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FOOD SERVICE

UNDERCOUNTER DISHWASHER, COMMERCIAL

SWFS018-02

CONTENTS

MEASURE NAME

Undercounter Dishwasher, Commercial

STATEWIDE MEASURE ID

SWFS018-02

TECHNOLOGY SUMMARY

Commercial dishwashers are used in almost all establishments that use non-disposable dishes, glassware, and utensils, such as restaurants, bars, schools, hospitals, nursing homes, churches, and institutional cafeterias. The commercial dishwasher can clean and sanitize a high quantity of kitchen wares in a short time by utilizing hot water, soap, rinse chemicals, and significant amounts of energy. The size requirement for a commercial dishwashing machines can be calculated by estimating the number of individuals served by the food service establishment. This information is a key determinant of the type of dishwasher that is most suited for a facility.

An ENERGY STAR-qualified commercial dishwasher is (on average) 40% more energy efficient and 40% more water-efficient than a standard model.[1] The ENERGY STAR requirements for both high-temperature and low-temperature stationary undercounter dishwashers specify maximum water consumption requirements as well as maximum idle energy use between wash cycles.

High efficiency commercial dishwashers reduce water heating requirements while maintaining cleaning performance by reducing heat losses, improving mechanical soil removal, and/or increasing component efficiencies. By using strategies such as waste air heat recovery, drain heat recovery, rinse water re-use, double-walled insulated construction, high efficiency anti-clogging nozzles, continuous filtering, and efficient boost heaters, water consumption can be reduced from as high as 2.0 gallons per rack (GPR) to less than 0.5 GPR, depending on the type of dishwasher.[2]

According to the North American Association of Food Equipment Manufacturers (NAFEM), *undercounter* units accounted for 43% of the 2009-2011 commercial dishwasher market share by sales volume.[3] Undercounter dishwashers are mostly found in bars and restaurants with bars, mainly used for washing glassware.

This measure includes both low-temperature and high-temperature undercounter dishwasher units. Low-temperature units meet the National Sanitation Foundation (NSF) mandated sanitation criteria via a final rinse chemical sanitizing solution that follows the wash cycle.[4] High-temperature units achieve sanitation

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[1] ENERGY STAR. 2017. “Commercial Dishwashers.” http://www.energystar.gov/products/certified-products/detail/commercial-dishwashers. Accessed on July 26.

[2] Fisher-Nickel, Inc. 2010. “Design Guide – Improving Commercial Kitchen Hot Water System Performance – Energy Efficient Heating, Delivery and Use.” March 26. Table 2.

[3] The source for this data (Size and Shape of the Industry Study) is no longer available.

[4] NSF Sanitation Foundation (NSF). 2017. *NSF/ANSI 3-2017. Commercial Warewashing Equipment.*

via a high-temperature booster of 180 °F water for the final rinse. These differences in sanitizing methods affect the division of energy consumption of low versus high-temperature units.

Most of energy used in a low-temperature unit is associated with primary water heating, with the remaining energy attributed to tank heaters and pumps. For high-temperature machines, less of the total energy consumption is for primary water heating with a significant portion for booster water heating, and the remaining is attributed to the motor, wash tank heater, controls, and standby energy. It is assumed that the motors and controls components do not vary significantly between standard and high-efficiency dishwasher units. However, water consumption, and therefore water heating requirements, does vary significantly between standard and high-efficiency units and constitutes the measure energy savings.

MEASURE CASE DESCRIPTION

The measure case specification is based upon the ENERGY STAR® Commercial Dishwashers Version 3.0 and includes high- and low-temperature under counter type dishwasher offerings.[5] The Tier 1 measure offerings meet the maximum water consumption and idle energy rate specifications; the Tier 2 offerings are 15% lower than the ENERGY STAR requirements.

Measure Case Specification

Statewide Measure Offering ID	Sanitization Temperature	Max. Water Consumption (GPR)	Max. Washing Energy (kWh/rack)	Max. Idle Energy Rate (kW)	Source
SWFS018A	High Temperature, Tier 1	0.86	0.35	0.30	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
SWFS018B	High Temperature, Tier 2	0.73	0.30	0.26	
SWFS018C	Low Temperature, Tier 1	1.19	0.15	0.25	
SWFS018D	Low Temperature, Tier 2	1.01	0.13	0.21	

The ENERGY STAR Program Requirements for Commercial Dishwashers used the ASTM F1696-07 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines[6] to estimate the energy and water consumption of both the base and measure case.

[5] ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.

[6] American Society for Testing and Materials (ASTM). 2007. *ASTM F1696-07 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines.* West Conshohocken (PA): ASTM International.

BASE CASE DESCRIPTION

The base case specification is based upon the previous ENERGY STAR Eligibility Requirements for Commercial Dishwashers. The Max water consumption was based on Version 1.2[7] while the idle rate was based off on Version 2.0.[8]

Base Case Specification

Dishwasher Type	Max. Water Consumption (GPR)	Max. Idle Energy Rate (kW)	Source
High Temperature	1.00	0.50	ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013.
Low Temperature	1.70	0.50	

CODE REQUIREMENTS

This measure is not governed by either state or federal codes and standards.

The ENERGY STAR Eligibility Requirements for Commercial Dishwashers, Version 3.0)[9] uses the ASTM F1696-07 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines[10] to estimate the energy and water consumption of both the base and measure case.

The revised ASTM F1696-15 test method[11] includes washing energy consumption tests methodology for undercounter dishwashers and will be referenced in future ENERGY STAR standards. The F1696-15 test methodology includes energy consumption per rack while washing racks of glasses.

[7] ENERGY STAR. 2007. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria Version 1.2." Effective October 11, 2007.

[8] ENERGY STAR. 2013. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria Version 2.0." Effective February 1, 2013.

[9] ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria Version 3.0." Effective July 27, 2021.

[10] American Society for Testing and Materials (ASTM). 2007. *ASTM F1696-07 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines.* West Conshohocken (PA): ASTM International.

[11] American Society for Testing and Materials (ASTM). 2015. *ASTM F1696-15 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines.* West Conshohocken (PA): ASTM International.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	n/a	-
CA Building Energy Efficiency Standards – Title 24	n/a	-
Federal Standards	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	DnDeemed	Ag
Normal replacement	DnDeemed	Ind
Normal replacement	DnDeemed	Com
Normal replacement	DnDeemDI	Ag
Normal replacement	DnDeemDI	Ind
Normal replacement	DnDeemDI	Com
Normal replacement	UpDeemed	Ag
Normal replacement	UpDeemed	Ind
Normal replacement	UpDeemed	Com
New construction	DnDeemed	Ag
New construction	DnDeemed	Ind
New construction	DnDeemed	Com
New construction	DnDeemDI	Ag
New construction	DnDeemDI	Ind
New construction	DnDeemDI	Com
New construction	UpDeemed	Ag
New construction	UpDeemed	Ind
New construction	UpDeemed	Com

Eligible Products

This measure includes new commercial low- and high-temperature undercounter dishwashers that meet the efficiency requirements presented in the Measure Case Description.

Eligible Building Types and Vintages

This measure is applicable for any nonresidential building type of any vintage.

Eligible Climate Zones

This measure is applicable in any California climate zone.

PROGRAM EXCLUSIONS

Used or rebuilt equipment is not eligible.

Other dishwasher types (conveyor, door-type, flight-type) are not eligible.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Food Service (FoodServ)

ELECTRIC SAVINGS (kWh)

Methodology

The basis for electric unit energy savings (UES) is the difference between the water heating unit energy consumption (UEC) of the base case and measure case dishwasher models. Because energy-efficient units require considerably less water, less energy is required for water heating. For both low- and high-temperature machines, the base case UEC is based on the energy required to heat water for the dishwashing and sanitizing cycles. The high-temperature unit water heating energy components are further split into *primary* and *booster* water heating.

The calculation of the annual electric UEC is calculated as the difference between the baseline UEC and the measure case UEC.[12] Note that motor energy and standby losses are assumed to be the same for both the base case and the measure case and are therefore not presented in the energy savings calculations.

$$UEC_{YEAR} = Electric\ Water\ Heater\ Energy + Booster\ Water\ Heater\ Energy + Idle\ Energy$$

[12] Southern California Gas Company (SCG). 2019. "WPSCGNRCC180529A_Rev00_Att_02_EnergyUseByCZ.xlsx"

Each term in the UEC calculation is detailed below, followed by all inputs and assumptions.

Electric Water Heater Energy Use

Electric water heater energy use is a function of water consumption (GPR), the number of racks washed per year, the UEC per gallon of water, and market penetration of electric water heating.

$$Electric\ \ Water\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Water\ Heater} \times MktPen_{elec}$$

$GPR = Water\ consumption\ (Gallons/Rack)$
$RACKS = Number\ of\ racks\ washed\ per\ day\ (Racks/day)$
$EDAYS = Operating\ days\ per\ year\ (days/yr)$
$UECGAL_{\ Water\ Heater} = UEC\ per\ gallon\ of\ water\ (kWh)$
$MktPen = Market\ penetration\ of\ electric\ water\ heating\ (\%,\ decimal)$

Water Consumption (GPR) The water consumption in gallons per rack was calculated as the maximum allowable consumption as shown in the Measure Offering table. Tier 1 units' maximum water consumption was set to ENERGY STAR maximum performance criteria[13], while Tier 2 units were determined to have water consumption 15% below ENERGY STAR maximum performance.

Racks per Day The number of racks per day is based on monitored data from five different restaurant sites (fast casual, fine dining, cafes, and quick service restaurants) and dishwasher leasing companies that track the racks per month as part of the equipment lease agreements. The monitored data was provided by the Food Service Technology Center (FSTC).[14] The undercounter dishwasher data was also interpolated from the door type dishwasher usage of 152 racks per day based on 6 field monitoring locations. Frontier Energy estimated that 3 times more racks are washed in door type dishwashers than undercounter dishwashers. It is estimated that an undercounter dishwasher washes 50 racks per day which is used in this analysis.

Door Type Dishwasher Racks Per Day Field Monitoring Results.

Location	Facility Type	Racks Washed Per Day
1	Fine Dining	165
2	Casual Dining	184
3	Casual Dining	50
4	Casual Dining	91
5	Fine Dining	188
6	Full-Service Restaurant	232
Average		152

[13] ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.

[14] Pacific Gas and Electric (PG&E). 2015. "Dishmachine Calcs 02092015.xls."

Operating Days per Year The commercial dishwasher hours and days per year of operation was derived from an independent survey of 54 food service establishments conducted by Navigant Consulting.[15] The survey sample included independent restaurants, casual concept (big chain) restaurants, and fast food chains. These assumed hours and days of operation align with assumptions for many other food service measures drawn from a food service equipment market potential study conducted for the California Energy Commission (CEC) by Fisher-Nickel, Inc.[16]

Market Penetration of Water Heating Fuel Types Electric and gas water heater fuel saturation was derived from CEUS 2006 data.

Market Penetration of Primary Water Heating Fuel

Primary/Booster Fuel Combination	Penetration (%)	Source
Electric	3%	Itron, Inc. 2006. California Commercial End Use Survey. Prepared for the California Energy Commission. CEC-400-2006-005. Table E-1.
Gas	97%	

UEC per Gallon of Water The UEC per gallon of water is based on the increase in water temperature required for a wash cycle, the specific heat of water, the density of water, and the heating equipment efficiency.

$$UECGAL_{Water\ Heater} = \left(\frac{\Delta T \times C \times \rho}{\eta}\right) \times \frac{kWh}{Btu}$$

ΔT = *Temperature rise (°F)*
C = *Specific heat of water, constant* $\left(\frac{Btu}{lb-°F}\right)$
ρ = *Density of water, constant* $\left(\frac{lbs}{gal}\right)$
η = *Electric heating equipment efficiency*
kWh/Btu = *Btu to kWh conversion factor*

Temperature rise (°F) – Average groundwater temperature data for each climate zone is used as the inlet temperature which needs to be raised to 140 °F to meet the minimum supply water temperature at the dishwasher. Groundwater temperature data was retrieved from the 2010 climate zone weather data files for the 2013 Building Energy Efficiency Standards (Title 24).[17] This water heating requirement applies to both low- and high-temperature machines.

Electric heating equipment efficiency (%) – Heating equipment efficiency varies between electric and gas units, as well as between external primary water heating and internal booster heating. The efficiency of a building electric water heater is assumed to be 98%, while gas water heaters are assumed to have a

[15] The source for this data or information is unknown.

[16] Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095.

[17] Reeves, P. (Consultant to California Public Utilities Commission, Energy Division). 2013. "Comparison-of-Ground-Temperatures-v2_byPaulReeves.xlsx."

recovery efficiency of 77%.[18] These efficiencies are used to determine energy consumption of the primary water heating in both low and high temperature units.

Electric Booster Water Heater Energy

For a high-temperature unit using a high-temperature sanitizing rinse, the following methodology was used to determine the additional energy required for the booster water heating. As with the electric water heater energy use, the booster water heater energy use is a function of water consumption (GPR), the number of racks washed per year, the UEC per gallon of water, and market penetration of electric booster heating.

Note that a low-temperature dishwasher will not have booster heater energy as part of the calculation and this term will equal zero for the low-temperature model.

$$Electric\ \ Booster\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Booster} \times MktPen_{booster,elec}$$

$GPR = Water\ consumption\ (GPR)$
$RACKS = Number\ of\ racks\ washed\ per\ day\ (Racks/day)$
$EDAYS = Operating\ days\ per\ year\ (days/yr)$
$UECGAL_{Booster} = UEC\ per\ gallon\ of\ water\ (kWh)$
$MktPen = Market\ penetration\ of\ electric\ booster\ water\ heating\ (\%,\ decimal)$

Water Consumption (GPR) Same as Electric Water Heater Energy Use (above)

Racks per Day Same as Electric Water Heater Energy Use (above)

Operating Days per Year Same as Electric Water Heater Energy Use (above)

UEC per Gallon of Water The UEC per gallon of water is based on the increase in water temperature required for a wash cycle, the specific heat of water, the density of water, and the heating equipment efficiency.

$$UECGAL_{Booster} = \left(\frac{\Delta T \times C \times \rho}{\eta}\right) \times \frac{kWh}{Btu}$$

$\Delta T = Temperature\ rise\ (°F)$
$C = Specific\ heat\ of\ water,\ constant \left(\frac{Btu}{lb-°F}\right)$
$\rho = Density\ of\ water,\ constant \left(\frac{lbs}{gal}\right)$
$\eta = Booster\ equipment\ efficiency$
$kWh/Btu = Btu\ to\ kWh\ conversion\ factor$

Temperature rise (°F) – For high-temperature machines, there is an extra sanitizing rinse that increases the water temperature via a dishwasher booster water heater an additional 40 °F, to 180 °F to meet the National Sanitation Foundation (NSF) mandated sanitation criteria. (The low-temperature machines meet this standard via a chemical rinse).

[18] California Public Utilities Commission (CPUC), Energy Division, Ex Ante Review Team. 2014. "DEER2015 Measure Summary Water Heater Energy Factor.xls."

Booster heating unit efficiency is used to determine the additional energy consumption of the booster water heating in high temperature units. Electric booster heating units are assumed to have an efficiency of 98%, and gas booster heating units are assumed to have an efficiency of 80%. These efficiencies are used to determine the additional energy consumption of the booster water heating in high temperature units. These engineering assumptions are consistent with those used by ENERGY STAR.[19]

Market Penetration of Booster Heating Fuel Types High temperature units attain energy savings via primary water heating and booster water heating. It is assumed that restaurants with electric primary heating will only install electric dishwashers with electric booster heating. While it is assumed that the vast majority of restaurants with gas primary water heating will install electric dishwashers with electric booster heating, for *undercounter* dishwashers, gas booster cases were not considered since there are no undercounter dishwasher models with a built-in gas booster heater.

The assumed percentages of market penetration for each primary/booster fuel combination are provided below. These percentages were applied to the primary water heating energy savings for low- and high-temperature units.

Market Penetration of Booster Water Heating Fuel

Booster Fuel Combination	Penetration (%)	Source
Electric	100%	Professional judgement.
Gas	0%	

Booster heater estimates are based upon personal communication with a Boxer Northwest commercial dishwasher retailer regarding booster heaters.

Annual Idle Energy

Annual idle energy use is a function of operating hours, wash time, idle energy rate, and the market penetration of primary and booster water heating fuel types.

$$Annual\ Idle\ Energy = EDAYS \times \left(EHOURS - RACKS \times \frac{TWASH}{MIN}\right) \times IDLERATE$$

EDAYS=	*Estimated operating days per year (days)*
EHOUR=	*Estimated operating hours per day (hrs)*
RACKS =	*Number of racks washed per day (Racks/day)*
TWASH =	*Estimated wash time per rack (min)*
MIN =	*Constant minutes per hour (min)*
IDLERATE =	*Measured idle energy rate (kW)*

Operating Hours per Day and **Operating Days per Year** The commercial dishwasher hours and days per year of operation was derived from an independent survey of 54 food service establishments conducted by Navigant Consulting.[20] The survey sample included independent restaurants, casual concept (big chain) restaurants, and fast food chains. These assumed hours and days of operation align with assumptions for

[19] ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.

[20] The source for this data or information is unknown.

many other food service measures drawn from a food service equipment market potential study conducted for the California Energy Commission (CEC) by Fisher-Nickel, Inc.[21]

Wash Time per Rack The time it takes to complete one wash cycle is assumed to be 2 minutes per rack.

Idle Energy Rate The idle energy rate for high-temperature and low-temperature machines is based upon the ENERGY STAR eligibility requirements in the Measure Case Description. The idle energy rate for base case machines is based upon the ENERGY STAR eligibility requirements in the Base Case Description.

Annual Electric Unit Energy Savings

The **annual UES** is calculated as the difference between the baseline and measure case annual UEC.[22]

$$UES_{YEAR} = UEC_{YEAR} = [UEC_{YEAR,Base} - UEC_{YEAR,Measure}]$$

Inputs and Assumptions

The inputs for the calculation of the annual electric UEC for both low- and high-temperature undercounter units are specified below.

Electric UEC Inputs – High-Temperature Undercounter-Type Dishwasher

Parameter	Base Case Model	Measure Case Model (Tier 1)	Measure Case Model (Tier 2)	Source
Specific heat of Water (Btu/lb/°F)	1	1	1	Given
Density of Water (lb/gal)	8.34	8.34	8.34	Given
Inlet water Temperature (°F)	Varies	Varies	Varies	Reeves, P. (Consultant to California Public Utilities Commission, Energy Division). 2013. "Comparison-of-Ground-Temperatures-v2_byPaulReeves.xlsx."
Setpoint Hot Water Temperature (°F)	140 °F	140 °F	140 °F	Engineering Judgement
Booster Heater Water Temperature Rise (°F)	40 °F	40 °F	40 °F	National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx."
Electric Water Heater Efficiency (%)	98%	98%	98%	California Public Utilities Commission (CPUC), Energy Division, Ex Ante Review Team. 2014. "DEER2015 Measure Summary Water Heater Energy Factor.xls."
Electric Water Booster Heater Efficiency (%)	98%	98%	98%	ENERGY STAR. 2015. "Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment." Updated February 2015.
Number of Racks per day (racks/day)	50	50	50	See Electric Water Heater Energy Use

[21] Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095.

[22] Southern California Gas Company (SCG). 2019. "SWFS018-01_Energy Calculations.xlsx."

Parameter	Base Case Model	Measure Case Model (Tier 1)	Measure Case Model (Tier 2)	Source
Water Consumption (Gal/Rack)	1.0	0.86	0.73	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Wash time per rack (min/rack)	2.0	2.0	2.0	Engineering Judgement
Idle Energy Rate (kW)	0.50	0.30	0.26	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Operating Days per Year	365	365	365	Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095.
Operating Hours per Day	12	12	12	
Market Penetration of Electric Water Heaters (%)	3%	3%	3%	See Market Penetration of Primary Water Heating Fuel Types
Market Penetration of Electric Booster Heaters (%)	100%	100%	100%	See Market Penetration of Booster Heating Fuel Types

Electric UEC Inputs – Low-Temperature Undercounter-Type Dishwasher

Parameter	Base Case	Low-Temp Measure Case (Tier 1)	Low-Temp Measure Case (Tier 2)	Source
Specific heat of Water (Btu/lb/°F)	1	1	1	Given
Density of Water (lb/gal)	8.34	8.34	8.34	Given
Inlet water Temperature (°F)	Varies	Varies	Varies	Reeves, P. (Consultant to California Public Utilities Commission, Energy Division). 2013. "Comparison-of-Ground-Temperatures-v2_byPaulReeves.xlsx."
Setpoint Hot Water Temperature (°F)	140 °F	140 °F	140 °F	Engineering Judgement
Electric Water Heater Efficiency (%)	98%	98%	98%	California Public Utilities Commission (CPUC), Energy Division, Ex Ante Review Team. 2014. "DEER2015 Measure Summary Water Heater Energy Factor.xls." ENERGY STAR. 2015. "Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment." Updated February 2015.
Number of Racks per day (racks/day)	50	50	50	See Electric Water Heater Energy Use
Water Consumption (gal/rack)	1.7	1.19	1.01	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Wash time per rack (min/rack)	2.0	2.0	2.0	Engineering Judgement

Parameter	Base Case	Low-Temp Measure Case (Tier 1)	Low-Temp Measure Case (Tier 2)	Source
Idle Energy Rate (kW)	0.50	0.25	0.21	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Operating Days per Year	365	365	365	Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095.
Operating Hours per Day	12	12	12	
Market Penetration of Electric Water Heaters (%)	3%	3%	3%	See Market Penetration of Booster Heating Fuel Types

Sample Calculation

A sample calculation of annual UEC of a base case high-temperature electric undercounter dishwasher in a commercial food service application that uses electric primary water heating is shown below.

Electric Water Heater Energy Use

$$UECGAL_{Water\ Heater} = \left(\frac{\Delta T \times C \times \rho}{\eta}\right) \times \frac{kWh}{Btu}$$

$$UECGAL_{Water\ Heater} = \left(\frac{(140\ °F - 61\ °F) \times \frac{1.0 Btu}{Lb \times F} \times \frac{8.34 Lb}{gal}}{0.98}\right) \times 0.0002931 \frac{kWh}{Btu} = 0.197 \frac{kWh}{gal}$$

$$Electric\ \ Water\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Water\ Heater} \times MktPen_{elec}$$

$$= 1.00 \left(\frac{Gal}{Rack}\right) \times 50 \left(\frac{Racks}{Day}\right) \times 365 \left(\frac{Day}{Yr}\right) \times 0.197 \left(\frac{kWh}{Gal}\right) \times \frac{3}{100} = 107.9\ kWh$$

Electric Booster Water Heater Energy

$$UECGAL_{Booster} = \left(\frac{\Delta T \times C \times \rho}{\eta}\right) \times \frac{kWh}{Btu}$$

$$UECGAL_{Water\ Heater} = \left(\frac{(40\ °F) \times \frac{1.0 Btu}{Lb \times F} \times \frac{8.34 Lb}{gal}}{0.98}\right) \times 0.0002931 \frac{kWh}{Btu} = 0.100 \frac{kWh}{gal}$$

$$Electric\ \ Booster\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Booster} \times MktPen_{booster,elec}$$

$$= 1.00 \left(\frac{Gal}{Rack}\right) \times 50 \left(\frac{Racks}{Day}\right) \times 365 \left(\frac{Day}{Yr}\right) \times 0.100 \left(\frac{kWh}{Gal}\right) \times \frac{100}{100} = 1{,}820.7\ kWh$$

Annual Idle Energy

$$Annual\ Idle\ Energy = EDAYS\ \times \left(EHOURS - RACKS \times \frac{TWASH}{MIN}\right) \times\ IDLERATE$$

$$Annual\ Idle\ Energy = 365\ days\ \times \left(12 \frac{hours}{day} - \left(\frac{50\ Racks}{day}\right) x \left(\frac{2\ min}{rack}\right) x \left(\frac{1\ hour}{60\ min}\right)\right) \times\ 0.5\ kW\ =\ 1885.8\ \ kWh$$

Annual Unit Energy Consumption

$$UEC_{YEAR} = Electric\ Water\ Heater\ Energy + Booster\ Water\ Heater\ Energy + Idle\ Energy$$

$$UEC_{YEAR} = 107.9\ kWh + 1{,}820.7\ kWh + 1{,}885.8\ \ kWh = 3{,}814.4\ kWh$$

PEAK ELECTRIC DEMAND REDUCTION (kW)

The **average peak demand** (baseline or measure case), or the average demand during the peak period, is a function of the unit energy consumption (UEC),[23] the number of hours during the peak period, and the assumed percent of total usage during the peak period.

$$PeakDemand_{\ avg} = \left(\frac{UEC\_YEAR}{EDAYS}\right) \times PeakUsePerc \div PeakHOURS$$

UEC_YEAR = *Annual unit energy consumption (kWh)*
EDAYS= *Estimated operating days per year (days)*
PeakHOURS = *Number of hours in the peak period (hours)*
PeakUsePerc= *Percent of total usage during peak period (%, decimal)*

The *End-use Water Demand Profile* study conducted by Aquacraft, Inc. for the California Public Utilities Commission (CPUC)[24] documents the hourly hot water demand of seven different restaurants. This study conducted on seven different restaurants concludes that 39.35% of total daily use occurs during the 5-hour peak demand period between 4:00 p.m. and 9:00 p.m. Therefore, it has been assumed that the probable contribution to the building peak demand is equal to the appliance average demand during the peak times.

Peak Demand Reduction

Peak demand reduction was calculated as the difference between base case and measure case average peak demand.[25] The average peak demand (base or measure case) was calculated as the daily unit energy consumption during the peak period divided by the number of hours during the peak period of 4:00 p.m. to 9:00 p.m.[26]

$$PeakDemandReduction = \left(PeakDemand_{avg,base} - PeakDemand_{avg,measure}\ \right)$$

$PeakDemand_{avg}$ = *Average demand, base or measure case (kW)*

Inputs and Assumptions

The table below provides the inputs for the calculation of peak demand reduction of a commercial door-type dishwasher (high- and low-temperature models).

[23] Southern California Gas Company (SCG). 2019. "WPSCGNRCC180529A_Rev00_Att_02_EnergyUseByCZ.xlsx"

[24] Aquacraft, Inc. 2011. *Embedded Energy in Water Studies. Study 3: End-use Water Demand Profiles.* Prepared for the California Public Utilities Commission. CALMAC Study ID: CPU0052.

[25] Southern California Gas Company (SCG). 2021. "SWFS018-02_Energy Calculations.xlsx."

[26] California Public Utilities Commission (CPUC). 2018. *Resolution E-4952.* October 11. O.P. 1.

Demand Reduction Inputs

Parameter	Value	Source
Percent of Total Daily Usage During Peak Period	0.39	Aquacraft, Inc. 2011. *Embedded Energy in Water Studies. Study 3: End-use Water Demand Profiles.* Prepared for the California Public Utilities Commission. CALMAC Study ID: CPU0052.
Number of Hours in Peak Period	5	California Public Utilities Commission (CPUC). 2006. *D 06-06-063 in the Order Instituting Rulemaking to Promote Consistency in Methodology and Input Assumptions in Commission Applications of Short-Run and Long-Run Avoided Costs, Including Pricing for Qualifying Facilities. (R.04-04-025).* June 29.

GAS SAVINGS (Therms)

The basis for gas unit energy savings (UES) is the difference between the water heating unit energy consumption (UEC) of the base case and measure case dishwasher models. Because energy-efficient units require considerably less water, less energy is required for water heating. For both low- and high-temperature machines, the base case UEC is based on the energy required to heat water for the dishwashing and sanitizing cycles. The high-temperature unit water heating energy components are further split into *primary* and *booster* water heating.

The calculation of the annual gas UEC is calculated as the difference between the baseline UEC and the measure case UEC.[27] Note that motor energy and standby losses are assumed to be the same for both the base case and the measure case and are therefore not presented in the energy savings calculations.

$$UEC_{YEAR} = Gas\ Water\ Heater\ Energy + GasBooster\ Water\ Heater\ Energy + Idle\ Energy$$

Each term in the UEC calculation is detailed below, followed by all inputs and assumptions.

Gas Water Heater Energy Use

Gas water heater energy use is a function of water consumption (GPR), the number of racks washed per year, the UEC per gallon of water, and market penetration of electric water heating.

$$Gas\ \ Water\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Water\ Heater} \times MktPen$$

$GPR = Water\ consumption\ (GPR)$
$RACKS = Number\ of\ racks\ washed\ per\ day\ (\#)$
$EDAYS = Operating\ days\ per\ year\ (days)$
$UECGAL = UEC\ per\ gallon\ of\ water\ (Therms)$
$MktPen = Market\ penetration\ of\ gas\ water\ heating\ (\%,\ decimal)$

Water Consumption (GPR) The water consumption in gallons per rack was calculated as the maximum allowable consumption as shown in the Measure Offering table. Tier 1 units' maximum water

[27] Southern California Gas Company (SCG). 2019. "WPSCGNRCC180529A_Rev00_Att_02_EnergyUseByCZ.xlsx"

consumption was set to ENERGY STAR maximum performance criteria[28], while Tier 2 units were determined to have water consumption 15% below ENERGY STAR maximum performance.

Racks per Day The number of racks per day is based on monitored data from five different restaurant sites (fast casual, fine dining, cafes, and quick service restaurants) and dishwasher leasing companies that track the racks per month as part of the equipment lease agreements. The monitored data was provided by the Food Service Technology Center (FSTC).[29] The undercounter dishwasher data was also interpolated from the door type dishwasher usage of 152 racks per day based on 6 field monitoring locations. Frontier Energy estimated that 3 times more racks are washed in door type dishwashers than undercounter dishwashers. It is estimated that an undercounter dishwasher washes 50 racks per day which is used in this analysis.

Operating Days per Year The number of days of operation per year.

Market Penetration of Water Heating Fuel Types Electric and gas water heater fuel saturation was derived from CEUS 2006 data.

Market Penetration of Primary Water Heating Fuel

Primary/Booster Fuel Combination	Penetration (%)	Source
Electric	3%	Itron, Inc. 2006. California Commercial End Use Survey. Prepared for the California Energy Commission. CEC-400-2006-005. Table E-1.
Gas	97%	

UEC per Gallon of Water The UEC per gallon of water is based on the increase in water temperature required for a wash cycle, the specific heat of water, the density of water, and the heating equipment efficiency.

$$UECGAL_{Water\ Heater} = \left(\frac{\Delta T \times C \times \rho}{\eta}\right) \times \frac{Therm}{Btu}$$

$\Delta T = Temperature\ rise\ (°F)$
$C = Specific\ heat\ of\ water,\ constant\left(\frac{Btu}{lb-°F}\right)$
$\rho = Density\ of\ water,\ constant\left(\frac{lbs}{gal}\right)$
$\eta = Gas\ heating\ equipment\ efficiency$

Temperature Rise (°F) – Average groundwater temperature data for each climate zone is used as the inlet temperature which needs to be raised to 140 °F to meet the minimum supply water temperature at the dishwasher. Groundwater temperature data was retrieved from the 2010 climate zone weather data files for the 2013 Building Energy Efficiency Standards (Title 24).[30]

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[28] ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.

[29] Pacific Gas and Electric (PG&E). 2015. "Dishmachine Calcs 02092015.xls."

[30] Southern California Gas Company (SCG). 2018. "SWFS018 CZ2010 Ground Water Temp.xlsx"

Heating Equipment Efficiency (%) – Heating equipment efficiency varies between electric and gas units, as well as between external primary water heating and internal booster heating. The efficiency of a building's electric water heater is assumed to be 98%, while gas water heaters are assumed to have a recovery efficiency of 77%. These efficiencies are used to determine energy consumption of the primary water heating in both low and high temperature units.

Gas Booster Water Heater Energy

For a high-temperature unit using a higher-temperature sanitizing rinse, the methodology was used to determine the additional energy required for the booster water heating as was followed for the Electric Water Heater Energy. The booster heater, however, is needed to increase 100% of the water from a temperature of 140 °F to 180 °F.

$$Electric\ \ Booster\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Booster} \times MktPen_{booster,gas}$$

GPR = Water consumption (GPR)
RACKS = Number of racks washed per year (racks/day)
EDAYS = Operating days per year (days/yr)
$UECGAL_{Booster}$ = UEC per gallon of water (kWh)
MktPen = Market penetration of gas booster water heating (%, decimal)

Market Penetration of Booster Heating Fuel Types Since gas booster fuel penetration is 0%, there is no gas booster energy usage.

Annual Idle Energy

Annual idle energy use is a function of operating hours, wash time, idle energy rate, and the market penetration of primary and booster water heating fuel types.

$$Annual\ Idle\ Energy = EDAYS\ \times \left(EHOURS - RACKS \times \frac{TWASH}{MIN}\right) \times\ IDLERATE$$

EDAYS=	*Estimated operating days per year (days)*
EHOUR=	*Estimated operating hours per day (hrs)*
RACKS =	*Number of racks washed per day (Racks/day)*
TWASH =	*Estimated wash time per rack (min)*
MIN =	*Constant minutes per hour (min)*
IDLERATE =	*Measured idle energy rate (Btu)*

Idle Energy Rate Since gas booster fuel penetration is 0%, there is no gas idle energy usage

Annual Gas Unit Energy Savings

The **annual UES** is calculated as the difference between the baseline and measure case annual UEC.[31]

$$UES_{YEAR} = UEC_{YEAR} = [UEC_{YEAR,Base} - UEC_{YEAR,Measure}]$$

[31] Southern California Gas Company (SCG). 2019. "SWFS018-01_Energy Calculations.xlsx."

Inputs and Assumptions

The inputs for the calculation of the annual gas UEC for both low- and high-temperature undercounter units are specified below.

Gas UEC Inputs – High-Temperature Undercounter-Type Dishwasher

Parameter	Base Case Model	Measure Case Model (Tier 1)	Measure Case Model (Tier 2)	Source
Specific heat of Water (Btu/lb/°F)	1	1	1	Given
Density of Water (lb/gal)	8.34	8.34	8.34	Given
Inlet water Temperature (°F)	Varies	Varies	Varies	Reeves, P. (Consultant to California Public Utilities Commission, Energy Division). 2013. "Comparison-of-Ground-Temperatures-v2_byPaulReeves.xlsx."
Setpoint Hot Water Temperature (°F)	140 °F	140 °F	140 °F	Engineering Judgement
Booster Heater Water Temperature Rise (°F)	40 °F	40 °F	40 °F	National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx."
Gas Water Heater Efficiency (%)	77%	77%	77%	California Public Utilities Commission (CPUC), Energy Division, Ex Ante Review Team. 2014. "DEER2015 Measure Summary Water Heater Energy Factor.xls." ENERGY STAR. 2015. "Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment." Updated February 2015.
Number of Racks per day (racks/day)	50	50	50	See Electric Water Heater Energy Use
Water Consumption (Gal/Rack)	1.0	0.86	0.73	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Wash time per rack (min/rack)	2.0	2.0	2.0	Engineering Judgement
Idle Energy Rate (kW)	0.5	0.3	0.26	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Operating Days per Year	365	365	365	Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095.
Operating Hours per Day	12	12	12	
Market Penetration of Gas Water Heaters (%)	97%	97%	97%	See Market Penetration of Booster Heating Fuel Types
Market Penetration of Electric Booster Heaters (%)	100%	100%	100%	See Market Penetration of Booster Heating Fuel Types

Gas UEC Inputs – Low-Temperature Undercounter-Type Dishwasher

Parameter	Base Case	Low-Temp Measure Case (Tier 1)	Low-Temp Measure Case (Tier 2)	Source
Specific heat of Water (Btu/lb/°F)	1	1	1	Given
Density of Water (lb/gal)	8.34	8.34	8.34	Given
Inlet water Temperature (°F)	Varies	Varies	Varies	Reeves, P. (Consultant to California Public Utilities Commission, Energy Division). 2013. "Comparison-of-Ground-Temperatures-v2_byPaulReeves.xlsx."
Setpoint Hot Water Temperature (°F)	140 °F	140 °F	140 °F	Engineering Judgement
Gas Water Heater Efficiency (%)	77%	77%	77%	California Public Utilities Commission (CPUC), Energy Division, Ex Ante Review Team. 2014. "DEER2015 Measure Summary Water Heater Energy Factor.xls." ENERGY STAR. 2015. "Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment." Updated February 2015.
Number of Racks per day (racks/day)	50	50	50	See Electric Water Heater Energy Use
Water Consumption (gal/rack)	1.7	1.19	1.01	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Wash time per rack (min/rack)	2.0	2.0	2.0	Engineering Judgement
Idle Energy Rate (kW)	0.5	0.25	0.21	ENERGY STAR. 2020. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (October 2020) Version 3.0." Effective July 27, 2021.
Operating Days per Year	365	365	365	Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095.
Operating Hours per Day	12	12	12	
Market Penetration of Gas Water Heaters (%)	97%	97%	97%	See Market Penetration of Booster Heating Fuel Types

Sample Calculation

A sample calculation of annual UEC of a base case high-temperature gas undercounter dishwasher in a commercial food service application that uses electric primary water heating is shown below.

Gas Water Heater Energy Use

$$UECGAL_{Water\ Heater} = \left(\frac{\Delta T \times C \times \rho}{\eta}\right) \div \frac{Btu}{Therm}$$

$$UECGAL_{Water\ Heater} = \left(\frac{(140\ °F - 61\ °F) \times \frac{1.0 Btu}{Lb \times F} \times \frac{8.34 Lb}{gal}}{0.77}\right) \div 100{,}000 \frac{Btu}{Therm} = 0.00856 \frac{Therm}{gal}$$

$$Gas\ \ Water\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Water\ Heater} \times MktPen$$

$$= 1.0 \left(\frac{Gal}{Rack}\right) \times 50 \left(\frac{Racks}{Day}\right) \times 365 \left(\frac{Day}{Year}\right) \times 0.0087 \left(\frac{Therms}{Gal}\right) \times \frac{97}{100} = 151.5\ Therms$$

Gas Booster Water Heater Energy

$$Electric\ \ Booster\ Heater\ Energy = GPR \times RACKS \times EDAYS \times UECGAL_{Booster} \times MktPen_{booster,gas} = 0\ Therm$$

Annual Idle Energy

$$Annual\ Idle\ Energy = \ EDAYS\ \times \left(EHOURS - RACKS \times \frac{TWASH}{MIN}\right) \times\ IDLERATE = 0\ Therms$$

Annual Unit Energy Consumption

$$UEC_{YEAR} = Gas\ Water\ Heater\ Energy + GasBooster\ Water\ Heater\ Energy + Idle\ Energy$$

$$UEC_{YEAR} = 144.0\ Therm/yr + 0\ Therm/yr + 0\ Therm/yr = 151.5\ Therm/yr$$

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."[32] This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.[33] 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." [34]

The EUL and RUL specified below. The estimated lifetime for this measure is the EUL adopted for other food service equipment, as documented in a retention study of gas energy efficiency measures conducted for the Southern California Gas Company, and the Energy Efficiency Policy Manual, version 2.0.[35] While these sources do not explicitly specify the EUL for an undercounter dishwasher, adopting

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

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

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

[35] Robert Mowris & Associates. 2005. *Ninth Year Retention Study of the 1995 Southern California Gas Company Commercial New Construction Program*. Prepared for Southern California Gas Company. Study ID Number 718A.

California Public Utilities Commission (CPUC), Energy Division. 2003. *Energy Efficiency Policy Manual v 2.0.* Page 18 Table 4.1.

the value common to other food service equipment types is reasonable. In particular, this estimate is lower than the door-type dishwasher EUL of 15 years; an undercounter dishwasher is easier to replace and costs about ⅓ to ½ less than a door-type dishwasher. Thus, it is reasonable to assume that an undercounter dishwasher will be replaced more often than a door-type model. Further, this estimate is close to the EUL assumed for the energy savings calculator for commercial kitchen equipment developed for ENERGY STAR.[36]

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	12	California Public Utilities Commission (CPUC), Energy Division. 2003. *Energy Efficiency Policy Manual v 2.0.* Page 18 Table 4.1.
RUL (yrs)	n/a	n/a

BASE CASE MATERIAL COST ($/UNIT)

The base case material cost for equipment *delivered via direct install* is equal to $0.

For *all other delivery types*, the base case material cost was calculated as the average unit cost of base case low-temperature and high-temperature commercial dishwasher models. Unit costs were obtained from various sources including the AutoQuotes online catalog, equipment sales reps, and manufacturer sources. Since food service equipment pricing in competitively sensitive information and prices vary widely according to buying volume and other factors, the sources for prices are not publicly available.

MEASURE CASE MATERIAL COST ($/UNIT)

The measure case material costs for *all delivery types* were calculated as the average unit cost measure case low-temperature and high-temperature commercial dishwasher models. Unit costs were obtained from various sources including the AutoQuotes online catalog, equipment sales reps, and manufacturer sources. Since food service equipment pricing in competitively sensitive information and prices vary widely according to buying volume and other factors, the sources for prices are not publicly available.

BASE CASE LABOR COST ($/UNIT)

The base case labor cost for equipment *delivered via direct install* is equal to $0.

For *all other delivery types*, the base case and measure case model installation costs are expected to be the same for the customer and thus not estimated for the incremental cost analysis.

MEASURE CASE LABOR COST ($/UNIT)

The measure case labor cost for equipment *delivered via direct install* will be derived as the average installation cost submitted by one or more implementation contractors. The actual installation cost can

[36] ENERGY STAR. 2015. “Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment.” Updated February 2015.

vary by contractor, the date when the work occurred, and by the volume of each specific contractor's business. Contractor costs are confidential information and are based upon contractually agreed upon pricing as established in their purchase order with the program administrator. Therefore, the program administrator program tracking systems are the only source for the labor installation cost data. The program administrator will utilize the actual program cost to evaluate the cost-effectiveness of the measure.

For *all other delivery types*, a high efficiency model does not require additional installation labor compared to a base case model. Since this measure is applicable for normal replacement and new construction installations, the base case and measure case model installation costs are expected to be the same for the customer and thus not estimated for the incremental cost analysis.

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.

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

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

Water savings is the primary non-energy impact associated with high efficiency commercial dishwashers. The calculation of annual water savings of an energy efficient (measure case) commercial dishwasher is calculated as the difference between the baseline and measure annual water consumption. The inputs for this calculation are specified in Electric Savings.

$$UWC = GPR \times RACKS \times EDAYS$$

$GPR = Water\ consumption\ (GPR)$
$RACKS = Number\ of\ racks\ washed\ per\ day\ (rack/day)$
$EDAYS = Operating\ days\ per\ year\ (days)$

$$UWS = UWC_{Base} - UWC_{Measure}$$

$UWC = Annual\ unit\ water\ consumption\ (gal/year)$
$UWS = Annual\ unit\ water\ savings\ (gal/year)$

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	N/A
Reason for Deviation from DEER	The 2016 DEER database does not contain information on energy use or savings or equipment costs for an energy-efficient commercial dishwasher.
DEER Measure IDs Used	N/A
NTG	Source: DEER. The NTG of 0.60 is associated with NTG ID: *Com-Default>2yrs*
GSIA	The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA*
EUL/RUL	Source: New: The value of 12 years is associated with EUL ID: *Appl-DW-UnderCounter*

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision
01	5/27/2019	Andres Marquez, Southern California Gas Company	Draft of consolidated text for this statewide measure is based upon: WPSCGNRCC180529A, Revision 0 (March 22, 2019) Consensus reached among Cal TF members.
	5/31/2019	Andres Marquez SoCalGas Jennifer Holmes, Cal TF Staff	Revisions for submission of version 01.
02	6/15/2021	Anders Danryd SoCalGas	Updated workpaper due to ENERGYSTAR version 3.0 for commercial dishwashing machines. Updated NTG ID
	7/28/2021	Anders Danryd SoCalGas	Updated calculations per CPUC comments (removed CDF, added specific heat of water to calculations)