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WATER HEATING

HOT WATER TANK INSULATION, NONRESIDENTIAL

SWWH018-01

CONTENTS

MEASURE NAME

Hot Water Tank Insulation, Nonresidential

STATEWIDE MEASURE ID

SWWH018-01

TECHNOLOGY SUMMARY

Many customers in the commercial, industrial, and agriculture sectors – particularly smaller, hard-to-reach businesses or cost sensitive industrial enterprises – install hot water tanks with no insulation. Commercial entities of all types may require stand-alone hot water tanks for service hot water applications. Larger storage tanks (greater than 100 gallons) are common in hospitals, schools, universities, and recreation centers. Industrial entities typically require storage tanks for hot water process needs and treatment. Applications are diverse across many industry types; examples are the food processing, refining, and chemical manufacturing subsectors.

This measure specifies the installation of tank insulation on a bare tank surface for existing tanks only. New hot water storage tanks are insulated as industry standard practice. The insulation reduces heat loss to the ambient air, resulting in energy savings at a relatively low cost. Insulation materials are generally fiberglass or foam with appropriate jackets for the location and are applied with thicknesses of one to two inches.

MEASURE CASE DESCRIPTION

The measure case is defined as the installation of insulation in an existing uninsulated hot water tank. The measure includes multiple measure offerings, defined by the thickness of insulation and the process temperature range (temperature inside the tank) as specified below. Savings are also provided for high and medium usage (defined by hours of operation), and for each California climate zone.

Measure Case Specification

Insulation Thickness (inches)	Process Temperature Range	Usage
1.0	120 °F – 170 °F	High Medium
	170 °F – 200 °F	High Medium
2.0	120 °F – 170 °F	High Medium
	170 °F – 200 °F	High Medium

BASE CASE DESCRIPTION

The base case for this measure is an existing bare, uninsulated hot water tank. Tanks can be used for domestic, service or process liquid or solutions applications in commercial, industrial, and agriculture facilities of any vintage, and generally store 100 gallons or more.

CODE REQUIREMENTS

This measure is not governed by either state Title 24 and Title 20 or federal codes and standards. However, the California Building Energy Efficiency Standards (Title 24),[1] Section 123 establishes requirements for tank insulation in the design and installation of space-conditioning and service water heating systems and equipment.

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	None.	n/a
Federal Standards	None.	n/a

Note, however, that the California Occupational Safety and Health Standards Board, Section 3308[2] requires employers to insulate or guard hot pipes and hot surfaces of 140 °F or higher that are located within seven feet of the floor or within 15 inches from stairways, ramps, or fixed ladders. Any tank requiring insulation per these standards is not eligible, as noted in Program Requirements.

NORMALIZING UNIT

Square feet of insulation material.

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

[1] California Energy Commission. 2012. *2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24)*. CEC-400-2012-004-CMF-REV2. Section 123.

[2] California Code of Regulations. Title 8, Section 3308.

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
Add-on equipment	DnDeemDI	Ag
Add-on equipment	DnDeemDI	Com
Add-on equipment	DnDeemDI	Ind
Add-on equipment	DnDeemed	Ag
Add-on equipment	DnDeemed	Com
Add-on equipment	DnDeemed	Ind

Eligible Products

This measure requires the installation of 1-inch or 2-inch fiberglass or foam insulation to an existing, bare liquid solution storage or transfer tank. The tank must be coupled to gas-fired commercial, industrial, or agriculture equipment that transfers heat to the contained liquid or solution.

Eligible Building Types and Vintages

This measure is eligible for most existing commercial, industrial, and agriculture facilities of any vintage, including, but not limited to offices, restaurants, retail, schools, colleges, hotels, motels, and recreational facilities.

Eligible Climate Zones

This measure is applicable in any California climate zone.

PROGRAM EXCLUSIONS

The following conditions or the following applications are not eligible:

- Tanks with pre-existing insulation.
- Replacement of old or damaged insulation.
- Tanks insulated to prevent burns.
- Insulation for exposed hot-water tanks within seven feet of the floor that are not otherwise guarded in such manner as to prevent contact.

The California Occupational Safety and Health Standards Board, Section 3308[3] requires employers to insulate or guard hot pipes and hot surfaces of 140 °F or higher that are located within seven feet of the floor or within 15 inches from stairways, ramps, or fixed ladders. Any tank requiring insulation per these standards is not eligible.

The 2016 version of the California Building Energy Efficiency Standards (Title 24), Section 110.3[4] establishes requirements for tank insulation in the design and installation of space-conditioning and service water heating systems and equipment. Any tank requiring insulation per these standards does not qualify for a rebate. (This would be the case for both new facilities and facilities undergoing renovations that would trigger code compliance.)

DATA COLLECTION REQUIREMENTS

The insulation thickness and process temperature (tank solution temperature) will determine the energy savings. The data collection requirements to ensure accurate determination of eligibility and to inform industry standard practice and future program design include:

- Process temperature (temperature inside the tank)
- Insulation material manufacturer
- Insulation material type
- Insulation material k-value rating
- Type of tank material (steel, fiberglass, etc.)
- Evidence of prior tank insulation (or any insulation fragments)
- Location where burns can be sustained (Yes/No)

USE CATEGORY

Service & domestic hot water

ELECTRIC SAVINGS (kWh)

Not applicable.

PEAK ELECTRIC DEMAND REDUCTION (kW)

Not applicable.

[3] California Code of Regulations. Title 8, Section 3308.

[4] California Energy Commission (CEC). 2012. *2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24).* CEC-400-2012-004-CMF-REV2. Section 123.

GAS SAVINGS (Therms)

The gas unit energy savings (UES) from this measure is the result of reduced heat losses on the tank surface and the reduced heating load on the connected gas-fired equipment. The savings were calculated as the difference in heat losses between the uninsulated tank surface (base case) and the insulated surface (measure case). The average boiler efficiency was then factored in to translate the reduced heat losses from the tank into reduced gas consumption of the boiler.

The annual energy saved by tank insulation can be calculated as the following:

$$UES_{gas} = \frac{HOURS \times (Q_b - Q_i)}{100{,}000 \times EFF} \times A_s$$

UES_{gas}= Annual gas unit energy savings (in therms)
$HOURS$ = Annual operating hours
Q_b = Heat Loss from Bare Tank (Btu/hr/ft²)
Q_i = Heat Loss from Insulated Tank (Btu/hr/ft²)
EFF = Efficiency (%) of the boiler to generate the hot water in the tank
A_s = Tank surface area, not included ends of tank (ft²)
100,000 = Conversion factor (1 therm = 100,000 Btu)

The parameters in this calculation are summarized below.

Annual Operating Hours. The calculation of gas energy savings of this measure assumes either continuous tank operation (high usage) or reduced tank operation (medium usage).

Heat Loss. The heat loss calculations were performed using industry-accepted software from the North American Insulation Manufacturers Association (NAIMA). The NAIMA 3E Plus v4.1 software uses the calculation methodology from the American Society for Testing and Materials (ASTM). ASTM C680-14: Standard Practice for Estimate of the Heat Gain or Loss and the Surface Temperatures of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs.[5]

Heat Loss Calculation Inputs

Input	Base Case	Measure Case	Source
Surface	Bare	Insulated	n/a
Tank Material	Steel (Steel is the most common material for hot water tanks) Emittance = 0.8		Professional judgment for typical applications
Insulation Material	n/a	Fiber glass-type insulation (cellular glass BLOCK, Gr1, C552-07).	Professional judgment for typical applications
Jacket Material	Aluminum, new Emittance = 0.04		Professional judgment for typical applications
Annual Operating Hours – High Usage	8,760		Professional judgment for typical applications

[5] American Society for Testing and Materials (ASTM). 2014. *ASTM C680-14: Standard Practice for Estimate of the Heat Gain or Loss and the Surface Temperatures of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs.* West Conshohocken (PA): ASTM International.

Input	Base Case	Measure Case	Source
Annual Operating Hours – Medium Usage	3,744		12 hours per day, 6 days per week (assumes mid-size industrial operation)
Process Temperature (°F inside the tank)	145 °F for low-temperature range 185 °F for high-temperature range		Temperatures are the midpoints of the process temperature range for each measure offering.
Annual average dry-bulb temperature (°F)	Varies by climate zone		California Energy Commission (CEC). 2012. 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24): Reference Appendices. CEC-400-2012-005-CMF-REV3. Appendix JA2.
Wind Speed (mph)	Varies by climate zone. Each monthly average Wind Speed was adjusted for the proper height at the plant (30% of the speed in the weather file) since weather station wind measurements are at heights of 10 to 30 feet		
Ambient Conditions – Indoor Tank	Air temperature: 75 °F Wind speed: 0 mph.		Professional judgment for typical applications

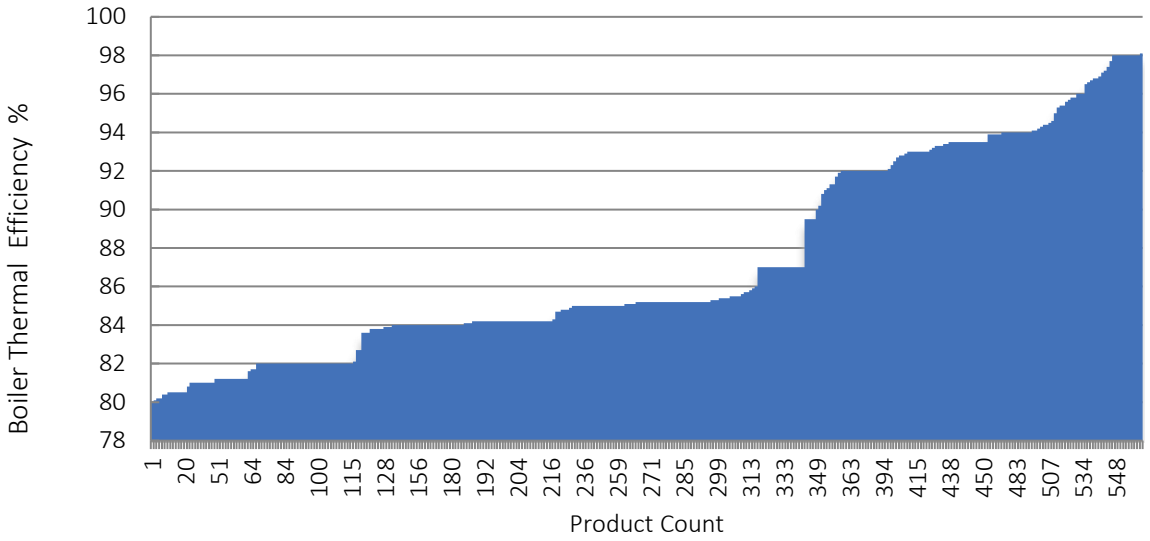
The temperature-dependent thermal conductivity of the fiberglass assumed in the 3E Plus software is shown in below. Foam insulation (the other acceptable type of material in this measure) has similar R-values to fiber glass and provides similar savings to fiberglass, since the savings are driven primarily by the heat losses from the base case (uninsulated tank).

Insulation Thermal Conductivity

Temperature (°F)	Thermal Conductivity (Btu-in/hr-ft^2-°F)
-150	0.20
-100	0.22
-50	0.24
0	0.27
50	0.30
75	0.31
100	0.33
200	0.40
300	0.48
400	0.58

Boiler efficiency. To convert reduced heat losses from the tank into energy savings of the boiler, boiler efficiency needs to be taken into account. Average boiler efficiency was calculated as the average efficiency of boilers certified in the California Energy Commission (CEC) Modernized Appliance Efficiency Database System (MAEDBS). The average efficiency of the boilers in this listing was calculated for hot water boilers, both for small and large boilers listings. The figure below shows the distribution of thermal efficiencies of certified hot water boiler thermal efficiencies from the CEC MAEDBS database; the average boiler efficiency is shown in the table below

Distribution of Thermal Efficiencies of Hot Water Boilers (300-2,500 kBtu/hr)



Average Boiler Efficiency

Input	Average Boiler Efficiency Rating	Source
Average Boiler Efficiency	82.5%	San Diego Gas and Electric (SDG&E). 2013. "WPSDGENRW0014r0 Ref 5 - CEC Appliances Database.pdf."

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.

As per Resolution E-4807, the California Public Utilities Commission (CPUC) defined the EUL of an add-on equipment measure as the minimum of the EUL of the measure itself and the RUL of the host equipment.[6] 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." This approach provides a reasonable RUL estimate without the requiring any prior knowledge about the age of the equipment

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

being replaced.[7] The RUL of the host equipment (which is the water heater tank) is therefore calculated as one-third of the EUL of a water heater.

The EUL and RUL specified for tank insulation are presented below. Note that the RUL of the host water heater complies with Resolution E-4952, which stipulated host equipment RUL values for add-on equipment measures.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (years) – tank insulation	7.0	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
EUL (yrs) – host water heater	15.0	California Public Utilities Commission (CPUC). 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
RUL (yrs) – host water heater	5.0	California Public Utilities Commission (CPUC). 2016. Resolution E-4807. December 16. Page 13. California Public Utilities Commission (CPUC). 2018. *Resolution E-4952.* October 11. Pp. A-37-38.

BASE CASE MATERIAL COST ($/UNIT)

Insofar as tank insulation is an *add-on equipment* measure, the base case material cost is equal to $0.

MEASURE CASE MATERIAL COST ($/UNIT)

Typical material costs for this measure were estimated using the McMaster-Carr online supply catalog published list prices retrieved in March 2014.[8] The measure cost was calculated as the simple average of costs of insulation materials (both 1" and 2" thicknesses) that meet program requirements.

BASE CASE LABOR COST ($/UNIT)

Insofar as tank insulation is an *add-on equipment* measure, the base case labor cost is equal to $0.

MEASURE CASE LABOR COST ($/UNIT)

The labor cost is based up data obtained from the 2014 version of RSMeans Mechanical Cost Data[9] and assumes a 25% overhead and profit markup.

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

[8] Southern California Gas Company. 2014. "WPSCGNRM1050101A-Rev02 Cost Calculation.xlsx"

[9] RSMeans. 2014. *RSMeans Mechanical Cost Data 2014. 37th Annual Edition.* Page 267, item # 23 07 16.10 2420/2440.

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. The 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 NTG") is applicable to all energy efficiency measures that have been offered through commercial, industrial, and agriculture sector programs for more than two years 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 - Industrial	0.60	
NTG - Agriculture	0.60	

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 Rates

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

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

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. The DEER database does not contain any measure for tank surface insulation. **Error! Reference source not found.** includes references for NTG, GSIA, and EUL values in DEER.

DEER Difference Summary

DEER Item	Comment / Used for Workpaper
NTG	Source: DEER 2014. The NTG of 0.60 is associated with NTGR_ID*: Com-Default>2yrs, Ind-Default>2yrs, Ag-Default>2yrs*
GSIA	The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA*
EUL/RUL	Source: DEER 2014. The value of 7 years is associated with EUL ID: *WtrHt-TankIns-Gas*.

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	03/31/2018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: PGECOPRO103 Revision 5 (May 14, 2014) WPSDGENRWH0014, Revision 0 (October 8, 2013) Consensus reached among Cal TF members.
	02/28/2019	Jennifer Holmes Cal TF Staff	Revisions for submission of version 01.