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APPLIANCE OR PLUG LOAD

DISHWASHER, RESIDENTIAL

SWAP006-03

CONTENTS

MEASURE NAME

Dishwasher, Residential

STATEWIDE MEASURE ID

SWAP006-03

TECHNOLOGY SUMMARY

A high-efficiency dishwasher incorporates 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.

Because a dishwasher requires hot water for the wash and rinse cycles, the estimated annual energy usage of a dishwasher under the U.S. Department of Energy (DOE) test method includes the energy required by the water heater to provide the hot water to the dishwasher. The total energy savings associated with a high-efficiency dishwasher generally results from a reduction of hot water required per wash cycle. The technologies described above that achieve this reduction will often result in a nominal increase in machine energy use, which is more than offset by a reduction in water heating energy required.

Residential standard-sized dishwashers that have earned ENERGYSTAR certification are on average 12% more energy efficient and 25% more water efficient than standard models.[1]

MEASURE CASE DESCRIPTION

This measure is defined as the installation of a high-efficiency dishwasher meeting the specifications designated below. The 199-kWh tier includes the most efficient dishwasher models available on the market in the U.S.

[1] United States EPA 2015. "ENERGY STAR Residential Dishwasher Final Version 6.0 Cover Memo" Page 1. April 2015

Measure Case Specification

Tier Level	Max. Estimated Annual Energy Use (EAEU) (kWh/yr)	Max. Water Consumption (gallons/cycle)	Source
≤ 199 kWh/yr	199 kWh	3.5	ENERGY STAR. 2017. "ENERGY STAR Dishwasher list 20171003.xls."

BASE CASE DESCRIPTION

The base case is defined as the existing standard-sized dishwasher with an annual energy use of at least 307 kWh per year, the maximum specified by the California Appliance Efficiency Regulations (Title 20). See Code Requirements.

CODE REQUIREMENTS

Standards for dishwashers are specified in the California Appliance Efficiency Regulations (Title 20)[2]. Title 20 specifies a maximum annual energy use (AEU) of 307 kWh for standard size dishwashers, effective May 30, 2013.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2014)	Section 1605.1(o). Dishwashers	May 30, 2013
CA Building Energy Efficiency Standards – Title 24	None.	n/a
Federal Standards	10 CFR 430.32(f)(3)	May 30, 2013

NORMALIZING UNIT

Each

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial

[2] California Energy Commission (CEC). 2014. *2014 Appliance Efficiency Regulations.* CEC-400-2014-009-CMF. Page 2, Table O.

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	UpDeemed	Res
Normal replacement	DnDeemed	Res
Normal replacement	DnDeemDI	Res
New construction	UpDeemed	Res
New construction	DnDeemed	Res
New construction	DnDeemDI	Res

Eligible Products

The dishwasher must meet ENERGY STAR Program Requirements for Residential Dishwashers (Version 6.0).[3] Please note that the offering is more stringent than the ENERGY STAR Most Efficient criteria.

Energy Efficiency Requirements for Residential ENERGY STAR Dishwashers

Tier Level	Max. Estimated Annual Energy Use (EAEU) (kWh/yr)	Max. Water Consumption (gallons/cycle)
ENERGY STAR	270 kWh	3.5
ENERGY STAR Most Efficient	240 kWh	3.2

Eligible Building Types and Vintages

This measure is eligible for all residential building types of any vintage that utilize natural gas water heating equipment.

Eligible Climate Zones

This measure is applicable in all California climate zones.

[3] ENERGY STAR. 2016. "ENERGY STAR® Program Requirements for Residential Dishwashers - Eligibility Criteria Version 6.0." Effective January 29, 2016

PROGRAM EXCLUSIONS

Compact residential dishwashers and commercial dishwashers are excluded from this measure.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Appliance and plug loads (AppPlug)

ELECTRIC SAVINGS (kWh)

The annual unit energy savings (UES) of the ENERGY STAR-qualified residential dishwasher were drawn directly from the Database for Energy Efficient Resources (DEER). The following tables specifies the measures and corresponding IDs for which unit energy savings were drawn directly from or created with the DEER READI tool.

The high efficiency, standard-sized, 199-kWh dishwasher measure offering has an EAEU between the existing 180-kWh and 260-kWh DEER 2020 dishwasher measure offerings. Thus, the UES for the 199-kWh dishwasher measure offerings were derived 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 equal to 307 kWh as the baseline unit energy consumption (UEC), which is consistent with the existing DEER measures.

DEER Measure Tech IDs

Statewide Measure Offering ID	Measure Description	DEER Energy Impact ID	DEER Version
SWAP006A	Efficient ≤ 199 kWh/yr, Residential Dishwasher	*Scaled* - Appl-Dishwash-StdSize-180-EAEU	D20v1

Example Calculation

An example calculation of the linear interpolation of the DEER data is provided below:

$$UES_{199\ EAEU} = UES_{260\ EAEU} + \left[\frac{(UES_{180\ EAEU} - UES_{260\ EAEU})}{(EAEU_{180} - EAEU_{260})} \times ((EAEU_{199} - EAEU_{260})\right]$$

$$UES_{199\ EAEU} = -9.90\ kWh/yr + \left[\frac{\left(\frac{19.1kWh}{yr} - \left(-\frac{9.9kWh}{yr}\right)\right)}{(180\ kWh/yr - 260\ kWh/yr)} \times (199\ kWh/yr - 260\ kWh/yr)\right]$$

$$UES_{199\ EAEU} = -9.90\ kWh/yr + \left[\frac{(29.0\ kWh/yr)}{(-8\ \ kWh/yr)} \times (-61\ kWh/y)\right] = 12.2\ kWh/\text{yr}$$

Calculated Electric Savings Example

Energy Impact ID	Climate Zone, BldgType	Appl-Dishwash-StdSize-180-EAEU, (kWh)	Appl-Dishwash-StdSize-260-EAEU, (kWh)	Calculated UES 199 EAEU, (kWh)
SWAP006A	CZ09, Res	19.1	-9.9	12.2

PEAK ELECTRIC DEMAND REDUCTION (KW)

The peak demand reduction was derived with the same methodology as the Electric Savings section.

Calculated Demand Reduction Example

Energy Impact ID	Climate Zone, BldgType	Appl-Dishwash-StdSize-180-EAEU, (kW)	Appl-Dishwash-StdSize-260-EAEU, (kW)	Calculated UES 199 EAEU, (kW)
SWAP006A	CZ09, Res	0.005	-0.002	0.003

GAS SAVINGS (THERMS)

The gas unit energy savings (UES) was derived with the same methodology as the Electric Savings section.

Calculated Gas Savings Example

Energy Impact ID	Climate Zone, BldgType	Appl-Dishwash-StdSize-180-EAEU, (therm)	Appl-Dishwash-StdSize-260-EAEU, (therm)	Calculated UES 199 EAEU, (therm)
SWAP006A	CZ09, Res	2.61	1.90	2.44

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 EUL for the residential high efficiency dishwasher is drawn from the ENERGY STAR typical product EUL for door-type units, shown below. Note that RUL is only applicable for add-on equipment and accelerated replacement measures thus not applicable for residential dishwashers.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	11.00	ENERGY STAR. 2013. "Savings Calculator for ENERGY STAR Certified Commercial Equipment."
RUL (yrs)	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 material cost of a base case standard-sized dishwasher was calculated as the average of published list prices obtained from online web scraping of multiple online retailer websites.[4]

MEASURE CASE MATERIAL COST ($/UNIT)

For *all delivery types*, the measure costs for each dishwasher efficiency tier were calculated as the average cost of dishwasher models in each category obtained from retailer websites.[5]

BASE CASE LABOR COST ($/UNIT)

For *all 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.

MEASURE CASE LABOR COST ($/UNIT)

For *all 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 residential 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 residential programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

Parameter	Value	Source
NTG – Residential	0.55	Itron, Inc. 2011. DEER Database 2011 Update Documentation. Prepared for the California Public Utilities Commission. Page 15-4, Table 15-3.

[4] Southern California Gas Company (SCG). 2017. "WPSCGREAP170726A-Rev00_Res HE Dishwasher Cost Analysis.xlsx."

[5] Southern California Gas Company (SCG). 2017. "WPSCGREAP170726A-Rev00_Res HE Dishwasher Cost Analysis.xlsx."

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 installation rate was derived from 603 participant telephone surveys conducted for the Residential Retrofit High Impact Measure Evaluation of the 2006 – 2008 residential energy efficiency programs.

Gross Savings Installation Adjustment Rates

Parameter	Residential ENERGY STAR Dishwasher	Source
GSIA	1.0	The Cadmus Group, Inc. 2010. *Residential Retrofit High Impact Measure Evaluation Report.* Prepared for the California Public Utilities Commission. Page 57, Table 49.

NON-ENERGY IMPACTS

The primary non-energy impact associated with high-efficient dishwasher is the reduction in water use. The difference in water consumption between the base and measure case represents the annual water savings achieved by a high-efficiency dishwasher measure. The water use per cycle was calculated as the average of all models from the 2017 ENERGY STAR Qualifying Product List (QPL).

$$WS = (WC_{Base} - WC_{Measure}) \times Cycles$$

WS = Water savings per year (gal)
WC_{base} = Water use of base case dishwasher (gal/cycle)
WC_{eff} = Water use of measure case dishwasher (gal/cycle)
Cycles = Number of cycles (cycles/year)

Water Savings Parameters

Tier	Average Water Use (gal/cycle)	Cycles/year	Source
Base Case	5.00	215	Code of Federal Regulations at 10 CFR 430.32(f)(3)
≤ 199 kWh	3.36	215	ENERGY STAR. 2017. "ENERGY STAR Dishwasher list 20171003.xls."

DEER DIFFERENCES ANALYSIS

This section provides a summary of DEER-based inputs and methods, and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

DEER Item	Comment / Used for Workpaper
Modified DEER methodology	No
Scaled DEER measure	Yes
DEER Base Case	Yes
DEER Measure Case	No

DEER Item	Comment / Used for Workpaper
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	No
DEER Version	DEER 2020 via READI v2.5.1
Reason for Deviation from DEER	199 kWh dishwasher measure is not currently in DEER
DEER Measure IDs Used	Appl-Dishwash-StdSize-180-EAEU *(Scaled)*
NTG	Source: DEER. The NTG of 0.55 is associated with NTG ID: Res-Default>2
GSIA	Source: DEER. The GSIA of 1.0 is associated with GSIA ID: *Res-DW-SCG*
EUL/RUL	Source: DEER, ENERGY STAR. The value of 11 years is associated with EUL ID: *Appl-EffDW*.

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	10/31/2017	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: WPSCGREAP170726A, Revision 0 (September 19, 2017) Consensus reached among Cal TF members.
	12/26/2018	Jennifer Holmes Cal TF Staff	Revisions for submittal of Version 01
	7/2/2019	Ayad Al-Shaikh Cal TF Staff	Update DEER IDs with DEER 2020 values
02	11/15/2020	Anders Danryd, Engineer SoCalGas	Updated savings from DEER2020 PA specific savings to DEER2020 PA “Any” Values per CPUC direction, added “New” vintage
	12/30/2020	Anders Danryd, Engineer SoCalGas	Text edits (updated references, added example calculations), added scaling formula to data spec file
	2/12/2021	Anders Danryd, Engineer SoCalGas	Removal of ENERGY STAR dishwasher due to market penetration
	5/18/2021	Anders Danryd, Engineer SoCalGas	Fixed error in EAD where Multifamily Existing savings were using Residential DEER savings values
03	7/21/2021	Anders Danryd, Engineer SoCalGas	Changed to revision 3 per CPUC request