Work Paper SCE17WH001

**Revision 2**

**Southern California Edison Company**

**Heat Pump Water Heater**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Solution and Measure Codes:** | WH-19955, WH-19956, WH-19957, WH-19958, WH-19959, WH-19960, WH-19961, WH-19962 |
| **Measure Description:** | Heat Pump Water Heater |
| **Base Case Description:** | Electric Storage Water Heater |
| **Units:** | Water Heater |
| **Energy Savings:** | Refer to Excel Calculation Attachment |
| **Gross Measure Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Measure Incremental Cost ($/unit):** | Refer to Excel Calculation Attachment |
| **Effective Useful Life:** | 10 years (EUL\_ID: WtrHt-HtPmp) |
| **Measure Application Type:** | Replace-on-Burnout (ROB) |
| **Net-to-Gross Ratio:** | 0.7 (NTGR\_ID: All-Default<=2yrs) |
| **Important Comments:** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 11/15/17 | John Baffa (TRC) | - This work paper is an update of SCE13WH001.3  - New calculation template update for 2017 program year  - Work paper is updated with 2016 Title-24 Residential code requirement and 2016 Title 20 code language.  - Solution Code WH-18930 has been removed and replaced with multiple new solution codes for different water heater sizes and efficiencies  - Measure and Base costs from WO017 and online retailers has been included for the new solution codes.  - All (16) California Climate Zones have been added to the calculation template.  -Savings from DEER 2017. |
| 2 | 10/17/18 | John Baffa (TRC) | -Converted EF to UEF values in measure names to match new Federal standards.  -Update to new Federal Code language stating UEFs. |

**Commission Staff and Cal TF Comments**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

The measures covered in this work paper involve replacing Title 20 code complaint Electric Water Heaters with Heat Pump Water Heaters of UEF 3.09 or above.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Heat Pump Water Heater (Various sizes and efficiencies) |
| Existing Condition | N/A |
| Code/Standard | Title 20 Compliant Electric Water Heaters (EF = 0.94 or greater, UEF=0.92) |
| Industry Standard Practice | Heat Pump Water Heater (UEF=2.91) for Base Capacities Above 55 Gallons |

**Measures and Codes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| N/A | N/A | WH-19955 | N/A | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.09) replaces ≤35 gallon Electric water heater (UEF = 0.92) |
| N/A | N/A | WH-19956 | N/A | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.31) replaces ≤35 gallon Electric water heater (UEF = 0.92) |
| N/A | N/A | WH-19957 | N/A | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.09) replaces >35 to 45 gallon Electric water heater (UEF = 0.92) |
| N/A | N/A | WH-19958 | N/A | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.31) replaces >35 to 45  gallon Electric water heater (UEF = 0.92) |
| N/A | N/A | WH-19959 | N/A | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.09) replaces >45 to 55 gallon Electric water heater (UEF = 0.92) |
| N/A | N/A | WH-19960 | N/A | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.31) replaces >45 to 55  gallon Electric water heater (UEF = 0.92) |
| N/A | N/A | WH-19961 | N/A | Efficient water heater: >55 to 75 gallon HP Elec (UEF=3.33) replaces >55 to 75 gallon Electric water heater (UEF=2.91) |
| N/A | N/A | WH-19962 | N/A | Efficient water heater: >75 gallon HP Elec (UEF=3.42) replaces >75 gallon Electric water heater (UEF=3.00) |

**Measure Requirements**

* “Instantaneous” and “tank less” water heaters do not qualify.
* The installed water heater storage capacity must be 50 gallons or greater.
* Only residential-style electric storage water heaters qualify for this rebate. A list of qualifying residential water heaters is at: [www.sce.com/appliances](http://www.sce.com/appliances).

**Market Applicability**

This measure is applicable to single-family, multi-family, and double-wide mobile home residential building types. The most significant barrier to water heater retrofit is the existing nature of water heater replacement. Two-thirds of consumers replace their water heaters due to the sudden failure of their existing water heater. When a water heater suddenly fails, most consumers purchase replacements that are the cheapest and most readily available model that are 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.

## 1.2 Technical Description

Conventional electric-resistance water heaters usually consist of a glass-lined steel tank with foam insulation. Energy efficient units have greater amount of insulation. Located at the base and top end of the tank are two electrical heating elements. Cold water enters the base of the tank and is heated by the lower electrical heating element. The water then rises to the top portion of the tank. This is where the hot water is drawn for consumption. During periods of high demand, the electrical heating element located at the top end of the tank can be turned on to provide additional water heating.

Heat pump water heaters heat water using a heat pump, allowing them to achieve much higher efficiency (energy factor), compared to electric-resistance water heaters. Similar to electric-resistance water heaters, most heat pump water heaters consists of a glass-lined steel tank with foam insulation. Heat pump waters water heaters are typically equipped with supplemental electric-resistance elements for periods of high demand.

## 1.3 Application Types and Delivery Mechanism

The delivery method for the above measure is:

* Financial Support / Down-Stream Incentive –Deemed
* Up-Stream Programs/ Up-Stream Incentive
* Mid-Stream Programs/ Mid-Stream Incentive

The program/install type for the above measure is:

* Replace on Burnout (ROB)

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Mid-Stream Programs | *See Mid-Stream Incentive in the Incentive Method Descriptions table.* |
| Up-Stream Programs | *See Up-Stream Incentive in the Incentive Method Descriptions table.* |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Up-Stream Incentive | The program gives a financial incentive to an upstream market actor (manufacturer or distributor) to encourage the manufacture, provision, or distribution of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive  Mid-Stream Buy Down | The program gives a financial incentive to a midstream market actor (distributor, vendor, or retailer) to encourage the promotion of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |
| On-bill Finance – Loan (OBF) | The program offers financing for the cost of an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |
| Up-Stream Incentive  Up-Stream Buy Down | The program gives a financial incentive to an upstream market actor (manufacturer or distributor) to encourage the manufacture, provision, or distribution of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

This work paper uses data from DEER 2017, which lists data for Heat Pump Water Heaters (HPWHs) replacing a base case Electric Storage Water Heaters (ESWHs).

**DEER Difference Summary**

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes |
| Scaled DEER measure | No |
| DEER Base Case | Yes – (Converted EF to UEF) |
| DEER Measure Case | Yes – (Converted EF to UEF) |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER 2017, READI v2.5.1 |
| Reason for Deviation from DEER | Federal Code switched from EF to UEF |
| DEER Measure IDs Used | Various – Refer to section 2. |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| All-Default<=2yrs | All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years | Any | Any | Any | 0.7 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The Installation Rate (IR) values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| WtrHt-HtPmp | Heat Pump Water Heater | Res | SHW | 10 | 3.3 |

### 1.4.2 Codes and Standards Analysis

The measures in this work paper are considered small water heaters. A small water heater can be defined as an ESWH with an input of 12 kW or less, or a HPWH rated at 24 amps or less. The following codes apply to the measures in this work paper:

**Title 20 (2016) [508]**

Section 1605.1(f)(2) provides minimum Energy Factor requirements for ESWHs and HPWHs:

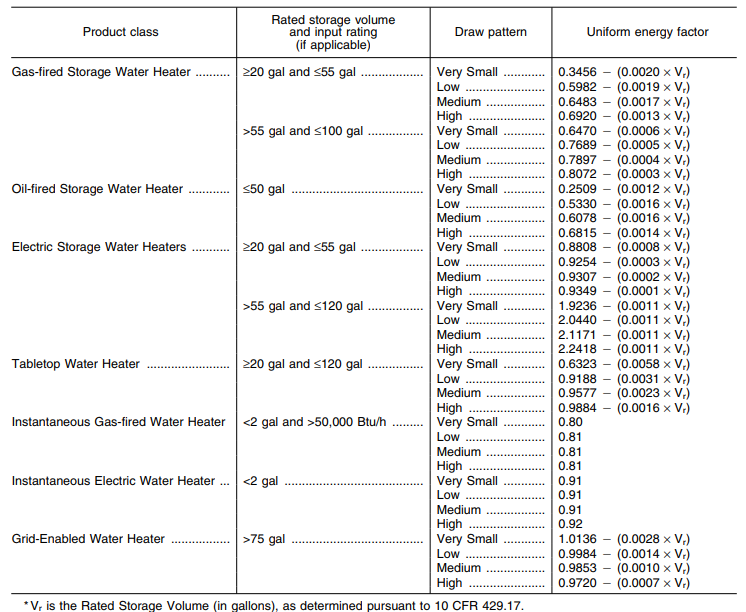
|  |
| --- |
|  |

**Title 24 (2016) [496]**

Section 110.1 references the requirements set in Title 20.

**Federal Standards – Code of Federal Regulations [393]**

The Code of Federal Regulations, 10 CFR 430.32(d) provides requirements for ESWHs but not HPWHs.



Note: Beginning June 12th, 2017, EF ratings were replaced with the new industry standard for measuring energy efficiency in water heaters, known as the Uniform Energy Factor (UEF). However, Title 20 and DEER are still using EF and have not been updated yet. Energy Star currently has certification requirements for either EF or UEF. This work paper and the associated solution codes have been converted to UEF from EF, using the equations in the calculation methodology section.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Applicable Code Reference** | **Effective Dates** |
| Title 24 (2016) | Section 110.1 Mandatory Requirements for Appliances | January 1, 2017 |
| Title 20 (2016) | Section 1605.1(f)(2) | January 1, 2017 |
| Code of Federal Regulations | 10 CFR 430.32(d) | January 1, 2017 |

**1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case**

The CPUC’s Revised DEER 2017 + DEER 2018 updates webinar (Attachment 4) shows that the 2012 California Lighting and Appliance Saturation Survey (CLASS) data reveals electric storage water heaters are not typically installed at 60 and 75 gallon capacities. Because of this, DEER set the base case for these sizes to be Heat Pump Water Heaters with EF=3.0 as ISP, which was determined based on the EFs of lower efficiency HPWHs on the market.

**1.5.1 Non-DEER Study Review**

For the residential application of this measure, data from the California Residential Saturation Survey (RASS) [195] indicates that approximately 7.1% of residential dwellings in SCE territory use electricity for domestic water heating.

**1.6 Data Quality and Future Data Needs**

# SCE’s proposed standard practice study, if approved by the CPUC, will investigate the existing customers’ operation of evaporative coolers, when installed in parallel to their existing DX cooling system. The Human Error Adjustment Factor (HEAF) requires that only one mechanical system at a time can operate, and this will be made clear to the customer. However, the customer may forget to do so and end up operating both DX and evaporative systems simultaneously. Therefore, a human error adjustment factor is required to de-rate savings. As there have been no studies performed to measure this particular factor, the HEAF has been set at 75% until this proposed study yields a more conclusive value. This version of the workpaper assumes that up to 25% of the savings will be lost due to non-ideal operation of the evaporative cooler and DX system.

# Section 2. Calculation Methodology

DEER 2017 has measures which replace an ESWH with a HPWH (UEF = 3.09 or greater). The new code efficiency formula for an ESWH was used to determine the base case efficiency. The following example uses a 40 gallon tank:

EF = 0.960-(0.0003xV) where V= volume, gal

EF = 0.960-(0.0003x40) = 0.948

The EF is then converted to the UEF, using the following equations:

For Heat Pump Water Heaters:

NEW UEF = 0.1513 + 0.8407 x EF + 0.0043\*DV

For Electric Storage Water Heaters:

NEW UEF = 0.4774 + 0.4740 x UEFWHAM

Where UEFWHAM is a coefficient determined based on EF, efficiency, and the draw pattern.

Energy savings are determined by comparing the annual energy usage of a heat pump water heater HPWH (UEF = 3.09 or greater) with an ESWH base case electric storage water heater.  Baseline and proposed efficiencies vary by storage capacity (Attachment 4). Savings values were taken directly from DEER 2017 [49] using the READI Tool v2.5.1 and are included in the table below. These results have not been modified and are only being included in the work paper for reference. All 16 California Climate Zones are included.

**DEER and READi Tool Outputs**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Code** | **DEER IDs** | **Measure Name** | **READI Data** |
| WH-19955 | RE-WtrHt-SmlStrg-HP-lte12kW-rep30G-3p24EF | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.09) replaces ≤35 gallon Electric water heater (UEF = 0.92) |  |
| WH-19956 | RE-WtrHt-SmlStrg-HP-lte12kW-rep30G-3p50EF | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.31) replaces ≤35 gallon Electric water heater (UEF = 0.92) |  |
| WH-19957 | RE-WtrHt-SmlStrg-HP-lte12kW-rep40G-3p24EF | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.09) replaces >35 to 45 gallon Electric water heater (UEF = 0.92) |  |
| WH-19958 | RE-WtrHt-SmlStrg-HP-lte12kW-rep40G-3p50EF | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.31) replaces >35 to 45  gallon Electric water heater (UEF = 0.92) |  |
| WH-19959 | RE-WtrHt-SmlStrg-HP-lte12kW-rep50G-3p24EF | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.09) replaces >45 to 55 gallon Electric water heater (UEF = 0.92) |  |
| WH-19960 | RE-WtrHt-SmlStrg-HP-lte12kW-rep50G-3p50EF | Efficient water heater: 50 to 55 gallon HP Elec (UEF=3.31) replaces >45 to 55  gallon Electric water heater (UEF = 0.92) |  |
| WH-19961 | RE-WtrHt-SmlStrg-HP-lte12kW-rep60G-3p50EF | Efficient water heater: >55 to 75 gallon HP Elec (UEF=3.33) replaces >55 to 75 gallon Electric water heater (UEF=2.91) |  |
| WH-19962 | RE-WtrHt-SmlStrg-HP-lte12kW-rep75G-3p50EF | Efficient water heater: >75 gallon HP Elec (UEF=3.42) replaces >75 gallon Electric water heater (UEF=3.00) |  |

Since these measures are ROB, the code or “Std” baseline savings from DEER 2017 are used. The Calculation Template (Attachment 1) shows these savings values.

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Residential Single Family | HeatPump\_WtrHt-RC | Residential |
| Residential Multi-Family | HeatPump\_WtrHt-RC | Residential |
| Residential Mobile Home - Double-Wide | HeatPump\_WtrHt-RC | Residential |

# Section 4. Costs

## 4.1 Base Case Cost

Base case material costs are from the Electric Storage Water Heater section of 2010-2012 WO017 [475] for electric storage water heaters of 30, 40, and 50 gallons, and online retailer prices for material base cases involving Heat Pump Water Heaters above 55 gallons. All labor costs are derived from the Electric Storage Water Heater section WO017.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Solution Code** | **BASE Cost ID** | **Material** | **Labor** | **Total** |
| WH-19955 | Stor\_EF-Elec-030gal-0.95EF | $566.57 | $295.47 | $862.04 |
| WH-19956 | Stor\_EF-Elec-030gal-0.95EF | $566.57 | $295.47 | $862.04 |
| WH-19957 | Stor\_EF-Elec-040gal-0.94EF | $626.01 | $313.12 | $939.13 |
| WH-19958 | Stor\_EF-Elec-040gal-0.94EF | $626.01 | $313.12 | $939.13 |
| WH-19959 | Stor\_EF-Elec-050gal-0.93EF | $685.46 | $330.76 | $1,016.22 |
| WH-19960 | Stor\_EF-Elec-050gal-0.93EF | $685.46 | $330.76 | $1,016.22 |
| WH-19961 | SCE17WH001\_02\_B001 | $1,599.00 | $348.41 | $1,947.41 |
| WH-19962 | SCE17WH001\_02\_B002 | $1,760.62 | $374.87 | $2,135.49 |

**4.2 Measure Case Cost**

Heat Pump Water Heaters of 3.24 EF or greater are not included in 2010-2012 WO017 [475]. Measure case costs were taken from online retailers. Not many products were available in the market for Heat Pump Water Heaters above 3.00 EF. Costs were found using limited available resources. Labor costs were considered to be the same as the base case costs, taken from the Electric Storage Water Heater section of WO017 [475].

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Solution Code** | **Measure CostID** | **Material** | **Labor** | **Total** |
| WH-19955 | SCE17WH001\_02\_M001 | $1,339.25 | $330.76 | $1,670.01 |
| WH-19956 | SCE17WH001\_02\_M002 | $1,199.00 | $330.76 | $1,529.76 |
| WH-19957 | SCE17WH001\_02\_M001 | $1,339.25 | $330.76 | $1,670.01 |
| WH-19958 | SCE17WH001\_02\_M002 | $1,199.00 | $330.76 | $1,529.76 |
| WH-19959 | SCE17WH001\_02\_M001 | $1,339.25 | $330.76 | $1,670.01 |
| WH-19960 | SCE17WH001\_02\_M002 | $1,199.00 | $330.76 | $1,529.76 |
| WH-19961 | SCE17WH001\_02\_M003 | $1,699.00 | $348.41 | $2,047.41 |
| WH-19962 | SCE17WH001\_00\_M004 | $1,899.00 | $374.87 | $2,273.87 |

**4.3 Full and Incremental Measure Cost**

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| WH-19955 | ROB | $807.97 | $807.97 | N/A |
| WH-19956 | ROB | $667.72 | $667.72 | N/A |
| WH-19957 | ROB | $730.88 | $730.88 | N/A |
| WH-19958 | ROB | $590.63 | $590.63 | N/A |
| WH-19959 | ROB | $653.79 | $653.79 | N/A |
| WH-19960 | ROB | $513.54 | $513.54 | N/A |
| WH-19961 | ROB | $103.00 | $103.00 | N/A |
| WH-19962 | ROB | $138.38 | $138.38 | N/A |

# Attachments

1. SCE17WH001.2 A1 - Calculation Template
2. SCE17WH001.2 A2 - Energy Impacts
3. SCE17WH001.2 A3 - Costs Calculations
4. SCE17WH001.2 A4 DEER Webinar

# References

References\_07112018\_101102

|  |  |
| --- | --- |
| [195] | California Statewide Residential Appliance Saturation Study (RASS) Web site |
| [393] | Code of Federal Regulations Title 10 - Energy |
| [475] | 2010-2012 WO017 Ex Ante Measure Cost Study Final Report (pgs 88 & 356) |
| [496] | 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24) |
| [508] | 2016 Appliance Efficiency Regulations (Title 20) |