

**eTRM**  
*best in class*

**APPLIANCE**  
**SWWH025-03 RESIDENTIAL HEAT PUMP  
WATER HEATER-FUEL SUBSTITUTION**

**CONTENTS**

Measure Name ..... 2  
Statewide Measure ID..... 2  
Effective Date..... 2  
Technology Summary ..... 2  
Measure Case Description ..... 4  
Base Case Description..... 5  
Code Requirements ..... 6  
Normalizing Unit..... 9  
Program Requirements..... 9  
Program Exclusions..... 12  
Data Collection Requirements ..... 12  
Use Category..... 13  
Electric Savings (kWh)..... 13  
peak electric Demand Reduction (kW) ..... 14  
Gas Savings (therms)..... 14  
Life Cycle..... 14  
Base Case Material Cost (\$/unit) ..... 15  
Measure Case Material Cost (\$/unit)..... 16  
Base Case Labor Cost (\$/unit) ..... 17  
Measure Case Labor Cost (\$/unit) ..... 17  
Net-to-Gross (NTG) ..... 17  
Gross Savings Installation Adjustment (GSIA) ..... 18  
DEER Differences Analysis..... 18  
Revision History ..... 20

**MEASURE NAME**

Residential Heat Pump Water Heater - Fuel Substitution

**STATEWIDE MEASURE ID**

SWWH025-03

**EFFECTIVE DATE**

January 18, 2021

**TECHNOLOGY SUMMARY**

Domestic water heaters are pressure vessels that transfer heat to water. The heater may heat the domestic water using a heat exchanger that works like an instantaneous water heater, with a separate tank for storage of hot water or may have an integral tank and heat exchanger. Heat pump water heaters use a direct expansion (DX) heat pump to transfer heat to the water. The heat pump condenser coils are located inside the insulated water storage tank where the flow of hot refrigerant is used to heat the water. In many heat pump water heaters, referred to as hybrid heat pump water heaters, supplemental electric resistance heating elements exist to meet heating requirements when the heat pump system cannot meet them alone. Cold water enters the base of the tank and is heated by condenser coils. The hot water then rises and continues to be heated by the condenser coils until the heated water is drawn for consumption at the top of the tank. Heat pump water heaters achieve higher efficiency compared to electric-resistance or natural gas water heaters and are typically equipped with supplemental electric-resistance elements for periods of high demand.

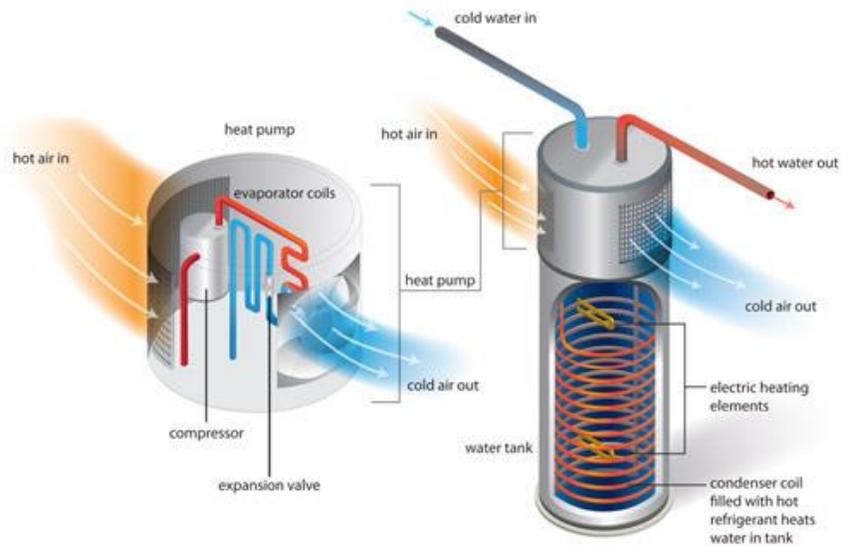


Figure 1 Hybrid heat pump water heater diagram<sup>1</sup>

The most significant barrier to water heater retrofits is the typical nature of water heater replacements. Approximately 37% of consumers replace their water heaters due to the sudden failure of their existing water heater<sup>2</sup>. When a water heater fails, most consumers will purchase a replacement that is the cheapest and most readily available model that is also easy to install. These prevailing attitudes do not encourage consumers to make the extra effort to find more advanced, energy-efficient technologies that are now available on the market.

The table below shows relevant water heater parameters.

Water Heater Parameter	Definition
Instantaneous Water Heater	“Tankless Water Heaters” eliminate energy lost to standby operation by only heating when flow sensor is activated. Instantaneous water heaters are more efficient than traditional storage water heaters. <sup>3</sup>
Storage Water Heater	Utilize a tank of water which is heated by a burner at the bottom. Efficient models have better insulation, heat traps, and secondary heat exchangers at the top of the tank. <sup>4</sup>

<sup>1</sup> Energy Star. How it Works — Heat Pump Water Heaters (HPWHs). 2021. <https://www.energy.gov/energysaver/water-heating/heat-pump-water-heaters>

<sup>2</sup> Ciani, A. (Russell Research). 2018. Water Heater Market Characterization Report. Prepared for the Northwest Energy Efficiency Alliance (NEEA). Report # E18-395. April 3.

<sup>3</sup> Energy Star. How it Works – Whole-Home Gas Tankless Water Heaters. 2020. [https://www.energystar.gov/products/water\\_heaters/water\\_heater\\_whole\\_home\\_gas\\_tankless/how\\_it\\_works](https://www.energystar.gov/products/water_heaters/water_heater_whole_home_gas_tankless/how_it_works)

<sup>4</sup> Energy Star. How it Works – High-Efficiency Gas Storage Water Heaters. 2020. [https://www.energystar.gov/products/water\\_heaters/water\\_heater\\_high\\_efficiency\\_gas\\_storage/how\\_it\\_works](https://www.energystar.gov/products/water_heaters/water_heater_high_efficiency_gas_storage/how_it_works)

Draw Pattern	Categorization used to define hot water first-hour rating and maximum flow parameters for water heaters. <sup>5</sup> Definitions for draw patterns can be found in the code section.
Uniform Energy Factor (UEF)	Efficiency factor normalized based on draw pattern and taken over a 24-hour period. It is the amount of energy delivered per normalized energy consumption. <sup>6</sup>

**MEASURE CASE DESCRIPTION**

This measure includes efficient heat pump water heaters. Efficiency requirements use the Uniform Energy Factor (UEF) metric, as required by federal regulations<sup>7</sup>. The minimum qualifying measure efficiencies exceed the California Title 20 and Code of Federal Regulations standards (see Code Requirements).

The measure case heat pump water heater equipment is be classified with following characteristics.

Equipment Type	Storage Capacity (gallons)	UEF
Heat Pump Water Heater	≤45	3.50
	>45 to ≤55	3.09
	>45 to ≤55	3.31
	>55 to ≤75	3.33
	>75	3.42

As this is a fuel substitution measure, the offerings include the replacement of specific existing case natural gas water heaters with the measure case equipment specified above.

SW Offering ID	Measure Case Description	Base Case Description
SWWH025A	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Storage Natural Gas Water Heater, 30 Gal, UEF=0.6
SWWH025B	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Storage Natural Gas Water Heater, 40 Gal, UEF=0.58
SWWH025C	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Storage Natural Gas Water Heater, 40 Gal, UEF=0.64
SWWH025D	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Storage Natural Gas Water Heater, 50 Gal, UEF=0.56
SWWH025E	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Storage Natural Gas Water Heater, 50 Gal, UEF=0.63
SWWH025F	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Storage Natural Gas Water Heater, 30 Gal, UEF=0.6

<sup>5</sup> Code of Federal Regulations. Title 10: Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, Subpart B—Test Procedures. Appendix E. 2016.

<sup>6</sup> National Institute of Standards and Technology (NIST). Water Heating Technologies and Ratings. <https://www.nist.gov/sites/default/files/documents/iaao/Healy.pdf>

<sup>7</sup> U.S. Department of Energy (DOE). 2016. “Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters.” *Federal Register: The Daily Journal of the United States*. 81 Fed. Reg. 250. December 29, 2016.

SWWH025G	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Storage Natural Gas Water Heater, 40 Gal, UEF=0.58
SWWH025H	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Storage Natural Gas Water Heater, 40 Gal, UEF=0.64
SWWH025I	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Storage Natural Gas Water Heater, 50 Gal, UEF=0.56
SWWH025J	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Storage Natural Gas Water Heater, 50 Gal, UEF=0.63
SWWH025K	Heat Pump Water Heater, >55 to ≤75 Gal, UEF=3.33	Storage Natural Gas Water Heater, 60 Gal, UEF=0.61
SWWH025M	Heat Pump Water Heater, >75 Gal, UEF=3.42	Storage Natural Gas Water Heater, 75 Gal, UEF=0.59
SWWH025O	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Tankless Natural Gas Water Heater, Low Draw, UEF=0.81
SWWH025P	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Tankless Natural Gas Water Heater, Med Draw, UEF=0.81
SWWH025Q	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09	Tankless Natural Gas Water Heater, High Draw, UEF=0.81
SWWH025R	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Tankless Natural Gas Water Heater, Low Draw, UEF=0.81
SWWH025S	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Tankless Natural Gas Water Heater, Med Draw, UEF=0.81
SWWH025T	Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31	Tankless Natural Gas Water Heater, High Draw, UEF=0.81
SWWH025U	Heat Pump Water Heater, ≤45 Gal, UEF=3.50	Storage Natural Gas Water Heater, 40 Gal, UEF=0.58
SWWH025V	Heat Pump Water Heater, ≤45 Gal, UEF=3.50	Storage Natural Gas Water Heater, 40 Gal, UEF=0.64

Measures L and N are excluded from this version of the workpaper, as DEER Water Heater Calculator v4.2 does not include these measure offerings.<sup>8</sup> Measure offering IDs were not reassigned to avoid confusion. DEER water heater calculator tool version 4.2<sup>9</sup> revised the baseline energy efficiencies for 60 and 75 gallon gas water heaters, altering measures K and M. It is possible that this calculator will be updated to include Measures L and N.

## BASE CASE DESCRIPTION

The base case equipment for this fuel substitution workpaper are Federal code compliant natural gas domestic hot water heaters. Both storage and instantaneous natural gas water heaters are being considered for the base case. This workpaper assumes that the existing case and standard case baselines use the same code compliant equipment. Base case equipment UEFs were taken directly from the DEER Water Heater Calculator v4.2<sup>10</sup>.

<sup>8</sup> California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator Documentation. "DEER-WaterHeater-Calculator-v4.2.xlsm." Updated September 16, 2020.

<sup>9</sup> California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator Documentation. "DEER-WaterHeater-Calculator-v4.2.xlsm." Updated September 16, 2020.

<sup>10</sup> California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator Documentation. "DEER-WaterHeater-Calculator-v4.2.xlsm." Updated September 16, 2020.

Equipment Type	Draw Pattern	Storage Capacity (gallons)	UEF
Storage Natural Gas Water Heater	Med	30	0.60
	Med	40	0.58
	High	40	0.64
	Med	50	0.56
	High	50	0.63
	High	60	0.61
	High	75	0.59
Tankless Natural Gas Water Heater (≤ 175 kBtu/hr)	Low	N/A	0.81
	Med	N/A	0.81
	High	N/A	0.81

### CODE REQUIREMENTS

Measures offered fall under California Building Energy Efficiency Standards (Title 24), California Appliance Efficiency Regulations (Title 20), and Federal Standards.

#### Existing Code / Requirements

Code	Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2019)	Section 1605.1(f)(1)	January 1, 2019
CA Building Energy Efficiency Standards – Title 24 (2019)	Section 110.1	January 1, 2020
Federal Standards – Code of Federal Regulations	10 CFR 430.32(d)	December 29, 2016
Federal Standards – Code of Federal Regulations	10 CFR 430 Subpart B, Appendix E, Section 5.4.1	December 29, 2016

#### Title 20 1605.1(f)(5) California Minimum Energy Factor Requirements for Water Heaters

Table F-5  
Standards for Residential-Duty Commercial Water Heaters

<b>Product Class</b>	<b>Specifications <sup>a</sup></b>	<b>Draw Pattern</b>	<b>Minimum Uniform Energy Factor <sup>b</sup></b>
Gas-fired Storage	> 75 kBtu/hr and ≤ 105 kBtu/hr and ≤ 120 gallons	Very Small	$0.2674 - (0.0009 \times V_r)$
		Low	$0.5362 - (0.0012 \times V_r)$
		Medium	$0.6002 - (0.0011 \times V_r)$
		High	$0.6597 - (0.0009 \times V_r)$
Oil-fired Storage	> 105 kBtu/hr and ≤ 140 kBtu/hr and ≤ 120 gal	Very Small	$0.2932 - (0.0015 \times V_r)$
		Low	$0.5596 - (0.0018 \times V_r)$
		Medium	$0.6194 - (0.0016 \times V_r)$
		High	$0.6740 - (0.0013 \times V_r)$
Electric Instantaneous	> 12 kW and ≤ 58.6 kW and ≤ 2 gal	Very Small	0.80
		Low	0.80
		Medium	0.80
		High	0.80
<sup>a</sup> Additionally, to be classified as a residential-duty commercial water heater, a commercial water heater must meet the following conditions: (1) if the water heater requires electricity, it must use a single-phase external power supply; and (2) the water heater must not be designed to heat water to temperatures greater than 180°F. <sup>b</sup> $V_r$ is the rated storage volume (in gallons), as determined pursuant to 10 CFR section 429.44.			

Title 24 110.1 California Mandatory Appliance Requirements

Title 24 adopts the requirements for Title 20 appliances.

Federal Standard 10 CFR 430.32(d) Minimum Energy Factor Requirements for Water Heaters

Product class	Rated storage volume and input rating (if applicable)	Draw pattern	Uniform energy factor
Gas-fired Storage Water Heater .....	≥20 gal and ≤55 gal .....	Very Small .....	0.3456 – (0.0020 × V <sub>r</sub> )
		Low .....	0.5982 – (0.0019 × V <sub>r</sub> )
		Medium .....	0.6483 – (0.0017 × V <sub>r</sub> )
		High .....	0.6920 – (0.0013 × V <sub>r</sub> )
	>55 gal and ≤100 gal .....	Very Small .....	0.6470 – (0.0006 × V <sub>r</sub> )
		Low .....	0.7689 – (0.0005 × V <sub>r</sub> )
		Medium .....	0.7897 – (0.0004 × V <sub>r</sub> )
		High .....	0.8072 – (0.0003 × V <sub>r</sub> )
Oil-fired Storage Water Heater .....	≤50 gal .....	Very Small .....	0.2509 – (0.0012 × V <sub>r</sub> )
		Low .....	0.5330 – (0.0016 × V <sub>r</sub> )
		Medium .....	0.6078 – (0.0016 × V <sub>r</sub> )
		High .....	0.6815 – (0.0014 × V <sub>r</sub> )
Electric Storage Water Heaters .....	≥20 gal and ≤55 gal .....	Very Small .....	0.8808 – (0.0008 × V <sub>r</sub> )
		Low .....	0.9254 – (0.0003 × V <sub>r</sub> )
		Medium .....	0.9307 – (0.0002 × V <sub>r</sub> )
		High .....	0.9349 – (0.0001 × V <sub>r</sub> )
	>55 gal and ≤120 gal .....	Very Small .....	1.9236 – (0.0011 × V <sub>r</sub> )
		Low .....	2.0440 – (0.0011 × V <sub>r</sub> )
		Medium .....	2.1171 – (0.0011 × V <sub>r</sub> )
		High .....	2.2418 – (0.0011 × V <sub>r</sub> )
Tabletop Water Heater .....	≥20 gal and ≤120 gal .....	Very Small .....	0.6323 – (0.0058 × V <sub>r</sub> )
		Low .....	0.9188 – (0.0031 × V <sub>r</sub> )
		Medium .....	0.9577 – (0.0023 × V <sub>r</sub> )
		High .....	0.9884 – (0.0016 × V <sub>r</sub> )
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h .....	Very Small .....	0.80
		Low .....	0.81
		Medium .....	0.81
		High .....	0.81
Instantaneous Electric Water Heater ...	<2 gal .....	Very Small .....	0.91
		Low .....	0.91
		Medium .....	0.91
		High .....	0.92
Grid-Enabled Water Heater .....	>75 gal .....	Very Small .....	1.0136 – (0.0028 × V <sub>r</sub> )
		Low .....	0.9984 – (0.0014 × V <sub>r</sub> )
		Medium .....	0.9853 – (0.0010 × V <sub>r</sub> )
		High .....	0.9720 – (0.0007 × V <sub>r</sub> )

\*V<sub>r</sub> is the Rated Storage Volume (in gallons), as determined pursuant to 10 CFR 429.17.

10 CFR 430 Subpart B, Appendix E, Section 5.4.1 Selection of Draw Pattern

Appendix E Section 5.4 defines the draw patterns definition using the first-hour rated and maximum GPM ratings.

**TABLE I—DRAW PATTERN TO BE USED BASED ON FIRST-HOUR RATING**

<b>First-hour rating greater than or equal to:</b>	<b>... and first-hour rating less than:</b>	<b>Draw pattern to be used in simulated-use test</b>
0 gallons	18 gallons	Very-Small-Usage (Table III.1).
18 gallons	51 gallons	Low-Usage (Table III.2).
51 gallons	75 gallons	Medium-Usage (Table III.3).
75 gallons	No upper limit	High-Usage (Table III.4).

**TABLE II—DRAW PATTERN TO BE USED BASED ON MAXIMUM GPM RATING**

<b>Maximum GPM rating greater than or equal to:</b>	<b>and maximum GPM rating less than:</b>	<b>Draw pattern to be used in simulated-use test</b>
0 gallons/minute	1.7 gallons/minute	Very-Small-Usage (Table III.1).
1.7 gallons/minute	2.8 gallons/minute	Low-Usage (Table III.2).
2.8 gallons/minute	4 gallons/minute	Medium-Usage (Table III.3).
4 gallons/minute	No upper limit	High-Usage (Table III.4).

NORMALIZING UNIT

Each

PROGRAM REQUIREMENTS

*Fuel Substitution Test*

Per CPUC Decision 19-08-009 Rulemaking 13-11-005 “Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution”, for all fuel substitution measures, the measure must ‘not increase total source energy consumption when compared with the baseline comparison measure available utilizing the original fuel’.<sup>11</sup> Also, the measure ‘must not adversely impact the environment compared to the baseline measure utilizing the original fuel. Fuel substitution calculations were conducted using CPUC’s “Fuel Substitution Calculator” to confirm the measures in this workpaper pass Parts One and Two of the Fuel Substitution Test.<sup>12</sup>

<sup>11</sup> California Public Utilities Commission (CPUC). 2019. “Decision 19-08-009 Rulemaking 13-11-005 Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution”. August 1.

<sup>12</sup> Southern California Edison (SCE). 2020. “SWWH025-02 Fuel Substitution Calculator.xlsx”.

*Measure Implementation Eligibility*

All measure application type, delivery type, and sector combinations that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
NR	DnDeemed	Res
NR	DnDeemDI	Res
NR	UpDeemed	Res
NC	DnDeemed	Res
NC	DnDeemDI	Res
AR	DnDeemed	Res
AR	DnDeemDI	Res

For Upstream offerings, only a number of representative measures are provided given that there will be some level of uncertainty as what heater technology (e.g., type and capacity) will be installed at the building relative to the original (existing) heater technology.

*Eligible Products*

**General Eligibility Requirements**

The heat pump water heater must meet the storage capacity and minimum efficiency requirements set forth in the Measure Case Description. Existing base equipment must be disposed.

*Eligible Building Types and Vintages*

This measure is applicable for all residential building types (single family, multifamily, and mobile homes).

*Eligible Climate Zones*

This measure is applicable in all California climate zones.

*Required Data Collection for All Measures*

To ensure that the appropriate incentives, savings, and cost effectiveness values are applied for each application, the following data must be collected for each application:

- Measure case equipment specifications including:
  - Manufacturer and model number
  - UEF
  - Storage volume in gallons
  - First Hour Rating (FHR)

- Customer site information including:
  - Climate Zone
  - Building Type (for Downstream and Direct Install measures)

#### *Required Documentation for Accelerated Replacement*

Preponderance of evidence (POE) must be documented. Notably, programs shall document if measure was replaced as a direct result of information, recommendations, and support provided by the Program Administrator, and programs shall require the collection and submission of documentation to ensure proper conformance to eligibility and implementation requirements. The following are the types of information that will be required for all projects:

- Customer/site information
- Specifications of existing equipment
- Proof that water heater is still operating as intended
- Existing water heater nameplate data with manufacturer date to confirm remaining useful life
- Replacement water heater information

To document POE, the provided Preponderance of evidence (POE) survey<sup>13</sup>, or similar, should be completed.

#### *Required Documentation for Normal Replacement in Upstream and Mid-Stream Delivery*

For upstream/midstream delivery types, the participant baselines and spillover effects are unknown. Furthermore, the manufacturer(s) and distributor(s) do not know if the purchased measure is replacing a gas or an electric baseline appliance. Claimed savings for these delivery types will be adjusted using the ratio of baseline gas appliance to total baseline appliances. These ratios will be determined from CPUC sponsored saturation studies. The implementer shall survey 10% of the midstream installations, to determine actual gas/electric baseline proportions, and the program administrator shall adjust claimed savings based upon these survey results. This survey will be conducted monthly, by e-mail. A sample survey question is as follows:

“What was the fuel source of the equipment you replaced?”

- a. Gas
- b. Electric
- c. I don't know/I'm not sure

In addition, for midstream delivery method, the implementer should provide the retailer or distribution location where the product was sold, rated capacity, and proposed commercial building type in which the product will be installed.

A survey will not be administered for upstream delivery types.

---

<sup>13</sup> SWWH025 POE Survey.docx

*Required Documentation for Normal Replacement, New Construction, and Accelerated Replacement in Downstream and Direct Install Delivery*

For downstream deemed and downstream direct-install delivery types, in addition to the standard information such as building type, climate zone, and capacity of the units, the following data must be submitted with each project application by the project developer:

- What is the existing fuel type for space heating?
- Did the site require any electric infrastructure upgrades for the proposed electrification measure? If yes, provide the itemized invoices with infrastructure upgrade costs.
- Did the owner install any other electrification measures at this site? If yes, list the measures and provide the itemized invoices with infrastructure upgrade costs (if any).

*Incentive Requirements*

Deployment of the program may require rebates or financial incentives to participants that exceed the Incremental Measure Cost (IMC). Incentives or rebates that exceed the incremental cost for a measure must be justified by individual PAs in addendum to workpaper submissions to document program implementation practice prior to program implementation.

**PROGRAM EXCLUSIONS**

As this is a fuel substitution measure, it is eligible for replacement of existing gas equipment. New construction measures are only eligible for Downstream application, when:

- Measures are installed in new areas of an existing building,
- Measures are installed in a major renovation of an existing building, or
- Measures are installed in capacity expansions of existing systems to serve existing and/or new load retrofits that require a new energy service.

These exceptions will follow the same baseline technology requirements as a Normal Replacement measure application type.

**DATA COLLECTION REQUIREMENTS**

Baseline equipment type and fuel source must be verified, for downstream and direct install measures.

Per CPUC Decision 19-08-009<sup>14</sup>, building infrastructure costs which include panel upgrades or gas line installations/upgrades required to facilitate these fuel substitution measures shall be collected for all downstream and direct install measures.

---

<sup>14</sup> California Public Utilities Commission (CPUC). 2019. "Decision 19-08-009 Rulemaking 13-11-005 Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution". August 1

USE CATEGORY

Service & domestic hot water

ELECTRIC SAVINGS (kWh)

Heat pump water heater savings for all measures are included in DEER2021 and are taken directly from DEER water heater calculator tool version 4.2<sup>15</sup>.

The energy savings of heat pump water heaters and electric storage water heaters are rated in uniform energy factor (UEF). Unit energy savings (UES) were modeled using the Database for Energy Efficient Resources (DEER) methodologies. Specifically, energy use and savings were derived using the DEER water heater calculator tool version 4.2<sup>16</sup>, a macro-enabled Excel workbook developed by consultants of the California Public Utilities Commission (CPUC) Energy Division to standardize the inputs and savings calculations for water heating measures. The calculator "utilizes hourly output from the DEER2014 DOE2 building prototypes for hot water loads and ambient conditions to estimate hourly energy use for a variety of water heaters."<sup>17</sup> Further, 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 DEER applicability parameters. Measure savings are determined by comparing the energy use associated with the technologies defined in the measure definition."<sup>18</sup>

This workpaper assumes that that the existing and standard base cases are both code compliance gas water heaters. Thus, AR measures will adopt the standard savings values for both the first and second baseline. NR measures also adopt the standard savings values as the first baseline.

The following EnergyImpactIDs were taken directly from version 4.2 of the DEER water heater calculator and used to calculate the measure savings in this workpaper.

SW Offering ID	DEER Water Heater Calculator v4.2 EnergyImpactID
SWWH025A	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-MD-3.09UEF-50g
SWWH025B	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-MD-3.09UEF-50g
SWWH025C	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-HI-3.09UEF-50g
SWWH025D	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-MD-3.09UEF-50g
SWWH025E	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-HI-3.09UEF-50g
SWWH025F	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-MD-3p31UEF-50g
SWWH025G	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-MD-3p31UEF-50g
SWWH025H	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-HI-3p31UEF-50g
SWWH025I	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-MD-3p31UEF-50g

<sup>15</sup> California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator Documentation. "DEER-WaterHeater-Calculator-v4.2.xlsm." Updated September 16, 2020.

<sup>16</sup> California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator Documentation. "DEER-WaterHeater-Calculator-v4.2.xlsm." Updated September 16, 2020.

<sup>17</sup> California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator Documentation. "DEER Water Heater Calculator Documentation v4.0 for DEER2021" Updated April 30, 2020.

<sup>18</sup> California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator Documentation. "DEER Water Heater Calculator Documentation v4.0 for DEER2021" Updated April 30, 2020.

SWWH025J	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-HI-3p31UEF-50g
SWWH025K	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep60G-HI-3p33UEF-80g
SWWH025M	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep75G-HI-3p42UEF-80g
SWWH025O	RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-replt200kBtuh-LW-3.09UEF
SWWH025P	RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-replt200kBtuh-MD-3.09UEF
SWWH025Q	RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-replt200kBtuh-HI-3.09UEF
SWWH025R	RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-replt200kBtuh-LW-3.31UEF
SWWH025S	RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-replt200kBtuh-MD-3.31UEF
SWWH025T	RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-replt200kBtuh-HI-3.31UEF
SWWH025U	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-MD-3p50UEF-40g
SWWH025V	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-HI-3.50UEF-40g

The following inputs were used to create the new measure cost for the ≤45 gallon heat pump water heater technology in the calculator. The inputs were informed by an analysis of the CEC appliance database, AHRI database, and Energy Star qualified product list<sup>19</sup>. Other inputs were taken based on similar measures in the water heater calculator or auto-calculated by the tool.

Input	Value
Storage Gallons (Gal)	40
Uniform Energy Factor (UEF)	3.50
Burner Capacity (kW)	4
Recovery Efficiency (%)	394%

### PEAK ELECTRIC DEMAND REDUCTION (KW)

In accordance with the requirements of the CPUC Fuel Substitution Technical Guidance, for Energy Efficiency, October 31, 2019, there will not be any peak demand reduction or penalty towards peak demand goal achievement from fuel substitution measures.<sup>20</sup>

### GAS SAVINGS (THERMS)

Gas consumption was calculated in the DEER Water Heater Calculator using the same methodology as the electric energy savings. Please refer to the Electric Savings (kWh) for details.

### LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would

<sup>19</sup> Southern California Edison (SCE). 2020. "SWWH025-02 Database Exports\_11-9-2020.xlsm"

<sup>20</sup> California Public Utilities Commission. 2019. "Fuel Substitution Technical Guidance for Energy Efficiency".

have remained in service and operational had the program intervention not caused the replacement or alteration.

Effective Useful Life (EUL) and Remaining Useful Life (RUL) for various water heaters are available in DEER2014. The measure EUL represents the heat pump water heater measure case. The measure RUL represent the base case of either a storage or tankless natural gas water heaters for the Accelerated Replacement (AR) measures. No RUL is applicable for the Normal Replacement (NR) or New Construction (NC) measures.

### Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
Measure: EUL (yrs) (EUL ID: WtrHt-HtPmp)	10.0	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
Measure: RUL (yrs) (RUL ID: WtrHt-HtPmp)	N/A	N/A
Baseline: EUL (yrs) (EUL ID: WtrHt-Res-Gas)	11.0	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
Baseline: RUL (yrs) (RUL ID: WtrHt-Res-Gas)	3.67	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
Baseline: EUL (yrs) (EUL ID: WtrHt-Instant-Res)	20.0	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
Baseline: RUL (yrs) (RUL ID: WtrHt-Instant-Res)	6.67	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."

### BASE CASE MATERIAL COST (\$/UNIT)

Baseline cost data was collected using online webscraping of applicable natural gas water heaters during the second quarter of 2020.<sup>21</sup> Retailers referenced include Home Depot, Lowes, Grainger, Menards, ABT, SupplyHouse, Supply.com, Zoro, AFSupply, TotalHomeSupply, GlobalIndustrial, HomePerfect, and AceHardware. Costs were averaged based on water heater type and relevant storage capacity bins. Since all the equipment collected were featured standard efficiency UEF values, only single cost values were calculated per storage capacity bin. Similarly, costs collected for the tankless water heaters showed flow rates which included only high-draw models, thus only a single base case tankless water heater cost was calculated. The table below show the resultant baseline technologies and their respective costs and sample sizes.

### Storage Water Heaters Base Material Cost

Baseline Technology	Average NGWH Cost	Sample Count
30-gallon Natural Gas Storage Water Heater	\$628.88	23
40-gallon Natural Gas Storage Water Heater	\$717.85	57
50-gallon Natural Gas Storage Water Heater	\$961.68	48

<sup>21</sup> Southern California Edison (SCE). 2020. "SWWH025-02 MeasureDataSpec.xlsx", Cost Data tab

60-gallon Natural Gas Storage Water Heater	\$1,139.46	11
75-gallon Natural Gas Storage Water Heater	\$1,437.09	26
Tankless Natural Gas Storage Water Heater	\$1,082.68	58

As the existing case and standard case equipment is assumed to be the same, they use the same costs. See cost spreadsheet for the collected baseline costs.<sup>22</sup>

### MEASURE CASE MATERIAL COST (\$/UNIT)

Measure cost data was collected in another workpaper, SWWH014-02 "Heat Pump Water Heater".

In SWWH014-02 the costs for heat pump water heaters were calculated as the average of costs of qualifying units sold by online retailers.<sup>23</sup> The market is limited for heat pump water heaters  $\geq 2.91$  UEF; costs were based upon seven models (represented by five manufacturers). These costs were determined to be representative of unit costs based on online retailer checks in the second quarter of 2020. This workpaper adopts these heat pump water heater costs as material costs directly. See cost spreadsheet for the collected measure costs.<sup>24</sup>

Material costs for the  $\leq 45$  gallon heat pumps were collected using online webscraping of applicable heat pump water heaters during the fourth quarter of 2020.<sup>25</sup> Retailers referenced mainly include Home Depot, Menards and SupplyHouse.

The table below show the resultant heat pump costs and sample sizes.

#### Heat Pump Water Heaters $\leq 45$ gallon Material Cost

Baseline Technology	Average NGWH Cost	Sample Count
$\leq 45$ -gallon Heat Pump Water Heater	\$1,377.61	21

**Infrastructure Costs.** For a natural gas water heater to heat pump water heater infrastructure, upgrades would include a capping off the natural gas line, closing exhaust vents, and running 240 power to the heater. Existing gas water heaters will typically only be using 120V power. These infrastructure costs were estimated using 2020 RSMMeans Online data<sup>26</sup> and online retailer costs. RSMMeans hourly labor rates

<sup>22</sup> Southern California Edison (SCE). 2020. "SWWH025-02 MeasureDataSpec.xlsx", Cost Data tab

<sup>23</sup> Southern California Edison (SCE). 2018. "SCE17WH001.2 A3 - Costs Calculations.xlsx."

<sup>24</sup> Southern California Edison (SCE). 2020. "SWWH025-02 MeasureDataSpec.xlsx", Cost Data tab

<sup>25</sup> Southern California Edison (SCE). 2020. "SWWH025-02 MeasureDataSpec.xlsx", Cost Data tab

<sup>26</sup> 2020 RSMMeans Electrical Cost Data

for a residential electrician<sup>27</sup> were used to estimate labor costs. See the table below for details and the cost calculations for more details.<sup>28</sup>

Description of Work	Labor Hours	Labor Cost	Material Cost	Total Cost
Cap Existing Gas Line w/ Brass Plug for Natural Gas lines.	0.250	\$22.90	\$4.04	\$26.94
Demolish Existing Vent	0.727	\$66.60	\$0.00	\$66.60
Water heater electrical hookup, includes breaker box, 20' of wiring	1.248	\$114.32	\$54.50	\$168.82
<b>Total</b>	<b>2.225</b>	<b>\$203.82</b>	<b>\$58.54</b>	<b>\$262.36</b>

### BASE CASE LABOR COST (\$/UNIT)

The estimated installation hours for each of the baseline water heater technologies and capacities in the workpaper were obtained from RSMMeans 2020<sup>29</sup> and multiplied by the RSMMeans 2020 hourly plumber rate (\$/hr).<sup>30</sup>

### MEASURE CASE LABOR COST (\$/UNIT)

The estimated installation hours for each of the heat pump water heater capacities in the workpaper were obtained from RSMMeans 2020<sup>31</sup> and multiplied by the RSMMeans 2020 hourly plumber rate (\$/hr).<sup>32</sup> Labor hours for heat pump water heaters were not specifically called out so the hours for electric water heaters were used and are assumed to be applicable.

### NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. Based on the CPUC’s Fuel Substitution Technical Guidance

<sup>27</sup> RSMMeans Residential Labor Rates, <https://www.rsmeansonline.com/References/LABORRATE/2-Year%202020%20Labor%20Rates/Residential%20Labor%20Rates.PDF> , “Residential Labor Rates.pdf”

<sup>28</sup> Southern California Edison (SCE). 2020. " SWWH025-02 MeasureDataSpec.xlsx", Cost Data tab

<sup>29</sup> 2020 RSMMeans Electrical Cost Data

<sup>30</sup> RSMMeans 2020 Residential Labor Rates. <https://www.rsmeansonline.com/References/LABORRATE/2-Year%202020%20Labor%20Rates/Residential%20Labor%20Rates.PDF>

<sup>31</sup> 2020 RSMMeans Electrical Cost Data

<sup>32</sup> RSMMeans 2020 Residential Labor Rates. <https://www.rsmeansonline.com/References/LABORRATE/2-Year%202020%20Labor%20Rates/Residential%20Labor%20Rates.PDF>

for Energy Efficiency<sup>33</sup> document, the value below should be used for fuel substitution measures until further data is available.

Net-to-Gross Ratios

Parameter	Value	Source
NTG – FuelSubst-Default	1.0	California Public Utilities Commission. 2019. Decision 19-06-008and California Public Utilities Commission. 2019. Fuel Substitution Technical Guidance for Energy Efficiency.

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method.

Gross Savings Installation Adjustment Rates

Parameter	GSIA	Source
GSIA	1.0	California Public Utilities Commission (CPUC), Energy Division. 2013. <i>Energy Efficiency Policy Manual Version 5</i> . Page 31.

DEER DIFFERENCES ANALYSIS

This section provides a summary of DEER-based inputs and methods, and the rationale for inputs and methods that are not DEER-based.

---

<sup>33</sup> California Public Utilities Commission. 2019. “Fuel Substitution Technical Guidance for Energy Efficiency”.

DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	Yes
Scaled DEER measure	No
DEER Base Case	Yes
DEER Measure Case	Yes
DEER Building Types	Yes
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	DEER Water Heater Calculator v4.2
Reason for Deviation from DEER	The <45gal HPWH measure was not available in v.4.2. It was added based on analysis of the CEC appliance database, AHRI database, and Energy Star qualified product list.
DEER Measure IDs Used	RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-MD-3.09UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-MD-3.09UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-HI-3.09UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-MD-3.09UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-HI-3.09UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep30G-MD-3p31UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-MD-3p31UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep40G-HI-3p31UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-MD-3p31UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep50G-HI-3p31UEF-50g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep60G-HI-3p33UEF-80g RE-WtrHt-FuelSub-SmlStrg-HP-lte6kW-rep75G-HI-3p42UEF-80g RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-repl200kBtuh-LW-3.09UEF RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-repl200kBtuh-MD-3.09UEF RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-repl200kBtuh-HI-3.09UEF RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-repl200kBtuh-LW-3.31UEF RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-repl200kBtuh-MD-3.31UEF RE-WtrHt-FuelSub-SmlInst-HP-lte6kW-repl200kBtuh-HI-3.31UEF
NTG	Source: DEER. The NTG of 1.0 is associated with NTG ID: FuelSubst-Default
GSIA	Source: DEER. The GSIA of 1.0 is associated with GSIA ID: Def-GSIA
EUL/RUL	Source: DEER. The EUL value of 10 years with EUL ID: WtrHt-HtPmp Source: DEER. The RUL value of 3.67 years with RUL ID: WtrHt-Res-Gas Source: DEER. The RUL value of 6.67 years with RUL ID: WtrHt-Instant-Res

## REVISION HISTORY

## Measure Characterization Revision History

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	11/13/2019	Lake Casco, PE, TRC	First draft of workpaper.
02	6/8/2020	Brandon Yamasaki, TRC Lake Casco, PE, TRC	Updates to measures, savings, and costs. Savings are derived from DEER Water Heater Calculator v4.1. Baseline costs are collected from a second quarter 2020 web scrape. Updated labor costs for all measures using RSMeans 2020. Removed Measures L and N because they did not exist in new DEER calculator.
03	11/11/2020	Lake Casco, PE, TRC	Added ≤45 gallon capacity water heater measures to the workpaper. Includes new savings with DEER Water Heater Calculator v4.2 and costs for measure.
	4/12/2021	Lake Casco, PE, TRC Kara Vega, TRC	Updates based on CPUC comments. Updates include: adding eligibility and data collection requirements, updated language describing measure case equipment, and clarification on baselines used for savings. Update all mentions of DEER Water Heater Calculator to version 4.2
	08/24/2021	Soe K. Hla PG&E	Adopted all measures for PG&E