Evaluation Report:
FutureFit Heat Pump Water Heater Pilot

Submitted to:

Silicon Valley Clean Energy

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ADM
ENERGY RESEARCH AND EVALUATION

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1. Executive Summary

Silicon Valley Clean Energy (SVCE) contracted with Sacramento Municipal Utility District (SMUD) to implement the residential FutureFit Heat Pump Water Heater (HPWH) Pilot (the Pilot). ADM Associates, Inc. (ADM) was contracted to conduct independent evaluation, measurement, and verification (EM&V) of the Pilot implemented in 2019 and 2020. There were 95 completed installations at the time of analysis, and a total of 102 completed installations at the close of the Pilot. This report provides the EM&V results and program recommendations from this evaluation.

1.1. Research Goals

The goals for this evaluation were to:

- Estimate greenhouse gas (GHG) emissions reductions;
- Estimate the annual gas usage reduction (in therms) per household;
- Estimate the annual electric energy usage increase (in kWh) per household;
- Generate typical daily load profiles for weekdays and weekends by month;
- Identify groups of usage patterns (e.g., morning versus evening hot water users, etc.);
- Conduct a cost savings analysis; and
- Conduct a participant survey to determine attribution and satisfaction.

1.2. Evaluation Methodology

A census of participants was used to evaluate GHG emission reductions, energy use, and costs for this Pilot. Program-attributable impacts were developed via a combined analysis of Sense Energy Monitor data[1], monthly gas and electric billing data, and participant surveys.

Figure 1-1 summarizes the total data collected for the impact analysis of the Pilot. Figure 1-2 summarizes the application of this data.

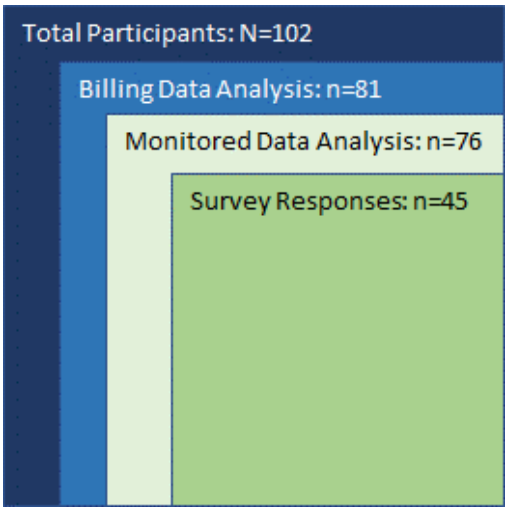


Figure 1-1. Summary of Participant Impact Data – Categorical Nesting

[1] https://sense.com/. Sense Energy Monitors were installed for 81 Pilot participants, which track energy use by circuit and transmit in real-time.

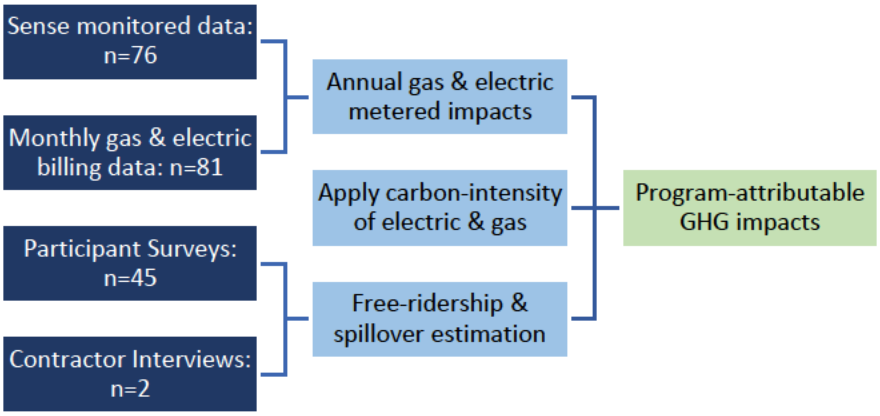


Figure 1-2. Impact Analysis Process Flow

Hourly HPWH monitored data was provided for 76 participants. Monthly electric and gas utility billing data was provided for 79 and 81 customers, respectively. An online survey was sent to 83 participants (the census of participants as of June 2020) to assess customer motivations for participating and program satisfaction. Finally, ADM assessed the potential impact of the COVID-19 pandemic and associated shelter-in-place (SIP) orders in the results of this study.

1.2.1. Supplementary Data Collection

ADM conducted the following supplementary data collection activities:

- **Drop-out customer surveys.** ADM surveyed 40 drop-out customers, 19 of which expressed written interest, and 21 who submitted and withdrew an application.
- **Review of comparable programs.** ADM reviewed comparable programs to assess appropriateness of SVCE program requirements and incentive levels.

1.3. Primary Findings Summary

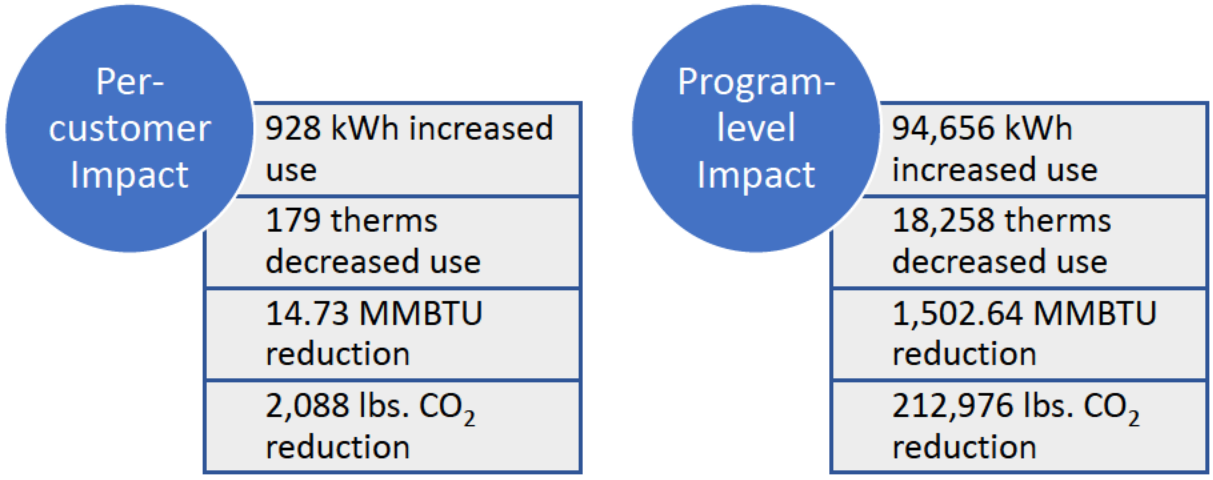


Figure 1-3. Energy Use & GHG Metered Impacts

In addition, ADM estimated net program-attributable impacts. Net program-attributable impacts account for the following factors:

- **Free Ridership:** "Free riders are project participants who would have installed the same energy efficiency measures if there had been no program."[2]. Recharacterizing this definition specific to the Pilot program, ADM defines free riders as:
    - Project participants who would have replaced their natural gas water heater with a heat pump water heater if there had been no program.
- **Spillover:** "Reductions in energy consumption and/or demand in a utility's service area caused by the presence of the program, beyond program related gross savings of participants. These effects could result from: (a) additional energy efficiency actions that program participants take outside the program as a result of having participated; (b) changes in the array of energy-using equipment that manufacturers, dealers, and contractors offer all customers as a result of program availability; and (c) changes in the energy use of non-participants as a result of utility programs, whether direct (e.g., utility program advertising) or indirect (e.g., stocking practices such as (b) above, or changes in consumer buying habits)."[3] This was evaluated for the Pilot by addressing whether participants who received incentives for electric panel upgrades engaged in subsequent deeper decarbonization efforts.

Free-ridership and spillover aggregate into the Net-to-Gross Ratio (NTGR), which is defined as:

$$NTGR = Energy\ Impacts \times (1 - FreeRider\%) \times (1 + Spillover\%)$$

The free-ridership and spillover rates are summarized in Figure 1-4.

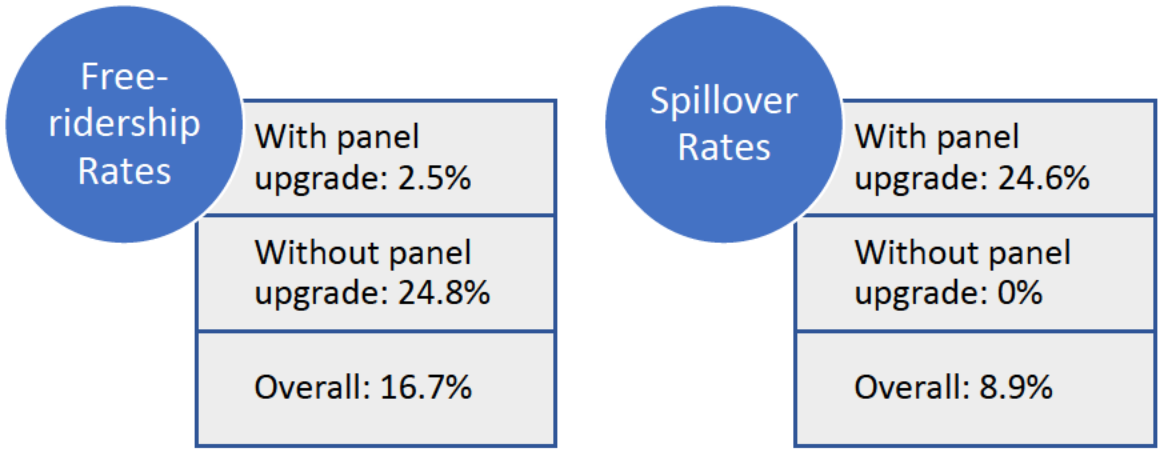


Figure 1-4. Free-ridership & Spillover Impacts

[2] CA Evaluation Framework, Pg. 94.
[3] Ibid. Pg. 441

The overall metered (gross) and program-attributable (net) impacts are summarized in Table 1-1. The "whole program" entries combine the results of all 102 Pilot participants.

Table 1-1. Overall Program Savings Impacts

		kWh Increase	Therms Decrease	GHG Reduction (lbs.)
Gross Impact	Per-participant	928	179	2,088
	Whole program	94,656	18,258	212,976
Net Impact	Per-participant	856	165	1,925
	Whole program	87,273	16,834	196,364

High-level survey findings are found in Figure 1-5 below.

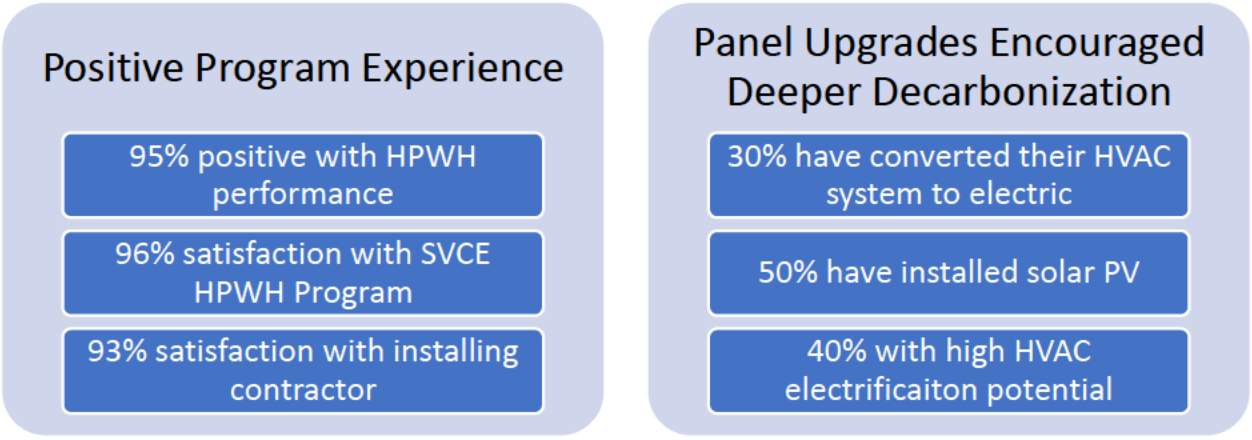


Figure 1-5. High-level Survey Findings

1.4. Secondary Findings Summary

1.4.1. Impact of COVID-19 on Results

ADM compared the average daily load profiles and average daily energy consumption for all customers, a self-reported "no change" group who reported no changes to daytime household occupancy due to SIP, and a self-reported "increased occupancy" group. All three groups experienced changes to their average daily load profiles, specifically regarding changes to the daytime peak and intensity of the evening peak.

Table 1-2 presents a comparison of the average daily energy consumption for all three groups for weekdays and weekends (including holidays).

Table 1-2. Pre-SIP and Post-SIP Average Daily Consumption Comparison

Group	Weekday (kWh/day)		Weekend (kWh/day)	
	Pre-SIP	Post-SIP	Pre-Sip	Post-SIP
All Customers	2.81	2.94	3.05	2.99
No Change Group	2.63	2.52	2.62	2.87
Increased Occupancy Group	2.62	3.37**	3.27	3.39
**Difference significant at 95% confidence				

Although the increased occupancy group showed a large increase in daily kWh for the pre/post-SIP periods, on average, there was not a substantial increase in daily kWh when considering all customers, including those that did not respond to the survey.

1.4.2. Participant Cost Results

The mean net installation cost (after incentives) is estimated to be $1,805 per unit. The gross installation cost, including all equipment and labor, is estimated to be $6,283 while the average rebate amount is estimated to be $4,478. High outliers skewed average costs; median installation cost was $5,790 while mean cost was $6,283.

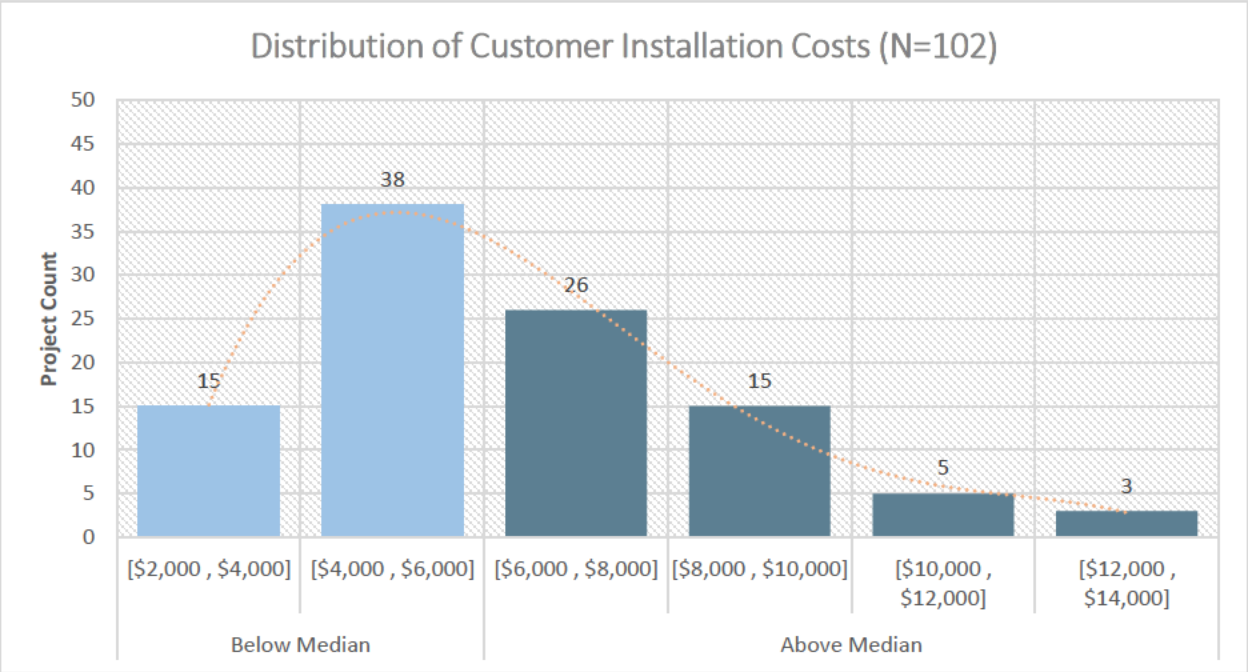


Figure 1-6. Distribution of Project Costs

Based on customer-specific SVCE rates and PG&E natural gas rates, program participants have first-year fuel cost savings of $31.69 by switching from natural gas water heaters to HPWHs. The average annual fuel cost for natural gas water heaters is $261.72. The average annual fuel cost for HPWHs is $230.03.

1.5. Recommendations

ADM's recommendations are as follows:

- **Continue to offer panel upgrade incentives.** Panel upgrade incentives are a key driver for market transformation. For some homes, electrification will require expansion to 200A panels, especially if it is to accommodate heating, ventilation, and air conditioning (HVAC), and potentially electric vehicle (EV) loads. Net-to-gross ratio (NTGR), for the purposes of this analysis, is defined as the percent of program impacts that were induced by the program, rather than reflecting naturally occurring adoption of the measures by participants. Need for some homes to expand to 200A panels was proven in the survey analysis as the overall net-to-gross ratio for customers without a panel upgrade was 75% while it was 127% for customers with a panel upgrade. The reason NTGR is greater than 100% is due to the panel upgrade facilitating HVAC electrification that was not incentivized by SVCE. The acquisition cost per net lb. of greenhouse gas after accounting for spillover is:
    - No panel upgrade: \$2.24/lb. of CO_2
    - With panel upgrade: \$2.28/lb. of CO_2
- **Consider development of electrification rebates for other end uses.** Forty percent of survey respondents were identified as "high electrification potential" for their heating load, through a combined lens of presence of gas equipment and indicating that they would be "very interested" in electrification of this equipment if a rebate covered one third of the installation cost.
    - **Alternatively, develop greater coordination/streamlined referral to other entities offering rebates.** This may include Pacific Gas & Electric (PG&E), Bay Area Regional Energy Network (BayREN), or Bay Area Air Quality Management District (BAAQMD). In some instances, these organizations offer incentives for electrification of other end-uses.
- **Conduct follow-up marketing or check-ins with panel upgrade customers.** ADM found that of the 10 panel upgrade participants surveyed, three completed additional electrification improvements; two of which stated that this would not have been considered without their 200A panel upgrade. As other decarbonization options are developed, panel upgrade participants from the Pilot should be a primary target for new offerings. Barring that, a follow-up survey (perhaps 18-24 months after installation) could be completed internally by SVCE or via an external vendor to assess if deeper electrification efforts were made.
- **Develop a trusted contractor list.** Sixteen percent of respondents noted that they would have found it helpful if SVCE provided a trusted contractor list, with one respondent specifically noting that they selected their contractor from the City of Palo

Alto Utilities contractor list for HPWHs. This aligns with program practices seen by the Bay Area Regional Energy Network (BayREN), City of Palo Alto Utilities, and Silicon Valley Power.

- **Examine possibilities to link customers with Sense metering data to their Green Button data.** Four percent of respondents indicated a desire for better metering of and access to their whole-house consumption in response to an open-ended question asking for further suggestions for the program. One key avenue for this could be the integration of future iterations of the program with the Data Hive Flagship Pilot[4], which can provide customers with more readily-available access to their whole-house metered data to supplement the circuit-level data from the Sense Energy Monitor.
- **Install Sense meters on the circuit containing the load of interest rather than having Sense do "smart disaggregation".** ADM found that in 44% of cases where the Sense meter was left to do smart disaggregation, it did not accurately capture the HPWH and required a supplementary visit by a contractor to address the issue by installing the CTs on the HPWH circuit to collect viable data. If SVCE is to continue to use Sense Energy Monitors in a programmatic capacity (or as a metering tool for future pilot studies), installation approaches should account for lessons-learned from the Pilot pertaining to the limits of Sense "smart disaggregation".
- **Develop permitting checklists/FAQs for the program.** Though the SVCE program webpage mentions applying for a permit, SVCE should consider a larger "permitting checklist for customers, developed in collaboration with member cities. This is more difficult for a Community Choice Aggregator than for a municipal utility as there is a greater range of code requirements to address. However, to the extent feasible, addressing this would be helpful. Sixty-two percent of Pilot participants have been from Sunnyvale or Mountain View. Addressing high-volume cities first could expedite this process in terms of providing value to potential participants.
- **Parties that administer overlapping programs should develop coordination and data sharing agreements.** The Evaluators found that multiple parties offer incentives for HPWHs within SVCE Member cities: SVCE, BayRen, and Pacific Gas & Electric (PG&E) all offer incentives for this technology with largely similar program requirements. Program administrators should as a practice endeavor to identify cases of overlapping offerings such as this, and develop data-sharing agreements where warranted. This would allow all parties to ensure the most efficient use of funds and would prevent potential double counting of impacts from a single project across multiple entities administering energy efficiency or decarbonization initiatives.

[4] https://data.svcleanenergy.org/

2. Introduction

The primary objective of this evaluation is to measure greenhouse gas (GHG) emissions reductions associated with the Pilot.

2.1. Program Overview

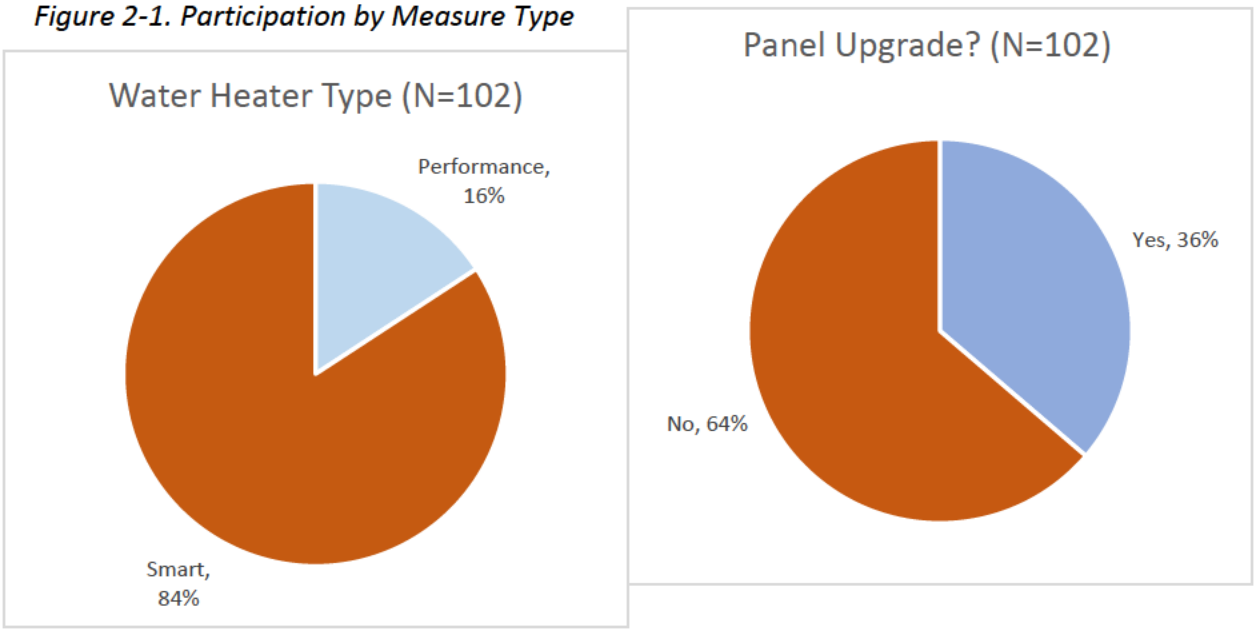
The Pilot is an electrification pilot program offered by SVCE in 2019 and 2020. The purpose of the Pilot is to reduce GHG emissions by incentivizing the installation of electric HPWH to replace natural gas water heaters in the residential sector. Customers who participate in the program receive a rebate towards the cost of installing a HPWH. The Pilot participants must also install a metering device to their HPWH and agree to wirelessly transmit metering data to SVCE as part of participating in this program.

A total of 166 customers applied for rebates through the Pilot. There were 102 rebates issued and 64 applications withdrawn.

2.2. Participation Summary

At the time ADM completed analysis, there were 83 participants in the Pilot. After this period, an additional 19 participants completed projects. For the purposes of extrapolating program impacts, results were extrapolated to all 102 participants. Figure 2-1 summarizes participation by measure type while Figure 2-2 summarizes participation by city.

Figure 2-1. Participation by Measure Type



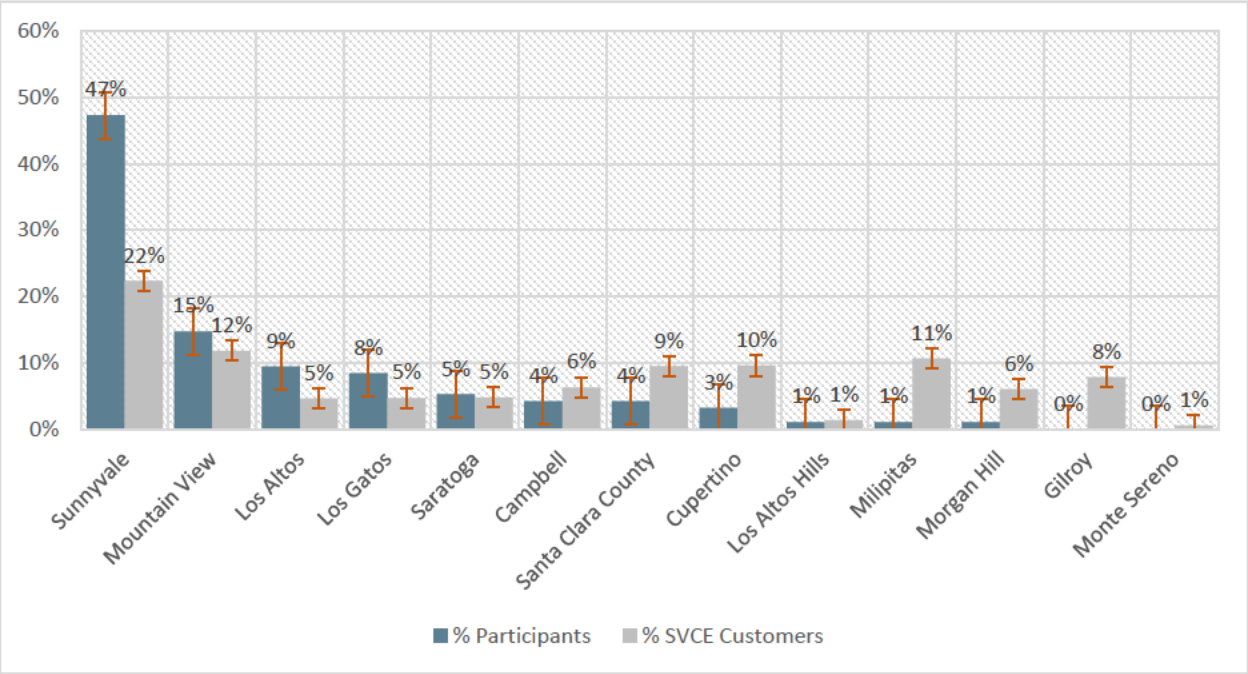


Figure 2-2. Participation by Member City

Sunnyvale had higher participation than its share of SVCE population by a significant margin. Some of this discrepancy may be attributed to demographics because there is a higher-than-average income level in Sunnyvale. However, in the participant survey, it was found that 11% of Sunnyvale respondents learned about the program from a contractor while no respondents from any other Member indicated that. Examining verbatim response descriptions, ADM found that participants from Sunnyvale had indicated learning of the program from a solar panel installer. SVCE staff noted that solar installers from Sunnyvale were actively engaged in discussions during the design and concept phase of the Pilot, and this has manifested in increased participation from this Member City.

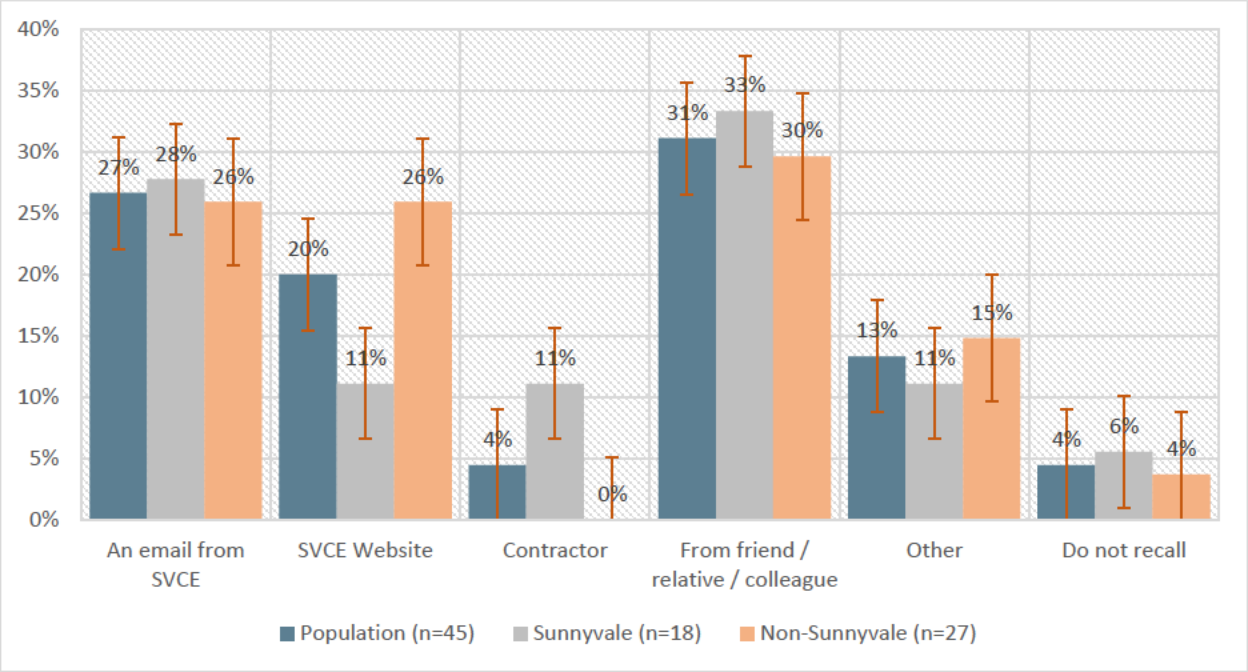


Figure 2-3. Source of Program Awareness – Sunnyvale Compared to Other Member Cities

3. Methodology

The following section details our approach to data acquisition and analysis for the Pilot program evaluation.

3.1. Data Sources

Electric metering data for the HPWHs were obtained via the Sense platform for all customers except for one customer who provided Aeotec data directly to SVCE via e-mail. Sense data were extracted from the Sense online tool on October 27, 2020. Gas and electric billing data for all customers dating back to 2018 was provided to ADM by SVCE.

3.2. Sampling

Due to the nature of the program requiring all participants to install a metering device, ADM relied on a census of available data to complete electric metering, gas billing, and GHG emissions analysis. Additionally, the census of participants who had a completed rebate in June of 2020 (83 participants) were invited to participate in the online customer survey.

3.3. Electric Monitoring Data Analysis

Electric monitoring data for most customers in the Pilot was done via a Sense meter installed at the customers' electrical panel. Sense monitors provide wireless data transmission which can be downloaded through an online platform. Sense devices monitor electric load in two different ways—they can monitor whole house load or can be installed on circuits dedicated to powering a single device. In most cases, the Sense monitors were installed on the circuit dedicated to the HPWH. However, for some customers, Sense monitors were installed at the whole-house level. The Sense platform automatically attempts to disaggregate electric load data into different end uses based on a machine learning algorithm.

ADM manually reviewed all Sense meter data to determine: (1) whether the meter was installed on a dedicated HPWH circuit and (2) for cases where the meter was installed at the whole house level, which disaggregated load best represented the HPWH. ADM performed an initial review of Sense data from December 2019 through March 2020. In some cases, Sense meters that were installed at the whole house level did not provide a distinguishable HPWH load. For these cases, Sense meters were reinstalled directly on the HPWH circuit. This reinstallation occurred for 31 participants.

One additional customer used an Aeotec meter installed on a dedicated HPWH circuit and provided data to SVCE via e-mail.

Of the 102 customers who participated in the Pilot: Seven customers could not be mapped back to a Sense meter device, one customer did not provide Aeotec metering data, three

customers had Sense metering data that could not be interpreted, and 25 customers began data collection after most of the data analysis had been completed.

3.3.1. Load Shape Generation

After reviewing the metering data, ADM then created an average load profile by taking the average across all customers by hour and date. ADM then segmented the load profile by month and weekday-type (weekdays versus weekends, with holidays[5] considered weekends) and took the average 24-hour load profile by month and weekday-type.

3.3.2. Annual Electric Energy Consumption Calculation

The average annual electric energy consumption was then calculated by taking the sum of the average daily weekday and weekend profiles by month to obtain the average daily kWh by weekday-type by month. These values were then multiplied by the respective number of weekdays and weekends (including holidays) per month.

3.3.3. Daytime versus Nighttime User Analysis

In addition to generating a load shape for all customers, SVCE was also interested in seeing if there were clusters of customers that use their water heaters at specific times of the day. To conduct this analysis, ADM first assessed the average daily peak time at which each customer used their water heater. After determining the peak hour by customer, ADM then split customers into "daytime" users, who have a peak load between 5 a.m. and 5 p.m., and "nighttime" users, who have a peak load between 5 p.m. and 5 a.m. Separate load profiles were then generated for daytime and nighttime users.

3.4. Gas Billing Data Analysis

Of the 93 customers who participated in the Pilot: 12 customers did not have sufficient gas billing data for this analysis, and two customers did not have information available regarding the installation date of their HPWHs. The remaining 79 customers were used to conduct a pre-post analysis to determine their gas savings.

To factor out weather-sensitive loads and isolate baseloads, ADM established the pre and post periods to include the summer months before and summer months after installation (June through September). For each customer, the gas savings were calculated by subtracting the average daily therms from the post period from the average daily therms in the pre period. An example of this calculation is provided in the following equation:

$$\Delta adt_{ix} = adt_{pre\_ix} - adt_{post\_ix}$$

[5] Holidays were defined as the 11 holidays observed by the State of California (https://www.calhr.ca.gov/employees/pages/state-holidays.aspx).

Where:

- adt represents the average daily therms;
- i represents a given customer;
- x represents a given month between June through September;
- pre is the pre-period; and
- $post$ is the post-period.

After calculating the average daily therm savings for each month for each customer, an average daily savings was then calculated for each month by averaging the average daily savings across customers. At that point, therm savings for non-summer months were estimated by using the water heating load profile derived from the electric metering data. An example of this calculation is provided in the following equation:

$$\Delta adt_x = scalar_x \cdot \Delta adt_{summer}$$

Where:

- x is the given non-summer month of interest;
- Δadt_{summer} is the weighted average daily therm savings for June through September; and
- $scalar$ is the ratio of energy usage for that given month compared to the average daily energy usage for summer as derived from the water heating load shape data.

3.5. GHG Emissions Savings Analysis

GHG emissions for gas consumption was estimated using 11.68 lbs. of CO_2 per therm as derived from the EPA Greenhouse Gas Equivalencies Calculator.[6] GHG emissions for electric energy consumption varied depending on whether SVCE customers were enrolled in SVCE's GreenStart or GreenPrime product. GHG emissions for GreenStart customers were estimated at 0.0023 lbs. of CO_2 per kWh and 0 lbs. of CO_2 per kWh for GreenPrime customers.

SVCE provided electric billing data for 81 participants. Of these 81 participants, 33 were enrolled in the GreenPrime product. Thus, the weighted average GHG emission for this Pilot was estimated as 0.0014 lbs. of CO_2 per kWh.

GHG emissions savings was thus calculated as the difference in emissions from the gas water heaters versus HPWH water heaters. The following equation provides an example of this calculation:

$$\Delta GHG = \left(11.68 \frac{lbs.of\ CO_2}{therm} \cdot NGWH\right) - \left(0.0014 \frac{lbs.of\ CO_2}{kWh} \cdot HPWH\right)$$

[6] https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculation18%s-and-references

Where:

- ΔGHG is the average annual GHG savings per household in units of lbs. of CO_2;
- $NGWH$ is the average annual gas consumption per natural gas water heater in units of therms; and
- $HPWH$ is the average annual electric consumption per HPWH in units of kWh.

3.6. Participant Survey

An online participant survey was administered through the SurveyGizmo platform. The survey assessed customer motivations for participating in the program, program satisfaction, and any feedback customers had for the Pilot. A copy of the survey instrument is provided in Appendix B: Participant Survey Instrument.

All 83 customers who had a completed rebate in June of 2020 were invited via e-mail to participate in the survey. Customers received an initial contact e-mail and two follow-up reminder e-mails. A total of 45 customers responded to the survey (54% response rate), which exceeds the number of participants needed to reach 90/10 confidence and precision.

3.7. Interested Customer Survey

An online participant survey was administered through the Qualtrics platform to customers who expressed interest in a heat pump water heater project by either adding their name to an interest list or by submitting a reservation for a heat pump water heater without receiving the program incentive. The intent of the survey was to assess potential barriers to project completion and program participation. Respondents were asked if they had installed the water heater outside of the program, the reasons for not participating in the program, and (if applicable) the reasons for not installing the heat pump water heater. A copy of the survey instrument is provided in Appendix C: Interested Customer Survey Instrument.

The 165 unique customers on the reservation or interest list were sent a survey invitation by email in March of 2021. Each customer received an initial contact followed by two follow up reminder emails. Forty customers responded to the survey, for an overall completion rate of 24%. Table 3-1 breaks down the response by customer group (i.e., on the interest or reservation list).

Table 3-1. Interested Customer Survey Response Break Out

Group	Population Size	Sample Size	Response Rate
Interest list	103	19	18%
Reservation list	62	21	34%
Total	165	40	24%

The presented results combined customer responses on the interest list and reservation list. Groups are weighted to account for the differences in sample and population sizes between these groups. The weight was calculated as 1/(n/N), where n is the size of the sample and N is the size of the population. The weight applied to responses from customers on the interest list was 5.42 and the weight applied to responses on the reservation list was 2.95.

3.8. Contractor Interviews

ADM contacted contractors to complete the interviews in September 2020 and March 2021 with the goal of completing five interviews.

For the September 2020 attempt, ADM placed up to three telephone calls with 19 contractors that had completed between 1 and 20 installations. One contactor completed an interview and one agreed to answer the questions online. Of the remainder, one contractor refused, and the others did not respond. One contractor provided the feedback that it was a busy time of year for them.

In March 2021, ADM made a second attempt to schedule interviews with a sample of 10 contractors who had completed between 1 and 22 projects, all of whom were also on the September 2020 contact list. Although the list included four contractors who completed one or two projects, the focus was on the more active contractors, who might be more responsive to an interview request. Additionally, SVCE contacted the contractors in advance to inform them of the research and encourage their participation. ADM placed three telephone calls and sent one email to each of the contractors on the list. None agreed to complete an interview.

3.9. Participant Cost Analysis

As part of this analysis, ADM looked at two sources of participant cost:

- **Installation cost:** The average gross cost of installing HPWHs including parts and labor, the average customer rebate, and the average net cost of installation less the customer rebate. This information is taken directly from SVCE's rebate tracking data.
- **Estimated fuel cost savings associated with HPWH installation:** the average fuel cost for the baseline natural gas water heater less the average fuel cost for the HPWH. This is calculated using 2020 rate information[7] weighted relative to customers' rate class for consumption-related costs only. Static infrastructure costs are not included in this calculation. Information regarding tiered usage was not available in either gas or electric billing data. To estimate a conservative cost savings, it was assumed that water heating fell into "baseline" or "Tier 1" usage. Time-of-use (TOU) rates for electric

[7] Residential rates for PGE were taken from: https://www.pge.com/tariffs/Res_Current.xlsx. The rate for December 2020 was not yet published at the time of writing—they were assumed to be the same as November 2020 for the purpose of reporting. Residential rates for SVCE were taken from: https://www.svcleanenergy.org/wp-content/uploads/2020/02/October-2020-Rate-Update-Residential.pdf.

energy usage were estimated using the month by weekday-type load shapes described in Section 3.3.1.

3.10. Impact of COVID-19 Pandemic on Program Results

On March 16th, 2020, seven counties in the greater San Francisco Bay Area region of California issued a SIP order in response to the ongoing COVID-19 pandemic with an effective date of March 17th, 2020.[8] This was followed by a statewide "safer at home" order issued on March 19th, 2020 with an effective date of March 20th, 2020.[9] These Orders have a direct impact on the results observed in this study due to increased daytime occupancy, which may increase the total amount of energy consumed by water heating per household and may also cause shifts in behavior associated with water heating.

To address the potential impact of SIP on program results, we performed an exploratory analysis on the average daily load profiles associated with the period shortly before and shortly after SIP went into effect on March 17th, 2020. We limited our analysis to the period between February 1st and April 30th of 2020 to avoid introducing weather-related changes into this analysis.

Additionally, as part of our customer survey, customers were asked how daytime occupancy had shifted in their household because of the SIP order.

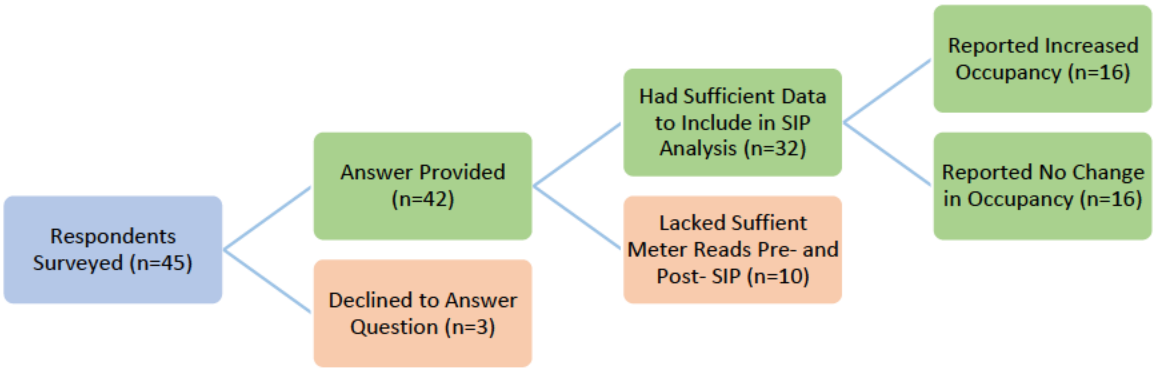


Figure 3-1. Respondent Disposition to Shelter-in-Place Questions

For each group of customers with the combination of valid survey responses and meter reads, ADM performed an exploratory pre-post analysis for the window between February 1st through April 30th, 2020 to determine whether SIP-related changes were present for both groups of customers.

[8] https://www.sccgov.org/sites/phd/news/Pages/press-release-03-16-20.aspx
[9] https://www.gov.ca.gov/wp-content/uploads/2020/03/3.19.20-attested-EO-N-33-20-COVID-19-HEALTH-ORDER.pdf

4. Electric & Gas Consumption and GHG Results

The following section presents the results of the electric metering analysis, the gas consumption data analysis, and presents the corresponding GHG impacts.

4.1. Electric Metering Data Results

Electric metering analysis included development of water heating load shapes, estimates of HPWH electric energy consumption, and identification of clusters of participants with similar usage patterns in the electric metering data.

4.1.1. Water Heating Load Shape

Figure 4-1 presents the average daily load shape for weekdays and weekends on an annual basis. Monthly weekday and weekend load shapes are presented in Appendix A: A HPWH in heat pump mode averages 0.2 kWh/hour while in back-up resistance mode it averages 4.5 kWh/hour. Based on this, the Evaluators concluded from the metering data that the HPWHs did not enter back-up heating mode.

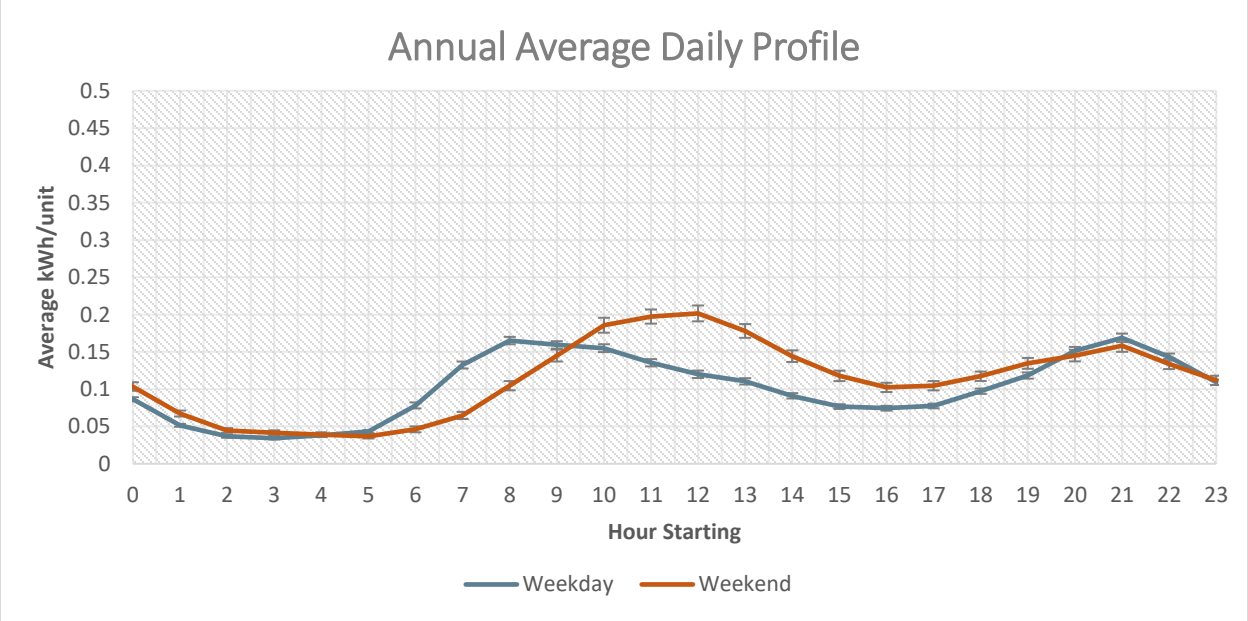


Figure 4-1. Annual Average Daily Profile for all Customers by Weekday-type

The water heating load shape has a bimodal distribution, peaking primarily either in the morning or later in the evening. Weekdays tend to peak at roughly 8 a.m. with a secondary peak at roughly 9 p.m. Weekends tend to peak later in the day at roughly 12 p.m. with a smaller yet still consistent secondary peak at roughly 9 p.m. Additionally, the magnitude of the weekend profile is larger than that of the weekday profile, suggesting greater daily hot water usage on the weekend.

4.1.2. Annual Electric Energy Consumption

Figure 4-2 presents the average daily kWh consumed by HPWHs by month and weekday-type.

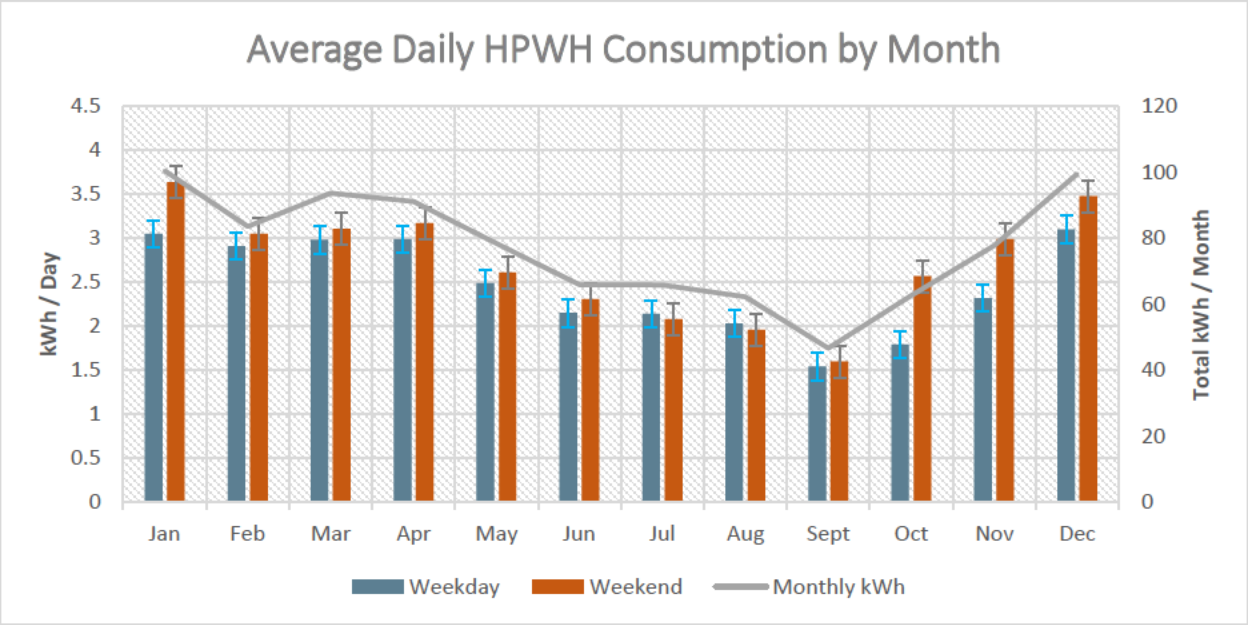


Figure 4-2. Average Daily HPWH Consumption by Month (kWh/unit)

On average, HPWHs installed through the program consumed 928 kWh/year per household. This is consistent with previous studies conducted by ADM in California.[10]

4.1.3. Daytime versus Nighttime User Analysis

One of SVCE's research goals for this evaluation was to determine whether there are clusters of customers that use their hot water heaters at specific times of the day. To accomplish this goal, ADM identified each customers' average peak water heating usage time.

Figure 4-3 presents the number of customers at each peak water heating usage time. As can be seen from the figure, the peak water heating usage time appears to distribute itself bi-modally, with most customers having a peak water heating usage time either in the morning between 8 a.m. and 10 a.m., or in the evening between 8 p.m. and midnight. Thus, ADM split the data set into two groups: a daytime user group, who have a peak usage between 5 a.m. and 5 p.m.; and a nighttime user group, who have a peak usage between 5 p.m. and 5 a.m.

[10] A metering study conducted by ADM for the Sacramento Municipal Utility District found a similar value of 966 kWh/unit. (https://www.smud.org/-/media/Documents/Corporate/About-Us/Reports-and-Documents/2018/HPWH-Field-Testing-Report-1-6-2016.ashx)

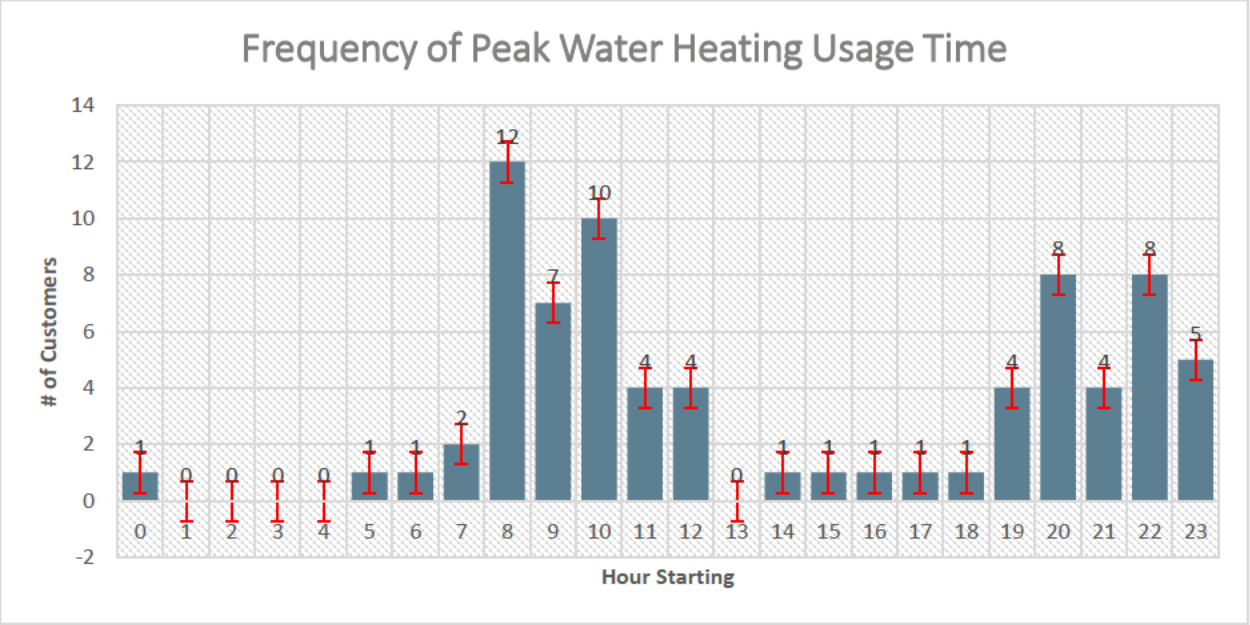


Figure 4-3. Frequency of Peak DHW Load Times

Of the participants with metering data, 44 customers were in the daytime user group. The water heating load shape for these customers is presented in Figure 4-4. As can be seen from the figure, although these customers primarily use water heating during the day, there is still a secondary peak in the evening, albeit to a significantly lower degree than the consolidated load shape across all participants.

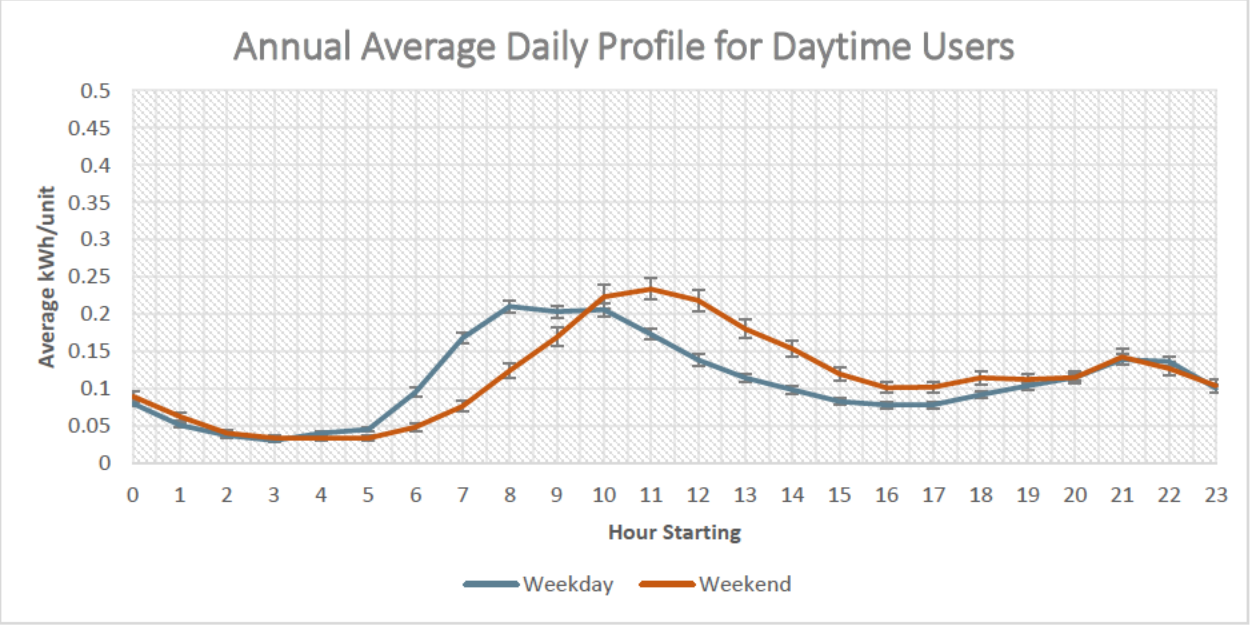


Figure 4-4. Annual Average Daily Profile for Daytime Users by Day-Type

Of the participants with metering data, 32 customers were in the nighttime user group. The water heating load shape for these customers is presented in Figure 4-5. As can be seen from the figure, there is a large discrepancy between how users in this group use water heating during weekdays versus weekends. Weekdays are generally unimodal in distribution, peaking solely between 8 p.m. and 10 p.m. However, this distribution shifts to a more bimodal distribution on weekends, with a secondary peak emerging between 12 p.m. and 2 p.m.

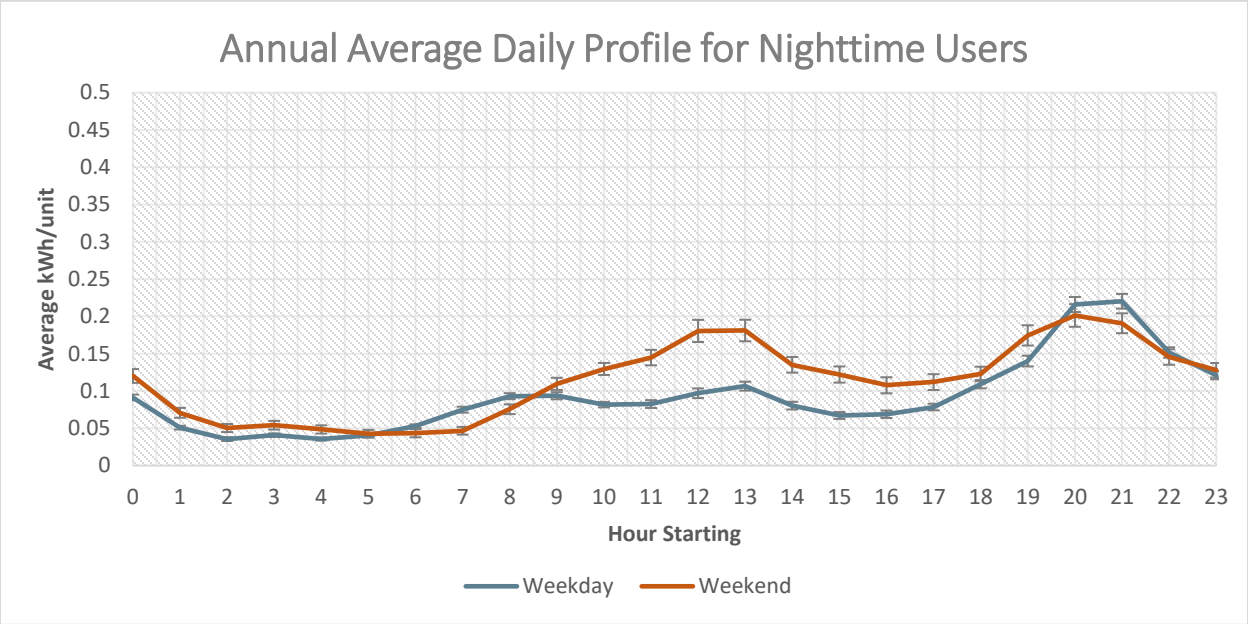


Figure 4-5. Annual Average Daily Profile for Nighttime Users by Day-Type Gas Consumption Results

4.2. Gas Consumption Results

Table 4-1 presents the results of the gas consumption analysis for the baseline natural gas water heaters. As noted in Section 3.4, a simple post minus pre subtraction was performed for the months of June through September. These values were then scaled according to the ratio of non-summer month average daily consumption to average summer month daily consumption as observed in the electric metering data.

Table 4-1. Consumption of Baseline Natural Gas Water Heaters.

Month	Therms/Day			Number of Days per Month	Month to Summer Scalar	Estimated Daily Savings	Estimated Monthly Savings
	Pre	Post	Delta				
1	n/a	n/a	n/a	31	1.64	0.62	19.37
2	n/a	n/a	n/a	28.25	1.50	0.57	16.11
3	n/a	n/a	n/a	31	1.53	0.58	18.05
4	n/a	n/a	n/a	30	1.54	0.59	17.58
5	n/a	n/a	n/a	31	1.28	0.49	15.13
6	0.87	0.31	0.60	30	n/a	0.60	17.88
7	0.52	0.23	0.30	31	n/a	0.30	9.22
8	0.47	0.22	0.28	31	n/a	0.28	8.74
9	0.50	0.18	0.35	30	n/a	0.35	10.55
10	n/a	n/a	n/a	31	1.02	0.39	12.07
11	n/a	n/a	n/a	30	1.31	0.50	14.99
12	n/a	n/a	n/a	31	1.63	0.62	19.18
Total	n/a	n/a	n/a	365.25	n/a	0.49	178.86

Based on the gas billing data analysis, participants saved 178.86 therms/year per household.

4.3. GHG Emissions Savings Results

As noted in Section 3.5, GHG emissions savings can be estimated using the following equation:

$$\Delta GHG = \left(11.68 \frac{lbs.\,of\ CO_2}{therm} \cdot NGWH\right) - \left(0.0014 \frac{lbs.\,of\ CO_2}{kWh} \cdot HPWH\right)$$

Where:

- ΔGHG is the average annual GHG savings per household in units of lbs. of CO_2,
- $NGWH$ is the average annual gas consumption per natural gas water heater in units of therms, and
- $HPWH$ is the average annual electric consumption per HPWH in units of kWh.

Using the values observed in Sections 4.1.2 and 0, the average GHG emissions savings can now be estimated as follows:

$$\left(11.68 \frac{lbs.\,of\ CO_2}{therm} \cdot 178.86\ therms\right) - \left(0.0014 \frac{lbs.\,of\ CO_2}{kWh} \cdot 927.59\ kWh\right) = 2088\ lbs.\,of\ CO_2$$

Therefore, the GHG emissions savings is approximately 2,088 lbs. of CO_2 per unit per year.

4.4. Impact of COVID-19 on Results

As noted in Section 3.10, one of the potential concerns for this evaluation stems from the SIP order which went into effect for most SVCE customers on March 17th, 2020. To parse out the potential impact of SIP on the electric metering data analysis, ADM first isolated data for the period between February 1st, 2020 through April 30th, 2020 and defined the Pre-SIP period as February 1st through March 16th and the Post-SIP as March 17th through April 30th. This was done to limit the potential impact of weather on this analysis. Additionally, only customers who had data prior to March 17th were included in the analysis. Thus, of the 76 customers for whom meter data were available, 58 customers were included in this analysis.

After isolating the appropriate data, the average daily load shapes for weekdays and weekends in the Pre-SIP and Post-SIP period were compared to see if there were any significant differences in the signature of these profiles. These load shapes are presented in Figure 4-6 and Figure 4-7.

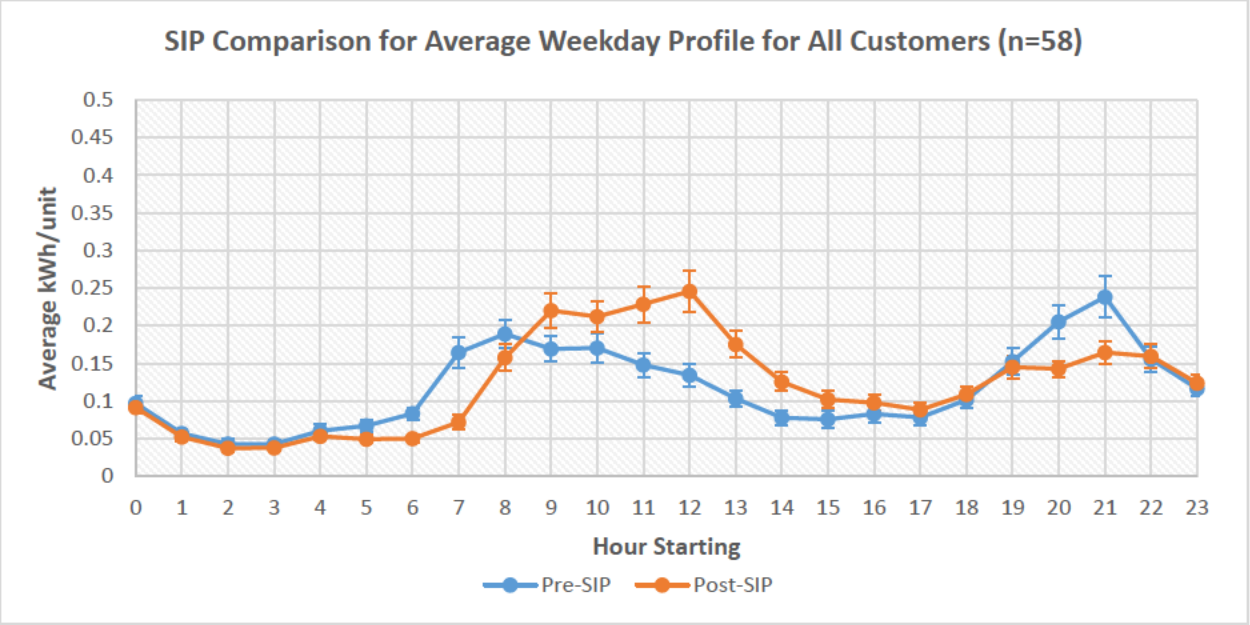


Figure 4-6. Comparison of Weekday Average Daily Load Profiles for all Customers in the Pre-SIP and Post-SIP Period

As can be seen in Figure 4-6, there is a substantial difference between the Pre-SIP and Post-SIP load shapes. In the Pre-SIP load shape, there is an earlier morning peak distributed roughly between 8 a.m. and noon and a secondary peak in the evening between 8 p.m. and 10 p.m. The morning peak appears to shift between 9 a.m. and 1 p.m. and increase in peak magnitude whereas the evening peak appears to decrease substantially in magnitude.

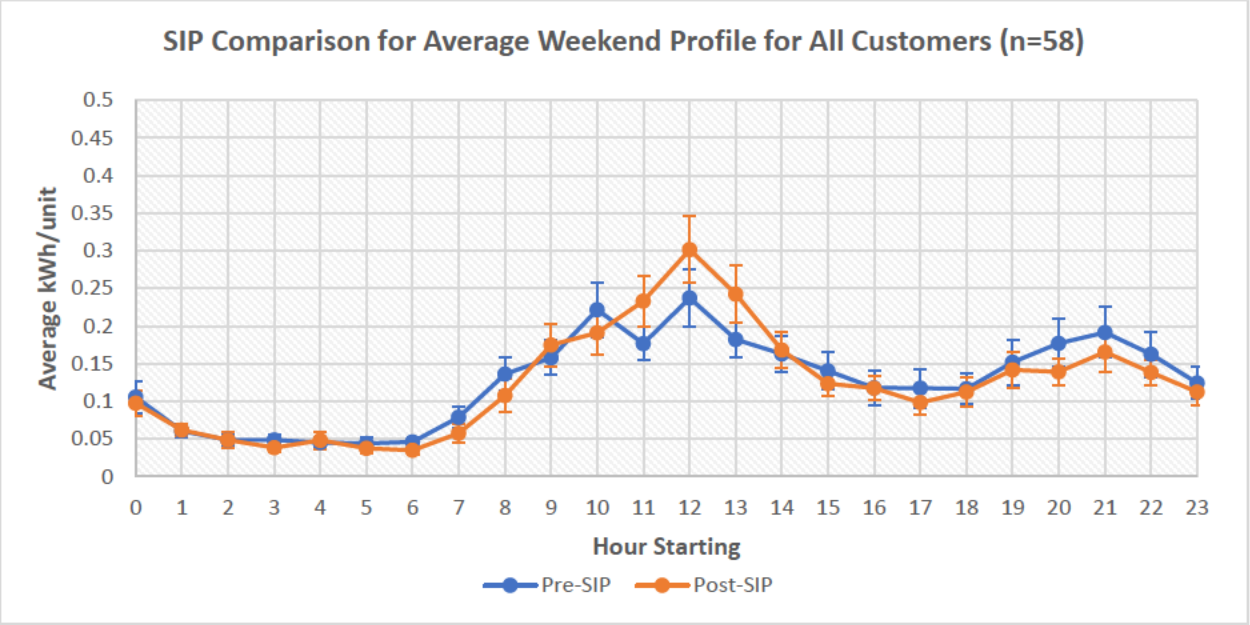


Figure 4-7. Comparison of Weekend Average Daily Load Profiles for all Customers in the Pre-SIP and Post-SIP Period

Unlike the weekday profiles, the weekend profiles do not appear to shift dramatically. Although the peak at noon on weekends appears to be more tightly distributed, this is most likely attributable to noise rather than a significant behavioral shift.

In addition to comparing the Pre-SIP and Post-SIP load shapes for all customers, ADM also reviewed survey responses pertaining to whether customers reported having a change in home occupancy due to SIP orders. Of the data available, ADM identified 16 customers with meter data who identified themselves as having "No Change" versus 16 customers with meter data who identified themselves as having an "Increased Occupancy" due to the SIP order.

Figure 4-8 and Figure 4-9 present the average weekday profiles for both the "No Change" and "Increased Occupancy" groups in the Pre-SIP and Post-SIP periods.

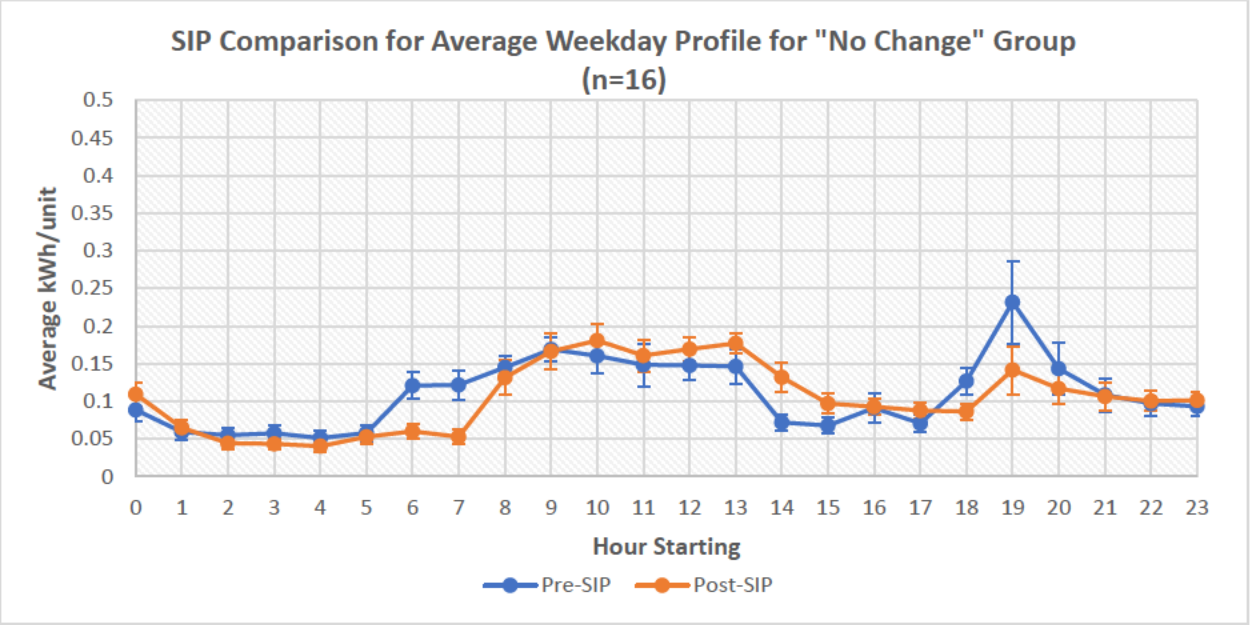


Figure 4-8. Comparison of Weekday Average Daily Profile for "No Change" Customers

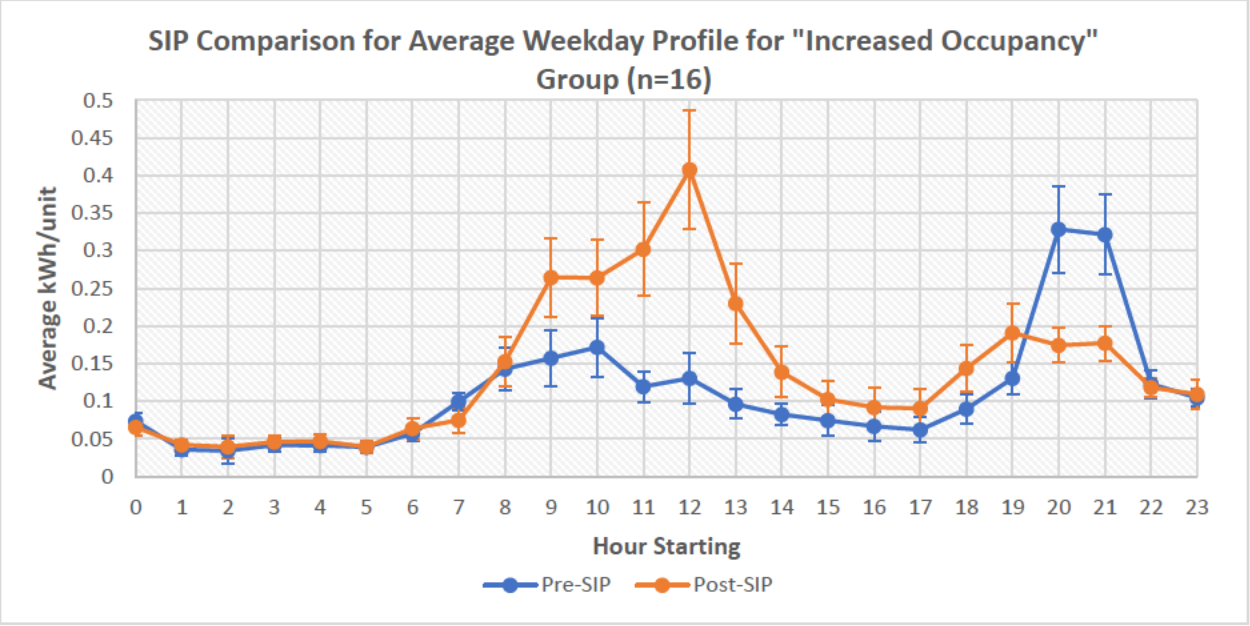


Figure 4-9. Comparison of Weekday Average Daily Profile for "Increased Occupancy" Customers

As shown in Figure 4-8 and Figure 4-9, both groups show a difference in the average daily profile between the Pre-SIP and Post-SIP periods. The "No Change" group shows a delay in the onset of the morning peak period and a reduction in the magnitude of the secondary evening peak. The "Increased Occupancy" group shows as substantial increase in the magnitude of the morning peak period and a substantial reduction in the evening peak, which has shifted from a primary peak to a secondary peak. Further, this data shows usage up to 0.40 kWh per hour,

indicating a high likelihood that the HPWH spent some time in back-up heating mode using the electric resistance element. The impacts are statistically significant at ±95% confidence.

Figure 4-10 and Figure 4-11 present the average weekend profiles for the "No Change" and "Increased Occupancy" groups.

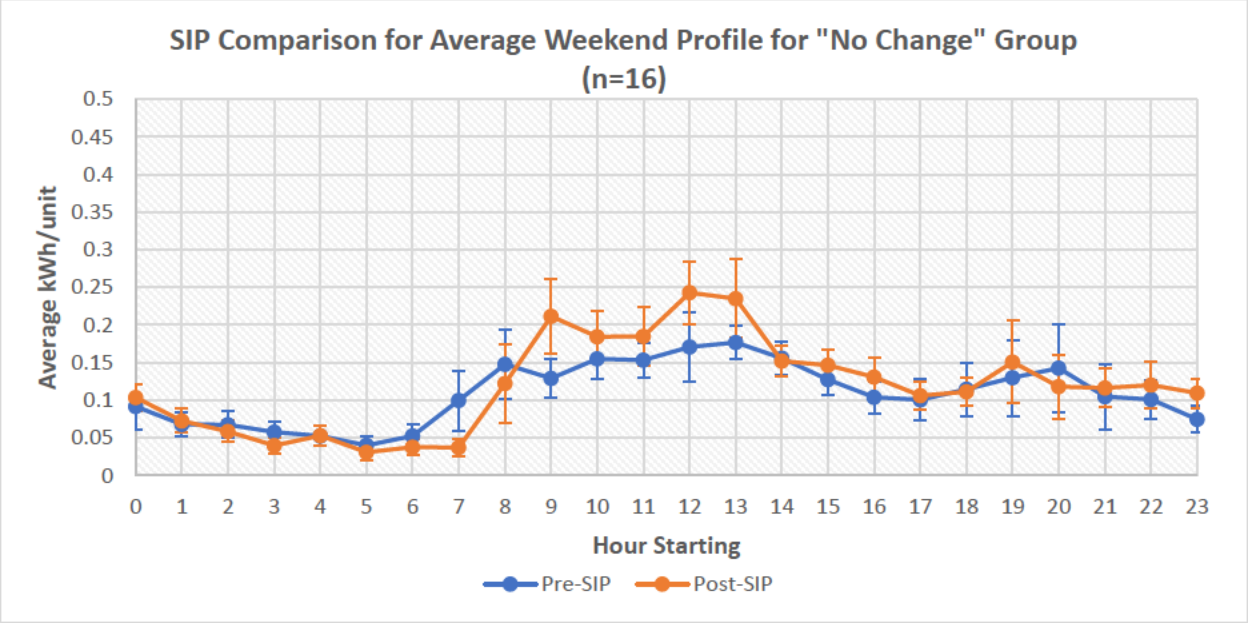


Figure 4-10. Comparison of Weekend Average Daily Profile for "No Change" Customers

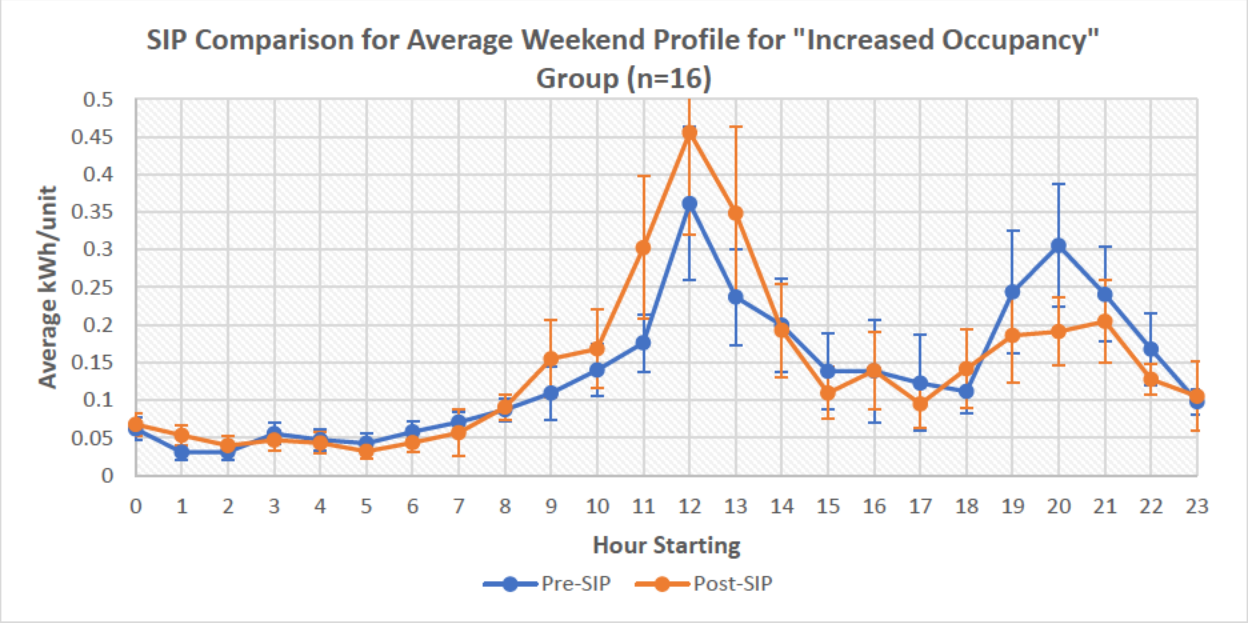


Figure 4-11. Comparison of Weekend Average Daily Profile for "Increased Occupancy" Customers

Unlike the weekday profiles, the weekend profiles have not substantially changed for either group of customers between the Pre-SIP and Post-SIP period. For the "Increased Occupancy" customers, a decrease in the evening peak and increase in the morning peak is still present, but to a lesser degree than their corresponding daytime profile. Similarly, "No Change" group appears to have a tighter distribution around the morning peak than prior to the SIP order, however, this could possibly be attributable to noise. For most hours, the differences are not statistically significant. However, when examining the pattern of impacts compared to those that indicated increased occupancy, we posit that significance would be hypothetically possible if this specific customer group were studied in greater detail with a larger focused sample size.

Finally, after comparing the load shapes for all customers, the "No Change," and the "Increased Occupancy" groups, ADM compared the average daily consumption for the HPWHs from the Pre-SIP and Post-SIP periods. Figure 4-12 summarizes the change in post-SIP compared to pre-SIP daily water heating kWh by customer group.

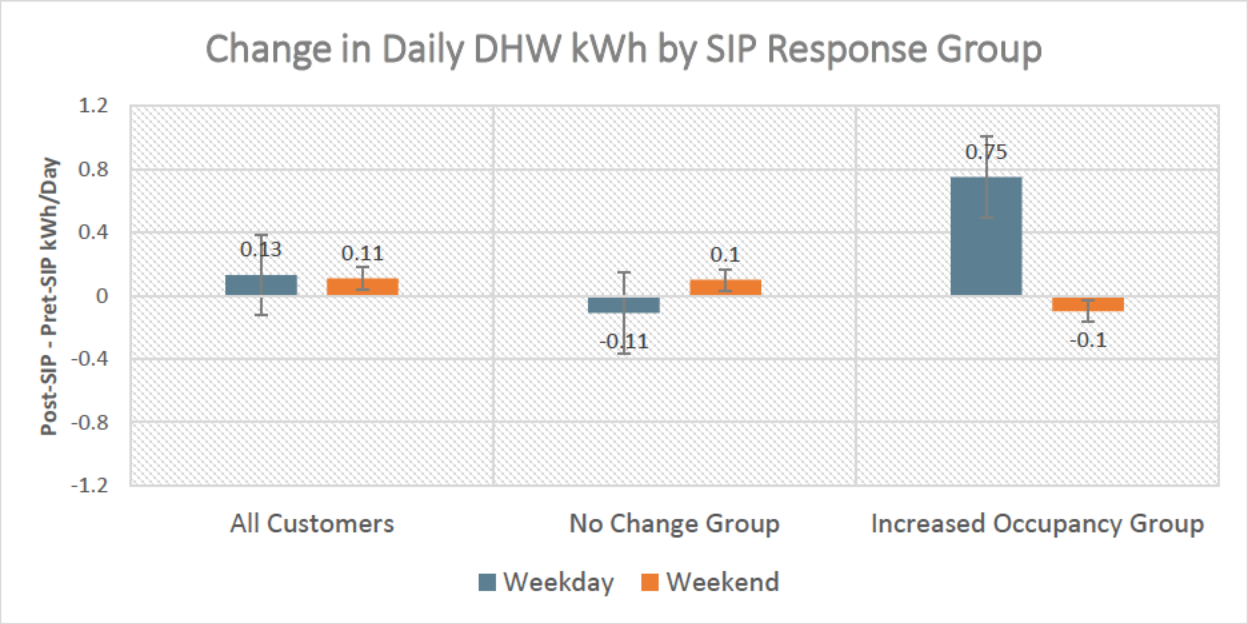


Figure 4-12. Pre-SIP and Post-SIP Average Daily Consumption Comparison

As can be seen from the table, there is a substantial increase in the weekday kWh for the "Increased Occupancy" group. However, the increase for the "All Customers" group is marginal, suggesting that despite the SIP order, the overall energy usage associated with the SIP order is minimal on average. This lends credence to the results observed for the electric energy consumption and natural gas consumption being valid despite the load shapes potentially showing shifts in daytime water heating usage relative to SIP.

5. Participant Survey Results

The following section presents the results of the participant survey.

As noted in Section 3.6, the participant survey assessed customer motivations for participating in the program, program satisfaction, and any feedback customers had for the program. Survey invitations were issued to all 83 participants who had a "Completed" rebate status at the time of the survey (June 2020) resulting in a total of 45 respondents.

5.1. Sampling Precision

The required sample size to meet 90% confidence and ±10% precision for a given coefficient of variation in a statistically infinite population is estimated as:

$$n = \left(\frac{1.645 * CV}{.10}\right)^2$$

Where,

1.645 = Z-value for two-tailed 90% confidence

.10 = Required precision (10%)

CV = Coefficient of variation = Standard deviation / mean

For survey efforts within a reasonably homogenous market, the California Evaluation Framework specifies an assumed CV of .5.[11] Using this, the required sample is:

$$n = \left(\frac{1.645 * .5}{.10}\right)^2 = 68$$

This sample estimate is then adjusted for smaller populations as follows:

$$n_0 = \frac{n}{1 + \frac{n}{N}}$$

Where,

n_0 = Finite population-adjusted sample size

n = The required sample for a statistically infinite population

N = total program population

At the time of administration of the survey, the program participant population was N=83. At this population, the required sample to meet ±10% precision at 90% confidence is:

[11] http://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf

$$n_0 = \frac{68}{1 + \frac{68}{83}} = 38$$

With 45 respondents surveyed, the sample met ±8.5% precision at 90% confidence.

5.2. Awareness of SVCE and Source of Program Awareness

Nearly all participants (98%) were aware that SVCE was their energy provider prior to learning of the program.

Figure 5-1 summarizes sources of program awareness. Thirty-three percent of respondents indicated having learned about the program form a friend, relative, or colleague. In aggregate, 60% learned about the program from an SVCE marketing effort (including email, the SVCE website, an SVCE event, bill insert, or SVCE staff person).

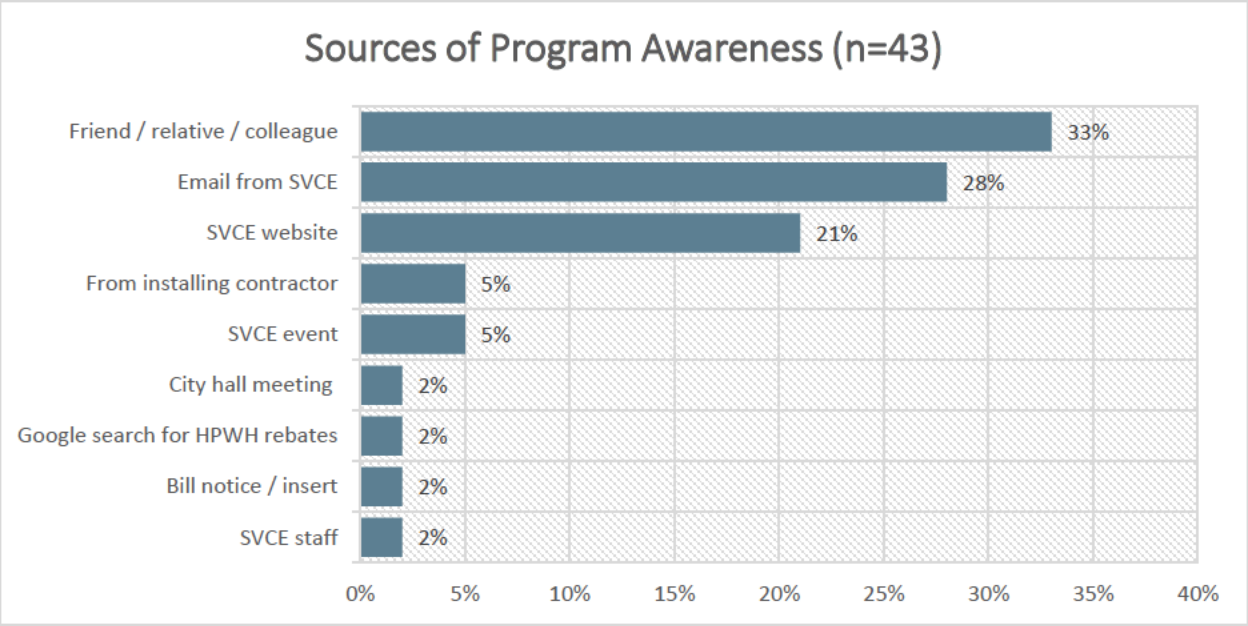


Figure 5-1. Sources of Program Awareness

5.3. Free-Ridership Estimation

5.3.1. Methodology

ADM estimated free-ridership for the Pilot. The estimated free-ridership was based on self-reported survey responses from customers who participated in the program.

Net savings factors and their impact on program savings are as follows:

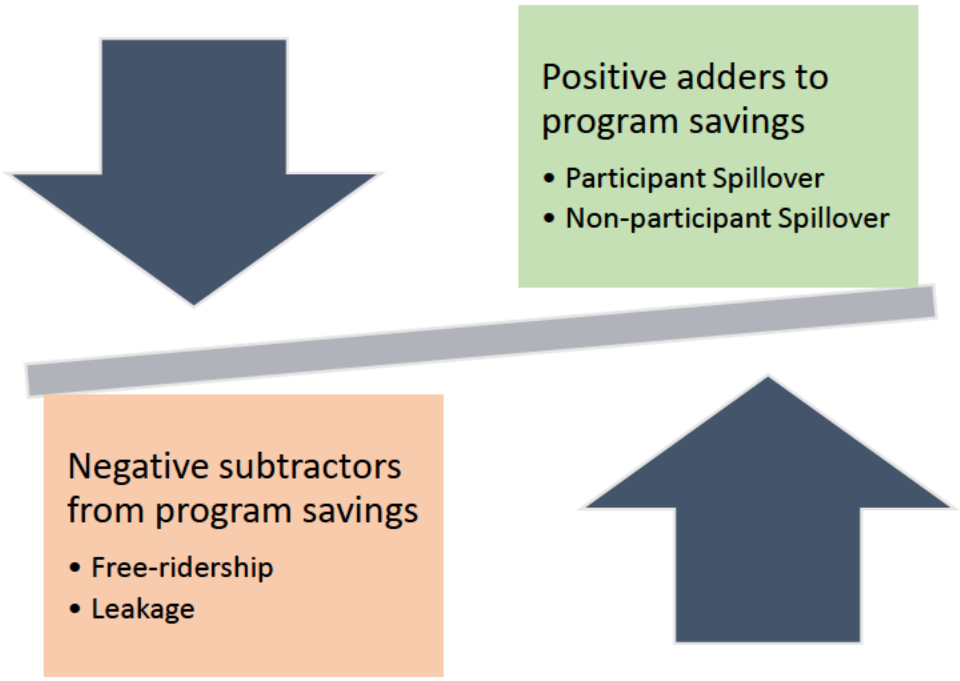


Figure 5-2. Net Savings Impact Parameters

These parameters are defined as follows:

- **Free-ridership:** the percent of program participants who would have implemented the same program measure or practice in the absence of the program. Free-riders can be total, partial, or deferred.[12]
    - **Total free-riders:** program participants who would have installed the same measure on the same timeline.
    - **Partial free-riders:** program participants who would have installed some level of conservation or decarbonization improvement in the absence of the program (for example, a customer who would have installed a standard electric resistance water heater to replace their gas water heater, instead of a heat pump water heater).
        - In practice, this value is also used to capture *probability of free-ridership.* Not all survey respondents provide answers that clearly point to full-, partial-, or no-free-ridership. In some instances, inconsistent responses may lead to a respondent being assigned a probability of free-ridership which captures that there is a chance that this respondent is a free-rider. This differs from "partial free-riders" conceptually, but in estimation of the overall free-ridership rate this value is mathematically identical.

[12] CA Evaluation Framework. Pg. 407

    - **Deferred free-riders:** program participants who would have installed the same measure at a later date in the absence of the program (e.g., they would have replaced their gas water heater with a HPWH 1-2 years later due to upfront costs).

- **Leakage:** cross-territory sales that occur when program-incented efficient products are installed outside of the funding entity's service territory.[13] The Pilot verifies eligibility of each applicant and as a result there was no leakage effect. Four projects were disallowed due to being out-of-territory (three located in San Jose and one in Burlingame).
- **Participant spillover:** the added benefit from projects completed by program participants that are *induced by the program but not funded by the program*. This manifests in the Pilot through the incentivizing of panel expansions. Panel expansions open avenues for other electrification. Thus, if the respondent is not a free-rider on their panel upgrade, but engages in further electrification outside the scope of the SVCE program, their decarbonization and electrification efforts are program-attributable.
- **Non-participant spillover:** the added benefit from projects completed by SVCE customers who *did not participate in the program.* This could occur as a result of program training of plumbing contractors who then sell a greater volume of HPWH retrofits than previously. This is addressed via contractor surveys; no non-participant spillover was identified for the Pilot.

The process is outlined in Figure 5-3 and explained in detail in the subsequent sections.

[13] 2006 DOE EERE Guide for Managing General Program Evaluation Studies.

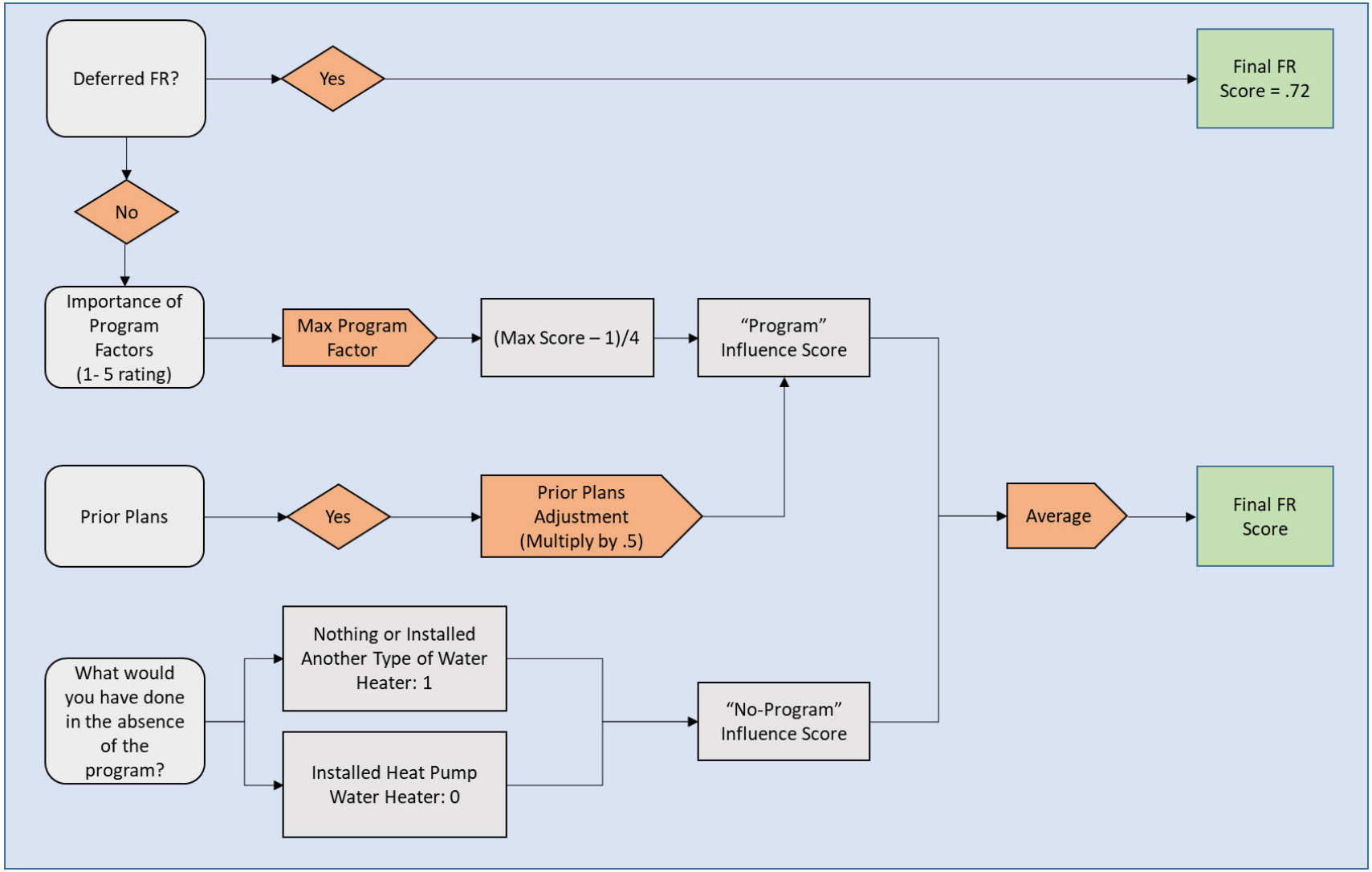


Figure 5-3. Free-Ridership Process Flow

5.3.2. Program Influence Score

This section presents findings related to the programs influence on the decision. A theme that emerged from responses to multiple questions on participant decision making is that the rebates were highly influential on the installation decision and the primary influence pathway. Based on a review of the responses, it is likely that very few of the participants would have installed the HPWH without the program rebates. In addition to the rebates, information provided by program staff or program materials were also influential. Installing contractors had little influence on the decision, a finding that is consistent with the respondent reports that they infrequently learned of the program from a contractor.

A program influence score was developed based on responses to two sets of questions. First, respondents provided information on prior plans to purchase the heat pump water heater when they learned of the heat pump water heater rebates. Specifically, respondents were asked:

- Were you already planning to install a heat pump water heater when you learned of the rebates available from SVCE?

Responses to this question were used to develop a plans adjustment score. The plans adjustment score was equal to .5 if the respondent stated they had prior plans, and equal to 1 if the respondent stated they did not have prior plans or did not know if they had prior plans.

Overall, participants were not planning to install a heat pump water heater when they learned of the rebates available from SVCE. Seventy percent of respondents stated that they were not planning on installing prior to learning of the rebates, and 30% of the respondents were planning on installing a heat pump water heater prior to learning of the rebates. Results are summarized in the table below.

Table 5-1. Plans to Install HPWH.

Response	Percent (n=40)
Yes	30%
No	70%

The heat pump water heater rebate and the $2,500 panel upgrade were the highest rated factors when it came to respondents' decision to install the HPWH. Ninety-eight percent of respondents stated that the heat pump water heater rebate was an "important" or "very important" factor when deciding whether to install the water heater. Other factors rated high in importance included the $2,500 panel upgrade rebate (90%), information provided by SVCE or a program representative (84%), and other information from SVCE including information on their website (63%). Forty percent of respondents ranked the information provided by the contractor as "very important." Results are summarized in the figure below.

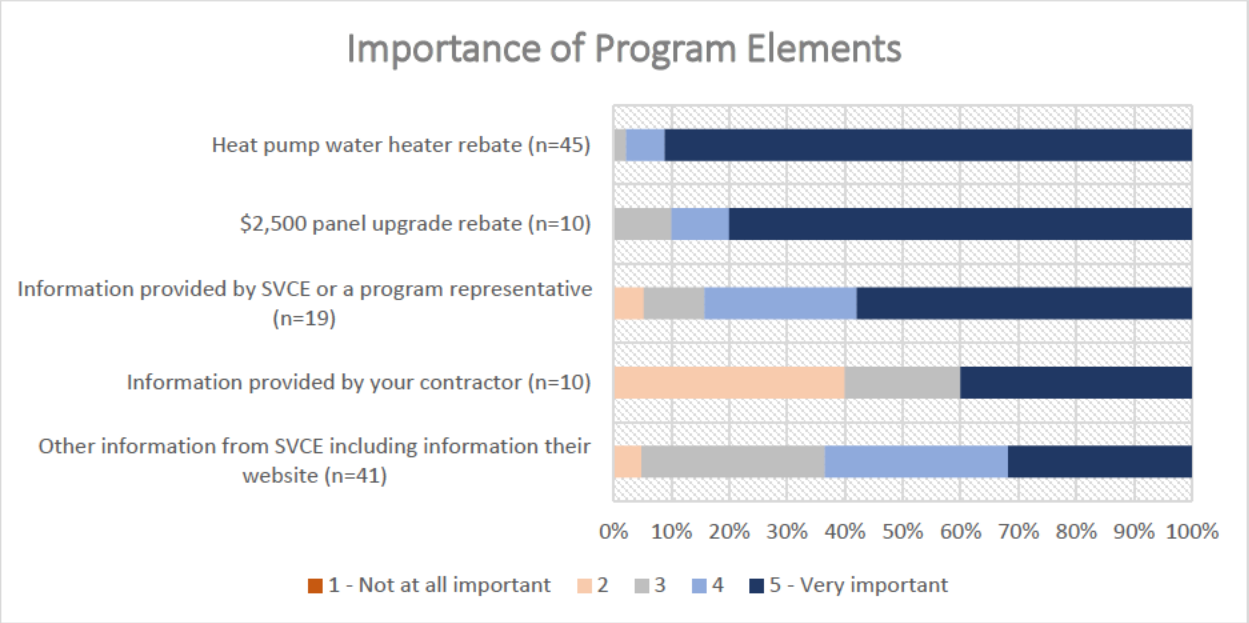


Figure 5-4. Level of Importance of Program Elements

The following factors were incorporated into the net-to-gross scoring:

- Factor 1: the heat pump water heater rebate;
- Factor 2: information provided by SVCE or a program representative;
- Factor 3: the $2,500 panel upgrade rebate (if applicable); and
- Factor 4: other information from SVCE including information on the website.

The ratings to these factors were scored, as shown in Table 5-2.

Table 5-2. Scoring for Rated Importance of Program Factors

Response	Score
1 (Not at all important)	0
2	0.25
3	0.5
4	0.75
5 (Very important)	1

Using the scored responses to these questions, a program influence score was calculated as equal to:

$$Program\ Influence\ = \frac{[\max(f_1, \ldots, f_4) - 1]}{4} \cdot Prior\ Plans\ Adjustment$$

Where,

f_1 through f_4 = the scores associated with factors 1 through 4.

5.3.3. No-Program Score

A no-program score was developed based on what respondents stated they most likely would have done if SVCE had not offered the rebate. Specifically, respondents were asked "What would you have most likely done if SVCE had not offered the [REBATE AMOUNT] rebate for the heat pump water heater?" Respondents were given the following options:

- Would not have installed a new water heater;
- Would have installed a less energy efficient electric resistance water heater;
- Would have installed a natural gas water heater;
- Would have installed an electric heat pump water heater; and
- Something else.

Under "something else", numerous respondents indicated a verbatim answer that comprised a delay of installation. This included "wait until later date", "wait until rebates are available", and "wait until gas water heater fails".

The overarching influence categorizations were established as:

- Installed a HPWH anyway (no program influence);
- Delayed installation of a HPWH (program advanced timeline of installation); and
- No installation of HPWH (program induced installation).

These response groups and the associated component answers are summarized in Figure 5-5.

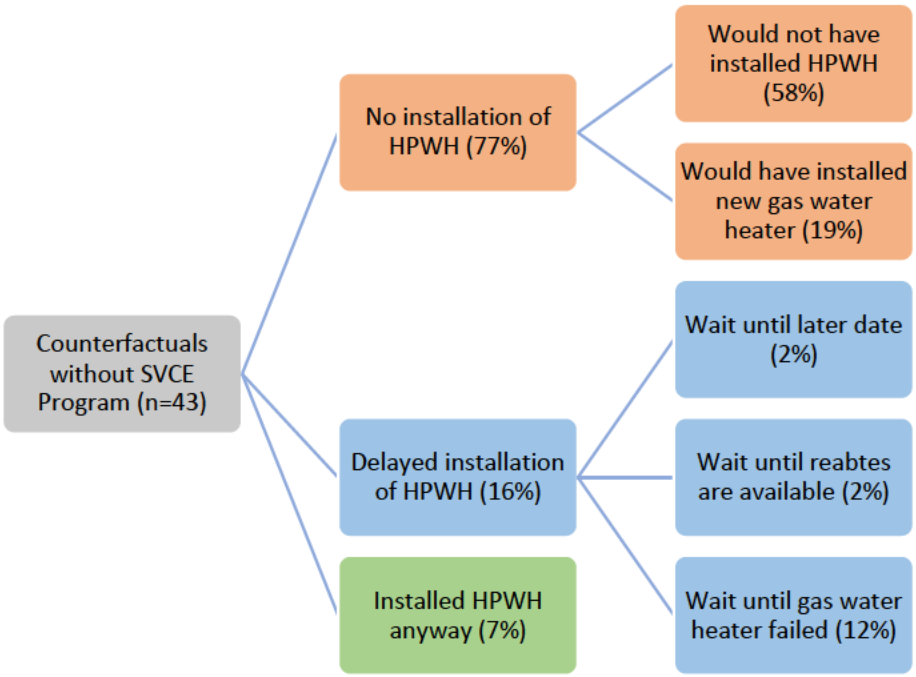


Figure 5-5. Counterfactuals without Program Support

ADM used these responses to develop a no program score that was equal to 1 or 0. The score was set equal to 0 (indicating no program influence) if the respondent stated they would have installed the same heat pump water heater; the score was set equal to 1 if the respondent stated they have installed a different type of equipment or would not have installed any equipment if the program had not been available.

Respondents that would have delayed installation are credited as having program influence (score = 1), with an added time-value adjustment factor.

This time-value adjustment factor is calculated as:

$$TimeValueAdjustment = \frac{GHGNPV_{2020\ Install} - GHGNPV_{Delayed\ Install}}{GHGNPV_{2020\ Install}}$$

Where,

$GHGNPV_{2020\ Install}$ = NPV of GHG impacts when installed in 2020, and

$GHGNPV_{Delayed\ Install}$ = NPV of GHG impacts when installed after old equipment failed.

Under the delayed install scenario, it is assumed that the installation is delayed until the remaining useful life (RUL) of the storage water heater expires. This value is equal to one-third its effective useful life (EUL) of 11 years, for an RUL of four years.

From this framework, the program obtains 28% of the total GHG value if a participant is induced to install early when they otherwise would have electrified after their old system failed, and this estimate is applied as the NTGR for respondents that indicated that the program advanced their timeline for installation.

5.3.4. Free-ridership Estimate

Combining these factors, free-ridership is estimated as:

- Advanced timeline: 1 - 28% = 72%
- No advanced timeline: = 1 – Average(Program Influence Score, No Program Score)

Table 5-3 summarizes the free-ridership results. As shown, free-ridership was generally low at 19.8% overall. Free-ridership was lower for those who received the electric panel incentive (2.5%) than for those who did not (24.8%).

Table 5-3. Summary of Free-ridership Results

Incentive Type	Number of Responses	Free-ridership
Received panel upgrade incentive	10	2.5%
Did not receive panel upgrade incentive	35	24.8%
Total	45	19.8%

5.3.4.1. Notable Differences from Respondents with Panel Upgrade Incentive

Respondents that received a panel upgrade demonstrated lower free-ridership rates. Table 5-4 specifies responses to key free-ridership questions delineated between those that did and did not receive a panel upgrade.

Table 5-4. Summary of Free-ridership Results

Incentive Type	No Panel Upgrade Incentive	Panel Upgrade Incentive
Prior plans to install?	31%	9%
Indicated that they would have stayed with gas water heating?	69%	90%
Indicated that they would have delayed installation to a later date?	20%	0%

Respondents that received a panel upgrade displayed demonstrably lower rates of prior plans and a significantly higher likelihood of remaining with gas water heating.

5.3.5. Spillover - Additional Equipment Installed After Panel Upgrade

The Evaluators conducted a battery of survey questions to address spillover impacts from the SVCE-rebated panel upgrade. Spillover is a factor that estimates the impacts of conservation or decarbonization efforts undertaken by program participants that were not incentivized by a utility program (or by a program by any agency in a position to claim energy impacts). Different types of spillover are summarized in Figure 5-6.

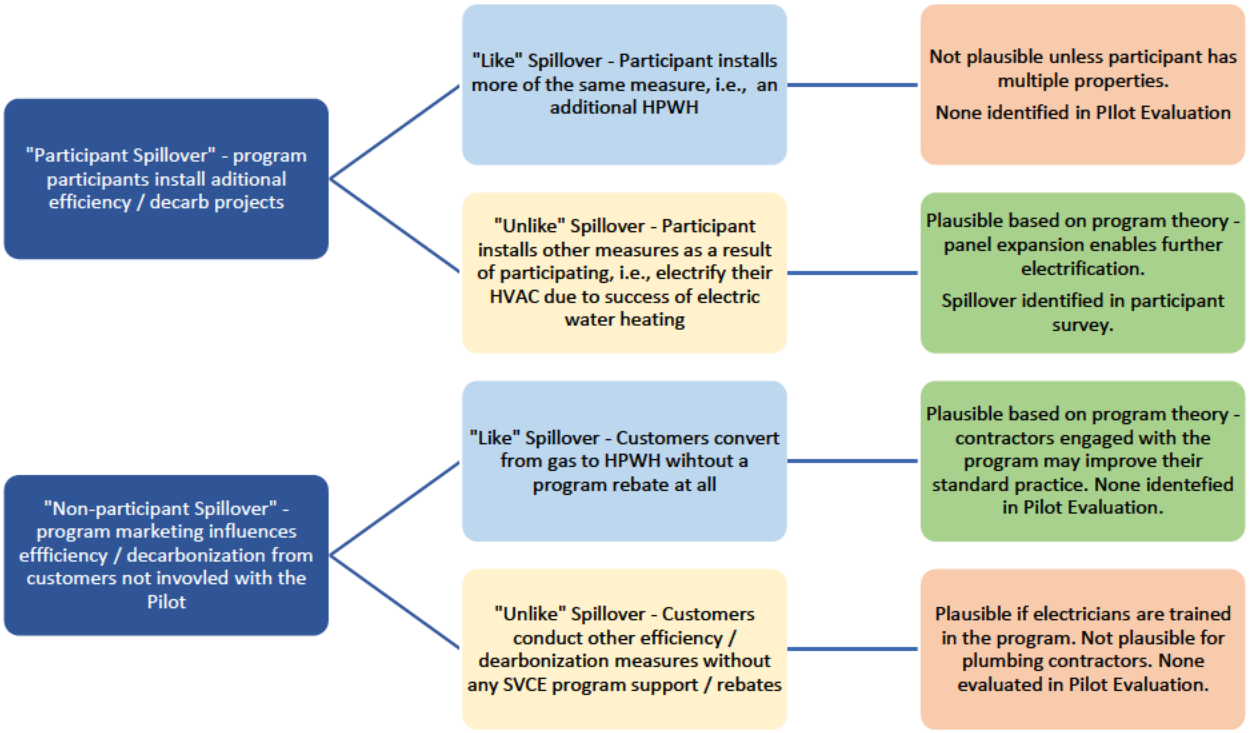


Figure 5-6. Taxonomy of Spillover Types

Respondents who upgraded their electric panel through the SVCE program were asked if they installed any additional equipment since installing the panel. Thirty percent stated that they replaced a gas heating system with an electric heating system such as a heat pump.

With the panel upgrade being of sufficient capacity to allow for electrification of other end-uses, spillover impacts resulting from this can be a reasonably expected outcome of program theory. Examining the survey responses of the panel upgrade recipients, the following key findings were synthesized in development of a spillover estimate:

- Of the ten panel upgrade recipients surveyed, three (30%) stated that they converted their HVAC system from gas to electric after the upgrade.
- Of those three, two (67%) stated that they would have been "not at all likely" to convert their HVAC system if they had not received the panel upgrade through the Pilot.
- Of those two that indicated a program-induced conversion of their HVAC system, both were scored as having 0% free-ridership / 100% NTGR; i.e., the panel upgrade and HPWH conversion were considered program-induced, and thus subsequent decarbonization activities after the panel upgrade can potentially be credited as spillover.

Spillover impacts per customer were not analyzed via billing data. To develop spillover estimates, ADM applied deemed kWh and Therms impacts from residential HVAC fuel

substitution[14] along with the same carbon intensity multipliers used for the primary analysis of HPWH fuel switching impacts. The Evaluators reviewed the home square footage and year built based off publicly available data (average square footage of 1,571 and home age of 60.5 years). Based on sizing norms per CA DEER, the estimated average size is 2.5 tons.

These savings impacts are:

- kWh: 1,224 increase
- Therms: 211 decrease
- GHG: 2,463 decrease

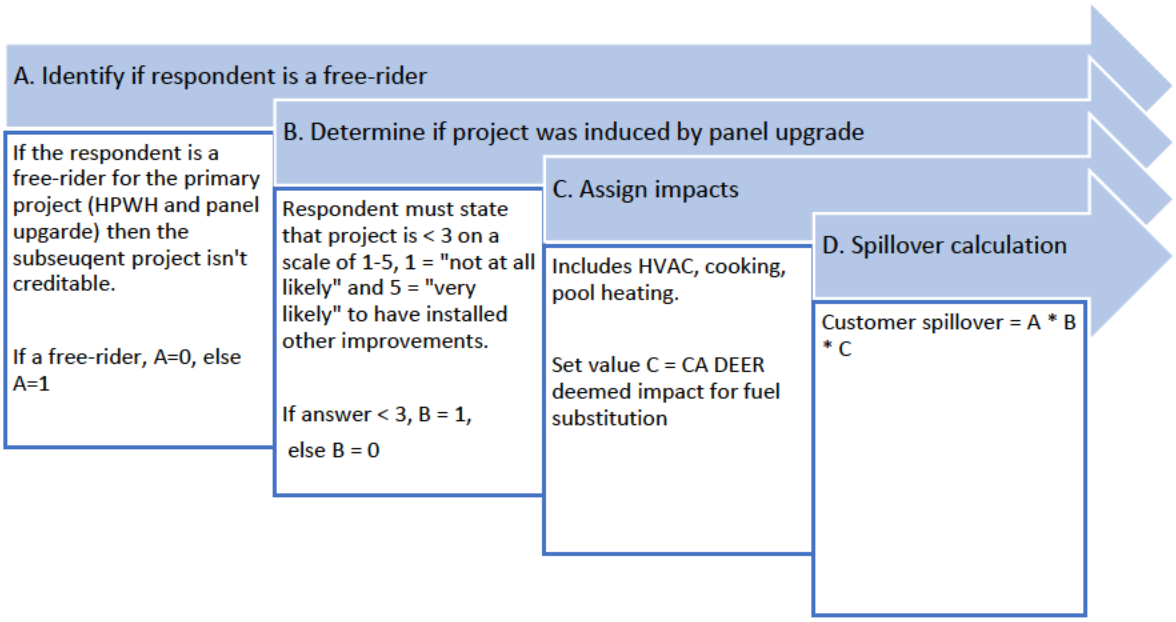


Figure 5-7. Calculation of Customer Spillover Impact

From the two identified heating system electrification projects, the estimated total customer savings impacts are:

- kWh: 2,448 increase
- Therms: 422 decrease
- GHG: 4,925 decrease

To develop a program-level estimate, the spillover calculation results for each customer is summed and extrapolated as follows:

$$Program\ spillover\ = Total\ Customer\ Spillover * \frac{Panel\ Upgrade\ Population}{Panel\ Upgrade\ Sample}$$

[14] CA DEER Workpaper SWHC045-01 Heat Pump HVAC, Residential, Fuel Substitution 051220

Where,

Total customer spillover = 4,925 lbs. GHG

Panel upgrade population N = 37

Panel upgrade survey sample n = 10

As an example, the resulting GHG spillover impacts is:

$$Program\ spillover\ = 4{,}925 * \frac{37}{10} = 18{,}223$$

With program-level gross GHG impacts of 212,976, the spillover percent is:

$$Program\ spillover\ \% = \frac{18{,}223}{212{,}976} = 8.6\%$$

Within the context of just panel-upgrade participants, their spillover impact would be estimated based on the total GHG impacts just from their HPWH retrofits. Within this measure group, spillover is:

$$Panel\ upgrade\ participant\ spillover\ \% = \frac{18{,}223}{74{,}003} = 24.6\%$$

Table 5-5 summarizes spillover impacts.

Table 5-5. Spillover Summary

Savings Impact	Per-Spillover Participant	Total for Participants with Spillover	Total Extrapolated Program Spillover
kWh	1,224 increase	2,448 increase	9,058 increase
Therms	211 decrease	422 decrease	1,561 decrease
GHG	2,463 decrease	4,925 decrease	18,226 decrease

5.3.6. Acquisition Cost of Net Attributable Program Impacts

The results of the free-ridership and spillover analysis have significant implications on the acquisition cost of GHG reductions by customer group. Table 5-6 summarizes the net impacts and acquisition costs per customer for those with and without the panel upgrade.

Table 5-6. Net Carbon Acquisition Cost

Group	Metered HPWH Carbon Reduction	Free-Ridership	Spillover	Net Carbon Reduction	Average Rebate	Acquisition Cost ($/lb. CO_2)
No Panel Upgrade	2,088	24.8%	0%	1,570	$3,524	$2.24
Panel Upgrade	2,088	2.5%	29.5%	2,694	$6,156	$2.29

Due to reduced free-ridership and the prevalence of spillover, customers that received the panel upgrade displayed carbon acquisition costs that are only 1.8% higher than those without a panel upgrade, despite receiving 75% more in rebates per customer. The impact of induced electrification of HVAC systems for a subset of panel upgrade participants significantly increases the value of their participation.

5.4. Sources of Awareness & Program Interest

The SVCE website and other materials were the primary source of information on the benefits of the heat pump water heater. Ninety-three percent of respondents learned of the benefits from the program website. SVCE representatives were another important source of awareness – 45% of respondents spoke with a representative about the benefits. Contractors did not provide much education on the benefits to participants – 76% or respondents stated they did not talk with their contractor about the benefits.

The SVCE rebates and reduced greenhouse gas emissions from the heat pump water heater were several of the top reported reasons why respondents decided to install a heat pump water heater. Ninety-three percent of respondents stated that their decision to install the heat pump water heater was influenced by the rebates, and 89% of those surveyed stated that the decision came from a desire to reduce greenhouse gas emissions. Seventy-eight percent of respondents stated their decision was motivated by a desire to use less energy to heat water and 62% of those surveyed stated that heat pump water heater cost less money to heat water. Results are summarized in the figure below.

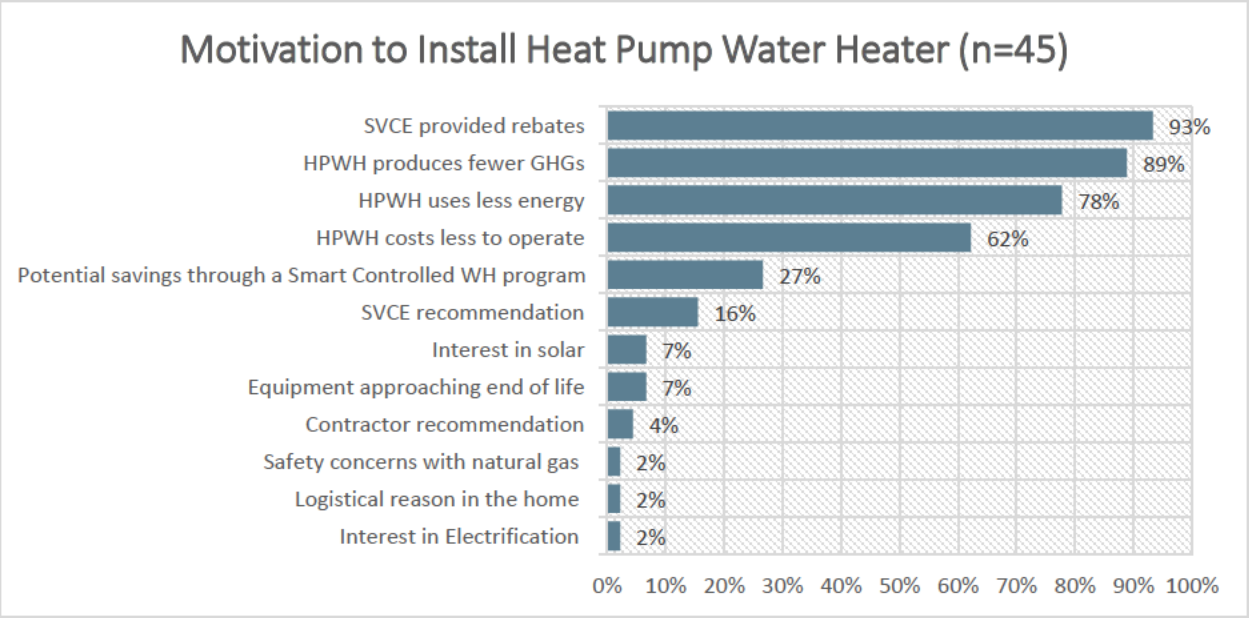


Figure 5-8. Motivation to Install Heat Pump Water Heater

5.5. Experience with Water Heater and Satisfaction

Participants were asked about their experience and satisfaction with the HPWH. Most participants reported positive experiences with the performance of the heat pump water heater. Eighty four percent of respondents stated that they have not had any problems with the heat pump water heater since it was installed. Seventy-four percent of respondents stated that the water heater completely met their expectations, and 26% of those surveyed stated that the water heater partially met their expectations. None reported that the water heater did not meet their expectations.

None of the respondents were dissatisfied with their experience with SVCE's heat pump water heater program or the contractor that installed the heat pump water heater. Ninety-six percent of the respondents stated that they were overall "satisfied" or "very satisfied" with the program. Ninety-two percent of respondents stated that they were overall "satisfied" or "very satisfied" with the contractor who installed their heat pump water heater. Sixteen percent of respondents self- installed their water heater.

5.6. Respondent Narrative Feedback

Respondents were asked to provide recommendations for improvement of the program. These verbatim responses were reviewed and grouped into overarching categories. A large share offered no comment (36%). Other comments were more generalized and not specifically actionable, including "expand the program" (16%) and "more marketing / awareness" (13%).

Of the recommendations by respondents, ones which are potentially actionable by SVCE or SMUD include:

- **Provide a list of trusted contractors (16%).** A significant share of respondents noted difficulty in finding contractors that have the capability to install a HPWH. Many noted having to cycle through numerous unqualified contractors or finding qualified contractors through the websites of other programs (one specifically noted a similar program administered by City of Palo Alto Utilities as their source of their contractor).
    - **ADM Recommendation:** Develop a trusted contractor list. This aligns with program practices seen by the Bay Area Regional Energy Network (BayREN)[15], City of Palo Alto Utilities[16], and Silicon Valley Power[17].

[15] https://bayrenresidential.org/find-a-contractor

[16] https://cityofpaloalto.org/gov/depts/utl/residents/save_energy_n_water/rebates/heat_pump_water_heater/hpwh_resources/default.asp

[17] https://www.siliconvalleypower.com/residents/save-energy/contractor-connection

- **Improve Sense metering (13%).** Respondents noted issues with Sense metering not capturing their HPWH load or expressing a desire to capture their whole-house load in addition to the HPWH load. Whole house metering would be attainable via Green Button data, and this desire for whole-house metering could perhaps be addressed with proper integration customers' existing interval meter data.
    - **ADM Recommendation:** Examine possibilities to link customers with Sense metering data to their Green Button data. This can fill what customers perceive as a "gap" in Sense metering data.
- **Provide guidance on permitting requirements (7%).** Seven percent of respondents noted that they found the permitting process to be more difficult than anticipated (with some not realizing that expansion of their panel requires a permit until after project launch). Though this was only 7% of total respondents, all who indicated this had received a panel upgrade. Of the panel upgrade respondents, 30% suggested that SVCE help set expectations on the permitting process.
    - **ADM Recommendation:** Though the SVCE program page mentions applying for a permit, SVCE should consider a larger "permitting checklist" for customers, developed in collaboration with member cities. This is more difficult for a Community Choice Aggregator than for a municipal utility as there is a greater range of code requirements to address, but to the extent feasible addressing this would be helpful. 62% of Pilot participants have been from Sunnyvale or Mountain View, so addressing high-volume cities first could expedite this process in terms of providing value to potential participants.

5.7. Electrification Potential

ADM assessed the electrification potential of various end-uses through the survey. The electrification potential was a function of the prevalence of non-electric equipment and the share of customers who stated that they would be very interested in replacing the equipment with electric equipment if a rebate that covered one third of the cost of installation was available. We note that these results are from a set of customers who have already electrified their water heating and may not be generalizable to the broader population of SVCE customers.

Gas furnaces have the greatest electrification potential. Gas furnaces are both common (owned by 79% of respondents) and interest in replacing them is also high. Clothes dryers are the second highest electrification potential measure. There was also a high interest in replacing gas fireplaces. Figure 5-9 presents the results.

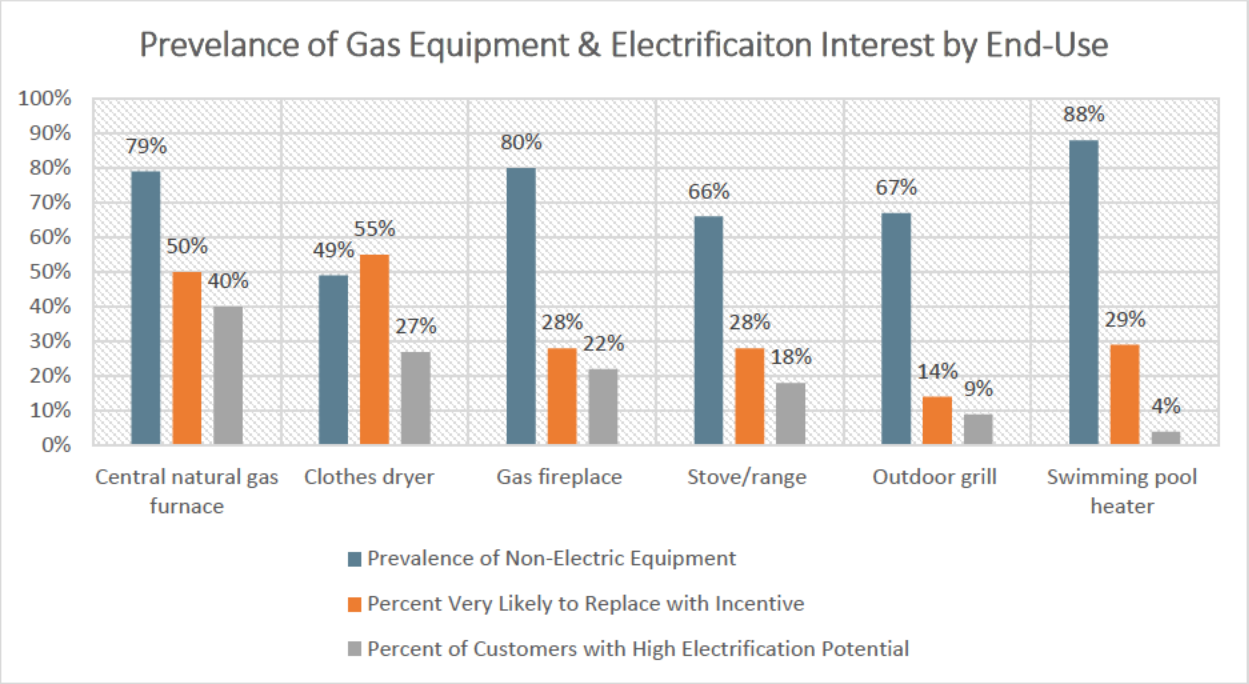


Figure 5-9. Electrification Potential & Interest

ADM then analyzed the GHG potential for gas-to-electric conversions with established consumption estimates in CA DEER:[18]

- Gas furnace to central air source heat pump[19]
- Gas clothes dryer to heat pump clothes dryer[20]
- Gas range to induction range (including an induction cooktop and electric resistant oven)[21]
- Gas swimming pool heater to heat pump swimming pool heater[22]

The BTUH and GHG potential by measure is summarized in Figure 5-10. Project costs and GHG reduction acquisition costs are presented in Figure 5-11.

[18] http://deeresources.net/workpapers
[19] DEER workpaper SWHC045.
[20] DEER workpaper SWAP014.
[21] DEER workpaper SWAP013.
[22] DEER workpaper WPSCGREWH170412A for estimates of consumption and gas efficiency. Fuel conversion assumed 3.0 COP for HPPH.

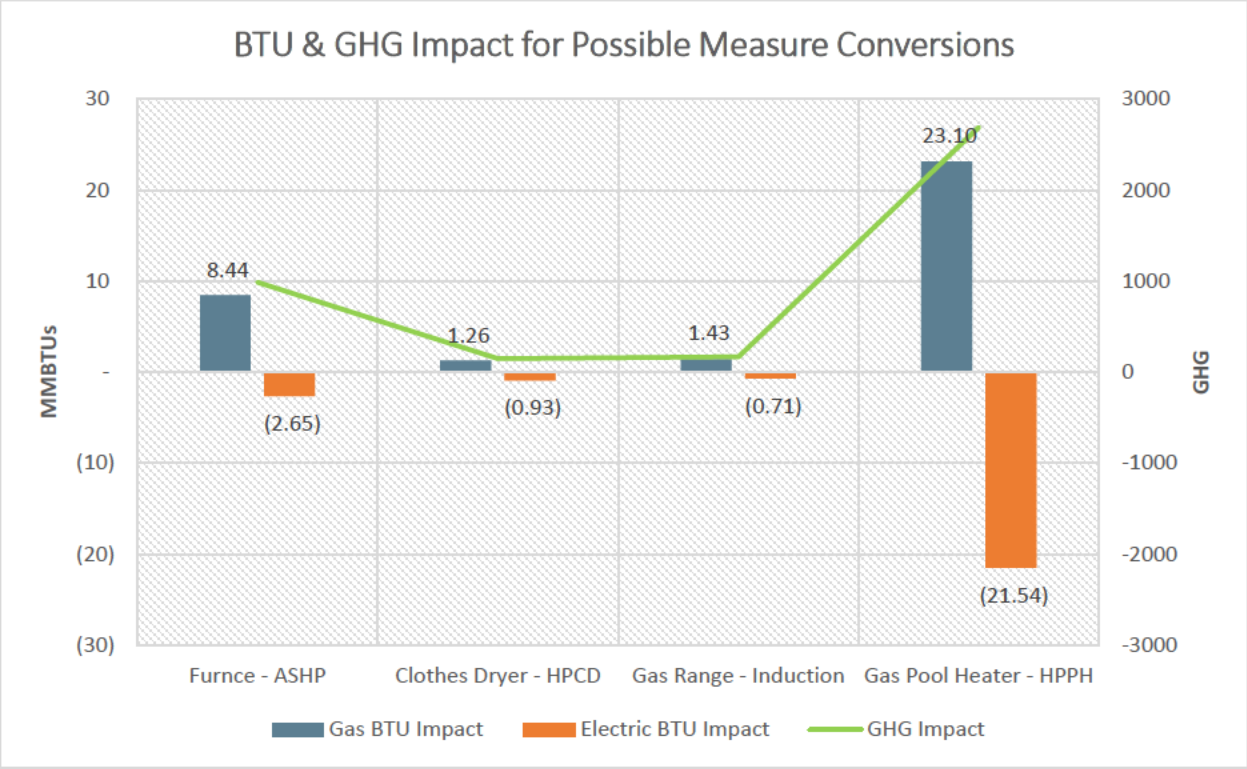


Figure 5-10. BTU & GHG Impact by Measure Conversion

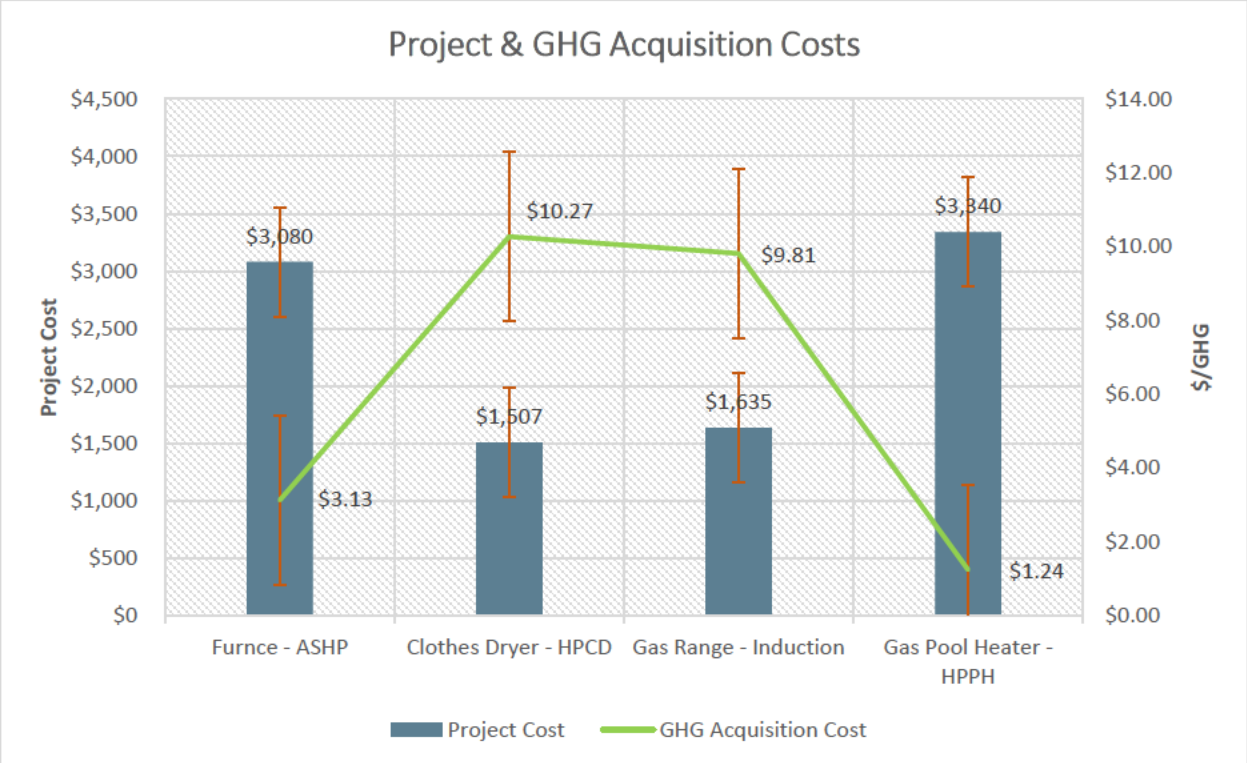


Figure 5-11. Project & GHG Acquisition Cost

6. Interested Customer Survey Results

As noted in Section 3.7, the intent of the survey was to assess potential barriers to project completion and program participation. Survey invitations were sent to 165 customers who had either reserved a heat pump water heater incentive or added their name to a list of interested customers.

6.1. Sampling Precision

The procedures for estimating the confidence and precision of the interested participant survey are the same as those described in Section 5.1.

For the interested customer survey, the population was N=165. With 40 responses, the sample met ±11.4% precision at 90% confidence.

Table 6-1 breaks out the response by customer group (i.e., on the interest or reservation list).

Table 6-1 Interested Customer Survey Response Break Out

Group	Population Size	Sample Size	Response Rate
Interest list	103	19	18%
Reservation list	62	21	34%
Total	165	40	24%

Results presented that combine responses from customers on the interest list and reservation list were weighted to account for the difference in sample and population sizes between these groups. The weight was calculated as 1/(n/N), where n is the size of the sample and N is the size of the population. The weight applied to responses from customers on the interest list was 5.42 and the weight applied to responses on the reservation list was 2.95.

6.2. Installation of Water Heaters Outside of the Program

Few customers installed heat pump water heaters outside of the program. Of the 40 respondents, two respondents reported installing a heat pump water heater outside of the program (5.4%). One customer was on the interest list and the other was on the reservation list. One respondent believed their heat pump water heater did not have a high enough Uniform Energy Factor to qualify. The other respondent said that their installer plans to have the rebate paid to them. This respondent stated they received a rebate from BayREN.

6.3. Barriers to installing a Heat Pump Water Heater

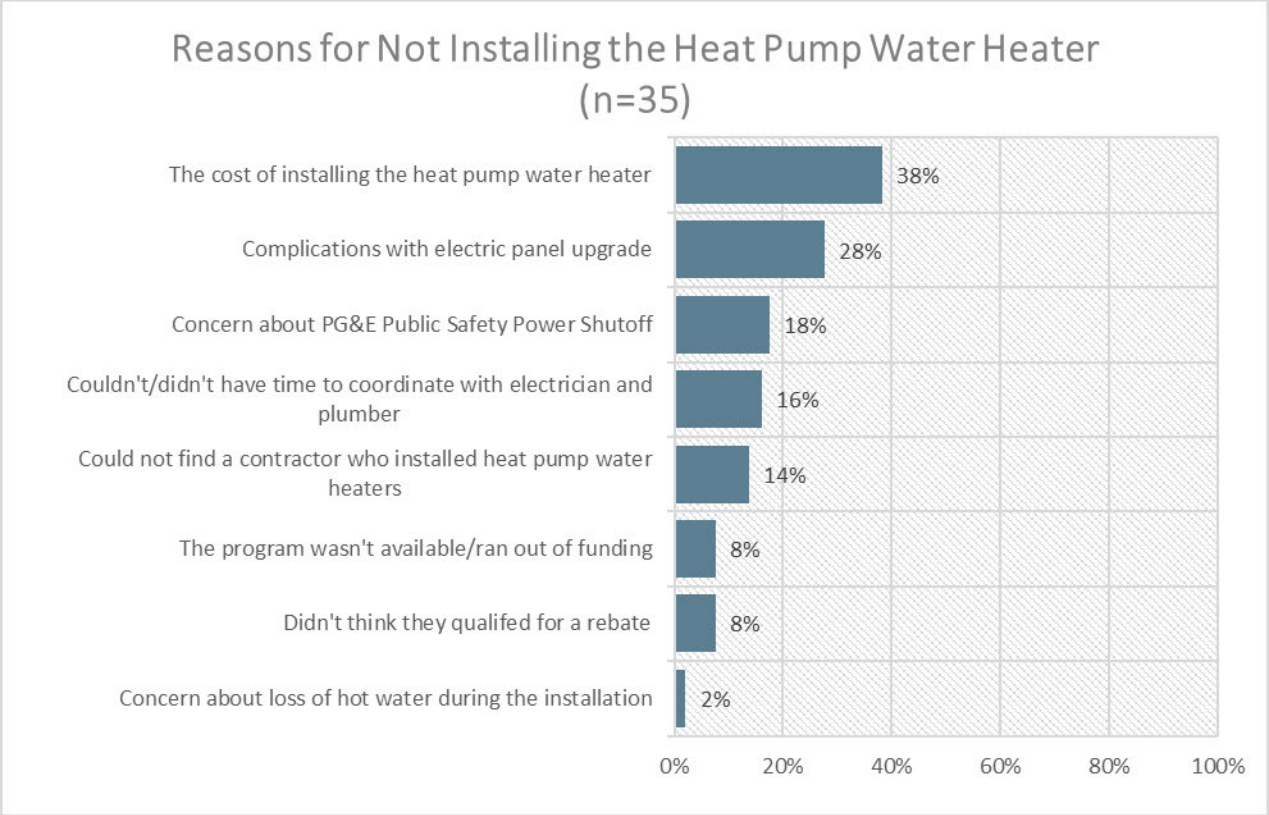


Figure 6-1 summarizes the reasons why interested customers did not install the heat pump water heater. Key findings are summarized below the figure.

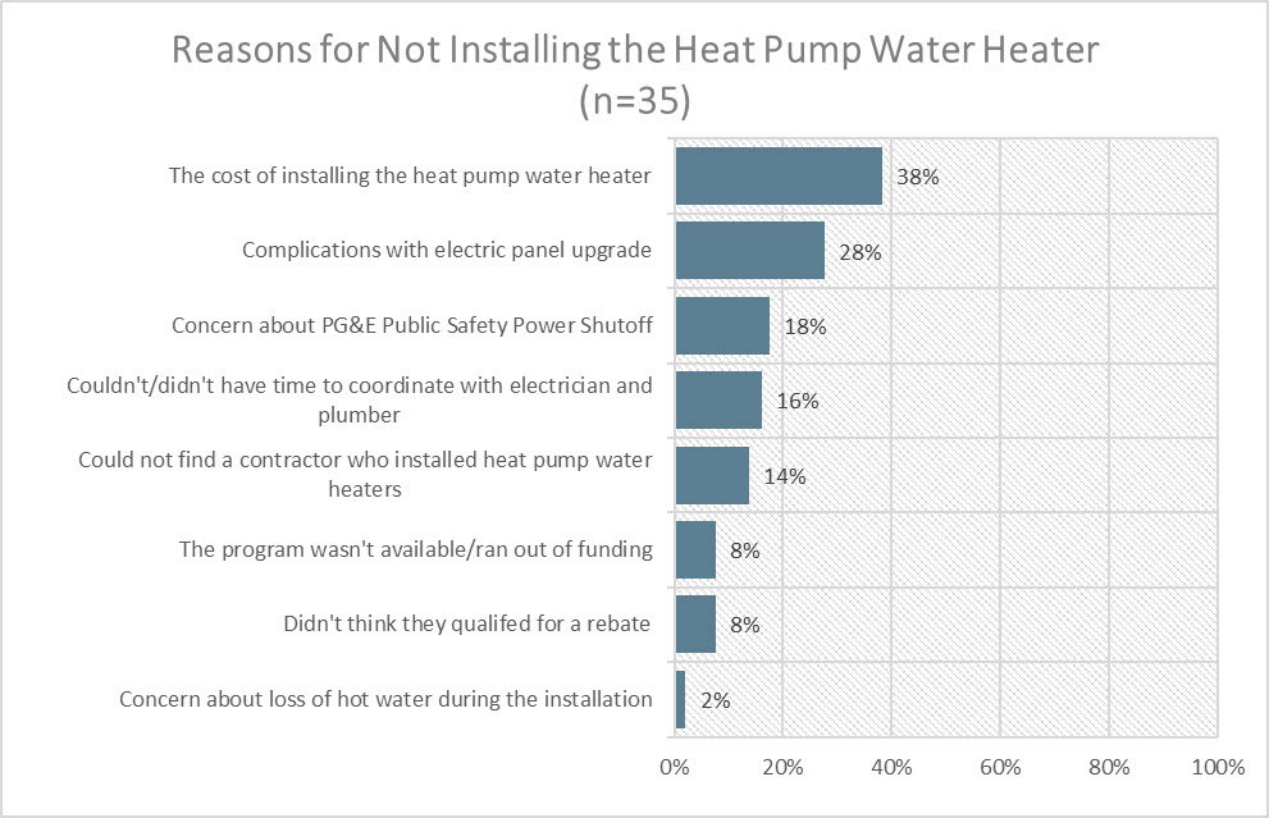


Figure 6-1 Reasons Given for Not Installing a Heat Pump Water Heater

- **The cost of the installation was the most common reason given for not installing the heat pump water heater.** Thirty-eight percent of respondents cited this as a reason. Cost was more frequently cited by customers on the reserved list (62% cited this as a factor) than those on the interest list (16% cited this as a factor). That difference may be driven by additional research and understanding that customers on the reserved list engaged in, which could have provided them with a clearer understanding of costs. For example, more customers on the reservation list (58%) received a quote from a contractor than those on the interest list (18%).
- **The quoted costs received by interested customers do not appear to be a factor in the role cost played in the decision not to install the water heater.** As shown in Figure 6-2, the quoted costs reported by customers were similar to the participant installation costs.

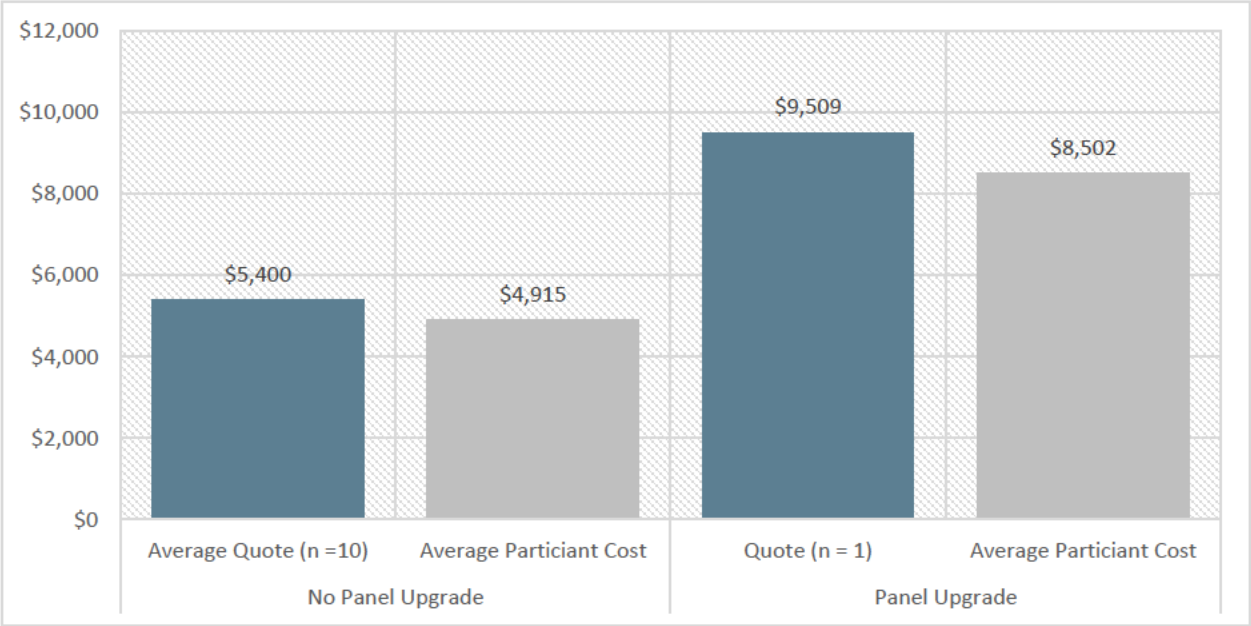


Figure 6-2 Quoted Costs Compared to Participant Installed Costs

- **Concerns about coordinating electricians and plumbers.** Sixteen percent of respondents mentioned coordinating electricians and plumbers as a concern.
- **Difficulty finding a contractor who installed heat pump water heaters.** Fourteen percent of respondents cited this as a reason.

Other reasons for not installing the water heater that the program may not be able to address include the following.

- **Complications with the panel upgrade (28%).**
- **Concerns about PG&E public safety shutoffs (18%).**
- **The program had run out of funding or wasn't available and customers didn't think they qualified for a rebate (8% cited each).**

Nineteen respondents provided additional reasons for why they did not go through the project. Below are the reasons that given that the program may be able to address.

- **Three respondents delayed the project but plan to install in the future.** Two customers reported that they delayed the project due to its cost. One reported that they delayed it because of COVID-19. This last respondent also noted that *"Having the list of contractors who installed systems along with the prices is fantastic, so that will be my starting point [for researching the project]."*

- **Discouraged by contractors they contacted (n=1).** The contractors the respondent spoke with discouraged the project and the respondent believed they were unfamiliar with this type of project.
- **Difficulty finding a contractor who will coordinate with battery storage solution (n=1).**

Below are reasons given that the program may not be able to address.

- **Project complexity was cited by four of the respondents.** Factors that respondents mentioned made the project complex were: the need to run an additional electric line from the street to the house at a high cost, general electric work for installing the 220V line, not wanting to deal with permitting, and electrical issues raised by PG&E *("PG&E was hard to deal with on the electrical upgrade to the house*").
- **Two respondents cited physical space requirements preventing the installation.** Both respondents reported that they did not have the space for the water heater.
- **Too much noise from the water heater (n=1).**
- **Waiting for the existing water heater to fail (n=1).**
- **Would need a larger unit because the heat pump water heater replenishes water more slowly (n=1).**
- **Prefer natural gas (n=2).** Two respondents stated that they like having a gas water heater.
- **Replaced a water heater under an emergency repair (n=1).** The respondent installed another gas water heater when their existing unit failed.

Based on these findings ADM has the following recommendations:

- **Consider developing a preferred contractor rating system.** SVCE already provides lists of contractors to customers. Marketing materials should note this to help ensure that customers are aware of this resource. Additionally, identifying plumbers or electricians that could help customers coordinate the work through contractor outreach or based on customer feedback on contractor ratings. Developing a rating system such as "Preferred Contractor" status that would identify these contractors may assist customers in selecting a contractor and encourage contractors to minimize customer project management. Preferred contractor status could also be used to promote those contractors most active in the program who may be best able to sell the benefits of the heat pump water Heater to their customers.
- **Engage in follow-up communications with customers interested in the program.** Three respondents mentioned that they had delayed their project. Sending emails to the customers on the interest and reservation lists may prompt them to install a heat pump water heater.

- **If feasible, identify electrical contractors who can support the water heater installation along with battery storage.** One customer stated that they were interested in a contractor that could also coordinate battery storage. Pairing the heat pump water heater offering with a battery storage option may also address customer concerns about losing hot water during a PG&E safety shutoff event.

6.4. Program Sources of Information on Benefits

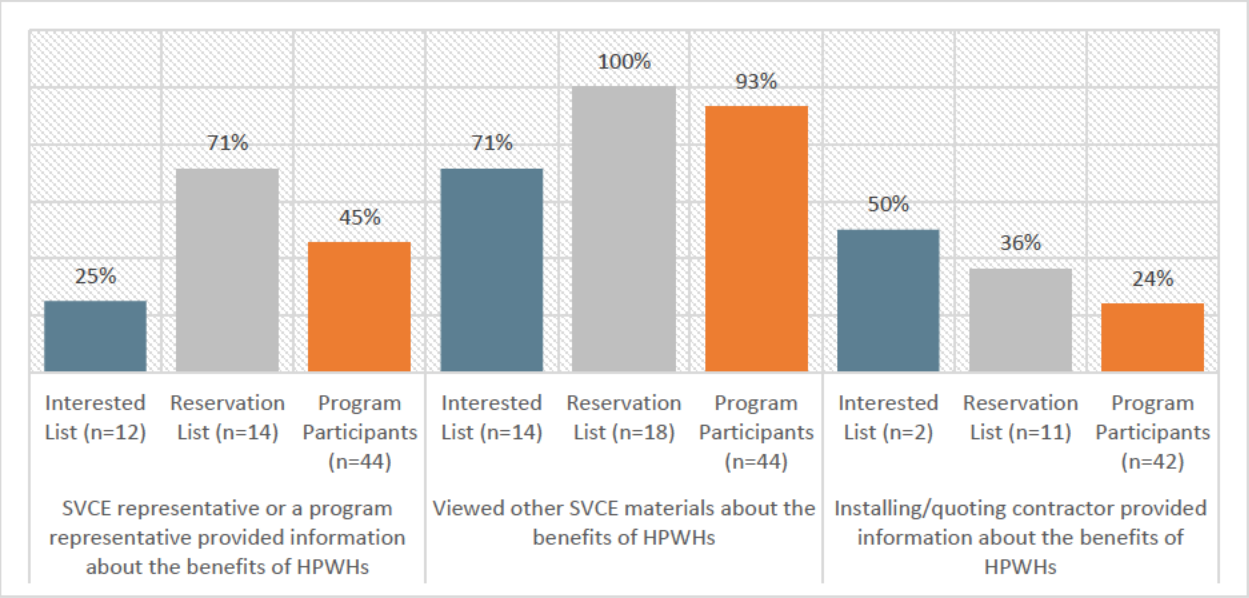


Figure 6-3 summarizes responses from customers on the interest list, reservation list, and program participants on questions related to the extent they engaged with program sources on the benefits of heat pump water heaters.

Respondents on the reservation list and those who participated in the program reported higher engagement with SVCE representatives and SVCE materials on the benefits of a heat pump water heater. Smaller shares of customers reported getting information on the benefits of heat pump water heaters from contractors.

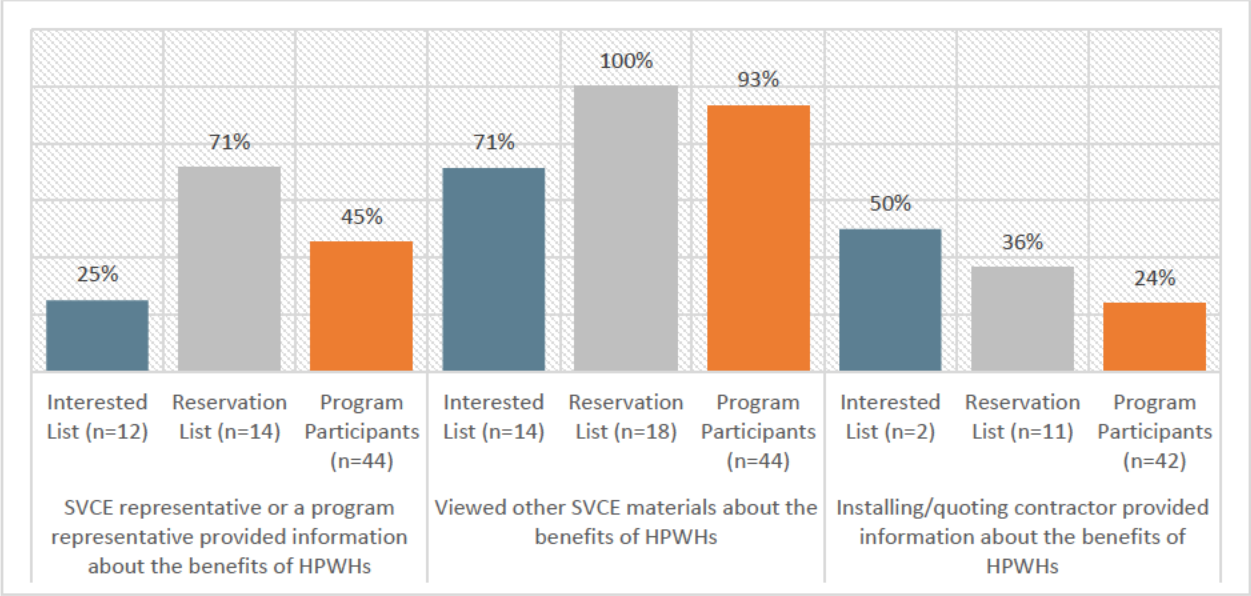


Figure 6-3. Summary of Customer Engagement

6.5. Respondent Narrative Feedback

This section summarizes additional comments provided by 17 respondents on the program.

- **Three respondents provided positive feedback.** These comments included remarks such as *"I'm very glad you offered this program back in 2019 and wish I had been able to participate"*, *"I hope the rebates are still around later this year. I especially like the rebate for the service panel upgrade which I will need"*, and *"Good work. Keep it up"*.
- **Four respondents had questions or comments about other types of projects.** These comments included, *"Water heaters are about the most complicated thing to install, given as you need both an electrician and a plumber (and in our case, other workmen). Seems that installing a stove would be easier"*, *"I need to get solar first"*, *"Will the rebate amount be increased?"*, and *"Are there rebates for pool heat pumps?"*.
- **Two customers said contractors discouraged the project.** This feedback included: *"I wanted the heat pump water installed along with the traditional water heater I have. The contractor said that was too much work"* and *"I went through the list provided with plumbers/contractors to get quotes, but it was time consuming and as I mentioned most of them said it was not a good idea"*.
- **Two customers said they needed additional guidance on how to complete the project.** These comments included a belief that program staff did not have enough information *"Your representative knew very little about the practicalities of this change, as I recall"* and *"Think of all the things that might stop someone from getting this work done and make it really easy. Partner with cities to have an expedited permit process. Or tell me that I won't need a new permit"*.

- **One customer said it was hard to get the equipment.** The respondent referenced a specific manufacturers water heater that was not in stock.
- **The complexity of the panel upgrade was cited by one respondent.** This respondent said, *"I got caught up in dealing with the electrical panel upgrade. I need at least a 200A panel, but for full electrification I might actually require a 400A panel. It just got to be a little much."*
- **Concerns about PG&E shutdowns was mentioned by one respondent.** The respondent stated that while cost and the panel upgrades had been a concern, after the PG&E shutdown, the respondent was concerned about not having hot water.

7. Contractor Feedback

ADM sought to complete interviews five participating contractors to get their insight into the heat pump water heater market and their feedback on the program. ADM completed one interview with a contractor and one contractor agreed to answer the questions in an online form.

The following sections provide a summary of the feedback from one contractor who completed an interview and one who agreed to complete a form online. We will refer to these as Contractor A and Contractor B, respectively, in the discussion below.

Overall, both contractors agreed that the program rebates were necessary to get most people to do these types of projects and that customers need electrical work to replace a gas water heater with heat pump water heater. Both contractors also provided positive feedback on the program.

7.1. Market Conditions

Contractor A noted that they do not do any replacements of natural gas water heaters with electric water heaters – neither electric resistance nor heat pump water heaters – outside of the program. This contractor thought that few customers would do this type of replacement without incentives. However, the contractor noted that their customers are interested in replacing natural gas water heaters with heat pump water heaters, but that expense is generally too great. Contractor A also noted that electrical work is required for every replacement of a natural gas water heater and about one-half of Contractor A's customers would need a panel upgrade to accommodate the water heater load. In general, the contractor said the replacement of gas water heaters could be done within a day.

Contractor B stated that about 75% of their work is installing heat pump water heaters, although not necessarily replacements of gas water heaters. Like Contractor A, this respondent stated that few customers would do the work without an incentive. Also, like Contractor A, Contractor B estimated that 50% of their customers need a panel upgrade and all need electrical work.

7.2. Program Feedback

Overall, Contractor A thought it was a "great program" that incentivized change and was good for the environment. Both contractors said that program staff were very responsive to questions about projects or the program.

The two contractors had mixed views of the installation of the Sense meter. Contractor A thought that the instructions on the Sense meter installation were not clear and that it added about two hours of time. This contractor performed one of these installations and involved a customer with solar power and noted that the solar connection aspect was a source of

confusion, specifically that there were two leads but three connections to make (main connection, water heater connection, and solar connection). Contractor B thought the instructions were clear and that it took one hour to install.

Contractor A noted that the 90 days to complete a project was not a problem for any projects, whereas Contractor B noted that they ran into some issues because of COVID related delays.

An issue noted by Contractor A was that it was not clear who the incentive would be paid to. The application uses the term “apply” but it is not clear if when the contractor submits the application, he or she is the applicant or if the customer is the applicant.

8. Participant Cost Results

This section presents the results of the participant cost analysis including a description of the average installation cost per HPWH and the estimated annual fuel cost savings.

8.1. Installation Cost

Table 8-1 describes the average cost per unit installed via the Pilot. The gross installation cost represents the cost per unit including equipment and labor. The net installation cost represents the cost per unit after subtracting the rebate amount.

Table 8-1. Average Installation Cost.

Cost Type	Average Cost/Unit
Gross installation cost	$ 6,283.12
Rebate amount	$ 4,477.97
Net Installation Cost	**$ 1,805.15**

Figure 8-1 summarizes the distribution of project installation costs across the participant population. Average installation cost was $6,283 while median installation cost was $5,790.

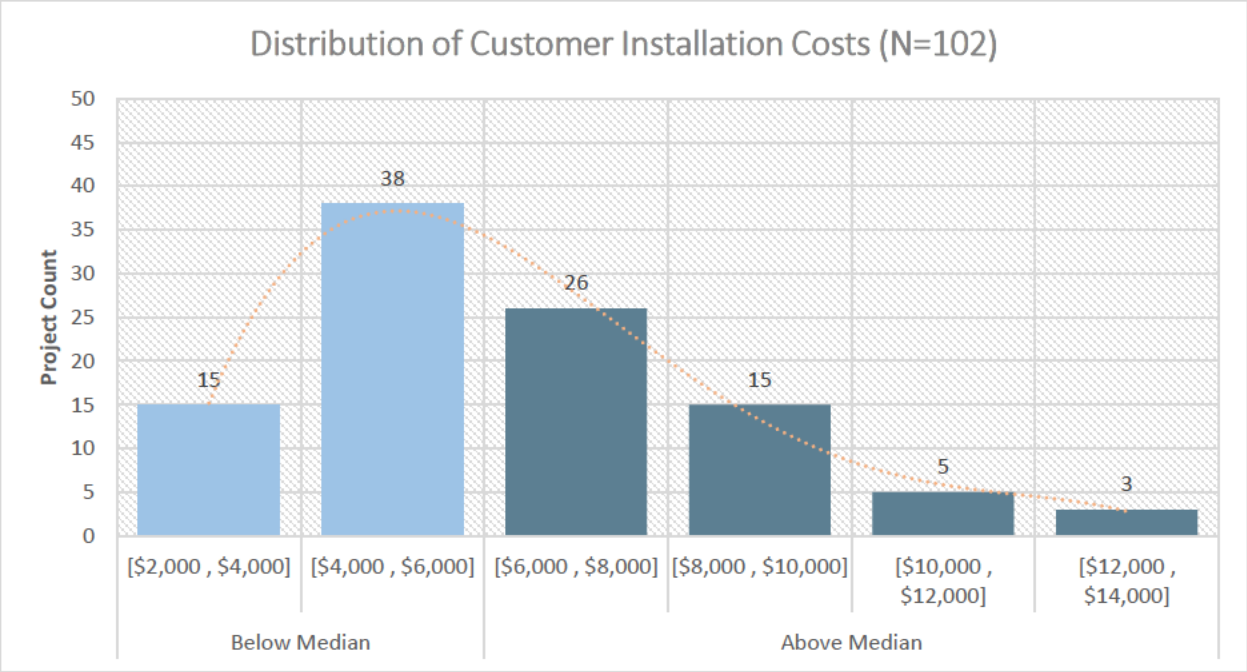


Figure 8-1. Distribution of Customer Installation Costs

Of the 102 participants, 37 received panel upgrades. All customers with panel upgrades had work completed by both a plumber and an electrician. Of the 65 participants that did not receive a panel upgrade, 31 (48%) required an electrician. Installation costs by customer type (pre-incentive) are presented in the figures below.

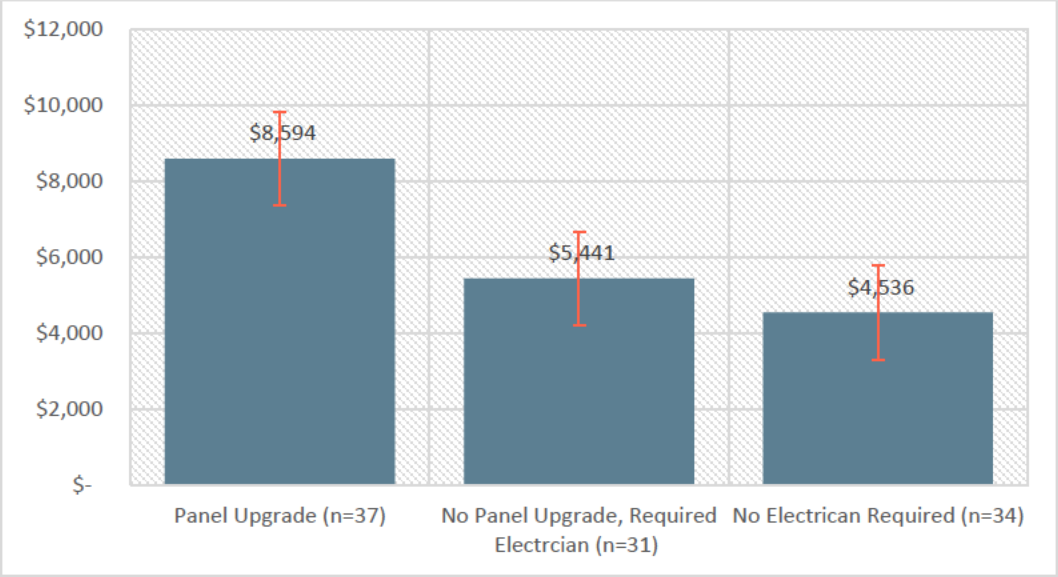


Figure 8-2. Installation Cost by Project Type

Further, SVCE indicated interest in encouraging installation of smart connected water heaters. Figure 8-3 below summarizes the cost by system type with and without the panel upgrade. For systems with no panel upgrade, the average installation cost is 4.5% higher. This converges to 3.9% higher when examining homes with a panel upgrade, which is likely attributable to the panel upgrade cost being independent of costs associated with Performance versus Smart water heater selection. Thus, its inclusion narrows the aggregate difference between the two groups in percentage terms.

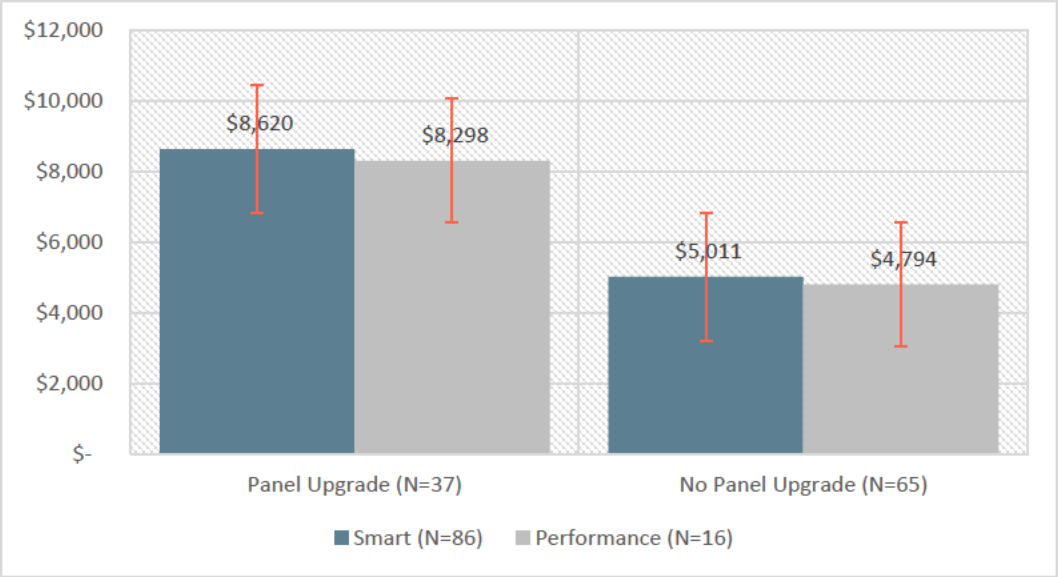


Figure 8-3. Installation Cost for Performance vs. Smart Water Heaters

The net installation cost presented in Table 8-1 represents the full purchased and installed cost of the HWPH along with the panel upgrade (for the weighted average of homes with panel

upgrades). To address the life cycle cost, ADM estimated the cost of a standard efficiency storage tank water heater installed upon failure of the existing system.

The existing gas water heater is assumed to have one-third of its EUL remaining[23]. Gas storage water heaters have an EUL of 11[24] years, so the rounded RUL is four years. With this four-year assumption, the process of calculating the base cost in an incremental cost estimation for the early replacement of a gas storage water heater with a HPWH is as follows:

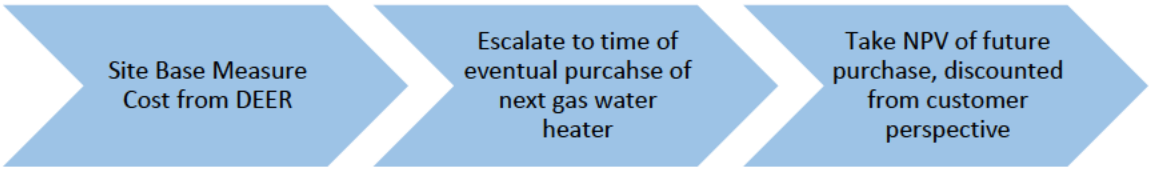


Figure 8-4. Process Flow for Calculation of Base Measure Cost

This is calculated as follows:

$$Time - Valued\ Base\ Measure\ Cost = \frac{(MeasureCost_{Base} * (1 + Inflation\%)^{RUL})}{(1 + ParticipantDiscountRate\%)^{RUL}}$$

Where,

- $MeasureCost_{Base}$ = Installed cost of minimum efficient gas water heater - $1,336.28[25]
- Inflation% = Current inflation rate – 2.28%[26]
- ParticipantDiscountRate% = 10%[27]
- RUL = 4 years

With this, the base measure cost in present-day dollars from the participant perspective is:

$$Time - Valued\ Base\ Measure\ Cost = \frac{(\$1{,}336.28 * (1 + .0228)^4)}{(1 + .10)^4} = \$998.83$$

8.2. Annual Fuel Cost Savings

This sub-section describes the annual fuel cost for the baseline natural gas water heaters and HPWHs, and the cost savings from the retrofit.

Table 8-2 provides an estimate of the annual fuel cost per unit baseline natural gas water heater based on 2020 fuel rates. At the time of authorship of this report, fuel prices had not yet been determined for December 2020. November 2020 rates were used for December.

[23] Standard RUL for CA DEER early replacement measures.
[24] CA DEER workpaper SWWH012-01, Storage Water Heater, Residential.
[25] Ibid.
[26] https://www.bls.gov/cpi/
[27] CPUC default, comprising credit card and loan rates.

Table 8-2. Annual Fuel Cost – Natural Gas Water Heater

Month	Therms/Month	Cost/Therm	Cost/Month
1	19.37	$ 1.45525	$ 28.18
2	16.11	$ 1.44503	$ 23.28
3	18.05	$ 1.48472	$ 26.81
4	17.58	$ 1.36982	$ 24.08
5	15.13	$ 1.36313	$ 20.62
6	17.88	$ 1.37740	$ 24.62
7	9.22	$ 1.37018	$ 12.63
8	8.74	$ 1.41454	$ 12.37
9	10.55	$ 1.55017	$ 16.36
10	12.07	$ 1.51484	$ 18.29
11	14.99	$ 1.59462	$ 23.91
12	19.18	$ 1.59462	$ 30.58
Total	179.31	n/a	$ 261.72

Table 8-3 provides an estimate for the annual electric fuel cost per unit HPWH installed for this program. The annual fuel cost is estimated for each of eight residential SVCE rate classes and then weighted relative to their respective presence in the billing data for the 81 customers for whom electric billing data were provided.

Table 8-3. Annual Fuel Cost – HPWH

Rate Class	Annual Fuel Cost	Weight	Weighted Value
E-1	$ 226.61	20%	$ 44.76
E-6	$ 216.75	19%	$ 40.14
E-TOU-A	$ 216.48	25%	$ 53.45
E-TOU-B	$ 247.18	2%	$ 6.10
E-TOU-C	$ 215.76	4%	$ 7.99
E-TOU-D	$ 257.68	2%	$ 6.36
EV-2A	$ 230.86	9%	$ 19.95
EV-A/EV-B	$ 244.27	20%	$ 48.25
Weighted Average	n/a	n/a	$ 227.01
GreenPrime adder[28]	$ 7.42	41%	$ 3.02
Total Weighted Average with GreenPrime	n/a	n/a	$ 230.03

Table 8-4 provides an estimate of the annual fuel cost savings associated with switching from natural gas water heaters to HPWHs.

[28] GreenPrime is an additional service offered by SVCE in which customers can opt to purchase electricity that has only been generated via renewable sources. This product incurs an additional $0.008/kWh charge. Of the 81 customers in the electric billing data set, 41% of customers had opted into the GreenPrime service and is thus represented in the electric fuel cost calculation.

Table 8-4. Annual Fuel Cost Savings per Unit

Cost Type	Annual Fuel Cost/Unit	
Natural gas water heater	$	261.72
HPWH	$	230.03
Annual Cost Savings	$	$31.69

8.3. Simple Payback Calculation

Based on the results of the installation cost estimation and the annual fuel cost savings calculation, ADM performed a simple payback calculation to estimate the length of time in which the annual fuel savings cost would offset participants' net installation cost. This calculation is summarized in the following equation:

$$\tau = \frac{Net\ Installation\ Cost - Time\ Valued\ Base\ Measure\ Cost}{Annual\ Fuel\ Savings\ Cost}$$

Where:

- τ is the number of years until the net installation cost is offset by the annual fuel savings cost.

Based on the results observed in Sections 8.1, the simple payback calculation is:

$$\frac{\$1{,}754.12 - \$998.83}{\$31.69} = 23.84\ years$$

Therefore, the annual fuel cost savings for participants offsets the incremental cost in approximately 23.84 years.

9. Recommendations & Conclusions

The following section provides a summary of the results presented in Sections 4 through 8 as well as recommendations for future programs.

9.1. Summary of Gas & Electric Consumption and GHG Results

A summary of the analysis on electric metering data, gas billing data, and GHG emissions is as follows:

- ADM generated a 24-hour load profile for weekdays and weekends (including holidays). Both curves were hallmarked by a bimodal curve with peaks at 8 a.m. and 9 p.m. for weekdays and 12 p.m. and 9 p.m. for weekends.
- The average energy usage per unit is estimated as 927.59 kWh/year per unit.
- There appear to be two clusters of participant types: (1) participants who primarily use hot water in the morning and (2) participants who primarily use hot water in the evening.
- The average fuel consumption for the baseline gas water heaters is approximately 178.86 therms/year per unit.
- The GHG emissions savings are approximately 2,088 lbs. of CO_2/year per unit.
- COVID-19 appears to have had an impact on the 24-hour water heating profiles regardless of whether participants reported having a change in daytime occupancy relative to SIP orders. This impact generally manifested as a reduction in the evening peak, an increase in the daytime peak, and a shift in the timing of the daytime peak to be later in the day. Despite these differences, the average daily consumption per unit has not been significantly impacted.

9.2. Summary of Participant Survey Results

At a high level, the key takeaways from the participant survey are:

- Nearly all participants (98%) were aware that SVCE was their energy provider prior to learning of the program.
- Friends, family, colleagues (33%) and e-mail communication from SVCE (28%) were the most common ways that respondents learned about SVCE rebates for HPWH installations.
- Overall, participants were not planning to install a HPWH until learning of the program (70%).

- The SVCE website was the primary source of information on the benefits of HPWHs (93%).
- SVCE rebates (93%) and GHG emission reduction (89%) were the primary motivators for program participants.
- Most participants reported positive experiences with the performance of the HPWH (84%).
- None of the respondents were dissatisfied with their experience with SVCE's HPWH program or the contractor that installed the HPWH.
- Thirty percent of survey respondents that received panel upgrade incentives also reported having replaced their gas central heating system with an electric system (30%) in addition to participating in the HPWH Pilot.
- Gas furnaces have the highest potential for future electrification (40%) although other end uses such as clothes drying (27%), gas fireplace (22%), and indoor cooking (18%) demonstrate a combination of gas system prevalence and consumer interest in electrification. Swimming pool heaters also demonstrate high potential per-customer, albeit for a much smaller subset of the total SVCE population.

9.3. Summary of Participant Cost Results

A summary of the participant cost results are as follows:

- The net installation cost is $1,805.15 per unit. The gross installation cost, including all equipment and labor, is $6,283.12, while the average rebate amount is $4,477.97.
- For the year 2020, participants saved approximately $31.69 per customer in fuel cost by switching from natural gas water heaters to HPWHs. The average annual fuel cost for natural gas water heaters is $261.72. The average annual fuel cost for HPWHs is $230.02.
- When accounting for the cost of a future gas water heater installation at the time of failure of the current system, the payback period for the HPWH retrofit is 23.84 years.

9.4. Recommendations

In general, the electric energy consumption observed for HPWHs and gas fuel consumption observed for natural gas water heaters fell within expected ranges. Results from this study pertaining to total consumption and GHG savings did not appear compromised by the COVID-19 SIP orders and thus should be generalizable for future reference. However, shifts in the average daily profiles relative to SIP orders appear to be present. Customers generally had a positive response to participating in the program and installed HPWH units in conjunction with other GHG reducing measures such as solar panels and electric central space heating.

ADM's program recommendations are as follows:

- **Continue to offer panel upgrade incentives.** Panel upgrade incentives are a key driver for market transformation. Home electrification will require expansion to 200A panels. This was proven in the survey analysis as the overall NTGR for customers without a panel upgrade was 75% while it was 127% for customers with a panel upgrade (with NTGR greater than 100% due to the panel upgrade facilitating HVAC electrification that was not incentivized by SVCE). The acquisition cost per net lb. of greenhouse gas after accounting for spillover is:
    - No panel upgrade: \$2.24/lb. of CO_2
    - With panel upgrade: \$2.28/lb. of CO_2
- **Consider development of electrification rebates for other end uses.** Forty percent of survey respondents were identified as "high electrification potential" for their heating load, through a combined lens of presence of gas equipment and indicating that they would be "very interested" in electrification of this equipment if a rebate covered 1/3 of the installation cost.
- **Conduct follow-up marketing or check-ins with panel upgrade customers.** ADM found that of the ten panel upgrade participants surveyed, three completed additional electrification improvements; two of which stated that this would not have been considered without their 200A panel upgrade. As other decarbonization options are developed, panel upgrade participants from the Pilot should be a primary target for new offerings. Barring that, a follow-up survey (perhaps 18-24 months after installation) could be completed internally by SVCE or via an external vendor to assess if deeper electrification efforts were made.
- **Develop a trusted contractor list.** Sixteen percent of respondents noted that they would have found it helpful if SVCE provided a trusted contractor list, with one respondent specifically noting that they selected their contractor from the City of Palo Alto Utilities contractor list for HPWHs. This aligns with program practices seen by the Bay Area Regional Energy Network (BayREN), City of Palo Alto Utilities, and Silicon Valley Power.
- **If Sense meters will be used in a programmatic capacity in future iterations of the Pilot, examine possibilities to link customers with Sense metering data to their Green Button data.** This could fill what customers perceive as a "gap" in Sense metering data.
- **Similarly, if Sense meters will remain in use, install Sense meters on the circuit containing the load of interest rather than having Sense do "smart disaggregation".** ADM found that in 44% of cases where the Sense meter was left to do smart disaggregation, that it did not accurately capture the HPWH and required a

supplementary visit by a contractor to address the issue by installing the CTs on the HPWH circuit to collect viable data.

- **Develop permitting checklists and FAQs for the Pilot.** Though the SVCE program page mentions applying for a permit, SVCE should consider a larger "permitting checklist" for customers, developed in collaboration with member cities. This is more difficult for a Community Choice Aggregator than for a municipal utility as there is a greater range of code requirements to address, but to the extent feasible addressing this would be helpful. Sixty-two percent of Pilot participants have been from Sunnyvale or Mountain View. Addressing high-volume cities first could expedite this process in terms of providing value to potential participants.
- **Work to obtain access to program participation data across the multiple program administrators for HPWH programs (or other relevant technologies).** Incentives for HPWHs are available to residential customers within SVCE's Member cities through SVCE, BayRen, and Pacific Gas & Electric (PG&E). Without a participant data-sharing agreement, it is possible for a single participant to obtain incentives from multiple entities, and the program administrators may benefit from coordination to ensure that a single project does not receive an excess of total incentive funds. SVCE should endeavor towards such an agreement in any instance where a program or pilot offering overlaps with existing programs from these entities.
- **Parties that administer overlapping programs should develop coordination and data sharing agreements.** The Evaluators found that multiple parties offer incentives for HPWHs within SVCE Member cities: SVCE, BayRen, and Pacific Gas & Electric (PG&E) all offer incentives for this technology with largely similar program requirements. Program administrators should as a practice endeavor to identify cases of overlapping offerings such as this, and develop data-sharing agreements where warranted. This would allow all parties to ensure the most efficient use of funds and would prevent potential double counting of impacts from a single project across multiple entities administering energy efficiency or decarbonization initiatives.

Appendix A: Monthly Water Heating Load Shapes

The following appendix provides a visualization of the average water heating load shapes by month, and weekday type normalized to a typical meteorological year.

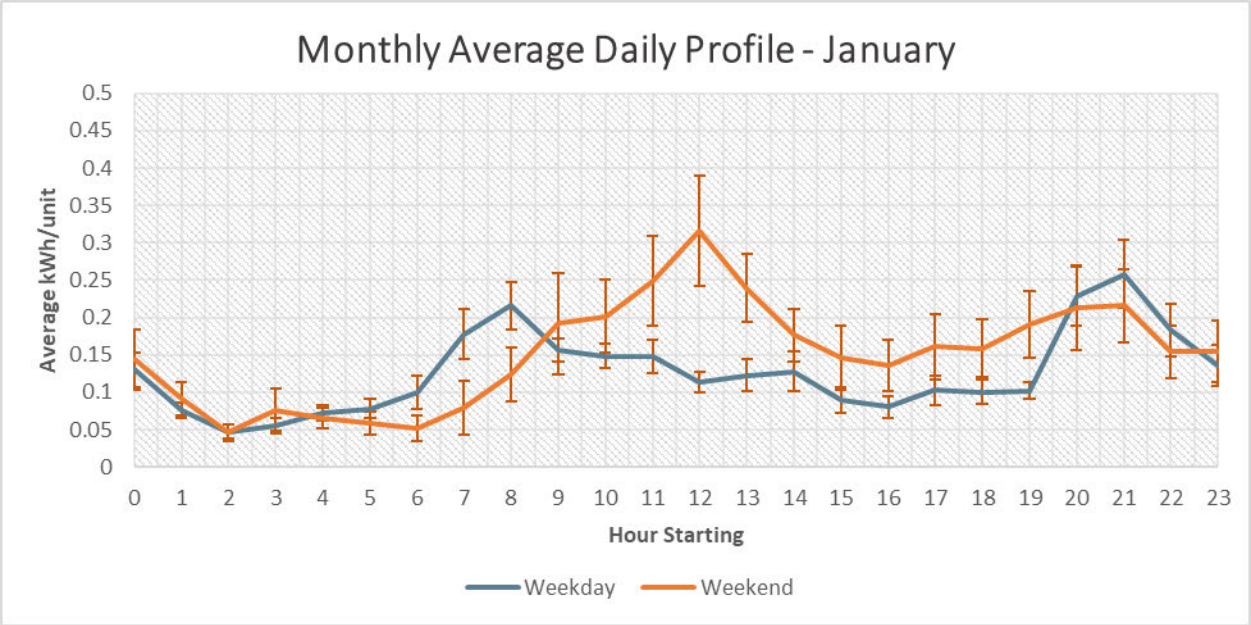


Figure A-1 Average Daily Load Profile for January

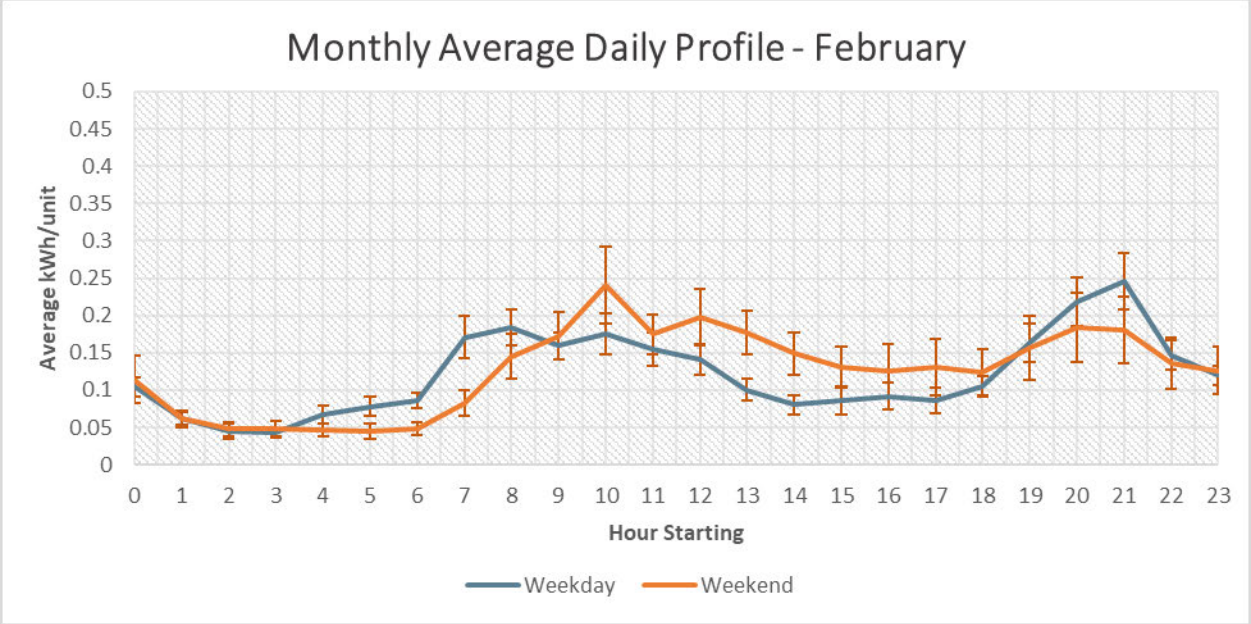


Figure A-2 Average Daily Load Profile for February

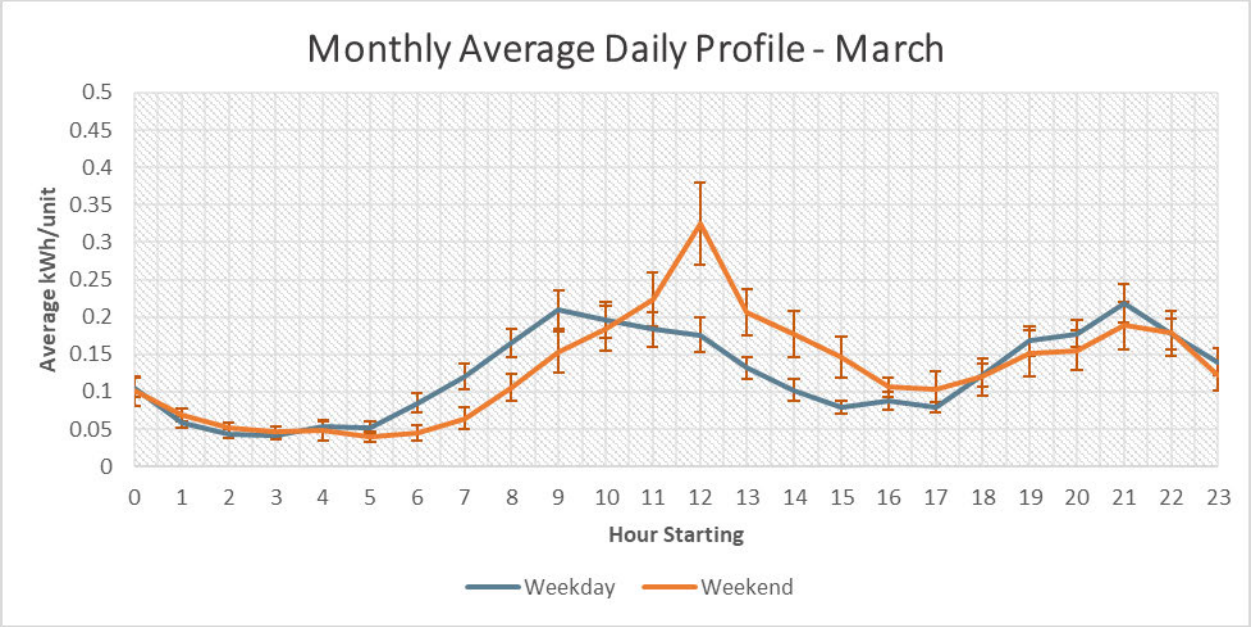


Figure A-3. Average Daily Load Profile for March

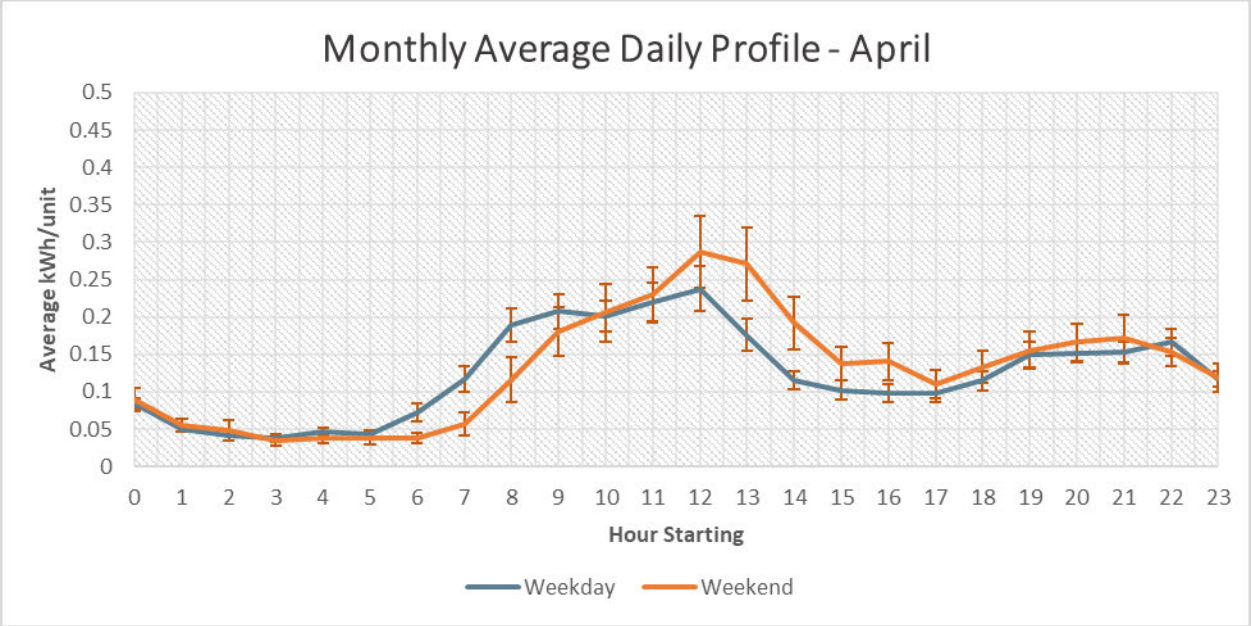


Figure A-4. Average Daily Load Profile for April

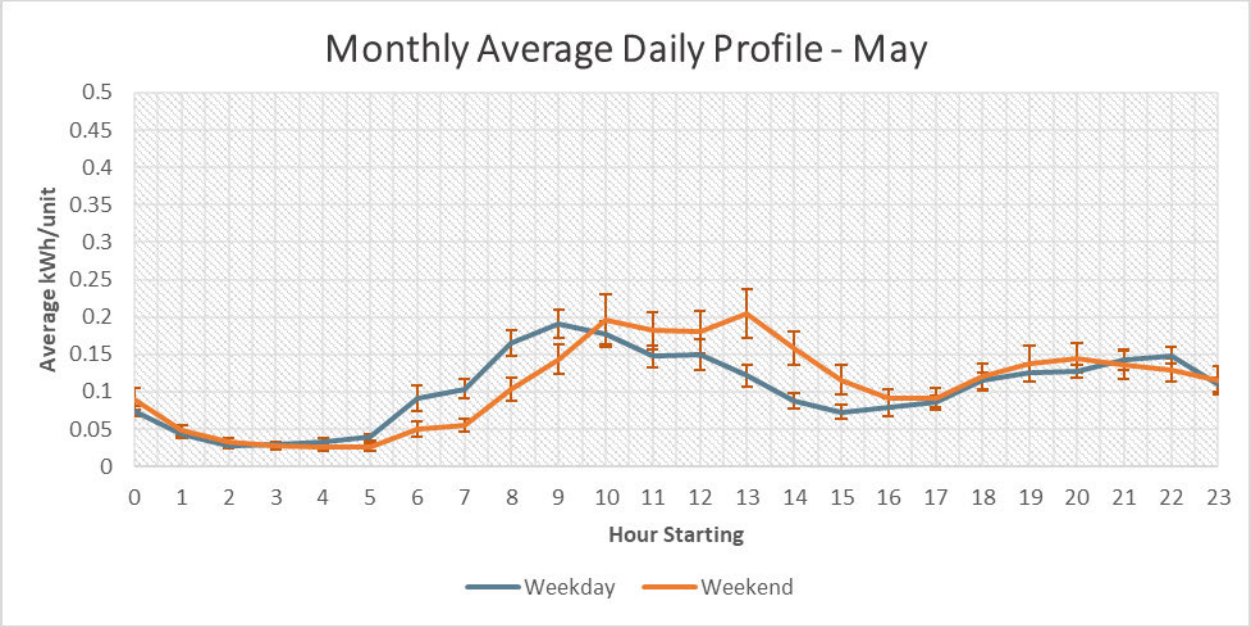


Figure A-5. Average Daily Load Profile for May

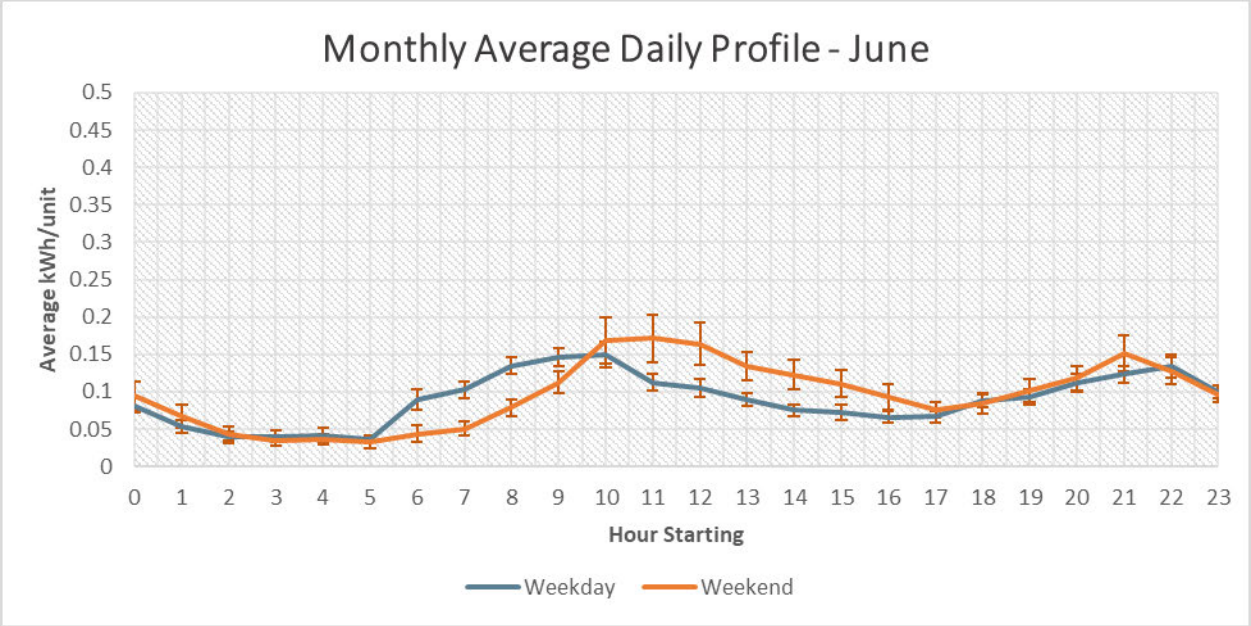


Figure A-6. Average Daily Load Profile for June

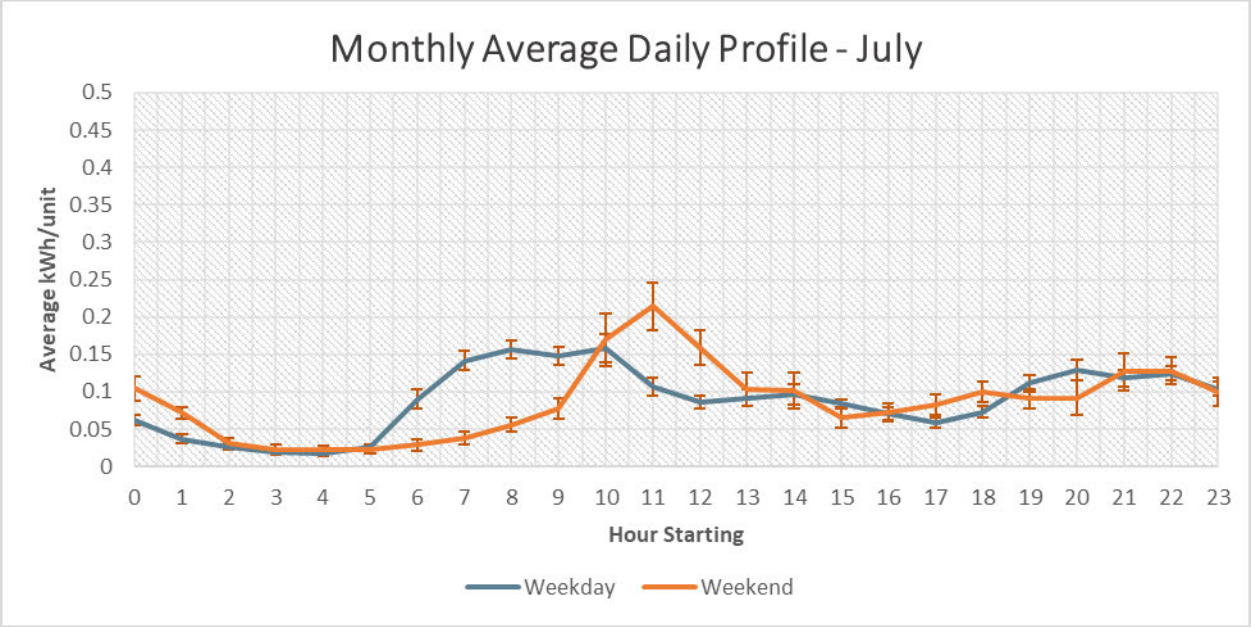


Figure A-7. Average Daily Load Profile for July

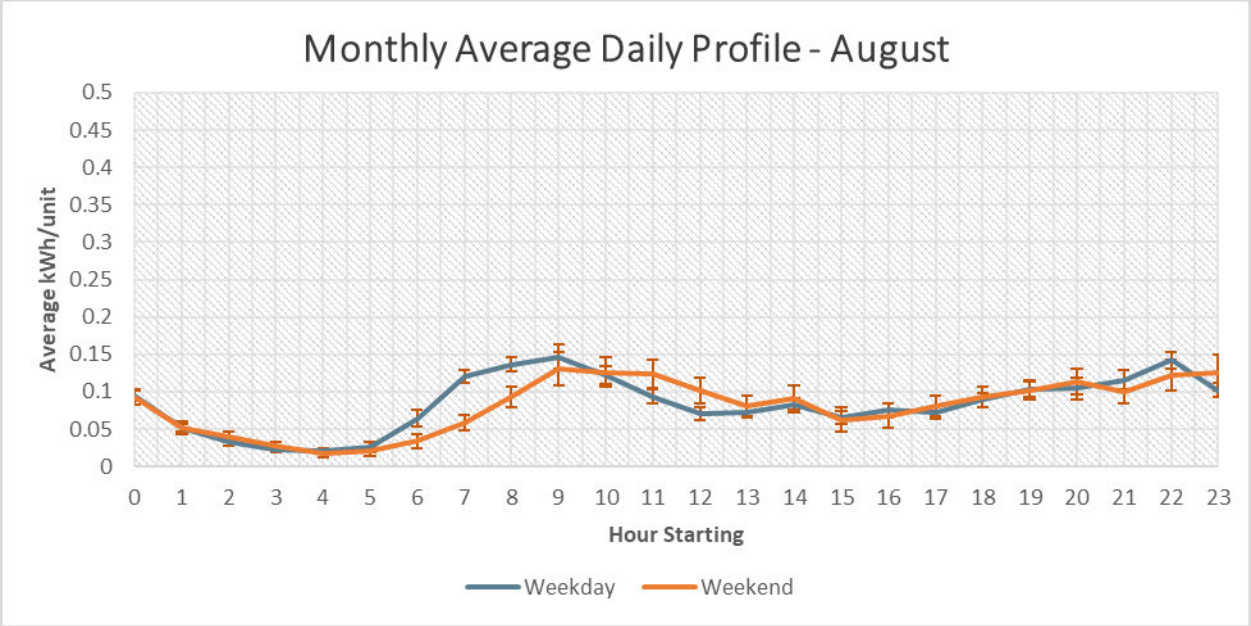


Figure A-8. Average Daily Load Profile for August

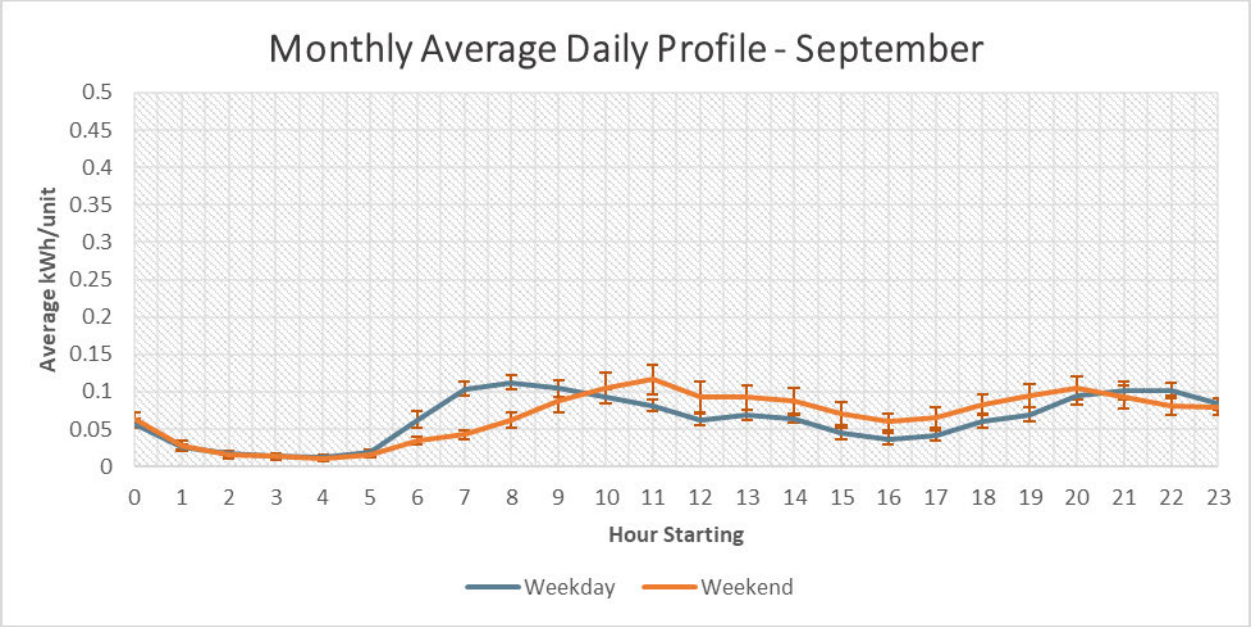


Figure A-9. Average Daily Load Profile for September

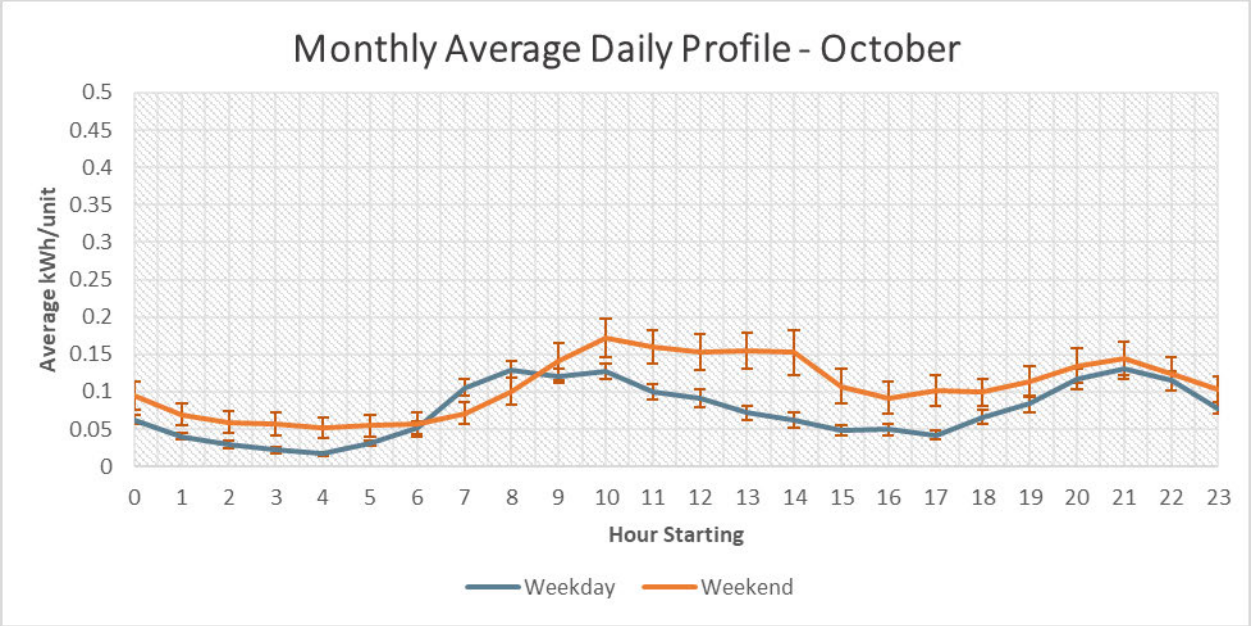


Figure A-10. Average Daily Load Profile for October

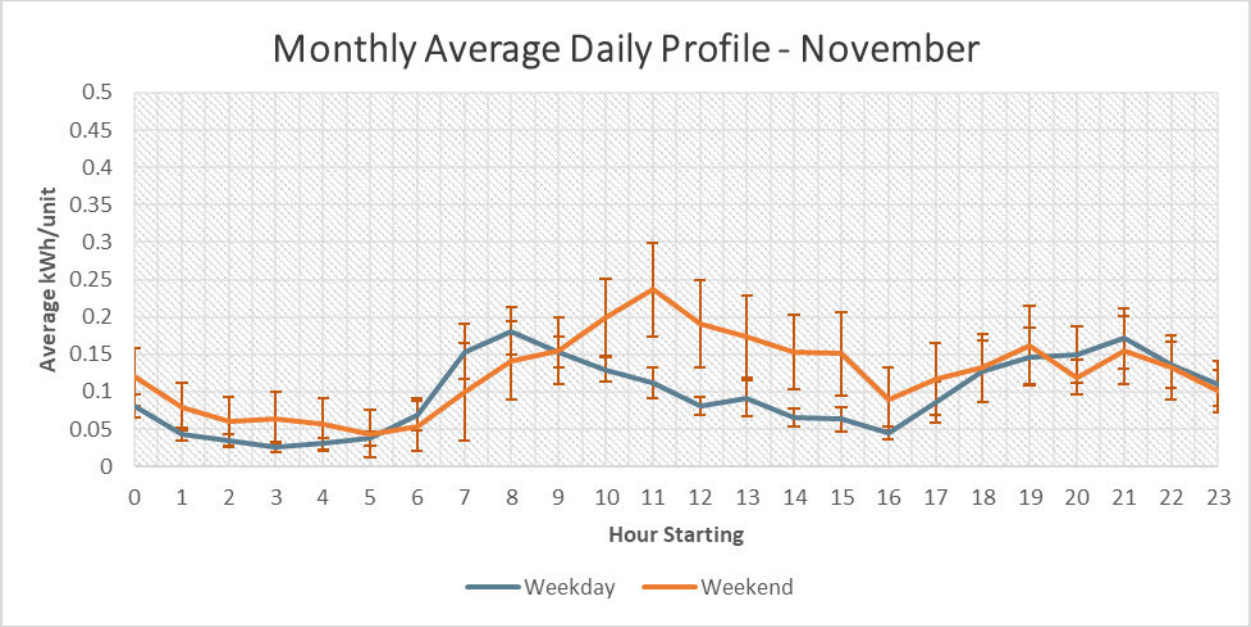


Figure A-11. Average Daily Load Profile for November

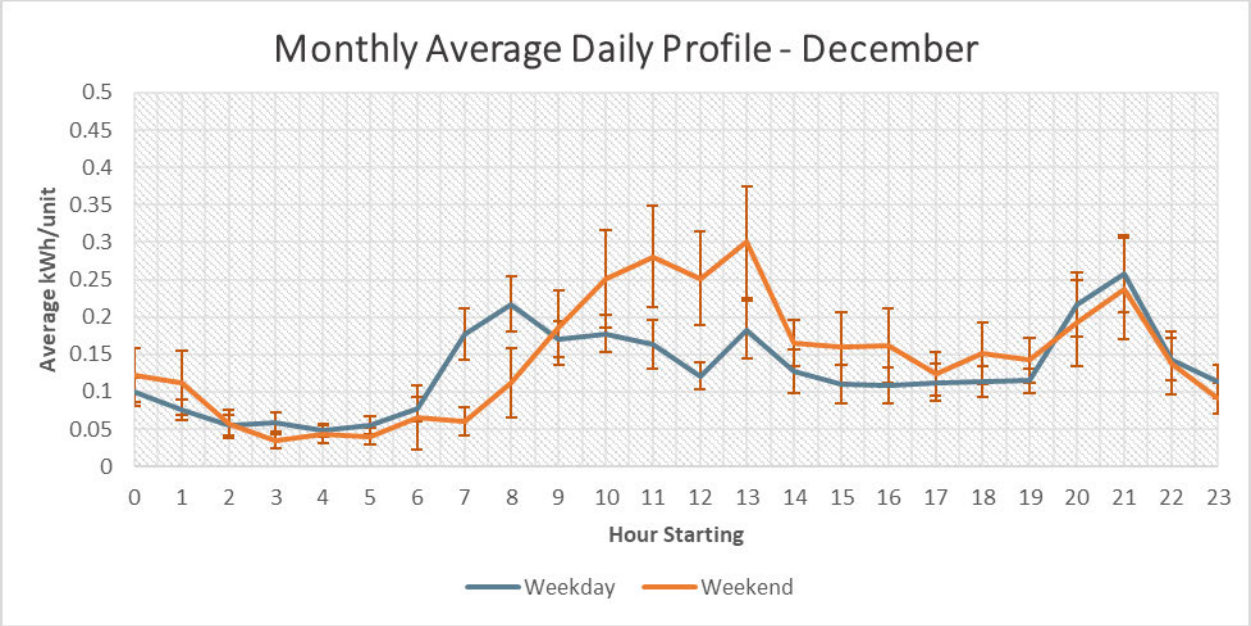


Figure A-12. Average Daily Load Profile for December

Appendix B: Participant Survey Instrument

Survey Variables

ACCESS_CODE	Random code to allow person to take survey and associate responses with data
ADDRESS	Information on location in the form of street address in city. i.e., 123 Main Street in Cupertino
CUSTOMER_EMAIL	Customer email address
CUSTOMER_PHONE	Customer phone
PANEL_UPGRADE	1 if received panel upgrade, else 0
PHONE	1 if survey administered by phone, else 0
INCENTIVE AMOUNT	$2000 if only installed heat pump water heater, $3500 if heat pump water heater was installed with the Smart Performance Package

9.5. Program Awareness

1. According to our records you received a rebate from SVCE for a for a heat pump water heater installed at your residence in [ADDRESS].
2.
3. Is that correct?

    1. Yes
    2. No, that is not correct. [Terminate survey: Thank you for that information. This concludes the survey.]

4. How did you first learn about the rebates SVCE offers for installing a heat pump water heater?

[Randomize 1 – 4]

    1. An email from SVCE
    2. By viewing the SVCE website
    3. From the contractor who installed the heat pump water heater
    4. From friend / relative / colleague
    5. In some other way (Please describe)
    98. Do not recall

5. Prior to learning of this program, were you aware that Silicon Valley Clean Energy was your energy provider?

1. Yes
2. No
98. Not sure

9.6. Attribution Water Heater

6. Were you already planning to install a heat pump water heater when you learned of the rebates available from SVCE?

   1. Yes
   2. No
   98. Not sure

7. Did an SVCE representative or a program representative provide you with information or talk to you about the benefits of heat pump water heaters?

   1. Yes
   2. No
   98. Not sure

8. Did the contractor that installed the heat pump water heater provide you with information or talk to you about its benefits?

   1. Yes
   2. No
   98. Not sure

9. Did you view any other material provided by SVCE, such as their website, about the benefits of heat pump water heaters?

   1. Yes
   2. No
   98. Not sure

10. There are many reasons why you might have decided to install a heat pump water heater. Which of the following were reasons for your decision to install the heat pump water heater? Select all that apply.

[Randomize order of 1- 6. Multiselect.]

   1. The heat pump water heater costs less money to heat water
   2. The heat pump water heater produces fewer greenhouse gas emissions
   3. SVCE provided rebates
   4. The contractor you worked with recommended it
   5. The heat pump water heater uses less energy to heat water

6. SVCE or an SVCE program representative recommended it
7. Potential additional savings through a future Smart Controlled Water Heater savings program
8. For some other reason (Please describe)
98. Not sure/ do not recall

11. What would you have most likely done if SVCE had not offered the [INCENTIVE AMOUNT] rebate for the heat pump water heater?

1. Would not have installed a new water heater
2. Would have installed a less energy efficient electric resistance water heater
3. Would have installed a natural gas water heater
4. The same thing, would have installed an electric heat pump water heater
5. Something else (Please describe)
98. Not sure

[Display if PANEL_UPGRADE =1]

12. According to our records you received a $2,500 rebate to upgrade your home's electrical panel to a 200 amp panel.
13.
14. Is that correct?

1. Yes
2. No
98. Don't know

[Display if Q12 = 1]

15. Would you have been able to install the heat pump water heater without replacing your old panel?

1. **Yes**, I could have used the old electrical panel
2. **No**, the old electrical panel was too small
98. Not sure

16. Please indicate how important each of the following were in your decision to install the heat pump water **[If PHONE = 1: using a scale where 1 means not at all important and 5 means very important]**?

Scale: 1 (Not at all important), 2, 3, 4, 5 (Very important), 98 = Don't know

[Randomize a – e]

a. The [INCENTIVE AMOUNT] heat pump water heater rebate
c. [Display if Q12 = 1] The $2,500 panel upgrade rebate
d. [Display if Q7 = 1] The information provided by SVCE or a program representative
e. [Display if Q8 = 1] The information provided by your contractor

f. **[Display if Q9 = 1]** Other information from SVCE including information on their website

17. Overall, how likely would you have been to install the electric heat pump water heater at about the time when you installed it**[If PHONE = 1, using a scale where 1 means not at all likely and 5 means very likely]**?

Scale: 1 (Not at all likely), 2, 3, 4, 5 (Very likely), 98 = Don't know

9.7. Spillover

[Display if PANEL_UPGRADE =1]

18. Have you done any of the following since upgrading your electrical panel through the SVCE program? Select all that apply.

[Randomize 1-6. Make 7 Exclusive. Multiselect.]

1. Purchased a plug-in electric vehicle
2. Replaced a gas heating system with an electric heating system such as a heat pump
3. Replaced a gas stove or oven with an electric stove top or oven
4. Replaced a gas clothes dryer with an electric clothes dryer
5. Installed solar panels **with** batteries
6. Installed solar panels **without** batteries
7. None of these

[Display if Q18 =1-6]

19. How likely is it that you would have taken those actions you mentioned if you had not upgraded your electrical panel through the SVCE program **[If PHONE = 1, using a scale where 1 means not at all likely and 5 means very likely]?**

Scale: 1 (Not at all likely), 2, 3, 4, 5 (Very likely), 98 = Don't know

9.8. Experience with Water Heater

20. Have you programmed the water heater to control its start and stop times?

1. Yes
2. No
98. Don't know

21. Have you had any problems with the heat pump water heater since it was installed?

1. Yes
2. No
98. Don't know

[Display if Q21 = 1]

22. What type of problem(s) have you had? Please select all that apply.

[Randomize 1 -5. Multiselect]

1. The water does not get hot enough
2. It takes too long for the water to get hot
3. The water temperature is inconsistent
4. It makes too much noise
5. It stopped working and needed to be repaired
6. Something else (Please describe)

23. Overall, would you say that the performance of the heat pump water heater…

1. Has completely met your expectations
2. Has partially met your expectations
3. Has not met your expectations
98. Not sure

[Display if Q23 = 2 or 3]

24. Why do you say that water heater has not completely met your expectations?

[Large text box]

9.9. Satisfaction

25. Overall, how satisfied are you with the contractor that installed your heat pump water heater?

[Scale: 1 (Not at all satisfied) – 5 (Very Satisfied), 6 self-installed]

26. Why did you give that answer?

[Large text box}

27. Overall, how satisfied are you with your experience with SVCE's heat pump water heater program?

[Scale: 1 (Not at all satisfied) - 5(Very satisfied)]

28. Why did you give that answer?

[Large text box]

29. Do you have any suggestions for improving the heat pump water heater program?

[Large text box]

9.10. Usage Change Questions

30. Many Californians have had their day-to-day schedule affected by the shelter-in-place order for COVID19. To help us understand how water usage may have changed, please enter the number of persons typically home during weekdays before the March 17th COVID shelter-in-place order and after the March 17th shelter in-place order.

1. I would prefer not to state

	Before March 17th COVID Shelter-in-place Order	After March 17th COVID Shelter-in-place Order
Number of Adults (18+ years old)		
Number of Children (0-17 years old)		

9.11. Electrification Potential

31. The next few questions are about your home. SVCE is interested in learning what opportunities there are for customers to make changes to their homes that reduce greenhouse gas emissions. Would you be willing to answer a few additional questions about your home?

    1. Yes
    2. No [Terminate Survey]

32. What is the main type of heating equipment used to provide heat for your home? [SELECT ONE]

    1. Central natural gas furnace
    2. Electric heat pump
    3. Built-in electric units installed in walls, ceilings, baseboards, or floors
    4. Built-in floor/wall natural gas furnace
    5. Built-in room heater burning gas, oil, or kerosene
    6. Heating stove burning wood, coal, or coke
    7. Portable electric heaters
    8. Fireplace
    9. Other (Please describe)

33. Does your home have a fireplace?

    1. Yes, a wood-only burning fireplace
    2. Yes, a natural gas burning fireplace
    3. Yes, a fireplace that burns natural gas and wood
    4. Yes, an electric fireplace
    5. No
    98. Not sure

34. Does your kitchen have a range/stove?

    1. Yes

2. No

[Display if Q34 > 0]

35. What fuel does your most used stove/range use?

1. Electricity
2. Natural gas from underground pipes
3. Propane (bottled gas)
4. Something else (Please describe)
98. Not sure

36. Does your household use an outdoor grill?

1. Yes, natural gas grill
2. Yes, propane grill
3. Yes, charcoal grill
4. Yes, electric grill
5. No

37. Does your home have a clothes dryer?

1. Yes
2. No
98. Not sure

[Display if Q37 = 1]

38. What type of fuel does your dryer use?

1. Electricity
2. Natural gas from underground pipes
3. Something else (Please describe)
98. Not sure

[Display if Q38 = 2 or 3]

39. Is there a (spare/unused?) 220/240 volt outlet where your dryer is located?

1. Yes
2. No
98. Not sure

40. Does your home have a swimming pool?

1. Yes
2. No

[Display if Q40 = 1]

41. Which fuels are used to heat the water in your swimming pool? If you use multiple fuels please select all that apply. [MULTIPLE SELECT]

    1. None, my swimming pool is not heated
    2. Electricity
    3. Natural gas from underground pipes
    4. Propane (bottled gas)
    5. Fuel oil
    6. Solar
    7. Other (Please describe)
    98. Don't know

42. Do you or any member of your household park a vehicle within about 20 feet of an electric outlet?

    1. Yes
    2. No

[Display if Q42 = 1]

43. Is there a 220/240 volt outlet within about 20 feet of where you or another member of your household park your vehicle? These are the larger outlets, like you would use to plug in a clothes dryer.

    1. Yes
    2. No
    98. Not sure

44. SVCE would like to know how interested you are in replacing equipment in your home that does not use electricity with similar equipment that does use electricity. For each of the following types of equipment, please indicate how interested you are in replacing that equipment with electric equipment, if **a rebate was provided that covered one third of the cost**:

45. a. [Display if Q32 = 1] Replace your central furnace with an electric heating system
46. b. [Display if Q33 = 1, 2, or 3] Replace your fireplace with an electric fireplace
47. c. [Display if Q35 = 2, 3, or 4] Replace your stove/range with an electric stove/range
48. d. [Display if Q36 = 1, 2, or 3] Replace your outdoor grill with an electric outdoor grill
49. e. [Display if Q37 = 2 or 3] Replace your clothes dryer with an electric clothes dryer
50. f. [Display if Q41 = 3, 4, or 5] Replace your swimming pool heater with an electric heater

Appendix C: Interested Customer Survey Instrument

Survey Variables

Variable	Definition
ACCESS_CODE	Random code to allow person to take survey and associate responses with data
ENGAGEMENT_TYPE	Either (1) “added your name to an interest list for” if the customer is on the interest list SVCE provided on March 3 2021 or (2) “reserved” if the customer is in the program tracking data with a reservation status of “Withdrawn”
NAME	Contact name
EMAIL	Customer email address

9.12. Screening Block

1. According to our records you [ENGAGEMENT_TYPE] a heat pump water heater rebate from Silicon Valley Clean Energy.

   Do you recall that?

   1. Yes
   2. No

[Display if Q1 =1]

2. Just to make sure that our records are correct, can you confirm that you **did not** get a rebate from Silicon Valley Clean Energy for installing a heat pump water heater?

   1. Yes, that is correct
   2. No, I did get a rebate from Silicon Valley Clean Energy for installing a heat pump water heater

[Display if Q2 =1]

3. Thank you for confirming that. Did you end up installing a heat pump water heater without getting a rebate for Silicon Valley Clean Energy?

   1. Yes **[Branch to Installed without Rebate Block]**
   2. No **[Branch to Did Not Install Block]**

[Terminate survey if Q1 or Q2 =2: Thank you for that information. This concludes the survey.]

9.13. Installed without Rebate Block

[Display Block if Q2= 1]

4. Why did you install a heat pump water heater without getting a rebate from Silicon Valley Clean Energy? (Please select all that apply)

[Multiselect] [Randomize options 1 - 4]

   1. The program wasn't available/ran out of funding when I installed the water heater
   2. I didn't think I qualified for a heat pump water heater rebate from Silicon Valley Clean Energy
   3. I didn't want to submit a rebate application
   4. I forgot to apply
   5. For some other reason (What was the reason?)

[Display if Q4 = 2]

5. Why did you not think you qualified for a heat pump water rebate from Silicon Valley Clean Energy?

[Display if Q4 = 3]

6. Why did you not want to submit a rebate application?

7. Did you get a rebate from any other utility or program? Please select all that apply.

[Multiselect]

1. No, did not receive a rebate from another utility or program **[Make exclusive]**
2. Bay Area Regional Energy Network (BayREN)
3. PG&E
4. San Jose Clean Energy
5. Silicon Valley Power (The municipal electric department for the City of Santa Clara)

9.14. Did Not Install Block

[Display Block if Q3 = 2]

8. Did you get a quote from a contractor for the cost of installing a heat pump water heater?

1. Yes
2. No
98. Don't recall

[Display if Q8 = 1]

9. Did the quote include the cost of upgrading your electrical panel to a 200 amp panel?

1. Yes
2. No
98. Don't recall

[Display if Q8 = 1]

10. Approximately how much was the quote you received? Your best guess is fine.

[Text box]

[Display if Q8 = 1]

11. Did the contractor that gave you the quote provide you with information or talk to you about the benefits of a heat pump water heater?

1. Yes
2. No
98. Not sure

12. Did an SVCE representative or a program representative provide you with information or talk to you about the benefits of heat pump water heaters?

1. Yes
2. No
98. Not sure

13. Did you view any other material provided by SVCE, such as their website, about the benefits of heat pump water heaters?

1. Yes
2. No
98. Not sure

14. Was the heat pump water heater project that you were considering part of a larger home remodeling project?

    1. Yes
    2. No
    98. Not sure

15. What were the main reasons for your decision to NOT install the heat pump water heater? Please select all that apply.

[Multiselect] [Randomize order of 1 - 9]

1. The cost of installing the heat pump water heater
2. Concern about losing hot water with an electric water heater during a PG&E Public Safety Power Shutoff
3. **[Display if Q14 = 1]** Cost overruns on the home remodeling project
4. Concern about loss of hot water during the installation
5. The program wasn't available/ran out of funding when I installed the water heater
6. I didn't think I qualified for a heat pump water heater rebate from Silicon Valley Clean Energy
7. Could not find a contractor who installed heat pump water heaters
8. Could not/did not have time to coordinate with electrician and plumber
9. Complications with electric panel upgrade
10. For some other reason(s)

[Display if Q15 = 6]

16. Why did you not think you qualified for a Silicon Valley Clean Energy rebate?

[Display if Q15 = 7]

17. What was the other reason(s) why you did not install the heat pump water heater?

[Display if more than one is selected in Q15]

18. Of those reasons you gave, which would you say is the most important reason for not installing the heat pump water heater?

    1. **[Display if Q15= 1]** The cost of installing the heat pump water heater
    2. **[Display if Q15= 2]** Concern about losing hot water with an electric water heater during a PG&E Public Safety Power Shutoff
    3. **[Display if Q15= 3]** Cost overruns on the home remodeling project
    4. **[Display if Q15= 4]** Concern about loss of hot water during the installation
    5. **[Display if Q15= 5]** The program wasn't available/ran out of funding when I installed the water heater
    6. **[Display if Q15= 6]** I didn't think I qualified for a heat pump water heater rebate from Silicon Valley Clean Energy

7. **[Display if Q15= 7]** Could not find a contractor who installed heat pump water heaters
8. **[Display if Q15= 8]** Could not/did not have time to coordinate with electrician and plumber
9. **[Display if Q15= 9]** Complications with electric panel upgrade

10. **[Display if Q15= 10]** For the other reasons you mentioned

19. Are you still interested in replacing your gas water heater with a heat pump water heater?

1. Very interested
2. Somewhat interested
3. Not really

[Display if Q19 = 1 or 2]

20. Would you like someone at SVCE to contact you with information about the heat pump water heater rebate program?

1. Yes
2. No

[Display if Q20 = 1]

21. Is the email below the best email to use to reach you? If not, please provide the best email address to reach you at.

[Text Box] [Prefill with EMAIL]

9.15. Concluding Block

[Display to all respondents]

22. Do you have any other comments or feedback for SVCE on the heat pump water heater program?

23. Do you have any other comments or feedback for SVCE on the programs or services they offer their customers?

24. What city is the residence where you [installed/planned to install] the heat pump water heater?

1. Campbell
2. Coyote
3. Cupertino
4. Gilroy
5. Hollister
6. La Honda
7. Livermore
8. Los Altos

9. Los Altos Hills
10. Milpitas
11. Monte Sereno
12. Morgan Hill
13. Mount Hamilton
14. Mountain View
15. Portola Valley
16. Redwood Estates
17. San Jose
18. San Martin
19. Saratoga
20. Stanford
21. Sunnyvale
22. Watsonville