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| Service & Domestic Hot Water  Heat Pump Water Heater, Multifamily & Commercial, Fuel SubstitutioN  SWWH028-01 |

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Measure Name

Heat Pump Water Heater, Multifamily & Commercial, Fuel Substitution

Statewide Measure ID

SWWH028-01

Effective Date

January 1st, 2022

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 an integral tank and heat exchanger. Heat pump water heaters use a direct expansion (DX) heat pump to transfer heat to the water. 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.

Besides single unit storage heat pump water heaters, multifamily, commercial, and industrial buildings can also use central hot water heating systems. These central systems come in three general varieties: integrated heat pump with tanks, split heat pump with tanks, and standalone heat pumps.[[1]](#footnote-1) The integrated heat pump and tank systems are the most simple and available system types. They can be installed alone or as a cluster to supply a central system. The split heat pump and tank systems have separated heat pump and tank systems which aid in flexibility during installation. The standalone heat pump systems are currently the largest types of systems available and do not come with tank, but tanks are generally specified separately based on design requirements.

Central systems can include various components including several water heaters, storage tanks, expansion tanks, mixing valves, circulation or recirculation pumps, heat exchangers, and electric resistance back-up heaters.[[2]](#footnote-2) Natural gas central domestic hot water systems often have larger capacity heating equipment than the heat pumps replacing them, which creates situations where a single natural gas heater is replaced with more than one heat pump heater. These situations may require additional updates to the plumbing systems that are not required in one-to-one replacements.

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 heater[[3]](#footnote-3). 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 find more advanced, energy-efficient models that are available.

Definitions of key terms are as follows:

* Instantaneous water heater (a “tankless water heater”): eliminates energy lost to standby operation by only heating when flow sensor is activated. An instantaneous water heater is more efficient than a traditional storage water heater.[[4]](#footnote-4)
* Storage water heater: utilizes a tank of water that 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.[[5]](#footnote-5)
* Draw pattern: categorizes hot water first-hour rating and maximum flow parameters for water heaters.[[6]](#footnote-6)  See Code Requirements for draw pattern derivation.
* Uniform energy factor (UEF): an efficiency metric that is normalized based on draw pattern and taken over a 24-hour period. UEF represents the amount of energy delivered per normalized energy consumption.[[7]](#footnote-7)
* Coefficient of Performance (COP): an efficiency metric representing the net heat delivered by the water heater divided by total electrical energy consumed, when both are in the same units. [[8]](#footnote-8)

Measure Case Description

This measure includes large efficient heat pump water heaters or central water heating systems with storage volumes ≥75 gallons. Efficiency requirements for water heaters less than 100 gallons use the uniform energy factor (UEF) metric. The minimum qualifying measure efficiencies exceed the California Title 20 and Code of Federal Regulations standards (see Code Requirements).

Larger heat pump water heaters are rated by Coefficient of Performance (COP). Larger gas-fired water heaters are rated by thermal efficiency (Et).

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

Measure Case Specification

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Storage Capacity (gallons)** | **Minimum Measure Efficiency** |
| Heat Pump Water Heater | 75 ≤ to < 100 | 2.94 UEF |
| Heat Pump Water Heater | ≥100 | 4.2 COP |

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

|  |  |  |
| --- | --- | --- |
| **SW Offering ID** | **Measure Case Description** | **Base Case Description** |
| SWWH028A | Multi-Family Residential Heat Pump Water Heater, 75≤ to <100 Gal, UEF=2.94 | Storage Natural Gas Water Heater, 80 Gal, Et = 0.81 |
| SWWH028B | Multi-Family Residential Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Storage Natural Gas Water Heater, 100 Gal, Et =0.80 |
| SWWH028C | Multi-Family Residential Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Instantaneous Natural Gas Water Heater, 76 to 200 kBtuh, Et =0.83 |
| SWWH028D | Multi-Family Residential Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Instantaneous Natural Gas Water Heater, > 200 kBtuh, Et =0.83 |
| SWWH028E | Commercial Heat Pump Water Heater, 75≤ to <100 Gal, UEF=2.94 | Storage Natural Gas Water Heater, 80 Gal, Et = 0.81 |
| SWWH028F | Commercial Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Storage Natural Gas Water Heater, 100 Gal, Et =0.80 |
| SWWH028G | Commercial Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Instantaneous Natural Gas Water Heater, 76 to 200 kBtuh, Et =0.83 |
| SWWH028H | Commercial Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Instantaneous Natural Gas Water Heater, > 200 kBtuh, Et =0.83 |
| SWWH028I | Industrial Heat Pump Water Heater, 75≤ to <100 Gal, UEF=2.94 | Storage Natural Gas Water Heater, 80 Gal, Et = 0.81 |
| SWWH028J | Industrial Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Storage Natural Gas Water Heater, 100 Gal, Et =0.80 |
| SWWH028K | Industrial Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Instantaneous Natural Gas Water Heater, 76 to 200 kBtuh, Et =0.83 |
| SWWH028L | Industrial Heat Pump Water Heater, ≥100 Gal, COP=4.2 | Instantaneous Natural Gas Water Heater, > 200 kBtuh, Et =0.83 |

Base Case Description

The base case is defined as a natural gas domestic hot water heater. The measure assumes that the existing case and standard case baselines are the same.

Base Case Specification

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Storage Capacity (gallons)** | **Et.** |
| Storage Natural Gas Water Heater | 80 | 0.81 |
| 100 | 0.80 |
| Instantaneous Natural Gas Water Heater | N/A | 0.83 |
| N/A | 0.83 |

Code Requirements

This measure is governed by the California Building Energy Efficiency Standards (Title 24), California Appliance Efficiency Regulations (Title 20), and Federal Standards. Title 24 adopts the Title 20 requirements.

**Applicable State and Federal Codes and Standards**

|  |  |  |
| --- | --- | --- |
| **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 |

**Code of Federal Regulations.** In December 2016 the U.S. Department of Energy (DOE) issued a Final Ruling in Docket No. EERE-2015-BT-TP-0007 that established a new efficiency rating for all residential and some commercial water heating technologies are rated.[[9]](#footnote-9) All water heaters within the scope of the ruling will no longer be rated with the energy Factor (EF), thermal efficiency (TE), or standby loss ratings; the Uniform Energy Factor (UEF) is the new metric for the energy efficiency of water heaters. A UEF rating is determined by assigning a water heater into one of four different categories of hot water usage and then evaluating its performance based on that usage.[[10]](#footnote-10) The four categories are based on draw pattern – very small, low, medium, and high. This allows water heaters to be compared more easily between different types (i.e., storage and tankless), as long as units are compared within the same bin.

With this final ruling, the DOE established a mathematical conversion between the values determined using the ER, TE, and SL test procedures and the values determined using the uniform efficiency descriptor test procedure. The DOE used the conversion factors to derive minimum energy performance standards based on UEF. The standards denominated in UEF are neither more nor less stringent than the EF-denominated standards for consumer water heaters and for commercial water-heating equipment based on the TE and SL metrics.

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

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.2). |
| 75 gallons | No upper limit | High-Usage (Table III.4). |

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.2). |
| 4 gallons/minute | No upper limit | High-Usage (Table III.4). |

**Title 20 1605.1(f)(1) California Minimum Energy Factor Requirements for Water Heaters**



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



Normalizing Unit

Heat pump water heater input capacity in kBtu/h (Cap-kBtuh).

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’. [[11]](#footnote-11) 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 measure package pass Parts One and Two of the Fuel Substitution Test.**[[12]](#footnote-12)**

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector 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.*

*Measure implementation must comply with all local and state requirements including but not limited to Energy Standards and NEC.*

Implementation Eligibility

|  |  |  |
| --- | --- | --- |
| **Measure Application Type** | **Delivery Type** | **Sector** |
| Normal Replacement | DnDeemed | Com |
| Normal Replacement | DnDeemed | Ind |
| Normal Replacement | DnDeemed | Res |
| Normal Replacement | DnDeemDI | Com |
| Normal Replacement | DnDeemDI | Ind |
| Normal Replacement | DnDeemDI | Res |
| Normal Replacement | UpDeemed | Com |
| Normal Replacement | UpDeemed | Ind |
| Normal Replacement | UpDeemed | Res |
| New Construction | DnDeemed | Com |
| New Construction | DnDeemed | Ind |
| New Construction | DnDeemed | Res |
| New Construction | DnDeemDI | Com |
| New Construction | DnDeemDI | Ind |
| New Construction | DnDeemDI | Res |
| Accelerated Replacement | DnDeemed | Com |
| Accelerated Replacement | DnDeemed | Ind |
| Accelerated Replacement | DnDeemed | Res |
| Accelerated Replacement | DnDeemDI | Com |
| Accelerated Replacement | DnDeemDI | Ind |
| Accelerated Replacement | DnDeemDI | Res |

***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 the 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?”

1. Gas
2. Electric
3. 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 efficiency, rated capacity, and proposed commercial building type in which the product will be installed.

The above survey will not be administered for upstream delivery types.

Additionally, per direction from Resolution E-5152,[[13]](#footnote-13) the following data must be collected for upstream and midstream programs:

* SiteID – A unique identifier for the installed location of the incentivized equipment
* EquipmentID - A unique identifier for each unit of incentivized equipment on the site
* Measure Size category – General size or capacity range specific to each measure type
* Equipment manufacturer – Manufacturer of the incentivized equipment
* Equipment model number – Manufacturer number that can be used to lookup size, features, performance, etc. for the incentivized equipment
* Rated capacity – Actual size, capacity, load rating, etc. for the incentivized equipment
* Rated efficiency unit (EfficUnit) – The engineering unit basis for the efficiency or performance rating, e.g., Unit Energy Factor (UEF) or Coefficient of Performance (COP)
* Rated efficiency (ref. EfficUnit) – Efficiency or performance rating value for the Rated efficiency unit basis
* Quantity per sales transaction, project, or site – Total units of incentivized equipment located at the site or project

*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/implementer:

* What is the existing fuel type for domestic hot water 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 POE survey, or similar, should be completed. [[14]](#footnote-14)

*Required Documentation for Downstream Deemed and Direct Install*

In order to validate measure eligibility requirements, Downstream and DI programs require additional data collection beyond that required for other delivery channels, e.g., Midstream/Upstream:

* Heat pump water heater system efficiency - UEF or COP
* First-hour rating (FHR) or maximum GPM of the heat pump water heater
* Installed location (conditioned, unconditioned space)
* For installations in conditioned space, the building heating and cooling type (e.g., Packaged AC with gas furnace, packaged heat pump, central plant CHW/HW)
* Is heat pump water heater exhaust ducted to outside or unconditioned space? (Yes/no)
* Is heat pump water heater intake ducted to outside or unconditioned space? (Yes/no)

Eligible Products

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

In some cases, heat pump water heaters systems may contain multiple heat pump units. The efficiency of the measure case must be the efficiency of the system package unit not the efficiency individual heat pumps which make up the unit. Similarly, the output capacity of the system should be used for estimating incentive amounts, not individual units.

Split- (built-up) heat pump water heater systems under (not exceeding) combined system rated output capacity of 1,000 kBtu/h are eligible. The COP and full output capacity of the individual heat pumps within the system package shall be used to establish if the equipment meets measure efficiency requirements. The heat pump equipment COP and full output capacity for split systems shall be tested in accordance with Appendix E to Subpart G of Part 431 - Uniform Test Method for the Measurement of Energy Efficiency of Commercial Heat Pump Water Heaters.[[15]](#footnote-15)

Eligible Building Types and Vintages

This measure is applicable for all existing commercial and industrial building types, and multifamily residential building type.

For upstream and midstream measures, the weighted Com building type should be used for the commercial measures. As no weighted savings exist for the industrial sector, the conservative savings for the MLI building type shall be used for upstream and midstream measure in that sector.

Eligible Climate Zones

This measure is applicable in all California climate zones.

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 and/or third-party implemented programs as applicable and for each instance in addendum to measure package submissions to document program implementation practice prior to program implementation.

Program Exclusions

This measure is not typically applicable for new construction installations. However new construction is included in the measure package because new services, as defined in *Fuel Substitution Technical Guidance for Energy Efficiency*, are eligible. [[16]](#footnote-16) 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.

This measure does not include water heaters used for space conditioning, industrial (process), and pools and/or spas applications.

Light commercial systems with total heat pump output heating capacity greater than 1,000 kBtuh are NOT eligible.

Data Collection Requirements

It is understood that central domestic hot water systems in commercial or multifamily buildings are often built-up systems which consist of one or more heat pumps connected to one or more storage tanks. Efficiencies, capacities, and other operating parameters for these types of systems differ from their individual components and vary based on system configurations and local conditions. New standards and test specifications are being developed by the Northwest Energy Efficiency Alliance (NEEA) which account for the full system efficiencies for various configurations and regional climate zones. NEEA’s Advanced Water Heating Specification Version 8.0 is expected to go into effect at the beginning of 2022 and will also establish efficiency tiers and a qualified product list. [[17]](#footnote-17)

In order to understand system efficiencies being installed in the California market, the following additional data, specifically for built-up systems, shall be collected for all incentivized measures:

* Total number of heat pump water heaters in the built-up system
* Total number of storage tanks and corresponding rated storage capacity
* Hydronic system diagram including hot water piping configuration and ALL hot water heat pump heaters and storage in the system.
* Manufacturer’s system specification sheet including (total rated) system efficiency (COP/SysCOP) at standard conditions.

The data collection along with NEEA’s upcoming specification will be used to identity relevant updates to the current measure package which could encompass a more holistic view of this central water heating measure.

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

Per CPUC Decision 19-08-009, 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. [[18]](#footnote-18)

Use Category

Service & Domestic Hot Water

Electric Savings (kWh)

The unit energy savings (UES) values for a heat pump water heater are available in the 2020 version of the Database for Energy Efficient Resources. However, DEER does not include the measures supported under this measure package.

Therefore, the unit energy consumption (UEC) and UES were derived from the DEER Water Heater Calculator tool version 4.2, 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. [[19]](#footnote-19) The calculator "utilizes hourly output from the DEER2014 DOE2 building prototypes for hot water loads (in gallons per minute, by building type) and ambient conditions (incoming “mains” water temperature, ambient indoor space temperature) to estimate hourly energy use for a variety of water heaters.”[[20]](#footnote-20)

The DEER Water Heater Calculator tool version 4.2 Com building type list includes two building types which are classified as Industrial (MBT and MLI). The Com Measure IDs were duplicated for Industrial sector referencing the Com Energy Impact IDs from the DEER Water Heater Calculator tool version 4.2 which include results for MBT and MLI building types.

Updates for Multifamily Building Type

It was observed that savings associated with the multifamily water heaters were low as compared to commercial measures. This is because the annual domestic hot water consumption profile for the multifamily building type is representative of a multifamily dwelling unit. Since the measures in this measure package are intended to be central or shared water heater systems, the domestic hot water consumption should reflect the use for multiple dwelling units served by one or more HPWHs.

The calculations for measure package SWWH010-0 Boiler, Multifamily are based on Southern California Gas’s “WPSCGREWH131030A\_Rev0\_\_MF\_CentralBlr\_Tankless\_2016.xlsx” calculation spreadsheet[[21]](#footnote-21) which establishes an average dwelling unit per multifamily building. The calculation spreadsheet assumes an average of 163.50 people per building with three occupants per dwelling unit based on ASHRAE, for an average of 54 dwelling units per multifamily building.

Updates were made to the DEER Water Heater Calculator v4.2 to estimate this central multifamily water heater usage. To do this, the existing MFm dwelling unit DHW hourly consumption profile was multiplied on an hourly basis by the average number of dwelling units per multifamily building to calculate the estimated total DHW consumption for the multifamily building. This new consumption profile only accounts for dwelling unit consumption and excludes common area consumption, which is conservative.

Residential savings in the DEER calculator are automatically calculated in units of “Each” water heater as opposed to “Cap-kBtuh”. There were several adjustments made throughout the calculator to accomplish this. Since the savings for this measure package use Cap-kBtuh, the calculator was adjusted so that the water consumption for one of the commercial building types (Assembly) used the updated MFm water consumption. Additionally, inputs on the “lookup” tab were updated to use the MFm values. The table below shows the updates made to the DEER calculator by SCE:

|  |  |  |  |
| --- | --- | --- | --- |
| **DEER Water Heater Calculator Tab** | **Input [spreadsheet column]** | **Original Value for Asm Building Type** | **New Value to Adjust for MFm Building Type** |
| HWgal | Assembly building annual hot water consumption in GPM [Col C] | Asm building type hot water GPM annual profile | Scaled MFm building type hot water GPM annual hourly profile. The load profile is scaled based on 54 dwelling units per building. |
| lookup | Ambient temperature profile for indoor HPWH, (“Tamb”) [Col C] | Conditioned interior temperature profile (“CondInt”) | Multifamily temperature profile (“UnCond”) based on comments from the CPUC. [[22]](#footnote-22) |
| lookup | Peak flow in gallons per hour (“Peak GPH”) [Col J] | 253 GPH | Automatically updated from HWgal tab based on updated hot water consumption profile. |

Separate calculation workbooks were used for the commercial, industrial, and multifamily measures.

As noted by CPUC,[[23]](#footnote-23) the DEER2023 update to the water heater calculator will include hot water profiles and technologies for central multifamily building. The next revision of this measure package will adopt those new impacts.

peak electric Demand Reduction (kW)

In accordance with the requirements of the *Fuel Substitution Technical Guidance*, issued by the California Public Utilities Commission (CPUC) in October 2019, there will not be any peak demand reduction or penalty towards peak demand goal achievement from fuel substitution measures.[[24]](#footnote-24)

Gas Savings (therms)

Gas unit energy consumption and savings were calculated using the same methodology as the electric energy savings. See Electric Savings 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.

The measure EUL represents the estimated lifetime of a heat pump water heater. The RUL is based upon either a storage or tankless natural gas water heater for the accelerated replacement (AR) application type. RUL is not applicable for the normal replacement (NR) application type.

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-Com*) | 15.0 | California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update\_2014-02-05.xlsx.” |
| Baseline: RUL (yrs) (RUL ID: *WtrHt-Com*) | 5.0 | California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update\_2014-02-05.xlsx.” |
| 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-Com)* | 20.0 | California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update\_2014-02-05.xlsx.” |
| Baseline: RUL (yrs) (RUL ID: *WtrHt-Instant-Com*) | 6.67 | 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 case material costs for both the storage and instant water heater technologies were calculated as the average of equipment costs obtained through online price research from various retailer websites in the second quarter of 2021.[[25]](#footnote-25) Costs were normalized by input kBtuh of the water heaters. Because the existing case and standard case equipment are assumed to be the same, the costs are assumed to be equal.

Base case natural gas systems typically have higher heating capacities than their heat pump replacements. To account for this, the ratio of baseline gas heater capacity compared to heat pump capacity was found using the outputs from the DEER Water Heater Calculator 4.2. The average baseline and measure case heating equipment capacities used by the DEER Water Heater Calculator 4.2 were found for each measure across all associated climates zones and building types. The ratios ranged from 2.7, for the measure replacing 80 gallons storage water heaters, up to 15.3 for the measures replacing instant water heaters greater than 200 kBtuh capacity. The base equipment cost per kBtuh were multiplied by the appropriate ratio for each measure.[[26]](#footnote-26)

Measure Case Material Cost ($/unit)

Based on online research there are currently limited large storage heat pump water heater units on the market. Furthermore, information on the heat pump input capacity from publicly available vendor literature is limited.

Instead, installation costs from the 2021 All-Electric Multifamily Compliance Pathway CASE report[[27]](#footnote-27) were used to establish measure case costs. The CASE team developed several bases of design representing the following central water heater systems: low-rise garden style, low-rise loaded corridor, mid-rise mixed use, and high-rise mixed use, for both single pass and multi-pass systems.

They then collected vendor pricing based on the bases of design to determine the full install cost. However, the costs developed by the CASE team represent new construction costs. As this measure package is for retrofit applications, only the material and labor costs associated with heat pump equipment, storage tanks, sensors, controls, and commissioning were taken to be used for the measure case cost in this measure package.[[28]](#footnote-28)

Each of the CASE scenarios featured different total heating and storage capacities. Average costs from designs with storage capacities less than 100 gallons were used for the 75 to less than 100 gallon measures. The average of all the costs were used for the 100 gallon or greater storage measures. All costs were normalized based on the CASE system design case heating capacity in kBtuh. [[29]](#footnote-29)

**Infrastructure Costs**.

The conversion from a central natural gas water heating system to a heat pump system could potentially include several upgrades not associated directly with the heating equipment, such as additional/updated piping, controls, valves, tanks, or heat exchangers. Additionally, expanded electrical infrastructure is often needed to account for the higher electrical load required for the heat pump system to operate.

The 2021 CASE[[30]](#footnote-30) study includes the costs for these electrical upgrades. Similar to the measure case material costs, the total costs associated with electrical infrastructure were obtained from the report, including costs for connecting electrical circuits to new equipment, as well as panel and main service modifications. These costs range from $10,000 to $25,000 in total, with an average cost of $20,000 for the systems included. The normalized cost per heat pump system capacity was found to be $203.07 per kBtuh.

For AR measures, it is required to use the Accelerated Replacement Cost (ARC)[[31]](#footnote-31). ARC is the cost of the efficiency measure installed in an Accelerated Replacement situation. The ARC is the FMC of the efficiency measure, reduced by the net present value of the FMC that would have been incurred to install the Standard Practice second baseline equipment at the end of the RUL. The ARC is calculated using the following formula:

Where:

FMC = full measure cost

IMC = incremental measure cost

D = CPUC-adopted PA discount rate (7.66% for PG&E service territory, 7.65% for SCE service territory, 7.38% for SCG service territory, and 7.55% for SDG&E service territory)

RUL = Remaining useful life (in years) of the early retired equipment

Base Case Labor Cost ($/unit)

Similar to the measure material costs, the measure labor costs were obtained from the 2021 All-Electric Multifamily Compliance Pathway CASE Report.[[32]](#footnote-32) Refer to the “Measure Case Material Cost” section for details.

Base case natural gas systems typically have higher heating capacities than their heat pump replacements. To account for this, the ratio of baseline gas heater capacity compared to heat pump capacity was found. The average baseline and measure case heating equipment capacities used by the DEER Water Heater Calculator 4.2 were found for each measure across all associated climates zones and building types. The ratios ranged from 2.7, for the measure replacing 80 gallons storage water heaters, up to 15.3 for the measures replacing instant water heaters greater than 200 kBtuh capacity. The base labor cost per kBtuh were multiplied by the appropriate ratio for each measure. [[33]](#footnote-33)

Measure Case Labor Cost ($/unit)

Similar to the measure material costs, the measure labor costs were obtained from the 2021 All-Electric Multifamily Compliance Pathway CASE Report.[[34]](#footnote-34) Refer to the “Measure Case Material Cost” section for details.

Please refer to section “Measure Case Material Cost” for AR measure cost calculation.

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).[[35]](#footnote-35) “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 (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  California Public Utilities Commission (CPUC), Energy Division. 2019. *Fuel Substitution Technical Guidance, Version 1.1.* October 31. |

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. *Energy Efficiency Policy Manual Version 5*. 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 | Yes |
| DEER eQUEST Prototypes | No |
| DEER Version | 2021 |
| Reason for Deviation from DEER | The DEER 2021 measures did not include the specific base and measure case combinations used in this measure package. Also, a new central MFm hot water load profile was added to the calculator. Commercial building type savings were reweighted to remove the industrial building types, MLI and MBT. |
| 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: *Def-GSIA* |
| EUL/RUL | Source: DEER. The EUL value of 10 years with EUL ID: WtrHt-HtPmp  Source: DEER. The RUL value of 5 years with RUL ID: *WtrHt-Com*  Source: DEER. The RUL value of 6.67 years with RUL ID: WtrHt-Instant-Res  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-Com |

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 | 6/24/2020 | Keith Valenzuela, Engineering Manager, AESC | First draft of workpaper. |
| 01 | 9/30/2020 | Keith Valenzuela, Engineering Manager, AESC | Revised impacts per updated DEER-WaterHeater-Calculator-v4.2 |
| 01 | 9/29/2021 | Lake Casco, PE,  Kara Vega,  TRC | Changed unit to “Cap-kBtuh” instead of “each” and added update eligibility requirements.  Updated eligibility requirements to better reflect usage of central or built-up water heating systems  Updated multifamily building type savings to reflect central water heating load.  Reweighted Commercial building type impacts to remove MLI and MBT  Updated costing based on 2021 online pricing and 2021 CASE report costs. |
| 01 | 9/29/2021 | Lake Casco, PE,  Kara Vega,  TRC | In Response to CPUC comments from 10/28/2021  Removed Industrial sector specific measures and included them in the Commercial measures to align with other commercial water heating measures (SWWH027-02)  Reverted commercial weighted savings.  Clarified eligibility requirements for COP and capacity data collection for heat pump equipment  Added data collection requirements for central built-up water heating systems  Updated fuel substitution calculator |
| 01 | 12/10/2021 | Andres Fergadiotti, PE | Addendum to report refrigerant avoided cost calculations in compliance with Resolution E-5152. |

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