electrification of existing buildings through heat pump goals that set the Commonwealth on a path to achieving one million homes and 300–400 million square feet of commercial buildings using electric heat pump for space heating by 2030”; and
- Ordered a phase-out of fossil fuel incentives offered by Mass Save.

# Rate Design

- Rate design – the way consumers pay for their energy – can be reformed to be more cost-reflective by capturing the extent to which a change in a customer’s timing or quantity of usage affects overall utility costs.
- Rate designs that do not change over time can cost the average customer more to switch from fossil gas to a heat pump, while a smarter rate design could save a consumer money if they were to switch from using fossil gas to a heat pump.
- Examples from in Colorado and Illinois demonstrate that a utility’s rates can be designed to encourage cost effective use of the power grid while also making heat pump operation more affordable.

The primary operating cost for electric heat pumps is the incremental costs on a customer’s electric bill. Those operating costs are determined by the structure and level of electric

[67] Theoharides, K. (2021, July 15). Letter regarding greenhouse gas emissions reduction goal for Mass Save. https://www.mass.gov/doc/greenhouse-gas-emissions-reduction-goal-for-mass-save/download

rates for that customer, which is often called rate design.[68] A customer's rates may contain two or three different elements, such as a customer charge, which is typically a set amount per month, energy charges which are based on kWh usage, and for many business customers demand charges, which are typically based on a customer's 15- or 30-minute individual peak demand. Existing rate design in most jurisdictions tends to be quite simple, particularly for residential customers with a modest customer charge and the bulk of costs recovered through a flat per-kWh energy charge.

The economics of switching from inefficient heating sources, whether that is piped methane gas, propane, heating oil, or electric resistance, will depend on the operating costs of those heating sources[69] compared to the new incremental costs from heat pump operation. Heating oil and propane prices are largely market-driven, but substantial portions of electric and gas rates are also affected by fuel markets – notably gas supply costs for gas utilities and fuel and wholesale market prices for electric utilities. Heating oil and propane prices are largely unregulated, but substantial portions of electric and gas rates are directly regulated by utility commissions.[70] Under recent market conditions, electric heat pump operating costs under typical rate designs are frequently competitive with oil and propane, but not necessarily with methane delivered by gas utilities.

Fortunately, there are smarter options than annual flat volumetric rates for electricity. In some jurisdictions, the flat kWh energy charge may vary by month or season. If a jurisdiction has higher costs and resource adequacy risks in the summer (summer peaking), it can be fair and efficient to charge higher prices in summer months and lower prices in other seasons. As this makes electricity cheaper in the winter, it improves the affordability of heat pumps used for heating. As heating electrification accelerates however, some jurisdictions may become winter-peaking and seasonal cost-based rate design may no longer favor winter usage.

Beyond rates that change from month to month, well-designed time-varying rates that change within a billing period can be a major improvement in the cost causation, recognizing that the utilities' cost to generate and deliver electricity can vary at different times. In a growing number of jurisdictions, customers have a default time-of-use kWh energy charge, which varies across the day and week according to a preset schedule. For example, for a given utility, it may be expensive to keep the system running on a hot summer afternoon when everyone is running their air conditioners, as illustrated below. These rates typically define a multi-hour "peak period," during which prices are higher than during "off-peak" hours. In addition to reflecting utility system costs, TOU rates have the

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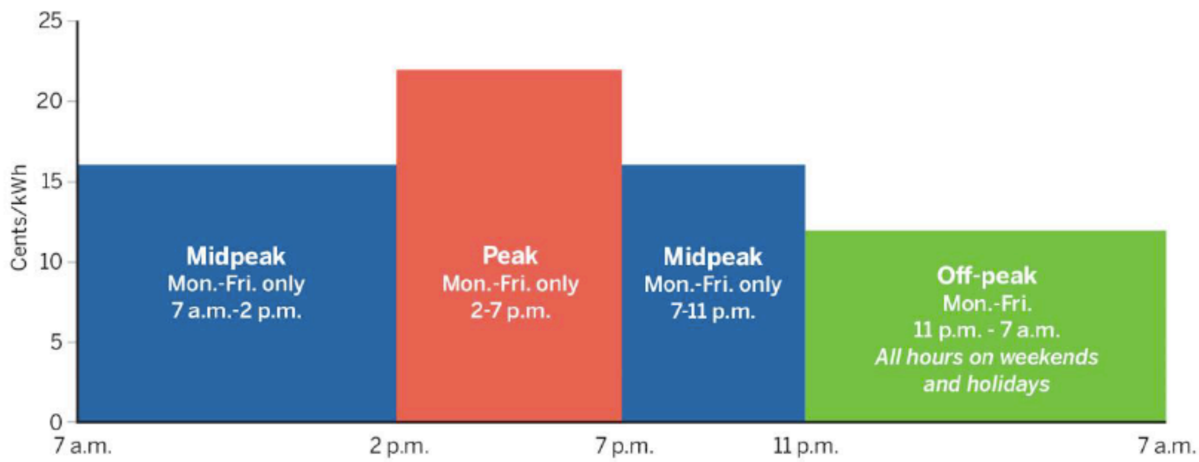
[68] For an overview of electric ratemaking and rate design, see Chapter 2 of Lazar, J., Chernick, P., Marcus, W., and LeBel, M. (Ed.). (2020, January). *Electric cost allocation for a new era: A manual*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/electric-cost-allocation-new-era/

[69] Electric heat pumps can also function as cooling in the summer. If the customer had existing air conditioning, a heat pump is frequently a more efficient replacement which can mean lower electricity bills in the summer.

[70] In some jurisdictions, non-utility retail suppliers can provide alternative supply to customers at a price that is not directly overseen by regulatory commissions. This can be true for both electric and gas supply and varies from state to state.

potential to improve the economics of heat pump operation. Seasonal distinctions can also be built into TOU rates.

**Figure 7. Illustrative three-period summer residential time-of-use rate**




More generally, time-varying rate designs allow consumers and utilities to capture value from changes in timing and quantity of energy use and can fairly and efficiently be applied to all customer end uses.[71]

Seasonal and time-varying rates are not the only rate designs with potential to improve the affordability of heat pumps, but many other variations have downsides that should be considered appropriately. For example, traditional electric heating residential customer classes frequently have lower kWh energy charges paired with customer charges that are significantly higher than could be justified by the cost to connect a customer alone. While this approach makes heat pumps more affordable, it can also encourage uneconomic and inefficient usage for other end uses. If made widely available to all residential customers, it would also attract large users who would benefit from such a rate, regardless of whether that usage was from an efficient electric heating source. Similarly, demand charges could be applied to residential customers and the incremental demand charge revenue could be used to reduce kWh rates. Of course, typical demand charge structures would likely be confusing for residential customers and demand charges for businesses are typically far in excess of what can be justified based on cost.[72] Residential rate designs with high customer charges and demand charges should be viewed with caution.

In addition, discounts to typical residential electric rates, which do not attempt to collect extra revenue with higher customer or demand charges, are another option that improves the affordability of heat pump operation. Such a rate, conceptually similar to low-income

[71] See LeBel, M., Shipley, J., Linvill, C., & Kadoch, C. (2021, November). *Smart rate design for distributed energy resources.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/smart-rate-design-distributed-energy-resources-2/

[72] LeBel, M., Weston, F., & Sandoval, R. (2020, November). *Demand charges: What are they good for?* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/demand-charges-what-are-they-good-for/

discount rates or economic development rates for business customers, does have some downsides. If applied to all customer usage, it can encourage inefficient consumption from other end uses. Targeting the discount to a limited number of end uses or incremental usage may be feasible, but likely comes with additional administrative costs.[73] These types of discounts may also encourage lock-in and it may be difficult to ever move customers back to a more normal rate. Discounts also lower the benefit to other ratepayers from accelerating heat pump adoption. If applied judiciously, discounts may be a reasonable solution but likely should be limited in magnitude and time duration.

# Existing Examples

## Fort Collins Utilities

The municipal utility in Fort Collins, Colorado offers electric heating customers a separate rate. The key difference between the electric heat rate and the standard rate is that on the electric heat rate customers do not pay a surcharge for kWh consumption that exceeds 700 kWh per month. On both the standard and electric heat rates, prices per kWh vary by season (summer and non-summer) and by hour (peak and off-peak). This structure gives customers the opportunity to pre-heat (or pre-cool) their homes to cut down on peak usage and help control electric bills.

With some simplifying assumptions we can estimate the potential customer cost savings from switching from a gas furnace to a heat pump that is operated on Fort Collins' electric heat rate. If a customer was able to concentrate 90% of space heating demand to off-peak hours,[74] being on the electric heat rate could mean that switching to a heat pump will save customers money on their annual space heating bills.[75] Combined with the up-front cost savings available through the IRA, such annual operating cost savings could bring the payback period for installing a heat pump to within its lifespan (~15 years) and help accelerate heat pump adoption.

## Commonwealth Edison

In Illinois, heating with gas is common but existing smart rate designs may help support electrification. In the city of Chicago, where the utility Peoples Gas serves roughly 880,000 customers, the operating economics of heat pumps are favorable, due, in part, to an electric heat rate available from the electric utility, Commonwealth Edison (ComEd). Existing single-family homes would save $8,976 over 20 years by electrifying home space

[73] For a California-specific discount rate proposal for incremental usage, see Moss, S., & McCann, R. (2022, April 12). *Proposing a clean financing decarbonization incentive rate*. M.Cubed. https://mcubedecon.com/2022/04/12/proposing-a-clean-financing-decarbonization-incentive-rate/

[74] In the non-summer months, off-peak hours are anytime other than Monday through Friday from 5-9 pm.

[75] Using simplifying assumptions, we calculate that a customer could say roughly $160 annually by using a heat pump rather than a natural gas furnace for space heating.

heating with a heat pump, including $941 in first-year bill savings.[76] The savings are the result of a combination of high gas prices in Peoples Gas territory and the availability of ComEd's electric heating rate. The monthly customer charge is slightly higher under the electric heating rate than the standard rate, but the per-kWh distribution rate is 2.2 cents lower. This makes larger loads like those associated with heat pumps more affordable on a per-kWh basis. The rate would be even more favorable to electrification if it included seasonal or time-varying elements because home heating demand, at least for the time being, occurs primarily during off-peak times of year and day.

# Workforce Training and Development

- To ensure the ability to deploy heat pumps at scale, states will need to focus on improving the skills of their workforce, including training for existing employees and apprentice-based programs to attract new workers.
- Different models for workforce training are being successfully demonstrated by the states of Maine and Massachusetts, by institutions like International Center for Appropriate and Sustainable Technology and Santa Fe Community College, and by companies like Mitsubishi.

A shortage of skilled technicians familiar with heat pumps is an important aspect of the current US workforce challenge and threatens to be a bottleneck to heat pump deployment.[77] The resulting lack of skilled technicians familiar with heat pumps threatens to be a bottleneck to residential heat pump deployment. States can overcome this challenge by investing in workforce training programs, engaging younger and nontraditional workers, and providing access and support to registered pre-apprenticeship and apprenticeship work-based learning models.[78] Removing barriers to entry in existing workforce development programs, such as requirements for certain educational attainment, having a driver's license, and access to a vehicle, can also broaden training program participation, especially from lower-income or historically marginalized communities.[79]

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[76] Twenty-year net present value; savings includes both capital and energy cost savings. See Neme, C., Hill, D., & Bourguet, L. (2022, November). *Cost savings and $CO_2$ emissions reductions of residential electrification in Peoples Gas territory*. Energy Futures Group, prepared for National Resources Defense Council. https://energyfuturesgroup.com/wp-content/uploads/2022/11/Peoples-Gas-Electrification-Economics-2022-Nov.pdf

[77] Northeast Energy Efficiency Partnerships. (2017). *Northeast/Mid-Atlantic air-source heat pump market strategies report — 2016 update.* https://neep.org/northeastmid-atlantic-air-source-heat-pump-market-strategies-report-2016-update

[78] Goger, A. (2020). *Desegregating work and learning through "earn-and-learn" models.* Brookings Institution. https://www.brookings.edu/research/desegregating-work-and-learning/

[79] Anne McKibbin, Elevate, personal communication, July 15, 2022.

The IRA includes $200 million in funding for the US Department of Energy to provide state energy offices with grants to train contractors in energy efficiency and electrification upgrades, including heat pumps.[80] To date, heat pump workforce training has been mostly done through trade school programs, large contractors that train employees in-house or heat pump manufacturers.[81] This new funding has created an opportunity for states to expand existing programs, or to fund the development of new heat pump training programs. The following list of heat pump training programs illustrates different approaches that states and others are taking.

## Examples of Heat Pump Workforce Training Programs

- The International Center for Appropriate and Sustainable Technology (ICAST) is partnering with Santa Fe Community College on a heat pump technician training pilot program.[82] The project objective is to create an advanced curriculum to train individual HVAC technicians in the design, installation, and maintenance of cold climate air source heat pumps in existing residential and small commercial buildings.
- Efficiency Maine, an independent organization overseen by the Maine Public Utilities Commission, offers free, online heat pump basics training through their heat pump installer training center. It also provides links to in-person heat pump classes offered by registered trainer organizations across the state.[83]
- Mass Save has courses that focus on cold climate heat pumps for residential installers participating in the Massachusetts Heat Pump Installer Network (HPIN).[84]
- In response to the anticipated increased demand for heat pumps, the manufacturing company Mitsubishi Trane HVAC US opened a new heat pump training and distribution facility on April 26, 2023, in Florence, New Jersey. The company plans to host 40 to 45 classes per year and train 500 to 600 students annually.[85]

[80] DC Sustainable Energy Utility. (2022). *A breakdown of how the Inflation Reduction Act could impact the District.* https://www.dcseu.com/news-blog/news-blog/blog-posts/how-will-the-inflation-reduction-act-affect-homes-and-businesses-in-the-district-here-s-a-breakdown

[81] Businesswire. (2023). *Mitsubishi Electric Trane HVAC US opens Florence, New Jersey distribution and training center.* https://www.businesswire.com/news/home/20230504005301/en/Mitsubishi-Electric-Trane-HVAC-US-Opens-Florence-New-Jersey-Distribution-and-Training-Center

[82] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2022b). *Training the next generation of heat pump HVAC technicians.* https://www.energy.gov/eere/buildings/articles/training-next-generation-heat-pump-hvac-technicians

[83] Efficiency Maine. (2023). *Heat pump training.* https://www.efficiencymaine.com/heat-pump-training/

[84] Mass Save. (n.d.). *Heat pump installer training opportunities.* https://www.masssave.com/trade-partners/heat-pump-installer-training

[85] Businesswire, 2023.

# Tariffed On-Bill Financing

- Tariffed on-bill financing can overcome the up-front cost barrier faced by customers interested in purchasing clean energy technologies like heat pumps.
- The on-bill financing costs, carried by the utility or a third party, are then recovered through a special tariff "attached to the meter" that serves the building, and which the utility customer pays.
- If the tariff is properly designed, the customer's added monthly payments will be less than the monthly amount they are saving on their utility bill due to the investment.
- Examples of utilities with on-bill financing programs include Duke Energy Progress and Duke Energy Carolinas (North Carolina) Midwest Energy (Kansas), Ouachita Electric (Arkansas), and Eversource (New Hampshire).

A tariffed on-bill (TOB) finance program is a tool that helps utility customers finance the purchase of clean energy technologies, including heat pumps.[86] The essence of TOB financing is that the customer does not have to pay the purchase and installation costs of the clean energy technology up-front, but instead repays those costs over time in the form of charges that appear on their utility bill. If the program is well designed, a customer's added monthly payments will be less than the monthly amount they are saving on their utility bill due to the new heat pump (or other energy-saving technology). This makes TOB financing a powerful tool for accelerating heat pump deployment among customers who otherwise may struggle to afford a heat pump, including low-income, energy-burdened, or otherwise disadvantaged customers.

With TOB financing, the up-front investment is made by a utility or third-party and recovered through a special tariff "attached to the meter" that serves the building. Typical TOB financing terms, conditions, and prices associated with that investment are described in one of the utility's retail service tariffs. Because the financing is attached to the utility bill, there is no loan to that customer and no need for a credit check. If the customer moves away, the tariff remains associated with the meter and the next occupant will enjoy the investment (and associated energy savings) and continue to pay the tariff until the

[86] Other on-bill financial assistance mechanisms include on-bill repayment programs, where a non-utility third party lends money to the customer and the customer repays the loan through a payment on their utility bill, and on-bill finance programs which are similar except the utility itself is the lender. Furthermore, there are numerous other financing approaches that states might consider. Please see Lowes, R., Gibb, D., Rosenow, J., Thomas, S., Malinowski, M., Ross, A. & Graham, P. (2022. November). *A policy toolkit for global mass heat pump deployment*. Regulatory Assistance Project, CLASP and Global Buildings Performance Network. https://www.raponline.org/toolkit/heat-pump-toolkit/

investment costs are fully recovered. The chances of failing to recover investment costs are low with TOB financing because recovery is not dependent on the ability of a specific customer to pay utility bills.

## Using Tariffed On-Bill Financing to Accelerate Heat Pump Deployment

The primary benefit of TOB financing for heat pumps is that it eliminates the barrier of an up-front cost for a customer to purchase a heat pump. Beyond eliminating upfront cost, on-bill financing programs have additional advantages compared to traditional customer loans. One of the most important of those for heat pump deployment is that on-bill programs tend to have longer durations than most consumer loans which allows for larger upfront investments and lower monthly payments. On-bill programs also have lower default rates than traditional customer loans which can support lower interest rates and thus lower costs for participating consumers. Another advantage is that the financing is not contingent on the participating customer's credit score. A good utility bill payment history can be enough to qualify a customer for on-bill financing.

## State Examples

The majority of TOB finance programs are based on the Pay As You Save or PAYS model developed by the Energy Efficiency Institute.[87] As of 2022, there were 16 PAYS TOB financing programs with nearly 6000 projects completed.[88] For example:

- Midwest Energy, a Kansas gas and electric coop, offers TOB financing to residential and commercial customers via its How$mart program for new heating and cooling systems and other energy efficiency upgrades;[89]
- Ouachita Electric, a coop in Arkansas, offers TOB financing for single family and multi-family residences as well as for commercial properties through its HELP PAYS program, which has had notable success reaching the multi-family market;[90] and
- Eversource, an investor-owned electric utility in New Hampshire, offers TOB financing to customers through its Municipal Smart Start program.[91]

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[87] Energy Efficiency Institute. http://www.eeivt.com

[88] See Energy Efficiency Institute. (2022, March). *2022 PAYS status update.* http://www.eeivt.com/wp-content/uploads/2022/03/2022-PAYS-Status-Update_3_29_22.pdf

[89] See Midwest Energy. (n.d.). *How$mart*. https://www.mwenergy.com/environmental/energy-efficiency/howsmart

[90] See Ouachita Electric Cooperative Corporation. (n.d.). *HELP PAYS (Pay As You Save - energy efficiency program).* https://www.oecc.com/help

[91] See NH Saves. (n.d.). *Municipal Smart Start program.* https://nhsaves.com/municipal-smart-start-program/

Most recently, the North Carolina Utilities Commission issued an order approving a TOB program proposed for Duke Energy Progress and Duke Energy Carolinas.[92] On October 1, 2023, the companies began implementing new rates to cover implementation.[93]

TOB financing is a natural complement to the IRA. With its support, states and utilities can deploy heat pumps at lower cost, thus reducing the upfront cost of heat pumps and making them more likely to qualify as a cost-effective measure under a TOB financing program.

A question for any state interested in implementing TOB financing will be whether statutory authority exists to do so or whether additional authority is needed. So far, none of the states that have implemented PAYS programs have needed authorizing legislation, although that may not be the case for all states.[94]

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[92] The Commission order recognizes that the program is intended to overcome the “first cost” barrier to provide “a mechanism for customers to install energy efficient upgrades and pay for those upgrades over time through their monthly electric bill.” See North Carolina Utilities Commission, Docket No. E-2, SUB 1309 and Docket No. E-7, SUB 1279, Order on August 23, 2023. https://starw1.ncuc.gov/ncuc/PSC/PSCDocumentDetailsPageNCUC.aspx?DocumentId=01312307-B3DE-4691-BF5C-B485B6BA676A&class=Order

[93] Duke Energy. (2023, September 29). *Duke Energy Progress receives approval for new rates in North Carolina, implements new programs to help customers* [Press release]. https://news.duke-energy.com/releases/duke-energy-progress-receives-approval-for-new-rates-in-north-carolina-implements-new-programs-to-help-customers

[94] Energy Efficiency Institute. (n.d.). *Implementing PAYS® in your state or at your utility*. http://www.eeivt.com/implementing-pays-in-your-state-or-at-your-utility/

# Conclusion

Our modeling has demonstrated that IRA programs like HEEHRA and 25C that support the deployment of clean and efficient heat pumps will help increase the adoption of these important technologies in American homes. However, it is also evident that, to ensure a greater response to the climate challenges that we all face, the application of state policy and program experiences will be critical to greater heat pump adoption.

The policy models and related strategies described in this paper provide additional approaches for states to spur greater familiarity, acceptance, and ultimately broader heat pump adoption. State and local policy makers and our public utilities are in a strong position to identify and adopt policy and strategy approaches relevant to their local needs and concerns that can broaden pathways to heat pump adoption for their constituents.

As we all move forward with strong federal government support, we can continue to learn from each other, share best practices that will reduce emissions in our housing, and make our homes safer and more comfortable. The authors hope that this paper encourages state and local governments to build upon the federal support provided by the IRA, and to coordinate various program offerings to secure the greatest benefits for their states and citizens.

# Appendix A: Modeling Assumptions

## Introduction

To estimate the number of households that would switch to heat pumps with IRA incentives compared to a pre-IRA baseline, we used a model developed by the U.S. Department of Energy for the current furnaces energy conservation standard rulemaking.[95] The model compiles the manufacturing, distribution, installation, maintenance, repair, and operation costs of different space and water heating equipment and compares the up-front and annual costs to determine whether a household will switch from a gas (methane or propane) furnace to a heat pump or electric furnace.[96] It then changes the cost parameters and iterates 10,000 times to capture a wide variety of combinations of the input parameters.

The values for the cost parameters vary based on:

- Characteristics of new equipment, such as costs and efficiencies, which is the focus of DOE's analysis;
- Local factors such as sales taxes, utility rates, labor rates;
- Household characteristics, such as income and discount rate;[97]
- House characteristics such as age, location, and existing equipment (e.g., furnace capacity, presence, and age of a central air conditioner), based on the 2015 Residential End Use Survey (RECS) building microdata.[98]

The switching model used the Oracle Crystal Ball[99] Monte Carlo analysis software to randomly step through different combinations of the assumptions and evaluate the costs and benefits of different equipment configurations under a range of economic and climate conditions: for example, a gas furnace and central air conditioner (CAC) combination versus a heat pump. House owners are assumed to switch to a heat pump under three conditions:

1. The house currently has a heat pump or CAC in addition to the gas furnace;

[95] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2022a.

[96] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2022c, June 13). *Technical support document: Energy efficiency program for consumer products and commercial and industrial equipment: consumer furnaces*, Appendix 8J. https://www.regulations.gov/document/EERE-2014-BT-STD-0031-0320

[97] The model does not factor in that owners of rental houses may have different incomes and discount rates than the occupants.

[98] U.S. Energy Information Administration. (2018, December). *2015 RECS survey data: Microdata*. https://www.eia.gov/consumption/residential/data/2015/index.php?view=microdata

[99] Oracle. (n.d.). *Oracle Crystal Ball (on-premises)*. https://shop.oracle.com/apex/f?p=DSTORE:PRODUCT:::NO:6:P6_LPI,P6_PPI:4509235234901805719915,

2. The heat pump would cost less up-front than a replacement furnace and air-conditioner;[100] and
3. Any higher operating costs from heat pumps would not exceed the up-front savings over 3 to 4 years, with the specific value within that range dependent on household income.[101]

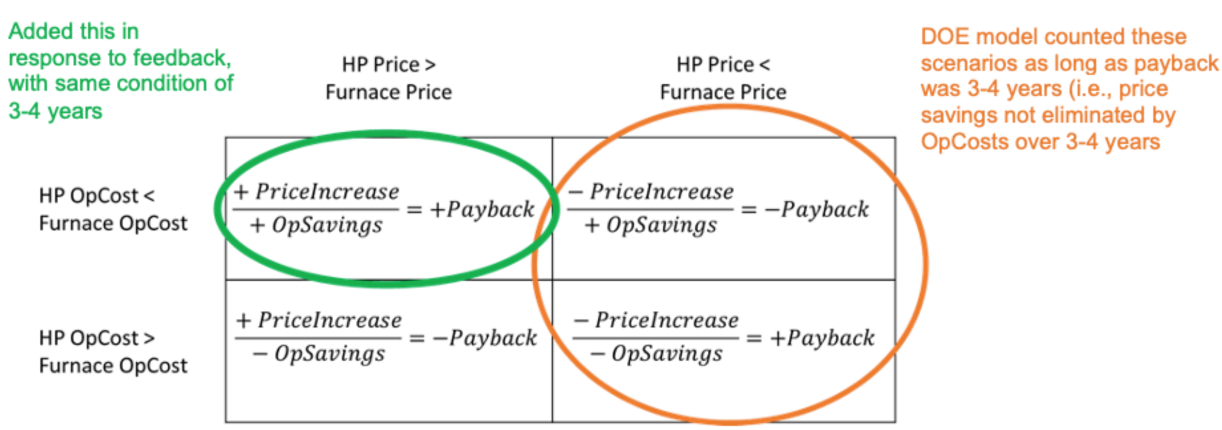
We note that this model does not consider households using electric resistance or oil, both cases where heat pumps are already cost-effective. Also, the model does not consider that house owners could switch to heat pumps in the absence of an existing heat pump or CAC, eliminating from consideration the households with neither piece of equipment that may be installing central cooling for the first time and would benefit from a heat pump instead of CAC.

# Changes to the Model's Default Assumptions

To model the impacts of the IRA, we modified the DOE model in several important ways.

**1. Including Higher Purchase Costs:** First, we relaxed the decision criterion that required heat pumps to cost less up front than an equivalent furnace and central air conditioner. This is illustrated in the figure below.

**Figure A-1. Heat pump switching decision criteria**




We also considered converting this payback period criterion to a full life-cycle cost/net present value evaluation, reflecting a more rational consumer that seeks to minimize the total cost over the equipment lifetime, under discounting. While this roughly tripled the number of heat pumps incentivized under 25C and roughly doubled the total under both IRA programs, we found that it increased the number of heat pumps in the pre-IRA

[100] The model further considers differences in lifetimes between furnaces and heat pumps; remaining lifetime of the CAC; and whether eliminating the furnace would "orphan" a gas water heater using a common vent, which would necessitate a venting modification or a new electric water heater.

[101] DOE cites the American Home Comfort Survey by Decision Analytics for this payback criterion.

baseline beyond what is seen in practice. For example, life-cycle cost accounting would result in half of today's electric furnaces switching to heat pumps, while in actuality electric furnace shipments are declining at a rate of 16% per year relative to the heating equipment market as a whole (see subsequent discussion). We therefore retained the DOE model's payback criterion of 3–4 years.

**2. Modeling the Situation Today:** Next, we edited the model to allow it to calculate switching today. By default, the model is designed to calculate switching as a result of proposed DOE standards, scheduled to take effect in 2029. We not only changed the effective year to 2025 (which impacts fuel, electricity prices, inflation), but also allowed for switching in the DOE "base case" or in the absence of the proposed standard. Finally, by default the DOE model does not analyze houses with condensing furnaces that would be unaffected by some of the installation costs associated with the proposed standard. We changed this setting as well. As a result, all gas furnace households would be subject to the switching analysis.

**3. A Wider Distribution of Heat Pump Efficiencies and Prices:** By default, DOE's model assumes a minimum-efficiency heat pump with a rated heating seasonal performance factor (HSPF) of 8.8 British thermal units per watt-hour (Btu/Wh) (this is equivalent to the current DOE standard at 7.5 HSPF2),[102] with the actual efficiency derated to reflect the impact of the climate at the location of each modeled house. These minimum-standards-compliant heat pumps have the following manufacturer production costs (in 2015 dollars), based on DOE's 2016 final rule that established the current standard.

**Table A-1. Manufacturer production costs for heat pumps compliant with minimum standards**

| 2-Ton | 3-Ton | 5-Ton |
|---|---|---|
| $935.73 | $1,030.86 | $1,358.58 |

Manufacturer, distributor, and installer markups are applied to this cost, as is a doubling factor when two heat pumps would be needed to replace a furnace larger than 75 thousand Btu per hour (kBtu/h). For example, a five-ton (60 kBtu/h) heat pump may have a retail price of $4,270 in 2020 dollars, but as it would be replacing a 125 kBtu/h furnace, one would need two heat pumps, so the price would double to $8,451. In addition, the DOE model adds an installation cost that is dependent on the location and the characteristics of the house: an additional $2,971 in the above example.

[102] Jones, J. (2022, September 20). *HSPF2: An industry update* [Presentation]. Washington State University Energy Program. https://www.energy.wsu.edu/documents/HSPF2%20An%20industry%20update.pdf

We replaced this minimum-standards-compliant heat pump with a distribution of efficiencies that reflects the range of models currently available on the market as reported by manufacturers to DOE.[103] We would sample from this distribution, summarized below in Table A-2, to model the efficiency of the heat pump under consideration by a given household.

**Table A-2. Distribution of heat pump efficiencies (efficiencies greater than 8.1 HSPF2 not shown due to space constraints)**

| HSPF (Btu/Wh) | HSPF2 (Btu/Wh) | Number of models | Cumulative distribution with lower rating |
|---|---|---|---|
| 8.9 | 7.5 | 312526 | 0% |
| 8.9 | 7.55 | 1509 | 42% |
| 9.0 | 7.6 | 6280 | 43% |
| 9.0 | 7.65 | 1216 | 44% |
| 9.1 | 7.7 | 17090 | 44% |
| 9.1 | 7.75 | 1530 | 46% |
| 9.2 | 7.8 | 160533 | 46% |
| 9.3 | 7.85 | 577 | 68% |
| 9.3 | 7.9 | 4589 | 68% |
| 9.4 | 7.95 | 839 | 69% |
| 9.4 | 8 | 33987 | 69% |
| 9.5 | 8.05 | 1182 | 74% |
| 9.6 | 8.1 | 103496 | 74% |

[103] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (n.d.). *Certification Compliance Management System (CCMS) – public database: air conditioners and heat pumps – central*, Appendix M1. https://www.regulations.doe.gov/certification-data/CCMS-4-Air_Conditioners_and_Heat_Pumps_-_Central__Appendix_M1.html#q=Product_Group_s%3A%22Air%20Conditioners%20and%20Heat%20Pumps%20-%20Central%2C%20Appendix%20M1%22.

To estimate the cost of this range of efficiencies, we replaced DOE's retail price and installation costs[104] with a total cost estimate based on data from efficiency programs in Massachusetts, California, Maine, and New York, which found a median total installed price of $13,000 for "a 1,500-square-foot home, with 2.5 tons (30 kBTU/hr) of heating/cooling, and an HSPF 10 (~HSPF2 8.5) heat pump in a moderate climate" with an additional $1,700 for each extra 500 square feet, $1,800 for each ton of heating capacity, and $700 each step up in heating efficiency (+1 HSPF) and 2,800 for cold climate.[105] Finally, we deflated the costs to July 2020 for consistency with the rest of DOE's analysis by dividing by a factor of 1.15.

For example, a 3-ton, 9.6 HSPF heat pump in a 1500 square-foot-home in the North (cold climate) would have a total installed cost of ($13,000 + 0.5 * $1,800 – 0.4 * $700 + $2,800)/1.15 = $14,278, in 2020 dollars.

4. By default the DOE model only analyzes gas furnaces — both methane and propane. To analyze the impacts of IRA incentives on other systems, we further modified DOE's model, overwriting gas rates in turn with electricity and oil, which we obtained from another part of the spreadsheet.

To better model the electric case, we also overwrote the default cost and efficiency of the gas furnaces with those for electric furnaces, also from another part of the spreadsheet, and removed costs that were included for gas-to-electric conversion, such as venting and electrical work, since those would not apply to houses that already have an electric furnace. DOE did not include cost or efficiency data for oil furnaces in the spreadsheet, so we kept these the same from the gas case.

We expect this part of the analysis to be much less accurate than the gas analysis for several reasons:

- As we did not modify the overarching sampling mechanism of the spreadsheet, this modified analysis is still taking buildings that originally had gas furnaces and instead fueling them with electricity or oil. Therefore, we are not accounting for differences in the types of houses that use the different fuels.
- We partly account for the geographic distribution of the fuels, which will impact the climate and building types associated with each, by taking DOE's regional results (North and South) and weighting them by the proportion of furnaces in each region from RECS 2020 (approximately 87% of oil furnaces are in the North while 78% of electric furnaces are in the South).[106]

[104] Further divided between air handler (indoor unit) and heat pump (outdoor unit) in the DOE model. We mapped the Rewiring America total installation cost to the DOE heat pump retail price, and later mapped the total IRA incentive to the air handler installation cost as both of these values were reported by the DOE model so could be easily tallied.

[105] Rewiring America (n.d.). *Upfront cost of home electrification* [Manuscript in preparation].

[106] Totals for South are from the South, Pacific, and Mountain South Regions, which are mostly aligned with DOE's South states. See U.S. Energy Information Administration, 2022.

- We also did not carefully model some second-order effects, such as gas versus electric water heaters, or potential differences in the prevalence of heat pumps and air conditioners in gas versus oil and electric houses. Again, we took the same gas houses and just changed the cost of the fuel and the cost and efficiencies of electric furnaces.

Nonetheless, we believe that this additional analysis can be helpful in identifying the size of the heat pump potential from electric and oil furnaces, which due to their higher operating costs, might be a significant target for IRA incentives.

The historical shipments for all consumer furnace types are shown below along with boilers, heat pumps, and central air conditioners (CACs) for comparison. In our analysis we only focus on the first three columns: non-weatherized gas, electric, and oil furnaces, excluding mobile-home furnaces. However, these three product types constituted 84% of the furnace and boiler market in 2020.

**Table A-3. U.S. shipments of various consumer heating and air conditioning technologies**

| Year | Non-weatherized gas furnace[107,108] | Electric furnace[109] | Non-weatherized oil furnace[110] | Mobile home gas furnace[111] | Mobile home oil furnace[112] | Weatherized gas furnace[113] | Oil or gas boiler[114] | Air-source heat pump[115] | Central air conditioner[116] |
|---|---|---|---|---|---|---|---|---|---|
| 2015 | 2,814 | 469 | 39 | 71 | 2 | 261 | 325 | 2,269 | 4,546 |
| 2016 | 2,943 | 491 | 38 | 81 | 2 | 273 | 307 | 2,430 | 4,901 |
| 2017 | 3,134 | 522 | 38 | 93 | 1 | 292 | 317 | 2,620 | 5,186 |
| 2018 | 3,417 | 567 | 39 | 97 | 1 | 319 | 365 | 2,920 | 5,396 |
| 2019 | 3,453 | 573 | 41 | 95 | 1 | 323 | 369 | 3,111 | 5,360 |
| 2020 | 3,351 | 556 | 37 | 94 | 1 | 314 | 336 | 3,418 | 5,910 |
| 2021 | 4,009 | 661 | 40 | NA | 1 | 377 | 400 | 3,917 | 6,282 |
| 2022 | 3,872 | 606 | 38 | NA | 1 | 344 | 399 | 4,334 | 6,054 |

[107] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2022d, June 13). *Technical support document: Energy efficiency program for consumer products and commercial and industrial equipment: consumer furnaces*, Table 9A.2.5.

[108] Air-Conditioning, Heating and Refrigeration Institute. (n.d.). *Furnaces historical data.* https://www.ahrinet.org/analytics/statistics/historical-data/furnaces-historical-data

[109] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2022e, November 22). *Consumer furnaces national impact analysis (NIA) (standby and off mode) spreadsheet (preliminary analysis) – hist. shipments*. https://www.regulations.gov/document/EERE-2021-BT-STD-0031-0015

[110] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2022e.

[111] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2022d.

[112] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2022e.

[113] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2022f, November 22). *Consumer furnaces national impact analysis (NIA) (AFUE) spreadsheet (preliminary analysis) – hist. shipments*. https://www.regulations.gov/document/EERE-2021-BT-STD-0031-0014

[114] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (2023, July 28). *Consumer boilers national impact analysis (NIA) (NOPR) spreadsheet – hist. shipments.* https://www.regulations.gov/document/EERE-2019-BT-STD-0036-0048

[115] Air-Conditioning, Heating and Refrigeration Institute. (n.d.). *Central air conditioners and air-source heat pumps*.

[116] Air-Conditioning, Heating and Refrigeration Institute. (n.d.). *Central air conditioners and air-source heat pumps*.

In the table below, we show how the percentage of the heating market for each of the analyzed furnace types has been declining over time, such that the sales of gas, electric and oil furnaces declined by 10%, 16%, and 37%, respectively, in 2020 compared to where they would have been had their share of the furnace, boiler and heat pump market remained the same as in 2015.

These lost sales add up to 583,000 in 2022. Together with the other furnaces and boilers the lost sales of heating equipment add up to 851,000 in 2022. This is very close to the lost sales for CACs — 875,000 in 2022 — had their share of the *cooling* market stayed constant since 2015. We believe that most of these decreases are due to a switch to heat pumps, as the total *increase* in air-source heat pump sales relative to a constant share of the combined *cooling and heating* market is 1,045,000 in 2022.

We compare these expectations of heat pump switching to the baseline switching results from our modifications of the DOE model at the bottom of Table A-4. This baseline includes the heat pump installations that would have occurred in the absence of IRA incentives and are useful for calibrating the model.

For example, in 2022 (the latest year for which data were available), furnace shipments declined 10%, 16%, and 37% for gas, electric, and oil, respectively. Meanwhile, DOE's model would predict 10%, 12%, and 11% switching to heat pumps. Therefore, the model explains between 30% and 100% of the conversions. For gas furnaces (the vast majority), the model appears to be on the mark. There appear to be additional factors that are reducing the popularity of oil furnaces that are not reflected in the model.

**Table A-4. Decline in the sales of the three analyzed furnace types relative to what they would have been, had their share of the heating market stayed constant since 2015**

| Year | Non-weatherized gas furnace | Electric furnace | Non-weatherized oil furnace |
|---|---|---|---|
| 2015 | 0% | 0% | 0% |
| 2016 | 0% | 0% | 7% |
| 2017 | 1% | 1% | 13% |
| 2018 | 2% | 2% | 19% |
| 2019 | 4% | 4% | 18% |
| 2020 | 8% | 9% | 27% |
| 2021 | 5% | 6% | 32% |
| 2022 | 10% | 16% | 37% |
| Baseline switching from modified DOE model: | | | |
| 2025 | 10% | 12% | 11% |

# Evaluating IRA Impacts

Next, we reduced the cost of heat pumps to reflect the two main heat pump incentives under the IRA. Because we were starting our analysis in 2025, we deflated the incentive amounts (which are provided in nominal dollars) back to 2020 for consistency with the rest of DOE's analysis by dividing by a factor of 1.22 (1.15 from 2020 to 2023,[117] then 3% inflation assumed for each subsequent year). We then applied the rebates as follows.

**High-Efficiency Electric Home Rebate Program (HEEHRA)**: To model the impacts of HEEHRA, we deflated the maximum $8,000 rebate to $6,557 in 2020 dollars. We applied this rebate to the Rewiring America total installed cost in the case of low-income households; or to half of the cost in the case of middle-income households.

We assigned modeled households falling between 0 and 39.99% of *national* income (0 to 80% of national median income; RECS income groups 1 and 2) into the low-income category and those falling between 40 and 79.99% of *national* income (80 to 160% of national median income; RECS income groups 3 through 6) into the middle-income category. This is slightly different from the income qualifications for HEEHRA, which depend on 0 to 80 and 80 to 150% of *area* median income, but is the closest we could do based on the available data.

**Nonbusiness Energy Property Tax Credit (25C)**: Section 25C requires that eligible heat pumps meet the Consortium of Energy Efficiency's (CEE) "highest efficiency tier (not including any advanced tier)".[118] This CEE "Tier 1" requires a heating seasonal performance factor or HSPF2 greater than or equal to 8.1 in the North and 7.8 in the South, among other requirements.[119] As DOE's spreadsheet uses the earlier HSPF metric, we had to convert the 8.1 HPSF2 in the CEE requirements by multiplying by 1.18 resulting in an HSPF of 9.558.[120] Each time a heat pump exceeded the above HSPF ratings, we subtracted a maximum of $1,639 ($2,000 deflated from 2025 to 2022) from 30% of the total installed cost.

We ignored the other CEE Tier 1 requirements (SEER2, EER2, connectivity, cold-weather performance) due to the challenge of identifying the models that meet all the CEE requirements[121] compared within the broader population of heat pumps. As a result, our model will tend to overestimate the number of heat pumps that can receive the 25C credit by more than a factor of two. For example, the share of heat pumps meeting the CEE Tier 1 ducted requirements in the South falls from 54% when considering only HSPF2 to 26%

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[117] U.S. Bureau of Labor Statistics. (n.d.). *CPI inflation calculator*. https://www.bls.gov/data/inflation_calculator.htm

[118] Inflation Reduction Act of 2022, Pub. L. No. 117–169, 13301(e), http://www.congress.gov/bill/117th-congress/house-bill/5376/text/pl

[119] Consortium for Energy Efficiency. (2023, January 1). *CEE residential electric HVAC specification – October 18, 2023*. https://cee1.my.site.com/s/resources?id=a0V2R00000sUQbyUAG

[120] Consortium for Energy Efficiency, 2023.

[121] Air-Conditioning and Refrigeration Institute. (2023, January 1). *Residential products meeting CEE's highest tier (not advanced tier)*. https://www.ahrinet.org/certification/cee-directory

when considering HPSF2, EER2, and SEER2. The requirements in the North are more stringent as they additionally include cold-climate performance.

This overcount of heat pumps that would qualify for the 25C incentive may, however, counteract another shortfall in the model. As mentioned above, the efficiency of heat pumps in each modeled house *is randomly sampled* from the distribution of today's models, so the model does not take into account that interested customers would seek out the qualifying models. Nonetheless, we also modeled the case where 100% of heat pumps would meet the 25C criteria (reflecting rapid market transformation, or 100% of households with positive economics seeking out qualifying models). Under this scenario, the number of 25C conversions increased by a factor of two.

# Appendix B: Additional IRA Provisions Supporting Heat Pump Adoption

- The **Home Owner Managing Energy Savings** (HOMES) (IRA § 50121) includes $4.3 billion in funding to support comprehensive home energy retrofits.[122] For energy efficiency upgrades that achieve at least 20% but less than 35% total household energy savings HOMES allows LMI single or multifamily homes to claim rebates for 80% of the total cost of up to $4,000 (50% up to $2,000 for all other households). For efficiency upgrades achieving more than 35% total energy savings, LMI households can claim 80% of the cost up to $8,000 (all other households can claim 50% of the cost up to $4,000 total).
- The **Greenhouse Gas Reduction Fund** (IRA § Section 60103) has also designated $27 billion to support the deployment of zero-emissions technology in low-income and disadvantaged communities.[123] The EPA is responsible for reviewing applications and allocating funding. It has identified building decarbonization as one of three key project priorities.[124] The EPA is including decarbonization of existing buildings in the program goals, making it possible that fund will support the deployment of heat pumps.
- The **Climate Pollution Reduction Grants program** (CPRG) (IRA § Section 60114), also administered by the EPA, is a two-part program. Part 1 ($250 million) provides formula grants to every state. This will support states to develop a carbon reduction plan. Part 2 ($4.6 billion) sets out a program of additional grants for states to carry out elements of their plans. The CPRG provides states with an opportunity to use federal funding to explore ways to modernize state and local economies, including ways to efficiently heat and cool homes.[125]

[122] Congressional Research Service. (2022, November 28). *The Inflation Reduction Act: Financial incentives for residential energy efficiency and electrification projects*. https://crsreports.congress.gov/product/pdf/IF/IF12258/2?itid=lk_inline_enhanced-template

[123] Orvis, R., Gopal, A., Rissman, J., O'Boyle, M., Baldwin, S., & Busch, C. (2022, December). *Closing the emissions gap between the IRA and 2030 U.S. NDC: Policies to meet the moment*. Energy Innovation. https://energyinnovation.org/wp-content/uploads/2022/12/Closing-The-Emissions-Gap-Between-IRA-And-NDC-Policies-To-Meet-The-Moment.pdf

[124] Fischer, A. (2023, June). *Update on the Greenhouse Gas Reduction Fund* [Presentation].

[125] U.S. Environmental Protection Agency. (2023, December). *Climate Pollution Reduction Grants*. https://www.epa.gov/inflation-reduction-act/climate-pollution-reduction-grants

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