**Work Paper PGECOAPP127**

**Clothes Washers**

**Revision # 1**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**High Efficiency Clothes Washers**

**Measure Codes CWWA, CWME, CWMEF**

# At-a-Glance Summary

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Applicable Measure Codes:** | **SCG:**  **ApgClw003,**  **ApgClw004** | **SCG:**  **ApgClw005,**  **ApgClw006** | **SCE:**  **AP-98665** | **SCG:**  **ApgClw009,**  **ApgClw010** | **PG&E: CWME**  **SCE:**  **AP-12634**  **SCG:**  **ApgClw007, ApgClw008**  **SDG&E:**  **TBD** | **PG&E: CWMEF** | **PG&E: CWWA**  **SDG&E:**  **TBD** | **PG&E: AP001**  **SCE:**  **AP-61333** |
| **Measure Description:** | Energy Star Residential Top-Loading Clothes Washer with a minimum Integrated Modified Energy Factor of 2.06 and maximum Integrated Water Factor of 4.3 | Energy Star Residential Front-Loading Clothes Washer with a minimum Integrated Modified Energy Factor of 2.38 and maximum Integrated Water Factor of 3.7 | Energy Star Residential Clothes Washer | Energy Star Residential Clothes Washer in commercial settings | Energy Star Most Efficient/ CEE Tier 2 Clothes washer with a minimum Integrated Modified Energy Factor of 2.74 and maximum Integrated Water Factor of 3.2 | Energy Star Most Efficient Residential coin-op clothes washer in common multifamily laundry area with a minimum Integrated Modified Energy Factor of 2.74 and maximum Integrated Water Factor of 3.2 | CEE Tier 3 Clothes washer with a minimum Integrated Modified Energy Factor of 2.92 and maximum Integrated Water Factor of 3.2 | Energy Star Commercial Clothes Washer with a minimum Modified Energy Factor of 2.2 and maximum Water Factor of 4.5 |
| **Energy Impact Common Units:** | each | each | each | each | each | each | each | each |
| **Base Case Description:** | Title 20 compliant top-loading standard clothes washer with IMEF of 1.29 and IWF of 8.4 | Title 20 compliant front-loading standard clothes washer with IMEF of 1.84 and IWF of 4.7 | Title 20 compliant top-loading and front-loading standard clothes washer weighted by market share | Title 20 compliant top-loading and front-loading standard clothes washer weighted by market share | Title 20 compliant top-loading and front-loading standard clothes washer weighted by market share | Title 20 compliant top-loading and front-loading standard clothes washer weighted by market share | Title 20 compliant top-loading and front-loading standard clothes washer weighted by market share | Title 20 compliant top-loading and front-loading standard clothes washer weighted by market share |
| **Base Case Energy Consumption:** | Varies by DHW fuel type | Varies by DHW fuel type | Varies by building type | Varies by DHW fuel type | Varies | 1469.3 kWh and 19.75 therms  Source: PG&E Calculations  \* These are weighted averages by fuel type for clothes dryer and water heater | Varies by building type, IOU | Varies by IOU |
| **Measure Energy Consumption:** | Varies by DHW fuel type | Varies by DHW fuel type | Varies by building type | Varies by DHW fuel type | Varies | 1047.9 kWh and  -0.19 therms  Source: PG&E Calculations  \* These are weighted averages by fuel type for clothes dryer and water heater | Varies by building type, IOU | Varies by IOU |
| **Energy Savings**  **(Base Case – Measure):** | Varies by DHW fuel type | Varies by DHW fuel type | Varies by building type | Varies by DHW fuel type | Varies | 421.36 kWh and 19.94 therms  Source: PG&E Calculations  \* These are weighted averages by fuel type for clothes dryer and water heater | Varies by building type, IOU | Varies by IOU |
| **Costs Common Units:** | each | each | each | each | each | each | each | each |
| **Base Case Equipment Cost ($/unit):** | Source: 2010-2012 Ex Ante Measure Cost Study  $584.90 | Source: 2010-2012 Ex Ante Measure Cost Study  $682.14 | Source: 2010-2012 Ex Ante Measure Cost Study  $638.38 | Source: 2010-2012 Ex Ante Measure Cost Study  $638.38 | Source: 2010-2012 Ex Ante Measure Cost Study  $638.38 | Source: 2010-2012 Ex Ante Measure Cost Study  $638.38 | Source: 2010-2012 Ex Ante Measure Cost Study  $638.38 | Source: 2014 DOE Commercial Clothes Washers Technical Support Document  $1,630.67 |
| **Measure Equipment Cost ($/unit):** | Source: 2010-2012 Ex Ante Measure Cost Study  $614.92 | Source: 2010-2012 Ex Ante Measure Cost Study  $699.52 | Source: 2010-2012 Ex Ante Measure Cost Study  $661.45 | Source: 2010-2012 Ex Ante Measure Cost Study  $661.45 | Source: 2010-2012 Ex Ante Measure Cost Study  $711.11 | Source: 2010-2012 Ex Ante Measure Cost Study  $711.11 | Source: 2010-2012 Ex Ante Measure Cost Study  $716.90 | Source: 2014 DOE Commercial Clothes Washers Technical Support Document  $2,176.25 |
| **Gross Measure Cost ($/unit)** | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Measure Incremental Cost ($/unit):** | $30.02 | $17.38 | $23.07 | $23.07 | $72.73 | $72.73 | $78.52 | $545.58 |
| **Effective Useful Life (years):** | Source: DEER 2011  11 years | Source: DEER 2011  11 years | Source: DEER 2011  11 years | Source: DEER 2011  11 years | Source: DEER 2011  11 years | Source: DEER 2011  11 years | Source: DEER 2011  11 years | Source: DEER 2011  11 years |
| **Measure Application Type:** | ROB | ROB | ROB | ROB | ROB | ROB | ROB | ROB |
| **Net-to-Gross Ratios:** | Source: DEER 2011  NTG: 0.31  Res-sAll-mCW | Source: DEER 2011  NTG: 0.31  Res-sAll-mCW | Source: DEER 2011  NTG: 0.31  Res-sAll-mCW | Source: DEER 2011  NTG: 0.31  Res-sAll-mCW | Source: DEER 2011  Varies by building type | Source: DEER 2011  NTG: 0.55  Res-Default>2 | Source: DEER 2011  Varies by building type | Source: DEER 2011  NTG: 0.60  Com-Default>2yrs |
| **Important Comments:** |  |  |  |  |  | This measure requires the clothes washer to be operational through a coin box or card reader. |  |  |

# Work Paper Approvals

The following Manager(s) approved this workpaper through the PG&E Electronic Data Routing System under Routing Requisition # \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| --- |
|  |
| **Grant Brohard**  Manager, Technical Product Support |
| **Carolyn Weiner**  Manager, Core Products Appliances |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **Revision Date** | **Section-by-Section Description of Revisions** | **Author (Company)** |
| **Superseded** |  | **PGECOAPP114 R3 Clothes Washers Res.doc, PGECOAPP115 R3 Clothes Washers Comm.doc, PGECOAPP120 R3 Clothes Washers MF.doc** | **These separate workpapers were all superseded by the new Revision 0.** |
| **Revision 0** | **02/10/2014** | **PGECOAPP127 R0 Clothes Washers.docx** | **Jia Huang (PG&E)** |
| **Revision 1** | **04/09/2015** | **PGECOAPP127 R1 Clothes Washers.docx**  **Updated calculations for March 2015 federal code change for residential clothes washers. Changed NTG. Statewide workpaper; includes measures for PG&E, SCE, SCG, and SDG&E. Added measures for commercial clothes washers.**  **Superceeded SCG workpapers:**  **WPSCGREAP111222A Chan Paek (SCG)**  **WPSCGREAP140211A Justin Westmoreland (AESC)** | **Jia Huang (PG&E)** |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

Table : Base and Measure Cases

|  |  |
| --- | --- |
| **Typical Base Case Description** | *Title 20 compliant top-loading or front-loading clothes washer* |
| **Typical Measure Description** | *Efficient clothes washer that meets minimum criteria for Energy Star, Energy Star Most Efficient, CEE Tier 2, or CEE Tier 3.* |

Table 2: Measure Names

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PG&E Measure Codes | SCE Solution Code | SCG Measure Codes | SDG&E Measure Codes | Measure name |
|  |  | ApgClw003, ApgClw004 |  | Energy Star Residential Top-Loading Clothes Washer |
|  |  | ApgClw005, ApgClw006 |  | Energy Star Residential Front-Loading Clothes Washer |
|  | AP-98665 |  |  | Energy Star Residential Clothes Washer |
|  |  | ApgClw009,  ApgClw010 |  | Energy Star Residential Clothes Washer in commercial settings |
| CWME | AP-12634 | ApgClw007, ApgClw008 |  | Energy Star Most Efficient Clothes Washer, >2.5 cubic ft |
| CWMEF |  |  |  | Energy Star Most Efficient Clothes Washer, Coin Operated |
|  |  |  | \*TBD | CEE Tier 2 Clothes Washer |
| CWWA |  |  | \*TBD | CEE Tier 3 Clothes Washer |
| AP001 | AP-61333 |  |  | Energy Star Commercial Clothes Washer |

***PG&E Catalog Description –***

**Energy Star Most Efficient Clothes Washer (CWME – (In Unit) & CWMEF – (Common Space))**

* Customer must have natural gas and/or electricity distributed by Pacific Gas and Electric Company (PG&E) to the installation address.
* Clothes washer must be an **Energy Star Most Efficient** model only.
* Clothes washer must have a Integrated Modified Energy Factor (IMEF) of 2.74 or greater.
* Clothes washer must have a Integrated Water Factor (IWF) of 3.2 or less.
* A capacity of greater than 2.5 cubic feet.

**High-Efficiency Clothes Washer (CWWA)**

This rebate is only available through participating Water Agencies.

* Customer must have natural gas and/or electricity distributed by Pacific Gas and Electric Company (PG&E) to the installation address.
* Clothes washer must be a **Consortium for Energy Efficiency (CEE) Tier 3** model.
* Clothes washer must have a Integrated Modified Energy Factor (IMEF) of 2.92 or greater.
* Clothes washer must have a Integrated Water Factor (IWF) of 3.2 or less.

***PG&E Program Restrictions and Guidelines***

***Terms and Conditions:*** Not all ENERGY STAR® clothes washers qualify for these rebates. Tier 1 and Tier 2 units based on the Consortium for Energy Efficiency (CEE) ranking do not qualify. Units from the Energy Star Most Efficient Products List and Tier 3 units on the CEE product list qualify for their respective rebates. A list of qualifying residential products for CEE is available at [www.cee1.org/resid/seha/rwsh/rwsh-prod.pdf](http://www.cee1.org/resid/seha/rwsh/rwsh-prod.pdf). A list of qualifying residential products for Energy Star Most Efficient is at <http://www.energystar.gov/ia/products/most_efficient/downloads/ME_ClothesWashers.xls>.

***Market Applicability:*** These measures are applicable to any residential-sized clothes washer intended to be installed in a residential, multi-family, or any nonresidential building type.

***SCE Measure Requirements –***

**Energy Star Eligibility Requirements**

* The clothes container volume must be ≥ 1.6 and ≤ 6.0 cubic ft.
* Configurations other than a front-loading or top-loading design do not qualify.
* Combination washer-dryers and residential clothes washers with an optional dry cycle do not qualify.
* Note that this work paper only offers the ESME measure for residential models greater than 2.5 cubic ft.

***SCG Measure Requirements –***

**Measure Description**

1. ApgClw003 applies to Energy Star Top-Loading Clothes Washer with a minimum Integrated Modified Energy Factor of 2.06 and maximum Integrated Water Factor of 4.3 using a natural gas water heater in their single family home.
2. ApgClw004 applies to Energy Star Top-Loading Clothes Washer with a minimum Integrated Modified Energy Factor of 2.06 and maximum Integrated Water Factor of 4.3 using an electric water heater in their single family home.
3. ApgClw005 applies to Energy Star Front-Loading Clothes Washer with a minimum Integrated Modified Energy Factor of 2.38 and maximum Integrated Water Factor of 3.7 using a natural gas water heater in their single family home.
4. ApgClw006 applies to Energy Star Front-Loading Clothes Washer with a minimum Integrated Modified Energy Factor of 2.38 and maximum Integrated Water Factor of 3.7 using an electric water heater in their single family home.
5. ApgClw007 applies to Energy Star Most Efficient Clothes washer with a minimum Integrated Modified Energy Factor of 2.74 and maximum Integrated Water Factor of 3.2 using a natural gas water heater in their single family home.
6. ApgClw008 applies to Energy Star Most Efficient Clothes washer with a minimum Integrated Modified Energy Factor of 2.74 and maximum Integrated Water Factor of 3.2 using an electric water heater in their single family home.
7. ApgClw009 applies to a Energy Star washing machine of residential size being used in a commercial setting with a natural gas water heater. These settings could include but are not limited to resturants, nail salons, spas, ect.
8. ApgClw010 applies to a Energy Star washing machine of residential size being used in a commercial setting with an electric water heater. These settings could include but are not limited to resturants, nail salons, spas, ect.

**Implementation Requirements**

1. The rebate applies to gas-for-gas equipment replacements on burnout or to new installations in existing buildings.

2. The rebate does not apply to new construction (NC).

3. Applicable to single family residential and some commercial applications

**Documentation Requirements**

1. Proof of purchase must be provided and can include all or any one of the following: the manufacturer’s name and equipment make and model number, retailer information, equipment cost, and invoice/receipt with payment in full.

2. Must provide IMEF and IWF identification as well as the cubic feet of the model.

3. The date purchased and the date installed.

**Terms and Conditions**

1. Single family residential clothes washer cannot be used in commercial applications.

2. No more than one unit can be rebated per household.

3. General terms and conditions for SCG measures can be found at [http://www.socalgas.com/for-your-home/rebates/terms-conditions.shtml](https://urldefense.proofpoint.com/v2/url?u=http-3A__www.socalgas.com_for-2Dyour-2Dhome_rebates_terms-2Dconditions.shtml&d=AwMFAg&c=hLS_V_MyRCwXDjNCFvC1XhVzdhW2dOtrP9xQj43rEYI&r=zzJFJ8zpcKvH-UuuNn1ZrQ&m=CCwDhAI5fJPWOvPne6r_LhdrPMc_fZF5Imlgs9twbTs&s=4YwhwAy4P_4FC6sySJhVdjePtxjFYIpgasUMvxfmd0c&e=)

***1.2 Product Technical Description***

Over 80% of households in the U.S. have clothes washers[[1]](#endnote-1). A significant amount of the energy used for clothes washing is used for heating the water, so machines that use less water are usually more energy-efficient. Horizontal-axis clothes washers tumble clothes through a much smaller pool of water than conventional models, saving up to 50 percent of energy consumed in the washing process. High-efficiency machines also have more efficient motors, spinning clothes two to three times faster than the conventional machines. This removes more water from the clothes which reduces the amount of time and energy required to dry them.

## 1.3 Measure Application Type

The DEER Measure Cost Data Users Guide found on [www.deeresources.com](http://www.deeresources.com) under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata\_format-V0.97.xls*, defines the terms as follows:

Table  Measure Application Type[[2]](#endnote-2)

*Identifies the measure application type in the Measure Implementation table in DEER2011.*

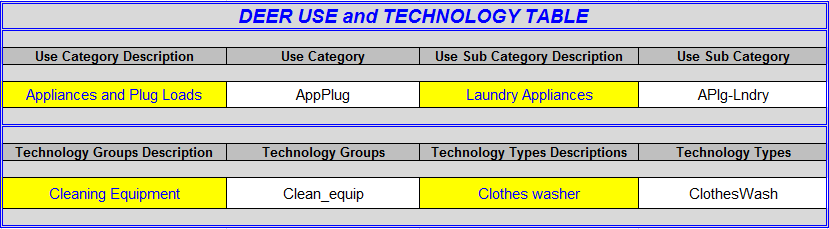
|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | *measure applied while existing equipment still viable, or retrofit of existing equipment* |
| ROB | Replace on Burnout | *measure applied when existing equipment fails or maintenance requires replacement* |
| NC | New Construction | *measure applied during construction design phase as an alternative to a code-compliant standard design* |

These measures are identified as ROB, or replace on burnout.

## 1.4 Product Base Case and Measure Case Data

## 1.4.1 DEER Base Case and Measure Case Information

The DEER 2011 data include: equipment useful life and Net to Gross for all measures in this workpaper.



**Net-to-Gross:**

The NTG value was obtained from the “DEER2011\_NTGR\_2012-05-16.xls” on the DEER website as required by Version 5 of the California Public Utilities Commission (CPUC) Energy Efficiency Policy Manual [351]. The relevant NTGR for this measure is shown in Table 4 below.

Table 4 Net-to-Gross Ratio

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| NTGR\_ID\* | Description\* | Sector\* | BldgType\* | ProgDelivID\* | NTG\* | Applicable Measure |
| Res-sAll-mCW | Clothes washer MEF 10% > Energy Star | Res | Any | Any | 0.31 | Residential Energy Star |
| Res-Default>2 | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Res | Any | Any | 0.55 | Energy Star Most Efficient, CEE Tier 3 |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | Any | 0.6 | Commercial Energy Star |

**Installation Rate (GSIA)**

The installation rate (IR) is identified in the calculation attachment. This value is obtained from the support table available in READi. Currently there is no versioning on the installation rate table. To address appropriate selection of the installation rate the date of the workpaper will serve as the last date checked for updated IR values. The installation rate varies by end use, sector, technology, application, and delivery method. The relevant IR values for this measure are shown in Table 5 below.

Table 5 Installation Rate

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

\*Denotes that the column is taken from the DEER GSIA Table.

**Spillage Rate**

Spillage rate will also be applied to measures however the values will not be tracked in the workpapers. The spillage rate will be tracked in an external table to be supplied to the Energy Division.

**READi Technology Fields**

To support the development of the ED ex ante tables, select fields from the ex ante database will be identified in the workpaper. For a full set of values associated with the measures in the workpaper refer the Excel calculation template. (In the event that the READi IDs do not support the technology in this workpaper simply indicate “Non-DEER”.)

Table 6 READi Tech IDs

|  |  |
| --- | --- |
| READi Field Name | Values included in this workpaper |
| Measure Case UseCategory | AppPlug |
| Measure Case UseSubCats | Laundry |
| Measure Case TechGroups | Clean-equip |
| Measure Case TechTypes | ClothesWash |
| Base Case TechGroups | Clean-equip |
| Base Case TechTypes | ClothesWash |

**EUL**

DEER14 update documentation provides EUL and RUL information to be used for the 2015 program year on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “DEER2014-EUL-table-update\_2014-02-05.xlsx” provides the RUL value as a flat 1/3 of the EUL value. The RUL value will only be applied to the first baseline period for retrofit measures that have applicable code that will affect the energy savings. In all other installation types and retrofit with no applicable code that affects the energy savings, the RUL is not applicable to either the first or second baseline period.

To obtain the EUL value the DEER14 update documentation, “DEER2014-EUL-table-update\_2014-02-05.xlsx” [436], was consulted. Table 7 below identifies the value/methodology used for the measures in this work paper.

Table 7 EUL Value/Methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **READi EUL ID** | **Description** | **Sector** | **Enduse** | **EUL (Years)** | **RUL (Years)** |
| Appl-EffCW | High Efficiency Clothes Washer | Res | Laundry | 11 | 3.7 |
| ComLau-EffCW | High Efficiency Clothes Washer (CEE Tiers 1,2,3) | Com | Laundry | 11 | 3.7 |

## 1.4.2 Codes & Standards Requirements Base Case and Measure Information

Table : Code Summary

|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Dates |
| Title 20 (2014) | Section 1605.1, Table P-2: Standards for Residential Clothes Washers | March 7, 2015 |
| Title 20 (2014) | Section 1605.1, Table P-3: Standards for Commercial Clothes Washers | January 8, 2013 |
| DOE | Code of Federal Regulations, 10 CFR 430.32(g)(3) | March 7, 2015 |
| DOE | Code of Federal Regulations, 10 CFR 431.156 | January 8, 2013 |

***Title 20:*** These measures fall under Title 20 of the California Energy Regulations. Under this regulation, the following is required:

The California 2014 Appliance Efficiency Regulations (Title 20)[[3]](#endnote-3) require that all residential and commercial clothes washers manufactured on or after the dates indicated below must meet the minimum efficiency requirements for MEF/IMEF and WF/IWF.

|  |  |  |  |
| --- | --- | --- | --- |
| **Residential Clothes Washers** | **Clothes Container Compartment Capacity (ft3)** | **Minimum Integrated Modified Energy Factor**  **(Effective March 7, 2015)** | **Maximum Integrated Water Factor (Effective March 7, 2015)** |
| **Compact Top-Loading Clothes Washers** | ˂ 1.6 ft3 | 0.86 | 14.4 |
| **Standard Top-Loading Clothes Washers** | ≥ 1.6 ft3 | 1.29 | 8.4 |
| **Compact Front-Loading Clothes Washers** | ˂ 1.6 ft3 | 1.13 | 8.3 |
| **Standard Front-loading clothes washers** | ≥ 1.6 ft3 | 1.84 | 4.7 |
| **Commercial Clothes Washers** | **Clothes Container Compartment Capacity (ft3)** | **Minimum Modified Energy Factor (Effective January 8, 2013)** | **Maximum Water Factor (Effective January 8, 2013)** |
| **Top-Loading Clothes Washers** | Any | 1.60 | 8.5 |
| **Front-Loading Clothes Washers** | Any | 2.00 | 5.5 |

***Title 24:*** These measures do not fall under Title 24 of the California Energy Regulations.

***Federal Standards:*** These measures fall under Federal DOE Energy Regulations. Title 20 minimum standards for residential and commercial clothes washers follow DOE federal minimum efficiency requirements. Federal standrads match the requirements cited in Title 20 in the table above.

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

***1.4.3.1 2009 Residential Appliance Saturation Survey (RASS)[[4]](#endnote-4)***

In 2009, the California Energy Commission funded and administered a Residential Appliance Saturation study that was implemented across the territories of the large investor-owned utilities. The study was implemented as a mail survey with an option for respondents to complete it online. The survey requested households to provide information on appliances, equipment, and general consumption patterns. Data collection was completed in early 2010.

**Energy Savings Assumption (ΔW, ΔTherms):**

* The 2009 RASS study was utilized to estimate the residential electric and gas water heater and dryer combinations for statewide residential homes. This distribution was used to weight various water-heating and drying energy source combinations to obtain a weighted average savings for kW, kWh and therms for this clothes washer measure. The residential distribution from RASS was used for multifamily common area and nonresidential units because no other comparable source was available for those applications. See section 2 for analysis details.

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

**Energy Savings Assumption (ΔW, ΔTherms):**

* The Department of Energy (DOE) division of Energy Efficiency and Renewable Energy (EERE) has issued residential and commercial Technical Support Documents (TSDs) addressing clothes washer equipment standards. The purpose of the Technical Support Documents is to provide technical analyses for the DOE Final Rules on appliance energy conservation standards. The most recent residential clothes washer Technical Support Document was published in April 2012[[5]](#endnote-5). This document includes per cycle energy use (in kWh) for various clothes washer efficiencies, an engineering analysis, unit shipment analysis as well as the number of cycles per year for the residential sector. The energy consumption values from the residential TSD were used to develop per cycle energy savings for residential, nonresidential, and multifamily components of the clothes washer program. The clothes washer program issues rebates for residential-sized units for all sectors, so the residential per-cycle energy consumption is appropriate for all sectors in the program. The clothes washer energy use is given in kWh, and is disaggregated by machine use, domestic hot water use, and dryer use (energy to remove moisture from the clothes). The TSD assumed an average dryer usage factor of 0.91, meaning that 91% of washer loads are dried in a clothes dryer. Upon investigation, it appears as though the dryer energy usage is exclusively for the removal of moisture from the load and does not account for the dryer motor energy to spin the drum. No sources could be located that provided a credible estimate of dryer machine energy usage. See section 2 for details.
* The latest DOE commercial clothes washers Technical Support Document issued in 2014[[6]](#endnote-6) focuses on the same information as the residential clothes washers TSD mentioned above. The commercial CWs TSD is used to estimate annual energy use and incremental costs for commercial clothes washers measures in this workpaper.

**Hours of Operation**:

* The 2012 residential clothes washer Technical Support Document cites an annual usage of 295 cycles per year. This number is used to calculate annual energy usage for clothes washers in residential and multifamily in-unit dwellings.
* The 2014 commercial clothes washer Technical Support Document (chapter 7) cites an average number of cycles per year of 1497 for commercial clothes washers (focusing on Laundromats) and 1095 for multifamily coin-operating machines. The commercial and multifamily common area energy savings were developed using the cycles per year estimates from the commercial TSD. See Section 2 for details.

***1.4.5 Time-of-Use Adjustment Factor***

We are required by CPUC decision 06-06-063 dated June 29, 2006 to apply time-of-use (TOU) adjustment factors on residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0.

***1.5 Summary of Inputs for Savings Calculations***

The following table provides references to sections that document the inputs for calculation:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Input Variable** | **Variations** | **Base Case Average Value** | **Measure Case Average Value** | | **Reference Section** |
| **Electric Savings** | Varies | Varies | Varies | | *Section 2.1* |
| **Gas Savings** | Varies | Varies | Varies | | *Section 2.3* |
| **Hours of operation** | Varies | Varies | Varies | | *Section 1.4.4* |
| **Full Cost** | ROB | Varies | Varies | | *Sections 4.1, 4.2* |
| **Incremental Cost** | ROB | Varies | | Varies | *Section 4.3* |
| **EUL /RUL** | ROB | 11 | 11 | | *Section 1.4.1* |
| **NTG** | One / many | Varies | Varies | | *Section 1.4.1* |
| **ISR** | Applies -- Yes / No |  |  | |  |
| **TOU Factor** | *A/C projects only* | N/A | N/A | | *Section 1.4.5* |

# 

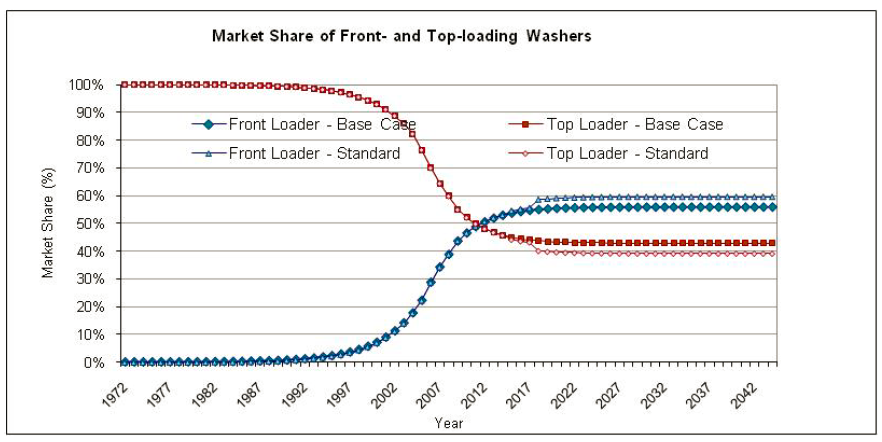
# Section 2. Calculation Methods

Table 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 |

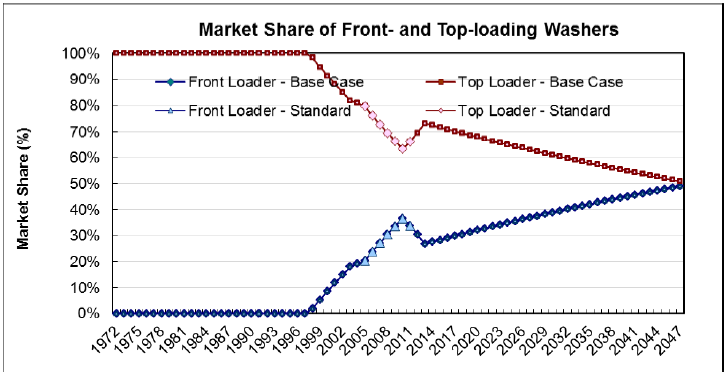
The residential clothes washer energy and demand savings were calculated from energy consumption values from the 2012 DOE Residential Clothes Washers Technical Support Document, as seen in Table 10 and Table 11. The base case is a market share weighting of Title 20 compliant top-loading and front-loading clothes washers. The DOE predicts a market saturation of 45% top-loading and 55% front-loading residential clothes washers (Figure 1). The base case for the Energy Star Top Loading and Energy Star Front Loading measures is composed entirely of the same type of washer because it is assumed that at the Energy Star tier, consumers will have a preference on the type of washer they want to buy. Title 20 requires a minimum IMEF of 1.29 for top-loading and 1.84 for front-loading standard sized clothes washers. The measure case IMEF is the minimum efficiency criteria for each tier. The measure case market share weighting is 100% top-loaders for the Energy Star Top-Loading measure, 0% top-loaders for the Energy Star Front-Loading, Energy Star Most Efficient, and CEE Tier 3 measures, and 45% top-loaders for the Energy Star measure.

Figure : Front- and Top-Loading Residential Clothes Washer Market Saturation



The 2014 commercial clothes washers TSD (chapter 9) contains baseline market share saturations for commercial clothes washers (Figure 2). Baseline market saturations for CCWs are currently about 70% top-loaders and 30% front-loaders. The DOE identified the maximum technologically feasible level (“max-tech”) for top-loading commercial clothes washers to be 1.85 MEF, which is substantially lower than the 2.2 MEF minimum efficiency level required by the Energy Star CCW spec. Currently, <1% of washers in the Energy Star CCW qualifying products list are top-loaders. Therefore, the measure case for Energy Star commercial clothes washers is assumed to be comprised entirely of front-loaders.

Figure : Front- and Top-Loading Commercial Clothes Washer Market Saturation



The energy use breakdown between the machine energy use, dryer energy use, and water heater energy use for residential clothes washers was obtained from the 2012 TSD. Table 10 and Table 11 provide data for washers with efficiencies only up to the current Energy Star level. Those values are used as a basis to estimate energy use breakdowns for the Energy Star Most Efficient and CEE Tier 3 tiers (Table 12). The volumes in Table 12 were derived by extrapolating IMEF vs volume data in Table 11. Energy use breakdown for Energy Star residential front-loading washers were derived by interpolating data between 2.20 MEF and 2.46 MEF. For ESME and CEE Tier 3, there is a lack of data available. Therefore, we used our best judgement to estimate the percentage breakdown of energy for those higher tiers.

Table 10. Top-Loading Standard Capacity Energy Use by Cycle for Residential CWs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **IMEF** | **Volume (ft3)** | **Energy Use (kWh/cycle)** | | |
| **Machine** | **Dryer** | **Water Heat** |
| 0.84 | 3.09 | 0.279 | 2.16 | 1.24 |
| 0.98 | 3.38 | 0.281 | 2.43 | 0.74 |
| 1.29 | 3.38 | 0.228 | 1.69 | 0.69 |
| 1.34 | 3.76 | 0.082 | 1.41 | 1.26 |
| 1.34 | 3.76 | 0.082 | 1.41 | 1.26 |
| 1.37 | 3.76 | 0.082 | 1.41 | 1.25 |
| 1.57 | 3.86 | 0.082 | 1.38 | 0.99 |
| 1.83 | 3.96 | 0.077 | 1.41 | 0.67 |
| 2.04 | 4.34 | 0.082 | 1.39 | 0.66 |

Table 11. Front-Loading Standard Capacity Energy Use by Cycle for Residential CWs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **IMEF** | **Volume** | **Energy Use (kWh/cycle)** | | |
| **Machine** | **Dryer** | **Water Heat** |
| 1.41 | 3.00 | 0.113 | 1.31 | 0.69 |
| 1.41 | 3.00 | 0.113 | 1.31 | 0.69 |
| 1.41 | 3.00 | 0.113 | 1.31 | 0.70 |
| 1.49 | 3.00 | 0.113 | 1.31 | 0.60 |
| 1.66 | 3.30 | 0.163 | 1.42 | 0.40 |
| 1.84 | 3.41 | 0.154 | 1.34 | 0.36 |
| 2.02 | 3.60 | 0.164 | 1.41 | 0.20 |
| 2.20 | 3.83 | 0.167 | 1.37 | 0.21 |
| 2.46 | 3.90 | 0.155 | 1.38 | 0.04 |

Table : Estimated Energy Use Breakdown for Front-Loading Energy Star and CEE Measures

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Measure** | **IMEF** | **Volume** | **Energy Use (kWh/cycle)** | | |
| **Machine** | **Dryer** | **Water Heat** |
| Energy Star | 2.38 | 3.9 | 0.160 | 1.38 | 0.09 |
| Energy Star Most Efficient | 2.74 | 4.2 | 0.150 | 1.36 | 0.04 |
| CEE Tier 3 | 2.92 | 4.4 | 0.130 | 1.34 | 0.04 |

Based on language in the Energy Policy Act of 2005 (EPACT 2005), DOE is required to rate commercial clothes washers with the same test procedure established for residential clothes washrs. Federal standards for commercial clothes washers effective January 8, 2013 are tested under Title 10 of the Code of Federal Regulations, subpart B, appendix J1. The appendix J1 test procedure evaluates energy efficiency using the modified energy factor (MEF) metric and water use using the water factor (WF) metric. In March 2012, DOE published a final rule amending its test procedures for residential clothes washers, which included minor amendments to appendix J1 and established a new test procedure at appendix J2. Appendix J2 uses an integrated modified energy factor (IMEF), which includes non-active and self-cleaning mode energy use, and integrated water factor (IWF), which includes water consumption for all cycles. Federal standards effective March 7, 2015 for residential clothes washers are tested under appendix J2. DOE performed an in-depth evaluation of the standby and off mode power characteristics of a representative sample of commercial clothes washers and has tentatively determined that establishing amended standards for commercial clothes washers based on an integrated energy metric would not be technically feasible. Instead, the DOE proposes amended standards based on the MEF\_J2, which would not incorporate standby and off mode power but follow appendix J2. The IWF metric under appendix J2 for water use will also be adopted for commercial clothes washers.

DOE conducted testing on a representative sample of five top-loading and five front-loading commercial clothes washers using both appendix J1 and appendix J2. DOE used the results from these tests to determine each model’s appendix J2 MEF\_J2/IWF ratings in relation to its appendix J1 MEF/WF ratings. The results, including an energy use breakdown between machine energy, dryer energy, and water heater energy, are provided in Table 13 and Table 14 (from 2014 CCW TSD).

Table : Top-Loading Commercial Clothes Washers: Per-Cycle Energy Use by Efficiency Level

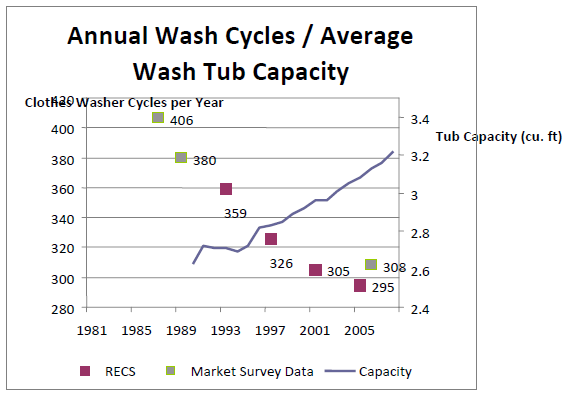
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MEF** | **MEF\_J2** | **Energy Use (kWh/cycle)** | | |
| **Machine** | **Dryer** | **Water Heat** |
| 1.60 | 1.15 | 0.220 | 2.08 | 0.391 |
| 1.70 | 1.35 | 0.210 | 1.58 | 0.506 |
| 1.85 | 1.55 | 0.100 | 1.62 | 0.408 |

Table : Front-Loading Commercial Clothes Washers: Per-Cycle Energy Use by Efficiency Level

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MEF** | **MEF\_J2** | **Energy Use (kWh/cycle)** | | |
| **Machine** | **Dryer** | **Water Heat** |
| 2.00 | 1.65 | 0.110 | 1.26 | 0.325 |
| 2.20 | 1.80 | 0.080 | 1.19 | 0.337 |
| 2.40 | 2.00 | 0.100 | 1.16 | 0.190 |
| 2.60 | 2.20 | 0.070 | 1.30 | 0.267 |

Figure 3 shows a trend of increasing washer capacity and decreasing number of cycles. Efficient washers also tend to have a larger capacity than their less efficient counterparts. In order to prevent these factors from skewing savings estimates we assume the total volume of clothes washed to be constant between the base and measure cases. A washer capacity of 3.1 cubic foot is used for all calculations. This corresponds to 295 cycles per year, which is the same frequency we assume for residential single family applications.

Figure : Trends in Water Usage and Capacity



The energy usage estimates in tables 10 to 14 assume the use of an electric dryer and electric DHW. Because the energy usage is expressed exclusively in kWh, the dryer and water heat energy values were converted to therms for the domestic hot water and dryer combinations that include gas as a fuel source. Energy savings estimates were developed for the following domestic hot water and dryer combinations: electric DHW / electric dryer, gas DHW / electric dryer and gas DHW / gas dryer. Per RASS 2009, 0% of California IOU customers have electric DHW / gas dryer combinations in their homes. RASS distributions are considered separately for PG&E, SCE, SCG, and SDG&E customers. Because gas dryers and gas-fired water heaters have a lower Energy Factor than electric dryers and electric water heaters, correction factors must be applied to facilities with gas dryers and/or gas DHW. According to the 2012 Clothes Washers TSD, for gas dryers, a Gas Dryer Correction Factor equal to 1.12 should be multiplied to the electric dryer usage. Likewise, for gas DHW, a Gas Water Heater Correction Factor of 1.33 is applied to the electric DHW usage. The Gas Water Heater Correction Factor is a ratio of the efficiency of an electric storage water heater to the efficiency of a gas storage water heater (1 for an electric water heater and 0.75 for a gas water heater according the 2012 residential clothes washer TSD).

Because interactive effects specific to clothes washers were unavailable, the HVAC interactive effects factors for CFLs were applied to the clothes washer measures. The interactive effect factors were selected for “IOU territory” (weighted by climate zone) and the “Existing” building vintage. The factors for PG&E, SCE, SCG, and SDG&E were used for the appropriate service territory. The “all Res” building type was used for the in-unit clothes washer measures, and the “small office” building type was used for the commercial and multifamily common area measures.

The attached excel workbook in the Appendix titled *Clothes Washer Workpaper Calculations R5.xls* details the calculations for this workpaper.

## 2.1 Electric Energy Savings Estimation Methodologies

Assuming the use of an electric dryer and electric water heater, the total annual energy savings is calculated as follows.

where

= average cycles per year of clothes washer usage.

c = clothes washer capacity, assumed to be 3.1 cubic feet.

= “Integrated Modified Energy Factor” of the base case clothes washer. Compliance with Title 20 requires minimum IMEF of 1.29 for top-loaders.

= “Integrated Modified Energy Factor” of the base case clothes washer. Compliance with Title 20 requires minimum IMEF of 1.84 for front-loaders.

= “Integrated Modified Energy Factor” of the measure case clothes washer for top-loaders, if applicable.

= “Integrated Modified Energy Factor” of the measure case clothes washer for front-loaders, if applicable.

/= Base case top-loading/front-loading market share.

/= Measure case top-loading/front-loading market share.

Electric energy savings can be achieved through reductions in machine energy use, domestic hot water use and dryer energy use depending on the fuel source for the domestic hot water and dryer. Electric energy savings are attributable to all domestic hot water / dryer fuel combinations since all units have electrical machine usage. Weighted electric energy savings were calculated using energy consumption values in tables 10 to 14 and RASS distributions for each IOU territory. Front- and top- loading energy savings were weighted according to the market share assumptions. The per cycle energy savings were translated to annual savings assuming 295 cycles/year usage for residential and multifamily in-unit clothes washers, 1095 cycles/year for multifamily common area clothes washers, and 1497 cycles per year for nonresidential clothes washers according to the respective technical support documents. The whole building impacts were calculated by applying CFL interactive effects factors to the end use impacts (in lieu of clothes washer-specific interactive effects factors). See Appendix attachment *Clothes Washer Workpaper Calculations R5.xlsx* details.

## 2.2. Demand Reduction Estimation Methodologies

Demand savings can be achieved through reductions in machine energy use, domestic hot water use and dryer energy use depending on the fuel source for the domestic hot water and dryer. Electric demand savings are attributable to all domestic hot water / dryer fuel combinations since all units have electrical machine usage.

Demand savings are based on a field study conducted multifamily laundry facilities in SCE’s service territory. The study showed that, on average, 36.7% of the cycles occurred during the period of 2pm to 5pm on weekdays; this is the coincident demand factor (CDF). The data also showed that the average washer cycle was 30 minutes. The following equation is used to estimate peak demand savings for residential clothes washers in a multi-family common area:

The whole building impacts were calculated by applying CFL interactive effects factors to the end use impacts (in lieu of clothes washer-specific interactive effects factors). See Appendix attachment *Clothes Washer Workpaper Calculations R5.xls* for details.

Peak demand savings for single-family, multi-family in-unit, and nonresidential applications are derived from scaling the multi-family peak demand savings by annual cycles of use.

## 2.3. Gas Energy Savings Estimation Methodologies

Gas energy savings for clothes washers are present in machines with gas water heaters and/or gas dryers. Gas water heaters are assumed to have an efficiency of 75% per the 2012 residential clothes washer TSD.

Weighted gas energy savings were calculated using energy consumption values in tables 10 to 14 and RASS distributions. Front- and top- loading energy savings were weighted according to market share. The per cycle energy savings were translated to annual savings assuming 295 cycles/year usage for residential and multifamily in-unit clothes washers, 1095 cycles/year for multifamily common area clothes washers, and 1497 cycles per year for nonresidential clothes washers according to the respective technical support documents. The whole building impacts were calculated by applying CFL interactive effects factors to the end use impacts (in lieu of clothes washer-specific interactive effects factors). See Appendix attachment *Clothes Washer Workpaper Calculations R5.xls* for details.

# *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.

## 3.1 Base Case Load Shapes

The base case load shape would be expected to follow a typical residential clothes washer end use load shape. There is no load shape specific to commercial clothes washers.

## 3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations.

The E3 Calculator contains a fixed set of load shapes selections that are the combination of the hourly avoided costs and the load shape data that was available at the time of the tool’s creation. The Residential target sector is the applicable occupancy type for this measure. The load shape that most closely fits this measure is DEER:Res\_ClothesDishWasher.

Table 15 Measure Case Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| RES weighted | RES | DEER:Res\_ClothesDishWasher |

# Section 4. Base Case & Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Measure Life Basis** | **First Baseline Period Gross Measure Cost (RUL)** | **Second Baseline Period Gross Measure Cost (EUL – RUL)** |
| ***ROB(replace on burnout)*** | EUL | Calculated as Incremental Measure Cost | N/A |

Because clothes washers are not an appliance that consumers will readily replace due to their high cost and long product life, clothes washers fall under the replace on burnout (ROB) installation type. Consequently, only the incremental equipment cost applies.

## 4.1 Base Case(s) Costs

The base case costs for residential clothes washers are based on the results from the 2010-2012 Ex Ante Measure Cost Study (WO17). The IMC values in the measure cost study are not directly applicable to these measures because the code minimum and measure efficiency levels in the workpaper are higher than those in the cost study. The research analyzed costs for top-loading and front-loading clothes washers and developed coefficients using hedonic price modeling. The MEF coefficients are 38.91 for top-loaders and 28.9 for front-loaders.The base case cost for a 2015 Title 20 compliant clothes washer is derived by using the MEF coefficients to calculate the IMC associated with the delta of the 2015 code minimum MEF and the reference MEF and adding it to the reference cost from the measure cost study. Base case top-/front- loading saturations are then applied to obtain a weighted base case cost.

The base case cost for commercial clothes washers are based on the 2014 Commercial Clothes Washers TSD. The baseline and incremental manufacturing costs for both top- and front-loading CCWs are obtained from Chapter 5. The sum of the production cost and material cost is the total manufacturing cost. The base case 70%/30% top-/front-loading market saturation is applied to obtain a weighted base case manufacturing cost. Chapter 6 contains manufacturer and distributor markups that can be applied to the manufacturing cost to derive the cost to the consumer. Multiplying the base case manufacturing cost by the manufacturer markup of 1.285 and baseline distributor markup of 1.37 gives the price that the consumer pays for the baseline clothes washer.

The labor cost of $153.00 for residential and commercial clothes washers is obtained from *RS Means Mechanical Cost Data, 2014[[7]](#endnote-7)*.

The base case costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Base Case Cost** |
| Energy Star Top-Loading | ROB | Code | $584.90 | $153.00 | $0 | $737.90 |
| Energy Star Front-Loading | ROB | Code | $682.14 | $153.00 | $0 | $835.14 |
| Energy Star | ROB | Code | $638.38 | $153.00 | $0 | $791.38 |
| Energy Star Most Efficient | ROB | Code | $638.38 | $153.00 | $0 | $791.38 |
| CEE Tier 3 | ROB | Code | $638.38 | $153.00 | $0 | $767.07 |
| Energy Star Commercial | ROB | Code | $1630.67 | $153.00 | $0 | $1783.67 |

*All costs are noted as $ per measure unit*

## 4.2 Measure Case Costs

The measure case costs are based on the results from the 2010-2012 Ex Ante Measure Cost Study (WO17). The IMC values in the measure cost study are not directly applicable to these measures because the code minimum and measure efficiency levels in the workpaper are higher than those in the cost study. The research analyzed costs for top-loading and front-loading clothes washers and developed coefficients using hedonic price modeling. The MEF coefficients are 38.91 for top-loaders and 28.9 for front-loaders.The measure case cost for each measure is derived by using the MEF coefficients to calculate the IMC associated with the delta of the measure case MEF and the reference MEF and adding it to the reference cost from the measure cost study. Measure case top-/front- loading saturations are then applied to obtain a weighted measure case cost.

The measure case cost for commercial clothes washers are based on the 2014 Commercial Clothes Washers TSD. The baseline and incremental manufacturing costs for both top- and front-loading CCWs are obtained from Chapter 5. The sum of the production cost and material cost is the total manufacturing cost. The inceremental manufacturing cost is derived by taking the difference between the manufacturing cost of a front-loading Energy Star CCW and the base case manufacturing cost, weighted by market share of top- and front-loaders. Chapter 6 contains manufacturer and distributor markups that can be applied to the manufacturing cost to derive the cost to the consumer. Multiplying the incremental manufacturing cost by the manufacturer markup of 1.285 and incremental distributor markup of 1.18 gives the incremental cost to the consumer. The measure case cost is the sum of the base case cost and the incremental measure cost.

The labor cost of $153.00 for residential and commercial clothes washers is obtained from *RS Means Mechanical Cost Data, 2014.*

The measure case costs are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Measure*** | **Measure Application Type** | **Baseline** | **Equipment Cost** | **Labor / Installation Cost** | **Maintenance / Other Cost** | **Total Measure Case Cost** |
| Energy Star Top-Loading | ROB | Code | $614.92 | $153.00 | $0 | $767.92 |
| Energy Star Front-Loading | ROB | Code | $699.52 | $153.00 | $0 | $852.52 |
| Energy Star | ROB | Code | $661.45 | $153.00 | $0 | $814.45 |
| Energy Star Most Efficient | ROB | Code | $711.11 | $153.00 | $0 | $864.11 |
| CEE Tier 3 | ROB | Code | $716.90 | $153.00 | $0 | $869.90 |
| Energy star Commercial | ROB | Code | $2176.25 | $153.00 | $0 | $2329.25 |

*All costs are noted as $ per measure unit*

## 4.3 Incremental & Full Measure Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Application Type** | **Gross Measure Cost**  **(RUL Period/First Baseline)** | **Gross Measure Cost**  **(EUL-RUL Period/ Second Baseline)** | **Incremental Measure Cost** |
| ROB | Measure Equipment Cost  – Base Case Equipment Cost | N/A | Measure Equipment Cost  – Base Case Equipment Cost |

# *4.3.1 Gross Measure Cost*

Not Applicable.

# *4.3.2 Incremental Measure Costs*

For ROB applications, the incremental cost is calculated using the following formula:

Incremental Cost = Measure Equipment Cost – Base Case Equipment Cost

**Summary Table for Section 4**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure ID** | **Measure Application Types** | **Base Case Total Cost** | **Measure Case Total Cost[[8]](#endnote-8)** | **Incremental Measure Cost** |
| Energy Star Top-Loading | ROB | $737.90 | $767.92 | $30.02 |
| Energy Star Front-Loading | ROB | $835.14 | $852.52 | $17.38 |
| Energy Star | ROB | $791.38 | $814.45 | $23.07 |
| Energy Star Most Efficient | ROB | $791.38 | $864.11 | $72.73 |
| CEE Tier 3 | ROB | $767.07 | $869.90 | $102.83 |
| Energy Star Commercial | ROB | $1783.67 | $2329.25 | $545.58 |

# Appendices













# References

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7. RS Means, *RS Means Mechanical Cost Data, 2014*. Sections 11 31 23.13, 11 23 33.13. [↑](#endnote-ref-7)
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   [↑](#endnote-ref-8)