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CONTENTS

MEASURE NAME

Pool Cover, Commercial

STATEWIDE MEASURE ID

SWRE001-01

TECHNOLOGY SUMMARY

Pool covers are protection and insulation products that lie on a swimming pool surface and thereby slow the heat loss and the evaporation rate, which in turn also reduces heat loss. If the pool is heated by a natural gas pool heater, the reduction in heat loss leads to a reduction in gas consumption. The pool cover is either manually or automatically pulled onto the pool or removed from the pool.

Evaporation is one of the main forms of heat loss from heated swimming pools and spas. A pool cover prevents pool water evaporation and associated heat loss from exposed pool surfaces with a layer on the pool surface. Since the primary mode of heat loss from a heated pool is by evaporation, reducing the evaporation will significantly reduce the heat loss. A pool cover will lower the air humidity over indoor pools as well, thereby reducing the latent cooling load of the air conditioning system. A secondary benefit is a reduction in the pool water lost through evaporation and a reduction in debris in the pool.

Three basic types of pool covers are: bubble/solar, vinyl, and insulated vinyl. [1]

Polyethylene floating pool covers (solar blankets) are made from a highly buoyant, air-filled bubble material that provides insulation and prevents heat loss through evaporation. When left on in sunlight, a solar cover will add as much as 10 degrees to an unheated pool. The solar cover will lay on top of the pool without tie-downs or anchors to hold it in place. Therefore, removal and storage of a solar cover is easy; they are often rolled-up on a large reel and wheeled out of the way.

Insulated vinyl floating pool covers have woven, high-density, UV stabilized polyethylene fabric outer layers and cross-linked polyethylene foam sandwiched between the outer layers. Outdoor pools need weighted edges to help prevent wind lift. Stainless steel storage reels are specifically designed for easy removal and storage of insulated floating pool covers. All-welded reels are constructed of stainless-steel tubing and have two hand wheels for ease of handling. Double and triple reels come with casters.

Soft vinyl pool covers are stretched over the pool to keep out debris and prevent heat loss through evaporation, but they provide little insulating value.

MEASURE CASE DESCRIPTION

This measure as defined as the installation of a pool cover on an uncovered outdoor or indoor commercial use pool that is heated with gas-fired equipment. This measure requires that the existing pool cover is no longer in use and has reached the end of its useful life and is no longer effective.

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[1] National Renewable Energy Laboratory (NREL). 2000. *Conserving Energy and Heating Your Swimming Pool with Solar Energy*. DOE/GO-102000-1077, FS104. 2000.

BASE CASE DESCRIPTION

The base case is defined as an uncovered indoor or outdoor pool at a commercial or multifamily facility.

CODE REQUIREMENTS

State or federal standards are not applicable to this measure. For newly constructed buildings, the 2016 the California Building Energy Efficiency Standards (Title 24) [2] require pool and spa heating systems with gas heaters for outdoor use to use a pool cover. The pool cover must be fitted and installed during the final inspection. Note, however, the pool cover requirements are not applicable for maintenance or repairs of existing pool heating or filtration systems. Other than the above, no federal, state, or regional codes were identified that impact the assumptions and methodologies used to quantify demand reduction and energy savings for a pool cover.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None.	n/a
CA Building Energy Efficiency Standards – Title 24 (2016)	Section 110.4	January 1, 2017
Federal Standards	None.	n/a

NORMALIZING UNIT

The normalizing unit is per square foot of installed pool cover (are-ft^2).

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.

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[2] California Energy Commission (CEC). 2012. *2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24).* CEC-400-2012-004-CMF-REV2. Section 110.4

Implementation Eligibility for Investor-Owned Utilities

Measure Application Type	Delivery Type	Sector
Add-on equipment	DnDeemed	Com
Add-on equipment	DnDeemed	Res

Eligible Products

This measure applies to outdoor and indoor heated swimming pools that do not already have pool cover. Energy efficiency programs are to target pools *without* existing pool covers.

 Eligibility requirements include:

- The pool must be heated with natural gas.
- The cover must have 1/8" thick (L), high-density polyethylene foam of thermal conductivity (K) Factor 0.25 Btu/ ft^2-Hr-°F/inch (based upon the ASTM D2326 standard, *withdrawn*).
- The new pool cover must cover at least 95% of the pool
- The new pool cover must have a minimum R-value of 0.5 ft^2-hr-F/Btu (R=L/K). R-value of 0.5 is the thermal resistance of the cover itself.
- 100% post inspection
- Proof of minimum five-year warranty (any combination of manufacturers and/or extended applies).
- Proof of cover thickness and K factor (found on the manufacturer specification sheet)
- Olympic size pools must have a storage reel system either manual or automatic winding and are subject to inspection.
- Rebate is applicable to installed pool cover; per pool only
- Rebate is based on the square footage of the pool area

Eligible Building Types

The primary target building types for this measure are *existing* schools/colleges (educational institutions), city (municipal) recreational centers, home owner associations (e.g., condominiums with common pools), private/health clubs, and multifamily residences (apartment buildings).

Eligible Climate Zones

The measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

New construction installations are not eligible.

DATA COLLECTION REQUIREMENTS

Data requirements are to be determined.

USE CATEGORY

Recreate

ELECTRIC SAVINGS (kWh)

Not applicable.

PEAK ELECTRIC DEMAND REDUCTION (kW)

Not applicable.

GAS SAVINGS (Therms)

Overview

The unit energy saving (UES) of a pool cover was calculated from the difference in the unit energy consumption (UEC) of an existing pool with no cover and the UEC of a pool with an eligible insulated pool cover (see Program Requirements).

The annual gas UES calculations are based on a **pool heat transfer model** developed for swimming pools in California to ascertain the benefits of using pool cover at various types of swimming pools in the California climate zones.

UES values were computed for both outdoor and indoor pools, by building type, and by climate zone with pool cover calculator tools developed by ICF International.[3] The UES calculation following the pool heat transfer model is based on an hourly Excel spreadsheet for one calendar year. The pool heat transfer model was compared to two other swimming pool energy savings calculation tools.[4]

Swimming Pool Characteristics

Typical outdoor and indoor swimming pool characteristics are provided in the following tables and summarized below.

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[3] ICF International. 2012. "Pool Cover-V30-2012-11-08.xlsm." November 8.

ICF International. 2012. "Pool Cover-V30-2012-11-08 - RB update indoor.xlsm" November 8.

[4] Washington State University (WSU). 2005. "Heating & Dehumidification Costs due to Evaporation from Swimming Pools." Accessed on June 4, 2012.

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

Swimming Pool Parameters

Pool Type / Building Type	Area (ft²)	Average depth (ft)	Solar Shading Factor (F_s)	Wind Shielding Factor (F_w)	Typical Activity Factor (F_a)	Winter Schedule	Summer Schedule
Outdoor Pool							
Schools/Colleges	4,689	6	0%	30%	1.00	11 a.m. - 8 p.m.	10 a.m.- 8 p.m.
City Recreation Centers	4,445	6	0%	0%	1.00	10 a.m.- 8 p.m.	9 a.m.- 8 p.m.
MF Residential	1,546	6	30%	40%	0.65	10 a.m.- 8 p.m.	8 a.m.- 10 p.m.
Private/Health Club	1,472	6	20%	30%	1.00	4 a.m.- 11 p.m.	4 a.m.- 11 p.m.
Indoor Pool							
Indoor Pool	1,000	6	100%	100%	1.00	5 a.m.- 9 p.m.	5 a.m.- 9 p.m.

Outdoor Pool Characteristics

The **area**, A_{pool}, is the pool water area exposed to the air (when a pool cover is not covering the pool).

The **average depth**, d_{pool}, is the pool volume divided by the pool surface area.

The **annual pool operating schedule** is described with an annual opening day, followed by a winter schedule, a summer schedule, and an annual closing day. Between annual opening and closing days, the schedule is defined by winter and summer pool opening and closing times. It assumed that the pool is covered and unused during the hours the pool is closed; and it is uncovered and actively used during the hours the pool is open.

The **wind shielding factor**, F_w, is used to adjust the airport wind speed to the poolside wind speed for calculating heat loss and evaporation rate. The wind shielding factor accounts for fences, buildings, and hedges which screen the pool from the wind.

- A pool surrounded by a wide flat open area, especially in the direction of the prevailing wind, has a wind shielding factor of 0%.
- A pool that is totally protected from the wind has a wind shielding factor of 100%.
- The wind shielding factor is assumed to be constant all year.
- The wind shielding factor is used to calculate the wind speed ratio, which is the ratio of the poolside wind speed to the wind speed measured at the local airport weather station. For a poolside anemometer about one foot above the pool and an airport weather station anemometer at ten meters above the ground, the maximum wind speed ratio (i.e., at 0% wind shielding factor) is estimated to be 0.6. The wind speed ratio is zero at 100% wind shielding factor.

The **solar shading factor**, F_s, is used to account for anything that shades the pool from the sun as it arcs across the sky. The solar shading factor is the average percentage of the pool that is shaded from the sun.

- A pool fully exposed to the sun has a solar shading factor of 0%.

- A fully shaded pool has a solar shading factor of 100% (e.g., a large awning or a tall building to the south might provide this shade).
- The solar shading factor is assumed to be constant all year.

The **pool activity factor**, F_a, is used to adjust the evaporation rate based on the level of activity supported in the pool.[5]

- A value for pool activity factor is recommended when the user selects the pool type.
- During the hours when the pool is uncovered and unoccupied, the typical pool activity factor for an unoccupied pool of 0.5 is applied.

The **pool location** (indoor/outdoor) was introduced to satisfy the large number of indoor pools that operate throughout the year. The Indoor pool will maintain higher room "space" temperature and higher relative humidity than the outdoor conditions specifically in winter.

Indoor Pool Characteristics

An indoor pool will exhibit those same conditions (and thus the same heating losses and calculations) as an outdoor pool cover, except:

- Indoor pool may have extended hours of operation based on the type of facility
- Indoor pool is totally protected from the wind and has a wind shielding factor of 100%.
- Indoor pool has a solar shading factor of 100%
- The outdoor air temperatures and relative humidity for each weather zone will be replaced by the indoor conditions of the pool (see table below).
- For the same indoor conditions, a similar savings estimate was obtained for different weather zones. Yet, for different pool operating schedules, higher savings were achieved in using the pool cover for longer hours.

The indoor pool space condition is important for calculating the evaporation losses and for the convection and radiation heat losses (to a lesser degree). The indoor conditions are monitored by:

- Room indoor temperature in degree (°F)
- Room relative humidity (%)

The default values used in the indoor swimming pools are provided below.

Indoor Pools Space Conditions

Parameter	Name	Default Value	Comment
Pool water temperature, default	T_{pool}	80 °F	Standard heating pool temp
Indoor air dry-bulb temperature setpoint	T_{air}	82 °F	2 °F higher than water temp
Indoor air relative humidity setpoint	*Rh%*	60%	10% above average

The indoor pool calculated gas savings is based only on the pool water heating and does not include any HVAC energy saving (gas or electric).

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[5] American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE). 2011. *2011 ASHRAE Handbook – HVAC Applications.* Atlanta (GA): ASHRAE.

Weather Data

The heat transfer model uses hourly weather data for each of the 16 climate zones of California. Climate zone weather data is based on the typical meteorological year (TMY) data derived from the 1961-1990 and 1991-2005 National Solar Radiation Data Base (NSRDB) archives maintained by the National Renewable Energy Laboratory (NREL).[6]

The climate zone is determined according to the pool location in California, and the incident solar radiation corresponds to a centrally located airport weather station within each climate zone.

Centrally located weather stations in each climate zone that were used to determine the latitude for incident solar heating of the pool), along with a few other weather stations in each climate zone are provided below.

California Weather Stations, Sorted by Climate Zone

Climate Zone	Centrally Located Weather Station	Other Weather Stations
1	Arcata Airport	Crescent City FAA
2	Ukiah Municipal Airport	Napa Co. Airport, Santa Rosa (AWOS)
3	San Francisco Int'l	Hayward Air Term, Monterey NAF, Oakland Metropolitan, Salinas Municipal
4	San Jose Intl Airport	Mountain View Moffat
5	Lompoc (AWOS)	Paso Robles Munic, San Luis Co Rgnl, Santa Maria Public
6	Los Angeles Int'l	Camarillo (AWOS), Long Beach Daugherty, Oxnard Airport, Point Mugu NAF, Santa Barbara Muni, Santa Monica Muni
7	San Diego Lindbergh	Camp Pendleton MC, Carlsbad/ Palomar, Chula Vista Brown, San Diego Miramar, San Diego North Is, San Diego/ Montgomery
8	Santa Ana John Wayne	Fullerton Municipal, Jack Northrop Fld
9	Burbank-Glendale	Chino Airport, Van Nuys Airport
10	Riverside Municipal	March AFB
11	Redding Municipal	Beale AFB, Red Bluff Muni, Redding Muni, Yuba County
12	Sacramento Metropolitan	Concord, Livermore Muni, Merced/Macready Fld, Modesto City-County, Sacramento Executive, Sacramento Metro, Stockton Metro, Travis AFB
13	Bakersfield Meadow	Fresno, Fresno Yosemite, Lemoore Reeves, Porterville (AWOS), Visalia Muni (AWOS)
14	Palmdale Airport	China Lake NAF, Daggett Barstow, Edwards AFB, Lancaster Gen. Wm. Fox, Palmdale Airport, Sandberg, Twentynine Palms
15	Palm Springs Int'l	Blythe Riverside, Imperial, Needles Airport, Palm Springs Thermal
16	Truckee-Tahoe	Alturas, Bishop Airport, Blue Canyon AP, Montague Siskiyou, South Lake Tahoe

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[6] (No author). (n.d.) "Weather File-v2.xlsx." Downloaded from the National Renewable Energy Laboratory (NREL) National Solar Radiation Database (NSRD) on January 28, 2010.

Ground Temperature Data

The **average ground temperature** was used to calculate heat loss to the soil beneath the pool and the energy required to heat the make-up water, and the lowest monthly average air temperature.

California Weather Stations Sorted by Climate Zone

Climate Zone	Centrally Located Weather Station	Ground Temperature	Lowest Monthly Average Temperature
1	Arcata Airport	54 ºF	49 ºF
2	Ukiah Municipal Airport	57 ºF	45 ºF
3	San Francisco Int'l	57 ºF	50 ºF
4	San Jose Intl Airport	59 ºF	49 ºF
5	Lompoc (AWOS)	58 ºF	52 ºF
6	Los Angeles Int'l	61 ºF	56 ºF
7	San Diego Lindbergh	62 ºF	57 ºF
8	Santa Ana John Wayne	63 ºF	55 ºF
9	Burbank-Glendale	64 ºF	55 ºF
10	Riverside Municipal	64 ºF	53 ºF
11	Redding Municipal	61 ºF	45 ºF
12	Sacramento Metropolitan	59 ºF	45 ºF
13	Bakersfield Meadow	64 ºF	47 ºF
14	Palmdale Airport	61 ºF	43 ºF
15	Palm Springs Int'l	73 ºF	56 ºF
16	Truckee-Tahoe	50 ºF	37 ºF

Energy Savings Calculation

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.

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

ΔT_{pool} is the hourly change in pool temperature, F
q_{in} is heat added to the pool via each heat transfer mechanism, Btu/hr
ρ_w is the density of water, lb/ft³
C_w is the specific heat of water, Btu/lb-F
A_{pool} is the area of pool, ft²
d_{pool} is the average pool depth, ft

The UES calculation accounts for the following **heat transfer mechanisms**:[7]

- 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 (with and without pool cover; with and without swimmers present)
- 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.

UES values were generated with the indoor and outdoor pool savings calculators[8] for all 16 climate zones and building types. Moreover, energy savings and water savings were analyzed by performing a sensitivity analysis using the default values and variations of parameters presented above.[9]

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."[10] This approach provides a reasonable RUL estimate without requiring any prior knowledge about the age of the equipment being replaced.[11] Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised add-on equipment 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."[12]

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

[8] ICF International. 2012. "Pool Cover-V30-2012-11-08.xlsm." November 8.

ICF International. 2012. "Pool Cover-V30-2012-11-08 - RB update indoor.xlsm" November 8.

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

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

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

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

The EUL and RUL are specified below. As Per Resolution E-4818,[13] *"For AOE measures, the EUL is the lesser of the RUL of the host equipment/system or the EUL of the measure."* For this pool cover measure, the host equipment is considered to be the pool, which will have an assumed maximum EUL of 20 years. One-third of 20 years is equal to 6.7 years, which is greater than that of the EUL of the pool cover measure. Therefore, the existing EUL ID below will be used.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	5.0	The reference for this data could not be located.
RUL (yrs)	n/a	-

BASE CASE MATERIAL COST ($/UNIT)

The base case scenario assumes a pool with no pool cover, therefore the base case material cost is equal to $0.

MEASURE CASE MATERIAL COST ($/UNIT)

Measure case costs were calculated as the average of cost estimates for commercial high efficiency pool covers (R-values of 0.5 or higher), which were provided by various local vendors in 2018.[14]

BASE CASE LABOR COST ($/UNIT)

The base case scenario assumes a pool with no pool cover, therefore the base case labor cost is equal to $0.

MEASURE CASE LABOR COST ($/UNIT)

The application of the pool cover is manual by a worker or automatic using a storage reel system. Thus, the measure case labor cost is equal to $0.

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. This NTG values are documented in the 2011 DEER Update Study conducted by Itron, Inc.[15] The sector average NTGs ("default NTGs") are applicable to all energy

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[13] California Public Utilities Commission (CPUC). 2017. *Resolution E-4818*. March 2. P.27.

[14] Southern California Gas Company (SCG). 2018. "Pool Cover Cost Analysis 2018.xlsx."

[15] Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared for the California Public Utilities Commission.

efficiency measures that have been offered through commercial, industrial, and agriculture sector energy efficiency programs for two years or less and for which impact evaluation results are not available.

Net-to-Gross Ratios

Parameter	Value	Source
NTG - commercial	0.60	Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3.
NTG – residential	0.55	

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.[16]

Gross Savings Installation Adjustment

Parameter	Value	Source
GSIA	1.0	California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31.

NON-ENERGY IMPACTS

Water savings from this measure (due to evaporation) were computed for both outdoor and indoor pools, by building type, and by climate zone with pool cover calculator tools used to compute gas energy savings. See Gas Savings and supporting documentation for details.[17]

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	No
DEER Measure Case	No

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

[17] ICF International. 2012. "Pool Cover-V30-2012-11-08.xlsm." November 8.

ICF International. 2012. "Pool Cover-V30-2012-11-08 - RB update indoor.xlsm" November 8.

DEER Item	Comment / Used for Workpaper
DEER Building Types	No
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	DEER READi version 2.5.1
Reason for Deviation from DEER	DEER READi (v2.5.1) does not contain commercial pool covers but only houses this measure within the database as an IOU Workpaper.
DEER Measure IDs Used	N/A
NTG	The NTG of 0.60 is associated with NTG ID: *Com-Default>2yrs, Ind-Default>2yrs,* 0.55 with NTG ID: *Res-Default>2yrs*
GSIA	The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA*
EUL/RUL	The value of 5 years is associated with EUL ID: *OutD-PoolCover*.

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision
01	03/31/2018	Jennifer Holmes, Cal TF Staff	Draft of consolidated text for this statewide measure is based upon PGE3PPRO109, Revision 3 (January 1, 2016) WPSCGNRWH150309A, Revision 0 (March 9, 2015) Consensus reached among Cal TF members.
			Update based upon: WPSCGNRWH150309A, Revision 1 (November 29, 2018)
	03/29/2019	Jennifer Holmes, Cal TF Staff	Revisions for submission of version 01
	5/28/2020	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.
	03/17/2021	Soe K Hla PG&E	Adopted all measures for PG&E