Transforming Residential Space Heating: Learning from Leading States

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ABSTRACT

Multiple states, utilities and organizations are promoting heat pumps as a key residential efficiency and decarbonization strategy. Substantial funds are being spent, and heat pump sales have increased but often not as quickly as will be needed to meet long-term targets. This paper reviews national data as well as a selection of the major state residential heat pump initiatives (California, Maine, Vermont, Massachusetts, New York, Colorado and Oregon/Washington), discussing strengths and weaknesses of these state efforts. Based on these case studies we suggest 15 tentative findings on factors contributing to program and policy success that can serve as a blueprint for future efforts. We recommend focusing on installing heat pumps when existing equipment needs to be replaced, since incremental costs of a heat pump at these times are much lower than replacing systems that are not near end-of-life. In order to prepare homes for these end-of-life replacements, we recommend preparatory programs that focus on weatherization, upgrading home electric service where needed, and promoting planned replacements of aging equipment that are likely to soon fail. Heat pump programs can help to increase heat pump sales, but programs should be complemented by policies such as building code reforms, emission-based equipment standards, clean heat standards, and home energy ratings. Heat pump programs can initiate a market transformation process, growing market share and creating a strong foundation for enacting policies that will further the market transformation process.

Introduction

Multiple state, utilities and other organizations are promoting heat pumps as a key residential energy efficiency and decarbonization strategy. Much money is being spent, and heat pump sales are increasing. The Air-Conditioning, Heating and Refrigeration Institute (AHRI) reports that 3.6 million heat pumps were shipped by member companies in 2023. Heat pump sales exceeded gas and oil warm-air furnace sales by 20% and heat pump sales were only 17% less than air conditioner sales (AHRI 2024). According to the Residential Energy Consumption Survey (RECS), which is compiled about every five years by the Energy Information Administration, 13% of U.S. housing units used a heat pump for space heating in 2020 (EIA 2023a). If we are to convert most homes to heat pumps, much work remains. This paper reviews efforts and progress to promote heat pumps in eight leading states – California, Maine, Vermont, Massachusetts, New York, Washington, Oregon, and Colorado. We begin with a description of the national picture, proceed to discussions on the eight states, and end with a discussion on trends and recommendations on heat pump market transformation.

The National Picture

To begin, it is useful to look at where use of heat pumps is now most common. As noted earlier, 13% of U.S. housing units were heated with a heat pump in 2020 (EIA 2023a). The top states for heat pump saturation in 2020 are all in the South and range from 23-46% saturation with South Carolina being highest followed by North Carolina, Alabama, Tennessee, Florida, Mississippi, Virginia, Georgia, Arizona and Kentucky (Olano 2022). There are some heat pump

programs in these states, often operated by electric coops. In addition, sales seem to be driven by modest incremental cost relative to central air conditioners and efforts by contractors to promote heat pumps (e.g., see Coastal Air Plus 2023).

Davis (2023), a professor at U.C Berkeley, analyzes the EIA data on heat pump adoption by state to find that "a one standard deviation increase in [heating degree days] decreases heat pump adoption by one-quarter, while a one standard deviation increase in electricity prices decreases heat pump adoption by one-third. Other factors like homeowner vs. renter, single-family vs. multi-unit and size of the home were found to be less important." Furthermore, he also finds that heat pump adoption does not vary with income levels.

Likewise, a look at new construction can also be illuminating. The Census Bureau conducts a periodic survey on construction practices. Nationwide, 45% of new homes started in 2022 used a heat pump (air-source or ground-source) as their primary heating system. But the percentage varies from 9% in New England to 82% in the South Atlantic, as shown in Figure 1 (Kuo 2023). The heat pump proportion is particularly high in the South Atlantic and East South Central regions where winters are mild, use of central air conditioning is widespread, and electricity prices are generally below the national average (Kuo 2023; EIA 2023b).

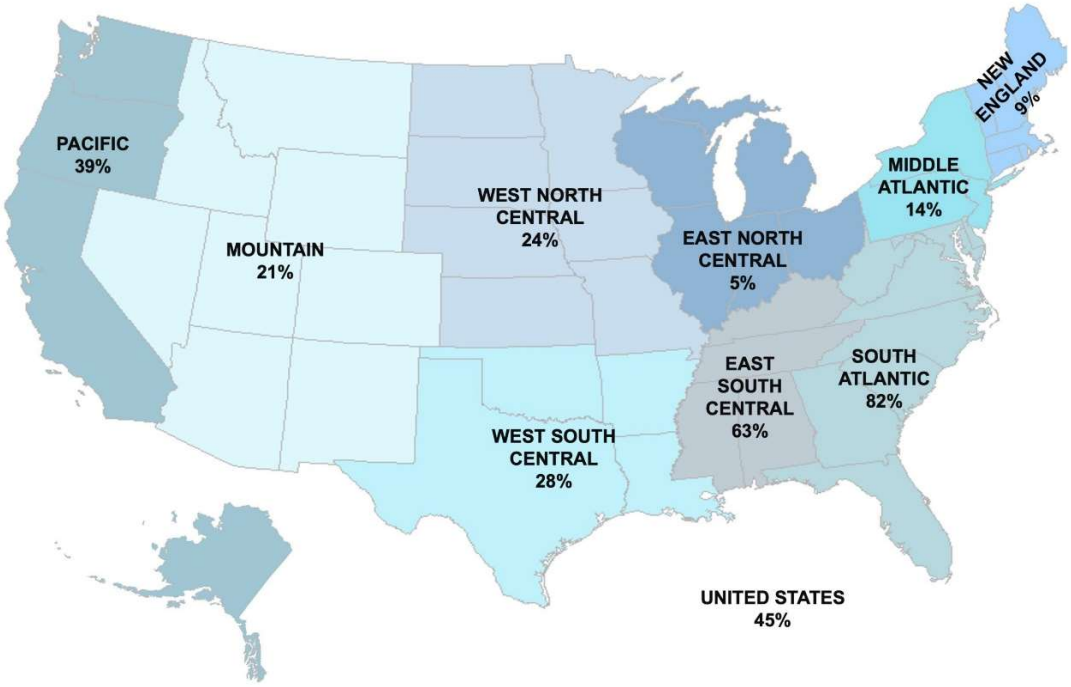

Figure 1. Share of new single-family homes started in 2022 with air or ground heat pumps. Source: Kuo 2023.

Case Studies

California

Various programs and policies have sought to promote heat pumps in California since about 2018 when the Sacramento Municipal Utility District (SMUD) began offering incentives for heat pumps and other electrification measures, followed by a variety of programs funded by other utilities (Nadel 2020). More recently, BayREN (a regional network in the San Francisco

Bay Area) has administered a heat pump program on behalf of many community choice aggregation providers. Southern California Edison proposed a large increase in their electrification programs but the request was denied by the California Public Utility Commission due to concerns about cost-effectiveness and rate impacts (St. John 2024).

In recent years, the California legislature has allocated greenhouse gas and taxpayer funds for heat pumps and other electrification measures through the TECH (equipment) and BUILD (new construction) programs. Total funding for these programs has exceeded $300 million. As of early-April 2024, 24,365 heat pumps for space heating had been installed under TECH at a median cost of $18,370 per unit including electrical work (TECH Clean California 2023). TECH has also funded a variety of innovative programs to spur heat pump adoption such as financing pilots, a consumer-facing website for information and incentives (www.switchison.org), and data analysis to help target homes that can best benefit from electrification, such as homes with old and inefficient heating systems (TECH Clean California 2022). They have found that: (a) homes in the top quartile of home air conditioning energy use have much better return on heat pump investments than other homes; (b) for every 10 years added to average home age in a tract, project cost increases by $826 on average; and (c) that project cost decreases logarithmically with the number of enrolled contractors serving a county (Kisch 2024). There is an additional marketing effort in development that is separate from TECH and not launched yet. Another major program that is now being developed is the Equitable Building Decarbonization program operated by the California Energy Commission. This program will provide direct installation of heat pumps and other electrification measures at no or low cost to income-qualified households (CEC 2024a). The Governor has proposed funding of about $640 million for this program in his January 2024 budget proposal (down from a $922 million initial proposed budget) (Greenling Institute 2024).

Electrification policy has also been a major focus in California. About seventy California communities have adopted restrictions on installing gas heat in new homes through several different mechanisms (BDC 2024); one of these mechanisms was found by a court to conflict with federal law (Egelco 2024) but the other mechanisms have not yet been challenged in court. The Bay Area Air Quality Management District (BAAQMD) adopted amendments requiring the elimination of nitrogen oxide (NOx) emissions from new water heaters by 2027 and new furnaces by 2029 (Balaraman 2023). The South Coast Air Quality Management District (Los Angeles area) is planning similar regulations as is the California Air Resources Board (CARB). The CARB standard would apply statewide and targets a 2030 effective date (CARB 2022).

The state building energy code (called Title 24) is also gradually changing to encourage use of heat pumps in new buildings as well as for replacing systems in existing buildings. The 2022 Title 24 encourages use of efficient electric heat pumps for space and water heating and establishes electric-ready requirements for new homes. The code generally establishes a performance baseline predicated on use of heat pump water heaters in most homes and use of space heating heat pumps in some coastal and southern portions of the state (CEC 2022). The proposed draft of the 2025 Title 24 uses both heat pump water and space heating systems in the performance baseline (CEC 2024b).

Another area of focus is electric rates for heat pumps. The legislature passed a law directing that electric rates be established that vary the fixed charge based on income, allowing charges per kWh to be lower. After much controversy, the CPUC is proposing a $24 per month fixed charge for most customers, but $6 or $12 for low and moderate-income customers (St. John 2024b). Peninsula Clean Energy has established an all-electric rate with higher fixed charges and

lower kWh charges. Mustacich and Herrschaft (2023) find that this rate can result in lower energy bills from switching from gas to electric appliances due to the lower kWh charges.

Overall, statewide data indicate that heat pumps have averaged about 20% of residential HVAC equipment sales in recent years (data is not public and source cannot be cited).

Finally, a non-profit, GridWorks, is working with one of the state's major utilities (Pacific Gas & Electric – PG&E) and others on analysis and mapping that would lead to replacing all heating systems in two neighborhoods with heat pumps and decommissioning the local gas distribution grid. Technical details have been developed and community outreach is now underway. One criteria for selecting neighborhoods was to avoid costs of local gas distribution system updates (Kempe 2023).

Maine

Maine is an early leader in promoting use of heat pumps in cold climates. Many homes in Maine are heated with fuel oil (approximately 54% as of 2020). A substantial number also use propane, a delivered fuel generally produced in association with oil production (EIA 2023a). Prices for both of these fuels are volatile and often expensive. In 2019, the state legislature set a goal of installing 100,000 heat pumps by 2025. To put this goal in perspective, as of 2022, there were about 580,000 households in the state (Census 2023). In 2023, the 100,000 heat pump goal was reached and the state set a new goal of 175,000 additional heat pumps by 2027. In addition, about 40,000 heat pumps were installed before the goal was set (Takemura 2023). If we assume an average of 1.6 heat pumps per home (per data from Efficiency Maine), the 140,000 heat pumps installed serve about 15% of Maine households.

Key strategies for meeting Maine's targets are consumer incentives and an aggressive program to support trade allies, both via a program operated by Efficiency Maine Trust (EMT), which operates programs statewide funded by utilities and other sources. Trade ally support includes a steady flow of online advertising and earned media, developing a searchable, online registry of heat pump installers, and providing scholarships for training programs at community colleges. In late-2023 rebates ranged from $200-800 per unit, varying with unit efficiency, backup fuel and the number of units installed. Higher incentives of $2,000 for the first unit are offered to low- and moderate-income households (EMT 2023a). In fiscal year 2023, 28,000 heat pumps were incentivized, a record, driven by high prices for heating oil, a growing contractor network, and word-of-mouth from previous heat pump installations. In addition, building envelope measures were installed in over 4,700 homes (EMT 2023b). An important contributor to heat pump sales in Maine have been higher summer temperatures and a desire for air conditioning (as of 2020, only 10% of Maine homes had central air conditioning; EIA 2023a). In addition, an initial focus on single-room heaters without controls that integrate with a home's main heating system made sales and installations easy (Brownsberg 2023a).

Up to 2023, heat pump installations in Maine emphasized ductless mini-splits (wall-mounted units with a separate outdoor condenser), typically serving as a supplement to a fossil-fired primary heating source. Program evaluations found that supplemental heat pumps, when operated concurrently with the old central furnace or boiler, fell well short of achieving their full potential, on average serving 18% of seasonal heating needed. In addition, EMT has conducted a number of successful pilots with heat pumps providing all heating down to -16° F. EMT has now modified its incentives to emphasize whole home systems rather than "room heaters" and will tailor its incentives to complement federal tax incentives (EMT 2023c). Under the new program, heat pumps must be sized to serve at least 80% of a home's annual heating load, with an

incentive of 40% of project costs up to a $4,000 cap for people of any income, double for those of lower incomes (EMT 2024).

Another development that should help further heat pump sales in Maine are discounted electric rates for use of heat pumps. Central Maine Power, the utility that serves much of the state, has offered two pilot optional rates that reduce the operating costs of heat pumps and help spur heat pump sales. In their seasonal rate pilot, the energy charge is lowered to under half a cent per kWh in winter (nearly 14 cents in the summer) and the monthly fixed cost is increased to nearly $38. This rate benefits electric heat customers who use a lot of power in the winter. The other optional rate, the electric technology rate, which is just for heat pump customers, charges 5 cents per kWh year-round plus a monthly fixed cost just over $30 (Yim and Subramanian 2023). Versant, the other major utility in the state, has similar rates.

Vermont

Vermont, like Maine, is a small northern state with a long-running statewide energy efficiency program. Efficiency programs are primarily offered by Efficiency Vermont (which is funded by utilities and cap-and-trade funds), with similar programs offered in Burlington (Vermont's largest city) by the city's municipal utility. In addition, Vermont has a couple of innovative policies that are helping to drive heat pump installations in the state. These are a "tier III" portfolio standard and a "clean heat standard."

The tier III program is part of Vermont's three-tier renewable portfolio standard. Tier I applies to renewable electricity generation procured by the state's utilities, tier II assists customers with distributed generation systems (e.g., photovoltaics), and tier III is a requirement for utilities to assist customers to reduce fossil fuel use. Under tier III, utilities must either procure additional renewable distributed generation eligible for Tier II or acquire fossil-fuel savings from energy transformation projects that reduce fossil fuel consumed by a utility's customers. Transformation projects include heat pumps, heat pump water heaters, electric vehicles and charging equipment, battery storage and custom projects. For Tier III, the required amount of savings is 2% of a distribution utility's annual retail sales in 2017, increasing by two-thirds of a percent each year until reaching 12% in 2032. In 2022, 65% of the tier III savings were from heat pumps (Vermont DPS 2023).

To assist distribution utilities to meet their tier III requirements, Efficiency Vermont administers a midstream heat pump program (rebates paid to contractors) on behalf of the electric distribution utilities. In this program, utilities and Efficiency Vermont share the cost of incentives for heat pump installations. Efficiency Vermont also assists local contractors with training and technical assistance and helps administer supplemental incentives offered by some utilities. In 2022 and 2023, rebates were provided for about 11,000 heat pump installations each year (Efficiency Vermont 2023). As a result of these programs, as of late-2023, over 63,000 heat pumps had been installed in the state (Efficiency Vermont 2023), and projections are for over 300,000 heat pumps to be installed by 2040 (see figure 2). Efficiency Vermont estimates that about 10% of systems are whole-home systems and the remainder of systems serve one or a few rooms (P. Bickel, Heat Pump Program Manager, Efficiency Vermont, pers. comm. Jan. 2024). To put these figures in perspective, in 2022 there were 265,000 households in Vermont (Census 2023). Thus, if we assume 1.6 heat pumps per home (based on Maine data), the 63,000 heat pumps installed represent about 15% of Vermont households.

Going forward, heat pump sales are likely to also be driven by Vermont's new clean heat standard (CHS). This standard, which applies to gas utilities and other entities that distribute

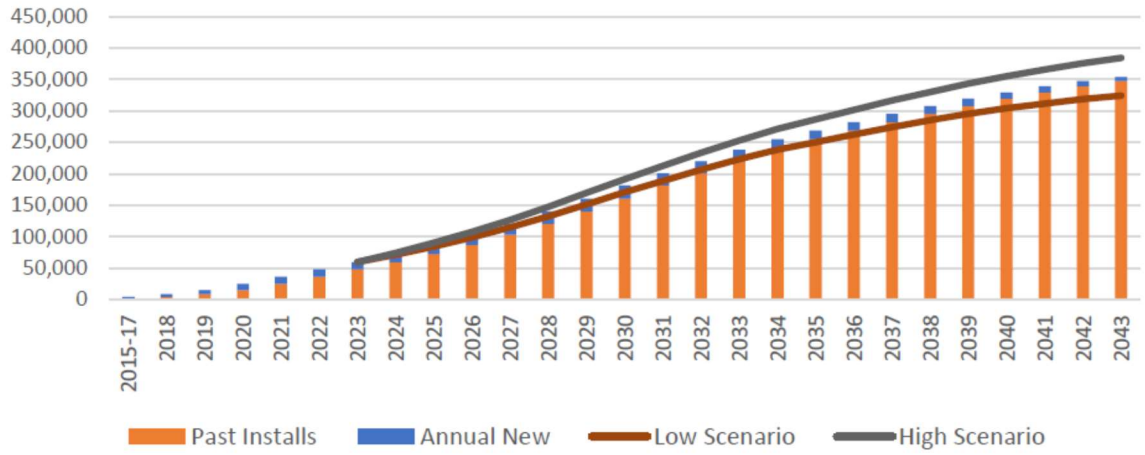

Figure 1. Actual and forecasted cumulative heat pump installations in Vermont. Source: Vermont DPS 2023b.

fossil fuels in the state, requires that a proportion of fossil fuel sales be displaced by measures that reduce greenhouse gas (GHG) emissions associated with space heating such as energy efficiency improvements to customer facilities, leak reduction from gas systems, use of lower carbon fuels, and use of electric heat pumps. Vermont adopted their CHS in 2023, with details to be decided via regulation, but with the objective of meeting the thermal portion of Vermont's goal of net-zero GHG emissions by 2050 (Vermont PUC 2023). As a result, Vermont Gas, has started offering rebates for electric heat pumps.

Massachusetts

As part of its climate plan, Massachusetts has a goal of having 2.8 million homes install heat pumps by 2050 (in 2022, Massachusetts had 2.7 million households; Census 2023). From January 2019 through December 2023, just over 80,000 customers received rebates for heat pumps through the statewide Mass Save programs, with over 25,000 rebates issued in 2023 alone (MEEAC 2024). In addition, about 2% of Massachusetts homes already used heat pumps as their primary heating system in 2020 (EIA 2023a); some of these were assisted by incentives offered by the Massachusetts Clean Energy Center (Mass CEC) prior to the Mass Save program. Adding these figures together, just under 5% of Massachusetts households are using heat pumps. This number is still substantially lower than the Maine number due to a variety of factors including differences in how each state counts the number of heat pumps and a lower saturation of oil and propane heat and higher electric rates in Massachusetts.

In Massachusetts, the primary program promoting heat pumps today is an incentive program offered by the sponsors of Mass Save. This program is a collaborative of Massachusetts' electric and natural gas utilities and energy efficiency service providers. Mass Save provides rebates of $10,000 for whole-home, whole-season cold-climate heat pumps and $1,250 per ton of cooling capacity for partial-use (part home or part of heating season) heat pumps. For moderate-income households, incentives are up to $16,000 for replacing oil, propane and electric resistance heating (gas customers can earn incentives if they sign an acknowledgement that their energy costs might go up). Beginning in 2023, the program has required that to receive a rebate, heat pumps must be installed by contractors with training and certification under the Mass Save Heat Pump Installer Network. For partial-use systems, integrated controls are required so that the heat pumps are used first and the backup system is

used only when needed. Finally, "sufficient weatherization" is required to receive a whole-home rebate by satisfying at least one of the following requirements: (a) home was built during or after 2000, (b) Home Energy Assessment report indicates less than $1,000 worth of weatherization recommended, or (c) weatherization recommendations made during or after 2013 have been completed. Heat pumps installed for whole-home heating and cooling that do not meet the weatherization requirement may be eligible for partial-use rebate amounts (Mass Save 2024).

While the heat pump market is in an earlier stage of development in Massachusetts than the states discussed above, the Mass Save program has resulted in envelope measure installations in about 60,000 homes per year, far more than Maine, even after adjusting for state population (Brownsberger 2023a). Another effort in the state are pilots in two Massachusetts communities to install a ground-source thermal energy network to serve all homes in a neighborhood. The first network is now being installed (Eversource 2024).

Recently, efforts have begun to re-examine electric rates for heat pump customers. For example, in November 2023, National Grid (Massachusetts' largest utility) proposed to eliminate the volumetric distribution charge entirely for participating all-electric households in Massachusetts, opting instead for a fixed monthly charge of $38.15 per month (Howard et al. 2023). And the Mass CEC is hiring a consultant to conduct a study of electric rates and recommend near- and long-term rate design that aligns with the Commonwealth's decarbonization goals.

There have been a number of recent published commentaries on Massachusetts' efforts to promote heat pumps. The President pro tempore of the State Senate wrote a post noting the high cost of heat pump installations (averaging over $20,000) and deep weatherization retrofits and questioning whether there are enough construction workers to do all this work. He suggests: "reassess[ing] our goals for retrofit of existing buildings, making it all the more important that we set high standards for new construction" (Brownsberger 2023b). Likewise, an article by a Vice President of one of state's major utilities, suggests a three-step strategy: (1) execute on no brainers (i.e., energy efficiency); (2) thoughtful and surgical electrification (i.e., the most cost-effective applications); and (3) exploration of solutions for full electrification (Subrahmanian 2023). An article that interviewed various people involved with the Massachusetts program included a claim by one observer that the $10,000 rebate spurred contractors to raise their prices (Francis 2023). And a working paper by a member of the MIT faculty notes the high cost of meeting winter peak demand in Massachusetts and suggests smart rates that encourage heat pump installation but discourage electric resistance backup. He suggests using fossil fuel systems as backup operating about 5% of the hours in the year (Michaels 2024).

New York

New York is another populous and colder climate state that is seeking to rapidly grow its heat pump market. In 2018 the New York State Energy Research and Development Authority (NYSERDA) and Department of Public Service (NY DPS) released the "New Efficiency: New York White Paper," which assessed potential growth in heat pump adoption as an important contributor to a new statewide energy efficiency target (NYSERDA 2019). Other state and stakeholder analyses also estimated potential growth in heat pump adoption as well as programs and policies to spur this growth (e.g., Lane et al. 2018).

In 2020, New York State (NYS) initiated a statewide heat pump framework designed to support customers in transitioning to energy-efficient electrified space- and water-heating technologies, with incentives offered through the NYS Clean Heat: Statewide Heat Pump

Program. This program is led by the state's electric utilities in collaboration with NYSERDA. Under NYS Clean Heat, the state's electric utilities administer incentives for air-source heat pumps, ground-source heat pumps, and heat pump water heaters via a consistent statewide program, while NYSERDA delivers coordinated consumer education and marketing campaigns, workforce development, and other market-enabling initiatives. The common program structure provides for both customer and contractor incentives, with specific incentive amounts varying by utility territory. Under the program, participating contractors need to follow best practices related to sizing, selecting, and installing heat pumps for cold climates.

Another effort in NYS is to develop 13 utility thermal energy network pilots around the state, which are proposed to link buildings though underground pipes that carry water; using air-to-water and water-to-water heat pumps, this infrastructure transfers heat from underground or recycled waste heat to warm and cool buildings (St. John 2024b).

In 2023, 26,500 heat pump projects were installed, a slight decrease from the prior year but about a 30% increase from the year before. Of the rebates, about 68% were for whole-home systems. By the start of 2024, there were 1,120 participating contractors in the program. As of the end of 2023, the program had achieved 240% of its six-year energy savings target but had spent 315% of its six-year budget (to cover this, some funds transferred from other programs and some additional funding was authorized) (NY DPS 2024).

Multiple studies of the performance of heat pumps installed in the state between 2018 and 2020 have reached the following conclusions (NYSERDA 2023):

- Cold-climate air source heat pumps (ccASHPs) and ground source (geothermal) heat pumps, when designed and sized to meet the building's heating load, provide adequate heating, cooling, and comfort in New York State within expected efficiency ranges.
- Improving the home's thermal performance increases energy savings and occupant comfort. In one study, respondents who installed a ccASHP and weatherization measures were significantly more likely to see a decrease in energy bills since installing a heat pump when compared to respondents who did not complete weatherization work.
- New York State homeowners who installed heat pumps are generally satisfied with them and report improved comfort as a key benefit.
- Homeowners decrease their heating fuel consumption through the installation and operation of heat pumps when heat pumps are sized to meet the full heating load of the home (e.g., on average fossil fuel use for space heating was reduced by 86%).
- Homeowners with existing heating systems that use electric resistance heat or delivered fuels save the most money, but all get comfort and health benefits.
- Energy savings won't be fully realized unless heat pumps are used by homeowners as originally intended: optimize heat pump use by using the heat pump first and using backup fuel equipment only when needed.
- Contractor training on sizing, design, and equipment selection and accompanying customer education on system operation are key to ensuring energy savings are realized.

While the program has achieved notable successes, it has also faced some challenges. As noted by Kinsey (2022), the program has periodically exceeded its planned budget, which triggered announcements of incentive cuts, which in turn triggered rushes to submit rebate applications before the deadline for receiving the old incentives. Kinsey instead recommends transitioning to lower but sustainable consumer incentive values, pairing these with midstream

and upstream incentives for installers, distributors and/or manufacturers, and reducing incentives in predictable ways over time.

In January 2022, Governor Hochul announced a goal for the state to achieve 2 million "climate-friendly" homes by 2030, meaning homes that are either electrified or electrification ready, the latter meaning weatherized; N.Y. is emphasizing an "efficiency first" approach. N.Y. had 7.6 million households in 2022 (Census 2023). The announcement recommends amending building codes to require new construction to have zero on-site greenhouse gas emissions (subsequently passed into law as a prohibition on fossil fuel equipment in new construction, starting in 2026 for small buildings and 2029 for larger ones). They also recommend training programs to build the workforce that will provide these services, establishing funds to help pay for the energy-efficient electrification of affordable housing, and working to increase the annual heat pump installation rate from about 20,000 units to more than 200,000 units by 2030 (Governor's Office 2022). Subsequent more detailed plans and roadmaps (NYSERDA 2022) include additional policy recommendations beyond the items mentioned above including point-of-sale energy disclosures and emissions-based standards that prohibit replacing fossil-burning equipment with like-kind equipment after a specified date (e.g., 2030 or 2035). In January 2024, the Governor endorsed legislation to end subsidies for new gas hook-ups and to end the obligation of gas utilities to serve all customers (French 2024).

Alternative rates for electric heating or heat pumps are also being explored. PSEG Long Island offers a long-standing Residential Electric Heating rate (Rate 580), which has been helpful for heat pump conversions. Currently, the rate is just over 5 cents kWh in the winter for sales in excess of 400 kwh per month. Consolidated Edison has a new opt-in "select pricing plan" that substitutes a new peak demand charge for the per kWh charge for the distribution service portion of bills (presently $0.15-0.17 per kWh). On a pilot basis, they are offering a one-year guarantee to heat pump customers that costs will be no higher than their standard rate (Con Ed 2024).

Oregon and Washington

These two states are discussed together as they are both the focus (along with Idaho and Montana) of the Northwest Energy Efficiency Alliance (NEEA), which has been a leader on heat pump deployment. The Northwest has a high proportion of electric resistance heat (e.g. about 32% in Oregon, 46% in Washington; EIA 2023a). NEEA, along with local utilities, have promoted ductless heat pumps to displace some of this electric resistance heat, with NEEA leading regional market conditioning efforts and the utilities providing incentives. The effort has included extensive efforts to enlist and train local contractors as well as a variety of promotion and research activities. Beginning in about 2014, NEEA and local utilities began promoting ducted whole-home variable speed heat pumps. A 2022 study on market influences on heat pump adoption in the Northwest credited incentives, contractor recommendations and consumer interest as the biggest drivers, while also noting the importance of contractor training, coordination of utility incentives, efforts to increase consumer and contractor awareness of heat pumps, and a desire for air conditioning driven by hotter summers (Kirszner, Hogan and Pitt, 2022). Another study prepared for NEEA estimated that heat pumps comprised 16-20% of regional HVAC equipment sales in 2022 and 2023 (Kan, Carey and Zahlan 2023). This is largely on top of the 13% of Oregon homes and 9% of Washington homes that used heat pumps as their primary heating source in 2020 (EIA 2023a).

In addition, a few policy efforts are worth noting. In Portland and several other Oregon cities, there is a mandatory program to provide energy rating information using DOE's Home

Energy Score when a single-family home goes on the market. These labels include both energy and GHG information and recommendations on how to improve home efficiency, including by installing heat pumps (Portland 2020). In Washington, the state is using its building code to encourage heat pumps in new construction. Specifically, in the new code, which took effect April 2024, each home must meet minimum requirements but also earn a specified number of points for measures that exceed code minimums. Measures earning points include extra insulation and installing heat pumps as a primary heating system (Cornfield 2023).

Colorado

Colorado is a colder climate state that is at an early stage of their heat pump journey, spurred by a CHS adopted in 2021. Their CHS calls for a 22% reduction in emissions by 2030, relative to 2015 levels. Xcel, the state's largest utility, has proposed a plan to achieve about 25% of the planned emissions reductions from electrifying 200,000 customers with heat pumps and other electric appliances. The remaining reductions would come from use of biogas, hydrogen blending, use of certified lower emissions gas, and carbon offsets. Environmental groups have suggested a greater reliance on electrification in the 2020s to better enable widespread electrification in the 2030s and beyond. In the debate on how much electrification to pursue, both sides claim that their plan will be cheaper (Plautz 2023). A decision on the proposed plan is expected in Fall 2024. In addition, several major cities (e.g., Denver and Boulder) have offered programs to assist homeowners to weatherize and install heat pumps.

Other Related Studies

We also note two other studies that have investigated the issue of how to design programs and policies to promote residential heat pumps. Campbell (2023) suggests that cost is just one barrier, and may not be the biggest barrier, particularly with new federal tax incentives and rebates available. He suggests that state and local policy be oriented to address remaining barriers such as: (a) expanding the labor force; (b) coordinating the complexity among contractors and other involved parties, and (c) preparing for electrification prior to equipment failure, upgrading electric service if needed. Smedick et al. (2023) suggest "foundational actions" to enhance the impact of federal home energy rebates: (1) prioritize investments to low-income households and disadvantaged communities; (2) slash upfront costs by stacking multiple incentives; and (3) develop supporting policy for building retrofits such as incentives for health, safety and electrical service upgrades, workforce training, pairing efficiency and electrification programs, and combining federal and state programs to decarbonize neighborhoods.

Tentative Findings

This discussion of heat pump programs and policies leads to several tentative findings:

1. Heat pumps can be used as a primary heating source in most of the U.S. Evaluations in N.Y. and experience elsewhere show that well-designed and installed systems can provide adequate heat and good comfort.
2. Building up a trained contractor network that knows how to size and install heat pumps is of critical importance so that heat pumps work well, provide comfort and savings and get a good reputation. This is shown by nearly all of the programs we profile.

3. As much as possible, weatherization should be packaged with or before electrification in order to improve comfort and reduce costs. Massachusetts and N.Y. have emphasized weatherization in their programs so that heat pumps are installed in efficient homes, improving occupant comfort and reducing both heat pump costs to homeowners and grid-build-out costs to all ratepayers. Massachusetts requires "sufficient weatherization" in order to receive a heat pump. On the other hand, if an existing air-conditioning or heating system needs to be replaced on an emergency basis, there will usually not be time to do efficiency first, but if the air conditioner is replaced and the existing heating system left in place, the heat pump can be sized assuming efficiency improvements will be done before the existing heating system reaches end of life.
4. Programs are increasingly emphasizing whole-home systems as is happening in N.Y. and Massachusetts, with the Northwest and Maine now moving in this direction. Whole-home systems allow more fossil fuel use to be displaced than partial-home systems.
5. Replacing existing fully-functioning equipment is expensive. It will be less expensive to focus on replacing existing equipment at end-of-life. But for this to happen, houses need to be made "electrification ready" prior to equipment failure, and/or programs need to target planned replacement of aging equipment prior to failure. A few programs are moving in this direction (e.g. in California and N.Y.) but much more work is needed to implement planned replacement and electrification-ready strategies.
6. It appears to be easier to sell heat pumps to displace oil, propane and electric resistance heat, due to the high cost of heating with these energy sources (e.g., as shown in Maine, Vermont, Massachusetts, N.Y., Oregon and Washington).
7. To the extent possible, target resources to low- and moderate income households who can least afford the cost of home electrification. Most of the states we profile have extra incentives or special programs targeting these households, with California's Equitable Electrification program particularly ambitious. And some states have percentage-of-income rates that cap electric bills to a specified percent of income, helping to protect low-income families (Yim and Subramanian. 2023).
8. Heat pumps are easier to sell in warmer climates and where electric rates are below the national average as shown by the RECS data (Davis 2023).
9. For cold climates, in order to fully heat a home, a heat pump with a cold climate rating is needed (such as ENERGY STAR cold climate). Nadel and Fadali (2022) find that cold climate heat pumps are useful in climates above about 4,500 heating degree days (the current climate in Washington, DC) and that above about 6,000 heating degree days (the current climate in Detroit) a fuel-based backup heating system may be useful to restrain growth in winter peak electric demand. Wilson et al. (2024) reach similar conclusions.
10. In the northern U.S., heat pump sales are also spurred by a desire to add air conditioning driven by higher summer temperatures as shown in Maine and the Northwest.
11. For areas with high rates, some rate reforms may be possible, as is now starting to happen in California, Maine, Massachusetts, Minnesota and New York (Yim and Subramanian. 2023).
12. Rather than just providing consumer incentives, providing midstream incentives to contractors or distributors may be more effective in motivating contractors and reducing consumer prices than just consumer incentives. Both California and Vermont have successfully used this practice.
13. Encourage both gas and electric utilities to promote heat pumps, including switching from fossil fuels. Most of our featured states permit and even encourage fuel switching, usually

subject to some type of cost-effectiveness guidance. Due in part to Vermont's clean heat standard, Vermont Gas is now promoting electric heat pumps. This is also starting to happen in Minnesota which has legislation allowing (but not requiring) gas utilities to propose and implement decarbonization plans.

14. Consider neighborhood-based approaches including bulk procurements and thermal networks, as being piloted in California, Massachusetts and N.Y. Working on entire neighborhoods could potentially allow gas pipe retirement.
15. Complementary polices can be very helpful for transforming markets to primarily heat pumps, but policy adoption will be much easier after heat pumps are well established in a region. Policy can help complete the market transformation process but enactment may be difficult before heat pumps are well proven and growing in market acceptance. Policy examples include:
    a. Building code reforms as shown by California, N.Y. and Washington;
    b. Emission-based equipment standards as now being developed in California and being considered in N.Y;
    c. Clean heat standards as shown by Colorado and Vermont;
    d. Home energy ratings as now being considered in N.Y. and being used in Portland, OR as well as Minneapolis, MN (Nelson and Smith 2018).

Conclusions and Recommendations

Many warm-climate states already use heat pumps as the primary heating source in more than 20% of their homes. Some cold-climate states with effective programs and policies are now using heat pumps in about 15% of homes (e.g. Maine, Vermont, Oregon and Washington). Successful programs include efforts to train contractors and encourage word-of-mouth from satisfied homeowners. Also, upstream or mid-stream incentives merit attention. We recommend focusing on installing whole-home heat pumps when existing equipment needs to be replaced, since incremental costs of a heat pump at these times are much lower than replacing systems that are not near end-of-life. In order to prepare homes for these end-of-life replacements, we recommend preparatory programs that focus on weatherization, upgrading home electric service where needed, and promoting planned replacements of aging equipment that are likely to soon fail. In general, we see growing preparatory programs in the 2020s, laying the groundwork for rapidly growing sales in the 2020s and 2030s. Heat pump systems have steadily improved; R&D should be continued to spur these efforts. Programs can help to increase heat pump sales, but these also need to be complemented by policies used in our profiled states such as building code reforms, emission-based equipment standards, clean heat standards, and home energy ratings. Programs can initiate a market transformation process, growing market share and creating a strong foundation for enacting policies that will further transform markets.

References

AHRI [Air-Conditioning, Heating and Refrigeration Institute]. 2024. "AHRI Releases December 2023 U.S. Heating and Cooling Equipment Shipment Data." www.ahrinet.org/system/files/2024-02/December%202023%20Statistical%20Release.pdf .

Balaraman, K. 2023. "Bay Area Regulators Opt to Phase Out NOx Emissions from Furnaces, Water Heaters, Prepare for Grid Impacts." *Utility Dive*. March 20.

www.utilitydive.com/news/bay-area-regulators-opt-to-phase-out-nox-emissions-from-furnaces-water-hea/645387/ .

BDC [Building Decarbonization Coalition]. 2024. “Zero Emission Building Ordinances.” www.buildingdecarb.org/zeb-ordinances . Visited Jan. 15, 2024.

Brownsberger, W. 2023a. “Learning from Maine.” www.willbrownsberger.com/learning-from-maine/ .

_____. 2023b. “Funding Building Decarbonization.” www.willbrownsberger.com/funding-building-decarbonization/ .

Campbell, A. 2023. “Filling in Home Electrification Gaps.” Energy Institute Blog, UC Berkeley. Oct. 23. www.energyathaas.wordpress.com/2023/10/23/filling-in-home-electrification-gaps/ .

CARB [California Air Resources Board]. 2022. “Zero-emission Appliances - Frequently Asked Questions (FAQs).” ww2.arb.ca.gov/our-work/programs/building-decarbonization/zero-emission-appliance-standards/faq .

CEC [California Energy Commission]. 2024a. “Equitable Building Decarbonization Program.” www.energy.ca.gov/programs-and-topics/programs/equitable-building-decarbonization-program .

_____. 2024b. “2025 Building Energy Efficiency Standards, Title 24 Parts 1 and 6, Express Terms, 45-day Language.” https://efiling.energy.ca.gov/GetDocument.aspx?tn=255315-2 .

_____. 2022. “2022 Building Energy Efficiency Standards, What’s New for Single-Family Residential.” www.energy.ca.gov/sites/default/files/2022-08/2022_Single-family_Whats_New_Summary_ADA.pdf .

Coastal Air Plus. 2023. “Why Buying a Heat Pump Instead of a Furnace Makes Sense.” https://coastalairplus.com/why-buying-a-heat-pump-instead-of-a-furnace-makes-sense/ . Visited Feb. 24, 2024.

Census. 2023. “Quick Facts.” U.S. Bureau of the Census. www.census.gov/quickfacts/ .

Con Ed [Consolidated Edison]. 2024. “Select Pricing Plan.” www.coned.com/en/accounts-billing/select-pricing-plan .

Cornfield, J. 2023. “Washington Makes Another Run at Heat Pump Rules.” Washington State Standard. Nov. 28. www.washingtonstatestandard.com/2023/11/28/washington-makes-another-run-at-heat-pump-rules/ .

Davis, L. 2023. “The Economic Determinants of Heat Pump Adoption.” National Bureau of Economic Research. www.nber.org/papers/w31344 .

Efficiency Vermont. 2023. “With More Than 63,000 Heat Pumps Installed, Vermont Leads the Northeast in Zero-Emissions Heating Systems.” Press Release. Dec. 1. www.efficiencyvermont.com/news-blog/news/with-more-than-63-000-heat-pumps-installed-vermont-leads-the-northeast-in-zero-emissions-heating-systems .

Egelco, B. 2024. “9th Circuit won’t let Berkeley enforce first-in-the-nation natural gas ban.” *San Franciso Chronicle*. Jan. 2. www.sfchronicle.com/politics/article/berkeley-gas-ban-18585687.php .

EIA (Energy Information Administration). 2023a. *2020 Residential Energy Consumption Survey*. State Data. www.eia.gov/consumption/residential/data/2020/index.php?view=state#hc .

_____. 2023b. "U.S. Electricity Profile 2022." www.eia.gov/electricity/state/ .

EMT (Efficiency Maine Trust). 2024. "Whole-Home Heat Pump Incentives." www.efficiencymaine.com/at-home/whole-home-heat-pump-incentives/ .

_____. 2023a. "2023 Residential Heat Pump Rebate Claim Form." www.efficiencymaine.com/docs/ Pre-11-7-2023-Residential-Heat-Pump-Rebate-Claim-Form.pdf .

_____. 2023b. *FY0223 Annual Report*. www.efficiencymaine.com/docs/EMT_FY2023-Annual-Report_11.21.2023.pdf .

_____ 2023c. "Making the Switch: The Imperative to Convert the Whole Home (or Whole Building) to Heat Pumps." Annual Event, Sept. 14. www.efficiencymaine.com/docs/AE2023-Session-1-Making-the-Switch-FINALpptx.pdf .

Eversource. 2024. "Networked Geothermal Pilot." www.eversource.com/content/residential/save-money-energy/clean-energy-options/geothermal-energy . Visited May 4, 2024.

Francis, J. 2023. "Fossil Fuels Targeted: Massachusetts Well Behind its Heat Pump Target." *Cape Cod Times*. Dec. 28. www.capecodtimes.com/story/news/environment/2023/12/28/heat-pumps-greenhouse-emissions-massachusetts-slow-reach-goal/71982955007/ .

Governor's Office. 2022. "Governor Hochul Announces Plan to Achieve 2 Million Climate-Friendly Homes by 2030." www.governor.ny.gov/news/governor-hochul-announces-plan-achieve-2-million-climate-friendly-,homes-2030 .

_____. 2024. "Governor Hochul Announces Highlights of FY 2025 Budget." www.governor.ny.gov/news/governor-hochul-announces-highlights-fy-2025-budget .

Greenlining Institute. 2024. "Cuts and Deferrals to Key Programs in 2024-2025 California Budget Proposal Spotlight Need for Systemic Change." Press Release. www.greenlining.org/2024/2024-ca-budget-cuts-and-defers-equity/ .

Howard, et al. 2023. "Pre-Filed Direct Testimony of Nicole Howard, Rasheeda David, Karsten Barde and Lauri Manicinelli." DPU 23-150. www.fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/18228407 .

Kan, C., J. Carey and J. Zahlan. 2023. "Variable Speed Heat Pump Baseline and Key Assumptions Review." Prepared by Cadmus for NEEA. www.neea.org/resources/variable-speed-heat-pump-baseline-and-key-assumptions-review .

Kempe, Y. 2023. "Plans to Get an Entire Block Off the Natural Gas System Take Shape in One California City." *Utility Dive*. Nov. 27. www.utilitydive.com/news/albany-ca-gas-pipeline-decommissioning-building-electrification-decarbonization .

Kinsey, N. 2022. "America's Heat Pump Market Has a Sugar-Crash Problem." Canary Media. Aug. 9. www.canarymedia.com/articles/heat-pumps/americas-heat-pump-market-has-a-sugar-crash-problem .

Kirszner, M., C. Hogan and R. Pitt. 2022. *Study of Influences on Northwest Variable Speed Heat Pump Adoption*. Prepared for NEEA. www.neea.org/img/documents/Study-of-Influences-on-Northwest-Variable-Speed-Heat-Pump-Adoption.pdf .

Kisch, T. 2024. "TECH Clean California." Power Point presentation. Jan. 29.

Kuo, F. 2023. "HVAC in New Construction 2022." Eye on Housing, National Association of Home Builders, Oct. 30. www.eyeonhousing.org/2023/10/hvac-in-new-construction-in-2022.

Lane, D, C. Badger, E. Levin and M. Sprayregan. 2018. *Ramping Up Heat Pump Adoption in New York State: Targets and Programs to Accelerate Savings*. VEIC. www.veic.org/clients-results/reports/ramping-up-heat-pump-adoption-in-new-york-state-targets-and-programs-to-accelerate-savings .

Mass Save. 2024. "2024 Residential Rebates." www.masssave.com/-/media/Files/PDFs/Save/Residential/rebate-forms/2024-Rebate-Matrix_Announcement.pdf .

MEEAC [Massachusetts Energy Efficiency Advisory Council. 2024. "4th Quarter 2023 Program Administrator KPI's." www.ma-eeac.org/results-reporting/quarterly-reports/ .

Michaels, H. 2024. "A Smart Home, Smart Rate Program is a 'No-brainer': Path to Clean Heat and Lower Electric Prices in Massachusetts and New England." Sloan School of Management, MIT.

Mustacish, P. and B. Herrschaft. 2023. "Bill Impacts of Decarbonizing Existing Single Family Homes." Silicon Valley Clean Energy and Peninsula Clean Energy. www.svcleanenergy.org/wp-content/uploads/SVCE-PCE-Single-Family-On-Bill-Impacts-Results-2023.pdf .

Nadel, S. 2020. "Programs to Electrify Space Heating in Homes and Buildings." ACEEE. www.aceee.org/topic-brief/2020/06/programs-electrify-space-heating-homes-and-buildings .

Nadel, S. and L. Fadali. 2022. *Analysis of Electric and Gas Decarbonization Options for Homes and Apartments.* ACEEE. www.aceee.org/research-report/b2205 .

Nelson, C. and I. Smith. 2018. *Transforming the Market for Energy Efficiency in Minneapolis: Recommendations for Residential Energy Efficiency Rating and Disclosure*. Center for Energy and the Environment. www.mncee.org/sites/default/files/report-files/Mpls-Residential-EE-Disclosure_White-Paper_20180912.pdf .

NY DPS [New York Department of Public Service]. 2024. "The NYS Clean Heat Program 2023 Annual Report."

NYSERDA [New York State Energy Research and Development Authority]. 2023. "Clean Heating and Cooling Reports." www.nyserda.ny.gov/About/Publications/Research-and-Technical-Reports/Clean-Heating-and-Cooling-Reports .

_____. 2022. The Future of Buildings, New York's Carbon Neutral Buildings Roadmap. www.nyserda.ny.gov/All-Programs/Carbon-Neutral-Buildings .

_____. 2019. NYSERDA 2019. New Efficiency: New York, Analysis of Residential Heat Pump Potential and Economics. Report Number 18-44. www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/PPSER/NYSERDA/18-44-HeatPump.pdf .

Olano, M. 2022. “Chart: Which states have the most heat pumps?” *Canary Media*. Aug. 12. www.canarymedia.com/articles/heat-pumps/chart-which-states-have-the-most-heat-pumps .

Portland. 2020. “Report to Portland City Council on Residential Energy Performance Rating and Disclosure (Ordinance No. 188143).” www.portland.gov/pdxhes/documents/report-portland-city-council-residential-energy-performance-rating-and-disclosure/download .

Smedick, D., R. Golden, S. Kumar and L. Reed. 2023. “How to Upgrade and Electrify Millions of US Homes and Builidngs.” RMI. Aug. 11. www.rmi.org/how-to-upgrade-and-electrify-millions-of-us-homes-and-buildings/ .

St. John, J. 2024a. “Who Should Foot the Huge Bill to Switch California Homes to Heat Pumps.” Canary Media. Feb. 5. www.canarymedia.com/articles/electrification/who-should-foot-the-huge-bill-to-switch-california-homes-to-heat-pumps .

_____. 2024b. “New York Will Repurpose Gas Pipelines to Pump Clean Heat into Buildings.” *Canary Media*. Jan. 16. www.canarymedia.com/articles/carbon-free-buildings/new-york-will-repurpose-gas-pipelines-to-pump-clean-heat-into-buildings .

_____. 2024c. “California Regulator Takes Income-Based Electric Bills Off the Table.” *Canary Media*. March 29. www.canarymedia.com/articles/utilities/california-regulator-takes-income-based-electric-bills-off-the-table .

Subrahmanian, T. 2023. “How Do We Scale End-Use Decarbonization?” *T&D World*. Sept. 27. www.tdworld.com/smart-utility/article/21273167/how-do-we-scale-end-use-decarbonization.

Takemura, A. 2023. “Heat Pumps Sold So Fast in Maine, the State Just Upped its Target.” *Canary Media*. July 23. www.canarymedia.com/articles/heat-pumps/heat-pumps-sold-so-fast-in-maine-the-state-just-upped-its-target .

TECH Clean California. 2023. “Public Data, Project Data Visualizations.” www.techcleanca.com/public-data/data-visualizations/ . Visited Jan. 15, 2024.

_____. 2022. “Annual Report 2021-2022.” www.techcleanca.com/about/news/november-28-2022/ .

Vermont DPS [Department of Public Service]. 2023a. “RES Tier III 2022 Verification Report.” www.publicservice.vermont.gov/sites/dps/files/documents/23-0773-INV%20-%202023.06.01%20-%20DPS%20Tier%20III%20Verification%20Report_as_filed.pdf .

_____. 2023b. *2023 Annual Energy Report*. www.legislature.vermont.gov/assets/Legislative-Reports/2023-Vermont-Annual-Energy-Report.pdf .

Vermont PUC (Public Utility Commission). 2023. “Clean Heat Standard.” www.puc.vermont.g’ov/clean-heat-standard .

Wilson, E., P. Munankarmi, B. Less, J. Reyna, and S. Rothgeb. 2024. *Joule* 8. www.cell.com/joule/abstract/S2542-4351(24)00049-7 .

Yim, E. and S. Subramanian. 2023. *Equity and Electrification-Driven Rate Policy Options*. Washington, DC: ACEEE. www.aceee.org/white-paper/2023/09/equity-and-electrification-driven-rate-policy-options .

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