Workpaper WPSCGREAP170726A

**Revision 0**

**Southern California Gas Company**

**Residential High Efficiency Dishwasher (199 kWh EAEU)**

# 

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | TBD |
| **Measure Description** | Installation of high efficiency, standard sized dishwashers (EAEU = 199 kWh) in residential buildings to save energy associated with water heating |
| **Base Case Description** | Existing standard sized dishwashers with an EAEU of 307 kWh or greater |
| **Units** | Each |
| **Energy Savings** | Values averaged across all IOUs and residential building types:   * 2.30 therms/each * 18.79 kWh/each   Refer to Excel Calculations (**Attachment A**) for full savings breakdown for all IOUs, climate zones, and residential building types. |
| **Full Measure Cost ($/unit)** | $1,483.86/each |
| **Incremental Measure Cost ($/unit)** | $1,483.86/each |
| **Effective Useful Life** | EUL of dishwasher: 11 years (EUL ID: Appl-EffDW) |
| **Measure Installation Type** | Replace on Burnout (ROB)  New Construction (NEW/NC) |
| **Net-to-Gross Ratio** | 0.7 (DEER NTGR ID: All-Default<=2yrs) |
| **Important Comments** | This workpaper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 9/19/17 | Nicole Loo, SCG  Megan Jimenez, SCG | Original workpaper |
|  |  |  |  |

# Commission Staff and Cal TF Comments

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| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
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Cal TF website: <http://www.caltf.org/>

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

Table : Base, Standard, and Measure Cases

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | High Efficiency Dishwasher - Standard Size - EAEU = 199 (EF = 1.17)[[1]](#footnote-1) |
| Existing Condition | Dishwasher - Standard Size - EAEU = 355, EF = 0.62, or Code Level for New Vintage |
| Code/Standard | Dishwasher - Standard Size - EAEU = 307, EF = 0.72 |
| Industry Standard Practice | Dishwasher - Standard Size - EAEU = 355, EF = 0.62, or Code Level for New Vintage |

Table : Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| TBD |  |  |  | High Efficiency Dishwasher - Standard Size - EAEU = 199 (EF = 1.17) |

**Eligibility Requirements**

This energy efficiency measure is applicable to residential building types that either do not have a dishwasher or currently have a dishwasher with an estimated annual energy use (EAEU) of 307 kWh or greater. Qualifying dishwashers for this measure must have an EAEU of 199 kWh and must be standard-capacity.

Only residential buildings that utilize natural gas powered water heating equipment are eligible to receive incentives for this measure. Natural gas must be supplied by a California investor owned utility (IOU).

**Implementation and Installation Requirements**

This measure is to be implemented in residential buildings as a New Construction (NEW/NC) or Replace on Burnout (ROB) measure for residences without a dishwasher or with a dishwasher with an EAEU of 307 kWh or greater. These building types include: Residential Mobile Home, Residential Multi-Family, and Residential Single Family. This measure is applicable to all California climate zones and building vintages.

## 1.2 Technical Description

High efficiency residential dishwashers with an estimated annual energy usage (EAEU) of 199 kWh are ENERGY STAR certified. Residential ENERGY STAR certified dishwashers use advanced technology to clean dishes using less water and energy. These technological advancements include soil sensors, improved water filtration, more efficient jets, and innovative dish rack designs. Soil sensors test the level of particulates in the water throughout the wash cycle and then adjust the cycle accordingly to minimize water and energy use. Improved water filtration keeps the wash water free of food particulates which allows for efficient use of detergent and water throughout the cycle. Efficient jets use less energy to spray detergent and water over the dishes when cleaning and innovative dish rack designs maximize the cleaning potential of the dishes. Residential standard-sized dishwashers that have earned ENERGY STAR certification are on average 12% more energy efficient and 30% more water efficient than standard models.[[2]](#endnote-1)

## 1.3 Installation Types and Delivery Mechanisms

Installation type descriptions are shown in **Table 3**.

Table : Installation 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 |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings. Delivery and incentive methods are shown in **Tables 4** and **5**, respectively.

Table : Delivery Method Description

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |

Table : Incentive Method Description

|  |  |
| --- | --- |
| **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 a deemed incentive to the customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

There are currently two DEER measures for high efficiency dishwashers in the residential sector. These DEER measures are for 180 kWh and 260 kWh dishwashers. This workpaper interpolates the DEER data for the 180 kWh and 260 kWh dishwashers in order to determine the savings for a 199 kWh dishwasher.

Table : DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | Yes: interpolated savings between 180 kWh & 260 kWh dishwashers |
| DEER Base Case | Yes |
| DEER Measure Case | No: EAEU = 199 kWh |
| DEER Building Types | Yes: DMo, MFm, SFm |
| DEER Operating Hours | Yes |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER 2014, READI v2.4.7 |
| Reason for Deviation from DEER | 199 kWh dishwasher measure is not currently in DEER |
| DEER Measure IDs Used | Appl-Dishwash-StdSize-180-EAEU  Appl-Dishwash-StdSize-260-EAEU |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this workpaper are in **Table 7**.

Table : NTG Values

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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 | Res | Any | Any | 0.7 |

**Spillage Rate**

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

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this workpaper are in **Table 8**.

Table : IR Values

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Res-DW-SCG | Residential Dishwasher; Annual Installation Rate | Res | Any | NonUpStrm | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this workpaper are in **Table 9**.

Table : EUL and RUL Values

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| Appl-EffDW | High Efficiency Dishwasher | Res | AppPlug | 11 | 3.67 |

### 1.4.2 Codes and Standards Analysis

Standards for dishwashers are outlined in California’s Title 20 Appliance Efficiency Code of Regulations. Applicable codes for this measure are stipulated in Title 20 of the California Code of Regulations Table O, which are shown in **Figure 1**. Title 20 requires a maximum energy use of 307 kWh/year for standard size dishwashers effective May 30, 2013. Thus, an EAEU of 307 kWh/year is used as the baseline for savings calculations for this workpaper.

Table : Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 20 (2016) | Section 1605.1(o). Dishwashers | May 30, 2013 |

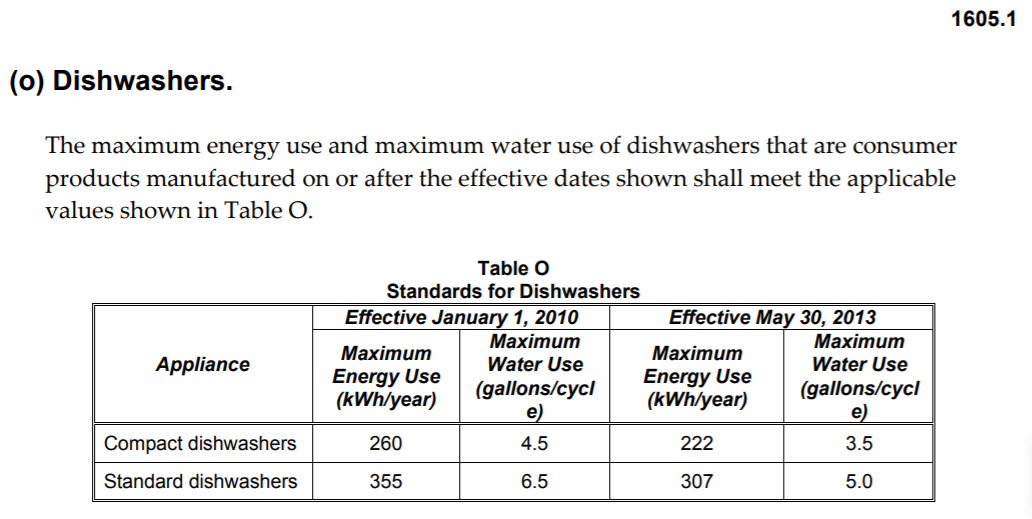


Figure : Title 20 Standards for Dishwashers

**Energy Star Criteria**

Standard-capacity ENERGY STAR dishwashers hold eight or more place settings and six serving pieces and have an estimated annual energy use (EAEU) of 270 kWh/year or less and water use of 3.5 gallons/cycle or less, as seen in **Table 11**.[[3]](#endnote-2)

Table : 2016 ENERGY STAR Criteria for Standard-Capacity Dishwashers[[4]](#endnote-3)

| **Equipment** | **Capacity** | **Current Criteria** |
| --- | --- | --- |
| Standard | ≥ 8 place settings + six serving pieces | ≤ 270 kWh/year ≤ 3.5 gallons/cycle |

**Energy Performance Metrics**

The ENERGY STAR dishwasher qualification criteria are based on specific energy consumption and water consumption levels. Energy factor (EF) was the ENERGY STAR dishwasher energy performance metric prior to 2009. The greater the EF, the more efficient the dishwasher. The federal EnergyGuide label on dishwashers shows the estimated annual energy consumption (EAEU) and cost. These figures use the energy factor, average cycles per year, and the average cost of energy to make the energy and cost estimates. The EF does not appear on the EnergyGuide label.[[5]](#endnote-4)

For the purposes of this workpaper, the EF of the 199 kWh EAEU dishwasher was estimated through linear interpolation to compare its performance to older dishwasher models with rated EFs. See **Attachment A** for the calculations.

**Test Method for ENERGY STAR Qualified Dishwashers**

The DOE test method defined in 10 CFR 430, Subpart B, Appendix C is used to determine ENERGY STAR dishwasher qualification and estimate dishwasher energy and water consumption.[[6]](#endnote-5)

The estimated annual energy use of the dishwasher is determined under typical conditions. This value includes the machine energy used by the dishwasher during a dishwashing cycle, any additional energy used by a water heater, and the energy used by the dishwasher while in standby mode. This estimated energy use is based on an annual usage of 215 loads per year. Actual energy consumption will vary depending on the customer’s usage patterns.[[7]](#endnote-6)

The estimated per cycle water use of the dishwasher is also determined under typical conditions, and is expressed as the number of gallons of water delivered to the machine during one cycle. Actual water consumption will vary depending on the settings chosen.[[8]](#endnote-7)

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

### 1.5.1 2012 Residential On-site Study: California Lighting and Appliance Saturation Study (CLASS)

**Overview**

The 2012 CLASS study was managed by the CPUC and conducted by KEMA, Inc. on behalf of the four California IOUs. The purpose of this study was to gather existing baseline data on California residential buildings as well as information on the equipment and lighting found in those building types. The results of the 2012 CLASS help ensure that accurate baseline information is reflected in residential programs. See **Attachment D** for full report.

**Techniques Used**

On-site inspections were conducted at a sample of homes in California to characterize:

* Building configurations (e.g. conditioned space square footage, room types) and specific construction components (e.g. attic insulation)
* Installed appliances and energy-consuming products (gas and electric) with high unit energy consumption (UEC) and high on-peak demand
* Lighting products installed by location in home and in storage
* Demographics of the household

**Results and Impacts**

Of the 1,987 homes surveyed between May and November of 2012, 1,428 dishwashers were found. The study found that approximately 71% of all homes have a dishwasher and dishwashers are more prevalent in townhomes and single-family detached homes than other residence types.

35.4% of dishwashers were reported to have been manufactured between 2006 and 2009, with 85% manufactured within the last 10 years. The average dishwasher age in the 1,428 sample is 7.6 years. Dishwashers manufactured in or before 1979 were not found in the surveyed homes.

The energy factor (EF) of most dishwashers fall within the range of 0.580 to 0.775 EF (over 67% of surveyed dishwashers). Dishwashers with EF less than 0.275 were not found. The average EF for the dishwashers surveyed was 0.61.

**Concerns**

As with any survey, sampling bias is a concern. Households that agreed to participate in the site surveys are more likely to include a person that is available to be at home during the day and/or to be more interested in energy use/energy efficiency than average. While it is nearly impossible to eliminate all bias, several steps were taken to minimize bias in the study including conducting recruiting calls during extended business hours and using bilingual telephone recruiters. In addition, strata and Census weights were applied to the results to reduce potential bias.

## 1.6 Data Quality and Future Data Needs

Overall, the 2012 CLASS study provides a sound overview of existing baseline conditions in the residential sector. However, since this study is 5 years old, more recent studies would need to be conducted to provide more accurate information on current conditions in the residential sector.

# Section 2. Calculation Methodology

## 2.1 Energy Savings Estimation Methodology

The proposed high efficiency, standard-sized, 199 kWh dishwasher measure has an estimated annual energy use (EAEU) between the existing 180 kWh and 260 kWh DEER 2014 dishwasher measures. Thus, the savings for the 199 kWh dishwasher measure were determined through linear interpolation of the existing DEER values for the 180 kWh and 260 kWh measures. The 199 kWh savings calculations use the 2013 Title 20 code of dishwashers with EAEU = 307 kWh as the base case, which is consistent with the existing DEER measures. **Table 12** summarizes the savings for the 199 kWh dishwasher measure. The full savings calculations and results are provided in **Attachment A**.

Table : Energy Savings Summary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Annual Energy Savings** | | |
| **IOU** | **Building Type** | **kWh** | **kW** | **Therms** |
| SCG | SFm | 14.135 | 0.00054 | 2.752 |
| MFm | 11.399 | 0.00110 | 1.997 |
| Dmo | 21.683 | 0.00242 | 2.651 |
| PGE | SFm | 19.388 | 0.00198 | 2.525 |
| MFm | 13.089 | 0.00131 | 1.478 |
| Dmo | 32.226 | 0.00346 | 2.135 |
| SCE | SFm | 15.745 | 0.00100 | 2.681 |
| MFm | 15.343 | 0.00122 | 1.831 |
| Dmo | 24.750 | 0.00272 | 2.547 |
| SDGE | SFm | 15.483 | 0.00322 | 2.693 |
| MFm | 19.746 | 0.00290 | 1.635 |
| Dmo | 22.506 | 0.00507 | 2.723 |
| **Average Values Across IOUs and Bldg Types** | | **18.79** | **0.00224** | **2.30** |

**Table 13** indicates which measures are taken directly from or created with the DEER READI tool.

Table : READI Data Used

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Measure Name** | **READI Data** |
|  | Energy Star(R) Dish Washer - Standard Size - Typical Water Heater fuel - EAEU = 180, EF = 1.26 | Appl-Dishwash-StdSize-180-EAEU |
| 530113 | Energy Star(R) Dish Washer - Standard Size - Typical Water Heater fuel - EAEU = 260, EF = 0.86 | Appl-Dishwash-StdSize-260-EAEU |

## 2.2 Water Savings Estimation Methodology

Annual water consumption is estimated for the base case and measure case. The difference in consumption between the base and measure case indicates the annual water savings achieved by the high efficiency dishwasher measure. See **Attachment A** for full savings calculations and results.

Equation : Annual Water Consumption (per dishwasher)

Where,

Equation : Annual Water Savings

Table : Water Savings Estimation (per dishwasher)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Water Use (gal/cycle) | Cycles/year[[9]](#footnote-2) | Annual Water Consumption (gal/year) |
| Baseline (EAEU = 307 kWh/year) | 5[[10]](#footnote-3) | 215 | 1075 |
| Measure (EAEU = 199 kWh/year) | 3.36[[11]](#footnote-4) | 215 | 722.4 |
|  |  | **Annual Water Savings** | **352.6** |

# Section 3. Load Shapes

Load shapes are used for portfolio lifecycle cost analysis. A load shape indicates the distribution of a measure’s energy savings over one year. A load shape is a set of fractions summing to unity, with one fraction per hour (or other time period). Multiplying a savings value by the load shape value for any particular hour yields the energy savings for that hour.

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 workpaper are listed in **Table 15**.

Table : Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Residential Mobile Home (DMo) Residential Multi-Family (MFm) Residential Single Family (SFm) | SCG:RES:DEER:Res\_ClothesDishWasher | RES |

# Section 4. Costs

## 4.1 Base Case Cost

The average cost of a 307 kWh/year EAEU standard-sized dishwasher is estimated to be $280.25. This was determined by conducting a dishwasher search through multiple online retail sites. The base case labor cost is $0. Please refer to **Attachment B** for full details.

## 4.2 Measure Case Cost

The average cost of a 199 kWh/year EAEU standard-sized dishwasher is $1,764.11. This was determined by conducting a dishwasher search through multiple online retail sites. Since this measure will be offered as a downstream prescriptive rebate, the labor cost will be $0. Please refer to **Attachment B** for full details.

## 4.3 Full and Incremental Measure Cost

Table : 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

Table : Full and Incremental Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | ($1764.11 + $0) – ($280.25 + $0) = **$1,483.86** | **$1,483.86** | N/A |
| NEW/NC |

# Attachments

Files included in a separate submission.

1. **WPSCGREAP170726A—Res HE Dishwasher Savings Analysis**—this file includes the annual savings values (gas, electricity, and water) for the SFm, MFm, and DMo residential building types for each IOU and their associated climate zones
2. **WPSCGREAP170726A—Res HE Dishwasher Cost Analysis**—this file contains the base case and measure case cost information
3. **WPSCGREAP170726A—Residential On-site Study: California Lighting and Appliance Saturation Study (CLASS 2012) Final Report**—this 2012 CPUC study describes equipment and lighting in existing residential buildings in California
4. **WPSCGREAP170726A—Energy Star Certified Residential Dishwashers**—this file contains the full list of Energy Star certified residential dishwashers

# References

1. EF for 199 kWh EAEU dishwasher was estimated through linear interpolation to compare its performance to the older dishwasher models with rated EFs. See Attachment A for reference. [↑](#footnote-ref-1)
2. Energy Star Certified Products: Dishwashers. <https://www.energystar.gov/products/appliances/dishwashers> [↑](#endnote-ref-1)
3. Energy Star Certified Products: Dishwashers. <https://www.energystar.gov/products/appliances/dishwashers> [↑](#endnote-ref-2)
4. Energy Star Dishwasher Key Product Criteria. <https://www.energystar.gov/products/appliances/dishwashers/key_product_criteria> [↑](#endnote-ref-3)
5. Energy Star Dishwasher Key Product Criteria. <https://www.energystar.gov/products/appliances/dishwashers/key_product_criteria> [↑](#endnote-ref-4)
6. DOE Test Method. 10 CFR 430, Subpart B, Appendix C. <https://www.ecfr.gov/cgi-bin/text-idx?SID=54444ece2c9e7cc589f6e09984cf67c7&mc=true&node=ap10.3.430_127.c1&rgn=div9> [↑](#endnote-ref-5)
7. Energy Star Most Efficient 2017—Dishwashers. <https://www.energystar.gov/most-efficient/me-certified-dishwashers> [↑](#endnote-ref-6)
8. Energy Star Most Efficient 2017—Dishwashers. <https://www.energystar.gov/most-efficient/me-certified-dishwashers> [↑](#endnote-ref-7)
9. DOE Test Method. 10 CFR 430, Subpart B, Appendix C [↑](#footnote-ref-2)
10. Title 20 of the California Code of Regulations Table O [↑](#footnote-ref-3)
11. Average of water use of 199 kWh/year dishwashers on Energy Star Certified Residential Dishwashers list [↑](#footnote-ref-4)