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Title Page

Propane Utilization in Buildings Across California

Final Report

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Where Innovation meets results

Disclaimer

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- Nonresidential and residential customers that completed the survey for their time and feedback.

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Abstract

The purpose and scope of the work the research team undertook, the work we performed, and brief findings and conclusions are presented below.

A.1. Purpose

The purpose of this study was to examine the utilization of propane in residential and nonresidential buildings in communities across California, to identify and evaluate strategies to encourage adoption of zero-emission (ZE) space and water heaters, and to inform the California Air Resources Board (CARB) and other State agencies in the development of ZE space and water heater standards and complementary policies.

For this report, zero-emission is defined as zero greenhouse gas (GHG) emissions emitted during the operation of space and water heaters at the building site. The CARB regulation concept is fuel neutral; while additional zero-emission technology types may be used for compliance, this analysis is based on data availability of zero-emission technologies that are currently available for sale.

A.2. Scope of Work

The research team conducted residential and nonresidential customer surveys within sampled communities across California using multiple recruitment methods. We collected 269 completed surveys. The research team also calculated estimated incremental cost, billing impacts and greenhouse gas (GHG) impacts of different ZE appliance packages.

A.3. Results and Conclusions

Survey results showed that while most respondents were willing to adopt ZE space and water heaters if purchase and installation costs were covered, some raised concerns regarding power outages and high electricity costs. Our analysis of California costs and GHG impacts showed that when customers using propane heating and water heating equipment adopt ZE technology, specifically heat pumps, it results in estimated bill savings and substantial GHG reductions in most scenarios (i.e., climate zones and building types), but the payback time was long. The study recommends several strategies to encourage the adoption of ZE appliances.

EXECUTIVE SUMMARY

Background and Methodology (Approach to Work)

CARB is developing ZE space and water heater standards in alignment with California's climate and air quality strategies as laid out in the 2022 Scoping Plan (CARB), 2022a) and the 2022 State Strategy for the State Implementation Plan (CARB, 2022b). The goal is to reduce GHG emissions from new residential and nonresidential space and water heaters sold in California and enhance air quality standards for human health. Many households and businesses in California use propane to power space and water heating, or wood burning to power space heating. Understanding these communities is important to help encourage the implementation of building decarbonization policies and programs. Through this study, CARB staff sought to understand the impacts of potential ZE regulations on communities who rely on propane or wood burning to power space or water heating, to encourage the adoption of ZE policy for space and water heating appliances.

To conduct the study, the research team:

- **Mined existing data, identified population of propane-users, and developed a representative sample:** We mapped areas with customers that use propane and developed a list of communities that have high percentages of propane or wood use (specifically, census blocks with ≥25% wood or propane for primary space heating).
- **Drafted and finalized survey instruments and recruitment plan with input from CARB and an advisory panel of community-based organizations (CBOs):** We drafted survey instruments and recruitment plans and gathered feedback from CBOs during stakeholder advisory meetings to finalize them.
- **Collected direct feedback using a survey of 269 propane-using customers:** We collected 225 residential and 44 nonresidential surveys.
- **Conducted analysis to understand the customer cost (first cost and energy bill impacts) and GHG impacts** and **evaluated potential strategies to encourage the use and installation of ZE appliances.** Using the survey responses and customer cost impacts, we developed draft recommendations to encourage the adoption of ZE appliances and refined these recommendations with feedback from CARB and the advisory panel.

Results

Most residential and nonresidential respondents had heard of heat pumps, although several disadvantaged groups (low-income, Native American, those who primarily speak Spanish at home, and those living in mobile or manufactured homes) had lower awareness. Also, all respondents had lower awareness of heat pump water heaters than heat pumps for space heating and cooling. If propane equipment were no longer available, survey respondents generally preferred heat pumps compared to electric resistance heaters. However, low-income respondents preferred portable, plug-in electric space heaters and those in the Southern Inland region preferred wood burning. Most respondents were not willing to pay $6,000 extra (or more) for heat pump equipment, which is lower than the estimated incremental cost ($10,500 to $16,000 for a heat pump and heat pump water in homes, and higher costs in nonresidential). While most respondents (68% of residential and 62% of nonresidential respondents) were favorable towards ZE equipment if purchase and installation costs were taken care of, some were not, citing concerns such as power outages and high electricity costs.

The customer costs and GHG impacts showed that when propane space and water heating equipment customers adopt ZE technology, specifically heat pumps, there are bill savings and substantial onsite and upstream GHG reduction in almost all scenarios (building types, utility types, and regions). The buildings with the greatest benefit were single-family homes in climates with high heating loads and the most extreme weather, such as the Northern Coastal, Sierra and Southern Inland regions.

For homes switching from propane to heat pump technologies, our cost analysis showed an incremental cost range between $9,500 and $12,500 for heat pumps and $1,000 to $3,500 for heat pump water heaters (compared to replacement with propane appliances). The energy cost analysis estimated that for single-family homes adopting heat pumps and heat pump water heaters that currently have propane equipment, statewide annual energy cost savings would be approximately $416 with a 19-year simple payback under IOU rates, $573 with a 15-year simple payback under IOU with CARE rates, and $584 with a 15-year simple payback under POU rates. Homes using wood for heat see less energy cost savings, but heat pumps can provide additional benefits such as increased comfort and improved indoor air quality.

Costs for nonresidential businesses varied much more due to different building types, sizes, and use patterns, but the incremental costs for typical buildings were as low as $1.39 per square foot (sf) cost savings and as high as a $12.15 per sf cost increase for heat pumps, and between $0.15 and $0.75 per sf cost increase for heat pump water heaters.

The most common nonresidential building types that used propane in California were small offices, followed by small hotels and restaurants, and they all saw energy cost savings from ZE retrofits in some zero-emission and utility rate scenarios. However, restaurants that used investor-owned utility (IOU) rates may not see the same magnitude of benefit as the other two building types. If small offices shifted from propane heaters and water heaters to standard heat pumps and heat pump water heaters, their statewide annual energy cost savings would be approximately $1.10/sq ft if their electricity provider is an IOU with a payback period of 10 years and $0.67/sq ft if their electricity provider is a POU with a payback period of 18 years.

Shifting to standard heat pumps and heat pump water heaters in the residential sector (for propane-using homes) reduces the total GHG emissions of these homes by approximately half

(48%) based on the 2025 grid mix and by almost three-quarters (74%) based on the forecasted electricity generation mix for the grid in 2040 - averaged across home types. Upstream emissions for the heat pump and heat pump water heater retrofits are projected to increase by an average of 55% in 2025 and 60% in 2040 compared to the existing homes, but onsite emissions decrease by an average of 95% compared to the existing homes, with the only remaining onsite emissions coming from backup propane heating use. The GHG emissions reductions are lower for an electric resistance package (which assumes an electric resistance furnace and electric resistance water heater), with reductions of approximately 21% based on 2025 grid and 64% by 2040 for electric resistance. But GHG emissions reductions are higher for low peak demand heat pump packages (which assume a cold climate heat pump and some solar PV to offset peak electricity consumption), with 66% reductions based on 2025 and 84% by 2040.

For nonresidential buildings, adopting standard heat pumps and heat pump water heaters reduces total GHG emissions by over one-quarter (28%) based on the 2025 grid and half (51%) based on the 2040 grid. Upstream emissions are projected to decrease by an average of 4% in 2025 and 3% in 2040 compared to the existing buildings, and onsite emissions would be eliminated in this scenario, as the project team did not assume that nonresidential buildings would keep the existing propane system in place for backup. Similar to residential buildings, GHG emission reductions are lower for electric resistance appliances and higher for low peak demand heat pump packages in nonresidential buildings.

Conclusions

Based on the study findings, the research team identified several strategies to encourage the adoption of ZE appliances, including the following:

- **Financial support.** We recommend purchase and installation costs for ZE appliances be covered for very low-income homeowners, offering on-bill financing for heat pumps and heat pump water heaters based on income, and offering tiered incentives for solar panels plus battery storage of backup energy, particularly in areas impacted by power outages.
- **Outreach and education to increase awareness of heat pumps.** We recommend working with local CBOs to conduct outreach and education to clarify CARB's rule and its benefits (once finalized), contractor training in rural areas, and for CARB to work with other state agencies to provide a clearinghouse of all relevant programs.
- **Cleaner wood burning technologies.** We recommend incentivizing fireplace inserts in existing fireplaces and requiring that new wood burning appliances meet the CARB Woodsmoke Reduction Program's (California Air Resources Board, 2025) emission limits.

- **Unique circumstances and policy considerations.** We recommend allowing the purchase of integrated dual-fuel systems in very cold climates and exceptions or phasing in regulations for customers with the highest economic burden (such as restaurants, according to our cost analysis).

Introduction

The sections below describe the purpose of the study, findings from previous studies that relate to this research, and who worked on this study.

Purpose of Project

CARB staff are currently working on developing a regulation that would establish greenhouse gas emission standards for new space and water heaters sold in California. (California Air Resources Board, 2023). CARB reports that the timeline for when this potential rule would take effect is still under consideration but would be 2030 or later.

In this report, zero-emission is defined as zero GHG emissions emitted during the operation of space and water heaters at the building site. The CARB regulation concept is fuel neutral and while additional zero-emission technology types may be used for compliance, this analysis is based on data availability of zero-emission technologies that are currently available for sale.

The objective of this study was to inform the development of ZE space and water heater standards and related building decarbonization policies, specifically as it relates to propane and wood burning equipment.

To achieve these goals, the two main objectives were to:

1. **Examine and characterize utilization of propane in nonresidential and residential buildings** in communities across California and characterize propane and wood burning users in California (in addition to other off-grid sources of energy generation). We mined existing secondary data on propane usage to identify the population of communities that are likely to use propane or wood for heating and space heating, developed a representative sample of these communities, and gathered information from residential and nonresidential customers in these communities through surveys. The surveys captured customers' current fuel choices and reasons for their fuel choices, attitudes towards ZE appliances, and their concerns about ZE appliances.
2. **Evaluate potential strategies to challenges related to the adoption of zero-emission space and water heater standards** within the communities that currently rely on propane. We used the survey results and worked with community-based organizations (CBOs) and other stakeholders to evaluate potential strategies to ease the adoption of ZE space and water heating appliances to reduce potential negative impacts

of decarbonization. As part of this evaluation, we estimated the energy billing impacts and incremental cost of the ZE appliances (compared to traditional propane or wood technologies) and used energy modeling of different building prototypes to calculate the energy, demand, and carbon (i.e., greenhouse emissions) impacts for propane customers to adopt ZE appliances. We then multiplied the energy use outputs by different billing rates to estimate billing impacts to customers.

The results will be used by CARB and other public agencies to inform building decarbonization policies and other initiatives.

Findings from Previous Studies

The research team gathered studies, reports, and surveys from California publication repositories and government agency websites. The existing body of research is limited because buildings with propane and wood usage represent a small percentage of the overall California building stock. However, inventories and surveys still highlight the use of propane and wood, and there have been a few studies conducted on populations that use propane at higher rates than the state average. The key findings from the literature review are summarized below:

Current California Propane Usage

According to the U.S. Energy Information Agency (EIA), residential consumers in California used 16 trillion BTUs of energy for all end uses from propane in 2020 (Energy Information Administration, 2023). In 2024, CARB reported that residential consumers in California used 22 trillion BTUs of propane energy, while commercial consumers used 14 trillion BTUs (California Air Resources Board, 2024). Between 2000 and 2022, residential propane usage across all end uses (i.e., space heating, water heating, cooking, and clothes drying) in California increased by 23%, with commercial usage experiencing a significant increase of 128% (California Air Resources Board, 2024).

The 2019 California Residential Appliance Saturation Survey (RASS) indicated that 4% of California households relied on fuel sources other than utility natural gas or electricity for both space and water heating, while 3% of households used a fuel type other than utility natural gas or electricity for primary space heating (DNV-GL, 2021). Specifically, RASS 2019 shows that 2.6% and 1.2% of homes in California use propane and wood, respectively, for their primary source of heating (DNV-GL, 2021). The EIA noted that in 2020, 5% of California homes (or approximately 625,000 homes) used propane for any end use, though only 2% (or approximately 250,000 homes) relied on it as their primary heating source (Energy Information Administration, 2023), which generally aligns with the RASS findings.

Current California Wood Usage

From 2000 to 2022, residential wood usage for any end use in California decreased by 44%, and commercial wood usage decreased by 38% (California Air Resources Board, 2024). The reasons for this are unknown but may be due in part to the replacement of wood with propane, natural gas, or electric heating. In 2022, residential consumers in California used 21 trillion BTUs of energy from wood, and commercial consumers used 3.8 trillion BTUs of energy from wood (California Air Resources Board, 2024). (Energy Information Administration, 2023) The RASS indicated that 8.3% of California homes use wood for some purpose, but 7.1% (around 888,000 homes) use it as secondary heating and only 1.2% (around 150,000 homes) use it as primary heating, with no other end use registering as a significant percentage of California homes using wood (DNV-GL, 2021). For many other studies of statewide heating fuel use, wood usage for primary heating does not represent a large enough population to include as a distinct category. It is usually grouped in with other fuels such as heating oil and solar energy.

Fuel Switching Households – Existing Fuel

A survey of households switching fuels through programs such as the Technology and Equipment for Clean Heating (TECH) program, a program that incentivizes installation of space conditioning heat pumps and heat pump water heaters, asked what fuels respondents used in their homes besides electricity and gas. The results can be outlined as follows: Out of the 395 single-family respondents, 30% used propane, 18% used wood, and three percent used wood pellets (Guidehouse, 2024). Out of the 160 multifamily respondents, 14% used propane, eight percent used wood, and three percent used wood pellets (Guidehouse, 2024).

Profile of Propane- and Wood-Using Homes and Communities

The San Joaquin Valley (SJV) is an area of California where many customers lack access to natural gas. A data gathering plan for energy use in SJV disadvantaged communities (DACs) found that propane was generally used by customers who own their homes and were ineligible for California Alternate Rates for Energy (CARE) due to income level (Opinion Dynamics, 2021). Fewer homes had access to utility natural gas in smaller communities in SJV: 74% compared to 96% in the entire SJV region (Opinion Dynamics, 2021). In the SJV study, 72% of homes without utility natural gas access used propane for at least one end use, while 42% of homes used wood for at least one end use (Opinion Dynamics, 2021). According to a California Public Utilities Commission (CPUC) low-income needs assessment, propane users had higher energy burdens than wood or wood pellets users (Sadhasivan, 2019).

Our analysis of the census data found that propane and wood-users are less likely to speak a language other than English or Spanish than the general population in California. Based on analysis of the American Community Survey (ACS), 5% of California households spoke Spanish and limited English, and 4% spoke a different language (not Spanish) and limited English. But the ACS data also showed that in census blocks with at least 25% propane users or 25% wood users, 0 to 4% of households spoke Spanish and limited English, and 0 to 1% spoke a different language (not Spanish) with limited English[1].

Opinions and Impacts of Propane and Wood

Customers using propane for heating in the SJV study spent nearly three times as much on propane than customers with natural gas heating spent on natural gas annually, $1,177 vs. $403 (Opinion Dynamics, 2021). Homes with electric heating were not specifically targeted in this study. All respondents that use propane and do not have natural gas access were asked why they use propane: 75% of propane customers say they use propane because natural gas is not available; other common responses include convenience or availability, while 12% say propane is more affordable (Opinion Dynamics, 2021). All respondents that used wood for heating and do not have natural gas access were asked why they use wood: 51% of wood customers said they used wood because natural gas was not available; 55% said wood was more affordable than natural gas (Opinion Dynamics, 2021). Propane users from the CPUC assessment report said they used propane because they could not get natural gas service or had trouble accessing program-funded electric heating equipment (Sadhasivan, 2019).

California Residential and Nonresidential Propane and Wood Use by Region and Electric Utility

The research team analyzed the US Census American Communities Survey (ACS) (United States Census Bureau, 2024) data to calculate the proportion of homes in California that use propane and/or wood as their primary space heating source by region and utility territory. For the nonresidential analysis, we analyzed the California Energy Commission Commercial End-Use Survey (California Energy Commission, 2022) data to calculate the proportion of nonresidential buildings by total floorspace and number of sites where at least 50% of heating is from propane in each utility territory. We did not calculate the proportion of homes or buildings in California that use propane for water heating because the census data does not have fuel type for water heaters, it only has fuel type for space heating.

Table 1 below shows our residential analysis by region. Overall, 3.5% (n=459,796) of homes in California use propane as their primary heating source, 1.3% (n=177,047) of homes use wood as their primary heating source, and 4.8% (n=636,843) of homes use propane or wood as their primary heating source. Looking at differences by region, homes in the Central Valley and Northern Coastal & Sierra regions use more propane or wood as their primary heating source (8.0%, n=238,518 and 8.1%, n=155,326, respectively) than homes in the other regions, while homes in the Southern Coastal region use the least amount of propane or wood (2.0%, n=130,222).

[1] This is shown as a range because it depended on the group. For example, for census blocks with >75% propane heating, 4% spoke Spanish and 0% spoke another language with limited English. For census blocks with >25% propane heating, 3% spoke Spanish and 1% spoke another language with limited English.

Table 1. Proportion of Residential Homes using Propane and Wood for Primary Space Heating by Region

Region	No. of homes in region[2]	Homes in region (%)	Homes using propane (%)	Homes using wood (%)	Homes using propane or wood (%)
Central Valley	2,970,989	22%	5.7%	2.3%	8.0%
Northern Coastal & Sierra	1,919,298	15%	4.6%	3.5%	8.1%
Southern Coastal	6,360,232	48%	1.8%	0.3%	2.0%
Southern Inland	1,973,029	15%	4.3%	1.2%	5.4%
Total[3]	**13,223,548**				
Statewide Weighted Average[4]			**3.5%**	**1.3%**	**4.8%**

Source: US Census Bureau American Customer Survey (United States Census Bureau, 2024)

Table 2 below shows our residential analysis by electric utility territory. Overall, 3.7% of homes in California use propane as their primary heating source and 1.4% of homes use wood as their primary heating source. It also shows that homes in the Pacific Gas & Electric territory use more propane or wood as their primary heating source than homes in the other utility territories, 5.7% and 2.9%, respectively. There is a difference between the statewide weighted average of homes in California that use propane and wood as their primary heating source by region (4.8%) and by electric utility (5.1%) because the statewide weighted average by electric utility does not include homes whose electric utility is a publicly owned utility.

[2] We calculated these numbers by multiplying the population values by the percentages from CEUS. These numbers are accurate to two significant digits.

[3] This includes almost all homes in California. Less than 1% (0.7%) of the total were not categorized under any regions, we have excluded those here.

[4] The statewide weighted average is weighted using the total number of homes in each region, to better reflect proportional contributions from different regions.

Table 2. Proportion of Residential Propane and Wood Using Homes for Primary Space Heating by Utility Territory

Electric utility	Total number of homes[5]	Homes using propane (%)	Homes using wood (%)
Statewide Weighted Average[6]		**3.7%**	**1.4%**
Total	**10,747,561**		
Pacific Gas & Electric	4,023,468	5.7%	2.9%
Southern California Edison	3,032,159	2.4%	0.6%
San Diego Gas & Electric	1,422,819	3.3%	0.6%
Los Angeles Department of Water and Power	1,694,052	1.7%	0.3%
Sacramento Utility Municipal District	575,063	2.8%	0.6%

Source: US Census Bureau American Customer Survey (United States Census Bureau, 2024)

Table 3 below shows our nonresidential analysis by electric utility territory. Data by region was not available, so this analysis shows data by electric utility territory. The data set breaks out the percent of floorspace within a building heated by propane; the results below show the percent of floorspace and percent of sites where the majority of the floorspace (i.e., at least 50%) are heated by propane. Overall, 0.81% (approximately 71,000 kft^2) of all commercial floor space (8,809,461 kft^2) and slightly more than 1% (approximately 6,600) of all commercial buildings (636,121) in California are heated with propane. As in the residential analysis, commercial buildings in the Pacific Gas & Electric territory use more propane than commercial buildings in the other utility territories.

[5] We calculated these numbers by multiplying the population values by the percentages from CEUS. These numbers are accurate to two significant digits.

[6] The statewide weighted average is weighted using the total number of homes in each utility territory, to better reflect proportional contributions from different utility territories.

Table 3. Proportion of Commercial Buildings Using Propane for Primary Space Heating by Utility Territory

Calculation method	Electric utility	Total floorspace/number of sites where majority of floor space is heated with propane (kft^2)[7]	% Total floorspace/number of sites where majority of floor space is heated with propane
Floorspace-Based	**Statewide**	**71,357**	**0.81%**
	Pacific Gas & Electric		1.78%
	Southern California Edison		0.26%
	San Diego Gas & Electric		0.51%
	Los Angeles Department of Water and Power		0.00%
	Sacramento Municipal Utility District		0.10%
Site-Based	**Statewide**	**6,679**	**1.05%**
	Pacific Gas & Electric		2.55%
	Southern California Edison		0.32%
	San Diego Gas & Electric		0.26%
	Los Angeles Department of Water and Power		0.00%
	Sacramento Municipal Utility District		0.25%

[7] We calculated these numbers by multiplying the floorspace and population values by the percentages from CEUS. These numbers are accurate to two significant digits.

Source: California Energy Commission Commercial End-Use Survey (California Energy Commission, 2022)

Overall Findings

The findings above highlight the importance of this study, because of the substantial number of propane and wood burning users in California. The previous studies noted above indicate that most people used propane or wood because they lack natural gas, it was in their home when they moved in, or (in the case of wood only) it was more affordable. As shown in the Survey Results section, these responses are similar to the survey results of our study for both residential and nonresidential customers when asked why they use propane or (for residential) wood.

The Research Team

Presented below are descriptions of each firm that contributed to the research for this study and their specific role. All firms are referred to as The Research Team (and we) throughout the report.

- **TRC** was the prime contractor and served as the point of contact with the CARB Contract Manager, led the sampling plan, developed the survey instrument, analyzed results, led meetings with stakeholders, completed the nonresidential customer recruitment for the survey, and led reporting tasks.
- **Resource Refocus (RR)** supported the sampling plan and identification of propane-using communities, led the calculation of bill impacts and emissions impacts, and supported reporting tasks.
- **Central California Asthma Collaborative (CCAC)** led the residential survey recruitment and served as a study advisor, including providing comments on the sampling plan, draft survey instrument, draft list of recommended strategies, and draft report.
- **Redwood Coast Energy Authority (RCEA)** served a supporting role as a study advisor, provided comments on the sampling plan, draft survey instrument, and draft list of recommended strategies, and assisted with survey recruitment.

Materials and Methods

The sections below describe the various phases of the project, including our overview approach to the project to meet study objectives, methodologies we used for sampling, conducting customer surveys, and analyzing customer costs and GHG impacts, evaluating potential strategies with feedback from stakeholders, quality assurance and quality control procedures, and any limitations to the research.

Overview of Approach

To meet the study objectives, the research team used a sequential approach to leverage existing data on propane usage, collected detailed primary data to fill gaps in our understanding of propane usage across California, and used detailed modeling and technical analysis to collect feedback for residential and nonresidential customers that use propane or (for residential) wood burning appliances; and to estimate first cost, energy billing cost, and GHG impacts of adopting ZE appliances. Based on results and with input from stakeholders, the research team recommended strategies for CARB regarding program interventions for financial support and education, and consideration for building policies. Figure 1 shows an overview of the study approach. Each of the steps is described in detail below.

Figure 1. Overview of Approach

The research team:

1. **Mined existing data of propane usage:** The research team leveraged the American Communities Survey (ACS) to get fuel type, home characteristics, and occupant demographics by block group, census tract, and Public Use Microdata Area (PUMA).

The ACS data was gathered from the IPUMS National Historical Geographic Information System (NHGIS) from the University of Minnesota (Minnesota, 2025). These regions were also mapped to ZIP codes using ACS crosswalk data. We used additional Census Bureau databases from NHGIS to get data on rural vs. urban geographic splits, presence of tribal nations in census tracts, and number of businesses per ZIP code. To add additional details to the ACS data, the research team mapped the CalEnviroScreen 4.0 (CES4.0) database to our data to include disadvantaged community distinctions (Assessment., 2025). The research team also mapped which utilities were in each region as well as how many master-metered propane meters were in each region using California Public Utilities Commission (CPUC) databases (CPUC, 2025b). Finally, we used the National Renewable Energy Laboratory's (NREL) ResStock and ComStock databases to map additional building details and California climate zones to each region (NREL, 2025).

2. **Identified population of propane-users and developed a representative sample**: The research team used the data sources from Step 1 to develop a list of communities that have high percentages of propane or wood use (specifically, census blocks with >=25% wood or propane as their primary space heating source) and included this list in Appendix A. Additional Methodology Details. Based on census data, census block groups with high wood usage are more likely to be in tribal areas than the statewide average. For example, ACS data shows that 86% of census block groups where at least 75% of households use wood as their primary heating source are in tribal areas. Based on this data, we then created a sampling plan with CARB feedback to identify a representative sample of these communities.
3. **Drafted survey instruments and other study design documents with CARB input.** We used our research team's expertise to draft study design documents, including the draft survey instruments. The residential and nonresidential surveys collected information on propane and wood usage (wood usage questions were only included in the residential survey), reasons for those choices, attitudes towards ZE space and water heating equipment, gathered information on possible strategies that incorporate ZE space and water heating equipment, and collected demographic (residential) and firmographic (nonresidential) data from respondents. We revised them based on CARB's input.
4. **Developed an advisory panel of CBOs and other stakeholders that provided feedback during the study, including an initial meeting on the study design:** The panel included CBOs and other organizations that are active in the propane-using communities to provide feedback on their constituents' perspectives throughout the project, including providing input on the key aspects of the study design (survey instrument, outreach methods, and an initial list of potential strategies for ZE space and water heating standards). We also requested their support for survey recruitment. Our research team paid honorariums to CBOs in recognition of their support of the study, including their participation in the stakeholder advisory meetings.
5. **Finalized survey instruments and other study design documents:** The research team revised the survey instruments and finalized the study design based on advisory

panel feedback.

6. **Collected direct feedback using a survey of 269 propane-using customers**: The research team used Qualtrics as a survey tool to field customer survey online and over the phone and collected 225 residential and 44 nonresidential surveys. We used eight strata based on four regions in California, with two strata (residential and nonresidential) within each region. We also aimed to complete surveys with different groups of residential customers (e.g., mobile or manufactured home, non-English speaking customers, tribal communities, renters[8], and low-income customers) and different business types for nonresidential customers that use propane, based on the data we collected in Step 1. We monitored survey completions and adjusted our recruitment process as needed to gather surveys from under-represented groups. There were fewer nonresidential surveys because there was a much lower response rate from nonresidential customers. For more detail on survey recruitment, please see the Number of Residential and Nonresidential Surveys Completions section.
7. **Evaluated strategies with CARB and the stakeholder advisory panel using the survey responses and conducted analysis to understand the incremental cost and bill impacts to customers**, as well as energy demand, and emissions impacts. The research team worked with our stakeholder advisory panel and CARB to discuss the results of the survey by demographic group and the results of the customer cost impacts and discussed which strategies(s) seemed more acceptable to different customer groups. We paid honorariums to CBOs in recognition of their support of the study, including their participation in the stakeholder advisory meetings.
8. **Presented results in a final report and seminar**. The research team developed a draft final report and a final report based on CARB's review. We will present the findings and final list of potential strategies during a public seminar in September 2025.

[8] We collected feedback from both owners and renters for both residential and nonresidential buildings, since owners' decision-making, renters' use of propane and wood appliances, and both of their attitudes towards zero-emissions appliances are important factors in developing strategies.

Sampling Methodology

The sampling methodology the research team used to identify communities for customer survey outreach is described below.

The research team used secondary data to identify areas in California that do not have natural gas lines, focusing on towns that were likely to have propane or wood use. We utilized census block group data to find the total number of propane heated homes and the wood heated homes for all block groups with the same United States Postal Service (USPS) town name. The sample included USPS towns with at least 25% propane and wood use, where the towns include both the towns themselves as well as surrounding areas. The research team randomly sampled towns and surrounding areas to achieve regional representation[9]:

- 13 towns in the **Northern Coast and Sierra Mountain** region,
- 13 towns in the **Central Valley** region,
- 10 towns in the **Southern Inland** region, and
- 7 towns in the **Southern Coastal** region.

We also included five towns and surrounding areas as well as six census-designated places (not the entire USPS town) where CCAC had contacts. Appendix A. Additional Methodology Details shows the list of towns in the sampled communities and their corresponding region. While we did outreach in all these communities, we did not get responses in them all, and we also received survey responses from communities outside of the sample because of CBO's contacts.

Survey Methodology

The description of the research team's survey instruments and recruitment methods are presented in the sections below.

Description of Survey

The research team developed residential and nonresidential surveys to understand why and how customers use propane or wood for space heating or water heating, customer attitudes towards ZE heaters, and customer receptivity towards ZE strategies. Survey sections included the following:

[9] The four regions roughly correspond to CEC Title 24 climate zone groupings: Northern (climate zones 1, 2, 11, and the northern part of 16), Central Valley (12 and 13), Central and Southern Coastal (3, 4, 5, 6, 7, and 8), and Southern Inland (9, 10, 14, 15, and the southern portion of 16).

- **Introduction & Screener** screened for respondents who used propane or wood as their main fuel or energy source for space or water heating.
- **Characteristics of Wood & Propane Use for Space Heating or Water Heating** asked respondents about additional heating equipment, temperature setpoints/comfort, reasons for using propane/wood, and propane costs.
- **Attitudes Toward Zero-Emission Space Heating Equipment & Strategies** asked respondents about their concerns with replacing their current equipment with electric equipment, perceptions of heat pumps, and receptiveness towards strategies that could reduce the negative impacts of adopting ZE equipment.
- **Attitudes Toward Zero-Emission Water Heating Equipment & Strategies** asked respondents about their concerns with replacing their current water heaters with electric water heaters, perceptions of heat pump water heaters, and receptiveness towards strategies that could reduce the negative impacts of adopting ZE equipment.
- **Wood Use (Residential only)** asked wood burning respondents about their wood burning equipment, how much and what type of wood they burn, and how they acquire and store their wood. This section was only asked of residential customers that used wood as their primary heating source and was not included in the nonresidential survey.
- **Household Characteristics and Demographics (Residential) / Firmographics (Nonresidential)** asked all residential respondents about household characteristics and demographics and asked all nonresidential respondents about firmographics. For the residential survey, this section included questions about income level, number of people living in the home, ethnicity, and tribal affiliation (where applicable) while the nonresidential survey asked for business type and if the business was a diverse business enterprise (minority-owned, woman-owned, and/or veteran-owned).

The research team fielded surveys from December 2024 through early March 2025. The 15-minute surveys were administered online or over the phone, in English or Spanish. The residential survey was available to both homeowners and renters, and the nonresidential survey was available to building owners and tenants. See Appendix F. Survey Instruments & Outreach Materials for the residential and nonresidential survey instruments.

Recruitment Methods

The research team used multiple recruitment methods for both the residential and nonresidential surveys to reduce bias and increase diversity in the sample. We targeted geographic diversity across the state through letters, CBOs, and for nonresidential customers, through local chambers of commerce.

Recruitment methods for the **residential** survey included:

- **Letters**: Sent roughly 5,000 letters to homes randomly selected from addresses available through Data Axle in sampled communities. See Appendix F. Survey Instruments & Outreach Materials for copies of the residential letter in English and Spanish.
- **Email and social media**: Sent emails to existing contacts and used social media posts to advertise the survey opportunity.
- **In-person events**: Handed out one-pagers at in-person meetings and events to promote the survey opportunity.
- **Emails to survey panel participants**: Emailed customers that had already signed up to take various surveys through a survey panel company, Dynata.
- **Phone calls**: Made phone calls to our partners' existing contacts in sampled communities.

Recruitment methods for the **nonresidential** survey included:

- **Letters**: Sent roughly 8,000 letters to businesses randomly selected from addresses available through Data Axle in sampled communities. See Appendix F. Survey Instruments & Outreach Materials for copies of the nonresidential letter in English and Spanish.
- **Email and social media**: Sent emails to existing contacts and about 1,300 customers in sampled communities using ZoomInfo contact information and used social media posts to advertise the survey opportunity.[10]
- **In-person events**: Handed out one-pagers at in-person meetings and events to promote the survey opportunity.
- **Phone calls**: Made phone calls to our partners' existing contacts in sampled communities.
- **Emails to survey panel participants**: Emailed customers that had already signed up to take various surveys through a panel company, CatalystMR.
- **Chambers of Commerce**: Sent emails to local chambers of commerce to forward to members.

The research team worked with CBOs and regional partners to recruit low-income, Spanish-speaking, tribal, and mobile or manufactured home respondents via email and social media, phone calls, and in-person meetings and events. The research team offered $35 gift cards for residential respondents and $50 gift cards for nonresidential respondents who completed the survey.

Table 4 below shows how survey respondents reported they heard about the survey.

[10] ZoomInfo is a paid service that provides contact information for businesses.

Table 4. Respondents' Self-Reported Recruitment Method for Residential and Nonresidential Surveys

	Letters	Email and social media	In-person events	Emails to survey panel participants	Phone calls	Total
Residential	74	56	43	39	12	**224***
Nonresidential	24	12	1	1	6	**44**

*Note that one residential respondent did not answer this question. The total number of residential responses for this question total to 224 while the total number of respondents for the residential survey is 225.

Number of Residential and Nonresidential Surveys Completions

The number of residential and nonresidential survey completions and the methods we used to weight the survey results are presented in the sections below.

Number of Survey Completions

Table 5 below shows the total number of completions for the residential and nonresidential surveys. The 225 completed residential surveys provides an estimate of proportion at 90% confidence with 6% or better absolute precision (with better precision with proportions that are different from 50%). The 44 completed nonresidential surveys provide an estimate of proportion at 90% confidence with 13% or better absolute precision.

Table 5. Number of Completions for Residential and Nonresidential Surveys

	Targeted Outreach	Panel Company	Total Respondents
Residential	186	39	**225**
Nonresidential	43	1	**44**

Although the research team performed more outreach for nonresidential customers, response rates were still lower than those for the residential survey. The research team sent roughly 8,000 letters to nonresidential customers vs. roughly 5,000 letters to residential customers and emailed the survey link to about 1,300 customers in sampled cities using contact information. But both the nonresidential letters and the ZoomInfo outreach had a response rate of about 0.3%, compared to a 1.5% response rate to the residential letters.

Of residential respondents, 93% completed the survey in English and 7% completed it in Spanish. All nonresidential respondents completed the survey in English. Please see the Survey Respondent Characteristics sections for additional respondent characteristics.

Weighting of Survey Results

The research team based the weighting scheme for the **residential** survey on both region—which was one of the key stratification variables identified in the study design—and the recruitment method, as proxied by the city. We aimed to balance the contribution from different regions, which served as a proxy for various group demographic characteristics, as well as other key factors like climate and utility. The research team also aimed to balance random sampling versus more convenient sampling determined by the location of subcontractors' and CBOs' contacts. Because the subcontractors' and CBOs' contact lists were more focused on disadvantaged communities, we used the propane and wood heating rates in disadvantaged communities as the basis for the weights for zip codes included in the subcontractors' jurisdictions.

The research team weighted the **nonresidential** survey responses proportionally by region, based on the population of households in California with either propane or wood heating. We used ACS data for the weighting scheme, as we expected that the proportion of businesses in a region roughly matched the proportion of people residing in a region.

Appendix A. Additional Methodology Details contains additional detail on the weighting schemes employed for the residential and nonresidential analysis.

Methodology to Analyze Customer Costs and GHG Impacts

To better understand the implications of the survey results and to inform strategies to retrofit buildings using propane with zero-emission technology, the research team investigated an array of zero-emission strategies using incremental first costs compared to baseline equipment as well as the operational impacts of these strategies. The building types, regions, and utilities selected for this analysis are shown in Table 6. Survey results and feedback from CARB and key stakeholders informed these selections; multifamily buildings were not included in the analysis due to the relative lack of propane use found in our initial evaluation.

Table 6. Building Types, Regions, and Utilities Used in Analysis

Cost and GHG Analysis Building Types, Regions, and Utilities			
Building Types	**Fuel Types, A/C Presence**	**Regions**	**Utilities**
• **Single-Family** • **Mobile homes** • **Restaurants**	• Propane heating and water heating baseline (all) • Wood heating and propane water heating baseline (single-family only)	• Northern Coastal • Sierra • North Central Valley	• PG&E (IOU*) • SCE (IOU) • Trinity PUD (POU**)

Cost and GHG Analysis Building Types, Regions, and Utilities			
• **Small hotels** • **Small offices**	• Existing A/C (all) • No existing A/C (single-family & Mobile home)	• South Central Valley • Southern Coastal • Southern Inland	• Modesto ID (POU) • Imperial ID (POU)

* IOU = investor-owned utility

** POU = publicly owned utility

Using these characteristics, the research team selected energy models created and run by NREL from the ResStock and ComStock databases. ResStock and ComStock are open-source modeling tools that represent the US building stock. As described in the ResStock Dataset 2024.1 Documentation, “This dataset is specifically intended to be a resource for state and local decision makers considering options for energy retrofits for their housing stock to reduce carbon emissions, energy use, and/or utility bills” (NREL, 2024b). ResStock and ComStock analyses allow for unique technology combinations (which are especially useful for baseline buildings with mixed-vintage components), include operational diversity (based on stochastic inputs), and are calibrated to actual utility load shapes. For this study, the research team selected a subset of models with available 15-minute energy data, resulting in around 1,500 models. More details about the breakdown of these models are available in Appendix D.

The research team studied three different packages for both residential and nonresidential buildings to look at the impacts of different zero-emissions technology:

1. A primary scenario using standard heat pump replacements, including a standard heat pump for space conditioning and a standard heat pump water heater. We refer to this as the “standard heat pump package”.

2. An alternative scenario using electric resistance equipment, including an electric resistance furnace and an electric resistance water heater with storage tank. We refer to this as the “electric resistance package”.

3. A low peak demand alternative scenario using high-efficiency heat pumps and peak load reduction measures, including a cold climate heat pump (that would use less energy during peak times because of its ability to reduce or avoid the use of electric resistance back-up heating) and a small direct current rooftop solar array that could reduce energy consumption at peak times. We refer to this as the “low peak demand package”.

Details about the specific equipment analyzed in the study are available in Appendix D.

Drafting and Evaluation of Recommended Strategies with Stakeholder Input

The research team developed a draft list of potential strategy categories based on past projects and industry experience. The purpose of this draft list of categories was to provide a framework for stakeholders to provide initial feedback and to inform the customer survey questions, so that customers could provide feedback on these ideas. The categories of strategies included financial assistance for ZE equipment, financial assistance for solar panel and storage, policy strategies, and customer and workforce education.

The research team then received feedback on these draft strategies through the customer survey. In addition, the research team calculated customer cost impacts (incremental first cost and billing impacts) as well as GHG impacts of the various ZE packages to help inform what types of technologies or customer groups would have particularly high incremental cost or no bill savings.

The research team then revised and refined the list of draft strategies based on these results and presented this revised list to the stakeholder panels for feedback. The research team held five stakeholder meetings to gather input, including two that work with nonresidential customers, two with residential, and one with both. In addition, the research team met with CARB for their input.

Based on this feedback, the research team further refined the list of recommended strategies for this report.

Quality Assurance and Quality Control Procedures

Senior subject matter experts provided oversight for the development of all data collection instruments, including development of the survey and customer impacts. In addition, these senior subject matter experts reviewed all results to provide quality control.

One challenge faced during the project was that bots attempted to take the survey. The research team discovered the bots when there was a surge in survey completions (a few hundred in one hour) after CBOs posted the survey opportunity on social media (Facebook). We immediately closed the survey and set up measures to reduce the instances of bots, including adding Captcha and reCAPTCHA questions, asking for survey takers to identify (from a coded list of options) all words starting with the letter “E”, and requiring responses to open-ended questions on thoughts and feelings (which are challenging for bots to complete). In addition, we set up a system to identify and remove bots from the responses to ensure that all responses retained for analysis were from legitimate responses.

The research team looked both for patterns in responses and strange or low-quality responses to help identify bots. We flagged bots based on criteria such as the following:

- **Location**: Respondents with IP address coordinates (latitude and longitude) outside of the United States[11]; different respondents with the same latitude/longitude coordinates or IP addresses as other respondents; respondents with high-risk IP addresses

[11] We also flagged respondents with an IP address outside of California to carefully review them for other criteria indicating that they may be bots, since we found that respondents from inside the U.S. but outside of California were a mix of humans and bots.

- **Similar responses**: Different respondents that used similar syntax, capitalization, and phrases as other respondents
- **Duration**: Respondents that completed the survey in less than 300 seconds
- **Timing**: Respondents that completed surveys at approximately the same time, late in the night (for example at 3am Pacific time)
- **Strange open-end responses**: Respondents that did not directly answer the question asked; respondents with "canned" or impersonal responses that appeared to be AI-generated
- **Unrealistic responses to pricing questions**: Respondents that provided unreasonably high or low responses to the cost to refill their propane tank, or (for residential customers only) their electricity bill (e.g., <$15 or >$1000 per month).

Senior subject matter experts reviewed cases where it was more challenging to determine if respondents were human or bots. For respondents that we were unsure about, even with the additional senior expert review, the research team removed their responses from analysis but provided them with the promised gift cards to be conservative in both directions. More detail on our bot detection process can be found in Appendix C. Bot Detection.

Limitations

While the research team met the target number of completions for residential surveys, we had fewer nonresidential survey completions than our target. This prevented us from identifying trends by region or business type. However, the 44 completed nonresidential surveys were still able to provide estimates of proportions at 90% confidence with 13% or better absolute precision, so we were still able to identify trends across all nonresidential customers.

The research team applied weights to both the residential and nonresidential survey data to generalize results to the population of propane and wood burning residents and businesses. We found that the weighting scheme for the residential survey, which was designed to account for non-random sampling within geographical regions, decreased the representation of some groups such as renters and low-income respondents in the overall sample. For this reason, in addition to reporting overall results, we break out results separately, showing unweighted results for several groups, including renters, low-income respondents, Spanish-speaking respondents, those residing in a mobile or manufactured home, and those who indicated they are "American Indian, Alaskan Native, or Native Hawaiian." This allows us to understand results for the overall population with weighting, but also individual groups without weighting.

The research team conducted hypothesis tests comparing the results between different groups when there was a compelling hypothesis related to the research objectives of the study, and not in cases where there was no such compelling hypothesis to test. Reporting the statistical significance of a result always relates to a specific hypothesis that may be implicit rather than explicitly stated, such as a result being different from zero, or two results being different from each other. In general, the null hypothesis was that there was no difference between two groups in the proportion providing a specific response to a question. For example, there is a compelling hypothesis related to the study objectives that there is no difference in percentage of respondents who use wood for heating because it was the existing fuel when they moved in between mobile or manufactured home occupants and occupants of other types of housing because it relates to different challenges between the two groups. There is not a compelling hypothesis to test regarding whether respondents were more likely to report being from the Central Valley than from the Southern Inland region because that is a function of the stratified sampling design. We did calculate statistical significance where there appeared to be a difference in results by demographic group (i.e. low-income, Native American) or region and reported results at the 90% confidence level. We did not calculate statistical significance when there did not appear to be differences based on visual observation.

The cost and GHG analysis are estimates, because exact results vary by home or building specifics including building size, occupant behavior, occupancy patterns, existing equipment, microclimate, etc. To mitigate this limitation, the research team used ResStock and ComStock which incorporate data from a variety of homes and building types. Similarly for the first cost estimates, the research team combined cost data from a variety of sources, including program data, RS Means, and contractor estimates. Consequently, the cost and GHG impacts provided in this report are estimates – not precise values.

Survey Results

This section includes key results of the residential and nonresidential surveys including:

- Survey Respondent Characteristics
- Why Survey Respondents use Propane or Wood
- Heat Pump and Heat Pump Water Heater Awareness
- Willingness to Replace Current Heating System and Water Heaters with an Electric Appliance
- Perceived Benefits and Drawbacks of Heat Pumps and Heat Pump Water Heaters

When reporting results, this section presents:

- All respondent characteristics as unweighted results to describe the sample of respondents that completed the survey.
- All other survey results for total respondents as weighted results to reflect the population of propane and wood burning buildings in California.
- Unweighted results when presenting results broken out for smaller sub-groups (e.g., low-income respondents, owners/renters, those living in mobile or manufactured homes, Native American respondents, and Spanish-speaking respondents), because weighting could potentially dilute the responses of these sub-groups.
- Statistical significance testing where there appeared to be a difference in results by demographic group (i.e. low-income, Native American) or region. Statistical significance was not tested when there did not appear to be differences based on visual observation.

For more discussion of the weighting scheme and considerations for presenting results, see Appendix A. Additional Methodology Details.

Survey Respondent Characteristics

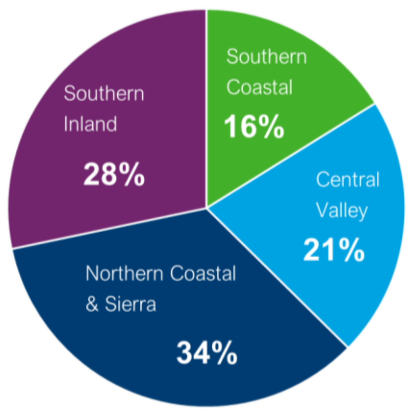
This section describes the characteristics of residential respondents who completed the survey, followed by characteristics of nonresidential respondents. All respondent characteristics are reported unweighted.

Residential Respondents

The research team was able to get representation for many diverse groups of residential respondents, and the sample for these groups is similar to the population of the state as illustrated in Table 7 and Table 8 below. Of the 225 residential respondents, 74 were low-income[12] which provides results with 90% confidence with no more than 10% absolute precision (with better precision with proportions that are different from 50%).

Figure 2 and Table 7 show where residential respondents lived across the state, and the sample of respondents is similar to the population[13].

Figure 2. Region Location of Residential Survey Respondents (n = 225)



Question A2b. Which of the following regions best describes where your primary home is located? (Unweighted Results)

Note: Total may not equal 100% due to rounding.

Table 7. Comparison of Residential Sample and Population by Region of California

Region of Residential Respondents	Sample % [a] (n = 225)	Population % [b]
Southern Coastal	16%	20%
Central Valley	21%	21%
Northern Coastal & Sierra	34%	42%
Southern Inland	28%	17%

[12] Low-income status was determined using criteria for the CARE program based on responses to survey questions asking household annual gross income and number of household residents (E4. Which of the following best describes your household's total annual gross income?; E3. Including yourself, approximately how many people live in your home full-time?) See: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/care-fera-program.

[13] The population is based on American Community Survey residential households that use propane or wood for primary heat in California.

[a] Sample results are reported unweighted.

[b] The population consists of ACS residential households that use propane or wood for primary heat in California.

Table 8 shows the majority of residential respondents spoke English and owned their homes, while about one-third of respondents were low-income. About 10% of respondents said they spoke Spanish as their primary language and around a quarter of respondents were renters. The respondent sample for these groups is similar to the population.

Table 8. Comparison of Residential Sample and Population by Demographic Categories

Residential Respondents	Sample % [a]	Population % [b]
Renter	24%	29%
Owner	76%	71%
Low-income [c]	38%	31%
Not Low-income	62%	69%
Speak English	88%	67%
Speak Spanish	10%	18%
Non-English Speaking other than Spanish	2%	15%

Question A4. Do you own or rent your home? (n = 225)

Question E2. What is the main language spoken in your home? (n = 224)

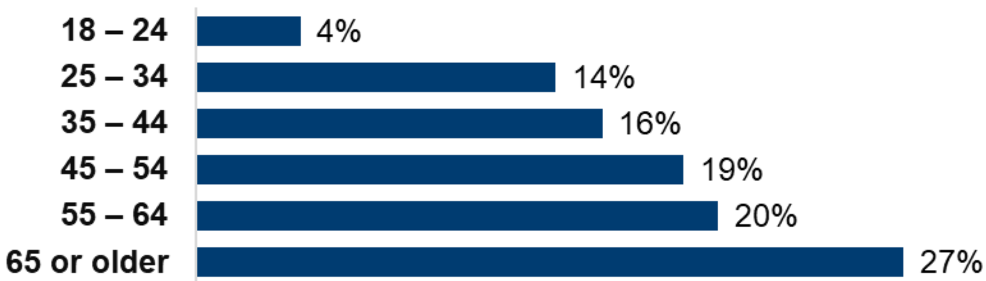
[a] Sample results are reported unweighted.

[b] The population consists of residential households that use propane or wood for primary heat in California.

[c] Low-income status was determined using criteria for the CARE program based on responses to survey questions asking household annual gross income and number of household residents (E4. Which of the following best describes your household's total annual gross income?; E3. Including yourself, approximately how many people live in your home full-time?) See: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/care-fera-program. Total n is 224, but 28 were omitted from the low-income calculation because they were missing household size and/or income and thus could not be categorized. Final n = 196.

Figure 3 shows that almost half of the residential respondents were 55 and older.

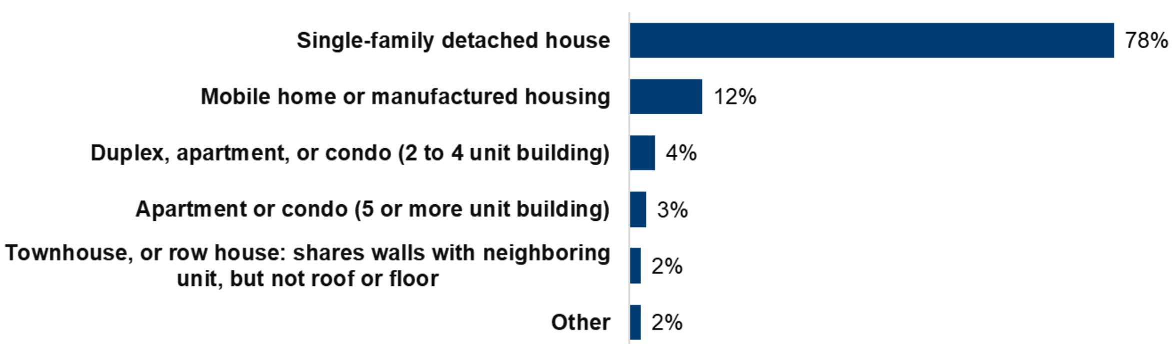
Figure 3. Age of Residential Survey Respondents (n = 223)



Question A3. What is your age? (Unweighted Results)

Figure 4 shows that almost 80% of residential respondents lived in a single-family detached house and 12% lived in a mobile or manufactured home. This is very similar to the population of propane and wood users, with 72% of the population[14] residing in a single-family detached house and 10% residing in mobile or manufactured housing.

Figure 4. Percentage of Residential Survey Respondents' Home Type (n = 222)



Question E5. Which of the following best describes your home? (Unweighted Results)

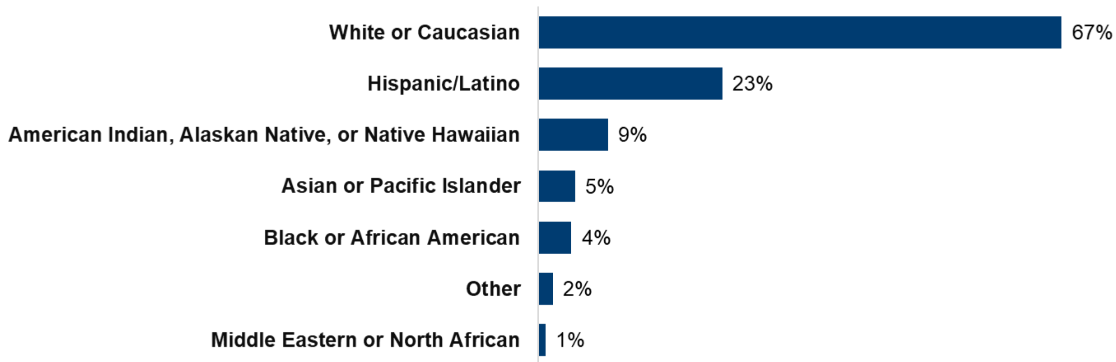
Note: Total may not equal 100% due to rounding. Other n=4: pool house, trailer, RV, top floor in a rural main street building.

Figure 5 shows that the majority (67%) of residential respondents were white or Caucasian, 23% were Hispanic or Latino, and almost 10% were Native American. Comparisons with the population are roughly consistent, although the population data measured race and ethnicity separately and does not include multiple responses but uses a "multi-ethnicity" category

[14] The population is based on American Community Survey residential households that use propane or wood for primary heat in California.

instead. For example, the population of wood and propane users is 57% White or Caucasian alone and 15% multi-ethnicity.

Figure 5. Percentage of Residential Survey Respondents' Race or Ethnicity (n = 213)



Question E1. Which of the following describes your race or ethnicity? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n=4: (1) White, Japanese, and African, (1) Filipino, Spaniard, and Greek, (2) no detail provided

For residential respondents to be able to take the survey, they had to report they either used propane or wood as their primary fuel for space heating or use propane as their primary fuel for water heating. Half of the residential respondents reported using propane to heat their home while slightly more than 70% reported using propane for water heating as shown in Figure 6. Almost 40% of residential respondents reported using wood to heat their home.

Figure 6. Proportion of Residential Respondents with Propane Space and Water Heating and Wood Space Heating

Question A7. Which of the following do you use most often to heat your space inside your home? (n = 224; Unweighted Results)

Question A8. What is the fuel (energy source) for the water heater in your home? (n = 223; Unweighted Results)

Note: Total sums more than 100% due to reporting multiple questions.

The breakout of propane space heating by region in Figure 7 shows that Central Valley and Southern Inland respondents reported using propane most often for their primary space heating fuel (60% and 56% respectively).

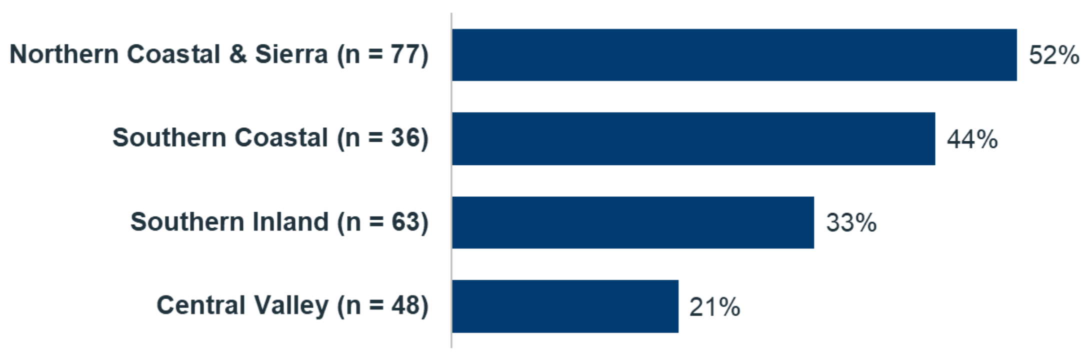
Figure 7. Proportion of Residential Respondents with Propane Space Heating by Region

Question A7. Which of the following do you use most often to heat your space inside your home? (Unweighted Results)

Note: The difference between the proportion propane space heating respondents for each of the region groups shown in the figure above and the proportion of responses among all residential respondents not in these regional groups is not statistically significant at the 90% confidence level.

Breaking out wood space heating by region in Figure 8 reveals a large difference among regions. About half of Northern Coastal & Sierra respondents (52%) use wood as their primary residential space heating fuel compared to only 21% of Central Valley respondents.

Figure 8. Proportion of Residential Respondents with Wood Space Heating by Region



Question A7. Which of the following do you use most often to heat your space inside your home? (Unweighted Results)

Note: The difference between the proportion of wood space heating respondents for the Northern Coastal & Sierra and Central Valley regional groups shown in the figure above and the proportion of responses among all residential respondents not in these regional groups is statistically significant at the 90% confidence level. The difference between the proportion of the remaining regional groups is not statistically significant.

The breakout of propane water heating by region in Figure 9 also demonstrates regional differences. Over 80% of Southern Inland respondents reported using propane for water heating (83%), compared to 58% of Northern Coastal & Sierra respondents.

Figure 9. Proportion of Residential Respondents with Propane Water Heating by Region

Question A8. What is the fuel (energy source) for the water heater in your home? (Unweighted Results)

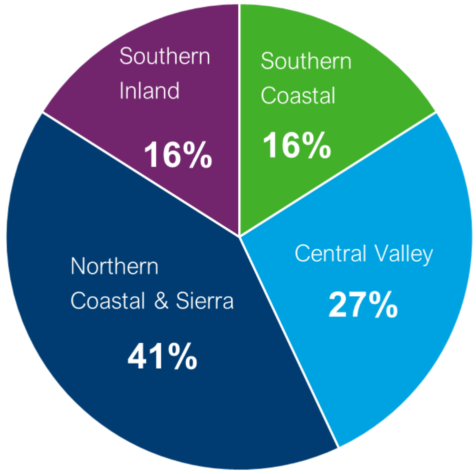
Note: The difference between the proportion of propane water heating respondents for the Southern Inland and Northern Coastal & Sierra regional groups shown in the figure above and the proportion of responses among all residential respondents not in these regional groups is statistically significant at the 90% confidence level. The difference between the proportion of the remaining regional groups is not statistically significant.

Nonresidential Respondents

Just as with the residential respondents, the research team was able to get representation from multiple business types of nonresidential survey respondents throughout California. Table 10 below illustrates that the business type sample with propane heating or water heating is similar to the population of the state. Office buildings were the most prevalent business type. While the survey was offered in both English and Spanish, all survey respondents completed the survey in English.

Figure 10 below displays the breakout of nonresidential survey respondents by California region, which is comparable to the population data in Table 9 below.

Figure 10. Region Location of Nonresidential Survey Respondents (n = 44)



Question A2b. Which of the following regions best describes where this commercial space is located? (Unweighted Results)

Table 9 below shows that the regional distribution of nonresidential respondents throughout California reflects the population data; note that the population used for comparison is that of residential households using propane or wood in California, assuming that the proportion of households roughly corresponds to the proportion of businesses in any given region.

Table 9. Comparison of Nonresidential Sample and Population

Region of Nonresidential Respondents	Sample % [a] (n = 44)	Population % [b]
Southern Coastal	16%	20%
Central Valley	27%	21%
Northern Coastal & Sierra	41%	42%
Southern Inland	16%	17%

[a] Sample results are reported unweighted.

[b] The population consists of nonresidential buildings that use propane for space heating or water heating in California, based on Comstock data.

The most prevalent business type in both the survey responses and population data is office with 34% of survey responses and 45% of population data, followed by hotel, motel or other lodging, and warehouses as illustrated Table 10 below.

Table 10. Nonresidential Survey Respondents' Business Type Categories, Compared to the Population

Nonresidential Respondents' Business Types	Sample Size	Sample % [a]	Population % [b]
Office	15	34%	45%
Hotel, motel, or other lodging	5	11%	11%
Warehouse	5	11%	33%
Retail	4	9%	0%
Healthcare, including outpatient and dental services	2	5%	2%
Restaurant – Full Service: sit-down restaurant with a full kitchen	2	5%	8%
Restaurant – Quick Service: fast-food, take-out, café, or deli	2	5%	0%
Grocery store/Convenience store/Liquor store	1	2%	NA [c]
Laundromat	1	2%	NA
School (K-12)	1	2%	0%
Church	2	5%	NA
Other	4	9%	0%

Question A4. Which of the following best describes your organization?

[a] Sample results are reported unweighted.

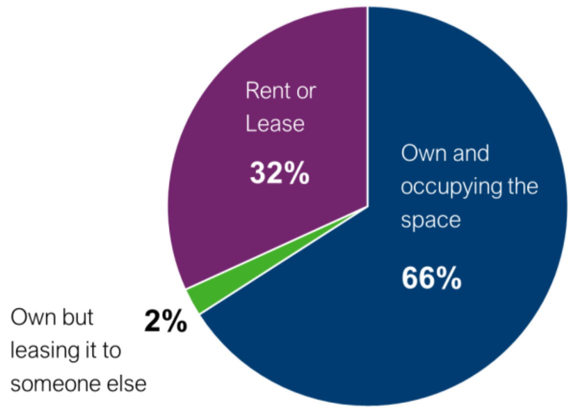
[b] The population consists of nonresidential buildings that use propane for space heating or water heating in California, based on Comstock data.

[c] NA = Not available

Note: Total may not equal 100% due to rounding. Other n = 4: Farm, dog rescue, gaming, car repair shop.

Two-thirds of respondents (66%) reported they owned and occupied their commercial space as shown in Figure 11.

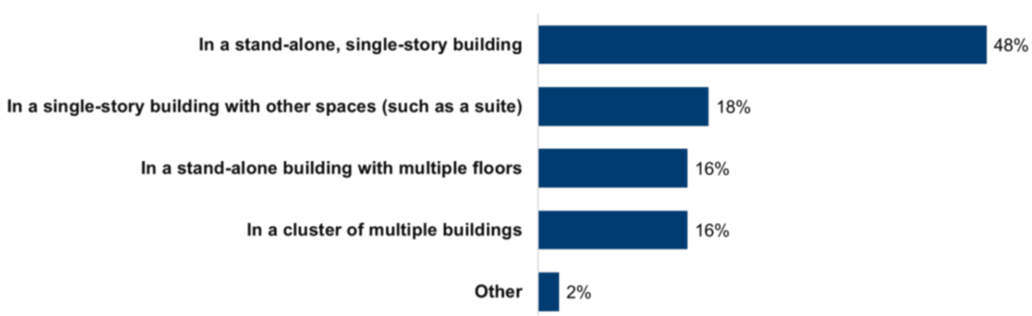
Figure 11. Percentage of Nonresidential Respondents that Own or Rent Their Space (n = 44)



Question B1. Which of the following best describes the ownership of the space where your organization is located? (Unweighted Results)

About half of respondents (48%) indicated they worked in stand-alone, single-story buildings as displayed in Figure 12.

Figure 12. Percentage of Nonresidential Survey Respondents' Building Type (n = 44)

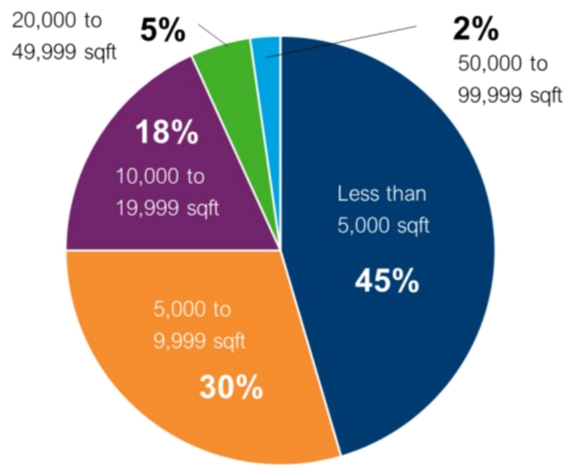


Question E1. Which of the following best describes where your organization is located? (Unweighted Results)

Note: Other n = 1: Within a double wide mobile home

Figure 13 shows that about 45% of respondents occupied facilities less than 5,000ft^2 and almost one-third of respondents (30%) occupied facilities between 5,000-9,999ft^2. Note that we use "facility" to refer to the space the business occupies, which is not necessarily the entire building.

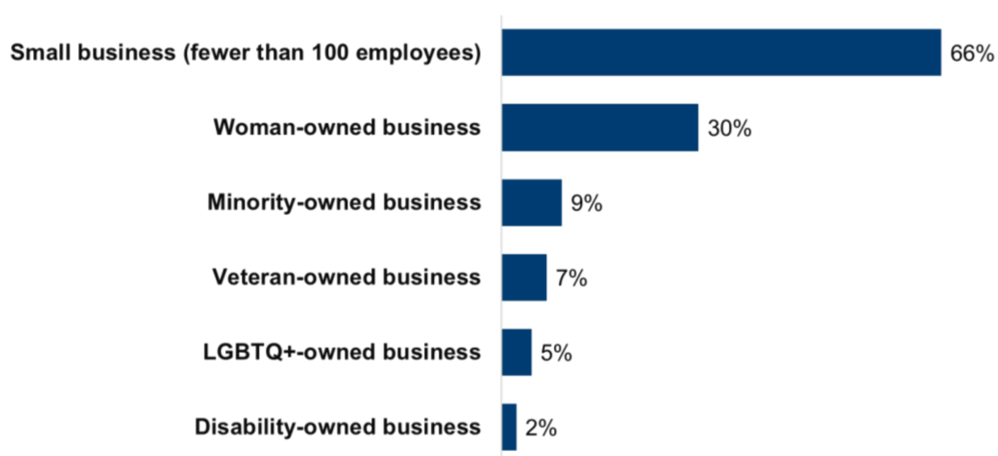
Figure 13. Square Footage of Facilities for Nonresidential Survey Respondents (n = 44)



Question A5. About how big (in square feet) is your organization's space? (Unweighted Results)

Figure 14 shows that two-thirds of nonresidential respondents (66%) reported they were small businesses and almost one-third of respondents (30%) reported they were woman-owned businesses.

Figure 14. Nonresidential Survey Respondents' Business Description (n = 44)



Question E3. Which of the following categories, if any, describes your organization? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. One person answered, "Don't Know" and 1 person answered "Prefer not to answer."

For nonresidential respondents to be able to take the survey, they had to report they either used propane as their primary fuel for space heating or as their primary fuel for water heating in their building. The majority of nonresidential respondents said they used propane for space heating (91%) and water heating (70%) as shown in Figure 15.

Figure 15. Proportion of Nonresidential Respondents with Propane Space and Water Heating (n = 44)

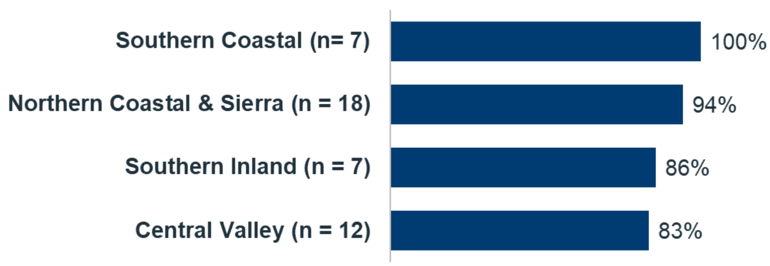
Question A7. Which of the following do you use most often to heat your space? (Unweighted Results)

Question A8. What fuel (energy source) does your water heater use? (Unweighted Results)

Note: Total sums more than 100% due to reporting multiple questions.

Figure 16 shows nonresidential respondents' use of propane as a primary space heating fuel was high within all four regions, although there were small variations. All Southern Coastal (100%) and almost all (94%) Northern Coastal & Sierra respondents reported primarily using propane for space heating.

Figure 16. Proportion of Nonresidential Respondents with Propane Space Heating by Region

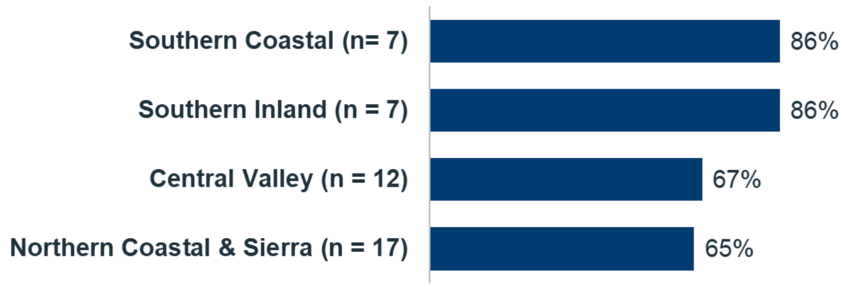


Question A7. Which of the following do you use most often to heat your space inside your home? (Unweighted Results)

Note: The difference between the proportion of propane space heating respondents for the Southern Coastal regional group shown in the figure above and the proportion of responses for all nonresidential respondents not in this group is statistically significant at the 90% confidence level. The difference between the proportion of the remaining regional groups is not statistically significant.

When broken out by region in Figure 17, the vast majority of Southern Inland and Southern Coastal nonresidential respondents (86% for both groups) indicated they primarily use propane for water heating. About two-thirds of Central Valley (67%) and Northern Coastal and Sierra (65%) respondents reported using propane for water heating.

Figure 17. Proportion of Nonresidential Respondents with Propane Water Heating by Region

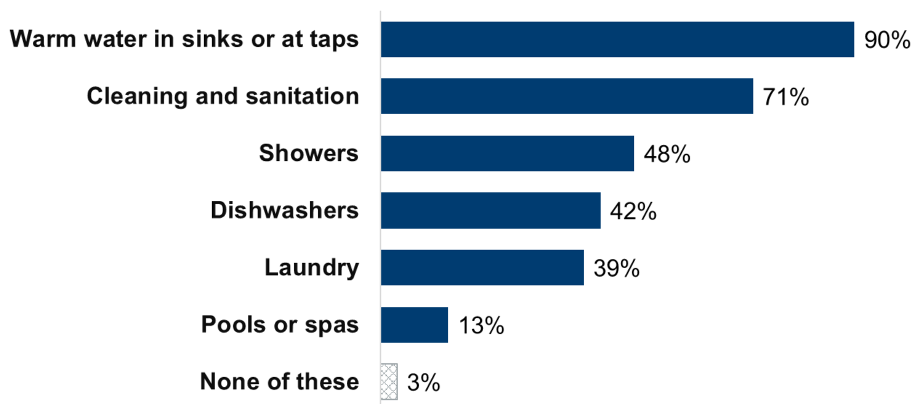


Question A8. What fuel (energy source) does your water heater use? (Unweighted Results)

Note: The difference between the proportion of propane water heating respondents for each of the regional groups shown in the figure above and the proportion of responses for all nonresidential respondents is not statistically significant at the 90% confidence level.

Figure 18 shows that the majority of respondents said they used propane for water heating in sinks or taps (90%) or for cleaning and sanitation (71%).

Figure 18. Percentage of Activities for Which Nonresidential Survey Respondents Use Propane to Heat Hot Water (n = 31)



Question B5. Is hot water used for any of the following? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

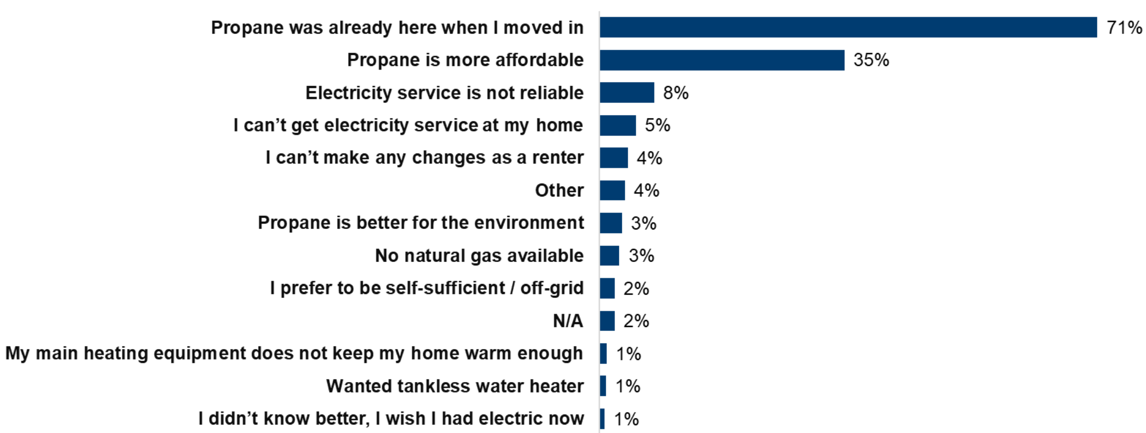
Why Survey Respondents use Propane or Wood

This section presents results on why residential and nonresidential survey respondents used propane to heat their home or water as well as why residential respondents used wood to heat their home or water.

Residential and Nonresidential Propane Results

The majority of residential and nonresidential respondents said they used propane to heat their home or water because it was already there when they moved in as shown in Figure 19 and Figure 20 below. More than one-third of residential and nonresidential respondents said they used propane because it was more affordable than electricity. This survey question allowed respondents to select multiple reasons for why they used propane, so the figures in this section have a sum of greater than 100%.

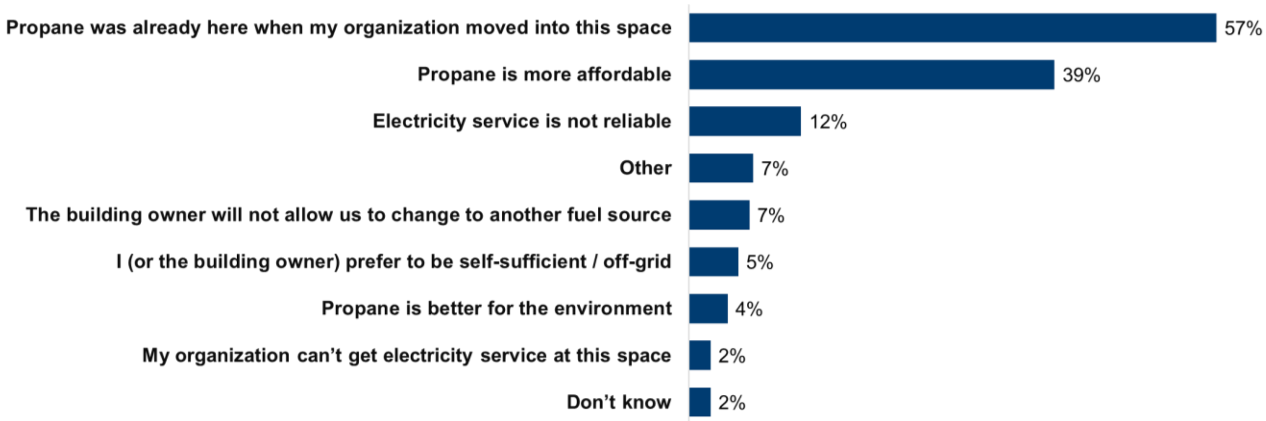
Figure 19. Residential Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 192)



Question B4a. Why do you use propane to heat your home or water instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. One respondent answered "Don't know." Other n = 8; examples of responses included: "Only propane is available here, combination of wood and propane is cheaper, no space for a large water tank, waiting for better hot water heat pumps to become available."

Figure 20. Nonresidential Respondents' Reasons for Using Propane to Heat their Space or Water Instead of Electricity (n = 44)



Question B6. Why does your organization use propane to heat your space or water instead of electricity? (Weighted Results)

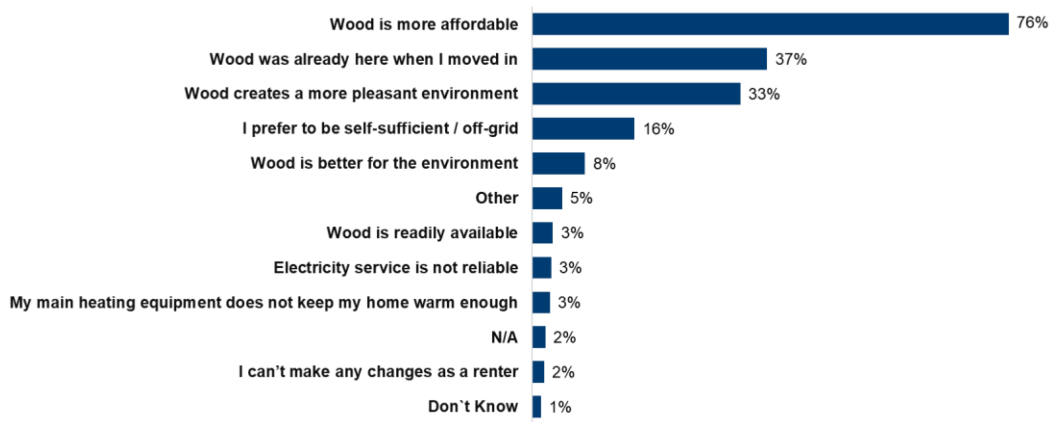
Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 3; example of responses included: "More efficient than electricity."

Breakout results for residential low-income respondents, mobile and manufactured home respondents, Spanish-speaking respondents, and the four different regions of California were very similar to the total residential respondent results and can be found in Appendix B. Additional Survey Results.

Residential Wood Results

For the residential respondents that said they used wood as their primary heat source, slightly more than three-fourths said they used wood to heat their home instead of electricity because it was more affordable as illustrated in Figure 21. Low-income respondent results were similar and can be found in Appendix B. Additional Survey Results.

Figure 21. Residential Respondents' Reasons for Using Wood to Heat Their Home Instead of Electricity (n = 87)



Question B5. Why do you use wood to heat your home instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. No respondents said they cannot get electricity service at their home. Other n = 4; responses mentioned wood being a better option for the age of their home, wood always being available when power is out due to storms and reducing the chance of wildfire. "

When the research team looked at why residential respondents use wood, slight demographic differences emerged as shown in Table 11. The majority of Native Americans[15] (80%) and mobile or manufactured home respondents (50%) said they used wood because a wood burning appliance was already there when they moved in. The next predominant reason for using wood for heating was because it was more affordable (60% of Native American respondents and half of mobile or manufactured home respondents said this). The research team calculated statistical significance testing for the responses from these demographic groups compared to the responses for all other residential respondents. The results with an * next to them illustrate when the difference in the demographic groups results and all other residential respondent results were statistically significant at a 90% confidence level.

Table 11. Mobile or Manufactured Home and Native American Respondents' Reasons for Using Wood to Heat Their Home or Water

Why do you use wood to heat your home or water instead of electricity?	Mobile or Manufactured Home (n = 10)	Native American (n = 10)
Wood was already here when I moved in	50%	80%*
Wood is more affordable	50%*	60%
Wood is better for the environment	10%	10%

[15] Native American includes respondents that identified as American Indian, Alaskan Native and/or Native Hawaiian.

Why do you use wood to heat your home or water instead of electricity?	Mobile or Manufactured Home (n = 10)	Native American (n = 10)
Wood creates a more pleasant environment	10%*	30%
I can't make any changes as a renter	10%	10%
I prefer to be self-sufficient / off-grid	10%	10%

Question B5. Why do you use wood to heat your home instead of electricity? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

*Indicates that the difference between the proportion of responses in these demographic groups and proportion of responses among all respondents not in these demographic groups is statistically significant at the 90% confidence level. Values without this symbol are not statistically significantly different from the proportion of respondents not in the demographic group.

Access to Electricity

Literature indicates it is very rare for customers not to have access to electricity. For example, the World Bank estimates that the percent of households with electricity access in the U.S. is 100% (Bank, 2023); the report did not provide specifically for California. The Residential Appliance Saturation Survey also shows all sampled customers have an electric utility (DNV-GL, 2021).

The survey results collected in this study showed that almost all customers are connected to the grid. For residential customers that reported using propane as their primary heating fuel, Figure 19 above shows that based on weighted survey results, 5% of residential respondents reported it was because they did not have electricity service. The unweighted results were lower: 1.5% for residential – representing three out of 192 respondents - reported they do not have electricity service. Of these three respondents, based on responses to other questions:

- Two may have misreported not having electricity service: In response to a later question, they both reported paying their entire electricity bill. One of them also lived in a mobile home and responded in a later question (specific to mobile-home customers) that their home was individually metered.
- One lived in a mobile home and reported using a generator and solar panels for electricity. In the later questions asking who paid the electricity bill, s/he left it blank. In the question to mobile-home dwellers on whether his/her home was individually metered or master-metered, s/he again reported not having access to electricity. This consistency in reporting indicated that this respondent truly did not have access to electricity. The respondent was Spanish-speaking and very low income.

For residential customers that reported using wood as their primary heating fuel, as shown in Figure 21 above, none (n=87) reported that the reason was because they did not have electricity service.

For nonresidential customers, one respondent (out of 44, or 2%) reported they use propane because they do not have access to electricity, as shown in Figure 16. However, in a later question, s/he reported paying the entire amount of their electricity bill, so may have misreported not having electricity service.

In total, three of the 225 residential customers (or 1.3%) reported they did not have electricity service. Of these, only one respondent (or 0.4%) provided consistent answers throughout the survey supporting that they do not have access to the electrical grid. One of the 44 nonresidential customers (or 2%) reported not having electricity service but later provided conflicting information. The survey results align with the findings from previous studies that lack of access to electricity service is near zero.

Heat Pump and Heat Pump Water Heater Awareness

Heat pump and heat pump water heater awareness results for all residential and nonresidential respondents as well as residential breakout groups and the four regions of California are presented in the sections below.

Awareness Results for All Residential and Nonresidential Respondents

The majority of residential respondents (73%) and nonresidential respondents (70%) were aware of heat pumps but were less aware of heat pump water heaters (44% and 53%, respectively) as shown in Figure 22 and Figure 23 below.

Figure 22. Residential and Nonresidential Respondents that are Aware of Heat Pumps

Question: C1. Have you ever seen or heard about heat pumps (an appliance that can heat and cool your home/business)? (Weighted)

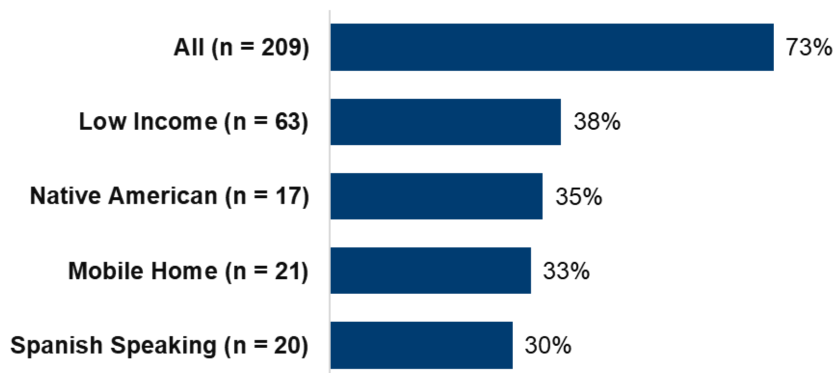
Figure 23. Residential and Nonresidential Respondents that are Aware of Heat Pump Water Heaters

Question D1. Have you ever seen or heard about heat pump water heaters (an appliance that can heat the water in your home/business)? (Weighted)

Awareness Results for Residential Breakout Groups

While the majority of total residential respondents (73%) said they were aware of heat pumps, only around one-third of low-income, Native American, mobile or manufactured home, and Spanish-speaking respondents said they were aware of heat pumps, as shown in Figure 24 below.

Figure 24. Total Residential and Breakout Group Respondents that are Aware of Heat Pumps



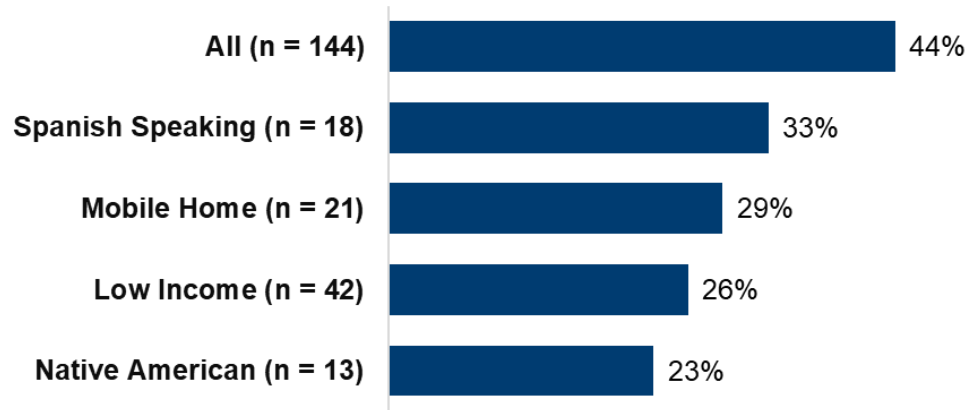
Question C1. Have you ever seen or heard about heat pumps (an appliance that can heat and cool your home)?

Note: All is reported as weighted results while the rest are reported as unweighted results.

Note: The difference in responses for each of the specific demographic groups shown in the figure above compared to all other residential respondents is statistically significant at the 90% confidence level.

Similarly, while 44% of all residential respondents said they were aware of heat pump water heaters, only about one-third of Spanish-speaking respondents and less than one-third of mobile and manufactured home, low-income, and Native American respondents said they were aware of heat pump water heaters, as shown in Figure 25 below.

Figure 25. Total Residential and Breakout Group Respondents that are Aware of Heat Pump Water Heaters



Question D1. Have you ever seen or heard about heat pump water heaters (an appliance that can heat the water in your home)?

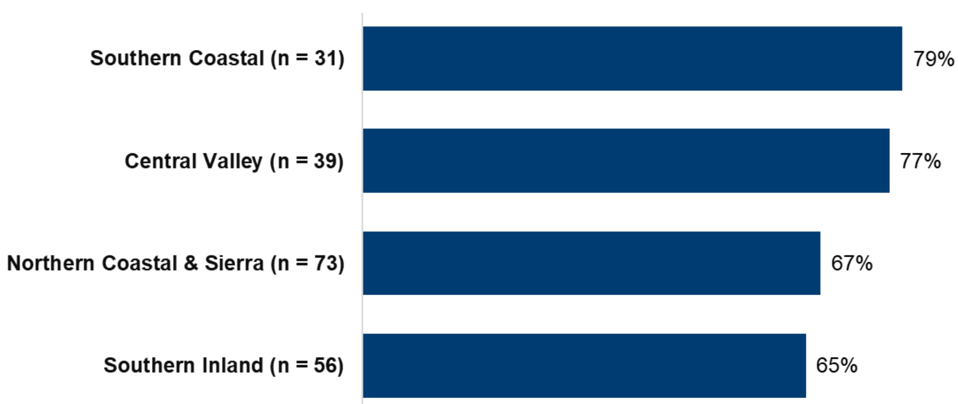
Note: All is reported as weighted results while the rest are reported as unweighted results.

Note: The difference in responses for the low-income and Native American demographic groups shown in the figure above compared to all other residential respondents is statistically significant at the 90% confidence level. The difference in responses of the remaining demographic groups is not statistically significant.

Awareness Results for Residential Respondents by Region

Similar to the total residential respondent results, the majority of respondents in each region said they were aware of heat pumps. There was somewhat less awareness in the Northern Coastal and Sierras and Southern Inland regions (67% and 65%, respectively) compared to the Southern Coastal and Central Valley regions (79% and 77%, respectively), as shown in Figure 26 below.

Figure 26. Residential Respondents by Region that are Aware of Heat Pumps

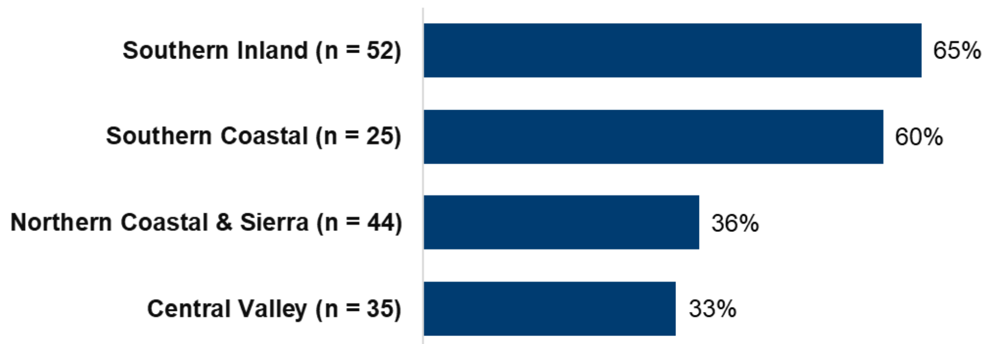


Question C1. Have you ever seen or heard about heat pumps (an appliance that can heat and cool your home)? (Weighted Results)

Note: The difference in responses for each of the regional groups shown in the figure above compared to all other residential respondents is not statistically significant at the 90% confidence level.

The majority of respondents in the Southern Inland (65%) and Southern Coastal (60%) regions said they were aware of heat pump water heaters while only around one-third of respondents in the Northern Coastal and Sierra and Central Valley regions said they were aware of them, as shown in Figure 27 below.

Figure 27. Residential Respondents by Region that are Aware of Heat Pump Water Heaters



Question D1. Have you ever seen or heard about heat pump water heaters (an appliance that can heat the water in your home)? (Weighted Results)

Note: The difference between responses for the Southern Inland and Southern Coastal regional groups shown in the figure above compared to all other residential respondents is statistically significant at the 90% confidence level. The difference between the responses for the remaining regional groups is not statistically significant.

Willingness to Replace Current Heating System and Water Heaters with an Electric Appliance

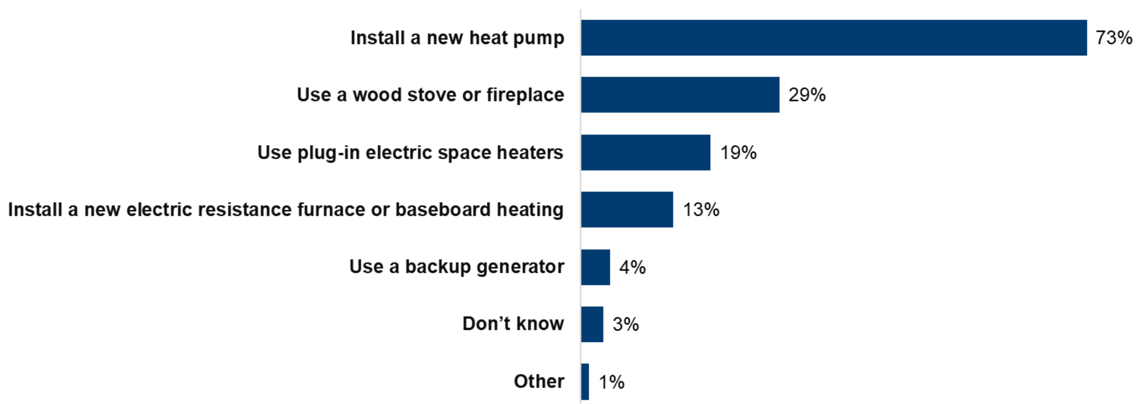
The sections below present results on 1) the type of equipment residential and nonresidential respondents would choose to replace their current heating system if propane equipment were no longer available, 2) how much extra they would be willing to pay to install a heat pump or heat pump water heater, and 3) their willingness to replace their current heating system or water heater with an electric appliance.

Replacement Options if Propane Heating Equipment Were No Longer Available - Residential and Nonresidential Respondent Results

The research team asked residential and nonresidential respondents to imagine their current heating system broke beyond repair and propane equipment was no longer available to purchase. We then listed replacement options and asked them which they would most likely choose. We explained that compared to an electric resistance furnace, a heat pump has a higher first cost but is cheaper to operate because it is more efficient. We also explained that an electric resistance furnace has a similar first cost to a propane furnace, is less expensive to purchase than a heat pump, but is more expensive to operate because it is inefficient. We allowed the respondents to select up to two choices.

Figure 28 illustrates more than 70% of all residential respondents said they would choose to install a new heat pump to heat their space if propane equipment was no longer available to purchase, and more than 40% separates this choice from the next top choice which was to use a wood stove or fireplace.

Figure 28. Options Residential Respondents Chose if Heating Equipment Broke and Propane Equipment Were No Longer Available (n = 82)

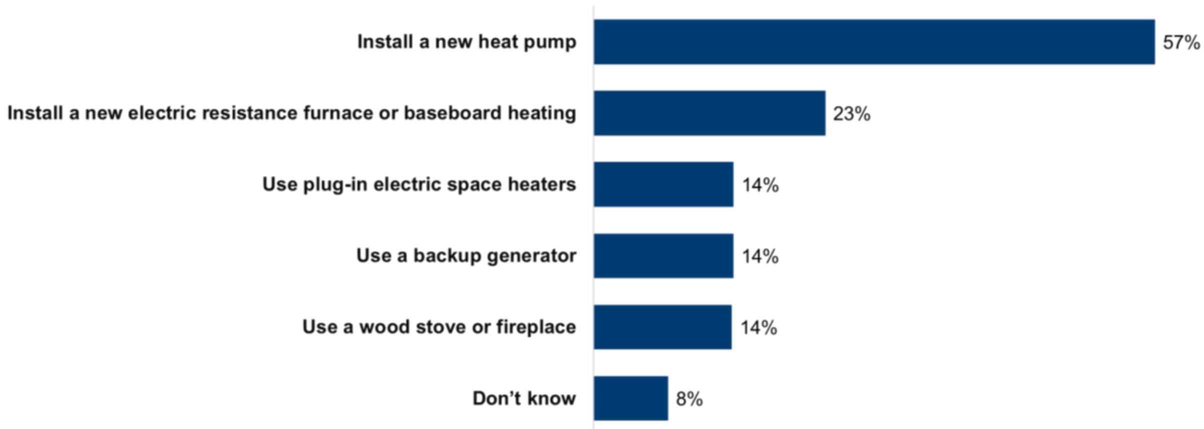


Question C3. Imagine that your current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n=2; example response included: “Would only get a heat pump if affordable and would need more solar with battery backup.”

Similarly, the majority of nonresidential survey respondents (57%) said they would install a new heat pump if propane equipment was no longer available, and more than 30% separates this option from the next top choice which was to install a new electric resistance furnace or baseboard heating, as shown in Figure 29 below.

Figure 29. Nonresidential Survey Respondents Equipment Choice if Propane Were no Longer Available (n = 27)

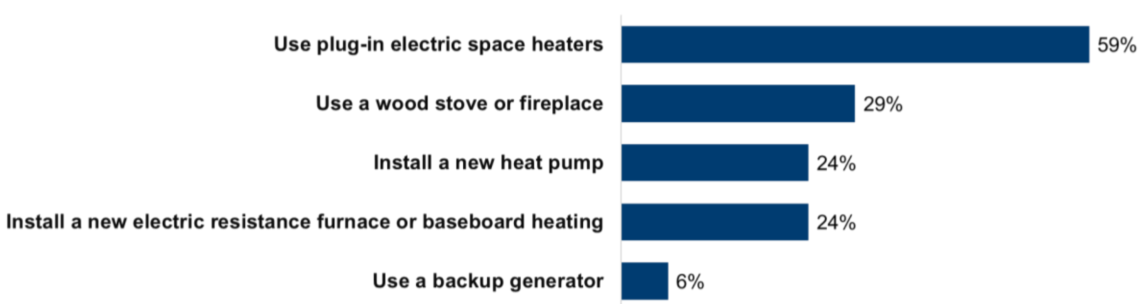


Question C4. Imagine that your organization's current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

Unlike the total residential respondent results, almost 60% of low-income respondents said they would choose to use a plug-in electric space heater to heat their space if propane equipment was no longer available to purchase, as shown in Figure 30. However, using a wood stove or fireplace was also their next top choice.

Figure 30. Options Low-income Respondents Chose if Heating Equipment Broke and Propane Equipment were no Longer Available (n = 17)



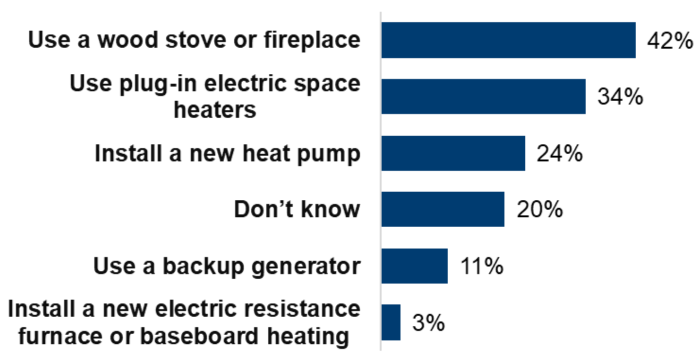
Question C3. Imagine that your current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

Note: The difference in responses for the low-income demographic group for options "use plug-in electric space heaters" and "install a new heat pump" compared to those options for all other residential respondents is statistically significant at the 90% confidence level. The difference in responses of the remaining options is not statistically significant.

Figure 31 shows results for respondents in the Southern Inland region where they said their top choice (at 42%) was to use a wood stove or fireplace followed by using a plug-in electric space heater (at 34%) to heat their space if propane equipment was no longer available to purchase. Results broken out for respondents in the Southern Coastal, Northern Coastal and Sierra and Central Valley regions were very similar to the total residential respondent results, with installing a new heat pump as the top choice and can be found in Appendix B. Additional Survey Results.

Figure 31. Options Southern Inland Region Respondents Chose if Heating Equipment Broke and Propane Equipment were no Longer Available (n = 28)



Question C3. Imagine that your current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

Note: The difference in responses for the Southern Inland regional group for all options shown in the figure above compared to the options for all other residential respondents is statistically significant at the 90% confidence level.

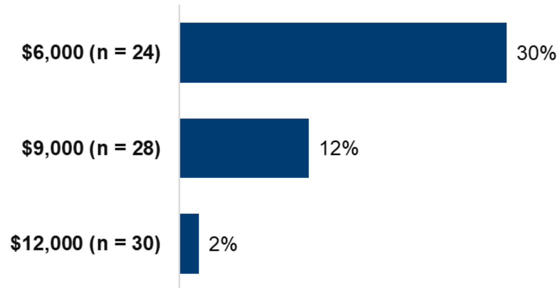
Willingness to Pay Extra for Heat Pumps and Heat Pump Water Heaters - Residential and Nonresidential Respondents

To understand what residential and nonresidential customers might be willing to pay to purchase and install a new heat pump, we asked respondents to imagine that they needed to replace their current heating system, assuming that the cost to install a new propane heating system is about $7,000. We then asked respondents if they would be willing to pay an extra amount to install a heat pump instead, randomly assigning respondents to one of three amounts: $6,000, $9,000, or $12,000 extra.

Thirty percent of residential respondents said they were willing to pay an extra $6,000 for a new heat pump and 12% said they were willing to pay an extra $9,000, as shown in Figure 32 below.

Results for nonresidential respondents were similar where 30% said they would be willing to pay an extra $6,000 (see these results in Appendix B. Additional Survey Results).

Figure 32. Residential Respondents Willing to Pay an Extra Amount of Money for a Heat Pump



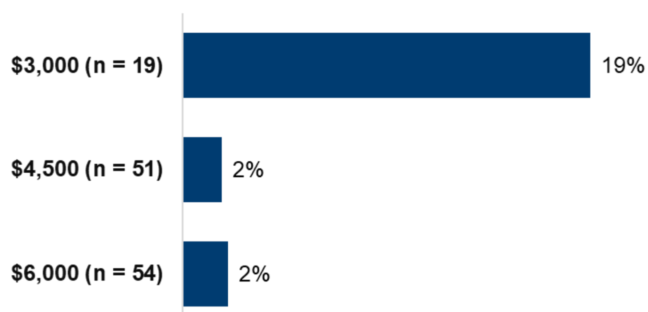
Questions: C4_1, C4_2, and C4_3. Would you be willing to pay an extra $6,000/$9,000/$12,000 for a new heat pump? (Weighted Results)

The sample size for low-income results was too small to report on but generally their willingness to pay extra for a heat pump results were lower compared to the total residential results.

Similarly, we asked respondents to imagine that they needed to replace their current water heater, assuming that the cost to install a new propane water heater is about $4,000. We then asked respondents if they would be willing to pay an extra amount to install a heat pump water heater instead, randomly assigning respondents to one of three amounts: $3,000, $4,500, or $6,000 extra.

Figure 33 shows almost 20% of residential respondents said they were willing to pay an extra $3,000 for a new heat pump water heater and only 2% said they were willing to pay an extra $4,500 or $6,000.

Figure 33. Residential Respondents Willing to Pay an Extra Amount of Money for a Heat Pump Water Heater



Question: D3_1, D3_2, and D3_3. Would you be willing to pay an extra $3,000/$4,5000/$6,000 for a new heat pump water heater? (Weighted Results)

Sample sizes for nonresidential results and residential low-income results were too small to report on but generally their willingness to pay extra for a heat pump water heater results were lower compared to heat pumps.

Willingness to Replace Current Heating System and Water Heater with an Electric Appliance

Residential Results

To understand how receptive residential customers are towards heat pumps packaged with other equipment, we asked residential homeowners when their current heating system fails, how willing would they be to replace it with an electric appliance if certain scenarios were allowed. We also asked residential renters when their current heating system fails, how supportive would they be if their landlord replaced it with an electric appliance if certain scenarios were allowed. Residential homeowners and renters were not asked similar questions about heat pump water heaters due to the length of the residential survey instrument.

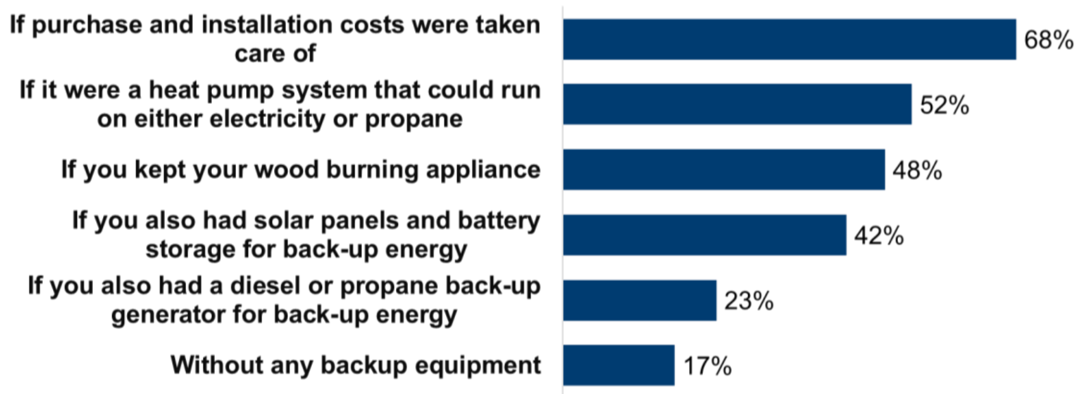
The results below combine responses from homeowners and renters unless otherwise specified.

Almost 70% of all residential respondents said they would be willing to replace their current home heating system with an electric appliance if purchase and installation costs were taken care of, as shown in Figure 34 below. Between 40% and 52% of all residential respondents also said they would be willing to replace their current home heating system with an electric appliance if:

- it was a heat pump system that could run on either electricity or propane,
- they could keep their wood burning appliance, or
- they also had solar panels and battery storage for backup energy.

Only 23% of residential respondents said they would be willing to replace their current home heating system with an electric appliance if they also had a diesel or propane backup generator for backup energy. Less than 20% of residential respondents said they would be willing to do this without any backup, indicating how important having backup energy equipment is to people.

Figure 34. Total Residential Respondents that are Willing to Replace their Current Heating System with an Electric Appliance (n = 195)

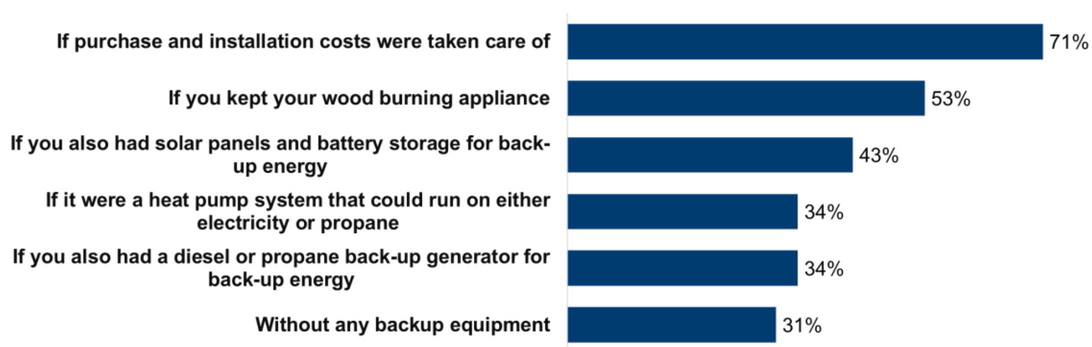


Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Weighted Results)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. Overall n = 195. For "If you kept your wood burning appliance" question, n = 106, as this question was asked only of those who reported burning wood for space heating. For "If purchase and installation costs were taken care of" question, n = 152, as this question was asked of homeowners only.

Slightly more than 70% of low-income respondents also said they would be willing to replace their current home heating system with an electric appliance if purchase and installation costs were taken care of, but more than 50% also said they would do this if they could keep their wood burning appliance. See Figure 35 below.

Figure 35. Total Low-income Respondents that are Willing to Replace their Current Heating System with an Electric Appliance (n = 61)



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

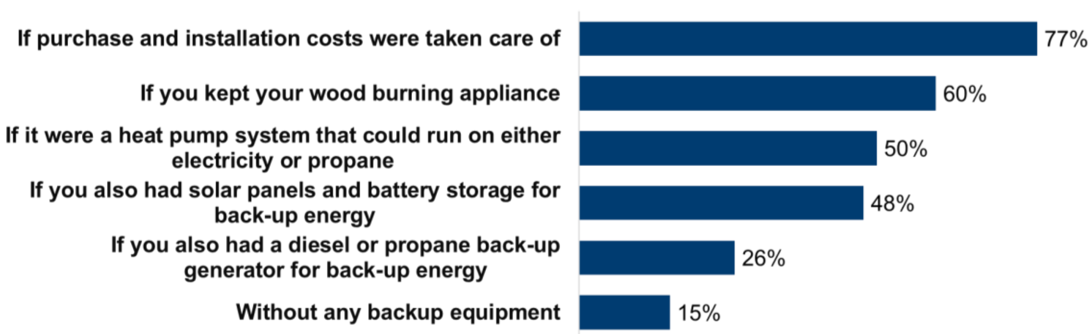
Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. Overall n = 61. For "If you kept your wood burning appliance" question, n = 30, as this question was asked only of those who reported burning wood for space heating. For "If purchase and installation costs were taken care of" question, n = 31, as this question was asked of homeowners only.

Note: The difference in responses for the low-income demographic group for options "if it were a heat pump system that could run on either electricity or propane", "if you also had a diesel or propane back-up generator for back-up energy" and "without any backup equipment" compared to these options for all other residential respondents is statistically significant at the 90% confidence level. The difference in responses for the remaining options is not statistically significant.

Results for Native American respondents and mobile and manufactured home respondents were very similar to the low-income respondent results. These can be found in Appendix B. Additional Survey Results.

The second most popular response differed for the Northern Coastal and Sierra and Southern Inland regions compared to the total residential respondents and are shown in Figure 36 and Figure 37 below. Sixty percent of respondents in the Northern Coastal and Sierra region would be more willing if they could keep their wood burning appliance while 47% of respondents in the Southern Inland region would be more willing if they could have solar panels and battery storage for backup energy. Both regions' third most popular response was if it were a heat pump system that could run on either electricity of propane, which was the total residential respondents' second most popular response.

Figure 36. Northern Coastal and Sierra Respondents that are Willing to Replace their Current Heating System with an Electric Appliance (n = 71)

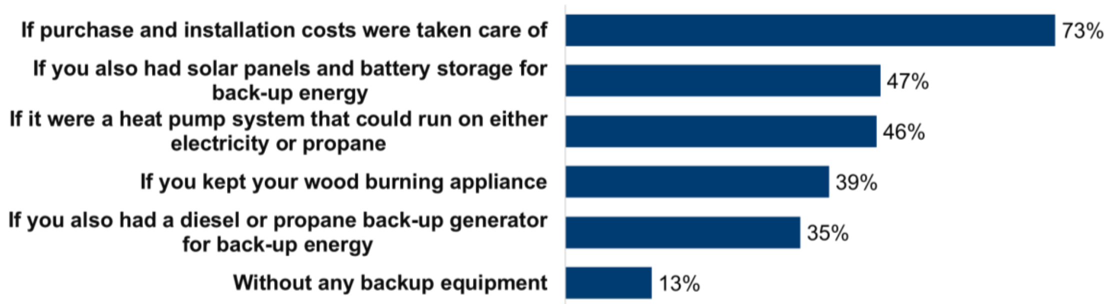


Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Weighted Results)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. Overall n = 71. For "If you kept your wood burning appliance" question, n = 45, as this question was asked only of those who reported burning wood for space heating. For "If purchase and installation costs were taken care of" question, n = 53, as this question was asked of homeowners only.

Note: The difference in responses for the Northern Coastal and Sierra regional group for options “if purchase and installation costs were taken care of” and “if you kept your wood burning appliance” compared to these options for all other residential respondents is statistically significant at the 90% confidence level. The difference in responses for the remaining options is not statistically significant.

Figure 37. Southern Inland Respondents that are Willing to Replace their Current Heating System with an Electric Appliance (n = 54)



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Weighted Results)

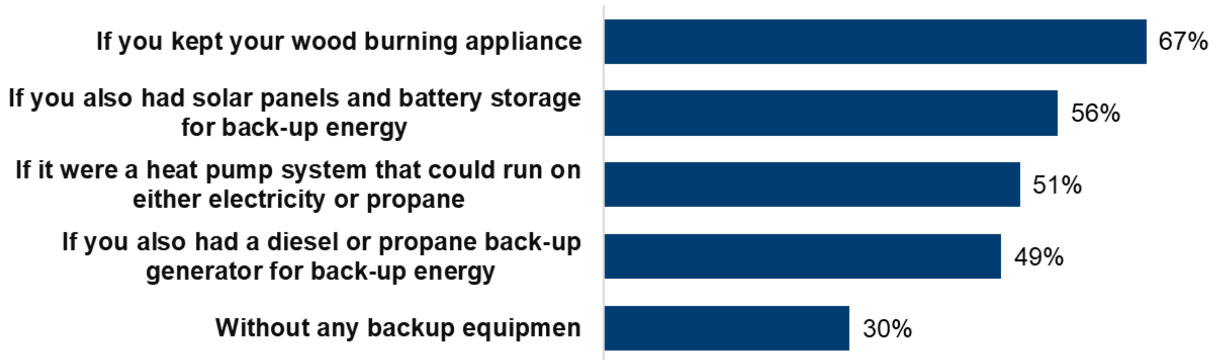
Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. Overall n = 54. For “If you kept your wood burning appliance” question, n = 27, as this question was asked only of those who reported burning wood for space heating. For “If purchase and installation costs were taken care of” question, n = 45, as this question was asked of homeowners only.

Note: The difference in responses for the Southern Inland regional group for option “if you also had a diesel or propane back-up generator for back-up energy” compared to this option all other residential respondents is statistically significant at the 90% confidence level. The difference in responses for the remaining options is not statistically significant.

Results for Spanish-speaking respondents and respondents located in the Southern Coastal and Central Valley regions were very similar to the total residential respondent results. These can also be found in Appendix B. Additional Survey Results.

While homeowner respondents’ results were very similar to the total residential respondent results, results for residential renters differed and are shown in Figure 38. More than 65% of renters said they would be willing to have their landlord replace their current heating system with an electric appliance if they could keep their wood burning appliance, compared to 48% for total residential results. More than 56% of residential renters said they would support their landlord doing this if they had solar panels and battery storage of backup energy, compared to 42% of total residential results.

Figure 38. Residential Renters that Support their Landlord Replacing the Current Heating System with an Electric Appliance (n = 43)



Question C6a-f. When your current home heating system fails, how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. Overall n = 43. For "If you kept your wood burning appliance" question, n = 15, as this question was asked only of those who reported burning wood for space heating.

Note: The difference in responses for the renters group for all options shown in the figure above compared to all other residential respondents is statistically significant at the 90% confidence level, except for the option "if it were a heat pump system that could run on either electricity or propane".

Breakout group and regional results for homeowners and renters can be found in Appendix B. Additional Survey Results.

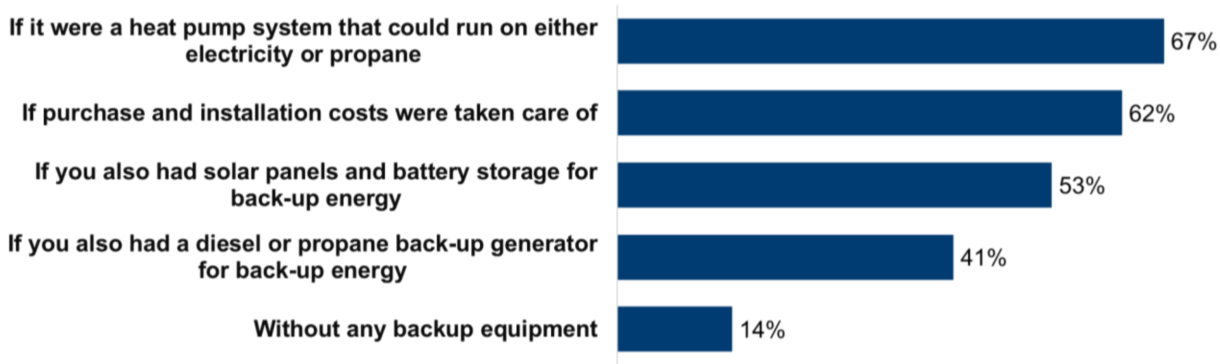
Nonresidential Results

To understand how receptive nonresidential customers are towards heat pumps and heat pump water heaters packaged with other equipment, we asked nonresidential building owners when their organization's current heating system or water heater fails, how willing would they be to replace it with an electric appliance if certain scenarios were allowed. We also asked nonresidential tenants when their organization's current heating system or water heater fails, how supportive would they be if the building owner replaced it with an electric appliance if certain scenarios were allowed.

The results below combine responses from building owners and tenants.

Figure 39 shows more than 60% of nonresidential respondents said they would be willing to replace their current space heating system with an electric appliance if they could install a heat pump system that could run on either electricity or propane or if purchase and installation costs were taken care of.

Figure 39. Nonresidential Respondents that are Willing to Replace their Current Heating System with an Electric Appliances (n = 39)

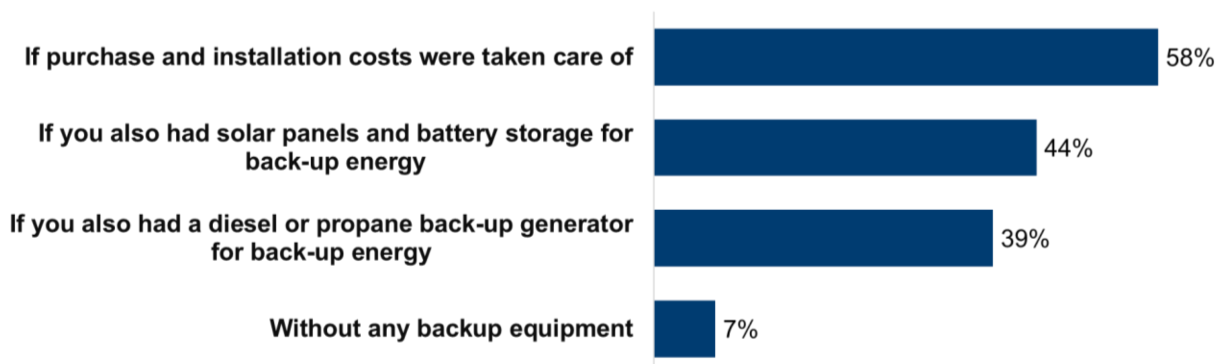


Question C8a-e and C9a-d combined. When your organization's current heating system fails, how willing would you be to replace it/how supportive would you be if the building owner replaced it with an electric appliance? (Weighted)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. Overall n = 39. For "If purchase and installation costs were taken care of" question, n = 26, as this question was asked of building owners only.

Similarly, almost 60% of nonresidential respondents said they would be willing to replace their current water heater equipment with an electric appliance if purchase and installation costs were taken care of, with having solar panels and battery storage for backup as the second most popular option as seen in Figure 40.

Figure 40. Nonresidential Respondents that are Willing to Replace their Current Water Heater with an Electric Appliance (n = 31)



Questions D6a-d and D7a-c combined. When your organization's current water heater fails, how willing would you be to replace it/ how supportive would you be if the building owner replaced it with an electric appliance? (Weighted)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. Overall n = 31. For “If purchase and installation costs were taken care of” question, n = 21, as this question was asked of building owners only.

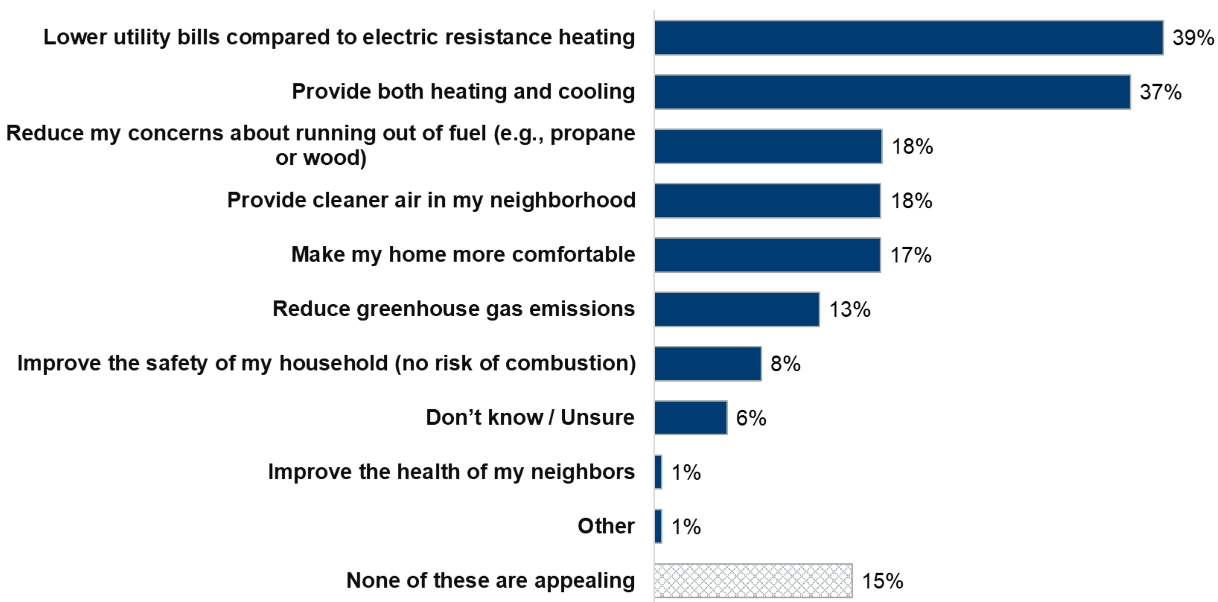
Perceived Benefits and Drawbacks of Heat Pumps and Heat Pump Water Heaters

The sections below describe survey respondents perceived benefits and potential concerns regarding heat pumps and heat pump water heaters. Survey questions allowed respondents to select multiple responses, so the figures in these sections have a sum of greater than 100%.

Perceived Benefits of Heat Pumps and Heat Pump Water Heaters

Both residential and nonresidential survey respondents said the top two potential benefits of heat pumps that appealed to them most were that heat pumps may lower utility bills compared to electric resistance heating and that they provide both heating and cooling. Almost 20% of residential respondents also reported that heat pumps would reduce their concerns about running out of fuel (33% of residential respondents also said this about heat pump water heaters, shown in Figure 43 below). A small portion of residential and nonresidential respondents (15% and 11% respectively) did not find any of the potential benefits listed appealing. These results are shown in Figure 41 and Figure 42 below.

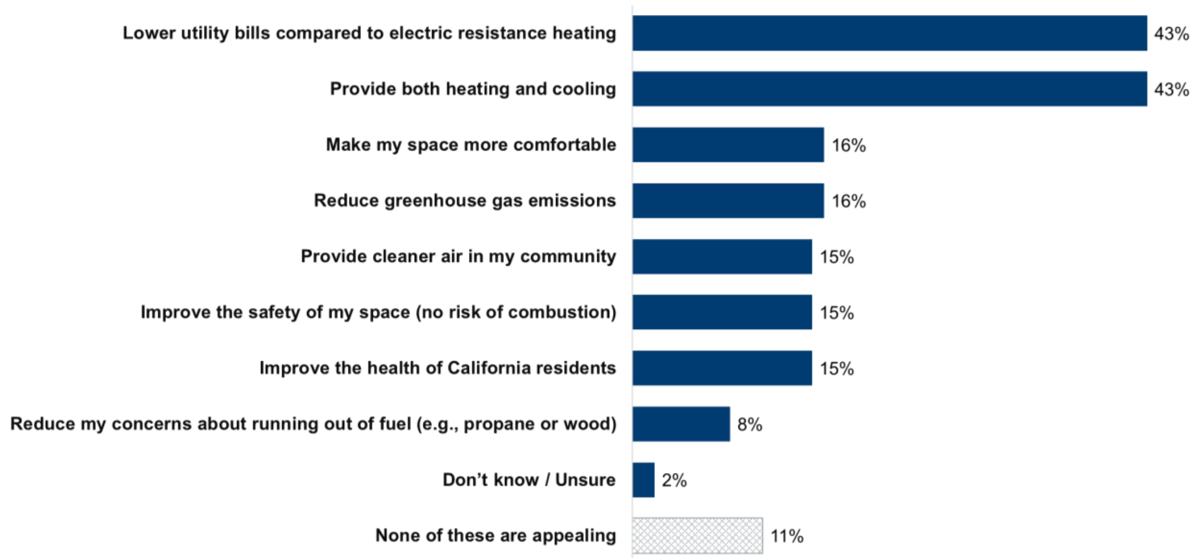
Figure 41. Potential Heat Pump Benefits that Appeal to Residential Respondents (n = 198)



Question C2. Which of these potential benefits about heat pumps are most appealing for your household? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 1: "More cost effective than propane".

Figure 42. Potential Heat Pump Benefits that Appeal to Nonresidential Respondents (n = 40)

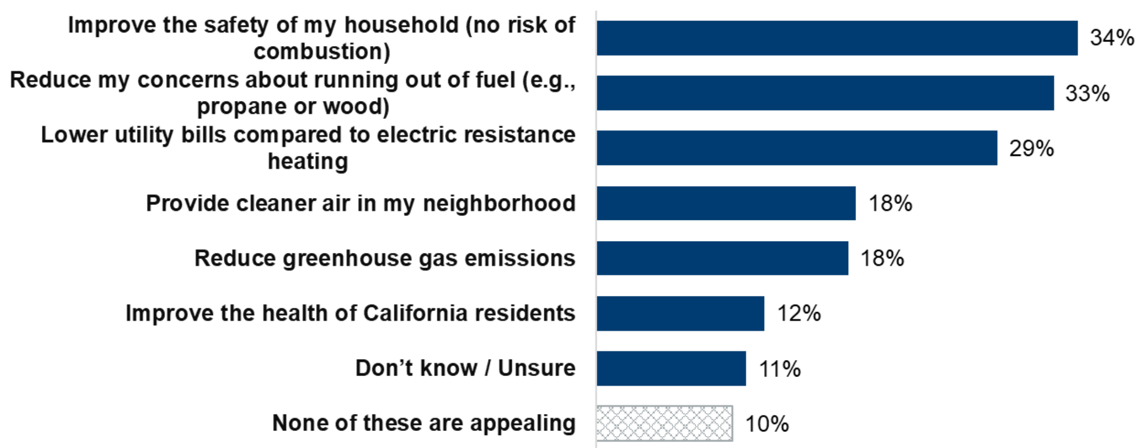


Question C2. Which of these potential benefits about heat pumps are most appealing for your organization? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

As shown in Figure 43, residential respondents said the top two potential benefits for heat pump water heaters were that they improve the safety of their household and reduce concerns about running out of fuel, while about 10% of the residential respondents did not find any of the potential benefits for heat pump water heaters appealing. The sample size for nonresidential respondents was too small to report results on.

Figure 43. Potential Heat Pump Water Heater Benefits that Appeal to Residential Respondents (n = 25)



Question D2. Which of these statements about heat pump water heaters is most appealing for your household? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

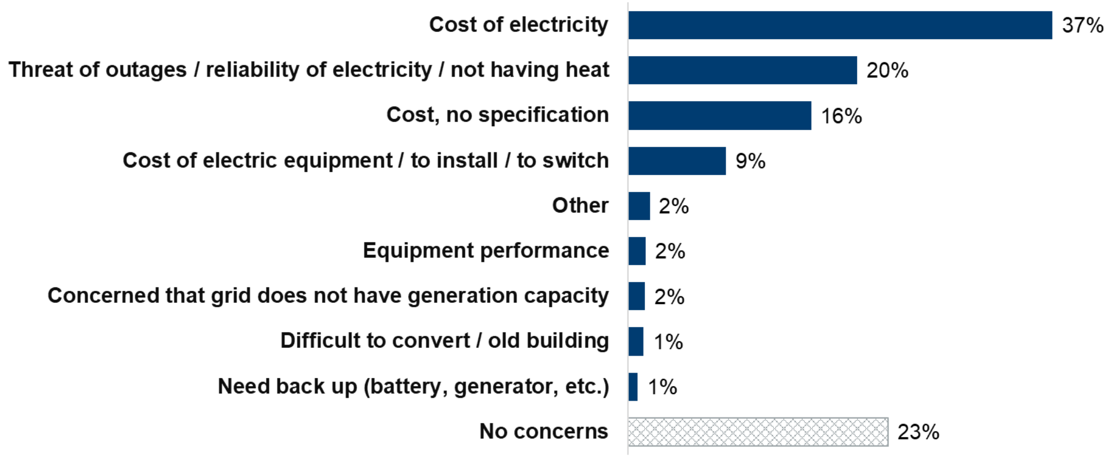
Potential Concerns with Electric Appliances

Homeowners, residential renters, nonresidential building owners, and nonresidential tenants all said their top concern with replacing their current heating system with an electric appliance was the cost of electricity. One respondent said, "The rising cost of electricity is a concern and being able to afford it in the future." Another said, "The monthly cost of the electricity bill would be outrageous considering the huge hike in cost recently. Electricity can be upwards of $450 per month."

The threat of power outages, reliability of electricity, and not having heat was the next main concern for homeowners as shown in Figure 44, while general concerns around cost was the next main concern for nonresidential building owners, as shown in Figure 45. One residential respondent said, "We lose power all the time. That means no hot food, no hot water and no heat when we lose power. We've lost power for as long as a week at a time. I'll fight for propane as long as I can." One nonresidential respondent said "Electric dryers cost more to run and are less efficient, leading to longer customer wait times and potential business loss. Electricity demand is high, and during power shortages or outages, we wouldn't be able to operate."

Almost 25% of residential respondents and 30% of nonresidential responses said they had no concerns with adopting an electric appliance.

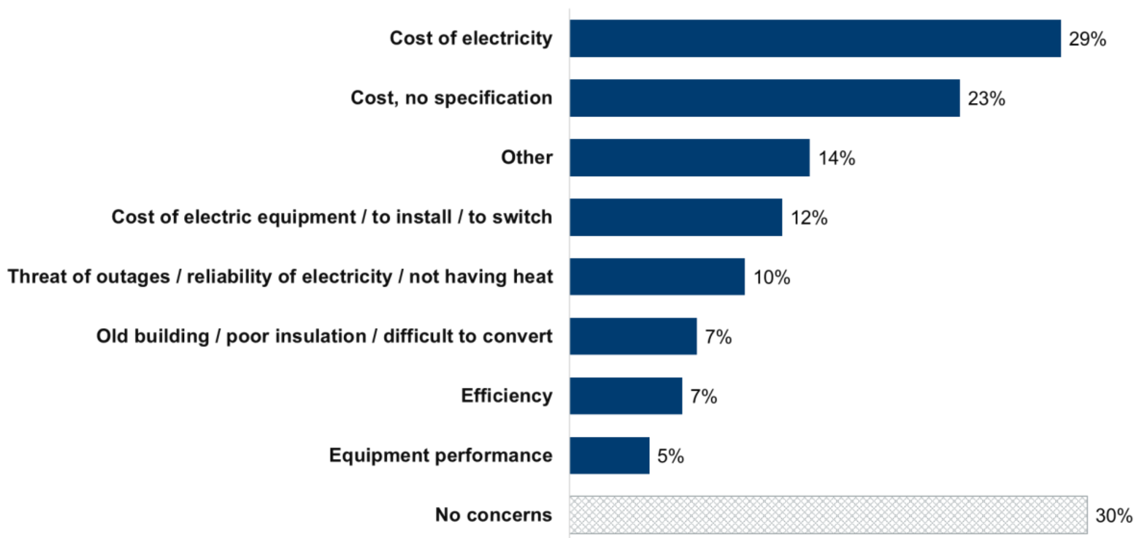
Figure 44. Homeowners' Concerns on Replacing their Current Heating System Replaced with an Electric Appliance (n = 156)



Question C0a. Imagine your home heating system breaks beyond repair, and you're the one making the decision to replace it. Also imagine that you can't replace it with another propane heating appliance. What concerns, if any, would you have replacing it with an electric heater? (Weighted Results)

Note: Sum is greater than 100% because respondents often stated multiple concerns in their response. Other n = 6; example responses included: "local crews knowing how to install heat pumps; permits".

Figure 45. Nonresidential Building Owners' Concerns on Replacing their Current Heating System Replaced with an Electric Appliance (n = 27)



Question C0a. Imagine your organization's heating system breaks beyond repair, and you're the one making the decision to replace it. Also imagine that you can't replace it with another propane heating appliance. What concerns, if any, would you have replacing it with an electric heater? (Weighted Results)

Note: Sum is greater than 100% because respondents often stated multiple concerns in their response. Other n = 4; Concerns included not wanting to replace a generator with electric, concerns about the space being too cold for workers, concerns about lack of access to natural gas, and a laundromat respondent's concerns about potential business loss due to longer customer wait times if electric dryers were used".

Similar to homeowners, 40% of residential renters were concerned about the cost of electricity if their landlord replaced their current heating system with an electric appliance, however, the majority (48%) said they did not have any concerns. The majority of nonresidential tenants (55%) also had no concerns about whether their building owner replaced their current heating system with an electric appliance. See results for residential renters and building tenants in Appendix B. Additional Survey Results.

The research team did not present results on potential concerns for replacing a water heater with an electric appliance because they were very similar to the heating system results. Homeowners, residential renters, nonresidential building owners, and nonresidential tenants all said their top concern with replacing their current water heater with an electric appliance was the cost of electricity.

Results of Customer Cost Impacts and Greenhouse Gas Modeling

The sections below present the research team's estimates of incremental costs, bill impacts and GHG impacts for customers adopting zero-emission technologies.

Incremental Cost Estimates

To evaluate the first cost impact of zero-emission technology, the research team compared the first costs to the cost of replacing the existing heating and water heating equipment in a building, assuming that the zero-emission retrofits would happen upon existing equipment failure.

Residential

The residential analysis is primarily based on cost data from RSMeans and an internal study completed by the research team for BayREN for baseline equipment (RSMeans, 2025). For the zero-emission technology, the analysis incorporated TECH installation data for heat pumps and heat pump water heaters, RSMeans for electric resistance equipment and envelope measures for the alternative scenarios, and California Distributed Generation Statistics from the CPUC for rooftop solar photovoltaic costs (TECH Clean California, 2025) (Energy Solutions, 2025).

Where sufficient cost estimates and observations were available, the research team developed linear regression models based on heating capacity for heating equipment and hot water storage size for water heating equipment; these models are shown in Appendix D. The ResStock and ComStock databases include heating capacity and hot water storage parameters for each model, which were used to determine an estimate for the first costs for the building models analyzed in this study.

The summary of the first costs is shown in Table 12. The baseline is to replace existing equipment (e.g., propane appliances); following saturation trends in ResStock, in some cases the baseline includes replacing air conditioning (e.g. single-family w/ AC, propane heat) but in other cases the baseline does not include replacing air conditioning (e.g., single-family w/o AC, Propane Heat; single-family w/o AC, wood heat), since ResStock indicates many building types would have no air conditioning or only window A/C. The heat pump costs include electrical panel upgrades for the buildings without existing air conditioning because the analysis assumed that the increase in electrical load from both heat pump heating and cooling would require a panel upgrade.

For the primary zero-emissions scenario, standard heat pumps with propane or wood backup heating, the costs for the buildings with existing air conditioning do not include electrical panel upgrades, as the existing air conditioning load will likely have a similar peak draw to the added electrical heating load. Heat pumps in this scenario will not have the added load of backup electric resistance strip heating. The research team also assumed the alternative scenario utilizing low-peak demand technology, which includes envelope upgrades and PV installation, will not require a panel upgrade, but all buildings in the electric resistance scenario will require a panel upgrade. Future work can look at a more granular evaluation of panel upgrade necessity based on existing characteristics, but a paper authored by TRC and Resource Refocus currently in press shows only around 5% of homes moving from gas or propane heating to heat pumps through California's TECH program required panel upgrades (Goebes, Battisti, & Davis, 2025).

Table 12. Median Residential Equipment & Installation Cost

Existing Building Type	Scenario	HVAC	Hot Water	Electrical Panel Upsizing	Additional Measures
Single-family w/ AC, Propane Heat	Baseline	$9,643	$2,549	N/A	N/A
	Heat Pump	$20,066	$4,617	N/A	N/A
	Electric Resistance	$14,467	$1,294	$3,680	N/A
	Low Peak Demand	$19,967	$2,251		$22,830
Single-family w/o AC, Propane Heat	Baseline	$7,952	$2,549	N/A	N/A
	Heat Pump	$19,666	$4,617	$2,602	N/A
	Electric Resistance	$14,664	$1,294	$3,680	N/A
	Low Peak Demand	$20,207	$2,251	N/A	$23,079
Single-family w/o AC, Wood Heat	Baseline	$7,952	$2,390	N/A	N/A
	Heat Pump	$17,683	$4,617	$2,592	N/A
	Electric Resistance	$13,786	$1,294	$3,680	N/A
	Low Peak Demand	$17,679	$2,251	N/A	$22,830
Mobile Home w/ AC, Propane Heat	Baseline	$9,190	$2,509	N/A	N/A
	Heat Pump	$17,062	$4,617	$2,602	N/A
	Electric Resistance	$8,524	$1,294	$3,680	N/A
	Low Peak Demand	$17,119	$2,251	N/A	$22,011
Mobile Home w/o AC, Propane Heat	Baseline	$5,956	$2,509	N/A	N/A
	Heat Pump	$15,982	$4,617	N/A	N/A
	Electric Resistance	$7,909	$1,294	$3,680	N/A
	Low Peak Demand	$16,040	$2,251	N/A	$21,877

Nonresidential

The commercial analysis is primarily based on data from RSMeans and an internal study completed by the research team for BayREN for the baseline equipment (RSMeans, 2025). For the zero-emission technology, the research team used RSMeans and the BayREN study results for heat pump and electric resistance equipment costs, TECH installation data for heat pump water heaters (assuming that they would generally be no larger than domestic water heaters for the nonresidential building types in this study), and RSMeans for additional efficiency measures in the low peak load scenario (TECH Clean California, 2025).

As in the residential study, the research team developed linear regression models based on heating capacity for heating equipment and hot water storage size for water heating equipment where sufficient estimates with varying equipment sizes were available; the TECH models are shown in Appendix D. The ResStock and ComStock databases include heating capacity and hot water storage parameters for each model, which we used to determine an estimate for the first costs for the building models analyzed in this study.

The summary of the first costs is shown in Table 13. The research team assumed the nonresidential buildings, which all had existing air conditioning, would not need panel upgrades.

Table 13. Median Nonresidential Equipment & Installation Cost per Square Foot

Existing Building Type	Scenario	HVAC	Hot Water	Additional Measures
Restaurant w/ A/C, Propane Heat	Baseline	$11.51	$0.38	N/A
	Heat Pump	$23.66	$1.13	N/A
	Electric Resistance	$17.60	$1.00	N/A
	Low Peak Demand	$25.27	$1.13	$3.40
Small Hotel w/ A/C, Propane Heat	Baseline	$14.15	$0.07	N/A
	Heat Pump	$12.76	$0.22	N/A
	Electric Resistance	$13.26	$0.24	N/A
	Low Peak Demand	$13.63	$0.22	$2.76
Small Office w/ A/C, Propane Heat	Baseline	$9.02	$0.27	N/A
	Heat Pump	$19.61	$0.84	N/A
	Electric Resistance	$13.98	$0.92	N/A
	Low Peak Demand	$20.94	$0.84	$3.24

Billing Impact Cost Estimates

The research team used ResStock and ComStock modeling results to determine the potential range of billing impacts of replacing propane heating and water heating with different zero-emissions equipment. We used hourly modeled electricity use coupled with TOU utility rates for electricity and annual propane or wood energy use coupled with the average cost of those fuels to evaluate the models, equipment and scenarios detailed in the previous section. The rates, which are current as of May 2025 and pulled directly from utility reporting or other fuel cost reporting, are summarized in Appendix D.

Residential

Primary Zero-emissions Scenario: Standard Heat Pump with Existing Fuel Backup

There is a range of billing impact results for each building type and region due to the array of ResStock models used by the research team. The research team used a ResStock retrofit package that included a replacement of the propane heating system with a mid-level efficiency heat pump and the existing propane heating system as backup heating. However, there was no ResStock package available that combined a heat pump retrofit and a heat pump water heater, so the research team used engineering calculations to model a heat pump water heater retrofit by multiplying propane water heating energy by the modeled propane water heater efficiency and dividing by the assumed heat pump water heater efficiency. The limitations to this approach are that heat pump water heaters and propane water heaters may not have the same load profiles, and that interactive impacts to heating and cooling loads are not captured. However, the research team deemed this to be the most effective approach for estimating the impacts of heat pump water heater retrofits.

Figure 46 shows the median total annual energy costs for all end uses, regulated and unregulated, for each region for single-family buildings with existing air conditioning by fuel type using the standard IOU rates.

Figure 46. Single-Family **With** A/C Median Total Annual Energy Cost by Fuel Type and Region

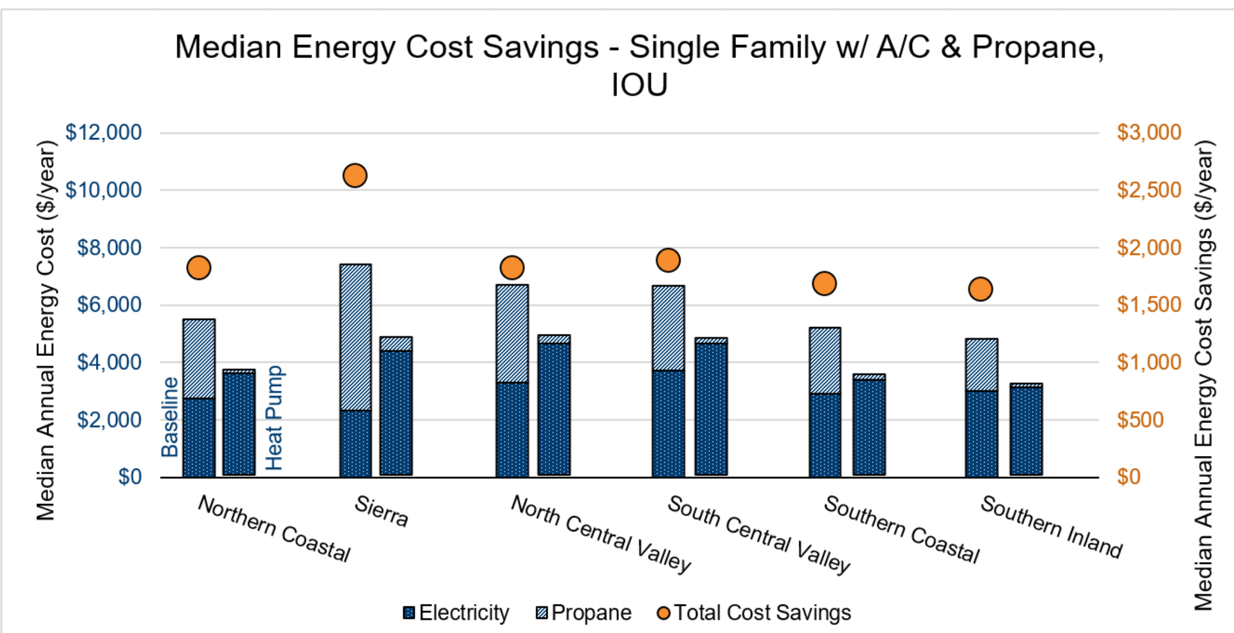
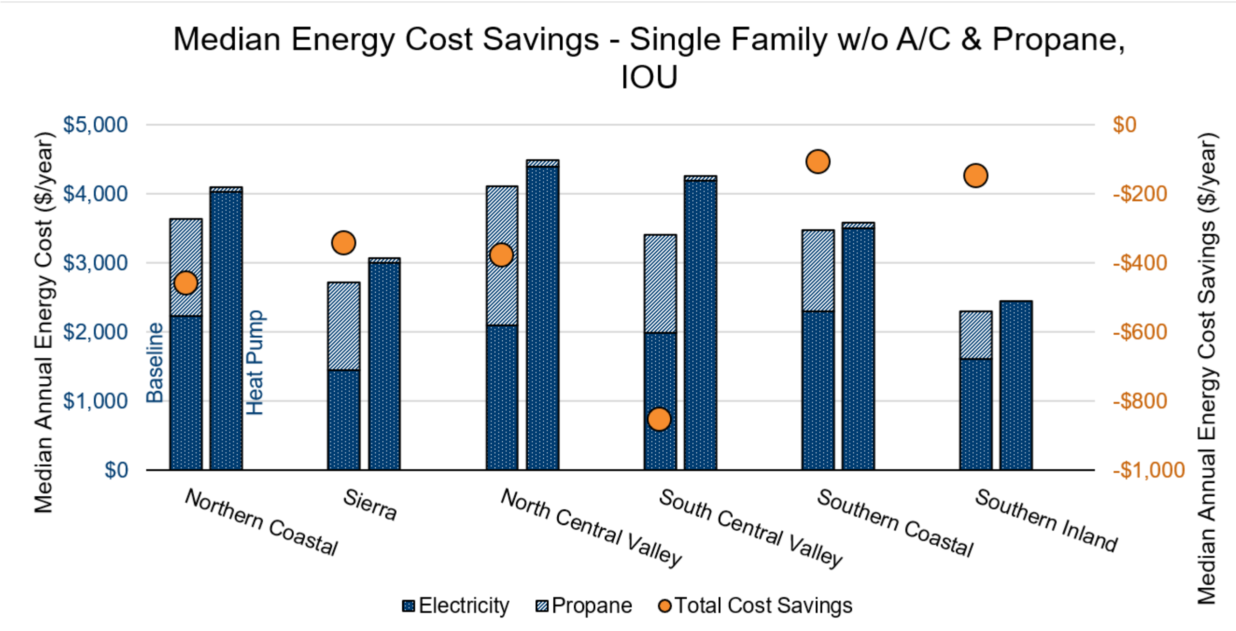


Figure 47 shows the same plot but for single-family homes without existing air conditioning. The median total energy cost savings are negative in every region; this is due to the addition of cooling energy for the heat pump that was not present in the baseline.

Figure 47. Single-Family **Without** A/C Median Energy Cost by Fuel Type and Region



The research team produced separate results for IOU rates and POU rates. Figure 48 shows a box and whisker plot for single-family models with existing air conditioning by region and utility type. The top of the boxes represents the 75th percentile of model annual energy costs, the bottom of the boxes represents the 25th percentile, and the line in the middle represents the median, or 50th percentile. The research team focused most of the cost analysis on homes with existing air conditioning, as those homes represent a more feasible value proposition for occupants. The boxplot shows that although there are a wide range of costs in each region and the magnitude of energy savings vary across regions, there is a clear trend of reduced energy costs for single-family models of all sizes, use patterns, utilities, and regions.

Figure 48. Boxplot of Annual Energy Costs for Single-Family w/ AC & Propane Heat

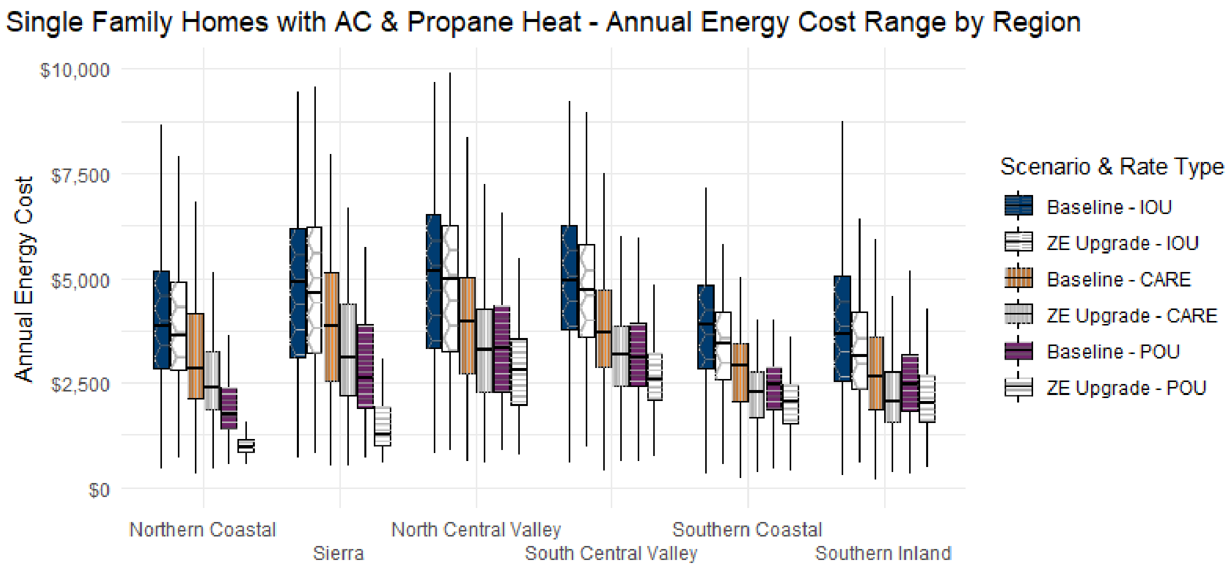


Table 14 shows additional details about the median energy cost impacts and overall cost effectiveness of the ZE space and water heater retrofit for single-family models with existing air conditioning. The table also includes a scenario in which panel upgrades are necessary. The simple payback represents the years of energy cost savings that would be required to offset the incremental first cost of the retrofit without considering a discount rate, inflation, or fuel price escalation rates. Energy cost savings from CARE and POU rates are similar, and both provide paybacks under 15 years without panel upgrades, whereas the standard IOU rate is closer to a 20-year payback. Additional results by region are shown in Appendix D.

Table 14. Single-Family Homes w/ AC & Propane Heat - Statewide Median Results Summary of Heat Pump Upgrade

Single-Family Homes w/ AC & Propane Heat				
Statewide	IOU	Baseline Energy Cost	$4,679	
		ZE Energy Cost	$4,010	
		Energy Cost Savings	**$669**	
	CARE	Baseline Energy Cost	$3,517	
		ZE Energy Cost	$2,661	
		Energy Cost Savings	**$857**	
	POU	Baseline Energy Cost	$2,947	
		ZE Energy Cost	$2,073	
		Energy Cost Savings	**$875**	
	Baseline Replacement Cost		$12,153	
	Panel Upgrade?		*No*	*Yes*
	ZE Replacement Cost		$24,901	$28,093
	Incremental Cost		$12,748	$15,940
	IOU Payback Period (years)		**19.1**	**23.8**

Single-Family Homes w/ AC & Propane Heat			
	CARE Payback Period (years)	**14.9**	**18.6**
	POU Payback Period (years)	**14.6**	**18.2**

Table 15 shows the median energy cost impacts and overall cost effectiveness of the ZE space and water heater retrofit for mobile home models with existing air conditioning. The energy savings are not as high as single-family homes, but equipment costs are similar, so the payback periods are longer. Additional results by region are shown in Appendix D.

Table 15. Mobile Homes w/ AC & Propane Heat - Statewide Median Results Summary of Heat Pump Upgrade

Mobile Homes w/ AC & Propane Heat				
Statewide	IOU	Baseline Energy Cost	$3,302	
		ZE Energy Cost	$2,868	
		Energy Cost Savings	**$435**	
	CARE	Baseline Energy Cost	$2,389	
		ZE Energy Cost	$1,912	
		Energy Cost Savings	**$477**	
	POU	Baseline Energy Cost	$2,175	
		ZE Energy Cost	$1,630	
		Energy Cost Savings	**$545**	
	Baseline Replacement Cost		$11,689	
	Panel Upgrade?		*No*	*Yes*
	ZE Replacement Cost		$21,463	$26,575
	Incremental Cost		$9,774	$14,886
	IOU Payback Period (years)		**22.5**	**34.3**
	CARE Payback Period (years)		**20.5**	**31.2**
	POU Payback Period (years)		**17.9**	**27.3**

The research team used ResStock single-family models with ductless propane heating to emulate heat transfer from a wood or pellet stove to model the impacts of wood heating customers adopting zero-emission technology. We multiplied the propane heating energy by the modeled propane furnace efficiency and divided by a weighted average of fireplace, wood stove, and pellet stove efficiencies based on the prevalence of each wood heating type in the survey to convert from propane heating energy to wood heating energy. As shown in the Wood Related Survey Results Appendix section, after normalizing results to 100%, our survey showed that the majority of wood-burners (66%) obtain their wood by buying it – primarily in cords, and 34% of respondents harvested wood from their property.[16] For the customers that gather wood from their property, wood fuel would be free for these customers. For simplicity, the research team opted not to include that segment of customers in the weighted cost results. Table 16

[16] After the survey was conducted, a stakeholder reported that the forest service offers wood for free. While the survey did not explicitly include a survey response option for receiving wood from the forest service, it did include an option for "Other", and no respondents selected it.

shows the details about the median energy cost impacts and overall cost effectiveness of the ZE space and water heater retrofit for single-family models with existing wood heating. Homes using standard IOU rates do not see energy cost savings, and only homes using POU rates see a median home with a payback less than 100 years. Additional results by region are shown in Appendix D.

Table 16. Single-Family Homes w/ Wood Heat - Statewide Median Results Summary of Heat Pump Upgrade

Single-Family Homes w/ Wood Heat				
Statewide	IOU	Baseline Energy Cost	$3,419	
		ZE Energy Cost	$3,883	
		Energy Cost Savings	**-$464**	
	CARE	Baseline Energy Cost	$2,563	
		ZE Energy Cost	$2,524	
		Energy Cost Savings	**$39**	
	POU	Baseline Energy Cost	$2,011	
		ZE Energy Cost	$1,627	
		Energy Cost Savings	**$383**	
	Baseline Replacement Cost		$10,501	
	Panel Upgrade?		*No*	*Yes*
	ZE Replacement Cost		$24,408	$26,712
	Incremental Cost		$13,907	$16,211
	IOU Payback Period (years)		**No Payback**	**No Payback**
	CARE Payback Period (years)		**No Payback**	**No Payback**
	POU Payback Period (years)		**36.3**	**42.3**

Alternative Zero-emissions Scenario: Electric Resistance Package

The ResStock database includes a collection of retrofit packages with different efficiency measures and heat pump types, but none of these include electric resistance electrification options for heating and water heating. To work around this, the research team used engineering calculations to convert the propane heating and water heating to electric energy based on the models' propane furnace and water heater efficiencies and assumed electric resistance furnace and storage water heater efficiencies. The research team assumed that the real hourly load use profiles of the two furnace and water heater fuel types are similar enough for the hourly and annual results to be a reasonable representation of the impact of electric resistance retrofits. The research team only focused on single-family homes with existing A/C for this package.

Table 17 shows details about the median energy cost impacts and overall cost effectiveness of the electric resistance space and water heating retrofit for single-family models with existing air conditioning. None of the energy rates analyzed produce a median building with positive energy savings, let alone a feasible payback period, even though the first costs are lower than the heat pump packages. Additional results by region are shown in Appendix D.

Table 17. Single-Family Homes w/ AC & Propane Heat - Statewide Median Results Summary of Electric Resistance Upgrade

Single-Family Homes w/ AC & Propane Heat			
Statewide	IOU	Baseline Energy Cost	$4,679
		ZE Energy Cost	$6,271
		Energy Cost Savings	**-$1,592**
	CARE	Baseline Energy Cost	$3,517
		ZE Energy Cost	$4,121
		Energy Cost Savings	**-$604**
	POU	Baseline Energy Cost	$2,947
		ZE Energy Cost	$3,041
		Energy Cost Savings	**-$94**
	Baseline Replacement Cost		$12,153
	ZE Replacement Cost		$19,458
	Incremental Cost		$7,305
	IOU Payback Period (years)		**No Payback**
	CARE Payback Period (years)		**No Payback**
	POU Payback Period (years)		**No Payback**

Alternative Zero-emissions Scenario: Low Peak Demand Package

The research team used an available ResStock retrofit package, electrification using cold climate heat pumps, which are variable speed heat pumps that are more efficient at cold temperatures than standard heat pumps to ideally minimize backup heating needs, with light envelope upgrades, to study the potential benefits of a more holistic and deeper zero-emission retrofit to avoid an increase in both energy bills and peak demand[17]. The research team also included a 4-kilowatt-direct current (kWdc) rooftop solar array in this scenario using the hourly profile generated by NREL's PVWatts tool for representative locations in each region. The research team only focused on single-family homes with existing A/C for this package.

Table 18 shows details about the median energy cost impacts and overall cost effectiveness of the low peak demand retrofit for single-family models with existing air conditioning. The energy cost savings are much larger than the standard heat pump package, and the payback periods are lower. However, this study used a single solar photovoltaic (PV) array size and did not

[17] Cold climate heat pumps are still often outfitted with an electric resistance backup strip heating and is out of the manufacturers' hands, instead in the hands of the installer. There is current research focusing on how much backup heating is actually needed in different climates and how to size cold climate heat pumps to avoid backup heat, but this was out of scope for this study. The study relies on the auto-sizing of heat pump and backup strip heating from the energy models from ResStock.

account for recent net metering rules impacting IOUs that may lessen the benefit of overgeneration for homes in which the PV was oversized for its needs. Therefore, the payback period may end up being longer with less benefit from the PV. Additional results by region are shown in Appendix D.

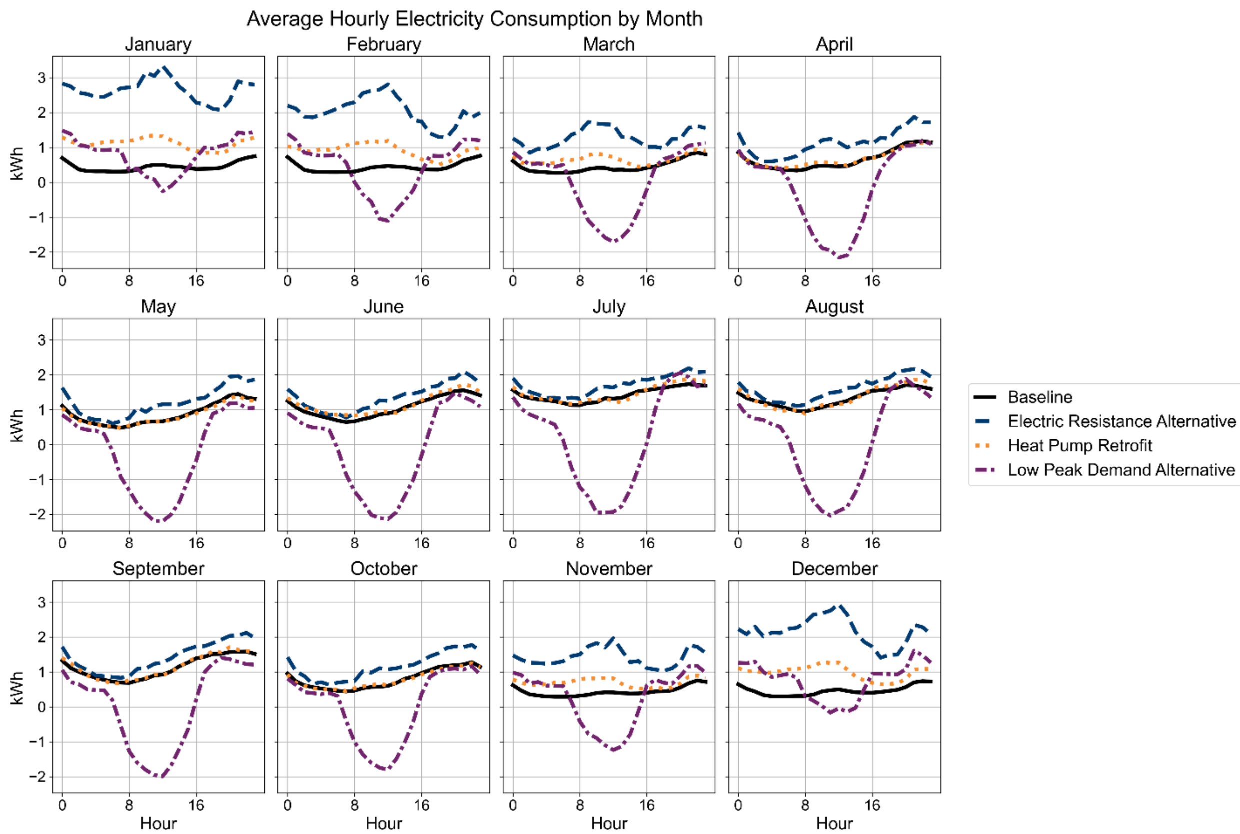
Table 18. Single-Family Homes w/ AC & Propane Heat - Statewide Median Results Summary of Low Peak Demand Upgrade

Single-Family Homes w/ AC & Propane Heat			
Statewide	IOU	Baseline Energy Cost	$4,679
		ZE Energy Cost	$1,443
		Energy Cost Savings	**$3,237**
	CARE	Baseline Energy Cost	$3,517
		ZE Energy Cost	$938
		Energy Cost Savings	**$2,580**
	POU	Baseline Energy Cost	$2,947
		ZE Energy Cost	$829
		Energy Cost Savings	**$2,118**
	Baseline Replacement Cost		$12,153
	ZE Replacement Cost		$41,079
	Incremental Cost		$28,926
	IOU Payback Period (years)		**9.0**
	CARE Payback Period (years)		**11.2**
	POU Payback Period (years)		**13.7**

Load Profiles

Figure 49 shows the average load profile by month before and after the heat pump package, which is the standard retrofit package including a standard heat pump and heat pump water heater, is applied to the ResStock single-family model with median energy cost savings, which is a home in the South Central Valley. The average summer daily peaks are still higher than the average winter daily peaks for the heat pump retrofit, but the electric resistance alternative winter peaks are significantly higher than the summer peaks, representing a shift in when the peak loads are occurring for this home. The low peak demand alternative package does not necessarily achieve its goal, as it has a similar peak load to the standard heat pump package, and is sometimes higher, likely due to the electric resistance backup kicking in on the coldest days of the year.

Figure 49. Average Hourly Electricity Load Profile of the Median Single-Family Home with A/C



Nonresidential

Primary Zero-emissions Scenario: Standard Heat Pump Package

The nonresidential bill impacts of the heat pump retrofit vary by building type. Additionally, the research team needed to make some adjustments to the modeling results offered by ComStock. Similar to the ResStock retrofit package options, a heat pump water heater retrofit was not available for the commercial models, so the research team used the same approach as in the residential analysis to model heat pump water heater energy use.

Many of the models for restaurants used propane for water heating but electric resistance for space heating. To look at the impact of electrifying both space and water heating in restaurants, the research team converted the baseline electric resistance heating energy to propane heating energy using engineering calculations, assuming the same load profile for both fuel types. The post-processed baseline results were compared to the heat pump retrofit results.

Finally, the ComStock database did not include a retrofit option for small hotels, so the research team used engineering calculations to convert the baseline propane heating energy use to heat pump heating energy use. There are limitations to this approach, as the load profiles of the two heating fuels are likely different, which impacts hourly billing estimates, but a more accurate approach was not available within the constraints of this analysis.

Table 19 shows additional details about the median energy cost impacts and overall cost effectiveness of the ZE space and water heater retrofit for small offices. The IOU rates show a quicker payback time than the POU rates for the median building, but both are under 20 years. Additional results by region are shown in Appendix D.

Table 19. Small Office w/ Propane Heat - Statewide Median Results Summary of Heat Pump Upgrade

Small Office w/ Propane Heat			
Statewide	IOU	Baseline Energy Cost/sf	$4.90
		ZE Energy Cost/sf	$3.80
		Energy Cost Savings/sf	**$1.10**
	POU	Baseline Energy Cost/sf	$2.13
		ZE Energy Cost/sf	$1.52
		Energy Cost Savings/sf	**$0.61**
	Baseline Replacement Cost/sf		$9.18
	ZE Replacement Cost/sf		$20.35
	Incremental Cost/sf		$11.17
	IOU Payback Period (years)		**10.1**
	POU Payback Period (years)		**18.3**

Table 20 shows additional details about the median energy cost impacts and overall cost effectiveness of the ZE space and water heater retrofit for small hotels. The payback results are not meaningful because the median incremental cost is negative, meaning the heat pump retrofit is less than the baseline retrofit, but there are modest energy cost savings. Additional results by region are shown in Appendix D.

Table 20. Small Hotel w/ Propane Heat - Statewide Median Results Summary of Heat Pump Upgrade

Small Hotel w/ Propane Heat			
Statewide	IOU	Baseline Energy Cost/sf	$2.54
		ZE Energy Cost/sf	$2.34
		Energy Cost Savings/sf	**$0.20**
	POU	Baseline Energy Cost/sf	$1.05
		ZE Energy Cost/sf	$0.89
		Energy Cost Savings/sf	**$0.17**
	Baseline Replacement Cost/sf		$14.26
	ZE Replacement Cost/sf		$12.98
	Incremental Cost/sf		-$1.28
	IOU Payback Period (years)		**Instant**
	POU Payback Period (years)		**Instant**

Table 21 shows additional details about the median energy cost impacts and overall cost effectiveness of the ZE space and water heater retrofit for restaurants. The IOU rates in this case produce negative energy savings for the median building, whereas the POU rates produce a favorable payback period under ten years. In part, this is likely due to the IOU and POU region being different for this restaurant model, the median of energy cost spending amongst all restaurants, than the small office median building, which showed a different trend between IOU and POU results, as well as differences in load shapes.

However, the restaurant models show much higher use of propane for water heating, especially in the afternoon and evening, which are peak periods in time-of-use rates, compared to the small office or hotel models. Converting this load to electricity greatly increases energy costs, especially for IOUs, which use particularly aggressive time-of-use rates. The propane use for heating in restaurants is more consistently spread throughout the day, meaning the impact of utility rate structure is less significant than for water heating. However, for small office models, heating is almost exclusively concentrated in the morning hours, and for small hotel models, heating is almost exclusively concentrated overnight and into the morning, so in both cases electrifying the propane heating load in those hours will benefit from the aggressive time-of-use rates used by IOUs. Additionally, restaurants have relatively less cooling load than small offices and hotels, and it is spread throughout the day more consistently, whereas small offices and hotels use cooling more exclusively in the afternoon and evening. Heat pumps typically provide an efficiency improvement over existing air conditioning systems, so while small offices and hotels see meaningful electricity reduction during peak periods, restaurants see fewer benefits from this cooling efficiency improvement spread over the whole day. This all contributes to why restaurants see energy cost savings from POU rates, but less so for IOU rates. Additional results by region are shown in Appendix D.

Table 21. Restaurant w/ Propane Heat - Statewide Median Results Summary of Heat Pump Upgrade

Restaurants w/ Propane Heat			
Statewide	IOU	Baseline Energy Cost/sf	$19.03
		ZE Energy Cost/sf	$19.82
		Energy Cost Savings/sf	**-$0.78**
	POU	Baseline Energy Cost/sf	$9.16
		ZE Energy Cost/sf	$7.46
		Energy Cost Savings/sf	**$1.70**
	Baseline Replacement Cost/sf		$11.89
	ZE Replacement Cost/sf		$24.77
	Incremental Cost/sf		$12.88
	IOU Payback Period (years)		**No Payback**
	POU Payback Period (years)		**7.6**

Alternative Zero-Emissions Scenarios

The findings from the electric resistance scenario and a low peak demand scenario for the nonresidential buildings tracked well with the residential findings. The electric resistance package was not cost effective by any metric for any building type other than the lower first cost, and the low peak demand scenario provided additional energy savings above the primary heat pump scenario and slightly better payback periods.

Greenhouse Gas Impacts

This section presents greenhouse gas (GHG) impacts for the baseline case, which includes buildings with propane or wood for heating and propane for water heating; and different zero-emissions packages. The GHG emissions reflect total GHG emissions from the building - both the emissions from the end uses that would change (heating and cooling, and water heating), as well as from all other end uses in the building. To evaluate GHG impacts, the research team used NREL’s Cambium tool to look at the hourly electricity GHG impact of the zero-emissions technology used in this study in 2025 as well as in 2040 to incorporate the changing emissions intensity of the California electric grid (NREL, 2024a). The research team used average load-based month-hour CO_2e emissions factors for the California Independent System Operator grid region from Cambium 2023 using the “mid-case” scenario. For propane, the research team used an EIA value (Energy Information Administration, 2024) for GHG emissions factor (6.29 kg CO_2 per therm of propane). For wood, the research team used a value derived by CARB (9.37 kg CO_2 per therm of wood combusted).

Residential

Table 22 shows the median annual combined onsite and upstream GHG emissions for each residential building type and retrofit scenario. All building types and scenarios improved GHG emissions over the baseline, although the low peak demand scenario had the greatest impacts in 2025, mostly due to the presence of rooftop solar. The impacts of the rooftop solar in the low peak demand scenario are less pronounced compared to the standard heat pump retrofit in 2040 due to the increasingly clean grid, negating some of the benefit of the onsite zero-emission generation.

Table 22. Median Residential GHG Emissions by Building Type and Scenario

Median Residential GHG Emissions (kg CO_2e/yr)								
	Baseline		Heat Pump Retrofit		Electric Resistance		Low Peak Demand	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG

Median Residential GHG Emissions (kg CO_2e/yr)								
Single-family w/ A/C, propane	4,115	3,165	2,152	884	3,394	1,243	1,417	524
Single-family w/o A/C, propane	3,549	2,934	1,960	715	2,737	982	1,352	506
Single-family w/o A/C, wood	5,060	4,386	1,962	696	2,907	1,034	1,413	518
Mobile home w/ A/C, propane	2,906	2,137	1,555	588	2,325	801	915	348
Mobile home w/o A/C, propane	2,452	1,993	1,516	554	2,075	717	1,083	406

Table 23 shows the median upstream (utility-delivered electricity) emissions for each building type and scenario. Table 24 shows the median onsite (propane and wood) emissions, which do not change over time, as propane and wood have a fixed emissions rate. The heat pump retrofit and electric resistance scenarios show an increase in upstream emissions from the baseline. However, the low peak demand scenario has instances of emissions savings, including 2025 GHG for single-family homes with A/C and propane and both 2025 and 2040 GHG for mobile homes with A/C and propane. Homes without A/C are adding cooling load, so it is unlikely for a home to see a reduction in upstream emissions without adding more solar photovoltaic capacity as well as an energy storage system. All of the retrofit scenarios show a significant reduction in onsite emissions, since the primary heating and water heating systems using propane are being replaced. The heat pump retrofit and electric resistance scenarios assume that the existing propane system is left for backup heating, which is the source of onsite emissions for those homes.

Table 23. Median Residential GHG Emissions - Upstream

Median Residential Upstream GHG Emissions (kg CO_2e/yr)								
	Baseline		Heat Pump Retrofit		Electric Resistance		Low Peak Demand	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG
Single-family w/ A/C, propane	1,445	495	1,954	686	3,312	1,162	1,417	524
Single-family w/o A/C, propane	921	306	1,902	656	2,737	982	1,352	506
Single-family w/o A/C, wood	1,008	334	1,940	674	2,885	1,012	1,413	518

Median Residential Upstream GHG Emissions (kg CO_2e/yr)								
Mobile home w/ A/C, propane	1,160	391	1,473	505	2,325	801	915	348
Mobile home w/o A/C, propane	690	231	1,486	524	2,075	717	1,083	406

Table 24. Median Residential GHG Emissions – Onsite

Median Residential Onsite GHG Emissions (kg CO_2e/yr)				
	Baseline	**Heat Pump Retrofit**	**Electric Resistance**	**Low Peak Demand**
Single-family w/ A/C, propane	2,671	199	82	0
Single-family w/o A/C, propane	2,628	58	0	0
Single-family w/o A/C, wood	4,052	22	22	0
Mobile home w/ A/C, propane	1,747	83	0	0
Mobile home w/o A/C, propane	1,762	30	0	0

The following table shows the percentage of savings relative to the baseline for moving to each of the ZE packages for onsite and upstream emissions combined. For example, to calculate savings for the 2025 heat pump retrofit for the first row, we subtracted GHG emissions (2,152) from the baseline emissions (4,115) and divided it by the baseline emissions (4,115) to calculate 48% reductions. As shown in Table 25, shifting to standard heat pumps and heat pump water heaters in the residential sector (for propane using homes) reduces GHG emissions by approximately half based on the 2025 grid (48%) and by almost three-quarters (74%) based on the forecasted electricity generation mix for the grid in 2040 - averaged across home types. The GHG emissions reductions are lower for electric resistance packages but higher for low peak demand heat pump packages (reductions of approximately 21% based on 2025 grid and 64% by 2040 for electric resistance, and 66% based on 2025 and 84% by 2040 for low peak demand heat pump packages).

Table 25. Median Residential GHG Reductions Compared to Baseline by Building Type and Scenario

Median Residential Upstream GHG Emissions Reductions (%)								
	Baseline		**Heat Pump Retrofit**		**Electric Resistance**		**Low Peak Demand**	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG

Median Residential Upstream GHG Emissions Reductions (%)								
Single-family w/ A/C, propane	--	--	48%	72%	18%	61%	66%	83%
Single-family w/o A/C, propane	--	--	45%	76%	23%	67%	62%	83%
Single-family w/o A/C, wood	--	--	61%	84%	43%	76%	72%	88%
Mobile home w/ A/C, propane	--	--	46%	73%	20%	63%	69%	84%
Mobile home w/o A/C, propane	--	--	38%	72%	15%	64%	56%	80%
Weighted average across all home types	--	--	**48%**	**74%**	**21%**	**64%**	**66%**	**84%**

Table 26 shows the percent reduction in upstream emissions compared to the baseline, and Table 27 shows the percent reduction in onsite emissions (a negative number represents an increase). On average, homes receiving the heat pump retrofit are projected to see a 55% increase in upstream emissions in 2025 and 60% increase in upstream emissions in 2040. The difference between 2025 and 2040 is likely due to the addition of electric heating load during hours on the grid that are hard to decarbonize, such as winter mornings and evenings. Electric resistance heating and water heating can double or triple upstream emissions from the baseline. Onsite emissions are virtually eliminated in most scenarios; even heat pump retrofits using propane as a backup see a 95% reduction in onsite emissions.

Table 26. Median Residential GHG Reductions Compared to Baseline - Upstream

Median Residential Upstream GHG Emissions Reductions (%)								
	Baseline		**Heat Pump Retrofit**		**Electric Resistance**		**Low Peak Demand**	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG
Single-family w/ A/C, propane	--	--	-35%	-39%	-129%	-135%	2%	-6%
Single-family w/o A/C, propane	--	--	-107%	-114%	-197%	-221%	-47%	-65%
Single-family w/o A/C, wood	--	--	-92%	-102%	-186%	-203%	-40%	-55%

Median Residential Upstream GHG Emissions Reductions (%)								
Mobile home w/ A/C, propane	--	--	-27%	-29%	-100%	-105%	21%	11%
Mobile home w/o A/C, propane	--	--	-115%	-127%	-201%	-211%	-57%	-76%
Weighted average across all home types	--	--	**-55%**	**-60%**	**-146%**	**-156%**	**-11%**	**-22%**

Table 27. Median Residential GHG Emissions Compared to Baseline – Onsite

Median Residential Onsite GHG Emissions Reductions (%)				
	Baseline	**Heat Pump Retrofit**	**Electric Resistance**	**Low Peak Demand**
Single-family w/ A/C, propane	--	93%	97%	100%
Single-family w/o A/C, propane	--	98%	100%	100%
Single-family w/o A/C, wood	--	99%	99%	100%
Mobile home w/ A/C, propane	--	95%	100%	100%
Mobile home w/o A/C, propane	--	98%	100%	100%
Weighted average across all home types	--	95%	98%	100%

The analysis finds that moving to zero-emission appliances increases upstream GHG emissions, virtually eliminates onsite GHG emissions and has a net impact of substantially reducing GHG emissions.

Nonresidential

Table 28 shows the median annual onsite and upstream GHG emissions per square foot for each nonresidential building type and retrofit scenario. Similar to the energy results, restaurant buildings are the most GHG-intensive. However, differing from the energy results, the electric resistance buildings are less GHG-intensive than the baseline for all building types and years, highlighting the GHG benefits of electricity compared to propane.

Table 28. Median Nonresidential GHG Emissions by Building Type and Scenario

Median Nonresidential Upstream GHG Impacts (kg CO_2e/ft^2-yr)								
	Baseline		Heat Pump Retrofit		Electric Resistance		Low Peak Demand	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG
Small Office	2.85	1.40	1.94	0.65	2.80	0.94	1.79	0.60
Small Hotel	1.55	0.75	1.21	0.41	1.45	0.49	1.18	0.39
Restaurant	12.31	6.73	9.76	3.28	10.91	3.66	9.08	3.05

Table 29 shows the upstream emissions by building type and scenario while Table 30 shows the onsite emissions for nonresidential buildings. The small office heat pump and low peak demand retrofits both result in lower upstream emissions than the baseline, while the restaurant shows an increase in upstream emissions for all scenarios. The lower upstream emissions are because efficient heat pump systems are replacing older HVAC systems with less efficient fans and air conditioners in relatively mild climates. All of the nonresidential retrofit scenarios result in all-electric buildings (the old propane equipment is assumed to be removed), so there are no onsite emissions for any retrofit scenarios.

Table 29. Median Nonresidential GHG Emissions - Upstream

Median Nonresidential Upstream GHG Impacts (kg CO_2e/ft^2-yr)								
	Baseline		Heat Pump Retrofit		Electric Resistance		Low Peak Demand	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG
Small Office	2.18	0.73	1.94	0.65	2.80	0.94	1.79	0.60
Small Hotel	1.19	0.40	1.21	0.41	1.45	0.49	1.18	0.39
Restaurant	8.38	2.80	9.76	3.28	10.91	3.66	9.08	3.05

Table 30. Median Nonresidential GHG Emissions – Onsite

Median Nonresidential Onsite GHG Impacts (kg CO_2e/ft^2-yr)				
	Baseline	Heat Pump Retrofit	Electric Resistance	Low Peak Demand
Small Office	0.66	0.00	0.00	0.00
Small Hotel	0.36	0.00	0.00	0.00
Restaurant	3.93	0.00	0.00	0.00

The following table shows the percentage of savings relative to the baseline for moving to each of the ZE packages in nonresidential buildings. As shown in Table 31, adopting standard heat pumps and heat pump water heaters results in GHG emissions reductions of approximately one-quarter (28%) based on the 2025 grid and half (51%) based on the 2040 grid. Similar to residential results, GHG emissions are lower for electric resistance appliances and higher for low peak demand heat pump packages.

Table 31. Median Nonresidential GHG Reductions Compared to Baseline by Building Type and Scenario

Median Nonresidential Upstream GHG Emissions Reduction (%)								
	Baseline		**Heat Pump Retrofit**		**Electric Resistance**		**Low Peak Demand**	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG
Small Office	--	--	32%	53%	2%	33%	37%	57%
Small Hotel	--	--	22%	46%	6%	35%	24%	48%
Restaurant	--	--	21%	51%	11%	46%	26%	55%
Weighted average across all bldg types	**--**	**--**	**28%**	**51%**	**4%**	**35%**	**32%**	**55%**

Table 32 shows the percent reduction in upstream emissions compared to the baseline (negative numbers represent an increase), and Table 33 shows the percent reduction in onsite emissions. The small hotel has virtually the same upstream emissions when going from the baseline to the heat pump or low peak demand retrofit, since efficient heat pump systems are replacing older HVAC systems with less efficient fans and air conditioners in relatively mild climates. Small offices are actually projected to have decreased upstream emissions due to the relatively low reliance on heating based on hours of occupation. Small offices make up the most common nonresidential building type using propane in California, so the weighted average upstream emissions change shows a slight reduction compared to the baseline.

Table 32. Median Nonresidential GHG Reductions Compared to Baseline - Upstream

Median Nonresidential Upstream GHG Emissions Reduction (%)								
	Baseline		**Heat Pump Retrofit**		**Electric Resistance**		**Low Peak Demand**	
	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG	2025 GHG	2040 GHG
Small Office	--	--	11%	11%	-28%	-28%	18%	18%
Small Hotel	--	--	-2%	-3%	-22%	-24%	1%	2%
Restaurant	--	--	-16%	-17%	-30%	-31%	-8%	-9%
Weighted average across all bldg types	**--**	**--**	**4%**	**3%**	**-27%**	**-28%**	**10%**	**10%**

Table 33. Median Nonresidential GHG Reductions Compared to Baseline – Onsite

Median Nonresidential Onsite GHG Emissions Reduction (%)				
	Baseline	**Heat Pump Retrofit**	**Electric Resistance**	**Low Peak Demand**
Small Office	--	100%	100%	100%
Small Hotel	--	100%	100%	100%
Restaurant	--	100%	100%	100%
Weighted average across all bldg types	**--**	**100%**	**100%**	**100%**

The analysis shows that upstream GHG emissions impacts vary by zero-emission scenario: in some cases, they increase, in some cases they decrease, in some cases the onsite GHG emissions decrease, and across all nonresidential scenarios the total GHG emissions decrease substantially when moving to zero-emission appliances.

Discussion

This section presents the research team's findings from the customer surveys, meetings with stakeholders, and customer cost and GHG analysis.

Survey and Stakeholder Panel Findings

Results of surveys and stakeholder meetings underscore the extent to which many communities rely on propane and wood, which are seen as more affordable than electric equipment. On the other hand, there does seem to be interest in heat pumps among most respondents, although cost is a substantial barrier. Low-income residential respondents were less likely to be aware of heat pumps and indicated they were most likely to use portable, plug-in electric space heaters if their current heating system were broken. Both residential and nonresidential respondents indicated that they value backup or dual-fuel equipment (e.g., heat pump system that could run on either electricity or propane). Key takeaways from the survey and stakeholder meetings are summarized below.

Propane was the existing equipment when respondents moved in, and both propane and wood are seen as more affordable than running electric equipment. The majority of residential (71%) and nonresidential (57%) respondents said they use propane for space- or water-heating because it was already there when they moved in. The second most common reason, with more than one-third of residential (35%) and nonresidential (39%) respondents, said that propane is more affordable than electricity. The main reason residential respondents reported they use wood to heat their home is because wood is more affordable (76%).

Overall, awareness of heat pumps was relatively high, while awareness of heat pump water heaters was substantially lower. The majority of residential respondents (73%) and nonresidential respondents (70%) said they were aware of heat pumps but were less aware of heat pump water heaters at 44% and 53% for residential and nonresidential respondents, respectively. Lower awareness of heat pump water heaters appears to be driven by lower awareness in the Northern Coastal & Sierra (36%) and Central Valley (33%) regions compared to the Southern Inland (65%) and Southern Coastal (60%) regions.

While overall awareness of heat pumps among residential respondents was relatively high, awareness of heat pumps was notably lower for disadvantaged groups. For low-income respondents, Native American respondents, those living in mobile/manufactured homes, and those who primarily speak Spanish at home, awareness of heat pumps was between 30% and 40%, compared to 73% for residential respondents overall. There was a similar pattern for heat pumps water heaters, with lower awareness among all of these groups, although the differences were not as stark. Stakeholders agreed that awareness of heat pumps among people in their communities is low and the need for workforce development, customer education, and outreach is high.

If propane equipment were no longer available for sale, respondents generally preferred heat pumps as an alternative, although low-income respondents preferred plug-in space heaters and those in the Southern Inland region preferred burning wood. When asked to imagine that their current heating system is broken beyond repair, and propane equipment is no longer available for purchase, 73% of residential respondents and 57% of nonresidential respondents indicated they would be likely to choose a new heat pump to heat their home or space. However, low-income residential respondents indicated they were most likely to use plug-in electric space heaters in this scenario (59%), with only 24% indicating they would install a new heat pump. Breaking out residential results by region showed that results were generally very similar to the overall population; however, residents in the Southern Inland region were most likely to use a wood stove or fireplace (42%), followed by using plug-in electric space heaters (34%).

The majority of respondents were not willing to pay $6,000 (or more) extra for heat pump equipment, suggesting that large incentives would be necessary to help cover incremental costs compared to propane equipment, especially for low-income residents. Assuming that the cost to install a new propane heating system is about $7,000, 30% of residential respondents said they would be willing to pay an extra $6,000 to install a heat pump instead and only 2% were willing to pay an extra $12,000. (The “extra” costs would be in addition to the $7,000 for the propane furnace). Results were similar for nonresidential respondents. Assuming that the cost to install a new propane water heater is about $4,000, almost 20% of residential respondents said they would be willing to pay an extra $3,000 to install a heat pump water heater instead, but only 2% said they were willing to pay an extra $4,500 or $6,000. Although sample sizes were too small to report, low-income respondents were less willing to pay these extra costs. Many stakeholders said the upfront costs for heat pumps are too expensive for people in their communities, and low-to-no interest financing or point-of-sale discounts would be needed to purchase them.

Even if all purchase and installation costs were taken care of, not all respondents were favorable toward ZE equipment, but both residential and nonresidential respondents indicated that they value backup or dual-fuel equipment. Almost 70% of residential and 62% of nonresidential respondents said they would be willing to install an electric appliance if purchase and installation costs were taken care of. This means that almost a third of residential and about 40% of nonresidential respondents felt either neutral or negative toward installing an electric appliance, even if purchase and installation costs were taken care of. However, almost 70% of nonresidential respondents said they would be willing to install an electric appliance if it were a dual-fuel heat pump system that could run on either electricity or propane. Around 20 to 40% of residential respondents also said they would be willing to install an electric appliance if there were some kind of backup equipment or fuel (e.g., propane, solar with battery storage). Only 15% of homeowners and 30% of residential renters would be willing to install an electric appliance without any backup equipment. Stakeholders also expressed the need to keep propane or wood as a backup, especially in rural or mountainous communities where grid reliability issues are more prevalent.

In addition to lower utility bills, non-energy benefits associated with heat pump equipment resonated with residential and nonresidential respondents. Both residential and nonresidential survey respondents said the top two potential benefits of heat pumps that appeal to them most are that they may lower utility bills compared to electric resistance heating and provide both heating and cooling. Residential respondents said the top two potential benefits for heat pump water heaters are that they improve the safety of their household and reduce concerns about running out of fuel. Fifteen percent of residential respondents and 11% of nonresidential respondents said none of the benefits were appealing to them.

Cost of electricity was a primary concern for adopting electric equipment for both residential and nonresidential respondents; concerns about power outages and reliability were also a concern for some homeowners. When asked in an open-ended question about concerns about adopting ZE equipment, homeowners (37%), residential renters (40%), nonresidential building owners (29%), and nonresidential tenants (16%) all said their top concern was the cost of electricity. The threat of power outages, reliability of electricity, and not having heat was the next main concern for homeowners (20%), while general concerns around cost was the next main concern for nonresidential building owners (23%). Roughly 20 to 30% of homeowners and nonresidential building owners, and about one-half of residential renters and nonresidential tenants said they did not have any concerns with installing an electric appliance.

Customer Cost and GHG Impact Findings

In most modeled buildings representing homes and businesses using propane across California, the research found that deploying zero-emissions technology, specifically heat pumps, will provide both annual energy cost savings and a payback period within a few decades. The length of the payback period is often quicker when a building using propane has the following characteristics:

- Large floor area
- High space conditioning loads and capacity
- Existing air conditioning
- Extreme climate – i.e., more heating and cooling degree days
- Public owned utility access or CARE rates

The following specific building types and characteristics do not provide annual energy cost savings based on our modeling:

- Homes using wood for heating
- Restaurants using propane for heating, except with certain POU rate types

A typical single-family home with existing air conditioning in California on a standard IOU rate can expect to see around a $670 reduction in annual energy costs, or 13% reduction overall, although some homes may see up to $1,045 energy cost savings, a 24% reduction, or as low as a $30 cost increase, a 3% increase. Upfront costs are likely to range from around $23,000 to $30,000 depending on the size of the system and possible panel upgrades; this cost is about 100% higher than replacement of the existing propane equipment.

The Rocky Mountain Institute (RMI) produced a report on the cost impacts of upgrading single-family homes to heat pumps in California and found an average cost savings of $620, with a range between around $100 to $1,200 of annual energy cost savings (RMI, 2025). The range and average both align with the findings in this study.

The research team also compared the impacts of using a standard heat pump with the existing system as backup heat to a more efficient cold-climate heat pump with electric resistance backup and a standard electric resistance furnace. The standard heat pump with propane backup had a slightly lower average and overall peak load than the cold-climate heat pump in a typical single-family home, but the overall energy cost savings were greater for the cold-climate heat pump. The electric resistance furnace had a peak load several times the magnitude of either system.

Nonresidential building types had more variation in energy cost outcomes due to the greater variance in occupancy, interior loads, size, and utility rates compared to the residential analysis. However, the median small office with a standard IOU rate had positive energy cost savings – around $1.10 per square foot, or a 23% reduction – and in general ranged between $0.24 per square foot, or an 8% reduction, and $1.62 per square foot, or a 24% reduction. Small hotel energy cost savings ranged between a 4% and 9% reduction, and restaurant energy cost savings ranged between a 4% increase and a 7% reduction. Small offices have the largest energy cost savings potential, likely due to the presence of internal equipment heat loads and occupancy schedules more favorable for time-of-use rates.

Overall, the GHG impact of propane customers adopting any zero-emission technology, even electric resistance heating, is substantial. In 2025, the onsite and upstream GHG impact of adopting a standard heat pump with propane backup for the median single-family home in California with air conditioning is a 48% reduction in CO_2e, and that value increases to a 72% reduction in 2040 due to projected changes to the electric grid in California. The nonresidential buildings have similar trends. Onsite GHG emissions are eliminated in the retrofit scenarios other than the residential scenarios using propane for backup heating, and even in those cases an average of 95% of onsite emissions are eliminated. Upstream GHG emissions increase marginally for the residential heat pump retrofits but can double or triple for the electric resistance scenario. On average, nonresidential upstream emissions stay relatively similar for the heat pump retrofits. For the heat pump retrofit scenario, small offices show a decrease in upstream emissions, small hotels show very similar upstream emissions compared to the baseline, and restaurants show a marginal increase in upstream emissions.

Based on our analysis, there are clear lifecycle cost and climate benefits for most building types that use propane heating to adopt heat pumps despite the higher first cost of the technologies.

How Our Results Relate to Other Studies

Customers using propane for heating in the SJV study spent nearly three times as much on propane than customers with natural gas heating spent on natural gas annually, $1,177 vs. $403 (Opinion Dynamics, 2021). Homes with electric heating were not specifically targeted in this study. All respondents that use propane and do not have natural gas access were asked why they use propane: 75% of propane customers say they use propane because natural gas is not available[18]; other common responses include convenience or availability, while 12% say propane is more affordable (Opinion Dynamics, 2021). All respondents that used wood for heating and do not have natural gas access were asked why they use wood: 51% of wood customers said they used wood because natural gas was not available; 55% said wood was more affordable than natural gas (Opinion Dynamics, 2021). Propane users from the CPUC assessment report said they used propane because they could not get natural gas service or had trouble accessing program-funded electric heating equipment (Sadhasivan, 2019).

Overall Findings

The findings above highlight the importance of this study, because of the high number of propane and wood burning users in California, and many are low-income or other disadvantaged groups. The study noted above indicates that most people used propane or wood because they lack natural gas, it was in their home when they moved in, or (in the case of wood only) it was more affordable. As shown in the Survey Results section, these responses are similar to the survey results of our study for both residential and nonresidential customers when asked why they use propane or (for residential) wood.

[18] As described in the Sampling Methodology section, to identify customers for the survey, this study identified a sample of communities where at least 25% of households use propane for heating. While we anticipated that the primary reason would be what most respondents reported – that natural gas is not available – it is possible that some customers choose propane for other reason.

Summary and Conclusions

The sections below provide a summary of the findings from the analysis the research team conducted on the residential and nonresidential customer survey results and on customer costs and GHG impacts. Given these findings, we have provided recommendations on potential strategies to address customer concerns with adopting zero-emission space and water heaters.

Summary of Customer Survey Results

Survey results found that customers typically use propane appliances because that was the existing equipment when respondents moved in, and both propane and wood are seen as more affordable than running electric equipment. Looking across all survey respondents, most residential and nonresidential respondents had heard of heat pumps, although disadvantaged groups (low-income, Native American, those who primarily speak Spanish at home, and those living in mobile or manufactured homes) had lower awareness of heat pumps. Also, all respondents had lower awareness of heat pump water heaters than heat pumps for space heating and cooling.

If propane equipment were no longer available, survey respondents generally preferred heat pumps (described in the survey as having a higher first-cost but lower operating cost compared to a propane furnace) as an alternate to their current heating system, and few preferred electric resistance appliances (described in the survey as having a similar first-cost but higher operating cost, compared to a propane furnace). However, low-income respondents preferred portable, plug-in, electric space heaters and those in the Southern Inland region preferred burning wood. Most respondents were not willing to pay $6,000 extra for heat pump equipment, suggesting that large incentives would be necessary to help cover current incremental costs compared to propane equipment, especially for low-income residents. While most respondents were favorable towards ZE equipment if purchase and installation costs were taken care of, some were not, citing concerns such as power outages. Both residential and nonresidential respondents indicated that they value backup or dual-fuel equipment. In addition to lower utility bills, non-energy benefits associated with heat pump equipment resonated with residential and nonresidential respondents, including the addition of air conditioning, improving safety, and reducing greenhouse gas emissions. Residential and nonresidential survey respondents had concerns regarding electricity costs for adopting electric equipment, as well as concerns regarding power outages and reliability.

Summary of Customer Cost and GHG Impacts

Based on RASS 2019, 2.6% of California households use propane and 1.2% use wood as their primary fuel for heating their home, or around 475,000 homes. Overall, the research team found that when existing California propane heating and water heating equipment customers adopt zero-emissions technology, specifically heat pumps, there are energy bill savings and substantial GHG reduction in almost all scenarios[19]. The buildings with the greatest benefit are single-family homes in climates with high space conditioning loads and the most extreme weather, such as the Sierra and Southern Inland regions. However, homes across all regions and characteristics are likely to see energy cost savings and a simple payback period within a few decades. Homes using wood for heat do not see the same levels of energy cost savings, but heat pumps can provide additional benefits in the form of increased comfort and improved indoor air quality. Our cost analysis showed a residential incremental cost range between $9,500 and $12,500 for heat pumps and $1,000 to $3,500 for heat pump water heaters (compared to replacement with propane appliances). Electric resistance equipment is not cost effective over the equipment lifetime and would greatly increase electric grid strain, but it still provides GHG benefits.

Customers of nonresidential buildings using propane also see benefits from adopting heat pumps. The most common nonresidential building types that use propane in California are small offices, small hotels, and restaurants, and they all see energy cost savings in some zero-emissions and utility rate scenarios, although restaurants using IOU rates (detail on the rates we used can be found in the Results of Customer Cost Impacts and Greenhouse Gas Modeling section) may not see the same magnitude of impact as the other two building types primarily due to the relatively large water heating load that is electrified at peak hours of the day (afternoon and evenings year-round). Utility rates, equipment types, and load shapes have a much larger role in determining individual building cost effectiveness for nonresidential buildings compared to residential buildings, so building owners and occupants in these buildings should perform more careful analyses before adopting ZE technology.

In all cases and building types, there are substantial onsite GHG benefits from adopting ZE technology. Upstream emissions tend to increase from the added heating loads, the magnitude of which depends on the building type and retrofit scenario. Onsite GHG emissions are eliminated except for a small amount for backup heating in residential buildings in the heat pump and electric resistance scenarios. Upstream GHG emission increases are minimal when shifting to heat pumps but can double or triple in magnitude when switching to electric resistance equipment, given the efficiency differences. Taken as a whole (combining upstream and onsite GHG emissions), GHG emissions substantially decrease in all zero-emissions scenarios for all building types, with greater savings for heat pumps than for electric resistance equipment.

Shifting to standard heat pumps and heat pump water heaters in the residential sector (for propane using homes) reduces total GHG emissions by approximately half based on the 2025 grid (48%) and by almost three-quarters (74%) based on the forecasted electricity generation mix for the grid in 2040 - averaged across home types. Upstream emissions for the heat pump and heat pump water heater retrofits are projected to increase by an average of 55% in 2025 and 60% in 2040 compared to the existing homes, but onsite emissions decrease by an

[19] Based on current costs for heat pumps and current electricity prices. It was beyond the scope of this project to forecast changes in heat pumps or estimate cost effectiveness under different projections for future electricity prices.

average of 95%, with the only remaining onsite emissions coming from backup propane heating use. The total GHG emissions reductions are lower for electric resistance packages but higher for low peak demand heat pump packages (reductions of approximately 21% based on 2025 grid and 64% by 2040 for electric resistance, and 66% based on 2025 and 84% by 2040 for low peak demand heat pump packages).

For nonresidential buildings, adopting standard heat pumps and heat pump water heaters reduces total GHG emissions by over one-quarter (28%) based on the 2025 grid and half (51%) based on the 2040 grid. Upstream emissions are projected to decrease by an average of 4% in 2025 and 3% in 2040 compared to the existing buildings, and onsite emissions would be eliminated in this scenario, as the project team did not assume that nonresidential buildings would keep the existing propane system in place for backup. Similar to residential buildings, upstream GHG emission reductions are lower for electric resistance appliances and higher for low peak demand heat pump packages in nonresidential buildings.

The research team developed the following recommendations for potential strategies to help encourage residential and nonresidential customers to adopt zero-emission space and water heaters based on findings from the customer surveys, meetings with stakeholders and customer cost and GHG analysis. CARB could consider using cap-and-trade funds for helping to fund some of these activities.

Cost Findings and Recommended Financial Support

This section presents cost findings and recommendations related to financial support. Recall that we provide incremental cost estimates for different system types in the Results section, Incremental Cost Estimates. As a summary of findings, our cost analysis showed a residential incremental cost range between $9,500 and $12,500 for heat pumps and $1,000 to $3,500 for HPWHs (compared to replacement with propane appliances). For nonresidential, our cost analysis showed a larger range that depended on the building type and size, but in general incremental costs for typical buildings were as low as a $1.39 per square foot (sf) cost savings and as high as a $12.15 per sf cost increase for heat pump systems, and between a $0.15 and $0.75 per sf cost increase for heat pump water heaters.

Finding 1. Many propane and wood burning users are low-income but expressed interest in adopting ZE emissions appliances if purchase costs were taken care of.

- About 70% of all residential and 62% of all nonresidential survey respondents, as well as the majority of residential low-income and Native American survey respondents, would be willing to replace their current heating system with an electric appliance if purchase and installation costs were covered.

Strategy 1. The research team recommends **purchase and installation costs** for electric appliances **should be covered for very low-income homeowners** (e.g., through a direct install program) when they need to replace their current heating system. To focus resources on those most in need, we recommend this strategy only be provided to very low-income homeowners (such as the lowest decile of household income based on CARE criteria). We recommend targeting homeowners for this strategy rather than renters since owners bear the upfront equipment cost.

Finding 2. Most customers (both residential and nonresidential) were interested in ZE appliances – particularly heat pumps, and some were willing to pay part of the incremental cost. However, a gap exists between the incremental cost that customers are willing to pay and the incremental cost of efficient ZE appliances (heat pumps and heat pump water heaters). Most propane customers would recoup investments through reduced energy bills from adopting ZE appliances.

- About 30% of all residential and nonresidential survey respondents said they would pay an extra $6,000 for a heat pump. Twelve percent of residential respondents said they would be willing to pay an extra $9,000 and 11% of nonresidential respondents said they would be willing to pay an extra $12,000 for a heat pump.
- Our cost analysis showed a residential incremental cost range between $9,500 and $12,500 for heat pumps and $1,000 to $3,500 for HPWHs (compared to replacement with propane appliances). Overall simple payback periods for these residential heat pump retrofits ranged depending on the home type and existing systems, from around nine years at minimum to over 100 years at maximum (so practically speaking – no payback), with a median of 19 years.
- Costs for nonresidential businesses varied much more due to different building types, sizes, and use patterns, but the incremental costs for typical buildings were as low as a $1.39 per square foot (sf) cost savings and as high as a $12.15 per sf cost increase for heat pump systems, and between a $0.15 and $0.75 per sf cost increase for heat pump water heaters. Overall simple payback periods for the nonresidential retrofits also ranged widely, from less than a year to no payback at all, but the median payback for a small office building was ten years.
- In general, a desirable payback period would be less than 20 years, which is approximately the lifetime of a typical residential- or small commercial-scale heat pump system, per a CPUC study on heat pump and furnace effective useful lives (DNV, 2024). A payback period longer than that would suggest that the retrofit may not be cost effective from a lifecycle perspective.
- The research team's energy cost analysis (for all building end uses) did find savings (bill reductions) for most residential and nonresidential propane customers for adopting ZE appliances.

- The energy cost analysis estimated that for single-family homes[20] that currently have propane equipment adopt ZE equipment, statewide annual energy cost savings would be approximately $416 with a 19-year simple payback under current IOU rates, $573 with a 15-year simple payback under current IOU with CARE rates, and $584 with a 15-year simple payback under current POU rates. See the Methodology to Analyze Customer Costs and GHG Impacts section for the assumptions for these calculations, including electricity rates assumed.
- We estimated the statewide annual energy cost savings for small offices that currently have propane equipment if they adopt ZE technology would be approximately $1.10/sq ft if their electricity provider is an IOU with a payback period of 10 years and approximately $0.67/sq ft if their electricity provider is a POU with a payback period of 18 years. This is due to both the higher flat customer charges in the POU rates, which devalue energy savings compared to higher energy charges, as well as the IOU's relatively extreme TOU rates; electric load is being added during times of low energy rates (morning heating) and being saved via more efficient cooling during times of high energy rates (afternoon cooling).
- We estimated the statewide annual energy cost savings for small hotels that currently have propane equipment if they adopt ZE technology would be approximately $0.20/sq ft if their electricity provider is an IOU or $0.17/sq ft if the provider is a POU, but the payback would be instantaneous due to a negative incremental cost (cost savings) for the heat pump equipment. We assumed the existing equipment would be a mix of central packaged rooftop A/C & propane furnaces and unitary packaged terminal air conditioners with propane heat based on the survey results, and we assumed the replacement equipment would be a mix of package terminal heat pumps and more centralized rooftop units[21]. Based on our cost sources, we found the average heat pump system (packaged terminal heat pumps) to be slightly cheaper than the existing propane replacement systems for typical small hotels.

[20] The research team calculated impacts for single-family and mobile homes, since census data showed they more frequently use propane and wood for heating and water heating than multifamily units. Full results for single-family homes and results for mobile homes are in the section Billing Impact Cost Estimates.

[21] We assumed that all hotels have A/C, since the 2022 Commercial End Use Survey in California (California Energy Commission, 2022) found that 98% of existing commercial lodging has A/C.

Strategy 2. The research team recommends time of sale rebates[22] **and on-bill financing for heat pumps and heat pump water heaters be offered based on income**. Tiers of support for customers could include the following:

- For low-income customers that are not very low-income (US Department of Housing and Urban Development, 2025) (qualifying for the direct install program recommended in Strategy 1), provide time-of sale rebates. This could be rebates at point-of-sale, where a third-party platform verifies income status, similar to how California implements Inflation Reduction Act (IRA) funds for low-income residents. Similarly, provide time-of-sale[23] rebates to nonresidential customers with high incremental costs, such as restaurants (food service facilities), an office swapping out unitary in-room propane heaters with a single multi-split heat pump system or central ducted system, or a hotel with instantaneous propane water heaters adopting a central heat pump water heater. Public agencies, like the California Public Utilities Commission (CPUC), could consider a midstream program, similar to TECH, where incentives were provided to contractors with the intention of passing on savings to customers. However, TECH data indicates higher costs for heat pumps than other programs that offer point-of-sale rebates[24].
- For low- and middle-income customers, and for nonresidential customers, offer financing to reduce the incremental cost, possibly through on-bill financing programs. Low-income customers could potentially leverage both the time-of-sale rebates and the financing. Income level limits could follow U.S. Housing and Urban Development (HUD) guidelines: (US Department of Housing and Urban Development, 2025).
- Consider allowing customers most in need (e.g., low-income customers, and small businesses) to combine both rebates and financing. Single-family homes in Northern California may also face a greater need since TECH reservations are currently unavailable in that region (TECH Clean California, 2025).

Finding 3. Customers expressed concern about adopting ZE appliances due to power outages, and some were more comfortable adopting ZE appliances if they had solar panels and battery storage for back-up.

- About 50% of all residential and nonresidential respondents said they would be willing to replace their current heating system with an electric appliance if they had solar panels

[22] Note that tax credits could also be considered. However, the feedback we received during our stakeholder panel meetings was that customers would rather receive funding up front to immediately offset the higher costs of new equipment rather than wait to receive a tax credit. In addition, in the nonresidential sector, some organizations (like nonprofits) potentially may not qualify for the tax credit.

[23] Time-of-sale means when the customer purchases the equipment.

[24] San Francisco Chronicle March 211, 2023: "What's the total cost to swap out gas heat for electric? One Bay Area homeowner says almost $20,000". https://www.sfchronicle.com/bayarea/article/bay-area-gas-appliance-ban-full-cost-17843287.php

and battery storage for backup energy. Almost 60% of residential low-income respondents and almost 40% of residential Native American respondents also said this.

- Several survey respondents and stakeholders during the panel meetings mentioned grid reliability and power outages being a concern with adopting an electric appliance.
- California is funding microgrids through the Microgrid Incentive Program, which provides funding for community, local and tribal government-driven, reliability and resilience projects. For example, California is supporting microgrid development for parts of circuit 1101 serving three tribal areas (CPUC, 2025a).

Strategy 3.1. The research team recommends providing **tiered incentives for solar panels plus battery storage for backup energy, particularly in areas frequently impacted by power outages**. This could include the following:

- Provide time-of-sale rebates or on-bill financing for solar panels plus battery storage, prioritizing low-income customers and areas that are most frequently impacted by extended grid outages.
- Leverage or expanding existing program offerings such as Self Generation Incentive Program (SGIP) for battery storage and Disadvantaged Communities Single-family Solar Homes (DAC-SASH) for solar panels.

Strategy 3.2. The research team recommends **collaboration amongst California utilities and state agencies** to align zero-emission requirements with other priorities and concerns known throughout the state. Possible options include the following:

- Continue supporting the development of microgrids in remote areas, including some tribal regions, where it is harder to increase grid capacity.

Finding 4. Energy efficiency can enhance cost savings when adopting ZE appliances.

An ACEEE study (ACEEE, 2024) showed how energy efficiency can reduce both the cost of installations by allowing for smaller capacity heat pumps and operational savings by reducing the use of electric resistance heating.

Strategy 4. The research team recommends the **CPUC and CEC partner with utilities** and work together to **increase customer bill savings** by **promoting deeper rebates for classic efficiency and weatherization measures when paired with installing zero-emission appliances**.

- Efficiency measures like air sealing and attic insulation can reduce heating and cooling loads. These measures both reduce the size of the heating and cooling equipment that needs to be installed and reduce electricity bills through less use of back-up heat (such as the electric resistance mode of heat pump equipment). Similarly, hot water pipe insulation can reduce energy needed from heat pump water heaters.

Awareness of Heat Pumps and Recommended Outreach and Education

Finding 5. A majority of the total population of respondents (both residential and nonresidential) reported they had heard of heat pumps, but only a minority of low-income, Native American, and Spanish-speaking customers had heard of them. Customers are concerned about adopting ZE appliances due to cost and electricity outages. There are various, disparate programs throughout California that could help customers adopt ZE appliances or install other cost saving measures but there is no central clearinghouse in existence that tracks all incentive programs for customers related to efficiency, zero-emissions appliances, and distributed energy technologies.

- For all residential and nonresidential respondents, 70% reported they had seen or heard about heat pumps. But there was much less awareness of heat pumps among residential low-income (38%), Native American (35%), and Spanish-speaking (30%) respondents.
- Around half (45% of all residential and 53% nonresidential respondents) reported they had not seen or heard of a heat pump water heater. Similar to the heat pump, there was even less awareness of heat pump water heaters among residential low-income (33%), Native American (35%), and Spanish-speaking (35%) respondents.
- For residential and nonresidential respondents that were familiar with heat pumps, the potential benefits that resonated most were that they could lower their utility bills and that they provide both heating and cooling.
- There are various programs that incentivize energy efficiency, zero-emissions appliances, and distributed energy technologies available throughout the state. However, it may be challenging for customers to identify them or understand their benefits as there is no central clearinghouse.

Strategy 5.1. The research team recommends **local customer outreach and education to clarify the potential CARB rule (once finalized) and its benefits.**

- Use a **"hub and spoke" outreach method** for customers where CARB works with medium-sized organizations, who in turn each work with multiple grassroot CBOs that have already established trust in the communities and are able to draw on existing, local connections.
- Have local CBOs provide input on what outreach channels, messaging, and benefits would resonate most with the populations they serve and allow for flexibility in education to accommodate different populations. Work with CBOs to clarify what would be allowed and what would be prohibited under CARB's potential rule and to educate them on

benefits of zero-emission appliances. Provide education in English and Spanish[25] and include CBOs that work with youth to educate customers and advertise workforce development opportunities, and advertise the clearinghouse mentioned in Strategy 5.2.

Strategy 5.2. The research team recommends **CARB promote existing websites with a clearinghouse** for different program offerings and incentives, and **work with other state agencies** to develop a **calculator tool** for contractors and customers to compare different options. CARB could:

- Point customers to clearinghouse websites, such as the Building Decarbonization Coalition's The Switch is On website[26], to help customers identify what programs, incentives, or tax credits they may be eligible for and links to program websites related to efficiency, electrification, battery storage, solar panels or other clean energy or resiliency measures.
- Work with other state agencies to develop an online tool where contractors and customers can input basic information about a home or building to compare impacts and illustrate benefits. To help promote the tool, CARB could work with organizations that operate the clearinghouse websites noted above to request they provide a link to this tool.

Finding 6. Stakeholders expressed concern that installation and maintenance costs would be higher if contractors need to travel to rural communities to install or fix ZE appliances, if there are no local contractors trained to install and repair equipment.

Strategy 6. The research team recommends **workforce development including local outreach and education.** Possible methods include:

- Train local maintenance crews on new heat pump and water heater heat pump equipment using local trade schools and outreach through local CBOs and labor unions. These workforce development opportunities will also provide jobs, helping to build support for ZE policies within communities.
- Provide links to tools that allow customers and contractors to identify when a panel upgrade is needed and load-balancing technologies[27] to avoid a panel upgrade in some cases. Build it Green is currently leading an effort to develop a tool like this and there is

[25] As shown in the section, Findings from Previous Studies, census data indicates that in census districts that primarily use wood or propane, 1 to 4% of households speak Spanish and limited English, and 1% speak a language other than Spanish and limited English. (Statewide, the census data shows that 4% of households speak limited English and a language other than Spanish, indicating that propane- and wood burning customers are less likely to speak a language other than Spanish or English.) Consequently, we recommend that outreach materials start in English and Spanish, although CARB could ask local CBOs to translate resources for communities speaking a different language.

[26] Home Page – The Switch is On: https://www.switchison.org

[27] Load-balancing technologies are devices that can be added to a building's electrical infrastructure to optimize an existing electrical panel. Examples include a circuit splitter that allows two loads to share one circuit with a controller to prioritize one over the other (e.g., water heater over an EV charger), and smart panels that can monitor and control multiple electrical loads.

a CalNEXT project that is currently exploring load balancing technologies. **CARB could leverage these efforts.**

- Offer trainings in English and Spanish in communities with a high percentage of Spanish-speakers.
- Work with local CBOs that are trusted by the community to educate and build trust for these technologies and changes; trained contractors can also act as trusted messengers.
- Consider educating building departments and inspectors on these new technologies.

Wood Burning Findings and Recommendations for Cleaner Burning Technologies

Finding 7. The majority of residents that currently use wood burning for heating reported they were more comfortable adopting ZE appliances if they could keep their wood burning heater[28]. In addition, 29% of residential respondents reported they would use a wood stove or fireplace if propane equipment were no longer available (the second most popular option after "install a new heat pump"). While CARB's potential rule does not place any restrictions on wood burning, the survey responses indicated that many customers may increase their wood burning if propane appliances were no longer an option for heating their home, so the potential rule could possibly lead to increased wood burning. **The research team's cost analysis also found low to no energy cost savings for wood burning customers adopting ZE appliances. Wood burning is also common in many Native American communities. However, wood burning releases air pollution.**

- The U.S. Environmental Protection Agency states that wood burning appliances release smoke (particulate matter), which can degrade air quality, and recommends a variety of cleaner-burning wood appliances (EPA, 2025).
- Fifty-five percent of all residential respondents, 65% of residential low-income respondents, and 55% of residential Native American respondents said they would be willing to install an electric heating appliance if they could keep their wood burning appliance as a back-up heating source.
- Almost 30% of all residential respondents said they would most likely choose to use a wood stove or fireplace to heat their home if propane equipment were no longer available to purchase. Almost 15% of residential low-income respondents also said this, indicating that wood burning could increase under CARB's potential rule.

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[28] The 2019 RASS shows that virtually all residential wood use in California is for space heating, so other end uses were not analyzed here (DNV-GL 2021).

- Cost savings for customers currently using wood to adopt ZE appliances were less certain, because of the low cost of wood. Our cost analysis found that only single-family homes on POU rates would see energy cost savings (around $270 per year) for current wood burning customers to adopt ZE equipment. If their electricity provider was an IOU or they were on CARE rates, our analysis estimated that they would not see any energy cost savings. However, this is based on homes that get 100% of their heating needs from wood and assumes a portion of customers procure wood for free, so the energy cost impact is heavily dependent on the amount and source of wood used.

- Based on census data, census block groups with high wood usage are more likely to be in tribal areas than the statewide average. For example, ACS data shows that 86% of census block groups where at least 75% of households use wood as their primary heating source are in tribal areas. See Appendix E for a map of California tribal lands.

Strategy 7. The research team recommends CARB continue to **encourage customers to install fireplace inserts in existing fireplaces and require that new wood burning appliances meet CARB's Woodsmoke Reduction Program[29] emission limits** to mitigate possible pollution increases under the potential rule.

- Continue to provide rebates for emissions reducing equipment in existing homes, such as through the Woodsmoke Reduction Program[30]. This program is implemented by the California Air Pollution Control Officers Association and provides incentives for homeowners to replace old, inefficient, and highly polluting wood stoves, wood inserts, or fireplaces with cleaner-burning and more efficient home heating devices. Prioritize rebates for Native American communities since many rely on wood burning appliances.

- Continue to incentivize cleaner wood burning heaters such as pellet stoves or EPA-certified wood stoves for new wood burning equipment.

Unique Circumstances and Policy Considerations

Finding 8. A majority of survey respondents were willing to adopt ZE appliances under a dual-fuel scenario, and energy modeling indicated that the cold climate areas of California would need some type of back-up heating for standard heat pumps or more expensive cold-climate heat pumps.

- More than 50% of all residential respondents and more than 65% of all nonresidential respondents said they would be willing to install a heat pump that can run on either

[29] Woodsmoke Reduction Program | California Air Resources Board

[30] Woodsmoke Reduction Program | California Air Resources Board

electricity or propane. Almost 65% of residential low-income respondents and almost 45% of residential Native American respondents also said this.

- Our energy use analysis found that residential and most nonresidential buildings in cold climates have high heating peak loads. This indicates that a standard heat pump would frequently use its electric resistance mode which could lead to higher bills, more upstream GHG emissions, and panel upgrades. Another option is cold-climate heat pumps. But in our billing analysis, cold-climate heat pumps using electric resistance backup still had higher peak loads in all climate zones as compared to standard heat pumps using the existing propane backup. Cold-climate heat pumps can also add around $1,000 to upfront project costs.

Strategy 8. The research team recommends allowing customers to have **dual-fuel systems in certain scenarios. The potential CARB concept would allow** customers to keep their current propane heating system as backup. The research team agrees with this aspect of the rule concept, especially in rural communities where grid reliability is a concern. In addition, CARB could consider allowing dual-fuel systems for some new purchases or offer additional incentives for cold-climate heat pumps.

- Consider allowing customers in cold climate zones of California (e.g., Northern Coastal & Sierra) to purchase a new dual-fuel heat pump - meaning one integrated heater that can run on either propane or electricity. This would help avoid purchasing an expensive high-capacity heat pump. It would also reduce operating costs by allowing customers to switch between propane and electricity during peak times (when electricity rates are highest).

Finding 9. Some climate zones and building types will not recoup their costs for heat pumps, and food service facilities face specific challenges for installing heat pump water heaters due to current health-code requirements.

- Climate zones with very low heating loads have long payback times for heat pumps. The mildest regions, Southern Coastal and Southern Inland, have payback times over 20 years for single-family buildings with A/C. Restaurants have the longest payback periods of the nonresidential buildings, although there is not a significant correlation to climate zone in our models, likely due to the higher waste heat produced by internal equipment in all restaurants that reduces the need for heating and thus reduces the impact of heat pumps as well as the relatively large water heating load being electrified, the use pattern of which coincides with peak electricity prices. Additionally, the current energy efficiency standard (Title 24, Part 6), discourages the installation of an electric resistance space heating appliance in all alterations, unless it replaces a previous electric resistance heating appliance.[31]

- The research team's energy cost analysis estimated that incremental costs for restaurants using propane to adopt heat pumps and heat pump water heaters are high at $12.88/sq ft, and the investment does not pay back. Also, food service facilities may have difficulty installing a heat pump water heater, because of health code requirements for sizing and supply water temperature that only account for efficiency of electric resistance water heaters – leading to expensive, oversized heat pump water heaters[32] (San Francisco Department of Public Health, 2025).

Strategy 9. The research team recommends that CARB **consider exceptions or phasing in new regulations for customers with the highest burden**. Possible options include:

- Work with the California Energy Commission (CEC) to reconsider the current Title 24 Part 6 requirement that discourages new ER heaters from being installed in climate zones with low heating loads.
- Consider adding more flexibility for restaurants (i.e., food service facilities) – particularly for water heaters given the current health code requirements. Restaurants have very high incremental costs for ZE appliances, and economies of scale will likely bring down the cost of heat pumps and heat pump water heaters in the future. The research team does not recommend a permanent exemption for restaurants, since they have the highest GHG emissions of all business types (per square foot) and so the greatest GHG savings from shifting to ZE appliances.
- Work with California health code officials to revise the health code requirement for sizing of heat pump water heaters in restaurants (food service facilities), described in Finding 9 above.

[31] See Title 24 Part 6 section 150.2(b)1G which – in the prescriptive path – does not allow electric resistance heating unless it replaces an existing electric resistance heater. However, projects could use the performance path to install a new electric resistance heater in an existing building.

[32] Those health code requirements assume that all electric water heaters installed in food service facilities have the efficiency of an electric resistance heater. Key metrics used for sizing (such as the recovery rate) assume electric resistance heating, which require larger water heating equipment than is actually needed if a heat pump water heater is used.

Recommendations for Future Research

Given the diversity of customers, geographic areas, and climate zones, we recommend these follow-up studies to further inform policy regarding ZE space and water heating equipment and strategies.

- **Study mapping areas with very low-income homeowners and heating fuel type (propane, wood, and possibly natural gas)**. This study recommends free installation of ZE equipment through an initiative such as a direct install program for very low-income homeowners. A follow-up study could identify which communities (e.g., census blocks) have high percentages of very low-income homeowners – for example in the bottom 10% of income based on ACS data, and (also from ACS) the heating fuels for those communities[33]. This information could help inform several recommendations, including which communities to target for the direct install program for propane users, which to target for wood burning customers to encourage them to install fireplace inserts. If CARB or other state agencies are considering assistance for very low-income natural gas users, the information could help inform which communities could be targeted for assistance for natural gas users.
- **Analysis of grid outages.** This study recommends supporting solar and battery and/or microgrids in areas impacted by frequent power outages. A follow-up study could use the electric system reliability annual reports from the CPUC[34], compared to census data showing high percentages of households using propane or wood for heating, to investigate which areas of the grid have frequent outages, typical duration, and plans for future grid expansion. The study could identify areas with long, frequent outages that are not expected to receive expanded grid capacity, since these would be well-suited for additional support. The study could also investigate pros and cons of providing deeper incentives for building-level solar plus storage incentives vs. support for community microgrids.
- **Identification of "very cold climates" and criteria for allowing integrated dual-fuel heat pumps**. This study recommends allowing the purchase of integrated dual-fuel heat pumps (i.e., equipment that could use either propane or electricity) in areas that are very cold and reliant on propane or wood. This would prevent the need for customers to install heat pumps with a high capacity (which are expensive) to provide heating at cold temperatures, or from buying standard heat pumps that frequently operate in electric resistance mode (which is inefficient and leads to high electricity bills). The scope of this study allowed for regional analysis, but not analysis for all 16 climate zones in California.

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[33] This study estimated the percent of customers using propane and wood for space heating that are low-income but did not estimate the percent that are very low income. However, a researcher could conduct that analysis using census data and/or by comparing responses to our survey's income question to responses to fuel for space heating.

[34] For example, the CPUC provides outage information here: Electric System Reliability Annual Reports

A future study could conduct analysis for all 16 climate zones to more specifically identify which areas of California should be categorized as “very cold” so should be considered for integrated, dual-fuel heat pumps because of climate needs. The study could also review equipment availability (e.g., heat pump capacities) and cost in these areas, to propose one or more criteria for a climate zone where dual-fuel heat pumps could be allowed. After identifying proposed criteria, the study could estimate the percentage of homes reliant on propane that meet the eligibility criteria. In addition, the study could review dual-fuel heat pumps to recommend criteria for this equipment (e.g., minimum specifications) and installation practices to increase the fraction of time that produces zero onsite emissions.

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List of Inventions Reported and Publications Produced

There are no inventions or publications (beyond this report) from this research.

Glossary of Terms, Abbreviations, and Symbols

Table 34. Glossary of Terms and Abbreviations

Abbreviation	Word or Phrase	Definition
ACEEE	American Council for an Energy-Efficient Economy	A nonprofit organization dedicated to promoting energy efficiency by advancing policies and practices that support economic prosperity, energy security, and environmental protection through research, advocacy, and public education.
ACS	American Community Survey	Ongoing annual survey conducted by the U.S. Census Bureau about U.S. residents. Collects information such as jobs and occupations and whether people own or rent homes.[35]
CARE	California Alternative Rates for Energy	A statewide program that provides 30-35% discount on electric bills and a 20% discount on natural gas bills for income-qualified customers.[36]
CBECS	Commercial Buildings Energy Consumption Survey	A national data collection effort that gathers detailed information on how commercial buildings are used and how much energy they consume, helping inform energy policy and efficiency programs.
CBO	Community based organization	Defined in this study as an organization that operates at the local level to support and serve one or more local communities with the local community and works directly with members of that (those) communities.
CEC	California Energy Commission	California's primary energy policy and planning agency.[37]
-	ComStock	Data with timeseries and annual energy consumption of the U.S. commercial building stock at the end-use level

[35] https://www.census.gov/programs-surveys/acs/about.html

[36] https://www.cpuc.ca.gov/consumer-support/financial-assistance-savings-and-discounts/california-alternate-rates-for-energy

[37] https://www.energy.ca.gov/

Abbreviation	Word or Phrase	Definition
		collected by the National Renewable Energy Laboratory.[38]
CPUC	California Public Utilities Commission	Regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies, in addition to authorizing video franchises.[39]
DAC	Disadvantaged Communities	Groups of people or geographic areas that face environmental, economic, or health burdens due to systemic underinvestment and historical marginalization.
EIA	Energy Information Agency	A U.S. government agency that collects, analyzes, and disseminates independent energy information to promote sound policymaking and public understanding.
GHG	Greenhouse gas	Gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride, which are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.[40]
HPWH	Heat pump water heater	Heat pump water heaters use electricity to move heat from one place to another instead of generating heat directly. In many cases they replace gas-fired water heaters and are significantly more energy efficient.[41]
IOU	Investor-owned utility	A privately-owned electric utility whose stock is publicly traded. It is rate regulated and authorized to achieve an allowed rate of return.[42]

[38] https://comstock.nrel.gov/page/datasets

[39] https://www.cpuc.ca.gov/about-cpuc/cpuc-overview/about-us

[40] https://www.eia.gov/tools/glossary/index.php?id=G

[41] https://www.energy.gov/femp/articles/heat-pump-water-heaters

[42] https://www.eia.gov/tools/glossary/index.php?id=Investor-owned%20utility%20(IOU)

Abbreviation	Word or Phrase	Definition
POU	Publicly owned utility	POUs are not-for-profit public agencies that supply and deliver electricity to their communities. POUs are governed by locally elected officials, such as city council members or, for some agencies, regionally elected directors.[43]
NREL	National Renewable Energy Laboratory	One of seventeen of the U.S. Department of Energy's national laboratories[44], the primary national laboratory for energy systems integration. NREL bridges foundational research with practical applications across fuels, storage, buildings, renewables, and emerging technologies.[45]
-	ResStock	Data with timeseries and annual energy consumption of the U.S. residential building stock at the end-use level collected by the National Renewable Energy Laboratory.[46]
TECH	Technology and Equipment for Clean Heating	A statewide initiative to accelerate the adoption of clean space and water heating technology across California homes in order to help California meet its goal of being carbon-neutral by 2045.[47]
USPS	United States Postal Service	National postal mail service.
ZE	Zero-emissions	An appliance or other equipment that does not release pollution at the site where it is used.

Appendix A. Additional Methodology Details

Appendix A includes additional details on the processes the research team followed for sample design and weighting, as well as lessons learned. The first two sections provide insight into how the research team used region, zip code, demographic characteristics, and other variables for

[43] https://www.cmua.org/Files/Capitol%20Day%202019/CMUA-POU-FAQ-2019-2-4.pdf

[44] https://www.energy.gov/national-laboratories

[45] https://www.nrel.gov/about

[46] https://resstock.nrel.gov/datasets

[47] https://techcleanca.com/

sample design and response weighting. The third section summarizes lessons learned regarding the study methodology.

Sample Design Details

The research team randomly sampled towns and surrounding areas in four regions of California to achieve regional representation. The four regions roughly corresponded to CEC Title 24 climate zone groupings: Northern Coastal & Sierra (climate zones 1, 2, 11, and the northern portion of 16), Central Valley (12 and 13), Central and Southern Coastal (3, 4, 5, 6, 7, and 8), and Southern Inland (9, 10, 14, 15, and the southern portion of 16). The sample was designed to balance recruitment costs and representativeness by selecting communities (based on US Postal Service (USPS) designations, thus including areas outside the municipalities' legal boundaries) with relatively high proportions of propane and wood burning space heat sources. We identified all USPS cities in California with at least 25% of homes relying on propane or wood for space heating based on the US Census Bureau's American Community Survey (ACS) as shown in Table 35. We then randomly ranked these USPS cities and selected cities up to the point where the total number of homes would be sufficient to achieve the sample targets, assuming a 0.5% response rate and building in a 20% buffer. We then selected all ZIP codes associated with the sampled USPS cities.

Table 35. List of USPS Cities with Homes Using at least 25% Propane or Wood for Space Heating

Region	USPS City	County
Central Valley	AMADOR CITY	Amador County
Central Valley	FIDDLETOWN	Amador County
Central Valley	JACKSON	Amador County
Central Valley	MARYSVILLE	Butte County
Central Valley	BURSON	Calaveras County
Central Valley	ANGELS CAMP	Calaveras County
Central Valley	COPPEROPOLIS	Calaveras County
Central Valley	GLENCOE	Calaveras County
Central Valley	MOKELUMNE HILL	Calaveras County
Central Valley	ALTAVILLE	Calaveras County
Central Valley	DIAMOND SPRINGS	El Dorado County
Central Valley	COLOMA	El Dorado County
Central Valley	GARDEN VALLEY	El Dorado County
Central Valley	FIDDLETOWN	El Dorado County
Central Valley	SHINGLE SPRINGS	El Dorado County
Central Valley	PLACERVILLE	El Dorado County
Central Valley	COOL	El Dorado County
Central Valley	GEORGETOWN	El Dorado County
Central Valley	RESCUE	El Dorado County

Region	USPS City	County
Central Valley	CAMINO	El Dorado County
Central Valley	EL DORADO	El Dorado County
Central Valley	LOTUS	El Dorado County
Central Valley	LATON	Fresno County
Central Valley	CARUTHERS	Fresno County
Central Valley	DUNLAP	Fresno County
Central Valley	BADGER	Fresno County
Central Valley	BIOLA	Fresno County
Central Valley	ARTOIS	Glenn County
Central Valley	BUTTE CITY	Glenn County
Central Valley	AHWAHNEE	Madera County
Central Valley	COARSEGOLD	Madera County
Central Valley	CATHEYS VALLEY	Mariposa County
Central Valley	RAYMOND	Mariposa County
Central Valley	AHWAHNEE	Mariposa County
Central Valley	COULTERVILLE	Mariposa County
Central Valley	CHOWCHILLA	Merced County
Central Valley	BALLICO	Merced County
Central Valley	AUBURN	Nevada County
Central Valley	PENN VALLEY	Nevada County
Central Valley	NEVADA CITY	Nevada County
Central Valley	GRASS VALLEY	Nevada County
Central Valley	CHICAGO PARK	Nevada County
Central Valley	AUBURN	Placer County
Central Valley	COLFAX	Placer County
Central Valley	RIO VISTA	Sacramento County
Central Valley	COURTLAND	Sacramento County
Central Valley	FARMINGTON	San Joaquin County
Central Valley	ACAMPO	San Joaquin County
Central Valley	MARICOPA	Santa Barbara County
Central Valley	LIVERMORE	Santa Clara County
Central Valley	ANDERSON	Shasta County
Central Valley	BELLA VISTA	Shasta County
Central Valley	DAVIS	Solano County
Central Valley	FARMINGTON	Stanislaus County
Central Valley	ELVERTA	Sutter County
Central Valley	KNIGHTS LANDING	Sutter County
Central Valley	CORNING	Tehama County
Central Valley	ORLAND	Tehama County
Central Valley	COTTONWOOD	Tehama County

Region	USPS City	County
Central Valley	CHICO	Tehama County
Central Valley	KAWEAH	Tulare County
Central Valley	EXETER	Tulare County
Central Valley	CALIFORNIA HOT SPRINGS	Tulare County
Central Valley	GROVELAND	Tuolumne County
Central Valley	COPPEROPOLIS	Tuolumne County
Central Valley	COLUMBIA	Tuolumne County
Central Valley	JAMESTOWN	Tuolumne County
Central Valley	SONORA	Tuolumne County
Central Valley	BIG OAK FLAT	Tuolumne County
Central Valley	ESPARTO	Yolo County
Central Valley	BROOKS	Yolo County
Central Valley	BROWNSVILLE	Yuba County
Northern Coastal & Sierra	ARNOLD	Alpine County
Northern Coastal & Sierra	KIRKWOOD	Amador County
Northern Coastal & Sierra	PIONEER	Amador County
Northern Coastal & Sierra	BERRY CREEK	Butte County
Northern Coastal & Sierra	MAGALIA	Butte County
Northern Coastal & Sierra	ARNOLD	Calaveras County
Northern Coastal & Sierra	KLAMATH	Del Norte County
Northern Coastal & Sierra	PIONEER	El Dorado County
Northern Coastal & Sierra	AUBERRY	Fresno County
Northern Coastal & Sierra	FERNDALE	Humboldt County
Northern Coastal & Sierra	HOOPA	Humboldt County
Northern Coastal & Sierra	ORICK	Humboldt County
Northern Coastal & Sierra	ALDERPOINT	Humboldt County
Northern Coastal & Sierra	BLUE LAKE	Humboldt County
Northern Coastal & Sierra	GARBERVILLE	Humboldt County
Northern Coastal & Sierra	BLOCKSBURG	Humboldt County
Northern Coastal & Sierra	BIG PINE	Inyo County
Northern Coastal & Sierra	BISHOP	Inyo County
Northern Coastal & Sierra	LOWER LAKE	Lake County
Northern Coastal & Sierra	COBB	Lake County
Northern Coastal & Sierra	LAKEPORT	Lake County
Northern Coastal & Sierra	CLEARLAKE OAKS	Lake County
Northern Coastal & Sierra	NICE	Lake County
Northern Coastal & Sierra	KELSEYVILLE	Lake County
Northern Coastal & Sierra	CLEARLAKE	Lake County
Northern Coastal & Sierra	SUSANVILLE	Lassen County
Northern Coastal & Sierra	JANESVILLE	Lassen County

Region	USPS City	County
Northern Coastal & Sierra	BIEBER	Lassen County
Northern Coastal & Sierra	DOYLE	Lassen County
Northern Coastal & Sierra	BASS LAKE	Madera County
Northern Coastal & Sierra	AUBERRY	Madera County
Northern Coastal & Sierra	DILLON BEACH	Marin County
Northern Coastal & Sierra	BOLINAS	Marin County
Northern Coastal & Sierra	FISH CAMP	Mariposa County
Northern Coastal & Sierra	CASPAR	Mendocino County
Northern Coastal & Sierra	REDWOOD VALLEY	Mendocino County
Northern Coastal & Sierra	FORT BRAGG	Mendocino County
Northern Coastal & Sierra	ALBION	Mendocino County
Northern Coastal & Sierra	COVELO	Mendocino County
Northern Coastal & Sierra	ELK	Mendocino County
Northern Coastal & Sierra	BOONVILLE	Mendocino County
Northern Coastal & Sierra	HOPLAND	Mendocino County
Northern Coastal & Sierra	POTTER VALLEY	Mendocino County
Northern Coastal & Sierra	LAYTONVILLE	Mendocino County
Northern Coastal & Sierra	BRANSCOMB	Mendocino County
Northern Coastal & Sierra	CALPELLA	Mendocino County
Northern Coastal & Sierra	ALTURAS	Modoc County
Northern Coastal & Sierra	ADIN	Modoc County
Northern Coastal & Sierra	CANBY	Modoc County
Northern Coastal & Sierra	CEDARVILLE	Modoc County
Northern Coastal & Sierra	BRIDGEPORT	Mono County
Northern Coastal & Sierra	MAMMOTH LAKES	Mono County
Northern Coastal & Sierra	BENTON	Mono County
Northern Coastal & Sierra	FAIRFIELD	Napa County
Northern Coastal & Sierra	NORDEN	Nevada County
Northern Coastal & Sierra	FORESTHILL	Placer County
Northern Coastal & Sierra	SODA SPRINGS	Placer County
Northern Coastal & Sierra	ALTA	Placer County
Northern Coastal & Sierra	QUINCY	Plumas County
Northern Coastal & Sierra	CANYON DAM	Plumas County
Northern Coastal & Sierra	CHESTER	Plumas County
Northern Coastal & Sierra	MEADOW VALLEY	Plumas County
Northern Coastal & Sierra	CHILCOOT	Plumas County
Northern Coastal & Sierra	BLAIRSDEN GRAEAGLE	Plumas County
Northern Coastal & Sierra	BELDEN	Plumas County
Northern Coastal & Sierra	HALF MOON BAY	San Mateo County
Northern Coastal & Sierra	PORTOLA VALLEY	San Mateo County

Region	USPS City	County
Northern Coastal & Sierra	HOLY CITY	Santa Clara County
Northern Coastal & Sierra	BEN LOMOND	Santa Cruz County
Northern Coastal & Sierra	BOULDER CREEK	Santa Cruz County
Northern Coastal & Sierra	PESCADERO	Santa Cruz County
Northern Coastal & Sierra	BURNEY	Shasta County
Northern Coastal & Sierra	CASTELLA	Shasta County
Northern Coastal & Sierra	ALLEGHANY	Sierra County
Northern Coastal & Sierra	DUNSMUIR	Siskiyou County
Northern Coastal & Sierra	GAZELLE	Siskiyou County
Northern Coastal & Sierra	HORNBROOK	Siskiyou County
Northern Coastal & Sierra	MOUNT SHASTA	Siskiyou County
Northern Coastal & Sierra	SOMES BAR	Siskiyou County
Northern Coastal & Sierra	MONTAGUE	Siskiyou County
Northern Coastal & Sierra	DORRIS	Siskiyou County
Northern Coastal & Sierra	MCCLOUD	Siskiyou County
Northern Coastal & Sierra	FORT JONES	Siskiyou County
Northern Coastal & Sierra	MACDOEL	Siskiyou County
Northern Coastal & Sierra	GUALALA	Sonoma County
Northern Coastal & Sierra	GEYSERVILLE	Sonoma County
Northern Coastal & Sierra	CALISTOGA	Sonoma County
Northern Coastal & Sierra	CAZADERO	Sonoma County
Northern Coastal & Sierra	FORESTVILLE	Sonoma County
Northern Coastal & Sierra	BODEGA BAY	Sonoma County
Northern Coastal & Sierra	ANNAPOLIS	Sonoma County
Northern Coastal & Sierra	CAMP MEEKER	Sonoma County
Northern Coastal & Sierra	GUERNEVILLE	Sonoma County
Northern Coastal & Sierra	BODEGA	Sonoma County
Northern Coastal & Sierra	BURNT RANCH	Trinity County
Northern Coastal & Sierra	BRIDGEVILLE	Trinity County
Northern Coastal & Sierra	LEWISTON	Trinity County
Northern Coastal & Sierra	DOUGLAS CITY	Trinity County
Northern Coastal & Sierra	LONG BARN	Tuolumne County
Northern Coastal & Sierra	MI WUK VILLAGE	Tuolumne County
Southern Coastal	COALINGA	Monterey County
Southern Coastal	CARMEL VALLEY	Monterey County
Southern Coastal	AROMAS	Monterey County
Southern Coastal	BIG SUR	Monterey County
Southern Coastal	CHUALAR	San Benito County
Southern Coastal	AROMAS	San Benito County
Southern Coastal	MARICOPA	San Luis Obispo County

Region	USPS City	County
Southern Coastal	BRADLEY	San Luis Obispo County
Southern Coastal	CRESTON	San Luis Obispo County
Southern Coastal	LOS GATOS	Santa Cruz County
Southern Inland	DEATH VALLEY	Inyo County
Southern Inland	GLENNVILLE	Kern County
Southern Inland	WELDON	Kern County
Southern Inland	KERNVILLE	Kern County
Southern Inland	INYOKERN	Kern County
Southern Inland	PINE MOUNTAIN CLUB	Kern County
Southern Inland	BODFISH	Kern County
Southern Inland	LAKE ISABELLA	Kern County
Southern Inland	LEBEC	Los Angeles County
Southern Inland	ADELANTO	Los Angeles County
Southern Inland	SANTA CLARITA	Los Angeles County
Southern Inland	ACTON	Los Angeles County
Southern Inland	LAKE HUGHES	Los Angeles County
Southern Inland	THERMAL	Riverside County
Southern Inland	AGUANGA	Riverside County
Southern Inland	WHITEWATER	Riverside County
Southern Inland	PHELAN	San Bernardino County
Southern Inland	BLYTHE	San Bernardino County
Southern Inland	LUCERNE VALLEY	San Bernardino County
Southern Inland	JOSHUA TREE	San Bernardino County
Southern Inland	ANGELUS OAKS	San Bernardino County
Southern Inland	PIONEERTOWN	San Bernardino County
Southern Inland	MORONGO VALLEY	San Bernardino County
Southern Inland	LANDERS	San Bernardino County
Southern Inland	RAMONA	San Diego County
Southern Inland	JACUMBA	San Diego County
Southern Inland	BOULEVARD	San Diego County
Southern Inland	JAMUL	San Diego County
Southern Inland	DESCANSO	San Diego County
Southern Inland	ALPINE	San Diego County
Southern Inland	JULIAN	San Diego County
Southern Inland	PAUMA VALLEY	San Diego County
Southern Inland	CAMPO	San Diego County
Southern Inland	VALLEY CENTER	San Diego County
Southern Inland	BONSALL	San Diego County

Table 36 displays the list of sampled towns and surrounding areas in the four regions.

Table 36. List of Sampled USPS Town Areas and Counties by Region

Region	USPS Town Area	County
Northern Coastal & Sierra	Alleghany	Sierra County
	Kirkwood	Amador County
	Quincy	Plumas County
	Ferndale	Humboldt County
	Lower Lake	Lake County
	Foresthill	Placer County
	Burnt Ranch	Trinity County
	Caspar, Redwood Valley	Mendocino County
	Gualala	Sonoma County
	Berry Creek	Butte County
	Burney	Shasta County
	Long Barn	Tuolumne County
Southern Inland	Ramona, Jacumba, Boulevard, Jamul	San Diego County
	Thermal	Riverside County
	Glennville	Kern County
	Lebec	Los Angeles County
	Phelan, Blythe, Lucerne Valley	San Bernardino County
Central Valley	Artois	Glenn County
	Farmington	San Joaquin County
	Brownsville	Yuba County
	Auburn, Penn Valley	Nevada County
	Catheys Valley	Mariposa County
	Diamond Springs, Coloma	El Dorado County
	Ahwahnee	Madera County
	Goshen*, Delano (includes Ducor*), Alpaugh*, Allensworth*	Tulare County
Southern Coastal	Carmel Valley, Aromas Big Sur	Monterey County
	Bradley, Creston	San Luis Obispo County
	Los Gatos	Santa Cruz County
	Aromas	San Benito County

*Added because CCAC had contacts here.

Weighting Details

As described in the report, the research team weighted the **residential** survey responses based on region and recruitment method (i.e., random vs. convenience sampling), as proxied by the zip code. Weighting based on other variables, such as demographic characteristics, would have been challenging because the research team did not have a comprehensive source for the breakdown of demographics among propane users as opposed to among the general population. Additionally, weighting on demographics would have run the risk of splitting the sample into a large number of cells, some of which would have had very few or no sample points.

Table 37 below shows the weights for the residential survey based on the combination of region and zip code:

Table 37. Residential Survey Weight Calculations based on Region and Zip Code

Region	Zip	Sampling Approach	Weight
Northern Coastal & Sierra	93602, 94020, 94080, 94102, 95003, 95006, 95018, 95066, 95454, 95490, 95497, 95514, 95519, 95540, 95545, 95546, 96124	Convenience	0.045389
	95457, 95470, 95527, 95536, 95631, 95646, 95971, 96013	Random	1.212584
Southern Inland	91763, 92019, 92028, 92060, 92128, 92233, 92257, 92324, 92407, 92501, 92563, 93285, 93501, 93505, 93518, 93531, 93561	Convenience	0.087737
	91935, 92065, 92274, 92356, 92371	Random	1.578609
Central Valley	93218, 93219, 93223, 93280, 93291, 93306, 93311, 93314, 93610, 93612, 93614, 93636, 93638, 93647, 93704, 93706, 95210, 95220, 95307, 95333, 95356, 95380, 95630, 95914, 95924, 96019	Convenience	0.259197
	93201, 93215, 95602, 95603, 95613, 95946	Random	9.177398
Southern Coastal	91911, 92037, 92051, 92115, 92805, 93101, 93420, 93436, 93446, 93460, 93465, 95023, 95036, 95043, 95123	Convenience	0.604193
	93426, 93432, 93920, 93924, 95004, 95030, 95032, 95033	Random	0.809966

The **nonresidential** survey responses were weighted proportionally by region. The research team used ACS (American Community Survey) data instead of Comstock for the population comparison for the nonresidential survey because ACS data was more representative of the population. The research team did not have a large enough sample to weight based on business type, which is more applicable for Comstock data. Additionally, Comstock represents buildings nationally, not just in California, and while it relies on regionally specific data, it is less specific to individual areas than the ACS data. Table 38 below shows the weights for the nonresidential survey based on the region.

Table 38. Nonresidential Survey Weight Calculations based on Region

Region	Sample N	Sample %	Population N	Population %	Calculated Sample Weight
Southern Coastal	7	16%	131,221	20%	1.25
Central Valley	12	27%	134,979	21%	0.78
Northern Coastal & Sierra	18	41%	275,239	42%	1.02
Southern Inland	7	16%	111,873	17%	1.06
Total	44	100%	653,312	100%	

After applying the sample weights to the analysis, the research team examined the resulting weighted data to determine how the weighting scheme influenced the representativeness of the survey results. As shown in Table 39, we first compared the residential unweighted sample characteristics to both the weighted sample characteristics as well as the population proportions. We found that in most cases the weighting scheme, which was designed to account for non-random sampling within geographical regions, decreases the representation of some groups such as renters and low-income respondents in the overall sample. For this reason, we determined that in addition to reporting overall weighted survey results, we would also break out results separately, showing unweighted results for several groups, including renters, low-income respondents, Spanish-speaking respondents, those residing in a mobile or manufactured home, and those who indicated they are “American Indian, Alaskan Native, or Native Hawaiian.”

Table 39. Characteristics of Residential Survey Respondents (Unweighted and Weighted), Compared to the Population

Characteristics of Residential Respondents (n = 225)	Unweighted Sample %	Weighted Sample %	Population* %
Renter	24%	13%	29%
Owner	76%	87%	71%
Low-income	38%	25%	31%
Not Low-income	62%	76%	69%
English	88%	88%	67%
Spanish	10%	11%	18%
Non-English other than Spanish	2%	1%	15%

Note: The population data is from the 2023 American Community Survey (ACS).

As shown in Table 40, we then compared nonresidential unweighted sample characteristics to both the weighted sample characteristics and the population proportions. In this case, the weighting did not influence the representativeness of business types (the weighted sample proportions are similar to the unweighted sample proportions). The proportion of business types in the survey sample are fairly similar to the population proportions, with the exception of warehouses (underrepresented in the sample), retail (not present in the population of comparison), and “other” business types (also not present in the population of comparison).

Table 40. Business Types of Nonresidential Survey Respondents (Unweighted and Weighted), Compared to the Population

Nonresidential Respondents' Business Types (n = 44)	Unweighted Sample %	Weighted Sample %	Population
Office	34%	34%	45%
Hotel, motel, or other lodging	11%	12%	11%
Warehouse	11%	10%	33%
Retail	9%	8%	0%
Healthcare, including outpatient and dental services	5%	5%	2%
Restaurant – Full Service: sit-down restaurant with a full kitchen	5%	5%	8%
Restaurant – Quick Service: fast-food, take-out, café, or deli	5%	5%	0%
Grocery store/Convenience store/Liquor store	2%	2%	NA
Laundromat	2%	2%	NA
School (K-12)	2%	2%	0%
Church	5%	5%	NA
Other	9%	9%	0%

Note: The population data is from NREL's ComStock database, 2024 release 1. The building prevalences in ComStock are based on the 2018 Commercial Buildings Energy Consumption Survey (CBECS) from the U.S. Energy Information Administration. They are less likely to be representative at highly specific geographic categorizations.

Lessons Learned

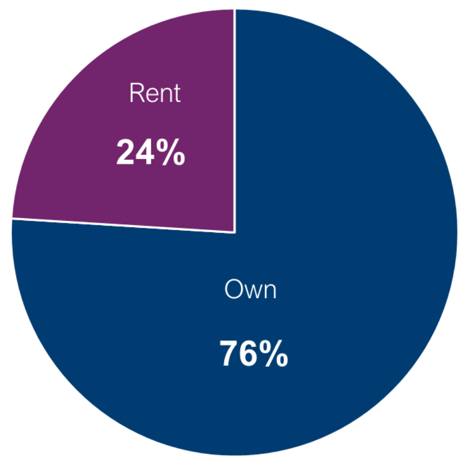
One challenge faced during the project was that bots attempted to take the survey after CBOs publicly posted the survey opportunity on social media (Facebook). We immediately closed the survey and set up measures to reduce the instances of bots, including adding Captcha and ReCAPTCHA questions, asking for survey takers to identify (from a coded list of options) all words starting with the letter "E", and requiring responses to open-ended questions on thoughts and feelings (which are challenging for bots to complete). However, the research team then needed to spend a great deal of effort to identify and remove bots from the responses to ensure that all responses retained for analysis were from legitimate responses. Two lessons learned from this experience were: 1) do not post incentivized survey links on publicly available sites and 2) include measures to identify and deter bots (such as ReCAPTCHA) from the beginning, for surveys that will be widely distributed.

Appendix B. Additional Survey Results

Survey Respondent Characteristics

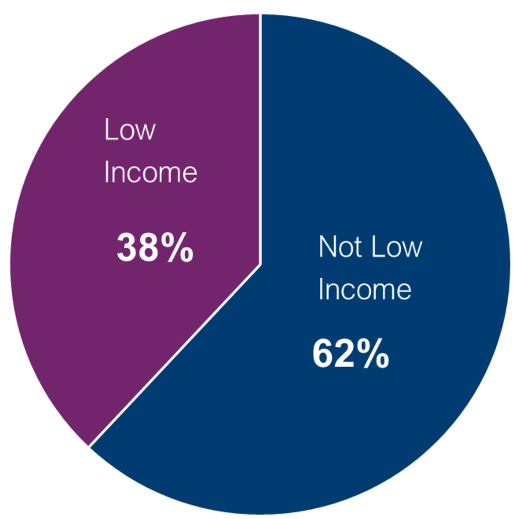
Additional details of characteristics of residential survey respondents are shown below.

Figure 50. Percent of Residential Respondents that Own or Rent Their Home (n = 225)



Question A4. Do you own or rent your home? (Unweighted Results)

Figure 51. Percent of Residential Respondents that are Low-income (n = 196)

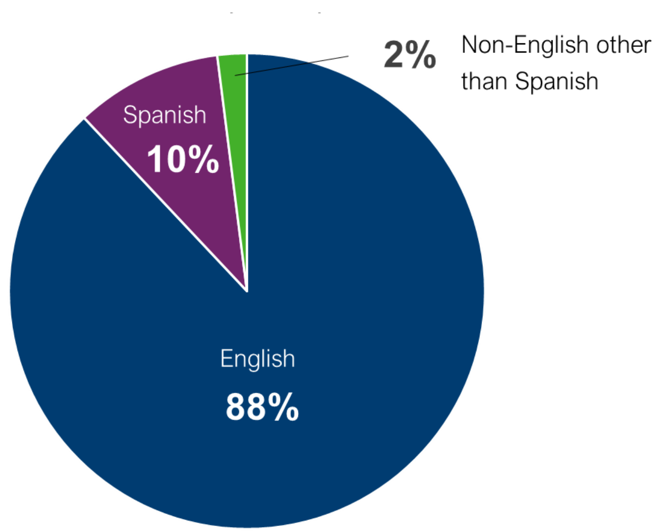


Question: E4. Which of the following best describes your household's total annual gross income? (Unweighted Results)

Question E3. Including yourself, approximately how many people live in your home full-time? (Unweighted Results)

Note: Low income status was determined using criteria for the CARE program based on responses to survey questions asking household annual gross income and number of household residents See: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/care-fera-program. Total n is 224, but 28 were omitted from the low-income calculation because they were missing household size and/or income and thus could not be categorized. Final n = 196.

Figure 52. Main Language Spoken in Residential Respondents' Home (n = 224)



Question E2. What is the main language spoken in your home? (Unweighted Results)

Note: Other n=4: Hungarian, Japanese, Hindi, Turkish

Figure 53. Proportion of Residential Respondents that Use Propane or Wood as a Secondary Heating Source (n = 140)

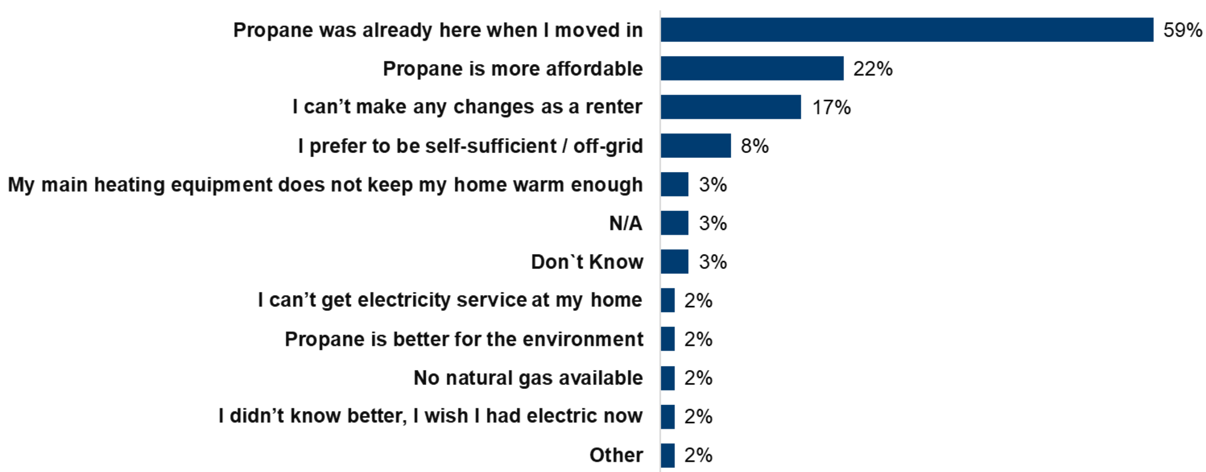
Question B1a. What is the energy source for the additional heating equipment in your home? (Unweighted Results)

Why Survey Respondents Use Propane or Wood to Heat their Home or Water

Reasons for Using Propane Among Sub-Groups

Similar to the total residential respondent survey results, the majority of low-income, Native American, mobile or manufacture home, and Spanish-speaking respondents said they used propane to heat their home or water instead of electricity because propane was there when they moved in.

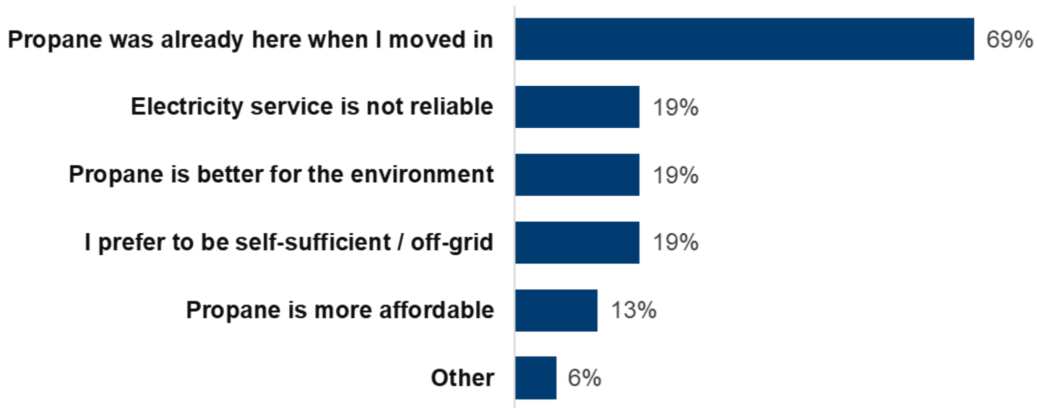
Figure 54. Low-income Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 59)



Question: B4a. Why do you use propane to heat your home or water instead of electricity? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 1.

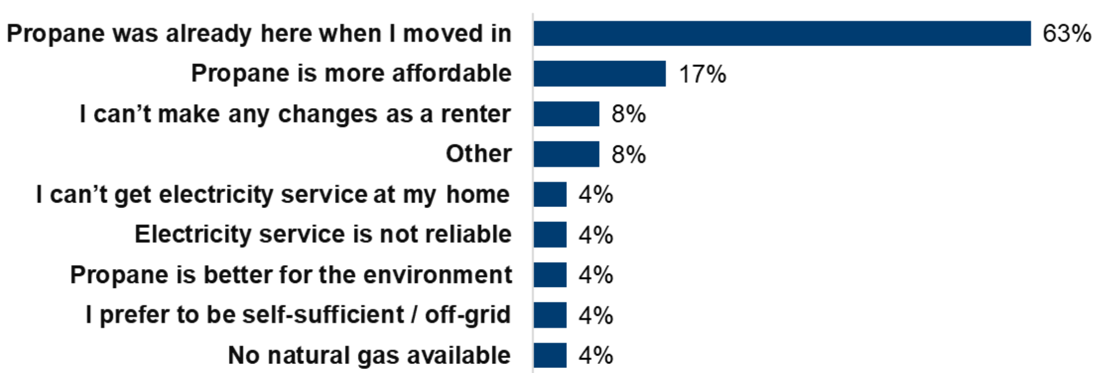
Figure 55. Native American's Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 16)



Question: B4a. Why do you use propane to heat your home or water instead of electricity? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 1.

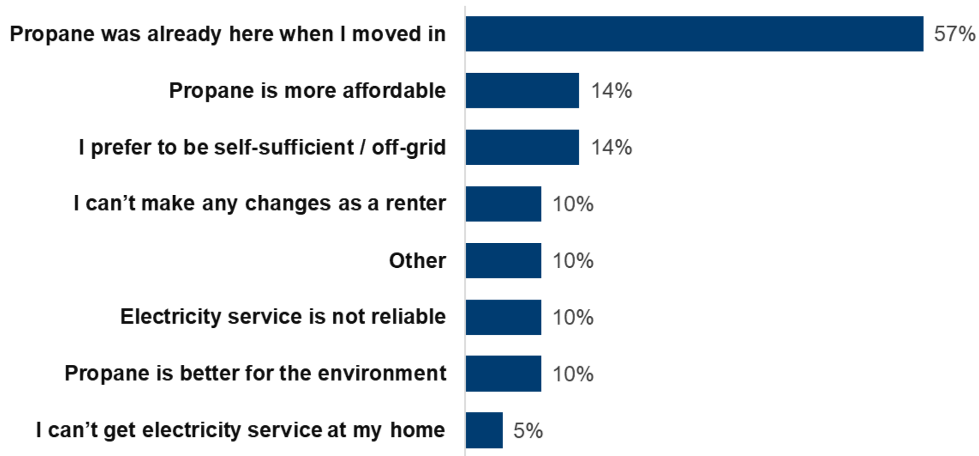
Figure 56. Mobile or Manufactured Home Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 24)



Question: B4a. Why do you use propane to heat your home or water instead of electricity? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n=2: "Propane is only available here, my home needs electrical upgrade".

Figure 57. Spanish Speaking Residential Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 21)



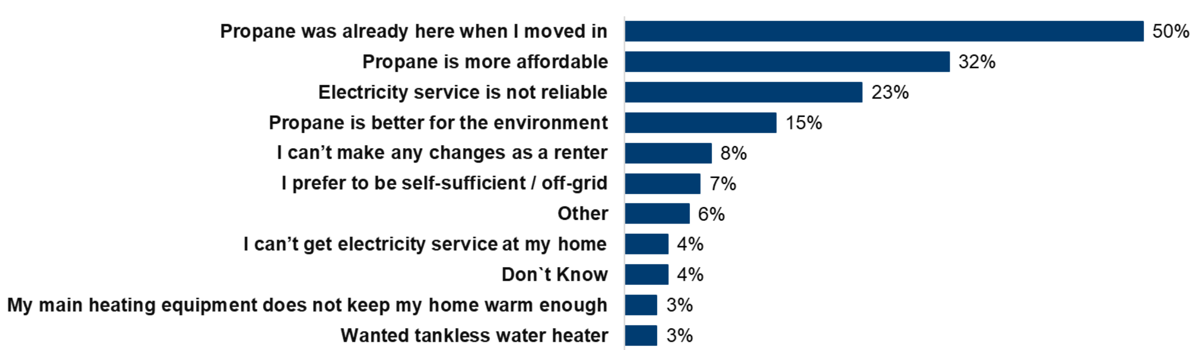
Question: B4a. Why do you use propane to heat your home or water instead of electricity? (Unweighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 2: "Propane is only available here and my home needs electrical upgrade".

Reasons for Using Propane by Region

Similar to the total residential respondent survey results, the majority of respondents within each region said they used propane to heat their home or water instead of electricity because propane was there when they moved in.

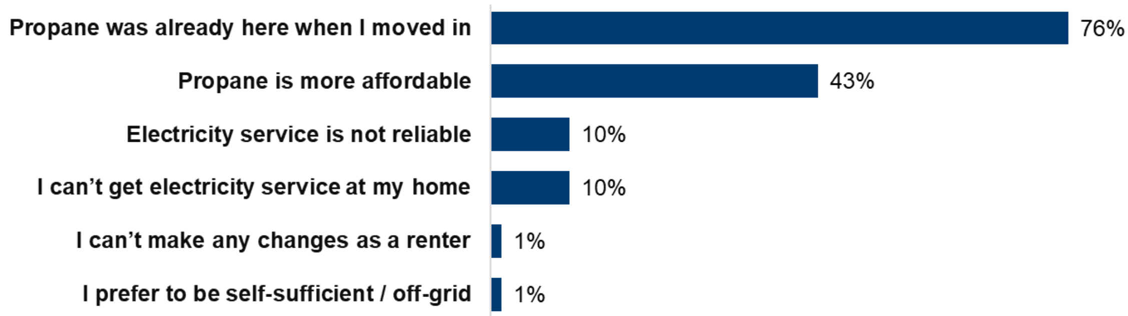
Figure 58. Southern Coastal Residential Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 28)



Question B4a. Why do you use propane to heat your home or water instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 2: "Combination of wood and propane is cheaper and quieter than running the furnace and no space for large water tanks".

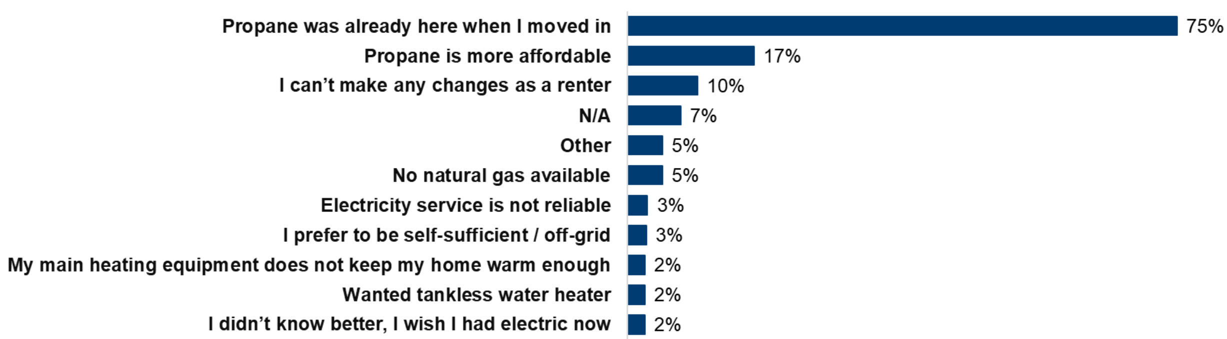
Figure 59. Central Valley Residential Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 43)



Question B4a. Why do you use propane to heat your home or water instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

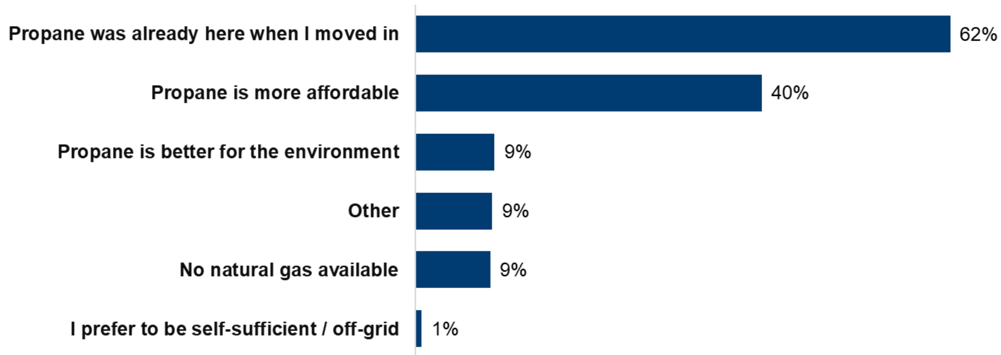
Figure 60. Northern Coastal and Sierra Residential Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 64)



Question B4a. Why do you use propane to heat your home or water instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 2: "Waiting for better hot water heat pumps and worked for a propane company when we installed our heating system".

Figure 61. Southern Inland Residential Respondents' Reasons for Using Propane to Heat Their Home or Water Instead of Electricity (n = 57)



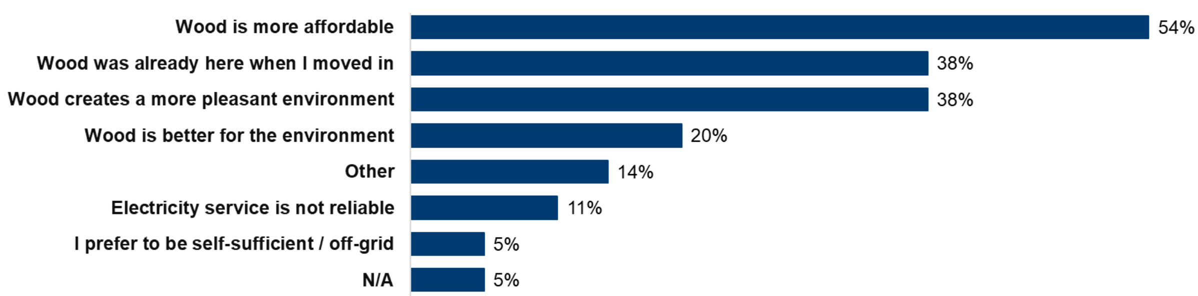
Question B4a. Why do you use propane to heat your home or water instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 3; examples responses include: "Use electricity for many other things, did not want to totally convert".

Reasons for Using Wood by Region

Similar to the total residential respondent survey results, the majority of respondents by region said they used wood to heat their home instead of electricity because wood is more affordable.

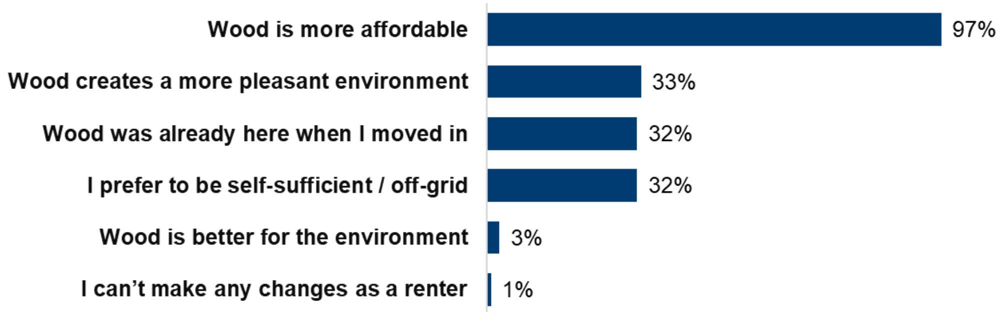
Figure 62. Southern Coastal Residential Respondents' Reasons for Using Wood to Heat Their Home Instead of Electricity (n = 16)



Question B5. Why do you use wood to heat your home instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 2: "Reduces chance of wildfire and wall heater is broken."

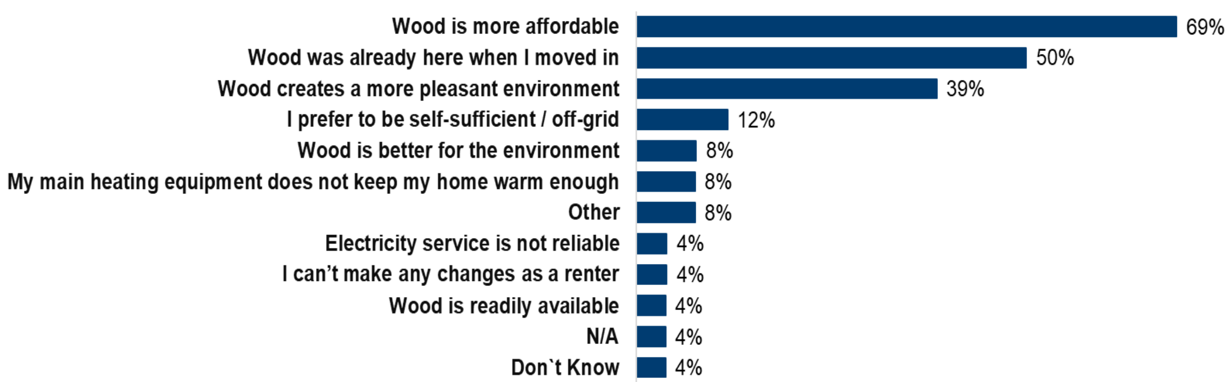
Figure 63. Central Valley Residential Respondents’ Reasons for Using Wood to Heat Their Home Instead of Electricity (n = 10)



Question: B5. Why do you use wood to heat your home instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

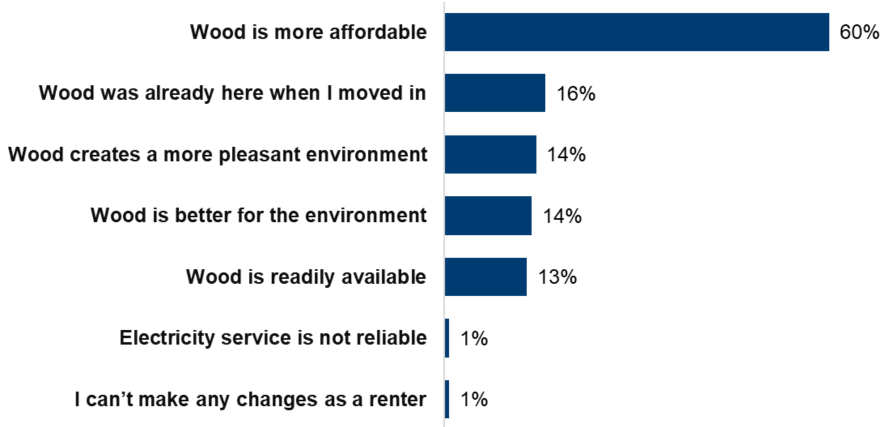
Figure 64. Northern Coastal and Sierras Residential Respondents’ Reasons for Using Wood to Heat Their Home Instead of Electricity (n = 40)



Question B5. Why do you use wood to heat your home instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n=2: "Reduces how often we have to turn the propane heater on and works even when the power is out, and wood is best for the age/construction of my home”.

Figure 65. Southern Inland Residential Respondents' Reasons for Using Wood to Heat Their Home Instead of Electricity (n = 21)



Question B5. Why do you use wood to heat your home instead of electricity? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

Possible Scenarios Respondents Would Choose if Current Heating System Failed

Unlike residential respondents overall who most commonly stated they would install a new heat pump, Spanish-speaking respondents most frequently said they would use plug-in electric space heaters if propane equipment were no longer available to purchase as shown in the table below. Similar to residential respondents overall, respondents in the Southern Coastal, Central Valley, and Northern Coastal and Sierra regions most frequently reported that they would choose to install a new heat pump to heat their space if propane equipment was no longer available to purchase.

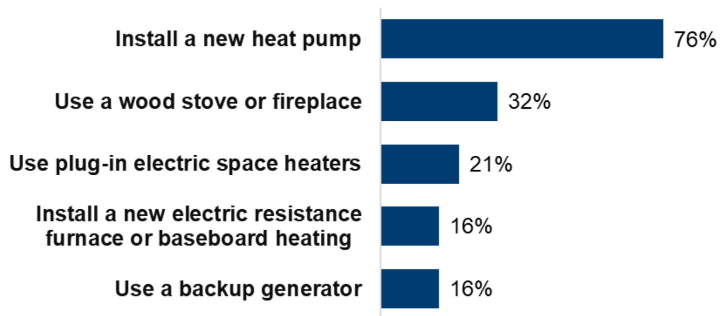
Table 41. Options Spanish Speaking Respondents Would Choose if Heating Equipment Broke and Propane Equipment were no Longer Available

Which of the following would you most likely choose to heat your space if propane equipment were no longer available to purchase?	Spanish Speaking (n = 13)
Use plug-in electric space heaters	46%
Install a new heat pump	38%
Install a new electric resistance furnace or baseboard heating	31%
Use a wood stove or fireplace	15%
Use a backup generator	8%
Don't know	8%

Question C3. Imagine that your current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Unweighted)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses

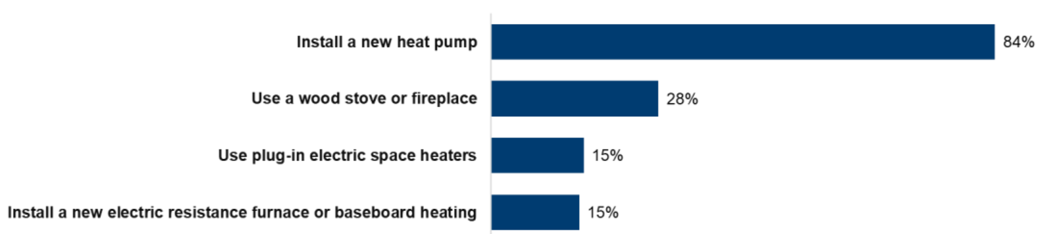
Figure 66. Options Southern Coastal Respondents Would Choose Heating Equipment Broke and Propane Equipment were no Longer Available (n = 12)



Question C3. Imagine that your current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

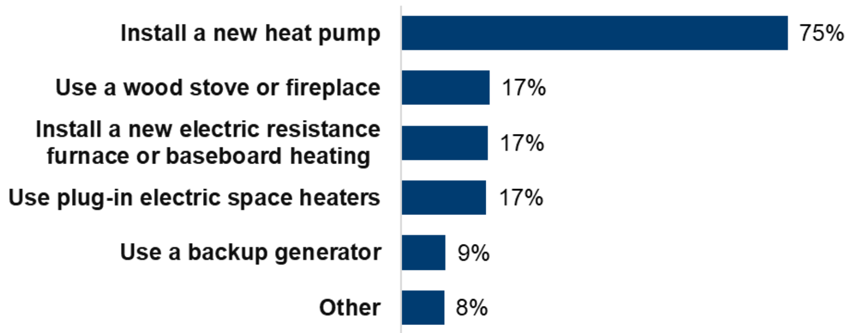
Figure 67. Options Central Valley Respondents Would Choose Heating Equipment Broke and Propane Equipment were no Longer Available (n = 21)



Question C3. Imagine that your current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses

Figure 68. Options Northern Coastal and Sierra Region Respondents Would Choose Heating Equipment Broke and Propane Equipment were no Longer Available (n = 21)



Question C3. Imagine that your current heating system is broken beyond repair, and propane equipment is no longer available for purchase. Which of the following would you most likely choose to heat your space? (Weighted Results)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses. Other n = 2: “Would only get a heat pump if affordable and would need more solar with battery backup".

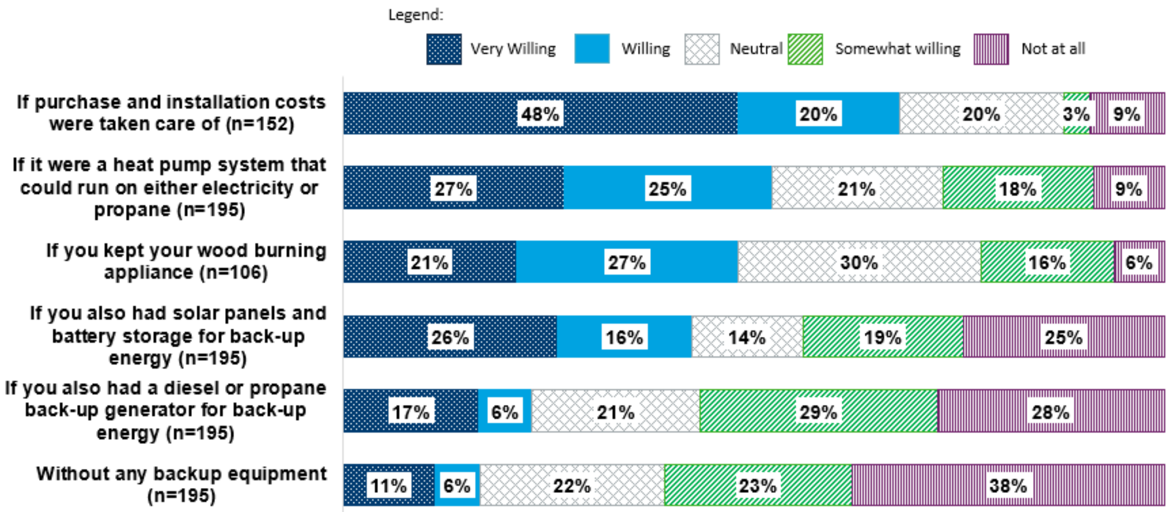
Willingness to Replace Current Heating System with an Electric Appliance

This section contains additional details regarding respondents’ willingness to replace their current heating systems with an electric appliance, as well as nonresidential respondents’ willingness to pay extra for a heat pump.

Residential Homeowners and Renters Combined

This section shows individual ratings for the combined sample of homeowners and renters, for willingness to replace their current home heating system with an electric appliance. This section also contains results specific to low-income, Native American, and Spanish-speaking respondents, those in mobile or manufactured homes, and those in the Southern Coastal and Central Valley regions.

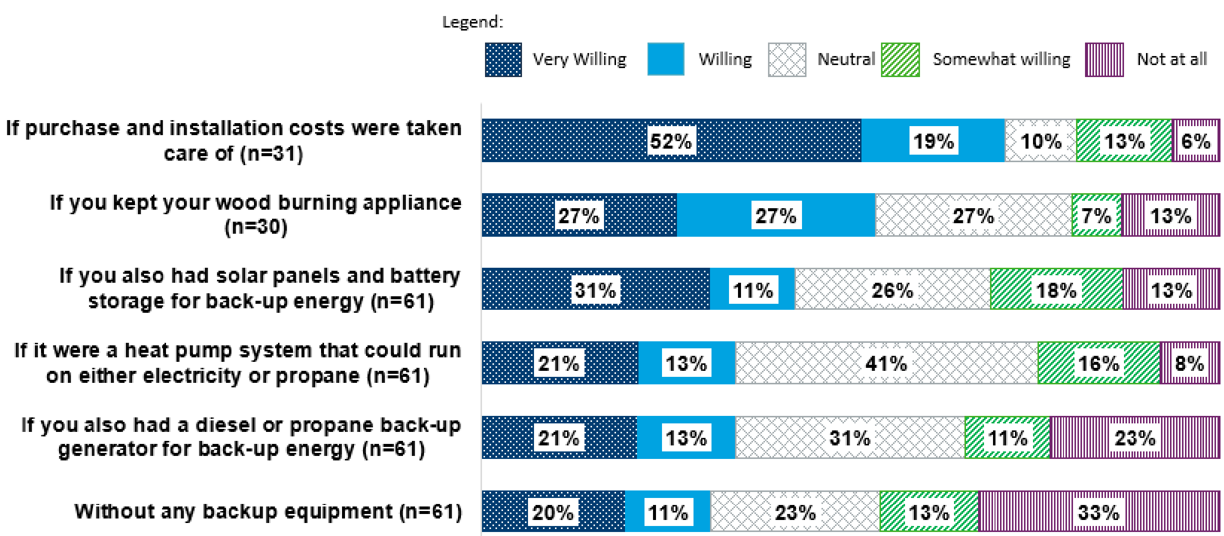
Figure 69. Total Residential Respondents' Willingness to Replace Current Heating System with an Electric Appliance



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Weighted Results)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 ("Not at all willing" for homeowners and "Not at all supportive" for tenants) and 5 ("Very willing" for homeowners and "Very supportive" for tenants). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

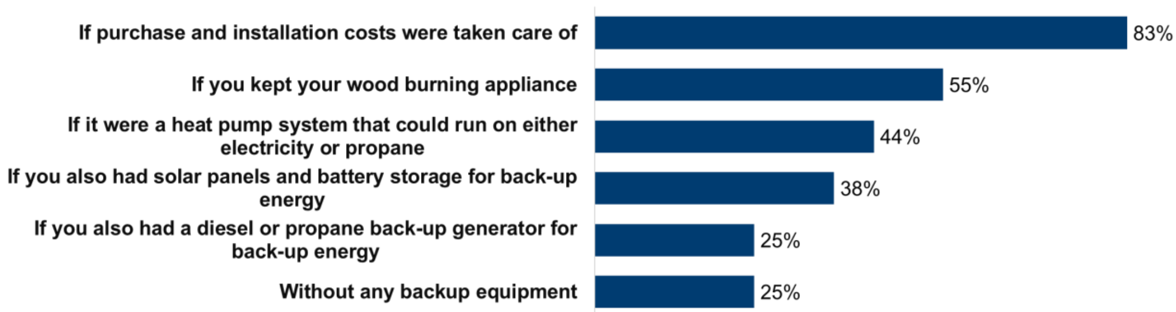
Figure 70. Low-income Respondents' Willingness to Replace Current Heating System with an Electric Appliance



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 (“Not at all willing” for homeowners and “Not at all supportive” for tenants) and 5 (“Very willing” for homeowners and “Very supportive” for tenants). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

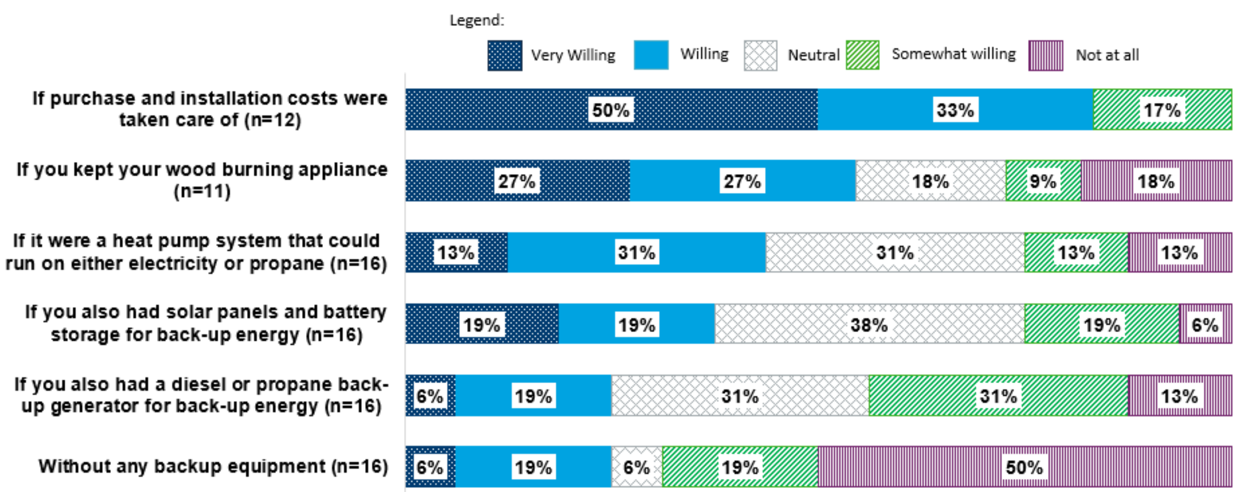
Figure 71. Native American Respondents’ Willingness to Replace Current Heating System with an Electric Appliance (n = 16)



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: Sum is greater than 100% due to combining questions. Respondents rated these scenarios as 4 or 5 out of a 5-point scale. For “If you kept your wood burning appliance” question, n = 11. For “If purchase and installation costs were taken care of” question, n = 1.

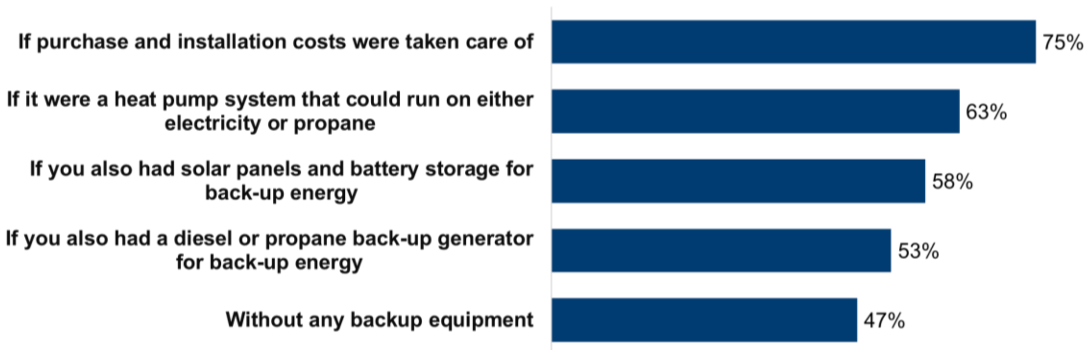
Figure 72. Native American Respondents’ Willingness to Replace Current Heating System with an Electric Appliance



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 (“Not at all willing” for homeowners and “Not at all supportive” for tenants) and 5 (“Very willing” for homeowners and “Very supportive” for tenants). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

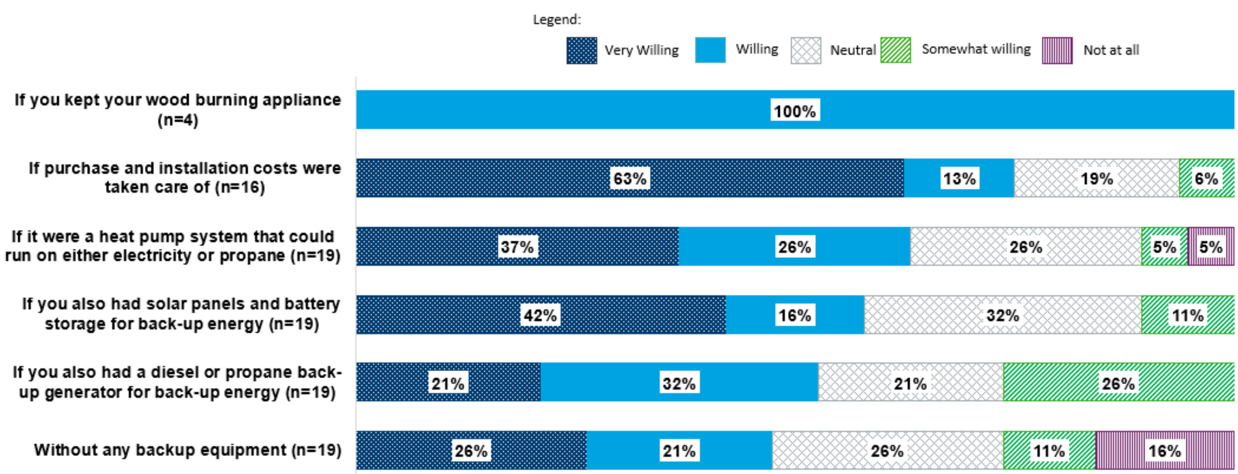
Figure 73. Spanish Speaking Respondents’ Willingness to Replace Current Heating System with an Electric Appliance (n= 19)



Questions C5a-f and C6a-e. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: Sum is greater than 100% due to combining questions. Respondents rated these scenarios as 4 or 5 out of a 5-point scale. 100% of respondents (n = 4) rated “If you kept your wood burning appliance” a 4 or 5. For “If purchase and installation costs were taken care of” question, n = 16.

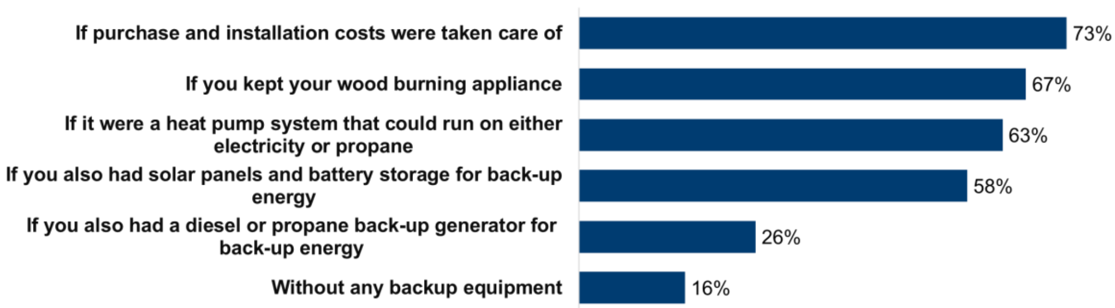
Figure 74. Spanish Speaking Respondents’ Willingness to Replace Current Heating System with an Electric Appliance



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 (“Not at all willing” for homeowners and “Not at all supportive” for tenants) and 5 (“Very willing” for homeowners and “Very supportive” for tenants). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

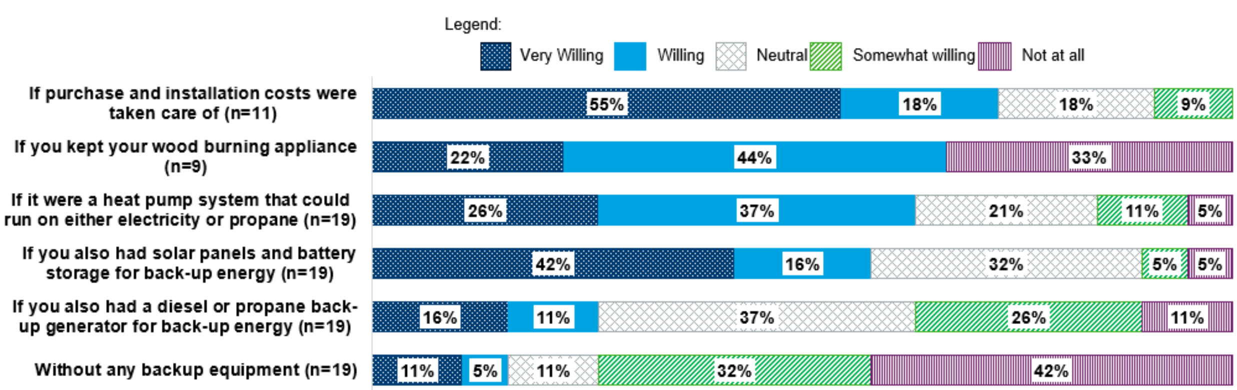
Figure 75. Mobile or Manufactured Home Respondents’ Willingness to Replace Current Heating System with an Electric Appliance (n = 19)



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: Sum is greater than 100% due to combining questions. Respondents rated these scenarios as 4 or 5 out of a 5-point scale. For “If you kept your wood burning appliance” question, n = 9. For “If purchase and installation costs were taken care of” question, n = 11.

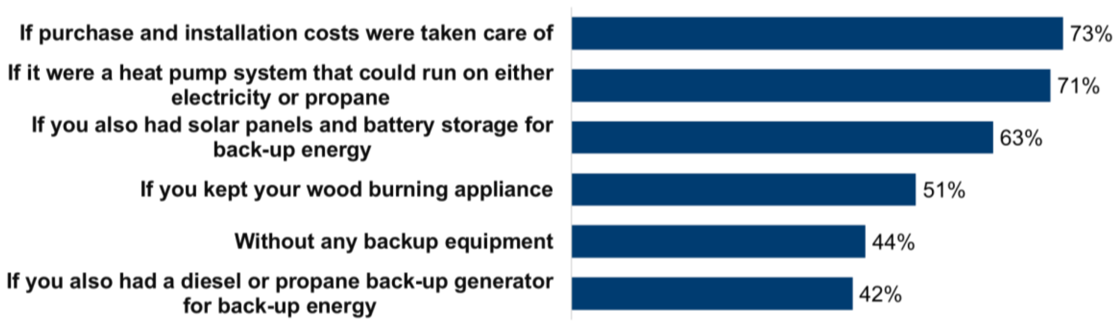
Figure 76. Mobile or Manufactured Home Respondents’ Willingness to Replace Current Heating System with an Electric Appliance



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 (“Not at all willing” for homeowners and “Not at all supportive” for tenants) and 5 (“Very willing” for homeowners and “Very supportive” for tenants). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

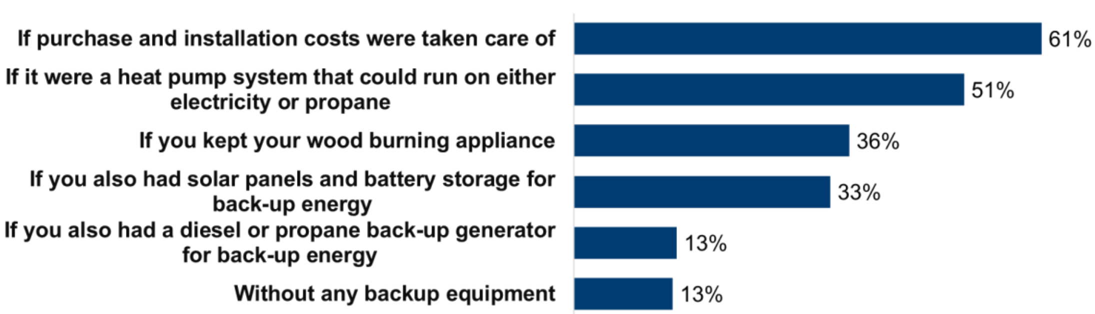
Figure 77. Southern Coastal Respondents’ Willingness to Replace Current Heating System with an Electric Appliance (n = 31)



Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Weighted Results)

Note: Sum is greater than 100% due to combining questions. Respondents rated these scenarios as 4 or 5 out of a 5-point scale. For “If you kept your wood burning appliance” question, n = 22. For “If purchase and installation costs were taken care of” question, n = 27.

Figure 78. Central Valley Respondents’ Willingness to Replace Current Heating System with an Electric Appliance (n = 39)



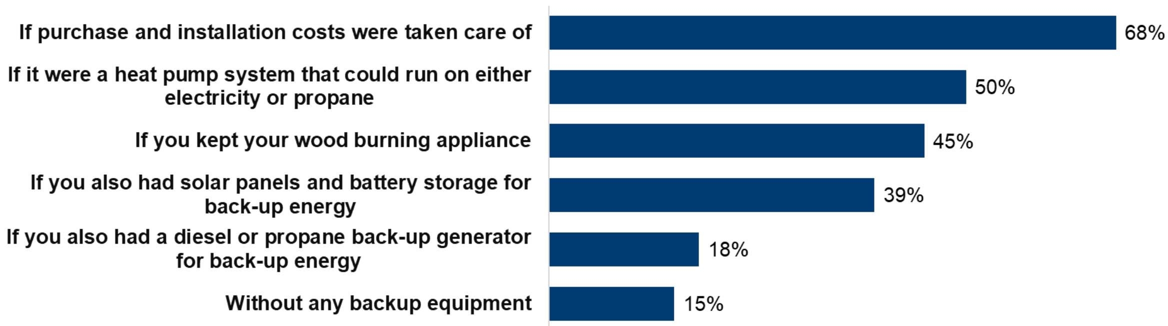
Questions C5a-f and C6a-e combined. When your current home heating system fails, how willing would you be to replace it/how supportive would you be if your landlord replaced it with an electric appliance? (Weighted Results)

Note: Sum is greater than 100% due to combining questions. Respondents rated these scenarios as 4 or 5 out of a 5-point scale. For “If you kept your wood burning appliance” question, n = 12. For “If purchase and installation costs were taken care of” question, n = 27.

Homeowners' Willingness to Replace Heating System with Electric Appliance

This section shows willingness to replace their current home heating system with an electric appliance, specifically among homeowners. This section also shows results for homeowners broken out by region.

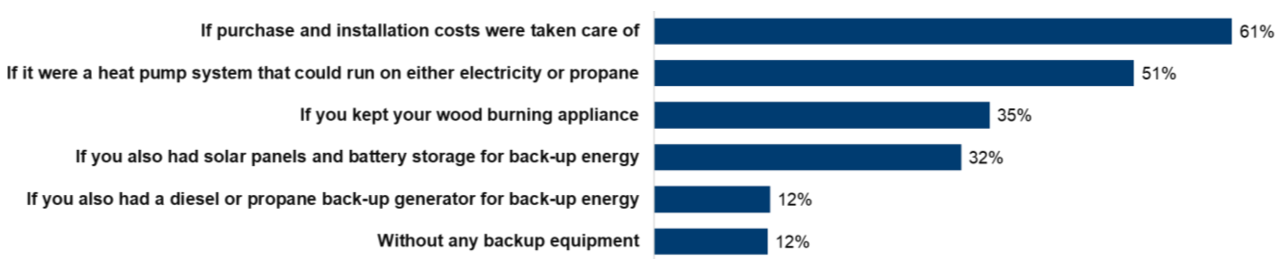
Figure 79. Residential Homeowners that are Willing to Replace Current Heating System with an Electric Appliance (n = 152)



Questions C5a-f. When your current home heating system fails, how willing would you be to replace it with an electric appliance? (Weighted Results)

Note: For "If you kept your wood burning appliance" question, n = 91.

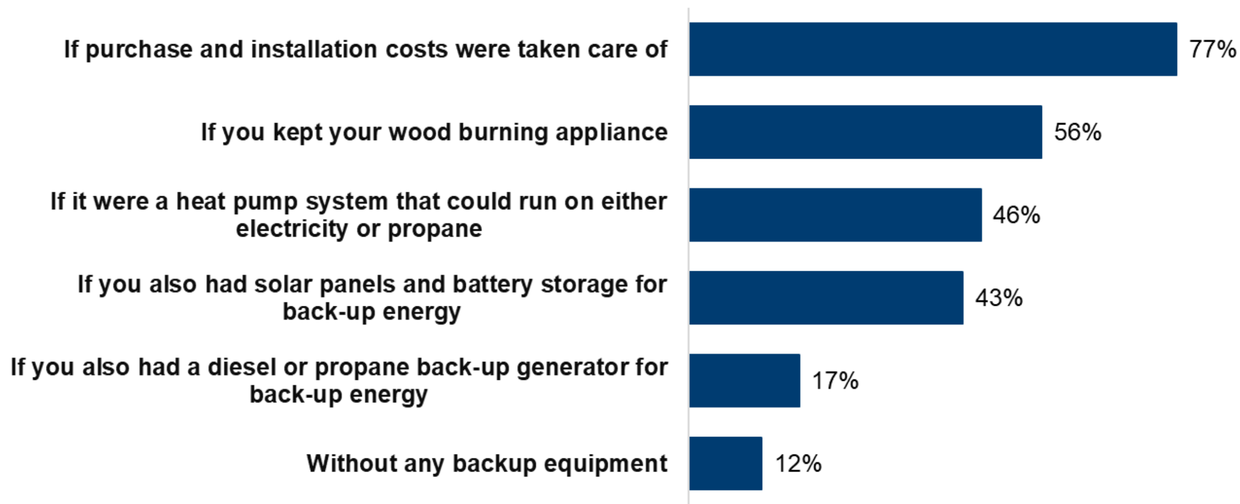
Figure 80. Central Valley Homeowner Respondents that are Willing to Replace Current Heating System with an Electric Appliance (n = 27)



Questions C5a-f. When your current home heating system fails, how willing would you be to replace it with an electric appliance? (Weighted Results)

Note: For "If you kept your wood burning appliance" question, n = 8

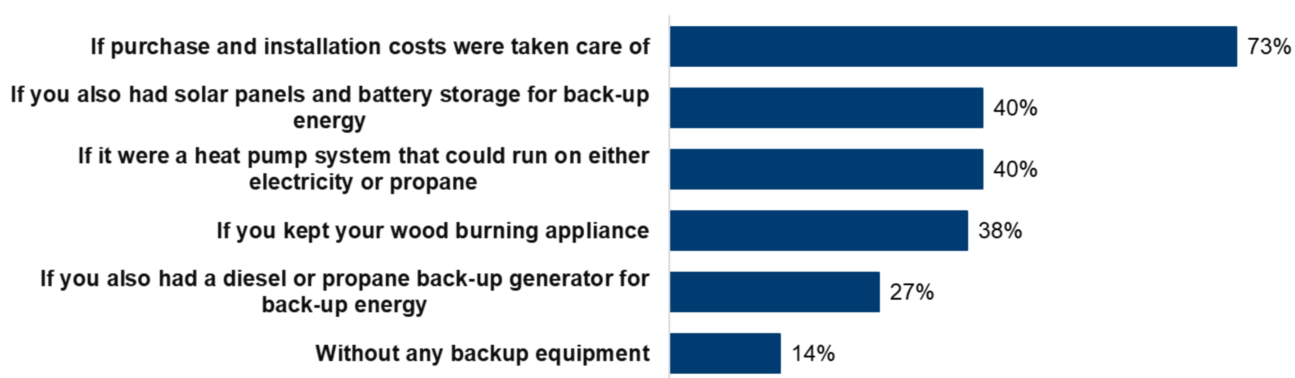
Figure 81. Northern Coastal and Sierra Homeowners that are Willing to Replace their Current Heating System with an Electric Appliance (n = 53)



Questions C5a-f. When your current home heating system fails, how willing would you be to replace it with an electric appliance? (Weighted Results)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. For “If you kept your wood burning appliance” question, n = 39.

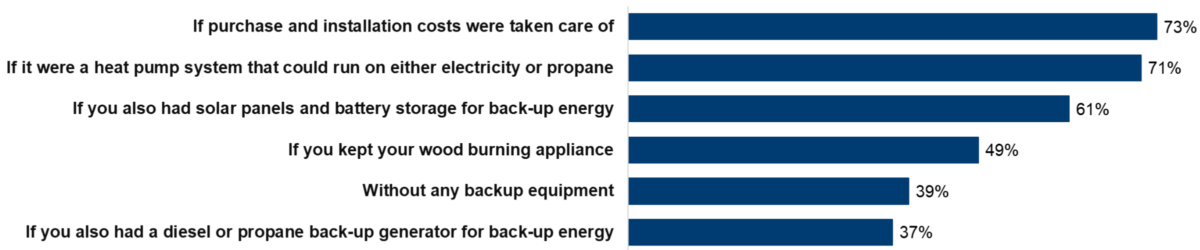
Figure 82. Southern Inland Homeowners that are Willing to Replace their Current Heating System with an Electric Appliance (n = 45)



Questions C5a-f. When your current home heating system fails, how willing would you be to replace it with an electric appliance? (Weighted Results)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale. For “If you kept your wood burning appliance” question, n = 23.

Figure 83. Southern Coastal Homeowners that are Willing to Replace Current Heating System with an Electric Appliance (n = 27)



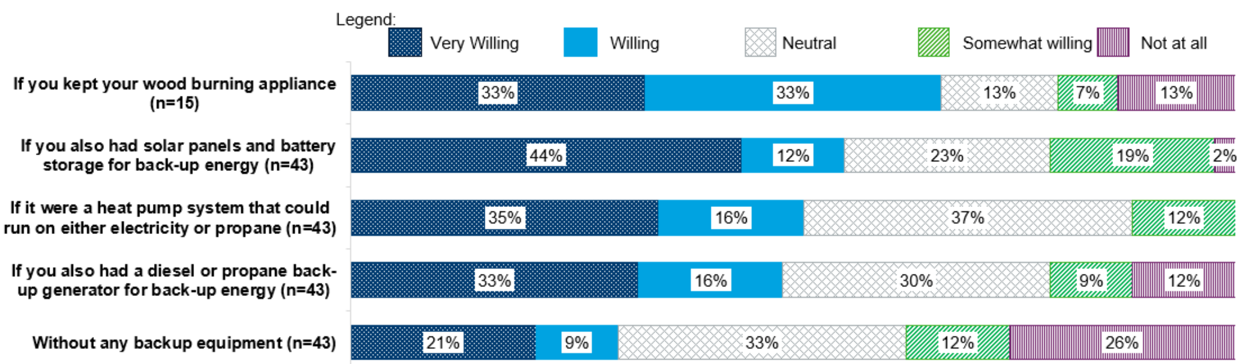
Question C5a-f. When your current home heating system fails, how willing would you be to replace it with an electric appliance? (Weighted Results)

Note: For “If you kept your wood burning appliance” question, n = 21.

Residential Renters’ Willingness to Replace Heating System with Electric Appliance

This section shows willingness to replace their current home heating system with an electric appliance, specifically among residential renters. This section also shows results for renters for the Central Valley and Northern Coastal and Sierra region.

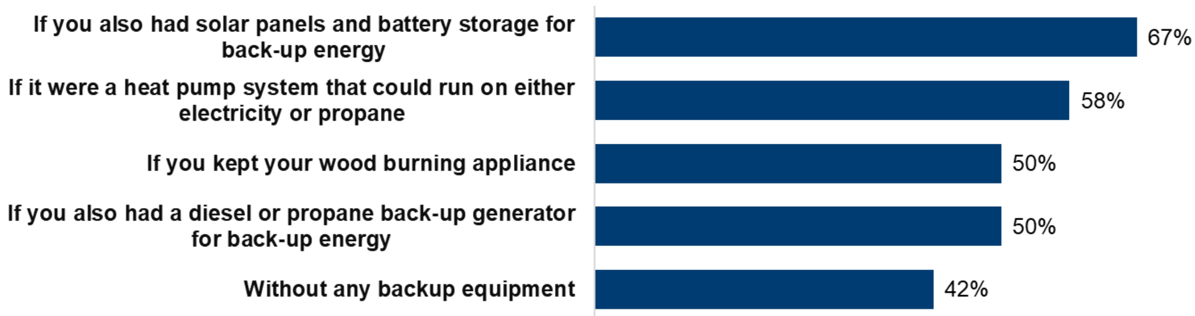
Figure 84. Residential Renter Respondents’ Willingness to Have Landlord Replace Current Heating System with an Electric Appliance



Questions C6a-e. When your current home heating system fails, how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted Results)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 (“Not at all supportive”) and 5 (“Very supportive”). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

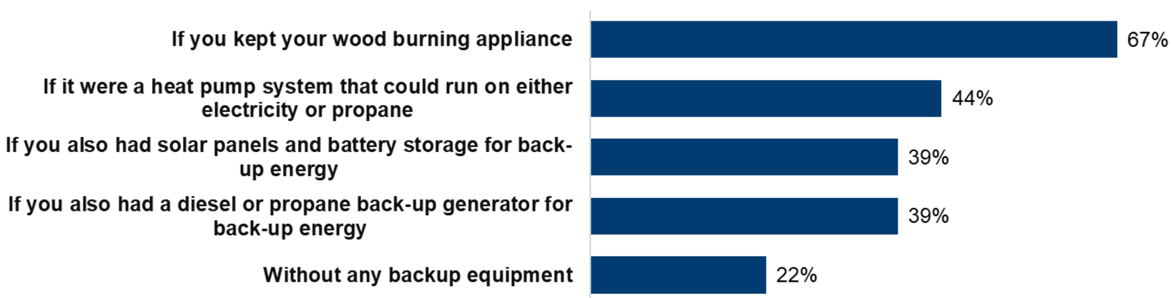
Figure 85. Central Valley Residential Renters that are Willing to Have their Landlord Replace the Current Heating System with an Electric Appliance (n = 12)



Questions C6a-e. When your current home heating system fails, how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted)

Note: For "If you kept your wood burning appliance" question, n = 4.

Figure 86. Northern Coastal and Sierra Residential Renters that are Willing to Have their Landlord Replace the Current Heating System with an Electric Appliance (n = 18)



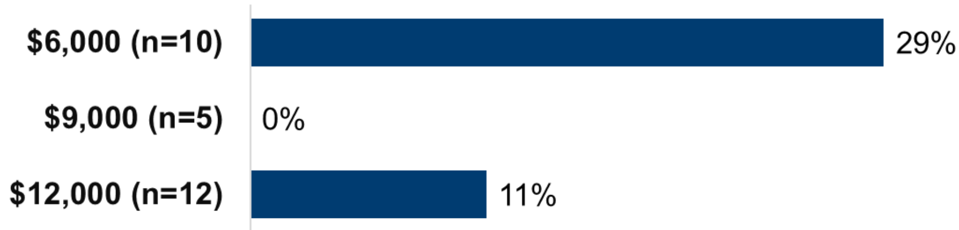
Questions C6a-e. When your current home heating system fails, how supportive would you be if your landlord replaced it with an electric appliance? (Unweighted)

Note: For "If you kept your wood burning appliance" question, n = 6.

Nonresidential Results

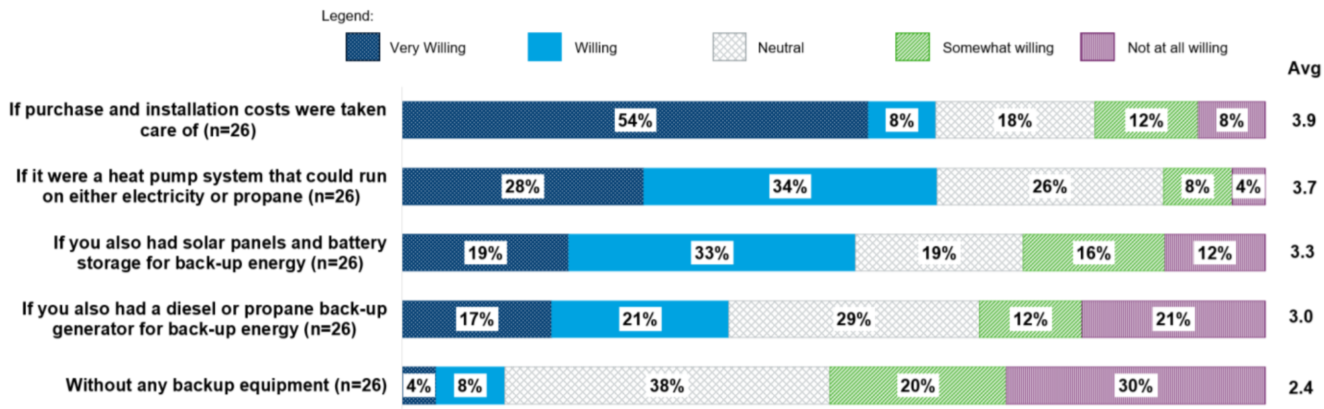
This section includes nonresidential respondent's willingness to pay varying amounts for a heat pump, as well as willingness to replace their current heating system with an electric appliance and willingness to replace their current water heater with an electric appliance. This is broken out by building owners and tenants.

Figure 87. Nonresidential Survey Respondents Willingness to Pay for a Heat Pump



Question C6_1, C6_2, and C6_3. Would you be willing to pay an extra … for a new heat pump? (Weighted)

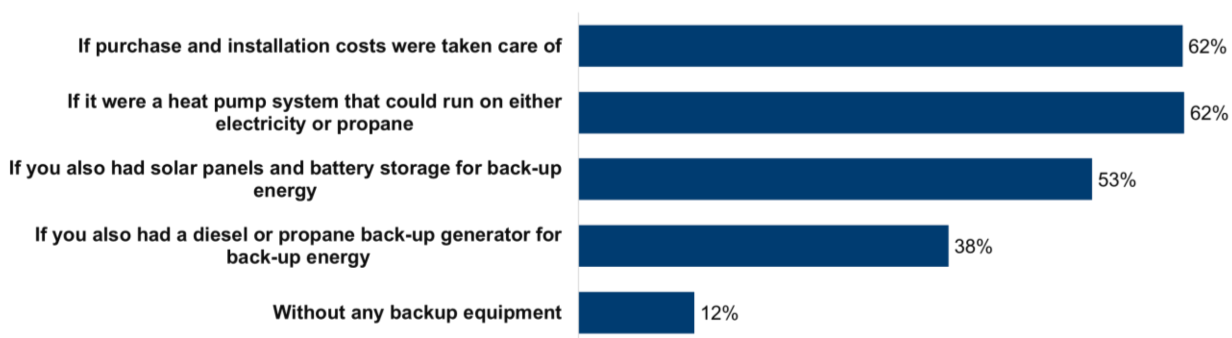
Figure 88. Building Owner's Willingness to Replace Current Heating System with an Electric Appliance



Question C8a-e. When your organization's current heating system fails, how willing would you be to replace it with an electric appliance? (Weighted)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 ("Not at all willing") and 5 ("Very willing"). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

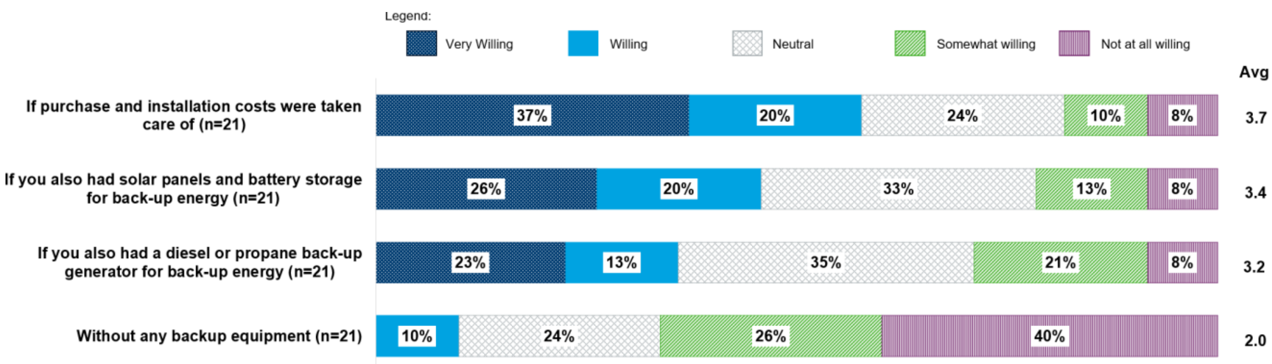
Figure 89. Building Owners Willing to Replace their Current Heating System with an Electric Appliance (n = 26)



Question C8a-e. When your organization's current heating system fails, how willing would you be to replace it with an electric appliance? (Weighted)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale.

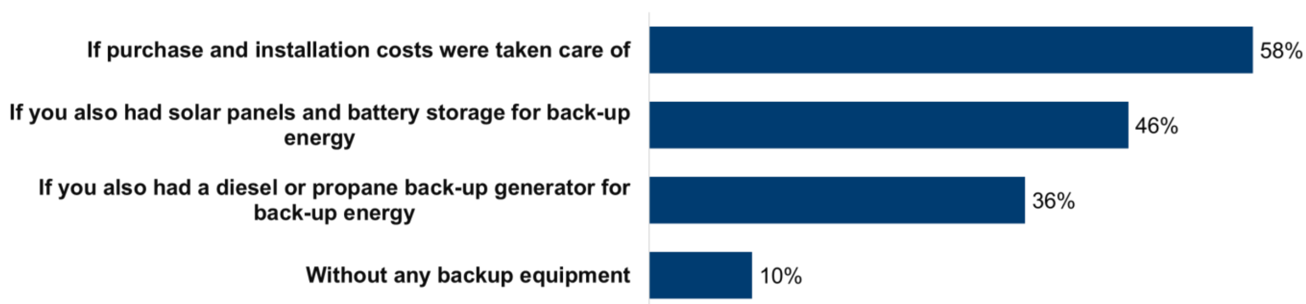
Figure 90. Building Owner's Willingness to Replace Current Water Heater with an Electric Appliance



Question D6a-d. When your organization's current water heater fails, how willing would you be to replace it with an electric appliance? (Weighted)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 ("Not at all willing") and 5 ("Very willing"). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

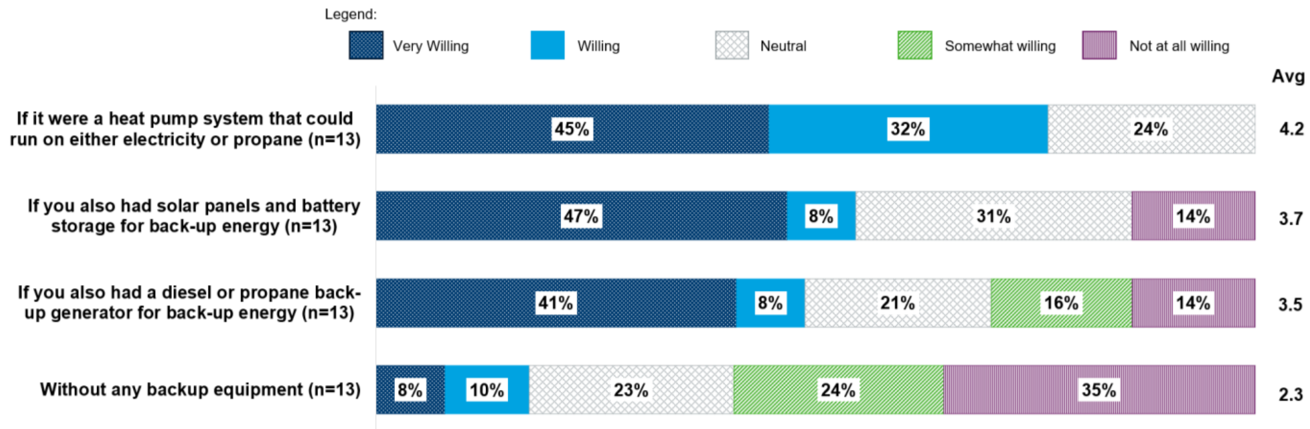
Figure 91. Building Owners Willing to Replace their Current Water Heater with an Electric Appliance (n = 21)



Question D6a-d. When your organization's current water heater fails, how willing would you be to replace it with an electric appliance? (Weighted)

Note: This figure shows the percentage of respondents who rated these scenarios with a 4 or 5 out of a 5-point scale.

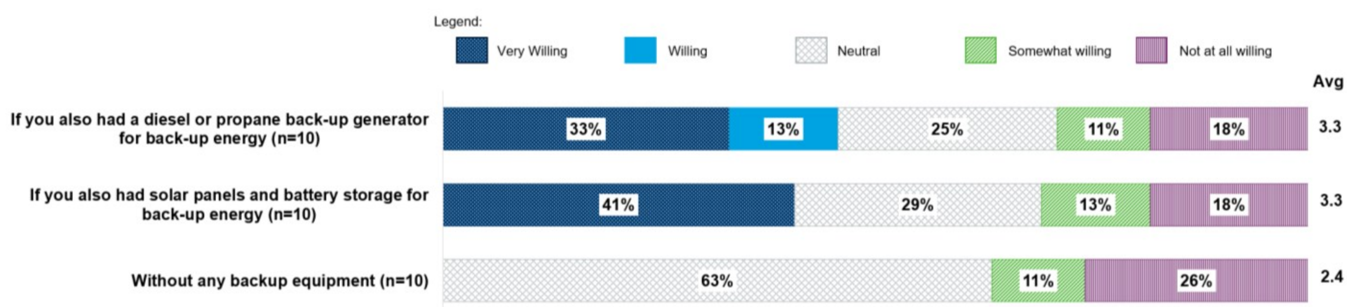
Figure 92. Building Tenant's Supportiveness to Replace Current Heating System with an Electric Appliance



Question C9 a-d. When your organization's current heating system fails, how supportive would you be if the building owner replaced it with an electric appliance? (Weighted)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 ("Not at all supportive") and 5 ("Very supportive"). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

Figure 93. Building Tenant's Supportiveness to Replace Current Water Heater Equipment with an Electric Appliance



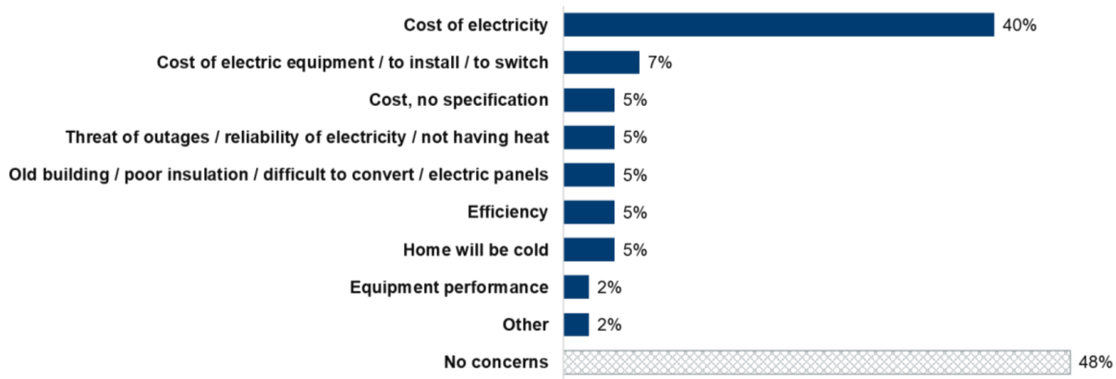
Question D7a-c. When your organization's current water heater fails, how supportive would you be if the building owner replaced it with an electric appliance? (Weighted)

Note: Respondents rated these questions on a 5-point scale, with anchors provided for 1 ("Not at all supportive") and 5 ("Very supportive"). Labels were not provided for values 2 through 4; the labels shown in the legend for this figure are for interpretive purposes.

Potential Concerns with Electric Appliances

Similar to overall residential and nonresidential respondents, the most common concern residential renters and building tenants had with replacing their current heating system with an electric appliance was the cost of electricity. Both residential renters (48%) and nonresidential tenants (55%) had substantial portions of respondents who were not concerned with building owners replacing their existing heating equipment with electric.

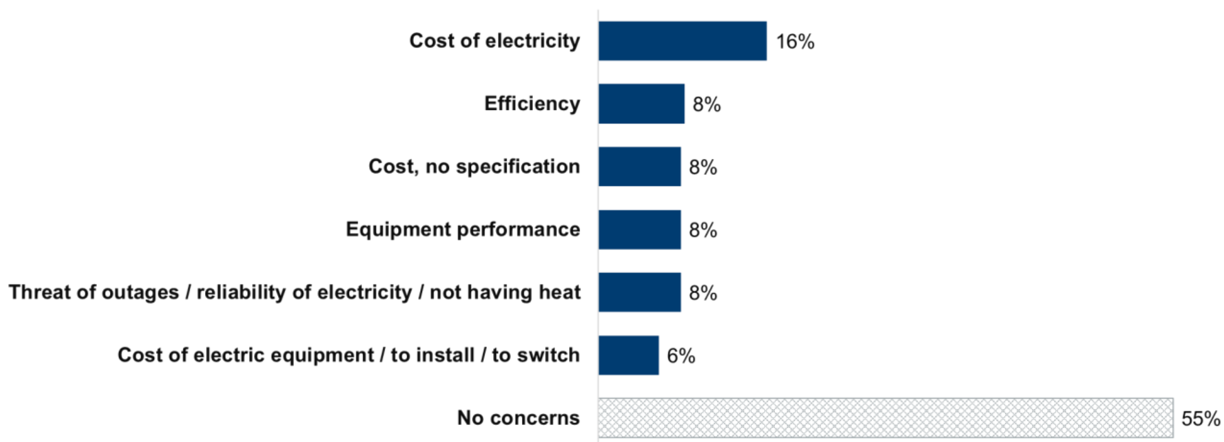
Figure 94. Residential Renters' Concerns on Having their Current Heating System Replaced with an Electric Appliance (n = 42)



Question C0b. Imagine your home heating systems breaks beyond repair, and the building owner can't replace it with another propane heating appliance. What concerns, if any, would you have if they replaced it with an electric heater? (Unweighted Results)

Note: Sum is greater than 100% because respondents often stated multiple concerns in their response. Other n = 1: "Accessibility and reliability."

Figure 95. Nonresidential Tenants' Concerns on Replacing their Current Heating System with an Electric Appliance (n = 13)



Question C0b. Imagine your organization's heating system breaks beyond repair, and the building owner can't replace it with another propane heating appliance. What concerns, if any, would you have if they replaced it with an electric heater? (Weighted Results)

Note: Sum is greater than 100% because respondents often stated multiple concerns in their response.

Residential and Nonresidential Propane Pricing Analysis

This section presents the methodology used to calculate both residential and nonresidential propane pricing across different tank sizes. The research team asked residential and nonresidential survey respondents for their propane tank size, as well as the approximate cost to refill their tank. Using their responses to both questions, we identified the average cost per tank size. Table 42 below summarizes the average price of propane per gallon, both weighted and unweighted.

Table 42. Average Price of Propane per Gallon (Weighted and Unweighted)

Sector	Tank Size	Average Price (Unweighted)	Average Price (Weighted)	Number of Responses (Unweighted)	Number of Responses (Weighted)	$/gal propane
RES	20 lbs.	~~$250.00~~ [a]	~~$102.28~~ [a]	11	12	$6.90 [b]
RES	120 gal	$327.17	$329.79	24	26	$2.75
RES	250 gal	$470.31	$477.42	69	72	$1.91
RES	500 gal	$790.35	$646.71	31	43	$1.29
RES	1000 gal	$784.00	$679.24	5	3	$0.68
NONRES	120 gal	$395.83	$408.33	6	6	$3.40
NONRES	250 gal	$482.56	$489.32	9	9	$1.96
NONRES	500 gal	$731.25	$737.19	8	8	$1.47
NONRES	1000 gal	$2,002.14	$1,934.94	7	8	$1.93

[a] Both the unweighted and weighted average price values for 20 lbs. size tanks are stricken out as they were not used in the final propane price per gallon calculation due to variation in prices.

[b] The research team observed a considerable variation in prices for the 20 lbs. propane tank size, so the value presented here is the average price per gallon from online research.

As seen on the table above, responses showed a clear trend of lower cost per gallon for larger tank sizes due to economies of scale. Since the research team did not observe a difference in cost within each tank size, we calculated the weighted average cost per gallon across all responses, and combined responses from both the residential and nonresidential surveys. The calculation came to $2.22 per gallon. However, we did not use this estimate because the survey only asked respondents for their tank size and the approximate cost to refill their tank. The survey did not ask respondents how full the tank was at the time of refill. It is likely that customers typically refill their tank when there is still some propane left in the tank, and our calculations above do not reflect this.

Thus, the research team used the Department of Energy’s EIA estimate for the national average of residential propane costs, which comes down to an average cost of $2.59 per gallon (Energy Information Administration, 2025). We arrived at this number by calculating the average cost of propane from October 2024 to March 2025. However, this is the national average cost of propane, and the EIA did not provide an average for a region that includes California. For this reason, the research team used the EIA estimate and added an additional 6% to the price, based on a previous study that assumes that the relationship between the national crude oil and propane prices would apply to California's crude oil and propane prices. The study found that the price of crude oil was typically higher in California than it is nationally (Evergreen Economics, 2024). Propane is a byproduct of crude oil refining, and crude oil prices are tracked at the state and national level, and the price of propane is strongly correlated with the price of crude oil (Evergreen Economics, 2024). Based on these assumptions, we estimated the California propane cost per gallon to be $2.74.

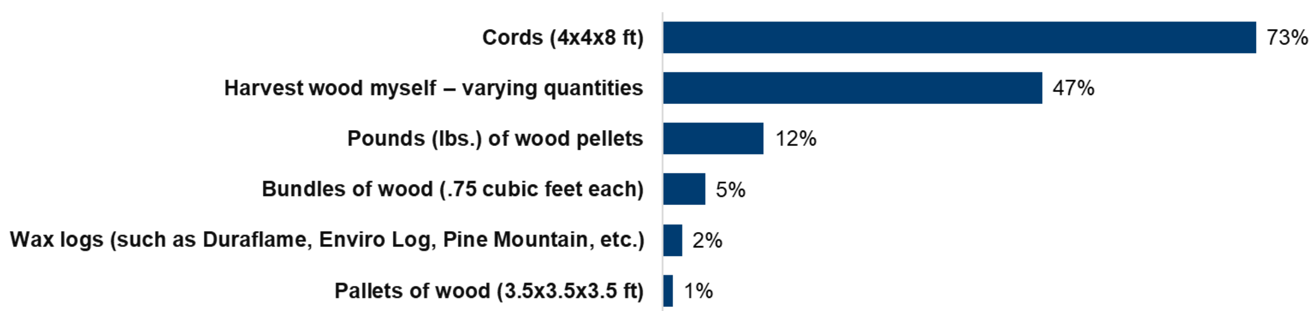
Wood Related Survey Results

This section contains information about how residential respondents reported purchasing wood along with additional questions related to wood burning that are not already contained in the main body of the report.

How Wood is Purchased

Almost 75% of residential respondents who said they used wood as their primary heating source get wood in cords. Almost half said they harvested their wood themselves, as shown in the figure below. Customers could select multiple options, so the responses totaled 140%. Normalizing the total results to 100%, 52% reported they purchase wood in cords (4x4x8ft), 34% reported harvesting wood themselves, 9% reported purchasing pounds of wood pellets, and the remaining responses accounted for 5%.

Figure 96. How Residential Respondents Get Wood (n = 86)



Question W2a. Which of the options below best describes how you get wood in your household? (Weighted)

Note: Sum is greater than 100% because respondents were allowed to select multiple responses.

Additional Survey Results Related to Wood

This section contains additional results related to wood burning among residential respondents.

Table 43. U.S. EPA Certification Labels Reported by Respondents for Their Wood or Pellet Stoves

Do you have a U.S. EPA certification label on your wood or pellet stove?	% of respondents (n = 36)
Yes, I have a certification label	83%
No, I do not have a certification label	17%

Question W1. Do you have a U.S. EPA certification label on your wood or pellet stove? (Weighted)

Table 44. Amount of Wood Respondents Reported Burning in a 12-Month Period

How Much Wood or Wax Logs Respondents Burned in the Past 12 Months (List of Answers Provided by Each Respondent)
1 Cords (4x4x8 ft)
1 Cords (4x4x8 ft)
1 Cords (4x4x8 ft)
1 Cords (4x4x8 ft), Harvest wood myself
1.5 Cords (4x4x8 ft)
1.5 Cords (4x4x8 ft)
1.75 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft)
2 Cords (4x4x8 ft), Harvest wood myself
2 Cords (4x4x8 ft), 20 Wax logs (such as Duraflame, Enviro Log, Pine Mountain, etc.)
2.5 Cords (4x4x8 ft)
2.5 Cords (4x4x8 ft)
2.5 Cords (4x4x8 ft), Harvest wood myself
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft)
3 Cords (4x4x8 ft), (No specified number) Truck loads
3 Cords (4x4x8 ft), (No specified number) Truck loads
3 Cords (4x4x8 ft), 2 Wax logs (such as Duraflame, Enviro Log, Pine Mountain, etc.)
3.5 Cords (4x4x8 ft)
3.5 Cords (4x4x8 ft), Harvest wood myself
4 Cords (4x4x8 ft)
4 Cords (4x4x8 ft)
4 Cords (4x4x8 ft)
4 Cords (4x4x8 ft)

How Much Wood or Wax Logs Respondents Burned in the Past 12 Months (List of Answers Provided by Each Respondent)
4 Cords (4x4x8 ft)
4 Cords (4x4x8 ft)
4 Cords (4x4x8 ft)
4 Cords (4x4x8 ft), Harvest wood myself
4.5 Cords (4x4x8 ft)
5 Cords (4x4x8 ft)
5 Cords (4x4x8 ft)
5 Cords (4x4x8 ft)
5 Cords (4x4x8 ft), Harvest wood myself
6 Cords (4x4x8 ft)
6 Cords (4x4x8 ft)
6 Cords (4x4x8 ft)
6 Cords (4x4x8 ft), Harvest wood myself
8 Cords (4x4x8 ft), Harvest wood myself
Face cords (1.5x4x8 ft), "A few logs here and there" as bundles of wood (.75 cubic feet each)
10 Bundles of wood (.75 cubic feet each)
10 Bundles of wood (.75 cubic feet each)
20 Bundles of wood (.75 cubic feet each)
12 Wax logs (such as Duraflame, Enviro Log, Pine Mountain, etc.)
50 Wax logs (such as Duraflame, Enviro Log, Pine Mountain, etc.)
20 Wax logs (such as Duraflame, Enviro Log, Pine Mountain, etc.), 50 Bundles of wood (.75 cubic feet each)
1 Pallet of wood (3.5x3.5x3.5 ft), 5 Bundles of wood (.75 cubic feet each)
10 Pallets of wood (3.5x3.5x3.5 ft)
3 Pallets of wood (3.5x3.5x3.5 ft), (Didn't specify number) Pounds (lbs.) of wood pellets
"A pallet of 40 pound bags of pellets."
1 ton of wood pellets
1,200 Pounds (lbs.) of wood pellets
2,000 Pounds (lbs.) of wood pellets
3,000 Pounds (lbs.) of wood pellets
3,500 Pounds (lbs.) of wood pellets
3,500 Pounds (lbs.) of wood pellets
5,000 Pounds (lbs.) of wood pellets
6,000 Pounds (lbs.) of wood pellets
"175 ft at 6-in diameter. My wood is custom cut smaller than normal firewood"
(Don’t know how many) Bundles of wood (.75 cubic feet each)
(Don’t know how many) Bundles of wood (.75 cubic feet each)
(Don’t know how many) Bundles of wood (.75 cubic feet each)
(Don’t know how many) Cords (4x4x8 ft)

How Much Wood or Wax Logs Respondents Burned in the Past 12 Months (List of Answers Provided by Each Respondent)
(Don't know how many) Pounds (lbs.) of wood pellets
(Don't know how many) Cords (4x4x8 ft), (Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
(Don't know how much) Harvest wood myself
Don't know

Question W2a. Which of the options below best describes how you get wood in your household? (Unweighted)

Questions W2b. Please indicate how much wood or wax logs you burned in the past 12 months in your wood burning device. (Unweighted)

Note: Each row represents one respondent's answers, combining W2a and W2b. Respondents could select up to two different ways that they get wood, so each row may contain more than one response. Responses in quotation marks are explanation provided by respondents where they selected "Other" in question W2a.

Table 45. Respondents' Preferred Storage Options for Wood and Wood Pellets

Which option best describes how you store your wood or wood pellets at home?	% of respondents (n = 85)
Completely covered, outdoors (e.g., under tarp or dedicated structure)	57%
Completely covered, no climate control (e.g., garage, shed, cellar)	28%
Partially covered, outdoors (some wood exposed)	8%
Not covered, outdoors (entirely exposed to elements)	4%
Completely covered with climate control (e.g., basement with AC/heating)	2%
Other	0%

Question W3. Which option best describes how you store your wood or wood pellets at home? (Weighted)

Note: Total may not equal 100% due to rounding.

Table 46. Wood Types Respondents Reported Burning

Which type of wood do you burn most often?	% of respondents (n = 79)
Oak	45%
Douglas Fir	16%
Madrone	14%
Pine	7%
Alder	3%
Maple	1%
Almond	1%
Other	13%

Question W4. Which type of wood do you burn most often? (Weighted)

Table 47. Wood burning Appliances Used as Respondents' Main Home Heating Source

What is the main appliance used to heat your home? (Among those who reported burning wood)	% of respondents (n = 87)
Woodstove (heated with logs / wood splits)	61%
Wood burning fireplace	24%
Pellet stove	12%
Wood burning furnace	3%
Other	0%

Question A7c. What is the main appliance used to heat your home? (Weighted)

Table 48. Energy Sources Respondents Reported for Additional Heating Equipment

What is the energy source for the additional heating equipment in your home?	% of respondents (n = 140)
Propane or other bottled gas (e.g., butane, liquid petroleum)	45%
Electricity	37%
Wood or wood pellets	12%
Kerosene	2%
Solar	2%
Natural gas	1%
Other	1%

Question B1a. What is the energy source for the additional heating equipment in your home? (Weighted)

Table 49. Additional Heating Equipment Among Those Who Reported Burning Wood

What is the other appliance used to heat your home? (Among those who reported burning wood as a secondary heating source)	% of respondents (n = 26)
Woodstove (heated with logs / wood splits)	43%
Wood burning fireplace	41%
Pellet stove	16%

What is the other appliance used to heat your home? (Among those who reported burning wood as a secondary heating source)	% of respondents (n = 26)
Other	0%

Question B1a_3. What is the other appliance used to heat your home? (Weighted)

Appendix C. Bot Detection Process

During fielding of the survey, the research team identified responses that were likely from bots[48], because they met several of the criteria described below (e.g., IP address outside the US., very short survey completion time, etc.). The research team believes that programmers of bots found out about the survey through social media postings (e.g., Facebook postings by community-based organizations recruiting participants), and that they targeted the survey because the survey advertisement offered a gift card for completion.

As described below, the research team used multiple criteria to determine if respondents should be flagged as bots or humans and removed the “likely bot” responses from the data.

Criteria Used for Bot Respondent Detection

The research team identified different criteria that could be used to flag responses that were likely bots. Because some criteria were clearly indicative of bots whereas other criteria did not necessarily indicate a fraudulent response on their own, the research team developed a system where responses were flagged as bots based on a combination of the type and number of criteria. Criteria were organized into three categories: Level 1, Level 2, and Level 3.

- **Level 1 (Bot)** criteria were strongly indicative of bots. **If a response met just one** of these criteria, it was flagged as a bot.
- **Level 2 (Bot)** criteria were indicative of bots, but less so than Level 1 (Bot) criteria. If a response met one of the Level 2 (Bot) criteria, **it also had to meet at least one other** criteria (in Level 2 or 3) to be flagged as a bot. This is because there are explanations for real respondents
- **Level 3 (Bot)** criteria were indicative of bots, but less so than Level 2 (Bot) criteria. If a respondent met one of the Level 3 (Bot) criteria, **they also had to meet at least two other criteria** (in Level 2 or 3) to be flagged as a bot. Table 50 below describes the different criteria:

Table 50. Bot Respondent Detection Criteria

Criteria Level	Criteria
Level 1 (Bot)	Survey duration was less than 300 seconds

[48] While we use the term “bots”, this method also identified and removed humans that did not meet the eligibility criteria for taking the survey – for example people that do not use propane or wood to heat their homes or water or that do not live in California, or where quality of responses was low.

Criteria Level	Criteria
	IP address was categorized as "High Risk" when entered into online IP address fraud check tool[49]
	Qualtrics Q_RecaptchaScore was less than 0.4[50]
Level 2 (Bot)	Qualtrics latitude / longitude coordinates were outside of the United States
	Qualtrics latitude / longitude coordinates were outside of California and were the exact same as the coordinates of one or more other respondents
	Qualtrics latitude / longitude coordinates were within California and were the exact same as the coordinates of three or more other respondents
	IP address was the same as the IP address of one or more other respondents
	Response to an open-ended question was very nonsensical or worded very strangely. Example: response to question asking about concerns they would have replacing their current heating appliance with an electric heater (D0a in the Residential survey) was "The greatest concern is safety risk. One can lose life to electricity shock"
	Response to an open-ended question followed a repeated structure used in other responses—for example, similar patterns of syntax, capitalization, or phrases
Level 3 (Bot)	Qualtrics latitude / longitude coordinates were outside of California (but not the exact same as three or more other respondents)
	IP address was categorized as "Medium Risk" when entered into online IP address fraud check tool[51]
	Qualtrics Q_RecaptchaScore was between 0.4 and 0.7[52]
	Zip code entered by respondent did not match respondent's selected region
	(*For Nonresidential survey*) Business name could not be found using a Google search in the respondent's indicated zip code
	Respondent's name was duplicative of another respondent's name
	Email address was strange—for example, did not match the name of the respondent, consisted of many different letters with no discernable words, had an unfamiliar domain name
	Respondent completed the survey around the same time as multiple other respondents and shows a pattern characteristic shared by those other respondents (for example, multiple respondents answered the survey around the same time and used the same operating system, or answered the same open-ended question with the same syntax)

[49] The research team used Scamalytics (https://scamalytics.com/), which offers a free IP address fraud check.

[50] Qualtrics' Q_RecaptchaScore uses Google's invisible reCaptacha technology and can be used to determine whether a response is more likely a bot or a human. (https://www.qualtrics.com/support/survey-platform/survey-module/survey-checker/fraud-detection/)

[51] See Footnote 49.

[52] See Footnote 50.

Criteria Used to Flag Respondents as Humans

The research team also used criteria that indicated that respondents were humans, not bots. We organized these criteria similarly to the Bot Detection Criteria in two categories: Level 1 and Level 2.

- **Level 1 (Human)** criteria were strongly indicative of human respondents. **If a respondent met just one** Level 1 (Human) criteria **and did not meet any of the Bot Detection criteria** described in Table 51, they were flagged as a human.
- **Level 2 (Human)** criteria were indicative of human respondents, but less so than Level 1 (Human) criteria. If a respondent met one of the Level 2 (Human) criteria, **they also had to meet at least one other** criteria **and not meet any of the Bot Detection criteria** to be flagged as a human. Table 51 below describes the different criteria:

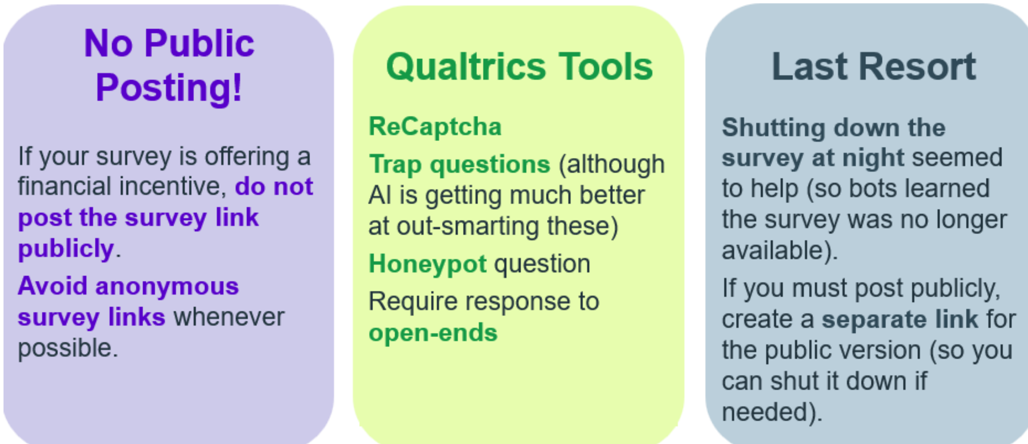
Table 51. Human Respondent Detection Criteria

Criteria Level	Criteria
Level 1 (Human)	Respondent mentioned something specific in an open-ended response, such as a utility name or a local landmark
	Research team recruited respondent via letter in the mail
	Research partner or community-based organization confirmed that they corresponded with respondent
Level 2 (Human)	Open-ended response made sense / was reasonable
	Respondent provided a reasonable answer regarding cost to fill their propane tank: • 20 lb. tank: $50 - $150 • 120 gallon tank: $100 to roughly $300 • 250 gallon tank: roughly $300 • 500 gallon tank: roughly $300 to $1,000
	Respondent provided a reasonable answer regarding the number of cords they purchase each winter (between 0.5 and several cords)
	Respondent answered that they found out about the survey from research partners that performed outreach in their region around the time they completed the survey: • CCAC for Central Valley • RCEA for the Northern Region • Ecology Action for the Central Region
	Respondent answered that they are Native American, and that they found out about the survey through Native Energy Resources

Lessons Learned for Future Studies

Based on our experience from this study, the research team identified the steps in Figure 97 below on how to reduce the risk of getting bot responses in a survey.

Figure 97. Steps to Reduce Risk of Bots Infiltrating a Survey



The research team also identified the following lessons learned on how to clean results if bots infiltrate a survey.

- Using multiple levels of criteria was helpful for using an efficient process for immediately filtering out Level 1 bot responses, while retaining responses that needed more review (Levels 2 or 3).
- There were several respondents that met one criteria for level 2 or 3 but were later determined to be human. For example, several respondents took the survey outside of California but were later confirmed as human because a CBO confirmed they had reached out to that person directly. This highlights the importance of using multiple criteria to flag respondents as bots.
- One respondent was initially flagged as a possible bot because she had a low ReCaptcha score (0.6), but she was later determined to likely be a human, since her open-ended responses made sense and her responses to similar questions in the survey were consistent. For example, she reported she did not have access to electricity, and she did not report a value for a later question that asked for an estimate of her electricity bill. This respondent met several categories that could be categorized as hard-to-reach, since she was Spanish speaking, low-income, and living in a mobile home. It is possible her low Recaptcha Score was because she is less familiar with technology and the Recaptcha test (e.g., select the squares with the traffic lights). Again, this highlights the importance of using multiple criteria to flag respondents as bots, and (for respondents that were harder to classify as bots or humans) reviewing both for indications they were a bot and for indications they were human. This is also an important equity consideration for future studies, particularly studies that target populations that may be less comfortable with technology.
- For some respondents where it was difficult to make a final determination if they were bots or human, the research team was conservative in both directions: we provided a gift card

but did not keep the data. The research team was able to make a final determination in most cases, so this case only applied to approximately a dozen respondents.

Appendix D. Additional Bill Impact Study Details

The ResStock and ComStock models used for the study are categorized in Table 52 below.

Table 52. Number of ResStock and ComStock Models Used by Building Type and Region

Building Types	Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
Single-family w/ AC, Propane Heat	112	72	160	143	94	166
Single-family w/o AC, Propane Heat	39	22	50	49	26	37
Single-family w/o AC, Wood Heat	40	6	22	25	14	18
Mobile Home w/ AC, Propane Heat	7	7	23	24	7	28
Mobile Home w/o AC, Propane Heat	4	1	6	6	1	11
Restaurant, Propane Heat w/ A/C	4	1	2	2	15	3
Small Hotel, Propane Heat w/ A/C	7	10	5	7	22	5
Small Office, Propane Heat w/ A/C	10	15	25	38	43	25

Specific equipment types used in each residential building type are shown in Table 53 below. Ranges in efficiency reflect ranges across the baseline models.

Table 53. Modeled Residential Equipment Details

Scenario & Equipment Type	HVAC	Hot Water	Additional Measures
Existing, Propane Heat w/ A/C	Packaged A/C & forced air propane furnace, 60%-90% AFUE	Propane water heater, tankless (95% AFUE) or storage (76% AFUE)	N/A
Existing, Propane Heat w/o A/C	Propane furnace (wall or forced air), 60%-92.5% AFUE	Propane water heater, tankless (95% AFUE) or storage (76% AFUE)	N/A
Existing, Wood Heat w/o A/C	Wood stove, 54% AFUE, or pellet stove, 68% AFUE	Propane water heater, tankless (95% AFUE) or storage (76% AFUE)	N/A
Primary Heat Pump Scenario	ASHP SEER 16, 9.5 HSPF, 70% capacity retention @ 5F, with existing propane backup	240V HPWH, 3.35 UEF	N/A
Electric Resistance Alternative	Packaged A/C & electric forced air furnace, 98% AFUE	Electric storage water heater, 92% AFUE	N/A
Low Peak Demand Alternative	ccASHP SEER 20, 11 HSPF, 90% capacity retention @ 5F, with electric resistance backup	120V HPWH, 3.0 UEF	30% reduction in air leakage, R-49 attic insulation, 4kW PV

Specific equipment types used in each nonresidential building type are shown in Table 54 below. Ranges in efficiency or different equipment types reflect ranges across the baseline models.

Table 54. Modeled Nonresidential Equipment Details

Scenario & Equipment Type	HVAC	SHW	Additional Measures
Existing Restaurant, Propane Heat w/ A/C	RTU Packaged Gas Furnace & A/C	Storage propane water heater, 80% AFUE	N/A
Existing Small Hotel, Propane Heat w/ A/C	Packaged Terminal A/C & Gas Heat or RTU Packaged Gas Furnace & A/C	Storage propane water heater, 80% AFUE	N/A
Existing Small Office, Propane Heat w/ A/C	RTU Packaged Gas Furnace & A/C	Storage propane water heater, 80% AFUE	N/A
Restaurant, Primary Heat Pump Scenario	RTU ASHP, Full Load COP of 3.42	240V HPWH, 3.4 UEF	N/A
Small Hotel, Primary Heat Pump Scenario	Packaged Terminal ASHP, Full Load COP 4.11, or RTU ASHP, Full Load COP of 3.42	240V HPWH, 3.4 UEF	N/A
Small Office, Primary Heat Pump Scenario	RTU ASHP, Full Load COP of 3.42	240V HPWH, 3.4 UEF	N/A
All Buildings, Electric Resistance Alternative	Packaged Electric Furnace & A/C, 98% AFUE	240V HPWH, 3.4 UEF	N/A
Restaurant, Low Peak Demand Alternative	RTU ccASHP, Full Load COP of 3.76	240V HPWH, 3.4 UEF	100% LED Lighting
Small Hotel, Low Peak Demand Alternative	Packaged Terminal ASHP, Full Load COP 4.50, or RTU ASHP, Full Load COP of 3.76	240V HPWH, 3.4 UEF	100% LED Lighting
Small Office, Low Peak Demand Alternative	RTU ASHP, Full Load COP of 3.76	240V HPWH, 3.4 UEF	100% LED Lighting

The linear models used to determine the costs of different heat pump types and sizes based on California's TECH program data are shown below. Additional models and estimates were made using RSMeans cost data.

Table 55. Residential Heat Pump Linear Cost Models from TECH Data

Heat Pump Type	Existing A/C?	Panel Upgrade?	Cost per project (Y-intercept)	Cost per Mbtu/hr (slope)	Sample size
Standard	Yes	No	$13,257	$189	11,478
Cold Climate	Yes	No	$13,815	$169	9,197
Standard	No	No	$9,532	$283	7,730
Cold Climate	No	No	$9,260	$302	8,701
Standard	Yes	Yes	$16,937	$131	599
Cold Climate	Yes	Yes	$15,558	$169	409
Standard	No	Yes	$11,855	$230	427
Cold Climate	No	Yes	$9,982	$320	487

The linear models used to determine the costs of different heat pump water heater types and sizes based on California's TECH program data are shown below. Additional models and estimates were made using RSMeans cost data.

Table 56. Residential Heat Pump Water Heater Linear Cost Models from TECH Data

HPWH Type	Panel Upgrade?	Cost per project (Y-intercept)	Cost per gallon (slope)	Sample size
Standard	No	$259	$109	3,309
High Efficiency	No	$4,100	$48	3,490
120V	No	-$3,976	$156	1,492
Standard	Yes	$3,908	$79	1,666

The fuel rates used in the study are summarized in Table 57 below.

Table 57. Utility and Fuel Rate Details

Utility and Fuel Rates				
Utility or Fuel Type	**Type**	**Rate**	**Details**	**Regions Used**
Pacific Gas & Electric	Residential	E-TOU-B	Between $0.58/kWh and $0.40/kWh	Northern Coastal Sierra, North Central Valley, South Central Valley, Southern Coastal
	Residential	E-ELEC	Between $0.61/kWh and $0.34/kWh, only for electric retrofits	
	Commercial	B-1 TOU	Between $0.51/kWh and $0.40/kWh	
Southern California Edison	Residential	TOU-D-4-9PM	Between $0.59/kWh and $0.26/kWh, tiered	South Central Valley, Southern Coastal, Southern Inland
	Residential	TOU-D-PRIME	Between $0.56/kWh and $0.24/kWh, only for electric retrofits	
	Commercial	TOU-GS-1-E	Between $0.60/kWh and $0.18/kWh plus $0.51/day	
Trinity Public Utilities District	Residential	Residential Service	Flat $0.047/kWh rate plus $39/month	Northern Coastal, Sierra
	Commercial	Commercial Service	Flat $0.065/kWh rate plus $58/month	
Modesto Irrigation District	Residential	D-RES	Between $0.21/kWh and $0.15/kWh, tiered, plus $32/month	North Central Valley, South Central Valley

Utility and Fuel Rates				
	Commercial	GS-TOU	Between $0.15/kWh and $0.08/kWh plus $217/month	
Imperial Irrigation District	Residential	TOU-D	Between $0.42/kWh and $0.12 per kWh plus $10.50/month	Southern Coastal, Southern Inland
	Commercial	TOU-GS	Between $0.52/kWh and $0.10 per kWh plus $17.50/month	
Propane	Both	$2.74/gallon	Derived from EIA national values	All
Wood	Residential	$8.30/mmBtu	Weighted average of CARB estimates of $/cord and $/pellet sack	All

The following tables show the full analysis results for residential homes with heat pump upgrades by region and by existing equipment type, single-family homes with both electric resistance and low peak demand upgrade alternatives, and nonresidential buildings with heat pump upgrades by region.

Table 58. Single-Family Homes w/ AC & Propane Heat - Results Summary of Heat Pump Upgrade by Region

Single-Family Homes w/ AC & Propane Heat - Results Summary of Heat Pump Upgrade by Region								
		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost	$4,176	$5,513	$5,698	$5,415	$4,223	$3,886
	ZE Energy Cost	$3,656	$4,737	$5,070	$4,871	$3,489	$3,141
	Energy Cost Savings	**$520**	**$777**	**$628**	**$544**	**$734**	**$745**
CARE	Baseline Energy Cost	$3,148	$4,328	$4,354	$4,077	$3,136	$2,950
	ZE Energy Cost	$2,425	$3,191	$3,343	$3,201	$2,299	$2,076
	Energy Cost Savings	**$723**	**$1,136**	**$1,011**	**$876**	**$837**	**$874**
POU	Baseline Energy Cost	$2,063	$3,167	$3,754	$3,486	$2,800	$2,694
	ZE Energy Cost	$1,000	$1,321	$2,858	$2,597	$2,063	$2,049
	Energy Cost Savings	**$1,063**	**$1,846**	**$896**	**$889**	**$737**	**$645**
Baseline Replacement Cost		$12,211	$12,770	$12,217	$12,231	$12,042	$11,980
ZE Replacement Cost		$25,034	$26,692	$25,002	$25,193	$24,364	$24,336
Incremental Cost		**$12,824**	**$13,922**	**$12,785**	**$12,962**	**$12,321**	**$12,357**
IOU Payback Period (years)		24.7	17.9	20.4	23.8	16.8	16.6
CARE Payback Period (years)		17.7	12.3	12.7	14.8	14.7	14.1
POU Payback Period (years)		12.1	7.5	14.3	14.6	16.7	19.2

Table 59. Single-Family Homes w/o AC & Propane Heat - Results Summary of Heat Pump Upgrade by Region

Single-Family Homes w/o AC & Propane Heat - Results Summary of Heat Pump Upgrade by Region		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost	$4,604	$2,619	$4,410	$3,601	$3,597	$2,292
	ZE Energy Cost	$4,092	$3,165	$4,640	$4,303	$3,621	$2,470
	Energy Cost Savings	**$512**	**-$546**	**-$230**	**-$701**	**-$24**	**-$178**
CARE	Baseline Energy Cost	$3,574	$2,204	$3,601	$2,816	$2,817	$1,809
	ZE Energy Cost	$2,679	$2,112	$3,063	$2,817	$2,370	$1,620
	Energy Cost Savings	**$895**	**$92**	**$538**	**-$1**	**$447**	**$189**
POU	Baseline Energy Cost	$2,208	$1,948	$3,359	$2,599	$2,502	$1,822
	ZE Energy Cost	$1,053	$988	$2,582	$2,344	$2,108	$1,639
	Energy Cost Savings	**$1,155**	**$960**	**$777**	**$255**	**$394**	**$183**
Baseline Replacement Cost		$9,123	$8,838	$8,998	$9,108	$9,018	$8,769
ZE Replacement Cost		$26,372	$24,398	$24,909	$25,285	$24,346	$24,013
Incremental Cost		**$17,249**	**$15,560**	**$15,911**	**$16,178**	**$15,328**	**$15,243**
IOU Payback Period (years)		33.7	No Payback	No Payback	No Payback	No Payback	No Payback
CARE Payback Period (years)		19.3	No Payback	29.6	No Payback	34.3	80.9
POU Payback Period (years)		14.9	16.2	20.5	63.4	38.9	83.3

Table 60.Single-Family Homes w/ Wood Heat - Results Summary of Heat Pump Upgrade by Region

Single-Family Homes w/ Wood Heating - Results Summary of Heat Pump Upgrade by Region							
		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost	$3,775	$4,049	$3,667	$3,067	$3,428	$2,173
	ZE Energy Cost	$4,048	$4,180	$4,768	$4,106	$3,746	$2,473
	Energy Cost Savings	**-$272**	**-$131**	**-$1,101**	**-$1,040**	**-$318**	**-$299**
CARE	Baseline Energy Cost	$2,773	$3,288	$2,889	$2,463	$2,460	$1,577
	ZE Energy Cost	$2,648	$2,717	$3,108	$2,686	$2,435	$1,619
	Energy Cost Savings	**$125**	**$571**	**-$219**	**-$223**	**$25**	**-$42**
POU	Baseline Energy Cost	$1,795	$2,425	$2,721	$2,301	$2,083	$1,577
	ZE Energy Cost	$993	$1,038	$2,606	$2,235	$2,184	$1,632
	Energy Cost Savings	**$803**	**$1,387**	**$116**	**$66**	**-$101**	**-$55**
Baseline Replacement Cost		$10,501	$10,501	$10,501	$10,501	$10,501	$10,501
ZE Replacement Cost		$24,678	$25,097	$24,998	$24,236	$24,181	$23,869
Incremental Cost		**$14,177**	**$14,597**	**$14,497**	**$13,736**	**$13,680**	**$13,368**
IOU Payback Period (years)		No Payback	No Payback	No Payback	No Payback	No Payback	No Payback
CARE Payback Period (years)		No Payback	25.5	No Payback	No Payback	No Payback	No Payback
POU Payback Period (years)		17.7	10.5	No Payback	No Payback	No Payback	No Payback

Table 61. Mobile Homes w/ AC & Propane Heat - Results Summary of Heat Pump Upgrade by Region

Mobile Homes w/ AC & Propane Heat - Results Summary of Heat Pump Upgrade by Region							
		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost	$3,197	$4,541	$3,559	$3,547	$2,247	$2,594
	ZE Energy Cost	$3,042	$4,157	$3,084	$3,532	$1,774	$2,338
	Energy Cost Savings	**$156**	**$384**	**$475**	**$16**	**$473**	**$257**
CARE	Baseline Energy Cost	$2,245	$3,599	$2,711	$2,927	$1,650	$2,005
	ZE Energy Cost	$1,977	$2,721	$2,055	$2,373	$1,154	$1,527
	Energy Cost Savings	**$268**	**$878**	**$656**	**$554**	**$496**	**$478**
POU	Baseline Energy Cost	$1,238	$2,427	$2,637	$2,706	$1,484	$2,016
	ZE Energy Cost	$853	$1,100	$1,835	$2,043	$1,109	$1,549
	Energy Cost Savings	**$385**	**$1,327**	**$802**	**$664**	**$375**	**$467**
Baseline Replacement Cost		$11,908	$12,022	$11,603	$11,698	$11,669	$11,646
ZE Replacement Cost		$22,136	$23,712	$21,089	$21,549	$21,314	$21,207
Incremental Cost		**$10,228**	**$11,690**	**$9,486**	**$9,851**	**$9,645**	**$9,561**
IOU Payback Period (years)		65.7	30.4	20.0	No Payback	20.4	37.3
CARE Payback Period (years)		38.2	13.3	14.5	17.8	19.4	20.0
POU Payback Period (years)		26.6	8.8	11.8	14.8	25.7	20.5

Table 62. Single-Family Homes w/ AC & Propane Heat - Results Summary of Low Peak Demand Upgrade by Region

Single-Family Homes w/ AC & Propane Heat - Results Summary of Low Peak Demand Upgrade by Region							
		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost	$2,753	$5,089	$3,383	$2,944	$2,299	$1,811
	ZE Energy Cost	$1,432	$2,091	$2,375	$1,766	$1,075	$997
	Energy Cost Savings	**$1,321**	**$2,998**	**$1,007**	**$1,178**	**$1,225**	**$814**
CARE	Baseline Energy Cost	$3,148	$4,328	$4,354	$4,077	$3,136	$2,950
	ZE Energy Cost	$931	$1,359	$1,544	$1,148	$699	$648
	Energy Cost Savings	**$2,217**	**$2,969**	**$2,810**	**$2,929**	**$2,437**	**$2,302**
POU	Baseline Energy Cost	$2,063	$3,167	$3,754	$3,486	$2,800	$2,694
	ZE Energy Cost	$635	$733	$1,422	$1,148	$827	$717
	Energy Cost Savings	**$1,428**	**$2,434**	**$2,332**	**$2,338**	**$1,972**	**$1,977**
Baseline Replacement Cost		$12,211	$12,770	$12,217	$12,231	$12,042	$11,980
ZE Replacement Cost		$40,581	$43,783	$41,219	$42,126	$40,100	$39,992
Incremental Cost		**$28,370**	**$31,014**	**$29,002**	**$29,894**	**$28,058**	**$28,012**
IOU Payback Period (years)		21.5	10.3	28.8	25.4	22.9	34.4
CARE Payback Period (years)		12.8	10.4	10.3	10.2	11.5	12.2
POU Payback Period (years)		19.9	12.7	12.4	12.8	14.2	14.2

Table 63. Single-Family Homes w/ AC & Propane Heat - Results Summary of Electric Resistance Upgrade by Region

Single-Family Homes w/ AC & Propane Heat - Results Summary of Electric Resistance Upgrade by Region							
		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost	$4,176	$5,513	$5,698	$5,415	$4,223	$3,886
	ZE Energy Cost	$6,045	$8,236	$8,372	$7,775	$5,629	$4,790
	Energy Cost Savings	**-$1,869**	**-$2,723**	**-$2,674**	**-$2,360**	**-$1,407**	**-$904**
CARE	Baseline Energy Cost	$3,148	$4,328	$4,354	$4,077	$3,136	$2,950
	ZE Energy Cost	$3,929	$5,375	$5,468	$5,054	$3,674	$3,127
	Energy Cost Savings	**-$781**	**-$1,048**	**-$1,115**	**-$977**	**-$538**	**-$178**
POU	Baseline Energy Cost	$2,063	$3,167	$3,754	$3,486	$2,800	$2,694
	ZE Energy Cost	$1,262	$1,702	$4,433	$4,073	$3,203	$3,045
	Energy Cost Savings	**$801**	**$1,465**	**-$680**	**-$587**	**-$403**	**-$351**
Baseline Replacement Cost		$12,211	$12,770	$12,217	$12,231	$12,042	$11,980
ZE Replacement Cost		$20,134	$27,424	$20,599	$20,923	$17,909	$16,983
Incremental Cost		**$7,923**	**$14,655**	**$8,382**	**$8,692**	**$5,867**	**$5,003**
IOU Payback Period (years)		No Payback	No Payback	No Payback	No Payback	No Payback	No Payback
CARE Payback Period (years)		No Payback	No Payback	No Payback	No Payback	No Payback	No Payback
POU Payback Period (years)		9.9	10.0	No Payback	No Payback	No Payback	No Payback

Table 64. Restaurants w/ Propane Heat - Results Summary of Heat Pump Upgrade by Region

Restaurants w/ Propane Heat - Results Summary of Heat Pump Upgrade by Region		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost/sf	$15.77	$17.31	$30.96	$26.00	$18.08	$16.32
	ZE Energy Cost/sf	$15.69	$18.80	$30.31	$25.05	$16.77	$14.74
	Energy Cost Savings/sf	**$0.08**	**-$1.49**	**$0.66**	**$0.95**	**$1.31**	**$1.58**
POU	Baseline Energy Cost/sf	$4.61	$5.34	$9.48	$9.48	$9.17	$9.79
	ZE Energy Cost/sf	$2.49	$3.58	$7.74	$7.74	$7.46	$7.98
	Energy Cost Savings/sf	**$2.13**	**$1.76**	**$1.74**	**$1.74**	**$1.71**	**$1.81**
Baseline Replacement Cost		$12.23	$10.38	$14.44	$14.44	$11.67	$12.83
ZE Replacement Cost		$25.89	$22.77	$32.33	$32.33	$24.77	$24.72
Incremental Cost		**$13.66**	**$12.39**	**$17.88**	**$17.88**	**$13.10**	**$11.89**
IOU Payback Period (years)		No Payback	No Payback	27.1	18.8	10.0	7.5
POU Payback Period (years)		6.4	7.0	10.3	10.3	7.7	6.6

Table 65. Small Hotels w/ Propane Heat - Results Summary of Heat Pump Upgrade by Region

Small Hotels w/ Propane Heat - Results Summary of Heat Pump Upgrade by Region							
		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost/sf	$2.11	$2.56	$2.77	$2.55	$2.44	$2.15
	ZE Energy Cost/sf	$2.06	$2.01	$2.69	$2.49	$2.34	$2.04
	Energy Cost Savings/sf	**$0.05**	**$0.55**	**$0.08**	**$0.06**	**$0.10**	**$0.11**
POU	Baseline Energy Cost/sf	$0.46	$0.90	$0.89	$0.90	$1.14	$1.25
	ZE Energy Cost/sf	$0.34	$0.45	$0.73	$0.81	$1.00	$1.13
	Energy Cost Savings/sf	**$0.12**	**$0.45**	**$0.17**	**$0.09**	**$0.14**	**$0.13**
Baseline Replacement Cost		$12.49	$16.47	$13.80	$14.48	$13.90	$17.69
ZE Replacement Cost		$11.42	$16.60	$12.48	$13.03	$12.84	$27.19
Incremental Cost		**-$1.07**	**$0.13**	**-$1.32**	**-$1.45**	**-$1.07**	**$9.50**
IOU Payback Period (years)		Instant	0.2	Instant	Instant	Instant	88.6
POU Payback Period (years)		Instant	0.3	Instant	Instant	Instant	76.0

Table 66. Small Offices w/ Propane Heat - Results Summary of Heat Pump Upgrade by Region

Small Offices w/ Propane Heat - Results Summary of Heat Pump Upgrade by Region							
		Northern Coastal	Sierra	North Central Valley	South Central Valley	Southern Coastal	Southern Inland
IOU	Baseline Energy Cost	$5.01	$3.78	$4.95	$4.58	$4.88	$5.29
	ZE Energy Cost	$3.87	$3.57	$4.52	$3.67	$3.56	$3.72
	Energy Cost Savings	**$1.13**	**$0.21**	**$0.42**	**$0.91**	**$1.32**	**$1.57**
POU	Baseline Energy Cost	$1.21	$1.20	$1.97	$1.94	$2.48	$3.17
	ZE Energy Cost	$0.70	$0.83	$1.55	$1.44	$1.58	$2.08
	Energy Cost Savings	**$0.51**	**$0.37**	**$0.43**	**$0.50**	**$0.90**	**$1.09**
Baseline Replacement Cost		$9.71	$11.25	$7.65	$7.13	$9.28	$11.17
ZE Replacement Cost		$19.57	$24.46	$23.39	$15.24	$18.86	$22.01
Incremental Cost		**$9.87**	**$13.21**	**$15.74**	**$8.11**	**$9.57**	**$10.84**
IOU Payback Period (years)		8.7	62.1	37.1	8.9	7.3	6.9
POU Payback Period (years)		19.5	35.8	36.9	16.1	10.6	10.0

Appendix E. Map of Tribal Lands

Figure 98 shows a map of California Tribal Lands from the U.S. EPA. According to the ACS (a subset of the American Census data), 86% of census block groups in California where at least 75% of households use wood as their primary heat sources are in tribal areas. The ACS defines tribal areas as American Indian reservations (state or federal), American Indian tribal subdivisions, off-reservation trust lands, State Designated Tribal Statistical Areas, and Tribal Designated Statistical Areas[53]. It was beyond the scope of this project to compare the tribal area definition from the ACS with EPA's definition of tribal lands for this map, but the EPA does list the American Census as one of the sources for its map.

[53] www.census.gov: My Tribal Area

Figure 98. California Tribal Lands (source: U.S. EPA[54])

[54] California Tribal Lands (epa.gov)

Appendix F. Survey Instruments & Outreach Materials

This appendix contains copies of the survey instruments and outreach materials used for the residential and nonresidential surveys.

Survey Instruments

This section contains the residential and nonresidential survey instruments used for data collection. The survey instruments indicate whether questions were asked of panel respondents compared to non-panel respondents. They also note which questions were added to help identify bot respondents as well as answer options added to open-ended questions for coding purposes during analysis.

2024 CARB Propane Building Utilization Residential Survey FINAL 2025.04.16.pdf

2024 CARB Propane Building Utilization Nonresidential Survey FINAL 2025.04.16.pdf

Outreach Materials

This section contains copies of the recruitment flyers sent to residences and businesses within the sampled communities advertising the residential and nonresidential surveys, in both English and Spanish.

CARB Residential Flyers_12-19-2024.pdf

CARB Nonresidential Flyers_12-19-2024.pdf