Home is Where the Heat Pump Is: Evaluating Use and Savings Among Income-Qualified New York Homes

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ABSTRACT

Delivered fuels (kerosene, propane, oil, and wood) represent about one-third of residential space heating energy usage and half of all energy use in the average New York household (EIA, 2024). These fuels emit more greenhouse gases than "transmitted fuels" such as natural gas and electricity, even when the electricity is generated from fossil fuels.

Home electrification is key to New York's decarbonization goals. In 2021 and 2022, the New York State Energy Research and Development Authority (NYSERDA) ran a pilot to incentivize low- and moderate-income residential delivered fuel customers in New York to install cold-climate air source heat pumps (ccASHP), ground source heat pumps (GSHP), or heat pump water heaters (HPWH). Many participating customers also installed insulation and air sealing upgrades to meet efficiency prerequisites.

This study gathered insights from contractors and customers through surveys and interviews and explored project documentation to assess program experiences, customer satisfaction with heat pumps, usage of new versus legacy systems, and utility bill savings. The study surveyed 176 income-eligible customers and 39 contractors, interviewed 13 contractors, and reviewed billing data for 72 homes.

The study found that customers were satisfied with their heat pumps, used them in place of legacy systems for most of their heating and cooling needs, and saved meaningfully on utility bills. Despite enhanced incentives for LMI households, contractors perceived costs as a dominant and persistent barrier to heat pump adoption. These findings provide insights into the benefits of home electrification for income-qualified NY households, along with lessons learned from contractors.

Introduction

Background and Scope

NYSERDA launched the Single-Family Low- to Moderate-Income (LMI)[2] Heat Pump Demonstration Study Pilot Program (the pilot program) in October 2020 to gauge interest in, adoption of, and explore the impacts related to heat pump technologies (ccASHP, GSHP, HPWH) in low- and moderate-income single-family housing with delivered fuels. The pilot program was a collaboration between the EmPower and Assisted Home Performance (AHP) with ENERGY STAR® programs (which were later consolidated into EmPower+) and New York State (NYS) Clean Heat.

To participate in the pilot, households applied to both EmPower+ and NYS Clean Heat and were required to meet certain insulation levels in their home. Participating households could receive enhanced incentives for ductless and central air source heat pumps (ASHPs), ground source heat pumps (GSHPs), heat pump water heaters (HPWHs), panel boxes, and heating system distribution upgrades. Table 1 shows

[1] Any opinions expressed, explicitly or implicitly, are those of the authors and do not necessarily represent those of the New York State Energy Research and Development Authority.

[2] Homeowners and renters living in one-to-four-unit housing and earning at or below the lower of 80% of state median income or area median income

the incentives available to a pilot project by technology, measure, and participation track, EmPower+ or AHP, respectively.

Table 1. Incentives Available by Technology, Measure, and Participation Track

Offering Description	Incentive Type	EmPower Track	AHP Track
Upstate ASHP	$/10,000 BTU	$3,000	$1,500
Downstate ASHP	$/10,000 BTU	$2,200	$1,100
Upstate GSHP	$/10,000 BTU	$3,750	$3,750
Downstate GSHP	$/10,000 BTU	$3,850	$3,800
Upstate HPWH	$/unit	Normal EmPower	$975
Downstate HPWH	$/unit	Normal EmPower	$825
Panel Box Upgrade / Distribution Imp.	≤ 100 Amps	Up to $2,000	50% of cost up to $1,000

Pilot program participants who completed projects between February 2021 and August 2022 were able to layer incentives through the EmPower+ and NYS Clean Heat programs.[3] In 2021 and 2022, 413 projects were completed through the pilot program.

NYSERDA commissioned Cadmus and Apex Analytics (collectively, the Cadmus team) to evaluate the pilot program, with the goal of validating modeled savings, assessing customer and trade ally satisfaction, and identifying opportunities to improve program design for stakeholders. The evaluation used qualitative approaches to document and categorize common project characteristics, understand customer and trade ally satisfaction, identify motivations and barriers to contractor and customer participation, review frequency and common causes of project delays, estimate the net cost for participating customers (including reduced maintenance and avoided fuel costs), and understand changes in cost estimates from the design stage through the installation. The team used a quantitative approach to calculate total bill savings by validating modeled energy savings and incorporating observed cost changes.

This paper presents the research methodology the Cadmus team used to carry out this evaluation, the results of that research, and conclusions drawn from those results with the goal of informing and supporting the development of future heat pump incentive programs.

Methodology

To complete this evaluation, the Cadmus team conducted in-depth interviews with contractors, fielded web and phone surveys of program participants (customers) and contractors, reviewed project files, and conducted a billing analysis of participating projects.

Surveys and In-Depth Interviews

The Cadmus team surveyed customers who received heat pumps through the pilot program. The respondents were asked about their experiences and satisfaction with the program and the performance of their new heat pumps. The survey also requested and offered an incentive[4] to customers to submit delivered fuel bills from before and after their heat pumps were installed. Of the 400 customers eligible for this survey, 166 completed it; 30 submitted usable delivered fuel receipts.

[3] Detailed information about NYS Clean Heat incentives can be found here: https://cleanheat.ny.gov/assets/pdf/NYS-Clean-Heat-Program-Manual.pdf

[4] Customers that submitted delivered fuel bills from before and after their heat pumps were installed and completed the survey received an $10 Amazon gift card.

The team also surveyed participating contractors about their experiences, recruiting some contractors for follow-up interviews. The team utilized follow-up interviews to collect more in-depth information about their participation in the program, including key barriers to participation for contractors and customers. Of the 74 contractors eligible for this survey, 38 completed it; of those, the team interviewed 13.[5]

Finally, the team developed and fielded a short survey to customers who had installed their heat pumps as of winter 2023, when an extreme cold weather event occurred in the Northeast.[6] The goal of this survey was to understand heat pump performance and customer behavior during the extreme weather event. The team added the survey to a different data collection instrument that was sent to all customers between February and April 2023. Forty-six customers completed the extreme weather survey.

Project File Review

The Cadmus team conducted a project file review to determine if the files included the pre- and post-installation data points necessary for the billing analysis. NYSERDA provided the team with a program database alongside project data files populated by participating contractors. The files included the cost of each component (such as heat pump equipment, water heaters, panel upgrades, distribution upgrades, and other non-heat pump project costs). In total, the team reviewed files for 351 projects and program data for all 413 projects.

Billing Analysis

To validate the energy savings model, the Cadmus team estimated the delivered fuel billing impacts for each site by comparing winter 2021-2022 consumption with pre-installation annual usage of delivered fuel for all sites with projects installed by October 1, 2021. The Cadmus team then compared these impacts with the estimated heat pump and water heating MMBtu savings estimates from the project files. The Cadmus team completed delivered fuel billing analysis on 30 sites with sufficient delivered fuel billing data. The team completed electric billing analysis on 210 projects with sufficient data.

The validity of the delivered fuel billing analysis was primarily attributable to the program's collection of high-quality pre-installation delivered fuel consumption data. The Cadmus team conducted surveys of customers to collect the post-installation delivered fuel consumption data needed to inform the model. To calculate site-specific delivered fuels estimates, the Cadmus team subtracted post-installation delivered fuel consumption from pre-installation consumption with a simple adjustment for heating degree days in the pre- and post-installation cases. Site-specific delivered fuel estimates were extrapolated to the full population using a ratio estimator, with program estimated savings as the denominator. All sites with data in the post case were included in the delivered fuels analysis. For programs targeting full electrification of delivered fuels, savings are strongly correlated to pre-installation delivered fuels consumption and often represent a substantial share of usage, commonly ranging from 50% to 100%. For the electricity portion of the billing analysis, the Cadmus team employed a site-specific variable-base degree day (VBDD) approach; however, the analysis was less successful than the delivered fuels and required exclusion of many sites for a variety of reasons, including:

[5] Contractors who completed the survey received a $50 Amazon gift card incentive. Those contractors that later completed the in-depth interview received an $100 Amazon gift card incentive.

[6] From February 3 to February 6, 2023, the Northeast experienced an extreme cold snap. During this period, temperatures ranged from 4 to -6 degrees Fahrenheit between New York City and Hartford, CT. This provided an opportunity for the Evaluation Team to assess customer satisfaction with heat pump technologies under adverse conditions.

- Missing billing or site data (14% of sites)
- Bimonthly or Estimated Read Billing Data. Some utilities had a significant number of estimated reads in the billing data which resulted in a reduction in the number of actual reads. The analysis required at least 12 months pre-data and 12 months post-data, with at least 10 actual reads. (21% of sites).
- Missing start dates (12% of sites)
- Negative bill reads (1.5% of sites)
- Missing zip codes (2% of sites)

Site-level results were highly variable, as the savings resulting from the heat pump could not be separated from total project savings, many of which included a variety of weatherization measures - some contributing to electric reductions while the ASHPs and HPWHs were expected to increase electricity use. Further complexity arose when considering sites with mixed heating baselines (where electricity as a secondary heating fuel). To address this, the Cadmus team disaggregated the electric billing analysis results by primary heating fuel savings, which is very important when conducting analysis of heat pumps displacing a mix of electric resistance and delivered fuels.

The electricity billing analysis produced a wide confidence interval, , especially for homes heating with electricity. Unexpectedly, these homes – those heated primarily with electricity - also demonstrated significant delivered fuel savings but partially explained the lower observed electricity savings. This uncertainty in the electricity impacts reflects the complexity of this evaluation, including the assessment of projects that include both electrification and energy efficiency measures and the presence of heat pumps displacing both delivered fuels and electric resistance heating.

Results

The following sections present analysis results for the following research categories: pilot program characterization, motivations and barriers, and savings validation.

Pilot Program Characterization

The Cadmus team analyzed key characteristics of the pilot program, including equipment types, supplemental services, and reliance on heating and cooling equipment.

Project types.

Customer homes were previously primarily heated with coal (2%), cord or pellet wood (16%), propane (27%), fuel oil (34%), or other fuels such as electricity and kerosene (21%). While some participating homes identified electricity as their primary heating fuel, customer surveys conducted by the Cadmus team revealed that many households relied on multiple fuels for heating, regardless of the primary heating fuel identified by the program data.

The most common system that customers (n=413) installed through the pilot program were ductless ccASHPs (69%), followed by central ccASHPs (14%) and GSHPs (8%). Customers installed HPWHs in 33% of projects, with 27% of projects including both heat pumps and HPWH equipment. Table 2 provides an overview of projects by heat pump technology.

Table 2. Summary of completed Pilot Program projects by technology type

Technology Type	Number of Projects Completed
Ductless Cold Climate ASHP (ductless ccASHP)	285
Central ccASHP	58
Unknown ASHP[b]	11
GSHP	35
HPWH	135
Total Installations[a]	**413**

[a] Many installations included more than one technology type, so the number of projects completed does not add to the total number of installations.
[b] Some project files did not include the type of heat pump installed.

Heating equipment use.

Most customer survey respondents (n=166) reported that they mainly use their heat pump system on its own for heating (69%, 108 of 156) and cooling (89%, 96 of 108). Participating in the pilot program did not require customers to decommission their legacy systems.

Customer responses indicated that, following heat pump installation, most used the heat pump as the primary system and relyied on the pre-existing heating equipment only as needed, with some noting concurrent operation of both systems. Fifty-three percent of surveyed contractors reported installing integrated controls in their projects; the remaining 47% did not. When asked why they used their pre-existing systems, most customers said their heat pump provided inadequate heating (37%, 18 of 49) or cooling (25%, 3 of 12), followed by those who thought the legacy system was more economical. Some customers also reported that the two systems served different areas or rooms in the home (24%, 12 of 49). In addition to the customer survey, almost half of the extreme cold weather survey respondents (42%, 17 of 40) reported using only their heat pumps during the extreme cold weather event. The remaining 58% of respondents to the extreme cold weather survey (23 of 40) supplemented their heating with a pre-existing or backup heating system or used only the backup system to heat their homes.

Cooling equipment use.

Prior to heat pump installation, 49% of surveyed customers reported cooling their homes with window air conditioners (82 of 168) and 42% reported using fans (72 of 168). After installation, most customers reported that they were able to meet their cooling needs with their heat pump system (89%, 96 of 108). Among households that continue to use their pre-existing cooling systems (n=12), respondents reported that the systems serve different rooms than the new heat pumps (2 of 12), that the heat pumps do not adequately cool the space (2 of 12), or that the older systems are more economical to operate (2 of 12). The remaining six provided a variety of responses, including “[the] fans are more convenient” and “I prefer to open windows.”

Equipment replacement.

Just over half of surveyed customers (54%, 91 of 168) reported that the pre-existing cooling equipment in their home was working without any issues at the time their heat pump was installed. These

customers most commonly reported that their primary source of cooling prior to installing the heat pump was window air conditioners (49%) and fans (43%).

Motivations and Barriers

The Cadmus team explored pilot program experiences, specifically motivations for and barriers to participation.

Motivations.

When asked about the factors influencing their decision to install heat pumps, surveyed customers reported similar motivations across ccASHP, GSHP, and HPWH equipment. Overall, financial considerations were the primary motivation for installing heat pumps, except among GSHP participants, who most frequently cited environmental concerns as their strongest motivation(Figure 1). Eighty-nine percent of heat pump customers (143 of 160) and 83% of HPWH customers (42 of 51) ranked "saving money" as their primary motivator for installing heat pump equipment. Most heat pump customers were also motivated by improving home comfort with better cooling (85%, 140 of 165) or better heating (81%, 131 of 161).

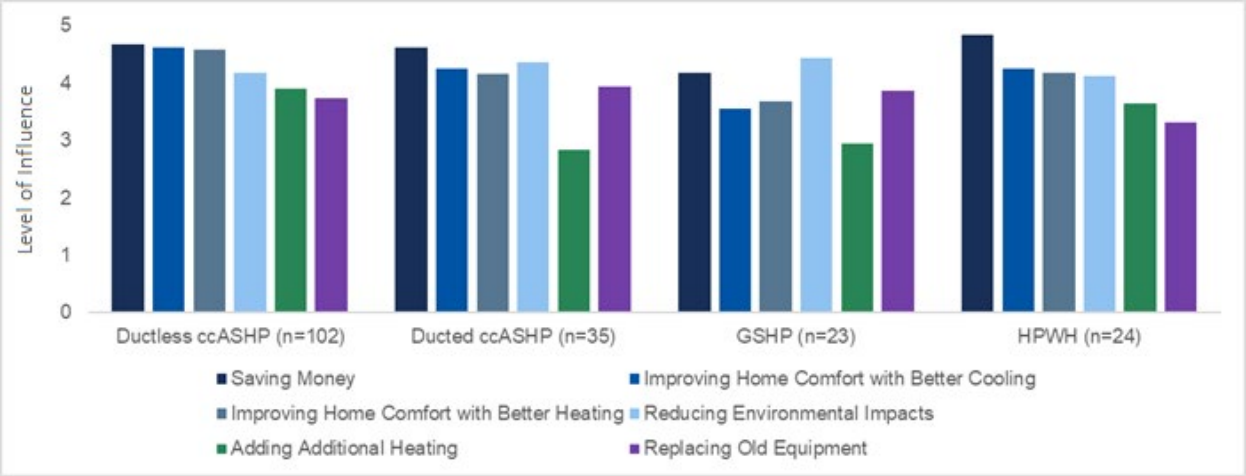

Figure 1. Average influence of customers' motivations for installing equipment

Source: Customer survey (n = 176)

Note: Customers ranked all motivators on a scale of 1-5, with 1 indicating *not influential* and 5 indicating *extremely influential*.

Replacing nonfunctional equipment was not a significant motivator for pilot program participants: 93% of survey respondents (157 of 168) said they replaced their old systems before they failed.

Barriers.

Despite enhanced project incentives for ancillary services (such as ductwork or electrical upgrades), building envelope upgrades, and the heat pumps themselves, interviewed and surveyed contractors identified cost as a persistent barrier, particularly for LMI customers interested in heat pump technologies. Nine of the 29 surveyed contractors interviewed cited cost or financing concerns as a prominent barrier to working with LMI customers. Specifically, one interviewed contractor explained that cost was an issue because some incentives (such as those for HPWHs) covered the cost of equipment but not installation. Interviewed contractors also reported a lack of home readiness and the presence of

structural challenges as the technical challenges they most commonly faced in completing heat pump installations (Figure 2).

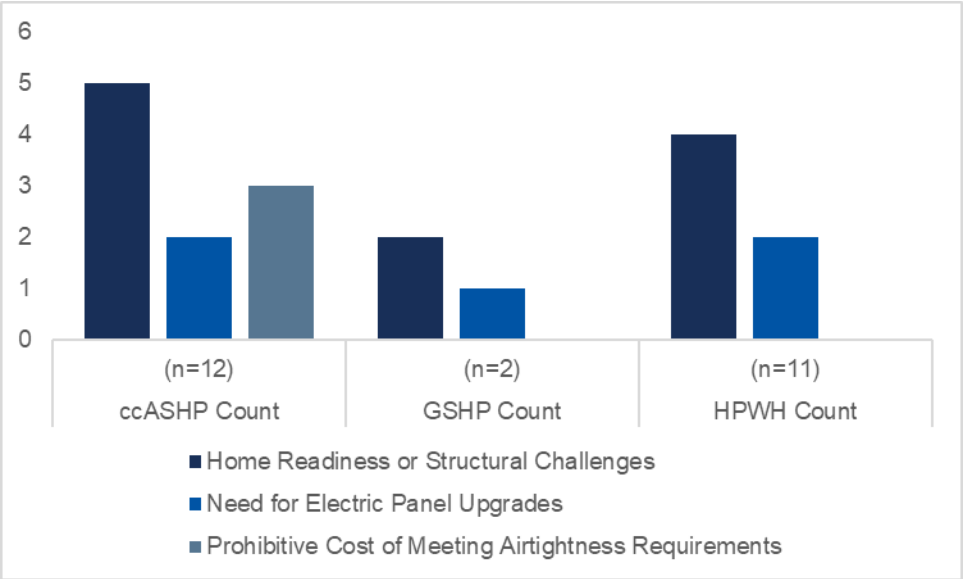

Figure 2. Technical or Structural Deficiencies Preventing Completion of Heat Pump Installations

Source: Contractor interviews (n = 13)

Note: Respondents frequently cited multiple barriers when answering this question. Answers regarding the cost of installation are not reported here.

Savings Validation

The Cadmus team determined the validity of NYSERDA's program-reported modeled savings by analyzing delivered fuel displacement (the amount of delivered fuel usage avoided by installing heat pump equipment) and utility bill savings (compared to the counterfactual scenario where heat pump equipment was not installed). The team also reviewed costs and upgrade specification changes, including project cost and upgrade changes, and investigated perceived reductions in costs and maintenance, including utility bill cost satisfaction and maintenance.

Delivered fuel displacement.

The Cadmus team analyzed delivered fuel displacement by comparing tracked savings from the project files with evaluated savings. Evaluated savings were estimated by subtracting the consumption estimates in the delivered fuels survey from the tracked pre-installation delivered fuel consumption. This sample had significant attrition due to gaps in submitted fuel consumption data as detailed in Table 3.

Table 3. Delivered Fuel Data Attrition.

Step	Count	% Attrition
Full Population of Completed Projects	413	-
a. Did Not Complete Survey	-307	74.3%
b. Did Not Provide Usable Delivered Fuel Data	-76	18.4%
Total Attrition	-383	92.7%
Final Modeled Accounts	30	-

Source: Project files (n = 413)

As shown in Table 4, overall, the delivered fuel savings derived from the billing analysis are similar to the savings reported in the project files, indicating an accurate savings model**.** For projects that displaced oil, propane, and kerosene heating, the average evaluated delivered fuel savings was 92 MMBtu, representing 96% of the savings estimated in the project files. For sites with wood heating displaced, the average evaluated delivered fuel savings was 113 MMBtu, representing 94% of the savings estimated in the project files. With a sample size of two, wood pellets have an estimated 87 MMBtu of evaluated savings, representing 100% of the savings estimated in the project files. Six projects had non-zero estimated savings despite having zero delivered fuel savings reported in their project files.

Table 4. Delivered Fuel Sample Impacts by Group

Group	Average Documented Baseline Delivered Fuel Consumption (MMBtu/home)	Average Documented Savings Estimated (MMBtu/home)	Average Evaluated Savings Estimated (MMBtu/home)	Realization Rate	n
Projects with zero reported delivered fuel savings	54	-	52	N/A	6
Oil, Propane, and Kerosene	103	95	92	96%	14
Wood	131	120	113	94%	8
Wood Pellets	87	87	87	100%	2

Source: Delivered fuel data (n = 30)
Note: MMBtu/home was calculated by subtracting consumption estimates in the delivered fuel survey from tracked pre-installation delivered fuel consumption levels.

Delivered fuel sample sizes were small due to the difficulty of collecting complete receipts for customers, limiting the evaluation team's ability to draw widespread conclusions or perform cross-group statistical testing. However, the sample and data were robust enough to evaluate the accuracy of the energy savings model.

As shown in Figure 3, the evaluated fuel savings for most of the oil and propane projects are slightly lower than the documented savings, with most points lying close to equal as represented in the dashed line.

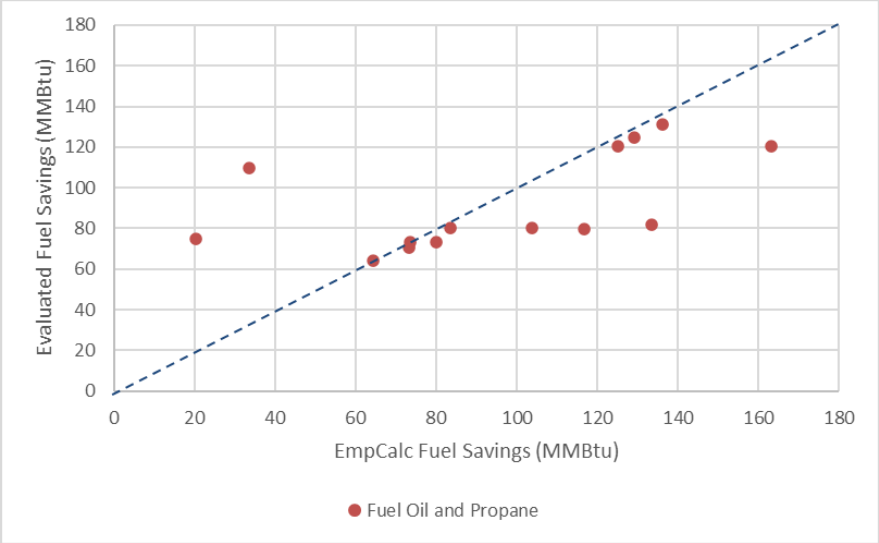

Figure 3. Evaluated versus Documented Fuel Oil and Propane Savings
Source: Project files (n = 351) and delivered fuel data (n = 14)
Note: "EmPCalc" is the technical name for customer project files

As shown in Figure 4, most wood projects and wood pellet projects have evaluated fuel savings that are comparable to documented project savings.

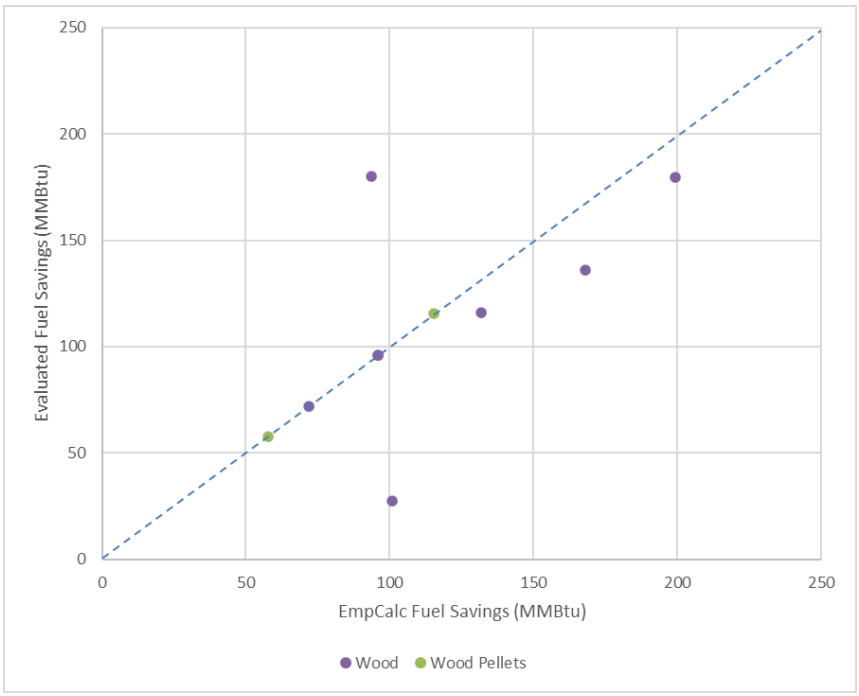

Figure 4. Evaluated versus Documented Wood and Wood Pellet Savings
Source: Project files (n = 351) and delivered fuel data (n = 10)
Note: "EmPCalc" is the technical name for customer project files

Utility bill impacts.

The Cadmus team estimated bill impacts using measured delivered fuel displacement, assumed seasonal coefficient of performance (a ratio of useful heating or cooling compared to energy input), and

energy prices for 2021 and 2022 to provide the direction and magnitude of likely bill impacts. The 2022-2023 winter had historically high energy prices, with delivered fuels costing approximately 50% more than they had over the previous three years.[7] As shown in Table 4, customers who originally used oil and firewood saved around $1,000 annually. Those who used propane saved around $1,400, and those who used kerosene saved around $1,800 annually.

Table 4. Estimated Household Annual Bill Savings by Fuel Type

Fuel	Average Reported Baseline Delivered Fuel (MMBtu)	Displaced Fuel (MMBtu)	Cost of Avoided Fuel	Increased Electricity Usage (kWh)	Electricity Cost	Annual Bill Savings
Oil	103	92	$3,300	10,756	$2,151	$1,149
Kerosene	103	92	$3,961	10,756	$2,151	$1,809
Propane	103	92	$3,568	10,756	$2,151	$1,417
Firewood	131	113	$2,258	6,617	$1,323	$934
Wood Pellets	87	87	$1,733	10,155	$2,031	$(299)

Source: Project files and database.
Note: Increased electricity usage estimated using assumed baseline equipment efficiency and annual average COP of 2.0 for the heat pump.

Customers with non-liquid delivered fuels, such as wood and wood pellets (16%, 68 of 438), may have had very different experiences than those with liquid fuels, and even different experiences than each other. Firewood can be expensive to purchase at market rate (up to an estimated average of $2,300 per household annually). However, it is possible that customers (particularly rural customers) are acquiring their wood in less expensive ways, such as harvesting it themselves or buying it in bulk from local suppliers. Therefore, while the savings for firewood could be over $900 annually, the high variability in cost from household to household leads to actual savings that are less certain.

Additionally, customers with wood and wood pellets are not as likely as those with other fuel types to realize utility bill savings from converting to a heat pump system. Wood pellets are not only an efficient fuel source but are also relatively inexpensive—it may cost less than $1,800 per year to warm a home with wood pellets. Based on the Cadmus team's analysis of the 2022-2023 winter fuel costs, participating wood pellet customers were at risk of losing approximately $300 for the season by switching to an electric heat pump system.

Most customer respondents reported that they were satisfied with their cooling costs since the installation of their heat pumps, with 81% (118 of 146) rating themselves as satisfied and only 3% (4 of 146) rating themselves as dissatisfied; the remaining 16% (24 of 146) were neither satisfied nor dissatisfied. There was slightly less consensus for heating costs: 61% (95 of 155) of surveyed customers rated themselves as satisfied with their heating costs, and 15% (23 of 155) rated themselves as dissatisfied; the remaining 24% (37 of 155) were neither satisfied nor dissatisfied.

[7] Detailed information about heating fuel prices can be found here: Weekly Energy and Fuels Markets Reports - NYSERDA

Conclusions

Conclusion 1: LMI customers are motivated to install heat pumps not only to save money but also to improve their home comfort and to replace systems before burnout. In addition, many surveyed delivered fuel customers are now meeting the majority of their heating and cooling needs with their new heat pumps, including during extreme weather events.

Most surveyed participants were motivated to install a heat pump to save money and to improve home comfort with better cooling or heating. In addition, most participants replaced their old heating or cooling systems before failure with their new heat pump. After installing the heat pump system, most participants with delivered fuel met their primary heating and cooling needs with their new heat pumps, even when temperatures fell below 0°. However, a small subset of participants still used their pre-existing heating and cooling systems because they either perceived them to be more economical than the heat pump or believed that the pre-existing system would help them remain comfortable.

Conclusion 2: Heat pumps and heat pump water heaters significantly displaced delivered fuels and lowered utility bills for LMI residents, especially for those with liquid delivered fuels.

The evaluated projects with liquid delivered fuels, such as oil, propane, and/or kerosene, had consistent fuel displacement levels and annual cost savings, while those with wood-based delivered fuels displayed higher variability in fuel displacement and lower cost savings.

Projects with liquid delivered fuels had relatively consistent fuel displacement (about 92 MMBtu), similar to what was estimated in the project files. Paired with 2022-2023 winter delivered fuel costs, estimated savings for these three fuel types for households that installed new pilot program equipment were all above $1,000 per year.

Conclusion 3: Current incentive mechanisms for the necessary envelope, weatherization, and ancillary electrification improvements in LMI households are not always sufficient to meet heat pump eligibility requirements.

Although NYSERDA and NYS Clean Heat provided incentives to LMI residents for envelope, weatherization, and ancillary electrification services to support heat pump systems,[8] the incentives for these services are not always sufficient to allow the customer to meet heat pump eligibility requirements for participation in the pilot program.

During surveys and interviews, contractors expressed general satisfaction with the level of incentives offered for ccASHPs, GSHPs, and HPWHs. In addition, although satisfaction with the incentives for ancillary services (such as ductwork or electrical upgrades) was lower than that for heat pumps, contractors noted that if no funding had been available for ancillary services, some projects would not have been completed because this additional work often adds significant costs to heat pump installations. These costs are partially mitigated by precursor programs to the pilot program, such as EmPower+, which provides funding for envelope and weatherization improvements for eligible homes.

Contractors mentioned that their concerns with the ancillary services and envelope incentives are specific to LMI customers. These contractors said that they do not want to propose work that would result in any out-of-pocket costs for LMI customers, and typically, the need for ancillary and envelope upgrades in LMI homes can be more extensive than in market-rate housing and more extensive than what is supported by EmPower+. Although contractors reported that LMI housing stock is generally in poor condition, they also acknowledged that needs vary greatly from home to home—while some homes may only need minor repairs or upgrades with little additional cost, others need significant repairs, which can lead to costs of tens of thousands of dollars before the home is eligible to receive a heat pump.

[8] Ancillary electrification services include items such as ductwork or electrical upgrades.

While retaining the standards for home envelope needs (to ensure they are electrification-ready before heat pumps are installed) can help customers save money and maintain comfort after a heat pump installation, it may be possible to refine the program design for future iterations to add flexibility, such as increasing funding for homes with more severe issues or adding nuance to the restrictions based on home envelope quality. At the same time, contractors understand that it can be difficult to establish different rules and different levels of funding for each home in a standardized incentive program. As of June 2025, the EmPower+ program is engaging with a consultant to investigate appropriate levels of pre-electrification insulation levels based on building typology and climate zone.

These findings highlight the strong appeal of heat pumps for LMI households using delivered fuels, with adoption driven by the pursuit of cost savings, comfort and reliability. The transition to heat pumps among this population has reduced reliance on expensive and carbon-intensive fuels – particularly liquid fuels, resulting in meaningful annual savings. However, broader adoption is constrained by funding and the frequent need for building envelope improvements and ancillary upgrades, which tend to be more extensive in LMI homes While existing incentive programs play a critical role, future program design should consider a more flexible or needs-based support to ensure all eligible households can participate and fully benefit from electrification.

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