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| Heat pump pool heater, Residential – Fuel Substitution  SWRE005-01 |

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Measure Name

Heat Pump Pool Heater, Residential – Fuel Substitution

Statewide Measure ID

SWRE005-01

Technology Summary

Pool water heaters are types of hot water heaters that are designed to tolerate the chemicals found in pool water. Similar to heat pump water heater systems, heat pump pool heaters are energy efficient pool heaters that use the vapor compression cycle rather than natural gas to heat incoming water. Unlike natural gas pool heaters which burn gas to generate heat, these systems take heat from the ambient air and move it to the pool water. This operation makes heat pump pool heaters capacity and efficiency dependent on ambient outdoor air temperatures. At lower temperatures their capacities and efficiencies reduce, but they can operate efficiently above temperatures between 45°F-50°F[[1]](#footnote-1).

**CEE High Efficiency Residential Swimming Pool Initiative (Consortium of Energy Efficiency, 2012).**[[2]](#footnote-2) The Consortium of Energy Efficiency(CEE) identified several promising opportunities for increased energy efficiency of residential swimming pools, including pool motors, pool timers, robotic cleaners, pool covers, and pool heaters. The CEE initiative utilized the U.S. Department of Energy (DOE) 2009 Residential Energy Consumption Survey (RECS) to determine market potential. In particular, of the 8 million U.S. households with a pool (in-ground and above-ground) with filtration equipment, 2.1 million have pool heaters. Of these households, 1.1 million use a natural gas heater that consume an average 38 million BTU/yr. The 2009 RECS also indicates that 6.4 million U.S. households have hot tub or spa heaters, 1.5 million of which are natural gas heaters. The RECS estimated that natural gas spa heaters consume an average of 35.9 million BTU/yr. Conversion to electric heat pump pool heaters has the potential to greatly reduce or eliminate this natural consumption.

**2009 California Residential Appliance Saturation Study (KEMA, Inc., 2010).[[3]](#footnote-3)** The study presents key findings from the 2009 California Residential Appliance Saturation Study (RASS) that was sponsored by the California Energy Commission (CEC). The study yielded unit energy consumption estimates for 27 electric and 10 natural gas residential end uses and appliance saturations for households within the California territories of the participating utilities. Data was collected through a mail survey that requested households to provide information on appliances, equipment, and general consumption patterns. The RASS study reports that pool heating and spa heating for a single family home in Southern California use approximately 220 and 52 therms/yr, respectively.

Measure Case Description

This measure is defined as the replacement of a standard efficiency natural gas-fired pool water heater with an energy efficient heat pump (HP) with a minimum COP of 5.5. The measure case equipment will exceed the Title 20 code requirements for a Coefficient of Performance (COP) of 3.5. See Code Requirements.

Due to pool size consideration and heating load requirements, different measure offerings for single family residences and multifamily common areas are offered. This measure is limited to installations of single heat pump systems due to concerns of excessive costs and noise impacts (single HP pool heaters generally range between 55db-65db[[4]](#footnote-4)).

Measure Offerings

|  |  |  |  |
| --- | --- | --- | --- |
| **Statewide Measure Offering ID** | **Measure Application Type** | **Base Description** | **Measure Description** |
| SWRE005A | Normal Replacement | Standard Efficiency Natural Gas Pool Heater in Single Family Pool | Efficient Heat Pump Pool Heater in Single Family Pool |
| SWRE005B | Normal Replacement | Standard Efficiency Natural Gas Pool Heater in Common Area Pool | Efficient Heat Pump Pool Heater in Common Area Pool |
| SWRE005C | Accelerated Replacement | Standard Efficiency Natural Gas Pool Heater in Single Family Pool | Efficient Heat Pump Pool Heater in Single Family Pool |
| SWRE005D | Accelerated Replacement | Standard Efficiency Natural Gas Pool Heater in Common Area Pool | Efficient Heat Pump Pool Heater in Common Area Pool |

Base Case Description

The base case is defined as a residential gas-fired pool water heater with a minimum thermal efficiency (TE) stipulated by the Federal Code of Regulations and California Appliance Efficiency Regulations (Title 20). See Code Requirements.

For accelerated replacement (AR) measures, the existing case is also assumed to be a Title 20 compliant natural gas pool heater. Thus, both the first and second baseline for AR measures are the same.

Based on the 2015 State-wide IOU Multifamily Pools study[[5]](#footnote-5), of the pools that were heated, natural gas heaters were the dominant technology in the market. Thus, natural gas heaters are assumed to be the standard practice technology.

Code Requirements

The California Appliance Efficiency Regulations (Title 20) requires a minimum coefficient of performance (COP) of 3.5 for heat pump pool heaters and a minimum thermal efficiency (TE) of 82% for all natural residential pool water heaters.[[6]](#footnote-6)

Per § 1605.3. State Standards for Non-Federally-Regulated Appliances, Energy Efficiency Standard for Heat Pump Pool Heaters. For heat pump pool heaters manufactured on or after March 1, 2003, the average of the COP at Standard Temperature Rating and the COP at Low Temperature Rating shall not be less than 3.5.

Per Title 24 2019 Section 110.4(b).2 the installation of any pool or spa equipment in a heated pool shall be installed with an outdoor pool cover.

Applicable State and Federal Codes and Standards

|  |  |  |
| --- | --- | --- |
| Code | **Applicable Code Reference** | **Effective Date** |
| CA Appliance Efficiency Regulations – Title 20 2019 | Section 1605.1.(g).1 | January 1, 2019 |
| CA Appliance Efficiency Regulations – Title 20 2019 | Section 1605.3(g).3 | January 1, 2019 |
| CA Building Energy Efficiency Standards – Title 24 2019 | Section 110.4 | January 1, 2020 |
| Federal Standards | 10 CFR Part 430.32 | April 16, 2013 |

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]](#footnote-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 Test.’[[8]](#footnote-8)

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.*

Implementation Eligibility

|  |  |  |
| --- | --- | --- |
| **Measure Application Type** | **Delivery Type** | **Sector** |
| Normal replacement (NR) | DnDeemed | Residential |
| Normal replacement (NR) | DnDeemDI | Residential |
| Normal replacement (NR) | UpDeemed | Residential |
| Accelerated replacement (AR) | DnDeemDI | Residential |

For upstream/mid-stream delivery method, the participant baselines are unknown and the spillover effects are unknown. The manufacturer or distributor does not 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]](#footnote-9). The implementer shall survey 10% of the mid-stream and upstream installations, to determine actual gas/electric baseline proportions, and the program administrator shall adjust claimed savings based upon these survey results.

Eligible Products

The heat pump pool heater must meet the minimum COP requirements in the Measure Case Description. The COP value used to verify the eligibility of the product should be the High Air Temperature - Mid Humidity value from the AHRI database.

This measure is eligible for heated pools installed in single family residential, and mobile home and multifamily “common areas” such as homeowner association properties and/or multifamily properties. The measure is limited to installations of single heat pump systems due to concerns of excessive costs, structural requirements, and noise impacts, among others.

Heat pump pool heaters typically have larger footprints than the base case natural gas pool heaters which may necessitate site upgrades such as larger concrete pads or supports and/or additional structural requirements. Implementers should consider all necessary installation requirements when pursuing this measure.

Pool heaters have minimum flow requirements which may be greater than minimum pool filter pump minimum flows. Implementer shall ensure that pool heater has an integrated safety shut-off feature that disabled equipment when minimum flows are not met or install an interlock (per heater’s manufacturer recommendation) with existing pool pump(s) to ensure minimum flows are met during equipment operation.

Measure implementation shall comply with all applicable Codes and Regulations including but not limited to latest versions of California Energy Standards Title 24, Part 6; the California Building Code; and National Electric Code. Since the installation of pool covers are required for alterations of pool equipment systems, Implementer shall insure that existing pool already includes a pool cover OR that as part of measure implementation a pool cover is install in full compliance with Code..

Eligible Building Types and Vintages

This measure is applicable for a pre-existing pool of a residential single family, multifamily, or mobile home for all existing building vintages. The single family pool measures, SWRE005A and SWRE005C, are only eligible for single family buildings. The common area pool measures, SWRE005B and SWRE005D, are only eligible for multifamily and mobile home buildings.

Eligible Climate Zones

This measure is applicable in all California climate zones.

Required Documentation for Accelerated Replacement

Preponderance of evidence (POE) must be documented. Notably, programs shall document if the 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. This must include whether the pool is for single family or multifamily common area
* Specifications of existing equipment
* Proof that natural gas pool water heater is still operating as intended
* Existing water heater nameplate data with manufacturer date to confirm remaining useful life
* Pool water temperature setpoint
* Replacement heat pump pool water heater information

To document POE, the provided Preponderance of evidence (POE) survey[[10]](#footnote-10), or similar, should be completed.

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

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

* What is the existing fuel type for pool 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 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 capacity, and proposed building type in which the product will be installed.

A survey will not be administered for upstream delivery types.

*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 workpaper submissions to document program implementation practice prior to program implementation.

Program Exclusions

As this is a fuel substitution measure, it is only eligible for replacement of existing gas equipment.

Spa equipment is not eligible.

Data Collection Requirements

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

Per CPUC Decision 19-08-009[[11]](#footnote-11), 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.

This workpaper currently uses DEER load shape “DEER:RefgFrzr\_Recyc-UnConditioned ” as it is the best approximation of this measure available. Future updates to this workpaper should evaluate latest CPUC load shape updates and/or create a new load shape more align with application.

Use Category

Recreation

Electric Savings (kWh)

See the Gas Savings section for details on the electric savings.

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.[[12]](#footnote-12)

Gas Savings (Therms)

The annual gas unit energy savings (UES) of a residential heat pump pool were calculated as the difference between baseline and measure case annual unit energy consumption (UEC). Since the measure case is an electric heat pump, the gas savings is simply the consumption of the baseline gas heater. There is also an electric energy penalty that is equal to the consumption of the heat pump.

This workpaper adopts the same calculation methodology and calculation tool as the CPUC approved SWRE001-01 Pool Cover and SWRE004-01 Pool and Spa Heater, Residential workpapers.[[13]](#footnote-13) Some modifications were made to the calculation tool in order to accommodate the inclusion of heat pump technologies. These modifications are described in the following sections.

Methodology

The annual UEC calculations are based on a pool heat transfer model. The pool heat transfer model was developed for swimming pools in California to ascertain the benefits of using efficient pool heaters at various types of swimming pools.

In general, the hourly change in the average pool water temperature is equal to the sum of the heat transferred into the pool each hour, divided by the specific heat of the pool.

*qin = Heat added to the pool via each heat transfer mechanism (BTU/hr)*

*ρw = Density of water (lb/ft3)*

*Cw = Specific heat of water (BTU/lb-°F)*

*Apool = Pool area (ft2)*

*dpool = Average pool depth (ft)*

The UES calculation accounts for the following heat transfer mechanisms:[[14]](#footnote-14)

* Natural gas-fired or heat pump pool heater to maintain the pool water temperature
* Solar direct radiative heating of the pool surface (reduced by shading and atmospheric clearness factor, which includes haze and cloud cover)
* Evaporative cooling from the pool surface
* Radiation heat transfer from the pool surface to the sky
* Convection heat transfer from the pool surface to the air (free convection under calm conditions, forced convection when windy)
* Conduction heat transfer from the pool water to the piping and the soil
* Heating the makeup water needed to replace pool water lost by evaporation.

Pool Heat Transfer Model

Annual BTU UEC was calculated for baseline and measure conditions to determine the energy savings. The BTU values were converted to either natural gas therms for the base case or electric kWh for the measure case to provide the final impact values.

The climate zone data was determined from the pool location in California. The incident solar radiation was determined using a centrally located airport weather station within each climate zone. NREL TMY3 weather files were used for this analysis.[[15]](#footnote-15)

Pool heaters do not have a regular heater operating pattern. Therefore, this analysis assumed a short pool heater operating schedule and calibrated the energy use with the pre-determined baseline.

The hourly baseline and measure case UEC values were calculated using the Pool Cover and Pool Heater Energy Savings calculator developed by ICF International.[[16]](#footnote-16) The pool heat transfer model was validated against the Energy Smart Pools software program (RSPEC!).[[17]](#footnote-17)

Heat Pump Performance Data

The following section details changes made to the original pool calculator to accommodate the use of heat pump water heater measure cases.

Unlike natural gas heaters, the performance of heat pumps is dependent upon ambient outdoor temperatures. To adjust heat pump performance across the year, this workpaper adopts a methodology similar to what is used in the DEER Water Heater Calculator v4.1[[18]](#footnote-18), which uses a COP adjustment factor. The COP adjustment factor scales the heat pump nominal COP by a factor based on a calculated relationship with ambient temperature. For this workpaper, the relationship between the wet-bulb temperature and heat pump COP for all eligible products is used.

Heat pump pool heater product data comprising of 311 models was extracted from the Air Conditioning, Heating, and Refrigeration Institute (AHRI) in August of 2020[[19]](#footnote-19) and filtered for heat pumps that meet the Title 20 minimum COP of 3.5. AHRI Standard 1160-2014[[20]](#footnote-20) is the method by which both Federal and Title 20 code require testing for heat pump pool heaters. This standard requires that heat pumps be tested at three sets of standard conditions which produce different heat pump capacities and COPs. See the table below for the standard test conditions.



A linear regression between the test wet-bulb temperature and heat pump COP for all heat pump models in the AHRI database was performed and the correlation is shown below.[[21]](#footnote-21)



These values represent the linear regressions for the AHRI data.[[22]](#footnote-22)

| **Slope** | **Intercept** | **R-Squared** |
| --- | --- | --- |
| 0.0572 | 1.4626 | 0.8455 |

Using the linear fit regression from the AHRI data, the estimated COP at each of the test conditions are shown below.[[23]](#footnote-23)

| **Test Condition** | **Test Wet Bulb Temperature (°F)** | **COP at WB Temperature** |
| --- | --- | --- |
| High Air Temperature - High Humidity Heating | 75.8 | 5.8 |
| High Air Temperature - Mid Humidity Heating | 71.2 | 5.5 |
| Low Air Temperature - Mid Humidity | 44.3 | 4.0 |

The weather dependent COP adjustment is calculated hourly by using the wet-bulb field from the climate zone’s weather file and dividing by the COP from the standard test condition to find the COP adjustment factor[[24]](#footnote-24). The High Air Temperature - Mid Humidity Heating was selected as the most representative test condition for the California pool season, so the COP value at that test condition is used as the normalizing value for the adjustment factor. The adjustment factor is calculated as follows:

Where:

And

The adjusted COP value is calculated in the tool hourly by multiplying the heat pumps nominal COP by the adjustment factor.

The hourly TMY weather files used in the calculation are from NREL and do not directly provide wet-bulb temperatures. The following equation from Stull estimates the wet-bulb temperature by using the dry-bulb temperature and relative humidity.[[25]](#footnote-25)



Per the study, the formula is accurate to within 0.54 °F for temperatures within the range of -4° F and 122° F and relative humidities between 5% and 99%. Since heat pumps for this analysis are assumed to run only during the operating season of May to September, this was deemed reasonable for the purposes of this workpaper. The calculator uses this equation to estimate the hourly wet-bulb temperature to be used in the COP adjustment equations.

Inputs and Assumptions

Baseline Consumption Calibration

To verify the baseline gas heating for swimming pools in single family residential homes, gas consumption bills were collected from customers with a heated pool in five different cities in Southern California. A billing analysis was done to baseline the home’s heating and water heating energy usage. Data for regional heating degree days (HDDs) were collected and charted against the monthly gas usage from the billing data. A linear regression analyses identified the relationship between heating gas usage and HDDs. The gas usage at the point where the linear regression line intercepts the Y-axis at zero HDDs was deemed non-space heating gas usage and assumed to be for hot water heating and other indoor gas uses. The difference between the annual gas usage and the calculated loads were attributed to the swimming pools and spa heating.[[26]](#footnote-26)

Utility Bill Heat Load Regression Analysis

Capacity and Efficiency Assumptions

Since the normalizing COP is found by using the High Air Temperature - Mid Humidity, the measure nominal efficiency used in the calculator reflects the efficiency at that test condition. An analysis of the AHRI database shows the following values for the COP at the High Air Temperature - Mid Humidity test conditions[[27]](#footnote-27):

| **Dataset Count** | **Average COP** | **Median COP** | **Minimum COP** | **Maximum COP** |
| --- | --- | --- | --- | --- |
| 311 | 5.54 | 5.50 | 4.10 | 6.80 |

A COP of 5.5 was selected for the measure case in this analysis since it is representative of both the average and median COP values in the dataset.

Many inputs to the pool heater calculator have been adopted from the previous CPUC approved SWRE004 – Residential Pool and Spa Heater workpaper. This includes pool operating characteristics such as water temperature, open season, and pool schedule, as well has pool physical characteristics such as wind shielding factor, activity factor and average pool depth. The pool surface area and baseline natural gas pool heater capacity from SWRE004 were also adopted for the single family pool calculations.

For common area pools, the pool surface area was calculated by using the weighted average pool volume of 27,527 gallons from SCE’s 2016 multifamily pool pump report [[28]](#footnote-28) and the 4.5 foot average depth from SWRE004. [[29]](#footnote-29)

The base case multifamily natural gas boiler capacities are based on the California Energy Commission appliance database and SCE’s 2016 multifamily pool pump report [[30]](#footnote-30). The list of base case gas pool heater models was downloaded from the CEC appliance database and the average capacity of the 236 entries in the database was found to be 360 kBTU/hr[[31]](#footnote-31). Furthermore, the average pool heater size from SCE’s 2016 multifamily pool pump report was found to be 352 kBTU/hr[[32]](#footnote-32). Thus, a baseline natural gas pool heater of 350 kBTU/hr is used for the multifamily pools in this analysis.

Baseline natural gas pool heaters are often oversized for their pool heating applications.[[33]](#footnote-33) Thus, heat pump pool heaters will usually have lower heating capacities than the natural gas heaters that they are replacing. This results in longer pool heating time but does not greatly affect the total energy required to heat the pool because the pool load (heat losses) does not change.

The US Department of Energy provides the following formula to estimate heat pump pool heater sizing based on pool surface area and temperature rise requirements:[[34]](#footnote-34)

The temperature rise is calculated as the difference in temperature setpoint of the pool water and the average temperature for the coldest month of the pool operating season. Using the TMY NREL weather data and the 80°F pool water setpoint from the pool calculator,[[35]](#footnote-35) the temperature rise for each climate zone was calculated. The analysis showed an average of 101 kBTU/hr and 166 kBTU/hr for single family and multifamily common area pools, respectively.[[36]](#footnote-36)

To further explore measure heat pump sizing, heat pump pool heater models were downloaded from the CEC appliance and AHRI databases.[[37]](#footnote-37) The average pool heater capacity of the 197 entries in the CEC database was found to be 105 kBTU/hr and the median was found to be 110 kBTU/hr. Likewise, the average heat pump pool heater capacity of the 311 entries in the AHRI database was found to be 103 kBTU/hr and the median was found to be 110 kBTU/hr. Furthermore, the heat pump pool heater size selected in a 2019 cost effectiveness study for single family pools prepared for the SDGE Codes and Standards team was 110 kBTU/hr.[[38]](#footnote-38)

To be conservative, a measure case heat pump pool heater of 110 kBTU/hr is used for the single family pool in this analysis. The multifamily common area pool capacity used for this analysis is 166 kBTU/hr based on the DOE sizing analysis.

The table below shows the inputs to the analysis tool and their sources.

UEC Calculation Inputs - Pool Heater

| **Variable** | **Description** | **Value** | **Source** |
| --- | --- | --- | --- |
| *Tpool* | Desired water temperature (°F) | 80 °F | Southern California Gas Company (SCG). 2017 "Pool Heater Energy Savings model.pdf.” |
| *FS* | Solar Shading Factor | 10% |
| *FW* | Wind Shield Factor | 50% |
| *Fa* | Pool Activity Factor | 0.5 |
| *Season* | Pool Season Start and End Dates | 5/1-9/30 |
| *Hours* | Season Open Hours | 12:00 PM-6:00PM |
| *dpool* | Average depth (ft) | 4.5 |
| *Apool* | Pool surface area (ft2) – Single Family Pools | 500 |
| *Apool* | Pool surface area (ft2) – Multi-family Common Area Pools | 818 | ADM Associates, Inc. 2016. “Metering and Measuring of Multi-Family Pool Pumps, Final Report – Phase 1 & 2”. Prepared for Southern California Edison, San Diego Gas and Electric, Southern California Gas, and Pacific Gas and Electric.  Calculated using 4.5 feet average depth in file Southern California Edison (SCE). 2021. " SWRE005-01 HP Pool Heater Analysis Summary.xlsx" |
| ȠPre Avg | Baseline thermal efficiency (TE, %) | 82% | California Energy Commission (CEC). 2019. 2019 Appliance Efficiency Regulations. CEC-140-2019-002 |
| Q*pre pool* | Baseline Gas Pool heater capacity (kBTU/hr) – Single Family Pools | 300 | Southern California Edison (SCE). 2021. " SWRE005-01 HP Pool Heater Analysis Summary.xlsx" |
| Q*pre pool* | Baseline Gas Pool heater capacity (kBTU/hr) – Multi-family Common Area Pools | 350 |
| ƞpost Avg | Measure Coefficient of Performance (COP) | 5.5 |
| Q*post pool* | Measure Heat Pump Pool heater capacity (kBTU/hr) – Single Family Pools | 110 |
| Q*post pool* | Measure Heat Pump Pool heater capacity (kBTU/hr) – Multi-family Common Area Pools | 166 |

Pool Cover Weighting

The use of a pool cover drastically reduces the amount of pool heating required by the heater. The installation of pool covers on new residential pools has been a requirement of Title 24 since the 2008 code cycle[[39]](#footnote-39). However, the use of pool covers is dependent upon the behavior of the owner of the pool. Based on the 2004 study from Koeller and Company,[[40]](#footnote-40) from a population of 38 residential pools in Southern California, only 42% of pools were found to use their pool covers. To account for the usage of pool covers on the energy consumption of the pool heaters, a weighted savings is used assuming that 42% of pools use covers and 58% of pools do not.

The pool heater calculation tool includes the ability to add pool covers to the analysis.[[41]](#footnote-41) For each set of calculations the same pool cover was assumed to cover 100% of the pool and be the same material in both the base and measure case calculations. Each pool cover has a different thermal resistance (R-value) which impacts the insulation that the pool cover provides. The pool calculator has three built-in options for pool covers. Their descriptions and R-values are included in the table below.

| **Pool Cover Type** | **Description** | **R-Value**  **(hr-ft2 -ׄF/Btu)** |
| --- | --- | --- |
| Vinyl | Soft vinyl pool covers that are stretched over the pool to keep out debris and prevent heat loss through evaporation, but they provide little insulating value. | 0.1 |
| Bubble/Solar | Made from a highly buoyant, air-filled bubble material that provides insulation and prevents heat loss through evaporation. | 1.5 |
| Insulated | Woven, high-density, UV stabilized polyethylene fabric outer layers and cross-linked polyethylene foam sandwiched between the outer layers. This pool cover provides the best insulation. | 2 |

The UES values with each of the pool cover options and the option with no cover were calculated for each climate zone using the inputs stated above. The findings were weighted based on assuming that 58% of pools have no cover and 42% of the pools use covers. For the sake of this analysis, the average UES values between all three pool cover types is used for the representative pool cover savings. The final savings per climate zone is calculated with the formula below:

The same savings values are assumed for common area pools in both MFm and DMo building types within the same climate zone. For accelerated replacement (AR) measures, the existing case is also assumed to be a Title 20 compliant natural gas pool heater. Thus, both the first and second baseline savings for AR measures are the same.

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 methodology to calculate the RUL conforms with Version 6 of the Energy Efficiency Policy Manual, which recommends “one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values.”[[42]](#footnote-42) This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.[[43]](#footnote-43) Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised add-on measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component.” [[44]](#footnote-44)

The EUL and RUL for a residential pool heater are specified below. An EUL ID specifically for a residential heat pump pool heater is not available. Since the technologies are both similar, in that they are both air to water heat pumps, the EUL for a residential heat pump water heater is used for the measure case.

A gas water heater for a pool heater is expected to have a similar expected lifetime as a pool pump. Additionally, an EUL ID specifically for a residential pool heater is not available. Thus, the EUL for a residential pool pump is adopted for the baseline natural gas pool heater. The estimated lifetime of a high-efficiency pool pump was derived from a Codes and Standards Enhancement (CASE) initiative study that assessed the impact of proposed revisions to the California Appliance Efficiency Regulations (Title 20) relating to pools and spas.[[45]](#footnote-45)

Effective Useful Life and Remaining Useful Life

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| EUL (Years)  EUL ID: WtrHt-HtPmp | 10 | California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update\_2014-02-05.xlsx.”  This EUL will be used for the heat pump pool heater. |
| EUL (Years)  EUL ID: OutD-PoolPump | 10 | Davis Energy Group and Energy Solutions. 2004. Codes and Standards Enhancement Initiative for PY2004: Title 20 Standards Development - Analysis of Standards Options for Residential Pool Pumps, Motors, and Controls. Prepared for Pacific Gas and Electric (PG&E). May 12.  This EUL will be used for the natural gas pool heater. |
| RUL (Years)  EUL ID: OutD-PoolPump | 3.3 | Davis Energy Group and Energy Solutions. 2004. Codes and Standards Enhancement Initiative for PY2004: Title 20 Standards Development - Analysis of Standards Options for Residential Pool Pumps, Motors, and Controls. Prepared for Pacific Gas and Electric (PG&E). May 12.  This RUL will be used for the natural gas pool heater. |

Base Case Material Cost ($/unit)

Base case material cost data was collected using online retailer data of applicable natural gas pool heaters during the fourth quarter of 2020.[[46]](#footnote-46) The prices were collected from the two most popular online retailers, Leslie Pools and Inyo Pools, and included brands such as Hayward, Jacuzzi, Raypack, Pentair, and Sta-Rite. Unit capacity ranged between 150 and 406 kBTU/hr, with an average capacity of 293 kBTU/hr. Unit efficiencies ranged between 82% and 84% thermal efficiency, with an average of 83%.

A linear regression of equipment cost versus heater capacity in kBTU/hr was performed using the collected data. The base costs were found using the linear regression formula and the single family and common area natural gas pool heater capacities assumed in the calculations.

Measure Case Material Cost ($/unit)

Measure material cost data was collected using online retailer data of applicable heat pump pool heaters during the fourth quarter of 2020.[[47]](#footnote-47) The prices were collected from the two most popular online retailers, Leslie Pools and Inyo Pools, and included brands such as Hayward, Jacuzzi, Raypack, Pentair, and Aquacal. Units capacity ranged between 36 and 143 kBTU/hr, with an average capacity of 109 kBTU/hr. Unit COPs ranged between 5.50 and 6.80, with an average of 5.86.

A linear regression of equipment cost versus heater capacity in kBTU/hr was performed using the collected data. The measure costs were found using the linear regression formula and the single family and common area heat pump pool heater capacities assumed in the calculations.

**Infrastructure Costs**. For a natural gas pool heater to heat pump pool heater installation, infrastructure upgrades would include capping off the natural gas line, adding a larger amperage service to the existing breaker, running 240V power to the heater, and potentially expanding the heater’s concrete pad. Existing gas pool heaters will typically only use a 20A breaker, but heat pump pool heaters will generally need a higher amperage service such as a 50A. Furthermore, heat pump pool heaters often have a larger footprint than gas pool heaters so an expansion of the pool heater’s concrete pad may be needed. These infrastructure costs were estimated using 2021 RSMeans Online data[[48]](#footnote-48) and online retailer costs. RSMeans hourly labor rates for a residential electrician and plumber[[49]](#footnote-49) were used to estimate labor costs. See the table below for details and the cost calculations for additional details.[[50]](#footnote-50)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description of Work** | **Labor Hours** | **Labor Cost** | **Material Cost** | **Total Cost** |
| Add 50A service to breaker feeding pool area | 1.29 | $89.59 | $130.82 | $220.41 |
| Run new wiring and cabling for higher service power, estimating about 50’ | 2.5 | $173.63 | $30.53 | $204.15 |
| Expand concrete pad for HP Pool Heater, estimating 5’x5’ pad added | 1.6 | $107.84 | $65.60 | $173.44 |
| Cap Existing Gas Line. Brass Plug for Natural Gas lines. | 0.25 | $16.85 | $4.04 | $20.89 |
| **Total** | **5.64** | **$387.91** | **$230.99** | **$618.89** |

Base Case Labor Cost ($/unit)

The estimated installation hours for the baseline natural gas pool heater were obtained from RSMeans 2021[[51]](#footnote-51) and multiplied by the RSMeans 2021 hourly plumber rate ($/hr).[[52]](#footnote-52) This labor assumes a retrofit application and excludes labor for new piping, wiring, or concrete pad.

Measure Case Labor Cost ($/unit)

The estimated installation hours for the heat pump pool heater measure were obtained from RSMeans 2021[[53]](#footnote-53) and multiplied by the RSMeans 2021 hourly plumber rate ($/hr).[[54]](#footnote-54) Labor hours for heat pump pools heaters were not specifically provided in RSMeans so the hours for the natural gas pool heaters were used. The RSMeans description of the labor for the natural gas pool heaters excludes any wiring or piping that would differentiate heat pump from the natural gas heater so the same cost is assumed to be applicable.

Net-to-Gross (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. Based on the CPUC’s Fuel Substitution Technical Guidance for Energy Efficiency[[55]](#footnote-55) document, the value below should be used for fuel substitution measures until further data is available.

NTGR 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. |

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. This GSIA rate is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment

|  |  |  |
| --- | --- | --- |
| **Parameter** | **GSIA** | **Source** |
| GSIA - Default | 1.00 | California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31. |

Non-Energy Impacts

Non-energy benefits for this measure have not been quantified.

DEER Differences Analysis

This section provides a summary of inputs and methods based upon the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Comment** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | No |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | None |
| Reason for Deviation from DEER | DEER does not contain Energy Efficient Heat Pump Pool Heaters. |
| DEER Measure IDs Used | None |
| 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 2014. The value of 10 years is associated with *EUL ID: WtrHt-HtPmp.*  The value of 3.3 years is associated with RUL ID: *OutD-PoolPump.* |

Revision History

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision Number** | **Revision Complete Date** | **Primary Author, Title, Organization** | **Revision Summary and Rationale for Revision** |
| 01 | 07/01/21 | Lake Casco PE, TRC  Kara Vega, TRC  Andres Fergadiotti, SCE | First draft of workpaper. |
|  | 12/06/2021 | Lake Casco PE, TRC | Addendum to report refrigerant avoided cost calculations in compliance with Resolution E-5152. |

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