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RECREATION
POOL OR SPA HEATER, RESIDENTIAL
SWRE004-01

CONTENTS

MEASURE NAME

Pool or Spa Heater, Residential

STATEWIDE MEASURE ID

SWRE004-01

TECHNOLOGY SUMMARY

Pool and spa water heaters are types of commercial hot water boilers that are designed to tolerate the chemicals found in pool and spa water. Therefore, heaters use Cupro-nickel heat exchangers and tubing that provide greater durability compared to the standard copper units. Cupro-nickel alloy metals tolerate fluctuating pH levels and salts in the water.

An energy efficient pool or spa water heater may have one or more of the following features: more insulation, high efficiency/low NOx burners, power burners, relatively large heat exchanger surfaces, and flue exhaust heat recovery systems.

CEE High Efficiency Residential Swimming Pool Initiative (Consortium of Energy Efficiency, 2012).[1] 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.

The CEE study also provided the following analysis:

- In 1990, gas-fired pool heaters were required to have a TE of 78% . On April 16, 2013 the required thermal efficiency (TE) increased to 82%. Energy savings from this change is approximately 1.6 MMBtu/yr per unit.
- A pool heater with 78.2% TE consumes about 34.1 MMBtu/yr, whereas a pool heater with 82% TE consumes 32.5 MMBtu/yr.
- The most efficient pool heaters in the market have a 95% TE and consume about 27.8 MMBtu/yr, which equates to energy savings of 6.3 MMBtu/yr per unit over the 1990 standard (78%) or 18% savings and 4.7 MMBtu/yr per unit over the 2013 standard (82%) or 15% savings.

[1] Consortium for Energy Efficiency (CEE). 2012. *CEE[SM] High Efficiency Residential Swimming Pool Initiative.* December.

2009 California Residential Appliance Saturation Study (KEMA, Inc., 2010).[2] 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

The measure case is defined as an energy efficient pool or spa heater with a thermal efficiency (TE) that meets the measure requirements below. Tier 1 denotes high-efficiency natural gas non-condensing heaters and Tier2 denotes high-efficiency natural gas condensing boilers. Tier 2 models may require additional modifications to the existing system configuration as the flue requirements are substantially different than the non-condensing alternative.

Measure Offerings

Statewide Measure Offering ID	Measure Offering Description
SWRE004A	Pool and Spa Heaters in Residential Buildings - 84% TE
SWRE004B	Pool and Spa Heaters in Residential Buildings - 90% TE

BASE CASE DESCRIPTION

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

CODE REQUIREMENTS

This measure is not governed by federal regulations. The California Appliance Efficiency Regulations (Title 20) requires a minimum thermal efficiency (TE) of 82% for all residential pool and spa water heaters.[3]

[2] KEMA, Inc. 2010. *2009 California Residential Appliance Saturation Survey. Volume 2: Results.* Prepared for the California Energy Commission. CC-200-2010-004.

[3] California Energy Commission (CEC). 2017. *2016 Appliance Efficiency Regulations*. CEC-400-2017-002.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2016)	1605.1(g)	April 16, 2013
CA Building Energy Efficiency Standards – Title 24	N/A	N/A
Federal Standards	N/A	N/A

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. 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
New Construction (NC)	DnDeemed	Residential

Proper documentation, such as equipment specification from CEC database, that verifies the thermal efficiency (TE) of the replacement heater must be submitted with the incentive application.

Eligible Products

The pool or spa heater must meet measure requirements in the Measure Case Description.

If the heater will be installed in a low NOx area, the replacement unit must also meet NOx emissions standards set forth by the governing air quality management district.

Eligible Building Types and Vintages

This measure is applicable for a pre-existing pool or spa of a residential single-family dwelling.

Eligible Climate Zones

This measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

None.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined. Field test data and an M&V plan may help verify savings. The plan can vary in depth and scope, but could include spot measurements or monitoring of pool heater use, and/or utility bill analysis.

USE CATEGORY

Recreation

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ELECTRIC SAVINGS (KWH)

Not applicable.

PEAK ELECTRIC DEMAND REDUCTION (KW)

Not applicable.

GAS SAVINGS (THERMS)

The annual gas unit energy savings (UES) of a residential pool and spa heater were calculated as the difference between baseline and measure case annual unit energy consumption (UEC).

Methodology

The annual gas UEC calculations are based on both a pool heat transfer model and a spa 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. The pool heat transfer model was modified slightly to determine the annual energy savings of the spa heater measures.

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.

$$\Delta T_{pool} = \frac{\Sigma q_{in}}{\rho_w C_w A_{pool} d_{pool}}$$

q_{in} = *Heat added to the pool via each heat transfer mechanism (Btu/hr)*

ρ_w = *Density of water (lb/ft³)*

C_w = *Specific heat of water (Btu/lb-°F)*

A_{pool} = *Pool area (ft²)*

d_{pool} = *Average pool depth (ft)*

The UES calculation accounts for the following heat transfer mechanisms:[4]

- Natural gas-fired 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 gas UEC was calculated for baseline and measure conditions to determine the energy savings.

The climate zone was determined from the pool location in California. The incident solar radiation was determined at a centrally located airport weather station within each climate zone.

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.[5] The pool heat transfer model was compared to one of the most accurate swimming pool energy savings calculation methods, the Energy Smart Pools software program (RSPEC!).[6]

Spa Heat Transfer Model

A major difference between a pool and a spa is the manner in which the spa heater capacity is determined. The spa heater is sized to bring the spa water temperature from ambient (when the spa has been closed and the spa heater has been turned OFF for many days) to the desired temperature in a fixed time (assumed to be two hours before opening). The minimum ambient temperature is assumed to be the average air temperature during the coldest month of the year.

The rated input of the spa heater is thus equal to the mass of the spa water times its specific heat, times the temperature change, divided by the thermal efficiency (TE) of the spa heater, divided by two hours.

The annual gas UEC for the baseline and measure case conditions were calculating using the Pool Cover and Pool Heater Energy Savings calculator that was developed for calculating heat losses from swimming

[4] Southern California Gas Company (SCG). 2018. "SWRE001 Pool Cover, Commercial Detailed Savings Methodology."

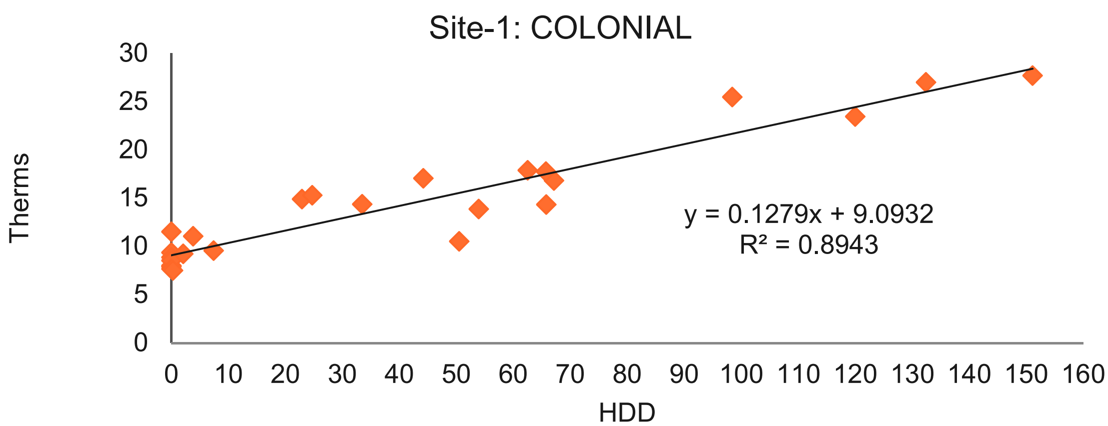
[5] Southern California Gas Company (SCG). 2018. "Pool Cover Summary & Savings Calculations 2018.xlsm."

[6] R.L. Martin & Associates, Inc. Energy Smart Pools Software (RSPEC!). (n.d.) Accessed July 4, 2012 at: http://www.rlmartin.com/rspec/software.htm.

pools. A minimum change of the input data was required - the pool surface area used in the pool heat loss calculation was replaced with the spa surface area.

Inputs and Assumptions

To verify the baseline gas heating for swimming pools and spas in residential homes, gas consumption bills were collected from customers with a heated pool or spa in five different cities in Southern California. A billing analysis were 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.[7]



Utility Bill Heat Load Regression Analysis

UEC Calculation Inputs - Pool Heater

Variable	Description	Value	Source
A_{pool}	Pool surface area (ft^2)	500	Southern California Gas Company (SCG). 2017 "Pool Heater Energy Savings model.pdf."
d_{pool}	Average depth (ft)	4.5	
T_{pool}	Desired water temperature (°F)	80 °F	
Q_{pool}	Pool heater capacity (MBtu/hr_	300	
$\eta_{post\ Avg}$	Measure case thermal efficiency (TE, %)	85%	
$\dot{V}_{post\ Avg}$	Baseline thermal efficiency (TE, %)	82%	California Energy Commission (CEC). 2017. *2016 Appliance Efficiency Regulations*. CEC-400-2017-002.

[7] Southern California Gas Company (SCG). 2017. "Customers database and heating baseline analysis.xlsx."

UEC Calculation Inputs - Spa Heater

Variable	Description	Value	Source
$\dot{V}_{spa}$	Spa capacity (gal)	600	Southern California Gas Company (SCG). 2017 "Spa Heater Energy Savings model.pdf."
d_{spa}	Footwell depth (ft)	3	
T_{spa}	Desired water temperature (°F)	90 °F	
Q_{spa}	Spa heater capacity (MBtu/hr)	200	
$\eta_{post\ Avg}$	Measure case thermal efficiency (TE, %)	85%	
η_{base}	Baseline thermal efficiency (TE, %)	82%	California Energy Commission (CEC). 2017. *2016 Appliance Efficiency Regulations*. CEC-400-2017-002.

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 5 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."[8] This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.[9] 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." [10]

The EUL and RUL for a residential pool or spa heater are specified below. A gas water heater for a pool or spa is expected to have a similar expected lifetime as a pool pump. Additionally, an EUL ID specifically for a residential pool or spa heater is not available. Thus, the EUL for a residential high efficiency pool pump is adopted for this measure. 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.[11] Note that RUL is only applicable for add-on equipment and accelerated replacement measures and is not applicable for this measure.

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[8] California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

[9] KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

[10] California Public Utilities Commission (CPUC). 2016. Resolution E-4807. December 16. Page 13.

[11] 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.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	10.0	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.
RUL (yrs)	n/a	-

BASE CASE MATERIAL COST ($/UNIT)

The base case material and labor costs were derived from data on equipment models downloaded from the California Energy Commission (CEC) Modernized Appliance Efficiency Database System (MAEDbS) data and from equipment vendors that sell pool water heaters in California. The table below represents an arithmetic average of the cost per MBtu/hr in each category.

Base Case Cost Inputs [12]

Heater Size (MBtu/hr)	Thermal Efficiency (% TE)	Equipment Cost ($)	Labor Cost ($)	Material Cost ($)
Base Case 400 MBtu/hr Pool Heater	82%	$2,089	$800	$0

MEASURE CASE MATERIAL COST ($/UNIT)

The measure case material and labor costs were derived from data on equipment models downloaded from the California Energy Commission (CEC) Modernized Appliance Efficiency Database System (MAEDbS) data and from equipment vendors that sell pool water heaters in California. For the purposes of determining incremental measure costs, the installation and start-up costs are assumed to be the same for the base case and Tier-I measure case equipment. However, the incremental measure cost for the condensing pool heater (Tier-II) includes costs for plumbing and exhaust parts. Lastly, the pricing below for tier I is from heaters with efficiency range of 84%-86% so 85% is shown as the pricing efficiency mean and similarly the pricing for tier II is from heaters with efficiency range of 94%-98% so 96% is shown as the pricing efficiency mean.

Measure Case Cost Inputs [13]

Heater Size (MBTUH)	Thermal Efficiency (% TE)	Equipment Cost ($)	Labor Cost ($)	Material Cost ($)
Measure Case 400 MBtu/hr Pool Heater	85%	$2,709	$800	$0
Measure Case 400 MBtu/hr Pool Heater	96%	$4,738	$900	$200

[12] Southern California Gas Company (SCG). 2017. "SWRE004-01 CEC appliance database_AHRI listing.xlsx."

[13] Southern California Gas Company (SCG). 2017. "SWRE004-01 CEC appliance database_AHRI listing.xlsx."

BASE CASE LABOR COST ($/UNIT)

See Base Case Material Cost.

MEASURE CASE LABOR COST ($/UNIT)

See Measure Case Material Cost.

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. These NTG values are based upon the average of all NTG ratios for all evaluated 2006 – 2008 commercial, industrial, and agriculture programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. These sector average NTGs ("default NTGs") are applicable to all energy efficiency measures that have been offered through commercial, industrial, and agriculture sector programs for less than two years and for which impact evaluation results are not available.[14]

NTGR Ratios

Parameter	Value	Source
NTG All-Default<=2yrs	0.70	Itron, Inc. 2011. DEER Database 2011 Update Documentation. Prepared for the California Public Utilities Commission. Page 15-4, Table 15-3.

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.

[14] Itron, Inc. 2011. DEER Database 2011 Update Documentation. Prepared for the California Public Utilities Commission. Page 15-4, Table 15-3.

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	DEER 2018, READI v2.5.1
Reason for Deviation from DEER	DEER does not contain Energy Efficient Pool Heaters.
DEER Measure IDs Used	None
NTG	Source: DEER. The NTG of 0.70 is associated with NTG ID: *All-Default<=2yrs*
GSIA	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: *OutD-PoolPump*

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision
01	11/07/19	RMS Energy Consulting, LLC	Draft of consolidated text for this statewide measure is based upon: WPSCGREWH170412A-R0
	5/27/2020	Eduardo Reynoso, SDG&E	Workpaper measure adoption by SDG&E, no changes to energy efficiency savings or cost. Updated Ex-ante Implementation data table. No other changes.