Work Paper WPSCGNRCC180529A

**Revision # 0**

**Southern California Gas Company**

**Under Counter Type Commercial Dishwashers**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | TBD |
| **Measure Description** | Commercial Undercounter Dishwasher, High Temperature, Tier 1 (ENERGY STAR)  Commercial Undercounter Dishwasher, High Temperature, Tier 2 (15% below ENERGY STAR)  Commercial Undercounter Dishwasher, Low Temperature, Tier 1 (ENERGY STAR)  Commercial Undercounter Dishwasher, Low Temperature, Tier 2 (15% below ENERGY STAR) |
| **Base Case Description** | Minimum ENERGY STAR specification (V1.2) averaged with High Temperature Undercounter Commercial Dishwasher monitored data |
| **Units** | Each |
| **Energy Savings** | Source: PG&E Foodservice Technology Center Calculations   |  |  |  |  | | --- | --- | --- | --- | |  |  | **Tier 1** | **Tier 2** | | **Low temperature** | **kWh** | 56 | 340 | | **Therms** | 79 | 106 | | **High temperature** | **kWh** | 1774 | 2285 | | **Therms** | 22 | 42 | |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Source: PG&E Foodservice Technology Center Calculations   |  |  |  | | --- | --- | --- | |  | **Tier 1** | **Tier 2** | | **Low temperature** | $621 | $1,641 | | **High temperature** | $376 | $658 | |
| **Effective Useful Life** | 12 years -- Source: DEER 2014 UseCategory Foodserv |
| **Measure Installation Type** | Replace on Burnout (ROB), or New Construction (NC). |
| **Net-to-Gross Ratio** | Source: 2016 DEER Com-Default =<2 yrs.  0.7 |
| **Important Comments** | Estimated Water Savings in Gallons/year   |  |  |  | | --- | --- | --- | |  | **Tier 1** | **Tier 2** | | **Low temperature** | 9,308 | 12,593 | | **High temperature** | 2,555 | 4,928 | |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 2/1/2017 | Denis Livchak | Workpaper created using Door type dishwasher workpaper WPSW14NRAP001 as template |
| 0a | 8/21/2018 | Andres Marquez/Chan Paek, SoCalGas | Incorporated QC Review Comments |
| 0b | 3/22/3018 | Andres Marquez | Minor corrections per CPUC request (typos and clarifications for built-in booster heater models.) |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper documents the inputs for the Energy Efficient undercounter Commercial Dishwashers measure. Of the many types of commercial dishwashers available, including door-type and conveyor-types, undercounter units accounted for 43% of the market share by sales volume (NAFEM Size and Shape of the Industry 2009-2011 data). Undercounter dishwashers are mostly found in bars and restaurants with bars, and are mainly used for washing glassware.

This work paper addresses both low temperature and high temperature undercounter dishwasher units. Low temperature units meet the National Sanitation Foundation mandated sanitation criteria via a final rinse chemical sanitizing solution that follows the wash cycle (NSF/ANSI 3-2017 standard). High temperature units achieve sanitation 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. For low temperature machines, most of energy used 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.

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/rack to less than 0.5 gallons/rack, depending on the type of dishwasher(Attachment 5, Table 2. page 8: <http://www.fishnick.com/design/waterheating/Water_Heating_Design_Guide_Final_FNi_disclaimer.pdf>

)

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Energy Efficient Undercounter Commercial Dishwashers |
| Existing Condition | Existing Undercounter Commercial Dishwashers |
| Code/Standard | Not Applicable |
| Industry Standard Practice | Baseline Undercounter Commercial Dishwashers |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  |  |  | Commercial Undercounter Dishwasher, High Temperature, Tier 1 (ENERGY STAR) |
|  |  |  |  | Commercial Undercounter Dishwasher, High Temperature, Tier 2 (15% below ENERGY STAR) |
|  |  |  |  | Commercial Undercounter Dishwasher, Low Temperature, Tier 1 (ENERGY STAR) |
|  |  |  |  | Commercial Undercounter Dishwasher, Low Temperature, Tier 2 (15% below ENERGY STAR) |

* **Eligibility requirements**: This measure includes new commercial low temperature or high temperature undercounter dishwashers and undercounter glasswashers that meet the qualifications listed in Table 1. Consult with the manufacturer or manufacturer’s representative to determine if a model meets the efficiency requirements in Table 1. Used or rebuilt equipment is not eligible. Customers must provide proof that the appliance has the gallons per rack (gal/rack) and idle energy rate that meets the requirements. See Table 1 below for the requirements.
* **Implementation and installation requirements**: The rebate is offered through two delivery channels, downstream and midstream, as shown in Section 1.3. This measure is applicable to any commercial application, including (but not limited to) casual dining and quick service restaurants, hotels, motels, schools, colleges and recreational facilities.

**Table 1 Energy Efficiency Requirements for Commercial Undercounter Type Dishwashers.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Code** | **Dishwasher Type** | **Gallons per Rack (gal/rack)** | **Idle Energy Rate** |
|  | High Temperature, Tier 1 | ≤0.86\* | ≤ 0.50 kW\* |
|  | High Temperature, Tier 2 | ≤0.73\*\* | ≤ 0.43 kW\* |
|  | Low Temperature, Tier 1 | ≤1.19\* | ≤ 0.50 kW\* |
|  | Low Temperature, Tier 2 | ≤1.01\*\* | ≤ 0.43 kW\* |

\*ENERGY STAR Test Method for Commercial Dishwashers (Rev.Feb 2013)

\*\*15% below ENERGY STAR Test Method for Commercial Dishwashers (Rev.June-2012)

## 1.2 Technical Description

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 very short time by utilizing hot water, soap, rinse chemicals, and significant amounts of energy. Size requirements for 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.

Commercial dishwashers that have earned the ENERGY STAR are on average 40 percent more energy efficient and 40 percent more water-efficient than standard models. [[1]](#endnote-1) The ENERGY STAR specifies the qualification requirements for both high temperature and low temperature stationary undercounter dishwashers. Qualified models must meet maximum water consumption requirements and use less energy while idling between wash cycles.

## 1.3 Installation Types and Delivery Mechanisms

Since there are no EM&V studies on the useful life of dishwashers and it is standard practice in the commercial foodservice industry to purchase equipment only when it is needed (e.g., replacement or additional capacity), this measure is focused on ROB and NC applications only.

**Measure Application Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |

As noted in Section 1.1, the rebate is downstream provided to the customer at the time of sale upon receipt of application and invoice. This is not a Direct Install program.

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| 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.  There was no specific Effective Useful Life (EUL) found in the DEER database for commercial dishwashers. This work paper adopts the typical product lifetime of 12 years for undercounter units based on DEER foodservice cooking EUL. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| All-Default<=2yrs | All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years | Com | Any | Any | 0.7 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The Installation Rate (IR) addresses the percentage of units that are claimed but not installed. Choose the appropriate IR values from READI. Most measure will use a default IR of 1. If there is a GSIA ID ending in “-All,” use it instead of an IOU-specific GSIA ID.

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

There was no specific Effective Useful Life (EUL) found in the DEER database for commercial dishwashers. This work paper adopts the 12-year EUL which is used for other foodservice measures.

The relevant EUL and RUL values for the measures in this work paper are in the table below. As a reference, the residential high efficiency dishwasher has 11 years of EUL in DEER (Appl-EffDW).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| Appl-DW-UnderCounter | Commercial UnderCounter Dishwashers | Com | AppPlug | 12 | 4 |

### 1.4.2 Codes and Standards Analysis

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

The ENERGY STAR V2 Test Method for Commercial Dishwashers (Commercial Dishwasher Program Requirements Version 2.0) uses the ASTM F1696-09 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines[[2]](#endnote-2) to estimate the energy and water consumption of both the base and measure case.

The revised ASTM F1696-15 test method 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.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | This measure does not fall under Title 24 of the California Energy Regulations. | N/A |
| Title 20 (2016) | This measure does not fall under Title 20 of the California Energy Regulations. | N/A |
| DOE | These measures do not fall under Federal DOE or EPA Energy Regulations. | N/A |

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

The EPA relies on its ENERGY STAR Partner organizations to provide shipment data to the EPA to estimate the market share of ENERGY STAR commercial food service equipment via a survey. Among the 20 responding manufacturers in 2013, 63% of units shipped in 2013 meet the ENERGY STAR 2.0 specification. However, these ENERGY STAR Partner manufacturers make up only 50% of the total market share of manufacturers in the commercial dishwashing market, and as a result, skew the data collected toward the efficient segment of the total market.

### 1.5.1 Hot Water Design Guide

* Design Guide, Fisher-Nickel Inc., Improving Commercial Kitchen Hot Water System Performance – Energy Efficient Heating, Deliver and Use, 03/26/2010
* Market covered – Commercial Foodservice
* Techniques used – End use monitoring
* Relevance to and impacts on this work paper – Documentation of baseline and energy efficient dishwasher hot water usage per rack.
* <http://www.fishnick.com/design/waterheating/Water_Heating_Design_Guide_Final_FNi_disclaimer.pdf>

## 1.6 Data Quality and Future Data Needs

* Dishwasher manufacturers are required to report their water consumption based on laboratory testing. The results used in the workpaper are based on these lab results. Field conveyor dishwasher monitoring showed that the units in operation use more water than their rating based on laboratory testing. The number of racks washed per day for a typical undercounter dishwasher is based on only a single field study and upright door-type dishwasher interpolations based on operator surveys.
* Further field studies are recommended to improve the quality of water consumption data. Undercounter Dishwasher water consumption and energy consumption monitoring at several field sites will help improve the assumptions used in this workpaper. The monitoring data can further be supplemented by a survey which quantifies the number of racks washed per day depending on the foodservice establishment (bar or full-service restaurant).
* The timeframe for the field research is dependent on utility interest in this data.
* The foodservice market is a slow adapter of new technologies, so it is highly unlikely that the data used in this workpaper will change unless the market is driven by incentives or mandatory requirements.

# Section 2. Calculation Methodology

## 2.1 Assumptions and Calculations from other sources—Base and Measure Cases

The base case for this measure is ENERGY STAR 1.2**[[3]](#endnote-3)** (Attachment 6), shown in Table 2. The measure case is an energy efficient (ENERGY STAR 2.0 Attachment 7) commercial undercounter dishwasher shown in Table 3.

This work paper includes both low temperature and high temperature units, to be replaced by low or high temperature units, respectively. Low-temperature commercial dishwashers are assumed to use water that is solely heated by an external gas or electric water heater. High-temperature units reuse wash water from the dishwashing water tank for the wash cycle and then additional clean water for the rinse cycle that is raised to 180°F via electric booster heater (no undercounter dishwasher models with built-in gas booster were found in the market). Rinse water is then collected and used to overflow the wash water tank providing heat recovery and a fresh water stream.

The basis for energy savings is the difference between the water heating energy required for the base case versus the energy efficient measure case. Because energy efficient units consume considerably less water, less energy will be required to heat less water, thus saving energy. For both low and high temperature machines, base case energy consumption (therms and kWh) is based on the energy required to heat water for the dishwashing and sanitizing cycles. The high temperature units water heating energy components further split into primary and booster water heating.

Motor energy and standby losses are assumed to be the same for both the base case and the measure case and are therefore not considered in the energy savings calculations. Idle energy rate to maintain a wash tank temperature for both high and low temperature washing machines is included in the calculation for annual energy consumption.

**Gallons per Rack**

The NSF provides a database of commercial dishwashers which reports the manufacturers’ calculated water consumption in gallons per rack.[[4]](#endnote-4) The database includes models that are no longer manufactured, as well as models that meet the ENERGY STAR performance criteria for reduced water consumption (1.19 gal/rack for low temperature units, and 0.86 gal/rack for high temperature units[[5]](#endnote-5)), but may not have applied for the ENERGY STAR label. For this work paper, models that are no longer manufactured have been excluded from the calculations.

**Table 2 Base Case Commercial Undercounter Type Dishwashers (ENERGY STAR 1.2 10/11/2007-2/1/2013)**

|  |  |  |
| --- | --- | --- |
| **Dishwasher Type** | **Gallons per Rack (gal/rack)** | **Idle Energy Rate** |
| High Temperature | <1.00 | ≤ 0.90 kW |
| Low Temperature | <1.70 | ≤ 0.50 kW |

**Table 3 Measure Case for Commercial Undercounter Type Dishwashers.**

|  |  |  |
| --- | --- | --- |
| **Dishwasher Type** | **Gallons per Rack (gal/rack)** | **Idle Energy Rate** |
| High Temperature Tier 1 | <0.86\* | ≤ 0.50 kW\* |
| High Temperature Tier 2 | <0.73\*\* | ≤ 0.43 kW\*\* |
| Low Temperature Tier 1 | <1.19\* | ≤ 0.50 kW\* |
| Low Temperature Tier 2 | <1.01\*\* | ≤ 0.43 kW\*\* |

\* Based on ENERGY STAR 2.0 Qualified Dishwasher

\*\* Based on 15% below ENERGY STAR 2.0 Qualified Dishwasher

**Racks per Day**

The racks-per-day variable is based on FSTC monitored data from a restaurant site and restaurant operator interviews. 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. As a comparison, the ENERGY STAR Savings Calculator (Reference viii), developed by U.S. EPA and DOE, assumes 75 racks washed per day.

**Table 4 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** |

**Hours of Operation:**

Hours of operation are based on restaurants serving lunch and dinner as referenced in the CEC Foodservice Equipment report in Section 4.1.3 (page 42)

<http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf>. For this measure the annual hours of operation are considered 4,380. (12 hrs/day \* 365 day/yr = 4,380 hr/year

)

**Energy Consumption (therms or kWh) per Gallon**

The energy consumption per gallon of water is based on the increase in water temperature required for a wash cycle, the specific heat of water (the energy required to raise one gallon of water by one degree), the density of water, and the equipment efficiency.

**Equation 1 - Energy Consumption per Gallon of Water**

Where:

Temperature rise in degrees Fahrenheit (°F)

Specific Heat

Density

Heating equipment efficiency

The following energy conversions are used to determine kWh and therms consumption:

1kWh

The specific heat of water and the density of water are constants and will not vary. The other two inputs are variable as based on the following assumptions.

The temperature rise in degrees Fahrenheit (°F) assumes an average inlet water temperature in the PG&E territory of 57.9° F [[6]](#endnote-6) and needs to be raised to 140°F to meet the minimum supply water temperature at the dishwasher. This is equivalent to an increase of 82.1°F for basic water heating in the building. This basic, or primary, water heating 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 another 40°F, to 180°F to meet the NSF sanitation standards. (The low temperature machines meet this standard via a chemical rinse).

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%[[7]](#endnote-7). These efficiencies are used to determine energy consumption of the primary water heating in both low and 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.[[8]](#endnote-8)

The following equation calculates the energy required to raise the primary water from 57.9°F to 140°F in a building with gas water heating.

**Equation 2 –Primary Gas Water Heating Energy Consumption per Gallon**

This same methodology is used to determine electric energy consumption, utilizing the electric water heating equipment efficiencies and the electric energy conversions.

**Equation 3 –Primary Electric Water Heating Energy Consumption per Gallon**

If this unit was a high temperature unit, using a higher temperature sanitizing rinse, the same methodology would be used to determine the additional energy required for the booster water heating. The booster heater will be needed to increase the 100% of the water from a temperature of 140°F to 180°F. The additional booster water heating energy is shown in the following equation.

**Equation 4 - Booster Electric Water Heating Energy Consumption per Gallon**

Because undercounter dishwashers can accommodate both gas and electric water heating for primary heating, the energy requirements for both gas and electric water heating per gallon are supplied in Table 5. However, undercounter dishwashers were found to only have built-in electric booster heaters, so no gas booster heating energy is shown.

|  |  |  |
| --- | --- | --- |
| **Table 5 Energy Consumption per Gallon Usage** | | |
| Gas Water Heater | 0.00874 | Therms/Gal |
| Electric Water Heater | 0.201 | kWh/Gal |
| Electric Booster Heater | 0.098 | kWh/Gal |

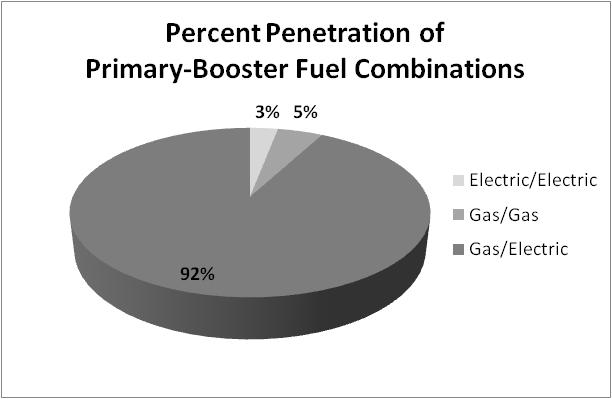
Primary water heating energy is directly related to the incoming water temperature into the heater. Each California climate zone has different groundwater temperatures. Table 6 shows the different water heating energies per gallon based on the local groundwater temperatures. These values are used in calculating gas and electrical savings for each climate zone in Table 17.

**Table 6 Water Heater Energy Consumption per Gallon Usage in Different Climate Zones**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Utility | Climate Zone | Average Groundwater Temperature (F) | Btu/gal | **therm/gal** | Wh/gal | **kWh/gal** |
| PG&E | CZ01 | 51.4 | 943.7 | **0.00944** | 224.1 | **0.217** |
| PG&E | CZ02 | 57.3 | 880.8 | **0.00881** | 209.2 | **0.203** |
| PG&E | CZ03 | 57.1 | 883.3 | **0.00883** | 209.8 | **0.203** |
| PG&E/SoCalGas | CZ04 | 59.5 | 857.1 | **0.00857** | 203.6 | **0.197** |
| PG&E/SoCalGas | CZ05 | 55.8 | 896.3 | **0.00896** | 212.9 | **0.206** |
| SoCalGas/SDG&E/SCE | CZ06 | 61.8 | 833.3 | **0.00833** | 197.9 | **0.192** |
| SoCalGas/SDG&E | CZ07 | 62.6 | 824.8 | **0.00825** | 195.9 | **0.190** |
| SoCalGas/SDG&E/SCE | CZ08 | 63.7 | 812.1 | **0.00812** | 192.9 | **0.187** |
| SoCalGas/SCE | CZ09 | 63.8 | 811.3 | **0.00811** | 192.7 | **0.187** |
| SoCalGas/SDG&E/SCE | CZ10 | 64.1 | 807.8 | **0.00808** | 191.8 | **0.186** |
| PG&E | CZ11 | 63.2 | 817.9 | **0.00818** | 194.2 | **0.188** |
| PG&E | CZ12 | 60.9 | 842.5 | **0.00843** | 200.1 | **0.194** |
| PG&E/SoCalGas/SCE | CZ13 | 64.1 | 808.3 | **0.00808** | 192.0 | **0.186** |
| SoCalGas/SCE | CZ14 | 62.7 | 823.5 | **0.00824** | 195.6 | **0.190** |
| SoCalGas/SCE | CZ15 | 75.5 | 687.2 | **0.00687** | 163.2 | **0.158** |
| PG&E/SoCalGas/SCE | CZ16 | 51.8 | 939.8 | **0.00940** | 223.2 | **0.216** |

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 for typical dishwasher setup is available and is installed a very small percentage of the time, assumed at approximately 5% for door type only dishwashers.[[9]](#endnote-9) The weighted average must account for three primary water heating and booster water heating categories: electric-electric, gas-gas, and gas-electric. However, for undercounter dishwashers, it is assumed that only 3 percent are electric-electric and the rest is gas-electric since no undercounter dishwasher with built-in gas booster heater models exist. The percentages for each category are summarized in Figure 1 based on the California Commercial End-Use Survey (CEC-400-2006-005) <http://www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF> Figures E-3 and E-4 (where electric water heating is 0.9% of the electric end use and gas water heating is 31.8% of the gas end use).

**Figure 1: Penetration of Primary Water Heating and Booster Water Heating Fuel Combinations**



These percentages were applied to the primary water heating energy savings for high and low temperature units as shown in Section 2. Low Temperature undercounter dishwashers are already supplied with hot water from the building’s water heating system, so they do not have internal heaters. This often results in almost no energy use during idle operation for low temperature undercounter dishwashers.

## 2.2 Summary of Inputs for Savings Calculations

The following tables (Table 7 & 8) provide references to sections that document the inputs. See the embedded calculation file for other climate zones and IOU territories:

**Table 7 Inputs for Savings Calculations for Measure – High Temp Tier 1 & 2**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case Average Value** | **Measure Case Average Value** | | **Reference Section** |
| **Tier 1** | **Tier 2** |
| **Electric Savings** | None | - | 1,774 kWh | 2,285 kWh | *Section 2.1* |
| **Gas Savings** | None | - | 22 Therms | 42 Therms | *Section 2.4* |
| **Hours of operation** | None | 12 | 12 | 12 | Section 1.4.1 |
| **Full Cost** | None | $3,773 | $4,149 | $4,431 | Section 4.3.1 |
| **Incremental Cost** | None | - | $376 | $658 | Section 4.3.1 |
| **EUL /RUL** | None | 12 years | 12 years | 12 years | Section 1.4.1 |
| **NTG** | None | 0.6 | 0.6 | 0.6 | Section 1.4.1 |
| **ISR** | No | 1 | 1 | 1 | Section 1.4.1 |
| **TOU Factor** | *A/C projects only* |  |  |  | *Section 1.4.5* |

**Table 8 Inputs for Savings Calculations for Measure – Low Temp Tier 1 & 2**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case Average Value** | **Measure Case Average Value** | | **Reference Section** |
| **Tier 1** | **Tier 2** |
| **Electric Savings** | None | - | 56 kWh | 340 kWh | *Section 2.1* |
| **Gas Savings** | None | - | 79 Therms | 106 Therms | *Section 2.4* |
| **Hours of operation** | None | 12 | 12 | 12 | Section 1.4.1 |
| **Full Cost** | None | $3,532 | $4,153 | $5,173 | Section 4.3.1 |
| **Incremental Cost** | None | - | $621 | $1,641 | Section 4.3.1 |
| **EUL /RUL** | None | 12 | 12 | 12 | Section 1.4.1 |
| **NTG** | None | 0.6 | 0.6 | 0.6 | Section 1.4.1 |
| **ISR** | No | 1 | 1 | 1 | Section 1.4.1 |
| **TOU Factor** | *A/C projects only* |  |  |  | *Section 1.4.5* |

## 2.3 Electric Energy Savings Estimation Methodologies

**Table 9 Baseline by Measure Application Type**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period: Energy Savings Baseline** | **Second Baseline Period: Energy Savings Baseline** |
| ***ROB*** (replace-on-burnout) | EUL | Code Baseline | N/A |
| ***NC*** (new construction) | RUL/EUL-RUL | Code Baseline | N/A |

Notes: For ROB measures, First Baseline is the baseline for the full EUL. There is no second baseline.

Using the market penetration percentages and the assumptions provided in Section 2.1, energy consumption can be calculated for both electric and gas fuel source. The following equation shows the calculation for a high temperature electric fueled undercounter dishwasher in a commercial food service that uses electric primary water heating. Low temperature dishwashers do not have booster heater energy as part of the calculation and can effectively be set to zero.

**Example Calculation for Base Case High Temperature Electric Water Heater Dishwasher Annual Energy Consumption**

*where,*

The results for both low and high temperature undercounter units are provided in the tables below. Detailed calculations are provided in an attached worksheet (Attachment 1).

**Table 10 Commercial Electric Booster Heater High Temperature Undercounter Dishwasher Base Case**

**and Measure Case Energy Consumption**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Measure Case Tier 1** | **Measure Case Tier 2** |
| Electric Booster Heater Energy per Gallon (kWh/gal) | 0.098 | 0.098 | 0.098 |
| Daily Booster Heater Water (Gal) | 50.0 | 43.0 | 36.5 |
| Daily Booster Heater Energy (kWh) | 4.90 | 4.21 | 3.58 |
| Market Penetration of Electric Booster Heaters (%) | 100 | 100 | 100 |
| Weighted Annual Booster Heater Energy (kWh/year) | 1789 | 1538 | 1306 |
| **Annual Energy Consumption (kWh)** | 1789 | 1538 | 1306 |
| **Estimated Booster Energy Savings (kWh/yr)** | - | 250 | 483 |
| Electric Cost ($/kWh) | 0.13 | 0.13 | 0.13 |
| Annual Energy Cost ($) | 233 | 200 | 170 |
| Estimated Cost Savings ($/yr) | - | 33 | 30 |
| Estimated Useful Life (EUL) | 12 | 12 | 12 |
| \* The fuel type for the water heater in the header refers to the primary water heater. The booster heater is assumed to 100% electric. |  |  |  |

**Table 11 Commercial High Temperature Undercounter Dishwasher Base Case and Measure Case Idle Energy Consumption**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Measure Case Tier 1** | **Measure Case Tier 2** |
| Number of Racks per day (racks/day) | 50 | 50 | 50 |
| Wash time per rack (min/rack) | 2 | 2 | 2 |
| Operating Hours/Day | 12 | 12 | 12 |
| Idle Energy Rate (kW) | 0.9 | 0.5 | 0.43 |
| Daily Idle Energy (kWh) | 9.30 | 5.17 | 4.44 |
| **Annual Idle Energy (kWh/year)** | 3395 | 1886 | 1622 |
| **Estimated Booster Energy Savings (kWh/yr)** | - | 1509 | 1773 |

**Table 12 Commercial Electric Water Heater High Temperature Undercounter Dishwasher Base Case and Measure Case Energy Consumption**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Measure Case Tier 1** | **Measure Case Tier 2** |
| **Electric** Water Heater Energy per Gallon (kWh/gal) | 0.201 | 0.201 | 0.201 |
| Number of Racks per day (racks/day) | 50 | 50 | 50 |
| Number of Racks per year (racks/year) | 18,250 | 18,250 | 18,250 |
| Water Consumption (Gal/Rack) | 1.00 | 0.86 | 0.73 |
| Daily Water Consumption (Gal) | 50.0 | 43.0 | 36.5 |
| Wash time per rack (min/rack) | 2 | 2 | 2 |
| Operating Days/Year | 365 | 365 | 365 |
| Operating Hours/Day | 12 | 12 | 12 |
| Electric Cost ($/kWh) | 0.13 | 0.13 | 0.13 |
| Daily Water Heater Energy Consumption (kWh) | 10.05 | 8.64 | 7.34 |
| Market Penetration of Electric Water Heaters (%) | 3 | 3 | 3 |
| **Weighted Annual Heater Energy Consumption (kWh/year)** | 110 | 95 | 80 |
| **Estimated Water Heating Energy Savings (kWh/yr)** | - | 15 | 30 |
| Total Energy Consumption and Demand (Electric Water Heater + Electric Booster + Idle) | | | |
| Weighted Annual Energy Consumption (kWh) | 5293 | 3519 | 3008 |
| **Estimated Energy Savings (kWh/yr)** | - | 1774 | 2285 |
| Average Peak Demand (kW) | 1.16 | 0.77 | 0.66 |
| Demand Coincidence Factor | 0.9 | 0.9 | 0.9 |
| **Demand Reduction (kW)** | - | 0.35 | 0.45 |
| Annual Energy Cost ($) | 688 | 457 | 391 |
| **Estimated Cost Savings ($/yr)** | - | 231 | 297 |
| Estimated Useful Life (EUL) | 12 | 12 | 12 |

**Table 13 Commercial Low Temperature Undercounter Dishwasher Base Case and Measure Case Idle Energy Consumption**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Measure Case Tier 1** | **Measure Case Tier 2** |
| Number of Racks per day (racks/day) | 50 | 50 | 50 |
| Wash time per rack (min/rack) | 2 | 2 | 2 |
| Operating Hours/Day | 12 | 12 | 12 |
| Idle Energy Rate (kW) | 0.5 | 0.5 | 0.43 |
| Daily Idle Energy (kWh) | 5.17 | 5.17 | 4.44 |
| **Annual Idle Energy (kWh/year)** | 1886 | 1886 | 1622 |
| **Estimated Booster Energy Savings (kWh/yr)** | - | 0 | 264 |

**Table 14 Commercial Electric Water Heater Low Temperature Undercounter Dishwasher Base Case and Measure Case Energy Consumption**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Measure Case Tier 1** | **Measure Case Tier 2** |
| Electric Water Heater Energy per Gallon (kWh/gal) | 0.201 | 0.201 | 0.201 |
| Number of Racks per day (racks/day) | 50 | 50 | 50 |
| Number of Racks per year (racks/year) | 18,250 | 18,250 | 18,250 |
| Water Consumption (Gal/Rack) | 1.70 | 1.19 | 1.01 |
| Daily Water Consumption (Gal) | 85 | 59.5 | 50.5 |
| Wash time per rack (min/rack) | 2 | 2 | 2 |
| Operating Days/Year | 365 | 365 | 365 |
| Operating Hours/Day | 12 | 12 | 12 |
| Electric Cost ($/kWh) | 0.13 | 0.13 | 0.13 |
| Daily Water Heating Energy (kWh) | 17.09 | 11.96 | 10.15 |
| Market Penetration of Electric Water Heaters (%) | 3 | 3 | 3 |
| **Weighted Annual Heater Energy Consumption (kWh/year)** | 187 | 131 | 111 |
| **Estimated Water Heating Energy Savings (kWh/yr)** | - | 56 | 76 |
| Total Energy Consumption and Demand (Electric Water Heater + Idle) | | | |
| Demand Coincidence Factor | 0.9 | 0.9 | 0.9 |
| Average On Peak Demand (kW) | 0.46 | 0.44 | 0.38 |
| Estimated On Peak Demand Reduction (kW) |  | 0.01 | 0.07 |
| Market Penetration of Electric Water Heaters (%) | 3 | 3 | 3 |
| Weighted Annual Heater Energy Consumption (kWh/year) | 2073 | 2017 | 1733 |
| **Estimated Energy Savings (kWh/yr)** | - | 56 | 340 |
| **Annual Energy Cost ($)** | **269** | **262** | **225** |
| **Estimated Cost Savings ($/yr)** | **-** | **7** | **44** |
| Estimated Useful Life (EUL) | 12 | 12 | 12 |

## 2.4 Demand Reduction Estimation Methodologies

A dishwasher actual contribution to a building’s peak demand may vary significantly depending on its usage pattern in relation to that of other electric equipment in the facility (operating schedule, appliance on time, etc.). However, it is generally known that the biggest water consuming appliance for any commercial food service is the dishwasher. Thus dishwasher water usage will be the largest contributor to overall usage and peak demand. The End-use Water Demand Profile study conducted on restaurants for the CPUC by Aquacraft documents hourly hot water demand.[[10]](#endnote-10) This study conducted on seven different restaurants concludes that 24.1% of total daily use occurs during the 3-hour peak demand period between 2:00pm and 5:00pm. Therefore, it has been assumed that the probable contribution to the building’s peak demand is equal to the appliance’s average demand during the peak times.

The demand estimation is based on estimated energy consumption savings divided over the peak demand hours of the unit. Applying a Coincidence Factor of 0.9 per the DEER methodology[[11]](#endnote-11), yields a Demand Savings of 0.35kW and 0.45kW for Tier 1 and Tier 2 high temperature machines heated by gas water heaters respectively.

*Where,*

*And*

## 2.5 Gas Energy Savings Estimation Methodologies

Using the market penetration percentages and the assumptions provided in Section 2.1, energy consumption can be calculated. The following equation shows the calculation for a high or low electric undercounter dishwasher in a commercial food service that uses gas primary water heater. Since all undercounter dishwashers are electric, the booster heater and idle energy calculation methodology is shown in section 2.3.

**Example Calculation for Base Case High Temperature Gas Water Heater Dishwasher Annual Energy Consumption**

*where,*

The results for both low and high temperature undercounter units are provided in the tables below. Detailed calculations are provided in Attachments.

**Table 15 Commercial Gas Water Heater High Temperature Undercounter Dishwasher Base Case and Measure Case Energy Consumption (Refer to Tables 10 & 11 for electrical savings)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Measure Case Tier 1** | **Measure Case Tier 2** |
| **Gas** Water Heater Energy per Gallon (Therms/gal) | 0.0087 | 0.0087 | 0.0087 |
| Number of Racks per day (racks/day) | 50 | 50 | 50 |
| Number of Racks per year (racks/year) | 18250 | 18250 | 18250 |
| Water Consumption (Gal/Rack) | 1 | 0.86 | 0.73 |
| Daily Water Consumption (Gal) | 50 | 43 | 36.5 |
| Wash time per rack (min/rack) | 2 | 2 | 2 |
| Operating Days/Year | 365 | 365 | 365 |
| Operating Hours/Day | 12 | 12 | 12 |
| Natural Gas Cost ($/Therm) | 1 | 1 | 1 |
| Electric Cost ($/kWh) | 0.13 | 0.13 | 0.13 |
| Daily Water Heating Energy Consumption (Therms) | 0.435 | 0.374 | 0.318 |
| Market Penetration of Gas Water Heaters (%) | 97 | 97 | 97 |
| **Weighted Annual Heater Energy Consumption (Therms/year)** | 154 | 132 | 112 |
| **Estimated Water Heating Energy Savings (therm/yr)** | - | 22 | 42 |
| Total Energy Consumption and Demand (Gas Water Heater + Electric Booster + Idle) | | | |
|
| Annual Energy Consumption (therm) | 154 | 132 | 112 |
| **Estimated Energy Savings (Therms/yr)** | - | 22 | 42 |
| Annual Energy Consumption (kWh) | 5183 | 3424 | 2927 |
| **Estimated Energy Savings (kWh/yr)** | - | 1759 | 2256 |
| Average Peak Demand (kW) | 1.14 | 0.75 | 0.64 |
| Demand Coincidence Factor | 0.9 | 0.9 | 0.9 |
| **Demand Reduction (kW)** | - | 0.35 | 0.45 |
| Annual Energy Cost ($) | 828 | 578 | 493 |
| **Estimated Cost Savings ($/yr)** | - | 250 | 335 |
| Estimated Useful Life (EUL) | 12 | 12 | 12 |

**Table 16 Commercial Gas Water Heater Low Temperature Undercounter Dishwasher Base Case and Measure Case Energy Consumption (Refer to Table 13 for electrical savings)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Measure Case Tier 1** | **Measure Case Tier 2** |
| Gas Water Heater Energy per Gallon (Therms/gal) | 0.0087 | 0.0087 | 0.0087 |
| Number of Racks per day (racks/day) | 50 | 50 | 50 |
| Number of Racks per year (racks/year) | 18250 | 18250 | 18250 |
| Water Consumption (Gal/Rack) | 1.70 | 1.19 | 1.01 |
| Daily Water Consumption (Gal) | 85.0 | 59.5 | 50.5 |
| Wash time per rack (min/rack) | 2 | 2 | 2 |
| Operating Days/Year | 365 | 365 | 365 |
| Operating Hours/Day | 12 | 12 | 12 |
| Natural Gas Cost ($/Therm) | 1 | 1 | 1 |
| Electric Cost ($/kWh) | 0.13 | 0.13 | 0.13 |
| Daily Water Heating Energy (Therms) | 0.740 | 0.518 | 0.439 |
| Weighted Annual Heater Energy Consumption (Therms/yr) | 262 | 183 | 156 |
| **Estimated Energy Savings (Therms/yr)** | **-** | **79** | **106** |
| Total Energy Consumption and Demand (Gas Water Heater + Idle) | | | |
| Demand Coincidence Factor | 0.9 | 0.9 | 0.9 |
| Average On Peak Demand (kW) | 0.42 | 0.42 | 0.36 |
| Estimated On Peak Demand Reduction (kW) |  | 0.00 | 0.05 |
| Market Penetration of Gas Water Heaters (%) | 97 | 97 | 97 |
| Weighted Annual Heater Energy Consumption (Therms/yr) | 262 | 183 | 156 |
| **Estimated Energy Savings (Therms/yr)** | **-** | **79** | **106** |
| Annual Dishwasher Energy Consumption (kWh/year) | 1886 | 1886 | 1622 |
| **Estimated Energy Savings (kWh/year)** |  | **0** | **264** |
| Annual Energy Cost ($) | 507 | 428 | 366 |
| Estimated Cost Savings ($/yr) | - | 79 | 141 |
| Estimated Useful Life (EUL) | 12 | 12 | 12 |

The energy savings for each climate zone were calculated based on groundwater temperatures in Table 6. It is assumed that 97% of the undercounter dishwashers are connected to primary gas water heaters and have electric booster heaters; and 3% have primary electric water heaters and electric booster heaters. Low Temp dishwashers do not have booster heaters and the kWh savings are due to a lower idle rate for Tier 2 dishwashers.

**Table 17 Energy Savings for 16 Climate Zones and IOU Territories**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | High Temp | | High Temp | |  | Low Temp | | Low Temp | |
|  | Tier 1 | | Tier 2 | |  | Tier 1 | | Tier 2 | |
|  | Gas (Therm) | Elec (kWh) | Gas (Therm) | Elec (kWh) |  | Gas (Therm) | Elec (kWh) | Gas (Therm) | Elec (kWh) |
| CZ01 | 23 | 1,777 | 45 | 2,288 |  | 85 | 61 | 115 | 346 |
| CZ02 | 22 | 1,776 | 42 | 2,286 |  | 80 | 57 | 108 | 341 |
| CZ03 | 22 | 1,776 | 42 | 2,286 |  | 80 | 57 | 108 | 341 |
| CZ04 | 21 | 1,775 | 41 | 2,285 |  | 77 | 55 | 105 | 339 |
| CZ05 | 22 | 1,776 | 43 | 2,287 |  | 81 | 58 | 109 | 342 |
| CZ06 | 21 | 1,775 | 40 | 2,284 |  | 75 | 54 | 102 | 336 |
| CZ07 | 20 | 1,775 | 39 | 2,284 |  | 74 | 53 | 101 | 336 |
| CZ08 | 20 | 1,774 | 39 | 2,284 |  | 73 | 52 | 99 | 335 |
| CZ09 | 20 | 1,774 | 39 | 2,284 |  | 73 | 52 | 99 | 335 |
| CZ10 | 20 | 1,774 | 39 | 2,283 |  | 73 | 52 | 99 | 334 |
| CZ11 | 20 | 1,774 | 39 | 2,284 |  | 74 | 53 | 100 | 335 |
|  |  |  |  |  |  |  |  |  |  |
| CZ12 | 21 | 1,775 | 40 | 2,285 |  | 76 | 54 | 103 | 337 |
| CZ13 | 20 | 1,774 | 39 | 2,284 |  | 73 | 52 | 99 | 334 |
| CZ14 | 20 | 1,775 | 39 | 2,284 |  | 74 | 53 | 101 | 336 |
| CZ15 | 17 | 1,772 | 33 | 2,279 |  | 62 | 44 | 84 | 324 |
| CZ16 | 23 | 1,777 | 45 | 2,288 |  | 85 | 60 | 115 | 346 |
| **PG&E** | 22 | 1,775 | 42 | 2,286 |  | 79 | 56 | 107 | 340 |
| **SCG** | 21 | 1,775 | 40 | 2,284 |  | 75 | 53 | 101 | 336 |
| **SDGE** | 20 | 1,774 | 39 | 2,284 |  | 74 | 53 | 100 | 335 |
| **SCE** | 20 | 1,774 | 39 | 2,284 |  | 74 | 52 | 100 | 335 |

## 2.6 Water Savings Estimation Methodologies

Water savings calculation is shown here as a reference.

*Where,*

*And*

**Table 18 Water Savings**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **High Temperature** | | |  | **Low Temperature** | | |
|  | **Base Case** | **Measure  Tier 1** | **Measure  Tier 2** |  | **Base Case** | **Measure  Tier 1** | **Measure  Tier 2** |
| Number of Racks per day  (racks/day) | 50 | 50 | 50 |  | 50 | 50 | 50 |
| Number of Racks per year  (racks/year) | 18,250 | 18,250 | 18,250 |  | 18,250 | 18,250 | 18,250 |
| Water Consumption  (Gal/Rack) | 1.0 | 0.86 | 0.73 |  | 1.70 | 1.19 | 1.01 |
| Daily Water Consumption  (Gal) | 50 | 43 | 36.5 |  | 85.0 | 59.5 | 50.6 |
| Annual Water Consumption  (Gallons/year) | 18,250 | 15,695 | 13,323 |  | 31,025 | 21,718 | 18,433 |
| **Annual Water Savings**  **(Gallons/year)** | - | 2,555 | 4,928 |  | - | 9,308 | 12,593 |

READI Data Used

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Measure Name** | **READI Data** |
| NA | NA | NA |
|  |  |  |

Demand reduction estimates must consider the DEER peak demand period, which is 2:00 PM to 5:00 PM during specific weekday periods and varies by climate zone:

|  |  |
| --- | --- |
| **Climate Zone** | **3-Weekday Period** |
| 1 | Sep 16 – Sep 18 |
| 2 | July 8 – July 10 |
| 3 | July 8 – July 10 |
| 4 | Sep 1 – Sep 3 |
| 5 | Sep 8 – Sep 10 |
| 6 | Sep 1 – Sep 3 |
| 7 | Sep 1 – Sep 3 |
| 8 | Sep 1 – Sep 3 |
| 9 | Sep 1 – Sep 3 |
| 10 | Sep 1 – Sep 3 |
| 11 | July 8 – July 10 |
| 12 | July 8 – July 10 |
| 13 | July 8 – July 10 |
| 14 | Aug 26 – Aug 28 |
| 15 | Aug 25 – Aug 27 |
| 16 | July 8 – July 10 |

**Table 19 KW Demand Savings High Temp Undercounter Dishwashers**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Base Case | Measure Case Tier 1 | Measure Case Tier 2 |
| Average Peak Demand (kW) | 1.14 | 0.75 | 0.64 |
| Demand Reduction (kW) | - | 0.35 | 0.45 |

**Table 20 KW Demand Savings Low Temp Undercounter Dishwashers**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Base Case | Measure Case Tier 1 | Measure Case Tier 2 |
| Average On Peak Demand (kW) | 0.42 | 0.42 | 0.36 |
| Estimated On Peak Demand Reduction (kW) |  | 0.00 | 0.05 |

# Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below..

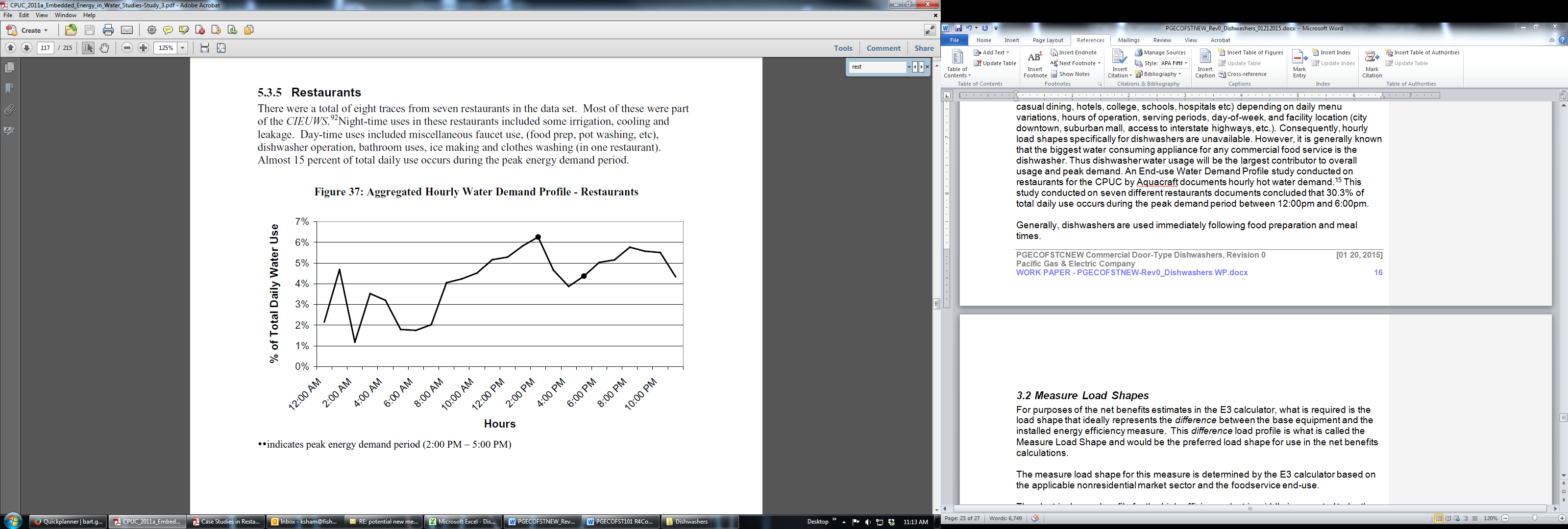
Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| All Commercial | NA (DEER Sit\_Down\_Restaurant:DHW HtPump)  Fast\_Food\_Restaurant:DHW HtPump) | NA |

## 3.1 Base Case Load Shapes

Commercial dishwasher load shapes differ among food service facilities (quick service, casual dining, hotels, college, schools, hospitals, etc.) depending on daily menu variations, hours of operation, serving periods, day-of-week, and facility location (city downtown, suburban mall, access to interstate highways, etc.). Consequently, hourly load shapes specifically for dishwashers are unavailable. However, it is generally known that the biggest water consuming appliance for any commercial food service is the dishwasher. Thus dishwasher water usage will be the largest contributor to overall hot water usage and peak hot water demand. An End-use Water Demand Profile study conducted on seven different restaurants for the CPUC by Aquacraft documents hourly hot water demand.13 Of the 12 hour period that the dishwasher is typically in operation, between the hours of 10:00 am and 10:00 pm daily, three of the hours are on-peak from 2:00pm to 5:00pm. By summing the aggregated hourly water demand usage during each interval, 24.1% of a dishwasher’s energy is consumed during on-peak hours. This data is included in the calculation file embedded at the end of this document.

**Figure 2: Aggregated Hourly Water Demand Profile - Restaurants**



Source: CPUC\_011a Embedded Energy in Water Studies – Study 3

## 3.2 Measure Load Shapes

The electric demand profile for the high-efficiency dishwasher is expected to be the same as the Base Case.

# Section 4. Costs

High-efficiency dishwashers typically have a higher list price than standard efficiency dishwashers. Equipment prices for these work papers were compiled from a number of sources including, Autoquotes, equipment sales reps and manufacturer sources. Since equipment pricing in food service is closely held information and prices vary widely according to buying volume and other factors, we cannot list the sources for prices specifically.

Retail pricing data was gathered from two major online appliance retailers:

* Webrestaurant Store (webrestaurantstore.com) with 5 warehouses located across the country on both the east and west coasts.
* Katom Restaurant Supply Inc. (katom.com)

The online retailers reflect the prices that a foodservice facility would pay for the equipment including the dealer discount. Prices from both stores were cross-referenced in order to verify that competitive retail pricing was used. The models selected for pricing research were representative of the products sold in each category. The incremental measure costs were determined based on pricing information on 10 low-temperature and 12 high temperature undercounter dishwashers. This included dishwashers from 7 most popular undercounter dishwasher manufacturers.

## 4.1 Base Case Cost

The following Measure Application Types are appropriate to these measures. The Base Case Costs are:

**Table 21 Base Case Costs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost** |
| Base High Temp |  | $3,773 | $N/A | $N/A | $3,773 |
| Base Low Temp |  | $3,532 | N/A | N/A | $3,532 |

*All costs are noted as $ per measure unit*

## 4.2 Measure Case Cost

The following Measure Application Types are appropriate to these measures. The Measure Case Costs are:

Table 22 Measure Case Costs

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Measure Code*** | **Measure Application Type** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
|  | NC, ROB | $4,149 | N/A | N/A | $4,149 |
|  | NC, ROB | $4,431 | N/A | N/A | $4,431 |
|  | NC, ROB | $4,153 | N/A | N/A | $4,153 |
|  | NC, ROB | $5,173 | N/A | N/A | $5,173 |

*All costs are noted as $ per measure unit*

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **Measure Description** | **1st Baseline** | **2nd Baseline** |
| HT Tier 1 | ROB/NC | $376 | $4,149 | N/A |
| HT Tier 2 | ROB/NC | $658 | $4,431 | N/A |
| LT Tier 1 | ROB/NC | $621 | $4,153 | N/A |
| LT Tier 2 | ROB/NC | $1,641 | $5,173 | N/A |

# Attachments

1. Dishwasher energy usage calculations (Tables 10, 11,12,13,14, 15, 16, and 18)
2. Dishwasher energy usage by climate zone (Table 6 and 17)
3. Dishwasher pricing and IMC calculations February 2017 (Tables 21 and 22)
4. Water Heating Fuel Type Split for Restaurants and Food Stores (Figure 1)
5. EUL Foodservice Equipment 12-year DEER 2014 Reference
6. Older Version of ENERGY STAR standard 1.2 used as the base case
7. Current Version of ENERGY STAR standard 2.0 used as a measure case
8. Water Heating Design Guide

# References

1. ENERGY STAR, <http://www.energystar.gov/products/certified-products/detail/commercial-dishwashers> [↑](#endnote-ref-1)
2. ASTM F1969-07 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines. Published July 2011. ASTM F1969-15 Standard Test Method for Energy Performance Single-Rack, Door-Type Commercial Dishwashing Machines (including undercounter machines). Published in 2016. [↑](#endnote-ref-2)
3. Basecase assumptions, <https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/Comm_Dishwasher_Spec_2v1.pdf?fd67-807c> [↑](#endnote-ref-3)
4. NSF Commercial Dishwasher Certification Database

   [↑](#endnote-ref-4)
5. ENERGY STAR Commercial Dishwashers Key Product Criteria available at:

   <http://www.energystar.gov/index.cfm?c=comm_dishwashers.pr_crit_comm_dishwashers> [↑](#endnote-ref-5)
6. CZ2010 Weather Files (weather files for 2013 Title-24)

   [↑](#endnote-ref-6)
7. DEER2015 Measure Summary Water Heater Energy Factor:

   [↑](#endnote-ref-7)
8. ENERGY STAR Commercial Dishwasher Energy Savings Calculator:

   [www.energystar.gov/buildings/sites/default/uploads/files/commercial\_kitchen\_equipment\_calculator.xlsx?5da4-3d90&5da4-3d90](http://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx?5da4-3d90&5da4-3d90)

   [↑](#endnote-ref-8)
9. Personal communication with Boxer Northwest commercial dishwasher retailer regarding booster heaters. Primary water heating percentages are based on Restaurant and Foodservice Retail sectors from Table E-1 of the Commercial End-Use Survey (CEC-400-2006-005) <http://www.energy.ca.gov/2006publications/CEC-400-2006-005/CEC-400-2006-005.PDF> [↑](#endnote-ref-9)
10. Aquacraft, Inc., Embedded Energy in Water Studies. Study 3: End-use Water Demand Profiles. CALMAC STUDY ID CPU0052

    <http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Water_Appliances_12-AAER-2C/California_IOU_Response_to_CEC_Invitation_to_Participate-Lavatory_Faucets_and_Faucet_Accessories_REFERENCES/CPUC_2011a_Embedded_Energy_in_Water_Studies-Study_3.PDF> [↑](#endnote-ref-10)
11. 2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report, pp. 3-15 to 3-18 Table 3-14. <http://deeresources.com/files/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf> [↑](#endnote-ref-11)