Residential Water Heater Sizing Measure Package Support

Final Report

ET22SWE0036

Prepared by:
TRC Advanced Energy

Advanced Energy
436 14th Street Suite 1020, Oakland, CA 94612
Contact: mfountain@trccompanies.com

Executive Summary

Currently, incentives for energy efficient water heater retrofits require a like-for-like replacement. However, there is anecdotal evidence that contractors upsize heat pump water heater (HPWH) replacements relative to existing gas water heaters. This project adds to current statewide water heating measure offerings by allowing incentives for non-like-for-like size replacements. HPWH consume significantly less energy compared to alternatives. While incentives based on tank size could be counterproductive because they could discourage retrofits from electric resistance and gas water heaters to heat pump water heaters

This project provides updates to the DEER Water Heater Calculator V 5.1 (California Public Utilities Commission, 2022). TRC utilizes data from existing fuel substitution workpaper development and an existing California Public Utilities Commission (CPUC)-approved water heater energy use calculator with prototype buildings and various water heater sizes. DEER Hot Water Calculator modeling across the California (CA) climate zones establishes like-for-like baselines for savings claims.

In addition, this report describes current practices for HPWH retrofits based on a survey of 16 plumbing contractors active in the TECH program, which incentivizes retrofits of legacy systems (electric resistance or gas water heaters) to heat pump water heaters. The survey[1] found that:

- Most contractor are upsizing tanks when moving from a gas or electric resistance water heater to a HPWH. Twelve (12) of 16 reported upsizing the tank when replacing a gas water heater with a HPWH, and 4 of 6 reported upsizing the tank when replacing an electric resistance water heater with a HPWH. Of the contractors that reported upsizing tanks moving from gas to a HPWH, two-thirds said they install a slightly larger tank, and one-third said they install a much bigger tank. The primary reason cited was that different technologies require a larger tank.
- For the electrical systems, contractors reported a HPWH replacement required circuit breaker upgrades in approximately half their projects, outlet upgrades slightly less often, but rarely was an electrical panel upgrade required.
- In the surveyed group of contractors (those who have installed a HPWH), the most common type of replacement is from natural gas water heater to a HPWH.

This report covers the DEER Water Heater Calculator V5.1 tool modifications, survey results, and provides some examples of water heating equipment retrofits from the California Energy Smart Homes Program.

[1] Note that these results may not reflect Statewide trends, since the project team specifically targeted plumbing contractors with at least some experience installing HPWHs through the TECH program.

Disclaimer

Abbreviations and Acronyms

Acronym	Meaning
CA	California
CESH	California Energy Smart Homes Program
CPUC	California Public Utilities Commission
DEER	Database of Energy Efficiency Resources
DHW	Domestic Hot Water
DWHC	DEER Water Heater Calculator
DX	Direct Expansion
EE	Energy Efficiency
ET	Emerging Technology
EU	End Use
HP	Heat Pump
HPaWHS	Heat Pump assisted Water Heating System
HPWH	Heat Pump Water Heater (s)
HPWHS	Heat Pump Water Heating System
HVAC	Heating, Ventilation, and Air Conditioning
PG&E	Pacific Gas and Electric
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SME	Subject Matter Expert
TECH	Technology and Energy for Clean Heating
UEF	Uniform Energy Factor
WB	Whole Building

Table of Contents

List of Tables

List of Figures

Background

Overview

Currently, incentives for energy efficient water heater retrofits require a like-for-like replacement. The project team receives regular word-of-mouth communication that contractors typically upsize the heat pump water heater (HPWH) tank compared to the tanks in existing gas water heaters during replacement to meet the hot water requirements of residents. Adding to the current statewide water heating measure offerings with new calculations will allow like-for-like replacements to qualify for future programs and result in a more energy efficient installed base of water heaters. A calculator exists as a macro-enabled Excel workbook developed by the CPUC to standardize the input and savings calculations for water heating measures. The simulation tool uses the technology definitions to determine the hot water energy use for each climate zone, building type and building vintage that are part of the standard Database of Energy Efficiency Resources (DEER) applicability parameters. The DEER calculator with new inputs and assumptions related to water heater upsizing produces energy use predictions in support of a future HPWH measure package.

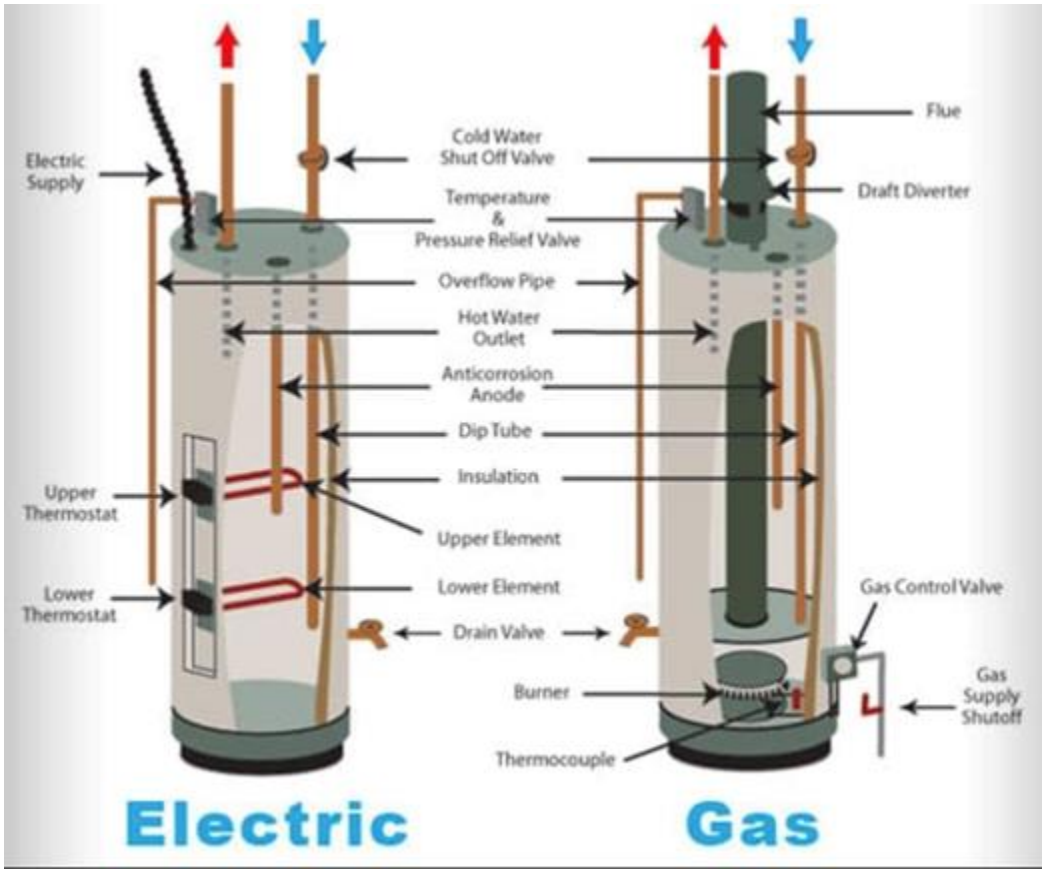
> **Providing incentives for non-like-for-like hot water tank retrofits is a critical step towards meeting California's decarbonization goals. This measure package presents a significant opportunity to achieve long term residential hot water system efficiency.**

Conventional Heaters and Heat Pump Water Heaters

Figure 1 shows schematics of two conventional residential hot water heaters. One version (gas-fired) burns natural gas to heat water. Natural gas water heaters comprise approximately 90% of the California residential installed base (Energy Code Ace, 2019). Another type (electric resistance) uses heat created by resistance in an electrical element to heat water directly by contact. Electric resistance water heaters make up approximately 6% of residential water heaters in California. Most of the remaining households (4%) use propane, wood, or solar to heat water. Both natural gas and electric resistance water heaters come with two configurations – with a storage tank and without a storage tank (i.e., tankless).

Tankless water heaters heat water instantaneously without the use of a storage tank. When a hot water faucet is turned on, cold water flows through a heat exchanger in the unit, and either a natural gas burner or an electric element heats the water. Current offerings for SWWH025-05 assume a "like for like" replacement based on the storage capacity of the existing natural gas water heater and the new HPWH. The project utilizes the existing fuel substitution workpaper data and an existing CPUC-approved water heater energy use calculator with prototype buildings and various water heater sizes. Energy consumption modeling across the California (CA) climate zones establishes like-for-like baselines for savings claims.

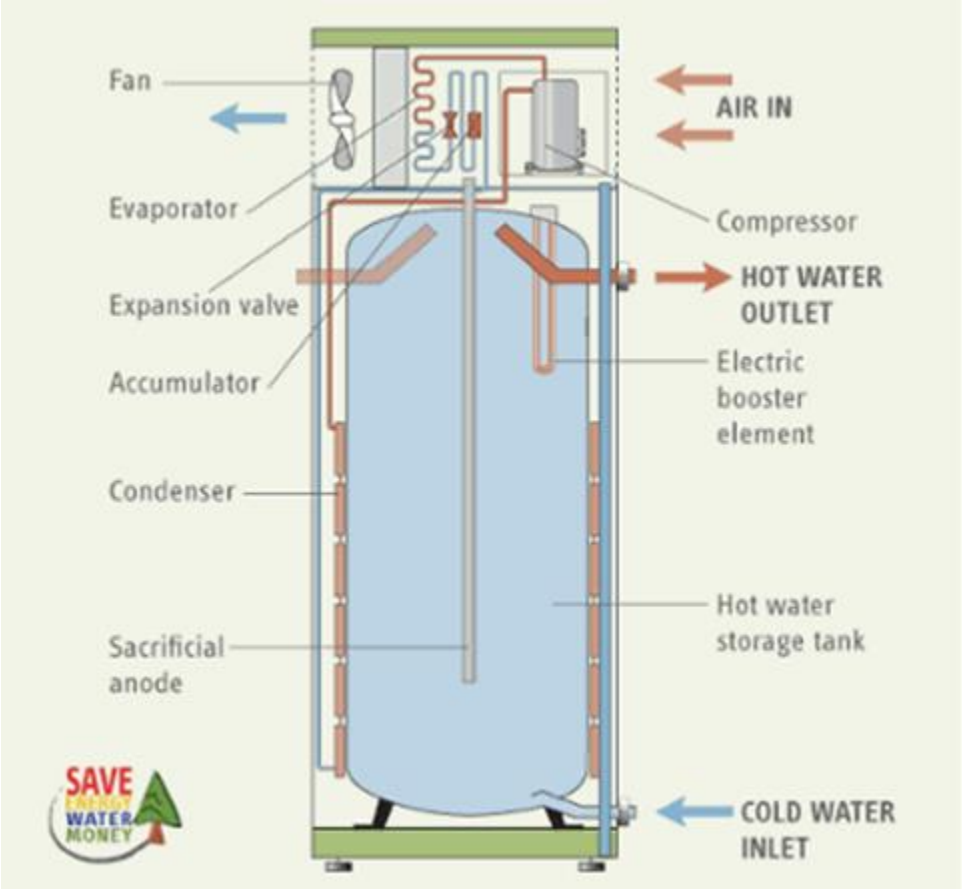
Figure 1 - Schematic of conventional gas-fired and electric resistance storage water heaters.



Source: InterNACHI.

Figure 2 shows a schematic of a residential HPWH. HPWH use a direct expansion (DX) heat pump (HP) to transfer heat to the water. The HP condenser coils are located inside the insulated water storage tank where the flow of hot refrigerant heats the water. In many HPWH, referred to as hybrid HPWH, supplemental electric resistance heating elements exist to meet heating requirements when the HP system cannot meet them alone. Condenser coils heat the cold water entering the base of the tank. The hot water rises, heated by the condenser coils until the heated water exits the top of the tank for consumption. HPWH achieve higher efficiency compared to electric-resistance or natural gas water heaters. Supplemental electric-resistance elements for periods of high demand are a typical addition.

Figure 2 - Typical Residential Heat Pump Water Heater



Source: Energy Vanguard

DEER Water Heater Calculator

General Description

This study supports adding new measure offerings to the residential HPWH fuel substitution measure package (SWWH025-05). The DEER Water Heater Calculator v5.1 (DWHC) (California Public Utilities Commission, 2022) calculates savings for the offerings in SWWH025. DWHC version 5.1, is the most recent version, deployed through a macro-enabled Excel workbook developed by consultants of the CPUC Energy Division to standardize the inputs and savings calculations for water heating measures. The DEER Water Heater Calculator v5.1 adopts residential hot water load profiles from CBECC-Res 2019/2021. The tool uses standardized "technology definitions to determine the hot water energy use for each climate zone, building type and building vintage that are part of the standard DEER applicability parameters." The calculator links technology definitions to DEER "TechID"'s stored in the tool. The tool calculates measure offering energy savings by taking the difference between the energy consumption of the base case and measure case TechIDs.

Table 1 - Key Components of the DWHC

Key Components of the DEER Water Heater Calculation Tool	
Technologies	New technologies to support the new water heater measures. The technologies span three technology types: storage water heaters, instantaneous water heaters, and HPWH. Specific TechID's reference water heater technologies used throughout the tool. **Usage Note**: The "Update" column (col W) can be set to TRUE or FALSE. If set to TRUE, the "Calculate All Results" button pressed on the TechCalc tab calculates TechID consumption values.
Calculation	The "TechCalc" worksheet documents all inputs and hourly calculations. This is a reference tab only.
TechCalc	The worksheet calculates the hourly energy use for a selected water heater technology and for a selected building type and location. Cells C4-C6 contain the indices for the technology type, building type and location. Cells J14-Z14 show annual results for consumption. The "Calculation" worksheet lists Details of the calculations. **Usage Note:** The "Calculate All Results" button automatically calculates the annual results for all permutations of building type and climate zone for all TechIDs that have been set to TRUE in the "Update" column in the Technologies tab. The TechResults tab contains the results for each permutation.
TechResults	The TechResults worksheet houses all previously calculated annual consumption results for each permutation of Tech ID, building type, and climate zone. Pressing the "Calculate All Results" button in the TechCalc tab populates the TechResults worksheet. This tab comes prepopulated with values from all existing TechIDs in the calculator. It only needs updating if new TechIDs are added.

Key Components of the DEER Water Heater Calculation Tool	
Measure	Comparisons of base and measure case equipment calculated by the tool are set up in this worksheet. **Usage Note:** The user must input selected TechIDs for the base (standard) and measure case equipment in columns H and I, respectively. The user must also input the number of units, normalizing unit ('each' or 'capacity' in kBtu), preexisting fuel type and storage capacity, and sector. The user must create a Measure ID and continue the numbering of the index column for any added rows. Standard formatting for Measure ID is emulated in DEER, but anything can be selected by the user based on their preference. An auto population function resets the cells and determines existing case equipment conditions. Last, cells J2-K3 for either residential or commercial sector allow calculation of a subset of measures.

Key Components of the DEER Water Heater Calculation Tool	
EnergyImpact	This worksheet houses all the of the previously calculated energy impacts for measures defined in the tool. Measure ID, building type, climate zone, and vintage define permutations of each measure. Savings related outputs include electric energy and demand, and natural gas savings above existing case and the standard case. Non-savings related outputs include normalizing unit and number of units assumed in the calculation, building areas, and electric and gas load shape profile IDs. The vintage parameters affect the "Pre" case savings only, as the assumption of existing case equipment varies by vintage. Also available are separate savings for whole building "WB" or end use "EU." This tool does not currently include any interactive effect impacts, so "WB" and "EU" both show the same values. Standard direction from the CPUC for measure package development is to use the "WB" for measure package savings values. Pressing the "Create all Com Impacts" or "Create all Res Impacts" buttons on the EnImpacts-Com and EnImpacts-Res tabs, respectively populates values in the EnergyImpact sheet. New measures do not trigger recalculation of savings for all existing measures because added values append to the existing data.
EnImpacts-Com **EnImpact-Res**	Calculated savings values for each Measure ID occurs in these two worksheets. By clicking the "Create all Com Impacts" or "Create all Res Impacts" buttons the tool runs through the subset of selected measures identified on the Measures tab, calculates savings for all building types and climate zones for that sector (Com or Res), and pastes them into the EnergyImpact Tab. Selecting the ID in the dropdown in cell B1 shows the savings for an individual Measure ID. The spreadsheet pulls in consumption values for the base (standard) and measure case equipment associated with the Measure ID. Cells G3-G4 show Tech IDs for the associated equipment. Each water heater or heating capacity (kBtu-h) has normalized consumption values provided in columns P-Z.

Components of the TechID

Gas Storage Water Heater Tech ID:

Stor_UEF-Gas-030gal-MD-0.64UEF

Heat Pump Water Heater Tech ID:

Stor_UEF-ElecHP-050gal-3.50UEF

Description of TechID for storage water heaters.

Water Heater Type_Efficiency Rating-Fuel Type-Storage Capacity-Draw Pattern(optional)-Efficiency

"Uniform Energy Factor (UEF) ratings are determined by assigning water heaters into one of four different categories (bins) of hot water usage and then evaluating their performance based on that usage. The 'first hour rating' of a water heater determines its' UEF assignment within its hot water usage bin. A higher UEF means a water heater is more energy efficient and will cost less to operate compared to other water heaters in the same bin. A water heater's UEF is only comparable with water heaters within the same bin. For example, a high bin water heater with a UEF of 0.95 does not perform exactly the same as a low bin water heater with a UEF of 0.95" (A.O. Smith, 2022).

Methods

Hot water tank sizing tool update

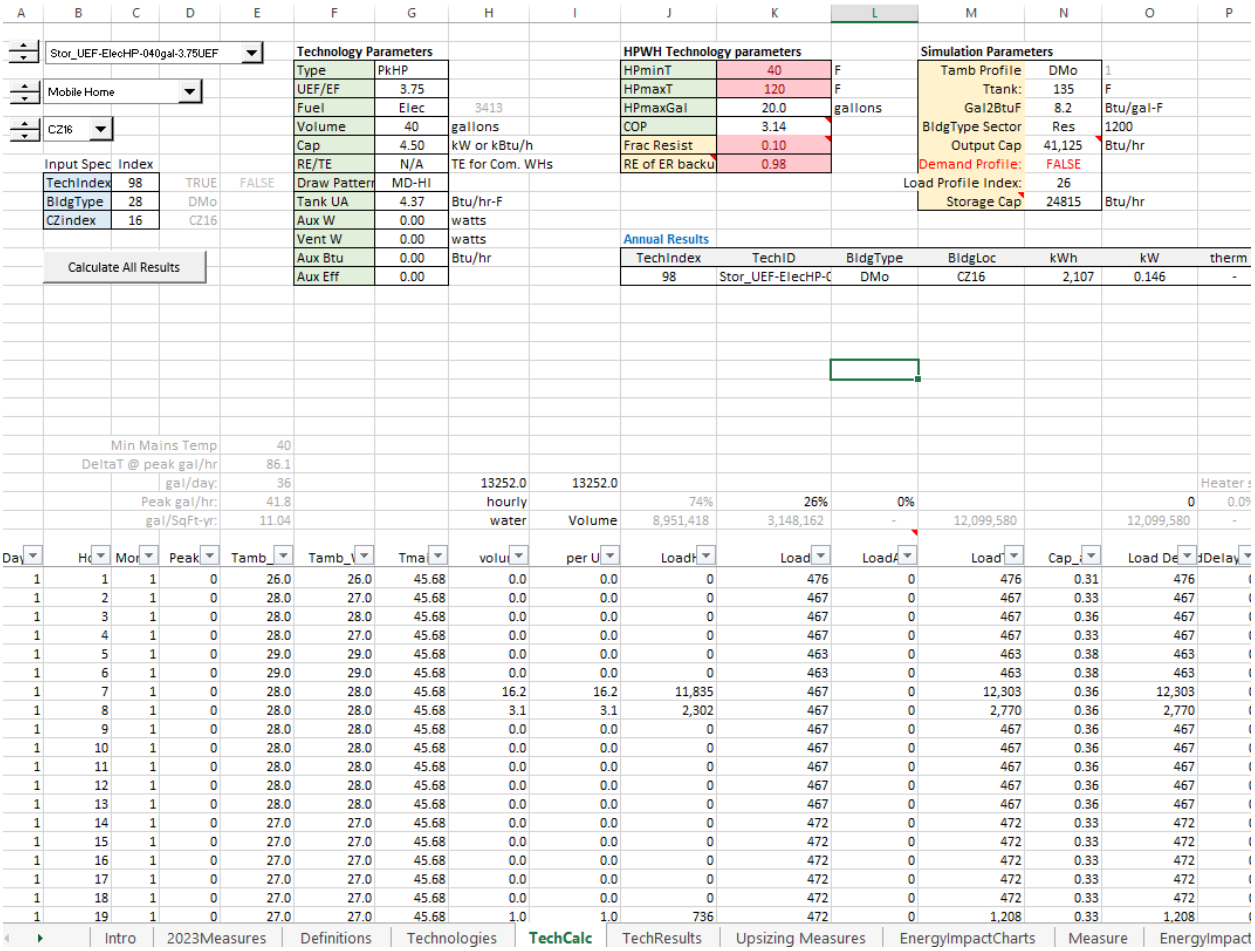
For this study, TRC updated the DEER Water Heater Calculator V 5.1 (California Public Utilities Commission, 2022) with data required to support a future water heating measure package development effort. The project utilized existing fuel substitution workpaper data and an existing CPUC-approved water heater energy use calculator with prototype buildings and various water heater sizes. Energy consumption modeling across the California (CA) climate zones establishes like-for-like baselines for savings claims.

Figure 3 shows a screen shot of the DEER Water Heater Calculator output. The technology parameters of the existing water heater are in columns F and G, the HPWH replacement in columns J and K with the annual results below.

Heat pump water heaters are more energy efficient because they move heat while gas water heaters create heat via combustion. Heat pump water heaters come with auxiliary backup heating in the form of electric resistance. Upsizing the tank minimizes operating time of inefficient resistance heating, allowing the heat pump to do most of the water heating work. To meet a home's hot water demand, a contractor selects a heat pump water heater with a high enough first hour rating. First hour rating is the number of gallons of hot water the heater can supply per hour - starting with a tank full of hot water.

The worksheet examples (Figure 4 and Figure 5) shows how the DEER Water Heater Calculator V 5.1 is currently used.

Figure 3 - DEER Water Heater Calculator (California Public Utilities Commission, 2022) Example Output



Technology Parameters			
Type	PkHP		
UEF/EF	3.75		
Fuel	Elec	3413	
Volume	40	gallons	
Cap	4.50	kW or kBtu/h	
RE/TE	N/A	TE for Com. WHs	
Draw Pattern	MD-HI		
Tank UA	4.37	Btu/hr-F	
Aux W	0.00	watts	
Vent W	0.00	watts	
Aux Btu	0.00	Btu/hr	
Aux Eff	0.00		

HPWH Technology parameters		
HPminT	40	F
HPmaxT	120	F
HPmaxGal	20.0	gallons
COP	3.14	
Frac Resist	0.10	
RE of ER backu	0.98	

Simulation Parameters		
Tamb Profile	DMo	1
Ttank:	135	F
Gal2BtuF	8.2	Btu/gal-F
BldgType Sector	Res	1200
Output Cap	41,125	Btu/hr
Demand Profile:	FALSE	
Load Profile Index:	26	
Storage Cap	24815	Btu/hr

Annual Results

TechIndex	TechID	BldgType	BldgLoc	kWh	kW	therm
98	Stor_UEF-ElecHP-(	DMo	CZ16	2,107	0.146	-

Source: Project Team

Figure 4 - Worksheet for Estimating Peak Hour Demand/First Hour Rating

Use	Average Gallons of Hot Water per Person	Times Used during 1 Hour		Gallons Used in 1 Hour
Shower	20	X	=	
Shaving (.05 gallon per minute)	2	X	=	
Hand dishwashing or food prep (2 gallons per minute)	3	X	=	

Automatic dishwasher	7	X		=	
Clothes Washer Top Loader H-Axis	25 18	X		=	
			Total Peak Hour Demand	=	X

Figure 5 - Completed Water Heater Sizing Worksheet

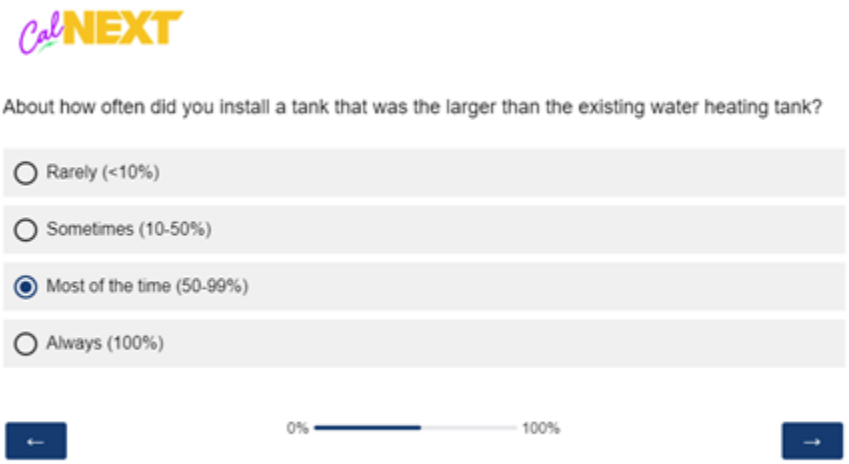
Use	Average Gallons of Hot Water per Person		Number of Times Used in 1 Hour		Gallons Used in 1 Hour
One shave	2	X	1	=	2
One hand dishwashing	3	X	1	=	3
Peak Hour Demand				=	66

Plumbing Contractor Survey

TRC merged two public data sets to compile a list of reachable California plumbing contractors. One dataset is Technology and Energy for Clean Heating (TECH) tagged the CA contractors by company name who have done at least one HPWH installation and the other dataset (Switch-Is-On) has a large list of contractors but only addresses and emails. The merged list has approximately 150 unique contractor emails screened for heat pump water heating installation from the TECH and Switch-is-on data sets. A verified heat pump water heater installation was the only criteria for contractor survey participation.

The plumbing contractor survey begins with some 'firmographic' questions. These questions help understand the size of the plumbing contractor's business and the quantity of residential HPWH retrofits (natural gas and electric resistance), the base case, and the technology replacing it. Do contractors also replace gas with gas or electric with electric? Or is it also gas with electric but not a heat pump? The survey also covers like-for-like and non-like-for-like tank sizing – both frequency and proportion, slightly larger or much larger (Figure 6). Finally, the survey concludes with a question about required electrical upgrades broken down by cost: small (outlet replacement) to large (panel replacement).

Figure 6 - Example Screen from the Survey



Source: Project Team.

DEER Water Heater Calculator Modifications

Current offerings for SWWH025-05 assume a “like for like” replacement based on the storage capacity of the existing natural gas water heater and the new HPWH. This update creates new measure offerings that reflect the upsizing of storage capacity and alignment of first hour rating values when replacing natural gas water heaters with HPWH. No specific tank size is recommended because the correct tank size varies by project. Factors that affect upsizing are: location of water heater, first hour rating, number of people in the house, and overall costs. The contractor makes the tank size decision based on these factors and there is no standard ‘oversizing’ recommendation.

Current offerings for SWWH025-05 have combinations of heat pump water heaters replacing existing storage or tankless water heaters. However, the workpaper assumes 'like for like' replacement based on storage capacity of existing gas water heaters. For example, Measure offering 'K' in the workpaper is for installing a heat pump water heater between 55 gallon and 75 gallon replacing a 60-gallon natural gas water heater. Furthermore, Measure K only includes a heat pump water heater with one UEF rating, UEF = 3.33.

This project expands the possible replacements by modeling permutations of UEF ratings and heat pump water heater tank sizes. In all cases, both the base and measure technologies for the new offerings already exist in the DWHC as TechIDs. Therefore, the updates to the tool include creating new measure offerings using different combinations of existing DEER TechIDs to reflect different combinations and upsizing of HPWH storage tank.

Table 2 shows the combinations of DEER TechIDs used in the completion of this work. Note that the first three rows show possible replacement tank sizes (55-75 gal.) over three different UEF's with a 40-gallon tank as the base case. The second three rows show the same replacement tank size range (55-75 gal.) over three different UEF's but with a 50-gallon tank as the base case – and so on for different replacement tank sizes, UEF's, and base case tank sizes.

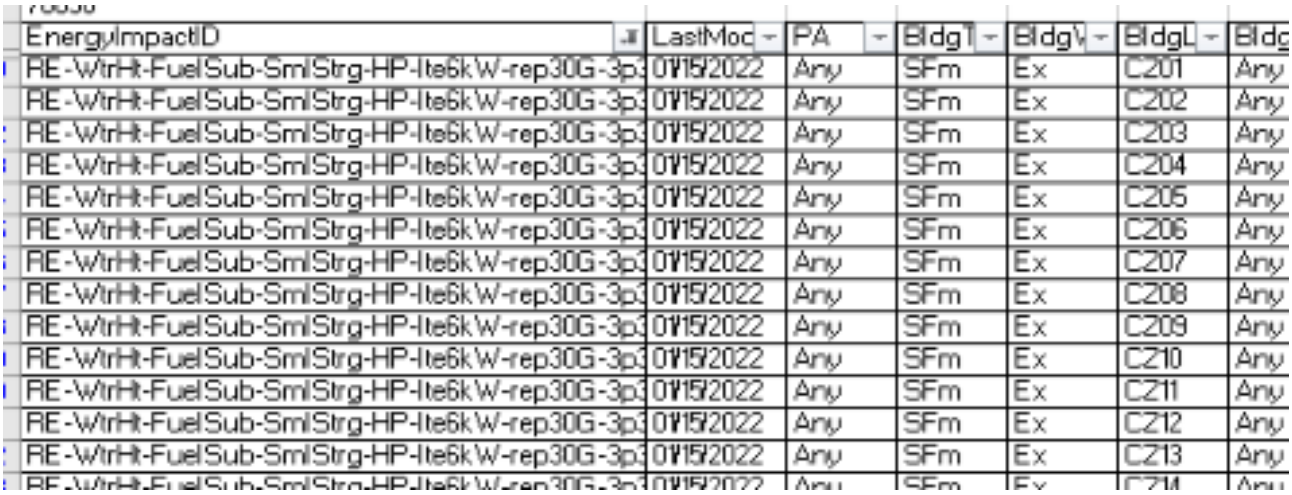
Table 2 - Measure Offering Descriptions

Measure Offering Description	Code/Standard TechID (Base Case)	Measure TechID (Measure Case)
Heat pump water heater, > 55 to ≤ 75 gal, UEF = 3.30 replacing storage natural gas water heater, 40 gal, UEF = 0.64	Stor_UEF-Gas-040gal-HI-0.64UEF	Stor_UEF-ElecHP-065gal-3.30UEF
Heat pump water heater, > 55 to ≤ 75 gal, UEF = 3.50 replacing storage natural gas water heater, 40 gal, UEF = 0.64	Stor_UEF-Gas-040gal-HI-0.64UEF	Stor_UEF-ElecHP-065gal-3.50UEF
Heat pump water heater, > 55 to ≤ 75 gal, UEF = 3.75 replacing storage natural gas water heater, 40 gal, UEF = 0.64	Stor_UEF-Gas-040gal-HI-0.64UEF	Stor_UEF-ElecHP-065gal-3.75UEF
Heat pump water heater, > 55 to ≤ 75 gal, UEF = 3.30 replacing storage natural gas water heater, 50 gal, UEF = 0.63	Stor_UEF-Gas-050gal-HI-0.63UEF	Stor_UEF-ElecHP-065gal-3.30UEF
Heat pump water heater, > 55 to ≤ 75 gal, UEF = 3.50 replacing storage natural gas water heater, 50 gal, UEF = 0.63	Stor_UEF-Gas-050gal-HI-0.63UEF	Stor_UEF-ElecHP-065gal-3.50UEF
Heat pump water heater, > 55 to ≤ 75 gal, UEF = 3.75 replacing storage natural gas water heater, 50 gal, UEF = 0.63	Stor_UEF-Gas-050gal-HI-0.63UEF	Stor_UEF-ElecHP-065gal-3.75UEF
Heat pump water heater, >75 gal, UEF = 3.30 replacing storage natural gas water heater, 50 gal, UEF = 0.63	Stor_UEF-Gas-050gal-HI-0.63UEF	Stor_UEF-ElecHP-080gal-3.30UEF
Heat pump water heater, >75 gal, UEF = 3.50 replacing storage natural gas water heater, 50 gal, UEF = 0.63	Stor_UEF-Gas-050gal-HI-0.63UEF	Stor_UEF-ElecHP-080gal-3.50UEF
Heat pump water heater, >75 gal, UEF = 3.75 replacing storage natural gas water heater, 50 gal, UEF = 0.63	Stor_UEF-Gas-050gal-HI-0.63UEF	Stor_UEF-ElecHP-080gal-3.75UEF

Heat pump water heater, >75 gal, UEF = 3.30 replacing storage natural gas water heater, 60 gal, UEF = 0.61	Stor_UEF-Gas-055gal-HI-0.61UEF	Stor_UEF-ElecHP-080gal-3.30UEF
Heat pump water heater, >75 gal, UEF = 3.50 replacing storage natural gas water heater, 60 gal, UEF = 0.61	Stor_UEF-Gas-055gal-HI-0.61UEF	Stor_UEF-ElecHP-080gal-3.50UEF
Heat pump water heater, >75 gal, UEF = 3.75 replacing storage natural gas water heater, 60 gal, UEF = 0.61	Stor_UEF-Gas-055gal-HI-0.61UEF	Stor_UEF-ElecHP-080gal-3.75UEF

The tool updates apply to residential building types only, with outputs provided in the DWHC as shown in Table 3 - DHWC outputs. Note, Table 3 only shows a sample of the DHWC outputs and does not reflect the actual savings for the anticipated measures.

Table 3 - DHWC outputs



EnergyImpactID	LastMod	PA	BldgT	BldgV	BldgL	Bldg
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ01	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ02	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ03	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ04	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ05	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ06	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ07	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ08	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ09	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ10	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ11	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ12	Any
RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-3p3	07/15/2022	Any	SFm	Ex	CZ13	Any

Results

Tool and Eligibility Updates

The updates to the DWHC result in savings values representative of replacing an existing gas water heater with a larger storage HPWH. Using these measure savings in a statewide measure package would enable incentives for these types of upsizing replacements. As shown in the survey results and example installation projects from the California Energy Smart Homes Program (CESHP), the practice of expanding heat pump water heater storage capacity is increasingly common in the market. Using the new updated tool, the following types of replacements would now be available for efficient heat pump water heaters:

- Replacing an existing 40 or 50-gallon natural gas water heater with a 65-gallon HPWH
- Replacing (2) existing 40 or 50-gallon natural gas water heater with (1) 80-gallon HPWH

Please refer to Appendix B for project details:

- Before-and-after equipment pictures
- AHRI certificate and specification sheets
- Invoice

Plumbing Contractor Survey

The project team conducted an electronic survey of plumbing contractors that are active in the TECH program, which incentivizes replacement of existing gas or electric resistance water heaters with HPWHs. The project team sent a survey link to contractors that had installed at least one HPWH through TECH, to ensure they could answer questions regarding HPWH tank sizing based on at least some experience. In total, 120 plumbing contractor targets received an email with an invitation to the survey and 16 contractors (or 13%) completed it. The project team provided a $100 incentive to increase the response rate.

Summary of Survey Results

Based on these survey responses[2], the project team makes the following observations:

1) Existing natural gas heater replacement with a new electric resistance heater rarely or never happens. Existing natural gas heater with new gas heater sometimes happens, and heat pump water heaters most often or always replace natural gas water heater (Figure 9 and Question 3)
2) Existing electric resistance heater replacement with a new natural gas heater never happens. New electric resistance heaters sometimes replace existing electric heaters, but heat pump

[2] Note that these results described here may not reflect Statewide trends, since the project team specifically targeted plumbing contractors with at least some experience installing HPWHs through the TECH program.

water heaters most often or always replace electric resistance water heaters (Figure 10 and Question 4Question 4).

3) A larger hot water tank is usually installed during a hot water heater retrofit (**Error! Reference source not found.** and Question 6)
4) Most often, using a different technology than the existing was the reason for upsizing the water tank. Only one contractor reported it was because customers wanted more hot water, and another because a financial incentive was available (**Error! Reference source not found.** and Question 8).
5) Most often, when an existing gas water heater was replaced with a HPWH, the replacement tank was slightly bigger than the existing tank (Figure 11 and Question 9).
6) Most often, when an existing electric water heater was replaced with a HPWH, the replacement tank was also slightly bigger than the existing tank (Figure 12 and Question 10).
7) When replacing a natural gas water heater with a heat pump water heater, the following steps in the retrofit are encountered (Question 11):
    a. Capping existing gas line (most of the time or always)
    b. Electric breaker upgrade (often but not always)
    c. Outlet upgrade (evenly split between never, sometimes, and 'often or always')
    d. Wiring and repatching (generally rare, but sometimes)
    e. Panel upgrade (rarely)

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Appendix A: Survey Results

'Firmographic' descriptors:

Question 1

What types of homes does your company serve? (N=16)

Response	Number	Percent
Single-family	7	44%
Low-rise multifamily	0	0%
Both	9	56%
Total	16	100%

Question 2

How many replacements of residential water heaters has your company done in the past year? (N=16)

Response	Number	Percent
1 to 10	5	31%
11 to 20	1	6%
More than 20	10	63%
Total	16	100%

Experience with HPWH Installations and Fuel Selection

Question 3

In the past year, how many natural gas water heaters has your company replaced with a heat pump water heater? (N=16)

Response	Number	Percent
None	0	0%
1 to 10	8	50%
11 to 20	1	6%
More than 20	7	44%
Total	16	100%

Question 4

In the past year, how many electric resistance water heaters has your company replaced with a heat pump water heater? (N=16)

Response	Number	Percent
None	8	50%
1 to 10	6	38%
11 to 20	1	6%
More than 20	1	6%
Total	16	100%

Question 5a

When a customer has an existing natural gas water heater, how frequently do you install each of the following types of retrofit? (N=16)

Retrofit	Never	Rarely	Sometimes	Most of the time	Always	Total
Natural gas	3 (19%)	3 (19%)	4 (25%)	5 (31%)	1 (6%)	16
Electric resistance	8 (50%	6 (38%	2 (13%)	0	0	16
Heat pump water heater	0	0	5 (31%)	7 (44%)	5 (25%)	16

Question 5b

(only asked if the answer to question 4 was zero)

When a customer has an existing electric water heater, how frequently do you install each of the following types of retrofit? (N=16)

Retrofit	Never	Rarely	Sometimes	Most of the time	Always	Total
Electric resistance	1 (13%)	1 (13%)	2 (25%)	2 (25%)	2 (25%)	8
Heat pump water heater	0	1 (13%)	1 (13%)	3 (38%)	3 (38%)	8

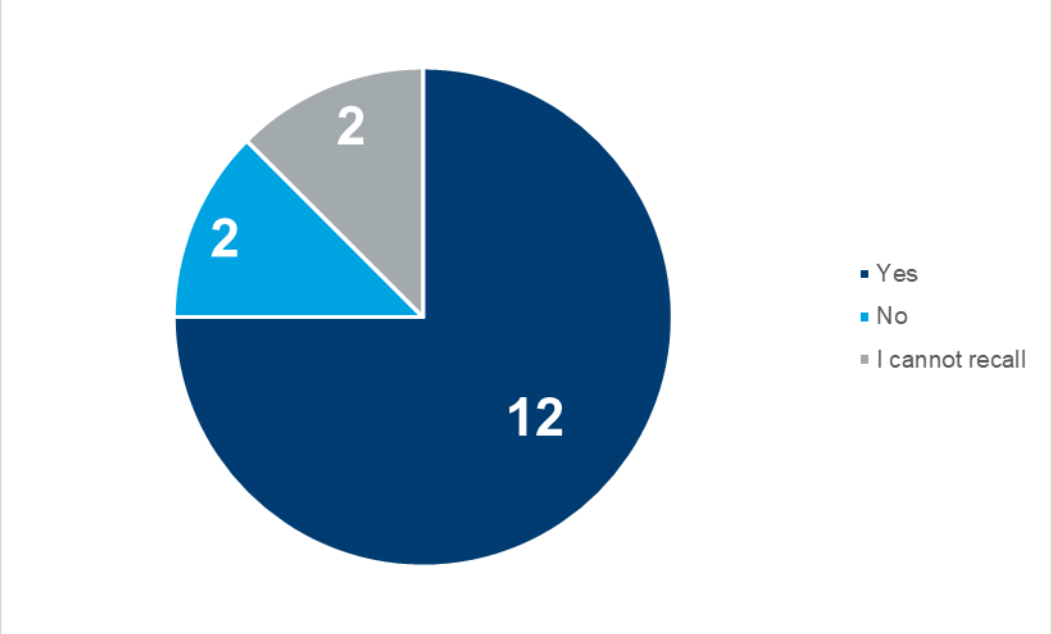
Tank sizing choices

Question 6

When replacing an existing water heater, have you installed a tank that is larger than the existing water heating tank in the last two years? (N=16)

Response	Number	Percent
Yes	12	75%
No	2	12.5%
I cannot recall	2	12.5%
Total	16	100%

Figure 7 - Fraction of Retrofits Upsizing the Water Tank (N=16)



Question 7

About how often did you install a tank that was the larger than the existing water heating tank? (N=12)

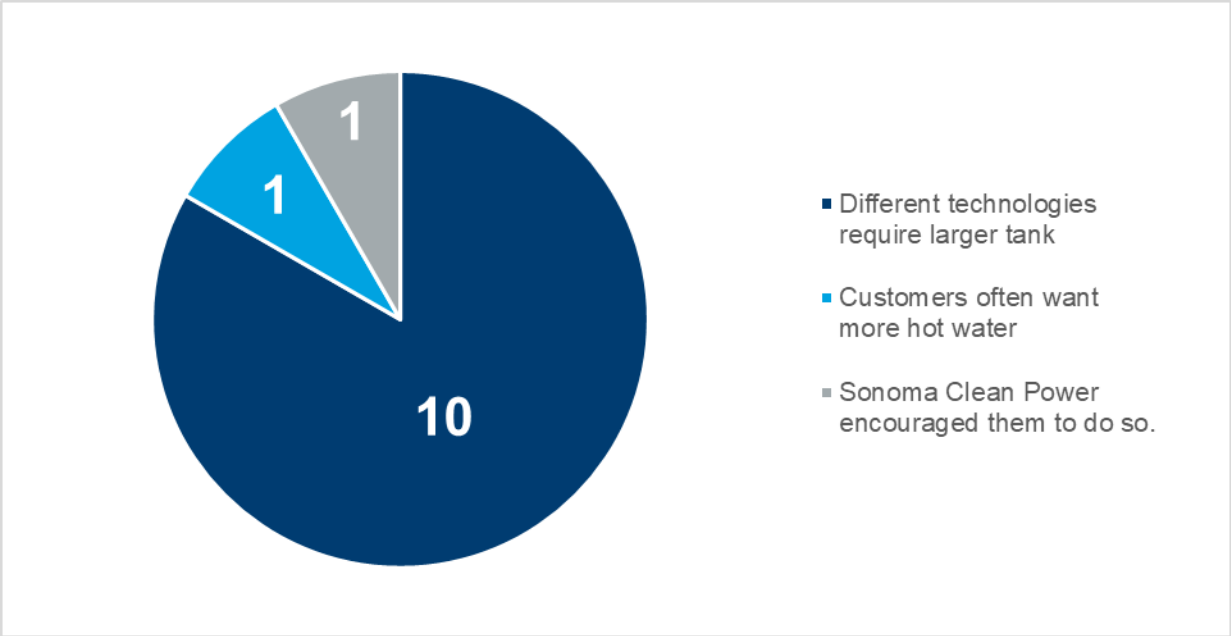
Response	Number	Percent
Rarely	1	8%
Sometimes	3	25%
Most of the time	5	42%
Always	3	25%
Total	12	100%

Question 8

What was the main reason that you installed a larger tank? (N=12)

Response	Number	Percent
Different technologies require larger tank	10	83.3%
Customers often want more hot water	1	8.3%
Sonoma Clean Power encouraged them to do so.	1	8.3%
Total	12	100%

Figure 8 - Reasons Given for Upsizing the Water Tank (N=12)



Question 9

If you replace a natural gas water heater with a newly installed heat pump water heater, how do you typically size the new tank? (N=16)

Response	Number	Percent
Much bigger tank for HPWH	4	25%
Slightly bigger tank for HPWH	8	50%
No difference	4	25%
Slightly smaller tank for HPWH	0	0%
Much smaller tank for HPWH	0	0%
Total	16	100%

Question 10

If you replace an electric resistance water heater with a newly installed heat pump water heater, how do you typically size the new tank? (N=8)

Response	Number	Percent
Much bigger tank for HPWH	2	25%
Slightly bigger tank for HPWH	4	50%
No difference	2	25%
Slightly smaller tank for HPWH	0	0%
Much smaller tank for HPWH	0	0%
Total	**8**	**100%**

Electrical upgrades

Question 11

How often are each of the following types of electrical upgrades needed when converting from a natural gas water heater to a heat pump water heater? (N=16)

Action	Never	Rarely	Sometimes	Most of the time	Always	Total
Cap existing gas lines	0	0	0	3 (19%)	13 (81%)	16
Breaker upgrade	0	2 (13%)	2 (13%)	5 (31%)	7 (44%)	16
Outlet upgrade	4 (25%)	1 (6%)	2 (13%)	5 (31%)	4 (25%)	16
Wiring and repatching	2 (13%)	7 (44%)	3 (19%)	2 (13%)	2 (13%)	16
Panel Upgrade	1 (6%)	6 (38%)	8 (50%)	0	1 (6%)	16

Open-ended question

Question 12

Is there anything else you'd like to tell us about heat pump water heating retrofits or tank sizing? (N=7)

Responder	Response
1	If not for Sonoma Clean Power's Grid Savvy program we'd size tanks to 50-65 gal. They also allow water heated to 135-140 degrees, so we ALWAYS install a mixing valve.
2	Air space is the biggest hurdle
3	Heat Pump water heaters have noise when in heat pump mode. We let our customers know of the additional noise of the unit.
4	In addition to significant tank size increases, we also install a thermostatic mixing valve with every project to allow for hotter tank temperatures in order to manage the slower recovery versus gas units.
5	Always install Thermostatic Mixing Valve w/ HPWH
6	The requirement now for a mixing valve to moderate temperature has in some instances allowed us to use the same size tank as the old one. However, it is on a case-by-case basis.
7	In the HVAC world, bigger heat pumps are not better. However, in the heat pump water heater world, the taller the tank the more efficient the system is, to a certain extent. Heat pump water heaters recover hot water much slower than gas, so a bigger tank is often needed to compensate. Space for small, medium, or larger heat pump water heaters is a very common constraint however.

Figure 9 – Natural Gas Water Heater Replacement Frequency (N=16)

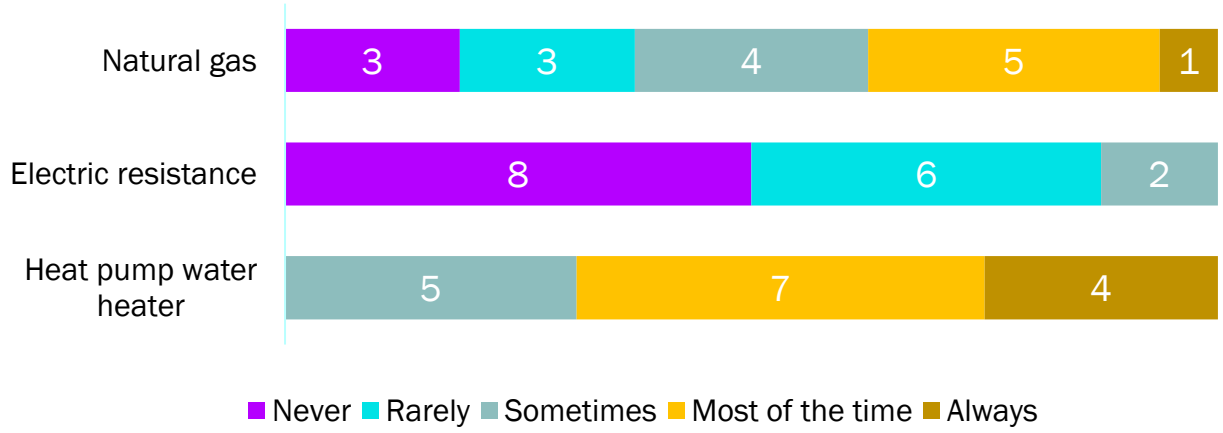


Figure 10 - Electric Resistance Heater Replacement Frequency (N=8)

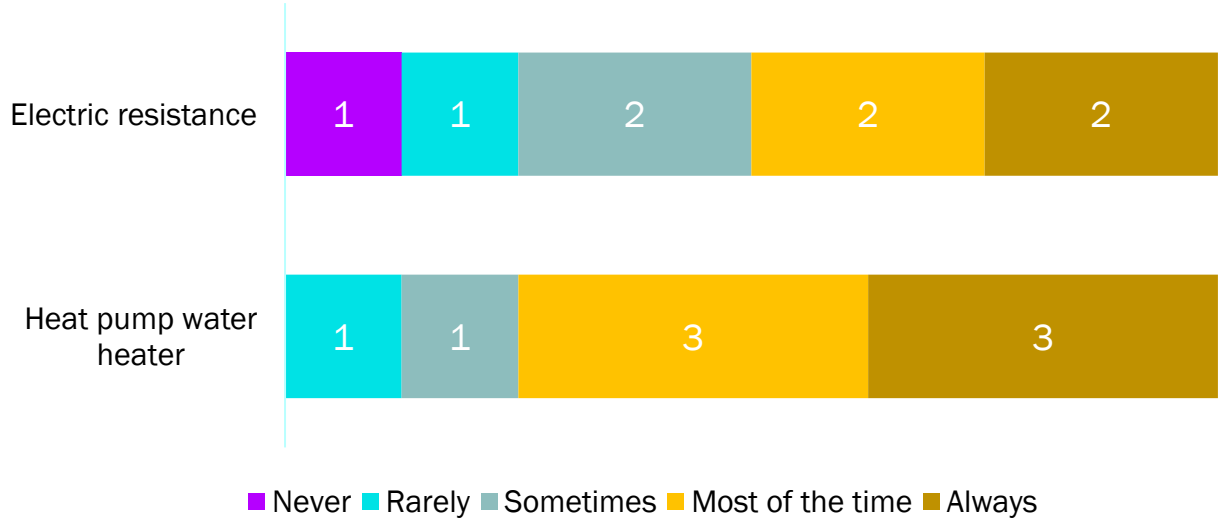
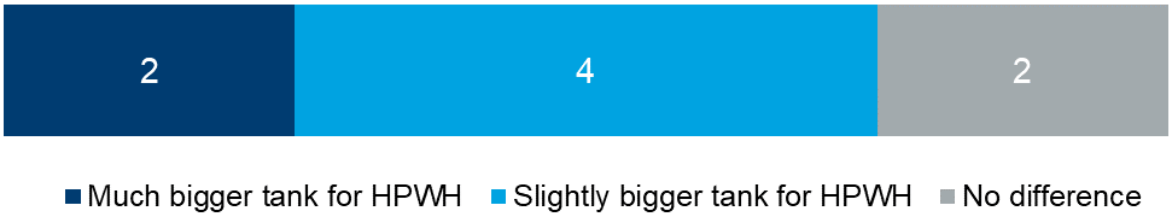
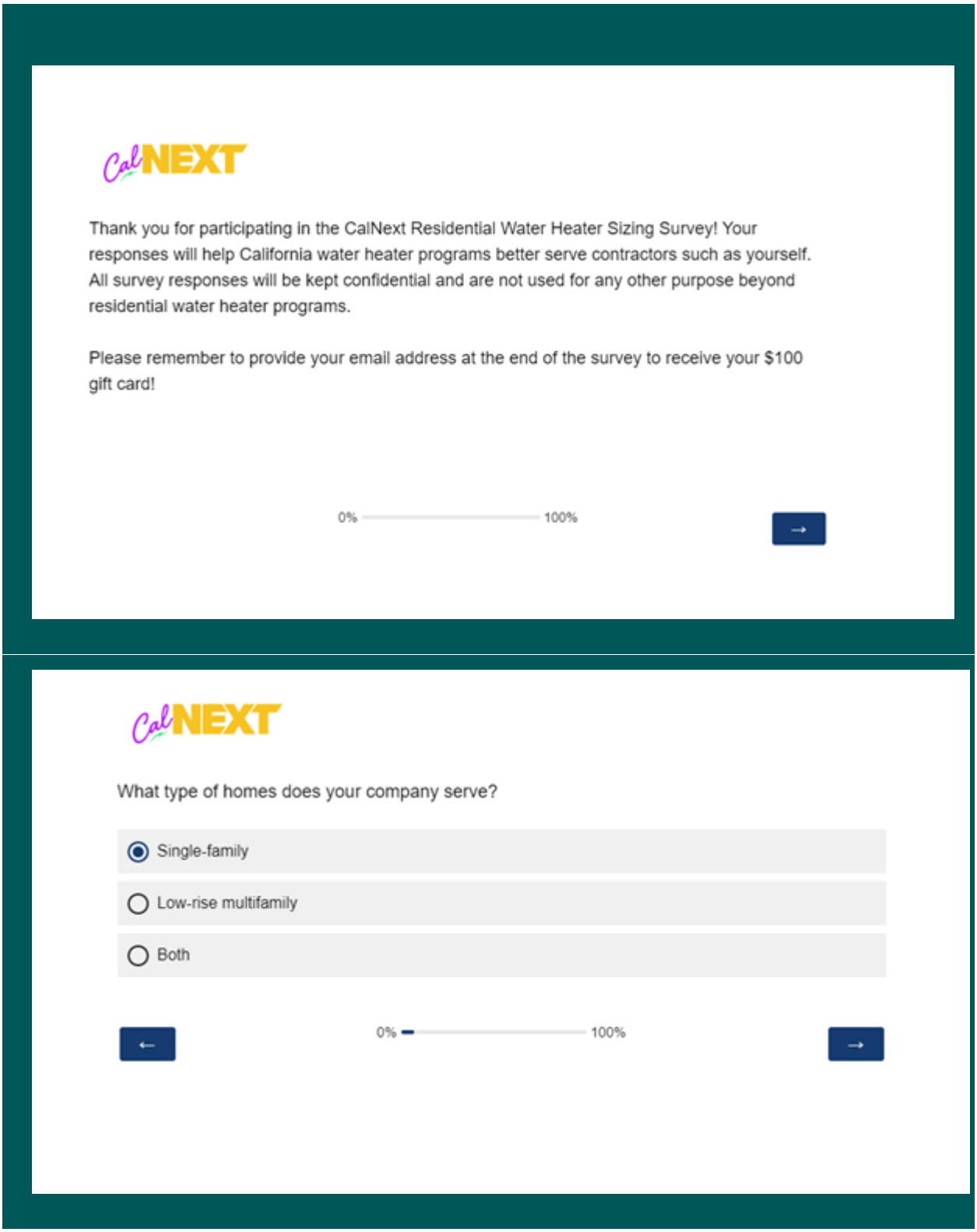


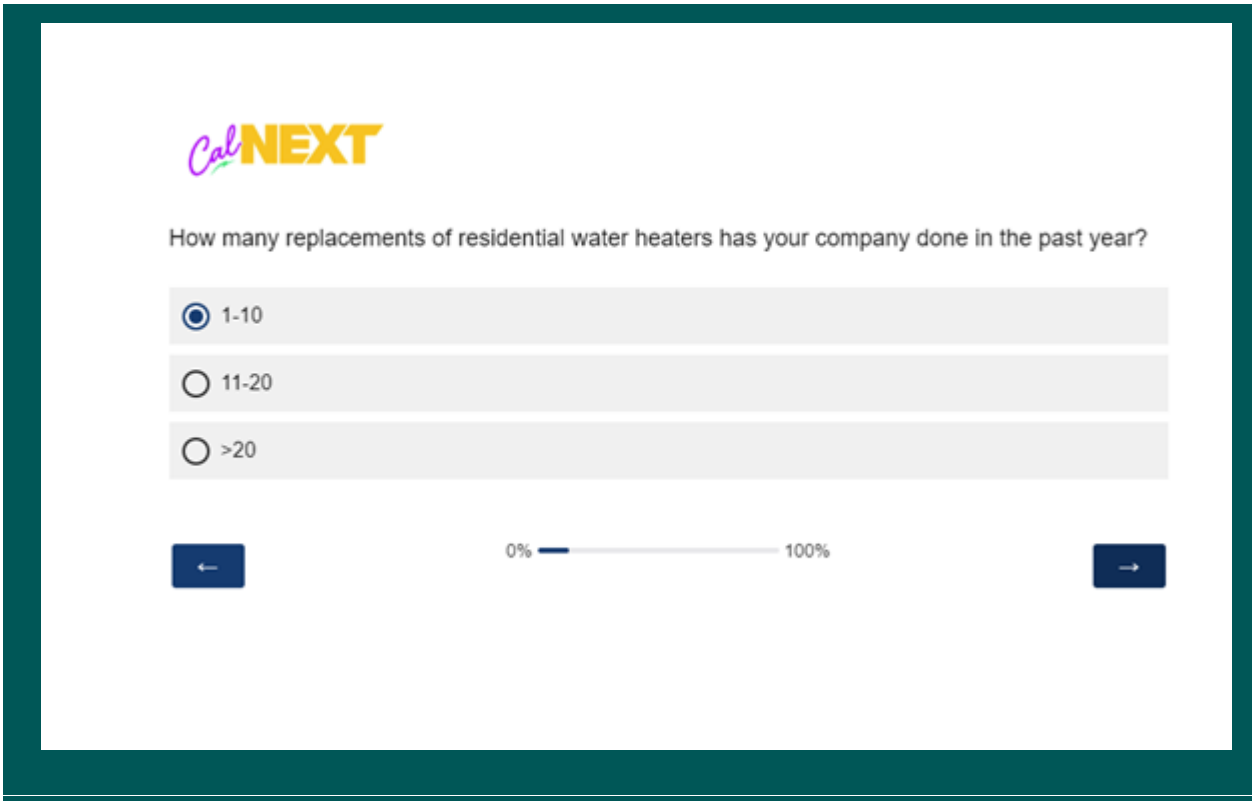
Figure 11 - Degree of Tank Sizing (natural gas base case) (N=16)

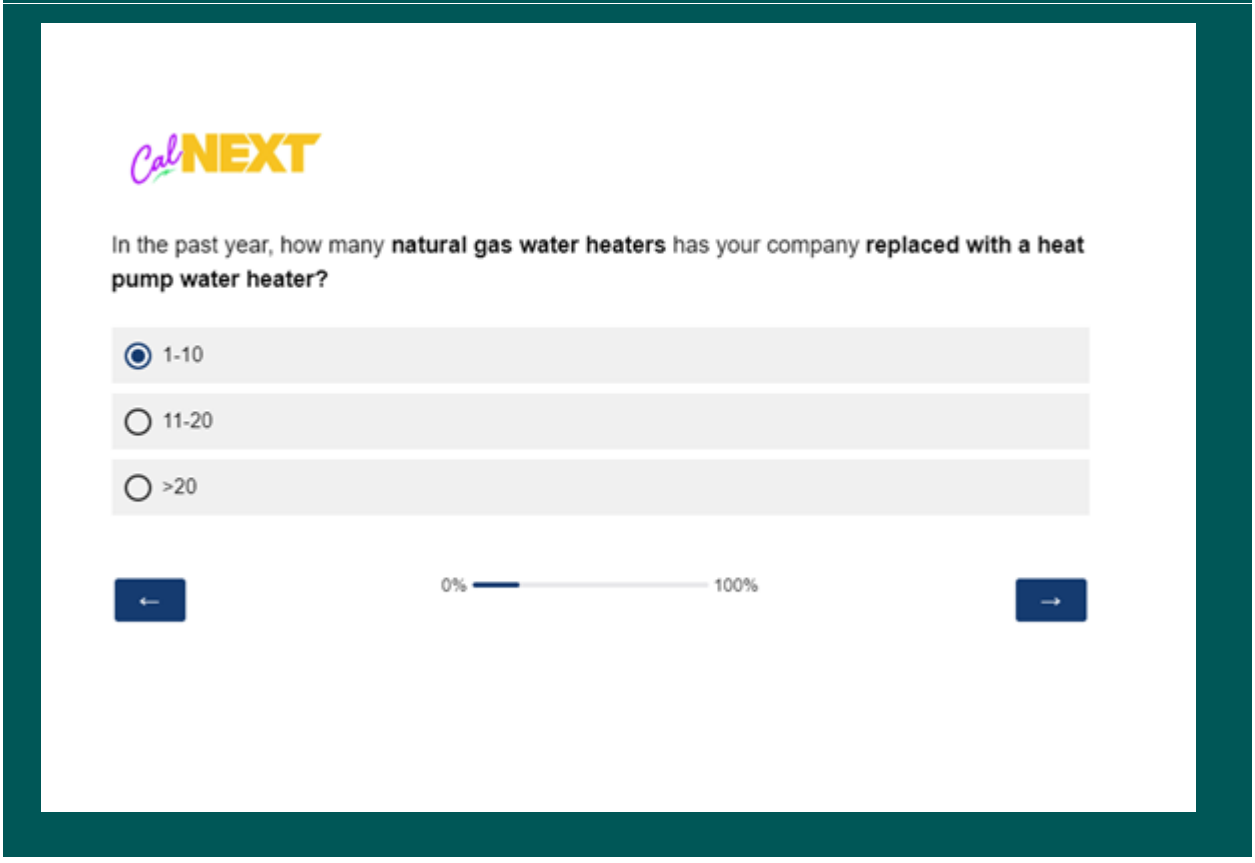
Figure 12 - Degree of Tank Sizing (electric resistance base case) (N=8)



Appendix B: Survey Instrument




How many replacements of residential water heaters has your company done in the past year?
1-10
11-20
>20
0%
100%


In the past year, how many natural gas water heaters has your company replaced with a heat pump water heater?
1-10
11-20
>20
0%
100%

When a customer has an **existing natural gas water heater**, how frequently do you install each of the following types of retrofit?

	Never	Rarely	Sometimes	Most of the time	Always
Natural Gas (existing)	○	○	○	○	○
Electric resistance	○	○	○	○	○
Heat pump water heater	○	○	○	○	○

When a customer has an **existing electric resistance water heater**, how frequently do you install each of the following types of retrofit?

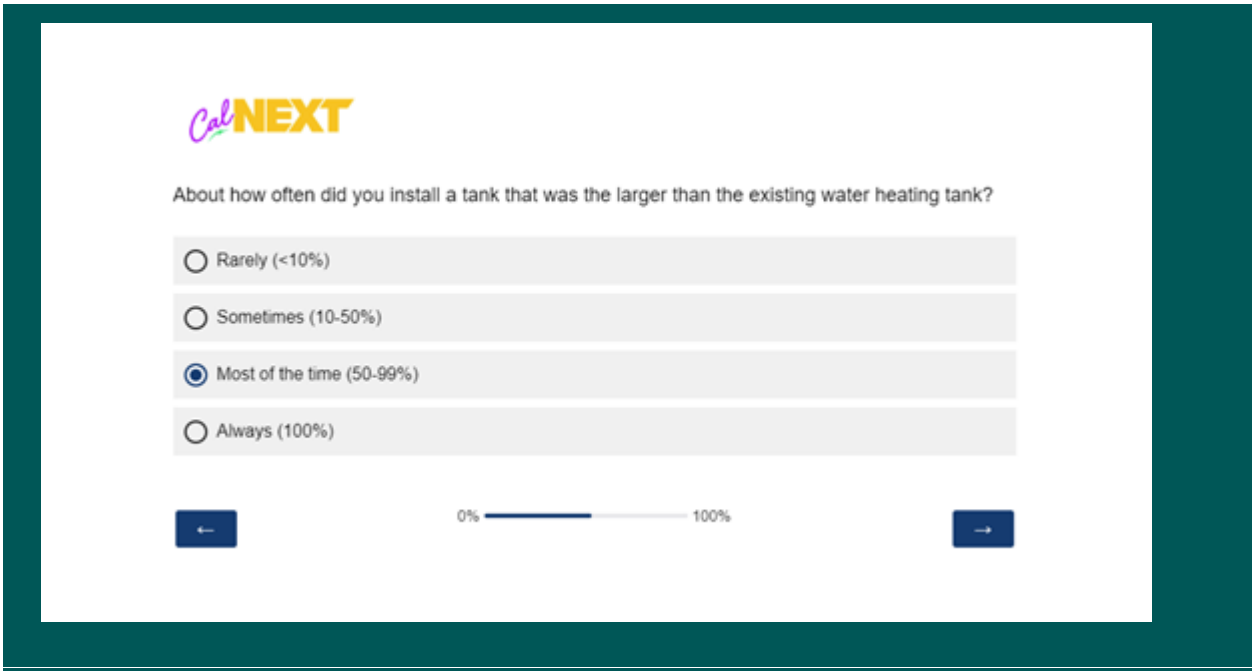
	Never	Rarely	Sometimes	Most of the time	Always
Electric resistance (existing)	○	○	○	○	○
Heat pump water heater	○	○	○	○	○

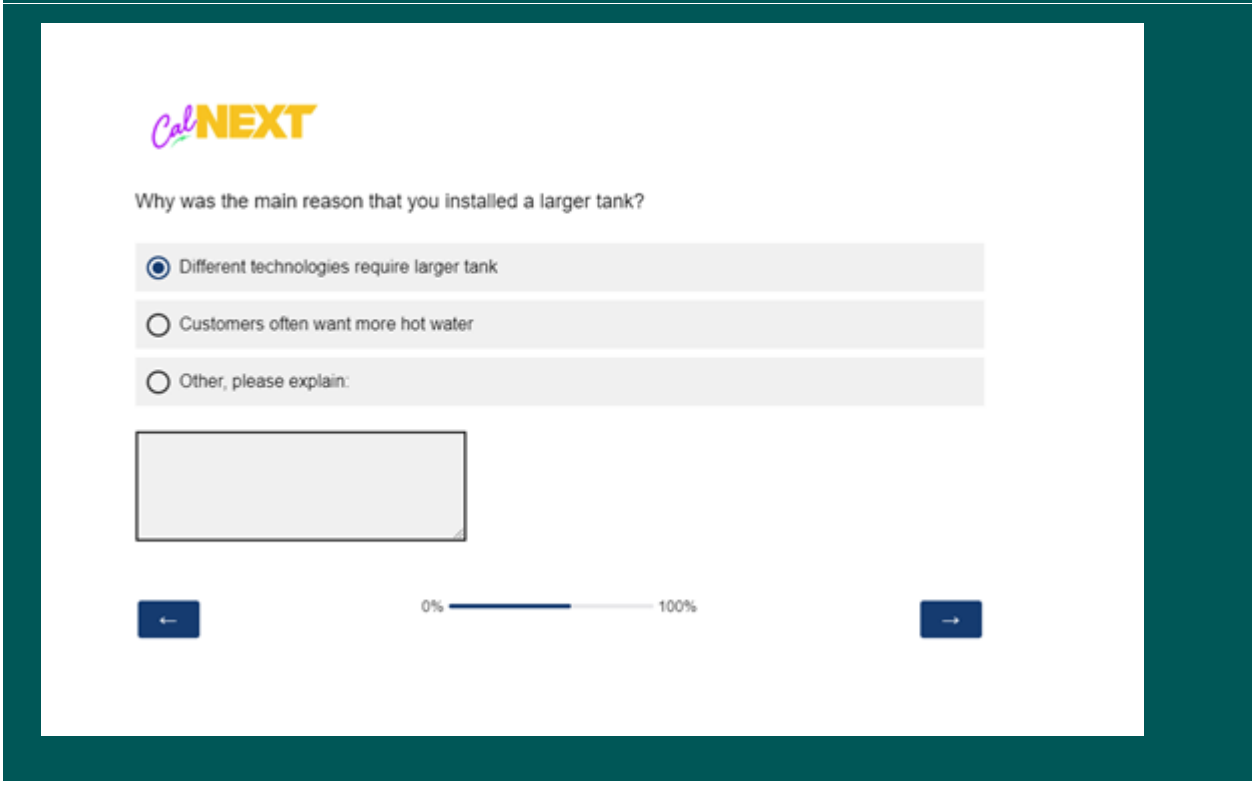
← 0% 100% →

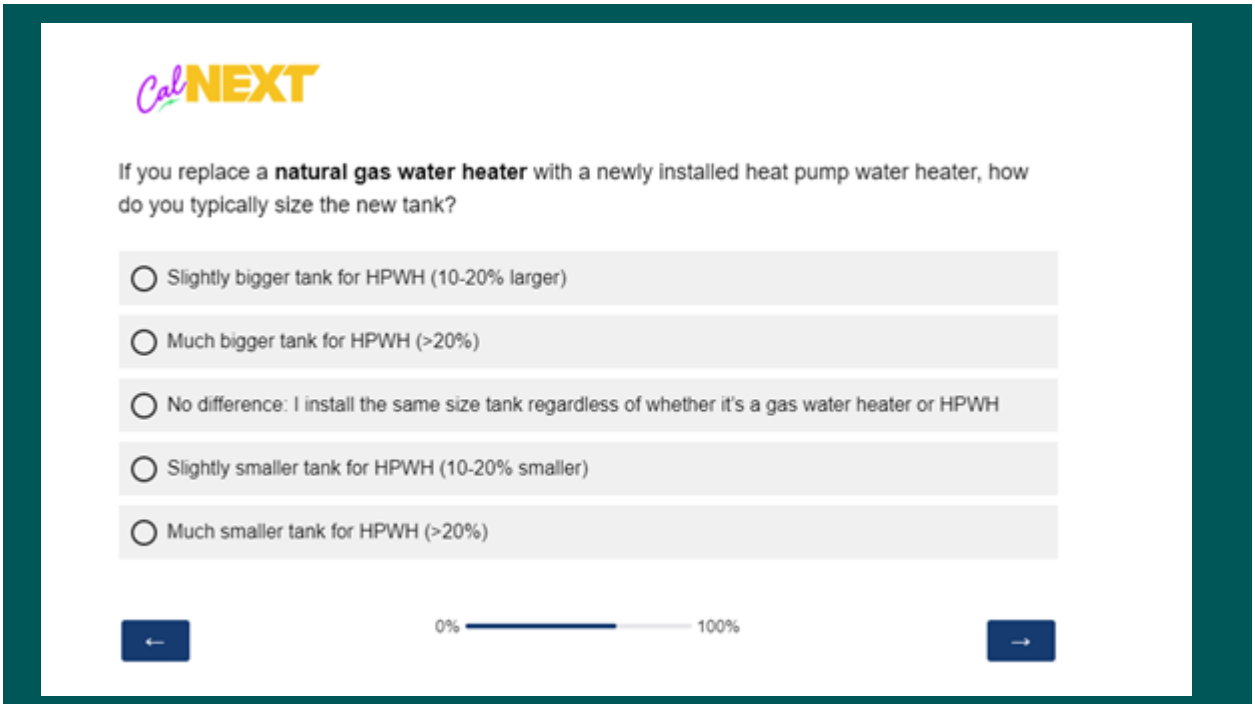
When replacing an existing water heater, have you installed a tank that is larger than the existing water heating tank in the last two years?

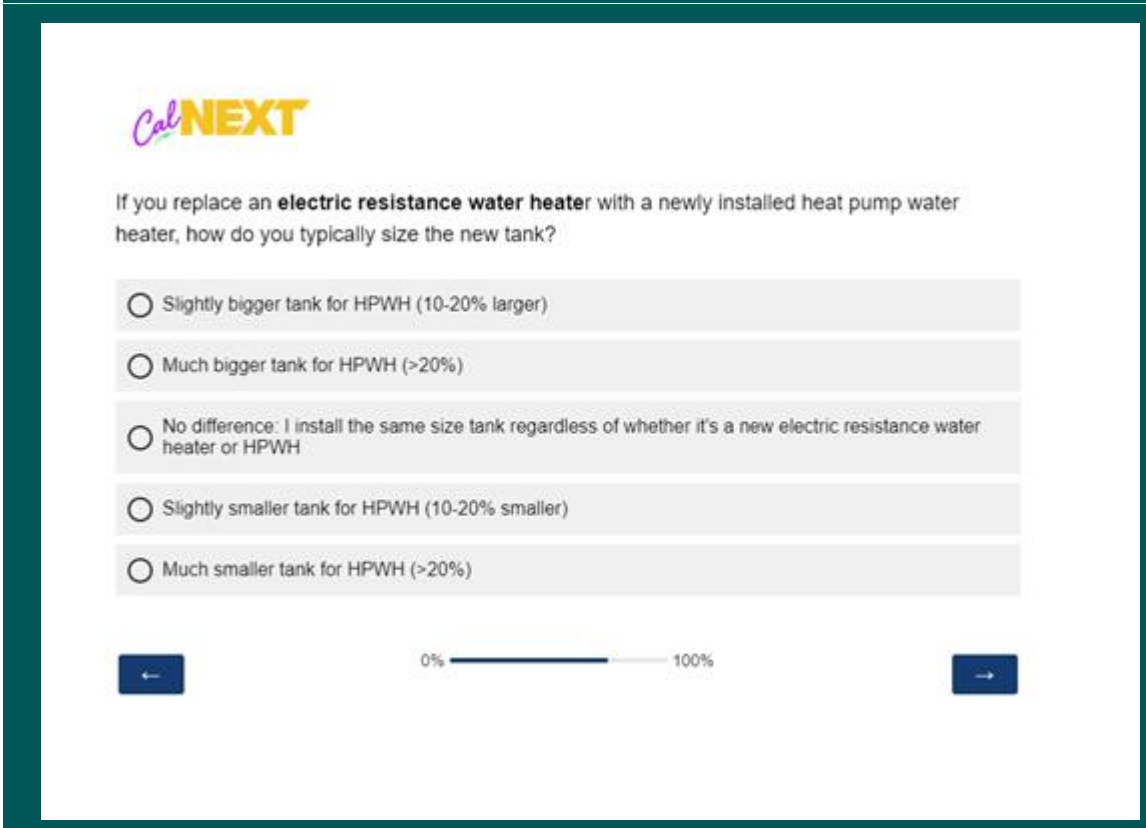
- ◉ Yes
- ○ No
- ○ I cannot recall

← 0% 100% →


About how often did you install a tank that was the larger than the existing water heating tank?
Rarely (<10%)
Sometimes (10-50%)
Most of the time (50-99%)
Always (100%)
0%
100%


Why was the main reason that you installed a larger tank?
Different technologies require larger tank
Customers often want more hot water
Other, please explain:
0%
100%


If you replace a **natural gas water heater** with a newly installed heat pump water heater, how do you typically size the new tank?
Slightly bigger tank for HPWH (10-20% larger)
Much bigger tank for HPWH (>20%)
No difference: I install the same size tank regardless of whether it's a gas water heater or HPWH
Slightly smaller tank for HPWH (10-20% smaller)
Much smaller tank for HPWH (>20%)
0%
100%


If you replace an **electric resistance water heate**r with a newly installed heat pump water heater, how do you typically size the new tank?
Slightly bigger tank for HPWH (10-20% larger)
Much bigger tank for HPWH (>20%)
No difference: I install the same size tank regardless of whether it's a new electric resistance water heater or HPWH
Slightly smaller tank for HPWH (10-20% smaller)
Much smaller tank for HPWH (>20%)
0%
100%

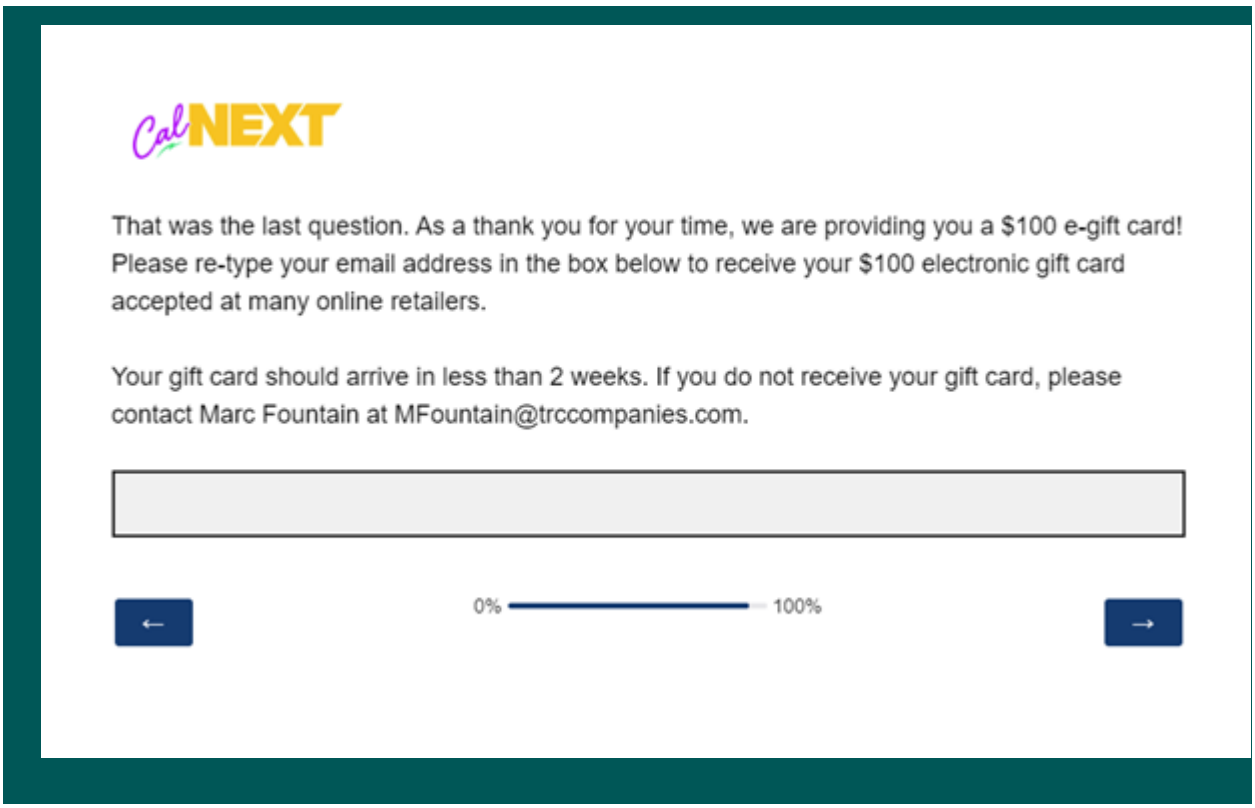
How often are each of the following types of electrical upgrades needed when converting from a natural gas water heater to a heat pump water heater?

	Never	Rarely	Sometimes	Most of the time	Always
Outlet upgrade	○	○	○	○	○
Breaker upgrade	○	○	○	○	○
Panel upgrade	○	○	○	○	○
Writing and repatching	○	○	○	○	○
Cap existing gas liners	○	○	○	○	○
Other, please specify: Something	◉	○	○	○	○

0% 100%

Is there anything else you'd like to tell us about heat pump water heating retrofits or tank sizing?

0% 100%

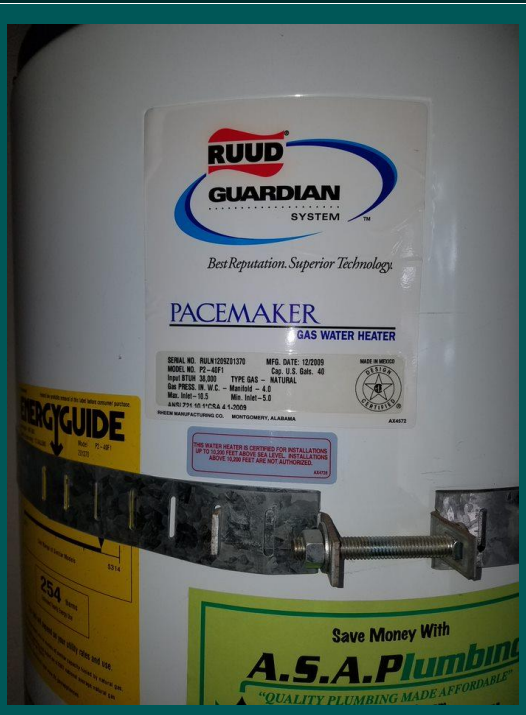

That was the last question. As a thank you for your time, we are providing you a $100 e-gift card! Please re-type your email address in the box below to receive your $100 electronic gift card accepted at many online retailers.
Your gift card should arrive in less than 2 weeks. If you do not receive your gift card, please contact Marc Fountain at MFountain@trccompanies.com.
0%
100%

Appendix C: Documented CESH Water Heater Retrofits

The two examples shown in this section are from the California Energy Smart Homes Programs and would qualify for an incentive using the updated tool.

Case 1: 65 Gallon HPWH Replacing 40 Gallon Gas Water Heater

Existing 40 Gallon Natural Gas Water Heater



Proposed 65 Gallon Replacement Heat Pump Water Heater

80 Gallon Heat Pump Water Heater Specification Sheet and ARI Certificate

PERFORMANCE **PLATINUM**™

Rheem

The new degree of comfort.®

PERFORMANCE **PLATINUM**™ **Hybrid Electric is the most efficient water heater available**

Efficiency
- High 3.75 - 4.0 UEF reduces operating cost
- ENERGY STAR® rated

Performance
- Delivers hot water faster than most standard electric water heaters – 60-87 gallons first-hour delivery, depending on model
- Ambient operating range: 37-145° F is widest in class, offering more days of HP operation annually; designed to meet Northern Climate Spec (Tier 4)

Easy Installation
- Easy access side connections
- Quick access to electrical junction box
- Easily replaces a standard electric water heater

Integration
- Electronic control for easy temperature adjustment and mode management
- Audible alarm for service alerts

EcoNet®

- Integrated EcoNet® WiFi-connected* technology (2.4 GHz only) and free mobile app gives users control over water systems, allowing for customizable temperature, vacation settings, energy savings and system monitoring at home or away. Visit Rheem.com/EcoNetConnect

Operation Modes
- Energy Saver
- Heat Pump
- High Demand
- Electric
- Vacation/Away: 2-28 days (or placed on hold indefinitely)

Plus...
- Premium grade anode rod with resistor extends the life of the tank
- 3/4" NPT water inlet and outlet; 3/4" condensate drain connections
- Incoloy stainless steel resistor elements
- Dry-fire protection
- Easy access, top mounted washable air filter
- 2" Non-CFC foam insulation
- Enhanced flow brass drain valve
- Temperature and pressure relief valve installed
- Low lead compliant

Warranty
- 10-Year limited warranty for tank and parts, 1-year full in-home labor warranty
  See Residential Warranty Certificate for complete information

Units meet or exceed ANSI requirements and have been tested according to D.O.E. procedures. Units meet or exceed the energy efficiency requirements of NAECA, ASHRAE standard 90, ICC Code and all state energy efficiency performance criteria.

* WiFi broadband internet connection required

PERFORMANCE **PLATINUM**
Hybrid
40, 50, 65 and 80-Gallon Capacities
208-240 Volt / 1 PH
Electric

LEED Points = 3

See specifications chart on back.

AHRI CERTIFIED®
www.ahridirectory.org

Certificate of Product Ratings

AHRI Certified Reference Number : 205574642 Date : 06-02-2022 Model Status : Active

Brand Name : RHEEM

Model Number : XE65T10H45U0

Rated as follows in accordance with Department of Energy (DOE) Water Heater test procedures as published in the latest edition of the Code of Federal Regulations, 10 CFR Part 430 Subpart B Appendix E and subject to verification of rating accuracy by AHRI-sponsored, independent, third party testing:

First Hour Rating (GPH) : 75

Uniform Energy Factor : 3.85

The following data is for reference only and is not certified by AHRI

Energy Source : Heat Pump with Tank

Heater Type : Storage

Usage Bin : High Usage

Nominal Capacity (gal) : 65

DOE Rated Storage Volume (gal) : 59

Input (kW) : 4.5

Recovery Efficiency, (%) : 467

Heat Traps : No

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†"Active" Model Status are those that an AHRI Certification Program Participant is currently producing AND selling or offering for sale; OR new models that are being marketed but are not yet being produced."Production Stopped" Model Status are those that an AHRI Certification Program Participant is no longer producing BUT is still selling or offering for sale.
Ratings that are downgraded by WAS indicate an involuntary re-rate. The new published rating is shown along with the previous (i.e. WAS) rating.

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AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE
we make life better™

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CERTIFICATE NO.: 13296685921360428†

65 Gallon HPWH Labor and Materials Cost

[redacted] Plumbing Company

INVOICE	#1105
SERVICE DATE	Apr 26, 2022
INVOICE DATE	Jun 15, 2022
DUE	upon receipt
AMOUNT DUE	$0.00

[redacted]

CONTACT US

[redacted]

[redacted]

Service completed by: [redacted]

INVOICE

Services	qty	unit price	amount
Water Heater - Heat Pump Water Heater Conversion	1.0	$3,100.00	$3,100.00

Includes the installation of one customer provided electric heat pump water heater (Rheem model XE65T10H45UO serial number [redacted]) with new brass ball valves, copper piping, brackets and required straps, expansion tank, flex connectors, seismic straps, drip pan, and condensate discharge piping per code. Cost not to exceed $3100 (current incentive for installation reimbursement from TECH Clean CA) unless tank is being relocated or additional home modifications are required. Installation qualifies for TECH Clean CA installation reimbursement, for which Pure Plumbing Company is an approved contractor to process the incentive reimbursement, contingent upon fund availability from TECH Clean CA. Installation costs are paid by the homeowner to Pure Plumbing Company and submitted for reimbursement from TECH Clean CA for the homeowner. 1 year parts and labor warranty is provided from [redacted] Plumbing Company in addition to the manufacturers warranty.

Total **$3,100.00**

Payment History

Apr 26 Tue 6:36pm Check $3,100.00

Material Cost - Propo....pdf

Gmail - We received your order!

Rheem Performance Platinum 65 Gal. 10-Year Hybrid High Efficiency Smart Tank Electric Water Heater — $2,163.00 — 1.00 — $2,163.00

Store SKU # 1005205475

Internet # [redacted]

Est Arrival: **Apr. 25**

Basic (Porch or Driveway)

To your doorstep or driveway (somewhere dry). No appointment needed; you will get a call the day before and don't need to be present for delivery.

Check Order Status

Orders may be canceled up to 45 minutes after purchase from your Home Depot MyAccount.

See cancelation rules and details.

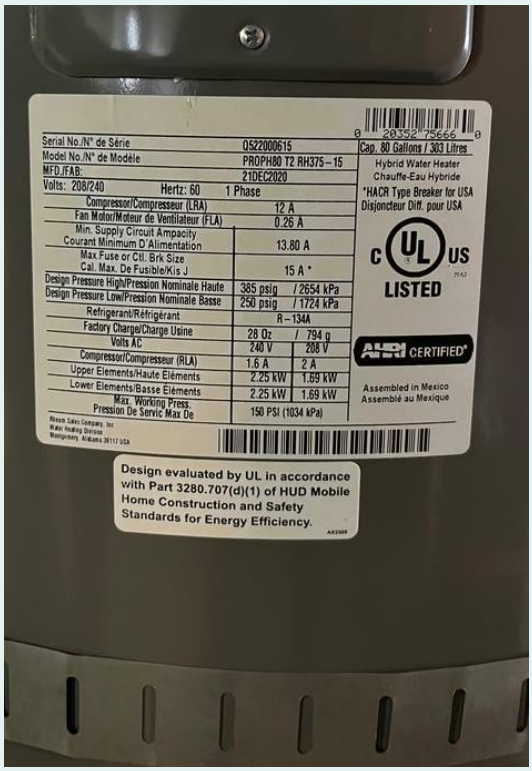
Subtotal	$2,163.00
Shipping	$75.00
Sales Tax	$173.45
Order Total	$2,411.45

Paid with Credit Card ending in [redacted]

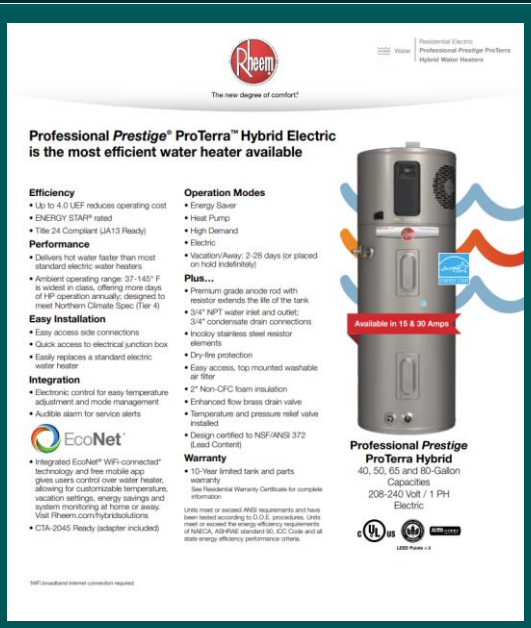
Case 2: 80 Gallon HPWH Replacing 2 (40 Gallon) Gas Water Heaters

Existing 40 Gallon Water Heaters

Proposed 80 Gallon Replacement Heat Pump Water Heater



80 Gallon Heat Pump Water Heater Specification Sheet and ARI Certificate



Rheem

The new degree of comfort™

Residential Electric
Professional Prestige ProTerra
Hybrid Water Heaters

Professional *Prestige*® ProTerra™ Hybrid Electric is the most efficient water heater available

Efficiency
- Up to 4.0 UEF reduces operating cost
- ENERGY STAR® rated
- Title 24 Compliant (JA13 Ready)

Performance
- Delivers hot water faster than most standard electric water heaters
- Ambient operating range: 37-145° F is widest in class, offering more days of HP operation annually; designed to meet Northern Climate Spec (Tier 4)

Easy Installation
- Easy access side connections
- Quick access to electrical junction box
- Easily replaces a standard electric water heater

Integration
- Electronic control for easy temperature adjustment and mode management
- Audible alarm for service alerts

EcoNet

- Integrated EcoNet® WiFi-connected* technology and free mobile app gives users control over water heater, allowing for customizable temperature, vacation settings, energy savings and system monitoring at home or away. Visit Rheem.com/hybridsolutions
- CTA-2045 Ready (adapter included)

*WiFi broadband internet connection required

Operation Modes
- Energy Saver
- Heat Pump
- High Demand
- Electric
- Vacation/Away: 2-28 days (or placed on hold indefinitely)

Plus...
- Premium grade anode rod with resistor extends the life of the tank
- 3/4" NPT water inlet and outlet; 3/4" condensate drain connections
- Incoloy stainless steel resistor elements
- Dry-fire protection
- Easy access, top mounted washable air filter
- 2" Non-CFC foam insulation
- Enhanced flow brass drain valve
- Temperature and pressure relief valve installed
- Design certified to NSF/ANSI 372 (Lead Content)

Warranty
- 10-Year limited tank and parts warranty

See Residential Warranty Certificate for complete information

Units meet or exceed ANSI requirements and have been tested according to D.O.E. procedures. Units meet or exceed the energy efficiency requirements of NAECA, ASHRAE standard 90, ICC Code and all state energy efficiency performance criteria.

Available in 15 & 30 Amps

Professional *Prestige*
ProTerra Hybrid
40, 50, 65 and 80-Gallon Capacities
208-240 Volt / 1 PH
Electric

LEED Points +3

AHRI CERTIFIED®
www.ahridirectory.org

Certificate of Product Ratings

AHRI Certified Reference Number : 205666400 Date : 04-06-2022 Model Status : Active

Brand Name : RHEEM

Model Number : PROPH80 T2 RHDT5-15

Rated as follows in accordance with Department of Energy (DOE) Water Heater test procedures as published in the latest edition of the Code of Federal Regulations, 10 CFR Part 430 Subpart B Appendix E and subject to verification of rating accuracy by AHRI-sponsored, independent, third party testing:

First Hour Rating (GPH) : 67

Uniform Energy Factor : 3.70

The following data is for reference only and is not certified by AHRI

Energy Source : Heat Pump with Tank

Heater Type : Storage

Usage Bin : Medium Usage

Nominal Capacity (gal) : 80

DOE Rated Storage Volume (gal) : 72

Input (kW) : 2.3

Recovery Efficiency (%) : 445

Heat Traps : No

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Ratings that are accompanied by WAS indicate an involuntary re-rate. The new published rating is shown along with the previous (i.e. WAS) rating.

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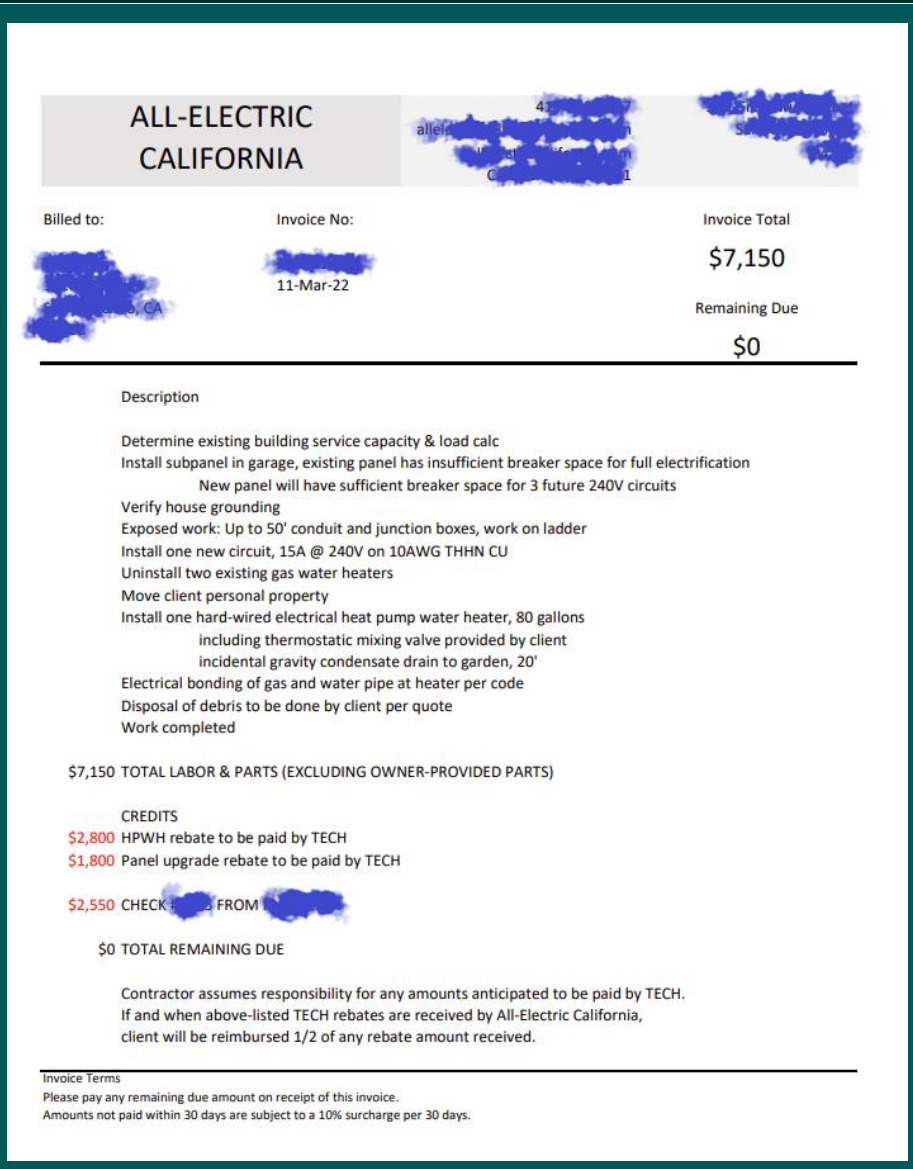
CERTIFICATE NO.: 13293746955506236

80 Gallon HPWH Labor and Materials Cost



ALL-ELECTRIC CALIFORNIA

[redacted]

Billed to: [redacted]

Invoice No: [redacted]
11-Mar-22

Invoice Total
$7,150

Remaining Due
$0

Description

Determine existing building service capacity & load calc
Install subpanel in garage, existing panel has insufficient breaker space for full electrification
New panel will have sufficient breaker space for 3 future 240V circuits
Verify house grounding
Exposed work: Up to 50' conduit and junction boxes, work on ladder
Install one new circuit, 15A @ 240V on 10AWG THHN CU
Uninstall two existing gas water heaters
Move client personal property
Install one hard-wired electrical heat pump water heater, 80 gallons
including thermostatic mixing valve provided by client
incidental gravity condensate drain to garden, 20'
Electrical bonding of gas and water pipe at heater per code
Disposal of debris to be done by client per quote
Work completed

$7,150 TOTAL LABOR & PARTS (EXCLUDING OWNER-PROVIDED PARTS)

CREDITS
$2,800 HPWH rebate to be paid by TECH
$1,800 Panel upgrade rebate to be paid by TECH

$2,550 CHECK [redacted] FROM [redacted]

$0 TOTAL REMAINING DUE

Contractor assumes responsibility for any amounts anticipated to be paid by TECH.
If and when above-listed TECH rebates are received by All-Electric California,
client will be reimbursed 1/2 of any rebate amount received.

Invoice Terms
Please pay any remaining due amount on receipt of this invoice.
Amounts not paid within 30 days are subject to a 10% surcharge per 30 days.