Opinion Dynamics

IMPACT OF INCENTIVES ON CUSTOMER FUEL SUBSTITUTION

RESEARCH FOR THE CALIFORNIA INVESTOR-OWNED UTILITIES

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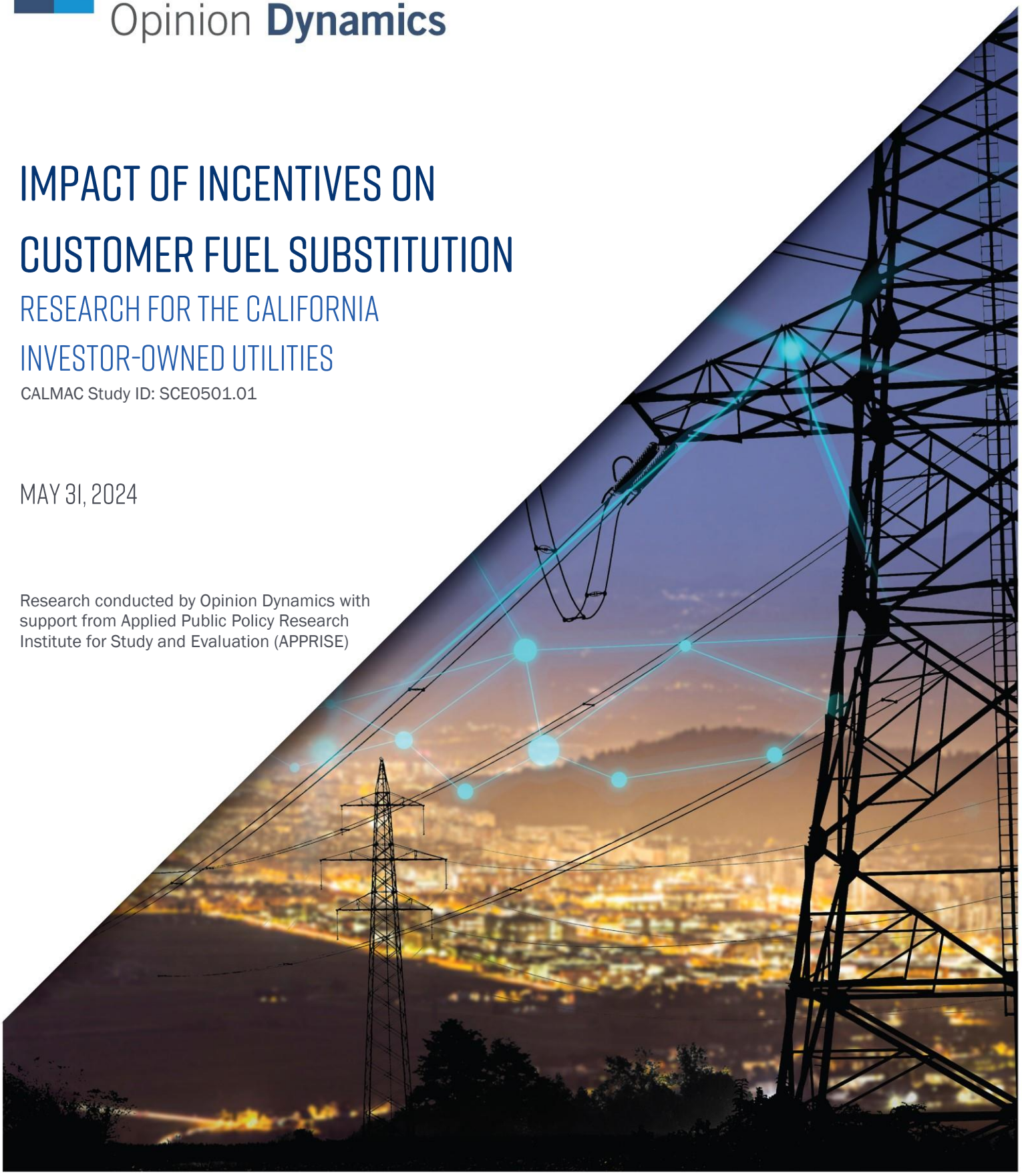

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I. EXECUTIVE SUMMARY

This study describes the impact of incentives on customer decision-making regarding fuel substitution within the California Investor-Owned-Utility (IOU) service territories: Pacific Gas & Electric (PG&E), Southern California Edison (SCE), Southern California Gas Company (SoCalGas), and San Diego Gas & Electric (SDG&E). As part of a larger effort seeking a viable electric alternative to gas measures, the California Public Utilities Commission issued Decision 23-04-035 directing "further studies on infrastructure costs and the impact of incentives on customer fuel substitution." The impact of incentives on customer fuel substitution is still largely undetermined and the decision directed California's Investor-Owned Utilities (IOUs) to fund a market study for market rate customers and for equity segment customers.[1] The Decision indicated, "Each of these market studies should seek to address what would happen to consumer choices if incentives for non-cost-effective and other gas efficiency measures are eliminated, and customer-side economics of heat pump installation." The overall purpose of this study is to provide the CPUC with valuable insights to inform future policy development to encourage greater fuel substitution in California.

Specifically, this study addressed the following research objectives:

- Quantify the impact of incentives on customer fuel substitution for market rate and equity customers;
- Understand the impact on consumer choices if incentives for non-cost-effective and other gas efficiency measures are eliminated;[2]
- Explore the level of incentives and for what electric equipment and services are needed to ensure that customers choose to pursue fuel substitution over conventional gas equipment;
- Assess the customer-side economics and other considerations for choosing to replace an existing gas unit with a heat pump; and
- Identify how local, state, and federal decarbonization resources (e.g., funding, technical support) may be used to support equity segment customers' adoption of fuel substitution measures.

I.I METHODS

The study findings are based upon three distinct data collection activities:

- **Landscape Analysis:** A literature review and equity stakeholder feedback informed a landscape analysis, which provided context and understanding of the fuel substitution landscape.
  - **Literature Review:** The Team reviewed and summarized existing research and available secondary sources to help characterize California's current market.
  - **Equity Stakeholder Feedback:** The Team conducted in-depth telephone interviews with 11 community stakeholders serving hard-to-reach or underserved customers and disadvantaged communities in IOU service territories (representing the equity segment of this study). The Team also conducted a public webinar at the initiation of the study and requested written stakeholder feedback to key research questions at that time.
- **Customer Surveys:** The online customer surveys captured perceptions and attitudes directly from 584 residential and 321 commercial customers, split into market rate and equity customer segments. These surveys included

[1] Decision 23-04-035 does not include the Energy Savings Assistance (ESA) program for income-qualified customers.

[2] Decision 23-04-035 intends to eliminate ratepayer-funded incentives for non-exempt, non-cost-effective gas efficiency appliances with a viable electric alternative.

questions about awareness and familiarity with heat pump technologies for space and water heating, barriers and opportunities for encouraging adoption, and willingness to pay at varying incentive levels. The surveys targeted IOU customers that use natural gas for at least one space or water heating end use.

1.1.1 CUSTOMER SEGMENTATION

Decision 23-04-035 directed California's IOUs to fund a market study for market rate and equity segment customers. The Research Team conducted the landscape analysis and online customer surveys to identify similarities and differences among the following customer sectors and segments:

- **Residential Market Rate:** All California households that are not equity segment households.
- **Residential Equity Segment:** Hard-to-reach or underserved customers and residents of disadvantaged communities, per Decision 23-06-055.
- **Commercial Market Rate:** All California businesses that are not equity segment businesses.
- **Commercial Equity Segment:** Small, hard-to-reach businesses located in disadvantaged communities, per Decision 23-06-055.

For more details about the characteristics of these customer segments, please see the Study Inclusion section of this report.

1.2 KEY FINDINGS

This section highlights the key findings from this market study.

1.2.1 CURRENT MARKET LANDSCAPE FOR SPACE HEATING AND WATER HEATING FUEL

According to secondary data, natural gas is the predominant fuel for space and water heating in California across both the residential and commercial sector. As shown in Table 1, residential equity customers (households with an income less than 80% state median income) are more likely than residential market rate customers (households with an income greater than 80% state median income) to use electricity for space heating (28% compared to 20%, respectively).[3] However, water heating fuel penetration is consistent regardless of household income. Less than 20% of all California households use electricity for water heating.

[3] Due to the limitations of secondary data, the Research Team could not always segment findings from the literature review based on the equity definitions included in Decision 23-06-055. The Team defines the specifications of equity and market rate segments in these instances.

Among commercial customers, about two-thirds (67%) use natural gas for space heating and more than half (58%) use natural gas for water heating, as shown in Table 1. The available secondary data did not allow for segmentation of commercial sector fuel penetration by market rate and equity segments. However, according to the 2018 Commercial Building Energy Consumption data, buildings with fewer than 10 main shift employees represent 74% of all commercial buildings for the Pacific region (<10 employees serves as an equity indicator as part of the definition of hard-to-reach businesses, per the CPUC).[4] Overall, commercial sector penetration of electricity for space and water heating is larger than the residential sector.

Table 1. California Fuel Penetration Across End Uses

Metric	Residential Market Rate[a]	Residential Equity[b]	Commercial Sector[c]
Space Heating			
Electricity	20%	28%	31%
Natural Gas	76%	68%	67%
Other	4%	4%	2%
Water Heating			
Electricity	19%	19%	40%
Natural Gas	78%	78%	58%
Other	3%	3%	2%

[a] *Source: 2020 Residential Energy Consumption Survey (RECS) for California households greater than 80% state median income.*
[b] *Source: 2020 RECS for California households with less than 80% state median income.*
[c] *Source: 2022 California Commercial End-Use Survey (CEUS) Appendix P for all California businesses.*

I.2.2 CURRENT MARKET PENETRATION FOR HEAT PUMP TECHNOLOGIES

TECH Clean California,[5] California's statewide initiative to accelerate the adoption of clean space and water heating technologies launched in 2021. Before then, incentives for heat pump technologies were available but did not have significant uptake among residential or commercial customers. Given the emerging nature of incentives in the marketplace and the nascence of heat pump technology itself in California, market penetration of heat pump technologies is currently low, especially among residential customers.

According to the 2020 Residential Energy Consumption Survey (RECS), only 4% of California households use heat pumps for space heating. Although California's residential heat pump penetration increased from 1% in 2009, it remains less than a third of the national average for space heating (14%). When broken down by income, 4% of California households with incomes greater than 80% state median income use heat pumps for space heating and 5% of California households with less than 80% state median income use heat pumps for space heating.

Specifically, looking at the residential equity segment, about one-third of low-to-moderate income (LMI) households (those with incomes less than 80% state median income) reside in multifamily buildings. The penetration rate among LMI multifamily households was nearly double that of the residential California average (9% compared to 4%). Less than 1% of California households use heat pump water heaters.

[4] https://www.eia.gov/consumption/commercial/data/2018/bc/pdf/b4.pdf
[5] https://techcleanca.com/

According to 2018 Commercial Building Energy Consumption data for the Pacific Census Division, commercial sector penetration of heat pumps is much higher than for residential (17% compared to 4%). This commercial sector statistic is for the full Pacific Census Division which includes California, Oregon, Washington, Hawaii, and Alaska. The California-specific commercial penetration is likely lower but was not tracked by 2018 Commercial Building Energy Consumption data.

Table 2. California Heat Pump Penetration Across End Uses

Metric	Residential Market Rate	Residential Equity	Commercial Sector
Space Heating			
Central Heat Pump	3%[a]	3%[b]	17%[d]
Ductless Heat Pump	1%[a]	2%[b]	
Water Heating			
Heat Pump Water Heater	<1%[c]		N/A

[a] *Source: 2020 RECS for California households greater than 80% state median income.*
[b] *Source: 2020 RECS for California households with less than 80% state median income.*
[c] *Source: 2019 Residential Appliance Saturation Survey (RASS) for all California households.*
[d] *Source: 2018 Commercial Building Energy Consumption data for the Pacific Census Division which covers California, Oregon, Washington, Hawaii, and Alaska.*

1.2.3 BARRIERS AND MOTIVATIONS TO FUEL SUBSTITUTION

Based on the landscape analysis and customer surveys, customers show uncertainty around how electric equipment will operate compared to natural gas alternatives and a limited understanding of the purpose of transitioning from natural gas equipment to electric equipment. Below we describe the key barriers to and motivations for fuel substitution.

UPFRONT/OPERATING COSTS

Overall, customers have concerns about heat pump technologies' upfront and operating costs. While incentives could address upfront costs, concerns over rising electricity rates serve as a barrier to substituting gas for electric equipment.

Residential customers indicated that annual operating costs and upfront costs are the primary drivers of customer decision-making for new space heating and cooling equipment (collectively driving 60% of the decision-making process).[6] Preference for one fuel type over the other accounted for less than one-fifth of preferences (17%). Among commercial customers, at least two-thirds of survey respondents indicated that upfront cost (73%), energy efficiency (67%), and operation/energy costs (66%) are key considerations when purchasing HVAC equipment.

The landscape analysis identified multiple studies that pointed to electric rate concessions as a necessity to encourage fuel substitution. Specifically, The *Equity and Electrification-Driven Rate Policy Options*[7] study reported that electrification necessarily increases electricity usage and demand, both overall and for individual customers. Without policy action to lower energy burdens—especially for LMI households—and efficiently incorporate new demand for electricity, increased electrification could result in higher electricity rates and electric bills, which could deter fuel substitution. According to the residential conjoint exercises conducted to estimate market demand for air source heat pumps, market demand increases from 23% to 31% for the residential segment in a simulated scenario where electricity rates decrease and gas rates increase.

[6] Note that survey questions informing these estimates asked customers to focus on equipment and operating costs and did not address associated installation or infrastructure costs.
[7] https://www.aceee.org/white-paper/2023/09/equity-and-electrification-driven-rate-policy-options

FAMILIARITY

Despite low adoption to-date, both residential and commercial customers generally demonstrate moderate levels of familiarity with heat pump technologies, though familiarity is somewhat lower for water heating than for HVAC. As shown in Table 3, about half of California's residential and commercial customers are familiar with HVAC heat pump technologies, while about one third are familiar with heat pump water heaters. The Research Team found no statistical differences in familiarity between the residential equity and market rate segments. However, among commercial survey respondents, statistically more equity customers reported being "not at all familiar" with heat pump space and water heating equipment than their market rate counterparts.

When asked about common benefits and drawbacks of heat pumps, many customers were not sure if they agreed or disagreed with these sentiments, indicating a lack of education about the technology. As shown in Table 3, more than one third of residential customers were unsure of stated heat pump benefits and more than half were unsure of common drawbacks. Up to one-quarter of commercial customers were unsure about common heat pump benefits, and only 14% of commercial survey respondents reported previous knowledge of the challenges or drawbacks of heat pumps.

About two-thirds of residential and commercial survey respondents would not adopt a heat pump technology, even if the utility covered 100% of the incremental cost of the equipment compared to a gas alternative (up to $1,500 for residential HVAC heat pumps and $1,000 for water heating). Many such customers say they are unfamiliar with heat pump technologies, suggesting additional education could increase future uptake.

Table 3. Familiarity with Heat Pump Technologies

Metric	Residential Market Rate	Residential Equity	Commercial Market Rate	Commercial Equity
% At least somewhat familiar with central air source heat pumps	52%	45%	46%	44%
% At least somewhat familiar with ductless mini split heat pumps	48%	49%	N/A[a]	N/A[a]
% At least somewhat familiar with water heat pump technology	34%	29%	38%	30%
% Considered new HVAC equipment but did not pursue a heat pump because they preferred a more familiar technology	29% (n=56)	40% (n=94)	50% (n=28)	45% (n=53)
% Unsure of heat pump technology benefits	31%-42% depending upon benefit	36%-44% depending upon benefit	15%-23% depending upon benefit	18%-26% depending upon benefit
% Unsure of heat pump technology drawbacks	42%-56% depending upon benefit	50%-62% depending upon benefit	Only 14% of commercial survey respondents reported previous knowledge of the challenges or drawbacks of heat pumps.	

[a] The commercial survey instrument did not include a question about familiarity with ductless mini split heat pumps.

Source: Opinion Dynamics survey

SEGMENT-SPECIFIC BARRIERS AND MOTIVATIONS

The landscape analysis and online customer surveys also indicated specific barriers and opportunities for heat pump adoption that impact each of this study's focused customer segments, as shown in Table 4.

Table 4. Segment-Specific Barriers and Motivations for Heat Pump Technology Adoption

Metric	Residential Market Rate	Residential Equity	Commercial Market Rate	Commercial Equity
Barrier	▪ Permitting hassles/costs ▪ Contractors not recommending heat pump equipment	▪ Utility bill affordability ▪ Wait until equipment failure for replacement ▪ Confined space for equipment installations ▪ Split incentive for renters (building owner is decision-maker) ▪ Less access to licensed contractors ▪ Window/room air conditioning replacement requires infrastructure upgrades	▪ Split incentive (building owner is decision-maker)	▪ Uncertainty of efficient heating performance ▪ Do not prioritize energy efficiency or equipment performance over cost
Motivation	▪ Environmental impacts ▪ Net metering customers invested in electrification	▪ Indoor air quality ▪ Smaller household size aligns with ductless options	▪ Carbon reductions ▪ Energy efficiency	▪ Smaller business size aligns with ductless options

Source: Landscape analysis and Opinion Dynamics survey

I.2.4 IMPACT OF INCENTIVES ON CUSTOMER DECISION-MAKING

Program administrators and policy makers can use purchase incentives to lift installations of heat pumps for space and water heating. Residential and commercial customers are more likely to install heat pumps when the utility provides a purchase incentive, as shown in Table 5. Market demand presented here reflects the portion of customers replacing gas space heating or water heating equipment who would be likely to pursue applicable heat pump equipment at each incentive level based on responses to customer surveys. Financial incentives covering the incremental cost of equipment can entice as much as one-third of the market to substitute fuels for space or water heating.[8]

Table 5. Heat Pump Market Demand by Customer Segment

Heat Pump Type and Incentive Level	Residential Market Rate (n=52)	Residential Equity (n=138)	Commercial Market Rate (n=67)	Commercial Equity (n=134)
Air Source Heat Pump for Space Heating (Replace on Burnout)[a]				
Minimum Incentive ($0)	24%	15%	21%	18%
Maximum Incentive ($1,500 for residential; 100% of incremental cost for commercial)	29%	21%	37%	34%
Heat Pump Water Heater for Water Heating				
Minimum Incentive ($0)	12%	11%	14%	12%
Maximum Incentive (100% incremental cost)	36%	34%	36%	33%

[a] The Research Team also tested an accelerated replacement scenario, but only among residential customers.

Source: Opinion Dynamics survey

[8] The market demand results presented here reflective of non-incentivized gas equipment costs.

Note that survey questions informing these estimates asked customers to focus on equipment and operating costs and did not address installation or infrastructure costs associated with each technology. Quantified infrastructure costs and their implications are the focus of a separate market study conducted in parallel with the research presented in this deliverable. Heat pump market demand estimates presented here are therefore most applicable to those customers for whom costly infrastructure upgrades would not be required to enable heat pump installation. Future heat pump market demand research should seek to incorporate recently established infrastructure cost findings to account for total installation costs when gauging impacts of incentives as the market continues to develop.

Although market demand for heat pumps increases as incentive levels increase, the relationship between the two is not linear. Regarding water heaters, the percentage increase in market demand is highest when the incentive shifts from covering 0% to 25% of the heat pump water heaters' incremental cost compared to a gas water heater. The study found diminishing returns in terms of percentage increase in demand for heat pump water heating equipment as incentives increased from 50%, to 75%, or 100% of the incremental cost. This is consistent across all customer sectors and segments, as shown in Table 6. This is also consistent with findings for commercial air source heat pumps.

Table 6. Percentage Increase in Market Demand for Heat Pump Water Heaters by Customer Segment

Incentive Level (as a % of Incremental Cost)	Residential Market Rate (n=221)	Residential Equity (n=322)	Commercial Market Rate (n=93)	Commercial Equity (n=139)
0% ($0)	N/A	N/A	N/A	N/A
25% ($250)	43%	44%	30%	32%
50% ($500)	21%	22%	26%	28%
75% ($750)	28%	30%	24%	26%
100% ($1,000)	37%	37%	28%	31%

Source: Opinion Dynamics survey

The Research Team relied on different methodologies to estimate market demand for residential air source heat pumps than for commercial air source heat pumps or water heating; however, the findings are similar. For residential market rate and equity customers, when the incentive increases from $0 to $500 for an air source heat pump, the percentage increase in market demand is higher than when the incentive increases to $1,000 or $1,500. This is consistent for both replace on burnout and accelerated replacement scenarios. However, an interesting difference in the replace on burnout and accelerated replacement scenarios is that the market demand for air source heat pumps for residential customers maxes out at the $1,000 incentive for the accelerated replacement scenario rather than $1,500 as it does for the replace on burnout scenario. Figure 1 and Figure 2 illustrate projected price sensitivity for the burnout and accelerated replacement scenarios, respectively.

Figure 1. Residential Heat Pump Price Sensitivity for Replace on Burnout

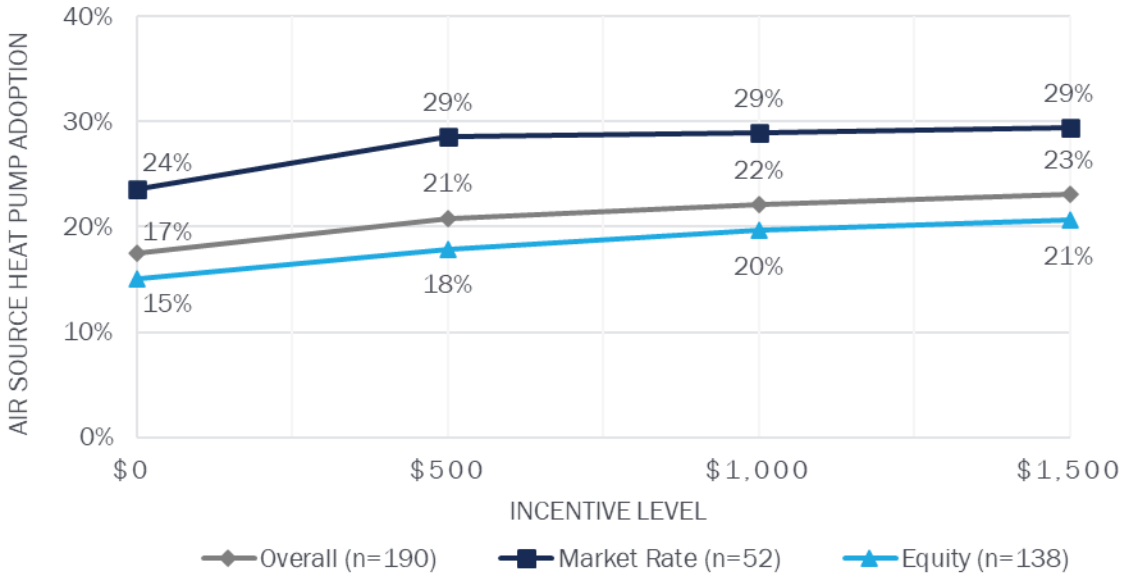
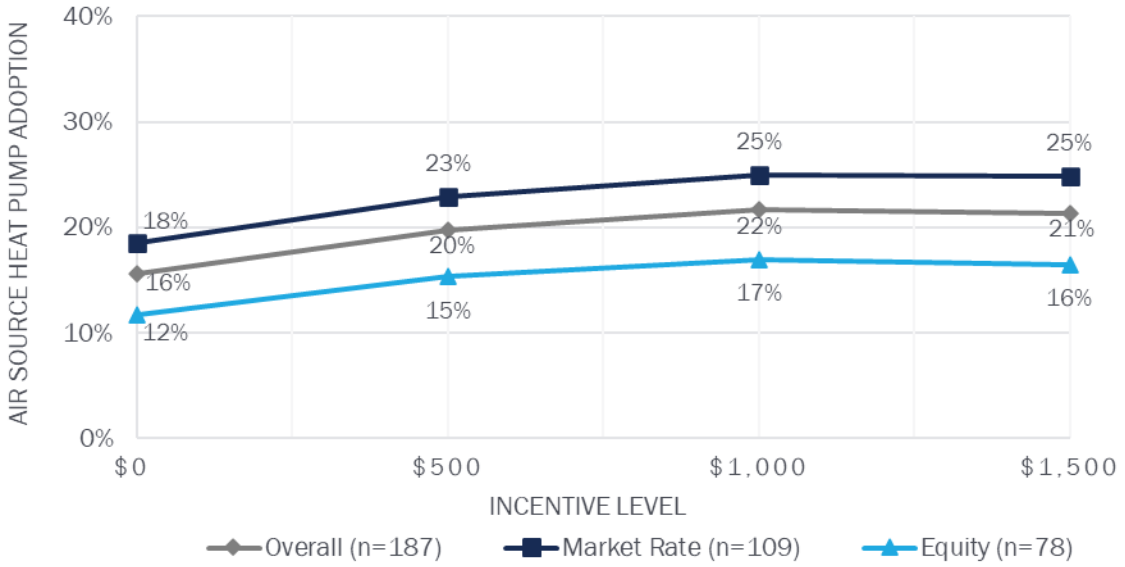


Figure 2. Residential Heat Pump Price Sensitivity for Accelerated Replacement



Equity customers are consistently less likely than market rate customers to substitute fuel for space or water heating, but incentives have relatively equal weight on both equity and market rate segments. This is consistent across both the residential and commercial sectors.

2. INTRODUCTION AND OVERVIEW

On April 6, 2023, the CPUC issued Decision 23-04-035 directing "further studies on infrastructure costs and the impact of incentives on customer fuel substitution." The impact of incentives on customer fuel substitution is still largely undetermined. The decision directed California's Investor-Owned Utilities (IOUs) to fund a market study for market rate and equity segment customers.[9] The decision indicated, "Each of these market studies should seek to address what would happen to consumer choices if incentives for non-cost-effective and other gas efficiency measures are eliminated, and customer-side economics of heat pump installation." The overall purpose of this study is to provide the CPUC with valuable insights to inform future policy development that encourages greater fuel substitution in California.

2.1 RESEARCH OBJECTIVES

This study aims to fulfill the following research objectives:

- Quantify the impact of incentives on customer fuel substitution for market rate and low-income/equity customers;
- Understand the impact on consumer choices if incentives for non-cost-effective and other gas efficiency measures are eliminated;[10]
- Explore the incentive level necessary for various electric equipment and services to ensure that customers choose to pursue fuel substitution over conventional gas equipment;
- Assess the customer-side economics and other considerations (e.g., workforce, costs, equipment availability) involved in choosing to replace an existing gas unit with a heat pump; and
- Identify how to leverage local, state, and federal decarbonization resources (e.g., funding, technical support) to support equity segment customers' adoption of fuel substitution measures.

2.2 STUDY INCLUSION

Decision 23-04-035 directed California's IOUs to fund a market study for market rate and equity segment customers. According to Decision 23-06-055, equity segment programs aim to provide energy efficiency to hard-to-reach or underserved customers and disadvantaged communities, advancing the *Environmental & Social Justice Action Plan*. For this study, the equity and market segments are defined as follows:

- **Equity Segment:** Hard-to-reach or underserved customers and disadvantaged communities, per D. 23-06-055.
- **Market Rate:** All customers that are not equity segment customers.

The *Environmental & Social Justice Action Plan Version 2.0* lists definitions for hard-to-reach, underserved, and disadvantaged communities, as shown in Table 7. This report reflects findings for residential and commercial sectors and compares results across the equity and market rate customer segments.

[9] Decision 23-04-035 does not include the Energy Savings Assistance (ESA) program for income-qualified customers.

[10] Decision 23-04-035 intends to eliminate ratepayer-funded incentives for non-exempt, non-cost-effective gas efficiency appliances with a viable electric alternative.

Table 7. CPUC Definitions for Environmental and Social Justice and Disadvantaged Communities

Equity Segment Category	Definition
Hard-to-Reach	Customers who do not have easy access to program information or generally do not participate in energy efficiency programs due to a combination of language, business size, geographic, and split incentive barriers. For the **Residential** sector (two criteria are considered sufficient if one of the criteria met is geographic): ▪ **Language** – Primary language spoken is other than English ▪ **Geographic** – Homes in disadvantaged communities (as designated by CalEPA) and/or areas other than the United States Office of Management and Budget Combined Statistical Areas of the San Francisco Bay Area, the Greater Los Angeles Area, and the Greater Sacramento Area or the Office of Management and Budget metropolitan statistical areas of San Diego County ▪ **Income** – Those customers who qualify for the California Alternative Rates for Energy (CARE) or the Family Electric Rate Assistance Program (FERA) ▪ **Housing Type** – Multifamily and mobile home tenants (rent and lease) For **Small Businesses** (two criteria are considered sufficient if one of the criteria met is geographic): ▪ **Language** – Primary language spoken is other than English ▪ **Geographic** – Businesses in disadvantaged communities (as designated by CalEPA) and/or areas other than the United States Office of Management and Budget Combined Statistical Areas of the San Francisco Bay Area, the Greater Los Angeles Area, and the Greater Sacramento Area or the Office of Management and Budget metropolitan statistical areas of San Diego County ▪ **Business Size** – Less than ten employees and/or classified as Very Small (customers whose annual electric demand is less than 20kW, or whose annual gas consumption is less than 10,000 therms, or both) ▪ **Leased or Rented Facilities** –Facility is rented or leased by business customer
Underserved	A community that meets one of the following criteria: ▪ **"Disadvantaged communities,"** or communities in the 25% highest scoring census tracts according to the California Communities Environmental Health Screening Tool (CalEnviroScreen), as well as all California tribal lands, census tracts with median household incomes less than 60% of state median income; and census tracts that score in the highest 5% of Pollution Burden within CalEnviroScreen, but do not receive an overall CalEnviroScreen score due to unreliable public health and socioeconomic data. ▪ **"Low-income communities,"** or census tracts with median household incomes at or below 80% of the statewide median income or with median household incomes at or below the threshold designated as low income by the Department of Housing and Community Development's list of state income limits. ▪ Located within an area identified as among the **most disadvantaged 25%** in the state, according to the California Environmental Protection Agency and based on CalEnviroScreen. ▪ A community in which at least **75% of public school students are eligible to receive free or reduced-price meals** under the National School Lunch Program. ▪ A community **located on lands belonging to a federally recognized California Indian tribe**.
Disadvantaged Communities	Communities in the **25% highest scoring census tracts according to CalEnviroScreen**, as well as all **California tribal lands**, census tracts with **median household incomes less than 60% of state median income**, and census tracts that score in the **highest 5% of Pollution Burden** within CalEnviroScreen, but do not receive an overall CalEnviroScreen score due to unreliable public health and socioeconomic data.

Source: CPUC. Environmental & Social Justice Action Plan Version 2.0. April 2022. esj-action-plan-v2jw.pdf

2.2.1 SURVEY RESPONDENT DEMOGRAPHICS

To ensure a representative population of equity customers was included in this study, the Research Team requested contact data from the IOUs for residential and commercial customers in census tracts identified by CalEnviroScreen as disadvantaged communities. Additionally, for commercial customers, all contacts included in the equity segment sample had an annual electric demand of less than 20 kW or annual gas consumption of less than 10,000 therms. The residential and commercial surveys were fielded in English and Spanish.

After prioritizing sampling residential customers in disadvantaged community census tracts to define the equity segment for this study, the Research Team confirmed that the cross-section of demographics for equity and market rate customers aligned with equity definition assignments. The demographic distribution of residential respondents is shown in Table 8.

Table 8. Demographics of Residential Survey Completes

Demographic	Residential Market Rate	Residential Equity	Overall
English is the primary language	93%	86%	89%
Receives CARE or FERA	12%	37%	25%
Annual household income less than $150,000	48%	66%	58%
Living in a multifamily building or mobile home	4%	6%	5%
Renters	2%	3%	3%

Similarly, for the commercial sector, the Research Team prioritized sampling customers with businesses located in disadvantaged community census tracts to define the equity segment for this study. Additionally, all businesses included in the commercial equity segment sample were considered small businesses based on annual energy consumption (as identified by the IOUs). The Research Team confirmed that the cross-section of demographics for equity and market rate commercial customers aligned with the equity definition assignments. Table 9 summarizes the demographic distribution of commercial respondents.

Table 9. Demographics of Commercial Survey Completes

Demographic	Commercial Market Rate	Commercial Equity	Overall
English is the primary language	95%	90%	92%
Business Size			
<10 Employees	44%	50%	48%
10+ Employees	56%	50%	52%
Facility ownership			
Own	64%	53%	57%
Rent	36%	47%	43%

2.3 METHODS

The research team utilized a mixed methods approach. The study began with a literature review of publicly available documents and fuel substitution research. This was combined with in-depth interviews of energy equity stakeholders to fulfill a landscape analysis. The findings were used to develop and field online surveys to fill in knowledge gaps in the landscape analysis.

2.3.1 LANDSCAPE ANALYSIS

LITERATURE REVIEW

The review of existing research and available secondary sources informed an understanding of California's current state of the electric and gas heating and cooling systems market. The Research Team assembled and reviewed existing research and secondary data sources directly applicable to customer preferences and impacts of incentives on electric and gas heating, cooling, and water heating equipment, emphasizing fuel substitution. The literature review sought to answer the following research questions:

- What is the market share and penetration of currently available electric and gas heating, cooling, and water heating equipment?
- What does existing research tell us about the influence of incentives on adopting high-efficiency electric and gas heating, cooling, and water heating equipment and fuel substitution?
- What are the key drivers and considerations when choosing between available heating, cooling, and water heating equipment?
- What additional costs (beyond incremental equipment costs) are associated with fuel substitution? What costs must be covered to make fuel substitution more likely for customers?
- What local, state, and federal decarbonization resources are available to customers interested in fuel substitution measures?

The Research Team identified six data sets and 16 research reports directly related to the research questions. The Team conducted searches of CPUC filings, California Energy Commission (CEC) proceedings, and websites of other California organizations studying these issues to identify appropriate research to review. The information sources included:

- Data Sets and Reports
- IOU Program Evaluation Reports
- Potential and Goals Studies
- Market Characterization Studies
- Technical Opportunities and Barriers Studies

The literature review focused on California-specific research and data. While there is some valuable information from other jurisdictions, it was determined that the California-specific information was more relevant to the study questions. The list of studies included in the literature review are detailed in Appendix A. Literature Review Sources.

EQUITY STAKEHOLDER INTERVIEWS

The Research Team conducted interviews to collect information from equity stakeholders on the priorities, barriers, and opportunities in the equity segment when considering new heating, cooling, or water heating equipment and fuel substitution overall. The interviews also explored how existing electric and gas incentives have affected decision-making in the equity sector, as well as the potential impact of proposed changes in those incentives (potential removal of non-cost-effective gas incentives). The interviews addressed the following research questions:

- What are the benefits and drawbacks of fuel substitution for equity segment customers?
- What are the primary barriers to and opportunities for equity segment customers adopting heat pump technologies?

- What are key drivers and considerations among equity customers when choosing between available heating, cooling, and water heating equipment?
- How have available electric and gas incentives for heating, cooling, and water heating equipment impacted equity segment customers' purchase decisions in recent years?
- What does it take to encourage equity segment customers to switch from natural gas and other delivered fuels to an all-electric building?
- What current and future partnership opportunities may exist for equity stakeholders to support fuel substitution among equity customers?

The Research Team conducted interviews with 11 organizations serving hard-to-reach or underserved customers and disadvantaged communities in IOU service territories. For each organization, the Team identified the best point of contact for each topic area, prioritizing those responsible for developing organizational policy, involved in program operation, and familiar with the households and businesses served by their organization. Most of the interviews were completed in one hour. The Research Team identified five types of equity stakeholder organizations to provide a valuable lens for informing key research questions:

- Low- and Moderate-Income (LMI) Program Managers: the Team reached out to organizations that manage programs that serve low- and moderate-income households. Those organizations have set policies and are responsible for deciding how their program will interface with ratepayer-funded energy efficiency and/or fuel substation programs.
- LMI Program Implementation Organizations: the Team contacted organizations that implement programs that serve low- and moderate-income households. Those organizations have direct experience working with equity segment customers and are likely to have insights into common opportunities and barriers regarding fuel substitution.
- Housing Program Managers: the Team reached out to the state housing program agency and housing technical assistance organizations to assess the extent to which they have incorporated clean energy objectives into their program designs. Their insights were particularly important to understanding whether and how existing energy-efficiency program incentives have been incorporated into retrofits of affordable multifamily housing and construction of affordable multifamily housing, and the extent to which fuel substitution initiatives have been incorporated into the policies for retrofits and new construction.
- Small Business Organizations: Small businesses, particularly those outside the major metropolitan areas and those whose owners speak a language other than English are an important part of the equity segment. The Team identified and reached out to organizations that are serving small businesses.
- Statewide and Community Advocacy Organizations: the Team contacted statewide and local organizations that advocate on behalf of equity customers for energy affordability and clean energy solutions.

The Team developed an initial list of the organizations that would be targeted for interviews (n=12) and shared it with the IOUs and other stakeholders. The Team conducted interviews with the 11 organizations listed in Table 10. A summary of the interview findings is included in Appendix B. Equity Stakeholder Interview Summary.

Table 10. Equity Stakeholder Interviews

Organization	Stakeholder Type	Stakeholder Role
CA Department of Community Services & Development (CSD)	LMI Program Manager	Implements federally funded Weatherization Assistance Program (WAP), the federally funded LIHEAP Equipment Replacement Program and LIHEAP Weatherization Program, and the state funded Low Income Weatherization Program (LIWP)

Organization	Stakeholder Type	Stakeholder Role
California Energy Commission (CEC)	LMI Program Manager	Responsible for administering the Inflation Reduction Act funds and for implementing the state-funded Direct Install Program
Association for Energy Affordability (AEA)	LMI Program Implementation Organization	Program implementer for the LIWP program, provides technical assistance for new construction through the BULD program, and furnishes technical assistance mainly to multifamily building owners on how to make use of other energy efficiency and fuel substitution programs
Community Resource Project	LMI Program Implementation Organization	Implementation contractor for the CSD programs, including WAP, LIHEAP Weatherization, LIHEAP Equipment Replacement, and LIWP
FCI Management	LMI Program Implementation Organization	Energy Savings Assistance (ESA) contractor that furnishes energy services for other California ratepayer funded programs and programs in other states
MAROMA Energy Services	LMI Program Implementation Organization	Implementer for the SCE Building Electrification Pilot that furnishes electrification services to low-income households
Pacific Asian Consortium in Employment (PACE)	LMI Program Implementation Organization	Implementation contractor for the CSD WAP and LIHEAP programs, as well as for the ESA programs.
California Housing Partnership (CHPC)	Housing Program Manager	Statewide organization that provides consulting services for construction of and retrofits in affordable multifamily housing
Small Business Utility Advocates (SBUA)	Small Business Organization	Nonprofit organization that represents, protects, and promotes the interests of small business utility customers
Hispanic Association of Small Businesses	Small Business Organization	The largest industry that HASB serves is the restaurant and food services industry, with restaurants being the primary type of business that they serve from inception; SCE collaborates with HASB to bring incentive programs to businesses; HASB primarily works in Southern California and the Inland Empire
Low Income Oversight Board (LIOB)	Statewide Advocacy Organization	Established by the legislature to advise the CPUC on low-income electric and gas customer issues and to serve as a liaison for the CPUC to low-income ratepayers and representatives

EQUITY STAKEHOLDER PUBLIC FEEDBACK

The Research Team supported the IOUs in soliciting feedback from equity stakeholders via the California Energy Efficiency Energy Contracts Public Document site (PDA). The IOUs posed a question to stakeholders publicly and requested written feedback in response to research questions,[11] such as:

- How may eliminating gas incentives impact hard-to-reach customers, underserved customers, and disadvantaged communities (including positive and negative impacts)?
- How can future ratepayer-funded programs best inform equity segment customers about fuel substitution benefits and support adopting fuel substitution measures?
- What considerations should be prioritized when the CPUC determines fuel substitution policy for equity segment customers?
- What local, state, and federal decarbonization resources are available to support equity segment customers' adoption of fuel substitution measures?

The Research Team discussed this opportunity for public feedback with stakeholders during a public webinar about the study's research plan. Small Business Utility Advocates was the only stakeholder to provide written feedback (albeit not through the PDA site).

[11] CPUC Energy Evaluation Public Comment (energydataweb.com)

2.3.2 ONLINE CUSTOMER SURVEYS

The residential and commercial customer surveys (English and Spanish) gauged familiarity and preferences regarding fuel substitution options among market rate and equity segments. The residential survey effort included both traditional self-report and choice-based conjoint survey questions. The commercial survey targeted a smaller number of completes and included self-report questions and a market demand analysis (given the population size and the expected response rate for commercial customers, a conjoint exercise was not viable for this segment). The survey efforts collectively answered the following research questions for both residential and commercial customers in equity and market rate segments:

- What level of awareness, familiarity, and interest exists in electric heating, cooling, and water heating equipment relative to non-electric alternatives?
- What are the primary barriers to and opportunities for encouraging the adoption of heat pump technologies?
- What are customers' relative preferences for individual electric and gas equipment features, and how do contractor recommendations contribute to those purchase decisions?
- What portion of customers with gas heat would be likely to adopt heat pumps at varying price levels and incentive levels?
- What is customers' willingness to adopt other low-carbon technologies to encourage fuel substitution?

The Research Team fielded both survey efforts online and recruited respondents by sending email invitations and asking a series of screening questions at the beginning of each survey to ensure the intended customer segments completed the surveys. The Team offered electronic gift cards to customers who qualified for and completed the survey to encourage survey participation. During fielding, the Research Team sent two email reminders to those who had yet to complete the survey. Additionally, the Research Team sent text messages to recruit respondents from the residential sample with cell phone numbers. The Research Team offered $10 for residential and $25 for commercial survey completes. The surveys were fielded in February and March 2024. During analysis, all statistical significance testing was conducted using a p-value of 0.1 or lower to identify differences in response between equity and market rate customers.

SURVEY SAMPLING

The Research Team requested and received customer contact data from the IOUs to compile the residential and commercial equity customer samples. The equity customer sample included residential customers and businesses with valid email addresses in California's disadvantaged communities or tribal area census tracts.[12] To minimize the data request burden for the IOUs, the Research Team utilized the 2021 California Energy Efficiency Market Adoption Characteristics Study survey sample to reach residential and commercial market rate customers. The Research Team designed the market rate survey samples to prioritize previous respondents from the 2021 California Energy Efficiency Market Adoption Characteristics Study and used the 2021 non-respondent contacts as a supplemental sample to increase survey completes. The team removed duplicate contacts from the market rate sample that also appeared in the equity sample.

For the residential equity sample, specifically, the Research Team developed the sample to prioritize survey outreach for disadvantaged community/tribal area customers who are also designated as CARE/FERA recipients,[13] receive their utility bill in Spanish, and/or occupy a multifamily/mobile home; as these are additional equity indicators identified in

[12] Based on the 2022 list provided by the California Office of Environmental Health Hazard Assessment. Source: https://oehha.ca.gov/calenviroscreen/sb535.

[13] CARE/FERA Program

the *Environmental & Social Justice Action Plan Version 2.0*, referenced in D. 23-06-055. Table 11 lists the total sample contacts included in the residential samples and the total number of survey completes by segment.

Table 11. Residential Sample Details

Segment	Sample	Completes	Yield
Market Rate	30,715	238	0.8%
Equity	43,694	346	0.8%
Total	**74,409**	**584**	**0.8%**

For the commercial equity sample specifically, the Research Team prioritized sampling businesses located in disadvantaged communities or tribal area census tracts (with valid email addresses) that had an annual electric demand of less than 20 kW or annual gas consumption of less than 10,000 therms, as well as those that are Spanish billed. Table 12 lists the total sample contacts included in the commercial samples and the total number of survey completes by segment.

Table 12. Commercial Sample Details

Segment	Sample	Completes	Yield
Market Rate	49,139	126	0.3%
Equity	35,091	195	0.6%
Total	**84,230**	**321**	**0.4%**

RESIDENTIAL CONJOINT EXERCISES

The Research Team used conjoint analysis to determine residential customers' relative preferences for individual features of available electric and gas equipment and willingness to pay for HVAC equipment. The Research Team randomized gas-heating residential survey respondents to receive one of two conjoint exercises: one based on the idea that the respondents' HVAC equipment had failed (replace on burnout) or a scenario in which the respondent wanted to replace inefficient HVAC equipment that was still working (accelerated replacement).

In conjoint terminology, the tested high-level program design elements are called "attributes," and various options for a given attribute are called "levels." Each attribute is independent from the other attributes, constituting an individual program element comprising several possible options. Respondents were presented with a series of screens, each of which asked them to choose between a randomized selection of hypothetical equipment options with varying levels of each attribute. In addition to these attributes and levels, the exercise also captured the customer's likelihood of choosing not to select any of the given hypothetical equipment options.

Conjoint Exercise 1: Replace on Burnout

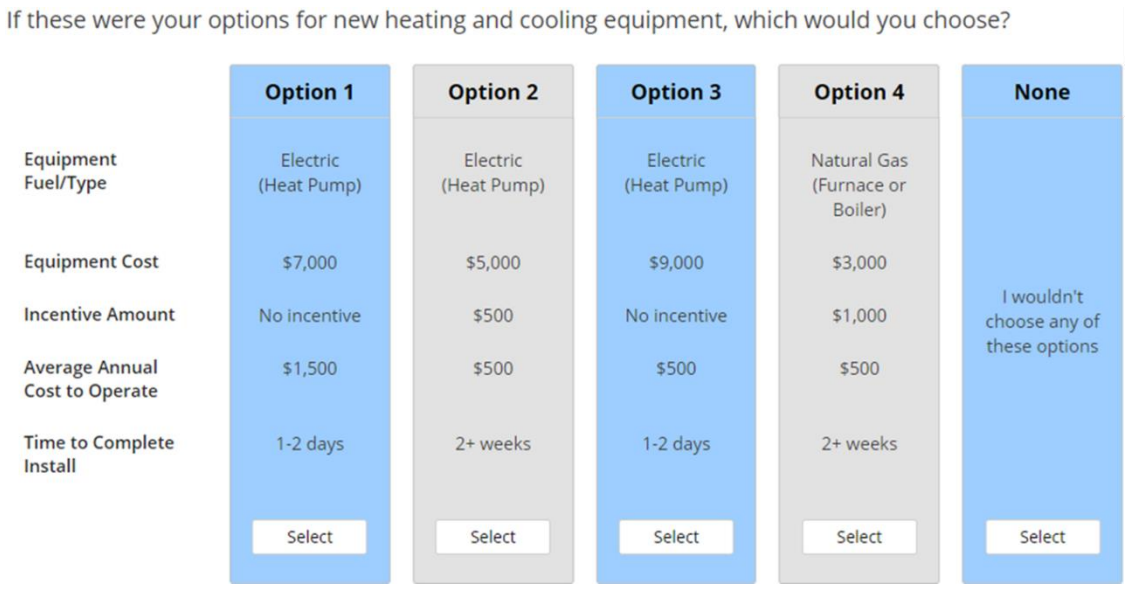
Table 13 shows the concepts tested in the conjoint exercise for a randomly selected half of respondents who were asked to imagine that their current HVAC equipment was about to fail. Respondents cycled through several screens (or choice sets) that asked them to choose between a randomized selection of hypothetical equipment options with varying levels of each attribute based on those presented in Table 13. The Research Team tested two equipment types: electric air source heat pump and natural gas furnace or boiler. The Team included various upfront equipment costs, ranging from $3,000 to $9,000. These costs were explicitly presented to customers as equipment costs and did not include associated installation or infrastructure costs. To gauge how incentives impact residential customers' decision-making on HVAC equipment, the Team included a range of incentive amounts from $0 to $1,500. The average annual operating cost was also included and ranged between $500 and $2,000. Lastly, for exercise one, the time to complete the installation was also included and consisted of 1–2 days, 3–7 days, 1–2 weeks, and 2+ weeks.

Table 13. Replace on Burnout Summary of Attributes and Levels

Attribute	Level 1	Level 2	Level 3	Level 4
Equipment Fuel/Type	Electric (Heat Pump)	Natural Gas (Furnace or Boiler)		
Equipment Cost	$3,000	$5,000	$7,000	$9,000
Incentive Amount	No incentive	$500	$1,000	$1,500
Average Annual Cost to Operate	$500	$1,000	$1,500	$2,000
Time to Complete Install	1–2 days	3–7 days	1–2 weeks	2+ weeks

On each screen, respondents could choose from one of the unique alternative configurations or "none" (i.e., choose not to purchase any of the offerings presented on their screen). Figure 3 provides an example of one possible choice set that respondents could have been shown.

Figure 3. Replace on Burnout Example Choice Set



Conjoint Exercise 2: Accelerated Replacement

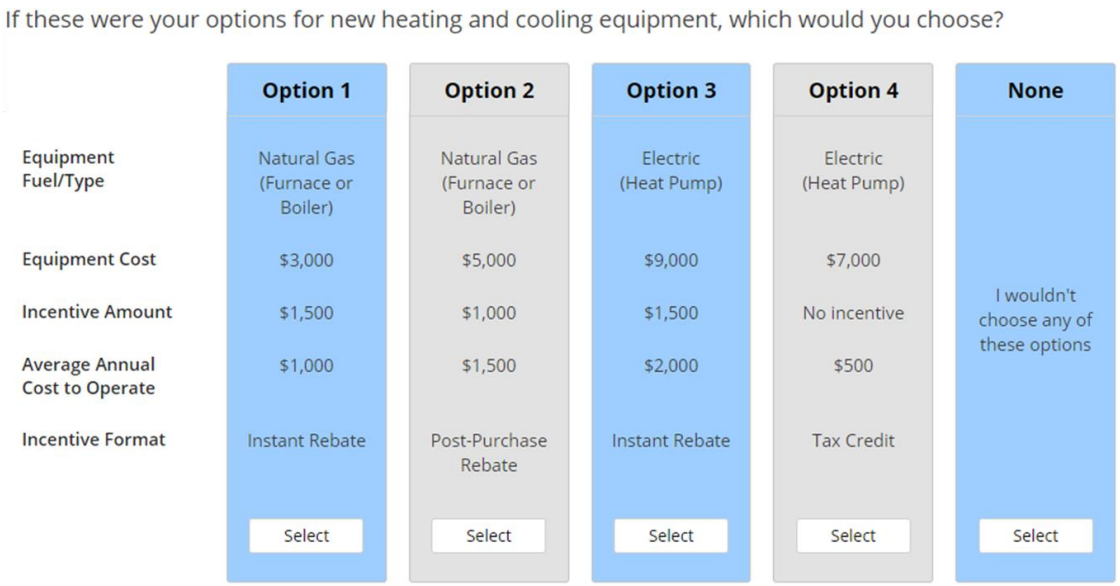
Table 14 shows the concepts tested in the conjoint exercise for the other randomly selected half of the respondents. This group was asked to imagine that their current HVAC system was still functioning, but they were considering an upgrade. The design of conjoint exercise two is the same as exercise one, except that the "time to complete install" attribute was replaced with an "incentive format" attribute. The Research Team assumed that the time to complete installation would not be as much a deciding factor in a scenario where the existing equipment still functioned. Incentive formats included in the exercise were instant rebates, post-purchase rebates, and tax credits.

Table 14. Accelerated Replacement Summary of Attributes and Levels

Attribute	Level 1	Level 2	Level 3	Level 4
Equipment Fuel/Type	Electric (Heat Pump)	Natural Gas (Furnace or Boiler)		
Equipment Cost	$3,000	$5,000	$7,000	$9,000
Incentive Amount	No incentive	$500	$1,000	$1,500
Average Annual Cost to Operate	$500	$1,000	$1,500	$2,000
Incentive Format	Tax Credit	Post-Purchase Rebate	Instant Rebate	

As with exercise one, respondents cycled through several screens that asked them to choose between a randomized selection of hypothetical equipment options with varying levels of each attribute. Figure 4 provides an example of one possible choice set that respondents could have been shown.

Figure 4. Accelerated Replacement Example Choice Set



MARKET DEMAND ANALYSIS (RESIDENTIAL AND COMMERCIAL)

The Research Team conducted a market demand study to examine the willingness of residential and commercial customers to substitute natural gas for electricity as a space or water heating fuel and to install efficient heat pump technologies. The study surveyed customers who used natural gas for space heating or water heating about how likely they would be to purchase air source heat pumps or heat pump water heaters upon failure of their existing equipment and when the utility provided a purchase incentive. The incentive covered a percentage of the incremental cost

between replacing their existing equipment (with new gas equipment) and the cost of the new heat pump technology.[14] Customers responded to a series of questions about their likelihood of installing heat pump technology that progressively raised the incentive level from 0% to 100% in increments of 25%. When the customer indicated they were "likely" or "very likely" to install the equipment or when the maximum incentive level of 100% was reached, the battery of incentive questions ended.

The market demand analysis sought to answer these research questions:

- What is the impact of incentives on the likelihood that a customer will substitute natural gas for electricity as a heating/water heating fuel and install a heat pump?
- How do different incentive levels affect the likelihood of installing heat pump technology?
- Do incentives affect equity and market rate customers differently?

Residential survey respondents answered market demand questions about heat pump water heaters (air source heat pump willingness to pay was calculated using conjoint exercises). Commercial survey respondents answered market demand questions about installing a packaged or split air source heat pump system, a heat pump water heater, or both types of heat pump technology. To qualify for the market demand analysis section of the surveys, customers must use gas for space heating and/or water heating.

As Table 15 shows, more than 500 residential customers (n=543), comprising 221 market rate and 322 equity customers, responded to the questions about willingness to install a heat pump water heater. For commercial, 160 customers responded to questions about their willingness to pay for packaged system air source heat pumps, including 52 market rate and 108 equity customers. Meanwhile, only 41 commercial customers provided answers regarding split system air source heat pumps, with 15 identifying as market rate and 26 as equity customers. To have an adequate sample size for air source heat pump analysis, the Team combined the responses of packaged and split systems for the modeling process. Two hundred thirty-two commercial customers responded to the questions about heat pump water heaters, split between 93 market rate and 139 equity customers.

Table 15. Market Demand Analysis Participant Counts

Measure Type	Market Rate Respondent Count	Equity Respondent Count	Total Respondent Count
Residential Heat Pump Water Heaters	221	322	543
Commercial Packaged System Air Source Heat Pumps	52	108	160
Commercial Split System Air Source Heat Pumps	15	26	41
Commercial Heat Pump Water Heaters	93	139	232

To estimate the impact of different incentive levels on heat pump technology installation, the Research Team estimated a multi-variate ordered logistic regression model. The likelihood of installation of heat pump technology can be modeled on a scale from 1 to 6 as a function of the different incentive levels and other explanatory variables such as the customer type (equity vs. market rate) and, for commercial customers, the number of employees, industry, or the building floor area. A separate model was estimated for each customer segment and product type combination (residential heat pump water heater, commercial air source heat pump, and commercial heat pump water heater). Appendix C. Market Demand Analysis Modeling Methodology presents the model specifications and coefficient estimates. The estimation of an ordered logit model enabled the Team to predict the probabilities of the response outcomes (the likelihoods from 1 to 6) for each respondent as a function of the incentive levels while controlling for other factors.

[14] Note that survey questions asked customers to focus on equipment costs and did not address associated installation or infrastructure costs.

After estimating the model and predicting the response outcomes for each respondent, the Team applied a propensity adjustment factor. Table 16 shows the propensity adjustment factors based on similar research in other jurisdictions (such as Michigan and Washington). The Team applied propensity adjustment factors for two reasons. First, even customers who report they are "likely" to adopt a heat pump technology may be substantially less likely than 100% to install it. As is often found in stated preference studies, intentions do not always align with behaviors in the real world. Thus, the factors are intended to more accurately reflect the true likelihood that respondents will install the equipment. Second, by applying the discount factors to the predicted response outcomes, the Team could predict *the percentage of respondents who would* install, rather than the probability distribution across response options, at each incentive level.

Table 16. Market Demand Analysis Propensity Adjustment

Willingness to Pay Response Option	Scale Rating	Propensity Adjustment
Very likely	6	90%
Likely	5	50%
Somewhat likely	4	25%
Somewhat unlikely	3	No adjustment – 0% expected to participate
Unlikely	2	No adjustment – 0% expected to participate
Very unlikely	1	No adjustment – 0% expected to participate

The survey was structured so that if a respondent indicated a likelihood of "likely" or "very likely," the respondent was not presented with the next level of incentive. This approach informed a key assumption for the analysis: if a participant indicated they were "likely" or "very likely" to adopt a measure at a certain incentive level, the Research Team assumed the respondent would maintain this stance if offered a higher incentive. Thus, even if the incentive increased to 75% or 100%, the Team conservatively assumed their likelihood of installing the equipment would not increase beyond their initial response. This assumption means the study's estimates may understate the heat pump installations that would occur with a given incentive amount.

3. DETAILED FINDINGS

This section details the combined results from the landscape analysis and online surveys. Findings are summarized by the study research objectives.

3.1 IMPACT OF INCENTIVES ON CUSTOMER FUEL SUBSTITUTION

The first objective aims to quantify the impact of incentives on customer fuel substitution for market rate and equity customers. To do so, the Research Team sought to understand the current fuel penetration of California and current adoption of heat pump technologies and fuel substitution incentives.

3.1.1 RESIDENTIAL SECTOR

MARKET PENETRATION

As shown in Table 17, the *2018-2022 American Community Survey* (ACS) indicates that 25% of California households are categorized as low-income and 34% are low- or moderate-income (LMI).[15] The CPUC definition of residential equity customers is not the same as the California definition of LMI households but there is a substantial overlap in the populations.[16]

Table 17. Number and Percent of California Households by Income Group

Income Group	Income Definition	Number of Households	Percent of Households
Low-Income Households	≤60% of California State Median Income (SMI)	3,311,819	25%
Moderate-Income Households	>60% ≤80% of California SMI	1,216,816	9%
Non-LMI Households	>80% of California SMI	8,787,202	66%
All Households		**13,315,837**	**100%**

Source: ACS (2018-2022) /All CA Households

The *2019 Residential Appliance Saturation Survey* (RASS) furnishes detailed information on the energy usage patterns for California households.[17] Most California households use natural gas for space heating, water heating, and cooking. A plurality of households uses natural gas for their clothes dryers. There is a relatively low penetration of heat pumps for space heating and very few heat pump water heaters.

The Research Team developed detailed tabulations using the RASS data; some of the important findings for this study include:

- Ownership Status – About two-thirds of California households are owners and one third are renters.
- Space Heating – About 80% of California households use heating equipment. Among those:
  - Heating Fuel - About 74% heat with natural gas, 23% heat with electricity, and 3% heat with other fuels;
  - Payment for Heat - About 97% pay directly for their heating fuel, while 3% have the payment included in rent;

[15] https://data.census.gov/
[16] The Study Inclusion section details the equity and market rate segment definitions for this study.
[17] https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study

- Efficient Electric Systems - About 4% use central heat pump equipment and 1% use through the wall heat pump equipment.
- Age of Equipment - About 16% of heating equipment is 3 years old or less.

- Air Conditioning – About 70% of California households report using air conditioning equipment.
  - Equipment Type – 56% of households report using a central system, 12% report using room air conditioners, and 1% report using evaporative coolers.
- Water Heating – Almost all California households use water heating equipment. Among those:
  - Heating Fuel - About 90% use natural gas, 7% use electricity, and 3% use other fuels;
  - Payment for Water Heat - About 93% pay directly for their heating fuel, while 7% have the payment included in rent;
  - Efficient Systems - About 7% use a natural gas tankless system, 1% use a natural gas condensing system, less than 1% use an electric tankless system, and less than 1% use a heat pump water heating (HPWH) system;
  - Age of Equipment - About 25% of water heating equipment is 3 years old or less.
- Cooking – Almost all California households use cooking equipment of some type. Among those:
  - About 60% use natural gas for a stovetop, 35% use electricity for a stovetop, and 3% use some other fuel for a stovetop (the RASS did not gather information on the share of households that use an induction cooktop).
- Clothes Dryers - About 84% of California households reported having a clothes dryer in their housing unit.
  - About 44% of households reported using a natural gas dryer, 38% reported using an electric dryer, and 2% reported using bottle gas for their dryer (the RASS did not gather information on the share of households that use a heat pump dryer).

The *2020 Residential Energy Consumption Survey* (RECS) furnishes a dataset that can be used to develop subgroup analyses, the California results can be compared to regional and national statistics, and the 2020 RECS can be compared to the 2009 RECS to examine changes in California over time.[18] Some important findings of our analysis of the RECS data include:

- Ownership Status – About two-thirds of non-LMI households are homeowners, while 55% of LMI households are renters.
- Space Heating – There are some differences between LMI and non-LMI households in terms of space heating, but the differences tend to be small.
  - Main Heating Fuel – About 28% of LMI households use electricity for heating compared to only 20% of non-LMI households.
  - Heat Pump Heating Equipment – About 5% of LMI households use heat pump equipment compared to 4% of non-LMI households.
  - Age of Equipment – 28% of LMI households have equipment that is less than 5 years old compared to 21% of non-LMI households.
- Air Conditioning – There are significant differences in air conditioning equipment between LMI and non-LMI households.
  - Use of Air Conditioning – 33% of LMI households have no air conditioner compared to 26% of non-LMI households.

[18] https://www.eia.gov/consumption/residential/

- Type of Equipment – 40% of LMI households have central air conditioning compared to 59% of non-LMI households; 2% of both LMI and non-LMI households report using ductless heat pump mini splits for cooling.
- Age of Equipment – 36% of LMI households have equipment that is less than 5 years old compared to 31% of non-LMI households.

- Water Heating – There is almost no difference in water heating between LMI and non-LMI households.
  - Water Heating Fuel – For both groups, 78% report using natural gas and 19% report using electricity.
  - Water Heating Equipment – About 8% of LMI households use a tankless water heater compared to 10% of non-LMI households.
  - Age of Equipment – 28% of LMI households have equipment that is less than five years old compared to 27% of non-LMI households.
- Cooking Equipment – LMI households use the same cooktop fuels as non-LMI households (70% use natural gas and 37% use electric). The incidence of induction cooktops is 2% for both LMI and non-LMI households.
- Clothes Dryers – LMI households have the same types of dryers as non-LMI households. Among those who have dryers, 50% have gas equipment and 50% have electric equipment.

Table 18 shows the change in the use of electricity for space heating and water heating in California compared to the changes for the Pacific Census region and the nation. In all geographic areas, there has been almost no change in the share of households that use electricity for space heating, but there has been a substantial increase in the share of households that use electricity for water heating.

Table 18. Incidence of Electricity for Space and Water Heating in California Over Time

Geographic Area	Space Heating Fuel is Electricity		Water Heating Fuel is Electricity	
	2009	2020	2009	2020
California	21%	20%	10%	19%
Pacific Census Region	28%	27%	26%	31%
National	34%	34%	41%	46%

Source: RECS (2009 & 2020)

Table 19 shows that California has had a large percentage increase in the share of households that use heat pump equipment for space heating, but it still is only about one-third the national average in terms of heat pump usage.

Table 19. Incidence of Heat Pumps in California Over Time

Geographic Area	Heat Pumps for Space Heating	
	2009	2020
California	1%	4%
Pacific Census Region	4%	5%
National	9%	14%

Source: RECS (2009 & 2020)

The *Low-Income Multifamily Characteristics Study* developed market statistics from the ACS, the RECS, and the American Housing Survey (AHS) Metropolitan Area samples focused on the low-income multifamily customer segment (which is included in the residential equity segment for the purposes of this study).[19] The study found that 9% of LMI multifamily households that heat and cool their homes report that they have heat pump equipment. About one-half of the homes had central heat pump equipment and the other one-half had ductless mini-split equipment. Additionally, about 6% of the households reported that they had an electric induction stovetop. Additional key findings with respect to market share from the study include:

- Population – About 25% of California households live in multifamily buildings (5+ units). About one-third of LMI households live in those buildings. About 60% of households in multifamily buildings are LMI households.
- Housing Unit Size – Most LMI multifamily households (80%) live in units that are 1,000 square feet or less. That is important because smaller units that have in-unit equipment often have equipment closets that are too small for some heat pump equipment.
- Energy End Uses – Most LMI multifamily buildings (78%) use natural gas for at least one end use. Natural gas is used for space heating in 34% of the units, for water heating in 68% of the units, and for cooking in 40% of the units. About 25% of units have clothes dryers in the unit with about half using electricity and half using natural gas.
- HVAC – Three-quarters (73%) of LMI multifamily households report that they heat their unit in a multifamily building and 69% report that they cool their unit. Most of the households that heat or cool their homes report that the HVAC equipment is in their unit.
- Water Heating – About two-thirds of LMI households report that their water heating is from a central water heating system. That is important because it is often easier for a multifamily building to replace a centralized domestic hot water system with a heat pump water heater than it is to replace gas-fired water heaters in each unit.

INFLUENCE OF INCENTIVES

The *2023 Energy Efficiency Potential and Goals Study* indicated that, while the fuel substitution incentives were designed to have the same impact on levelized measures costs (LMCs) as the energy efficiency incentives, the program data demonstrated that the adoption rate for fuel substitution measures was far lower than the adoption of comparable energy efficiency measures.[20] The study projected that an aggressive approach to fuel substitution would require raising the incentive level cap from 75% of incremental costs to 90% of incremental costs.

The *California Heat Pump Residential Market Characterization and Baseline* study found that incentive programs are vital for promoting heat pump adoption in California to address the primary challenge of high upfront costs.[21] These programs must offer financial advantages but also require simple application processes to attract builders, contractors, and homeowners. Issues like complex eligibility and low awareness hinder their effectiveness. The study indicated existing incentives for air source heat pumps and heat pump water heaters have been effective, but most of these programs have been offered through Community Choice Aggregators (CCAs), municipal utilities, and Regional Energy Networks (RENs) rather than through the IOUs (until the TECH Clean California statewide initiative was launched in 2021).

[19] https://www.veic.org/clients-results/reports/low-income-multifamily-housing-characteristics-study

[20] https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/energy-efficiency-potential-and-goals-studies/2023-potential-and-goals-study

[21] https://www.calmac.org/publications/OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf

3.1.2 COMMERCIAL SECTOR

MARKET PENETRATION

The *2022 California Commercial End Use Survey* provides building statistics for California's commercial sector.[22] A summary of the changes in floorspace, electric and natural gas consumption, and electric and natural gas intensity over time in California:

- Floor Space –commercial floorspace grew by 21% from 2006 to 2018, and by an additional 4% from 2018 to 2022.
- Electricity Usage and Intensity –commercial electric usage increased by 13% from 2006 to 2018, and then decreased by 7% from 2018 to 2022. Electric intensity declined by 7% from 2006 to 2018, and by an additional 11% from 2018 to 2022.
- Natural Gas Usage and Intensity –commercial natural gas usage increased by 33% from 2006 to 2018, and then decreased by 6% from 2018 to 2022. Natural Gas intensity increased by 9% from 2006 to 2018, but then declined by 10% from 2018 to 2022.

The study includes information on the heating fuel and water heating fuel shares for natural gas:

- Heating Fuel – overall, the share of commercial floorspace with natural gas heat was little changed. It was 68% in 2006 and 67% in 2022. The changes by building type included:
  - Small Office Buildings – 51% to 56%
  - Large Office Buildings – 81% to 86%
  - Restaurants – 82% to 65%
  - Lodging – 38% to 57%
- Water Heating Fuel – overall, the share of commercial floorspace with natural gas water heat was little changed. It was 56% in 2006 and 58% in 2022. The changes by building type included:
  - Small Office Buildings – 32% to 49%
  - Large Office Buildings – 53% to 62%
  - Restaurants – 84% to 79%
  - Lodging – 90% to 90%

The *2018 Commercial Building Energy Consumption*[23,24] data provides national and regional statistics for the commercial sector. Findings for the Pacific Census Division which covers California, Oregon, Washington, Hawaii, and Alaska include:

- Number of Employees – Buildings with fewer than 10 main shift employees represent 74% of all commercial buildings and about 34% of the floorspace in commercial buildings. Businesses with fewer than 10 employees can be considered hard-to-reach by the CPUC (part of the commercial equity segment of this study).
- Incidence of Heat Pumps – Heat pumps furnish building space heating in 15% of buildings and for about 17% of building floorspace.

[22] https://www.energy.ca.gov/sites/default/files/2024-02/2022%20CEUS%20Final%20Report_ada.pdf
[23] https://www.eia.gov/consumption/commercial/data/2018/bc/pdf/b4.pdf
[24] https://www.eia.gov/consumption/commercial/data/2018/bc/pdf/b5.pdf

- HVAC Upgrades – About 11% of buildings and about 22% of building floorspace had an HVAC upgrade of some type between 2000 and 2018.
- Building Equipment Management – For 75% of commercial buildings and building floorspace, the building owner alone is responsible for management of energy using equipment.
- Building Equipment Decision-Making – For 81% of commercial buildings and 79% of building floorspace, the building owner alone is responsible for making decisions on equipment purchases.

3.2 IMPACT ON CUSTOMER CHOICES IF GAS INCENTIVES ARE ELIMINATED

The second research objective aims to understand the impact on consumer choices if incentives for non-cost-effective and other gas efficiency measures are eliminated. Table 20 lists the fuel substitution measures included in the California eTRM.[25] Incentives for gas alternatives of these measures are likely to be eliminated (if not already).

Table 20. Fuel Substitution Measures

Measure	Building Segment	End Use	eTRM Measure
Residential Sector			
Ductless Heat Pump	Residential	HVAC	SWHC044-04
Ducted Heat Pump	Residential	HVAC	SWHC045-03
Heat Pump Water Heater	Residential	Water Heating	SWWH025-07
Large Heat Pump Water Heater	Multifamily	Water Heating	SWWH028-03
Cooking Appliances	Residential	Cooking	SWAP013-03
Heat Pump Clothes Dryer	Residential	Laundry	SWAP014-03
Heat Pump Pool Heater	Residential	Pool	SWRE005-03
Commercial Sector			
Packaged Heat Pump Air Conditioner	Commercial	HVAC	SWHC046-03
Heat Pump Water Heater	Commercial	Water Heating	SWWH027-04
Large Heat Pump Water Heater	Commercial	Water Heating	SWWH028-03
Fryer	Commercial	Cooking	SWFS021-04
Convection Oven	Commercial	Cooking	SWFS022-03

Source: California eTRM

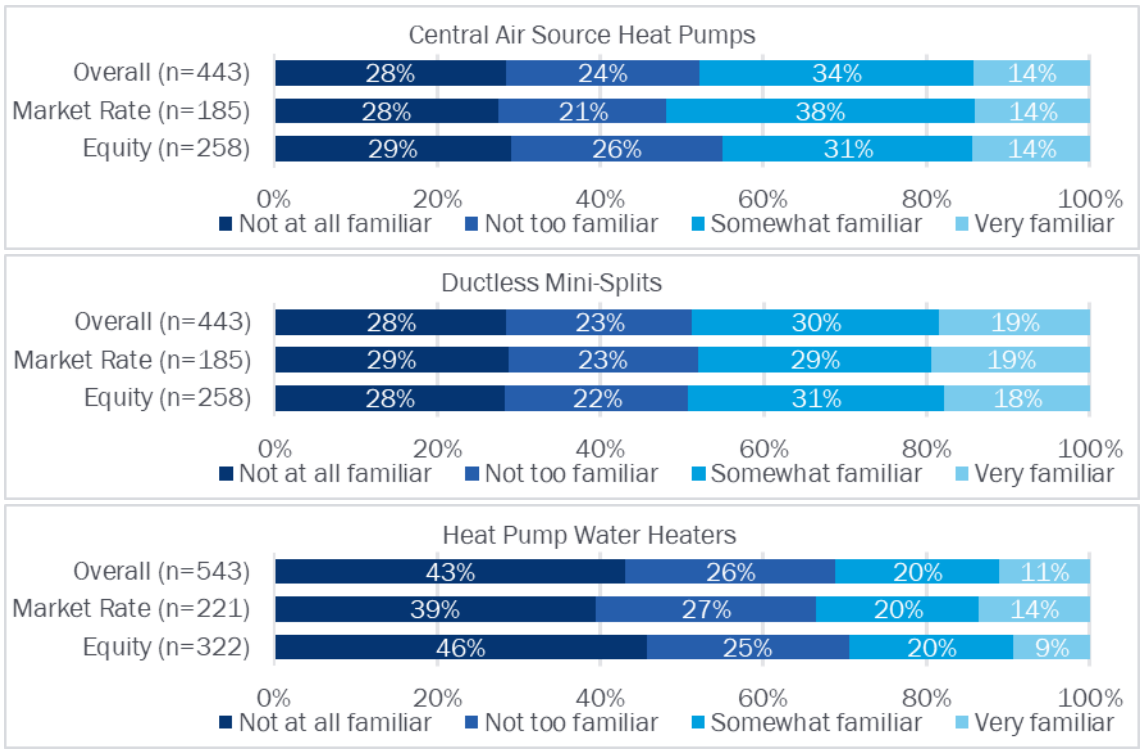
[25] https://www.caetrm.com/about/

3.2.1 RESIDENTIAL SECTOR

FAMILIARITY

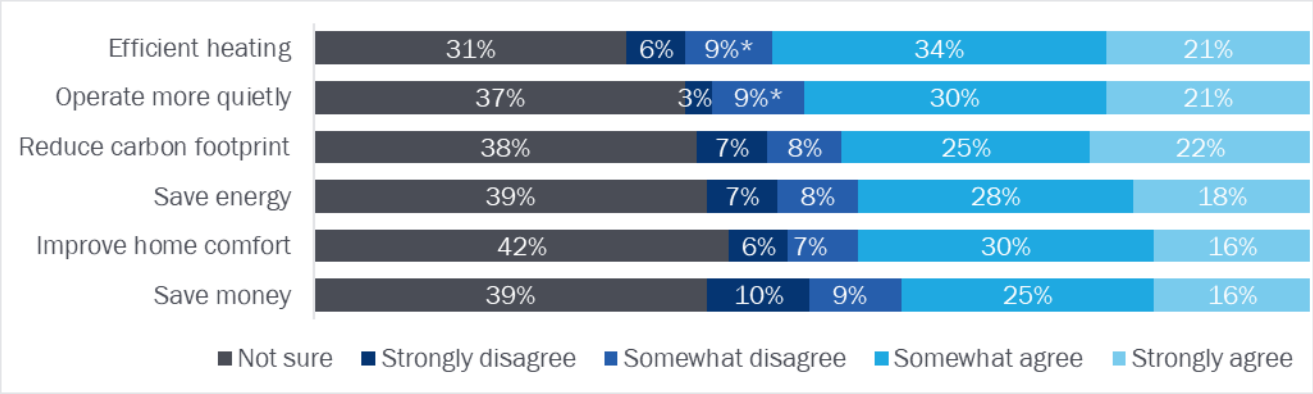
According to the online customer survey conducted as part of this study, about half of residential survey respondents with gas HVAC were at least somewhat familiar with HVAC heat pump equipment (48% for central air source heat pumps and 49% for ductless mini-splits). Fewer residential respondents were familiar with heat pump water heaters, with just under one-third of residential customers reporting that they were somewhat or very familiar with the technology (31%). The Research Team found no statistical differences in familiarity between the residential equity and market rate segments. Figure 5 summarizes survey respondents' self-reported level of familiarity with HVAC and water heating heat pump equipment by customer segment.

Figure 5. Residential Familiarity with Heat Pumps



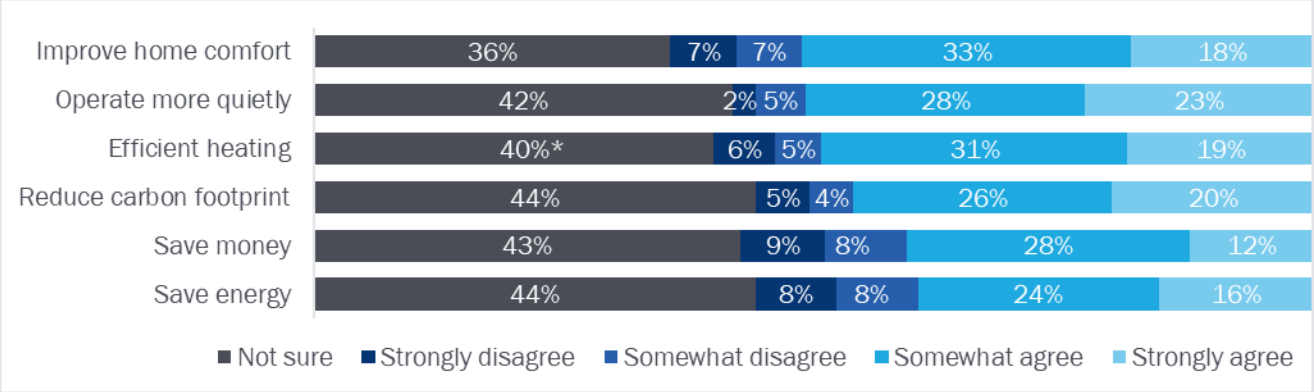
About half of the residential customers agreed with the stated benefits associated with heat pump technologies, including the ability to heat efficiently (52%), operate quietly (51%), and improve home comfort (48%). Only a small portion of customers disagreed that heat pumps have these benefits. Those who disagreed with the leading benefits of air source heat pumps disagreed mostly with the statements that air source heat pumps can save costs compared to natural gas and other types of heating (18%), that they can save energy compared to other types of heating (16%), and that they can improve home comfort (13%). Overall, at least one-third of residential respondents were unsure of their agreement with stated heat pump benefits (ranging from 31% to 44%). Equity respondents were significantly more likely to be unsure whether air source heat pumps provide efficient heating than market rate respondents (40% and 31%, respectively). In addition, market rate respondents were significantly more likely than equity respondents to somewhat disagree with the perceived benefits of efficient heating (9% market rate; 7% equity) and quiet operation (9% market rate; 5% equity). Figure 6 and Figure 7 summarize respondents' level of agreement with each potential benefit of air source heat pumps by segment.

Figure 6. Residential Perception of Benefits to Air Source Heat Pumps (Market Rate; n=185)



* Indicates a statistical difference across the market rate and equity segments.

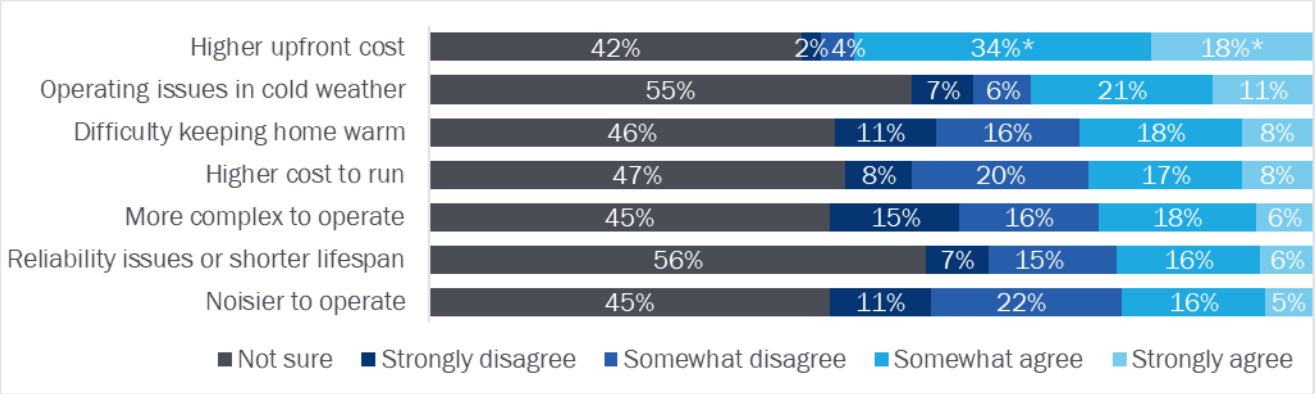
Figure 7. Residential Perception of Benefits to Air Source Heat Pumps (Equity; n=258)



* Indicates a statistical difference across the market rate and equity segments.

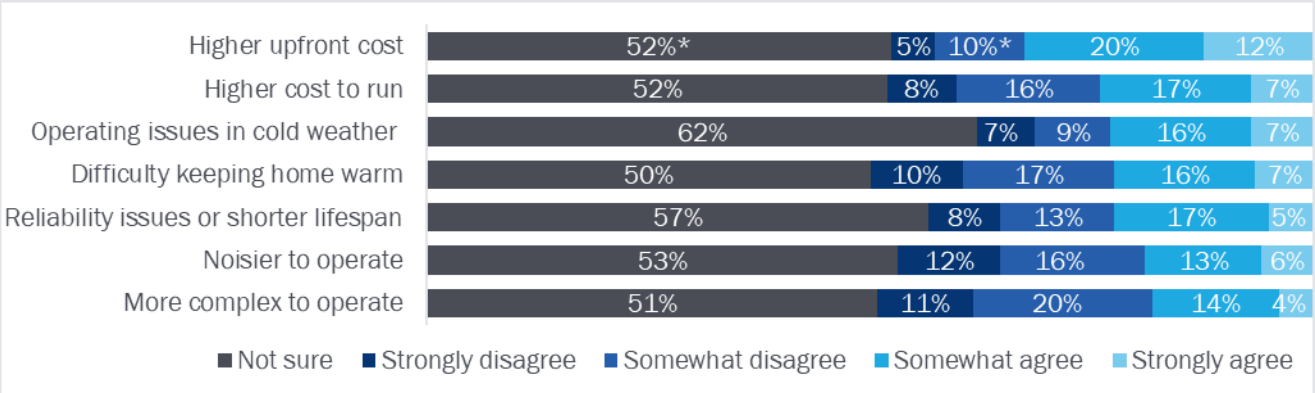
When asked about challenges associated with air source heat pumps, about half of respondents indicated awareness of some drawbacks with the technology. Both market rate and equity customers agreed that upfront cost was a challenge or drawback to adopting air source heat pumps (52% at least somewhat agree). However, significantly more market rate customers agreed that upfront cost was a challenge than equity customers (52% and 32%, respectively). Furthermore, around half of customers (between 42% and 56%) are unsure about their agreement with each potential drawback to heat pump technology. Figure 8 and Figure 9 provide a more detailed summary of the most common barriers to residential heat pump adoption.

Figure 8. Residential Perception of Drawbacks to Air Source Heat Pumps (Market Rate; n=185)



* Indicates a statistical difference across the market rate and equity segments.

Figure 9. Residential Perception of Drawbacks to Air Source Heat Pumps (Equity; n=258)



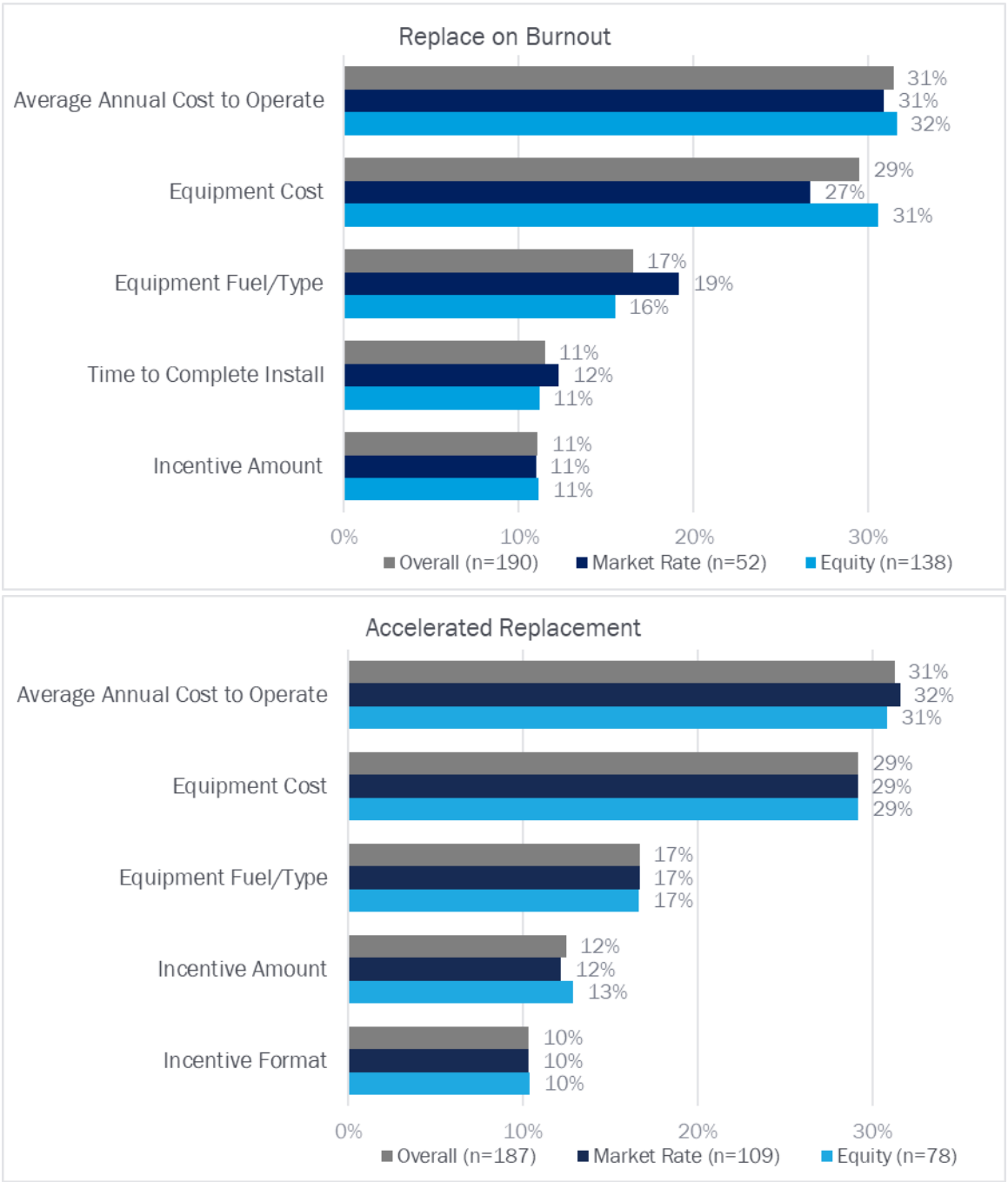
* Indicates a statistical difference across the market rate and equity segments.

PURCHASE DECISIONS

As part of the survey, customers responded to a series of hypothetical purchase decisions between varying product options, allowing the Research Team to quantify preferences for individual product attributes (such as equipment cost, time to complete install, annual operating costs, fuel type, and incentive level) through a conjoint analysis. By modeling customer response associated with each attribute, the Team determined the relative importance of each product attribute on customers' purchase decisions.

As shown in Figure 10, annual operating costs and upfront costs are the primary drivers of customer decision-making for new space heating and cooling equipment (collectively driving 60% of the decision-making process).[26] Preference for one fuel type over the other accounted for just under one-fifth of preferences (17%), while the time to complete install and incentive amount collectively accounted for under one-fourth of overall decision-making (22%). Notably, incentive amount (in Exercise 1: Replace on Burnout) and incentive format (in Exercise 2: Accelerated Replacement) were the least influential attributes in residential customers' decision-making out of all attributes presented in the conjoint exercises.

Figure 10. Average Importance of Factors on HVAC Equipment Decisions

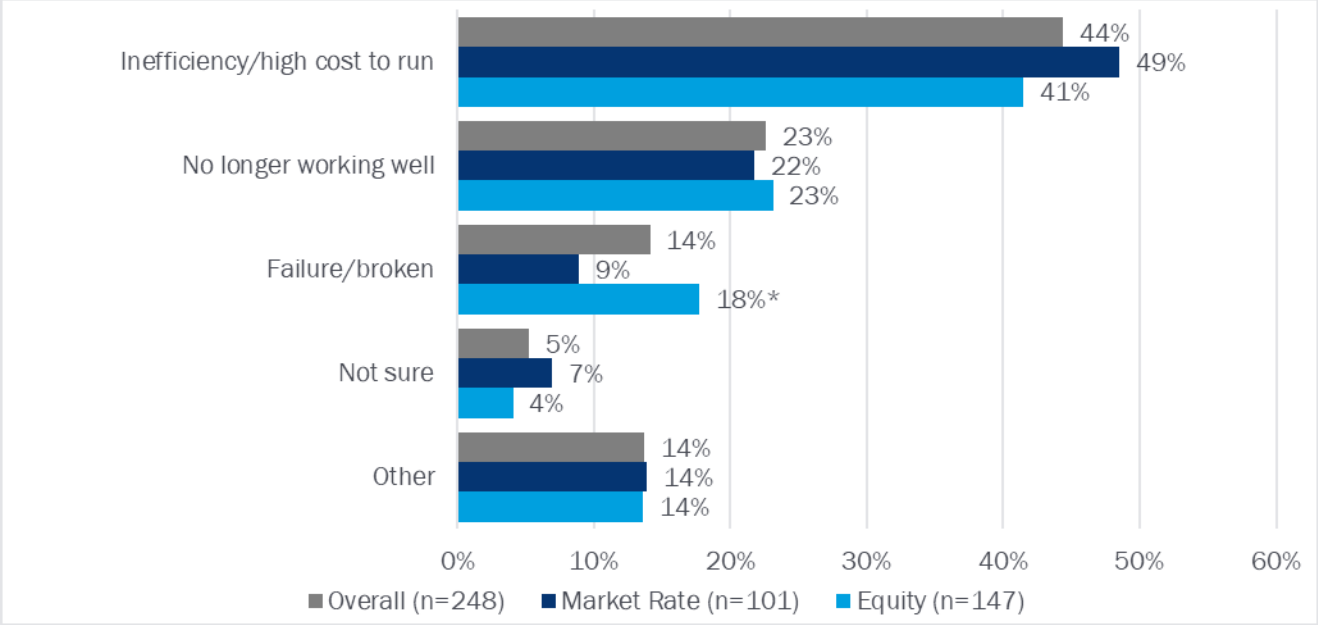


[26] Note that survey questions asked customers to focus on equipment and operating costs and did not address associated installation or infrastructure costs.

BARRIERS

The survey instrument also asked about barriers to heat pump adoption from customers who recently considered replacing their HVAC equipment but did not pursue a heat pump. Nearly half of residential respondents reported considering or installing new space heating or cooling equipment within the past three years (42%). The most cited reasons for considering new space heating and cooling equipment were inefficiency or the high cost of running existing equipment (44%) and that existing equipment was no longer working well (23%). Equity customers were significantly more likely than market rate customers to indicate that failure of their existing heating and cooling equipment prompted them to consider a new system (18% and 9%, respectively). "Other" responses included unknown age of equipment, a prior lack of air conditioning, and environmental concerns with gas systems. Figure 11 shows the reasons for considering new space heating and cooling equipment.

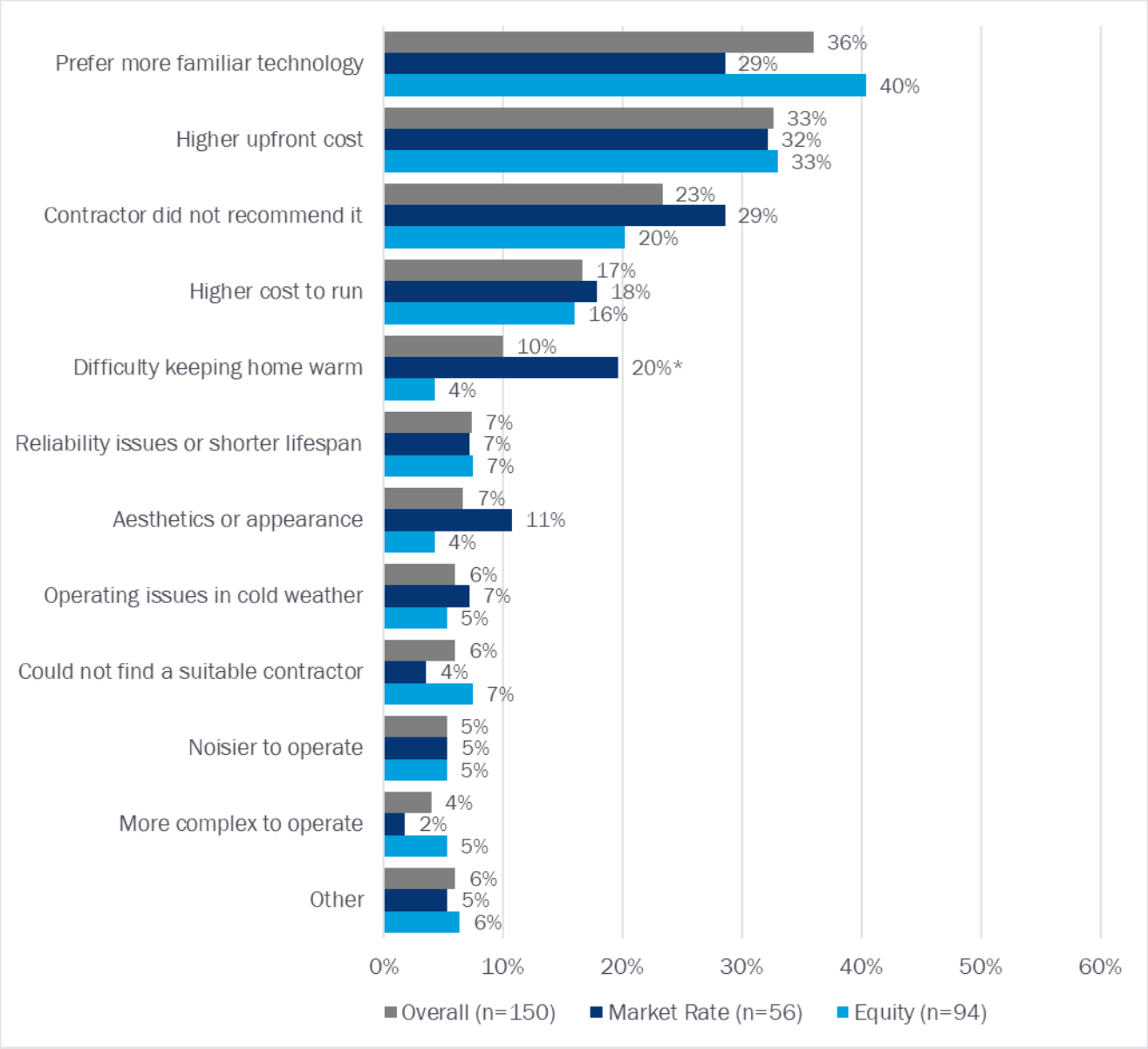
Figure 11. Residential Reasons for Considering New Space Heating and Cooling Equipment



* Indicates a statistical difference across the market rate and equity segments.

Of respondents who recently considered new HVAC equipment, half indicated that they considered switching to an electric heat pump (n=124). Residential natural gas customers who recently considered new HVAC equipment but did not install an electric heat pump most often cited a preference for more familiar technology (36%), upfront costs (33%), or contractor recommendations (23%) as reasons for not installing a heat pump. Equity and market rate customers responded similarly in most areas; however, market rate customers more often pointed to concerns around a heat pump's ability to keep their home warm than equity customers (20% and 4%, respectively). Figure 12 provides a more complete list of reasons cited by respondents for not pursuing the installation of an air source heat pump.

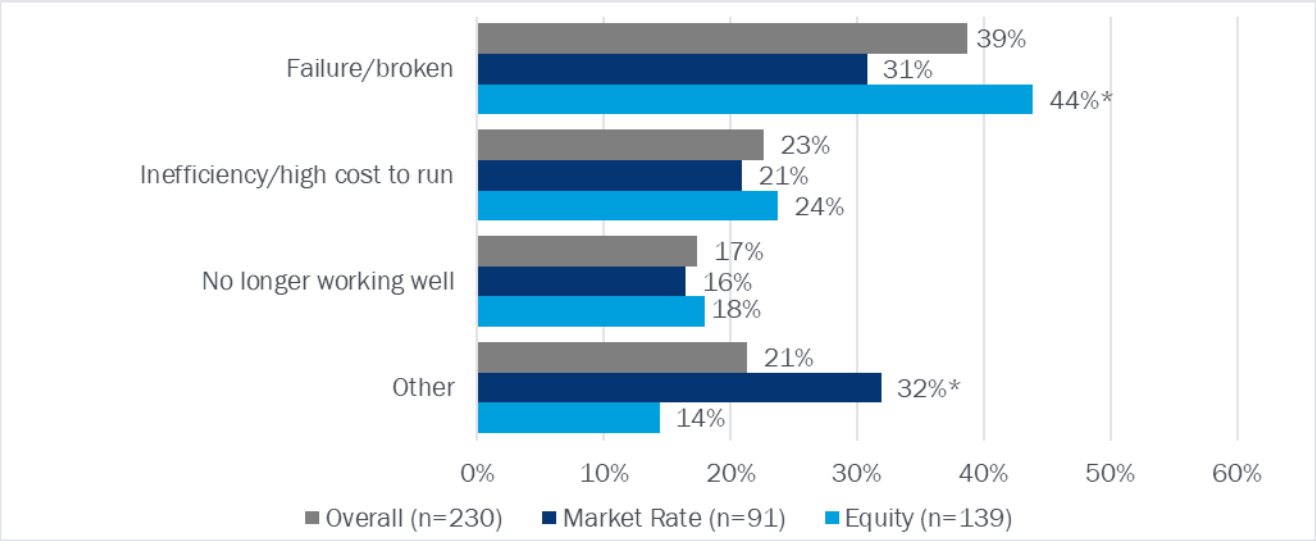
Figure 12. Residential Barriers to Heat Pump Adoption



* Indicates a statistical difference across the market rate and equity segments.

Among respondents with gas water heating, 39% considered replacing their water heating equipment within the past three years, with 40% considering heat pump water heaters (n=230). Of those who considered new water heating equipment within the past three years, the most common reasons for considering new equipment were the failure of their existing water heater (39%), followed by inefficiency or the high cost of running existing equipment (23%). Again, equity customers were more likely than market rate customers to consider new water heating equipment due to the failure of their existing equipment (44% and 31%, respectively). "Other" responses included the existing water heater being old or having limited remaining life (7%), environmental concerns with gas systems (5%), and the system taking up too much space or needing to be relocated (3%). Figure 13 shows the breakdown of reasons for considering new water heating equipment.

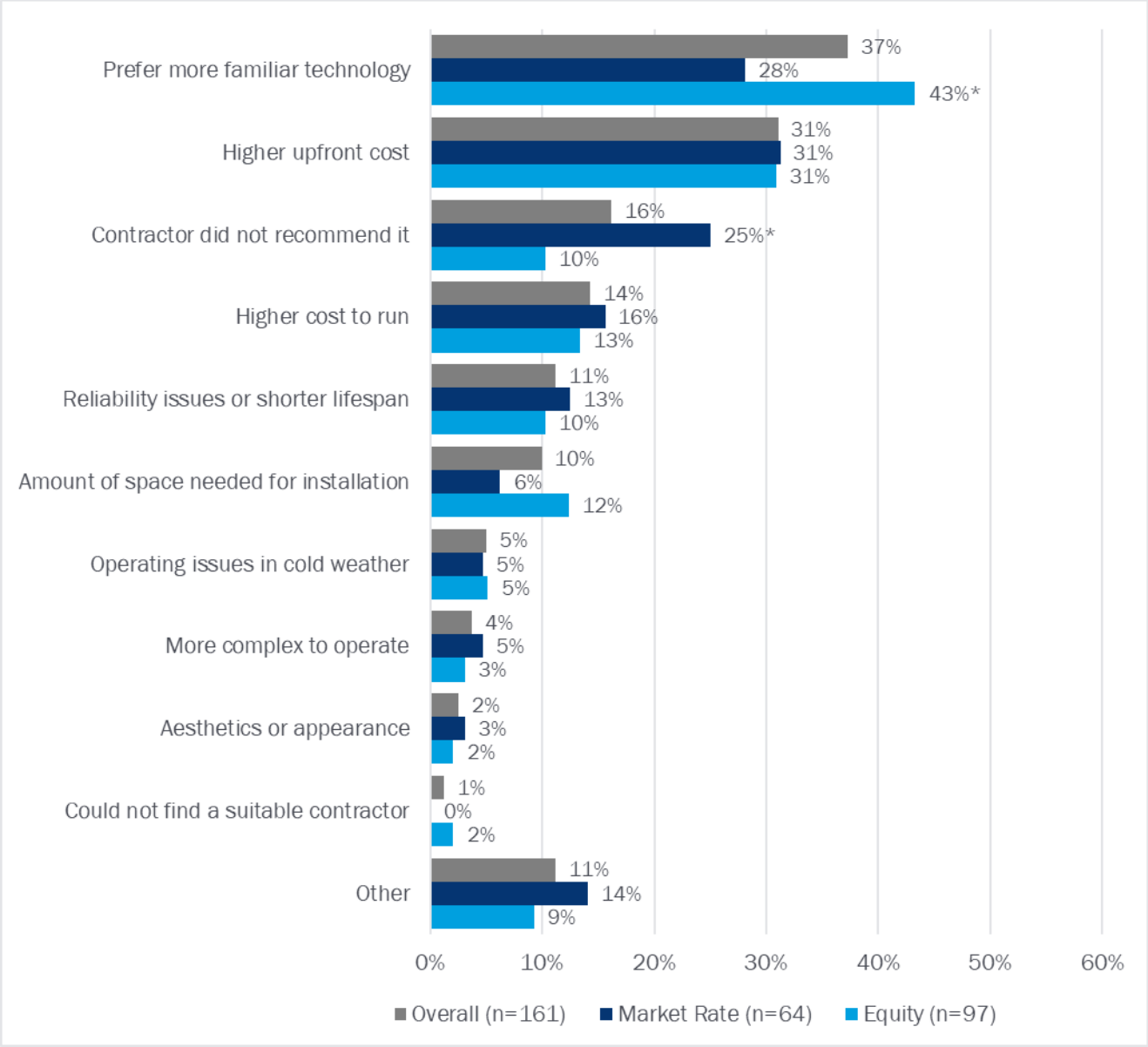
Figure 13. Residential Reasons for Considering New Water Heating Equipment



* Indicates a statistical difference across the market rate and equity segments.

Among the residential customers who recently considered new water heating equipment but did not pursue a heat pump water heater, the leading barriers cited were a preference for more familiar technology (37%), upfront costs (31%), and contractor recommendations (16%). Equity customers were more likely to point to a lack of familiarity than market rate customers (43% and 28%, respectively). Equity customers were also less likely to point to contractor recommendations than market rate customers (10% and 25%, respectively). "Other" responses included that existing equipment was still functioning and did not yet require replacement and concerns about power outages causing a lack of hot water. Figure 14 further details the residential barriers to heat pump water heater adoption.

Figure 14. Residential Barriers to Heat Pump Water Heater Adoption



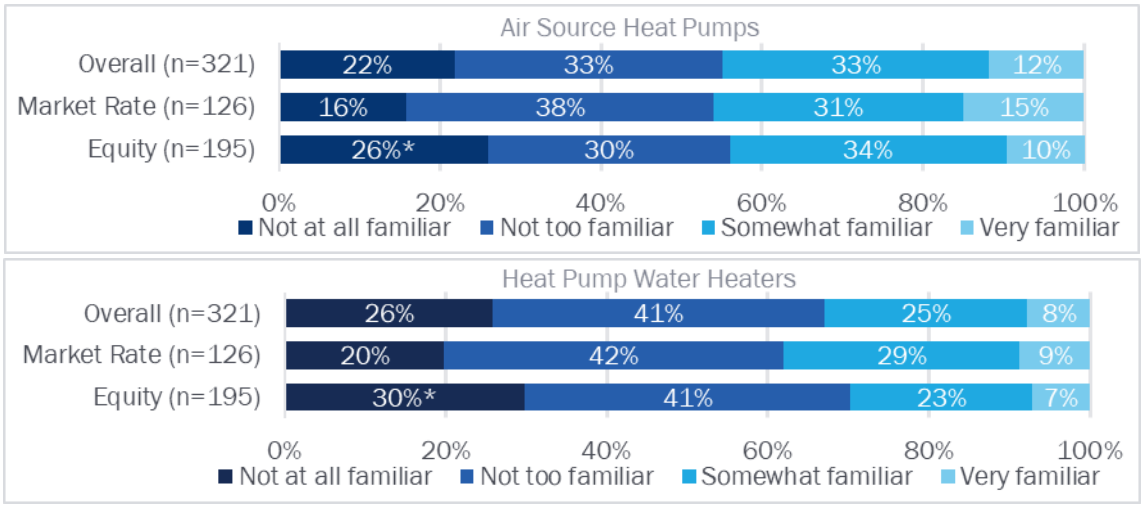
* Indicates a statistical difference across the market rate and equity segments.

3.2.2 COMMERCIAL SECTOR

FAMILIARITY

About half of commercial survey respondents were at least somewhat familiar with air source heat pumps (45%), but fewer were familiar with heat pump water heaters (33%). Among commercial respondents, statistically, more equity customers reported being not at all familiar with both types of heat pump equipment than their market rate counterparts (26% for air source heat pumps and 30% for heat pump water heaters). Figure 15 further details commercial customers' familiarity with air source heat pumps and heat pump water heaters.

Figure 15. Commercial Familiarity with Air Source Heat Pumps and Heat Pumps Water Heaters



Most commercial survey respondents agree with stated heat pump benefits (ranging from 59% to 74%). However, up to one-quarter of commercial respondents reported being unsure about most benefits (ranging from 15% to 26%). Commercial equity customers were more likely than market rate customers to be unsure whether heat pumps could save energy (25% compared to 15%, respectively) compared to other types of heating. Figure 16 and Figure 17 detail the level of agreement with heat pump benefits between market rate and equity segments.

Figure 16. Commercial Agreement with Benefits of Heat Pump Technologies (Market Rate; n=119)

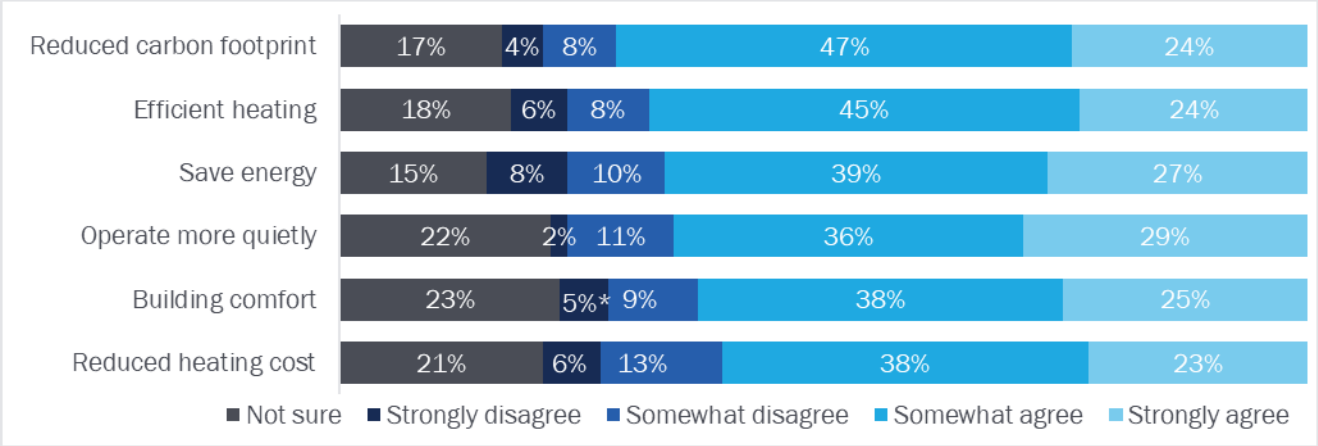
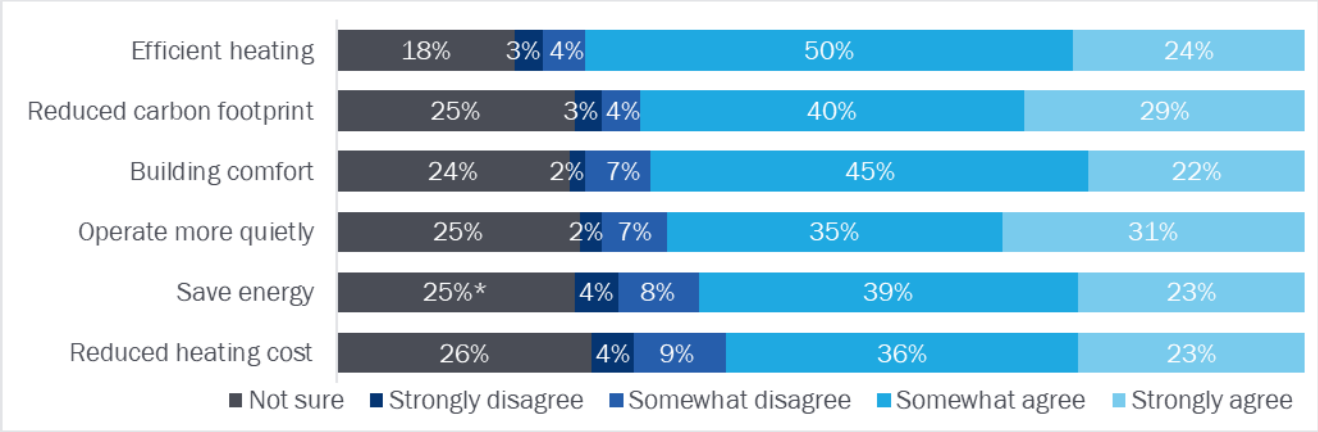
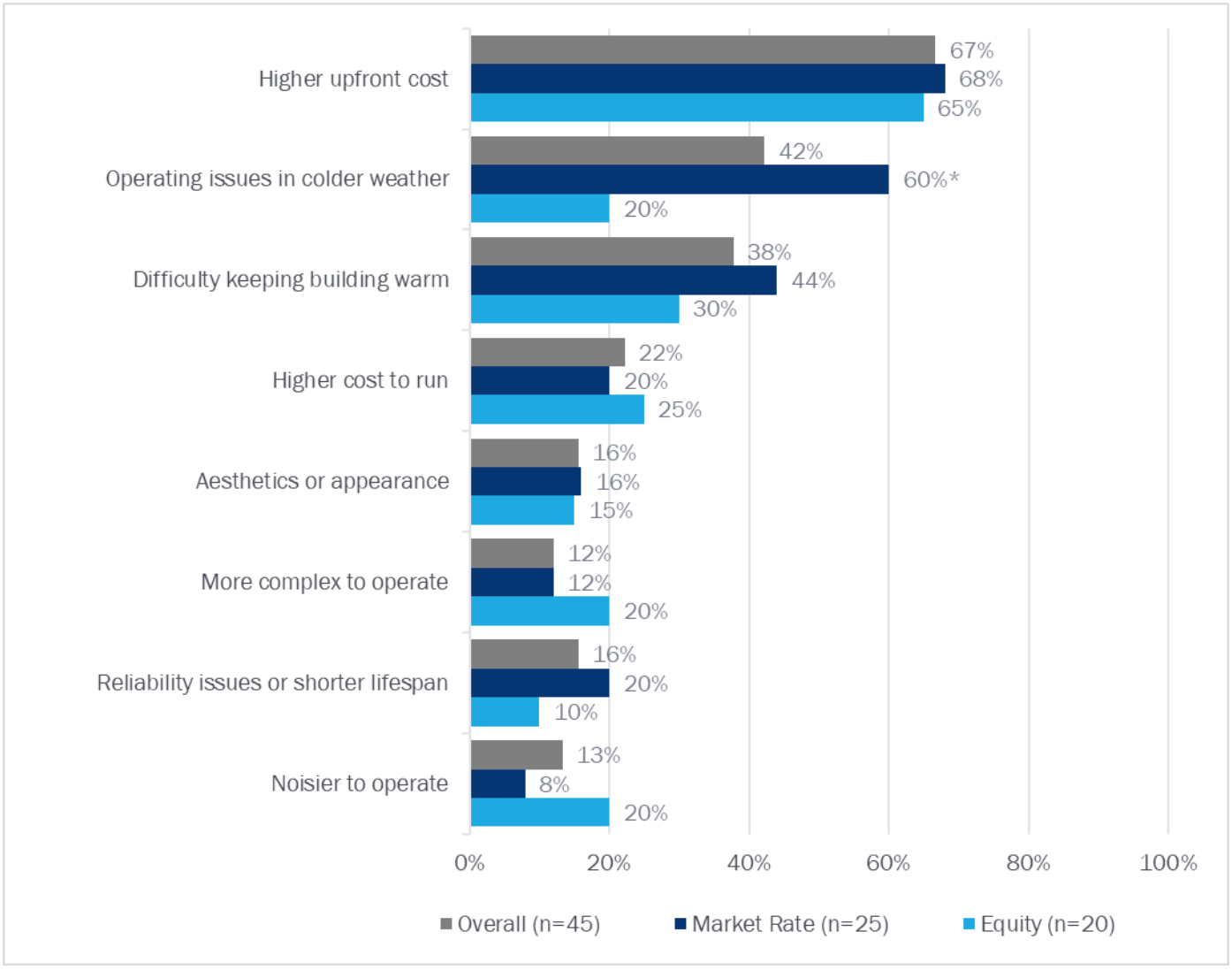


Figure 17. Commercial Agreement with Benefits of Heat Pump Technologies (Equity; n=179)



Only 14% of commercial survey respondents reported previous knowledge of the challenges or drawbacks of heat pumps. Among those aware of heat pump drawbacks, the most commonly identified challenges of heat pumps were higher upfront costs (67%), operating issues in cold weather (42%), and difficulties keeping the building warm (38%). Commercial equity customers were less likely to point out operating issues in cold weather compared to market rate customers (20% and 60%, respectively). Figure 18 further details the commercial awareness of barriers to heat pumps.

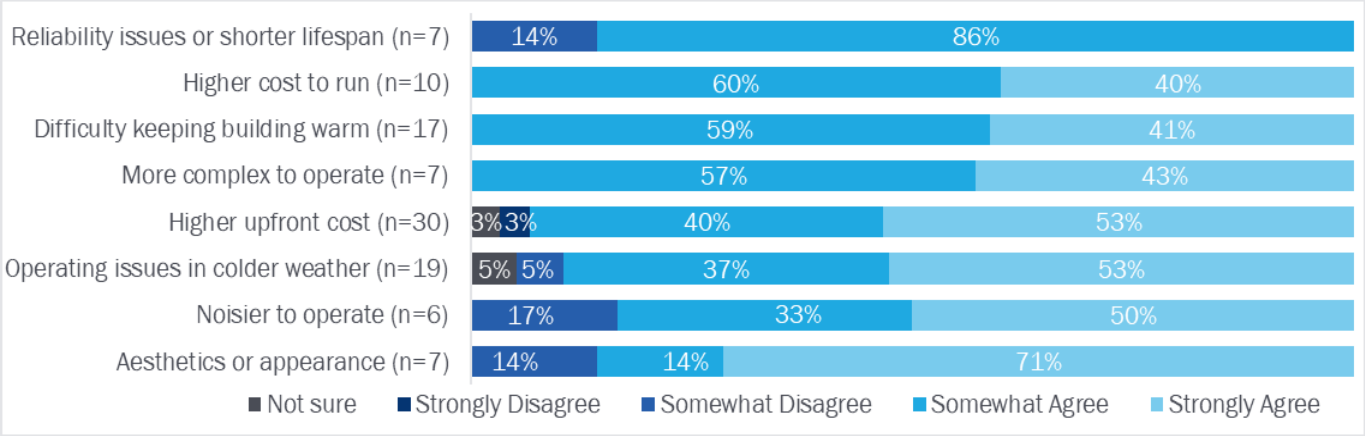
Figure 18. Commercial Awareness of Barriers to Electric Heat Pumps



* Indicates a statistical difference across the market rate and equity segments.

Most of the commercial customers aware of heat pump challenges agreed with the stated barriers, as shown in Figure 19 (ranging from 40% to 71% strongly agree). Only a small portion of these customers disagreed with these barriers (ranging from 5% to 17%); however, the overall sample size for this question was very low given the limited previous awareness of barriers at all.

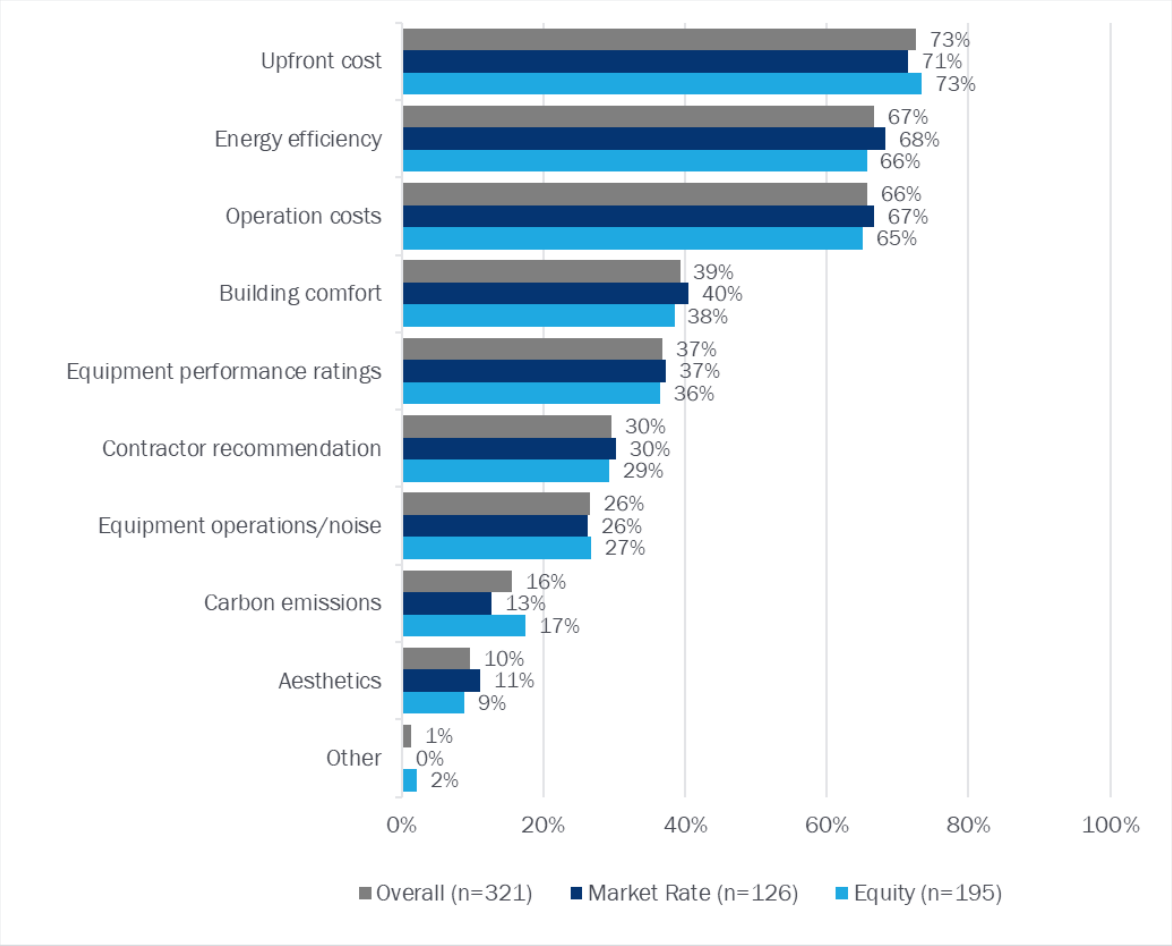
Figure 19. Commercial Agreement with Barriers to Electric Heat Pumps



PURCHASE DECISIONS

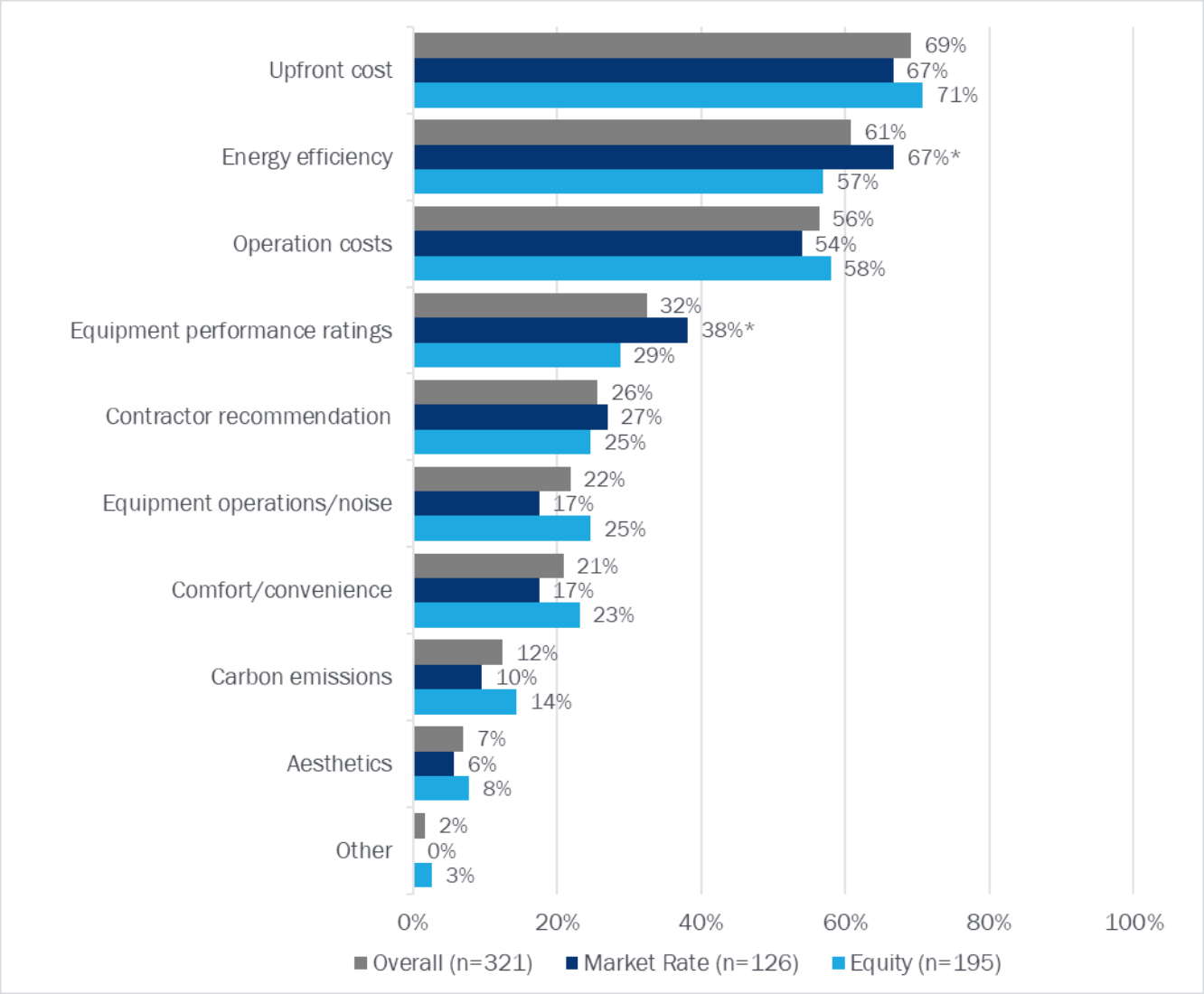
For purchase decisions, at least two-thirds of commercial customers cite upfront cost (73%), energy efficiency (67%), and operation/energy costs (66%) as key considerations for HVAC equipment. Figure 20 summarizes customer-reported key drivers of HVAC purchase decisions. The Research Team found no statistical differences in purchase decision considerations for HVAC equipment among commercial equity and market rate segments.

Figure 20. Commercial Key Drivers of HVAC Purchase Decisions



When selecting water heating equipment, most commercial customers prioritize upfront cost (69%), energy efficiency (61%), and operation/energy costs (56%). Commercial equity customers were less likely to consider energy efficiency or performance ratings than market rate respondents (57% versus 67% and 29% versus 38%, respectively). Figure 21 summarizes the key drivers of water heating purchase decisions.

Figure 21. Commercial Key Drivers of Water Heating Purchase Decisions



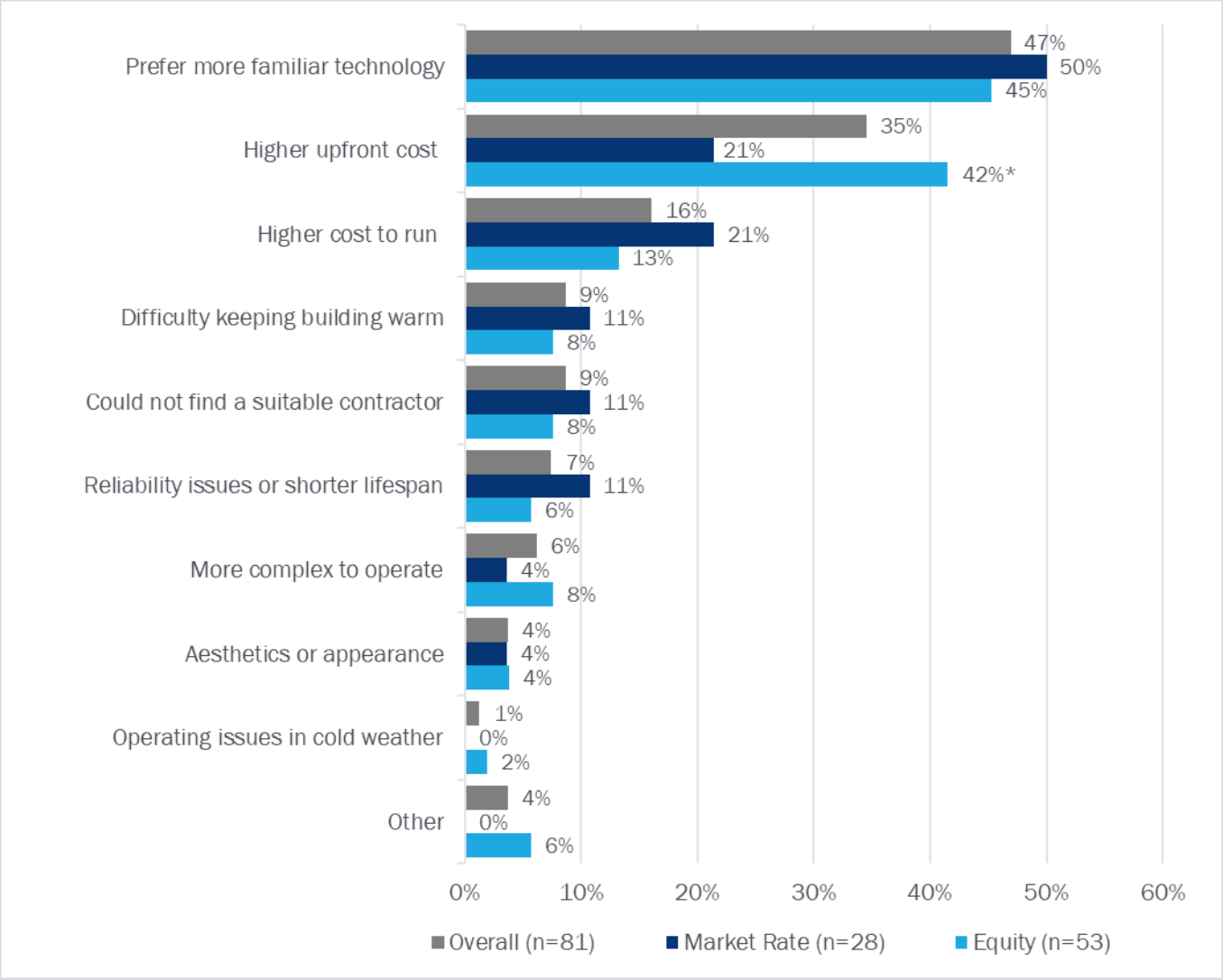
* Indicates a statistical difference across the market rate and equity segments.

BARRIERS

The survey instrument asked about barriers to heat pump adoption from commercial customers who recently considered replacing their HVAC equipment but did not pursue a heat pump. Over one-third of commercial customers considered new HVAC equipment in the past three years (36%), split between a complete system upgrade and upgrading a specific component of the system (19% and 17%, respectively). Only about one-third of those considering new HVAC equipment considered an air source heat pump (33%, n=117).

Among commercial respondents who recently considered new HVAC equipment but did not pursue an electric heat pump, most cited a preference for more familiar technology (47%), upfront costs (35%), or costs to run (16%) as reasons for not installing one. Equity and market rate customers responded similarly in most areas; however, equity customers are more likely to point to higher upfront costs (42% and 21%, respectively). Figure 22 details the reasons cited by commercial respondents for not pursuing a heat pump.

Figure 22. Commercial Barriers to Electric Heat Pumps Adoption

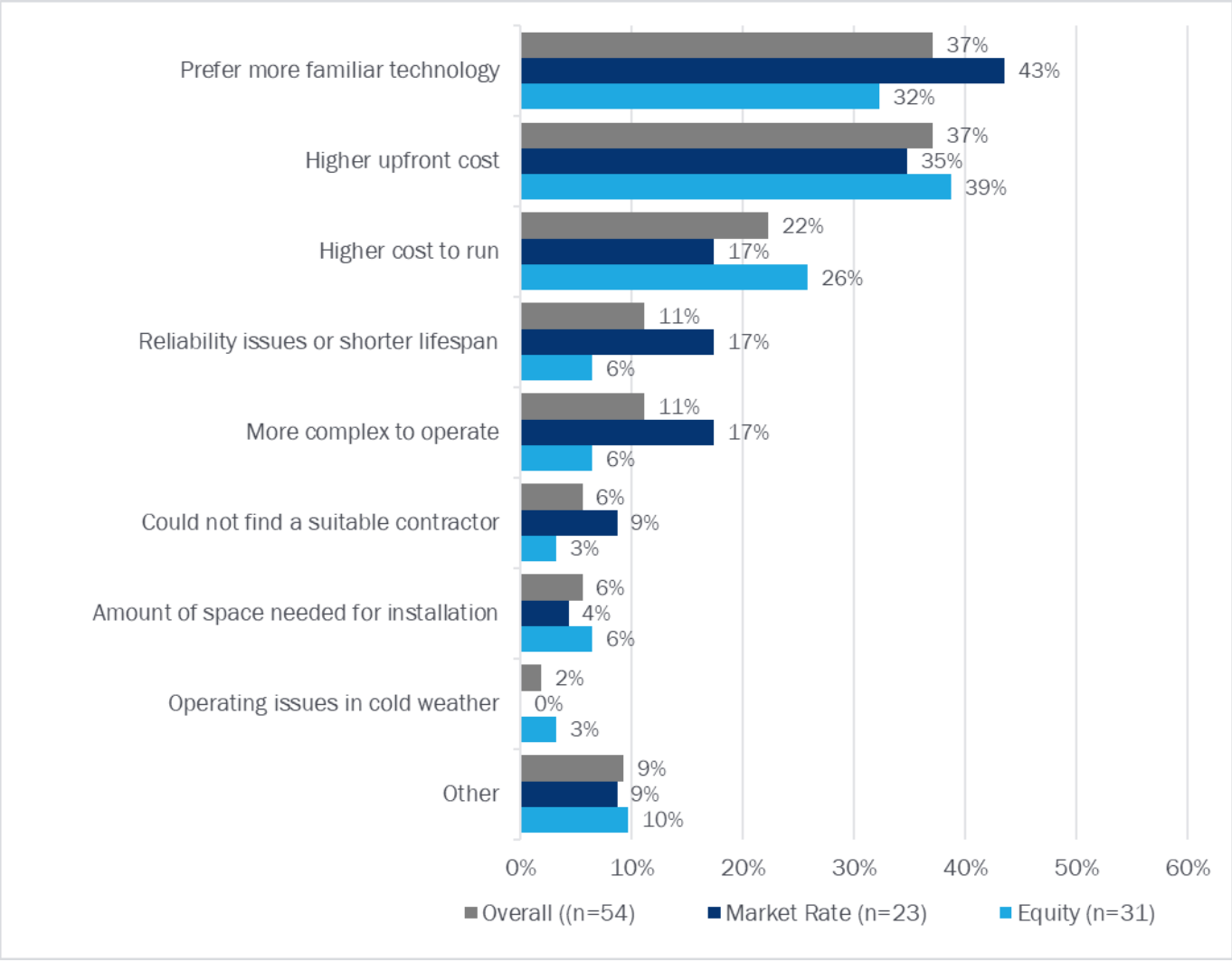


* Indicates a statistical difference across the market rate and equity segments.

One-quarter of commercial customers considered a new water heating equipment system in the past three years (24%). Primarily, commercial customers considered new water heating equipment because their existing system failed or broke (56%). Other reasons included the system not working as well as it used to (14%) and energy bills being too high due to old or inefficient equipment (12%). Of those commercial customers considering new water heating equipment in the past three years, only 16% considered a heat pump water heater.

Among respondents who recently considered new water heating equipment but did not pursue a heat pump water heater, most cited a preference for more familiar technology (37%), upfront costs (37%), or costs to run (22%) as reasons for not installing a heat pump water heater. Equity and market rate customers responded similarly in most areas. Figure 23 provides reasons cited by commercial respondents for not pursuing the installation of a heat pump water heater.

Figure 23. Commercial Barriers to Electric Heat Pumps Water Heater Adoption



3.3 EFFECTIVE INCENTIVE LEVELS FOR FUEL SUBSTITUTION

The third research objective aims to explore the level of incentives required for customers to choose fuel substitution over conventional gas equipment and identify the electric equipment and services needed to support this shift. The market demand and estimated heat pump adoption rates presented in this section are reflective of non-incentivized gas equipment costs.

3.3.1 RESIDENTIAL SECTOR

RESIDENTIAL HEAT PUMP UTILITY SCORE (VIA CONJOINT ANALYSIS)

In addition to the predicted preference for the most important HVAC product attributes when making purchase decisions (discussed in Section 3.2.1), the residential conjoint analysis also produced average utility scores. These scores represent the relative importance of each product attribute compared to varying levels of that attribute and help illustrate respondents' range of opinions. Utility scores should only be compared within attributes, not between attributes.

The utility scores per attribute, as shown in Figure 24 and Figure 25, are scaled to be normalized zero-centered differences. That is, the utilities for different levels of each attribute are adjusted to sum up to zero. As such, a negative score indicates that the level is relatively less preferred than other levels within the same attribute. In contrast, a positive score indicates that the level is relatively more preferred than the others within the attribute. Due to the nature of the zero-centering, even if all attribute levels are considered excellent by respondents, some will be given positive utility scores, and some will be given negative scores. The raw utilities for each respondent have been multiplied by a constant to ensure that the range of utilities for attributes averages 100 to arrive at these rescaled utility scores. As a result, each respondent has nearly equivalent weight when computing average utilities across the sample.

Figure 24 and Figure 25 demonstrate the average normalized utility scores for each level per product attribute. The utility scores exhibit respondents' preference for lower price points for upfront cost and annual cost to operate. In addition, they reflect respondents' relative preference against lower or zero incentive amounts. In Exercise 1: Replace on Burnout, respondents demonstrated a preference against longer times to complete installation. In Exercise 2: Accelerated Replacement, respondents preferred the incentive format of an instant rebate over the others (tax credit and post-purchase rebate).

Figure 24. Replace on Burnout Relative Preferences by Level

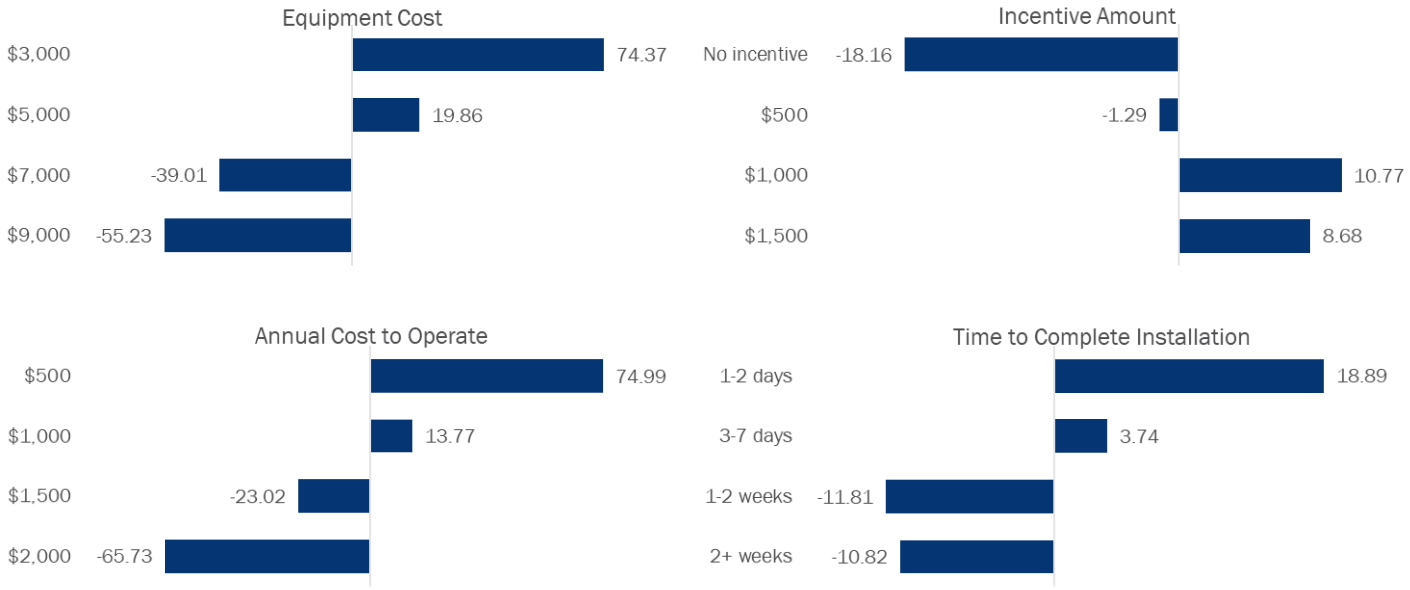
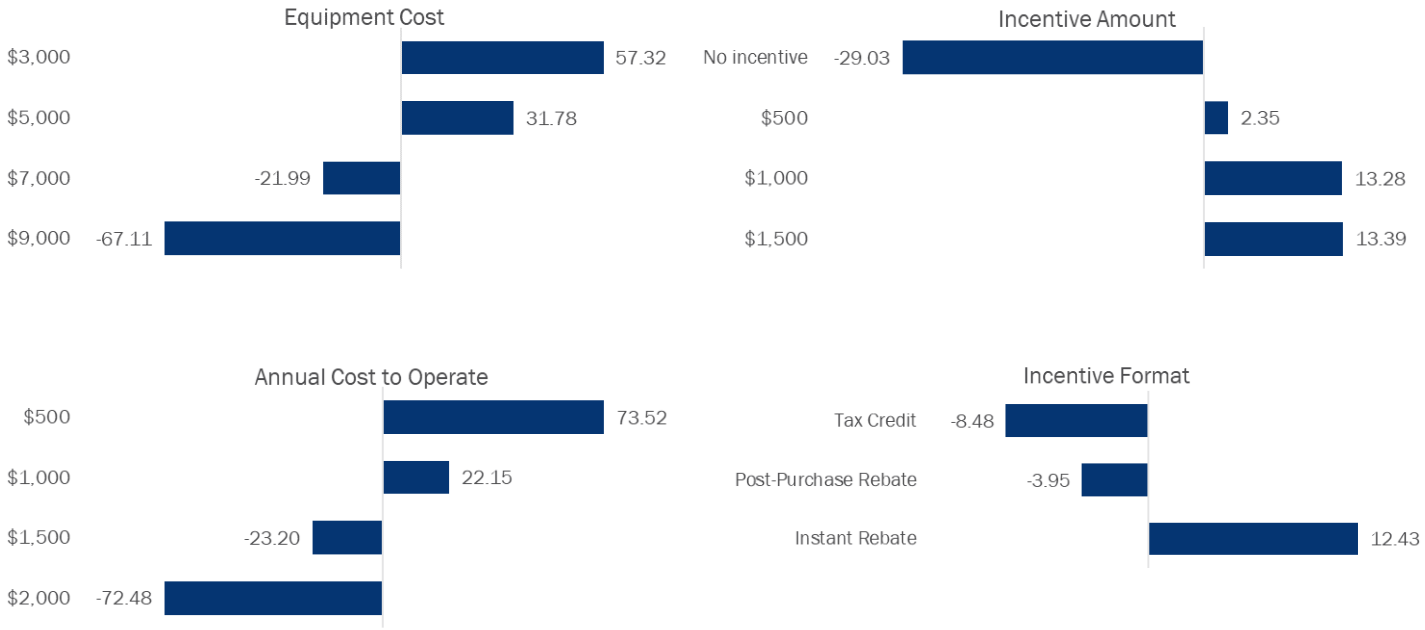


Figure 25. Accelerated Replacement Relative Preferences by Level



RESIDENTIAL HEAT PUMP MARKET DEMAND (VIA CONJOINT ANALYSIS)

Based on the quantified preferences (the utility scores), the Research Team was able to simulate choices between specific available product attributes. The Team created three simulated projections with different annual operating costs for air source heat pumps and gas furnaces or boilers, as shown in Table 21. In each scenario, it is assumed that the household has central air conditioning and the equipment choice is for space heating.

Table 21. Residential Heat Pump Market Simulation Scenarios

Program	Equipment Cost	Incentive Amount	Annual Cost to Operate	Rate Assumption	Equipment Usage
Scenario 1: Represents Current Market Conditions					
Electric Heat Pump	$8,500	$0–$1,500	$750	$0.29/kWh	2,593 kWh
Gas Furnace or Boiler	$3,300	$0	$800	$1.87/therm	1,531 kWh; 191 therms
Scenario 2: Assumes Electric Rates Decrease and Gas Rates Remain Stable					
Electric Heat Pump	$8,500	$0–$1,500	$520	$0.20/kWh	2,593 kWh
Gas Furnace or Boiler	$3,300	$0	$660	$1.87/therm	1,531 kWh; 191 therms
Scenario 3: Assumes Electric Rates Decrease and Gas Rates Increase					
Electric Heat Pump	$8,500	$0–$1,500	$520	$0.20/kWh	2,593 kWh
Gas Furnace or Boiler	$3,300	$0	$830	$2.76/therm	1,531 kWh; 191 therms
Scenario 4: Assumes Electric Rates Increase and Gas Rates Remain Stable					
Electric Heat Pump	$8,500	$0–$1,500	$990	$0.38/kWh	2,593 kWh
Gas Furnace or Boiler	$3,300	$0	$940	$1.87/therm	1,531 kWh; 191 therms

Notes: Rate assumptions for California residential customers were formulated using data from the US EIA.
Annual costs to operate a gas furnace or boiler are inclusive of gas usage associated with the furnace as well as electric usage associated with the furnace fan and a central air conditioner.
Sources: Electric Power Monthly - US Energy Information Administration (EIA), 2024.
https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.
California price of natural gas delivered to residential consumers (dollars per thousand cubic feet), March 29, 2024.
https://www.eia.gov/dnav/ng/hist/n3010ca3M.htm.

Scenario 1: Current Market Conditions

In the first simulated scenario in which air source heat pumps have similar annual operating costs to a combination of central AC and a gas furnace ($750 and $800, respectively), as many as 24% of market rate customers would adopt an air source heat pump with no incentive. This scenario represents current market conditions for electricity and natural gas rates in California based on EIA rate data,[27,28] and equipment usage assumptions from the 2019 RASS.[29] Notably, the Research Team found diminishing returns after the first $500 incentive increase for the replace on burnout scenario and after the first $1,000 for the accelerated replacement exercise. Figure 26 and Figure 27 illustrate projected price sensitivity with average annual energy costs for the burnout and accelerated replacement scenarios,

[27] Electric Power Monthly - U.S. Energy Information Administration (EIA), 2024.
https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a.
[28] California price of natural gas delivered to residential consumers (dollars per thousand cubic feet), March 29, 2024.
https://www.eia.gov/dnav/ng/hist/n3010ca3M.htm.
[29] "2019 California Residential Appliance Saturation Study," California Energy Commission, July 2021,
https://www.energy.ca.gov/sites/default/files/2021-08/CEC-200-2021-005-P0.pdf.

respectively. Overall, residential equity customers are less likely than market rate customers to choose a heat pump at any incentive level.

Figure 26. Scenario 1: Heat Pump Price Sensitivity with Average Energy Costs (Replace on Burnout)

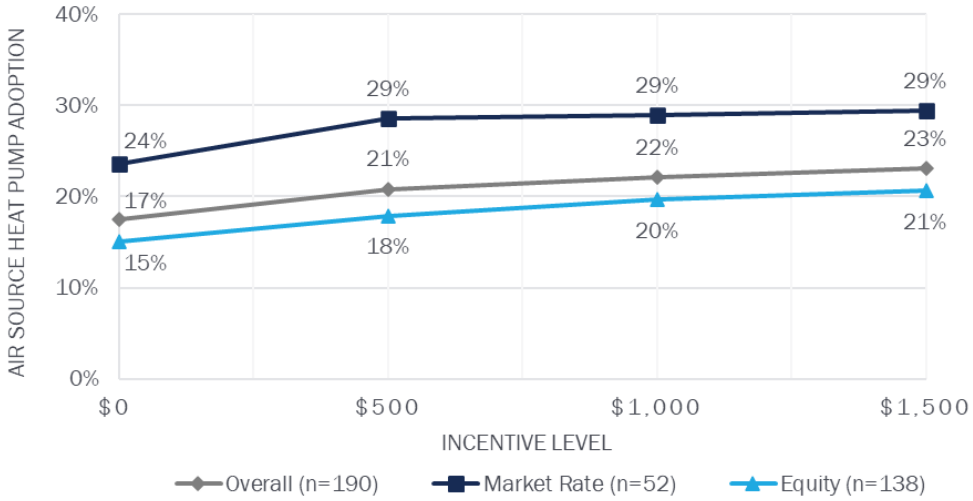
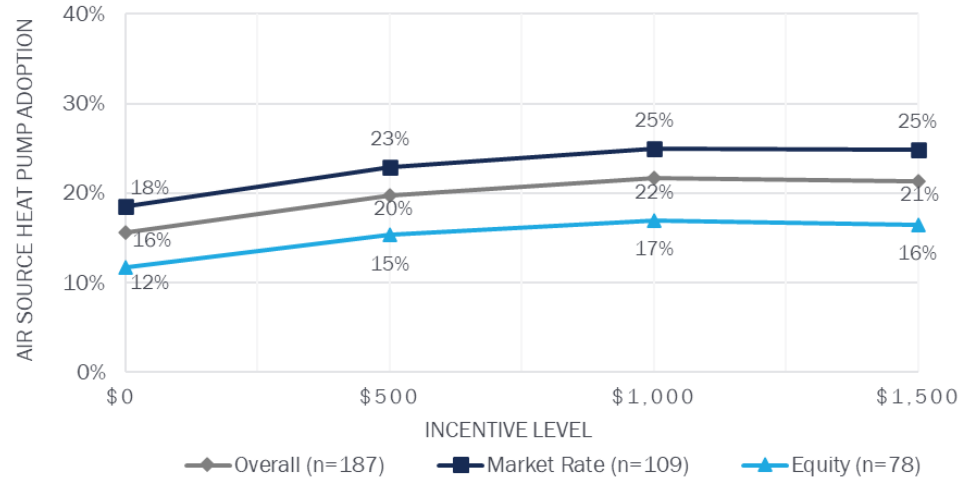


Figure 27. Scenario 1: Heat Pump Price Sensitivity with Average Energy Costs (Accelerated Replacement)



Scenario 2: Assumes Electric Rates Decrease and Gas Rates Remain Stable

The Research Team conducted further market simulations to identify how changes in electricity and gas rates may affect the impact of incentives on customers' decision to adopt air source heat pumps. Using the 2019 RASS data on equipment usage and EIA average energy costs, the Research Team calculated the current average annual costs to operate an air source heat pump and a combination of central AC and a natural gas furnace or boiler.

In a simulated scenario in which average annual electric operating costs were reduced by 31% and natural gas costs remained aligned with current market conditions ($520 for an air source heat pump and $660 for a central AC and natural gas furnace or boiler),[30] as many as 27% of customers overall would adopt a heat pump at an incentive of $1,500. Equity customers exhibited less likelihood than market rate customers to adopt an air source heat pump at all

[30] This estimate is based on proprietary utility rate research conducted by Opinion Dynamics in California in response to potential legislation encouraging utility rate designs that motivate electrification.

incentive levels in all scenarios. Figure 28 and Figure 29 show predicted demand for air source heat pumps under varying incentive conditions, with electricity rates 31% below the current California average.

Figure 28. Scenario 2: Heat Pump Price Sensitivity Assuming Reduced Electric Rates and Stable Gas Rates (Replace on Burnout)

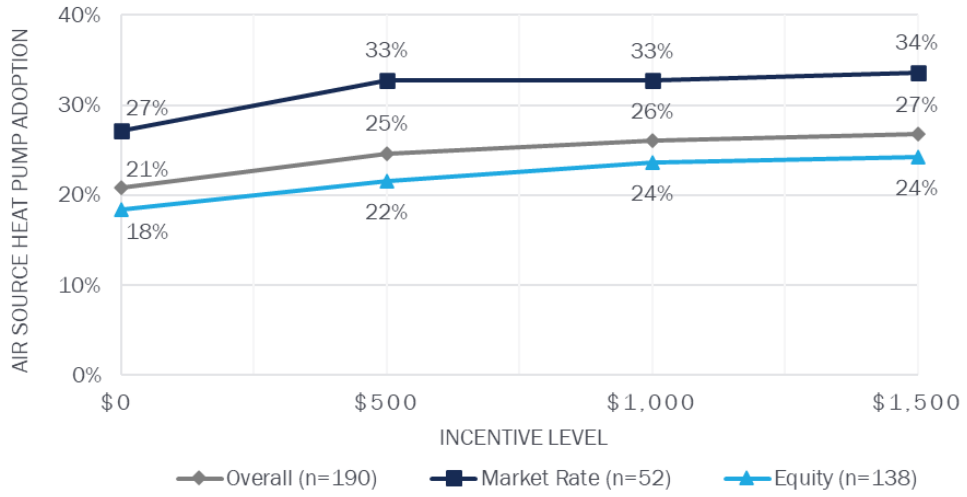
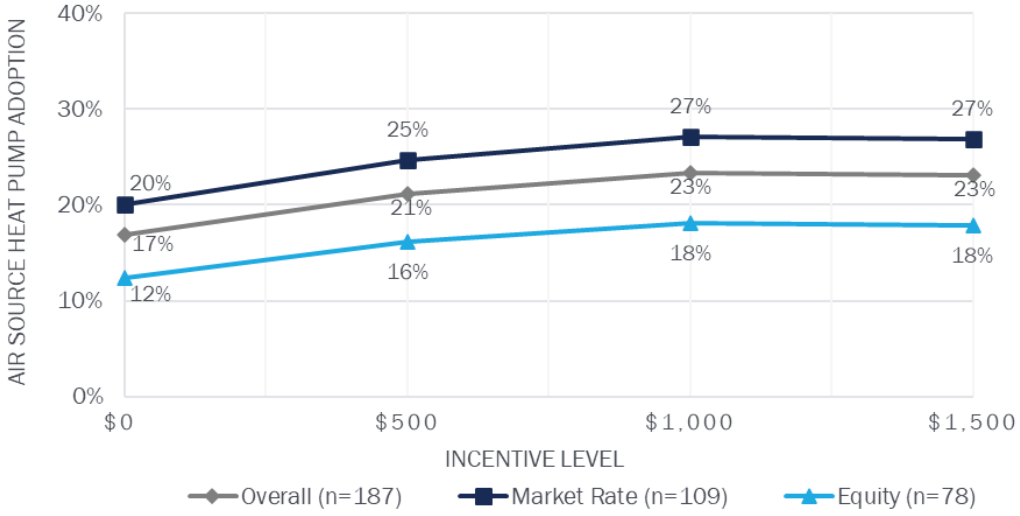


Figure 29. Scenario 2: Heat Pump Price Sensitivity Assuming Reduced Electric Rates and Stable Gas Rates (Accelerated Replacement)



Scenario 3: Assumes Electric Rates Decrease and Gas Rates Increase

The Research Team also estimated price sensitivity under a simulated scenario where electricity rates decreased by 31% (like in Scenario 2), but natural gas prices increased at a rate similar to natural gas price volatility documented over the past five years (an increase of 48%). Under these assumptions, the annual cost to operate an air source heat pump was $520, and $830 for a natural gas furnace or boiler. Under these conditions, as many as 31% of (market rate) customers would adopt an air source heat pump with no incentive. Notably, under these conditions, market rate

customers have the highest percent of adoption of all the scenarios (39%) at an incentive of $1,500. These results are exhibited in more detail in Figure 30 and Figure 31.

Figure 30. Scenario 3: Heat Pump Price Sensitivity Assuming Reduced Electric Rates and Increased Gas Rates (Replace on Burnout)

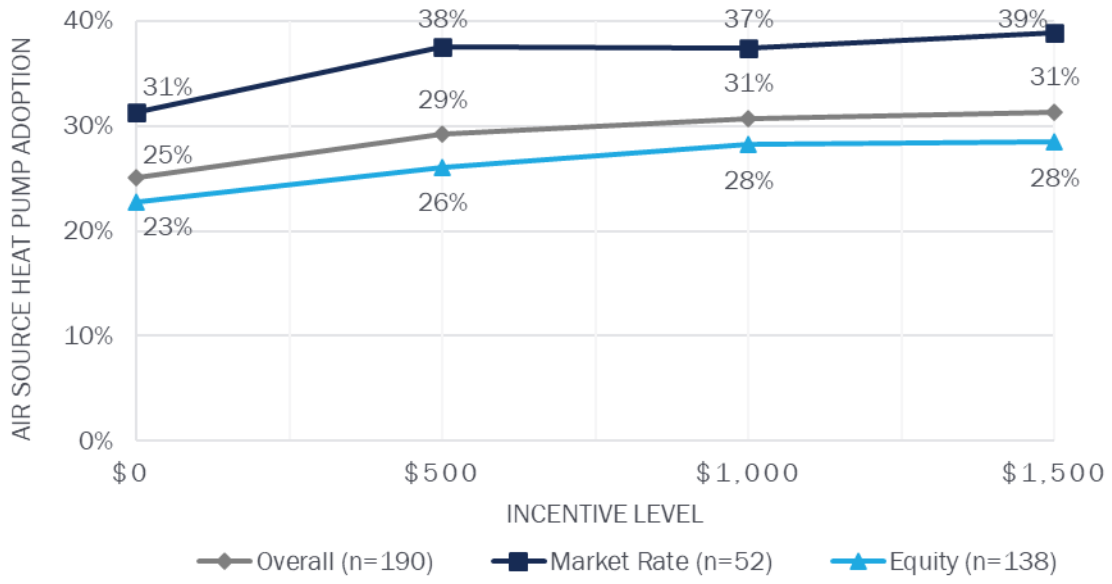
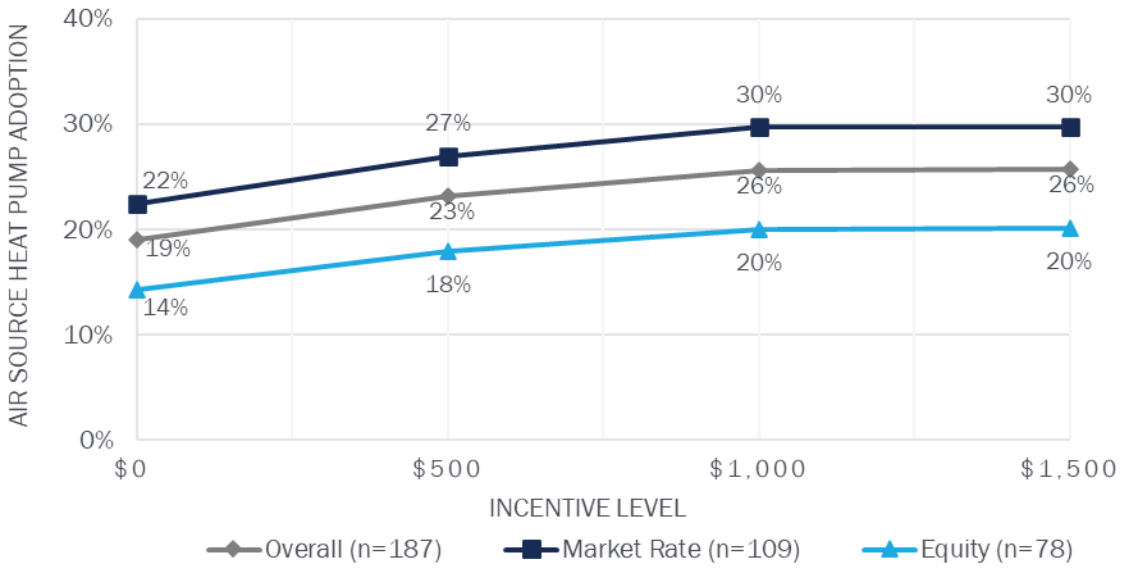


Figure 31. Scenario 3: Heat Pump Price Sensitivity Assuming Reduced Electric Rates and Increased Gas Rates (Accelerated Replacement)



Scenario 4: Assumes Electric Rates Increase and Gas Rates Remain Stable

Lastly, the Research Team estimated price sensitivity under a simulated scenario where electricity rates increased by 31% (i.e., inverse of Scenario 2) and natural gas rates remained aligned with current market conditions. Based on these assumptions, the annual energy costs amounted to $990 for an air source heat pump and $940 for a natural gas furnace or boiler. Under these conditions, 15% of customers replacing failed equipment would adopt an air source heat pump with no incentive and 20% would adopt one with a $1,500 incentive. Rates of heat pump adoption are slightly

lower across all incentive levels and for both segments with these increased electric rates compared than with existing electric and gas rates. These results are exhibited in more detail in Figure 32 and Figure 33.

Figure 32. Scenario 4: Heat Pump Price Sensitivity Assuming Increased Electric Rates and Stable Gas Rates (Replace on Burnout)

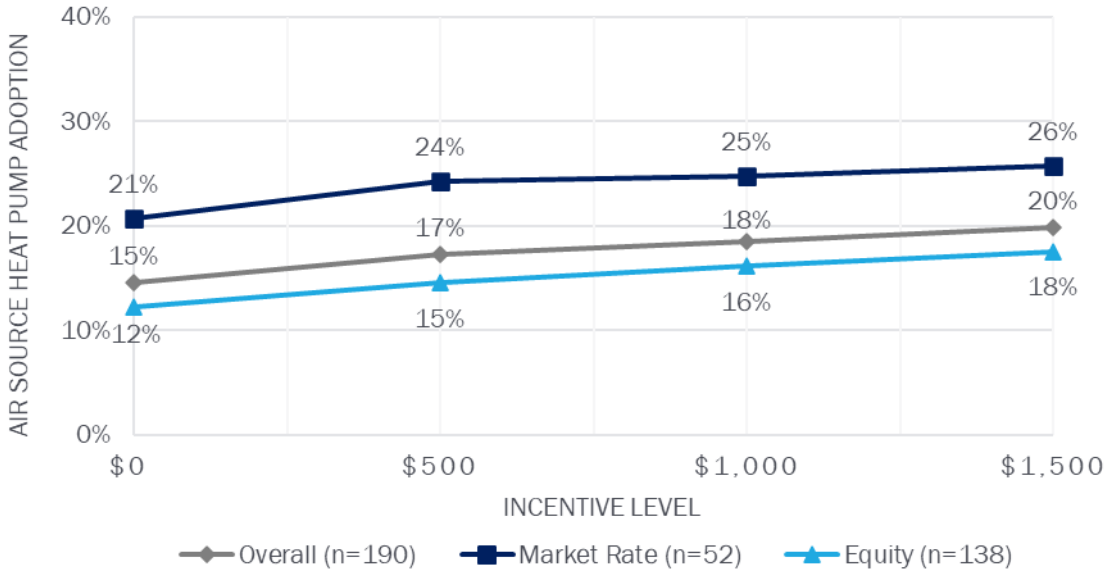
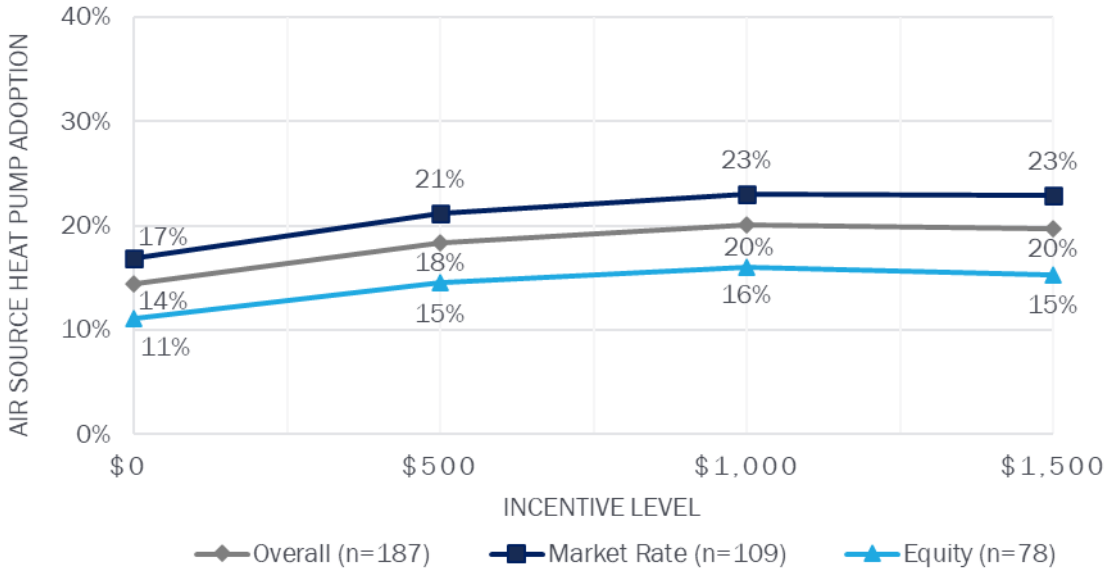


Figure 33. Scenario 4: Heat Pump Price Sensitivity Assuming Increased Electric Rates and Stable Gas Rates (Accelerated Replacement)



RESIDENTIAL HEAT PUMP WATER HEATER MARKET DEMAND ANALYSIS

Using a separate methodology, described in Section 2.3.2, the Research Team conducted a market demand analysis to model the likelihood that residential customers would install a heat pump water heater at different incentive levels.

Figure 34 shows the predicted installation rates for all residential customers, market rate, and equity residential customers as a function of the incentive level. Just over 10% of residential customers opt to install heat pump water heaters without incentives; however, incentives boost installations, though the boost in installation varies across all

incentive levels. With an incentive that covers 100% of the incremental cost of a heat pump water heater, installations reach a maximum of about 34%. Thus, two-thirds of residential customers say they will use gas for water heating or install an electric resistance water heater rather than a heat pump water heater, even if the utility covers 100% of the incremental cost.

While incentives lift heat pump water heater adoption, a larger percentage of respondents (29%) say they wouldn't adopt, even if the utility covers 100% of the incremental cost. These respondents said they were unlikely to install a heat pump water heater and reported being unfamiliar with the technology. Most of these respondents cited unfamiliarity with the technology (69%), the upfront cost of the water heater (37%), or annual energy operating costs as a barrier (36%).

Figure 34. Residential Heat Pump Water Heater Market Demand Curve

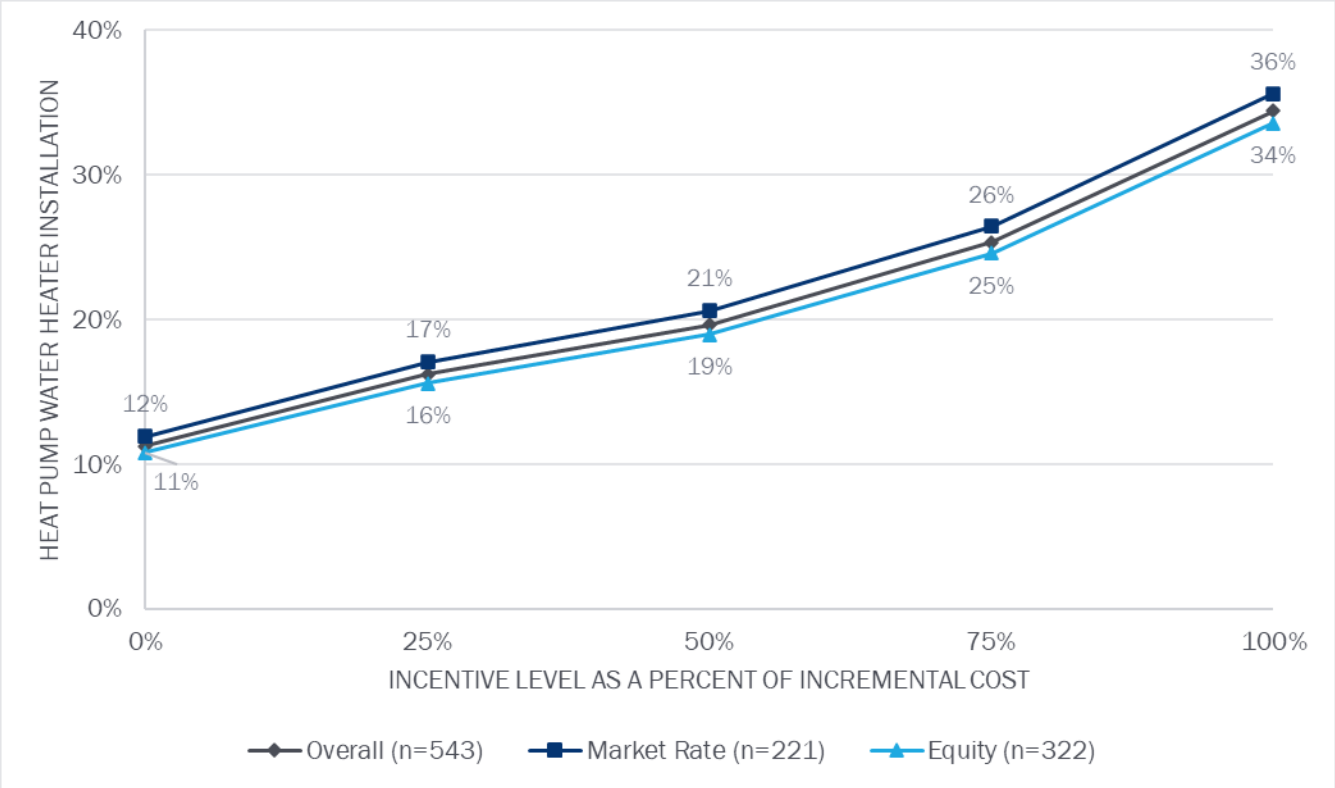


Table 22, Table 23, and Table 24 report the predicted percentage of residential customers installing heat pump water heaters (also presented in Figure 34), the percentage point change in customers installing at each incentive level, and the percentage increase in customers installing for all residential customers, residential market rate customers, and residential equity customers. Based on the residential customer segment responses, the largest percent increase in market demand occurs at an incentive level of 25% of the heat pump water heater's incremental cost (44% increase in demand at this incentive level). In addition, these tables report estimates of the elasticity of installations with respect to incentives at each incentive level. The elasticity is the percent change in installations from a one percent change in incentives. For example, in Table 22, at a 25% incentive level, the elasticity of demand is 0.18, indicating that for every 1% increase in the incentive level, the installations increase by approximately 0.18%. Demand for heat pump water is most sensitive to increases in incentives between the 75% and 100% incentive levels, with an elasticity of demand of 1.06, indicating that for every 1% increase in the incentive level, the installations increase by approximately 1.06%. It is most sensitive because a 33% increase in the incentive level from 75% to 100% results in a percentage increase in demand of about 36%. (In contrast, doubling incentives from 25% to 50% of incremental costs only results in a 21%

increase in demand.) This indicates that consumer demand is most sensitive to increases in incentives when the utility increases the incentive to cover 100% of the incremental costs.

Table 22. Summary Table of Residential Heat Pump Water Heaters Results for Combined Segments

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	11.28	11.28	N/A	N/A
25%	16.21	4.93	43.73	0.18
50%	19.64	3.44	21.22	0.29
75%	25.34	5.70	28.99	0.63
100%	34.39	9.06	35.74	1.06

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

As shown in Table 23 and Table 24, at each incentive level, residential equity customers install heat pump water heaters at a lower rate than market rate customers. This difference is statistically significant. However, overall, equity and market customers respond to incentives similarly (with a similar percentage increase in market demand at each incentive level).

Table 23. Summary Table of Residential Heat Pump Water Heaters Results for Market Rate Segment

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	11.94	11.94	N/A	N/A
25%	17.07	5.12	42.9	0.18
50%	20.61	3.54	20.76	0.28
75%	26.43	5.82	28.24	0.62
100%	35.59	9.16	34.66	1.03

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

Table 24. Summary Table of Residential Heat Pump Water Heaters Results for Equity Segment

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	10.81	10.81	N/A	N/A
25%	15.62	4.80	44.36	0.18
50%	18.98	3.37	21.57	0.29
75%	24.59	5.61	29.54	0.64
100%	33.57	8.98	36.53	1.08

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

3.3.2 COMMERCIAL SECTOR

COMMERCIAL HEAT PUMP MARKET DEMAND ANALYSIS

Similar to the approach used for residential water heaters, the Research Team used a market demand analysis methodology to model the likelihood that commercial customers would install an air source heat pump at different incentive amounts. Figure 35 shows the predicted installation rates for heat pumps among all commercial customers and for market rate and equity commercial customers as a function of the incentive level. Overall, about 20% of commercial customers are willing to install air source heat pumps without financial incentives. However, commercial equity customers are less inclined to install air source heat pumps across all incentive levels compared to market rate customers. Despite their generally lower inclination to install heat pumps, equity customers respond similarly to changes in financial incentives as other customer groups.

Figure 35. Air Source Heat Pump Market Demand Curve

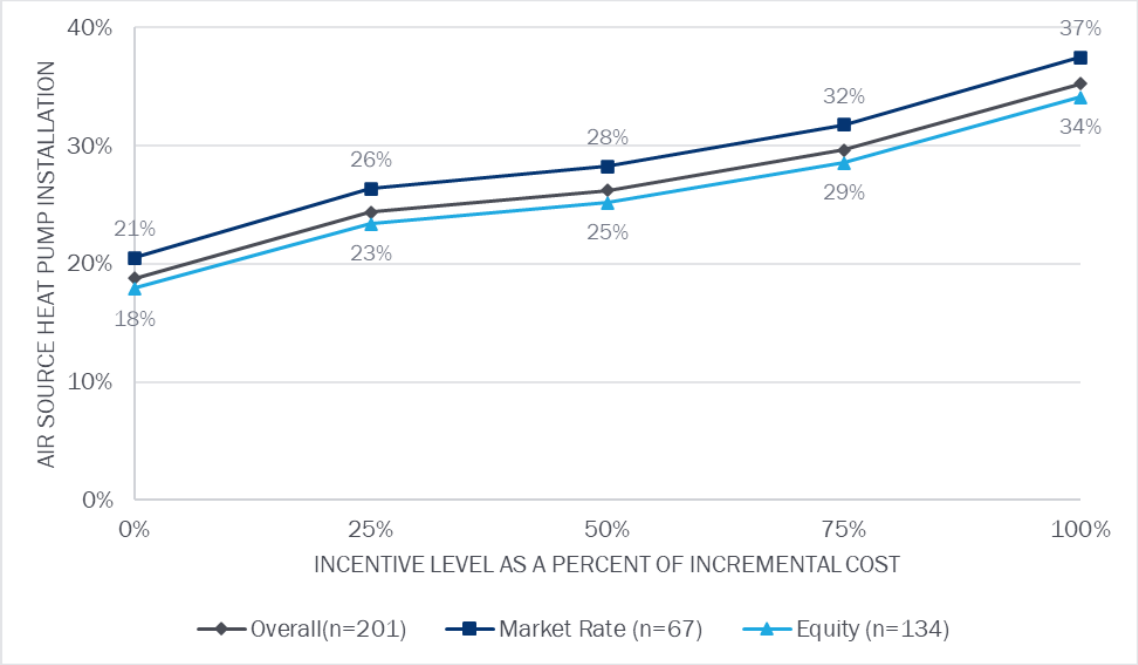


Table 25, Table 26, and Table 27 report the predicted percentage of commercial customers installing heat pumps (also presented in Figure 35), the percentage point change in customers installing heat pumps at varying incentive levels, and the percentage increase in customers installing for all commercial customers, commercial market rate customers, and commercial equity customers. Overall, the probability of installing air source heat pumps increases as financial incentives are increased. However, the largest percentage increases in commercial air source heat pump installations occur when the utility increases the incentive from 0% to 25%. This is true for all commercial customers as well as equity and market rate customers. Table 25 shows an approximate 30% increase in demand when incentives increase to 25%.

In addition, these tables report estimates of the elasticity of installations with respect to incentives at each incentive level. As shown by the elasticity estimates, demand for air source heat pumps is most sensitive to increases in incentives when the utility lifts the incentive from 75% to 100%. When a utility increases the incentive to cover 100% of the incremental cost, we expect demand to be highly responsive.

Table 25. Summary Table of Commercial Air Source Heat Pump Results for Combined Segments

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	18.78	18.78	N/A	N/A
25%	24.37	5.59	29.78	0.13
50%	26.19	1.82	7.46	0.11
75%	29.62	3.43	13.10	0.31
100%	35.23	5.61	18.94	0.61

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

The elasticity estimates in Table 26 and Table 27 show very small differences between market rate and equity customers in the responsiveness to incentives. Thus, although equity customers install air source heat pumps at a lower rate, the incentives have similar effects on the likelihood they install.

Table 26. Summary Table of Commercial Air Source Heat Pump Results for Market Rate Segments

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	20.52	20.52	N/A	N/A
25%	26.35	5.83	28.40	0.12
50%	28.23	1.88	7.12	0.10
75%	31.75	3.52	12.48	0.29
100%	37.46	5.71	18.00	0.58

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

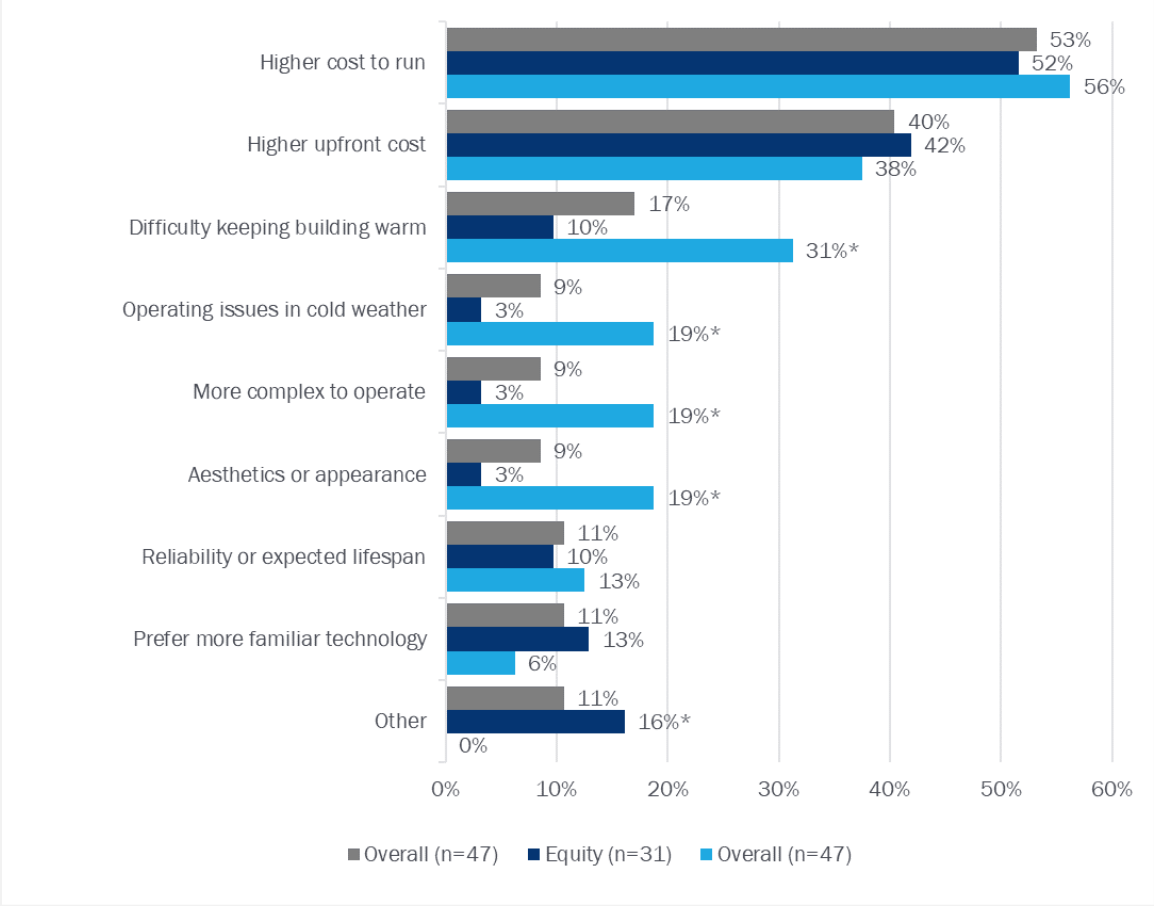
Table 27. Summary Table of Commercial Air Source Heat Pump Results for Equity Segments

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	17.90	17.91	N/A	N/A
25%	23.38	5.47	30.56	0.13
50%	25.17	1.79	7.65	0.11
75%	28.56	3.39	13.45	0.32
100%	34.12	5.56	19.47	0.62

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

The survey instrument also asked why commercial customers are unlikely to ever install a packaged air source heat pump. Most pointed to cost to run (53%), upfront cost (40%), or difficulty keeping the build warm (17%). Equity customers were less likely to consider difficulty keeping the building warm, operating issues in cold weather, more complex to operate, or aesthetic or appearance than market rate respondents (10% versus 31%, 3% versus 19%, 3% versus 19%, and 3% versus 19%). Figure 36 summarizes the key reasons commercial customers are unlikely to install a packaged air source heat pump. A very small portion of commercial customers indicated they would be very unlikely to install a split system air source heat pump (n=8).

Figure 36. Commercial Reasons to Be Unlikely to Install a Packaged Air Source Heat Pump



* Indicates a statistical difference across the market rate and equity segments.

COMMERCIAL HEAT PUMP WATER HEATER MARKET DEMAND ANALYSIS

Figure 37 presents the modeled market demand results for commercial heat pump water heaters, offering insights into customer inclinations toward installing the measure at different incentive levels. Approximately 13% of commercial customers are interested in installing heat pump water heaters even without any financial incentives. The willingness to install heat pump water heaters increases when financial incentives increase. Commercial equity customers show a lower propensity to install heat pump water heater systems than other groups at each incentive level. However, they display a similar pattern of increased installation likelihood in response to higher incentives.

Figure 37. Commercial Heat Pump Water Heater Market Demand Curve

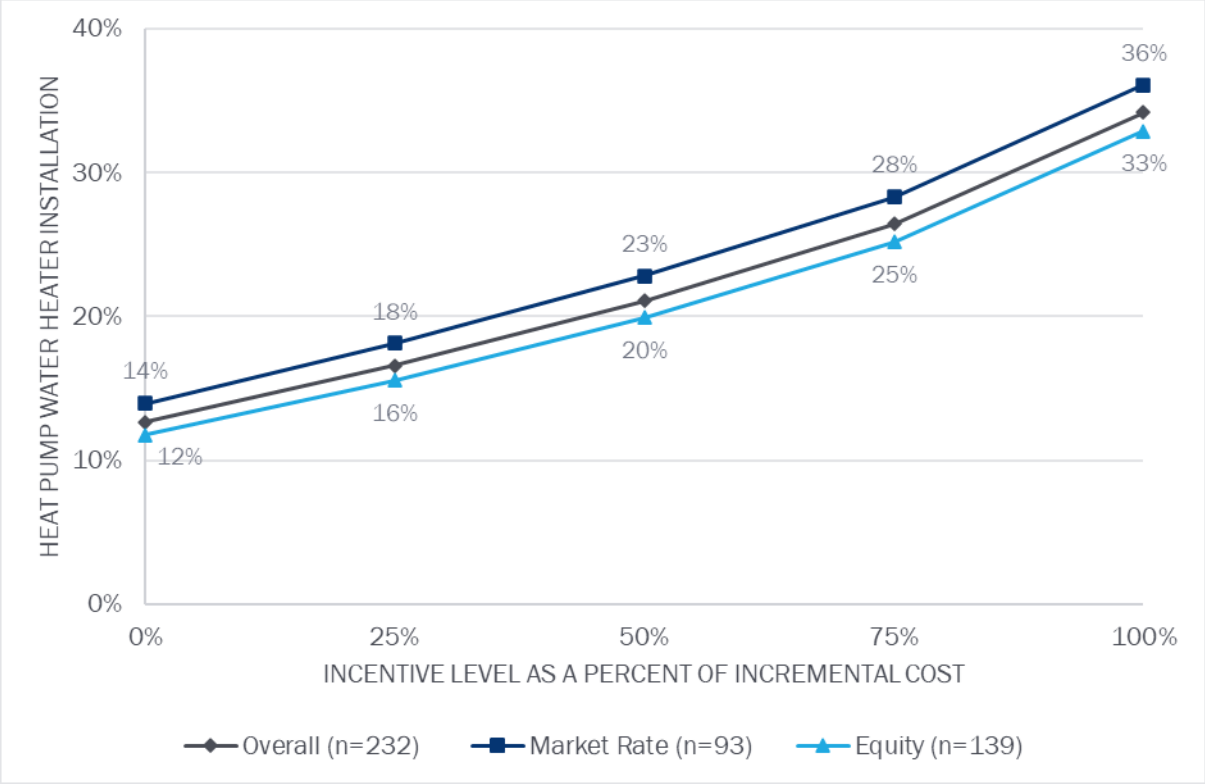


Table 28, Table 29, and Table 30 report the predicted percentage of commercial customers installing heat pump water heaters, the percentage point change in customers installing heat pump water heaters at varying incentive levels, and the percentage increase in customers installing at each incentive level for all commercial customers, commercial market rate customers, and commercial equity customers. The most significant rise in heat pump water heater installations occurs when the incentive increases from 0% to 25%. This lift is evident across all commercial customer segments. However, further increases in incentives also produced large percentage increases in heat pump water heater installations. Doubling the incentive from 25% to 50% lifted installations by about 27%. In addition, these tables report estimates of the elasticity of installations with respect to incentives. As shown by the elasticity estimates, demand for heat pump water heaters is most sensitive to increases in incentives when the utility lifts the incentive from 75% to 100%. A one percent increase in incentives raises installations by about 0.9%.

Table 28. Summary Table of Commercial Heat Pump Water Heaters Results for Combined Segments

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	12.65	12.65	N/A	N/A
25%	16.58	3.93	31.03	0.13
50%	21.08	4.50	27.16	0.36
75%	26.43	5.35	25.39	0.56
100%	34.16	7.73	29.24	0.89

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

As the elasticity estimates in Table 29 and Table 30 show, there are only small differences between market rate and equity customers in the responsiveness to incentives. Thus, although equity customers install heat pump water heaters at a lower rate, the incentives have similar effects on the likelihood they install.

Table 29. Summary Table of Commercial Heat Pump Water Heaters Results for Market Rate Segment

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	13.96	13.96	N/A	N/A
25%	18.12	4.16	29.8	0.13
50%	22.81	4.69	25.89	0.34
75%	28.30	5.49	24.05	0.54
100%	36.09	7.79	27.54	0.85

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

Table 30. Summary Table of Commercial Heat Pump Water Heaters Results for Equity Segment

Incentive Level as a Percent	Market Demand (% respondents installing)	Increase in Market Demand	Percentage Increase in Market Demand	Elasticity of Demand
0%	11.78	11.78	N/A	N/A
25%	15.55	3.77	32.01	0.14
50%	19.92	4.38	28.14	0.37
75%	25.18	5.26	26.41	0.58
100%	32.87	7.69	30.52	0.93

Notes: Market Demand was estimated based on the results from the ordered logit model. The Increase in Market Demand is the percentage point increase in installations from increasing incentives. Percentage Increase in Market Demand is the Increase in Market Demand divided by the Market Demand at the immediately lower incentive level. The Elasticity of Demand is the percent change in installations from a one percent change in incentives. The elasticity was estimated as an arc elasticity using the midpoint of each segment of the installation demand curve as the reference point for calculating the percentage changes in demand and incentives.

3.4 CUSTOMER-SIDE ECONOMICS FOR ELECTRIFICATION

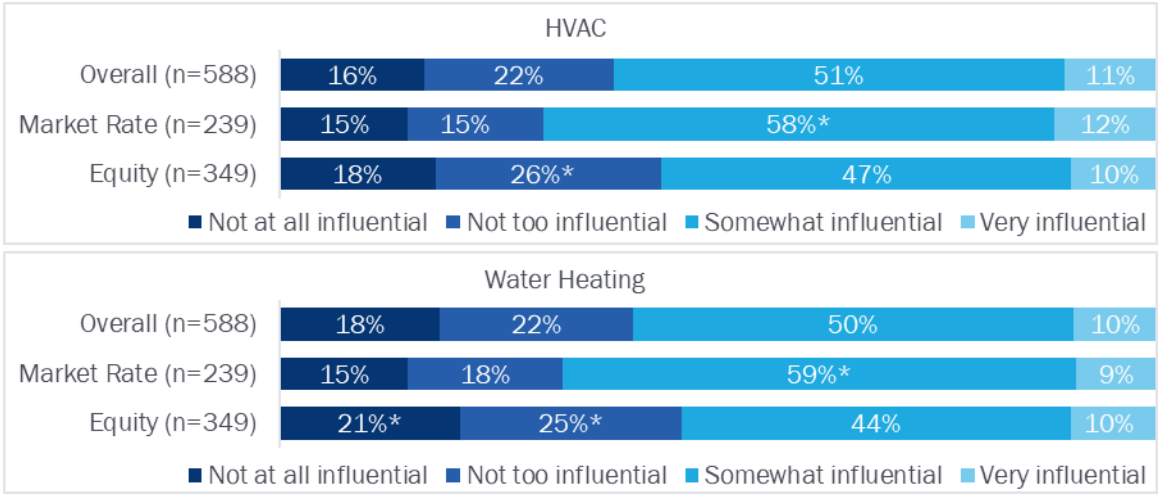
The fourth research objective aims to assess the customer-side economics and other considerations when replacing an existing gas unit with a heat pump.

3.4.1 RESIDENTIAL SECTOR

CONSIDERATIONS

Overall, about 60% of this study's online customer survey residential respondents suggested contractor recommendations are at least somewhat influential on their choice of HVAC and water heating equipment. Market rate customers were significantly more likely than equity customers to describe a contractor's recommendation on HVAC equipment as somewhat influential (58% and 47%, respectively). Similarly, market rate customers were significantly more likely than equity customers to describe a contractor's recommendation on water heating equipment as somewhat influential (59% and 44%, respectively). Additionally, residential equity customers were significantly more likely than market rate customers to describe a contractor's recommendation as not at all influential to their HVAC equipment decisions (26% and 15%, respectively) and their water heating equipment decisions (25% and 18%, respectively). Further details of these results are shown in Figure 38.

Figure 38. Residential Influence of Contractor Recommendation on Equipment Decisions



* Indicates a statistical difference across the market rate and equity segments.

Additionally, the *Technology and Equipment for Clean Heating (TECH) Initiative Baseline Market Assessment Study* reported there were 128,263 licensed contractors outside of DACs compared to just 25,309 contractors in DACs indicating equity customers may find it more difficult to access experienced contractors in their area.[31]

Although contractor recommendations may not be as important to equity customers, the *Technology and Equipment for Clean Heating (TECH) Initiative Baseline Market Assessment Study* indicated a higher percentage of residential respondents from DACs (residential equity customers) than from non-DACs (residential market rate) rated a utility's endorsement as very or extremely important when deciding to buy an HVAC heat pump, for both heating (47% vs. 28%) and cooling (43% vs. 30%) systems.

[31] https://www.calmac.org/publications/OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf

Regarding the residential equity customer segment, the *2022 Low Income Needs Assessment (LINA) Study* focused on low-income renter household energy-related needs and barriers to participation in the ESA program.[32] Since the ESA program is made available to income-qualified households at no costs, it furnishes good insights into the barriers to participation in energy efficiency and fuel substitution programs; however, Decision 23-04-035 that ordered this market study does not include the ESA program for income-qualified customers. About one-half of LINA survey respondents expressed little or no interest in participation in the ESA program, reasons included:

- Need for Efficiency Upgrades – About two-thirds perceived that their appliances were already efficient and did not perceive that there were any additional actions that could reduce their energy usage.
- Hassle Factor – About half reported that it is too much trouble to get approval from their landlord, and about 40% reported concerns about having strangers in their home or providing personal information.
- Lifetime Costs – Additional barriers to ESA participation that survey respondents reported were that their landlord might decide to increase their rent because of the improved equipment. About 40% perceived that their bills were already low, so they did not feel the need to participate in the ESA program.

The *Low-Income Multifamily Characteristics* study noted that upfront costs including engineering costs, permitting, and materials procurement are hurdles often not covered by utility programs, and that the costs for ancillary measures (e.g., panel upgrades) are not often met by utility programs but required to move projects forward.

NON-EQUIPMENT COSTS

As mentioned in Barriers section earlier, lifetime costs are as big of a consideration for customers as upfront costs. The *Equity and Electrification-Driven Rate Policy Options* study reported that electrification necessarily increases electricity usage and demand, both overall and for individual customers.[33] Without policy action to lower energy burdens—especially for equity households—and efficiently incorporate new demand for electricity, increased electrification could result in higher electricity rates and electric bills, which could deter fuel substitution. The three rate policy options discussed in the paper would address these additional costs, lower energy burdens, and encourage electrification in the following ways:

- **Percent of Income Payment Plans (PIPPs):** PIPPs reduce energy burdens for low-income households by capping utility bill payments at a set percentage of a participant's income.
- **Rate designs that enable heating electrification:** Electric rates designed around the operational efficiency of heat pumps could help shift newly electrified heating demand to make better use of the electric system, reduce costs, and encourage fuel switching. Such rate designs include time-based volumetric rates, seasonal rates with appropriate peak periods, and charging customers for demand on a kW basis to reflect their contribution to system capacity costs.
- **Making fixed charges more progressive in California:** As of March 2024, California is considering establishing an income-graduated fixed charge with at least three income thresholds in order to lower monthly bills for low-income households.[34] California has especially low fixed charges and high volumetric charges to encourage frugal electricity use, but now faces challenges due to the spike in volumetric energy charges in recent years, making California's volumetric rates one of the highest in the nation which has discouraged electrification.

Beyond rates, the *California Heat Pump Residential Market Characterization and Baseline* study listed the following as

[32] https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2023/07/2022_LINA_Report_120922_FINAL.pdf

[33] https://www.aceee.org/white-paper/2023/09/equity-and-electrification-driven-rate-policy-options

[34] https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M528/K422/528422138.PDF

the most important non-equipment costs that customers must consider when purchasing fuel substitution equipment:[35]

- Installation Costs – Upfront costs are higher for air source heat pumps and are even more substantial for ground source heat pumps.
- Electric Panel Upgrades –Subject matter experts perceived that most homes do not require panel upgrades, but when needed, they often were expensive and sometimes were not feasible.
- Space and Placement Requirements – Survey respondents reported that it was more common for installations to require modification of indoor and outdoor spaces to accommodate the size of heat pump units and the heat exchanger space requirements.
- Permitting and Regulatory Compliance – Survey respondents noted that it was more challenging to obtain permits and follow codes attempting to implement fuel substitution projects.

MOTIVATIONS

The *2021 California Energy Efficiency Market Adoption Characteristics Study* furnished valuable information on the factors that would affect customers' willingness to adopt certain energy efficiency measures when compared with replacement of standard efficiency equipment. In this study, survey respondents were asked to rate the importance of a range of factors on a scale from 1 to 5 in terms of the impact on their decision to adopt certain energy efficiency measures. Ratings were aggregated to determine the importance of six value factors: Lifetime Costs, Upfront Costs, Hassle Factor (encompassing factors such ease of use and installation), Non-Consumption Performance (encompassing factors such as aesthetics, noise level, and comfort), Eco Impacts, and Social Signaling (encompassing factors such as appearing environmentally conscious and being early adopters in their community). The study did not include low-income residential customers but did breakout responses by building segment (single-family and multifamily). As shown in Table 31, differences between the two building segments were small.

Table 31. Overall Value Factor Mean Scores by Building Segment

Market Segment	Lifetime Costs	Upfront Costs	Hassle Factor	Non-Consumption Performance	Eco Impacts	Social Signaling
Single-Family Residential (n=598)	3.6	2.7	3.2	3.2	4.1	3.1
Multifamily (n=104)	3.4	2.8	3.4	2.8	4.2	3.6

Source: 2021 California Energy Efficiency Market Adoption Characteristics Study

For fuel substitution technologies, specifically, single-family residential customers generally gave slightly higher ratings than multifamily customers, particularly for Eco Impacts and Non-Consumption Performance, as shown in Table 32.

Table 32. Fuel Substitution Value Factor Mean Scores by Building Segment

Market Segment	Lifetime Costs	Upfront Costs	Hassle Factor	Non-Consumption Performance	Eco Impacts	Social Signaling
Single-Family Residential (n=513)	3.4	2.8	3.2	3.3	3.4	N/A
Multifamily (n=69)	3.3	2.8	3.3	3.1	3.0	N/A

Source: 2021 California Energy Efficiency Market Adoption Characteristics Study

[35] https://www.calmac.org/publications/OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf

The 2022 LINA study identified some important reasons for ESA program participation and strategies that could be effective in engaging low-income households in programs.

- Health Benefits – One important service delivered by fuel substitution is health benefits by improving the indoor air quality and improving the effectiveness of home heating and cooling systems. The potential health benefits of electrification are a particularly important value proposition for residential equity customers.
- Targeting – Focusing program outreach efforts on elderly and disabled households who tend to have a greater need for heating, cooling, or ventilation for health reasons, and on households with larger numbers of household members who tend to use more energy would be effective.
- Co-Marketing – Jointly marketing the program to building owners and their tenants so that the tenant does not have to approach the landlord for approval to participate.

The *Low-Income Multifamily Characteristics* study conducted interviews with stakeholders about how to move the multifamily electrification market forward.[36] The stakeholders suggested that building owners/managers would need at least two important sets of information to be likely to engage in electrification measures. First, they would need the program to furnish technical assistance related to the design and implementation of any electrification initiative. Second, they would need a "proof of concept" example that would clearly demonstrate that the types of upgrades proposed for their building have been successfully implemented in a similar building.

Policies need to be developed that support the positive aspects of heat pump equipment and that help to address the potential negative issues. The *California Heat Pump Residential Market Characterization and Baseline*[37] surveys identified a number of factors that influence the ability of decisionmakers to choose and contractors to install heat pump equipment, including:

- Local Codes and Regulations: Local reach codes and bans on natural gas in new construction are significant factors influencing the decision to install heat pumps.
- Environmental Concerns and Energy Efficiency: Homeowners, especially single-family homes in environmentally progressive communities, are motivated by the desire for more energy-efficient solutions, pushing the demand for heat pumps.
- Cost Considerations and Incentive Programs: The upfront cost of heat pumps compared to gas equipment and high electricity rates are major barriers, and incentive programs are necessary to make the economics work for broader adoption.
- Performance: Homeowners are concerned with the performance related to climate and how noisy the equipment is when in use.
- Space, Comfort, and Aesthetics: Homeowners consider the amount of rentable or livable space a system requires, the aesthetics of indoor units, and the comfort benefits heat pumps provide.
- Specific Needs: The type of heat pump chosen depends on the specific requirements of the project, including size, budget, and the desired heating/cooling capacity.

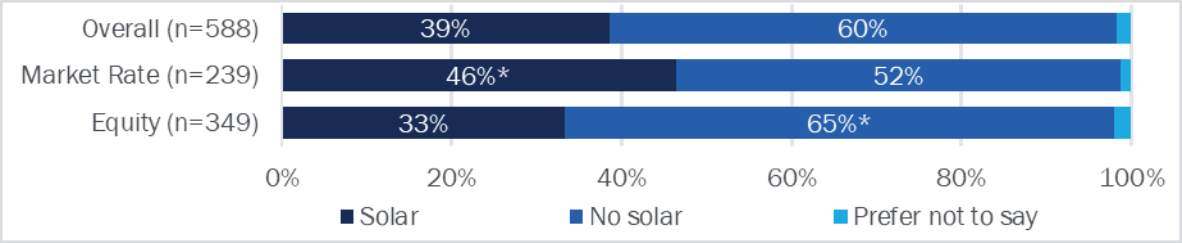
The *TECH Clean California Heat Pump: Insights into Customer Experience and Satisfaction* study surveyed single-family homeowners and renters who received a TECH-incented heat pump water heater or HVAC heat pump.[38] The survey found that the TECH incentives were an important factor in making the decision to install the heat pump equipment. However, most of the survey respondents indicated that they either had solar PV in place or planned to install solar PV in the near future. As such, the decision to install heat pump equipment was partially related to customers with solar

[36] https://www.veic.org/clients-results/reports/low-income-multifamily-housing-characteristics-study
[37] https://www.calmac.org/publications/OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf
[38] https://opiniondynamics.com/wp-content/uploads/2024/01/TECH-Customer-Experience-and-Satisfaction-Report.pdf

PV's focus on using electric equipment.

According to the online customer surveys conducted by the Research Team for this market study, nearly 40% of residential respondents reported having solar panels in their homes. However, market rate customers were significantly more likely to report having solar panels (46%) than equity customers (33%), as shown in in Figure 39.

Figure 39. Residential Incidence of Home Solar PV



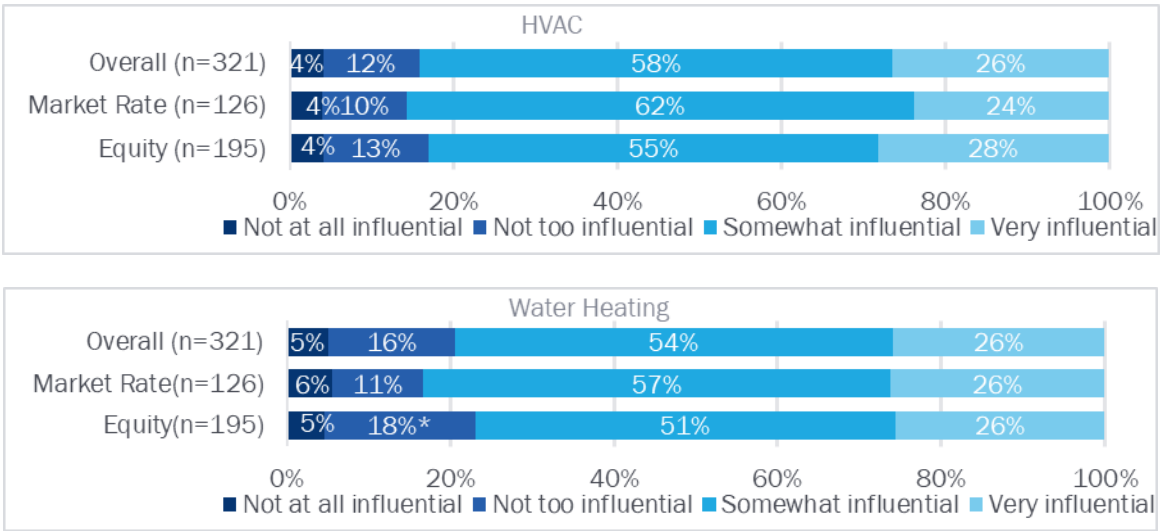
* Indicates a statistical difference across the market rate and equity segments.

3.4.2 COMMERCIAL SECTOR

CONSIDERATIONS

According to the online customer surveys conducted for this study, more than 80% of commercial customers reported that contractor recommendations were at least somewhat influential when deciding on HVAC and water heating equipment (84% and 80%, respectively). Commercial equity customers were more likely than market rate customers to say contractors' recommendations about water heating equipment were not too influential (18% versus 13%, respectively).

Figure 40. Commercial Influence of Contractor Recommendation on Equipment Decisions



* Indicates a statistical difference across the market rate and equity segments.

MOTIVATIONS

As indicated for the residential sector, the *2021 California Energy Efficiency Market Adoption Characteristics Study* furnished information on the factors that would affect willingness to adopt certain energy efficiency measures when compared with replacement of standard efficiency equipment. As shown in Table 33, the most important value factor was Eco Impacts for commercial customers. In general, there was not much variation between ratings for Lifetime Costs, Hassle Factor, Non-Consumption Performance, and Social Signaling for any of the market segments.

Table 33. Overall Value Factor Mean Scores by Market Segment

Market Segment	Lifetime Costs	Upfront Costs	Hassle Factor	Non-Consumption Performance	Eco Impacts	Social Signaling
Commercial (n=757)	3.6	2.5	3.2	3.0	4.1	3.6

Source: 2021 California Energy Efficiency Market Adoption Characteristics Study

For fuel substitution technologies specifically, commercial customers show similar ratings across value factors, as indicated in Table 34.

Table 34. Fuel Substitution Value Factor Mean Scores by Market Segment

Market Segment	Lifetime Costs	Upfront Costs	Hassle Factor	Non-Consumption Performance	Eco Impacts	Social Signaling
Commercial (n=195)	3.3	3.2	3.2	2.9	3.2	N/A

Source: 2021 California Energy Efficiency Market Adoption Characteristics Study

3.5 DECARBONIZATION RESOURCES TO SUPPORT EQUITY SEGMENT

The final research objective aims to identify how local, state, and federal decarbonization resources may be used to support equity segment customers' adoption of fuel substitution measures. The landscape analysis revealed that there are a number of different funding resources that are available to help make progress toward electrification.

The Inflation Reduction Act and the Bipartisan Infrastructure Law both contain billions of dollars of energy-related funding, much of which (per the federal Justice 40 initiative[39]) must be allocated towards equity segment customers:

- The Inflation Reduction Act (IRA) Home Owner Managing Energy Savings (HOMES) and High-Efficiency Electric Home Rebates Act (HEEHRA) programs, together called the Home Energy Rebate programs, are two of the most notable sources of potential funding. The *2023 Energy Efficiency Potential and Goals Study* determined that the IRA will have a significant impact on achievable potential for energy efficiency equipment (14%-15% increase) and for fuel substitution equipment (41%-42% increase) compared to a market scenario with no IRA funding. The largest impacts were seen for residential heat pump HVAC and water heating measures.
  - The Home Energy Rebate programs are funded by the IRA but the details of these two programs are up to state energy offices to determine. Both programs apply to the residential sector only and HEEHRA is designed specifically for residents below 150% of Area Median Income (AMI) in California, the CEC has determined that HEEHRA funds will be distributed, at least initially, through the TECH Clean California initiative. The state allocation for California for the HOMES and HEEHRA program combined is $582 million. California has already applied for $290 million of that funding for the HEEHRA program and is awaiting approval from the Department

[39] https://www.whitehouse.gov/environmentaljustice/justice40/

of Energy (DOE). California is proposing to allocate 60% (or $175 million) of its awarded HOMES funds through the Equitable Building Decarbonization program.[40]

- The IRA Greenhouse Gas Reduction Fund grant competition awards were announced on April 2022, and California, through the California Infrastructure Economic Development Bank (Ibank) was awarded nearly $250 million, and a number of multi-state initiatives were additionally awarded that will benefit California low-income single- and multifamily affordable housing residents. As mentioned in Section 3.4.1, decreasing the cost of solar through these grants may have added benefits for fuel substitution measure adoption.
- The Energy Efficiency and Conservation Block Grant (EECBG) Competitive Program (through the Bipartisan Infrastructure Law) awarded $200,000 to Albany, California, StopWaste, and BayREN for a pilot program aiming to electrify all the buildings on a city block in order to enable gas line decommissioning. The project's title "Targeted Gas Line Decommissioning for Equitable Electrification" indicates its equity focus. Meanwhile, five county, tribe, and city EECBG projects in California, totaling more than $2 million have thus far been awarded funding via formula awards.
- The Buildings Upgrade Prize through the DOE Building Technologies Office awards funding and technical assistance via the Residential Retrofits for Energy Equity (R2E2) initiative. Three California entities have been awarded through phase one of this program.
- The Green and Resilient Retrofit Program (GRRP) for Multifamily Housing is funded via Section 30002 of the IRA and focuses on improving U.S. Department of Housing and Urban Development (HUD)-assisted multifamily properties. A number of California properties have been awarded a portion of the $544 million funding as of March 2024.

3.5.1 CALIFORNIA STATE RESOURCES

The *California Heat Pump Residential Market Characterization and Baseline* surveys identified funding sources other than those offered through federal resources, including:[41]

- Tax Credits from the California Tax Credit Allocation Committee (CTCAC)
- Senate Bill (SB) 1477 Programs, including the Technology and Equipment for Clean Heating (TECH) and the Building Initiative for Low-Emissions Development (BULD).
- Funding from the HUD, including CDBG and tax credits.

Tax Credits from the California Tax Credit Allocation Committee (CTCAC) and the programs implemented under SB 1477 will have positive impacts on fuel substitution. As indicated in earlier sections of this report, the BULD and TECH initiatives have already increased building electrification in California. In addition, the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) is already having an impact on heat pump financing by partnering with the TECH Clean California initiative through its GoGreen financing programs.[42] The Community Development Block Grant (CDBG) and other HUD loans have an impact on decisions made, specifically, for affordable housing.

The *Technology and Equipment for Clean Heating (TECH) Initiative Baseline Market Assessment Study* (conducted in October 2022) reported that there were seven programs in California offering HVAC heat pump incentives and 18 programs for heat pump water heaters. The majority in both cases were available in the Bay Area and associated with BayREN. The literature reviewed by the Research Team did not suggest that these resources (state or federal) were

[40] https://www.energy.ca.gov/programs-and-topics/programs/equitable-building-decarbonization-program
[41] https://www.calmac.org/publications/OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf
[42] https://www.gogreenfinancing.com/

currently being stacked with incentives offered by the IOUs for fuel substitution (although there is legislation that may allow this in California). Better collaboration or coordination across funding organizations might be effective in improving the rate of adoption of fuel substitution.

APPENDIX A. LITERATURE REVIEW SOURCES

The Research Team identified six data sets and 16 research reports that were determined to be most directly related to the study's research objectives. The team already had extensive knowledge of many of the data sources but also conducted searches of CPUC filings, CEC proceedings, and websites of other California organizations that are studying these issues. The literature review focused on California-specific research and data. The information sources included the following:

- Data Sets and Reports
- IOU Program Evaluation Reports
- Potential and Goals Studies
- Market Characterization Studies
- Technical Opportunities and Barriers Studies

DATASETS AND REPORTS

RESIDENTIAL DATASETS AND REPORTS

2019 Residential Appliance Saturation Study (CA RASS). This study has information from both individual households and multifamily building managers. The primary focus of this analysis will be on the 2019 incidence of gas and electric equipment. The RASS report also has some useful information on changes over time from the prior RASS.

https://www.energy.ca.gov/publications/2021/2019-california-residential-appliance-saturation-study-rass

2020 Residential Energy Consumption Survey (RECS). This national survey has a relatively large sample of CA residents. The advantage of the RECS is that the Research Team can use a public dataset to examine more detailed questions about how the equity population differs from the market rate population. (Note: Only data on the dimensions specified in the RASS tabulations is available from the RASS. From the RECS, the Research Team could develop custom tabulations. For example, equipment age by income.)

https://www.eia.gov/consumption/residential/data/2020/

2018–2022 American Community Survey (ACS). Because the definition of residential equity population is relatively complex (i.e., not simply low- and moderate-income households), it was useful to develop population estimates using the ACS public use file and the Census ACS tabulations.

https://www.census.gov/data/developers/data-sets/acs-5year.html

COMMERCIAL DATASETS AND REPORTS

2018–2022 California Commercial End Use Survey (CA CEUS). The Research Team extracted information from the report to provide more detailed information on the number and types of commercial buildings in California. However, the study data tables were not yet published at the time of writing.

https://www.energy.ca.gov/data-reports/surveys/california-commercial-end-use-survey

2018 Commercial Building Energy Consumption Survey (CBECS). This national survey can only furnish information for the West Census region. However, it does have information on the share of commercial buildings with different equipment types, and it does furnish information by the size of the business. The Research Team only used CBECS data that were not included in the CEUS.

https://www.eia.gov/consumption/commercial/

DATASETS AND REPORTS ACROSS ALL MARKET SECTORS

CEDARS. The California Energy Data and Reporting System furnishes detailed statistics on the funding, number of program participants, and accomplishments of each CPUC demand management, energy efficiency, and fuel substitution program. This system was used to furnish landscape information on the investments currently being made into each program that addresses equipment efficiency and fuel substitution measures.

https://cedars.sound-data.com/

IOU PROGRAM EVALUATION REPORTS

The CPUC requires the IOUs to conduct program evaluations that assess the performance of ratepayer-funded programs in terms of energy savings and carbon reduction, program realization rates, program attribution, cost-effectiveness, and engagement of equity segment customers.

Final Impact Evaluation: Residential Energy Efficiency Program Year 2021. This report presents the results of an evaluation of energy savings from Southern California Gas Company's Residential Energy Efficiency Program (REEP) in program year (PY) 2021. REEP consists of three subprograms: the Home Energy Efficiency Rebate Program (HEER), the Multifamily Energy Efficiency Rebate Program (MFEER), and the Energy Efficiency New Homes Program (EENHP).

https://www.calmac.org/publications/___CPUC_REEP_2021_Evaluation_Final_wApps.pdf

Comfortably California Statewide Third-Party Program, Program Year 2021. This report produces findings from an evaluation of the Comfortably California Program—a midstream/upstream statewide program implemented by CLEAResult and overseen by San Diego Gas & Electric that incentivizes HVAC energy-saving technologies—for PY 2021.

https://pda.energydataweb.com/api/view/2813/PY%202021%20Statewide%20Third%20Party%20Programs%20Evaluation%20-%20Comfortably%20California%20HVAC.pdf

Local Third-Party Programs - Program Year 2021. This report presents findings on an evaluation conducted for seven local third-party programs in PY 2021. Local third-party programs are programs with utility-specific design elements that serve a single utility's customers.

https://www.calmac.org/publications/Group_A_PY2021_Local_Third-Party_Impact_Evaluation_-_Final_Report_CALMAC.pdf

POTENTIAL AND GOALS STUDIES

The Potential and Goals Studies are conducted every two years. The most recent versions are from 2023. These studies synthesize information from other sources and develop their models to assess the potential for the adoption of energy efficiency and fuel substitution measures.

2023 Energy Efficiency Potential and Goals Study. This study pulls together information from a variety of sources, including program data and market potential studies, to develop estimates of the energy and demand savings and fuel substitution potential. The CPUC decision was released just before the publication of this report. While the report did not explicitly account for the CPUC decision, the authors were aware of the proceeding and developed some estimates of the potential impact of the CPUC decision on energy efficiency adoption rates for gas-burning equipment and fuel substitution. The study also examined fuel substitution program participation rates and furnishes valuation information on the program take-up rates. Note that the potential study made explicit measurements of the levelized measure costs of energy efficiency and fuel substitution measures.

https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/energy-efficiency/2023-potential-goals-study/final-2023-group-e-pg-study-report.pdf

Low Income Program Energy Efficiency Potential Study / 2023 Potential and Goals Study. The 2023 Low Income Program Potential Study (2023 Study) forecasts energy efficiency (EE) and Fuel Substitution (FS) potential for investor-owned utility (IOU) Energy Savings Assistance (ESA) programs for 2024–2035.

https://pda.energydataweb.com/api/view/3863/2023%20PGS_CPUC%20Low%20Income%20Report_FINAL_2023-08.pdf

MARKET CHARACTERIZATION STUDIES

The Market Characterization Studies conduct primary and secondary research to characterize the current state of the market for the adoption of energy efficiency measures and/or fuel substitution.

2021 California Energy Efficiency and Market Adoption Characteristics Study. This study included interviews with residential and commercial customers to assess their awareness of and attitudes toward adopting energy efficiency measures.

https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/energy-efficiency/2021-potential-goals-study/market-adoption-report-final.pdf?sc_lang=en&hash=131848F75C4A50EB35D9247F45FB4257

2022 Low Income Needs Assessment Study(s). The most recent study was completed in 2022 and focused on low-income renter household needs and participation barriers concerning the measures and services offered through the Energy Savings Assistance (ESA) program. Note that prior studies focused on low-income single-family homeowners.

https://liob.cpuc.ca.gov/wp-content/uploads/sites/14/2023/07/2022_LINA_Report_120922_FINAL.pdf

Low-Income Multifamily Housing Characteristics Study. This study provides information on the barriers and opportunities in low-income multifamily housing for deploying efficient electrification and decarbonization technologies in the hard-to-reach customer segment.

https://www.veic.org/Media/Default/Reports/CalNEXT%20-%20Low-Income%20Multifamily%20Housing%20Characteristics%20Study.pdf

2023 Essential Use of Electricity Study. This study used the 2019 RASS data to determine baseline electricity needs for affordability and sustainability and to develop an interactive tool for analyzing essential usage across different geographic and demographic segments. It included in-depth interviews with a small sample of 2019 RASS survey respondents who had medically necessary equipment and a quantitative survey with a larger sample of 2019 RASS survey low-income survey respondents.

https://pda.energydataweb.com/api/view/2796/Essential%20Use%20of%20Electricity%20Study%20Final%20Report%20with%20Web%20Tool%20User%20Guide%2003-31-2023.pdf

TECHNICAL OPPORTUNITIES AND BARRIERS STUDIES

Equity and Electrification-Driven Rate Policy Options. This paper discusses the potential and equity implications of higher electricity rates that may result from electrification efforts. It explores rate policy solutions for addressing affordability concerns and reducing energy burdens for LMI households.

https://www.aceee.org/white-paper/2023/09/equity-and-electrification-driven-rate-policy-options

2022 Service Upgrades for Electrification Retrofits Study. This study examines the challenges of integrating service upgrades into electrification projects. It looks at how utilities can improve the service upgrade process and makes recommendations for effectively integrating service upgrades into electrification projects. It included a survey of homeowners, as well as interviews with contractors, utility, CPUC, and building department staff. (Note: This study focused on the residential sector.)

https://www.redwoodenergy.net/research/service-upgrades-for-electrification-retrofits-study-final-report-2

2022 California Heat Pump Residential Market Characterization and Baseline Study. This study developed a market baseline of heat pump costs and characterized the California heat pump market. It included an examination of the opportunities and barriers of integrating heat pumps into both affordable and market rate new construction.

https://www.calmac.org/publications/OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf

2022 Technology and Equipment for Clean Heating (TECH) Initiative: Baseline Market Assessment. Before the TECH Initiative incentives launched, this study characterized the baseline conditions in the space- and water-heating markets for heat pumps in 2021.

https://www.calmac.org/publications/TECH_Baseline_Market_Assessment_Final_Report.pdf

TECH Clean California Heat Pump Equipment: Insights into Customer Experience and Satisfaction. This study consisted of an online survey conducted in late 2022 to gauge the experiences and satisfaction of single-family homeowners and renters who received a TECH-incentivized or subsidized heat pump.

https://opiniondynamics.com/wp-content/uploads/2024/01/TECH-Customer-Experience-and-Satisfaction-Report.pdf

Closing the Electrification Affordability Gap. This report discussed the electrification affordability gap in the San Francisco Bay Area and proposed strategies to close the gap for the low-income population. In April 2023, the Bay Area Air Quality Management District (BAAQMD) required newly installed furnaces and water heaters to emit zero nitrogen-oxide within the next decade (in 2027 for water heaters, 2029 for furnaces, and 2031 for commercial water heaters and boilers).

https://www.spur.org/publications/spur-report/2024-02-26/closing-electrification-affordability-gap

2023 CalNEXT Residential HPWH Market Study and Measure Gap Analysis. The analysis aimed to study current market characteristics and emerging trends in the residential heat pump water heater market. The project aims to use the findings to recommend near-term additions to the California Electronic Technical Reference Manual (eTRM) heat pump water heater measure packages, highlight areas where the need for new measure offerings may emerge in the next five years, and suggest improvements to the Database of Energy Efficiency Resources (DEER) water heater savings calculator tool.

https://calnext.com/wp-content/uploads/2023/12/ET23SWE0035_Residential-HPWH-Market-Study-and-Measure-Gap-Analysis_Final-Report.pdf

APPENDIX B. EQUITY STAKEHOLDER INTERVIEW SUMMARY

This appendix summarizes the equity stakeholder interviews conducted by the Research Team.

BENEFITS AND DRAWBACKS OF FUEL SUBSTITUTION FOR EQUITY SEGMENT CUSTOMERS

BENEFITS

- Individual Household Benefits
  - Improved safety (fewer indoor air quality and fire risks)
  - Improved comfort and control (some types of electric equipment)
- Multifamily Building Benefits
  - Improved safety (fewer indoor air quality and fire risks)
  - Improved comfort and control (some types of electric equipment)
- Community Benefits
  - Improved neighborhood air quality
  - Longer term benefits of decarbonization/DACs and equity households are the most vulnerable to impacts of climate change.

DRAWBACKS

- Individual Households Drawbacks
  - Potentially higher energy bills (depends on current equipment and time of use)
  - Potentially poorer equipment performance (depends on current equipment)
  - Gas water heating and cooking equipment operates during electric outages.
- Multifamily Building Drawbacks
  - Can shift costs from building owner to individual tenants.
  - Can increase maintenance costs if individual unit equipment fails.

PRIMARY BARRIERS/OPPORTUNITIES FOR EQUITY SEGMENT CUSTOMERS ADOPTING HEAT PUMP TECHNOLOGIES

OPPORTUNITIES

- Individual Household Opportunities
  - Complementary when installing renewable energy.
- Multifamily Building Opportunities
  - Complementary when installing renewable energy.
  - Can be incorporated as part of periodic building upgrade activities.

- Building owners can use loan products that are available.

- Community Opportunities
  - Community workforce development programs can help to build the electrification workforce.

BARRIERS

- Individual Household Barriers
  - Higher equipment cost when equipment needs to be replaced.
  - Non-equipment costs including electric service upgrades and landscaping.
  - Hard to find knowledgeable contractors.
- Multifamily Building Barriers
  - Larger buildings have transformers that present several barriers, including determining ownership, upgrade cost, and upgrade schedule.
  - Training building managers on how to operate new equipment.
- Community Barriers
  - Contractors lack experience with heat pump equipment.
  - Local building codes have not been updated to streamline the fuel substitution permitting process.
- Viable Electric Alternatives
  - It was reported that … for certain housing units and certain multifamily buildings … there is no viable electric alternative available to replace gas-burning equipment.

KEY DRIVERS AND CONSIDERATIONS AMONG EQUITY CUSTOMERS WHEN CHOOSING BETWEEN AVAILABLE HEATING, COOLING, AND WATER HEATING EQUIPMENT

- Individual Household Drivers
  - Want to be sure that new equipment will perform as well as or better than current equipment.
  - Want to see that increases in electric bills are not greater than reductions in gas bills.
- Multifamily Building Drivers
  - Want to be sure that new equipment will perform as well as or better than current equipment and will not result in tenant complaints.
  - Want some evidence from other buildings that promised benefits will be experienced by their building.
  - Want to be assured that maintenance costs will be the same or will be reduced.

HOW AVAILABLE ELECTRIC AND GAS INCENTIVES FOR HEATING, COOLING, AND WATER HEATING EQUIPMENT HAVE IMPACTED EQUITY SEGMENT CUSTOMERS' PURCHASE DECISIONS IN RECENT YEARS

- Single Family Homes
  - We did not find any stakeholder that reported that equity households in single family homes have been using available natural gas incentives. However, the impact evaluation of the SCG Residential Energy Efficiency Program (REEP) found that about 20% of the program participants were in DACs and that 8% of program participants would be classified as Hard to Reach (HTR). However, most of the HTR households were in multifamily buildings, rather than single family homes.
  - We did not find any stakeholder that reported that equity households in single family homes are making use of fuel substitution incentives.
  - Note that, to the extent that space heating and water heating efficiency programs use mid-stream incentives, those would not be well understood by stakeholders.
- Multifamily Buildings
  - AEA reports that they are making extensive use of fuel substitution incentives for multifamily buildings.
  - When electrification is not feasible or is cost-prohibitive, multifamily building AEA reports that owners are still making use of natural gas incentives to improve efficiency and reduce longer-term energy costs.

WHAT IT WILL TAKE TO ENCOURAGE EQUITY SEGMENT CUSTOMERS TO SWITCH FROM NATURAL GAS AND OTHER DELIVERED FUELS TO AN ALL-ELECTRIC BUILDING

- Single Family Homes
  - Programs would need to provide electric equipment at a cost that is less than or equal to the cost of replacing equipment with standard efficiency gas equipment.
  - Programs would need to include funding for non-equipment costs.
- Multifamily Buildings
  - Programs would need to include funding for technical consultation.
  - Programs would need to include funding for non-equipment costs.
  - Programs would need to work with IOUs on improving the process for assessing electric service and transformer needs.
- Communities
  - Programs would need to include workforce development initiatives that increase the supply of technical staff who can specify and install heat pump equipment.
  - Programs need to furnish training and technical assistance to municipal building offices to update local building codes and train building inspectors on the proper installation of heat pump equipment.

CURRENT AND FUTURE PARTNERSHIP OPPORTUNITIES FOR EQUITY STAKEHOLDERS TO SUPPORT FUEL SUBSTITUTION AMONG EQUITY CUSTOMERS

- Current Partnerships
  - The ratepayer-funded Energy Savings Assistance (ESA) program does not currently focus on fuel substitution.
  - The publicly funded weatherization programs – WAP, LIHEAP Weatherization, and LIHEAP Equipment Replacement – are not currently focused on increasing equipment energy efficiency (using natural gas incentives) or electrification (using fuel substitution incentives). When new equipment is needed, they most often "replace like with like." [Note: In some other states, WAP and LIHEAP funds are used to pay for the cost of the standard efficiency equipment and the IOU incentives are used to pay for upgraded equipment. However, CSD has not adopted that practice.
  - The publicly funded LIWP program does directly support fuel substitution for a limited number of equity segment households.
  - When one organization delivers multiple programs (ESA, WAP, LI-WX, LIWP), they can assess which program or set of programs best fits each household. However, when two or more organizations deliver the different programs, they are prohibited from sharing information because of CA privacy rules.
- Future Partnerships
  - The Low Income Oversight Board (LIOB) has proposed that ESA *should* have a greater focus on fuel substitution.
  - The CEC is implementing the Inflation Reduction Act HOMES and HEEHRA programs that will potentially increase the amount of fuel substitution. The CEC manager of the IRA programs reported that the 50% of the HOMES program funding will be added to the funding for the CEC Direct Install Program along with state taxpayer funds and Cap-and-Trade funds. The other 50% of the HOMES funds will be a pay for performance program. She also reported that, in Phase 1, the HEEHRA program administered in conjunction with the TECH Clean California program.
  - Increased funding for the LIWP program would increase the ability of existing stakeholders to deliver more fuel substitution.
  - It was proposed that the IOUs need to make use of Community Based Organizations (CBOs) to effectively engage equity segment households and affordable multifamily housing owners.

APPENDIX C. MARKET DEMAND ANALYSIS MODELING METHODOLOGY

The team's purpose for conducting the multivariate analysis was twofold: Firstly, to accurately predict the strength of the relationship between the incentive level and the likelihood of installation while controlling for other potential influential factors. Secondly, to test whether incentives impact equity and market customers differently.

We employed an ordered logistic regression model to analyze the self-reported likelihood of installing a heat pump with a given incentive from the utility. The model dependent variable was an ordered response from 1 to 6:

1= the respondent reported being “very unlikely” to install

2= the respondent reported being “unlikely” to install

3= the respondent reported being “somewhat unlikely” to install

4= the respondent reported being “somewhat likely” to install

5= the respondent reported being “likely” to install

6= the respondent reported being “very likely” to install

We assume there is an unobservable (latent) index of a respondent’s *l* likelihood of installing a heat pump z_i^*:

$$z_i^* = \alpha + \gamma \%\text{incentive} + x_i'\beta + \varepsilon_i$$

where:

%incentive = the incentive as a percentage of the incremental cost from 0 to 100%

x_i = a vector of individual respondent characteristics such as floor area, employees, and net metering

ε_i = model error term assumed to follow an extreme value distribution

α = model constant term

γ = coefficient indicating the impact of the incentive on the index of installation likelihood

β = coefficient indicating the impacts of variables in x_i

We do not observe z_i^*, only the self-reported likelihood on a scale from 1 to 6, as indicated above. In the ordered logistic model, we posit that the respondent’s stated likelihood of adoption is determined as follows:

$z_i^{vu} = 1$ if $z_i^* < c_1$ and equals zero, otherwise

$z_i^{u} = 1$ if $c_1 \leq z_i^* < c_2$ and equals zero, otherwise

$z_i^{su} = 1$ if $c_2 \leq z_i^* < c_3$ and equals zero, otherwise

$z_i^{sl} = 1$ if $c_3 \leq z_i^* < c_4$ and equals zero, otherwise

$z_i^{l} = 1$ if if $c_4 \leq z_i^* < c_5$ and equals zero, otherwise

$z_i^{vl} = 1$ if $z_i^* \geq c_5$ and equals zero, otherwise

where:

c_1, c_2, …, c_5 are latent threshold parameters that determine, in conjunction, with z_i^* the response likelihood for the individual. Estimates of the threshold parameters are obtained through maximum likelihood estimation of the model.

Given this setup and the assumption z_i^* is a random variable with an extreme value distribution, the probability a respondent reports a particular likelihood on the six-point scale can be represented as follows:

$$Prob(z_i^{vu} = 1) = F(c_1 - (\alpha + \gamma\%incentive + x_i'\beta))$$

$$Prob(z_i^{u} = 1) = F(c_2 - (\alpha + \gamma\%incentive + x_i'\beta)) - F(c_1 - (\alpha + \gamma\%incentive + x_i'\beta))$$

$$Prob(z_i^{vl} = 1) = 1 - F(c_5 - (\alpha + \gamma\%incentive + x_i'\beta))$$

where:

F is the cumulative probability function corresponding to the extreme value distribution.

We explained the likelihood of installation as a function of the incentive amounts, as well as control variables such as company size, industry sector, income, customer segment, and employee.

As noted in the main body of the report, the survey was structured in such a way that if a respondent indicated a likelihood of "likely" (5) or "very likely" (6), the respondent was not presented with the next question about the next higher incentive level and the battery ended. To construct a balanced panel data set having the same number of observations for each respondent, we made the following assumption: if a participant indicated they were "likely" or "very likely" to adopt a measure at a certain incentive level, they would maintain this stance if offered a higher incentive. Thus, even if the incentive increased to 75% or 100%, we conservatively assumed their likelihood of installing the equipment would not increase beyond their initial response.

We estimated separate order logistic models by maximum likelihood for residential heat pump water heaters, commercial air source heat pumps, and commercial heat pump water heaters. Each model included a set of indicator variables for the different incentive amounts. We estimated multiple specifications for each market and product and chose the final specification based on individual variable and joint variable significance tests and the Akaike Information Criterion (AIC).

MODEL SPECIFICATIONS

Equation 1. Model Specifications for Commercial Market Demand Analysis

$$Likelihood = \beta_{incentive\ 25} incentive\ 25 + \beta_{incentive\ 50} incentive\ 50 + \beta_{incentive\ 75} incentive\ 75 + \beta_{incentive\ 100} incentive\ 100 + \beta_{equity}\ equity_{\square} + \varepsilon$$

Where:

$Likelihood$ = Likelihood scale (1-6)

$Incentive\ 25$ = Indicator variable for the 25 percent incentive (coded "0" if, coded "1" if a 25 percent incentive question was asked)

$Incentive\ 50$= Indicator variable for the 50 percent incentive (coded "0" if, coded "1" if a 50 percent incentive question was asked)

$Incentive\ 75$ = Indicator variable for the 75 percent incentive (coded "0" if, coded "1" if a 75 percent incentive question was asked)

$Incentive\ 100$ = Indicator variable for the 100 percent incentive (coded "0" if, coded "1" if a 100 percent incentive question was asked)

$Equity$ = Indicator variable for the participant segment (coded "0" if participant was from a market rate segment, coded "1" if participant was from an equity segment)

ε = Error term

Equation 2. Model Specifications for Residential Market Demand Analysis

$$Likelihood = \beta_{incentive\ 25} incentive\ 25 + \beta_{incentive\ 50} incentive\ 50 + \beta_{incentive\ 75} incentive\ 75 + \beta_{incentive\ 100} incentive\ 100 + \beta_{equity}\ equity_{\square} + \beta_{footage} footage + \varepsilon$$

Where:

$Likelihood$ = Likelihood scale (1-6)

$Incentive\ 25$ = Indicator variable for the 25 percent incentive (coded "0" if, coded "1" if a 25 percent incentive question was asked)

$Incentive\ 50$= Indicator variable for the 50 percent incentive (coded "0" if, coded "1" if a 50 percent incentive question was asked)

$Incentive\ 75$ = Indicator variable for the 75 percent incentive (coded "0" if, coded "1" if a 75 percent incentive question was asked)

$Incentive\ 100$ = Indicator variable for the 100 percent incentive (coded "0" if, coded "1" if a 100 percent incentive question was asked)

$Equity$ = Indicator variable for the participant segment (coded "0" if participant was from a market rate segment, coded "1" if participant was from an equity segment)

$Footage$ = Categorical variable for the participant household size (coded "1" if home is less than 500 square feet, "2" if home is between 500 and 999 square feet, "3" if home is between 1,000 and 1,499, "4" if home is between 1,500 and 1,999, "5" if home is between 2,000 and 2,999, "6" if home is between 3,000 and 3,999, "7" if home is 4,000 or more)

ε = Error term

MODEL RESULTS

Table 35. Air Source Heat Pump Model Outputs

Variables and Intercepts	Value	Std. Error	t-statistic	p-value
incentive_25	0.43	0.18	2.46	0.01
incentive_50	0.56	0.18	3.18	0.00
incentive_75	0.80	0.18	4.48	0.00
incentive_100	1.16	0.18	6.46	0.00
Equity	-0.21	0.12	-1.78	0.08
1|2 threshold	-1.96	0.17	-11.40	0.00

Variables and Intercepts	Value	Std. Error	t-statistic	p-value
2|3 threshold	-0.83	0.15	-5.44	0.00
3|4 threshold	-0.02	0.15	-0.11	0.92
4|5 threshold	1.19	0.16	7.60	0.00
5|6 threshold	2.90	0.18	15.81	0.00

Table 36. Commercial Heat Pump Water Heater Model Outputs

Variables and Intercepts	Value	Std. Error	t-statistic	p-value
incentive_25	0.39	0.16	2.42	0.02
incentive_50	0.78	0.16	4.73	0.00
incentive_75	1.20	0.17	7.12	0.00
incentive_100	1.76	0.17	10.19	0.00
Equity	-0.23	0.11	-2.20	0.03
1|2 threshold	-1.20	0.14	-8.60	0.00
2|3 threshold	-0.34	0.13	-2.53	0.01
3|4 threshold	0.53	0.13	3.95	0.00
4|5 threshold	1.65	0.14	11.58	0.00
5|6 threshold	4.11	0.20	20.21	0.00

Table 37. Residential Heat Pump Water Heater Model Outputs

Variables and Intercepts	Value	Std. Error	t-statistic	p-value
incentive_25	0.50	0.11	4.73	0.00
incentive_50	0.79	0.11	7.38	0.00
incentive_75	1.22	0.11	11.15	0.00
incentive_100	1.84	0.11	16.28	0.00
Equity	-0.06	0.07	-0.86	0.39
Footage2	0.69	0.46	1.51	0.13
Footage3	1.01	0.44	2.29	0.02
Footage4	1.09	0.44	2.45	0.01
Footage5	1.09	0.45	2.46	0.01
Footage6	1.08	0.46	2.32	0.02
Footage7	1.29	0.50	2.61	0.01
Footage98	0.66	0.47	1.40	0.16
1|2 threshold	0.40	0.45	0.89	0.38
2|3 threshold	1.08	0.45	2.40	0.02
3|4 threshold	1.88	0.45	4.19	0.00
4|5 threshold	2.89	0.45	6.39	0.00
5|6 threshold	4.93	0.46	10.76	0.00

ODDS RATIOS

Based on an ordered logit model, we can calculate an odds ratio for each independent variable included in the model. An odds ratio above 1 signifies that an increase in the predictor variable boosts the odds of landing in a higher category of the dependent variable. Conversely, an odds ratio below 1 suggests a decrease in those odds. For categorical

predictor variables, we compare each category against a reference or omitted category, which is zero incentive, with the odds ratio reflecting the odds change compared to that reference category.

Table 38. Air Source Heat Pump Odds Ratios

Variables	Odd Ratios
incentive_25	1.54
incentive_50	1.75
incentive_75	2.22
incentive_100	3.20
Equity	0.81

Table 39. Commercial Heat Pump Water Heater Odds Ratios

Variables	Odd Ratios
incentive_25	1.48
incentive_50	2.18
incentive_75	3.30
incentive_100	5.83
Equity	0.79

Table 40. Residential Heat Pump Water Heater

Variables	Odd Ratios
incentive_25	1.64
incentive_50	2.20
incentive_75	3.39
incentive_100	6.30
Equity	0.94
Footage2	1.99
Footage3	2.76
Footage4	2.97
Footage5	2.98
Footage6	2.93
Footage7	3.65
Footage98	1.93

APPENDIX D. DATA COLLECTION INSTRUMENTS

The Research Team relied on the following data collection instruments to field the residential customer survey, commercial customer survey, and equity stakeholder interviews, respectively.

Residential Customer Survey Instrument:

CA IOU FS Impact of Incentives Residential Survey Instrument

Commercial Customer Survey Instrument:

CA IOU FS Impact of Incentives Commercial Survey Instrument

Equity Stakeholder Interview Guide:

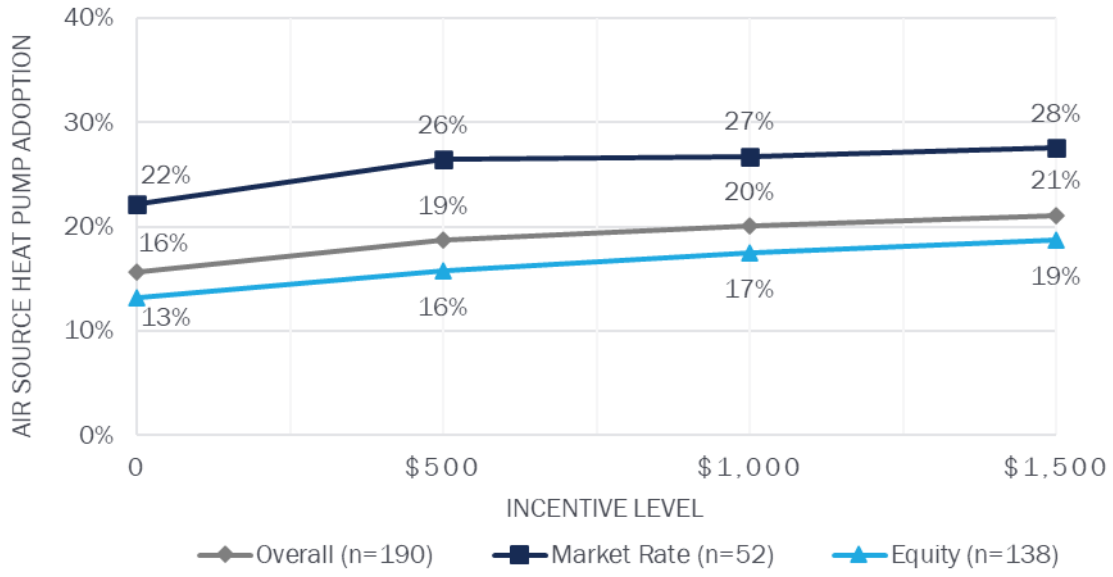
CA IOU FS Impact of Incentives Stakeholder Interview Guide

APPENDIX E. RESIDENTIAL HEAT PUMP MARKET DEMAND WITH ALTERNATIVE GAS RATE ASSUMPTION

The Research Team received feedback during the public comment period suggesting the gas rate of $1.87/therm, (drawn from U.S. EIA-provided CA residential statewide average gas rates for December 2023 to represent current gas costs)[43] may overstate the actual current cost of gas for California IOU customers. Based on additional review of publicly available documentation of January 2024 gas rates for PG&E, SoCalGas, and SDG&E residential general service gas customers,[44] we established an alternative blended average gas rate of $1.32/therm. Using this lower gas rate, we estimated annual energy costs of $750 for an air source heat pump and $700 for a natural gas furnace or boiler, reflecting a $100 decrease in the assumed annual energy cost for a natural gas furnace or boiler (which also includes electric usage associated with a central air conditioner and furnace fan).

Using this alternative gas cost assumption, the Research Team estimated price sensitivity for heat pump adoption under current market conditions (otherwise equivalent to Scenario 1 presented in Section 3.3). Under these conditions, 16% of customers replacing failed equipment would adopt an air source heat pump with no incentive and 21% would adopt one with a $1,500 incentive. Rates of heat pump adoption are 1-2 percentage points lower across all incentive levels when using alternative gas rate assumptions relative to those with the higher gas rate reflected in Scenario 1. These results are detailed in Figure 41 and Figure 42.

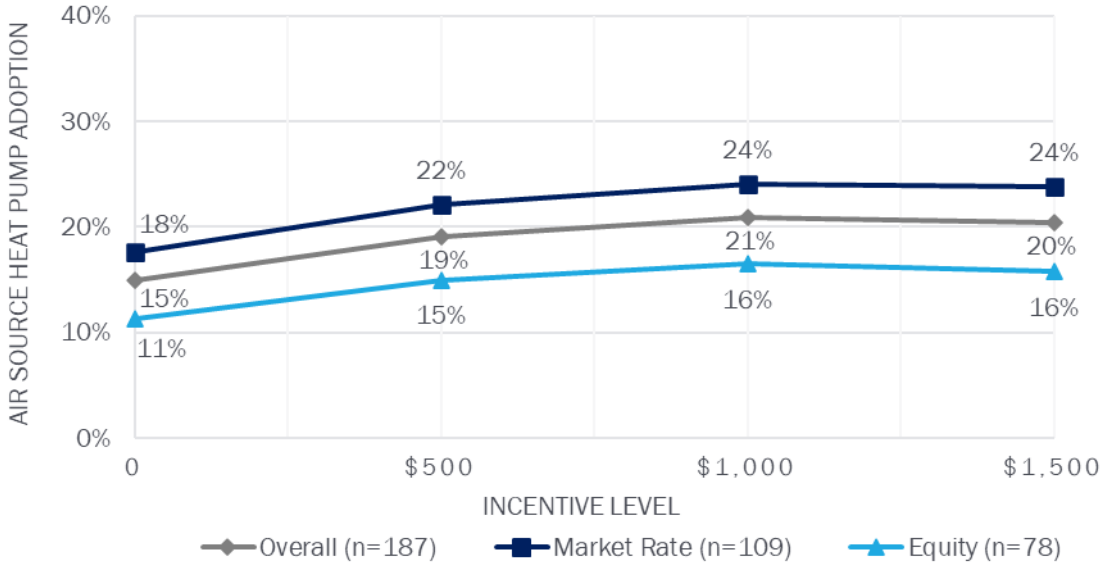
Figure 41. Heat Pump Price Sensitivity with Average Energy Costs and ((Replace on Burnout)



[43] California price of natural gas delivered to residential consumers (dollars per thousand cubic feet), March 29, 2024. https://www.eia.gov/dnav/ng/hist/n3010ca3M.htm

[44] https://tariff.socalgas.com/regulatory/tariffs/tm2/pdf/submittals/GAS_6237-G.pdf (SoCalGas); https://www.pge.com/tariffs/assets/pdf/adviceletter/GAS_4847-G.pdf (PG&E); https://tariff.sdge.com/tm2/pdf/submittals/GAS_3261-G.pdf (SDG&E)

Figure 42. Heat Pump Price Sensitivity Assuming Increased Electric Rates and Stable Gas Rates (Accelerated Replacement)



APPENDIX F. RESEARCH TEAM RESPONSES TO PUBLIC COMMENTS

Research Team Responses to Public Comments

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