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APPLIANCE
**SWWH025-01 RESIDENTIAL HEAT PUMP
WATER HEATER-FUEL SUBSTITUTION**

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MEASURE NAME

Residential Heat Pump Water Heater - Fuel Substitution

STATEWIDE MEASURE ID

SWWH025-01

EFFECTIVE DATE

December 13, 2019

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. Two electrical heating elements exist at the base and at the top of the tank, which utilizes foam insulation. Cold water enters the base of the tank and is heated by the lower electrical heating element. The water then rises to the top of the tank where the heated water is drawn for consumption. 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.

The most significant barrier to a water heater retrofit 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 heater¹. 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. ²

¹ Ciani, A. (Russell Research). 2018. Water Heater Market Characterization Report. Prepared for the Northwest Energy Efficiency Alliance (NEEA). Report # E18-395. April 3.

² Energy Star. How it Works – Whole-Home Gas Tankless Water Heaters. 2019. https://www.energystar.gov/products/water_heaters/water_heater_whole_home_gas_tankless/how_it_works

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. ³
Draw Pattern	Categorization used to define hot water first-hour rating and maximum flow parameters for water heaters. ⁴ 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. ⁵

MEASURE CASE DESCRIPTION

This measure includes efficient heat pump water heaters. Efficiency requirements use the Uniform Energy Factor (UEF) metric, as required by federal regulations⁶. 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 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
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

³ Energy Star. How it Works – High-Efficiency Gas Storage Water Heaters. 2019.

https://www.energystar.gov/products/water_heaters/water_heater_high_efficiency_gas_storage/how_it_works

⁴ Code of Federal Regulations. Title 10: Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, Subpart B—Test Procedures. Appendix E. 2016.

⁵ National Institute of Standards and Technology (NIST). Water Heating Technologies and Ratings.

<https://www.nist.gov/sites/default/files/documents/iaao/Healy.pdf>

⁶ 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.

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=0.77
SWWH025L	Heat Pump Water Heater, >55 to ≤75 Gal, UEF=3.33	Storage Natural Gas Water Heater, 60 Gal, UEF=0.79
SWWH025M	Heat Pump Water Heater, >75 Gal, UEF=3.42	Storage Natural Gas Water Heater, 75 Gal, UEF=0.76
SWWH025N	Heat Pump Water Heater, >75 Gal, UEF=3.42	Storage Natural Gas Water Heater, 75 Gal, UEF=0.78
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

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. The measure assumes that the existing case and standard case baselines are the same.

Equipment Type	Draw Pattern	Storage Capacity (gallons)	UEF
Storage Natural Gas Water Heater	Med	30	0.6
	Med	40	0.58
	High	40	0.64
	Med	50	0.56
	High	50	0.63
	Med	60	0.77
	High	60	0.79
	Med	75	0.76
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
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Title 20 1605.1(f)(1) California Minimum Energy Factor Requirements for Water Heaters

Table F-2
Standards for Water Heaters Regulated Under 10 C.F.R. Section 430.32(d)

Product Class	Rated Storage Volume and Input Rating (if applicable)	Draw Pattern	Minimum Uniform Energy Factor*
Gas-fired Storage Water Heater	≥ 20 gallons and ≤ 55 gallons	Very small	0.3456 – (0.0020 × V _r)
		Low	0.5982 – (0.0019 × V _r)
		Medium	0.6483 – (0.0017 × V _r)
		High	0.6920 – (0.0013 × V _r)
	> 55 gallons and ≤ 100 gallons	Very small	0.6470 – (0.0008 × V _r)
		Low	0.7889 – (0.0005 × V _r)
		Medium	0.7897 – (0.0004 × V _r)
		High	0.8072 – (0.0003 × V _r)
Oil-fired Storage Water Heater	≤ 50 gallons	Very small	0.2509 – (0.0012 × V _r)
		Low	0.5330 – (0.0016 × V _r)
		Medium	0.6078 – (0.0016 × V _r)
		High	0.6815 – (0.0014 × V _r)
Electric Storage Water Heaters	≥ 20 gallons and ≤ 55 gallons	Very small	0.8808 – (0.0008 × V _r)
		Low	0.9254 – (0.0003 × V _r)
		Medium	0.9307 – (0.0002 × V _r)
		High	0.9349 – (0.0001 × V _r)
	> 55 gallons and ≤ 120 gallons	Very small	1.9236 – (0.0011 × V _r)
		Low	2.0440 – (0.0011 × V _r)
		Medium	2.1171 – (0.0011 × V _r)
		High	2.2418 – (0.0011 × V _r)
Tabletop Water Heater	≥ 20 gallons and ≤ 120 gallons	Very small	0.8323 – (0.0058 × V _r)
		Low	0.9188 – (0.0031 × V _r)
		Medium	0.9577 – (0.0023 × V _r)
		High	0.9884 – (0.0016 × V _r)
Instantaneous Gas-fired Water Heater	< 2 gallons and >50,000 Btu/h	Very small	0.80
		Low	0.81
		Medium	0.81
		High	0.81
Instantaneous Electric Water Heater	< 2 gallons	Very small	0.91
		Low	0.91
		Medium	0.91
		High	0.92
Grid-Enabled Water Heater	> 75 gallons	Very small	1.0136 – (0.0028 × V _r)
		Low	0.9984 – (0.0014 × V _r)
		Medium	0.9853 – (0.0010 × V _r)
		High	0.9720 – (0.0007 × V _r)

* V_r = Rated Storage Volume in gallons.

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 _r)
		Low	0.5982 – (0.0019 × V _r)
		Medium	0.6483 – (0.0017 × V _r)
		High	0.6920 – (0.0013 × V _r)
	>55 gal and ≤100 gal	Very Small	0.6470 – (0.0006 × V _r)
		Low	0.7689 – (0.0005 × V _r)
		Medium	0.7897 – (0.0004 × V _r)
		High	0.8072 – (0.0003 × V _r)
Oil-fired Storage Water Heater	≤50 gal	Very Small	0.2509 – (0.0012 × V _r)
		Low	0.5330 – (0.0016 × V _r)
		Medium	0.6078 – (0.0016 × V _r)
		High	0.6815 – (0.0014 × V _r)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Very Small	0.8808 – (0.0008 × V _r)
		Low	0.9254 – (0.0003 × V _r)
		Medium	0.9307 – (0.0002 × V _r)
		High	0.9349 – (0.0001 × V _r)
	>55 gal and ≤120 gal	Very Small	1.9236 – (0.0011 × V _r)
		Low	2.0440 – (0.0011 × V _r)
		Medium	2.1171 – (0.0011 × V _r)
		High	2.2418 – (0.0011 × V _r)
Tabletop Water Heater	≥20 gal and ≤120 gal	Very Small	0.6323 – (0.0058 × V _r)
		Low	0.9188 – (0.0031 × V _r)
		Medium	0.9577 – (0.0023 × V _r)
		High	0.9884 – (0.0016 × V _r)
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 _r)
		Low	0.9984 – (0.0014 × V _r)
		Medium	0.9853 – (0.0010 × V _r)
		High	0.9720 – (0.0007 × V _r)

* V_r 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

First-hour rating greater than or equal to:	... and first-hour rating less than:	Draw pattern to be used in simulated-use test
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

Maximum GPM rating greater than or equal to:	and maximum GPM rating less than:	Draw pattern to be used in simulated-use test
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’.⁷ 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 Test⁸.

⁷ 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.

⁸ Southern California Edison (SCE). 2019. “SWWH025-01 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
Normal Replacement	DnDeemed	Res
Normal Replacement	DnDeemDI	Res
Normal Replacement	UpDeemed	Res
New Construction	DnDeemed	Res
New Construction	DnDeemDI	Res
Accelerated Replacement	DnDeemed	Res
Accelerated Replacement	DnDeemDI	Res

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

For upstream/mid-stream delivery method, the participant baselines are unknown and the spillover effects are unknown. The manufacturer or distributor doesn't know whether 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 (Residential Appliance Saturation Survey (RASS))⁹. The implementer shall survey 10% of the mid-stream 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. 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 mid-stream delivery method, the implementer should provide the retailer or distribution location where the product was sold, rated capacity, and proposed building type where the product will be installed (single family, multi-family or mobile homes).

⁹ California Energy Commission. 2010. “2009 California Residential Appliance Saturation Study”.

A survey will not be issued for upstream delivery method.

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 to 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).

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) survey¹⁰, or similar, should be completed.

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).

¹⁰ SWWH025 POE Survey.docx

Eligible Climate Zones

This measure is applicable in all California climate zones.

Incentive Amounts

Fuel substitution measures face market barriers, including [consumer market failures and supplier market failures](#).¹¹ Deployment of the program may require rebates or financial incentives to participants that exceed the measure cost.¹²

PROGRAM EXCLUSIONS

This measure is not applicable for new construction installations. However new services, as defined in *Fuel Substitution Technical Guidance for Energy Efficiency*, are eligible.¹³ New service measures are only eligible for Downstream and Direct Install 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 19-08-009¹⁴, 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.

¹¹ Energy+Environmental Economics. April 2019. "Residential Building Electrification in California

https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

Consumer economics, greenhouse gases and grid impacts".

¹² Originally defined in D.92-09-080, the dual test was last modified in D.05-04-051

¹³ California Public Utilities Commission (CPUC), Energy Division. 2019. *Fuel Substitution Technical Guidance, Version 1.1*. October 31. Page 3.

¹⁴ 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 values are included in DEER2020, however, they use an electric resistance baseline and are not applicable to this fuel substitution measure.

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 3.4,¹⁵ 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 along with new technology definitions to estimate the hourly energy use of gas, electric, and heat pump water heaters. This tool was developed as a replacement of an earlier version (v3.3) to accommodate the modeling requirements of heat pump water heaters and to provide a relatively easy method to add new measures and technologies based on PA program requirements."¹⁶ 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."¹⁷

The DEER water heater calculator v3.4¹⁸ did not include 60 and 75-gallon storage water heater technologies which used UEF or which varied by draw pattern. These measures were added to the calculator to be included as baselines. The calculator tool uses energy factor (EF) to calculate the consumption, thus the applicable UEF values were converted to EF values via equations provided by Federal Code¹⁹ which are available in the within the tool. The remaining calculation values such as burner capacity, recovery efficiency, tank insulation (UA), auxiliary consumption and pilot light parameters were

¹⁵ California Public Utilities Commission (CPUC), Energy Division. 2019. DEER2020 Small Storage and Small Instantaneous Water Heater Energy Use Calculator. "DEER-WaterHeater-Calculator-v3.4.xlsm." Updated August 30, 2019.

¹⁶ California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2015 Service and Domestic Water Heater Measures Update." October 1. Page 3.

¹⁷ California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2015 Service and Domestic Water Heater Measures Update." October 1. Page 10.

¹⁸ California Public Utilities Commission (CPUC), Energy Division. 2019. DEER2020 Small Storage and Small Instantaneous Water Heater Energy Use Calculator. "DEER-WaterHeater-Calculator-v3.4.xlsm." Updated August 30, 2019.

¹⁹ Code of Federal Regulations. Docket No. EERE-2015-BT-TP-0007. "Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Consumer and Commercial Water Heaters." Section III.D2(a)

adopted from technologies of similar size and efficiency provided in the water heater calculator v3.2²⁰. The table below shows a sample of the previous Tech IDs and adopted values for each baseline.

Current Baseline	Previous Tech ID ²¹	Burner Capacity (kBtu/hr)	Recovery Efficiency	Tank Insulation (BTU/hr-F)	Ventilation Fan Power (kW)	Pilot Light Capacity (Btu/hr)	Pilot Light Efficiency
Storage Natural Gas Water Heater, 60 Gal, UEF=0.77	Stor_EF-Gas-060gal-0.78EF	40	90%	4.13	50	350	67%
Storage Natural Gas Water Heater, 60 Gal, UEF=0.79	Stor_EF-Gas-060gal-0.80EF	40	92%	4.02	50	350	67%
Storage Natural Gas Water Heater, 75 Gal, UEF=0.76	Stor_EF-Gas-075gal-0.78EF	70	90%	4.03	50	350	67%
Storage Natural Gas Water Heater, 75 Gal, UEF=0.78	Stor_EF-Gas-075gal-0.80EF	70	92%	3.92	50	350	67%

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.²²

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 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) measure.

²⁰ California Public Utilities Commission (CPUC), Energy Division. 2018. DEER2020 Small Storage and Small Instantaneous Water Heater Energy Use Calculator. "DEER-WaterHeater-Calculator-v3.2.xlsm." Updated September 1, 2018.

²¹ California Public Utilities Commission (CPUC), Energy Division. 2018. DEER2020 Small Storage and Small Instantaneous Water Heater Energy Use Calculator. "DEER-WaterHeater-Calculator-v3.2.xlsm." Updated September 1, 2018.

²² California Public Utilities Commission. 2019. "Fuel Substitution Technical Guidance for Energy Efficiency".

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)

Base cost data for natural gas water heaters has been collected in existing workpapers SWWH012-01 "Storage Water Heater, Residential" and SWWH013-01 "Tankless Water Heater, Residential". Costs for 60-gallon and 75-gallon storage water heater were selected from WO017.

In SWWH012-01 material costs for storage water heaters were derived from data drawn from the 2010-2012 WO017 Ex Ante Measure Cost Study Final Report²³ prepared by Itron, Inc. Because this study presents material and labor cost for water heaters units rated with energy factor (EF), the EF values were converted to UEF and a regression analysis was completed to determine the cost for each corresponding UEF rating.²⁴

In SWWH013-01 material costs for tankless water heaters were derived from the U.S. Department of Energy (DOE) Technical Support Document (TSD): Pool Heaters, Direct Heating Equipment and Water Heaters (EERE-2006-STD-0129).²⁵ The extracted data includes both labor and material cost.²⁶ While the DOE data is older than the cost data presented in the 2010-2012 Ante Measure Cost Study conducted by Itron, Inc.,²⁷ a comparison with project invoices showing cost information²⁸ for tankless water heaters confirms the DOE data is representative of measure case material costs.

²³ Itron, Inc. 2014. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. Prepared for the California Public Utilities Commission. Appendix F.1, page 11.

²⁴ Southern California Gas Company. 2018. "WPSCGREWH180207A-Rev00_Att. A - Cost Regression.xlsx"

²⁵ U.S. Department of Energy (DOE). 2009. Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters. Prepared by Navigant Consulting, Inc. and Lawrence Berkeley National Laboratory. Docket ID: EERE-2006-STD-129.

See: Southern California Gas Company. 2014. "WPSCGREWH120919A-Rev4 Rev2 Cost Data.xlsx"

²⁶ Southern California Gas Company. 2014. "WPSCGREWH120919A-Rev4 Rev2 Cost Data.xlsx"

²⁷ Itron, Inc. 2014. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. Prepared for the California Public Utilities Commission.

²⁸ Southern California Gas Company. 2018. "WPSCGREWH120919A-Rev4 Invoice Summary.xlsx."

No existing workpaper material costs could be found for the baseline 60-gallon and 75-gallon storage water heaters. Material costing was obtained through online price research from various retailer websites in the fourth quarter of 2019²⁹. High efficiency models were excluded from the dataset. No correlation could be found between efficiency and cost, thus the average cost per storage capacity was used for the relevant 60-gallon and 75-gallon storage baselines, regardless of UEF.

60-gallon and 75-gallon Storage Water Heaters Base Material Cost

Baseline Technology	Average HPCD Cost	Sample Count
60-gallon Natural Gas Storage Water Heater	\$1,225.47	8
70-gallon Natural Gas Storage Water Heater	\$1,412.85	21

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.³⁰

MEASURE CASE MATERIAL COST (\$/UNIT)

Measure cost data has been collected in existing workpapers SWWH014-01 "Heat Pump Water Heater". In SWWH014-01 the costs for heat pump water heaters were calculated as the average of costs of qualifying units sold by online retailers.³¹ The market is limited for heat pump water heaters ≥ 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 first quarter of 2019.

This workpaper adopts these heat pump water heater costs as material costs directly. See cost spreadsheet for the collected baseline costs.³²

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 RSMean Online data³³ and online retailer costs. RSMean hourly labor rates for a residential electrician³⁴ were used to estimate labor costs. See the table below for details and the cost calculations for more details.³⁵

²⁹ Southern California Edison (SCE). 2019. "SWWH025-01 MeasureDataSpec.xlsx", Online Costs tab

³⁰ Southern California Edison (SCE). 2019. "SWWH025-01 MeasureDataSpec.xlsx", Cost Data tab

³¹ Southern California Edison (SCE). 2018. "SCE17WH001.2 A3 - Costs Calculations.xlsx."

³² Southern California Edison (SCE). 2019. "SWWH025-01 MeasureDataSpec.xlsx", Cost Data tab

³³ 2019 RSMean Electrical Cost Data

³⁴ RSMean Residential Labor Rates, <https://www.rsmeanonline.com/References/LABORRATE/2-Year%202019%20Labor%20Rates/Residential%20Labor%20Rates.PDF>, "Residential Labor Rates.pdf"

³⁵ Southern California Edison (SCE). 2019. "SWWH025-01 MeasureDataSpec.xlsx", Cost Data tab

Description of Work	Labor Hours	Labor Cost	Material Cost	Total Cost
Cap Existing Gas Line w/ Brass Plug for Natural Gas lines.	0.250	\$16.89	\$4.00	\$20.89
Demolish Existing Vent	0.727	\$49.11	\$0.00	\$49.11
Water heater electrical hookup, includes breaker box, 20' of wiring	1.095	\$73.97	\$42.00	\$115.97
Total	2.072	\$139.96	\$46.00	\$185.97

BASE CASE LABOR COST (\$/UNIT)

Base case labor costs for both the storage and tankless natural gas water heaters were derived using the same methodology used to develop base case material costs. Please refer to the base case material cost section for more details.

No existing workpaper labor costs could be found for the baseline 60-gallon and 75-gallon storage water heaters. These costs were adopted from the 2010-2012 WO017 Ex Ante Measure Cost Study³⁶. Costs for “High Efficiency Small Gas Storage Water Heater - 60 Gal, 0.70 EF” and “High Efficiency Small Gas Storage Water Heater - 75 Gal, 0.70 EF” were selected. The cost data were scaled to 2018 cost values using an average of all 12 California cities in the 2018 RS Means Historical Cost Indexes table³⁷. The RSMeans Historical Cost Index can be used to compare costs of projects between different cities and years. The ratio of cost indexes provides the percent change expected in the price between the specified years. A comparison of the cost indexes for 2012 and 2018 for the average of 12 California cities in the 2018 (209.3 and 239.9, respectively) reveals a cost increase of 14.6%. This percentage increase value was applied to the WO017 data to reflect 2018 costs.

³⁶ Itron, Inc. 2014. 2010-2012 WO017 Ex Ante Measure Cost Study Final Report. Prepared for the California Public Utilities Commission.

³⁷ RSMeans Historical Cost Index <https://www.rsmeansonline.com/References/CCI/3-Historical%20Cost%20Indexes/3-Historical%20Cost%20Indexes.PDF>

RSMMeans Historical Cost Index

Input	Value	Source
Price index adjustment (%)	14.6%	RSMMeans Historical Cost Index https://www.rsmeansonline.com/references/unit/refpdf/hci.pdf "RSMMeans Cost Index.pdf"

MEASURE CASE LABOR COST (\$/UNIT)

Measure labor costs were adopted from existing workpaper SWWH014-01 "Heat Pump Water Heater". In SWWH014-01 the install costs for heat pump water heaters are assumed to equal the base case labor costs for equivalent electric resistance water heater capacities, as presented in the electric storage water heater section of the 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc.³⁸ The costs from the Ex Ante Measure Cost Study were then converted to 2018 values using RSMMeans historical cost index ratios.³⁹

Smaller 30, 40, and 50-gallon heaters are replaced with 45 to 55-gallon heat pump water heaters, thus the labor cost for these measures is equal to the base labor cost of a 50-gallon electric resistance storage heater. The labor costs for larger heat pump water heaters are based on 60 and 75-gallons and are assumed to be equal to that of 60 and 75-gallon electric resistance storage heaters.

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. The NTG for fuel substitution measures was stipulated in Decision 19-08-009, *Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution*, issued by the California Public Utilities Commission (CPUC).⁴⁰ "When a fuel substitution measure passes the Fuel Substitution Test, it shall be included in the cost-effectiveness analysis of the portfolio with a net-to-gross (NTG) ratio assumption of 1.0, until such time as evaluated NTG information is available, when the assumption shall be updated on a prospective basis." (OP 1)

Net-to-Gross Ratios

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

³⁸ Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report*. Prepared for the California Public Utilities Commission.

³⁹ Gordian. (n.d.) "RSMMeans Cost Index.pdf."

⁴⁰ California Public Utilities Commission (CPUC). 2019. *Decision 19-08-009 in the Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues (R.13-11-005)*. Issued August 5. OP 1.

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.

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	N/A
Reason for Deviation from DEER	The DEER 2020 database does not include natural gas heat pump water heater baselines.
DEER Measure IDs Used	N/A
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: <i>Def-GSIA</i>
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.
	05/19/2020	Jesse Manao SCE	Correction in EAD Table: - Fixed misspelling on Load Shape. - Added "NC" MeasAppType permutations in ImplementationExAnte. - Fixed Install Hours, Labor Rate, and IE Table Name.