Opinion Dynamics

CALIFORNIA HEAT PUMP RESIDENTIAL MARKET CHARACTERIZATION AND BASELINE STUDY

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Direct emissions from residential and commercial buildings comprise 12 percent of California's greenhouse gas (GHG) emissions and mostly stem from natural gas appliances such as furnaces and water heaters. Building GHG emissions are second only to California's transportation sector when accounting for electricity use, water use, and wastewater treatment. Beneficial electrification is an essential strategy to meet California's ambitious GHG reduction goals, by simultaneously shifting away from fossil fuel sources on both the demand and supply side of the grid. Electrifying residential building energy end uses—largely using high-efficiency heat pump technologies for space conditioning and water heating and, less so, electric dryers for drying and heat pump pool heaters for pool heating—will be instrumental to reducing building energy use because they offer a low- or no-carbon pathway to meeting critical building functions traditionally achieved through GHG-emitting appliances.

RESEARCH OBJECTIVES AND METHODS

The primary objectives of this study were to develop a market baseline of heat pump costs and a market characterization of the California heat pump market, including air source heating and cooling heat pumps (ASHPs), heat pump water heaters (HPWHs), ground source heating and cooling heat pumps (GSHPs), heat pump clothes dryers (HPCDs), and heat pump pool heaters (HPPHs). The study also explored the opportunities and barriers of integrating heat pumps into affordable and market-rate new construction as well as gathered best practices for program design and implementation from other jurisdictions with mature heat pump programs. The specific study objectives included:

- Conducting a market baseline of heat pump technologies in the residential retrofit and new construction markets in California;
- Investigating trade ally experiences deploying heat pumps to improve heat pump delivery and anticipate barriers to delivering this technology at scale;
- Understanding California market rate and affordable new construction trade allies' motivations and barriers to building all-electric residential and multifamily housing units; and
- Conducting a heat pump program best practices assessment with other jurisdictions with mature heat pump programs.

To achieve these objectives, the evaluation team conducted the following research activities.

- A literature review of existing information available on each of the five heat pump technology markets
- Analysis of the 2019 California Residential Appliance Saturation Study for appliance saturation and baseline market trends for each of the five heat pump technologies and the HARDI California HVACR Unitary Market Report for ASHPs
- Telephone interviews with 47 trade allies across the five heat pump technologies to understand barriers and successes associated with heat pump sales, installation, service, and maintenance
- Telephone interviews with 34 market-rate and low-income new construction trade allies, including architects, engineers, builders, consultants, housing authority staff, local government staff, general contractors, and developers to understand barriers and opportunities for the introduction of heat pump technologies into housing new construction
- Telephone interviews with heat pump program staff from six utilities or energy efficiency organizations to understand best practices and lessons learned from implementing heat pump programs
- Two Delphi studies—one with 15 ASHP contractors and another with 7 HPWH contractors—to understand upfront equipment, installation, design, and incremental operation and maintenance costs. A Delphi study is a systematic, multi-round, interactive research methodology administered to a group of experts to elicit the best thinking of the group about a complex issue.

Opinion Dynamics analyzed key findings from the market analysis, trade ally interviews, interviews with program staff of mature heat pump programs, and the two Delphi studies to identify important insights to consider when developing strategies to accelerate adoption of heat pump technologies.

RESIDENTIAL NEW CONSTRUCTION FINDINGS

Residential new construction presents a large opportunity for increased heat pump installations.

- **Heat pump use in new construction is limited now, but is expected to grow significantly in the next five years.**
  - Two-thirds (67%) of the new construction trade allies interviewed for this study (10 of 15) expect heat pumps to grow "a lot" in the next five years.
  - Heat pump use in new construction is expected to grow given the increase in local reach codes incorporating heat pumps and bans on the use of natural gas in new construction.
  - Tax credits will also spur heat pump technology growth. For example, currently the low-income tax credit system, the most popular funding source for affordable housing, encourages heat pumps because builders can profit from utility bill savings by using the California Utility Allowance Calculator.
  - A growing number of people without air conditioning are starting to demand it, yielding more interest in heat pumps.

Builders recognize the cost savings associated with building electric over gas, for example, avoiding costs associated with trenching and piping gas infrastructure, avoiding coordination and delays associated with involving a gas utility, and spurring more health and safety benefits. When builders and architects decide what type of space and water technology to install in new construction, they factor in multiple considerations including local building code requirements, budget, livable space, placement constraints, and the skill level of labor involved.

- **Awareness of heat pumps is growing among new construction trade allies but knowledge of how to specify such equipment in building plans is limited.**
  - Less than half (46%) of the trade allies we interviewed were able to identify the benefits of avoiding natural gas infrastructure.
  - Many new construction trade allies remain unfamiliar with heat pumps, how they work, or their design requirements. Reportedly as few as five percent of California architects are aware of heat pumps.
  - Training new construction trade allies to install heat pumps is essential to growing the heat pump market.
- **Upfront cost is the largest barrier, especially in the affordable housing market.**
  - Four out of five builders (84%) report that the upfront cost of heat pumps is the biggest hurdle for affordable housing owners.

LESSONS LEARNED FROM MATURE HEAT PUMP PROGRAMS OUTSIDE CALIFORNIA

Interviews with program staff in states that have achieved some success in deploying heat pump technologies (e.g., New York, Vermont, Washington, Oregon, Maine, and a Southwestern state) provide insight into the design and implementation of effective heat pump programs.

- **The majority of mature heat pump programs reviewed employ a midstream program design (five of six, 83%).** By definition, upstream and midstream program efforts generally incentivize distributors to stock high-efficiency equipment and manufacturers to develop high-efficiency products. By incentivizing heat pumps earlier in the supply chain, building relationships with market actors, and promoting additional training and education for trade allies, programs can greatly influence the market.
- **Programs are more effective if they work with a limited number of distributors.** Five of the six program managers interviewed recommended working with a limited number of distributors to increase their investment in the program. By developing relationships with distributors, program managers were able to influence stocking habits, track the market share of technology, promote high-efficiency units to contractors, and offer technical trainings to contractors in the program.
- **Developing a strong contractor network is critical to success.** Almost all of the program managers we interviewed (83%, five of six) emphasized the importance of developing a strong contractor network. They recommended identifying a small number of high-volume contractor companies to initially train to install heat pumps; educate on best practices for energy efficiency and carbon reduction; and promote heat pump units to customers.
- **A multifaceted approach to incentivizing contractors is needed.** Effective strategies to incentivize contractors to participate in heat pump programs include offering continuing education credits, technical training opportunities, or free heat pump units to give contractors firsthand experience with the technology in their home.

- **Customer-targeted marketing campaigns build awareness and demand.** Conducting customer marketing campaigns to promote awareness and educate customers about the benefits of heat pumps as well as how to properly use them to achieve maximum savings. Customer outreach and education is a necessary step to build awareness of and demand for heat pump technology among California homeowners.

HEAT PUMPS FOR SPACE CONDITIONING

This study characterizes the market for two types of heat pumps for space conditioning—air-source heat pumps (ASHPs) and ground-source heat pumps (GSHPs). ASHPs extract heat from outdoor air, even in cold weather, and use that to heat a home. When properly installed, an ASHP can deliver one and a half to three times more heat energy to a home than the electrical energy it consumes. GSHPs work by extracting heat from the ground and transferring air into the home during the winter and during the summer. GSHPs can reduce the energy consumption from 20 percent to 50 percent in cooling mode and 30 percent to 70 percent in heating mode when compared to conventional HVAC systems.

Market Adoption

Table 1 below summarizes the market adoption, growth potential, and pricing associated with heat pump technology in general for space conditioning, and for ASHPs and GSHPs specifically.

Table 1. Heat Pump Market Adoption and Pricing for Space Conditioning

	Heat Pump Technology for Space Heating	ASHPs	GSHPs
2020 Status	Nascent and growing	Nascent and growing	Nascent and growing “at a snail’s pace”
Adoption	Of the 12.2 million space heating units across residences in the California IOU territories, 4 percent are electric heat-pump technology.	165,588 shipped to CA in 2020, 3.5 million sold in US in 2020 (up from 3.1 million in 2019)	50,000 installed in U.S. annually; 95% sold to contractors and 5% direct to customer; 100% were for new construction in 2020. (No California installation data could be located.)
Growth Potential	Almost half of homeowners in California with natural gas or electric space heating as their primary heating source have units that are over 14 years old, indicating that a large proportion of homeowners will need to replace their heating system in the next decade.	Almost half of homeowners in California with natural gas or electric space heating as their primary heating source have units that are over 14 years old, indicating that a large proportion of homeowners will need to replace their heating system in the next decade.	Replacement of GSHPs at the end of effective useful life is a key driver of adoption, price increase of loop drilling has severely impacted adoption rates in CA. Development of “loop leasing” may increase adoption rates. Primary market barrier to growth is poorly designed/installed systems
Pricing	Ranging from ~$11,500 for ASHPs and up to $30k for GSHPs.	Average total cost of installation = $11,534 for ASHPs, ~$4,500 higher than a natural gas furnace due to added complexity and “risk pricing.” 60% of contractors reported that their customer’s primary concern was high up-front costs. Contractors believe incentives will play a pivotal role in future growth.	Upfront cost ranges from $10k-$30k depending on system type, home size, and property characteristics, which is cost prohibitive for about 50% of potential customers. On average, GSHPs are 130% of the typical air-source technology (range: 33%–300%; median: 130%). Contractors believe incentives will play a pivotal role in future growth.

Supply-Side Perceptions & Considerations

Key takeaways from contractors regarding their perceptions of heat pump technology for space conditioning and factors they consider when recommending this technology are as follows:

- Contractors see the benefits of heat pump systems now and in the future; however, not all are convinced that switching to an electric system is always the best option for a homeowner.
- Existing home specifications such as ductwork, fuel source, electrical service heat pump location, insulation, air tightness, and the presence of solar, determine whether a contractor will recommend a heat pump system. For recommending GSHPs specifically, contractors also consider cost, equipment space, impacts to landscape appearance, and installation (drilling) noise concerns.
- Key concerns among contractors include costly electrical panel upgrades, location and space for equipment, cold climates, lack of familiarity with technology, high electricity rates, customer callbacks, refrigerant leaks, and permitting processes and costs. For GSHPs specifically, contractors are also concerned with the availability of drillers, geological issues, length of time to install, environmental regulations, lot size, and recent certification and permitting changes implemented on vertical bore drillers.
- Contractors report that most customers are aware that ASHPs exist but lack technical knowledge and often hold misperceptions about the technology.

Training Needs for ASHPs and GSHPs

- Contractors are interested in participating in heat pump training opportunities related to the installation, service, and maintenance of ASHP technologies.
- Training opportunities are essential to continue to develop the HVAC workforce's familiarity with ASHPs and drive market adoption.
- The GSHP equipment distributor interviewed indicated that familiarity with the systems and knowledge of the technology among general contractors is the primary barrier to increasing GSHP installations.
- Market actors indicated that general Ground Source Heat Pump Association (GSHPA) training, International Ground Source Heat Pump Association (IGSHPA) certification training, building envelop efficiency and Title 24 code training as training needs in California.

HEAT PUMPS FOR WATER HEATING

HPWHs are all-electric, high-efficiency water heaters that, unlike gas-powered water heaters and electric resistance water heaters, heat water by transferring heat from the surrounding air rather than creating new heat. HPWHs are up to three times more efficient than gas and electric resistance water heaters.

Market Adoption

Table 2 below summarizes the market adoption, growth potential and pricing associated with heat pump technology for water heating.

Table 2. Heat Pump Market Adoption and Pricing for Water Heating

	Electric Water Heating	HPWHs
2020 Status	Small	Non-existent to "small"
Adoption	Of the 12.1 million water heating units installed in California in 2019, only one percent of that equipment is electric and high-efficiency	Estimate unavailable – Not counted in 2019 RASS study
Growth Potential	Anticipate some degree of growth in the next five to ten years, especially given California's focus on decarbonization	Anticipate some degree of growth in the next five to ten years, especially given California's focus on decarbonization Trade allies suggest utility incentive Trprograms will have an impact on market growth
Pricing	Average price is ~\$3,500 for electric tankless; range \$1,665–\$5,850	Average price is ~\$3,900; range \$1,400–5,825

Supply-Side Perceptions & Considerations

Key takeaways from contractors regarding their perceptions of heat pump technology for water heating use and factors they consider when recommending it are as follows:

- System sizing is important, as the price of HPWHs increase significantly as size increases, which is unlike other standard water heaters.
- Contractors consider number of occupants in the household, existing fuel source, and customer budget among other factors when recommending a HPWH.
- Contractors reported positive perceptions of working with HPWHs, noting that HPWHs provide an important benefit to the energy grid by acting as "thermal batteries."
- Training and Customer Education needs for HPWHs.
- Contractors reported that customers are rarely aware of HPWHs and usually do not understand their functionality. Contractors reported that customer interest and education on the benefits of heat pump systems is essential to grow demand throughout the state.
- Trade allies reported that valuable training content includes sales, installation, maintenance, and technical troubleshooting. The time and cost associated with training are barriers to contractors.

HEAT PUMPS FOR CLOTHES DRYERS

HPCDs work as closed loop systems by heating the air, using it to remove moisture from the clothes, and then reusing it once the moisture is removed. A heat pump dryer typically uses one-third to one-half the energy per load compared to conventional dryers.

Market Adoption

Table 3 below summarizes the market adoption, growth potential, and pricing associated with heat pump technology for clothes drying.

Table 3. Heat Pump Market Adoption and Pricing for Clothes Drying

	HPCD
2020 Status	Niche market
Adoption	44% of California Residential Appliance Saturation Survey (RASS) respondents have an electric dryer; however, the RASS data does not indicate the specific type of electric dryer. However, given that distributors noted that their sales of HPCDs are almost exclusively in situations where existing venting is not possible or there is not enough space for larger laundry units, the estimate of the number of HPCDs in California is low. Sales/shipment data on HPCDs is unavailable.
Growth Potential	Distributors/retailers noted that HPCDs are good options for small residences undergoing renovation as they can be placed in a small space and do not require a vent. None of the retailers that we interviewed were aware of any utility incentives, some noted that incentives would likely motivate customers to purchase them.

Supply-Side Perceptions & Considerations

Key takeaways from contractors regarding their perceptions of heat pump technology for clothes drying and factors they consider when recommending it are as follows:

- The interviewed retailers of heat pump clothes dryers indicated that the market for HPCDs is a niche market and that they therefore do not actively stock these items.
- HPCDs are not suitable for large households who do larger loads more frequently.
- Space and venting limitations traditionally drive interest in HPCDs.
- Customers express concerns regarding costs, extended drying times, as well as the fact that clothes come out of HPCDs cool instead of warm.

Training and Customer Education needs for HPCDs

- Retailers mentioned that expanding education and training opportunities to designers, contractors and salespeople would increase market adoption.
- There is an opportunity for additional customer education about how to use HPCD most effectively to maximize savings.
- Educating salespeople about all of the benefits of HPCDs including environmental benefits and less damage to clothing, will make them better equipped to sell.

HEAT PUMPS FOR POOL HEATING

HPPHs, powered by electricity, have a fan that draws warm heat in from the outside and circulates the air through an exterior evaporator air coil. HPPHs do not generate heat; they simply capture and exchange heat. HPPHs work efficiently as long as the outside temperature remains above the 45˚F–50˚range.

Market Adoption

Table 4 below summarizes the market adoption, growth potential, and pricing associated with heat pump technology for pool heating.

Table 4. Heat Pump Market Adoption and Pricing for Pool Heating

	HPPHs
Adoption	The estimated number of residential in-ground pools in California is 1.3 million. Half of these pools are heated, and among those 60 percent are heated using natural gas, nine percent are heated with electricity, and only 1 percent are heated with an electric HPPH.
Growth Potential	Respondents believe the California market will grow significantly over the next five to ten years. Over half of interviewed respondents reported solar photovoltaics (PV) as a primary driver for future market growth. Most respondents felt that the presence of incentives could significantly increase sales of HPPH.
Pricing	Installation costs are slightly higher than natural gas options due to the additional labor needed to move and place the equipment (weight is ~300 pounds) in addition to the equipment generally costing slightly more than natural gas options. HPPHs produce about one-third of the heating capacity as a standard natural gas heater unit, requiring different pool heating operations. Typical recommendations include maintaining higher pool temperature levels during the week and using insulating pool covers. The manually installed insulated pool covers typically cost $300 per cover while automated pool cover systems can cost upwards of $15,000, which constitutes a major barrier to HPPH adoption.

Supply-Side Perceptions & Considerations

Key takeaways from contractors regarding their perceptions of heat pump technology for pool heating and factors they consider when recommending it are as follows:

- Perceptions of the current state of the market were mixed with half of respondents providing a negative view and half expressing optimism. Respondents who provided a positive outlook of the market were those who installed units in municipal utility service territories. Evidently, municipal utility areas have a stronger market for HPPHs due to the lower electricity costs in these territories. In contrast, respondents in IOU service territories report less HPPH market activity and suggest that the activity in these areas is limited to homes with solar PV either already installed or planned to be installed soon.
- Installers perceive HPPHs as more energy efficient than standard natural gas pool heaters.
- Installers identify pool size and customer usage habits as primary considerations when recommending HPPHs. Other considerations include availability of fuel types, customer budget, space availability for equipment, and whether PV is installed.
- Contractors expressed concerns regarding HPPH technology including performance in low humidity and cooler regions, location suitability due to space requirements, length of time to procure a HPPH, and the need for an electrical sub-panel upgrade.
- Contractors perceive HPPHs to provide operational cost savings, be quieter than standard pool heaters, and have much longer warranties than other types of units.

Training and Customer Education needs for HPPH

- Respondents identified a number of training needs, including training on the general technology of HPPHs to increase installer awareness and electrical training associated with installing HPPHs.
- A distributor explained that the education of installer professionals is paramount to sustained growth of the HPPH market.

1. INTRODUCTION

California has some of the most comprehensive and ambitious clean energy policies in the world. Senate Bill 100[1] commits California to get 100 percent of its electricity from clean sources by 2045. James Temple of the MIT Technology Review calls this bill "one of the world's most aggressive clean energy policies," and Danny Cullenward, an energy economist and lawyer at Carnegie Institution for Science describes the bill as "the most important climate law in U.S. History."[2] California has made remarkable progress in growing clean energy's share of electricity generation, which exceeded the 2020 target of 33 percent coming from sources like wind and solar as set by the renewable portfolio standard and has set a goal of 100 percent carbon-free electricity by 2045.[3] California has adopted aggressive greenhouse gas emission reduction targets, including returning to 40% below 1990 by 2030, and carbon neutrality by 2045.[4] Yet, most buildings remain reliant on fossil fuels, especially for space and water heating.

Direct emissions from residential and commercial buildings comprise 12 percent of California's GHG emissions and mostly stem from natural gas appliances such as furnaces and water heaters. Building GHG emissions, including those from the industrial sector, are second only to California's transportation sector when accounting for electricity use, water use, and wastewater treatment.[5] Beneficial electrification is an essential strategy to meet statewide GHG reduction goals, by simultaneously shifting away from fossil fuel sources on both the demand and supply side of the grid. On the demand side, fuel substitution (changing from one regulated fuel to another) and fuel switching (changing from one unregulated fuel to a regulated fuel) are both credible pathways to reducing GHE emissions. Electrifying residential building energy end uses—largely using high-efficiency heat pump technologies for space and water heating and, less so, electric dryers for drying and heat pump pool heaters for pool heating—will be instrumental to reducing building energy use because they offer a low- or no-carbon pathway to meeting critical building functions that have traditionally been achieved through GHG-emitting appliances.

To address these emissions, the California Legislature passed Senate Bill (SB) 1477, which calls on the California Public Utilities Commission (CPUC), in consultation with the California Energy Commission (CEC), to develop two programs with a combined annual budget of $50 million per year focused on reducing direct GHG emissions from buildings: Technology and Equipment for Clean Heating (TECH) Initiative and the Building Initiative for Low-Emissions Development (BUILD) Program. The TECH Initiative is designed to accelerate adoption of new heat-pump based technologies for space and water heating. These technologies are in the early phases of adoption and are, therefore, scarce in the residential market today. Given the potential of heat-pump based technologies to reduce GHG emissions, the CPUC, in consultation with the CEC, is looking to heat-pump based technologies as a key element to meet its carbon-free goals. The BUILD Program is intended to put California on a path to carbon-free homes by 2045. The BUILD Program is also designed to encourage the design and construction of low-emission, energy-efficient buildings, with co-benefits that include reduced energy utility bills for low-income occupants and improved comfort, safety, and indoor air quality.

With this mandate, along with significant programmatic efforts including the Self Generation Incentive Program (SGIP), Energy Efficiency programs, and Low-Income/Disadvantaged Communities initiatives, significant resources have been allocated to heat pump technologies. In order to track progress of these programs and measure market effects of these programs in the future, the Opinion Dynamics Team conducted a market baseline and characterization study of the California heat pump market.

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[1] SB 100, Pavley. California Renewables Portfolio Standard Program: emission of greenhouse gases. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100

[2] Temple, James. "California advances an ambitious climate policy that should be a model for the world." MIT Technology Review, August 28, 2018. https://www.technologyreview.com/2018/08/28/2152/california-advances-an-ambitious-climate-policy-that-should-be-a-model-for-the-world/

[3] SB 100, Pavley. California Renewables Portfolio Standard Program: emission of greenhouse gases. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180SB100

[4] Executive Order B-55-18 to Achieve Carbon Neutrality. https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

[5] California Energy Commission. (January 2019). Final 2018 Integrated Energy Policy Report Update Volume II. Retrieved April 16, 2019, from https://www.energy.ca.gov/2018publications/CEC-100-2018-001/CEC-100-2018-001-V2-CMF.pdf

1.1 STUDY OBJECTIVES

The primary objectives of this study were to develop a market baseline of heat pump costs and a market characterization of the California heat pump market, including air source heating and cooling heat pumps (ASHPs), heat pump water heaters (HPWHs), ground source heating and cooling heat pumps (GSHPs), heat pump clothes dryers (HPCDs), and heat pump pool heaters (HPPHs). The study also explored the opportunities and barriers of integrating heat pumps into affordable and market-rate new construction as well as gathered best practices for program design and implementation from other jurisdictions with mature heat pump programs. The specific study objectives included:

- Conducting a market baseline of heat pump technologies in the residential retrofit and new construction markets in California;
- Investigating trade ally experiences deploying heat pumps to improve heat pump delivery and anticipate barriers to delivering this technology at scale;
- Understanding California market rate and affordable new construction trade allies' motivations and barriers to building all-electric residential and multifamily housing units; and
- Conducting a heat pump program best practices assessment with other jurisdictions with mature heat pump programs.

In this report, Opinion Dynamics details our findings from this comprehensive effort. In this section, we discuss the methods we employed in this study as well as potential limitations of those methods. Next, we characterize the role of heat pumps in the new construction market. We then discuss the best practices and lessons learned from our mature heat pump program review. Following that section, we then present the data for each of the five key heat pump technology markets; and finally, we provide a synthesis of key findings and associated recommendations from across all the research efforts.

1.2 METHODS

The following section provides an overview of the data collection methods used in this study. Please note that in some cases quotes from interviews have been edited for clarity and readability.

Market Data Analysis

Heat pump markets are in a nascent stage of development in California. In order to evaluate each heat pump program's ability to achieve targeted market effects and longer-term market transformation, understanding the baseline measure of market size, market saturation, cost data and other key market metrics is important. Opinion Dynamics completed a brief literature review of existing information available on each of the five heat pump technology markets. We also analyzed the 2019 California Residential Appliance Saturation Study data for appliance saturation and baseline market trends for each of the five heat pump technology areas as well as reviewed the HVACR Unitary Market Report: California Data[6] for air-source heat pumps.

In-Depth Interviews with Heat Pump Trade Allies

Trade allies play an essential role in helping customers decide on new equipment. As such, they can provide invaluable insights to understanding the barriers and successes associated with heat pump sales, installation, service, and maintenance. In addition, trade allies can discuss marketing and selling heat pumps to customers and help us understand why homeowners do or do not choose these technologies. Finally, they can provide firsthand data on equipment availability and system sizing. With this in mind, we conducted a total of 47 interviews with trade allies across five heat pump technologies (Table 5). For these interviews, Southern California Edison supplied some ASHP and HPWH contacts. The remaining contacts came from web searches and the Dun & Bradstreet Database. Distributors were eligible for an interview if they stocked or sold heat pump equipment. Installers were eligible for an interview if they had installed at least two heat pumps or were at least familiar with heat pumps.

Table 5. Number of Trade Allies Interviewed by Heat Pump Technology

Technology	Number of Trade Allies Interviewed
Air Source Heat Pumps	10
Heat Pump Water Heaters	12
Ground Source Heat Pumps	9
Heat Pump Clothes Dryers	7
Heat Pump Pool Heaters	9
Total	47

[6] HARDI and D+R International. 2021. HARDI Unitary HVAC Market Report. All Rights Reserved.

These interviews lasted between 45 and 60 minutes and took place between August 2020 and November 2020. We provided a $150 incentive as a thank you for their time. Specific objectives of these interviews and the interview guide we utilized are in Appendix A.

In-Depth Interviews with California Market-Rate and Low-Income New Construction Builders

California's decarbonization and affordable housing goals likely will create a challenging intersection for builders that must balance their bottom line, affordability for their residents, and their efforts to reach California's increasingly stringent code. To give builders and other stakeholders the tools to meet this challenge successfully, we must first understand what barriers or opportunities exist when introducing technologies like heat pumps into affordable housing new construction as well as new construction at large. With this in mind, these interviews focused on understanding new construction trade allies' awareness, knowledge, and perceptions of heat pumps; their decision-making criteria when selecting technologies; new construction market trends in California; and their perception of customer interest in heat pumps. For the builder interviews, respondents were qualified for an interview if they had explored putting heat pump technology in one of their projects, regardless of whether the heat pumps were installed. Contacts came largely from web-searches of firms who design or build affordable housing, multifamily buildings, custom single-family homes, and production single-family homes. Pacific Gas & Electric also supplied some contacts that built above-code homes as part of their Advanced Energy Rebuild program. We also relied on snowball sampling whereby one respondent recommended others suitable for the study. For local government contacts, we prioritized jurisdictions that had enacted natural gas bans in new construction or had local reach codes and sought those contacts working in the Building or Sustainability Departments. We conducted a total of 34 interviews (Table 6) from September through November 2020.

Table 6. Number of Trade Allies Interviewed by Job Title

Respondent's Job Title	Count
Architect	6
Engineer	6
Consultant	5
Builder	4
Housing Authority Staff	4
Local Government Staff	4
General Contractor	3
Developer	2
Total	34

These interviews lasted between 45 and 60 minutes. We provided a $150 incentive as a thank you for each participant's time. Specific objectives of these interviews and the interview guide we utilized are in Appendix B.

In-Depth Interviews with Heat Pump Program Staff in other U.S. Jurisdictions

Since several jurisdictions have successfully deployed heat pump programs, some with 5 or more years of experience, we interviewed heat pump program staff from six utilities or energy efficiency organizations. These interviews lasted approximately 60 minutes and took place in October and early November 2020. We employed a four-stage approach to conducting this peer research. First, in the planning stage, we identified the utilities with mature heat pump program through prior knowledge, a brief literature review and a web search. Then, we determined the Key Performance Indicators (KPIs), functions, and key areas to explore in the benchmarking research. This included program designs, products targeted, program theories of change, drivers and barriers experienced, customer concerns and motivations, best practices, and key lessons learned. In the data collection phase, we recruited the benchmarking panel, collected program secondary data, and conducted interviews with program staff from the selected utilities. Upon agreeing to participate in the study, we requested program data such as program theory logic models, marketing and outreach plans, implementation documentation, and past evaluation studies. We paid special attention to normalizing data during the analysis so that we are comparing "apples to apples" across utilities. Finally, we synthesized the data to understand best practices and contextualize those findings in the context of California's landscape. Specific objectives of these interviews and the interview guide we utilized are in Appendix C.

Delphi Study with ASHP and HPWH Contractors

To effectively evaluate the outcomes of programs, it is essential to determine what would have happened absent programmatic interventions. Since heat pump measures are relatively new additions to programs, we have a unique opportunity to measure baselines for market KPIs. Given that the current state of research could benefit from primary data collection around heat pump costs, Opinion Dynamics conducted two modified Delphi studies focused on ASHP costs and HPWH costs. We focused on understanding upfront equipment costs, installation costs, design costs, and incremental operation and maintenance costs.

A Delphi study is a systematic, multi-round, interactive research methodology administered to a group of experts to elicit the best thinking of the group about a complex issue. We selected an online Delphi method to capture installation costs because it allowed us to protect participants' identity within the group, leverage contractors from across the state of California, and moderate and guide the feedback and discussion process to revise and redirect questions based on initial responses from the first round. It also helped us maximize the benefits of group discussion while minimizing the disruptive dynamics that can occur during face-to-face or virtual interactions.

We used three sources for contractor recruitment. The first was through a contractor panel maintained by Symmetric Sampling, a sample and panel provider. Symmetric accessed two panels that, together, comprised thousands of California contractors. Our second source was filtering through Dun & Bradstreet's Hoovers database, a commercial data cloud, to find heat pump contractors in California. Finally, we utilized past relationships with trade allies to identify potential study participants. During outreach, we screened contractors to ensure that they worked with residential heat pump technologies in California. Contractors were only eligible to participate in the Delphi study if they reported experience and familiarity with heat pumps and their incremental costs in the residential market. They also needed to have installed at least two heat pumps in homes within the last year.

We initially planned for three rounds for the Delphi study. Given challenges in recruitment, however, we combined the second and third round into a single, longer round. The first round took place at the end of November into the first week of December 2020. The second round took place in January of 2021. To encourage participation in the study and reduce the risk of declining participation throughout the study, we provided contractors with a financial incentive upon completion of the study. Initially, we offered participating contractors a $500 mailed check as a thank you for completing the two rounds of the Delphi. We modified our incentive approach after observing a low response rate during Round 1. We increased the incentive amount to $600; contractors were mailed a $200 check following Round 1 and a $400 check following Round 2. Table 7 provides the number of recruited contractors, the number of recruits who completed each round, and the associated response rates.

Table 7. Number of Recruits and Completes in each Delphi Panel and Round

Recruits	Air Source Heat Pump	Heat Pump Water Heater
Round 1		
Number of Recruited Contractors*	36	32
Number of Completes	19	10
Response Rate	53%	31%
Round 2		
Number of Recruited Participants**	18	9
Number of Completes	15	7
Response Rate	83%	78%

*Initially, 27 ASHP contractors agreed to participate in the Delphi study; we recruited nine additional contractors after the data collection period had started. 24 HPWH contractors were initially recruited, and we recruited an additional eight later in the fielding period.
**One contractor from each group did not move on to Round 2 due to incomplete information provided in Round 1.

Specific objectives of these interviews and the interview guide we utilized are in Appendix D.

1.3 LIMITATIONS

This study involved gathering a large amount of qualitative data. Our research faced a few important limitations consistent with qualitative research:

- **Generalizability.** A common limitation often cited in relationship to qualitative research is the lack of generalizability–the extent to which findings from a study apply to a wider population. While this study involved research with over 100 market actors, these findings still must be regarded as directional in nature.
- **Recruitment.** Given the California wildfires in 2020 and COVID-19, recruiting proved more challenging than usual resulting in a smaller number of participants than we initially targeted. We initially targeted to complete ten interviews with trade allies in each of the five heat pump technology markets. We also had targeted 20 participants completing both rounds of the ASHP and HPWH Delphi studies.
- **Social Desirability Bias.** Given the nature of interviews, participants may respond more favorably to questions thus not representing their true feelings.
- **Volume of Data.** The volume of data generated through our numerous interviews and secondary data review was significant. In order to ensure all data were tracked, coded, and synthesized we utilized NVIVO, a powerful software for qualitative data analysis. Even with this tool, however, trends may have been missed during analysis.

The Delphi study also involved similar limitations including:

- **Generalizability.** All participants needed internet access and technology to participate in the Delphi study which may impact our ability to apply the findings to contractors without internet access and technology. In addition, this research included small sample sizes. This study was completed in California which tends to have more expensive materials and labor than other states, so these estimates are likely high on a national basis.
- **Attrition.** Common to all Delphi studies, attrition can be a challenge between study rounds. While we did experience some attrition between rounds, it was limited.

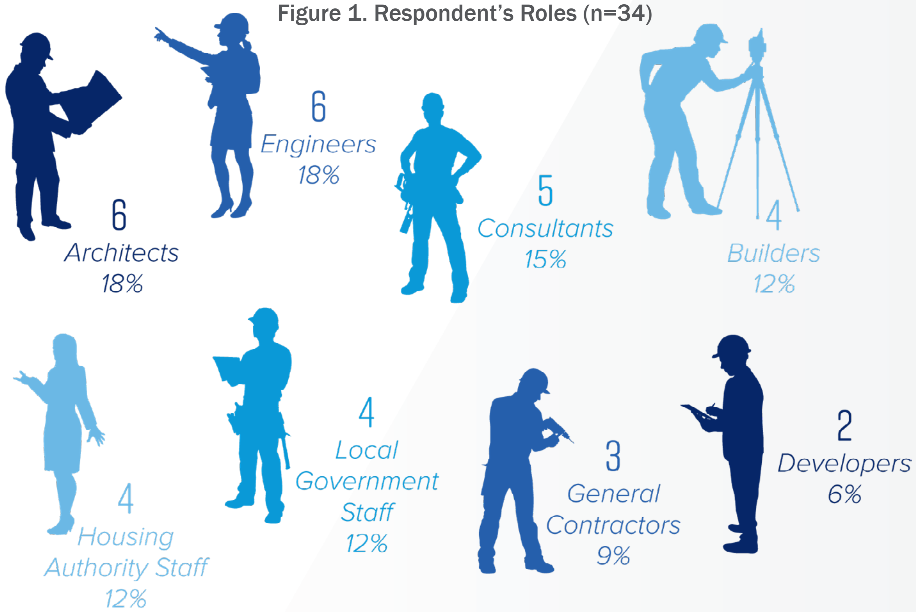
2. RESIDENTIAL NEW CONSTRUCTION

California's decarbonization and affordable housing goals will require carbon reductions in buildings' energy use; heat pumps for space heating/cooling and water heating are an effective way to do that. Widespread deployment of heat pumps will require builders and design teams to be familiar with heat pump technology and recommend them to clients. Understanding the challenges confronting market actors as they seek to install heat pumps will help inform California of what market interventions will be necessary for increased heat pump installations. This chapter presents a characterization of the market for heat pumps in residential new construction and gut rehabs in California in late 2020. It identifies how heat pumps are used for space heating/ cooling and water heating in the single-family and multifamily sectors along with barriers to further deployment and the factors encouraging heat pump installations. We also investigated the role of codes and incentive programs in influencing the market, and training needed by key market actors. Such information will help the CPUC, CEC, and IOUs develop programs and trainings that encourage heat pump installations and reduce the GHG emissions associated with natural gas.

2.1 DESCRIPTION OF RESPONDENTS

The evaluation team conducted 30 interviews with new construction professionals including developers, builders, architects, and engineers representing both the market-rate and low-income residential markets. The evaluation team also interviewed four local government staff and housing authority staff. About half of the respondents (51%) self-identified as an Architect, Engineer, or Consultant though everyone had job titles involving the planning, designing, and building of homes in California (Figure 1). Two of the builders were production builders who build all the single-family homes in a new neighborhood. Three interviewed local government staff worked in their government's sustainability departments and one worked in the building department.[7]

Figure 1. Respondent's Roles (n=34)

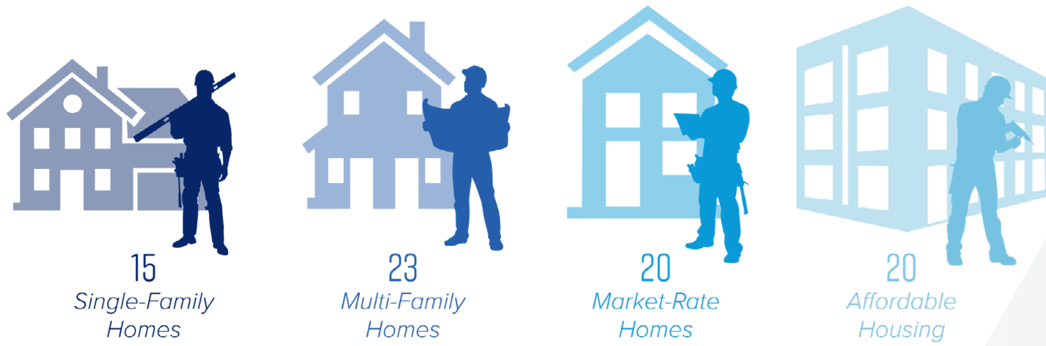


Most consultants (4 of 5; 80%) were researching and supporting HPWH installations in multifamily buildings. The fifth consultant researched and encouraged high performance single-family homes. Two of the four Housing Authority Staff were responsible for maintaining the equipment at the portfolio of properties, but all four were involved in decision-making and participated in development conversations about which mechanical equipment should be selected for new properties.

A majority of respondents had experience working on multifamily homes and half worked on single-family homes, with eight people working on both types (Figure 2). The respondents were evenly split between working on market-rate homes (n=10), affordable housing (n=10), or both sectors (n=10). Lastly, roughly a third of the builder respondents (n=11) worked in the Bay Area while another third (n=10) worked in Southern California; the remaining interviewees either performed work across California (n=7) or worked specifically in the Central Valley (n=2). All four of the local government staffs' jurisdictions were on the coast but included south and central California as well as the Bay Area.

[7] We included local government staff in this research to illuminate the role of local governments with reach codes in influencing the market and to understand aspects of energy code compliance. For these reasons, they were asked questions tailored to their role and that deviated somewhat from the rest of the sample.

Figure 2. Sectors in Which Builders Work (n=30)



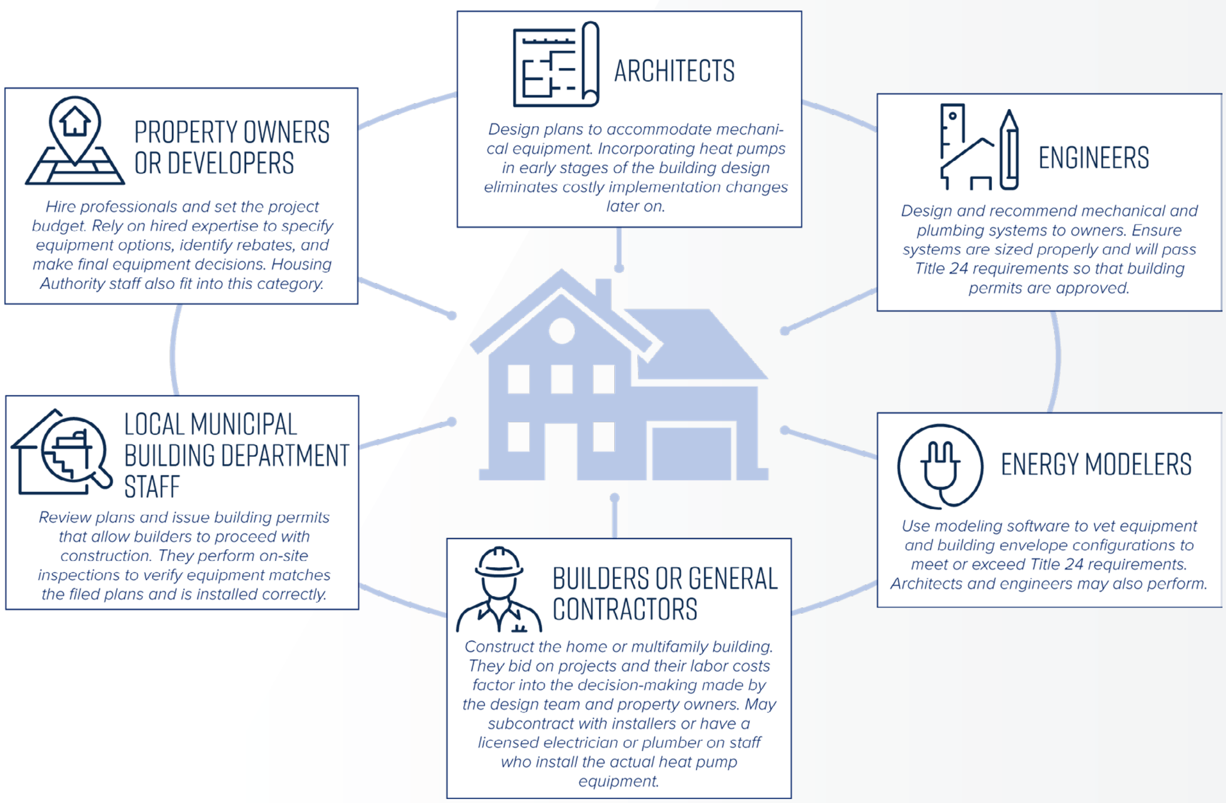
The study specifically targeted individuals with knowledge of California's electrification goals. As such, most of the respondents (n=24) considered themselves to be highly knowledgeable about California's push toward all-electric buildings. Another eight respondents have, at minimum, heard of the push toward all-electric while only two were unaware of the California all-electric building goals. In addition to having knowledge of California's electrification goals, most respondents (n=26) had professional experience working with all-electric homes or buildings. Two respondents had not worked on all-electric homes, however, they noted that their work seemed to be moving toward all-electric. These two reported having worked on homes that were predominately electric aside from a single element, such as natural gas water heating. All four interviewed local government staff worked at jurisdictions that had reach codes or natural gas bans in new construction and were highly aware of California's electrification goals.

2.2 OVERALL NEW CONSTRUCTION MARKET

New Construction Dynamics

A variety of market actors are involved in residential new construction and each can influence a residential building's mechanical equipment and fuels used. We sought to include representatives of each new construction role in our study to characterize how they think about electrification (Figure 3). Throughout the report, we refer to the "design team," which is usually comprised of the architect who designs the building and the mechanical, electrical, and plumbing (MEP) engineer who design the MEP systems. If a separate energy modeler is involved, they are also part of the design team.

Figure 3. New Construction Market Stakeholders



Architects, engineers, and contractors advise their clients on the equipment for projects. They must be familiar with heat pumps and comfortable recommending them to clients. One Housing Authority representative we spoke with who reported they had no heat pumps at their properties said the reason they had not considered heat pumps was because the design teams they worked with had never recommended a heat pump. A single-family builder reported that,

> *If California really wants to propagate heat pumps, the education they should be doing is to architects, HVAC contractors, and to contractors in general. Education needs to go to the people who can advise clients.*

The design team members ensure that the building meets the State of California's energy code, but also any reach codes that local governments have enacted. Many market actors we spoke to worked in jurisdictions that have banned natural gas in new construction. These market actors must also consider other local laws such as zoning laws, fire and safety laws, and egress laws when designing the buildings and homes.

Communication among the design team members and the property owner is important if the project is to meet its efficiency goals. When projects start to exceed their budget, often the more expensive, efficient mechanical equipment will be a candidate for elimination. All-electric construction with heat pumps and energy efficiency goals has a better chance of being met if they are accounted and planned for from the beginning of the project, gaining support from all stakeholders involved.

Not all building department staff are well-versed on heat pumps and many need trainings on heat pumps and high-performance construction, according to eight of nine interviewees (89%) mentioning this topic. Some interviewed builders working on high-performance homes and buildings are using the latest building science, but the building department officials may not have seen such a situation before. When this occurs, the builder must justify their choices to the building officials and educate them. Two interviewees, including a production home builder, mentioned this in relation to venting requirements and one said this was an issue with piping condensate from a centralized HPWH. One architect expressed the following,

> *Quite often we run into building officials who don't understand building science and require things like a vented crawl space or vented attic when the whole idea of energy efficiency is to do away with that and make it more efficient. So, [there is] a lack of training by the city staff. This is disheartening.*

The ninth interviewee said that building department officials and inspectors have become more familiar with heat pumps over the last five years, particularly in their jurisdiction of Sacramento.

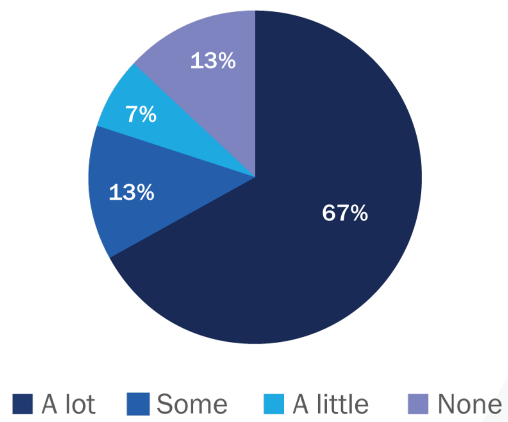
Building department staff have little opportunity to influence equipment. By the time building department staff see a project, the design has been completed and the staff are verifying the plans meet code. There is little to no opportunity to intervene in the design of the building and change something as major as the space and water heating equipment. Plans reviewers at the building department can intervene, however, if it appears an architect has not allowed adequate space for a heat pump. An interviewed building department staff said if they notice there may not be enough space for a HPWH, for example, they will write on the plans "Verify that the mechanical space is adequate per manufacturer's installation instructions." They cited at least one HPWH project where they will not release the hold on the permit because the HPWH's pressure release valve would not fit into the mechanical closet. Also, more complicated projects can involve pre-application discussions with building department staff and those provide greater opportunity for the staff to intervene. For example, if the building department knew about an incentive for water heaters, they could pass along that information to the project applicant during the pre-application discussion, thereby facilitating a heat pump installation.

> Building departments can play a role in supporting heat pump installations. Staff need to be trained on heat pumps so they can intervene when they notice a problem on plans and in the field. With appropriate training, they can play a role in and enhancing awareness and ensuring proper installation.

Heat Pump Market Growth

Respondents saw the heat pump market growing in California over the next five years (n=15). A majority of respondents (10 of 15; 67%) expected "a lot" of growth in the heat pump market over the next five years while fewer said that they expect "some" growth, "a little" growth, or no growth (Figure 4). A common rationale that several respondents gave to explain their expectations (33%) had to do with the heat pump market needing to grow in response to meeting local reach codes. Among these respondents who expected a lot to some growth, half (50%) reported they already install them regularly but see heat pumps becoming increasingly important to meeting California's energy goals as time goes forward.

Figure 4. Heat Pump Market Growth Predictions (n=15)



The three respondents who expected little to no growth said it was due to lack of awareness and a preference for business as usual—particularly for installing tankless water heaters over HPWHs. A Housing Authority staff member who was not very familiar with heat pumps explained their low growth expectations by saying,

> *Being brutally honest, [I expect] little to no growth, because we don't know much about heat pumps.*

A production builder was one respondent who expects no growth in their company's installation of heat pump over the next five years. They noted that demand for single-family housing increased during the COVID-19 pandemic, so in an effort to build homes affordable to a greater percentage of the population, the builder made energy efficiency upgrades optional. They reported about 30 percent of homebuyers opted for the all-electric upgrades. With 70 percent of homebuyers not valuing the upgrades at the point that the builder has priced them, the builder has chosen to no longer offer heat pumps in upcoming communities they develop.

A majority of respondents (16 of 19; 84%) saw local government reach codes driving heat pump installations compared to a minority who said environmental progressiveness is encouraging heat pump installations (3 of 19; 16%). While we did not directly ask about the difference in motivations by this breakdown, 19 respondents voluntarily commented on what they saw as really moving the needle on heat pumps. The large majority reported that local reach codes were the reason they or their clients installed heat pumps or that continued municipal adoption of all-electric reach codes is what will be necessary to encourage more heat pump installations. Six respondents (6 of 19; 32%) also voiced the opinion that the next iteration of the state energy code should be all-electric and that would be a better approach than a piecemeal, city by city approach.

CONSIDERATION

Local government reach codes are a key to driving heat pump installations.

Two of the three that saw environmental goals pushing heat pump installations were commenting on the single-family market. They said the environmental progressiveness of their upper-income clients was what dictated the decision to go all-electric and install heat pumps. They were driven to "be green." The third respondent commented that, in the multifamily market, the biggest driver for heat pumps was "getting away from fossil fuels."

All 14 respondents that spoke to California's climate agreed that California's climate is ideal for heat pumps. They noted that even in places like Lake Tahoe that get very cold, manufacturers make heat pumps that work effectively at very cold temperatures. In addition, some of the outlying mountainous areas do not have natural gas service, making heat pumps an even more attractive equipment choice. A few respondents mentioned that heat pump systems may not be the best choice for areas along the coast that do not really need cooling. Homes built there with tight envelopes and energy recovery ventilators (ERVs) could avoid the high cost of heat pumps and put in electric resistance or hydronic in-floor heating and achieve thermal comfort in an all-electric home without a heat pump for space heating.

> California's climate is ideal for heat pumps.

Some interviewees noted that in the single-family market, each year a growing number of people who were without air conditioning are starting to demand it. Heat pumps that provide heating and cooling in one piece of equipment can be an attractive value proposition. As one single-family architect said,

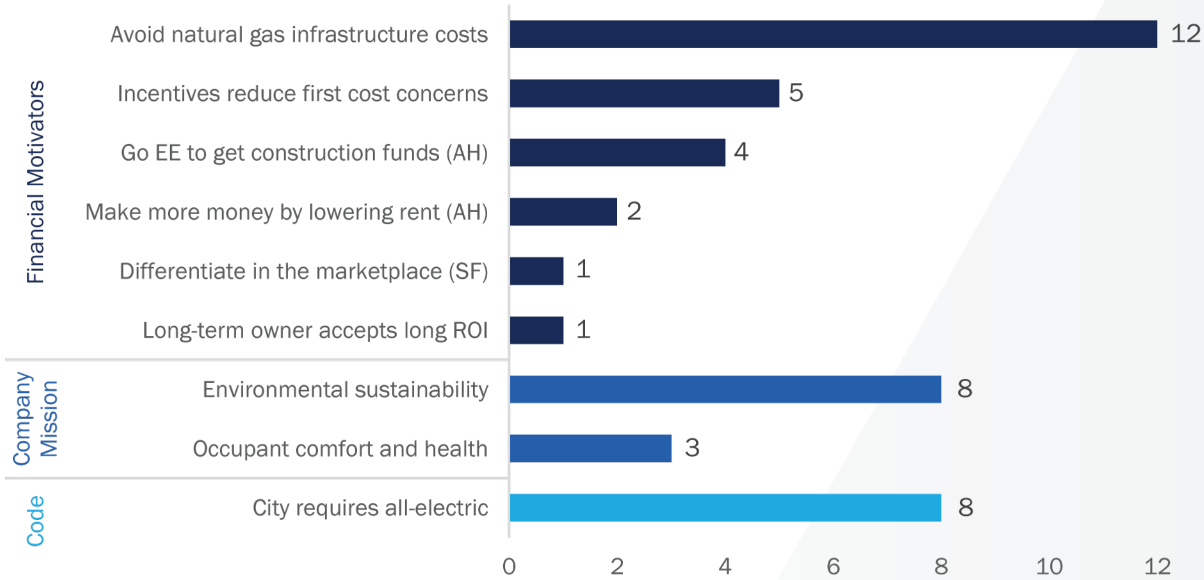
> *It's hard to explain to them the value of heat pumps unless they really, really want the cooling.*

Respondents indicated that a lack of awareness of heat pumps is a concern because builders may install a central air conditioner and furnace instead of the heat pump. The cooling provided by heat pumps can be particularly beneficial for low-income communities. One local government representative indicated that disadvantaged communities tend to get hotter than higher-income communities because they tend to be sited near highways and in areas with few trees. One interviewed Housing Authority staff member reported they normally do not install air conditioning but were required to on one project because the property was one block away from a highway and they used heat pumps to meet that need. Unfortunately, they did not remember the name of the program or policy that required that.

Motivations to Choose Heat Pumps

Financial benefits were the most common motivators for installing heat pumps in new residential buildings, according to data from all 30 interviewed builders (Figure 5). Other motivators included the homeowner wanting to be sustainable and developers' sustainability-related missions. Local jurisdictions' reach codes and natural gas bans in new construction were also commonly cited reasons.

Figure 5. Motivations to Choose Heat Pumps (n=30)



Note: Multiple responses allowed. (AH) following a reason indicates it is particular to the affordable housing context and (SF) indicates it was particular to the single-family market.

In the following sections, we discuss each of these motivators in more detail.

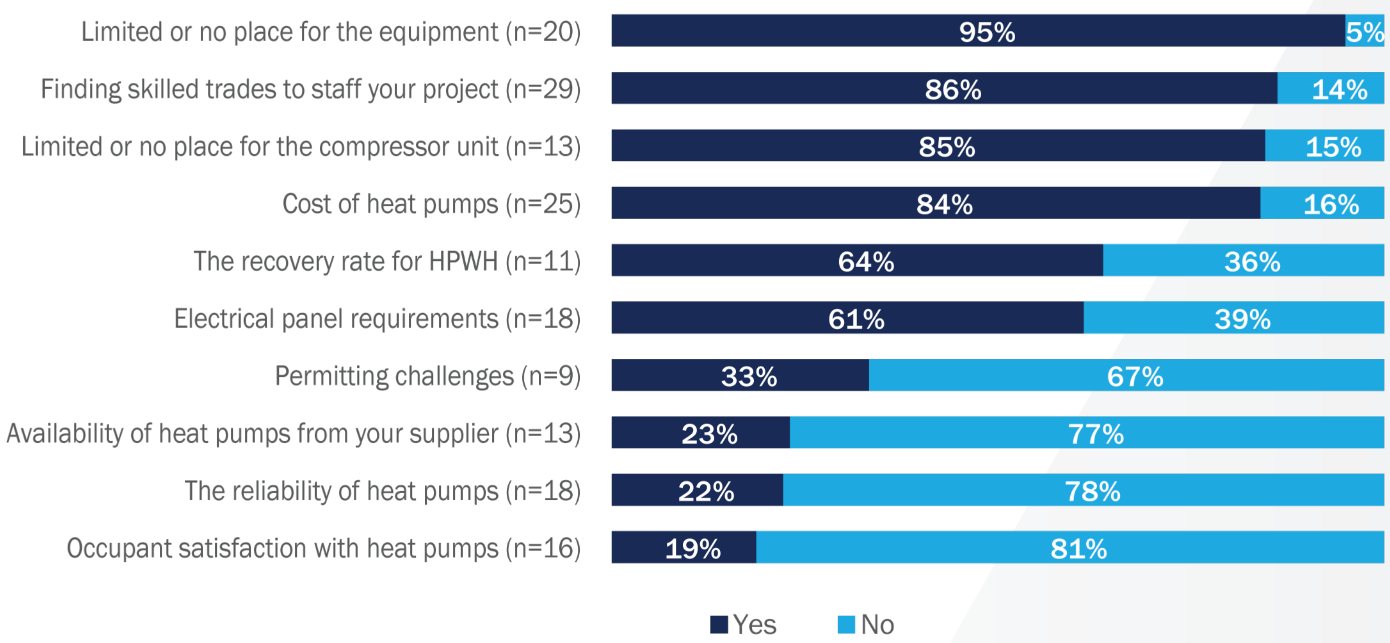
Concerns about Heat Pumps

Space and placement constraints, along with a lack of appropriately skilled trades and high upfront costs were the primary concerns that interviewed builders reported about heat pumps (Figure 6). Two of the top three concerns, reported by a large majority of respondents related to placement of the equipment (more often in the case of HPWHs) or placement of the compressor unit (in the case of ASHPs and DHPs). These concerns related to the air, space, and temperature requirements inside the building or placement of the compressors outside the building or home. However, one production home builder, who was in the minority, reported no concerns about the placement of the compressor unit, noting that it has the same footprint that a central air conditioner (CAC) would outside the home. The production home builder clarified that without the need for a CAC, the heat pump can easily be designed to fit in the space a CAC would have been.

> CONSIDERATION
>
> Builders are concerned with the lack of appropriately skilled trades, space needs, and high upfront costs for heat pump technologies.

A large majority (25 of 29; 86%) also expressed concerns about finding appropriately skilled trades to staff their projects. Many contractors and builders remain unfamiliar with heat pumps and prefer to install equipment with which they have experience. They may inflate their prices when bidding on jobs including equipment with which they are unfamiliar (see Section 7.9 for more information). Finally, the higher upfront cost of heat pumps, particularly DHPs, was a concern among a majority of interviewed builders.

Figure 6. Heat Pump-Related Concerns



Close to two-thirds of respondents expressed concerns about the HPWH's slower recovery rate than natural gas tankless or tanked water heaters and reported that designers must account for the recovery rate when determining the HPWH's tank size and holding temperature for individual units, though only one of these mentioned the concern for the single-family sector. Additionally, a little more than half of 18 respondents (11 of 18; 61%) noted concerns about exceeding the electrical panel capacity when building all-electric. When electrifying a building, particularly in large renovations, builders must pay attention to not exceed the panel capacity of apartment or home, nor the service capacity of the site. Utility infrastructure concerns are discussed in more detail in Section 7.7.

Builder share contractor concerns regarding HPWH's slow recovery rates compared to natural gas water heaters.

Few interviewed builders reported concerns about the availability of heat pumps from suppliers (23%), the reliability of heat pumps (22%), or occupant satisfaction with heat pumps (19%). The few mentions of concerns with reliability were in relation to HPWHs that have failed in single-family homes. Satisfaction concerns were limited to needing to instruct tenants on how to operate their DHPs since the technology was often new to occupants.

2.3 MULTIFAMILY NEW CONSTRUCTION MARKET

The multifamily market includes structures with four or more units and does not include condos and townhomes. This section includes market-rate and affordable housing whereas Section 7.5 discusses in more detail the affordable housing context.

Respondents emphasized that multifamily property owners are driven by their bottom line more than anything else. Developers in the multifamily market want to maximize the number of units they can sell or rent and minimize the space taken up by mechanical equipment, whether in-unit or elsewhere in the building. Architects and engineers consider the cost of equipment and how much space it uses when selecting mechanical equipment in order to maximize rentable or sellable space.

The upfront cost of heat pumps is the biggest hurdle to heat pump installations for affordable housing owners, according to 11 of 12 (92%) affordable housing respondents addressing this topic. The twelfth respondent viewed the cost savings from avoiding natural gas infrastructure as offsetting the increased cost of heat pumps. The remainder though, said that they would install heat pumps more frequently if it was more affordable to do so and that the biggest deciding factor for equipment is its cost. As one respondent said about all-electric construction more generally,

> Upfront costs are the biggest barrier to heat pump installations for affordable housing builders.

> *There's not resistance to go all electric. It seems like it's just a cost problem.*

Space Heating and Cooling

Eighteen of the 20 respondents with experience in the multifamily market discussed space heating and cooling. These respondents viewed space heating and cooling with heat pumps as easier to implement than water heating with heat pumps in the multifamily context because the equipment is similar to that with which the workforce is used to working, such as air conditioners, rooftop units, and VRF systems. While both ducted and ductless heat pumps are common in multifamily buildings, ductless heat pumps (DHPs) still have an upfront cost premium and ducted ASHPs are perceived as more cost-effective.

The design and layout of the units drive the decision to go with ducted or ductless heat pumps: ducted heat pumps are better for units with two bedrooms or more. For studio apartments or one-bedroom apartments, a ductless unit can provide sufficient conditioned air for the space. But larger apartments, with two or three bedrooms would require multiple DHPs, increasing the cost to the point where it is prohibitive, and it makes more sense to use a ducted ASHP. When siting an ASHP that will use ducts, designers try to place it centrally in the unit to shorten the duct runs. One multifamily developer provided the following example. A one-bedroom apartment with a DHP system would have one head in the living room and one head in the bedroom; its price is reportedly comparable to a single-zone ducted ASHP. Adding another bedroom and head would increase the costs by $1,500 and with a third bedroom it would be $3,000 more than a ducted system. He concluded,

> *We're very cost-conscious on this. We think the pricing on the DHPs is dropping but it's not to a point yet where we can go with ductless instead of ducted in multifamily unless it's a studio or one-bedroom project like for seniors or special needs.*

In high-rise multifamily buildings with several dozens of units, however, siting all of the condensers can become a problem. The condensers need access to outside air. Sometimes they are all put on the roof in what has been called a "compressor farm." But other items are competing for that roof space, such as solar panels and firefighter access. When there is not enough roof space, designers will place them on balconies. This has worked but can cause concerns in market-rate units where someone who wants to relax and enjoy their balcony does not want to share it with a heat pump condenser. One developer said this situation prohibited them from installing a heat pump in an expensive condo. In addition, some jurisdictions, such as the Cities of Ventura and Santa Monica, have policies that prohibit the condensers from being visible from the street, limiting their placement. In one project, they had to install a large screen to hide the 131 condensers, which added to project costs. One option that has been popular in hotels, are vertical terminal air conditioners (VTACs). This heat pump resides in a closet and connects through the wall to the outside. It is controlled via a thermostat. These are becoming more common in multifamily high-rise buildings, including affordable housing due to smaller amount of space it needs. Three respondents mentioned using this type of heat pump in their multifamily projects.

Informing tenants of proper heat pump operation is important to ensure tenant benefits, according to two interviewees. Heat pumps reportedly have lower fan velocities than furnaces or older heat pumps and their operation is slightly different. An interviewee relayed a story in which tenants were calling to say their heat pumps were not cooling their apartments. The interviewee learned the tenants were turning the heat pump off when they went to work and then it would take three hours to cool the apartment upon their return. After advising the tenants to leave the heat pump on all day while they were at work, the complaints stopped. Another interviewee in the multifamily space said they provide a resident services manual that describes how to use heat pumps, including not turning it off when leaving the unit.

> CONSIDERATION
>
> Educating tenants on how to operate heat pumps is essential to ensuring tenants realize all the benefits of a heat pump.

Water Heating

Seventeen of the 20 respondents experienced in the multifamily sector commented on heat pumps for water heating. This section draws on their answers and reviews how large, centralized HPWHs are used and how unitary HPWHs are used. For both types of HPWHs, the amount of space they take up compared to gas-fired or tankless alternatives is a primary barrier to incorporating them into multifamily units along with market actors' unfamiliarity with them. The costs of natural gas water heating have been substantial and many multifamily property owners are moving to a centralized HPWH combined with solar to reduce their water heating costs. One affordable housing developer reported their natural gas water heating costs range between $4,000 to $40,000 annually per building. An architect estimated that 90 percent of California's multifamily mid-rise and high-rise projects use a centralized gas-fired boiler with a storage tank, which represents a substantial opportunity for fuel-substitution. In the next section we describe the opportunities and barriers to centralized heat pump water heating in more detail.

Centralized HPWHs

Centralized heat pump water heating systems have larger storage tanks and require more space in a multifamily building than do gas-fired systems. The HPWH's recovery rate is slower than gas-fired equipment, so designers design large storage tanks, which take up premium space in the building. Also, gas-fired boilers can be placed almost anywhere in a building, including a basement. The HPWH units have more placement constraints due to their need for sufficient ambient air and, as result, sometimes the compressors or tanks go on the roof. Having extra weight on the roof means that a structural engineer had to design the building to support this weight, which translates into extra steel and costs for the developer. Finding the proper space, and enough of it, either with single units or a clustered approach, is a primary reason why developers will go with a smaller and more flexible gas-based system.

A challenge with centralized hot water heating is that there is no off-the-shelf product available, and centralized HPWH systems require complex designs, controls, and commissioning of those controls. That level of complexity is a big departure from the gas-fired centralized water heating boilers. For example, the HPWHs need access to sufficient ambient air, while the gas-fired boiler only needs a small ventilation shaft with a flue. The refrigerant requirements are also different. An engineer described the complexity of designing centralized heat pump systems in the following the way,

> *"The way that we're doing stuff with the central heat pumps is a lot different than the way we did it with gas. It was really easy with gas. And there's a lot of reasons why [it's harder with central HPWH]. You've got to design in reliability concerns, backup, multiple stages, and you've got the swing tanks and primary storage. All of those pieces have to kind of work together. There's no off-the-shelf product, and there's no control capability within the heat pumps themselves to be able to handle that logic."*

Several respondents mentioned that design teams are unfamiliar with centralized HPWHs and are still "getting up to speed" on how to design them and have needed specialized consultants to assist them. These systems have been relatively rare, and most design firms do not have experience designing these systems. Installers, too, do not have much experience with these systems, which drives up labor costs. A common problem with improper design of a centralized HPWH is that the system has trouble maintaining the desired temperature. As a result, some designers increase the tank's holding temperature to 130 or 135 degrees; thus, increasing energy use. Additionally, because these systems can be sophisticated to operate, they are also more expensive to maintain and are more difficult to troubleshoot when something goes wrong. Low-income housing, though, tends to have centralized water heating systems because then the owner-operator only has one set of equipment to maintain instead of maintaining dozens of individual water heaters.

CONSIDERATION

Training on centralized HPWHs in multifamily buildings will potentially drive increased installations.

One concern about a centralized water heating system, whether gas-fired or heat pump, is the recirculation line that runs throughout the building. The line continuously circulates hot water throughout the building so that a tenant does not have to wait for hot water when they turn on their faucet or shower. These lines can waste energy, however, so designers try their best to reduce or eliminate that recirculation line. The recirculating line also requires the water temperature to be increased up to 150 degrees when a recirculating loop is used. An affordable housing developer mentioned how their company is grappling with the complexity of the centralized HPWH. They want to use solar to heat the water to avoid their high natural gas bills. They are struggling to find space for the storage tank close enough to the compressor. Putting the storage tank farther away complicates the design of the recirculation loop.

Unitary HPWHs

Unitary HPWHs have the compressor integrated above the tank into a single unit. Space constraints are a primary factor limiting the uptake of in-unit HPWHs. Individual HPWHs cannot fit in small, cramped closets and need to be in larger closets with ventilation. Including a large, ventilated closet for every single unit is often not viable from a design standpoint because it will take up too much usable square footage. To get around this, HPWH are sometimes placed in corridors or balconies to avoid taking up space for the unit. One respondent noted that their efficiency performance is poorer outside, but it has been easier for them to manage that than to give up space in the unit. The space constraint may be a larger challenge in affordable housing than market rate. Respondents reported that market-rate, for-sale multifamily units tend to have individual water heaters in the units.

A benefit of individual HPWHs is that it is one self-contained unit that is tested at the factory, it comes in a box, and the installer just has to connect the pipes and electricity. The recharge rate is less of a concern for individual HPWH compared to centralized HPWH because this unitary equipment has a hybrid mode that allows an electric resistance heating element to turn on if the water temperature gets low enough. From an energy efficiency standpoint, it is best to avoid having the unit use the electric resistance heating element as much as possible. Multiple designers mentioned they wanted to see more HPWH products on the market with larger heat pumps that have higher recovery rate so that the units can avoid using those resistance elements.

A new approach gaining traction in low-rise multifamily housing is to use one HPWH that serves two to four units. Mentioned by five respondents, this "clustered approach" could use an 80- or 100-gallon HPWH that serves multiple units with a very small recirculation line. The HPWH is usually in a closet between the units or in a hallway closet. By having the water heaters distributed throughout the building, it may take up more space, but it uses less energy than a system with a long recirculating loop. In addition, if one of the HPWHs breaks, the maintenance staff can easily install a new one, a small number of tenants are affected, and tenants are not without hot water for long. And, when there are multiple of the same HPWH, replacement parts can be kept in stock and building staff can easily switch out a spare part, so the unit is not down for long. We heard that the ease of replacement was a motivating factor for at least one property owner to choose the clustered approach. The clustered approach has been used successfully on low- and mid-rise multifamily buildings up to 12 units.

Operations and Maintenance of Equipment

Property owners consider equipment maintenance in decision-making and want to know the equipment has worked effectively at other properties, but they are willing to try equipment that their operations and maintenance (O&M) staff might not be familiar with. Drawing on 20 interviewees' comments, there is a strong preference for simple equipment with readily available replacement parts. As one Housing Authority staff member explained,

> *We go with simple systems and it works for us in the long run because it's affordable to install, maintain, and replace when it does go out.*

Another affordable housing developer reported,

> *The equipment can't be fragile or complicated or hard to maintain. It has to be pretty straightforward.*

Interviewees perceived heat pumps for space heating/cooling and unitary HPWHs as straightforward equipment, but centralized HPWHs were seen as more complicated. Reducing maintenance costs is important because many smaller multifamily buildings may not have full-time maintenance staff. For larger multifamily buildings and affordable housing properties, the maintenance staff are more akin to janitorial staff that have taken on additional responsibility, so ensuring maintenance is straightforward and simple can be a big consideration.

If it is a new system that the property owner is not familiar with and they do not know how it will affect their O&M staff, they want to know that the system has worked well in comparable situations, according to five interviewees. This situation is more of an issue with water heating because HPWHs are new to California's multifamily market compared to heat pumps for space heating which have been part of the market over the last decade. Multiple consultants we spoke with reported they had clients who refused to move forward with a HPWH solution until they were shown another project where they were installed and operated successfully. In one case, the consultant had to point to a project in New Zealand because the equipment had not yet been used in the United States.

Another reason why multifamily property owners may be willing to go with equipment their O&M staff are not familiar with is that there is often a hand-off meeting and training that occurs after the new equipment has been installed. The maintenance staff will meet with the mechanical subcontractors or a manufacturer's representative and get trained on the system and how to maintain it. Or the property owner may enter into a service agreement with the installation contractor who will properly maintain the equipment, according to one interviewee.

One type of heat pump used in multifamily buildings for its simplicity is a packaged terminal heat pump (PTHP), also called a packaged terminal air conditioner heat pump (PTAC heat pump). These can be an inexpensive way of putting a heat pump in each room of a multifamily unit. It avoids labor and material costs associated with ductwork and running refrigerant lines. It does not have an outside condenser unit. They are wall-mounted and have two small grills on the outside of the building—one for air intake and one for exhaust air. If using one PTHP per unit, it would be limited to a studio apartment or a one-bedroom with a transfer fan between the bedroom and living room.

2.4 SINGLE-FAMILY MARKET

The single-family market in this study focused on detached single-family homes including custom built homes and those built as part of a whole neighborhood, such as production homes. Included in the single-family market research was a discussion about accessory dwelling units (ADUs). A series of laws went into effect on January 1, 2020 that relaxed restrictions on ADUs in California. As a result, ADU construction increased in 2020, and that was reflected in our interviews on single-family home construction. Similar to the multifamily market, DHPs are a great choice for smaller spaces like ADUs.

Some of the challenges faced in the multifamily market also exist in the single-family market. These include the need to properly place HVAC heat pumps' compressor unit outdoors, the HPWH taking up more room indoors than tankless water heaters, the upfront cost, lack of awareness among contractors, and builders' reluctance to try new equipment were present in both markets.

Space Heating and Cooling

Fourteen of the 20 builders with experience in the single-family sector commented on heat pumps for space heating and cooling. This section discusses how builders approach using ducted and ductless heat pumps.

Both production home builders we interviewed prefer ducted heat pumps due to costs and aesthetics. Like their multifamily counterparts, the single-family developers said that there is still a financial premium on DHPs whereas ducted ASHPs are more cost-effective. Also, the cost of DHPs in homes that would require multiple heads is significantly higher than a centralized ASHP system. The need to place the multiple heads throughout the home also raises aesthetic concerns. In fact, aesthetic concerns were a strong barrier mentioned by single-family builders for both high-end homes and more affordable homes. In addition, the labor market is more familiar with ducted systems, which influences large-scale builders. A production builder explained how the labor market's familiarity with ducted systems causes their firm to go that route. They reported,

CONSIDERATION

Single-family production builders prefer ducted heat pumps due to costs and aesthetics.

> *"The trades and suppliers in our industry are very used to doing things a certain way. When you switch too drastically from what's common, costs tend to be extra high and things can get missed; trades in the field will miss things, and we might miss things as the builder because it's uncommon for us too. Trying to stay with things that are as common as possible seems to be that the best route for a builder trying to figure their way through all this."*

In short, when building ground-up new construction outside of an ADU, builders prefer ducted systems due to their cost-effectiveness, the labor market's familiarity with them, and to avoid consumer dissatisfaction with DHP heads on the wall.

DHPs are great applications for ADUs and have advantages in certain situations. ADUs are similar to the situation of one-bedroom and studio apartments in that they are the appropriate size and configuration for a single-head DHP. Avoiding material and labor costs with ductwork is also an advantage that can save time, as well. Finally, multiple DHPs in a home can be an attractive feature to homeowners who want the ability to heat and cool only the space they are in or who want the opportunity to heat one space and cool another at the same time.

CONSIDERATION

Ductless heat pumps are particularly attractive for use in ADUs.

There is a disconnect between the building code that encourages heat pumps and the planning/zoning codes' setback requirements. The outside compressor location is a challenge with single-family construction. Setback requirements and laws concerning decibel levels at the property line restrict the available locations for the unit. This is not an issue with a gas-fired furnace because they do not have an outside component. An architect described encountering this challenge. They said,

> *In this big property, there was only one sweet spot where we could put it [the compressor]. And, so I think that it's really, really important that, as cities and jurisdictions want to see heat pumps, they understand that they're going to have to help in finding places that are approved for them.*

An interviewed local government staff person who conducts building inspections reported that they have seen some compressor locations that are close to being in violation, but never had a compressor location that failed an inspection. Also, interviewees noted that people like to use their backyard as a relaxing space and might not want to share it with a compressor unit.

Water Heating

Sixteen of the single-family new construction professionals we spoke to had experience with HPWHs, and we report their experiences in this section. There are a variety of customer concerns about HPWH and challenges to HPWH installation in single-family settings. Finding sufficient space and appropriate placement for the HPWH was the biggest challenge reported.

- **The size of the storage tank and compressor on top take up valuable space that a tankless unit does not.** Tankless units can be mounted on a wall inside or outside of the house, but tanked HPWHs sit on the ground inside the house, which can be a challenge in cramped garages, in ADUs, and in remodels when the space allocated for the water heater is set. If there is no attached garage, the HPWH may go in a closet, but allocating square footage for such a closet will take away space for other living areas.
- **The trades are unfamiliar with HPWHs and prefer business as usual, which has largely been gas tankless water heaters.** Contractors have deep experience selling tankless water heaters, understand them to be less costly, and perceive them as more efficient than HPWH. Three single-family home builders reported that the HPWH they installed was the first one for the plumber they hired. And three respondents described stories where they had to call four plumbers before they could find one who would agree to install a HPWH.
- **HPWH cool down the ambient space's temperature.** HPWH extract heat from the space they are in, effectively cooling it. This cooling can be a benefit in the summer because the homeowner could have an air-conditioned garage, if installed there. But people reportedly use more hot water in the winter and extracting heat from a conditioned space can increase the heating load. One architect said they duct the HPWH exhaust air out of the house to avoid this issue. Two respondents desired greater options for HPWHs, including those that may be placed outside.
- **Upfront cost can be a barrier.** A few respondents mentioned that HPWHs are more expensive than alternatives and that rebates do not effectively bring the cost down to the point where homeowners consider them.
- **Higher operating cost compared to gas.** Two respondents mentioned that the cost of electricity compared to gas will make homeowners reluctant to move from a gas water heater to an electric one.
- **Noisy performance.** A single-family home builder and a local government staff member mentioned concerns with the noisy performance of a HPWH. They suggested the best placement for a HPWH would be in a utility area away from a living space to avoid complaints about noise.

Homeowner education is necessary to overcome preference for tankless water heaters. Homeowners have been attracted to tankless water heaters because they provide endless hot water and have been perceived as more efficient because they are not heating water all day long. Homeowners will require education to understand the benefits of a tanked, storage water heater such that they value it over tankless options. As a builder reported,

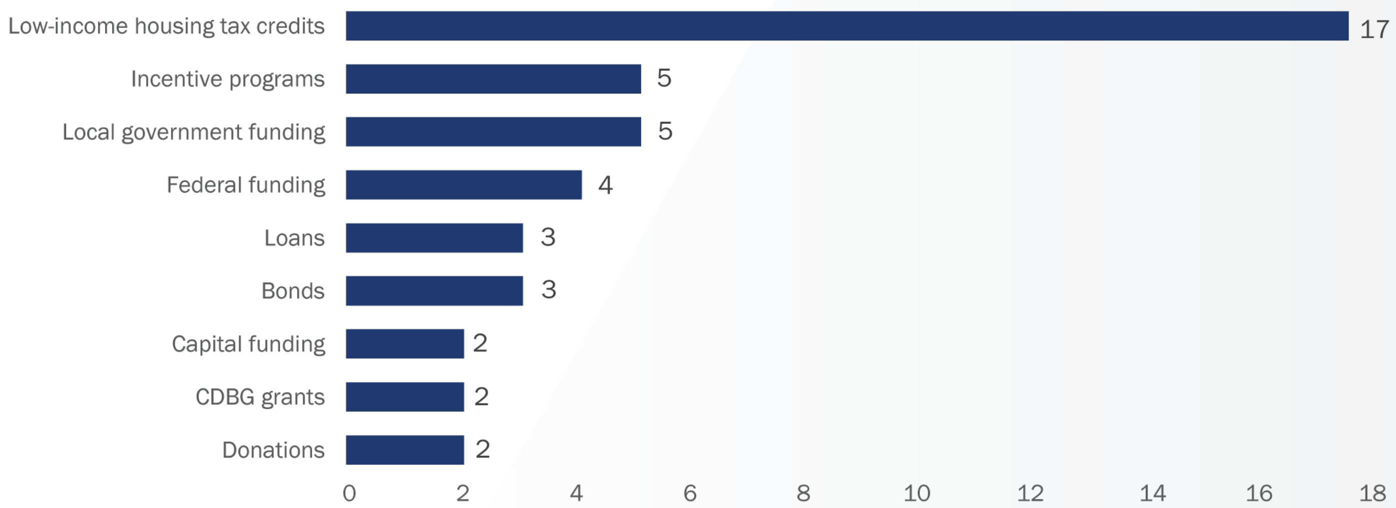
> *"It feels like a step backward when you have a HPWH, because you have this giant tank that takes up space and then it's losing heat. That's going to be a hard move for consumers." A local government representative added that homeowners may be unsure of who to call to install a HPWH, not knowing whether they need to call an electrician, a plumber, or both.*

Storage HPWHs represent an opportunity to alleviate stress on the grid if tied in with demand response programs. Five respondents noted that greater adoption of HPWHs can be a resource for the grid if they are treated as storage batteries and linked with demand response programs. One consultant asserted that HPWHs should be valued more in Title 24 software calculations because of the potential to reduce the duck curve and enhance resiliency of the grid.

2.5 AFFORDABLE HOUSING

The funding sources available to affordable housing developers in California have motivated heat pump installations. The majority of interviewees with knowledge of affordable housing (17 of 20) said the primary funding source for affordable housing projects is low-income housing tax credits dispensed through the California Tax Credit Allocation Committee (CTCAC) (Figure 7). Respondents estimated that the CTCAC contributes funds to between 80 percent and 99 percent of affordable housing projects in California.[8] Other types of funding, such as incentive programs and local and federal government funding were also cited as supporting affordable housing project (Figure 7).

Figure 7. Financial and Funding Sources for Affordable Housing (n=20)



Note: Multiple responses allowed.

[8] One respondent reported that the low-income housing tax credits are limited to mixed-fuel buildings, but we were unable to verify that.

The low-income tax credit system, the most popular funding source for affordable housing, encourages energy efficiency because builders can profit from utility bill savings by using the California Utility Allowance Calculator (CUAC). When using the low-income tax credits, the rent, including utilities, is set at a fixed price. The California Utility Allowance Calculator (CUAC) estimates a tenant's utility bills given the building characteristics and location. However, actual utility costs vary depending upon the performance of the building. If the tenants' bills are below the fixed allowance, then the building owner may collect the difference as part of the fixed rent they charge. Respondents reported that energy efficiency and renewable energy investments to lower the tenant utility bills using the CUAC have been a strong motivator for affordable housing operators to exceed the energy code and choose heat pump equipment. A housing developer reported,

> *The tax credits are the trick. We can justify more energy efficient, but expensive equipment.*

Besides the low-income housing tax credits, respondents reported piecing together multiple sources of financial support to fund their projects. Five respondents reported leveraging incentive programs throughout the state. Notably, these were not offered through the IOUs. The incentive programs they mentioned included,

- **Solar on Multifamily Affordable Housing (SOMAH).** The financial incentives to install solar on multifamily affordable housing make a clear case to transition water heating systems from natural gas to electric heat pumps so that the building may use the electricity provided by the PV system or to lower tenant utility bills under the CUAC. One consultant characterized this program in the following way,

> *Programs such as this are huge and enable a developer to say yes to what the state wants to achieve.*

- **Affordable Housing and Sustainable Communities Program (AHSC).** An architect reported that the AHSC program requires one-third of total energy use to be provided through on-site renewables. They said,

> *"AHSC projects push us into heat pump solutions, whether decentralized HPWH or centralized heat pump boilers, because the PV footprint for the heat pump is one-third smaller than for the natural gas boiler. [...] So, we've been landing on heat pump water solutions for all the AHSC projects."*

- **California's Low-Income Weatherization Program (LIWP):** This program, supported by the California Air-Resources Board, incentivizes GHG reduction emissions. Switching multifamily water heating from gas to electric heat pumps results in substantial GHG reductions and, thus, substantial incentives through this program.
- **South Coast Air Quality Management District** funded a Multifamily Affordable Housing Electrification Project for the Association of Energy Affordability to electrify water heating space heating, cooking, and laundry systems. Consultants operating under this program have also helped shift affordable multifamily housing to HPWHs.
- **Bay Area Multifamily Building Enhancements Program** from BayREN: The program has a Clean Heating Pathway that encourages electrification of water heating, space heating, and cooking. The program prioritizes properties located in disadvantaged communities and provides access to consultants, rebates, and financing.

In addition, the Sustainable Communities Legislation under the California Environmental Quality Act offers streamlined environmental approval for buildings that exceed energy code by 15 percent or have water reduction of 20 percent. One interviewee said that the expedited approval and shortened project timeline has been "meaningful to their clients" and has served as a motivator to install heat pumps to exceed the energy code.

Respondents also mentioned using funds from local governments such as counties or cities. Federal funds were another source of financial support, including funds from the US Department of Housing and Urban Development (HUD) and community development block grants (CDBG). Loans requiring interest payments were used by a minority of interviewees. One interviewee explained that most banks have a community investment division that offers loans for low-income housing projects and they will use occasionally use those to support projects.

There is less opportunity to cut efficient equipment when budget constraints arise in affordable housing, because of the funding streams they use. When an affordable housing team needs to save on project costs, they are unlikely to eliminate efficient mechanical equipment. Affordable housing respondents said the items that may get cut when the budget gets tight are things like cabinetry, fixtures, and finishes. Affordable housing developers are willing to spend more upfront for high-efficiency equipment because it will help them:

- Qualify for the low-income housing tax credits;
- Make their proposals more attractive when competing for local funding; and,
- Allows them to earn more in rent when the tenant's utility bills are lower than the CUAC calculation.

While the majority of respondents reported these funding sources motivate heat pump installations, one respondent asserted that these sources do not motivate heat pump installation. They said that the low-income housing tax credits expect that a building meets certain sustainability thresholds and there are no advantages for being more efficient. They reported,

> *When applying for tax credits, your competitiveness goes down if your cost of construction goes up.*

In their experience, all-electric construction was more costly than mixed-fuel construction. They described a mismatch between the CPUC encouraging all-electric construction and the CTCAC penalizing the more expensive, all-electric construction and desired the two to be more "in sync."

Affordable housing property owners usually own their properties for a long time and are more willing to accept longer paybacks on efficient equipment than are developers who will flip the property and sell to a new owner in a few years. Two affordable housing developers said that they look for a 10-year payback on equipment. A consultant suggested that market-rate developers tend to flip properties in under five years and would prefer equipment with ROIs under that. This consultant said,

> *If they're a long-term holder, you have a better chance of showing them the value-add combined with an emotional ploy for environmental justice. And getting them to bite off on something that may fall outside of their normal parameters for approval.*

Eight respondents reported that their organization has a sustainability component to their mission and the mission was a factor that contributed to their heat pump installations. These eight respondents did not elaborate much on how their mission influences their equipment decisions but said that they were willing to pay the higher upfront cost of heat pumps because they viewed the heat pump project as helping them fulfill the sustainability component of their mission.

2.6 STATE AND LOCAL ENERGY CODES

This section reviews the influence and constraints presented by the statewide energy code as well as local reach codes. We also discuss the role and influence of building departments in encouraging heat pump installations.

2019 Title 24 Energy Code

Respondents more often use the customized, performance-based approach to meeting Title 24 2019 Energy Code because of the flexibility it provides instead of the inflexible prescriptive approach. Half of the 19 respondents who provided insight on this topic (10 of 19; 53%) reported they rely on the performance-based approach for all projects while another eight noted usually trying both approaches and choosing the ideal pathway given the situation. The last respondent noted relying on a modeling specialist for the pathway decision. No respondents reported always using a prescriptive approach for their projects.

The performance approach allows for the ability to model a variety of mechanical equipment and envelope components, including heat pumps. The flexibility provided by the performance-based approach was the most common reason respondents gave for using it (12 of 19; 63%). What's more, seven respondents specifically brought up the inability to reliably model heat pumps under a prescriptive approach. These respondents said that the prescriptive model unfairly penalizes heat pumps in its modeling calculations, making it more difficult to demonstrate compliance with energy code and obtain a permit. As one engineer said,

> *"Our designs tend to be things that do not necessarily tow the prescriptive line, so we have to model them to demonstrate equivalency."*

The respondents who reported trying both pathways noted that the prescriptive approach could be simpler, less time consuming, and more straightforward on simple projects or small remodels. One respondent described their firm's approach,

> *"Our default going into is that we'd use the performance approach and revert back to prescriptive if something is being unfairly penalized in the performance approach."*

Another described the limited situations in which they would pursue a prescriptive approach,

> *"I've only done prescriptive once or twice and that's when we do small master bedroom bath remodels to a very leaky house and it's a way to keep yourself from going nuts trying to persuade a value-conscious homeowner, usually a retiree or soon-to be retirees, that they have to take on a whole energy efficiency upgrade and they're not ready. So, we do prescriptive as a simple way to meet code."*

Respondents report that the Title 24 2019 Energy Code lags behind available technology which makes it difficult for designers to specify the newest and best systems. Title 24 2019 Energy Code requires that measures be proven to be cost-effective in isolation for the measure to be included. This requirement means that the code is not including measures newer to the market and is prioritizing older equipment whose initial costs have come down over time. For example, respondents said heat recovery chillers and heat recovery ventilators are not in the model. Reportedly, many conventional builders and subcontractors use the energy code to determine what is the most cost-effective feature and follow what the Title 24 2019 compliance calculations tell them. The result is that those builders are using lower-performing equipment than they could be. This situation does not help transform the market because average builders and contractors are not demanding heat pumps when they follow the code.

For example, the way the Title 24 2019 Energy Code treats a HPWH in a single-family home makes it more difficult to meet code.[9] An architect relayed a story of how adding a HPWH to a single-family home model penalized the code compliance margin by -48 percent in the 2019 code. They were able to pass code because everything else in the home was very high performing, had a tight envelope, and a heat recovery ventilator. The interviewee noted that most regular practitioners who are not making everything in the home high-performing, will not go with a HPWH because of the way the Title 24 2019 code treats it in the compliance calculations. In the multifamily market, one respondent noted they have a client who may revert to a gas-fired water heating system because the Title 24 2019 Energy Code shows they are noncompliant with the centralized HPWH plus heat recovery chiller-an issue addressed in the 2022 Energy Code update.

The plumbing codes sections of Title 24 assumes fixture flow rates that lead to oversizing of HPWHs, according to three interviewees. It is important to note that the plumbing code sections of Title 24 are not within the Energy Code (Part 6). The pipe sizing methodology in Title 24 is outdated and the assumed fixture flow rates are higher than they actually are today. An engineer reported that even the “medium” flow rate is still too high, and their firm tends to always choose the “low” flow rate. A savvy designer needs to be aware of this limitation in Title 24 and design around it. This presents an opportunity to update the code to reflect the flow rates that exist today.

> CONSIDERATION
> Title 24 is perceived by some to be a barrier to designing and building high performance homes.

Title 24 2019 Energy Code has been effective for moving the laggards in the market and ensuring they meet an increasingly stringent code, but may not be serving the needs of practitioners building high performance homes. Multiple interviewees we spoke with said they complete the Title 24 report to obtain the construction permit, but ignore its results related to home performance and energy. Several interviewees asserted that, as of late 2020, Title 24 is sending the wrong message and not encouraging high performing homes nor heat pump installations. If the state is serious about encouraging decarbonization, Title 24 must be changed so that it sends the right signals and encourage electrification. The CEC updates the Energy Code every three years. The CEC adopted the 2022 Energy Code on August 11, 2021.

In December 2021, the California Building Standards Commission approved the updates. The 2022 Energy Code will go into effect January 1, 2023. This code update addresses many of the concerns with the 2019 Energy Code expressed by builders in this study. The 2022 Energy Code encourages efficient electric heat pumps, establishes electric-ready requirements for new homes, expands solar photovoltaics and battery storage standards, strengthens ventilation standards, and more. Specific examples of updates addressing heat pumps and fuel substitution include adding a source energy metric and moving to a partial heat pump baseline.

> CONSIDERATION
> Like contractors, builders believed reach codes are an effective driver of heat pump installations. Engagement with the builder community prior to reach code adoption is essential to their success.

Reach Codes

More than a quarter of builder respondents (8 of 30; 27%) reported that local reach codes were the reason they installed heat pumps. Reach codes have been effective in driving heat pump installations for both space and water heating. Yet, we heard from respondents that it is important that the builder community feels supported and engaged when the code changes. Toward this end, cities with reach codes have hosted roundtables with developers to get their input on the proposed changes. Importantly, the developers in attendance represented the spectrum of the population including individual property owners constructing ADUs to developers building large mixed-use multi-story buildings.

Many stakeholders believe that a piecemeal, city-by-city approach is not the best way to meet climate goals. Six respondents agreed that the most effective way to achieve more all-electric construction is to have the state mandate it. They noted that California will not meet its goals if it enacts all-electric construction mandates one city at a time. One local government representative stated,

> “*I think a lot of jurisdictions are just waiting for the state to implement policies and programs that’ll dribble down to city level. I know we have to do that. Even though [my city] is a leader in many ways, we are very reliant on state leadership when it comes to building efficiency standards, vehicle emission standards and electric vehicle infrastructure, and cleaning up the grid.*”

[9] The California Energy Commission is working to address this issue in the 2022 code.

Although builder respondents prefer a statewide all electric mandate rather than individual jurisdictions adopting reach codes that serve only sections of the state, federal preemption law currently presents a barrier to the state of California's ability to unilaterally require all electric new construction. In addition, cost effectiveness considerations based on climate zone, building stock, and community preferences supports local jurisdictions passing reach codes. Currently, one in five Californians live in a jurisdiction with a pro-electrification reach code, which is moving the market in this direction, even if not through a statewide energy code at this time. Interviewed local government staff with reach codes also encouraged their peers to adopt reach codes because much of the legwork has been done by the Statewide Codes and Standards Program. There are studies on cost-effectiveness, example code language, checklists, and more. Despite this, a lack of staff time and bandwidth was cited as the main barrier preventing more local governments from pursuing reach codes. Without internal staff available, the local governments are seeking funding to pay consultants to help them enact reach codes.

2.7 UTILITY INFRASTRUCTURE

Sometimes there are challenges providing adequate electric service to the site to accommodate heat pumps in both new construction and gut rehabs, but there are also advantages to avoiding natural gas infrastructure.

Electric Infrastructure

Builders using heat pumps and constructing all-electric must ensure the building's demand stays below the service line's threshold or face extra work, extra costs, and delays when interacting with the utility to increase service capacity; major rehabs may also require expensive panel upgrades (n=28). A majority of respondents reported issues in their projects related to heat pumps or all-electric construction that required additional service capacity or panel capacity as compared to building homes without heat pumps. They described how heat pumps added to project costs or delayed the project timeline (Table 8).

Table 8. Electric-Infrastructure Related Issues (n=28)

Electric Infrastructure-Related Issue	Number of Respondents	Percent of Respondents
Utility-related upgrades delay project	15	54%
Expensive to upgrade panel or electric system at site	13	46%
Expensive to increase service capacity to site	9	32%
Service lines or transformer need to be upgraded	9	32%

When heat pumps and other electrical equipment require additional capacity, however, developers may need to involve the local utility, which delays projects. Utilities become involved with projects to relocate lines or upgrade service lines or transformers depending on the location of the new construction. One engineer told a story of planning one and a half years of lead time to have an IOU upgrade a transformer supplying their project, but that the IOU took two years to provide the service needed to the site. These types of delays lengthen the amount of time it takes to bring all-electric buildings online, making it more difficult to reach the state's goals.

Adding electric infrastructure does not just introduce uncertainty in the timeline, it also adds costs that the developer may not have anticipated. A multifamily developer in the Bay Area reportedly had to pay $300,000 to bring more electric service to their site for their all-electric building using heat pumps. If a major rehab or new construction project requires the utility's service drop wire to be enlarged, it could cost between $6,000 and $30,000 depending on the distance and whether it is overhead or underground, according to one interviewed local government representative. A different local government representative said that service line extensions in their area range from $0 to $11,000 per home and did not know the reason for the price range. One builder mentioned that they were unable to electrify stoves at a multifamily building because they would have exceeded the service line's threshold of 400 amps. If all the stoves were electrified, the building would have needed a 600-amp service and they would have to pay to bury the overhead electrical service line.

CONSIDERATION

When heat pumps require service line enlargement or transformer upgrades to the project site, the added costs and delays to obtain sufficient electrical service can negatively affect a project.

Older homes in older parts of cities will have outdated infrastructure. To accommodate heat pumps in these gut rehabs, two respondents had to change a home's electric system from single-phase to three-phase. For water heaters, a gas water heater might be in an area with 120 volts, 15 amps of service, when a HPWH would require 240 volts and 30 amps of service. Three respondents reported that if a heat pump installation required a panel upgrade in a single-family home, that the cost of the upgrade is substantial enough to move away from the heat pump option. See Sections 2.6 and 3.6 for more information about panel upgrades and their costs for ASHPs and HPWHs. In all these cases, the homeowner or property owner is responsible for covering the costs associated with the service capacity upgrades, which seemed unfair to a few interviewees. One could argue it is in the electric utility's best interest to have the line enlarged because they will be supplying more energy and receiving more revenue.

Two local government representatives suggested that utilities need to be more responsive when customers need an infrastructure upgrade and that that utilities should be transparent on infrastructure planning. These local government staff suggested that there be a map of all the utility infrastructure so that they could see what service potential the lines have and when upgrades would be required. They stated this type of information would help developers plan for the infrastructure costs associated with their developments. As one of the staff said,

> *It's really hard for a developer that is building all electric to design their system and then down the road realize there's all these additional costs for upstream upgrades in the grid.*

Natural Gas Infrastructure

Though there can be challenges with needing additional electric infrastructure, avoiding natural gas infrastructure was a driver for constructing all-electric and installing heat pumps. Fourteen respondents explained the advantages of excluding natural gas infrastructure in their projects:

- **Avoiding the costs associated with trenching and piping gas infrastructure,** particularly if a new line is needed. One architect in the single-family home market reported that a new gas line from their IOU costs between $10,000 and $20,000. Even retrofit projects require capping of the old gas line and installation of a new one. For homeowners who want to keep gas stoves, the cost of the gas line alone can motivate them to choose an electric cooking solution.

  In multifamily buildings, the cost of piping gas to every unit and venting it from every unit requires significant labor, materials, and time, so much so that it motivates multifamily builders to go all-electric or limit natural gas to centralized services, such as hot water for a laundry room. An engineer explained that some developers see the lower cost of a gas furnace and prefer that, but do not take into account all the labor involved with piping it and servicing it, so they aren't thinking about all the costs involved. This engineer said,

  > *We always bring up the cost of expanding natural gas infrastructure and try to quantify it. I feel people don't recognize how important that can be in terms of budget.*

- **Avoiding coordination and delays associated with working with a gas utility.** In areas where the gas provider differs from the electric provider, the developer only needs to coordinate with one utility which reduces risks for their project timeline. As another engineer reported,

  > *The headache of not having to deal with another service line from [IOU] is something that our clients have considered and value.*

- **O&M teams do not need safety equipment nor tools** required for working with gas.
- **The homeowner or tenant pays one utility bill instead of two.** Each bill comes with fixed delivery costs no matter how little energy was used, so the resident avoids fixed utility costs by having only one fuel service.
- **All-electric customers can take advantage of time-of-use rates** to save money if they use their electric appliances during off-peak times.
- **Avoiding natural gas has health and safety benefits.** Avoiding natural gas does the following:
  - Contributes to improved indoor air quality because the equipment is not off-gassing fumes such as methane or carbon monoxide. As such, the homeowner or property owner does not need carbon monoxide detectors.
  - Is safer in case of an earthquake because there is less risk of fire and explosion.
  - Installing an induction cooktop means someone cannot burn themselves when they could with a gas flame.

A production home builder shared a nationwide practice that can cause a developer to use natural gas in their projects. They reported gas utilities are able, in certain instances, to defer the costs of installing the gas infrastructure by requiring developers to install gas appliances. As a result, some communities have development restrictions that require the developers to install gas equipment in the homes.

2.8 INCENTIVES

The interviewed market actors used new construction incentives and were largely unaware of IOUs' heat pump rebates. A majority of respondents (n=26) knew of new construction incentive programs and saw heat pumps as an instrumental way to exceeding the energy code to earn the rebate (Table 9). Both production builders, for example, were unaware of heat pump specific incentives, though they had both participated in other zero net energy-focused incentive programs. While about three-quarters of respondents who were aware of new construction incentives (20 of 26; 77%) also reported having used them; only one of the four respondents who knew of the heat pump specific incentives reported having used them. All four local government staff were aware of electrification incentives but are not included in the table because they are not in a position to use incentives in their projects.

CONSIDERATION

Most new construction trade allies are unaware of heat pump incentives.

Table 9. Number of Builders Aware of and Who Use Incentives

Actions	Number of Respondents	Number of Respondents
Awareness (out of 30 builders)	**Aware**	**Not Aware**
New Construction Incentives	26	4
Heat Pump Specific Incentives	4	26
Use (out of those aware)	**Uses**	**Does Not Use**
Uses Any Incentives (n=26)	20	6
Uses Heat Pump Specific Incentives (n=4)	1	3

The respondents who knew about incentive programs encouraging electrification for new construction projects emphasized how CCAs and municipal utilities were leading the way compared to the IOUs. Four individuals, for example, mentioned how Sacramento Municipal Utility District's (SMUD) rebates were clear, understandable, well-promoted, and influential in decision-making. The other positive mentions of incentives included offerings by CCAs such as Marin Clean Energy (n=3), Peninsula Clean Energy (n=1), and Sonoma Clean Energy (n=4); several individuals also discussed utilizing incentives from the Regional Energy Networks (RENs) such as BayREN (n=3) and SoCalREN (n=1). The sentiment was so strong that one local government staffer commented that they worry for communities that do not have a CCA because they felt those communities are in danger of being left behind as the state moves to all-electric construction.

Respondents had mixed opinions about whether the incentives influenced customers' decisions to purchase energy efficient equipment. Of the 26 respondents aware of new construction incentive programs, 15 found them influential while 11 said the incentive amounts were not large enough to convince a customer to purchase a heat pump. Those reporting that incentive programs had an influence in project decision-making mostly referred to the non-utility programs described in Section 7.5. A few who reported influence referred to CCA-sponsored programs and said reducing the upfront cost helps the high-efficiency equipment fit within the project budget. One single-family, market-rate builder explained,

> *After they compare the price between a heat pump with rebates to a furnace, the concern goes down. My experience with clients is that the return on investment is in the back of their mind, but smack in front of their face is the upfront cost.*

However, 11 respondents mentioned that the incentives were still not enough to reduce the cost of the heat pump to the point where an average homeowner would want the equipment. One builder gave the example of a $1,000 HPWH incentive being inadequate when a HPWH unit and installation costs $3,000 and a gas water heater is $600.

Other respondents reported that the incentives were too difficult to find and apply for (n=8). Other than SMUD's incentives, respondents said that new construction incentives and heat pump incentives in general are not well promoted and are difficult to find on utility websites. Respondents also reported navigating incentives from local governments, utilities, manufacturers, as well as state and federal tax breaks. As one Bay Area architect said about identifying and applying for incentives,

> *It's so cumbersome and complicated that by the time you fill in all the paperwork and get the receipts in the right place and navigate each city's incentive program, you're so annoyed.*

Other designers also said it was not worth their time to pursue a $100 or $500 rebate because of the onerous applications and thus were not passing along the potential savings to their clients. One engineer reported their firm has explicitly decided not to pursue any rebate programs because, as they said,

> *The documentation burden is very high and the rebate for the project team does not even cover the cost of doing the work for the rebate.*

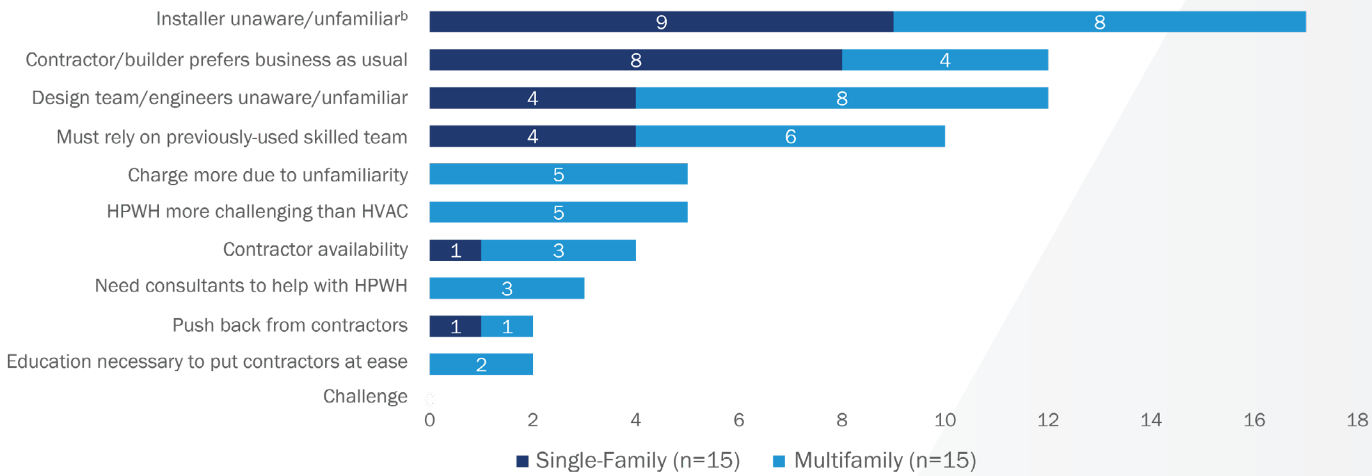
Some respondents (n=5) recommended midstream heat pump incentives for either design teams, contractors, or distributors. These respondents saw midstream incentives as having a greater influence in the market than homeowner incentives. One engineer cited their experience receiving design team incentives up to $10,000 per project and how that motivation elevated his company's EE work. Others did not think it was appropriate to target homeowners because it is the contractor's job to know how different mechanical equipment performs in different situations and recommend what equipment is best for the home. One respondent likened that decision to asking a patient which heart valve they think is best for them. Along these lines, a local government staff member reported that BayREN partnered with CCAs in the Bay Area to offer $1,000 to contractors who install HPWHs in single-family and low-rise multifamily homes.[10] They described this as an effective strategy and now contractors are putting HPWHs on their trucks instead of gas waters and that incentive "has been a huge driver in the Bay Area," according to them.

[10] Reportedly, this offering also included contractor training.

2.9 THE LABOR MARKET

A lack of awareness and familiarity with heat pumps from design teams to installers was reported as a primary challenge to expanding heat pump adoption in both the single-family and multifamily sectors (Figure 8). Most respondents commented on labor market issues (28 of 34) with 15 mentioning issues related to the single-family market and 15 mentioning issues for the multifamily market. Four respondents' comments overlapped sectors.

Figure 8. Challenges in the Labor Market to Heat Pump Adoption (n=28)[a]



a Multiple responses allowed.
b Three respondents mentioned this as a challenge in both sectors.

The largest challenge confronting California is the workforce's lack of awareness and familiarity with heat pumps and a preference for systems with which they are familiar. Respondents mentioned this challenge as more acute for builders and subcontractors than for architects and engineers, though it is an issue for all groups. An architect working in the multifamily space reported that as few as "5 percent to 10 percent of industry designers are familiar with the terminology" of heat pumps. The contractors reportedly perceive a furnace as a less expensive upfront cost and recommend those for single-family clients. We heard contractors also pushed back on clients who want heat pumps, particularly HWPHs. One consultant interviewee pointed out that plumbers are not accustomed to working with electricity, and this lack of experience may make them hesitant to suggest HPWHs. Interviewees reported that the majority of installers do not understand heat pump equipment and are resistant to changing their habits and ways of working. An architect in the Bay Area reported,

Lack of a skilled workforce familiar and experienced with heat pumps is a major barrier to driving heat pump installations.

> *We have had some success with electrifying our projects and getting gas out of them, but more often than not, there is pushback. I'd say mostly from builders on the mechanical/HVAC side and we find that we're constantly undermined, and it feels unfortunate to me.*

We discussed how this played out in Section 7.4, where single-family home builders prefer to go with ducted heat pump designs because they are closer to what the workforce has historically seen. Larger-scale and market-rate developers want to get a home built as fast as possible so they can start renting it or sell it. As such, they want to avoid anything that slows down design and construction, such as heat pump equipment unfamiliar to the workforce, according to one interviewee. As another interviewee reported,

> *I don't think that your average home building company wants to think about this. I think they've gotten used to putting in gas tankless heaters, and they want to just keep doing what they do.*

The unfamiliar builders and contractors who are willing to bid on jobs with heat pumps tend to engage in “risk pricing.” Risk pricing refers to an inflation of labor costs to cover the unknowns associated with a job. Builders who have never done a heat pump project cannot predict with certainty how many hours it will take the laborers and so they budget for that risk. Accurate pricing for installing heat pump systems is critical though because the design teams and property owners making equipment selection decisions consider the labor costs and may choose a non-heat pump alternative if the labor costs prohibit a heat pump. A few interviewees noted that labor prices are higher in a competitive market where there is not a large supply of contractors skilled with this equipment. One engineer reported they have seen labor prices for heat pumps about twice has high in California than they have seen in “more developed, more mature markets like Seattle.”

> CONSIDERATION
>
> Builders and contractors unfamiliar with heat pumps likely are engaging in “Risk pricing” to cover potential unknown costs.

Another engineer mentioned a story in which they put a project out to bid for a project using chilled beams and the labor cost estimates they received were “outrageous;” they knew it should not cost that much to install a system of that size. They decided to re-issue the bid, and as part of the process, they conducted training sessions to show the contractors what was involved with installation. Reportedly,

> *“When they realized it’s similar to a reheat coil they’ve seen before, and once they realized what they were dealing with, the pricing came way down.”*

The engineer suggested that builders in the centralized HPWH market could do a similar process where training is included in when going out to bid.

As a result of the workforce unfamiliarity and risk pricing, one-third of builder respondents (n=10) reported that they repeatedly use the same designers and contractors. One interviewee reported that there is “a small contingent” of knowledgeable and experienced designers in California and that is who they rely on. A multifamily consultant reported they take this into account with their clients. They reported,

> *“One thing I’ve done is steer my clients toward MEP designers who had experience to make sure they have a positive experience going all electric.”*

Two interviewees mentioned they had not experienced a lack of skilled contractors in their areas. An interviewed Housing Authority staff member reported that because none of their internal staff know how to work on the heat pumps they already have installed, they must hire certified contractors qualified to work on them in order to not invalidate the equipment warranties. They said that there were able to find them without trouble because they were close to Los Angeles and Bakersfield. The other interviewee reported relying on a few skilled contractors to complete their projects but that “in Sonoma County, there’s a slightly higher than average amount of knowledge or progressiveness in the building technology sector.”

Four respondents voluntarily mentioned that the availability of the new construction workforce was another challenge. Two mentioned that their availability fluctuates with the amount of new construction going on, and at one point one had difficulty finding a plumber for their project. A Bay Area local government representative reported that availability is a problem year-round in their area because a lot of remodeling and ADU construction is occurring and “contractors are overloaded.” They also reported,

> *“Some folks have called every contractor on our list who’s approved for rebates, and none have any availability for the next three to six months.”*

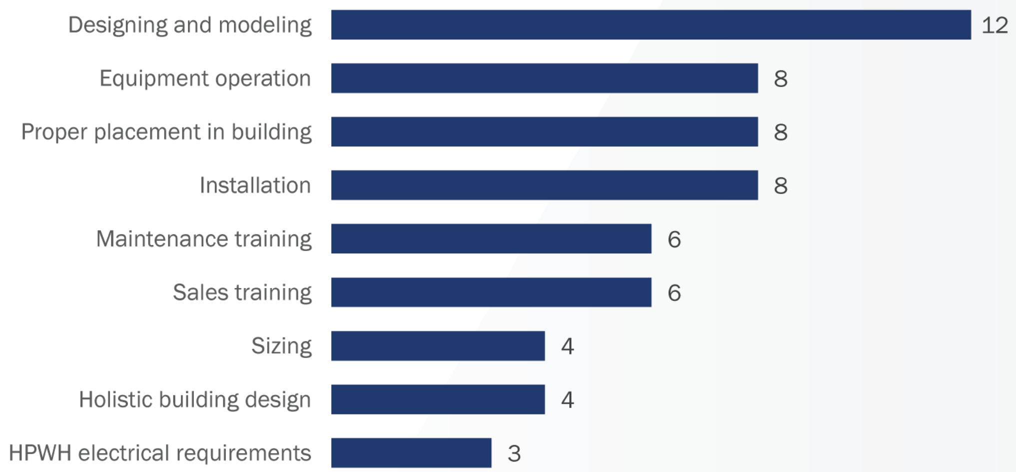
Figure 8 also showed that in the multifamily sector, centralized HPWH projects are more complicated than heat pump HVAC projects and that the workforce has very limited experience with centralized HPWH projects. As a result, the property owners bring in consultants who have the necessary expertise to advise their projects. See Section 7.3 for a more developed discussion.

> *A single-family builder reported, my experience, from the architect through all of the on-site workers and sub-contractors—it's very challenging, because none of them, even the younger ones, are familiar with the new technology. They don't know their availability, how to design them in the project or how to service them. I know that they're learning as they're installing. That's the biggest problem right now I see, is lack of familiarity with new products. But they're learning quickly. Especially in California as folks are becoming more and more aware and demanding it.*

2.10 TRAINING

Training on heat pumps is needed on a variety of topics for the range of professionals involved in new construction (Figure 9). Architects must know how to properly place the systems within the structure, engineers must design and size the systems, builders must know how to construct and install them, and contractors must know how to troubleshoot and maintain them.

Figure 9. Heat Pump-Related Trainings Needed (n=29)



Note: Multiple responses allowed.

Respondents most commonly reported that the industry needs training on how to design heat pump systems and model them in Title 24 compliance software. This type of training should be targeted at architects and engineers. One engineer we spoke with suggested that heat pump manufacturers publish "curves" for the major energy modeling tools used by engineers. They wished manufacturers provided more guidance on how to model their systems effectively and suggested that something as simple as a one-page PDF on how to model their equipment would be a great help for energy modelers.

A theme of the interviews was the lack of familiarity with heat pumps among new construction professionals and building owners. As such, eight respondents mentioned a need for general trainings on how heat pumps operate, including their pros and cons compared to alternative equipment, information on operating costs, and any environmental benefits. This information is needed for decision-makers at Housing Authorities and one respondent added that this type of education would be important for homeowners as well.

Stemming from the concerns about equipment placement and compressor locations, eight respondents saw training for architects focused on where to place heat pumps in a building as important. Proper installation of the equipment was also cited as a training need. Two respondents suggested that installation training include proper discharge of refrigerant for ASHP and DHP systems. One respondent mentioned that installation training should reduce the practice of risk pricing. In addition, maintenance teams need instruction to know how to troubleshoot equipment and properly maintain it, so it performs well and does not fail prematurely.

CONSIDERATION

Training and technical assistance for architects, engineers, designers, builders, and contractors will drive increased heat pump installations in new construction

Sales training was another need mentioned by respondents. Contractors' general business model is not to encourage customers to try relatively newer and more expensive equipment. As such, sales training should focus on why the higher upfront cost of heat pumps is justified and ensure the customer feels confident with their choice of heat pump equipment.

Four respondents mentioned that trainings should not focus solely on heat pumps but should include a more holistic view of the building. These respondents said that more people will be likely to attend a training on whole-building performance than a training on a specific type of equipment. They also noted the interactive effects between the building envelope, lighting, and mechanical equipment and said that should be included in any heat pump training. Finally, a few respondents mentioned the specific need for plumbers who have not typically dealt with electrical requirements to learn about them, so they feel comfortable installing HPWHs. Interestingly enough, no one mentioned needing a C-10 Electrical License to work on the electrical system.

A variety of market actors and organizations are positioned to support heat pump-related trainings, according to 15 respondents (Table 10). Six respondents saw value in learning from their peers or colleagues. This could be in the form of peer-to-peer networks, architects learning from engineers at their firm, or Housing Authority decision-makers learning from what their peers have done. Five respondents reported that trainings should come from the State of California or the CPUC. One of these specifically mentioned the value of the Energy Code Ace trainings and website that are provided by the California Statewide Codes & Standards Program.

Four people wanted to learn technical details from heat pump manufacturers, but other respondents thought manufacturers may present biased information. Two respondents saw the IOUs playing a role in trainings, such as they do through their Energy Centers. Local governments could also play a role in training. One Housing Authority staff member viewed a local government's Housing and Community Development Department as a reliable source of information about mechanical equipment options. Others saw building science experts or consultants as a good source for learning about heat pumps, for example, the Association for Energy Affordability. Finally, a Housing Authority staff person also said they learn from their primary trade association, the Corporation for Supportive Housing, and the state could involve them to promote heat pumps to affordable housing organizations.

Table 10. Sources for Heat Pump-Related Trainings (n=15)

Source	Number of Respondents
Experienced peers	6
CPUC or State, such as Energy Code Ace	5
Manufacturers	4
IOUs	2
Local governments	2
Building science or consultant experts	2
Trade associations such as the Center for Supportive Housing	1

Note: Multiple responses allowed.

Building departments can be a source of information and provide trainings, particularly those in governments with reach codes. Interviewed local government officials emphasized the need to engage builders when designing and implementing reach codes. As one said,

> *Builders feeling like they've been heard and helped is really powerful.*

When engaging with builders, building department staff can ensure that builders are using the most up-to-date code and that the builder is interpreting the code correctly, which is a valuable form of assistance. Cities with reach codes have also provided a wealth of information on their websites, including new construction guides, design assistance services, utility incentives, or alternative financing resources. The four local government representatives we interviewed reported offering the following services to buildings and contractors in their communities:

- **Four-hour long workshops with expert energy modelers,** including presentations on how to design and build to meet Title 24 and the local reach code.
- **Interdisciplinary, in-person trainings** on codes and standards, quality insulation installation, and air sealing, among other topics. A mix of building professionals attended the trainings, which the local government staff member reported allowed the architects, contractors, and structural engineers to interact and learn from one another.
- **All-electric building construction support office hours and hotline** paid for by the city and run by a third party. The third-party experts answer technical questions that are outside of the building department staff's knowledge. The experts also reportedly "circle back with the building department and provide the answers and the reasonings, in order to build capacity" among the building department staff, according to one interviewed local government staff member.
- **A new construction guide** that takes a deep dive into the local reach code requirements and suggests strategies for how to comply with the reach code and design all-electric buildings.
- **A green building education program** to educate builders and contractors. The heat pump component of the training reviews topics such as the coefficient of performance, their reliability, and the different use modes. The training reportedly helps to put builders at ease with heat pumps and reduce anxieties around liabilities.

Partly because of COVID-19, respondents suggested that trainings be conducted online (Table 11). The online trainings might be in the form of videos, tutorials, or webinars, or like the Energy Code Ace website. Case studies were viewed as valuable to show heat pumps are a proven technology with high demonstrated performance. Three respondents thought heat pump education would be best conducted in the field, with hands-on training, particularly for community college students. Two wanted to see more efforts from the CPUC or IOUs to reach out to designers and installers to do broad promotion and education on heat pumps. Another two respondents thought it was important to have market actors complete certification tests following classes to show they are qualified to work on the equipment.

Table 11. Methods for Heat Pump-Related Trainings (n=11)

Method	Number of Respondents
Online webinars or videos	6
Case studies, literature	3
Hands-on, in the field	3
Outreach from CPUC or IOUs	2
Class with certification test	2

Note: Multiple responses allowed.

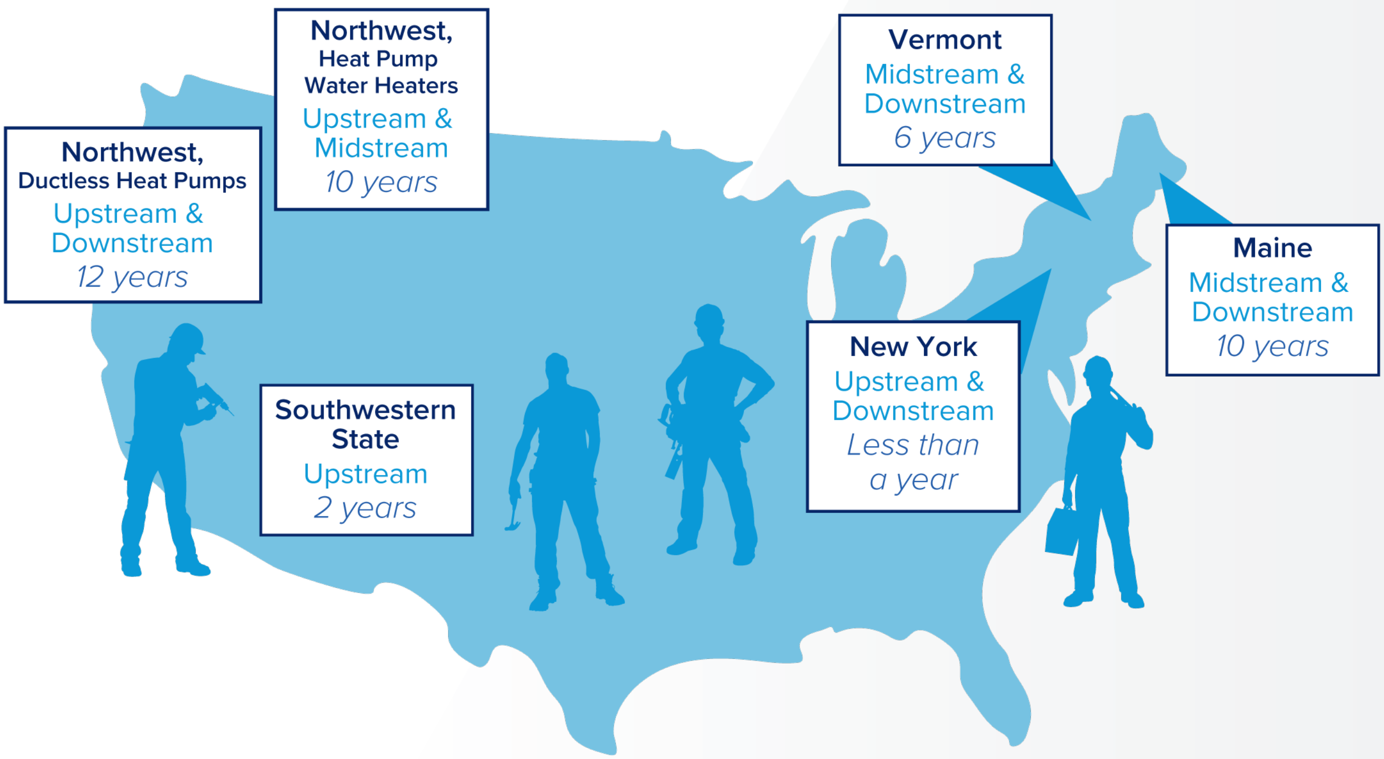
3. MATURE HEAT PUMP UTILITY PROGRAMS

Early heat pump programs have been affected by positive market conditions that have driven interest in heat pump technology as well as negative market conditions that have prevented heat pumps from gaining traction in specific markets. The emergence of the cold-climate heat pump coupled with the rise in the cost of heating fuel drove interest in one of the first ductless mini-split programs in Maine in 2011. However, other programs have also seen how skilled labor shortages and lack of supply from distributors can inhibit heat pump adoption in residential settings. Given the right market conditions including ample distributor supply, a well-educated contractor network, and improved customer awareness, heat pump programs could further penetrate the space and water heating market and achieve higher rates of market transformation. The evaluation team conducted interviews with program staff in states that have achieved some success in deploying heat pump technologies (e.g., New York, Vermont, Washington, Oregon, Maine, and a Southwestern state[11]) to understand how programs could be best positioned to affect market transformation. The evaluation team used these interviews to identify best practices and lessons learned that California can consider leveraging to design and implement more effective heat pump programs. The following sections detail the program characteristics and design, market transformation levers, and best practices that the interviews uncovered.

3.1 DESCRIPTION OF RESPONDENTS

The evaluation team conducted six interviews with program staff from states that have achieved success in deploying heat pump technologies (Figure 10).

Figure 10. Map of Programs Interviewed



[11] Program staff requested that we not identify the state in which they run programs.

Five out of the six programs were upstream or midstream offerings that emphasized relationships with distributors and contractors, rather than end use customers. Heat pump programs varied in both program age and location. Program ages ranged from a couple of years to over a decade of incentivizing heat pump technologies to residential customers. The geographic spread of the programs provided insight into how climate influences program expectations and models as well as influences customer application of heat pump technology. Table 12 outlines various characteristics of each program.

Table 12. Program Characteristics

Program Factor	Maine	Vermont	Southwestern State	New York	Northwest, Heat Pump Water Heaters	Northwest, Ductless Heat Pumps
Program Type	Downstream	Midstream & Downstream	Upstream[1]	Upstream[2] & Downstream	Upstream & Midstream	Midstream
Program Age	10 years	6 years	2 years	Less than a year[3]	10 years	12 years
Program Budget	$24,300,000[4]	$2,500,000	Program budget unavailable	$454,000,000[5]	$3,476,000	$1,382,000
Offerings	Ducted and ductless heat pump systems[7]	Air to water heat pumps; centrally ducted heat pumps; heat pump heating and cooling systems	Heat pump water heaters	Air source heat pumps; ground source heat pumps	Heat pump water heaters	Ductless heat pump
Financing	Yes	No	No	Yes	No	No[6]
Income Qualified Offerings	Offers up to $2,500 in rebates for low-income households	Offers increased incentives and free or reduced cost services for renters and homeowners	No	Tiered financing for moderate- and low-income customers	No	No

[1] This program provides incentives to manufacturers for the full cost of residential units.
[2] This program does not incentivize manufacturers; they simply have relationships with manufacturers to stay in the loop about new HVAC technology and model launches.
[3] The umbrella organization that supports state utilities ran the New York program beginning in 2017 then the electric utilities picked up running the incentive programs in March 2020.
[4] This budget encompasses all DHP related spending across all programs that offer DHPs in Maine in FY21
[5] This figure is split across six utilities statewide in addition to $230,000,000 to support market development, market transformation of the heat pump market, and electrification.
[6] While the program does not offer financing, some of their utility partners have created utility backed opportunities.
[7] Maine's portfolio also offers heat pump water heaters through a Midstream initiative; however, our interview focused on the Home Energy Savers Program which offered ductless heat pumps.

3.2 PROGRAM DESIGN

Among the six programs, we reviewed, midstream and upstream models were the most commonly implemented program designs. These models target distributors and manufacturers to influence heat pump technology adoption earlier in the supply chain.

Upstream programs work with manufacturers to design and manufacture intuitive heat pump units. By working with manufacturers, upstream programs may design heat pump units that are easier for a contractor to install and then explain proper usage to customers. In the case of a heat pump water heater (HPWH) unit, programs have worked with manufacturers to make the default setting "heat pump or efficiency" as opposed to "hybrid mode" or "electric mode." Midstream programs incentivize distributors to stock heat pump units to make them more readily available to contractors and end-use customers. Working with distributors enables programs to influence distributor stocking habits as well as access contractor networks and training resources to promote heat pump technology.

Midstream and upstream programs have the potential to achieve greater savings than traditional downstream programs because they intervene higher up in the supply chain, which generally enables these programs to reach a larger share of the market than traditional programs. Program managers emphasized their holistic approach to driving market transformation. The program manager for the HPWH program in the Northwest described how they work with multiple points along the supply chain,

> *We have worked all the way from product design to now working more down in midstream with installers to get them on board with adopting the technology, distributors to make sure that the technology is stocked and, retailers to make sure the technology is stocked and that the sales professionals on the floor know what they are.*

Three out of the six heat pump programs emphasized distributor relationships in their program design. By building strong relationships with distributors, program managers felt they were on the path to effectively transform their heat pump markets. Three of the most mature programs (Vermont and both programs in the Northwest) have leveraged distributor relationships in their program implementation and have seen progress in market transformation. The HPWH program in the Northwest specifically targets the largest distributors in the area, then incentivizes them to sell more heat pump technology using a tiered bonus structure that provides more money to the distributor at the end of the year, depending upon how many heat pump units they have sold. This HPWH program manager also noted that if they could go back in terms of program planning, they would have identified just a few distributors and manufacturers as champions of the technology, instead of working with as many distributors as possible. The Ductless Heat Pump (DHP) program manager in the Northwest reported that they are ending their heat pump program since they feel they have done enough to support market transformation and have decided to let the utilities in their region take over the program. Their goal was to saturate the ductless heat pump market and so far, almost all the distributors in their region are very active in the DHP market and 96 percent of contractors that they surveyed reported that they install ductless heat pumps. So, while the market has not fully transformed in terms of customer adoption, the Northwest program manager felt that they have transformed the distributor and contractor populations through their targeted recruitment practices. Vermont took a similar approach tracking distributor participation and their market share more anecdotally as indicators of market transformation; however, while this program worked with distributors to engage them in program activities but did not necessarily apply the same targeted approach as other programs. The Vermont program manager emphasized that their engagement model was customer first, then contractor, and then distributor. They highlighted that while distributor relationships are important to promote training and outreach, the focus of their program is on customer education and contractor outreach and training.

CONSIDERATION

Working with a limited number of distributors to get them more invested in the heat pump program will be more effective that casting a wide, but shallow net according to multiple program managers.

Maine's DHP program and Vermont's heat pump programs work with supply chain actors like distributors and installers to increase awareness of their program and support their customer awareness campaign efforts regarding cold-climate heat pump usage. Their program design is geared more towards customer education and engagement to improve their customer's understanding of heat pump technology. While New York's heat pump program does not currently engage at a midstream level, they are researching the supply chain for heat pumps in their state so that they may make an informed decision about what the best point of intervention may be.

Contractor education and training is another significant goal of all the programs to ensure enough qualified contractors to install the number of heat pump units going through the program. Since program managers generally found that distributors were already holding trainings for installers or that distributors were better suited to hold more technical trainings than program implementers, they would partner with distributors to offer trainings in their area. Maine's DHP program, Vermont's program, and both programs in the Northwest partner with distributors to provide trainings to contractors. Vermont's program and the HPWH program in the Northwest offers Continuing Education Credits (CECs) to contractors to incentivize them to participate in trainings. The DHP program manager in the Northwest also reported that distributors have built local training centers over the years to train contractors. While they did not attribute the increase in training centers directly to the actions of their program, they felt that it was a sign of overall growth of heat pump technology in their region. To increase adoption among contractors, program managers suggested the "deep dive" approach with a limited number of distributors. The Northwest HPWH program manager recommended that programs identify high volume installation companies to partner with, rather than trying to recruit as many companies as possible.

> *"I think if I could go back and do things over again, I would work with distributors and manufacturers and utilities and just identify a few installation companies that we could build up as champions for the technology and then kind of have them pull up some of their competitors. So instead of initially working a mile wide with a bunch of people work a mile deep with just a few people."*

By using targeted recruitment practices, programs were able to train fewer installers which resulted in more contractors who were well-trained to install heat pumps, actively invested in the program, and would promote heat pump technology to their customers. The Vermont program manager noted that by working with multiple points along the supply chain they were able to ensure sufficient availability of quality heat pump products through increased distributor engagement in addition to adequate knowledge among contractors to perform installations and service. The heat pump programs in Vermont and in the Northwest have developed relationships with contractors to improve program adoption and promote additional avenues for installer training either through contractor awareness campaigns or through contractor networks. Vermont's program has developed a contractor network that is broken up into various trade groups that each focus on a specific technology including ductless heat pumps, air to water heat pumps, and centrally ducted heat pumps. They use their contractor network to promote the program, train contractors on technical concepts, inform contractors of best practices for energy efficiency, and educate contractors on effective selling strategies for end-use customers. The Northwest DHP program's trade ally network is focused on ductless heat pump installers, but similar to Vermont, emphasizes best practices for energy efficiency and meeting utility program requirements.

> **CONSIDERATION**
>
> For midstream programs, consider developing relationships with a small number of high-volume contractor companies to train contractors to install heat pumps, educate them on best practices for energy efficiency and carbon reduction, and promote heat pump units to customers. Using this relationship, programs may use repeated interventions and learning opportunities to affect change in installer habits.

While customers are not the primary focus of a midstream or upstream program, it is still important to have a customer-facing educational component that raises awareness about heat pump technologies. With adequate supply from distributors and contractor networks in place, most programs that we studied factored customer education and marketing into their program design as well. Through customer awareness campaigns, programs marketed the benefits of heat pump technologies to customers to build name recognition of heat pump technology and drive demand. Vermont reported that in addition to contractor and distributor engagement they have started doing direct outreach with customers. They have started to see more heat pumps being installed as "the standard go-to unit."

> *"What we're beginning to see in terms of market change is that heat pumps start to shift into the place of being the standard go-to product. We have more businesses, more available products, more contracting firms that do the installation. It's no longer a niche activity. And more customers, of course, are now asking for and looking for options and opportunities to install heat pumps. So again, we are definitely seeing that awareness has become very high for on the customer side around heat pumps."*

Maine's DHP program is the only downstream program in our sample. A central program focus is customer education and outreach. They specifically focus their customer outreach efforts on how customers can maximize the benefits or their heat pump in cold climates and debunking performance myths. They help educate customers by providing user tips with each installation to ensure that customers are knowledgeable about the different features of their heat pump so they may use it more effectively. Other than user tips, Maine uses digital advertising to promote their program, as well as attending in-person community events and home energy fairs. Vermont's program emphasized that even though they are applying a midstream model, they work really hard to not lose the level of customer engagement required to transform the HVAC market.

CONSIDERATION

Customer engagement is key to driving awareness and demand for heat pump technology. In conjunction with working with distributors and contractors, promoting heat pump technologies direct to end-use customers will help drive uptake of these technologies.

Program design should also consider the structure of the state utilities. A few of the programs that we spoke to including Maine, Vermont, New York, and both Northwest programs have overarching agencies and organizations who are invested in promoting energy efficiency in their state. It is important to take into consideration how these organizations help support utilities in implementing heat pump programs using distributor engagement, contractor networks, or direct end-use customer awareness campaigns. In the Northwest, the DHP program emphasized how utility rebates and outreach have really pushed customer awareness and the success of DHPs in the region. Both Northwest programs have included cross-promotion of utility programs through market transformation efforts and rebates; however, the majority of the financial incentive comes from the utility. In Vermont, their midstream heat pump program is separate from utility programs; however, they do communicate with one another to report how many units are being incented through the midstream program. In order to streamline various rebate programs for end-use customers, Vermont has introduced a statewide rebate form to make participation as simple as possible. Vermont's program also connects the participant with their respective utility to claim savings. New York implemented a very similar strategy as Vermont and has merged all of their contractor applications into one. In Maine, the Efficiency Maine Trust serves as the independent program administrator for all energy efficiency programs in the state; the utilities do not provide separate financial incentives or manage any related initiatives that require coordination.

> *There was no doubt in anybody's mind that it had to be one program for all of New York state because many of the contractors work in different areas or have branches in different areas. To put the burden on them to try to understand what to do here, what are the program rules here, and on the manufacturing and distributor level, was too much. They don't operate in a vacuum.*

New York's experience is indicative of the challenges of multiple utility programs targeting one technology. These multiple programs are often confusing and off-putting to supply chain actors who operate in more than one jurisdiction. These programs found that simplifying the application process as much as possible at the state level helps promote program participation. Ensuring that utility programs work in collaboration with organizations such as the CPUC will better promote heat pump programs and increase adoption.

CONSIDERATION

Consider working with utilities across California to streamline heat pump programs for end-use customers, provide consistent support and training opportunities to trade allies across the state, and ensure that distributors are equipped to promote heat pump programs across jurisdictions.

Program Metrics

Each program had established metrics to track their success, the most common of which we summarize in Table 13. Most programs tracked key performance indicators for their program with the overall goal of market transformation. For example, while Vermont keeps market transformation in mind,

> *It isn't so much a specific program goal, as much as it is an organizational driver. It's the strategic underpinning of the decisions that we make.*

Similarly, the HPWH program in the Northwest performs a progress evaluation every year to measure their market influence.

Table 13. Heat Pump Program Goals & Metrics

Key Performance Indicator & Goals	Maine	Vermont	Southwestern State	New York	Northwest, HPWH	Northwest, DHP
Contractor participation	Yes	Yes	No	Yes	Yes	Yes
Distributor participation	No	Yes	No	No[1]	Yes	Yes
Customer awareness	Yes	Yes	No	Yes	Yes	Yes
Total number of incented units	Yes	Yes	Yes	Yes	Yes	Yes
MWh Savings	Yes	Yes	Yes	Yes	Yes	Yes
Contractor training & certification	No[2]	Yes	No	Yes	Yes	Yes
GHG/ Carbon Reduction	Yes	Yes	No	Yes	No[3]	No

[1] New York's program does not currently work with distributors, but their utility partners are beginning to engage distributors in the program through pilot programs.
[2] While Maine's DHP program staff do not directly provide technical trainings, they do set specific requirements and provides content for qualifying third-party trainings. It also offers scholarships to help installers receive training from community colleges and other industry resources.
[3] While the Northwest HPWH program does not currently track or use GHG metrics, they may begin to soon.

3.3 MARKET TRANSFORMATION LEVERS

These six programs have achieved some level of market transformation using a range of levers including: customer education, contractor education and training, marketing and community engagement, cost-effectiveness, market alignment, and statewide goals.[12] This section will describe the various market transformation levers that programs across the country have utilized to bolster their heat pump program goals.

Manufacturer & Distributor Engagement

As mentioned above, programs strongly emphasized manufacturer and distributor relationships to transform their heat pump markets. By interacting with upstream and midstream market actors, programs stayed informed about new products coming onto the market, offered technical trainings to installers through distributor networks, and some tracked the market share of heat pump units through detailed sales data that distributors shared with program managers.

[12] It should be noted that the Northwest HPWH program is also pursuing a federal standard requiring heat pump level technology for all electric tanks, 45 gallons or greater, which would fundamentally change the heat pump market.

While the Southwestern State program incentivizes manufacturers directly, New York's program works with manufacturers to keep an eye on emerging technologies; however, neither programs work with distributors directly. Most of the other programs focused on distributor relationships rather than manufacturer relationships. Vermont and both Northwest heat pump programs actively engage with distributors to stock and sell heat pump products to contractors. In addition to end-user rebates, the Northwest DHP program also pays distributors a small administrative fee to track unit sales in their territory. This way, the program can track if they are achieving market transformation through their programmatic efforts by understanding the market share of heat pump unit sales. The DHP program manager in the Northwest noted that while their program is over a decade old, they still believe that they are early on the adoption curve for heat pumps in terms of customer adoption. They have seen growth in the heat pump market, however, as almost all distributors and installers in their jurisdiction stock or install heat pumps and it constitutes a large part of each of their businesses. The HPWH program manager in the Northwest, on the other hand, noted that they are ending their program since they feel that they have achieved sufficient market transformation in terms of distributor and contractor adoption.

Contractor Engagement, Training, and Education

Contractor education and training is another key component of program design to leverage market transformation. Five out of the six programs used contractor engagement as a key indicator of program performance and market transformation, as shown in Table 9. Programs worked with high volume contractor companies to champion heat pump technologies within residential markets. By working with just a few contractor companies at first, the programs focused their efforts and developed quality relationships with a limited number of contractors who invested in promoting heat pump technology to their customers. Vermont's program incentivized contractors to join their installer network by offering free technical trainings, project support, lead generation, financing options for customers, and marketing support. Using this network, they are able to track participation among installers over time and gauge the effectiveness of their outreach efforts in the installer community.

The Northwest DHP program manager noted that one of the main barriers they have encountered is contractor reluctance to installing new technologies.

> *"...an HVAC contractor is very skittish about bringing new technology and promoting or pushing a new technology onto a homeowner. It's very easy for them to go in and replace like for like. Or to say, maybe I'm going to add this thing. You're keeping your other thing that's kind of the easier one but if a homeowner is unfamiliar with it and the installer has to educate the homeowner themselves and convince them of it, they run the risk of the homeowner being dissatisfied or confused or not running it properly, requiring more callbacks to fix it or explain it."*

Contractors are mostly concerned about the risk of callbacks if a unit is not installed correctly, which is consistent with findings from other populations studied as part of this research. As a creative solution, the DHP program in the Northwest offers contracting companies a free unit to install in their own homes, so they can gain first-hand experience with installation and performance of the unit. They also recommended making the installation a community event with other company members and interested parties to showcase the technology and installation process. By demonstrating the value proposition of a heat pump rather than just telling them about it, contractors are more confident in their experience with the technology and more likely to recommend them to customers.

CONSIDERATION

Offer a handful of contracting companies a free heat pump unit to install in their own homes so they can gain firsthand experience with an installation and living with the unit. Encourage contractors to make the installation a community even with other company members or interested parties to showcase the technology and installation process.

Programs in Maine, Vermont, and both programs in the Northwest also recommended either supporting trainings through distributors or partnering with distributors to conduct technical trainings to incentivize contractors to participate in the program. The Northwest HPWH program also noted that contractors are more likely to get on board with trainings if they are coming from a distributor or manufacturer rather than a utility program. Distributors also have a vested interest in ensuring that their products are installed properly since incorrect installation could lead to equipment malfunction, dissatisfied customers, and contractor callbacks. Vermont's program and the HPWH program in the Northwest offers contractors trainings that qualify for CECs. By providing technical trainings through the distributor network, distributors can provide quality technical trainings, contractors can earn certifications or CECs if the training qualifies, and the program will have enough qualified installers that are willing to promote heat pump technology.

Another incentive that programs used to boost contractor participation was marketing support. Many programs offered support to their installer community to promote heat pump technologies in their advertising. New York's program instituted a cooperative marketing program which offered to pay for a portion of installers marketing materials to effectively promote their program and heat pumps. A few noted that word of mouth within residential communities contributed quite a bit to program uptake of heat pump units.

Figure 11. Creative Solutions to Education and Training

Contractor Engagement, Training, and Education

Upstream and midstream programs primarily focus on distributor and manufacturer relationships to incentivize units; however, to affect market transformation, programs must also promote customer awareness and education. Programs need to increase awareness of heat pump options among customers to build demand for these technologies. Since customer awareness of heat pump technologies is relatively low, programs should focus on building name recognition among customer bases so that when a qualified installer recommends a heat pump to a customer, there is name recognition and a base level of knowledge about the technology already. The Northwest HPWH program manager noted that one of their biggest problems regarding customer perception and education is that customers do not care about their water or air heating units. Most people do not save or plan for the purchase of a new water heater or furnace, and when their unit does fail, it is often an unexpected and burdensome expense. Increasing customer awareness of heat pump incentives and familiarity with heat pump technology will help to make that conversation between a contractor and customer much easier. The Northwest HPWH program manager also reported that one of the largest barriers they face in recruiting new contractors to participate in the program is customer education. Installers are not likely to do customer education on specific units since they are not trying to sell the unit, they are trying to sell their service as a contractor.

The Northwest DHP program manager emphasized that in addition to focusing on the supply chain, programs must build customer awareness and grow customer education for heat pumps to achieve more penetration in the HVAC market.

> *"What we're beginning to see in terms of market change is that heat pumps start to shift into the place of being the standard go-to. We have more businesses, more available products, more contracting firms that do the installation. It's no longer like a niche activity. And more customers, of course, asking for and looking for options and opportunities to install heat pumps. So again, we are definitely seeing that now heat pumps have become somewhat of a household, not name, but the awareness has just become very high for on the customer side around heat pumps."*

Maine and Vermont's program managers also noted that a significant barrier they have faced in their programs is ensuring that customers understand the optimal settings for their heat pump to ensure they realize maximum energy savings and greenhouse gas reductions. Because heat pumps are often used in addition to central heating systems in cold climates, it is imperative that the heat pump and furnace settings are balanced so that the heat pump is the primary source of heat, with the furnace only acting as support where needed. Oftentimes the furnace heat overrides the heat pump so that the heat pump does not turn on. It has taken some years for the programs we interviewed to identify and solve this issue. Proper training and awareness for contractors and homeowners was critical in solving this problem. One misconception driving this phenomenon was the incorrect assumption that heat pumps do not work in cold climates and that only a furnace can effectively heat a home during the winter causing many homeowners to turn their heat pump off in the winter. For savings to be maximized, the heat pump must remain on at all times. Maine's program found that providing customers with a packet of user tips helped to mitigate user errors. This problem further emphasizes the need for programs to conduct customer awareness and education campaigns to ensure that end-use customers are not only incentivized to install heat pumps, but also to use them in a way that maximizes savings.

Ensuring that customers understand how to use their heat pump units requires that the contractor install the heat pump correctly and is able to explain to the customer how to use their heat pump once installed. Maine and Vermont's programs have conducted numerous education campaigns to ensure that customers understand how to properly use their heat pumps after installation. This barrier does not apply in most California regions, since the California climate largely favors full, not partial, replacements of existing gas heating systems. However, it should be considered when designing programs targeted at climate zones which do have periods of cold weather.

> CONSIDERATION: Conduct customer marketing campaigns to promote awareness and educate customers about the benefits of heat pumps as well as how to properly use heat pumps to achieve maximum savings.

3.4 CONSIDERATIONS OF PROGRAM CONTEXT

There are certain considerations that should be made for the information that we gathered from programs in other states. Some of these programs operate under different cost-effectiveness rules that seemingly make heat pumps more cost-effective to install than California. Other jurisdictions also take into consideration the societal benefits associated with installing heat pumps in addition to measuring greenhouse gas emission savings. Vermont's program uses a statewide screening tool to determine cost-effectiveness; however, they mentioned that ultimately the tool uses societal benefits and GHG savings as indicators of cost-effectiveness. It is important to understand how the rules around cost-effectiveness differ in California and therefore may affect which units are incentivized. However, California may still learn from the tactics that other programs have utilized to promote heat pump technologies in their regions.

Another factor to consider is that other utilities transition customers from oil heating to a hybrid oil and electric system in which an air source heat pump would act as a secondary system to offset the cost of heating for a customer. There is a significant financial incentive for customers to install air source heat pumps since the cost of heating their homes with oil is exceedingly expensive in these regions. Considering that majority of California customers use natural gas to heat their homes, the financial incentive for these customers is much less attractive given that natural gas is more often cheaper than electricity. Customers are much less likely to convert from a natural gas-powered furnace or water heater given the upfront cost of heat pump technology in addition to the fact that electricity is often more expensive than gas in California. Therefore, it is important to take into consideration how the value propositions for customers vary by region. California programs should consider promoting comfort, reliability, and environmental benefits when trying to sell customers heat pump technology rather than focusing completely on upfront and operating cost. The program should provide comprehensive trainings on how the program works to incentivize heat pump installations as well as how heat pump technology is a better choice in the long term.

In addition to energy costs, HPWH specifically can be a hard technology to implement in homes given their space and air flow requirements. The HPWH program manager in the Northwest noted that heat pump water heaters specifically have not aligned with the market in their region because they have seen that many customers have standard electric tanks in small spaces. Given that HPWHs require at least 1,000 cubic feet of air space in order to heat water properly, this stands as a major barrier for customers who do not have space for such a large unit.

4. AIR SOURCE HEAT PUMPS

Air source heat pumps are an efficient electric heating and cooling option for homes. When properly installed, an ASHP can deliver one-and-a-half to three times more heat energy to a home than the electrical energy it consumes. This is possible because a heat pump moves heat rather than generates heat. Most heating systems, such as a natural gas furnace, modifies the temperature of a building by burning fuel to generate hot air that is circulated throughout a home. An ASHP extracts heat from outdoor air, even in cold weather, and uses that to heat a home. In the summer, an ASHP works in reverse transferring the inside heat to the outdoor unit.

ASHPs can either be ducted or ductless. In a ducted system (Figure 12), the heat pump uses ducts to spread heated or cooled air to the different rooms in a house. In a ductless system (Figure 13), the heat pump delivers heated or cooled air directly into the living space, without the use of ducts.

Figure 12. Ducted Air Source Heat Pump

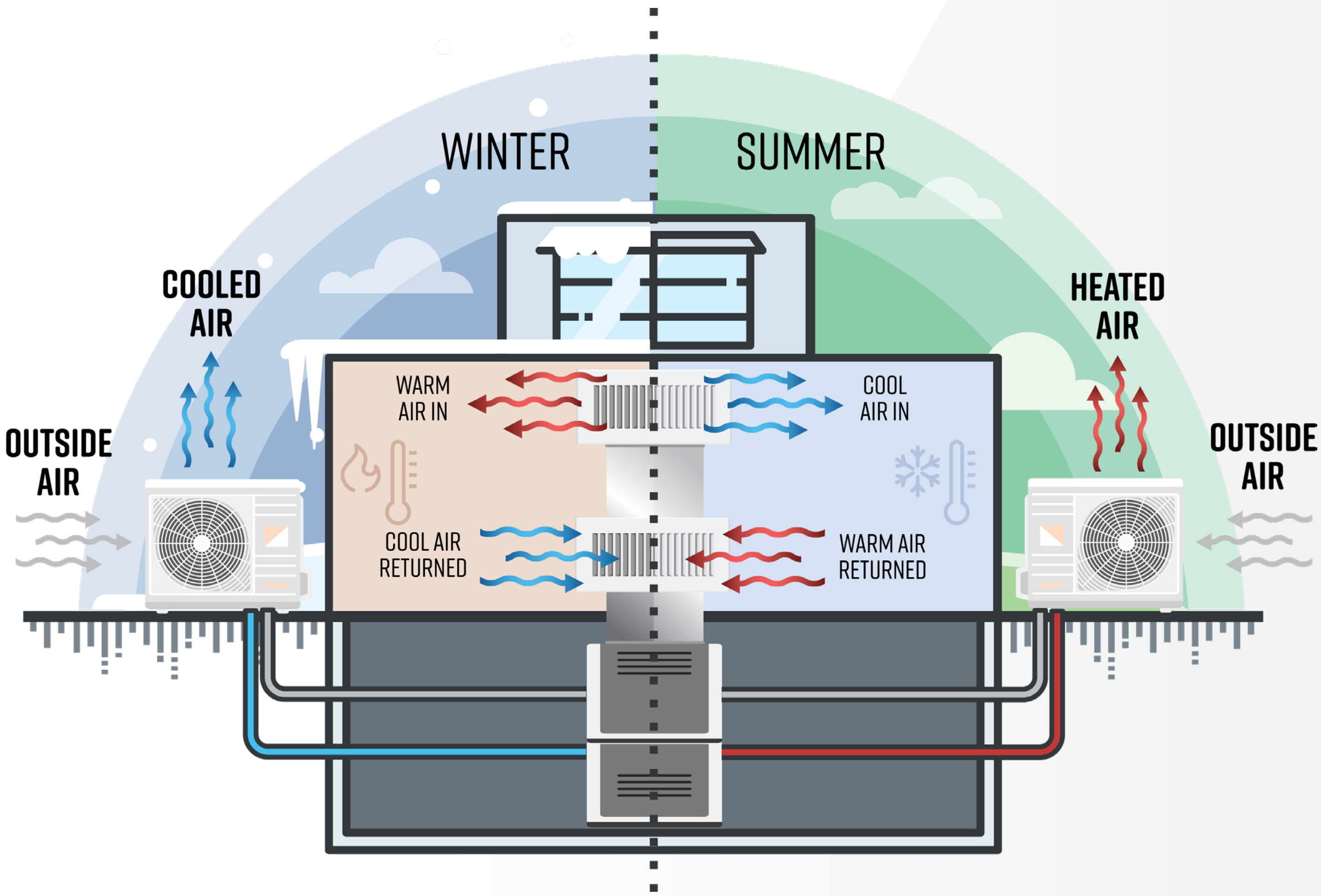
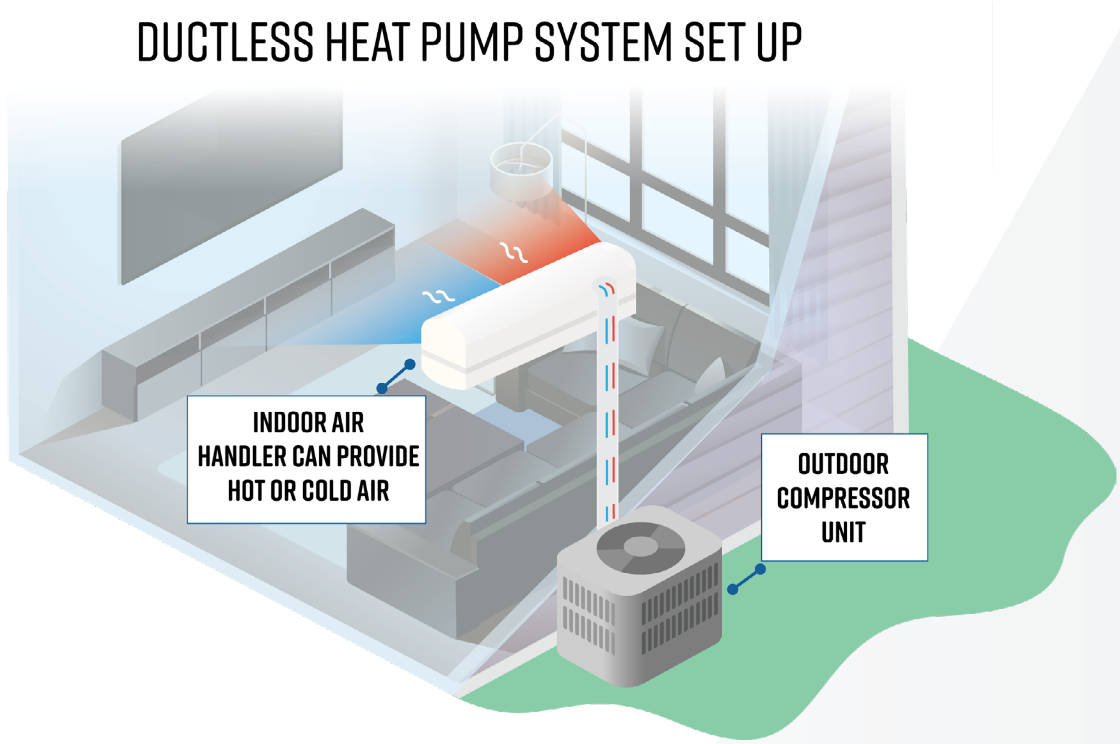


Figure 13. Ductless Air Source Heat Pump

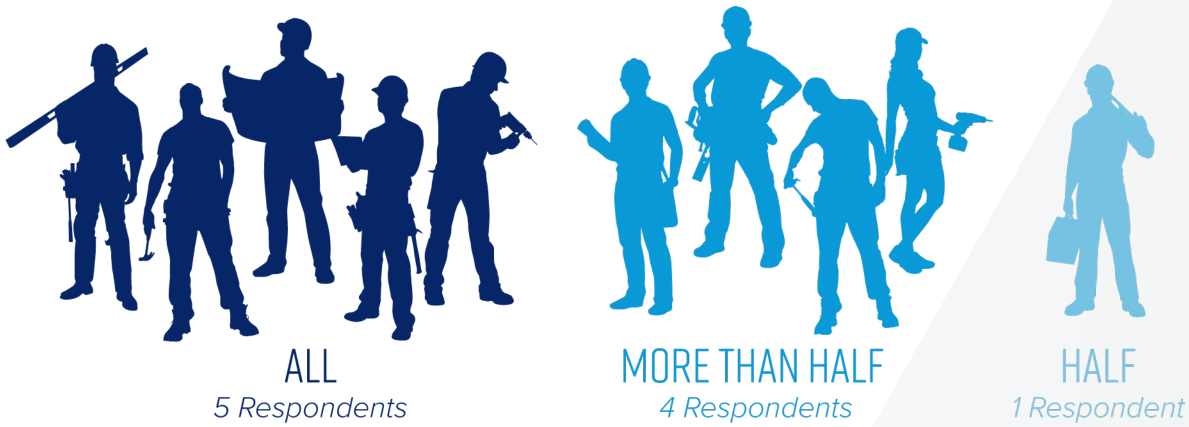


Both ductless and ducted ASHP systems have the capacity for single and multi-zoning. Zoning allows for a vast amount of control so that a homeowner does not have to be heating or cooling their whole house at once and each room can be at the ideal temperature for the homeowner. In a single zone system, a ductless mini-split system includes one outdoor unit and one indoor unit, connected by refrigerant tubing and electrical wiring. In a multi-zone system, one outdoor unit connects to multiple indoor units to provide comfort in multiple rooms in a home. Air source heat pumps also come with different compressor speeds: Single stage, Two-stage, and Variable capacity. Single stage compressors operate at 100% capacity all the time regardless of the heating or cooling demand. This means that single stage compressors operate using more energy than necessary for small changes in home temperature which can lead to over heating or cooling. Two stage compressor systems run at two speeds, low for milder heating and cooling needs and high for days with higher heating and cooling demand. Typically, two stage units are more efficient than single stage units since they don't run at full capacity 100% of the time. Finally, there are variable speed compressors that operate at the most efficient speed to meet comfort levels demanded by the home while maintaining efficiency by not running at 100% capacity all the time like a single stage compressor. Variable speed units operate at the lowest speed possible to provide consistent, energy efficient heating or cooling to a home.

4.1 DESCRIPTION OF RESPONDENTS

The findings in this section represent the viewpoints of heat pump trade allies from three data collection activities: in-depth interviews with heat pump contractors, in-depth interviews with heat pump distributors, and a Delphi study of heat pump contractors. Figure 14 depicts the percentage of interviewed contractor jobs working in residential settings compared to commercial jobs. Nine interviewed contractors (90%) spend more than half their time servicing residential properties.

Figure 14. Distribution of Interviewed Contractors' Residential Jobs (n=10)

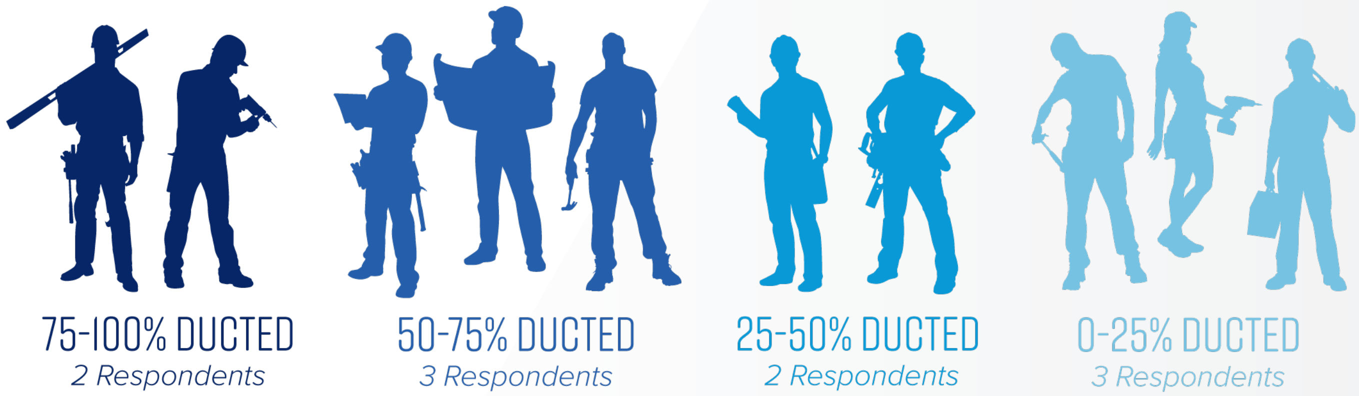


Among their residential jobs, 80 percent of all contractors' work is on single family jobs, with two respondents working exclusively on single-family residences. All contractors conduct installation, service, and maintenance.

Interviewed contractor experience with heat pump installations over the past year ranges from one to 150 heat pumps, with the median number of installations being 25 and an average of 53. Lifetime experience in installing heat pumps ranged from 60 to over 1,000 heat pumps. Nearly all (9 of 10; 90%) respondents installed at least 12 heat pumps in the past year.

Half of interviewed contractors spend 50 percent or more of their time working with ducted heat pump systems (Figure 15). One contractor just installs hybrid systems.[13]

Figure 15. Percentage of Ducted versus Ductless Heat Pump Jobs among Interviewed Contractors (n=10)



The three distributors we interviewed sell equipment exclusively to contractors. All of the distributors work for companies that have been selling ASHP technologies for at least 15 years. Distributors sell a wide variety of heat pump brands and models, with examples being Mitsubishi®, Rheem®, Bosch®, and American Standard®. Two respondents were willing to provide the proportion of their HVAC business that heat pumps represent. They reported that 30–50 percent of their HVAC business is ASHP sales. Interviewed respondents' service territories spanned many regions across California, including San Diego, Los Angeles, San Jose, and Sacramento. Among the 10 interviewed contractors, five serve northern California regions and the other half serve southern California. Two of three distributors also work in southern California.

[13] In a hybrid air source heat pump system, the air source heat pump uses a traditional furnace for auxiliary or backup heating.

Participants in both rounds of the ASHP Delphi study are shown in Figure 16. Participants represented many regions across the State of California—the Bay Area, Los Angeles, San Diego, Sacramento, the San Joaquin Valley, and the Gold Country region. Delphi participants reported being "pretty" or "very" familiar with ASHP installations and costs. Roughly two-thirds of the Delphi participants serve Southern California regions while the remaining third are located in Northern or Central CA.

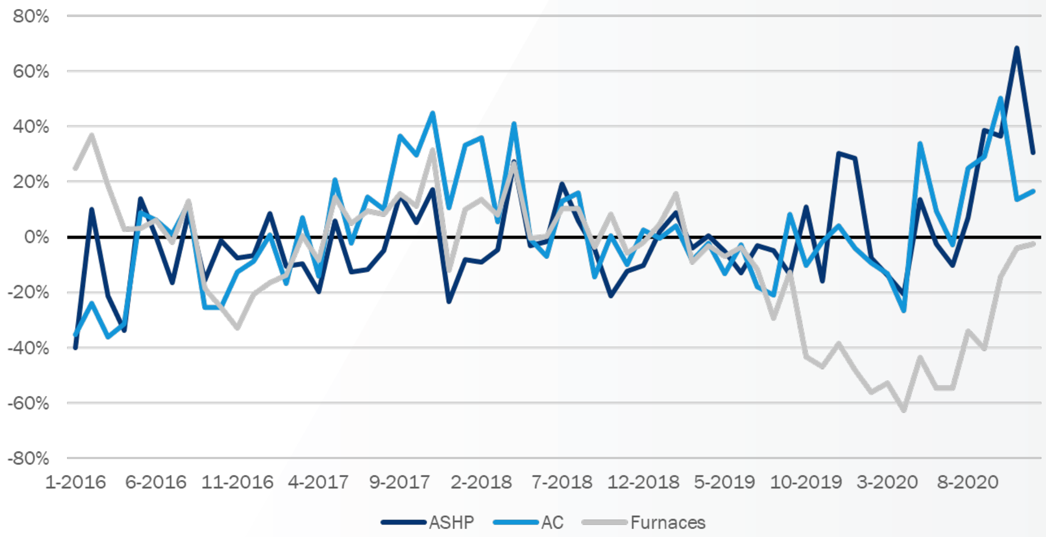
Figure 16. Number of Participants by Delphi Study Round

To differentiate the findings among contractor groups, we refer to contractors from the Delphi study as "Delphi participants" and contractors from the interviews as "interviewed respondents" throughout this chapter.

4.2 OVERALL AIR SOURCE HEAT PUMP MARKET

When considering how to best assess the market for space and water heating technology, it is important to consider where the technology is right now in terms of market adoption. The Air Conditioning, Heating, and Refrigeration Institute reports roughly three and a half million air source heat pumps were sold in the US in 2020, up from 3.1 million in 2019.[14] According to the HVACR Unitary Market Report for California, there seems to be an increase in sales of ASHPs over central air conditioners as shown in Figure 17. In the latter half of 2020, sales of ASHPs trended higher than sales of central air conditioners. This may indicate that there is an upward trend in the popularity of ASHP units compared to central air conditioners and furnaces for heating and cooling needs. It also may reflect additional incentives available for this ASHPs. Conversely, furnace sales have decreased over time, likely due to the time of year and potentially indicating that ASHPs are becoming a more popular replacement unit for heating and cooling needs.

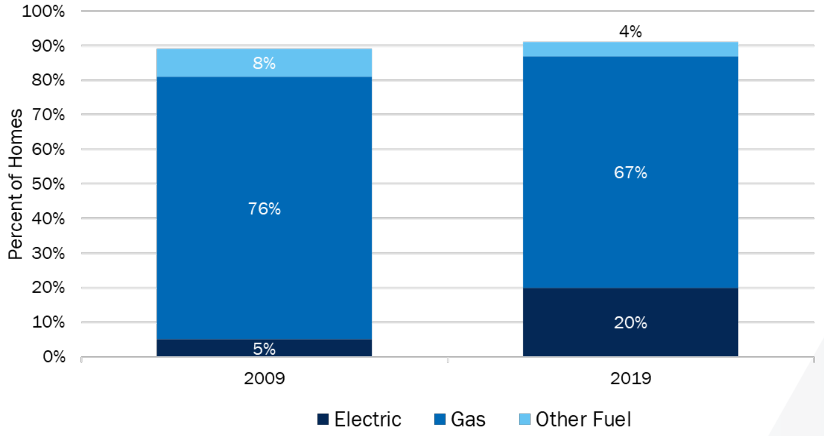
Figure 17. Year-Over-Year Monthly Market Sales Growth in California



[14] Air Conditioning, Heating, and Refrigeration Institute (AHRI). 2020. "AHRI Releases December 2020 U.S. Heating and Cooling Equipment Shipment Data." https://www.ahrinet.org/App_Content/ahri/files/Statistics/Monthly%20Shipments/2020/December_2020.pdf

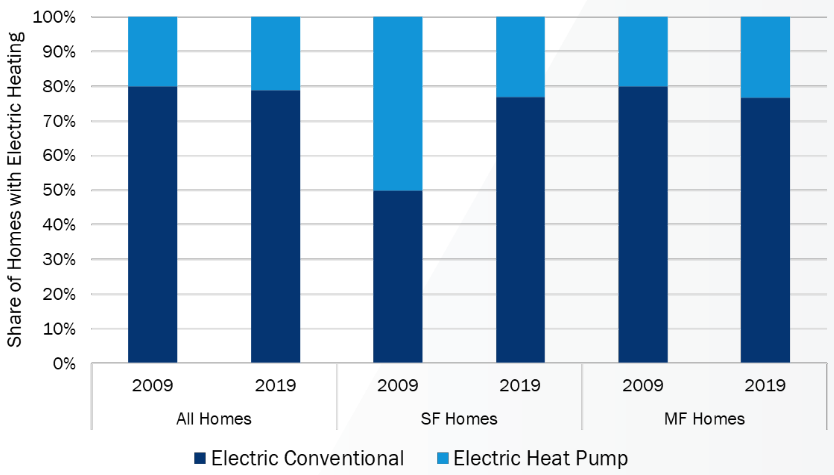
The air source heat pump market is a nascent, but growing market in California. Appliance saturation studies in California show residential electric use for space heating has quadrupled over the last 10 years (Figure 18).

Figure 18. 10-Year Comparison of Electric vs. Gas Space Heating Saturation in California



Despite the large growth in electric space heating, the proportion of electric space heating provided by heat pumps (as opposed to conventional electric heating) has not significantly changed in the residential sector. Figure 19 shows heat pumps holding a relatively stable share of the electric heating market, at roughly 20 percent. Data for single-family homes shows the share of heat pumps has decreased. While there has been growth in the total stock of heat pumps in the installed base, it has been far outpaced by the growth in conventional electric space heating.

Figure 19. 10-Year Comparison of Share of Electric Heating by Home Type

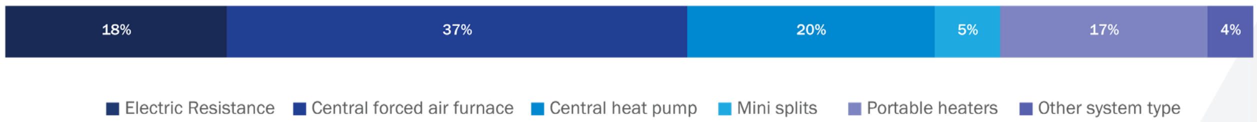


Of the 91% percent of respondents that said that they pay for space heating, approximately 20 percent (Figure 20) have electric space heating however most of this technology is not considered to be highly efficient. There are 12.2 million space heating units across residences in the CA IOU (Investor-Owned Utilities) territories and only 4 percent of that equipment is electric heat-pump technology (Figure 21).[15]

Figure 20. Space Heating Systems Fuels (n=36,437)

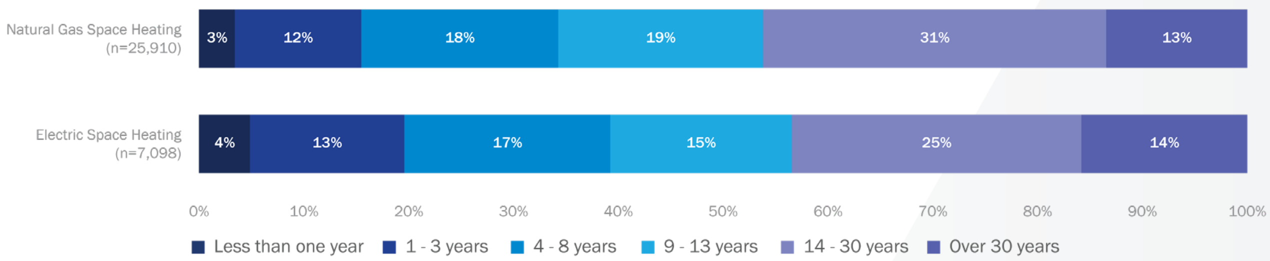
[15] Air Conditioning, Heating, and Refrigeration Institute (AHRI). 2020. "AHRI Releases December 2020 U.S. Heating and Cooling Equipment Shipment Data." https://www.ahrinet.org/App_Content/ahri/files/Statistics/Monthly%20Shipments/2020/December_2020.pdf

Figure 21. Types of Space Heating Systems (n=36,437)



Almost half of respondents (44%) who used natural gas as their primary space heating source noted that their unit was over 14 years old (Figure 22). Electric space heating shows a similar breakdown in terms of age of the unit with almost 40 percent of units reported being over 14 years old. Since the greatest potential for change out of appliances is at the end of their effective useful life, this indicates a large opportunity in the market for heat pump space heating to replace traditional natural gas heaters and conventional electric heating as these units fail over time.

Figure 22. Age of Space Heating Unit by Fuel Type

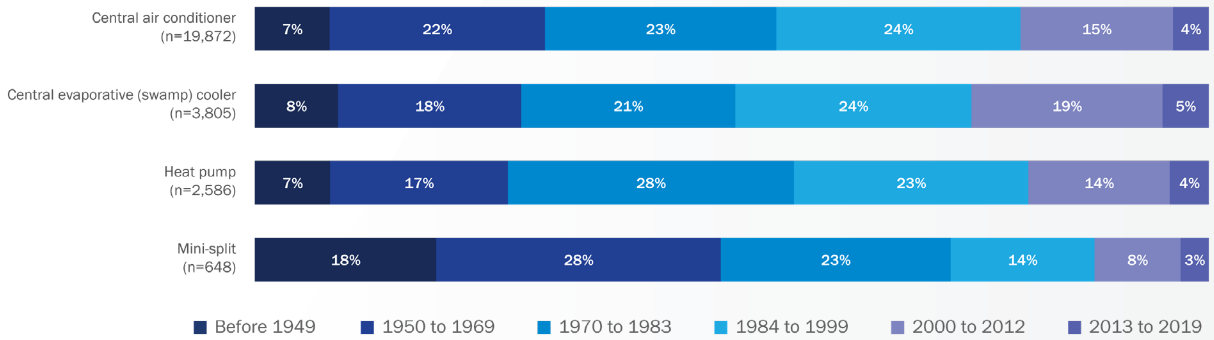


Next, respondents were asked about the cooling systems that they have in their home. Of the 59 percent of respondents that said that they pay for space cooling, the majority (84%) of them have a central air conditioner as shown in Figure 23. The next most popular cooling systems are central evaporative coolers (16%), heat pumps (11%), and mini splits (3%).[16] This shows that there is a large opportunity for high efficiency heat pump and mini-split units to penetrate the HVAC market.

Figure 23. Types of Space Cooling Systems (n=23,636)

Almost 40% of all central air conditioners (35%) and central evaporative coolers (34%) are over 14 years old indicating that there is a large proportion of homeowners in California that will need to replace their cooling system in the next decade. The youngest systems tended to be heat pump and mini split cooling systems[17] with 43 percent of heat pumps and 54 percent of mini splits being under 8 years old as shown in Figure 24.

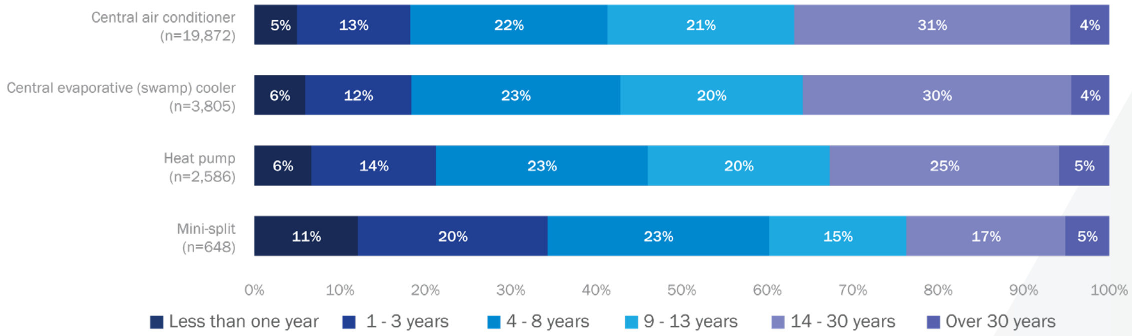
Figure 24. Age of Space Cooling Unit by Fuel Type



[16], [17] The RASS survey data does not directly differentiate between ductless and ducted heating and cooling units. It only includes data on heat pumps and mini-splits.

Approximately half of respondents with mini splits also tended to have older homes (built before 1969) most likely due to the fact that older homes are less likely to have central ductwork (Figure 25). Comparatively, only 28 percent of respondents with homes built before 1969 have a central air conditioner.

Figure 25. Age of Home by Space Cooling Fuel Type



All interviewed contractors (n=13) see the benefit of heat pump systems now and into the future, especially if customers demonstrate interest. However, they are not all convinced that switching to an electric system is always the best option for a homeowner. These respondents recommend heat pump systems to their customers at least 40 percent of the time, including three contractors who recommend heat pumps on 100 percent of their jobs. Many Delphi study participants (12 of 15; 80%) also report they frequently recommend a heat pump to their customer if the existing home specifications are suitable.

Contractors from the interviews and Delphi study cited many reasons for heat pump preference, ranging from improved performance and durability, short payback period when coupled with rebates, and a more efficient home that supports California's electrification goals. One interviewed contractor who recommends heat pumps on every job said,

> *To me, and maybe I'm just so excited here, but to me they're the best air conditioning and heating system I've ever installed. No, no concerns [with heat pump installations].*

Air Source Heat Pump Recommendation Considerations

Consider developing clear value propositions for heat pumps for multiple home characteristics, considering climate, existing ductwork, existing fuel source, existing electrical supply, presence of solar, suitability of heat pump location and existing insulation.

While all interviewed respondents are proponents of heat pump technologies, they do not all agree on policies geared toward electrification and only perceive heat pumps as the appropriate system for a residence under certain conditions. They report that heat pumps are not always the best option and should not be prescribed to every home. Contractors from the interviews and the Delphi study typically consider the following factors when recommending a heat pump to a customer.

- **Climate.** Most Delphi participants (12 of 15; 80%) noted that climate is an important consideration when installing heat pumps. The warm, mild, and dry climate of much of California is ideal for heat pumps. Eight participants report that heat pumps are not as well suited for climates that experience more extreme temperatures, notably those that frequently drop below freezing and experience snowfall in the winter. This weather may be more prevalent in mountainous, inland regions of California. In freezing or snowy conditions, heat pumps can perform less efficiently because the auxiliary heat strips are turned on and the exterior units can be buried under snow, requiring defrosting and additional electrical pull. However, cold climate heat pumps are a good alternative for climates that often experience temperatures at or below 30 degrees as normal heat pumps begin to decline in efficiency at that temperature. Cold climate heat pumps can operate at temperatures reaching -15 degrees Fahrenheit making them ideal substitutes for contractors who are concerned about air source heat pump performance in cold weather.[18]

[18] https://goingductless.com/news/all-about-cold-climate-ductless-heat-pumps

- **Existing ductwork.** Existing ductwork emerged as a common consideration for interviewed contractors when determining the appropriate usage of a heat pump system (6 of 10; 60%). Heat pump installations are more expensive in terms of upfront cost if the job requires upgrades to the residence's ductwork. In some cases, modifications to the existing ductwork are needed, which can cause the installation quote to be cost-prohibitive for the homeowner, especially if the entire duct system needs replacement. Ducting modifications are warranted when existing ducts are poorly designed, old, too small, too short, or contain asbestos. The existing ductwork also impacts some contractors' recommendations for installation of a ductless versus ducted system. Most interviewed respondents (8 of 10; 80%) report that there are not any situations in which they would first recommend a ductless system in a home that already has the needed ductwork in place unless the customer specifically requests converting to ductless. The remaining two contractors recommend ductless on "almost every job." While one contractor indicated that installing a ductless system under these conditions would be more expensive upfront, he believes that the ductless system would cost 60 to 70 percent less to operate than the ducted. Another contractor in the majority disagrees. When asked if he would ever recommend a ductless system in a home with ductwork, he replied,

  > *What would the advantage of that be? Again, I've got all the labor of running the extra refrigerant lines, electrical, condensation, all the additional complications and risks. And now instead of ducting to every room in the house, I'm only providing heating and cooling to the places where the air handlers are. I'm forcing the homeowner to spend more money to get less benefit. So that would never be my first choice.*

  Contractors agree, however, that under circumstances where there is not an opportunity to add ducting to the residence or the homeowner does not want to pay to install new ductwork, then a ductless mini-split system is the better option.

- **Existing fuel source and electrical service.** Existing fuel source also emerged as a common consideration for interviewed contractors when determining the appropriate usage of a heat pump system (4 of 10; 40%). The upfront cost of a heat pump installation can be more expensive if the job requires a change to the fuel type, such as the common scenario of replacing a natural gas furnace with an electric ducted heat pump. Two Delphi participants noted they only recommend an electric heat pump to a customer if the home has no existing access to natural gas, as the process and cost of upgrading the electrical can be significant. In some cases, the main service panel needs upgrading as the existing amperage is not enough to support a heat pump.

- **Solar.** If a home already has a solar PV system installed or has plans to install one, the home can be a good candidate for an electric heat pump, according to four Delphi participants. If a home has solar, contractors are more likely to recommend a heat pump as the system likely generates enough annual wattage to support the electrical pull of a heat pump and the electric operating costs of the heat pump will be comparable or less than that of a natural gas furnace.

- **Suitability of heat pump location.** For ducted systems, five interviewed contractors reported that an important consideration for installation is the size and suitability of the physical space the heat pump would occupy. Their primary concern is space restriction, given that HVAC equipment is typically stored in confined spaces of the home, like an attic or crawl space beneath the floor. For example, a ducted heat pump may not be feasible in parts of a home with a recent addition because the addition may not have below floor or attic access. Three Delphi participants also reported that a home needs to have adequate interior and exterior space to house the parts of the heat pump. Situations in which there is either no space for the indoor unit for the ducted system or ductwork would warrant a ductless system due to space restrictions.

- **Insulation and Air Tightness.** Two interviewed contractors mentioned insulation and air tightness as a factor that they take into consideration when installing heat pump systems. Eight Delphi participants also noted that their heat pump recommendations and quotes often depend on how well-insulated and weatherized a home is. If a home has adequate insulation in the walls and ceiling, heat loss will be minimized, and the heat pump should be able to operate effectively and efficiently.

Model and Capacity Recommendations

Delphi participants recommended a variety of manufacturers of ASHPs, although Goodman and Carrier were recommended the most, by roughly two-fifths of participants (Table 14).

Table 14. Recommended Air Source Heat Pump Manufacturers (n=19)

Manufacturer	Count of Participants
Goodman®	5
Carrier®	4
Rheem®	3
Lennox®	2
American Standard®	2
York®	2
Trane®	1

4.3 STOCKING AND SALES PRACTICES

Among the three interviewed distributors, all sold heat pump equipment directly to contractors who install heat pumps in residential settings. One of these respondents refused to provide the percentage of their HVAC business that is comprised of heat pumps sold; however, the other two reported that about 50 percent and 35 percent of their business is heat pump units sold, respectively. One interviewed distributor also noted their heat pump sales increased by approximately 25 percent over the past year. In terms of the distribution between job type for heat pumps sold in the last year, one distributor said sales were approximately 90 percent retrofit and 10 percent new construction, another reported new construction as “a small portion” of their business, and the third distributor said they often do not know whether the job is new construction or retrofit based on the order. One interviewed distributor also offered that the majority of their residential sales are for single-family homes, but among their multifamily sales, they are exclusively heat pump orders.

Respondents seem to hold differing opinions on the market demand across new construction and retrofit settings. One distributor asserted that “retrofits is where the market is,” indicating that there are many residents in California that are switching from conventional electric to solar who typically also switch to heat pumps, and they do not see many instances of new home construction with heat pumps. Another found that single family homes under new construction often get “higher-end systems” like heat pumps, specifically ducted systems.

> CONSIDERATION
> Existing solar is a significant driver of heat pump technology interest.

All three distributors that sell heat pump equipment to contractors expect that the market could grow in the coming years. They expect incentives to play a role in market growth. One distributor reported that incentives could be especially beneficial for growing customer interest in heat pump offerings with improved efforts to educate contractors on incentive availability and heat pump functionality. All distributors offer training to contractors who purchase from them. One distributor reported that his company provides contractors with marketing and sales training and literature on heat pumps to give to their customers, while the other two provide technical trainings related to heat pump installations and servicing, both in-house and through manufacturers. In terms of marketing heat pump equipment, distributors primarily rely on their purchasing contractors to promote the technology. They engage contractors through social media and online advertising, local trade publications, flyers, postcards, and incentives for contractors. The distributors all report that they do not market heat pump equipment any more or less than other HVAC equipment they offer. One distributor summarized their approach to marketing specific HVAC equipment, saying,

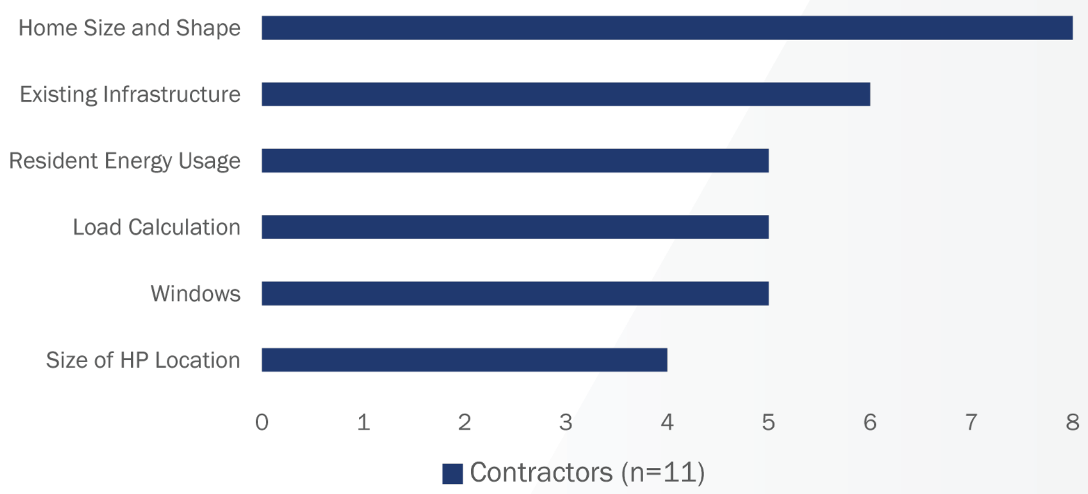
> CONSIDERATION
> All distributors expect the air source heat pump market to grow, especially with additional incentives.

We want to sell all our products, not just a certain segment. So, we promote the brand, the features, and benefits of the equipment. Then it's up to the homeowner and the contractor to decide what system is best for each specific job. We don't choose one over the other: furnace, heat pump, or air handler versus outside condenser. We don't pick and choose; we just promote all benefits of all products equally.

4.4 INSTALLATION CONSIDERATIONS

Most interviewed contractors take several factors into consideration when sizing a heat pump system, though some recommend a specific system regardless of the specifications (Figure 26). Under certain conditions some contractors will advise customers against installing a heat pump, but this is rare among respondents. Notably, respondents vary in their opinions on what portion of the home's heating and cooling load should be addressed.

Figure 26. Top Contractor Considerations for Heat Pump Installations (n=11)



Note: Multiple responses allowed. Findings from contractor interviews.

Most interviewed contractors reported that they consider the home size and shape among their top considerations when sizing a heat pump system. They also consider a residents' energy usage, the presence and location of windows, existing insulation and air tightness, and heating and cooling load calculations.

- **Size and shape:** Eight contractors reported the size of the home as one of their top considerations when determining the appropriate sizing of a heat pump, for both ducted and ductless systems. The square footage of a residence impacts the sizing of a system because contractors want to ensure that temperature adequately regulates throughout the entire structure without pulling additional electricity unnecessarily. Two contractors reported that they consider square footage in conjunction with the insulation properties and air tightness of a home because a better-insulated home allows the heat pump to function more efficiently. Therefore, two homes of equal size but with varying degrees of airtightness would necessitate differently sized systems. Two Delphi contractor participants also mentioned that they believe square footage is a good indicator of installed capacity. Their rule of thumb is that homes need 1 ton every 400-600 square feet. Residence shape also plays a role in contractors' considerations for determining the appropriate size and properties of a heat pump system. Notably, shape factors strongly into contractor recommendations for ductless systems over the installation of ducted systems. For example, home additions are common in the California market, and those additions may not be designed to host ductwork or have a suitable location for a ducted heat pump system. One contractor explained,

> *When you walk into a home, it's probably anywhere from 40 to 100 years old. Now, in that timeframe, people will probably have modified it. So, the homes down here are not so much designed as evolved. They'll add a master suite, they'll add a family room, they'll add something. The additions typically don't have the same construction style as the original house—the original house could be on a crawl space, which gives you access underneath the floor. But the addition could be on a concrete slab, which means you have no floor access ... That's where the ductless systems really shine, they will let you get heating and cooling into spaces that a ducted system can't reach.*

Installing ductless systems necessitates not only considering the square footage of the home, but also the size and shape of individual rooms in which the indoor air handler is located. Size and shape of the room matters for ductless installation because it affects system sizing and heat pump location suitability based on window location and direction. Amount of sunlight exposure affects the efficiency of temperature regulation, and the air handler must be located on an exterior wall.

- **Resident energy usage.** Five contractors reported that residents and their energy usage factor is a top consideration when sizing both ducted and ductless heat pump systems. In addition to the number of residents impacting the home's energy usage and subsequently the sizing of their HVAC system, some contractors also consider their consumption habits. One contractor noted that they often ask customers how frequently they entertain others in their home, while another asks the consumer what temperature that they typically like the inside of their home to be. Lastly, one respondent indicated that if a customer has what they deem to be "uncontrollable" electrical consumption, then they would not recommend a heat pump installation because the customer would have "huge" electric utility bills.
- **Windows and insulation.** The number, location, and insulation quality of windows in a residence can impact a contractors' decision-making process for sizing and installing heat pump systems. Five respondents indicated that they factor in the windows when sizing ducted and ductless heat pumps. One contractor noted that newer homes tend to have better insulated, double pane windows which positively affects the efficiency of a system. The position of the windows and the resultant amount of natural sunlight impacts the amount of work a system needs to do to maintain the target room temperature, especially in ductless applications where the air handler is regulating the temperature of one space. Contractors need to factor windows into their systems sizing considerations because, unlike insulation and ductwork, they cannot replace or remove windows from the residence to improve its insulation and potential to regulate indoor air temperatures. Interview respondents also consider the insulation properties of the home for heat pump sizing because the better the insulation, the better the ability of the heat pump to operate at its most efficient capacity. Over half of Delphi participants corroborated this finding, concluding a well-insulated home will require less heating and cooling load than a home with a low R-value insulation.

Respondent opinion varied on the significance of property type as a role in determining system sizing. While one contractor reported that his system sizing considerations do not differ based on whether a property is a multifamily or single-family dwelling, another felt that there are needed distinctions. The former contractor said that considerations depend on infrastructure and not on residence type. However, the latter emphasized that multifamily projects with several stories do not have the same heating and cooling loads as a single-family home because of the variation in temperature regulation across floors. The contractor explained,

> *The main loss of heat in the wintertime and the main heat gain in the summertime is your roof. Heat rises in the winter, so all your heat tends to go up into your attic. And then in the summertime you get that solar radiation hitting the roof for anywhere from four to 14 hours a day, which is a huge heat load to the home. Well, if you're talking about a three-story building, the first and second floors don't have that load. So, you don't have the need to have as much equipment or capacity.*

This contractor also always recommends heat pumps for multi-story multifamily properties because the contractor does not have to install a flue for a gas system, which requires venting the combustion gases through the roof and running the pipe through each floor of the building.

Load Calculations

Contractor opinion varies in how best to calculate heating and cooling load and what portion of the heating and cooling load the system should cover. While some interview respondents argued that it is always best to cover 100 percent of the load, others felt strongly that it is important to not oversize the system in order to maximize energy efficiency. Four contractors (4 of 10, 40%) plan to cover 100 percent of the heating load when sizing a heat pump system for a home, while three respondents (3 of 10, 30%) reported that they do not often consider the heating load in their sizing calculations, and the remaining three (3 of 10, 30%) do not want to cover 100 percent of the load and, in some cases, would prefer to err on the side of under sizing the system.

> Contractor training addressing how to appropriately size air source heat pumps may be needed.

The rationale for covering 100 percent of the heating load is that the system provides as much potential for heat in the residence as possible, minimizing the likelihood of customer dissatisfaction with performance and callbacks. For example, one contractor reported that to ensure there is “no issue” with his ductless heat pump installation, he said that if he calculates that a room requires 6,000 BTUs of heating and 5,000 BTUs for cooling, he will put a 9,000 BTU system to cover both.

In terms of a ducted system, one contractor that always seeks to cover 100 percent of the load explains how a residence may not be a good candidate for a heat pump system using an example of a home with a heating load of 49,000 BTUs and 31,000 BTUs for cooling,

> *Whether a home is a candidate for a heat pump to us is, you know, let’s say you have a house that’s 31,000 BTU’s of cooling but it’s got a subfloor with no insulation and they’re not interested in spending the money to insulate it properly. Then you got a heating load of 49,000 BTU’s but you got a cooling load of 31,000, at that point the home is not a candidate for a heat pump because the A/C side would be a 3-ton air conditioner, but your heating load would maybe be a 4-ton at which point your cooling side is grossly oversized. And I don’t want to put in 10 kilowatts of auxiliary heat because that just defeats the whole purpose of putting in the heat pump.*

For this contractor, if he cannot equally cover the heating and cooling at 100 percent without the installation of auxiliary heat strips to support the heating load, then he will not recommend a heat pump system. However, some contractors are not concerned with heating load calculations in their service territory because of the moderate weather. Among the three contractors who are less concerned with heating load, two work in the Los Angeles area and one works in San Diego, geographical areas that do not experience extreme cold weather.

Other respondents use load calculations to determine adequate system sizing that will meet customers’ usage demands and maintain their comfort, but they cover as little portion of the load as they can to meet that demand. These contractors reported concerns with system oversizing throughout the industry, because oversizing negates the system efficiency potential and can lead to unnecessarily expensive utility bills.

Sizing Example

In the Delphi study, when asked to recommend the installed capacity of an ASHP for a 1,400-square-foot home built before 1978, nearly two-fifths of participants recommended a 3-ton unit. Three participants recommended a 4-ton unit, while three others recommended a 2.5-ton unit. According to Delphi participants, installed capacity depends on several factors. Two participants noted that 3 tons is a good “rule of thumb” and is generally sufficient for California homes. Three participants reported that older homes likely need a larger capacity, such as 4 tons, as these homes tend to have poor insulation and will need a higher heating and cooling capacity due to heat loss. Another consideration when determining the heating and cooling capacity is the location of the home: a home located in a cooler climate will likely need a 4-ton unit, while a home located on the coast with very mild weather would likely need a 3-ton unit.

4.5 CUSTOMER PERCEPTIONS

The majority of interviewed contractors (8 of 10; 80%) report that customers are generally aware of heat pumps, though despite their interest, customers lack technical knowledge of heat pumps and often hold misconceptions of their functionality. Contractors report that customers are increasingly aware of heat pumps as an energy efficient option available to them; however, they are not often knowledgeable on heat pump functionality which has both positive and negative implications on customer perception. Contractors typically need to educate customers on how heat pumps are different than their traditional system in terms of energy usage and carbon footprint, and whether or not it is truly the right system for their specific situation.

> CONSIDERATION
>
> Customers are often aware of heat pumps but often do not understand their functionality.

According to contractors, customers are most commonly aware of heat pumps through available utility incentives, manufacturer referrals, and personal research based on the customers’ preferences. However, trade allies were not always able to provide rationale for how customers became aware of heat pumps. For example, one contractor indicated the following when prompted about why his customers bring up heat pump technologies as something they want,

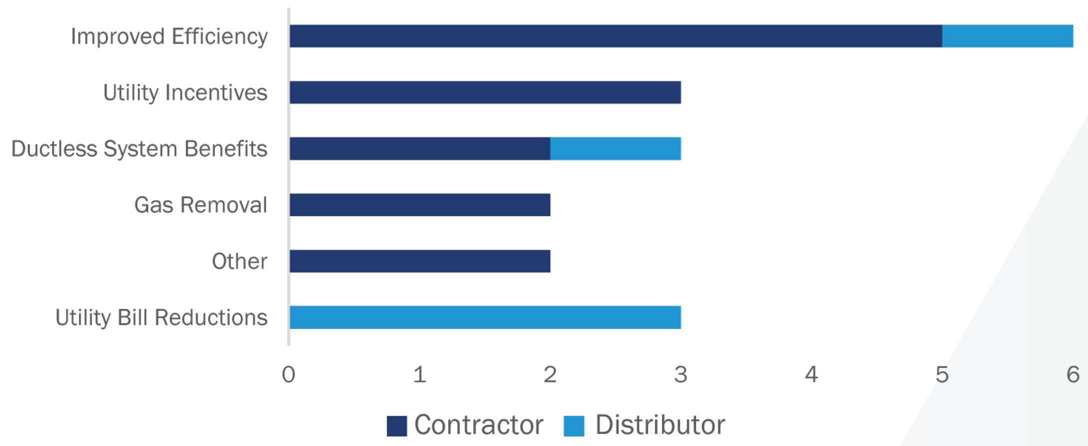
> *“For reasons that I don’t understand. I mean, there’s nothing sexy about my industry, but the heat pump has a certain tech sizzle to it. People have heard of it and they want to talk about it.”*

Despite the curiosity, the interviewed respondent reported that customers are not often committed to integrating heat pumps in their home unless the contractor recommends it. They are ultimately more concerned with the contractor’s opinion than their own considerations when determining what works best for their specific home infrastructure specifications.

Customer Motivations and Benefits

Customers are motivated by improving their energy efficiency, saving money, and leveraging the availability of incentives. Many homeowners are becoming increasingly interested in the ability to integrate ductless mini-split heat pump systems in their residences. The primary motivation for customers to install heat pump systems in their homes is improved efficiency compared to their existing HVAC system; this is especially the case if they have solar installed. Other customer motivations include reduced utility bill costs, desire to eliminate gas usage, availability of incentives, and interest in the unique perks that ductless systems offer (Figure 27).

Figure 27. Trade Ally Perception of Customer Motivations for Heat Pump Installations (n=14)



Note: Multiple responses allowed.

The evaluation team spoke to 12 interviewed respondents about customer motivations for heating and cooling their homes, while the remaining respondent did not speak to customer motivations due to limited experience in their role interacting with homeowners. The majority of interviewed trade allies (8 of 12; 67%) indicated that homeowners wanting to make changes to how they cool their homes drives more interest in heat pumps than changes to how they heat their homes. Among the remaining four interviewed trade allies, two reported that homeowners are more motivated by how they heat their residence, and the other two respondents deemed it to be about a 50/50 split depending on the season. California homeowners seem to be more motivated by how they cool their homes than how they heat due to climate conditions. When customers are unaware that heat pumps are capable of both heating and cooling their home, contractors report that homeowners are pleasantly surprised.

CONSIDERATION

Changes to cooling in homes often drives customer interest in heat pumps.

Homeowners also show strong interest in ductless mini-split heat pump installations. Customers want to use ductless units as an opportunity to regulate temperature of individual rooms in their home and integrate temperature regulation in areas of the home where there previously was none. In some cases, contractors receive requests from customers to completely replace their existing centralized system by removing the ducting and integrate a ductless mini-split system. One contractor reported that the primary motivations that he hears from customers for doing this is so that they can control heating and cooling on a room-by-room basis rather than turning on a system for the entire house.

While interview respondents and Delphi participants agree that heat pumps are generally reliable, efficient systems, many barriers for adoption still exist and there is a need for further education opportunities. Key concerns among contractors include:

- **Costly electric panel upgrades.** Six of ten interviewed contractors noted electrical panel upgrades in the heat pump installation process are rarely required, but very costly to complete. Panel upgrades often necessitate integrating electricians in the installation process and the project becomes more expensive for the customer. Customers who need a panel upgrade to move to a heat pump will often forego the opportunity due to the cost. One contractor reported,

> *Most customers won't put the heat pump in if it needs a panel upgrade. Part of my whole business focus is helping people electrify as much as possible without upgrading their panel; we call ourselves good stewards of the electric panel.*

Delphi participants echoed a similar sentiment: 10 of 15 participants described electrical upgrades as a primary barrier in switching to a heat pump. Common situations where costly electrical upgrades are needed include:

- The main service panel is less than 200 amps or there is not enough room to support an additional circuit for the heat pump components, such as the air handler.
- The existing wiring is incorrectly sized or there is not enough wiring.
- The home is old and has outdated or faulty electrical equipment, such as the thermostat, breaker, starter capacitator, or a blown fuse.

- **Location and space for equipment.** Eight Delphi participants expressed concern over the location of the heat pump equipment in the home, as well as the amount of space in the location, such as the size of the attic. If components of the heat pump, such as the indoor air handler, must be located far from the main service panel, electrical modification costs will be higher as additional electrical wiring will need to be run.
- **Cold climates.** Nearly all Delphi participants (12 of 15) explained that warm and mild climates are conducive to optimal heat pump performance while climates with extreme temperatures are not as ideal as equipment may require defrosting and additional heating capacity in the winter months. This can cause operating costs in the winter to be higher and more cost-prohibitive for customers.
- **Lack of familiarity.** Some interviewed trade allies indicated concern about other contractors' willingness to begin working with heat pumps. They report that some contractors are afraid or unwilling to learn new systems that are unfamiliar to them. For example, one contractor told us,

> *"People tend to lean back toward things they're comfortable with and contractors are no different. If they have the idea that it'll be more work to install or there won't be as much return on their work, they won't do it."*

- **High electricity rates.** Three interviewed contractors (3 of 10, 30%) do not always recommend heat pumps because they are concerned with the cost of electricity as compared to the cost of natural gas in California, suggesting that they would be more willing to install heat pumps if the price of the energy sources were similar. Seven Delphi participants echoed a similar sentiment, where the operating cost of a heat pump system is more costly than that of a natural gas furnace due to high electricity prices in California, which affects their likelihood to recommend a heat pump.
- **Customer callbacks.** Among the seven interviewed contractors we asked about customer callback concerns following their heat pump installations, two respondents (29%) considered callbacks as a concern. One contractor rationale was that there is "little room for error" in terms of installing heat pumps due to their complexity, which means mistakes are more likely to occur. The other respondent indicated that customer callbacks are a concern because heat pump systems by nature do not last as long as traditional air conditioning units. The expected lifespan for heat pumps that are well maintained range between 12 and 15 years as compared to a lifespan for traditional units of 16 to 20 years. Because heat pump systems function year-round and traditional air conditioning systems do not, heat pumps have more operating hours per year and thus more wear and tear on the system. The remaining five contractors reported rarely receiving customer callbacks on heat pump systems and do not receive more calls on heat pumps than other types of systems.
- **Refrigerant leaks.** Most interviewed contractors reported that they are not concerned with refrigerant leaks either during or after installation assuming contractors install the heat pumps correctly (5 of 7; 71%). However, one contractor felt refrigerant leaks should be more of a concern among stakeholders in California because it will inhibit the state's ability to meet its climate goals. According to the contractor, there is a large amount of refrigerant lost through leaks as a result of poor installation techniques, which necessitates improved training and regulations to ensure adequate installation processes. While there are currently hefty fines for willfully releasing refrigerant, contractors sometimes just add refrigerant to a system because it is leaking instead of fixing the leak. This contractor believes there is not enough regulation to control the refrigerant issue. The concern is that if contractors are not educated on heat pump installations effectively, they may unintentionally release refrigerant into the atmosphere during the installation process, which could ultimately do more damage for global warming than the benefit of moving from a gas system to a heat pump system.

> *The regulatory piece would be to stop letting systems be installed so badly. Another training thing—this is important because customers are coming to us wanting global warming reduction because that's a large portion of their motive—we don't have great evidence one way or the other, but anecdotally I think that, and there's not a lot of disagreement and this is accepted as how it is, but the amount of refrigerant that is lost through leaks due to poor install is enormous. The rules about managing refrigerant have heavy fines for releasing it willfully. You get a huge fine and the person who turns them in is financially rewarded. That doesn't do anything for the contractors who make money going around to houses and adding a little refrigerant because it's leaking. One of the things I wonder about as I work in support of heat pumps: are we screwing ourselves in the long run because of the lack of requirements for control of refrigerant? We talked about carbon emissions and how bad they are, but depending on the refrigerant, it's between 1800–2000 times more destructive than carbon and it's leaking.*

- **Permitting processes and costs.** Three interviewed contractors (38%) had concerns related to heat pump permitting in their area. The challenges involved managing the variations in code across the service territory. One contractor in San Diego County struggles with maintaining knowledge and awareness of different sets of codes across each city within the county, as they are not always informed when changes to code occur or having difficulty discerning the rules for each area of the service territory. Another contractor also experiences challenges with managing the varying regulations across cities in the Los Angeles and Orange county regions, specifically as it relates to heat pump condenser location. He noted,

> *A lot of cities have very tight rules about where we can place the condensers, especially on the sides of people's homes. So, we can fit it there, there's usually room. It's just sometimes the city won't let us do it.*

Four Delphi participants mentioned permitting costs are higher for heat pump installations than for a natural gas furnace replacement.

- **Other concerns.** One interviewed contractor noted a potential problem for ductless mini-split wall-mounter air handlers. He reported that they can be a "disaster" if not installed properly because of the placement of the condensate drain. Every air handler requires a condensate drain, and if the handler is installed above the ceiling line then the contractor can rely on gravity drainage. However, if the contractor installs the air handler below the ceiling line, then it either necessitates the usage of a pump or the drainage could result in water damage if the heat pump were to fail. The respondent commented,

> *And here's the thing about gravity, it never, ever fails. Heat pumps are pretty good, but you can't say never. They do fail, and when they do fail you can have an awful mess.*

Another interviewed contractor reported concern with whether the move from a gas-based HVAC system to one powered by electricity is truly more efficient. He relayed the process as he understands it, explaining:

> *Let's be honest, even though my Mitsubishi VRF 22 SEER, top of the line multi-head system is highly energy efficient, there's still a gas power plant 80 miles away that has to generate the electricity and send it down the transmission wires before I see it. Then you have all those transmission losses plus you can't convert 100% of the BTUs in natural gas into steam to run your steam generator to generate electricity. There's always losses, efficiency losses. That big plume of steam coming up, that's all heat that was in the natural gas you just burned that you're losing. Better to burn that BTU in the home where you could deliver all the heat directly to the homeowner rather than go through the generation losses and the transmission losses, and the mechanical wear and tear on the system down the road. So, we're going to burn gas to heat anyway.*

The general sentiment among interviewed contractors was that if the market demands heat pump technologies, then they will follow. Contractors will learn to install and continue to recommend and install heat pumps if customers in California continuously ask for them. While some installers lead the way in promoting heat pumps to their customers, respondents indicated that some will only bring heat pumps into their business if they feel there is real market demand for them.

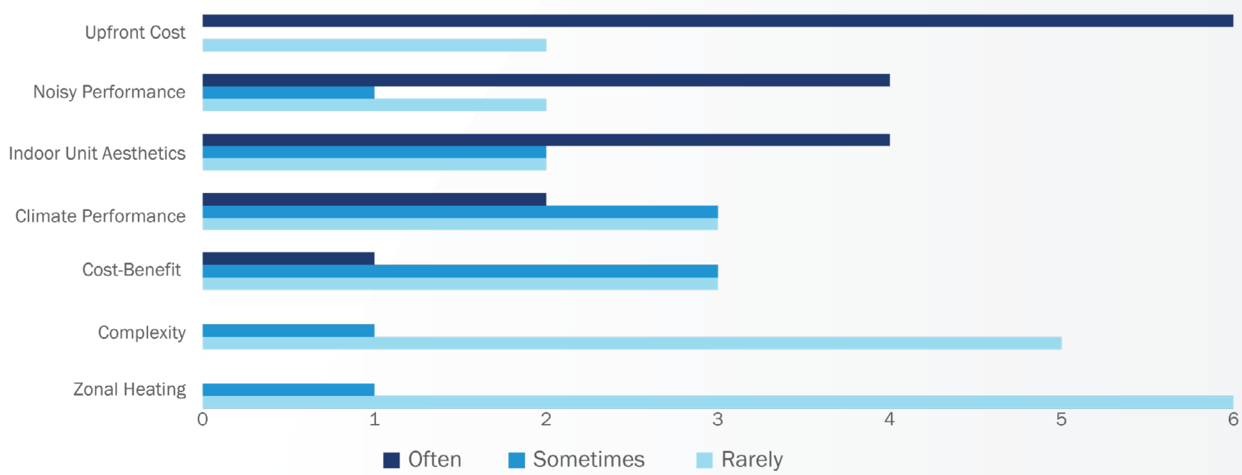
Customer Concerns

> CONSIDERATION
>
> Customers primary concern related to heat pumps is the upfront cost.

Contractors report that customers' primary concern related to heat pump installations is the upfront cost, though they are also concerned with system specifications related to performance and comfort. The evaluation team probed contractors about the frequency at which they hear certain potential concerns from their prospective customers (Figure 28). According to heat pump contractors, the primary concern of potential customers is often upfront cost. One-third of Delphi participants (5 of 15; 33%) also reported that the upfront unit cost of a ducted heat pump can be a deterrent for installing one among customers, as they tend to be more expensive than a natural gas furnace.

Other concerns include noisy performance, the aesthetics of indoor ductless units, performance related to climate, and the cost-benefit of heat pumps over time. Notably, customers are more concerned with issues related to cost and performance and seemingly less concerned with the complexity of heat pump systems and zonal heating qualities of ductless systems.

Figure 28. Contractor Perception of the Frequency of Customer Concerns (n=10)



Note: The number of respondents for each individual topic ranged from six to eight contractors, though the evaluation team collected feedback related to customer concerns from all 10 interviewed contractors. Multiple responses allowed.

Some interviewed contractors (3 of 10; 30%) also reported that prospective customers are concerned with the utility bill costs associated with heat pumps. Two additional contractors also mentioned concerns related to moving from gas to electric and the associated higher cost of electricity. Customers fear that their electric utility bills will be larger if they use a heat pump in their home rather than their existing conventional system. Contractors report customers worry that their heat pump will be more expensive to operate, citing,

> *Even though heat pumps are efficient, customers are concerned about how much energy they will use, how much it'll cost to operate it because the compressor on a heat pump is used to both heat and cool. It just reverses the flow of refrigerant. So, after educating a customer on how a heat pump works, then their concern becomes, 'Well, if I spend $300 to cool my house, am I going to spend $300 to heat my house.*

Two interviewed contractors also mentioned that homeowners worry about heat pump performance lags, meaning that it will take too long to heat their residence compared to gas furnaces. One respondent reported that this is a misconception borne from the capabilities of older versions of the technology, while the other cited that it is a stereotype to emerge from contractors with a "bad image" of heat pumps who incorrectly size their systems. There is a misconception from homeowners that heat pumps are unable to keep up with heating demand because they decrease in efficiency in colder climates. One contractor reports that while this can be true for ductless mini-split systems, it does not apply to ducted systems. He went on to say that ducted systems do not function like single stage or conventional HVAC equipment, but contractors often treat heat pumps that way which results in oversizing the system and subsequent inefficient performance.

Interviewed contractors also report challenges selling ASHPs for multifamily buildings. Property management companies are not always receptive to heat pump installations because they are incentivized to select the system with the least expensive upfront cost. They are not financially motivated by reduced utility bills since they do not pay the utility bill, the renter does. One contractor reported that it was a challenge to convince multifamily property managers and owners that, "it not only increases the value of their home to have a more efficient system, but it would also cost less for their customers." Some multifamily properties also belong to Homeowners' Associations that follow specific requirements, including rules on fuel type and permitted HVAC systems, which may not allow heat pump installations.

Two out of three of the distributors also provided perceived homeowner concerns with purchasing heat pump technologies. They also reported that a major concern for customers is heat pump performance compared to other systems; customers fear that the heat pump will not cool their home as quickly as their existing system. One distributor reported that in addition to upfront cost concerns, homeowners with solar can sometimes be less concerned with their HVAC system efficiency. These homeowners hold the misconception that because they have solar energy, their homes are already "efficient." One interviewed respondent explained,

> *Then some people have solar, so they don't even care that their system is 30 years old or whatever, but I try to tell them. I try to let them know, just because you have solar doesn't mean that you're being efficient.*

4.6 AIR SOURCE HEAT PUMP COSTS

To better understand the incremental costs of residential ASHP installations, Delphi participants filled out hypothetical quotes for installing a natural gas furnace and an ASHP in the following home scenario (Figure 29). We collected data on costs related to equipment removal, equipment units, installation labor and materials, ducting modifications, as well as natural gas, electric, and ventilation modifications. We then computed a total cost for ASHP installations. Contractors do not typically break down estimate.

Figure 29. Home Specifications for Air Source Heat Pump Install

Home Vintage	Home Type	Home Stories	Home Square Footage	Home Weatherization	Existing Ductwork Present	Existing Heating Type	Existing Heating System Location	Existing Cooling Type	Existing Cooling System Location	200 Amp Service Panel
Pre-1978	Single-family	1	1400	Little to none	Yes	Natural Gas Furnace	Attic	None or Room Air Conditioners	N/A	No

Equipment Removal Costs

The average cost to remove the existing equipment from this home in order to install an ASHP, considering both labor and material costs, was $724 (Table 15). Costs ranged from $600 to $2,300. This was marginally higher than the cost to remove equipment to install a new natural gas furnace installation, which averaged $555. Most Delphi participants felt that the average ASHP cost was in line with their estimates (6 of 15; 40%) or slightly lower than what they were expecting (6 of 15; 40%). One participant increased their cost after seeing the average and range of costs in Round 2.

Table 15. Equipment Removal Costs

Equipment	Minimum	Maximum	Median	Average
Natural Gas Furnace	$0	$2,640	$400	$555
Air Source Heat Pump	$600	$2,300	$500	$724

Equipment removal costs tend to be lower if the removal process is easy: simply replacing the fan coil and not replacing or upgrading any ducts. Equipment removal costs are also lower if the home is in a location with lower labor costs. Removal can be more expensive if unforeseen issues arise during the process or if the internal configuration of the home or equipment location is odd, which is especially prevalent in old Victorian homes in San Francisco. Additional labor is often spent on disassembling the existing equipment, removing lines, cutting wires, and flushing coolant. Two participants noted that at times asbestos is detected in the existing ducts or pipes during disassembly, requiring an asbestos abatement company to come in and remove the asbestos. This increases the cost significantly.

Equipment Unit Costs

Delphi participants reported a wide range of unit equipment costs for ASHPs; costs ranged from $1,114 to $7,428, with an average cost of $3,387 (Table 16). Many participants were not surprised by the variability, as several factors determine the unit cost of a heat pump. This cost element saw the largest difference between a natural gas furnace and heat pump, where the average natural gas furnace cost was nearly $2,000 less expensive than the heat pump.

Table 16. Equipment Unit Costs

Equipment	Minimum	Maximum	Median	Average
Natural Gas Furnace	$635	$3,586	$1,210	$1,575
Air Source Heat Pump	$1,114	$7,428	$3,000	$3,387

Participants reported the following prominent determinants of equipment cost variance:

- **Type of heat pump**. Six Delphi participants noted that heat pump costs vary because there are multiple types of heat pumps in the market with varying sizes, capacities, and motors.
- **Heat pump brand.** Delphi participants explained that equipment costs vary because some brands are more expensive than others. Big name brands such as Carrier may be more costly than off-brand heat pumps due to varying degrees of quality.
- **Equipment markup.** Participants represented a variety of contractor companies from different regions of California. It is natural for companies to mark up the cost of the equipment differently as they have varying business practices. Higher equipment costs align with more overhead coverage and a higher profit margin.
- **Heat pump efficiency.** Air source heat pumps that have higher SEER ratings are often more expensive than models with lower SEER ratings. Four participants noted this as a reason for cost variability.
- **Supplier relations.** Two participants reported that having a good relationship with suppliers or distributors is financially beneficial. Contractors can purchase a large volume of heat pump units at a lower cost if they maintain a good relationship with suppliers and/or distributors.

A large component of the equipment costs of installing an ASHP is the air handler. An air handler unit consists of an evaporator coil, a blower motor, and typically an electric heat strip. The air handler is designed to efficiently circulate conditioned air through the duct work. Air handler upgrade costs ranged from $500 to $4,000, with the average being $1,826. Air handler upgrades can be more expensive if the location of the air handler is far from the main service panel in the home, which can require the costly installation of lengthy and complex electrical conduits, as reported by six participants. At times, upgrading the air handler component of the system can require additional equipment replacements, such as heat strips, the fan coil, refrigerant lines, or the condensate drain. This increases the air handler labor and material costs significantly, according to five participants. Furthermore, similar to the variance of the heat pump unit costs, air handler costs vary due to different brands, quality, and type. For example, an air handler with a variable speed motor will be more expensive than one with a single speed motor.

Installation Labor and Material Costs

Delphi participants reported a wide range of labor costs for the ASHP installation, with $570 as the minimum and $13,000 as the maximum (Table 17). The average cost to install an ASHP was $2,888, roughly double the average cost of installing a natural gas furnace.

Table 17. Installation Labor and Material Costs

Equipment	Minimum	Maximum	Median	Average
Natural Gas Furnace	$260	$4,000	$1,113	$1,495
Air Source Heat Pump	$570	$13,000	$1,950	$2,888

Most participants (11 of 15; 73%) reported labor costs are dependent upon the geographical location of the installation. Some regions, such as some parts of the Bay Area, are more expensive than other areas, such as other communities such as economically distressed communities. Contractor companies that service affluent areas charge more for labor to cover higher overhead and rent. Another reason for installation labor cost variability is the structure and age of the home. Older homes with odd internal configurations will likely need more ductwork and electrical modifications than newer, production homes. Thus, more time and labor are needed to complete the install.

Ducting Modification Costs

Participants reported a wide range of costs related to ducting modifications for both the natural gas furnace and the heat pump installation. The average ducting modification cost for a heat pump installation was $2,277 (Table 18), only marginally higher than the furnace average. One participant modified their original cost from Round 1 to be 10%–15% higher in Round 2, after explaining their Round 1 cost was not representative of the industry average due to conducting work in lower income areas.

Table 18. Ducting Modification Costs

Equipment	Minimum	Maximum	Median	Average
Natural Gas Furnace	$0	$10,286	$600	$1,702
Air Source Heat pump	$109	$9,843	$1,300	$2,277

The extent of ducting modifications needed for a given ASHP installation depends on the existing condition and presence of ducts throughout a home. In some cases, a ducted heat pump system may be able to utilize the existing ductwork to circulate conditioned air in the home, therefore modifications and costs would be minimal. Some contractors assumed this was the case for the scenario, where only the duct plenums needed to be adapted to the new system.

There are many scenarios where ducts or the entire duct system need replacement, which align with the higher reported costs for this cost element. As described by Delphi participants, ductwork can be a time-consuming and tedious process. Factors that determine the need for ducting modifications or entire duct system replacement include existing ducts that are old, poorly designed ductwork, ducts that contain asbestos, small ducts that will not support high refrigeration from a heat pump, or inaccessible ducts.

Natural Gas, Electric, and Ventilation Modification Costs

Delphi panelists reported an average cost of $1,982 to cover the natural gas, electric, and ventilation modifications of the ASHP installation (Table 19). This cost was not drastically different than the modification costs for the furnace installation, which averaged $1,844. Two participants altered their original costs in Round 2. One participant increased their cost by $1,000, explaining there was a likelihood that the home in the scenario had electrical wiring not sufficient for the heat pump, thus would require wire upgrades. Another participant also reported increasing their cost after seeing the group average.

Table 19. Natural Gas, Electric, and Ventilation Modification Costs

Equipment	Minimum	Maximum	Median	Average
Natural Gas Furnace	$108	$17,000	$520	$1,844
Air Source Heat Pump	$242	$12,000	$940	$1,982

Participants who reported costs on the higher end assumed the main service panel would need to be upgraded to a 200-amp panel in this scenario. This alone typically costs between $1,900 and $4,000. Participants who reported on the lower end assumed no panel upgrades were needed; merely labor to disconnect the gas line. Most participants reported that the majority of the modifications needed during a heat pump installation relate to the electrical upgrades, which would be likely for this scenario as there was no existing 200-amp service panel. Other reasons for higher costs include the “difficulty factor” of the installation, meaning the modifications can be tricky due to the structure and age of the home.

Total Costs

The average total costs between the natural gas furnace and ASHP were significantly different. The heat pump total cost average was roughly $4,500 higher than the furnace, which averaged around $7,000 (Table 20). After seeing the group averages in Round 2, two participants increased their ASHP total costs, and one participant increased their total estimate for the furnace installation.

Table 20. Total Installation Costs

Equipment	Minimum	Maximum	Median	Average
Natural Gas Furnace	$1,620	$36,168	$4,821	$7,099
Air Source Heat Pump	$3,132	$37,900	$9,800	$11,534

Participants explained that in their experience, heat pumps have always been significantly more expensive to purchase and install than a furnace.Contractors also discussed “risk pricing.” Risk pricing refers to an inflation of labor costs to cover the unknowns associated with a job. Contractor with less experience installing heat pumps indicated that when they cannot predict with certainty how many hours it will take laborers, they budget for that risk. This is especially the case with older homes and more complex installations. Delphi participants explained the core reasons for the cost differences between these systems:

- Converting a natural gas HVAC system to accommodate a heat pump system is inherently more complex and time-consuming than replacing the system with a furnace. This is due to the potential significant changes to the ductwork and electrical system. Entire duct system replacement and upgrading the main service panel are line items that can be cost-prohibitive for the customer.
- Current average equipment prices between a furnace and a heat pump are not comparable, as the heat pump equipment consists of more components, such as the air handler upgrade. According to Delphi participants, heat pump units typically cost $1,000 to $2,000 more than furnaces on average.

4.7 INCENTIVES

Contractors are aware of and participate in utility incentive programs because they increase market awareness and provide monetary incentive for customers to select the program’s target technology; however, trade allies report challenges with the current eligibility and paperwork requirements of specific heat pump programs. Overall, contractors believe heat pump incentive programs will play a vital role in the future growth of the technology throughout California.

Contractors believe incentives will play a pivotal role in the future growth of the heat pump market in California.

Both interviewed respondents (12 of 13; 92%) and Delphi participants (10 of 15; 67%) are aware of utility incentive opportunities and have experience participating in rebate programs for a variety of HVAC technologies. Almost all contractors agree that utility incentives impact customer demand for the targeted technology and improve sales, though they have concerns related to pricing and structure of incentive programs. It should be noted that contractors are mainly aware of incentive opportunities for their customers but many (10 of 15; 67%) are unaware of any incentives that are available to contractors at point of purchase. Over half of Delphi participants (8 of 15; 53%) always recommend heat pump incentives to customers if they are aware of any.

Trade allies are most commonly aware of SCE incentive programs, and some are familiar with utility rebates available through PG&E, SDG&E, and SMUD (Table 21). Trade allies also work directly through their local municipal utilities, including San Diego County, Modesto, and Turlock Irrigation Districts. One distributor also received rebates through one of their manufacturers, Trane, to sell their equipment to contractors.

Table 21. Incentive Program Awareness and Participation among Interviewed Trade Allies (n=14)

Rebate Program	Awareness	Participation
SCE	5	5
PG&E	2	2
SDG&E	3	2
SMUD	2	1
Local Municipality	3	3
Manufacturer	1	1
Does not participate	4	-

Two contractors reported that they do not participate in any incentive programs, though they do know that such programs exist. One contractor does not participate because he used to participate in a low-income retrofit program with an IOU, but he stopped participating because the program was “slow” in processing paperwork and incentives. The other contractor does not participate in incentive programs because he does not feel that a rebate would affect a customer’s decision to get a heat pump for their home. However, most respondents feel that rebates provide customers with an additional incentive to educate themselves on heat pumps and purchase the technology for their homes. Contractors report that their experience participating in utility incentive programs as being beneficial to them and their customers. One contractor speculated,

> *I probably brought in tens of millions of dollars into municipalities and school districts for those programs. So, programs [garner] quite a bit of interest as soon as there’s incentive money available [for customers and his company].*

Delphi participants reported a range of rebate amounts that make a heat pump installation attractive to a customer. Some contractors reported the rebate amount per ton, while some cited a rebate amount for the overall system. Four contractors reported the monetary value per ton, which ranged from $200 per ton to $600 per ton. This equals a range of $400 (2-tons) to $2,400 (4 tons) per system, depending on the capacity. Five contractors reported an overall rebate amount for a system. This ranged from $500 to $3,500. Two contractors felt that any rebate amount would help the customer, thus did not report a specific value. Additionally, one contractor noted that no level of incentive would be attractive as the operating electricity cost of a heat pump would still be much higher than what any rebate could cover. Another contractor noted that no rebate is needed to make a heat pump installation attractive as it is already cost-effective in the long term.

Interviewed contractors report that rebates play a strong role in educating customers and incentivizing them to purchase, and they will be essential to the continued growth of heat pump sales in California in the future. Over half (8 of 15; 53%) of Delphi participants report that if they participate in an incentive program themselves, they will always pass on the financial benefit of a rebate to their customer. One contractor tripled the amount of heat pump installations for his business due to utility incentive program participation. He explained that other contractors’ businesses could benefit from participating in rebate programs as well, though the industry is “not replete with a lot of a business-minded contractors.” One distributor explained that, to his surprise, many contractors that he sells to had “no clue these things existed,” but they would likely participate if they were aware of heat pump rebate programs. The distributor said,

> *I thought everyone would be all over it, but they weren’t. [IOUs] do a poor job of wanting to give that money away.*

In addition to increased program visibility, contractors felt that the programs could be improved in terms of structure and pricing. Four contractors reported that the programs are too stringent in structure, citing application complexity and rebate requisites as an issue. Contractors (n=3) feel that jobs in which the homeowner must switch fuel sources should be eligible for a rebate. Another contractor proposed that incentive programs would be better structured if they considered the residence in a more comprehensive manner using a “whole house approach” in which homeowners receive rebates for transitioning to all-electric using methods that the contractor deems are best for the home, including batteries, adequately sized heat pumps, and an appropriate air filtration system. Heat pump installations can provide high efficiency and lower install costs for homeowners, but the contractor argues that is just one way to make their home more efficient, “but they may be making it worse or missing out on other benefits” by taking only the heat pump approach.

4.8 TRAINING OPPORTUNITIES

Contractors are highly supportive of increased availability and participation for training opportunities related to the installation, service, and maintenance of heat pump technologies. All interview respondents (n=11) who discussed training opportunities acknowledged the value of providing educational resources on heat pump technologies for contractors. Some contractors and distributors believe that offering more training opportunities will greatly improve the growth of heat pump prevalence in California, but some think that the systems are simple enough or that contractors already know enough that it is not perceived as necessary. Notably, six participants of the Delphi study reported that training costs are an incurred cost not passed on to the customer; affordable or discounted training opportunities would likely financially benefit these contractors.

> CONSIDERATION
>
> Contractors believe that training is essential to growing the heat pump space heating and cooling market.

Among the three distributors, all offer trainings for contractors. Their training subject matter is related to heat pump installation, system troubleshooting, sales, and marketing practices. One distributor reported that they offer both online courses and in-person demonstrations by heat pump brand representatives. Another distributor has staff members whose role is to organize technical trainings for contractors that purchase their HVAC supplies, and that they are currently focusing their educational opportunities on heat pumps in order to promote sales. While COVID-19 has had an impact on distributors' ability to conduct in-person trainings, some have pivoted to virtual options during the pandemic.

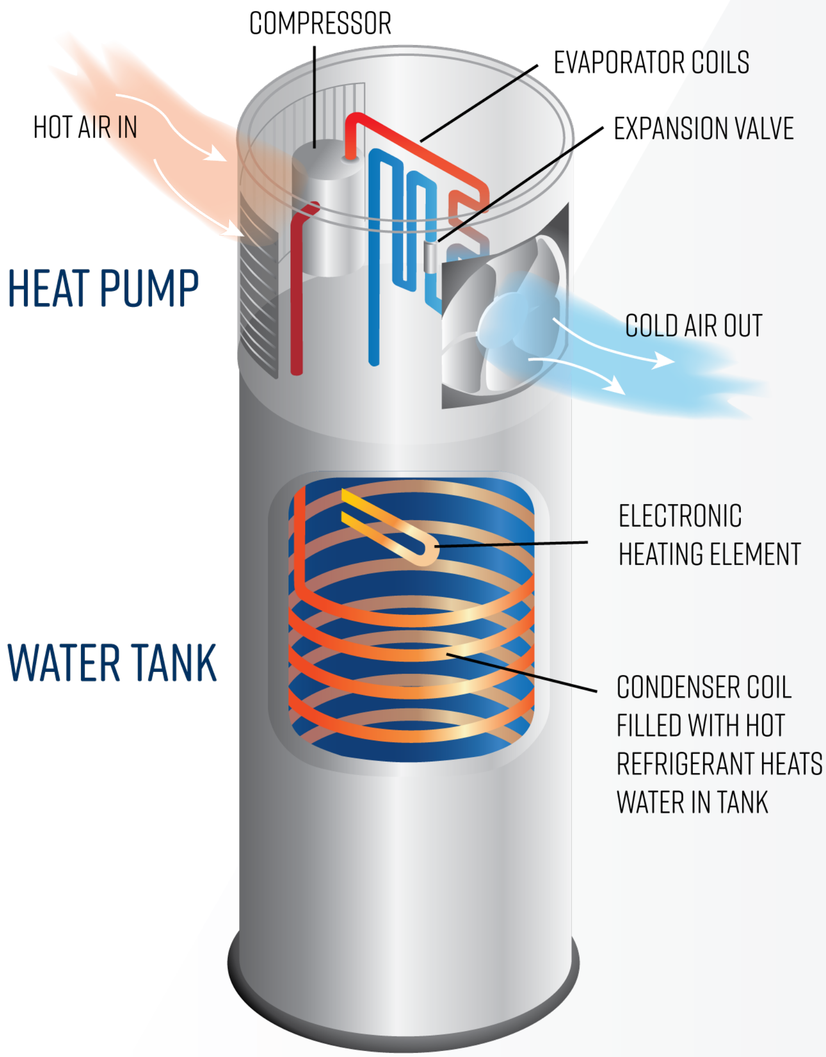
Contractors unanimously agree that training opportunities are essential in order to continue to develop the HVAC workforce's familiarity with installation and service of heat pumps. One contractor stated,

> *"Like I tell all my guys, 'You can never learn too much.' Especially in this industry, it's always changing, there's always things moving around. So, service training would be a great, great need. I'd send all my guys to that."*

5. HEAT PUMP WATER HEATERS

Heat pump water heaters are all-electric, high-efficiency water heaters that, unlike gas-powered water heaters and electric resistance water heaters, heat water by transferring heat from the surrounding air rather than creating new heat. A fan brings air in through an air filter and evaporator coil. The evaporator coil contains refrigerant, which absorbs heat from the air. The refrigerant is then pumped through a compressor, which increases the temperature of the refrigerant. The hot refrigerant is circulated through a closed-loop system from the compressor through a coil that wraps the tank. As the refrigerant passes through the coil, heat is transferred from the refrigerant into the water. Transferring heat rather than creating it allows HPWHs to be up to three times more efficient than gas and electric resistance water heaters, conserving power and reducing energy bills (Figure 30). If the surrounding air is cold, then the HPWH will have to work harder to heat it up, making them less efficient in cold climates. HPWHs typically work best in locations that remain in the 40ºF–90ºF (4.4ºC–32.2ºC) range year-round and provide at least 1,000 cubic feet of air space around the water heater. Since the HPWH pulls heat from the air, they tend to cool the spaces where they are located.

Figure 30. Heat Pump Water Heater



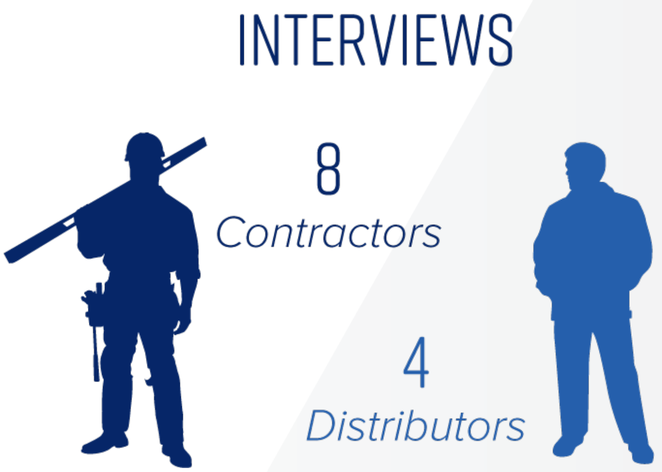
HPWHs also can provide another important benefit to the energy grid—they can act as thermal “batteries” to store renewable energy (such as when solar energy is abundant in the middle of the day), and avoid using electricity in the evening, when it is more likely to be generated by the dirtiest power plants. With good tank insulation, it is possible for the water in the storage tank to retain its heat for at least 12 hours, or even longer with well-insulated pipes and fittings.[19]

[19] Delforge, Pierre. “Heat Pump Water Heaters as Clean Energy Batteries.” Expert Blog (blog). National Resources Defense Council, Inc. January 7, 2020. https://www.nrdc.org/experts/pierre-delforge/heat-pump-water-heaters-clean-energy-batteries

5.1 DESCRIPTION OF RESPONDENTS

The evaluation team conducted 12 interviews with HPWHs trade allies. Heat pump water heater installation, service, and maintenance experience ranges among respondents. While one respondent's lifetime installations are two HPWHs, another contractor estimated that he has installed approximately 40 in his career. In the past year, installation experience ranged from none to 12 HPWHs. The service territories of the interviewed participants range northern and southern California. Two contractors work in and around San Francisco, two in San Jose, two in Sacramento, and two in the Los Angeles area.

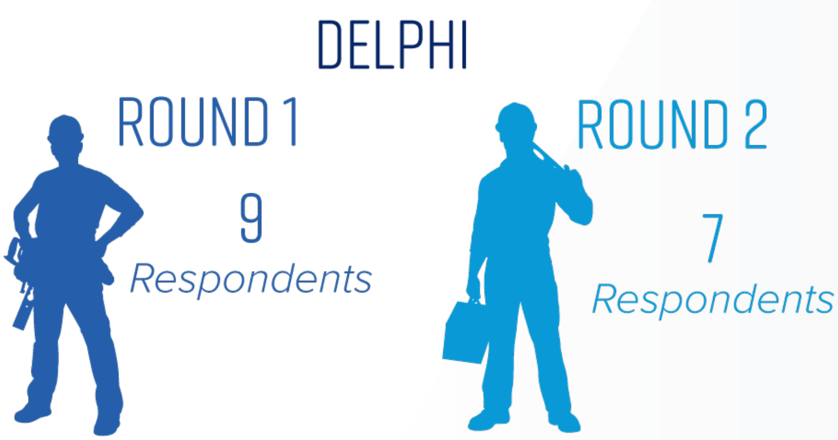
Figure 31. Interviewed HPWH Trade Allies



All contractors primarily work in residential settings, varying from 70 to 100 percent residential jobs. Among their residential work, all contractors have experience working in single-family and multifamily settings, though all but one contractor (7 of 8; 88%) conduct the majority of their jobs on single-family homes. The remaining contractor splits his work 60 percent multifamily and 40 percent single-family. Seven contractors (88%) spend the majority of their time working on gas-fueled water heaters, including four contractors whose jobs are at least 95 percent gas systems. The remaining contractor works exclusively with electric water heaters; he does not install gas water heaters but reported that nearly every existing system on his jobs are gas.

Among the four distributor interviewees, two worked in the greater Sacramento area, one in greater San Francisco, and the fourth worked in southern California near Los Angeles. All four distributors either primarily or exclusively sell to contractors, with one respondent who also sells directly to homeowners and another who also sells to wholesalers. Experience working with HPWH technologies ranges from three to 25 years, with the median years of experience being four. Heat pump water heater brands sold by distributor respondents range from Rheem®, Ruud®, A O Smith®, Sanden, Daikin®, Hubbell®, Chilltrix, and Aermec. While one distributor did not provide information related to the portion of their business that is HPWHs, the other three said that their plumbing businesses are between 0.1 to 10 percent HPWHs based on units sold.

Figure 32. Number of Participants by Delphi Study Round



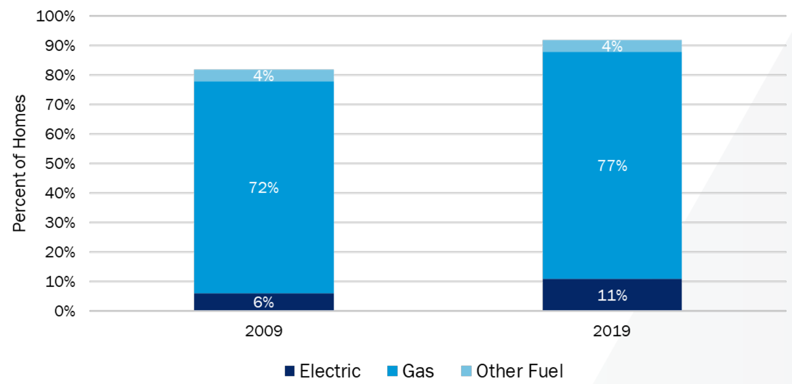
The evaluation team also conducted a Delphi study with HPWH contractors (Figure 32). Delphi participants came from a variety of regions in California. Four contractors worked in the Bay Area, two worked in the Sacramento area, two others served cities in Southern California, and one worked in the central region.

5.2 OVERALL HEAT PUMP WATER HEATER MARKET

The Air Conditioning, Heating, and Refrigeration Institute reports roughly four and a half million residential storage gas water heaters and four million six hundred thousand residential storage electric water heaters were shipped in the United States in 2020. Residential storage gas water heater shipments grew 4.7% and residential electric storage gas water heaters grew 10.8% between 2019 and 2020. Three companies manufacture 90% to 95% of all residential water heaters in the United States: AO Smith®, Rheem®, and Bradford White®. Other smaller manufactures include Nyle Systems, Stiebel Eltron®, General Electric®, and Midea.[21] ENERGY STAR® reports that 8% of water heaters are replaced each year.[22]

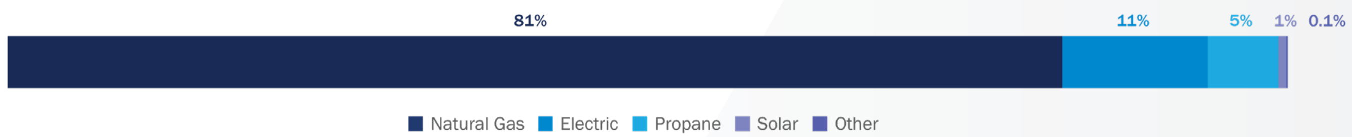
Appliance saturation studies in California show that residential electric use for water heating has almost doubled over the past ten years (Figure 33).

Figure 33. 10-Year Comparison of Electric vs Gas Water Heater Saturation in California



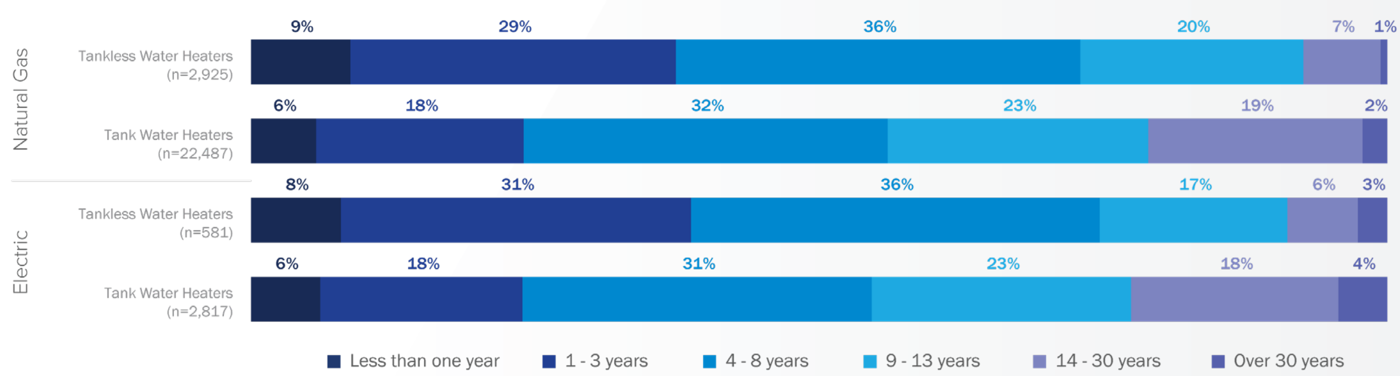
In 2019, 11% of the market had electric water heating compared to only 6% in 2009. There are 12.1 million water heating units and only 1% of that equipment is electric and high efficiency (Figure 34).[23]

Figure 34. Types of Water Heating Fuels (n=32,629)



Respondents were then asked about the age of their water heater. There seems to be a higher incidence of tankless water heating systems being installed in more recent years as approximately 40% of tankless natural gas and electric water heaters are less than 3 years old and only 8-9% are over 14 years old. Trade allies confirmed this trend. Comparatively, only 24% of tanked natural gas and electric water heaters are less than 3 years old and 21% and 22% respectively are over 14 years old as shown in Figure 35.

Figure 35. Age of Water Heater by Type of Water Heater



[20] Air Conditioning, Heating, and Refrigeration Institute (AHRI). 2020. "AHRI Releases December 2020 U.S. Heating and Cooling Equipment Shipment Data." https://www.ahrinet.org/App_Content/ahri/files/Statistics/Monthly%20Shipments/2020/December_2020.pdf

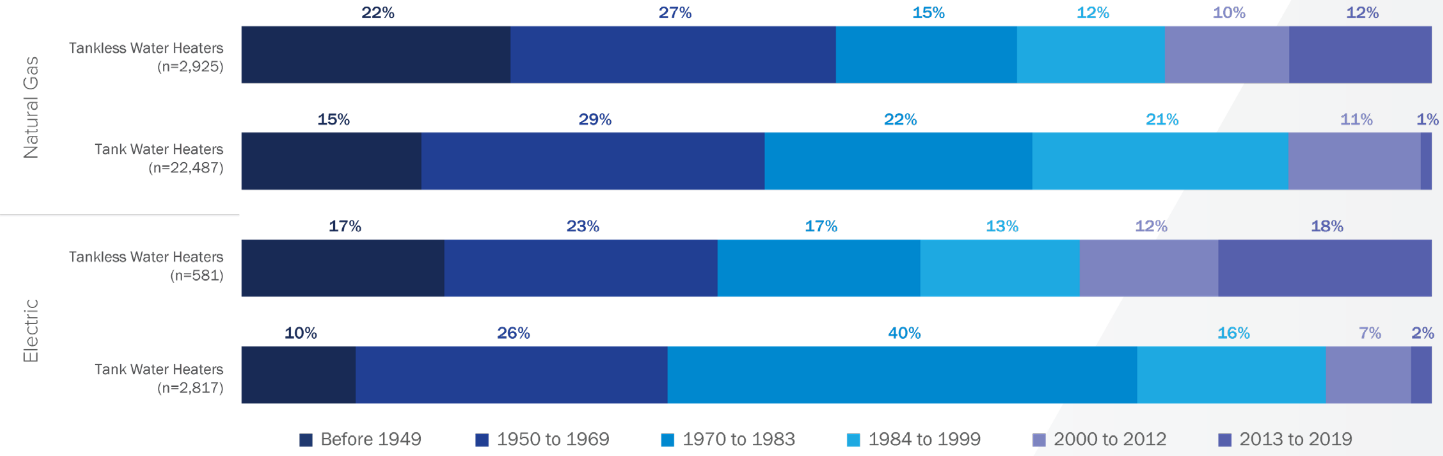
[21] Butzbaugh, Joshua B., Linda J. Sandahl, and Michael C. Baechler. 2018. "US HPWH Market Transformation: Where We've Been and Where to Go Next." United States.

[22] ENERGY STAR®. 2009. "New Technologies New Savings. Water Heater Market Profile 2009." U.S. Department of Energy.

[23] For water heating, 11% of the market is electric and we estimate that 1% of that is likely potentially high-efficiency equipment.

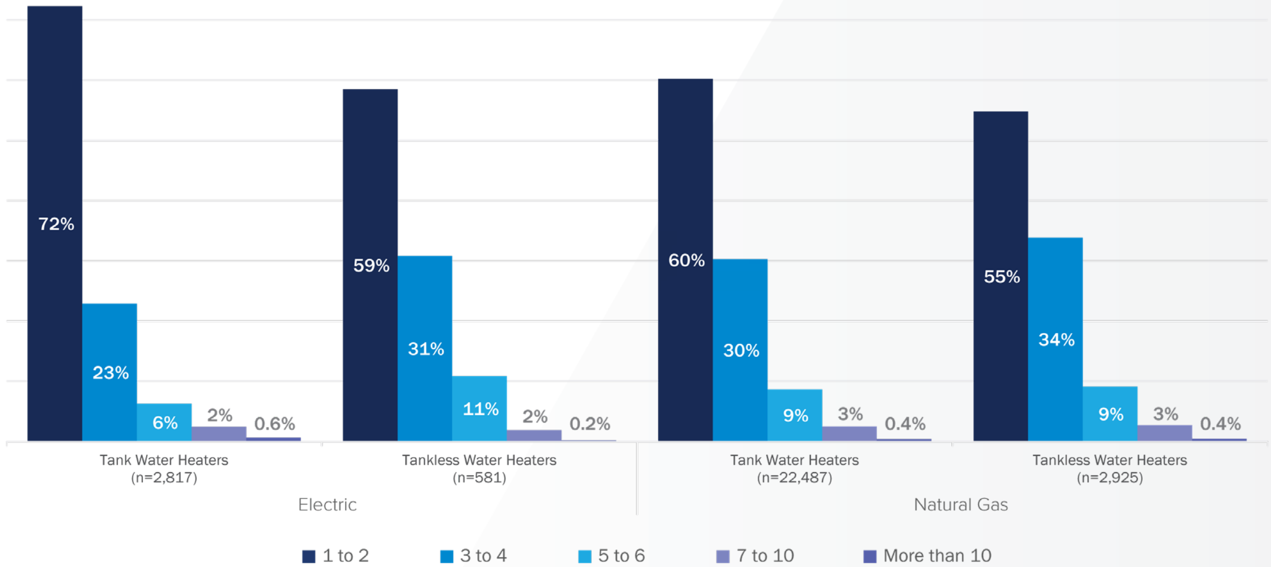
As shown in Figure 36, only 10% of homes that have an electric tank water heater installed were built prior to 1949 most likely due to the panel upgrade that is required to install most electric tank water heaters.

Figure 36. Age of Home by Water Heating Type



One consideration for installing electric HPWHs is the size of the household since the recovery time of HPWHs is longer than traditional storage water heaters. Ensuring that the proper tank size is used for larger households is key to incentivizing installation in homes. A little over 70% of households with an electric tank water heater had one to two people, which was also discussed by the HPWH contractors in the study (Figure 37).

Figure 37. Number of Residents by Water Heating Type



The majority of both interview respondents and Delphi participants reported positive perceptions of working with and recommending HPWHs to customers. Nine interview respondents (75%) responded positively to the proposition of continuing to work with HPWHs in the future. All Delphi participants (n=7) reported they would recommend an HPWH to a customer if the conditions of the home and household were suitable for the equipment. Three of these participants expressed very positive perceptions of HPWHs, describing them as environmentally friendly, efficient, durable, and cost-effective when coupled with federal tax incentives or utility rebates.

Interviewed trade allies also described their perceived benefits of HPWH technologies, which included the potential for increased profit, the ability to learn and troubleshoot more “sophisticated” technology, and the opportunity to offer a “superior”” product in terms of energy efficiency. Two distributors (17%) mentioned the potential for profit because the labor and mark-up price of the unit can be twice the cost for a customer than installation of a traditional system, resulting in higher profit for the installer.

While all interviewed trade allies are willing to continue to work with HPWH technologies as market demand continues, three trade allies (3 of 12; 25%) do not find value in HPWH adoption and expressed some unwillingness in promoting such systems. These trade allies viewed tankless water heaters as more efficient and cost-effective than HPWHs. Despite the demonstrated reluctance from these trade allies, ultimately, they each indicated a willingness to install HPWHs if their customers wanted it. One trade ally said the following about why he continues to work with HPWHs,

> *People want them, and they’re using the rebates, and so, hey, as long as taxpayers are paying the rebate money, it’s good to go.*

Current Market and Expected Growth

Ten interview respondents (10 of 12; 83%) described the current market for HPWHs in their service territories as somewhere in the range between small and non-existent. In particular, four trade allies reported that the current market for tankless water heaters is growing faster than HPWHs in their areas. Another respondent reported that the market for HPWHs is dependent on the region, indicating that areas with better rebate programs have a stronger market. The remaining respondent described the current market as “dynamic,” and he attributed growth in HPWHs popularity to the push for electrification in California.

CONSIDERATION

The market for tankless water heaters in some areas is growing faster than the heat pump water heater market.

All interview respondents anticipate some degree of growth in the market for HPWHs in California in the next five to ten years. Four trade allies specified that the primary reason for growth will be due to the emphasis the state has placed on electrification policies. Among the four, one distributor reported that government mandates are the only factor that will impact market growth in California. He said that HPWHs would “go away tomorrow if there wasn’t a government mandate.” The reason cited was that electric water heaters are an “inferior” product to gas, and ultimately these systems do not provide enough hot water. Another distributor who thought that state policy would be a primary cause for growth because of the emphasis in California placed on environmentally friendly building science, saying,

> *In California, they’re more sensitive to green technology than in other places. The market will continue to boom for the foreseeable future. That’s the natural progression in building science, so as more and more counties adopt green technology, the heat pump will fall in line there.*

One interviewed respondent was unsure about whether he expected his HPWH sales to grow in the next few years. When posed with the question, he replied,

> *I don’t know. I really don’t know. I mean, there was a time that people would laugh at electric cars, and now it’s like the most common thing in the world.*

5.3 STOCKING AND SALES PRACTICES

Among the four interviewed distributor respondents, HPWHs make up a small portion of their overall business. While one distributor did not report on what percentage of their revenue in the last year came from HPWHs, the remaining three respondents reported percentages of less than 1 percent.

In terms of stocking practices, contractors typically do not keep HPWHs in stock due to the current low demand. One contractor reported that in order to start stocking HPWHs on their trucks, there would need to be a drastic change in the market. The respondent explained the current stocking practices for trucks in the field, saying,

> *"Every one of my trucks will have a 40 gallon and we'll have a 50 gallon, at least one or two. They should also have possibly a 75 gallon. Because those you can take, walk in, see it, fix it, replace it, and you're done. A heat pump is not that easy, you can't do it. While I stock a lot of tankless water heaters in my warehouse, I don't keep any on the truck either, because it's not something that is a slap-in, you need the right parts to install it. Now, if there was somebody who wanted to pay us to keep one on the truck, I might do that."*

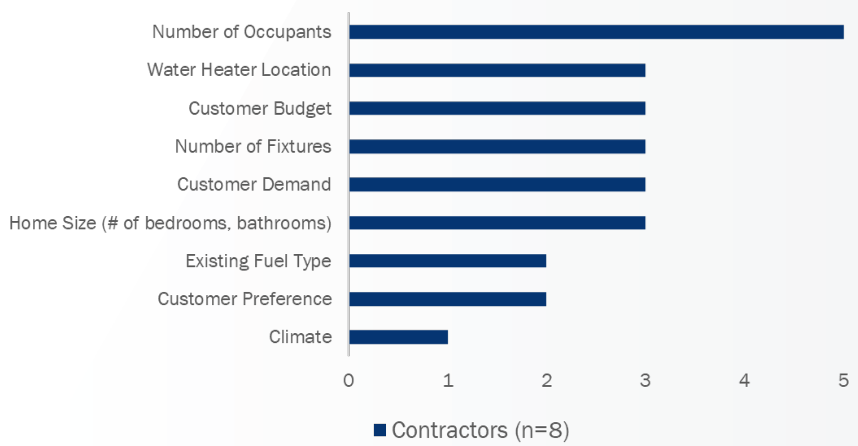
Four contractors reported that they have never had any challenges with obtaining an HPWH from their supplier. Average time to acquire the system from their supplier is typically a day or less.

5.4 INSTALLATION CONSIDERATIONS

Contractors consider multiple factors when recommending an HPWH to a customer. Top considerations cited by interview respondents and Delphi participants included the number of occupants in the household, water heater location, customer's budget, existing fuel source, and whether the home has a solar PV system. Figure 38 depicts the top considerations among interviewed contractors when recommending the appropriate water heater system to a customer.

Contractors consider number of occupants in the household, existing fuel source and customer budget among other factors when recommending a HPWH.

Figure 38. Top Considerations for Recommending Water Heater Installations among Interviewed Contractors (n=8)



System sizing is important, as the price of HPWHs increases as size increases, which is unlike other standard water heaters. Contractors from the interviews and the Delphi study typically consider the following factors when determining and sizing a suitable water heater system for a customer:

- **Home size.** Home size as a system sizing consideration varied in contractor description from the number of bedrooms, the number of bathrooms, and home square footage. Interviewed contractor opinion differed in how to assess home size from the standpoint of sizing the water heater. Two Delphi participants reported using the number of bathrooms as a sizing determinant. One interviewed contractor reported that he prefers to report size based on the number of the bedrooms rather than the number of bathrooms because the bedrooms are a better indicator of the home water demand over time. He explained with the following,

> *You can have a two-bathroom house with five bedrooms, so the bedrooms tell you the size of the family. A couple with a child might have a four-bedroom house, but the problem is when you leave, the next family will have all four bedrooms occupied so the heat pump water heater needs to supply that. More bedrooms mean more people. It's not always about how many faucets are running. It's about how many showers are taken during the day.*

- **Number of occupants.** Home Three Delphi participants explained that they size water heater systems based on the number of household occupants. For a two-person household, participants use a 40-gallon tank, while a four-person household requires a 50- or 60-gallon tank, depending on the water demand. A home with more than four occupants requires an 80-gallon tank. Three Delphi participants also noted that having a smaller household, four occupants or less, is ideal for an HPWH. Having fewer people in the home means less hot water usage, helping the water heater system recovery time, which tends to be slower than other water heater types. Five interview respondents also reported that the number of household occupants is a top consideration when recommending a water heater system.
- **Equipment location.** Most Delphi participants (5 of 7; 71%) noted that the location of a water heater in the home is very important in determining the ideal system. For a HPWH, the location should be spacious and well-ventilated. The ideal locations for an HPWH are in the garage, as such spaces tend to be larger and have enough space for air flow, circulation, venting equipment, and vertical height for changing the equipment filter. Closets tend to be too small for adequate ventilation but can modified to provide more ventilation. To keep the installation cost down, a participant noted the location of the HPWH should require very little retrofitting or ducting.
- **Existing fuel type.** Four Delphi participants reported an ideal scenario for recommending an HPWH is a home that has an existing 200-amp electrical panel with a 240v hookup. This implies there is likely enough electric supply to support the HPWH without having to upgrade the main service panel or modify the electrical system of the home, which can add significant costs to the installation. Interviewed contractors reported that they are more likely to recommend a gas-fueled system to a homeowner if the existing fuel type in the home is gas because it is less expensive to replace. While these respondents acknowledged the efficiency potential of HPWHs, various barriers to adoption prevent them from making the recommendation more frequently.
- **Solar.** Four Delphi participants reported that if a home has an existing solar PV system, that will increase their likelihood of recommending an HPWH system. Solar is helpful for keeping the HPWH's operating costs low; the solar panel generation would help offset electrical costs and shorten the payback period.
- **Homeowner Interest.** Two Delphi participants explained that an HPWH recommendation is easier when the homeowners are already familiar and interested in the technology. One of these participants noted it helps when the homeowner has an environmental attitude.

Delphi participants also discussed the tendency to oversize HPWHs. Five participants reported sometimes oversizing a water heater system to extend the capacity of the system, to enable the homeowner to participate in demand response programs, and to mitigate the risk of running out of hot water during power outages in areas with frequent power issues. Four participants explained that oversizing the system is more expensive for the homeowner. As a result, many times they do not oversize so that the project stays within budget.

> CONSIDERATION
> Some contractors oversize a HPWH to extend capacity, especially for larger families, and enable homeowners to participate in demand response programs.

One interview respondent reported that they exclusively recommend HPWHs to customers, regardless of the aforementioned considerations. The remaining contractors (7 of 8; 88%) had varying experiences in how often they recommend a HPWH system but none of them reported doing so frequently. One contractor, who typically does not recommend HPWHs, provided the following scenario as an example for when he would recommend one:

> *"The customer recently called us out [to her home] for a tankless. She had a 6,000-square-foot home and she said 'My water heater's leaking. I have a 75-gallon.' But she was complaining about not having enough hot water and she wanted to [go] tankless, but based on her demand, I did not recommend her going with a tankless. I actually recommended in her situation, because she had the space and the closet room, to fill with either a high recovery or a heat pump system. So, that way she can get enough hot water to fill up her deep soaker tub and stuff like that."*

Interviewed contractor considerations are consistent between single-family homes and multifamily buildings, though multifamily necessitates some additional consideration. Space for the physical tanks is a top factor, especially for buildings that use individual water heating rather than a shared hot water system. One contractor noted that tank systems are a more suitable option for large multifamily buildings because it is often the existing set-up, and they want to stick with their existing infrastructure.

Electrical Upgrade Situations

Electrical upgrades are often required in many HPWH installation scenarios. Delphi participants described two typical scenarios:

- **Existing electrical panel needs upgrading.** If the existing main service panel is less than 200 amps, then it is likely that the panel will need upgrading to support the electrical draw of the electric HPWH. This may be the case if the existing water heater is fueled by natural gas and is being replaced with an electric water heater, where a 220-volt electrical circuit may need to be run. Electrical panel upgrades are often expensive and require licensed electricians to conduct the work. Three participants noted they would subcontract out this electrical work to an electrician, which could also increase the overall installation cost significantly.
- **The panel is sufficient but other electrical parts need upgrades.** Delphi participants noted that at least some type of electrical work is usually required when installing an HPWH, beyond the electrical panel upgrade. Some situations are simple, while others are timely and expensive. Common electrical upgrades include installation of an electrical outlet for the water heater, a new 220-volt electrical circuit from the panel to the water heater, adding the condensate pump, or lengthening electrical wire.

Model Recommendations

Delphi participants recommended several manufacturers of HPWHs. A. O. Smith® was recommended the most, by roughly two-fifths of participants (Table 22).

Table 22. Recommended Heat Pump Water Heater Manufacturers

Manufacturer	Count of Participants (n=9)
A. O. Smith®	4
Rheem® [24]	4
Bosch®	1

[24] Two participants noted that they recommended Ruud® models which is a brand manufactured by Rheem®.

5.5 CUSTOMER PERCEPTIONS

Half of the interviewed contractors (4 of 8; 50%) reported that customers are rarely aware of the availability of HPWHs. Among them, two respondents have never had a customer ask them about an HPWH as an option for their home. One contractor specified that not only are his customers often unaware of HPWH availability, but also the customers that are familiar with HPWH systems are not interested in the technology for their home. He provided the following reason,

> *It's not me that's stopping [heat pump adoption] from happening. It's the customers. The customers are just, 'Let's keep it cheap. Let's keep it simple and get me hot water and get out of my house as quickly as possible.' That's the genre of customers I have around here.*

Interviewed contractors reported that customer interest and education on the benefits of HPWH systems is essential to the growth of demand throughout the state. One contractor shared that he anticipates the more people who are educated about the capabilities of an HPWH, the more customer interest will grow. In particular, one contractor emphasized that customer interest would grow if people became aware of the potential for HPWHs to improve their utility bill costs.

CONSIDERATION

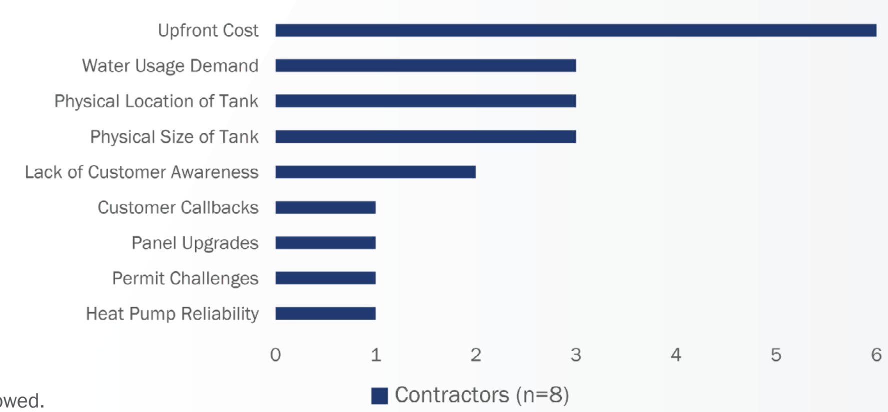
Customer education on the benefits of heat pump water heater systems is essential to grow demand throughout California.

The remaining four interviewed contractors have worked with customers who demonstrated interest in HPWHs, two of whom reported that customers learned about the technology through incentive programs. One of the respondents said that the customers who learned about HPWHs through the incentive programs are typically motivated by the desire to receive a rebate.

Some interviewed trade allies (4 of 12; 33%) reported that homeowners with solar will likely benefit more from HPWH adoption in their residence. One contractor reported that customers are rarely aware of HPWH technologies, but those who do approach him about HPWH installations are people with solar systems installed. Customers with solar energy benefit from an HPWH because they are motivated to transition all the home's energy usage to electric.

Contractors expressed multiple concerns with HPWH adoption. Among interviewed contractors, respondents were primarily concerned with the upfront cost of equipment and installation, the installation processes, meeting customer water usage demand, and an inability to provide hot water during a power outage. Delphi participants reported barriers related to electrical panel upgrades, adequate space for the equipment, and a lack of customer awareness or interest. Figure 39. depicts interviewed contractor concerns related to working with HPWHs. Respondents' primary concern was the upfront cost of the equipment and installation (6 of 8; 75%). Concerns related to installation processes included having adequate location for the HPWH tank, the physical size of the tank, electric panel upgrades, and permitting challenges.

Figure 39. Interviewed Contractor Concerns with Heat Pump Water Heaters (n=8)



Note: Multiple responses allowed.

Upfront cost of the HPWH created concern for the contractors because it deters customers' willingness to move forward with installation in their home. Two Delphi participants also described upfront cost as a key barrier for moving forward with HPWH installations. One respondent explained in an interview,

> *I typically don't recommend [heat pump water heaters] just because of the initial costs. In our business, it comes down to numbers 95% of the time. So, most customers want the cheapest thing, and then they'll get the cheapest thing with the product that will get the job done.*

Delphi participants reported the cost of installing an electric HPWH in place of a natural gas water heater can be prohibitive to homeowners if the home does not have an existing 200-amp service panel and 220v hookup. In these scenarios, the panel must be upgraded, which significantly increases the total cost of the installation. Other concerns included the ability to meet customer water usage demand and the physical size and location for tanks within the residence. Interviewed contractors were of the opinion that HPWHs cannot always fulfill the demands of families with high water usage, especially in terms of recovery after the tank is emptied. One interview respondent felt that, under perfect conditions, an HPWH pulls ambient heat out of the air and heats the water in the tank, which can be a comparatively slow, but energy-efficient process compared to other systems. Therefore, the respondent's opinion was that HPWH is not ideal for large families with high demand, because once the tank is emptied of hot water it can take longer to recover. Over half of the Delphi participants (4 of 7; 57%) echoed the same sentiment: HPWHs work better in households with fewer occupants due to slower recovery time. One interviewed contractor summarized how this can lead to customer dissatisfaction,

> CONSIDERATION
>
> Contractors are reluctant to offer HPWHs to larger families due to the lower recovery rate as compared to natural gas units.

> *That's the biggest consideration: do you have any large sudden water demands? Because those are the things that'll make you look real bad if it doesn't work.*

Physical location and size of the space available for the water heater is also a contractor concern. Three interviewed contractors (38%) each reported concerns with location and space. The suitability of the water heater location is important because HPWHs need plenty of air circulation and a location for the condensation line and where to drain it. This was echoed by Delphi participants, where three explained that the location of the equipment needs to be large enough to house the equipment. These participants reported a garage or attic would be ideal locations for the equipment, while a closet would be too limiting. Ultimately, contractors recommended that the water heater should be located in a large and well-ventilated space, otherwise the physical space will fill with cold air without anywhere to go. If the cold air is not ducted and becomes trapped in the space, the HPWH operates more consistently to generate heat and loses its efficiency potential.

The HPWH size is also a concern because the tanks are large and require a space to accommodate its size. For example, water heaters located in smaller homes, apartments or condominiums are commonly located in tight closets, which may not be a plausible space for an HPWH due to the inability to physically fit or the circulation need. A Delphi participant described an installation scenario where a major closet remodel was required because the space was physically too small for the water heater equipment. One interviewed contractor was specifically concerned with the size of the HPWH tanks for his geographic region,

> *[Heat pump tank size] is not suitable to probably 40% of homes, especially in the mecca of San Francisco, because they have microhomes. Some of the old homes are microhomes and they will not fit.*

Other contractors, however, do not find space to be an issue, reporting finding different locations for the water heater. Varying opinions suggest that challenges related to the physical size and space differ based on contractor experience and location.

> *Most everybody is either putting it in a basement, which is big, or they're putting it in a large garage, so there hadn't been any issues of that because the ventilation is fine on those and you can always vent it out.*

The contractor who expressed concern with reliability and callbacks was particularly concerned with the manufacturer. The respondent reported challenges with acquiring parts through one of the leading manufacturers of HPWHs in California. The parts are not always readily available to the contractor and, while he has not yet had any callbacks from customers, there is concern about the potential for faulty parts and systems from the manufacturer leading to customer dissatisfaction.
Another barrier of HPWH adoption surfaced in the Delphi study: two participants noted that some HPWH models are noisy and this can be a deterrent during the sale process of convincing a customer to choose an HPWH.

One interviewed distributor reported that he considers HPWHs as "highly efficient," but prefers tankless to an HPWH system because he views them as equal in terms of efficiency and the HPWH is more expensive. He also expressed concern with using an electric water heater due to the potential for power outages. The second distributor did not support HPWH adoption because he did not see the benefits, citing HPWHs are "great in theory, but terrible in practice." The respondent said the following,

> *I mean there really isn't a benefit for contractors to offer heat pump water heaters for their customers, other than if there was a massive financial incentive for them. But in terms of putting one in and telling the customer, 'Oh, this is going to be awesome,' they're going to get a call back that it's too loud and they don't have enough hot water.*

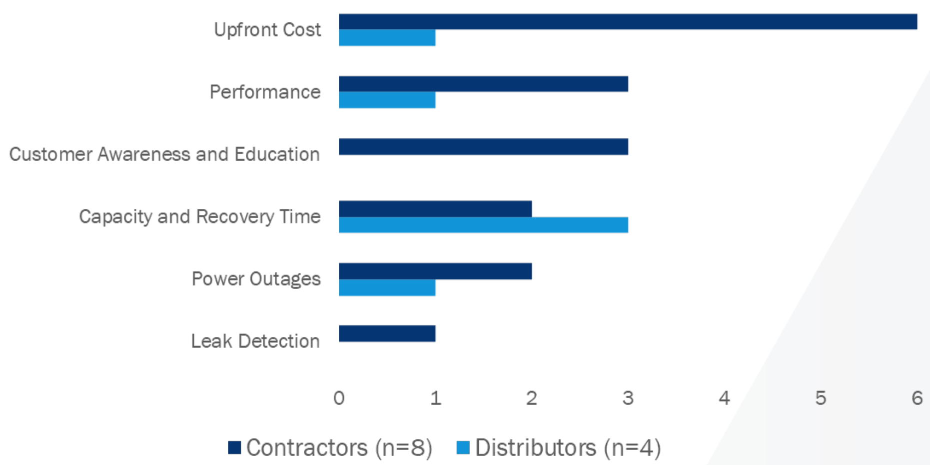
One interviewed contractor reported an unwillingness to promote HPWH systems because he had concerns with the added demand on the electric grid and the gas piping infrastructure already exists to operate high efficiency gas appliances. When asked how they feel about working with HPWHs in the future, the respondent reported the following,

> *I think it's a big joke. But the problem is, I'm not in control of who's telling the joke. If enough people go along with it, then that means that I'm going to have to adapt my course. Like I stated originally, the most efficient use of natural resources, power, is to just have a meager, gas-sipping, high efficiency boiler unit and indirect water heater. Or just whatever it is, a very high efficiency gas appliance. Your power grid issues, which are the most impacted things here in California with the rolling blackouts as we used to have about 10 or 15 years ago. I remember those. You immediately solve the problem. Our gas piping infrastructure is in place, and instead of having heinously low efficiency gas appliances, we now have efficiencies in the 90s, mostly.*

Perceived Customer Concerns

Figure 40 depicts interviewed trade ally perceptions of customer concerns regarding their water heater system, which largely mirror the contractor concerns discussed above. Common concerns for customers when determining whether a HPWH is suitable for their home include upfront cost of the system and installation, overall performance and system recover time to meet usage demands, and homeowner unfamiliarity with the technology and its functionality.

Figure 40. Interviewed Trade Ally Perception of Customer Concerns (n=12)



Note: Multiple responses allowed.

Interviewed distributor and contractor respondents reported that upfront cost is a key concern for the customer (7 of 12; 58%). As one interviewed contractor expressed,

> *Most of my customers, they want their water heater to work in their garage. They don't want to look at it. They don't want to think about it. They don't care about it. They don't care about the environment. They just want the hot water when they need it, and how cheap can you do it.*

Both interviewed trade allies and Delphi participants described customer unfamiliarity with HPWH technology as a hinderance in customer HPWH adoption. Many customers have not heard of HPWHs or are unfamiliar with their functionality, which can lead to reluctance to select it for their home. One contractor reported that customer lack of awareness is one of the main barriers to heat pump adoption in California, explaining,

> *I don't see any long-term weakness with a HPWH system. It's just practicability. It's just getting people to have them and want them, and it being a common everyday thing, I think that's going to be the biggest transition, just getting them in people's homes.*

In addition to lack of customer awareness of heat pump systems, interviewed trade allies also reported that customers who are aware often lack education on system functionality and their advantages. For example, one contractor said most of his customers do not understand the environmental implications of a gas system or the rationale for moving from a gas to electric system in their home.

Heat pump water heater performance, capacity, and recovery time were leading concerns for customers, according to interviewed trade allies. While three interviewed contractors and one distributor (4 of 12; 33%) reported customer concern with overall performance and reliability, two contractors and three distributors (5 of 12; 42%) specifically mentioned HPWH tank capacity and its ability to recover hot water supply after periods of high demand as a concern in their homes.

> CONSIDERATION
> Customers and contractors were most concerned about HPWH performance, capacity, and recovery time.

Another concern was related to the use of electricity as the power source for a water heater. Two interviewed contractors (25%) said that the prevalence of power outages can create customer resistance to electric water heater adoption. One respondent reported that selling electric water heaters to customers in California can be challenging because of their inability to produce hot water during an outage. This contractor reported a need for a back-up power option for electric water heaters in the event of blackouts before he can be a “fan” of HPWH systems. The other reported that his customers bring up power outage concerns in about 25 percent of HPWH discussions. One contractor also reported that his customers are often concerned about leak detection. They ask specifically about leak detection and whether it has an audible alarm in order to avoid flooding in the residence.

5.6 HEAT PUMP WATER HEATER COSTS

To better understand the costs of residential HPWH installations, Delphi participants filled out hypothetical quotes for installing a residential tankless water heater and an HPWH in the following home scenario (Figure 41). We collected data on costs related to equipment removal, equipment units, installation materials and labor, electric supply and space ventilation materials and labor, and plumbing modifications. We then computed a total cost for ASHP installations. Contractors do not typically break down quotes into these specific components. Knowing this, we first asked contractors to estimate a total cost and then asked contractors to estimate costs for the specific elements. In almost all cases, the total estimate was within 10% of the computed estimate.

Figure 41. Home Specifications for Heat Pump Water Heater Install

Home Vintage	Household Size	Existing Water Heater Type	Existing Water Heater Location	200 Amp Service Panel	Existing 240V Electric Hookup
Pre-1978	2 person	Natural Gas Storage-Tank	Garage	Yes	Yes

Equipment Removal Costs

Participants reported an average cost of $247 to cover the materials and labor associated with removal of any existing equipment before installing an HPWH (Table 23). While the range of costs seem large, spanning from $0 to $563, only one participant (1 of 7; 14%) quoted $0 explaining that they include the cost of removal in their estimate for installation labor while the rest of the participants quoted costs much closer to the average cost. The participant said the same for their tankless water heater quote as well. The difference between average cost of equipment removal for a tankless water heater versus an HPWH was very small with tankless water heaters installations having a slightly higher average equipment removal cost of $304.

Table 23. Equipment Removal Costs

Equipment	Minimum	Maximum	Median	Average
Tankless Water Heater	$0	$915	$225	$304
Heat Pump Water Heater	$0	$563	$240	$247

Over half of the participants (5 of 9; 56%) reported the average equipment removal cost for an HPWH installation to be accurate and in line with what they quoted. One participant felt that the average cost was higher than expected; they explained that they utilize a fixed rate for equipment removal that stays constant for all jobs or home specifications. Conversely, the other contractors cited the variability of each job as a reason for costs to be higher, emphasizing the influence of the geographical location of the home and condition of existing equipment in removal cost.

Equipment Unit Costs

The average unit cost for an HPWH unit and a tankless water heater were very similar: $1,575 and $1,484, respectively (Table 24). Similarly, the two units had a comparable range and median value showing the similarity in upfront unit cost between the two types of units.

Table 24. Equipment Unit Costs

Equipment	Minimum	Maximum	Median	Average
Tankless Water Heater	$750	$3,050	$1,500	$1,484
Heat Pump Water Heater	$700	$3,250	$1,300	$1,575

Participants provided a large range of HPWH unit costs, varying from $700 to $3,250. Potential reasons for the range in HPWH unit costs include:

- **Type of HPWH.** There are many different HPWH models, sizes, and brands available that vary in price due to perceived quality associated with brand name models compared to off-brand models.
- **Contractor experience**. Contractors' varying levels of experience with HPWH installations cause variation in the mark up on equipment prices to cover any overhead associated with install. Also, contractors with more HPWH projects can buy units in bulk driving down unit cost.
- **Location of installation.** The location of the HPWH installation can greatly affect the cost of install in terms of labor and materials costs.

Installation Materials and Labor Costs

Delphi participants reported an average cost of materials and labor associated with installation of an HPWH of $805 with quotes ranging from $300 to $1,850 (Table 25). The range of HPWH installation costs is reflective of tankless water heater installation costs as well.

Table 25. Installation Materials and Labor Costs

Equipment	Minimum	Maximum	Median	Average
Tankless Water Heater	$0	$1,300	$500	$647
Heat Pump Water Heater	$300	$1,850	$650	$805

Most of the participants (6 of 7; 86%) attributed the wide range in materials and labor costs for installation to innate differences between contractors. Cost-shifting differences include contractor experience level, the amount of contractor competition in a given location, and HPWH brands available. The presence of more contractors with HPWH installation experience in a given area leads to competition driving prices down, but as experience levels increase so does quality of work and cost of installations. Participants emphasized the competitive landscape of the HPWH market as driving a lot of cost variation across the industry.

Electric Supply and Space Ventilation Materials and Labor Costs

For the HPWH installation quote, the costs of materials and labor for electric supply and space ventilation were split into two separate line items, while the tankless water heater quote combined natural gas, electric, and ventilation modifications into one line item. For the sake of comparison, all are shown in Table 26 below. The combined minimum, maximum, median, and average costs of HPWH electric supply and space ventilation are very similar to the respective quotes for a tankless water heater.

Table 26. Electric Supply and Space Ventilation Materials and Labor Costs

Equipment	Minimum	Maximum	Median	Average
Tankless Water Heater – Natural Gas, Electric, and Ventilation Modifications	$0	$1,500	$505	$536
Heat Pump Water Heater – Electric Supply	$0	$920	$330	$403
Heat Pump Water Heater – Space Ventilation	$0	$650	$200	$234
Heat Pump Water Heater – Combined Electric Supply and Space Ventilation	$0	$1,570	$530	$637

While the average cost of combined electric supply and space ventilation for an HPWH ($637) is only marginally higher than the average cost for a tankless water heater ($536), participants reported a wide range of costs for both water heater units. Participants explained that the predominate reason for the variation in electric supply costs was whether or not an electrician needed to be hired. A little over half (4 of 7; 57%) of the participants reported being licensed electricians themselves and thus not needing to outsource any electrical work reducing costs, while the rest (3 of 7; 43%) would have to involve an electrician to complete any electrical upgrades. One of the two participants to quote $0 for this line item reported they would increase their original quote from $0 to $330 to budget for electrical upgrades they did not consider previously.

Participants reported location of the water heater and the time involved in installation as the main reasons of cost variation in space ventilation costs. Two participants reported that they would alter their space ventilation quotes after reviewing the average of all participants. One increased their cost by $200 to a total of $400 and the other increased their original cost of $95 to $550 to account for both materials and labor.

Plumbing Modification Costs

The average cost of plumbing modifications for an HPWH reported was $403, which is more expensive than the $289 average costs for plumbing modifications for a tankless water heater (Table 27). While the range of plumbing modification costs for an HPWH were similar compared to the tankless water heater range reported, participants reported a median HPWH cost almost double that of the tankless water heater quote ($502 and $275, respectively).

Table 27. Plumbing Modification Costs

Equipment	Minimum	Maximum	Median	Average
Tankless Water Heater	$0	$795	$275	$289
Heat Pump Water Heater	$0	$700	$502	$403

Similar to many of the other costs, many participants (5 of 7; 71%) reported that location, both of the unit within the home as well as geographically in the state, was a predominate reason for the wide variation in reported costs.

Total Costs

The range and average of total costs between the HPWH and the tankless water heater were similar. Participants reported an average total cost for a HPWH as $3,908 with a range from $1,400 to $5,825 (Table 28). The average total cost for a tankless water heater was $3,471 with a range from $1,665 to $5,850.

Table 28. Total Costs

Equipment	Minimum	Maximum	Median	Average
Tankless Water Heater	$1,665	$5,850	$3,449	$3,471
Heat Pump Water Heater	$1,400	$5,825	$3,894	$3,908

In general, almost all participants (6 of 7; 86%) agreed with the lack of difference between the total cost of a HPWH and a tankless water heater given the home specification provided in Figure 30. When asked about the reason for the range in total costs, participants noted factors like location (both of the unit within the house and of the home generally), contractor experience, and customer budgets as potential cost shifters. Many of the participants also reported the extent of electrical upgrades needed as a potential for large amounts of variation between installations.

5.7 INCENTIVES

Eight interview respondents (8 of 12; 67%) reported experience working with incentive programs related to residential water heating installations, while all Delphi participants (n=7) reported familiarity with such programs. Participants listed a variety of incentive programs, summarized in Table 29.

Table 29. Heat Pump Water Heater Incentive Program Awareness among Delphi Participants (n=7)

Rebate Program	Count
PG&E	5
BayRen	4
Rheem	3
Federal Tax Credit	3
Sonoma Clean Power	2
Other Bay Area programs[a]	1

[a] Other programs included Marin Clean Energy, East Bay Community Energy, Silicon Valley Clean Energy, San Jose Clean Energy, and CleanPowerSF.

Interviewed trade allies suggested that utility incentive programs are having an impact and will continue to have an impact on HPWH market growth. One distributor summarized this sentiment with the following,

> *"I think the incentives and the regulations are going to drive this whole thing. It's an expensive unit, more than twice the cost of a gas unit. It's half the recovery ability of the gas unit and it costs twice as much. And it's three to four times more efficient. So, you have opposing reasons to look at this unit. It's more efficient, it's better for the grid, and we can save our carbon footprint with less natural gas. Great, everyone would say that's good. But now you have to offset that with, you have to pay twice as much for it."*

Another distributor echoed this statement by saying, "If the utility has a strong rebate in place, then the market is strong." Customers are motivated by the financial incentive and it piques their interest. Evidently, some customers are already aware of these rebate programs. Most Delphi participants (6 of 7; 86%) reported that many of their customers come to them already aware of financial incentives for HPWHs. One interview respondent worked with a customer that purchased one of his "lavish" HPWHs that costs approximately $10,000 because his incentive from a non-IOU was close to $26,000 when including solar and battery plus storage as part of their project.

Five interview respondents reported that they do not work with rebate programs for water heating equipment, either because they do not think the monetary value provides enough incentive (3 of 5; 60%) or because they were unaware of the programs (2 of 5; 40%). One Delphi participant explained that no HPWH rebate program could provide large enough incentives to offset the high electricity costs associated with operating the equipment. Additionally, while one distributor currently participates in a rebate program, they noted that they planned to leave the program at the end of the year. The distributor reported that the program structure was confusing and did not feel comfortable with the amount of money he had to spend upfront and subsequently wait until the end of the month for reimbursement. One contractor said that there is "no reason" to install any HPWH other than those that qualify for a rebate because "it's not cost effective for them at this time." The respondent emphasized that, while he does not participate in rebate programs nor recommend the technology to his customers, the "rebate is key" in maintaining customer demand.

Delphi participants reported monetary values that could make a HPWH installation attractive for a customer. While one participant reported no monetary value would make it worthwhile, three others quoted an amount between $1,000 and $2,000 per system. One participant felt that a lower amount, $300, would be appropriate. Two participants provided more ambiguous amounts: whatever the cost difference is between a HPWH and a traditional gas water heater, and 15 percent of the upfront unit cost of the HPWH.

Some rebate programs exist to provide HPWH installers with incentives at point-of-purchase. About half (4 of 7; 57%) of the Delphi participants were aware of these incentive opportunities and listed several of them: Rheem®, Energy Solutions, and BayRen. In scenarios where contractors receive the rebate instead of the customer, most participants (5 of 7; 71%) typically pass on the financial savings from the rebate to their customer, either by lowering the total installation cost or directly passing on the rebate. This establishes goodwill between the contractor and the customer, improving the likelihood of referral. Three Delphi participants reported they were not aware of any point-of-purchase rebate programs for contractors.

5.8 TRAINING OPPORTUNITIES

Among the ten interview respondents who we asked about training opportunities, nine (90%) reported that they find value in training. Distributors noted that they offer trainings within their company or through their manufacturers. Trade allies reported that valuable training content includes sales, installation, maintenance, and technical troubleshooting. One respondent highlighted what he thinks is missing from current training opportunities,

> *"The problem is when the manufacturer does a training, they teach you about that particular unit, how it works, what wire goes where, and how to install this particular unit. On the other side, you get these sales trainings and they're just guys trying to teach guys how to close a job. There's nothing in the middle that takes the person and says, how do I apply this technology to this house. In order for someone to figure that out, they have to seek out that training through a bunch of little pieces here and there and put together the path themselves."*

This contractor outlined a gap in his training experiences and indicated that he would like to see company-wide trainings that are hosted in-house and take place overall several days to provide firsthand experience with installation and troubleshooting processes. The respondent emphasized the value in training an entire company at one time in order to effectively implement what was learned. He provided the following on the training content,

> *The utilities have great trainings about how a blower door test works, but nothing about how to tell if the house is right for a heat pump, how to communicate with the customer, or how to work with the customer to make the right decision. They teach installers how to install, but no one teaches the middle. The only entity you'll get to train that is someone who's actually doing it and willing to share.*

Another interview respondent emphasized that the main barriers to participating in trainings are travel and cost. Contractors must invest time on learning that could be spent out in the field with customers. When in-person, the trainings can also require contractors to travel long distances and pay out-of-pocket to invest in their education. One respondent suggested that in order to get a particular technology "off the ground" and "get something more common in the market, free and easy is the best method." The respondent said that offering trainings in a free and convenient manner for the contractors could be an opportunity promote emerging technologies.

6. GROUND SOURCE HEAT PUMPS

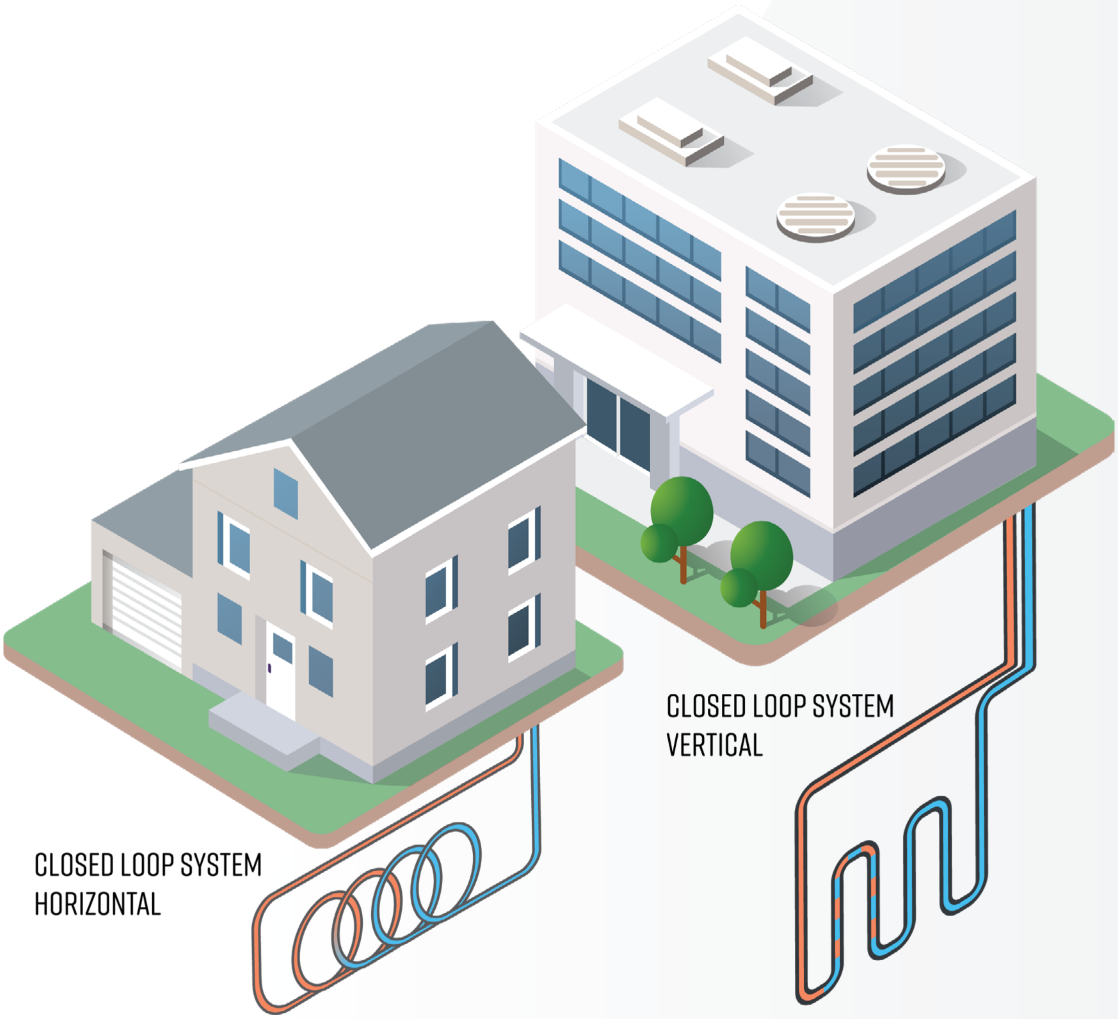
Ground source heat pumps, also known as geothermal heat pumps, rely on the fact that the underground temperature remains a fairly consistent temperature throughout the year—warmer than the air above the surface during the winter and cooler than the air above the surface during the summer. During the winter, an GSHP extracts heat from the ground and transfers warm air into the home. During the summer, heat is extracted from a home and transferred to the ground. The ground, in other words, acts as a heat source in winter and a heat sink in summer. Ground source heat pump can reduce the energy consumption from 20 percent to 50 percent in the cooling mode and 30 percent to 70 percent in heating mode when compared to conventional HVAC systems.[25] System life is estimated at up to 24 years for the inside components and 50 plus years for the ground loop. A GSHP system includes three principal components:

1. **Earth Connection Subsystem.** A series of connected pipes, commonly called a "loop," are buried in the ground near the building to be conditioned. The loop can be buried either vertically or horizontally (Figure 42). It circulates a fluid (water, or a mixture of water and antifreeze) that absorbs heat from, or relinquishes heat to, the surrounding soil.

2. **Ground Source Heat Pump Subsystem.** For heating, a GSHP removes the heat from the fluid in the earth connection, concentrates it, and then transfers it to the building. For cooling, the process is reversed.

3. **Heat Distribution Subsystem.** Conventional ductwork is generally used to distribute heated or cooled air from the GSHP throughout the building.

Figure 42. Ground Source Heat Pump Loops



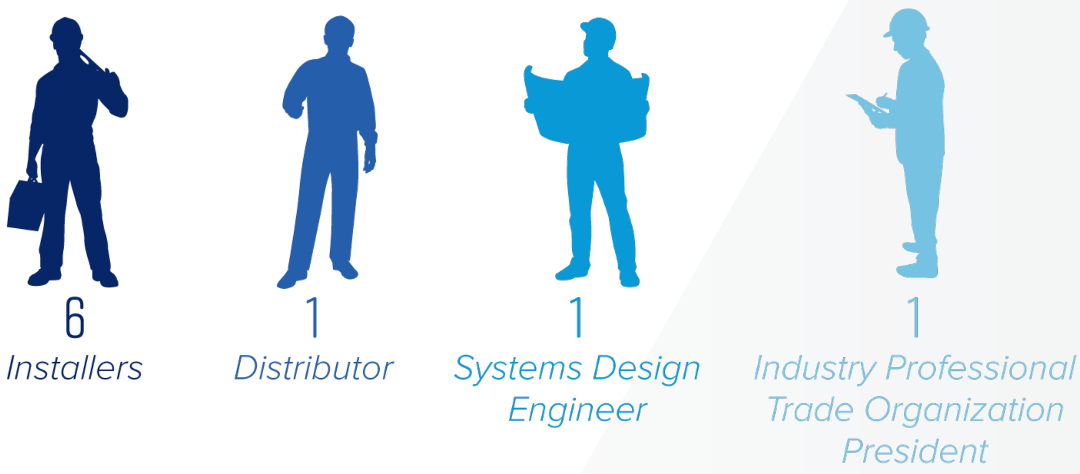
[25] https://www.geoexchange.org/library/renewable-and-ready/

Residential GSHPs are a proven technology with historically variable rates of installation within California over the last four decades. While initial interest in the technology remains high, market adoption rates have dropped, as compared to even a decade ago, while energy costs have continued to climb, and the efficiency gains of these systems become even more attractive.

6.1 DESCRIPTION OF RESPONDENTS

The findings represent the viewpoints of nine GSHP trade allies (Figure 43). The respondents represented three regions of the State—the greater Bay Area, including Silicon Valley, the Northern Sierra Mountain region, and one respondent along the California and Oregon border. We could not locate GSHP professionals in the Southern California region, and interviews with multiple engineering and architectural professionals in the Southern California region revealed that no GSHP residential installations occur there due to their relatively moderate temperatures and the effectiveness of air-source heat pumps. The respondents have a significant history of participation in this market space, with several conducting operations for over 20 years. Combined, the experts represent over 144 years of installation and design experience of GSHPs in California's market.

Figure 43. Interviewed GSHP Trade Allies



Of the respondents who currently conduct GSHP installation activities in the state, the total number of GSHP units installed was 1,200 over a 30-year span, though three respondents accounted for over 900 of those installed units (range: 20-400 units; median: 150 units). A single respondent performed numerous GSHP installations on a military base during this period and these numbers skewed the total count.

6.2 OVERALL GROUND SOURCE HEAT PUMP MARKET

Market data for GSHPs is scarce. There are approximately 50,000 GSHPs installed in the United States each year.[26] However, no specific California installation data could be located. Some market analysts expect the HPPH market to grow at a compound annual growth rate CAGR of 3.4% worldwide during the period between 2018 and 2024.[27] Eminent players across the GSHP industry are Swegon®, Thermic Energy, Solarbayer, Wolf®, Toshiba®, Systemair®, Weishaupt®, Trane®, Vaillant®, Viessmann®, Glen dimplex, Stiebel Eltron®, Bosch® Thermotechnology, Danfoss®, Modine®, Mitsubishi Electric®, Daikin®, NIBE®, Carrier®, Bard HVAC, Spectrum Manufacturing, Green Planet Supply Technologies, OCHSNER Warmepumpen, ClimateMaster®, Earthlinked® Technologies and Nortek Global HVAC.

[26] https://www.energy.gov/energysaver/heat-and-cool/heat-pump-systems/geothermal-heat-pumps
[27] https://www.gminsights.com/industry-analysis/geothermal-heat-pump-market

The market actors we spoke with indicated that there is a lot of interest in GSHPs in the residential market driven by environmental interests, including a desire for individuals to be carbon neutral and be trendsetters. One installer indicated that he receives on average seven phone calls a week inquiring about GSHPs. Most installations occur in larger high-end residential homes as the economics of installation in smaller homes are challenging. As one market actor described,

> *I think there is a lot of interest in GSHPs because of the current challenges in the state. However, the clients I work with are higher end custom home clients. These are not a typical install in a housing development—They are usually 'McMansion' installs. I have designs for various sizes of homes and there is a growing interest in GSHPs. I wish we could level the playing field and allow all economic backgrounds to have access to this technology.*

Market actors indicated the key benefits of GSHP technology are significant heating and cooling cost savings, low environmental impacts, and that GSHP systems are very quiet. According to the International Ground Source Heat Pump Association website, the Department of Energy (DOE) and the Environmental Protection Agency (EPA) have both endorsed GSHPs as highly efficient and environmentally friendly space heating and cooling technology. All the market actors we spoke with confirmed this fact, with one installer stating,

> *GSHPs are the most energy-efficient heating and cooling system on the market and they have a low carbon footprint.*

A majority of GSHP installers (5 of 6) stated that repair and maintenance of GSHP systems made up about 50% of their total business activity. Respondents indicated that their total GSHP installation activities in the past two years were either 100% residential installations (n=3) or 50% residential and 50% commercial (n=3). There were no reports of any multifamily or low-income sector GSHP installations performed within the State during the previous two years. As one contractor explained,

> *We only installed in single-family homes. We have done feasibility studies for GSHPs for multifamily, but they just never happened—typically due to the first costs. We had a project in Davis for multifamily but the people who set up the project did not seek the required funding for square feet and that made GSHP not feasible. It was a big disappointment. A lot of affordable housing projects want this due to the much lower costs of operations, but the first cost hurdle is very challenging.*

The interviewed distributor reported that single-family homes are an excellent platform for GSHP adoption and that the opportunity for utility companies to install ground loops at the street level would allow homes to access the loops and mainstream the technology in California. The types of single-family homes most suitable for GSHP system installations are larger homes and those that currently use propane as a heating source. As one installer explained,

> *I am excited when I have a propane client due to the paybacks because geothermal is much more cost effective against propane, I push geothermal much harder.*

Replacement of GSHPs that are at the end of their effective useful life is another driver of the GSHP market. One market actor explained that utilities supported GSHPs in the late 1990s and early 2000s and those systems are due for replacements. From his experience, homeowners who have GSHPs most of the time want to replace these systems with new GSHPs.

> *Having pre-existing GSHP systems in my area does drive new customers and, if they have a loop already in the ground, they will generally all get the geothermal as a replacement. It is kind of locked-in, especially if they are still paying (the loop) off.*

6.3 STOCKING AND SALES PRACTICES

The equipment distributor provided multiple product offerings to the public and to contractors, including GSHP equipment. They reported 95% of their GSHP sales are to contractors and 5% are to homeowners. They determined that 100% of their GSHP sales last year went to new construction installations. When asked what percentage of their HVAC business is composed of GSHP sales, the interviewee responded that it was 30% of total sales in units and 40% of total sales revenue. They characterized current market operations in California for GSHPs as "slow."

The distributor offers one brand due to its perceived market dominance in the space: the ClimateMaster brand of GSHP equipment. The interviewee stated that if the regional volume of sales increased then they would stock GSHP equipment in their store. When ordering GSHP equipment, delivery time is approximately four to six weeks after an order is placed.

When asked if the distributor would enter into an agreement with the State to pass-through incentives to GSHP customers, the response was positive, with the following explanation,

> *I would have to look at the details. Many of the things that come through the State in the form of incentives are burdensome to the contractors and distributors, they make people jump through a lot of hoops. Contractor incentives are paltry compared to actual install costs of these systems and the pre/post assessment and the billing analysis assessments can be a whole day long. The HERS inspection and the post inspection take a lot of time for the homeowner. Right now, it is work from home so maybe it is better on the homeowner, but the cumbersome nature of the incentives from contractors for any of the programs are not really being thought out by people in the field. The city inspection process, if things go right, takes two weeks. If they can streamline that and not make it so cumbersome, then we would do that.*

All installer respondents reported no difficulties in procuring GSHP equipment from suppliers. They reported the longest lead-time requirement as four weeks. The time needed to procure GSHP equipment did not negatively impact GSHP installations because the installation timeline is dictated by the availability of drilling contractors. Installers' preferred suppliers are found in Table 30.

CONSIDERATION

The availability of a drilling contractor dictates the schedule for an GSHP installation, not the time needed to procure equipment.

Table 30. Preferred Ground Source Heat Pump Equipment Suppliers (n=7)

Distributor	Incidence
ClimateMaster Inc	3
WaterFurnace Renewable Energy Inc.	2
Enertech Global LLC	1
Green Equipment Options	1
Western Nevada Supply Co.	1

Contractor respondents reported that far more residential clients contact them with initial interest in a GSHP unit than are installed. First-cost issues are a primary hinderance with some installers (2 of 6) requiring a deposit before they perform an initial feasibility analysis for the home installation. This practice was adopted as a preventative measure to ensure that the customer has initial buy-in and will not cancel the project when presented with the system first costs and after considerable time was invested by the installer.

When asked about the perceived recent changes in the GSHP market, respondents provided the responses found in Table 31.

Table 31. Recent Ground Source Heat Pump Market Developments (n=8)

Type of Market Development	Incidence
Technology developments (variable speed, digital controls, modular “plug-and-play” designs)	3
COVID-19 impacts	2
Increased interest in electrification and ‘going green’	1
Cost and operational effectiveness of mini-split and air-source heat pumps	1
The incorporation of domestic water heating with HVAC in GSHP loop operations	1
None	1

Note: Multiple responses allowed.

Most respondents (6 of 8) reported the California GSHP market is growing, with one characterizing the growth occurring “at a snail’s pace.” Two respondents reported either no growth in their area or that their current business operations were exclusively the replacement of GSHP units that were at end-of-life. This last individual reported some spillover interest in his area for new installations but with no recent new adoptions.

CONSIDERATION

While most GSHP trade allies think the market is growing, the growth is minimal.

When asked about the primary drivers for current market growth in GSHPs, respondents reported the results found in Table 32. COVID-19 was cited as a driver because people are at home more and “thinking about their houses more.”

Table 32. Drivers for Increased Market Adoption of Ground Source Heat Pumps (n=8)

Market Driver	Incidence
Education	3
Customer spillover from interactions with 'friends back East' or neighbors with GSHP installed	2
Climate change	3
Wildfires/PSPS shutoffs	1
COVID-19	1
Tax credits	1
Advertising	1

Note: Multiple responses allowed.

Respondents primarily cited financial factors when asked about future drivers for market growth in GSHPs over the next 5 to 10 years (Table 33).

Table 33. Primary Future Market Drivers in the Ground Source Heat Pump Market (n=8)

Market Driver	Incidence
Utility incentives	2
Technical innovation	1
Energy efficiency & cost of operations	1
Cost of natural gas	1
Future state-level regulations & incentives	2
Local prohibitions on natural gas new construction	2
Advertising	1

6.4 INSTALLATION CONSIDERATIONS

Respondents were asked about their approach to determining the feasibility of GSHP installation at a given location and any specific challenges that they may have experienced in providing these installations. We discuss their answers below.

In all cases, respondents reported that open-loop systems, defined as systems that draw and discharge water from a lake, pond, or river, are not feasible in California due to extensive environmental permitting processes involved. Characterization of the previous two years of installations revealed that, of the 25 residential systems installed in California, 6 were horizontal loops and 19 were vertical loops. Several installers indicated that the prevalence of vertical loop installations was due to the lot size where the residence was situated and that smaller lots would not support a lower-cost horizontal loop installation on site. In some climate zones in California, the soil is very rocky and dense making horizontal loop installations more feasible that vertical loop installations.

CONSIDERATION

Vertical loop GSHP systems are more prevalent due to lot size, but in some climate zones, horizontal loop systems are more feasible due to soil conditions.

All respondents reported that they would size a GSHP system to meet 100% of the customer's heating load, with 6 of 8 reporting the use of the Manual J (Title 24 approved) heat load calculator. One of these respondents noted that the Title 24 Manual J calculation methodology was inappropriate for GSHPs and that this produced an additional hurdle for adoption.

In all cases, the selection of GSHPs as the appropriate unit was independent of the pre-existing system type, fuel, and material condition.[28] All installers indicated that customer preference and budget considerations were the exclusive market driver. One respondent noted that a whole-house approach was his preferred method when rightsizing a GSHP system and that a successful retrofit with associated measures in place would reduce the GSHP system first costs by a significant margin due to the lower heating demand on the system.[29] In all cases, except in extremely cold weather climates where a back-up heating system is required by code, respondents stated that they would always remove the operational system that was being replaced during a home retrofit.

The time lag between initial customer contact and GSHP installation was reported to be 35 days on average (range: 7 to 60 days; median: 32 days) with one respondent stating that an installation may take as long as six months for permitting approval. No respondent declared that voltage or supply panel issues were a significant barrier to market adoption of GSHPs with two respondents noting that if the supply panel service was ever an issue that they would incorporate a “soft-start kit” that would reduce the GSHP compressor’s starting surge.

6.5 CUSTOMER PERCEPTIONS

Respondents who do not exclusively install GSHP systems reported that customers were the first to initiate conversations about GSHPs about 50% of the time (range: 1% to 100%; median: 50%). The respondent who reported 100 percent customer initiation attributed this to their advertisement portfolio that strongly promoted GSHPs. Two other respondents stated that they only performed GSHP installations and so had a natural 100 percent customer initiation rate.

The customer drivers for market adoption of GSHPs as reported by installers are in Table 34. The main customer drivers for GSHP retrofits in the residential market appear to be the desire to save on energy, save on costs, and save the environment by moving to a ‘greener’ option.

Table 34. Perceived Customer Motivations for Ground Source Heat Pump Adoption (n=8)

Customer Motivations for Adoption	Incidence
Energy savings	4
Lower fuel costs (fuel substitution)	4
Ideology (being ‘green’)	4
Increased comfort	1
HVAC noise reduction	1
Being an early adopter	1
Awareness of local energy co-op incentives	1

Note: Multiple responses allowed.

[28] When replacing a current system with GSHPs, the most common fuel type in the previous system was either natural gas or propane.
[29] This respondent explicitly mentioned the following building envelope activities that would reduce the heating load requirements of the GSHP system: R38 attic insulation, low-E windows, infrared wall insulation scan, and a blower door leak test.

Most respondents reported that neither heating nor cooling prompted customer interest in GSHPs specifically. Of the GSHP systems that were not replacing a previously operational GSHP, five out of seven respondents reported that air conditioning was already present in the home 100 percent of the time. As one respondent explained, the customer base for GSHPs is primarily composed of more affluent homeowners and that these individuals "always" had air conditioning installed. Another respondent noted the homes that typically do not have air conditioning are usually in the Bay Area, where they are seeing an increasing interest in air conditioning due to climate change.

> *I am getting calls from people in the Bay Area that did not have air conditioning, that now want air conditioning due to the increased heat for a few weeks of the year at least. I would say about 50% of all my retrofit jobs did not have air conditioning but they are not just looking at heating they are interested in converting and they also want air conditioning, which is a nice selling point.*

When discussing the feasibility of GSHP units with the customer, respondents reported that first costs were the primary concern (5 of 7). Other concerns were associated with impacts to landscape appearance, installation (drilling) noise concerns, equipment space considerations, and general performance concerns (n=1 each).

When asked about typical customer concerns around the installation and use of GSHPs, the interviewed contractors responded with the concerns listed in Table 35.

Table 35. Incidence Rate of Customer Concerns about Ground Source Heat Pumps (n=7)

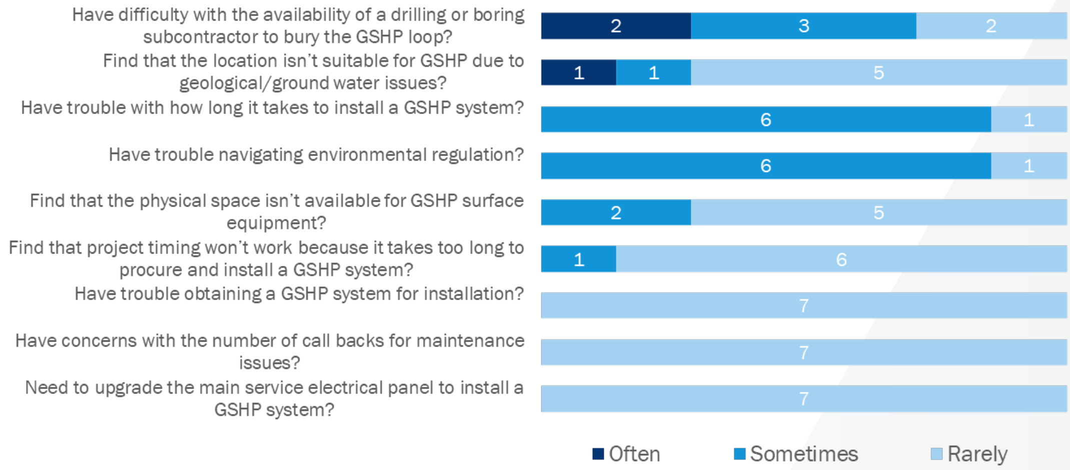
How often are customers. . .	Often	Sometimes	Rarely
Aware of GSHPs before you talk to them?	5	1	1
Aware that GSHPs provide both heating and cooling?	5	2	-
Concerned about upfront costs?	6	1	-
Concerned about the cost/benefit over time?	-	3	4
Concerned about performance on cold or hot days?	1	1	5
Concerned that the system is complex?	-	4	3
Concerned about using zonal heating – that is, independent heating systems for separate rooms?	1	4	2
Concerned about losing heating/cooling during power outages?	4	1	2
Concerned about performance or reliability in general?	2	2	3
Other Concerns – Earthquakes	-	-	2
Other Concerns – Gophers	-	-	1
Other Concerns – Public Safety Power Shutoffs (PSPS) backup generators or batteries	1	-	-
Other Concerns – Normal lifespan of underground piping	-	-	1

In response to these concerns brought up by customers, respondents mentioned a variety of discussion points that they would share to assuage them. The most common was that GSHP systems had a very long (25 year) effective useful life and very low operational costs (n=3 each). Additional points were the lower cost of maintenance, as compared to air-source systems (n=2), the potential for true net-zero emissions operations when combined with rooftop solar PV, safety from carbon monoxide poisoning, and increased comfort in the home (n=1 each).

Contractor Concerns

The barriers to GSHP installation as reported by interviewed contractors are summarized in Figure 44. Challenges related to the geology and drilling the loop were encountered most frequently. Interviewees responded with “Often,” “Sometimes,” or “Rarely” to the question, “How often do you…”

Figure 44. Incidence Rates of Installation Barriers of Ground Source Heat Pumps (n=7)



Recent changes in GSHP loop drilling costs have severely impacted market adoption rates in California. This issue appears to be the result of recent certification and permitting changes implemented on all vertical bore drillers, which were likely adopted due to groundwater contamination fears. One respondent felt strongly that ground water and surface water contamination concerns were unfounded and resulted from policymakers’ misperceptions of how vertical bore holes are filled. The end result of these changes appears to have severely reduced the availability of certified drilling rig operators, leading to a prohibitive cost for the installation of the primary GSHP system type—a vertical bore closed loop system.

CONSIDERATION

Multiple installers explained that the lack of qualified loop drillers have driven GSHP costs up due to changes in licensure requirements.

Of the installation service professionals interviewed, none expressed any optimism that any of the potential barriers to GSHP installations would be reduced in California over the next 5 to 10 years. In fact, a minority expected that they would “get worse” (n=3). The sole interviewed GSHP systems design engineer expressed “hopefulness” that the environmental and permitting hurdles would be reduced going forward. One panelist expressed that no benefit would be produced unless “there is legislative change.”

> *California is creating problems in geothermal modeling systems. There are specific problems with Manual J modeling with regard to ground source heat pumps and this impacts Title 24 applications with the building departments. If we cannot model it properly through their channels, then they will not accept it in Title 24 as efficient. The CEC system is antiquated, and they don’t want to spend the money to bring it current, so we have to spend the money to get the modelling right and take a hit through that process.*

The GSHP equipment distributor interviewed provided additional insights to the contractor interviews. A primary recommendation from all market actors, both in and out of state, is for the development of “loop leasing” as a way to streamline the market adoption rates of this technology. Since the cost of installing an individual loop system is often cost-prohibitive, utilities, such as Eversource in Massachusetts, are considering constructing a district geothermal system in which multiple customers would be connected to a shared loop system. The utility would pay the initial costs for the system and customers would pay the utility for use of the system allowing utilities to recoup their initial investment over time. This activity would obviate the permitting and certification requirements of independent drillers as well as significantly reduce the incremental unit installation costs. The reduced noise, increased comfort, reduced energy use, reduced maintenance costs and longer effective useful life of GSHPs make this technology very attractive and it should be more widely adopted in the residential sector. The successful clearing of these market barriers will work to provide rapid assistance in meeting California’s carbon reduction goals.

CONSIDERATION

Some utilities are considering “loop leasing” as an innovative way to provide clean heating through GSHPs to customers.

> *I do like the idea of the utility company doing loop leasing. It would massively increase unit sales and get the equipment into the houses. We would really increase volume if they did something like that. It is the drillers and the permitters that is the main cost burden. If they permitted the whole street and put in the racetrack loop, then we would sell a lot more. The drilling is the expensive part. This one or two units at a time installation business really slows down sales. In addition, once the GSHP is in the house it is very quiet. There are cities that are pushing for reductions in noise pollution. If the housing is close together then the sound (of multiple air-source units) becomes a real issue.*

Permitting and Title 24 applications, as well as environmental applications, were identified as a burden by the majority of interviewed contractors (4 of 7; 57%). Concern regarding the Manual J treatment of GSHP efficiency modeling was expressed by the systems design engineer who stated that there was an incorrect attribution of energy use within the model (with regard to GSHP operations) and that this produced an unnecessary burden for the Title 24 application process.

The GSHP equipment distributor we interviewed indicated that familiarity of the systems and knowledge of the technology in the general contractor space is the primary barrier to greater GSHP installations. It is very difficult for contractors to pitch the sale of a product if they have limited experience and understanding of the technology, its benefits, and its viability. If this knowledge and experience gap is addressed, the distributor believes sales would increase, especially if homeowners were informed of the long-term payback opportunities of GSHP systems.

6.6 GSHP Costs

Upfront cost for a GSHP ranges between $10k -$30k depending on the system type, home size and property characteristics. When asked about the incremental costs of GSHPs over standard air-sourced HVAC options, the average response by respondents was 130% of the typical air-source first costs (range: 33% to 300%; median: 130%). When asked to describe the impacts of these first costs on a customer’s willingness to adopt GSHPs, three respondents reported that about 50% of potential customers find these costs prohibitive, that the impacts are generally characterized as both “major” and a “deal breaker” (n=2) and that they make adoption of GSHPs unfeasible for homes smaller than 2,000 square-feet (n=1).

Part of the main difficulty I have had is the permitting experience with this technology in different counties. Some counties have more of these systems and others have more experience with water wells but not a GSHP loop. In this case they are trying to adapt that same experience to GSHPs, but it isn't the same thing. The state-level ground water controls are given by the state and the counties just do the best that they can based on staffing and experience, so the counties call each other and try to get information from each other 'What do you guys do?' and that is just how it happens.

6.7 INCENTIVES

Respondents indicated there are no California utility incentives for GSHP loop development in the state, with the notable exception of those areas that both have both high winter heating demand and a lack of natural gas services. Three respondents with current or prior utility incentive experience reported that utility incentives have induced higher market adoption rates of GSHPs. All four respondents, who do not currently benefit from incentives in their area, stated that the introduction of utility incentives would help grow the GSHP market. Similarly, all installation respondents stated that the federal tax credit provided significant benefit (n=7).

However, a caveat was offered that suggested that the targeting of incentives that addressed only the incremental equipment costs would be ineffectual, since the primary first cost hurdle is associated with the drilling of the ground loop. One respondent offered the historic perspective that, at one time, a regional municipal utility in the northern portion of the state was offering a $1,000 incentive for each borehole drilled, which has moderate success.

We are on the verge of finding a way to get the horizontal ground loop to fit under a regular new construction house pad. We are getting into a hybrid geofield system, with thermal storage, hydronics and natural air cooling at night, so that the geothermal footprint will fit under a house. I have faith that we will get there.

6.8 TRAINING OPPORTUNITIES

When asked about any desired professional training that would be helpful to increase GSHP sales in California, respondents reported the results found in Table 36.

Table 36. Desired Training Programs for GSHP Installers (n=8)

Type of Training	Incidence
General GSHP technology/vocational school or IGSHPA certification training	4
Continuing professional education & conference attendance	2
Built environment/Building envelope efficiency	2
Title 24 code training	1

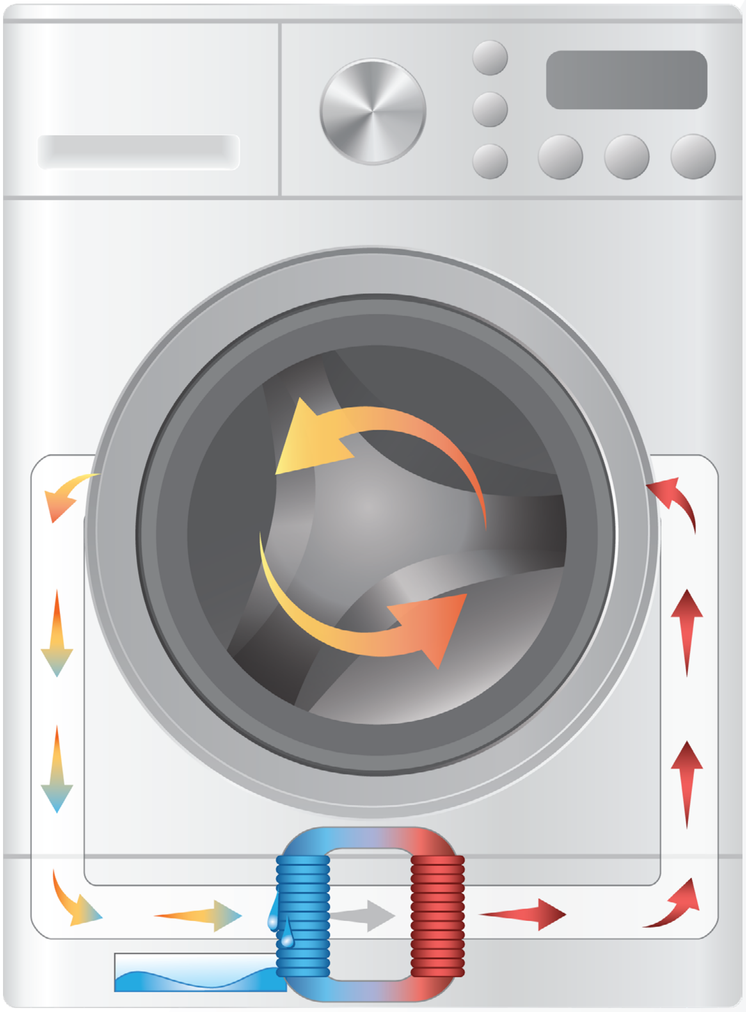
A primary market barrier to increased GSHP adoption was identified to be poorly designed and installed systems. These systems, typically installed by non-IGSHPA[30] certified technicians in the past, can produce negative perceptions of the technology in the current market space. One respondent stated that he required all his employees to attend this international certification training, which is now being offered online, but that the registration costs were a burden to his potentially increased staffing. The respondents universally declared that additional training resources were needed in the current market space.

> “*I work with California GEO and we are starting a building professionals' course to help people to understand the technology and how it applies to California as compared to other states. This training is for the general public as well. . . IGSHPA (International Ground Source Heat Pump Association) is now in transition, they have provided training for installers, but the professional engineer's license is much more important. For California GEO, we are in collaboration with them, but we are focusing more on ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) for the international standard that we helped develop with Canada and are currently assisting in developing for the California mechanical code. We want more than a check box on the Title 24 code application, and we feel that CA is a good growth potential market. We don't want the supply of professionals to be a limiting factor.*”

[30] International Ground Source Heat Pump Association (IGSHPA)

HPCDs work as closed loop systems by heating the air, using it to remove moisture from the clothes, and then reusing it once the moisture is removed (Figure 45). The HPCD uses refrigerant to catch hot air, push it through a compressor to make it hotter than before and then push that hot air through the dryer drum to dry clothes. Rather than releasing warm, humid air through a dryer vent to the exterior of the home as a conventional dryer does, an HPCD sends it through an evaporator to remove the moisture and deposits the water in an accessible compartment, allowing the homeowner to remove the water and pour into a sink, or recycle it for other uses, such as watering houseplants. Other options for draining the water tank are using a drain hose (provided by the manufacturer) to discard the water automatically in a nearby sink or drainpipe or installing a device that allows an HPCD to use the clothes washer drain to remove the water.

Figure 45. Heat Pump Clothes Dryer



The HPCD market is small with several subsets:

- **All-in-one units.** A single laundry unit that is a combined washer and dryer.
- **Hybrid units.** Units that have electric heat strips to augment the heating cycle and reduce the drying time.
- **Smaller units.** These units are 24-inch-wide machines that can be used when space is constrained.
- **Larger units.** There are very few 27-inch-wide models available, but no 29-inch-wide models currently available on the market.

7.1 DESCRIPTION OF RESPONDENTS

The findings in this section represent the viewpoints of seven market actors in the HPCD market.

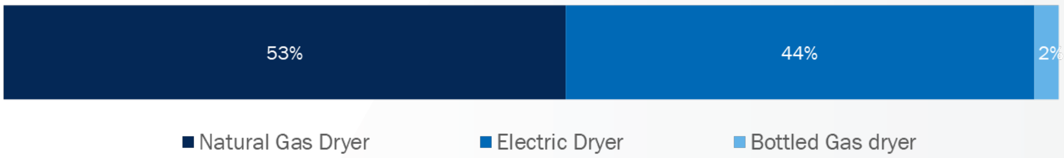
Figure 46. Interviewed HPCD Trade Allies

The small retailer carries only one brand of HPCD. He has been selling them for about five years. He sells six to eight units per month. The typical buyers are homeowners and renters who come to the store specifically looking for a HPCD, since they have a small space or cannot vent to the exterior. The large retailers are more experienced with HPCDs, with up to 15 years selling this appliance type. The large retailers carry three to six different brands of the units. The two distributors that we interviewed carry from five to eight brands of HPCDs and have been in this market for 15 to 20 years.

7.2 OVERALL HEAT PUMP CLOTHES DRYER MARKET

Approximately 80 percent of homes in the U.S. are equipped with clothes dryers. In 2019, a total of 3,613,587 dryers were shipped in the United States. Of those, 2,927,000 were ENERGY STAR® rated, with 36 percent being electric and 45 percent being gas.[31] The majority of these dryers are condenser dryers which use a heating element to dry laundry and pump exhaust outside through a vent. HPCDs are ventless, and while ventless dryers seem unusual to many Americans, they have been popular in Europe for generations. Popularity in Europe is driven by a preponderance of small old buildings where large, vented dryers are not feasible. Manufacturers of HPCDs include Beko®, Blomberg®, Bosch®, LG®, Miele®, Samsung®, Summit, and Whirlpool®. A little over half of respondents to the RASS Study indicated that they had a natural gas dryer while 44 percent of respondents indicated that they had an electric dryer[32] as indicated in Figure 47.

Figure 47. Number of Clothes Dryers by Fuel Type (n=28,892)



[31] ENERGY STAR®. "Unit Ship and Market Penetration Report Calendar Year 2019 Summary." https://www.energystar.gov/sites/default/files/asset/document/2019%20USD%20Summary%20Report.pdf
[32] The RASS data does not indicate the specific type of electric dryer.

Most distributors and retailers see HPCDs as a good option for retrofit and renovation projects where there are physical limitations of the dryer that can be installed, or additional dryers are desired. Participants indicated that HPCDs are not very common in new construction projects because the designers and contractors will devote enough space for the laundry equipment, provide the correct access to the equipment (that meets ADA compliance), construct adequate options for the ventilation, as well as include 220-volt circuits to handle appliances that draw high currents, such as clothes dryers. As one contractor explained,

> CONSIDERATION
>
> HPCDS are a niche market targeted at customers who have a small space and/or cannot vent to the exterior.

> *The new construction markets are going to be primarily full-size laundry because they're building it with that in mind ... 99% of the new home market's going to be your full-size vented dryer.*

The small retailer sells six to eight units per month. The large retailers report selling twenty to sixty units per month, often through multiple retail locations. All large retailers sell 70 percent to 80 percent of their units to homeowners and renters. Contractor business makes up the difference, primarily for renovation projects. The distributors sell 75 percent to 98 percent of their units to contractors, and this type of equipment represents 5 percent to 10 percent of total clothes dryer sales. These sales are almost exclusively for renovation projects, and they are almost always because of venting issues or a lack of available space. Given that distributors/retailers noted that their sales of HPCDs are almost exclusively in situations where existing venting is not possible or there is not enough space for larger laundry units, the estimate of the number of HPCDs in California is low.

7.3 STOCKING AND SALES PRACTICES

All retailers explained that the units they stock are driven by demand. None suggested that they would devote valuable space to stock items for which there is no, little, or niche-market demand.

If there was a utility incentive program, retailers would be glad COVID-19 has had an impact on the market for HPCDs. Reduced factory operational hours and production due to the pandemic has made it difficult to fulfill orders and get units into their stores. This is happening across the board for all distributors and retailers, both large and small. It is also happening for other materials and appliances that builders order to build new homes and complete renovations.

> CONSIDERATION
>
> Utility incentive programs targeting HPCDs would motivate retailers to stock HPCDs.

Most retailers that we spoke with do not actively market HPCDs. They rarely use point-of-sale (POS) materials to help sell HPCDs. Most of their marketing budgets are devoted to kitchen appliances or to support manufacturer incentives. All retailers and distributors did say that they would consider marketing HPCDs if there was a state or utility program to leverage.

> *We use a consultative sales process instead of a great deal of marketing. Our salespeople are very experienced (15 years each) and speak with customers on the retail sales floor. Secondarily, we use the merchandising materials that we receive online and finally, we sometimes use the point-of-sale information. Generally, the point-of-sale information comes from the vendors and generally we are not plastering it everywhere, but we will make a brochure available. If there is a particularly good graphic, our salespeople will point it out. If the owner sees sales grow enough, and if there are enough brands and model offerings, then he could potentially dedicate a segment of the sales floor to this technology. State or utility brochure or POS material would be useful, especially if it said 'rebate' on it.*

A few retailers believe that the all-electric mandates are a trend for the future and will drive electric dryers and, very probably, HPCDs since they cost less to operate. When one retailer was asked if they expected to see more or fewer HPCDs in the future they responded,

> *I expect more, especially since California is trying to outlaw all gas appliances. However, until they [do], I do not see us stocking or promoting these units as a priority.*

One distributor we talked with indicated that sales experience and active selling makes a difference in promoting the HPCD market, saying,

> *HPCDs—were 5% of our sales or less a year ago. Today, though, we have a new sales rep that we hired from a competitor. He brought many new build and rehab customers from the city over to our firm. He has probably doubled our sales in these areas. So—it is about 10% HPCD sales now.*

7.4 INSTALLATION CONSIDERATIONS

Certain retrofit and renovation circumstances are viewed to be more conducive to the installation of HPCDs. These include situations where there are space limitations, such as when only a 24-inch appliance will fit or when there is not enough clearance in the room for the additional five inches of space required for the vent hose. Another situation where HPCDs are a viable option is in homes where there are venting limitations, including when there is no vent available and it is difficult, or impossible to add a vent, or when there are common walls that do not allow venting to the outside. HPCDs are also a good option where homeowners want a second dryer unit. For example, for upstairs use, when they already have another vented dryer downstairs. One retailer describes the impacts of HPCDs,

> *What happens in those old Victorian mansions that were made in like 1910 to 1930 [in San Francisco], there was only one laundry room, and so maybe the upstairs didn't have a proper laundry room or they didn't have ventilation, they didn't have gas way up there or whatever. This is something that's really kind of revolutionized, at least in San Francisco, the TIC (tenants in common) market.*

Their smaller size can be a benefit when fitting into existing small spaces but due to their smaller size, many retailers believe that a HPCD is a bad choice for large families with children that need to do larger loads of laundry more frequently. Retailers also believe the market for large capacity washers is so high that consumers are less inclined to purchase a HPCD that can only accommodate half the washer load at a time. The lack of larger machines (27- and 29-inch) seems to be a limitation to broader appeal in the market. One retailer states that some of the population will look at the small size and say, "'Ugh, that's just too small for my king-sized comforter." Retailers believe, however, that despite their size, HPCDs can work well for single people or married couples, especially if they do not mind the extra time required to dry clothes.

CONSIDERATION

Large capacity dryers are popular today. The lack of larger machines (27- and 29-inch) is a barrier to adoption of HPCDs.

One retailer from San Francisco pushes the sales of HPCDs, explaining to customers that they do cost more up front, but that they are 50% more efficient than standard electric clothes dryers, they save energy and money on electric bills, are the "green" option since they do not combust natural gas or use as much electricity, and they only take 15% more time than a standard electric dryer to dry a load.

> *… So you're basically using half the juice and you're only using 15% longer. That means that before the cycle took an hour, it's going to take 69 minutes. When you break it down like that to a consumer, they're not caring about nine minutes.*

There was some disagreement amongst the interviewees regarding the time it takes to dry a load of clothes with a HPCD relative to a standard electric dryer. The above retailer says 15% longer, one distributor tells builders and property managers that it will take twice as long to dry a load of clothes, another small retailer also tells customers it will take twice as long.

7.5 CUSTOMER PERCEPTIONS

A distributor described the current market for HPCD as a "niche market" with a retailer stating that the HPCD was "not broadly understood as an important and valuable technology." Most retailers say that people only choose HPCDs when they must, since they cost more up front (almost double), they typically dry smaller loads, and they take longer to dry clothes. As a retailer describes,

> *I think most people who have (installed a HPCD), if they had the ability to put in a vented dryer would do so, but a lot of them are limited by what they have available.*

Often the people who come into a retail showroom to specifically buy a HPCD have one of a few scenarios in play: (1) they do not have the ability to vent a dryer; (2) they do not have a space larger than 24-inches for a dryer; or (3) they have solar, understand the efficiency of these units, and want the greenest choice. As a retailer shared,

> *Well, almost every time that the customer is on solar panels heat pump clothes dryers comes up.*

Customers sometimes complain that clothes coming out of a HPCD lack the warm, toasty feel that many customers are used to from a vented dryer. Customers sometimes perceive that the clothes are still wet because of this cooler feeling even though they are actually dry. Vented dryers have a history of over drying, which is where most fabric damage occurs. According to one retailer, this is often an overlooked benefit of HPCDs and other ventless dryer technology.

7.6 INCENTIVES

Most of the retailers and distributors felt that utility, state, or federal incentives would help boost HPCD sales. The respondents that just sell reactively—when asked for the product by a customer—did not feel that incentives would help increase sales since customers only buy them when they have venting or space limitations. Two retailers, however, felt that incentives would help. Incentives provide third-party credibility in a customer's mind, since a respected third party is putting their support behind the technology as a good choice. Incentives also provide a great way for salespeople to engage in conversations with retail customers on the showroom floor.

7.7 TRAINING OPPORTUNITIES

Knowledge about HPCD units is low. As a result, to expand the market for HPCDs, program budget dollars will be required for education and point-of-sale materials. Salespeople, contractors, and designers should be targeted, as should multifamily project owners and homeowners. They need to understand the true costs and benefits of the technology. Salespeople and their managers need to understand the technology options and how to better sell the units. Environmental benefits are typically overlooked by those in sales since they are not asked about them and do not see that as instrumental to closing a sale of any type of laundry equipment. One large distributor recommended that training courses be developed for designers and contractors to earn continuing education units (CEUs) toward their professional accreditations, since this would be a great way to get them to learn about the technology and its costs and benefits.

CONSIDERATION

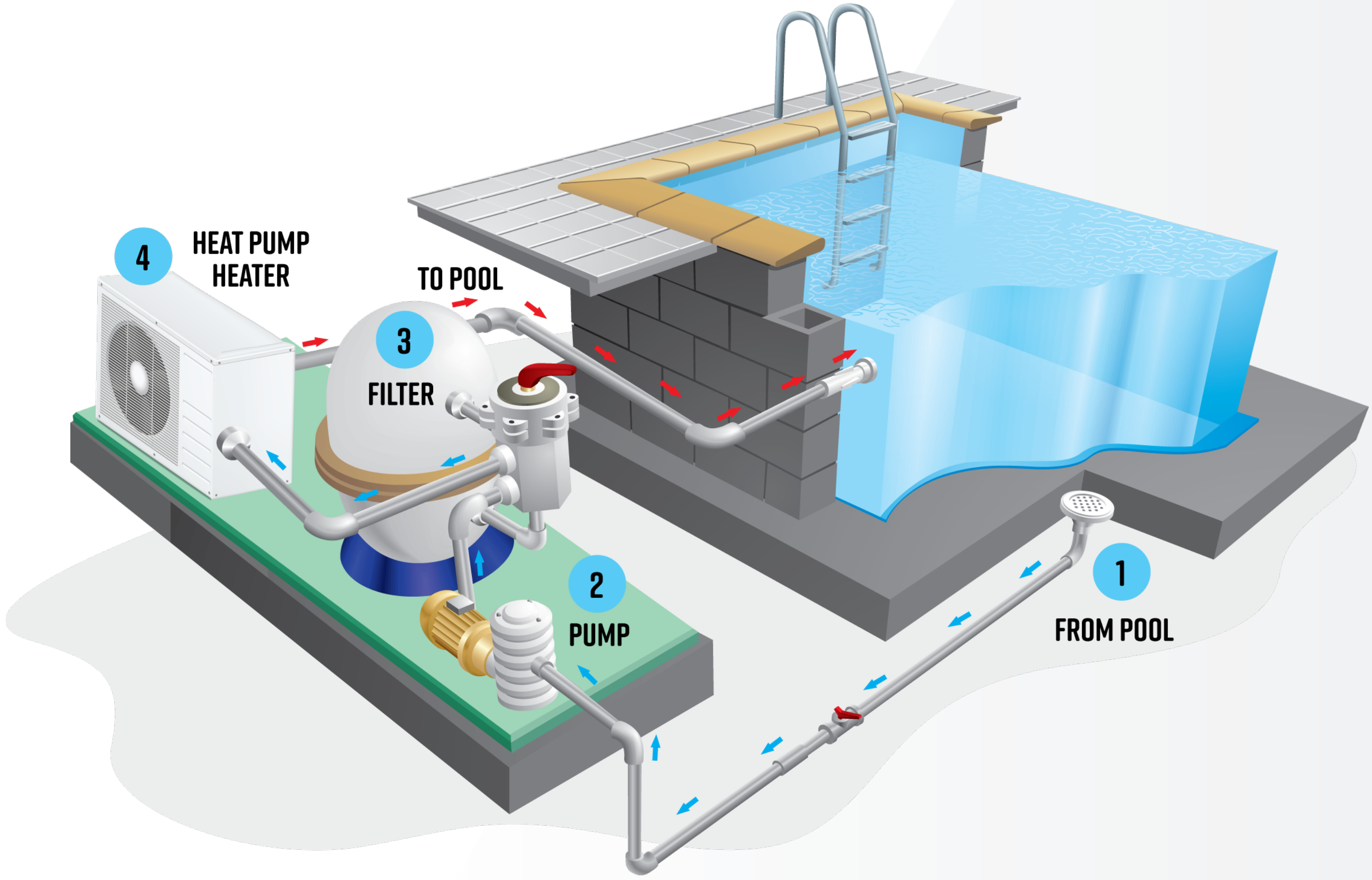
Training is key to driving increased interest in HPCDs.

8. HEAT PUMP POOL HEATERS

The heating of pools and spas in California has a significant environmental and energy demand footprint. Historically, natural gas fired heaters have been the preferred pool heating method; electrical resistance heating has been much less prevalent. Solar pool heating units have also been adopted by the residential sector, accompanying the rise in rooftop solar photovoltaic (PV) arrays. In the early 1980s, manufacturers began to offer HPPHs as an energy efficient electrical heating option for pool owners.

HPPHs, powered by electricity, have a fan that draws warm heat in from the outside and circulates the air through an exterior evaporator air coil. The outside air temperature should be above 45°F for the HPPH to work efficiently. The cooler the outside air they draw in, the more energy they use. HPPHs do not generate heat; they simply capture and exchange heat. Refrigerant located within the evaporator coil absorbs the heat and transforms it into gas, which is then pumped through a compressor. The compressor increases the heat of the gas and passes it through the heat exchange condenser. The water in the pool is heated when the condenser transfers the heat from the hot gas to the pool water that is circulating through the heater. The heated water is then returned to the pool (Figure 48).

Figure 48. Heat Pump Pool Heater



8.1 DESCRIPTION OF RESPONDENTS

We conducted interviews with nine industry professionals who had direct installation, distribution, and customer sales experiences with HPPHs to better understand the current HPPH market in California and identify any potential market barriers that prevent wider adoption of these units (Figure 49). Initial identification and recruitment of potential candidates posed challenges due to the limited adoption of HPPH technology across the state. Interviewed respondents conduct business in three regions of California. The first and most active group of respondents provide pool maintenance, service, construction, and warranty repair services in Northern California. This group is primarily located in areas served by the Sacramento Municipal Utility District (SMUD) and the City of Roseville municipal electric utility. These participants also report installing some HPPHs in the surrounding PG&E service territory. The second group of respondents provide pool services and construction in the greater Los Angeles region with one respondent conducting pool service and maintenance operations in the City of Palm Desert.

Figure 49. Interviewed HPPH Trade Allies

Note: Of the nine professionals interviewed, five of them also did sales.

Interviewed respondent experience with HPPH installations over the past year ranged from two to 40 installations, with the median number of installations being six. Lifetime experience in installing HPPHs ranged from five to 100 heat pumps. Heat pump pool heater installations accounted for an average of 31 percent of respondents' business activity, with some reporting less (10%) and others reporting more (90%). On average, 55 percent of respondents' business activity related to pools was installation of new pool equipment. Single-family residential jobs comprised 95 percent of their activities.

We conducted an additional interview with a general pool equipment wholesale distributor with HPPH stocking and sales experience in California. This interview was designed to increase understanding of the HPPH market with additional insights into equipment reliability, customer interactions, and stocking decisions for these units. The respondent reported that his promotion of HPPHs over the last 20 years was instrumental in developing the current market in the greater Sacramento area; his business was the only one that he was aware of that kept significant inventory of these units in stock.

8.2 OVERALL HEAT PUMP POOL HEATER MARKET

The estimated number of residential in-ground pools in California is 1.3 million. Half of these pools are heated, and among those 60 percent are heated using natural gas, nine percent are heated with electricity, and only 1 percent are heated with an electric HPPH. The HPPH market is a fragmented market with many vendors. The largest manufacturers are AquaCal, Hayward, Jandy, Pentair, and Rheem. As shown in Figure 50, almost half (47%) of all pools in California are not heated according to the RASS data. Of those pools that are heated, the majority of pools are heated using natural gas (60%). The next most common heating method is solar heater (23%) followed by electricity (9%). Only 1% of these households heated their pool using an electric HPPH.

Figure 50. Pool Heaters by Fuel Type (n=2,259)

Some market analysts expect the HPPH market to grow as a CAGR of over 5% during the period between 2019 and 2025.[33] Interviewed respondents also confirmed that they believe the California market will grow significantly over the next five to ten years. All interviewed respondents also perceive HPPHs as more energy efficient than standard natural gas pool heating, which was identified as the current industry norm in California. One respondent compared the efficiency between the two units,

> *It is really not close when it comes to efficiency, they are very, very efficient. The unit is more expensive than a gas unit but the savings make them pay for themselves. Gas heaters are like a V8 car so they run faster but the heat pump pool heaters are more cost efficient to run and if you go solar, and I think everyone is going solar, then heating would be free.*

Of the respondents' residential pool heater installation jobs in California, HPPHs are installed, on average, 30 percent of the time. Recommendations for HPPHs in single-family residential settings are biased toward service territory, according to interview respondents. Respondents recommend HPPHs to customers in municipal utility service territories nearly 100 percent of the time, regardless of previous heater fuel type. Recommendations in municipal utility service territories are likely more common than in IOU service territories because these municipalities typically offer lower costs of residential electricity, which allows for lower operating cost of HPPHs. The rate of HPPH recommendations for replacements within IOU service territories was predominantly limited to only those homes with photovoltaic solar either already installed or planning to be installed soon. One respondent, operating in the greater Los Angeles area, reported that his business in the HPPH sector was exclusively the result of a contracted agreement with a local photovoltaic installation company that provides home electrification service assistance. One respondent explained,

HPPHs are more often recommended in municipal utility service territories than in IOU service territories.

> *In Santa Monica you can't install gas (on new construction jobs) anymore. So that will be probably the main reason this market will grow. You cannot get gas; it is going to be impossible pretty soon. Obviously, as well, are the benefits of them—their energy efficiency. Rooftop solar will also increase demand. If I see them with solar, they are getting a heat pump.*

[33] https://www.prnewswire.com/news-releases/pool-heat-pump-market-size-to-reach-revenues-of-usd-7-5-billion-by-2025--arizton-301157942.html

Half (4 of 8) of interviewed respondents described the current HPPH market in negative terms, such as, “low” or “troubled.” The other half of respondents used terms like “great,” “growing,” and “getting stronger every day” when describing the current state of the market. Respondents who provided a positive outlook of the market were those who installed units in municipal utility service territories; four respondents noted that lower electricity costs in these territories help them sell more HPPH units as the long-term operation can be more cost effective than gas heaters. Municipal utility areas evidently have a stronger market for HPPHs due to lower costs of electricity, allowing for the development of a more mature market for these units over the last decade. In contrast, respondents reveal there is less market activity in IOU service territories; photovoltaic adoption rates and the coincident desire for household electrification is the primary market drivers in these areas.

CONSIDERATION

Perceptions of the current state of the HPPH market were mixed with half of respondents providing a negative view and half expressing optimism.

When asked about recent developments in the HPPH market, some (3 of 8; 38%) respondents described the emergence of new technical innovations, such as smart controls, variable speed, hybrid units, low-temperature operability, and staggered start-up capability. One-quarter of respondents noted that increased customer awareness is a new market development. The remaining three respondents reported there have not been any recent developments in the HPPH market.

Over half of interviewed respondents reported solar PV as a primary driver for future HPPH market growth. One respondent described,

> *“SMUD lower cost electricity rates are driving the market in my area. Less expensive electricity, PV solar, and the government saying we won’t be able to sell gas appliances in the future, those are the reasons for future market growth. Our sales outside of the SMUD service territory are significantly less. If they have solar then that would be the difference.”*

Other market drivers included general transformation as the market matures, energy efficiency and lower operating costs, natural gas rates, and state and local policies (Table 37).

Table 37. Drivers for Increased Market Adoption of Heat Pump Pool Heaters (n=8)

Market Drive	Count
Solar PV	5
General market transformation in progress	3
Energy efficiency & cost of operations	1
Cost of natural gas	1
Future state-level regulations & incentives	1
Local prohibitions on natural gas new construction	1

The pool equipment distributor believed the HPPH market has been growing considerably in recent years; their annual sales of HPPHs was only one or two units 15 years ago, but now they sell three to five units per week. Nearly all sales are associated with single-family residential homes, with a 65 percent–35 percent split between retrofit and new construction activity.

HPPHs are estimated to make up 2% of the new construction and 5% of the retrofit markets in California.

When characterizing the new construction and home retrofit markets, the distributor stated that natural gas heaters held 90 percent of total market share in both categories, with HPPHs making up approximately 2 percent of new construction and 5 percent of retrofit sales. Solar pool heaters had a slightly higher incidence of sales for new construction when compared to home retrofits with a reported total share of sales at 5 percent and 1 percent, respectively.

8.3 INSTALLATION CONSIDERATIONS

Pool size and customer usage are important factors in determining the appropriate pool heater type. Nearly two-thirds of respondents (5 of 8; 63%) listed pool size and customer pool use as their primary considerations when considering the appropriate type of heater unit to install at a job site. Secondary considerations included availability of fuel types in the pool equipment room, customer budget, space availability for equipment onsite, and whether PV was installed onsite.

All respondents noted that HPPHs produce about one-third of the heating capacity as a standard natural gas heater unit, thus they require different pool heating operations depending on customer usage. Typical recommendations for HPPH operations involve maintaining higher pool temperature levels during the week even if pool use is only on weekends. This is due to the long heating time required to achieve the desired pool swimming temperatures when using an HPPH. In these cases, respondents strongly recommend insulating pool covers to preserve the heat and reduce total electricity demand. Respondents explained that manually installed insulated pool covers typically cost $300 per cover while automated pool cover systems can cost upwards of $15,000.

The long heating time required to heat a pool makes HPPHs poor choices for weekend vacation homes.

Respondents reported a wide range of recommendations for pool heater replacement based on existing fuel types and system requirements. When performing a pool heater installation where the existing heater is natural gas and no electric subpanel is available in the pool equipment room, one-quarter of respondents would only recommend a natural gas heater system, while five respondents would always provide HPPHs as an option. The remaining respondent only performed new construction or gut remodel services thus was not asked this question. The presence of a spa onsite would greatly influence respondents to recommend a pure natural gas system or a hybrid (natural gas + HPPH) system. Hybrid systems, which are typically recommended when the pool size is larger than 35,000 gallons or if there is an onsite spa, are beneficial because the operating costs for the homeowner will be lower, as a purely electric HPPH system would be costly to operate when the heating load is high. A split system would use some gas and some electric, which would lower the overall operating costs, as gas rates are lower than electric. Hybrid systems are a recent development in the market and are readily available today.

Half of respondents reported occasionally upgrading the main service supply of a home from a 100-amp service to a 200-amp service to support the electrical operations of an HPPH. A respondent described a scenario where a main service panel replacement was needed,

> *[A main service supply panel replacement] can happen if we are dealing with an overloaded panel, if they have too many electrical devices. We only find that in older installations. I let the contractor know our needs for the new installation and sometimes I will get a call back through the manufacturer (of HPPHs) because of a warranty claim and I will find out that they have all these other loads pulling electricity (electric car, etc.). You don't have enough power to supply the heat pump. That has happened once or twice, but it is not too common. If they go solar, then they want more electrical devices.*

Additional power is required due to the large starting surge that occurs during normal HPPH compressor operations. A starting surge requires a supply minimum of 50 to 60 amps at the pool subpanel, depending on the length of the wire run to the unit. The pool equipment distributor noted that the need for a 200-amp service upgrade is more common for older homes. Two respondents explained that some newer models offer a staggered startup that helps significantly reduce the electrical draw of the starting surge. This technology does not appear to have entered wide adoption and is considered quite novel by respondents.

Respondents who perform electrical subpanel installation services reported it takes roughly one day to conduct the additional work. Main service panel upgrades can take longer--up to an additional two weeks. Respondents reported that this timeline is not typically considered a barrier among customers when choosing to install an HPPH. For new construction and gut remodel operations, this timeline coincides with permitting application wait times and does not typically affect the installation schedule.

Respondents explained that HPPHs are never carried "on the truck" for immediate installation as these units are prohibitively heavy and large. Typical installation jobs require three laborers to place the units and lift equipment if difficult terrain is involved.

The pool equipment distributor reported there is no type of residential building or pool structure that is more or less suitable for HPPHs, nor are single-family vs. multi-family homes an issue. The distributor mentioned that northern Sierra Nevada mountainous regions are deemed generally unsuitable for HPPH installation due to low ambient air temperatures and excessive freezing of cooling coils.

8.4 HEAT PUMP POOL HEATER STOCKING AND SALES

The pool equipment distributor reported that his business regularly stocks 15 models of HPPHs and approximately 10 percent of all pool heater stock and sales were HPPHs. Revenue from HPPH sales, as a percent of total store revenue, was estimated to be two or three percent. Typical wait times for delivery from HPPH manufacturers was estimated to be between ten days and as long as a month depending on the time of year and availability. The distributor also noted there are no current HPPH manufacturers operating in the state.

> CONSIDERATION
>
> There are no heat pump pool heater manufacturers operating in California.

The distributor reported that manufacturers offer classes in his area three to five times per year and they also hold an annual trade show for pool equipment, where HPPHs are well represented. The distributor also noted that their installer customers always bring up HPPHs first in conversations.

The majority (7 of 8; 88%) of interviewed respondents reported they maintain no personal inventory of HPPH units but rather go through local distributors. Brand promotion is determined by historic interactions with manufacturers, including perceived representative availability and product representation. One respondent reported having entered a promotional contract license with a single manufacturer. Most respondents preferred either SCP Distributors LLC or Leisure Supply as their pool equipment supplier (Table 38).

Table 38. Preferred Pool Equipment Distributors (n=8)

Distributor	Count
SCP Distributors LLC	6
Leisure Supply (Division of Keller Supply Company)	5
Superior Pool Products LLC	2
Pool Discount Mart Inc.	1
Pool & Electric Products Inc.	1

8.5 CUSTOMER PERCEPTIONS

The primary market barriers of HPPHs are the current cost of electricity in the state's IOU service territories and a general lack of customer awareness and familiarity with the technology. Interviewed respondents reported their customers sometimes initiate discussions about HPPHs. Respondents who are located within the Southern California Edison service territory reported lower awareness of HPPHs among their customers.[34] While respondents who perform work in the Sacramento region reported a higher awareness among customers with 50 percent to 80 percent of HPPH discussions initiated by the customer.

Respondents described a variety of customer concerns around the installation and use of HPPHs, found in Table 39 below.

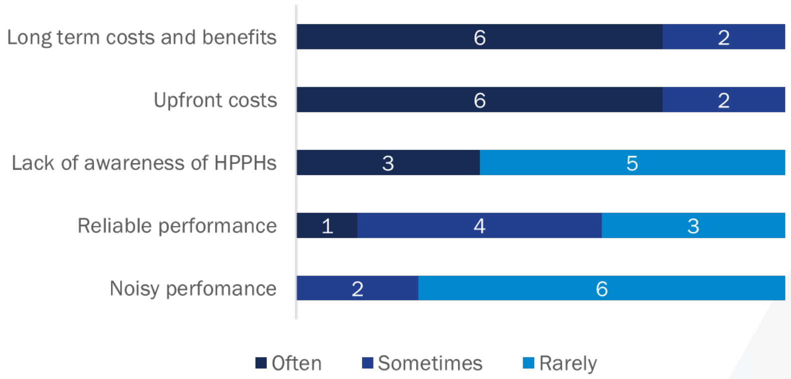
Table 39. Customer Concerns About Heat Pump Pool Heaters (n=8)

Concern	Count
Time needed to achieve desired pool temperature	2
Installation costs	2
Cold climate/Winter months operations	2
Operation costs (without PV)	2
Availability of electrical supply at pump room	1
Operation noise	1
Newness of product	1

[34] No panel participants operated exclusively within PG&E or SDG&E service territories.

Respondents also reported the prevalence of customer concerns about HPPHs, which is summarized in Figure 51 below. Three-quarters of respondents noted that the upfront and long-term costs of HPPHs are often brought up as concerns among their customers. Two respondents also brought up other customer concerns, which are not presented in the figure below. These include the time it takes to heat up the pool and seasonal usability.

Figure 51. Incidence of Customer Concerns for Heat Pump Pool Heaters



The distributor respondent asserted that the primary questions he receives from pool installation professionals are about the basic suitability and general technology of HPPHs. He noted there is also a low familiarity among installers.

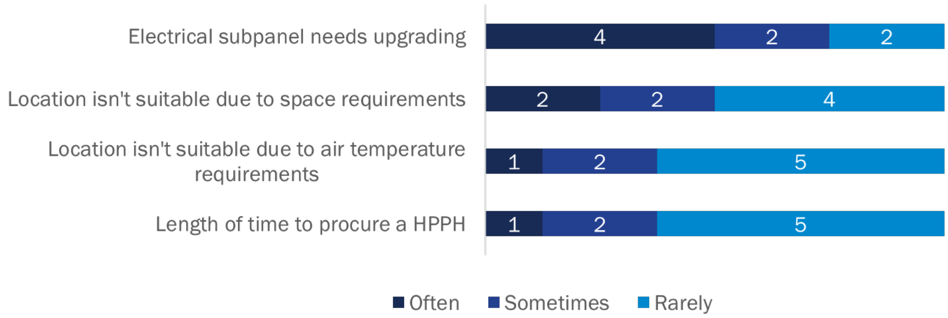
> *People just don't know how they work. They know just that they work in other places. It is funny because a lot of the service guys doing chlorine and such, people think of them as the experts, but they really know very little. They think they don't work here, but there are thousands of these HPPHs here, so making them aware of how they work and setting the expectations is the real challenge.*

Respondents shared a variety of discussion points that they bring up to assuage customer concerns. Most commonly, the operational cost savings of an HPPH can produce a shorter payback period when coupled with a solar PV system. In addition, respondents tell customers that HPPHs are quieter than natural gas heaters, units typically come with a much longer warranty than other types of units, and HPPHs can maintain pools at constant swim temperatures throughout swim season, meaning heat-up time is not an issue.

Respondents noted no additional costs associated with the decommissioning of existing natural gas pool heating systems but did report the installation of HPPHs is slightly more than that of a natural gas heater. This is due to the additional labor costs associated with the placement of the HPPH units, which are estimated to be about 300 pounds. In addition, the HPPH units are slightly more expensive than natural gas heater units. One-quarter of respondents noted these additional costs impact their ability to sell and install HPPHs.

Respondents also discussed the prevalence of barriers to install HPPHs (Figure 52). Some respondents noted HPPH technology does not perform optimally in low humidity areas, which is an issue in the Palm Springs region, even though these units are commonly installed in desert environments in other states. Air temperature and humidity play important roles in creating a heat source for HPPHs; the more moisture in the air, the more heat the HPPH can extract. Two respondents noted that some HPPH manufacturers have developed new models that work better in drier or cooler climates to address these performance issues. Other service professionals who operate in locations along the Southern California coastline remarked that this technology "wouldn't work here" due to the lower average temperatures in these areas, even though much cooler autumn temperatures are found in the Sacramento region where these units are prevalent.

Figure 52. Incidence of Installation Barriers of Heat Pump Pool Heaters (n=8)



Interviewed respondents agreed that the HPPH barriers associated with customer awareness, stocking delays, and reliability concerns will become less prevalent over the next five to ten years. There is an expectation that the recent impacts of COVID-19 on supply chains will eventually fade and the technology development of HPPHs and their market adoption rates will continue to grow. The distributor reported the likely challenge for the HPPH market in the future will be potentially high electricity costs, when compared to natural gas rates. This risk for adoption may be alleviated eventually, however, through the implementation of a natural gas ban for all residential appliances. The distributor mentioned that future state policy changes will likely be the driver of the HPPH market going forward. The increased adoption of solar photovoltaics and the observation that the state is attempting to move to zero carbon electrical generation would spur additional demand for the “greener option” of HPPHs.

8.6 INCENTIVES

Interviewed respondents were unaware of any utility incentives for HPPH units. Most felt that the presence of incentives could significantly increase sales of these items. The distributor echoed this sentiment. HPPH incentives are necessary to increase the rate of adoption for these units and that future state policy of restrictions on natural gas appliances could have a significant effect on the market. One respondent suggested that discounted pool covers should be provided along with HPPH unit incentives to facilitate proper HPPH operation.

Utilities incentivizing heat pump pool heaters would increase sales of these units.

8.7 TRAINING OPPORTUNITIES

Respondents reported a variety of desired HPPH training topics (Table 40). Most notably were trainings on the general technology of HPPHs to increase installer awareness and electrical training associated with installing HPPHs.

Table 40. Desired Training Programs for Heat Pump Pool Heater Installers (n=8)

Type of Training	Incidence
General HPPH technology education	4
Electrical training	4
Plumbing training	1
EPA refrigeration technician certification training	1
Whole house electrical modeling (with PV)	1
Pool heating demand modeling (rightsizing)	1
HPPH automation and timer programming	1

The distributor explained that the education of installer professionals is paramount to sustained growth of the HPPH market. They mentioned that they regularly hold training seminars for local professionals, offered by manufacturers, in their office.

9. SUMMARY AND CONSIDERATIONS

Direct emissions from buildings comprise 12 percent of California's GHG emissions and mostly stem from natural gas appliances such as furnaces and water heaters. Building GHG emissions are second only to California's transportation sector when accounting for electricity use, water use, and wastewater treatment.[35] Beneficial electrification is an essential strategy to meet statewide GHG reduction goals, by shifting away from fossil fuel sources on both the demand and supply side of the grid simultaneously.

Decarbonizing buildings involves both constructing new buildings and retrofitting existing buildings. Unlike most historical market transformations that happen over decades, mitigating the impacts of buildings on climate change requires decarbonization strategies that are fast and far-reaching. The quicker California can transition to constructing new buildings and retrofitting existing buildings that minimize emissions, the faster climate change can be abated.

To reach California's aggressive goals, the deployment of heat pumps as well as building envelope improvement retrofits across residential building stock must rapidly scale. California's climate is ideal for using heat pumps, especially for both space and water heating. Transitioning the building sector strategically and cost-effectively, however, is challenging. While early adoption program designs have had moderate success, the greatest potential for change out of appliances is at the end of their effective useful life. The relatively long-life of space heating equipment, often estimated between 20 and 30 years, means that equipment installed today could still be in service in 2051. While HPWHs, HPCDs, and HPPHs have shorter lives, it remains critical to take advantage of the point when homeowners naturally replace these systems in order to accelerate California's transition to a decarbonized economy.

Opinion Dynamics analyzed key findings from the market analysis, trade ally interviews, new construction market actor interviews, interviews with program staff of mature heat pump programs, and the two Delphi studies to identify several important insights to consider when developing strategies to accelerate adoption of heat pump technologies. We highlight these below:

Residential New Construction

- **Current Heat Pump Market for Residential New Construction.** Currently, the use of heat pumps in residential new construction is limited but growing. Two-thirds of interviewed builders expected their use of heat pumps to grow "a lot" in the next five years. Local reach codes and bans on the use of natural gas in new construction are driving heat pump installations. Programs incentivizing greenhouse gas emission reductions drove heat pump installations for multifamily buildings, while in the single-family market, environmentally progressive homeowners, and Bay Area homeowners desiring air conditioning for the first time, were moving the market on heat pumps. Also, the low-income tax credit system, the most popular funding source for affordable housing, encourages heat pumps because builders can profit from utility bill savings by using the California Utility Allowance Calculator.
- **Builder Perception of Heat Pump Benefits.** Many of the progressive builders saw energy-related and financial benefits to using heat pumps and avoiding natural gas. They found heat pumps to be energy efficient and offer thermal comfort benefits for the residents.
- **Considerations when Recommending Heat Pumps.** Builders consider local codes, incentive programs, the client's budget, and seek to maximize the amount of rentable or livable space in the home. DHPs were preferable for ADUs and studio or one-bedroom apartments, and ASHPs were preferable for homes and apartments with two or more bedrooms.
- **Builder Concerns with Heat Pump Adoption.** Space and placement constraints, along with a lack of appropriately skilled trades and high upfront costs were builders' primary concerns about heat pumps. Their concerns related to placement of the equipment inside the home (more often in the case of tanked HPWHs) or placement of the compressor unit outside the home (in the case of ASHPs and DHPs). Architects must be aware of and take into account the heat pump technologies' requirements of space and temperature and design those into their plans.

[35] California Energy Commission. (January 2019). Final 2018 Integrated Energy Policy Report Update Volume II. Retrieved April 16, 2019, from https://www.energy.ca.gov/2018publications/CEC-100-2018-001/CEC-100-2018-001-V2-CMF.pdf

- **Sizing Heat Pumps.** In the new construction context, heat pumps are sized to provide 100 percent of the space and water heating needs. Some engineers upsize the HPWH to account for its slower recovery rate compared to gas-fired water heaters.
- **New Construction Workforce Awareness of Heat Pumps.** The average builder and design team member (e.g., architect, engineer) are not aware of heat pumps, how they work, or their design requirements. Reportedly as few as 5 percent of California architects are aware of heat pumps. This is a serious constraint because property owners depend upon their architects and engineers to specify equipment options in the design phase when heat pumps can be properly accommodated. In addition, construction professionals and installers have limited awareness and inflate their prices to cover unknowns, which discourages property owners from selecting heat pumps.
- **Building Department Staff Awareness of Heat Pumps:** Building department staff awareness of heat pumps is relatively low, but has improved over the last few years, particularly in jurisdictions with reach codes. With appropriate training, building department staff can play a role in enhancing awareness of heat pump technologies and ensuring their proper installation.
- **Heat Pump Training.** Builders saw a strong need for heat pump training on a variety of topics for the entire range of professionals involved in new construction. Architects must know how to properly place the systems within the structure, engineers must design and size the systems, builders must know how to install them, and contractors must know how to troubleshoot and maintain them. The topic area where market actors might need the most education and training is on centralized HPWHs for multifamily buildings.
- **Heat Pump Cost.** A large majority (84%) of builders reported the upfront cost of heat pumps as a barrier, and cost is the biggest hurdle to heat pump installations for affordable housing owners. Yet, the substantial cost savings from avoiding labor and materials needed to pipe and extend natural gas infrastructure can help offset the increased cost of heat pumps. Among space heating/cooling options, builders viewed ASHPs as more cost-effective than DHPs for both the single- and multi-family markets.
- **Heat Pump Incentives.** Incentive programs have been a key driver of heat pump installations and will be necessary for more widespread heat pump adoption. Builders and other new construction professionals were more familiar with new construction incentives available for exceeding the energy code than for heat-pump specific rebates. The programs they used were mostly offered through CCAs and municipal utilities rather than through the IOUs. Builders reported difficulty identifying and applying for some heat pump rebates and reported the rebate amount must be high enough to be worth it to pursue.

Mature Heat Pump Utility Programs

- **Program Design and Implementation.** Most of the utility programs that we studied implemented midstream and upstream program designs. Even those programs that implemented downstream programs emphasized the need for programs to develop relationships with contractors and distributors to influence market transformation. Midstream programs not only have the ability to incentivize heat pumps higher in the supply chain but also, as programs build relationships with market actors, they can promote additional training and education through distributors and increase program participation.
- **Distributor Relationships.** Multiple heat pump program managers recommended working with a small number of distributors in the beginning of the program in order to get them more invested in the heat pump program. By developing relationships with distributors, programs managers were able to influence stocking habits, track the market share of heat pump technology, promote high efficiency heat pump units to contractors, and offer technical trainings to contractors in the program.

- **Contractor Networks.** Almost all heat pump program managers emphasized the importance of developing a strong contractor network. Similar to the approach with distributors, program managers recommended identifying a small number of high-volume contractor companies to initially train to install heat pumps; educate them on best practices for energy efficiency and carbon reduction; and promote heat pump units to customers. Programs may also incentivize contractors to participate in the program by offering CECs, technical training opportunities with distributors, or free heat pump units to give contractors firsthand experience with the technology in their home.
- **Customer Outreach.** Program managers recommended conducting customer marketing campaigns to promote awareness and educate customers about the benefits of heat pumps as well as how to properly use heat pumps to achieve maximum savings. Customer outreach and education is a necessary step to build awareness and demand of heat pump technology among California homeowners.

Air Source Heat Pumps

- **Current Air Source Heat Pump Market.** The ASHP market is a nascent, but growing market in California. The Air Conditioning, Heating, and Refrigeration Institute reports roughly three and a half million air source heat pumps were sold in the US in 2020, up from 3.1 million in 2019.[36] According to the HVACR Unitary Market Report for California, there seems to be an increase in sales of ASHPs over central air conditioners in 2020. In the latter half of 2020, sales of ASHPs trended higher than sales of central air conditioners. Appliance saturation studies in California show residential electric use for space heating has quadrupled over the last 10 years; however, the proportion of electric space heating provided by heat pumps has not significantly changed in the residential sector. There are 12.2 million space heating units across residences in the CA IOU territories but only 4 percent of that equipment is electric heat-pump technology. Almost half of homeowners in California with natural gas or electric space heating as their primary heating source noted that their units were over 14 years old. Since the greatest potential for change out of appliances is at the end of their effective useful life, this indicates a large opportunity for heat pump space heating. Almost 35 percent of all central air conditioners and central evaporative coolers (34%) are over 14 years old, also indicating that there is a proportion of homeowners in California that will need to replace their cooling system in the next decade.
- **Contractor Perception of Air Source Heat Pump Benefits.** Contractors see the benefit of heat pump systems now and into the future, especially if customers demonstrate interest. However, contractors are not all convinced that moving to an electric system is always the best option for a homeowner. Many respondents recommend a heat pump to their customer if the existing home specifications are suitable. Contractors cited many benefits of ASHPs, ranging from improved performance and durability, short payback period when coupled with rebates, and a more efficient home that supports California's electrification goals.
- **Contractor Considerations when Recommending an Air Source Heat Pump.** Contractors consider the following factors when recommending an ASHP: climate, existing ductwork, fuel source, electrical service, suitability of air source heat pump location, insulation, air tightness, and presence of solar.
- **Contractor Concerns with Air Source Heap Pump Adoption.** Key concerns among contractors include costly electrical panel upgrades, location and space for equipment, cold climates, lack of ASHP familiarity, high electricity rates, customer callbacks, refrigerant leaks, and permitting processes and costs.
- **Sizing Air Source Heat Pumps.** Contractor opinion of the best way to calculate heating and cooling load and what portion of the heating and cooling load the system should cover varies. While some contractors argued that it is always best to cover 100 percent of the load, others felt strongly that it is important to not oversize the system in order to maximize energy efficiency.
- **Air Source Heat Pump Customer Awareness.** Contractors report that most customers are aware of ASHPs; however, they lack technical knowledge of ASHPs and often hold misperceptions of their functionality.

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[36] Air Conditioning, Heating, and Refrigeration Institute (AHRI). 2020. "AHRI Releases December 2020 U.S. Heating and Cooling Equipment Shipment Data." https://www.ahrinet.org/App_Content/ahri/files/Statistics/Monthly%20Shipments/2020/December_2020.pdf

- **Stocking Air Source Heat Pumps.** Distributors sell heat pump equipment directly to contractors who install heat pumps in residential settings. One contactor specifically called out the need for enhanced training regarding refrigerant handling.
- **Air Source Heat Pump Training.** Contractors are highly supportive of increased availability and participation for training opportunities related to the installation, service, and maintenance of space heating heat pump technologies. Some contractors and distributors believe that offering more training opportunities will greatly improve the growth of heat pump prevalence in California, while others think that the systems are simplistic enough or that contractors already know enough that they do not perceive additional training as necessary. All distributors currently offer training to contractors covering heat pump installation, system troubleshooting, sales, and marketing practices.
- **Air Source Heat Pump Cost.** The average total costs for equipment and installation of an ASHP and a natural gas furnace are significantly different. The heat pump total cost average ($11,534) is roughly $4,500 higher than the furnace, which averages around $7,000.
- **Air Source Heat Pump Incentives.** Contractors believe incentives will play a pivotal role in the future growth of the space heating and cooling heat pump market in California. Contractors are aware of and participate in utility incentive programs because they increase market awareness and provide monetary incentive for customers to select the program's target technology; however, trade allies report challenges with the current eligibility and paperwork requirements of specific heat pump programs.

Heat Pump Water Heaters

- **Current Heat Pump Water Heater Market.** Roughly 4.5 million residential storage gas water heaters and 4.6 million residential storage electric water heaters were shipped in the United States in 2020. Residential storage gas water heater shipments grew 4.7 percent and residential gas water heaters grew 10.8 percent between 2019 and 2020. Appliance saturation studies in California show that residential electric use for water heating has doubled over the past ten years. Of the 12.1 million water heating units installed in California in 2019, however, only 1 percent of that equipment is electric and high efficiency. Most interview respondents described the current market for HPWHs in their service territories as somewhere in the range between small and non-existent. All interview respondents anticipate some degree of growth in the market for HPWHs in California in the next five to ten years, especially given California's focus on decarbonization.
- **Contractor Perception of Heat Pump Water Heater Benefits.** Many contractors reported positive perceptions of working with and recommending HPWHs to customers. HPWHs also can provide another important benefit to the energy grid—they can act as thermal "batteries."
- **Contractor Considerations when Recommending a Heat Pump Water Heater.** Contractors consider multiple factors when recommending a water heater to a customer, including the number of occupants in the household, water heater location, customer's budget, existing fuel source, and whether the home has a solar PV system. A large barrier in installing electric heat pump water heaters is the size of the household. Some contractors are hesitant to recommend HPWHs to homeowners with large families due to the longer recovery time of heat pumps when compared to traditional storage water heaters.
- **Contractor Concerns with Heap Pump Water Heater Adoption.** Contractors are primarily concerned with the upfront cost of equipment and installation, the installation processes, meeting customer water usage demand, electrical panel upgrades, adequate space for the equipment, an inability to provide hot water during a power outage, and a lack of customer awareness or interest.
- **Sizing Heat Pump Water Heaters**. System sizing is important, as the price of HPWHs increase significantly as size increases, which is unlike other standard water heaters. Contractors consider the following factors when sizing a HPWH: home size, number of occupants, equipment location, existing and existing fuel type. Some contractors report they may oversize a heat pump water heater system to extend the capacity of the system, to enable the homeowner to participate in demand response programs, and to mitigate the risk of running out of hot water during power outages in areas with frequent power issues.

- **Stocking Heat Pump Water Heater.** Heat pump water heaters make up a small portion of distributor's overall business, they do not typically keep them in stock, but this does not create a barrier to contractors obtaining the equipment.
- **Heat Pump Water Heater Customer Awareness.** Contractors reported that customers are rarely aware of the availability of HPWHs and usually do not understand their functionality.
- **Heat Pump Water Heater Training.** Contractors reported that customer interest and education on the benefits of heat pump systems is essential to grow the demand throughout the state. Distributors noted that they offer trainings within their company or through their manufacturers. Trade allies reported that valuable training content includes sales, installation, maintenance, and technical troubleshooting. The time and cost are barriers to training for contractors.
- **Heat Pump Water Heater Cost.** The range and average of total costs between the heat pump and the tankless water heater were similar. Participants reported an average total cost for a heat pump as $3,908 with a range from $1,400 to $5,825. The average total cost for a tankless water heater was $3,471 with a range from $1,665 to $5,850. In general, almost all Delphi participants agreed with the lack of difference between the total cost of a heat pump and a tankless water heater given the home specification provided in the study. Participants indicated that location (both of the unit within the house and of the home generally), contractor experience, customer budgets, and potential electrical upgrades are factors that influence total cost. Two distributors mentioned the potential for profit with HPWHs because the labor and mark-up price of the unit can be twice the cost for a customer than installation of a traditional system, resulting in higher profit for the plumber.
- **Heat Pump Water Heater Incentives.** Trade allies suggested that utility incentive programs are having an impact and will continue to have an impact on heat pump market growth. The majority of contractors indicated familiarity with HPWH incentive programs.

Ground Source Heat Pumps

- **Current Ground Source Heat Pump Market.** Market data for GSHPs is scarce. It is estimated that approximately 50,000 GSHPs are installed in the United States each year. Some market analysts expect the GSHP market to grow at a compound annual growth rate CAGR of 3.4 percent worldwide during the period between 2018 and 2024. Replacement of GSHPs that are at the end of their effective useful life is a key driver of the California GSHP market. However, recent changes in GSHP loop drilling costs have severely impacted market adoption rates in California. Most respondents reported the California GSHP market is growing but at a "snail's pace."
- **Contractor Perception of Ground Source Heat Pump Benefits.** Key benefits of GSHP technology are significant heating and colling cost savings, low environmental impacts, and that GSHP systems are very quiet.
- **Contractor Considerations when Recommending a Ground Source Heat Pump.** Contractors consider costs, impacts to landscape appearance, installation (drilling) noise concerns, and equipment space considerations when recommending a GSHP. All respondents reported that open-loop systems, defined as systems that draw and discharge water from a lake, pond, or river, are not feasible in California due to extensive environmental permitting processes involved. The majority of GSHPs are vertical loop installations due to the lot size where the residence is situated. Horizontal loops systems are seen more in areas with rocky clay-like soil.
- **Contractor Concerns with Ground Source Heap Pump Adoption.** Contractors report the following concerns regarding GSHPs: availability of drillers, geological issues, length of time to install GSHP system, costs, environmental regulations, lot size and recent certification and permitting changes implemented on vertical bore drillers. All market actors report that the development of "loop leasing" is an exciting way to increase the market adoption rates of GSHPs.
- **Sizing Ground Source Heat Pumps.** All respondents reported that they would size a GSHP system to meet 100 percent of the customer's heating load, with many reporting the use of the Manual J (Title 24 approved) heat load calculator. One of these respondents noted that the Title 24 Manual J calculation methodology was inappropriate for GSHPs and that this produced an additional hurdle for adoption.

- **Stocking Ground Source Heat Pumps.** Distributors do not currently stock GSHPs due to the custom-design nature of the GSHP space. The equipment distributor we spoke with reported 95% of their sales are to contractors and 5 percent are to homeowners. Last year 100 percent of this equipment distributor's GSHP sales were new construction installations. All installers reported no difficulties in procuring GSHP equipment from suppliers. They reported the longest lead-time requirement as four weeks. The time needed to procure GSHP equipment did not negatively impact GSHP installations because the installation timeline is dictated by the availability of drilling contractors.
- **Ground Source Heat Pump Customer Awareness.** The market actors we spoke with indicated that there is a lot of interest in GSHPs in the residential market driven by environmental interests, desire to save on costs, and desire for individuals to be carbon neutral and be trendsetters. Contractors reported that far more residential clients contact them with initial interest in a GSHP unit than are installed.
- **Ground Source Heat Pump Training.** Respondents identify a primary market barrier to increased GSHP adoption is poorly designed and installed systems. These systems, typically installed by non-IGSHPA[37] certified technicians in the past, can produce negative perceptions of the technology in the current market space. The GSHP equipment distributor indicated that familiarity of the systems and knowledge of the technology among general contractors is the primary barrier to increasing GSHP installations. Market actors indicated that general GSHP training, IGSHPA certification training, building envelope efficiency and Title 24 code training as training needs in California.
- **Ground Source Heat Pump Costs.** Respondents reported that the incremental costs of GSHPs over standard air-sourced HVAC options on average was 130 percent of the typical air-source first costs (range: 33% to 300%; median: 130%). Respondents report that about 50 percent of potential customers find these costs prohibitive, indicating that they are characterized as both "major" and a "deal breaker."
- **Ground Source Heat Pump Incentives.** Respondents indicated there are no California utility incentives for GSHP loop development in the state, with the notable exception of those areas that both have both high winter heating demand and a lack of natural gas services. Respondents believe that utility incentives will induce higher market adoption rates of GSHPs.

Heat Pump Clothes Dryers

- **Current Heat Pump Clothes Dryer Market.** According to the RASS Study, approximately 53 percent of California respondents who said that they had a clothes dryer said that it was a natural gas dryer while 44 percent said that they had an electric dryer. Distributors noted that HPCDs are good options for small residences undergoing renovation as they can be placed in a small space and do not require a vent, however, in new construction typically designers and contractors devote enough space to accommodate larger vented laundry equipment. Distributors noted that their sales of HPCD are almost exclusively in situations where existing venting is not possible or there is not enough space for larger laundry units to be installed.
- **Installation Considerations for Heat Pump Clothes Dryers.** Space and venting limitations traditionally drive interest in HPCDs. However, retailers also mentioned that HPCD are not suitable for households that need to do larger loads of laundry more frequently such as large families. In combination with the demand for large capacity washers, HPCD can be seen as a less desirable option for people since it can only accommodate half of the washer load at a time. HPCD would be an ideal option for single people or married couples that have less clothes to wash on a consistent basis.
- **Heat Pump Clothes Dryer Stocking and Sales Practices.** Retailers of heat pump clothes dryers indicated that they do not actively stock HPCDs since the demand for these types of units is low. Retailers did mention that utility incentives could push them to stock more HPCDs. Retailers also mentioned that they do not actively market HPCDs since their marketing budgets are primarily focused on kitchen appliances or manufacturer incentives. Some retailers noted that trends moving towards electrification could increase interest in technologies such as HPCDs.

[37] International Ground Source Heat Pump Association (IGSHPA)

- **Customer Perceptions of Heat Pump Clothes Dryers.** Retailers mentioned that the main two customer concerns regarding HPCDs is upfront cost and extended drying times. The cost of a HPCD can be an initial barrier since it costs almost twice as much as a traditional dryer; however, they are far more efficient than a standard natural gas dryer. Customers also express concerns about extended drying times as well as the cool nature in which the clothes come out compared to feeling warm like a vented dryer. One overlooked benefit of HPCD is less damage to clothes since traditional dryers have a history of over drying.
- **Heat Pump Clothes Dryers Incentives.** None of the retailers that we interviewed were aware of any utility incentives available for HPCDs. Some retailers noted that incentives would most likely motivate customers to purchase HPCDs more often.
- **Heat Pump Clothes Dryers Training Opportunities.** Retailers mentioned that expanding education and training opportunities to designers, contractors, and salespeople would increase the penetration of HPCDs in the market. Educating salespeople about all of the benefits of HPCDs including environmental benefits and less damage to clothing, they will be better equipped to sell HPCDs to customers. There is also an opportunity for additional customer education about how to use a HPCD most effectively in order to maximize savings and ensure that clothes are being dried properly.

Heat Pump Pool Heaters

- **Current Heat Pump Pool Heater Market.** According to the RASS data, half of all pools in California are heated and among those 60 percent are heated using natural gas. Nine percent of pools are heated with electricity, and only 1 percent of them were heated with an electric HPPH. Half of interviewed respondents describe the current HPPH market in negative terms, while the remaining half described the market as strong and growing. Recent developments in the HPPH market, as described by respondents, include new technical innovations and increased customer awareness, while three respondents reported there have not been any recent developments to the market. Interviewed respondents believe the California market will grow significantly over the next five to ten years, and they perceive HPPHs as more energy efficient than standard natural gas pool heaters. Over half of interviewed respondents reported solar PV as a primary driver for future HPPH market growth. Other market drivers included general transformation as the market matures, energy efficiency and lower operating costs, natural gas rates, and state and local policies.
- **Installation Considerations for Heat Pump Pool Heaters.** Most respondents listed pool size and customer usage habits as their primary considerations when considering the appropriate type of heater unit to install at a job site. Secondary considerations included availability of fuel types in the pool equipment room, customer budget, space availability for equipment onsite, and whether PV was installed onsite. Although uncommon, installation professionals also noted that if a customer has a large electric load, panel upgrades may be required in order to install a HPPH.
- **Contractor Perception of Heat Pump Pool Heater Benefits.** Contractors reported that operational cost savings of an HPPH can produce a shorter payback period when coupled with a solar PV system. In addition, respondents tell customers that HPPHs are quieter than natural gas heaters, units typically come with a much longer warranty than other types of units, and HPPHs can maintain pools at constant swim temperatures throughout swim season, meaning heat-up time is not a concern.
- **Contractor Concerns with Heat Pump Pool Heater Adoption.** Potential barriers reported by respondents related to HPPH adoption include HPPH technology performance in low humidity and cooler regions, location suitability due to space requirements, length of time to procure a HPPH, and the need for an electrical subpanel upgrade.
- **Stocking Heat Pump Pool Heaters.** The majority of interviewed respondents reported they maintain no personal inventory of HPPH units but rather go through local distributors. The interviewed pool equipment distributor reported his business regularly stocks 15 models of HPPHs and approximately 10 percent of all pool heater stock and sales were HPPHs. The distributor also noted there are no current HPPH manufacturers operating in the state.

- **Heat Pump Pool Heater Customer Awareness.** Lack of customer awareness and familiarity with HPPH emerged as a primary market barrier to adoption. Interviewed respondents reported their customers sometimes initiate discussions about HPPHs. Respondents who are located within the Southern California Edison service territory reported lower awareness of HPPHs among their customers, while respondents who perform work in the Sacramento region reported a higher awareness among customers with 50 percent to 80 percent of HPPH discussions are initiated by the customer.
- **Heat Pump Pool Heater Training.** None of the retailers that we interviewed were aware of any utility incentives available for HPCDs. Some retailers noted that incentives would most likely motivate customers to purchase HPCDs more often.
- **Heat Pump Clothes Dryers Training Opportunities.** Respondents reported a variety of desired HPPH training topics, notably, trainings on the general technology of HPPHs to increase installer awareness and electrical training associated with installing HPPHs. One respondent reported regularly holding onsite training seminars for local professionals, which are offered by manufacturers.
- **Heat Pump Pool Heater Cost and Incentives.** In addition to upfront installation costs of HPPHs, respondents reported other cost concerns related to the overall cost of electricity and pool cover systems. Additionally, interviewed respondents were unaware of any utility incentives for HPPH units. Most felt that the presence of incentives could significantly increase sales of these items.

APPENDIX A. IN-DEPTH INTERVIEWS WITH HEAT PUMP TRADE ALLIES

We conducted in-depth interviews with heat pump installers, distributors, manufacturers, and retailers to investigate their experiences deploying heat pump technologies. The core research objective was to improve heat pump delivery and anticipate the barriers of delivering these technologies at scale. Specific research topics included:

- Perceptions on the heat pump market in general and predicted market trends in next 5-10 years.
- Perceptions on the benefits, drawbacks, and technical challenges of heat pump technologies.
- Perceptions of customer awareness, interest, and concerns.
- Considerations when selling and sizing heat pumps and availability from suppliers.
- Considerations for previous system configuration decommissioning, use of back-up systems, and controls strategy.
- Equipment, installation, and maintenance costs for heat pump clothes dryers and heat pump pool heaters.
- Utility program potential impact on heat pump markets.

INSTRUMENTS

The instruments used for the in-depth interviews with heat pump trade allies are embedded in the following sections.

Installer Guides

ASHP Trade Ally Interview Guide.pdf
HPWH Trade Ally Interview Guide.pdf
GSHP Trade Ally Interview Guide.pdf
HPPH Trade Ally Interview Guide.pdf
Dryer Trade Ally Interview Guide.pdf

Distributor Guides

ASHP & HPWH Distributer Guide.pdf
GSHP & HPPH Distributer Guide.pdf
Dryer Distributer Guide.pdf

Manufacturer Guide

Dryer Manufacturer Guide.pdf

Retailer Guide

Dryer Retailer Guide.pdf

APPENDIX B. IN-DEPTH INTERVIEWS WITH BUILDERS

We interviewed builders and representatives from building and planning departments to better understand the motivations and barriers of building all-electric homes. We were interested in exploring the challenges of introducing new technologies like heat pumps into affordable housing new construction and new construction at large. Listed below are the core research topics covered in the builder in-depth interviews.

- Awareness and familiarity with California's electrification goals and heat pump technologies across market rate and low-income housing.
- Training needs in terms of planning, designing, and building all electric homes.
- Knowledge of heat pump rebates for residential new construction; role of program rebates and tax credits in decision-making.
- Perceptions of the benefits and drawbacks of utilizing heat pumps in market rate and low-income new construction.
- Cost considerations for new developments with special consideration of affordable housing limitations.
- Role of Codes and Standards in decision-making.
- Perceptions of customer awareness, interest, and concerns with efficient appliances, heat pump technologies, and sustainable home attributes in general.
- Marketing and sales techniques with respect to efficiency, sustainability, and heat pumps.
- Predicted market trends in the next 5 years.

INSTRUMENTS

Embedded below are the two guides used in the builder in-depth interviews.

Builder Interview Guide.pdf

Building & Planning Interview Guide.pdf

APPENDIX C. IN-DEPTH INTERVIEWS WITH HEAT PUMP PROGRAM STAFF IN OTHER U.S. JURISDICTIONS

We conducted in-depth interviews with heat pump program staff in other U.S. jurisdictions that have mature heat pump programs. These interviews were intended to capture program best practices. Research topics covered in the interviews included:

- Program efforts undertaken to deploy heat pump technologies and transform the market.
- Heat pump program budgets.
- Lessons learned and barriers faced during the administration of heat pump programs.
- Market drivers that led to the deployment of heat pumps.
- Customer motivations for adopting heat pumps.
- Incidence of heat pump hot water heater thermal storage.
- Incidence of heat pump installations being paired with energy efficiency envelope, solar and other DER programs.

INSTRUMENTS

The guide used for the in-depth program staff interviews is embedded below.

Program Manager Interview Guide.pdf

APPENDIX D. DELPHI STUDY WITH ASHP AND HPWH CONTRACTORS

The Delphi study collected primary data from individuals interfacing with the air source heat pump and heat pump water heater markets. The core objective of the Delphi study was to develop cost baselines for KPIs. These included:

- Upfront incremental equipment costs.
- Upfront incremental installation costs, including labor and infrastructure upgrades.
- Upfront permitting costs and timelines.
- Upfront incremental design costs.
- Annual incremental operation and maintenance costs.

INSTRUMENTS

The Delphi study consisted of two groups of contractors participating in two rounds of data collection. Linked below are the four instruments used to collect the primary data.

ASHP Delphi Round 1.pdf

ASHP Delphi Round 2.pdf

HPWH Delphi Round 1.pdf

HPWH Delphi Round 2.pdf

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