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| **Service & Domestic Hot Water**  Heat Pump Water Heater, Commercial  SWWH031-01 |

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Measure Name

Heat Pump Water Heater, Commercial

Statewide Measure ID

SWWH031-01

Technology Summary

Conventional electric-resistance water heaters usually consist of a glass-lined steel tank with foam insulation. Energy efficient units have a greater amount of insulation. Located at the base and top end of the tank are two electrical heating elements. Cold water enters the bottom of the tank and is heated by the lower electrical heating element. The water then rises to the top portion of the tank, 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 use a direct expansion (DX) heat pump to transfer heat to the water. The heat pump condenser coils are located inside the insulated water storage tank where the flow of hot refrigerant is used to heat the water. In many heat pump water heaters, referred to as hybrid heat pump water heaters, supplemental electric resistance heating elements exist to meet heating requirements when the heat pump system cannot meet them alone. Cold water enters the base of the tank and is heated by condenser coils. The hot water then rises and continues to be heated by the condenser coils until the heated water is drawn for consumption at the top of the tank. Heat pump water heaters achieve higher efficiency compared to electric-resistance water heaters. Like electric-resistance water heaters, most heat pump water heaters consist of a glass-lined steel tank with foam insulation. Heat pump water heaters 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 their existing water heater's sudden failure.[[1]](#footnote-2) When a water heater fails, most consumers will purchase a replacement that has the lowest price 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:

* 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.[[2]](#footnote-3)
* Draw pattern: categorizes hot water first-hour rating and maximum flow parameters for water heaters.[[3]](#footnote-4)  See Code Requirements for draw pattern derivation.
* Uniform energy factor (UEF): an efficiency metric that is normalized based on draw pattern and taken over 24 hours. UEF represents the amount of energy delivered per normalized energy consumption.[[4]](#footnote-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 regulations.[[5]](#footnote-6) The minimum qualifying measure efficiencies are based on the DEER water heater calculator tool version 4.2 and 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 the following characteristics.

Measure Case Specification

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

The offerings include replacing specific existing base case electric water heaters with the measure case equipment specified above.

|  |  |  |
| --- | --- | --- |
| **SW Offering ID** | **Measure Case Description** | **Base Case Description** |
| SWWH031A | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09 (Com) | Storage Electric Water Heater, less than 35 Gallons, Medium Draw, 0.92 UEF |
| SWWH031B | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31 (Com) | Storage Electric Water Heater, less than 35 Gallons, Medium Draw, 0.92 UEF |
| SWWH031C | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09 (Com) | Storage Electric Water Heater, 35 to less than 45 Gallons, Medium Draw, 0.92 UEF |
| SWWH031D | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31 (Com) | Storage Electric Water Heater, 35 to less than 45 Gallons, Medium Draw, 0.92 UEF |
| SWWH031E | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09 (Com) | Storage Electric Water Heater, 45 to less than 55 Gallons, Medium Draw, 0.92 UEF |
| SWWH031F | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31 (Com) | Storage Electric Water Heater, 45 to less than 55 Gallons, Medium Draw, 0.92 UEF |
| SWWH031G | Heat Pump Water Heater, >55 to ≤65 Gal, UEF=3.33 (Com) | Heat Pump Water Heater, 55 to less than 65 gallons, 2.91 UEF |
| SWWH031H | Heat Pump Water Heater, >65 Gal, UEF=3.42 (Com) | Heat Pump Water Heater, more than 65 gallons, 3.00 UEF |
| SWWH031I | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09 (Ind) | Storage Electric Water Heater, less than 35 Gallons, Medium Draw, 0.92 UEF |
| SWWH031J | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31 (Ind) | Storage Electric Water Heater, less than 35 Gallons, Medium Draw, 0.92 UEF |
| SWWH031K | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09 (Ind) | Storage Electric Water Heater, 35 to less than 45 Gallons, Medium Draw, 0.92 UEF |
| SWWH031L | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31 (Ind) | Storage Electric Water Heater, 35 to less than 45 Gallons, Medium Draw, 0.92 UEF |
| SWWH031M | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.09 (Ind) | Storage Electric Water Heater, 45 to less than 55 Gallons, Medium Draw, 0.92 UEF |
| SWWH031N | Heat Pump Water Heater, >45 to ≤55 Gal, UEF=3.31 (Ind) | Storage Electric Water Heater, 45 to less than 55 Gallons, Medium Draw, 0.92 UEF |
| SWWH031O | Heat Pump Water Heater, >55 to ≤65 Gal, UEF=3.33 (Ind) | Heat Pump Water Heater, 55 to less than 65 gallons, 2.91 UEF |
| SWWH031P | Heat Pump Water Heater, >65 Gal, UEF=3.42 (Ind) | Heat Pump Water Heater, more than 65 gallons, 3.00 UEF |

Base Case Description

The base case measure is defined as an electric storage water heater with a 30, 40, or 50-gallon storage volume. This workpaper assumes that the existing case and standard case baselines use the same code compliant equipment. The minimum base case efficiencies align with the Code of Federal Regulations standards (see Code Requirements).

The California Public Utilities Commission (CPUC) Energy Division webinar on 2019 Database of Energy Efficient Resources (DEER) and the DEER 2017 and 2018 Updates[[6]](#footnote-7) presented an analysis of the 2012 California Lighting and Appliance Saturation Survey (CLASS) data[[7]](#footnote-8) that showed electric storage water heaters are not typically installed at 65 and 80-gallon capacities. Baselines reflect code UEFs and those on the market based on AHRI/CEC database analysis and are taken directly from the DEER Water Heater

Calculator v4.2.

Base Case Specification

|  |  |
| --- | --- |
| **Storage Capacity (gallons)** | **Efficiency (UEF)** |
| < 35 | 0.92 |
| < 35 ≤ 45 | 0.92 |
| < 45 ≤ 55 | 0.92 |
| < 55 ≤ 75 | 2.91 |
| > 75 | 3.00 |

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. The minimum baseline efficiencies are based on Federal Standards, which exceed 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.[[8]](#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.[[9]](#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

Each

Program Requirements

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. The 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) for which this measure is applicable.

Implementation Eligibility

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

Eligible Products

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.

In some cases, heat pump water heaters may contain multiple heat pump units. The efficiency of the measure case must be the efficiency of the package unit, not the efficiency of individual heat pumps that make-up the unit.

Split-system heat pump unit assemblies are eligible. However, they shall be treated as one package of one or more heat pumps serving a storage tank. Efficiency and performance ratings for the entire package shall be provided by the manufacturer. The efficiency of an individual heat pump within the package shall not be sufficient.

Eligible Building Types and Vintages

This measure is applicable to all existing commercial and industrial building types.

Eligible Climate Zones

This measure is applicable in all California climate zones.

*Required Data Collection for All Measures*

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

* Measure case equipment specifications including:
  + Manufacturer and model number
  + UEF
  + Storage volume in gallons
  + First Hour Rating (FHR)
* Customer site information including:
  + Climate Zone
  + Building Type (for downstream measures)

Incentive Requirements

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

Program Exclusions

Replacement of an "instantaneous" or "tankless" water heaters does not qualify. A new heat pump water heater with a storage capacity of less than 45 gallons does not qualify. New construction measures are only eligible for Downstream application, when[[10]](#footnote-11):

* 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

Data collection requirements include the customer location, building type, replacement type (if downstream), and installed equipment quantity and capacity.

Use Category

This technology must serve service & domestic hot water end uses only. Equipment installed in commercial and industrial processes, such as clothes washing, food preparation, and non-potable industrial heating processes are not eligible for this measure.

Electric Savings (kWh)

The unit energy savings (UES) values for a heat pump water heater are available in the 2021 version of the Database of Energy Efficient Resources (DEER). The DEER UES values include system sizing assumptions ranging from 30 to 120 nominal gallons.

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.[[11]](#footnote-12) The calculator "utilizes hourly output from the DEER2014 DOE-2 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."[[12]](#footnote-13)

The DEER Water Heater Calculator tool version 4.2 includes a Com building list, which includes two building types, which are classified as Industrial (MBT and MLI). New Energy Impact IDs and Measure IDs were created for the Industrial sector for use with MBT and MLI building types.

peak electric Demand Reduction (kW)

Peak demand reduction is calculated in the DEER Water Heater Calculator v4.2. The calculator implements a detailed NREL event schedule to capture the peak loads for commercial buildings. This schedule is different from that used for energy (kWh) calculations. An 8760 hourly peak demand profile is generated from the NREL schedule for each climate zone. Annual demand impact is then calculated as the average kWh reduction over the defined DEER peak period. Demand reduction is calculated from the difference between the baseline and measure demand impacts.

Gas Savings (therms)

Not applicable.

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. EUL is often, but not always, derived from measure persistence or retention studies. 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 EUL specified for the heat pump water heater is specified below.

**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.” |
| Baseline: RUL (yrs) (RUL ID: *WtrHt-Com*) | 5.0 | California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update\_2014-02-05.xlsx.” |

Base Case Material Cost ($/unit)

The workpaper will reference SWWH014-02 Heat Pump Water Heater - Residential, costs. Due to the size of the units, it is assumed costs would be the same for commercial and residential material costs. Baseline cost data for the 30, 40, and 50 gallon water heaters was collected using online web scraping of applicable electric water heaters during the second quarter of 2020.[[13]](#footnote-14) Retailers referenced include Home Depot, Lowes, Grainger, Menards, SupplyHouse, and Supply.com. Costs were averaged based on relevant storage capacity bins. Only electric water heaters with UEFs relevant to the baseline were included. Online retailer prices were also used for base cases involving heat pump water heaters with a storage capacity greater than 55 gallons (specifically, 60 and 75-gallon capacities) and were collected during the same period as the measure case costs. Although these capacities greater than 55 gallons are not the same as those used in the savings sections of this workpaper, the difference does not make an appreciable impact on costs. These costs were determined to be representative of unit costs based on online retailer checks in the first quarter of 2020.

Measure Case Material Cost ($/unit)

Measure case equipment costs[[14]](#footnote-15) were calculated as the average of costs of qualifying units sold by online retailers.[[15]](#footnote-16) The market is limited for heat pump water heaters ≥ 3.00 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 2020.

Base Case Labor Cost ($/unit)

Due to the size of the units, it is assumed costs would be the same for commercial and residential installation. The estimated installation hours for each of the baseline water heater technologies and capacities in the workpaper were obtained from RSMeans 2020[[16]](#footnote-17) and multiplied by the RSMeans 2020 hourly plumber rate ($/hr).[[17]](#footnote-18)

Measure Case Labor Cost ($/unit)

The estimated installation hours for each of the heat pump water heater capacities in the workpaper were obtained from RSMeans 2020[[18]](#footnote-19) and multiplied by the RSMeans 2020 hourly plumber rate ($/hr).[[19]](#footnote-20) Labor hours for heat pump water heaters were not specifically called out, so the hours for electric water heaters were used and are assumed to be applicable.

Net-to-Gross (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention.

Net-to-Gross Ratios

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| NTG – Com-Default>2yrs | 0.6 | 2011 Deer Database 2011 Update Documentation |
| NTG – Ind-Default>2yrs | 0.6 | 2011 Deer Database 2011 Update Documentation |

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 | No |
| 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 Hot Water Calculator version 4.2 uses a default Norm Unit of per kBTUh. This workpaper uses a Norm Unit of per Each. |
| DEER Measure IDs Used | N/A |
| NTG | Source: DEER. The NTG of 0.6 is associated with NTG ID: NTG – Com-Default>2yrs & NTG – Ind-Default>2yrs |
| 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 |

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 | 12/23/2020 | Michael Frischmann, Principal, EcoMetric Consulting | First draft of workpaper. |
| 12/06/2021 | Akhilesh Endurthy, Solaris-Technical, LLC. | Addendum to report refrigerant avoided cost calculations in compliance with Resolution E-5152. |

1. Ciani, A. (Russell Research). 2018. Water Heater Market Characterization Report. Prepared for the Northwest Energy Efficiency Alliance (NEEA). Report # E18-395. April 3. [↑](#footnote-ref-2)
2. ENERGY STAR. (n.d.) “How it Works – High-Efficiency Gas Storage Water Heaters.” [↑](#footnote-ref-3)
3. 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. [↑](#footnote-ref-4)
4. Healy, B. (National Institute of Standards and Technology, NIST). (n.d.) “Water Heating Technologies and Ratings.” [↑](#footnote-ref-5)
5. 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. [↑](#footnote-ref-6)
6. California Public Utilities Commission (CPUC), Energy Division. 2017. “DEER2019 and Revised DEER2017 + DEER2018 Updates.” July 18. [↑](#footnote-ref-7)
7. DNV GL. 2014. WO21: Residential On-site Study: California Lighting and Appliance Saturation Study (CLASS 2012). Prepared for the California Public Utilities Commission, Energy Division. CALMAC Study ID: CPU0095.01. [↑](#footnote-ref-8)
8. 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. Vol. 81, No. 250. December 29. [↑](#footnote-ref-9)
9. A.O. Smith. (n.d.) “What Does UEF Mean To You?”  [↑](#footnote-ref-10)
10. California Public Utilities Commission (CPUC), Energy Division. 2019. Fuel Substitution Technical Guidance, Version 1.1. October 31. Page 3. [↑](#footnote-ref-11)
11. California Public Utilities Commission (CPUC), Energy Division. 2020. DEER2021 DEER Water Heater Calculator. " DEER-WaterHeater-Calculator-v4.2.xlsm." Updated September, 2020. [↑](#footnote-ref-12)
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13. Southern California Edison (SCE). 2020. " SWWH025-02 MeasureDataSpec.xlsm", Cost Data tab [↑](#footnote-ref-14)
14. Southern California Edison (SCE). 2018. "SCE17WH001.2 A3 - Costs Calculations.xlsx." [↑](#footnote-ref-15)
15. Heat pump water heaters of 3.24 EF or greater were not included in 2010-2012 Ex Ante Measure Cost Study conducted by Itron, Inc. [↑](#footnote-ref-16)
16. 2020 RSMeans Electrical Cost Data [↑](#footnote-ref-17)
17. RSMeans 2020 Residential Labor Rates. https://www.rsmeansonline.com/References/LABORRATE/2-Year%202020%20Labor%20Rates/Residential%20Labor%20Rates.PDF [↑](#footnote-ref-18)
18. 2020 RSMeans Electrical Cost Data [↑](#footnote-ref-19)
19. RSMeans 2020 Residential Labor Rates. https://www.rsmeansonline.com/References/LABORRATE/2-Year%202020%20Labor%20Rates/Residential%20Labor%20Rates.PDF [↑](#footnote-ref-20)