



FOOD SERVICE
UNDERCOUNTER DISHWASHER, COMMERCIAL
SWFS018-01

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MEASURE NAME

Undercounter Dishwasher, Commercial

STATEWIDE MEASURE ID

SWFS018-01

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

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 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 includes high- and low-temperature dishwasher offerings based upon the ENERGY STAR® Commercial Dishwashers Version 2.0.⁵ 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. Idle Energy Rate (kW) | Source |
|-------------------------------|--------------------------|------------------------------|----------------------------|--|
| SWFS018A | High Temperature, Tier 1 | 0.86 | 0.50 | ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. June 2012) Version 2.0." Effective February 1, 2013. |
| SWFS018B | High Temperature, Tier 2 | 0.73 | 0.43 | |
| SWFS018C | Low Temperature, Tier 1 | 1.19 | 0.50 | |
| SWFS018D | Low Temperature, Tier 2 | 1.01 | 0.43 | |

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 Machines⁶ to estimate the energy and water consumption of both the base and measure case.

BASE CASE DESCRIPTION

The base case specification is based upon the ENERGY STAR Eligibility Requirements for Commercial Dishwashers, Version 1.2.⁷

⁵ ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013.

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 Specification

| Dishwasher Type | Max. Water Consumption (GPR) | Max. Idle Energy Rate (kW) |
|------------------|------------------------------|----------------------------|
| High Temperature | 1.00 | 0.90 |
| 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 2.0)⁸ uses the ASTM F1696-07 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines⁹ to estimate the energy and water consumption of both the base and measure case.

The revised ASTM F1696-15 test method¹⁰ 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.

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

⁸ ENERGY STAR. 2012. “ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0.” Effective February 1, 2013.

⁹ 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.

¹⁰ 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.

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 all California climate zones.

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.¹¹ 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.

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

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 and booster heating.

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

$$GPR = Water\ consumption\ (GPR)$$

$$RACKS = Number\ of\ racks\ washed\ per\ day\ (\#)$$

¹¹ Southern California Gas Company (SCG). 2019. "WPSCGNRCC180529A_Rev00_Att_02_EnergyUseByCZ.xlsx"

EDAYS = Operating days per year (days)

UECGAL = UEC per gallon of water (kWh)

MktPen = Market penetration of electric water heating (% , decimal)

Water Consumption (GPR). The National Sanitation Foundation (NSF) provides a database of commercial dishwashers that reports manufacturer calculated water consumption in gallons per rack (GPR).¹² The database includes models that meet the ENERGY STAR performance criteria¹³ for reduced water consumption (1.19 GPR for low-temperature units, and 0.86 GPR for high-temperature units), even models that qualify but for which the ENERGY STAR label was not pursued. The water and energy consumption calculations for this measure exclude models that are no longer manufactured.

Racks per Year. The number of racks per year is equal to the number of racks per day multiplied by the assumed number of days of operation per year.

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 |

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 weight of water, and the heating equipment efficiency.

¹² National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx."

¹³ ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013.

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

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

ΔT = Temperature rise (°F)

C = Specific heat of water, the energy required to raise one pound of water by one-degree, 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

The parameters to calculate the UEC per gallon of water are explained below.

Temperature rise (°F) – This analysis assumes an average inlet water temperature of 61.0 °F that 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).¹⁵ This water heating requirement applies to both low- and high-temperature machines. 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).

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 recovery efficiency of 77%.¹⁶ These efficiencies are used to determine energy consumption of the primary water heating in both low and high temperature units.

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.¹⁷

Electric 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

¹⁵ Southern California Gas Company (SCG). 2018. "SWFS018 CZ2010 Ground Water Temp.xlsx"

¹⁶ California Public Utilities Commission (CPUC), Energy Division, Ex Ante Review Team. 2014. "DEER2015 Measure Summary Water Heater Energy Factor.xls."

¹⁷ ENERGY STAR. 2015. "Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment." Updated February 2015.

Water Heater Energy. The booster heater, however, is needed to increase 100% of the water from a temperature of 140 °F to 180 °F.

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

$$GPR = \text{Water consumption (GPR)}$$

$$RACKS = \text{Number of racks washed per year (\#)}$$

$$UECGAL = \text{UEC per gallon of water (kWh)}$$

$$MktPen = \text{Market penetration of electric booster water heating (\%, decimal)}$$

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.

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, gas booster heating is available and is installed in 5% of *door type* only dishwashers. For *undercounter* dishwashers it is assumed a small percentage have electric-electric, the remainder is assumed to be gas-electric; 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 Primary Water Heating and Booster Water Heating Fuel Combinations

| Primary/Booster Fuel Combination | Penetration (%) | Source |
|----------------------------------|-----------------|-------------------------|
| Electric/Electric | 3% | Professional judgement. |
| Gas/Gas | 0% | |
| Gas/Electric | 97% | |

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

Primary water heating percentages are based on:

Itron, Inc. 2006. California Commercial End Use Survey. Prepared for the California Energy Commission. CEC-400-2006-005. Table E-1.

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.

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

$$EDAYS = \text{Estimated operating days per year (days)}$$

$$EHOUR = \text{Estimated operating hours per day (hrs)}$$

$$TWASH = \text{Estimated wash time per rack (min)}$$

$$MIN = \text{Constant minutes per hour (min)}$$

$$IDLERATE = \text{Measured idle energy rate (kW)}$$

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.¹⁸ 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.¹⁹

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.

Market Penetration of Booster Heating Fuel Types. See Electric Booster Water Heater Energy.

Annual Electric Unit Energy Savings

The **annual UES** is calculated as the difference between the baseline and measure case annual UEC.²⁰

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

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 | |
| Density of Water (lb/gal) | 8.2 | 8.2 | 8.2 | |
| Inlet water Temperature (°F) | 61.0 °F | 61.0 °F | 61.0 °F | California Energy Commission (CEC). 2011. "CZ2010 Weather Files.xls." Average water temperature across PGE territory. |
| Setpoint Hot Water Temperature (°F) | 140 °F | 140 °F | 140 °F | The source for this data is unknown. |
| 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." |

¹⁸ The source for this data or information is unknown.

¹⁹ 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.

²⁰ 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 |
|---|-----------------|-----------------------------|-----------------------------|--|
| Electric Water Heater Energy per Gallon (kWh/gal) | 0.201 | 0.201 | 0.201 | Calculated value. |
| Electric Booster Heater Energy per Gallon (kWh/gal) | 0.098 | 0.098 | 0.098 | See UEC per Gallon of Water under Electric Water Heater Energy Use |
| 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. |
| Electric Water Booster Heater Efficiency (%) | 98% | 98% | 98% | |
| 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 | National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx." |
| Daily Water Consumption (gal) | 50.0 | 43.0 | 36.5 | Calculated = Racks per Day x Gal/Rack |
| Daily Booster Consumption (gal) | 50.0 | 43.0 | 36.5 | Calculated = Racks per Day x Gal/Rack |
| Wash time per rack (min/rack) | 2 | 2 | 2 | The source for this data is unknown. |
| Idle Energy Rate (kW) | 0.9 | 0.5 | 0.43 | ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013. |
| Operating Days per Year | 365 | 365 | 365 | Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. <i>Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment</i> . 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 |
| 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 | |
| Density of Water (lb/gal) | 8.2 | 8.2 | 8.2 | |
| Inlet water Temperature (°F) | 61.0 °F | 61.0 °F | 61.0 °F | California Energy Commission (CEC). 2011. "CZ2010 Weather Files.xls." Average water temperature across PGE territory. |
| Setpoint Hot Water Temperature (°F) | 140 °F | 140 °F | 140 °F | The source for this data is unknown. |

| Parameter | Base Case | Low-Temp Measure Case (Tier 1) | Low-Temp Measure Case (Tier 2) | Source |
|---|-----------|--------------------------------|--------------------------------|---|
| Electric Water Heater Energy per Gallon (kWh/gal) | 0.201 | 0.201 | 0.201 | Calculated value. See UEC per Gallon of Water under Electric Water Heater Energy Use |
| 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 | California Public Utilities Commission (CPUC), Energy Division. 2013. "Workpaper Disposition for Water Fixtures." February 22. California Public Utilities Commission (CPUC), Energy Division. "DEER-WaterHeater-Calculator-v1.0.xlsm." Pacific Gas and Electric (PG&E). 2015. "Dishmachine Calcs 02092015.xls." See "Monitored Data + GPR" tab. National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx." |
| Daily Water Consumption (gal) | 85.0 | 59.5 | 50.5 | Calculated = Racks per Day x Gal/Rack |
| Wash time per rack (min/rack) | 2 | 2 | 2 | The source for this data is unknown. |
| Idle Energy Rate (kW) | 5.17 | 5.17 | 4.44 | ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013. |
| Operating Days per Year | 365 | 365 | 365 | Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. <i>Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment</i> . 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.

$$\text{Electric Water Heater Energy} = \left(\frac{\text{Gal}}{\text{Rack}} \right) \times \left(\frac{\text{Racks}}{\text{Year}} \right) \times \left(\frac{\text{Energy}}{\text{Gal}} \right) \times \text{Market Penetration}$$

$$= 1.00 \left(\frac{\text{Gal}}{\text{Rack}} \right) \times 18,250 \left(\frac{\text{Racks}}{\text{Year}} \right) \times 0.201 \left(\frac{\text{kWh}}{\text{Gal}} \right) \times 0.03 = 110 \text{ kWh}$$

$$\text{Electric Booster Heater Energy} = \left(\frac{\text{Gal}}{\text{Rack}} \right) \times \left(\frac{\text{Racks}}{\text{Year}} \right) \times \left(\frac{\text{Energy}}{\text{Gal}} \right) \times \text{Market Penetration}$$

$$= 1.00 \left(\frac{\text{Gal}}{\text{Rack}} \right) \times 18,250 \left(\frac{\text{Racks}}{\text{Year}} \right) \times 0.098 \left(\frac{\text{kWh}}{\text{Gal}} \right) \times 1.0 = 1,789 \text{ kWh}$$

$$\text{Annual Idle Energy} = \text{Operating days} \times (\text{Operating hours} - \text{wash time}) \times \text{Idle Energy Rate (kW)}$$

$$= 365 \times \left(12 \text{ hours/day} - \left(\frac{50 \text{ Racks}}{\text{day}} \right) \times \left(\frac{2 \text{ min}}{\text{rack}} \right) \times \left(\frac{1 \text{ hour}}{60 \text{ min}} \right) \right) \times 0.9 \text{ kW} = 3395 \text{ kWh}$$

$$\text{Annual Energy Consumption} = 3395 \text{ kWh}$$

PEAK ELECTRIC DEMAND REDUCTION (kW)

The actual contribution to building peak demand can vary significantly depending on the dishwasher usage pattern in relation to that of other electric equipment in the facility (operating schedule, appliance ON time, etc.).

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),²¹ the number of hours during the peak period, and the assumed percent of total usage during the peak period.

The *End-use Water Demand Profile* study conducted by Aquacraft, Inc. for the California Public Utilities Commission (CPUC)²² documents the hourly hot water demand of seven different restaurants. This study conducted on seven different restaurants concludes that 24.1% of total daily use occurs during the 3-hour peak demand period between 2:00 p.m. and 5:00 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 was calculated as the difference between base case and measure case average peak demand, multiplied by a coincident demand factor (CDF).²³ The average peak demand (base or

²¹ Southern California Gas Company (SCG). 2019. "WPSCGNRCC180529A_Rev00_Att_02_EnergyUseByCZ.xlsx"

²² 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.

²³ Southern California Gas Company (SCG). 2019. "SWFS018-01_Energy Calculations.xlsx."

measure case) was calculated as the unit energy consumption divided by the number of hours during the peak period of 4:00 p.m. to 9:00 p.m.²⁴

$$Demand_{avg} = \left(\frac{UEC_YEAR_{kWh}}{EDAYS} \right) \times \left(\frac{Usage\ During\ Peak}{Total\ Daily\ Usage} \right) \div PEAKHours$$

$$Demand_{avg,base} = \left(\frac{5,293\ kWh}{Year} \right) \times \left(\frac{1\ year}{365\ days} \right) \times (24.1\%) \div 5\ hrs = 0.7\ kW$$

$$Demand_{avg,measure} = \left(\frac{3,519\ kWh}{Year} \right) \times \left(\frac{1\ year}{365\ days} \right) \times (24.1\%) \div 5\ hrs = 0.46\ kW$$

And

$$PeakDemandReduction = [(Demand_{avg,base} - Demand_{avg,measure}) \times CDF]$$

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

CDF = Coincident demand factor

$$Measure\ Case\ Tier\ 1\ Demand\ Reduction = (0.7kW - 0.46kW) \times 0.9 = 0.216\ kW$$

Peak Demand Reduction Inputs

| Parameter | Value | Source |
|--------------------------|-------|--|
| Coincident demand factor | 0.90 | Ittron, Inc. 2005. <i>2004-2005 Database for Energy Efficiency Resources (DEER) Update Study - Final Report</i> . Prepared for Southern California Edison. Pages 3-15 to 3-17, Table 3-14. |

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.²⁵ 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.

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

²⁴ California Public Utilities Commission (CPUC). 2018. *Resolution E-4952*. October 11. O.P. 1.

²⁵ 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.

Gas Water Heater Energy Use

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 and booster heating.

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

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 National Sanitation Foundation (NSF) provides a database of commercial dishwashers that reports manufacturer calculated water consumption in gallons per rack (GPR).²⁶ The database includes models that meet the ENERGY STAR performance criteria²⁷ for reduced water consumption (1.19 GPR for low-temperature units, and 0.86 GPR for high-temperature units), even models that qualify but for which the ENERGY STAR label was not pursued. The water and energy consumption calculations for this measure exclude models that are no longer manufactured.

Racks per Year. The number of racks per year is equal to the number of racks per day multiplied by the assumed number of days of operation per year.

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).²⁸ 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.

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 weight of water, and the heating equipment efficiency.

$$\text{UEC per Gallon (Therm)} = \left(\frac{\Delta T \times C \times \rho}{\eta \times} \right) \times \frac{\text{Therm}}{\text{Btu}}$$

²⁶ National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx."

²⁷ ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013.

²⁸ Pacific Gas and Electric (PG&E). 2015. "Dishmachine Calcs 02092015.xls."

where:

ΔT = Temperature rise ($^{\circ}\text{F}$)

C = Specific heat of water, the energy required to raise one pound of water by one-degree, constant
 $\left(\frac{\text{Btu}}{\text{lb-}^{\circ}\text{F}}\right)$

ρ = Density of water, constant $\left(\frac{\text{lbs}}{\text{gal}}\right)$

η = Gas heating equipment efficiency

Therm/Btu = Btu to therm conversion factor

The parameters to calculate the UEC per gallon of water are explained below.

Temperature Rise ($^{\circ}\text{F}$) – This analysis assumes an average inlet water temperature of 61.0 $^{\circ}\text{F}$ that needs to be raised to 140 $^{\circ}\text{F}$ 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).²⁹ This water heating requirement applies to both low- and high-temperature machines. For high-temperature machines, there is an extra sanitizing rinse that increases the water temperature via a dishwasher booster water heater an additional 40 $^{\circ}\text{F}$, to 180 $^{\circ}\text{F}$ to meet the National Sanitation Foundation (NSF) mandated sanitation criteria. (The low-temperature machines meet this standard via a chemical rinse).

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.

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.³⁰

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.

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

EDAYS= Estimated operating days per year (days)

EHOUR= Estimated operating hours per day (hrs)

²⁹ Southern California Gas Company (SCG). 2018. "SWFS018 CZ2010 Ground Water Temp.xlsx"

³⁰ ENERGY STAR. 2015. "Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment." Updated February 2015.

$TWASH =$ Estimated wash time per rack (min)
 $MIN =$ Constant minutes per hour (min)
 $IDLERATE =$ Measured idle energy rate (Btu)

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.³¹ 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.³²

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.

Annual Gas Unit Energy Savings

The **annual UES** is calculated as the difference between the baseline and measure case annual UEC.³³

$$UES_YEAR = [UEC_YEAR_{Base} - UEC_YEAR_{Measure}]$$

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 | |
| Density of Water (lb/gal) | 8.2 | 8.2 | 8.2 | |
| Inlet water Temperature (°F) | 61.0 °F | 61.0 °F | 61.0 °F | California Energy Commission (CEC). 2011. "CZ2010 Weather Files.xls." Average water temperature across PGE territory. |
| Setpoint Hot Water Temperature (°F) | 140 °F | 140 °F | 140 °F | The source for this data is unknown. |
| 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." |

³¹ The source for this data or information is unknown.

³² 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.

³³ 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 |
|---|-----------------|-----------------------------|-----------------------------|---|
| Gas Booster Heater Energy per Gallon (therms/gal) | 0.0087 | 0.0087 | 0.0087 | Calculated value. |
| Electric Booster Heater Energy per Gallon (kWh/gal) | 0.098 | 0.098 | 0.098 | See UEC per Gallon of Water under Electric Water Heater Energy Use |
| 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. |
| Electric Water Booster Heater Efficiency (%) | 98% | 98% | 98% | |
| 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 | National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx." |
| Daily Water Consumption (gal) | 50.0 | 43.0 | 36.5 | Calculated = Racks per Day x Gal/Rack |
| Daily Booster Consumption (gal) | 50.0 | 43.0 | 36.5 | Calculated = Racks per Day x Gal/Rack |
| Wash time per rack (min/rack) | 2 | 2 | 2 | The source for this data is unknown. |
| Idle Energy Rate (kW) | 0.9 | 0.5 | 0.43 | ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013. |
| Operating Days per Year | 365 | 365 | 365 | Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. <i>Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment</i> . 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 | |
| Density of Water (lb/gal) | 8.2 | 8.2 | 8.2 | |
| Inlet water Temperature (°F) | 61.0 °F | 61.0 °F | 61.0 °F | California Energy Commission (CEC). 2011. "CZ2010 Weather Files.xls." Average water temperature across PGE territory. |
| Setpoint Hot Water Temperature (°F) | 140 °F | 140 °F | 140 °F | The source for this data is unknown. |

| Parameter | Base Case | Low-Temp Measure Case (Tier 1) | Low-Temp Measure Case (Tier 2) | Source |
|--|-----------|--------------------------------|--------------------------------|---|
| Gas Water Heater Energy per Gallon (kWh/gal) | 0.0087 | 0.0087 | 0.0087 | Calculated value. See UEC per Gallon of Water under Electric Water Heater Energy Use |
| 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 | California Public Utilities Commission (CPUC), Energy Division. 2013. "Workpaper Disposition for Water Fixtures." February 22. California Public Utilities Commission (CPUC), Energy Division. "DEER-WaterHeater-Calculator-v1.0.xlsm." Pacific Gas and Electric (PG&E). 2015. "Dishmachine Calcs 02092015.xls." See "Monitored Data + GPR" tab. National Sanitation Foundation (NSF). (n.d.) NSF/ANSI 3 - Commercial Warewashing Equipment. "Com Dishwashers NSF Energy Star.xlsx." |
| Daily Water Consumption (gal) | 85.0 | 59.5 | 50.5 | Calculated = Racks per Day x Gal/Rack |
| Wash time per rack (min/rack) | 2 | 2 | 2 | The source for this data is unknown. |
| Idle Energy Rate (kW) | 5.17 | 5.17 | 4.44 | ENERGY STAR. 2012. "ENERGY STAR Program Requirements for Commercial Dishwashers. Eligibility Criteria (Rev. July 2012) Version 2.0." Effective February 1, 2013. |
| Operating Days per Year | 365 | 365 | 365 | Spoor, C., D. Zabrowski, and L. Mills. (Fisher-Nickel, Inc.) 2014. <i>Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment</i> . 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.

$$\begin{aligned} \text{Annual Gas Water Heater Energy} &= GPR \times RACKS \times EDAYS \times UECGAL \times MktPen \\ &= 1.0 \left(\frac{\text{Gal}}{\text{Rack}} \right) \times 18,250 \left(\frac{\text{Racks}}{\text{Year}} \right) \times 0.0087 \left(\frac{\text{Therms}}{\text{Gal}} \right) \times 0.97 = 154 \text{ Therms} \end{aligned}$$

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.”³⁴ This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.³⁵ 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.”³⁶

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 2.0.³⁷ While these sources do not explicitly specify the EUL for an undercounter dishwasher, adopting 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.³⁸

³⁴ California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

³⁵ KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

³⁶ California Public Utilities Commission (CPUC). 2016. *Resolution E-4807*. December 16. Page 13.

³⁷ 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.

³⁸ ENERGY STAR. 2015. "Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment." Updated February 2015.

Effective Useful Life and Remaining Useful Life

| Parameter | Value | Source |
|---------------------|-------|-------------------------|
| EUL (yrs) – measure | 12 | Professional judgement. |
| 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 is 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 is 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 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 | 0.70 | Itron, Inc. 2011. <i>DEER Database 2011 Update Documentation</i> . Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3. |
| NTG - industrial | 0.70 | |
| NTG - agriculture | 0.70 | |

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. <i>Energy Efficiency Policy Manual Version 5</i> . 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.

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

$$GPR = \text{Water consumption (GPR)}$$

$$RACKS = \text{Number of racks washed per day (\#)}$$

$$EDAYS = \text{Operating days per year (days)}$$

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

$$UWC = \text{Annual unit water consumption (gal per year)}$$

$$UWS = \text{Annual unit water savings (gal per year)}$$

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 | <p>The 2016 DEER database does not contain information on energy use or savings or equipment costs for an energy-efficient commercial dishwasher.</p> <p>There was no specific Effective Useful Life (EUL) found in the DEER database for commercial dishwashers. The typical product lifetime of 12 years for undercounter units based on the EUL approved for other food service equipment.</p> |
| DEER Measure IDs Used | N/A |
| NTG | Source: DEER. The NTG of 0.70 is associated with NTG ID: <i>All-Default<=2yrs</i> |
| GSIA | The GSIA of 1.0 is associated with GSIA ID: <i>Def-GSIA</i> |
| EUL/RUL | Source: New: The value of 12 years is associated with EUL ID: <i>Appl-DW-UnderCounter</i> |

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 | Andrez Marquez SoCalGas Jennifer Holmes, Cal TF Staff | Revisions for submission of version 01. |