**Work Paper CODE**
**Appliances and Plug Loads**
**Revision # 2**

**Natural Resources Defense Council**

# Clothes Washer Recycling

**June 4, 2015**

# At-a-Glance Summary

| | |
|---|---|
| Measure description | Recycling of working, used inefficient clothes washers |
| Program delivery method | Downstream or midstream |
| Measure application type | Early Retirement (ER) |
| Base case description | Top-loading clothes washer with center agitator remains in use |
| Energy and demand impact common units | Each |
| Peak Demand Reduction (kW/unit) | PG&E: SFm/MFm In Unit: 0.3010 kW<br>MFm Common Area: 1.1550 kW<br>SCE: SFm/MFm In Unit: 0.1621 kW<br>MFm Common Area: 0.6379 kW<br>SCG: SFm/MFm In Unit: 0.1309 kW<br>MFm Common Area: 0.5033 kW<br>SDG&E: SFm/MFm In Unit: 0.1768 kW<br>MFm Common Area: 0.7293 kW |
| Energy savings (Base case – Measure) (kWh/unit) | PG&E: SFm/MFm In Unit: 591.16 kWh<br>MFm Common Area: 1988.11 kWh<br>SCE: SFm/MFm In Unit: 312.46 kWh<br>MFm Common Area: 1073.59 kWh<br>SCG: SFm/MFm In Unit: 246.52 kWh<br>MFm Common Area: 847.00 kWh<br>SDG&E: SFm/MFm In Unit: 326.01 kWh<br>MFm Common Area: 1186.58 kWh |

| | |
|---|---|
| Gas savings<br>(Base case – Measure)<br>(therms/unit) | PG&E: SFm/MFm In Unit: 4.31 therms<br>MFm Common Area: 49.04 therms<br>SCE: SFm/MFm In Unit: 18.61 therms<br>MFm Common Area: 83.71 therms<br>SCG: SFm/MFm In Unit: 21.42 therms<br>MFm Common Area: 91.07 therms<br>SDG&E: SFm/MFm In Unit: 17.37 therms<br>MFm Common Area: 80.79 therms |
| Water savings<br>(Base case – Measure)<br>(gallons/unit) | SFm/MFm In Unit: 7,013 gallons<br>MFm Common Area: 26,031 gallons |
| Full measure cost[1]<br>($/unit) | $0 |
| Incremental measure cost[2]<br>($/unit) | $0 |
| Effective useful life<br>(years) | 3.67 years |
| Net-to-gross ratio(s) | 0.70 |
| Important comments | |

[1] Full measure cost = measure equipment cost + measure labor cost
[2] Incremental measure cost = Measure equipment cost – Baseline equipment cost

# Document Revision History

| Revision # | Revision Date | Section-by-Section Description of Revisions | Author (Name, PA) |
|---|---|---|---|
| 0 | 02/13/2015 | Original work paper release | Ben Chou, NRDC |
| 1 | 04/14/2015 | At-a-glance summary – Included water savings per unit<br><br>Section 1.2 – Removed vintage eligibility requirement<br><br>Sections 1.3.1, 1.3.5, 2, 2.2 – Included discussion of CPUC staff comments<br><br>Section 2.3 – Added discussion of water savings methodologies<br><br>Section 5.2 – Modified to include proposed research plan to support this measure | Ben Chou, NRDC |
| 2 | 06/04/2015 | At-a-glance summary – Added savings numbers by utility<br><br>Section 1.3.4 – Added reference to newly revised high efficiency clothes washer work paper (PGECOAPP127 R1)<br><br>Sections 1.3.5, 2.2.1, 2.2.3, 2.3 – Updated annual cycles for MFm common area laundry<br><br>Section 2.2 – Revised Table 11 to include DHW/dryer fuel share distributions by utility and revised Table 12 to include CFL HVAC interactive effects factors by utility<br><br>Section 2.2.2 – Demand savings calculation updated to follow PGECOAPP127 R1 approach<br><br>Section 2.3 – Revised water savings based on new MFm common area laundry annual cycles | Ben Chou, NRDC |

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|---|---|---|---|
| | | Appendix 1 – Updated savings calculation spreadsheet<br><br>Appendix 2 – Updated to include April 2015 CalTF comments | |

## Commission Staff Review and Comment History

| Revision # | Date Submitted to Commission Staff | Date Comments Received | Commission Staff Comments |
|---|---|---|---|
| Abstract | October 2014 | October 2014 | See Appendix 2 |
| | | | |

# Table of Contents

# General Measure & Baseline Data

## 1.1 Product Measures

**General Description**

This work paper describes the early retirement of a used, inefficient top-loading clothes washer so that it can no longer remain in service and therefore, is diverted from the secondary or used appliance market. Essentially, this measure aims to prevent the transfer of older, less efficient clothes washers to another location within the utilities' service territory when it is no longer needed in a participant's home.

**Technical Description**

Clothes washers use significant amounts of both energy and water. Water is used during the cleaning process, and energy is used to heat water for use in some cleaning cycles, agitate clothes to remove dirt and stains, and spin clothes to remove excess moisture. The latter significantly impacts the energy use of clothes dryers as well.

Older, top-loading clothes washers represent up to 20 percent of a household's indoor water usage and 10 percent of a household's overall water use.[1] According to the 2012 California Lighting and Appliance Saturation Study (CLASS),[2] more than two-thirds of residential clothes washers in use are top-loading machines, which generally are the greatest consumers of both water and energy. Further, nearly 55 percent of top-loading machines in use are more than 10 years old—purchased well before the most recent efficiency standards became effective.

Historically, top-loading clothes washers (typically, vertical-axis) contained a center agitator to remove dirt and stains from clothes. Within the last few years, more efficient top-loaders that use impeller technology (instead of a center agitator) have entered the market. Yet many of these "legacy design" top-loaders with center agitators remain in use. Newer top-loaders with impellers typically use less water and energy than conventionally-designed top-loaders, where the center agitator physically agitates the clothes. In contrast, newer, more efficient top-loaders with impeller technology utilize a moving plate to swirl the water and clothes around. Today's top-loaders also generally have faster spin speeds, which result in better water extraction and reduce the energy needed for drying.

There are nearly 1 million new clothes washers purchased in California each year, and many of these purchases likely are replacing old, inefficient top-loaders. There is a key near-term opportunity to ensure that these old, inefficient clothes washers being replaced are recycled instead of being sold or given away to a recipient household—surveys suggest more than half of working top-loading clothes washers being replaced likely remain in use through the secondary market.[3]

## 1.2 Program Implementation Overview

**Implementation Methods**

This measure would involve downstream program delivery whereby customers receive a monetary incentive for allowing retailers to pick up qualified old clothes washers during delivery of a new clothes washer. Vendors would then retrieve these units from retailer warehouses for demanufacturing and recycling. This is the preferred approach as the recycling pick-up is coincident with delivery of the new washer, thus reducing burdens on the customer and eliminating costs associated with a separate pick-up.

A second option would be to allow for the scheduling of used clothes washer pick-up in the same manner as existing utility recycling programs for refrigerators and freezers. This approach would enable customers who purchase their new clothes washers from a non-participating retailer or customers with second units to receive a rebate for recycling their units. Transportation and administrative costs with this option, however, would be higher.

A midstream incentive that provides a rebate to retailers and/or appliance delivery/pick-up vendors in exchange for used clothes washers that meet the necessary specifications also may be implemented. Interviews with industry experts suggest that 25% of the used clothes washers that recyclers receive from retailers and residential households are resold and remain in use.[4] More broadly, approximately 30-40% of all used appliances picked up by retailers are resold instead of recycled.[5]

## Program Restrictions and Guidelines

Eligible units for this program are working, top-loading residential clothes washers with a center agitator (example shown in Figure 1). These types of clothes washers are typically found in single-family homes and in individual units and laundry common areas in multi-family buildings.

**Figure 1. Residential top-loading clothes washer with center agitator**

## Measure Application Type

As this measure seeks the removal of working, inefficient clothes washers from service by preventing them from entering the secondary market, it is early retirement (ER).

## Implementation Requirements

Implementer will need to verify clothes washer type and working condition during pick-up at customer household to ensure eligibility. Additionally, implementation and subsequent EM&V will support data collection on baseline energy consumption, address questions raised about the secondary market, and inform future work paper revisions.

## 1.3 Product Parameter Data

### *1.3.1 DEER Data*

The DEER does not include measures for inefficient clothes washers. There is a remaining useful life (RUL) value for high efficiency clothes washers in DEER2011, which is utilized here as there is no other DEER data available.

The DEER does not include any energy savings estimates for this measure, but DEER2011 does include measures for refrigerator and freezer recycling. The unit energy savings analysis presented here for clothes washers attempts to follow the DEER methodology for these appliance recycling measures. However, clothes washer data limitations (e.g., lack of robust metering data, participant/nonparticipant surveys) preclude an exact replication of the methodology.

**Table 1.** DEER Difference Summary

| DEER | Used in Work Paper Approach? |
|---|---|
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER base case used | No |
| DEER measure case used | No |
| DEER building types Used | SFm, MFm |
| DEER operating hours used | No |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Version | DEER 2011 |
| DEER ID and Measure Name (Sample) | TBD |

**Net-to-Gross**

**Table 2.** DEER Net-to-Gross Ratios

| From DEER Tables | | | | | |
|---|---|---|---|---|---|
| NTGR_ID | Description | Sector | Building Type | NTG | Program Delivery |
| All-Default<=2yrs | All other EEM with no evaluated NTGR; new technology in | All | Any | 0.7 | All |

| | | | | | |
|---|---|---|---|---|---|
| | program for 2 or fewer years | | | | |

According to DEER2011, the default that would apply to this measure is 0.7. Per the savings methodology presented in the Work Order 35 report (WO35) and the National Renewable Energy Laboratory's Uniform Methods Project,[6] which are specific to refrigerator/freezer recycling, the gross savings estimate for this measure includes secondary market impacts. The net savings for this measure excludes the savings that would come from units that would have been recycled in the absence of the program.

CPUC staff commented that using a net-to-gross ratio other than the residential default value would not be appropriate for this measure. Accordingly, the DEER default value of 0.7 is applied to this measure.

**Effective Useful Life / Remaining Useful Life**

**Table 3.** DEER EUL Values/Methodology

| READi EUL ID | Market | End Use | Measure | EUL (Years) | RUL (Years) |
|---|---|---|---|---|---|
| Appl-EffCW | Res | AppPlug-Laundry | High Efficiency Clothes Washer | 11 | 3.67 |

CPUC staff commented that a RUL of 1/3 EUL is a good starting point; however, additional research into the secondary market should be conducted to determine whether used appliances are typically refurbished in a manner that extends their life. This comment is addressed in the proposed research plan attached in Section 5.2 of this work paper.

**In-Service Rate / First Year Installation Rate:**

**Table 4.** Installation Rate

| From DEER Tables | | | | | |
|---|---|---|---|---|---|
| GSIA_ID | Description | Sector | Building Type | GSIA Value | Program Delivery |
| Def-GSIA | Default GSIA | Any | Any | 1.0 | Any |

**READi Technology Fields**

**Table 5.** READi Tech IDs

| READi Field Name | Values included in this workpaper |
|---|---|
| Measure Case UseCategory | Appliances and Plug Loads |
| Measure Case UseSubCats | Laundry Appliances |
| Measure Case TechGroups | Cleaning Equipment |
| Measure Case TechTypes | Clothes washer |
| Base Case TechGroups | Cleaning Equipment |
| Base Case TechTypes | Clothes washer |

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

The California Title 20 standard requires that all top-loading standard size (≥ 1.6 cu. ft) clothes washers meet the minimum standards in Table 6 after the effective dates listed. The Title 20 standard for residential clothes washers is equivalent to the federal standard due to federal preemption. The Title 20 standard is used for calculating secondary market impacts, and the unit energy savings under this scenario is derived from the standard going into effect on March 7, 2015.

The March 2015 standards are equivalent to a modified energy factor (MEF) of 1.72 and a water factor (WF) of 8.0 under the previous methodology. The new energy and water metrics, integrated modified energy factor (IMEF) and integrated water factor (IWF), mainly differ from the prior metrics used, MEF and WF, due to the addition of standby and off-mode energy consumption.

IMEF has units expressed in cubic ft/kWh/cycle and is defined below.[7] *C* represents the clothes washer capacity in cubic ft, $E_{TE}$ represents the total machine electrical and hot water energy consumption in kWh, $D_E$ represents the energy consumption for removal of moisture from test load in kWh, and $E_{TLP}$ represents the combined low-power mode energy consumption in kWh.

$$IMEF = \frac{C}{(E_{TE} + D_E + E_{TLP})}$$

IWF has units expressed in gallons/cycle/cubic ft and is defined below. $Q_T$ represents total weighted water consumption for all cycles, and *C* represents the clothes washer capacity in cubic ft.

$$IWF = \frac{Q_T}{C}$$

**Table 6. California Title 20 Code for Residential Clothes Washers[8]**

| Washer Type | Capacity | Minimum Integrated Modified Energy Factor (IMEF) | | Minimum Integrated Water Factor (IWF) | |
|---|---|---|---|---|---|
| | | *Effective 3/7/15* | *Effective 1/1/18* | *Effective 3/7/15* | *Effective 1/1/18* |
| Top-loading | Standard (≥ 1.6 cu. ft) | 1.29 | 1.57 | 8.4 | 6.5 |

### 1.3.3 Relevant EM&V Studies

While there are no known EM&V studies for a clothes washer recycling program specifically (as there are no known clothes washer recycling incentive programs), refrigerator/freezer recycling EM&V studies were reviewed to develop this work paper. The methodology for calculating gross and net unit energy savings is based off *Appliance Recycling Program Impact Evaluation, Volume 1: Report, Work Order 35* (2014), prepared for the CPUC by KEMA.[9] Clothes washer metering data of energy and water consumption for the base case comes from The Cadmus Group, *Residential Retrofit High Impact Measure Evaluation Report* (2010).[10] Additionally, the ADM Associates et al., *Evaluation Study of the 2004-05 Statewide Appliance Recycling Program* was reviewed to better understand the savings methodology for existing recycling programs for refrigerators and freezers.[11]

### *1.3.4 Relevant Work Paper Dispositions*

There are no known past or current work papers for clothes washer recycling. However, *Clothes Washers for Residential Applications (3.2 MEF & 3.0 WF)* WPSCGREAP140211A Rev 0, *High Efficiency Clothes Washers Residential* PGECOAPP114 Rev 3, *High Efficiency Clothes Washers* PGECOAPP127 Rev 0 and Rev 1, and *Refrigerator or Freezer Recycling* PGECOAPP119 Rev 5 were reviewed for content and applicability to this measure.

Specifically, the methodology presented here for determining Title 20 unit energy consumption, including DHW/dryer fuel share and usage cycles per year, is consistent with the existing SCG and PGE clothes washer work papers. The methodology for determining interactive effects and the calculation for energy demand savings for this work paper are consistent with the approaches used in PGECOAPP127 Rev 1.

### *1.3.5 Other Sources for non-DEER Methods*

In addition to the aforementioned sources, the methodology for this work paper, especially for secondary market impacts, was informed by the National Renewable Energy Laboratory (NREL) Uniform Methods Project's (UMP) *Chapter 7. Refrigerator Recycling Evaluation Protocol* (2013).[12]

To calculate the annual unit energy consumption, the number of annual clothes washer cycles for single-family homes and multi-family in unit as well as the per cycle energy and water consumption for a clothes washer meeting the Title 20 standard comes from the 2012 DOE Residential Clothes Washer Technical Support Document (TSD).[13] The number of annual clothes washer cycles for multi-family common area laundry is from the 2014 DOE Commercial Clothes Washer TSD.[14] This is consistent with the existing high efficiency clothes washer work papers as previously described in Section 1.3.4.

CPUC staff commented that previous evaluations (e.g., 2006-2008 High Impact Measure Evaluation Report) and the CLASS report should be examined for information on annual clothes washer cycles and other data that may present a more reasonable estimate of energy use. As described in Section 1.3.3, the High Impact Measure report is used to estimate the energy and water usage of the base case. While the CLASS report does contain data on the average energy factor of clothes washers in households, this data is based on information matched from the appliance efficiency database and not based on *in-situ* metering studies. Metering data from the High Impact Measure report is used in lieu of the CLASS data because the existing appliance recycling program relies on metering studies to evaluate energy savings. Additionally, the CLASS report does not contain data on the number of annual clothes washer cycles.

Data from the 2009 California Residential Appliance Saturation Study (RASS) is used to inform the population weights of dryer and domestic hot water heating fuel sources for each IOU.[15] Although the RASS has data on annual clothes washer cycles, the DOE TSDs are used instead because existing clothes washer work papers use these values. It is for this same reason that the annual clothes washer cycles from the 2010 *High Impact Measure Evaluation Report* are not used.

Additionally, while the RASS does have metering data for clothes washers, it does not specify the proportion of hot water heating and dryer energy consumption that results from clothes washing. This information is critical because the overwhelming majority of the energy consumption attributable to clothes washers is derived from hot water and dryer energy usage (approximately 92%-95% combined).

# Section 2. Calculation Methods

CPUC staff commented on an earlier work paper abstract for this measure, which proposed an energy savings estimation methodology that included the energy embedded in water. Because water-energy nexus savings are not approved for current work papers, the methodology presented in this section no longer includes consideration of embedded energy savings.

## 2.1 Program Implementation Analysis

**Table 7.** Baseline by Measure Application Type

| Measure Application Type | Baseline | Baseline Technology | Duration |
|---|---|---|---|
| ER | First | Top-loading residential clothes washer w/ center agitator | 3.67 |
| | Second | N/A | N/A |

There is no energy savings associated with a second baseline because there would be no savings attributable to the program once the used clothes washer becomes inoperable in a recipient household.

## 2.2 Energy Savings Estimation Methodologies

Gross savings for this measure is defined as the difference in energy consumption with the program and without the program as shown in Table 8. Without the program, it is assumed that the used clothes washer remains in use at a recipient household through the secondary market. With the program, the average energy consumption of the recipient household is weighted by the three scenarios that would result from the removal of used clothes washers by the program:

1. Recipient household does not purchase a clothes washer (UEC = 0);
2. Recipient household purchases a Title 20 clothes washer (UEC = Title 20 UEC); and
3. Recipient household purchases a used clothes washer (UEC = base UEC).

In the absence of primary research data, the NREL UMP recommends that evaluators assume that half of recipient households find an alternate unit, with half of those alternate units being a similar used appliance and half being a new standard efficiency unit.[16] Because there is no primary research available, those weights are utilized in the analysis for this work paper.

CPUC staff commented on the savings analysis used in an earlier work paper abstract for this measure, which neglected to account for secondary market impacts. As described above, the energy savings methodology now includes an assessment of these impacts. Due to the lack of secondary market research specific to clothes washers, the methodology follows the refrigerator recycling approach of the NREL UMP. Additionally, Section 5.2 of this work paper includes a proposed research plan that identifies key questions related to the secondary clothes washer market that once answered will better inform energy savings estimates for this measure.

**Table 8.** Description of Simplified Gross Savings Calculation[17]

| Unit Disposition | Location | Consumption Without Program (A) | Consumption With Program (B) | Gross Savings = (A – B) |
|---|---|---|---|---|
| Kept but Unused | Participant Household | No consumption | No consumption | No savings |
| Transferred from Participant Household | Recipient Household | Base UEC | Weighted UEC based on recipient household action given removal of program units | $UEC_A - UEC_B$ |

Net savings is equal to gross savings minus free ridership (i.e., units that would have been destroyed without the measure). The approach for determining gross and net energy savings presented here are consistent with the CPUC's legal decision outlined in Appendix A of Decision D. 11-07-030.[18] Savings attributable to the measure result from units that would remain on the grid absent the recycling program and are discounted by the weighted average of the recipient household scenarios. Please refer to Figure 2 for the evaluation schematic of net energy savings.

CPUC staff commented on an earlier work paper abstract for this measure, which identified that 16% of households keep and still use their old clothes washer. Because there is no additional data at present to validate this information, the work paper analysis does not claim any savings from used clothes washers retained for use as second units. Additionally, this anecdote is identified for further investigation in the proposed research plan included in Section 5.2 of this work paper.

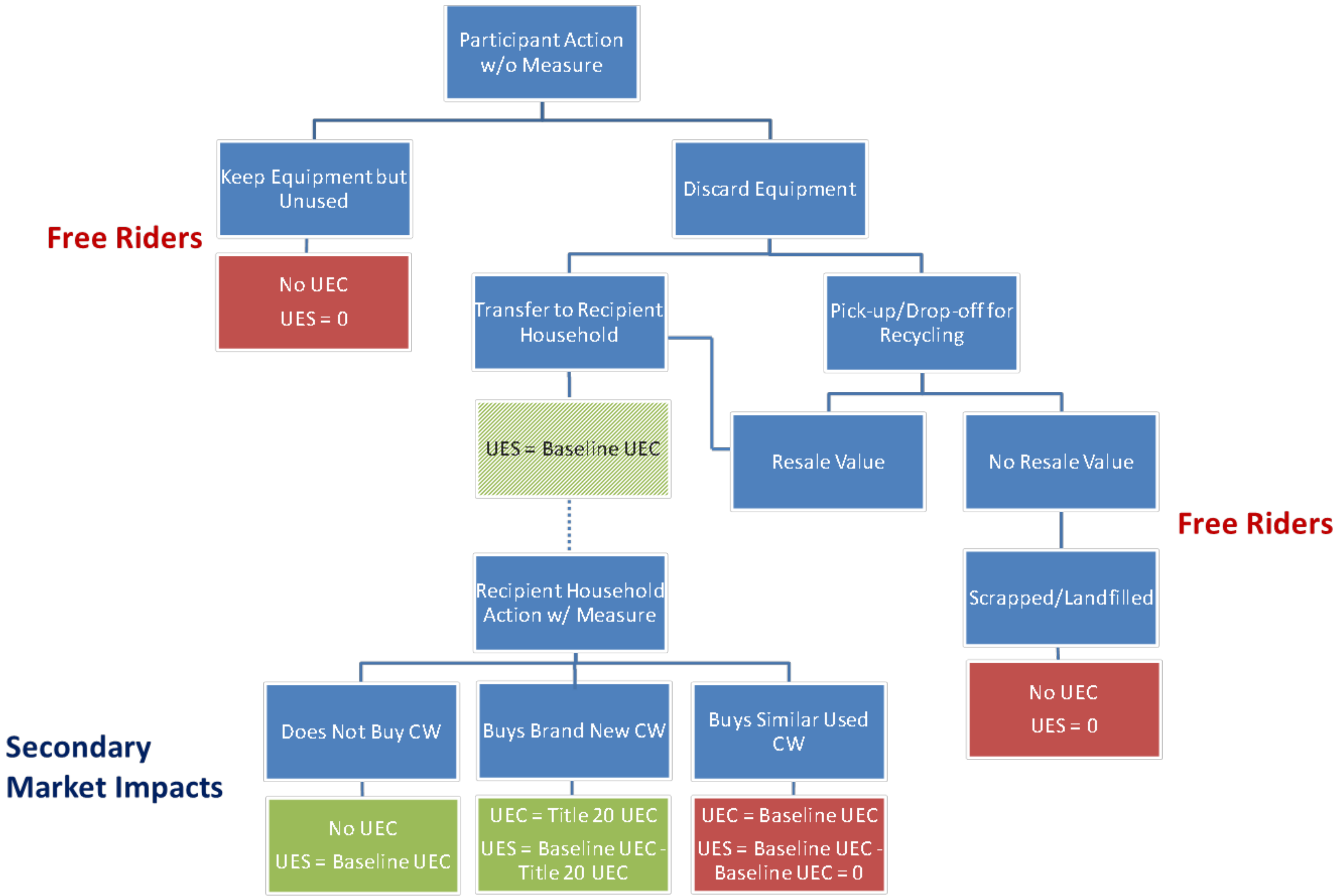


**Figure 2. Net Savings Evaluation Schematic**

The clothes washer energy and demand savings for the base case are calculated from energy and water consumption values from the *2010 High Impact Measure Evaluation* Report.[19] Specifically, the average energy consumption values for non-ENERGY STAR clothes washers purchased between 2006 and 2008 in PG&E and SDG&E service territories are used as shown in Table 9. The values for these clothes washer types are used instead of average consumption values for ENERGY STAR and higher efficiency levels (e.g., CEE Tier 1, 2, or 3) because they are most likely to contain the technology type targeted by this measure (i.e., top-loading clothes washer with center agitator).

There is no energy usage directly associated with the measure case because the recycled unit is no longer in operation. However, to calculate the secondary market impact of this measure (i.e., the impact on the recipient household of the used clothes washer) in the scenario where a Title 20 clothes washer is purchased in lieu of a used clothes washer, the energy use is calculated using the top-loading energy use for machines with an MEF of 1.72 as seen in Table 10. This MEF level is equivalent to the Title 20 standard for standard size, top-loading clothes washers that went into effect on March 7, 2015.

CPUC staff commented that the household saturation rate of dryers are lower than that of clothes washers so an effort should be made to account for clothes washer energy use that does not include corresponding dryer energy use. According to the CLASS report, the saturation rates of clothes washers and dryers are nearly within the margin of error (clothes washers: 80.7% ± 1.6; dryers: 77% ± 2.0). As such, accounting for the very small difference in clothes washer and dryer household saturation rates would not significantly impact the savings estimates. Additionally, the DOE Test Procedure does not assume that all clothes washer loads are dried in a clothes dryer. Instead, a dryer usage factor of 0.91 is used.[20]

**Table 9.** Average Per Cycle Energy Usage by Fuel (Source: pg. 46, *2010 High Impact Measure Evaluation Report*)

| Efficiency | Water Heating Fuel Use/Cycle | | Dryer Usage/Cycle | | Clothes Washer Usage/Cycle |
|---|---|---|---|---|---|
| | Therm | kWh | Therm | kWh | kWh |
| Non-ENERGY STAR | 0.03 | 0.58 | 0.14 | 3.66 | 0.21 |

**Table 10.** Top Loading Standard Capacity Energy and Water Use by Cycle (Source: Tables 7.2.1 and 7.3.1, 2012 Technical Support Document for Residential Clothes Washers)

| MEF | Volume | Energy Use (kWh/cycle) | | | Water Use (gal/cycle) |
|---|---|---|---|---|---|
| | | Machine | Dryer | Water Heat | |
| 1.26 | 3.09 | 0.279 | 2.16 | 1.24 | 30.6 |
| 1.40 | 3.38 | 0.281 | 2.43 | 0.74 | 33.5 |
| **1.72** | **3.38** | **0.228** | **1.69** | **0.69** | **28.5** |
| 1.80 | 3.76 | 0.082 | 1.41 | 1.26 | 29.9 |
| 1.80 | 3.76 | 0.082 | 1.41 | 1.26 | 29.9 |
| 1.80 | 3.76 | 0.082 | 1.41 | 1.25 | 29.9 |
| 2.00 | 3.86 | 0.082 | 1.38 | 0.99 | 24.9 |
| 2.26 | 3.96 | 0.077 | 1.41 | 0.67 | 19.6 |
| 2.47 | 4.34 | 0.082 | 1.39 | 0.66 | 8.5 |

Because the energy usage in Table 10 is expressed exclusively in kWh, the dryer and water heat energy values are converted into therms for the domestic hot water and dryer combinations that use gas a fuel source, which is consistent with the methodology described in existing high efficiency clothes washer work papers.

For both the energy consumption associated with the base case and the Title 20 recipient household scenario, energy savings estimates are developed for the following domestic hot water and dryer combinations: electric DHW/electric dryer; electric DHW/gas dryer; gas DHW/electric dryer; and gas DHW/gas dryer. RASS fuel share distributions are considered separately for PG&E, SCE, SCG, and SDG&E (as shown in Table 11).

**Table 11.** PG&E, SCE, SCG, and SDG&E DHW/Dryer Fuel Share.

| W/H and Dryer Population Weights | Gas WH | Electric WH |
|---|---|---|
| *PG&E* | | |
| Gas Dryer | 40% | 0% |
| Electric Dryer | 58% | 2% |
| *SCE* | | |
| Gas Dryer | 72% | 0% |
| Electric Dryer | 21% | 7% |
| *SCG* | | |
| Gas Dryer | 78% | 0% |
| Electric Dryer | 21% | 1% |
| *SDG&E* | | |
| Gas Dryer | 66% | 1% |
| Electric Dryer | 31% | 1% |

Because interactive effects specific to clothes washers are unavailable, the HVAC interactive effects factors for CFLs are applied to this clothes washer recycling measure following the approach described in PGECOAPP127 Rev 1. The interactive effects 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 corresponding service territory (as shown in Table 12). The “all Res” building type is used for in unit clothes washers (both single and multi-family), and the “small office” building type is used for multi-family common area laundry units.

**Table 12.** PG&E, SCE, SCG, and SDG&E CFL HVAC Interactive Effects Factors

| Building Type | HVAC Factors | | |
|---|---|---|---|
| | kW/kW | kWh/kWh | therm/kWh |
| *PG&E* | | | |
| Res | 1.0227 | 1.3498 | -0.023993 |
| Small Office (MFm common area) | 1.0573 | 1.2199 | -0.0037191 |
| *SCE* | | | |
| Res | 1.0709 | 1.384 | -0.019179 |
| Small Office (MFm common area) | 1.1356 | 1.2811 | -0.0017047 |
| *SCG* | | | |
| Res | 1.0709 | 1.384 | -0.019179 |
| Small Office (MFm common area) | 1.1356 | 1.2811 | -0.0017047 |
| *SDG&E* | | | |
| Res | 1.033 | 1.276 | -0.018 |
| Small Office (MFm common area) | 1.1476 | 1.2516 | -0.00039308 |

The Excel workbook in Appendix 1, entitled “NRDC_CW_Recycling_WP_rev2,” includes the detailed energy savings calculations for this work paper.

### 2.2.1 Electric Energy Savings Estimation Methodologies

Electric energy savings can be achieved through reductions in machine energy use, domestic hot water use, and dryer energy use, depending on the fuel sources for the domestic hot water heater and dryer. There are electric savings attributable to all domestic hot water and dryer fuel combinations because all clothes washers have direct electric energy usage (e.g., for agitating and spinning clothes). Electric energy savings are calculated using the energy consumption values in Tables 9 and 10 and weighted by the RASS DHW/dryer fuel combinations in Table 11.

Per cycle energy savings are converted into annual savings assuming 295 cycles/year for residential clothes washers in single family homes and multi-family in unit laundry in accordance with the 2012 Residential Clothes Washer TSD.[21] Similarly, 1095 cycles/year is used to convert per cycle energy savings into annual savings for residential clothes washers in multi-family common area laundry in accordance with the 2014 Commercial Clothes Washer TSD.[22] Whole building impacts are calculated by applying CFL interactive effects factors to the end use impacts.

### 2.2.2 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 used for the domestic hot water heater and dryer. Electric demand savings are attributable to domestic hot water and dryer fuel combinations because all units have electrical machine usage.

The demand savings calculation for this work paper follows the approach described in PGECOAPP127 Rev 1, which calculates demand savings using a field study conducted in multi-family 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:

$$kW\ Reduction = \frac{kWh\ savings}{year} * \frac{year}{\#\ of\ cycles} * \frac{cycle}{0.5\ hours} * CDF$$

Demand savings for PG&E, SCE, SCG, and SDG&E are calculated in this work paper using this formula. Whole building impacts are then calculated by applying the CFL interactive effects factors in Table 12 to the end use impacts. See the attachment in Appendix 1 for details.

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

### 2.2.3 Gas Energy Savings Estimation Methodologies

Gas energy savings can be achieved through reductions in domestic hot water use and dryer energy use. Gas water heaters are assumed to have an efficiency of 75% per the 2012 Residential Clothes Washer TSD.[23] Additionally, a gas correction factor of 1.12 is applied to gas dryer use due to the additional energy used by gas dryers compared to electric dryers. This correction factor also is from the 2012 Residential Clothes Washer TSD.[24] Gas energy savings are calculated using the energy consumption values in Tables 9 and 10 and weighted by the RASS DHW/dryer fuel combinations in Table 11.

Per cycle energy savings are converted into annual savings assuming 295 cycles/year for residential clothes washers in single family homes and multi-family in unit in accordance with the 2012 Residential Clothes Washer TSD.[25] Similarly, 1095 cycles/year is used to convert per cycle energy savings into annual savings for residential clothes washers in multi-family homes in accordance with the 2014 Commercial Clothes Washer TSD.[26] Whole building impacts were calculated by applying CFL interactive effects factors to the end use impacts.

## 2.3 Water Savings Estimation Methodologies

Significant water savings will be realized by this measure due to the high water consumption of old top-loading clothes washers. Waters savings estimates are:

- Single Family / Multi-family in unit: 7,013 gallons per year
- Multi-family common area: 26,031 gallons per year

Water savings are calculated according to the methodology described in Section 2.2. The water savings for the base case are calculated using the per cycle water consumption values for non-ENERGY STAR clothes washers purchased between 2006 and 2008 in PG&E and SDG&E service territories as found in the *2010 High Impact Measure Evaluation Report* and shown in Table 13.

**Table 13.** Average Per Cycle Water Usage (Source: pg. 42, *2010 High Impact Measure Evaluation Report*)

| Efficiency | Average Hot Water (gal/cycle) | Average Cold Water (gal/cycle) | Total Water Use (gal/cycle) |
|---|---|---|---|
| Non-ENERGY STAR | 3.8 | 37.4 | 41.2 |

Per cycle water consumption is converted into annual consumption assuming 295 cycles/year for residential clothes washers in single family homes and multi-family in unit in accordance with the 2012 Residential Clothes Washer TSD.[27] Similarly, 1095 cycles/year is used to convert per cycle energy savings into annual savings for residential clothes washers in multi-family laundry in accordance with the 2014 Commercial Clothes Washer TSD.[28]

There is no water usage directly associated with the measure case because the recycled unit is no longer in operation. However, as described in Section 2.2, the savings for this measure includes consideration of secondary market impacts (i.e., the impact on the recipient household of the used clothes washer), specifically three possible scenarios for a recipient household: (1) does not purchase a clothes washer; (2) purchases a Title 20 clothes washer; and (3) purchases a used clothes washer. These scenarios are weighted according to the NREL UMP recommendations due to a lack of secondary market research specific to clothes washers.

To calculate the secondary market impact of this measure in the scenario where a Title 20 clothes washer is purchased, the water use is calculated using the top-loading water use for machines with an MEF of 1.72 as seen in Table 10. This MEF level is equivalent to the Title 20 standard for standard size, top-loading clothes washers that went into effect on March 7, 2015.

The Excel workbook in Appendix 1, entitled "NRDC_CW_Recycling_WP_rev2," includes the detailed water savings calculations for this work paper.

# Section 3. Load Shapes

The occupancy type most applicable to this measure is the residential target sector, and the load shape that most closely fits is *DEER:Res_ClothesDishWasher*. 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.

# Section 4. Base Case, Measure, and Installation Costs

**Table 14.** Measure cost summary by application type

| Measure Application Type | Base Case Equipment Cost ($/unit) | Measure Equipment Cost ($/unit) | Installation Cost ($/Unit) | Incremental Measure Cost ($/unit) | Full Measure Cost (1st Baseline period)[3] ($/unit) | Full Base Cost (2nd baseline period)[4] ($/unit) |
|---|---|---|---|---|---|---|
| ROB | | | N/A | | N/A | N/A |
| NC | | | N/A | | N/A | N/A |
| ER | $0 | $0 | $0 | N/A* | $0 | N/A |
| REA | | | | N/A* | | |

* IMC may be useful for determining program incentive.

The only costs for this measure are the program administration cost and program incentive cost.

[3] Full measure cost = measure equipment cost + installation cost, for first baseline period

[4] Full base cost = 2nd baseline equipment cost + installation cost, for the second baseline period

### 4.1 Base Case(s) Costs

The base case cost for this measure is zero because this is discretionary removal of the customers' existing equipment.

### 4.2 Measure Case Costs

Customer does not incur any cost for participating in the program. Therefore, the measure case cost is zero.

### 4.3 Installation/Labor Costs

There are no applicable installation/labor costs for this measure.

### 4.4 Incremental & Full Measure Costs

There are no applicable incremental or full measure costs.

## Section 5. Additional Data Needs

### 5.1 Interim Work Paper Status

Interim work paper approval is not being sought for this work paper because implementation and subsequent EM&V is needed to support baseline energy consumption assumptions, secondary market impacts, and an appropriate NTG value.

### 5.2 Data Collection Needs

Please see the attached document for additional information on research objectives and questions that should be addressed through a research plan to evaluate the viability of energy and water savings for this measure.

CW_Recycling_WP_
Research_Plan_ver 2

# Appendix 1 - Supplemental Files

NRDC_CW
recycling_WP_rev2.x

# Appendix 2 – CalTF and Commission Staff Comments / Review

Responses to Commission Staff comments also are included in the attached document.

Summary of
Recommendations for

# Appendix 3 - Measure Application Type Definitions

The DEER Measure Cost Data Users Guide found on www.deeresources.com under *DEER2011 Database Format* hyperlink, DEER2011 for 13-14, spreadsheet *SPTdata_format-V0.97.xls*, defines the measure application type terms as follows:

Measure Application Type

| Code | Description | Comment |
|---|---|---|
| ER | Early retirement | Measure applied while existing equipment still viable, or retrofit of existing equipment |
| EAR | Retrofit Add-on | Retrofit to existing equipment without replacement |
| 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 |

Baseline Technologies for UES and Cost calculations[5]

| Measure Application Type | Baseline | Baseline Technology | Measure Cost Calculation | Duration |
|---|---|---|---|---|
| ER | First | Existing technology | Measure equipment cost + labor cost | RUL = 1/3*EUL[6] |
| | Second | Code or standard | (-1)*(Code/standard equipment cost + labor cost) | EUL - RUL |
| REA | First | Existing technology | Measure equipment cost + labor cost | EUL |
| | Second | N/A | N/A | N/A |
| ROB | First | Code or standard | (Measure equipment cost + labor cost) – (Code/standard cost + labor cost) | Full EUL |
| | Second | N/A | N/A | N/A |
| NC | First | Code or standard | (Measure equipment cost + labor cost) – (Code/standard cost + labor cost) | Full EUL |

[5] According to the Energy Efficiency Policy Manual v.5 at page 32, the measure cost for an early-retirement case is "the full cost incurred to install the new high-efficiency measure or project, reduced by the net present value of the full cost that would have been incurred to install the standard efficiency second baseline equipment at the end of the [RUL] period". Page 33 elaborates that "the period between the RUL and EUL defines the second baseline calculation period…the measure cost for this period is the full cost of equipment, including installation, for the second baseline equipment measure".

[6] The Energy Efficiency Policy Manual v.5 at page 33 states "the remaining useful life (RUL)…[is established by DEER] as one-third of the expected useful life (EUL) for the equipment type".

| | | | | |
|---|---|---|---|---|
| | Second | N/A | N/A | N/A |

Measure cost overview developed by SCE:

Measure Cost
rev9.docx

# Appendix 4 – CPUC Quality Metrics

CPUC workpaper development actions to ensure quality are listed below, adapted from ex ante implementation scoring metrics described in Attachment 7 of Decision (D).13-09-023. The corresponding scoring metrics are shown below.

| Metric | Workpaper Development Action to Ensure Quality |
|---|---|
| 2 | Address all aspects of the Uniform Workpaper Template[7] |
| 3a[8] | Include appropriate program implementation background |
| 3b | Include analysis of how implementation approach influences development of ex ante values |
| 3c | Include all applicable supporting materials |
| 3d | Include an adequate[9] description of assumptions or calculation methods |
| 4 | Pursue up-front collaboration on high impact measures with Commission staff prior to formal submission for review |
| 7 | Include analysis of recent and relevant existing data and projects that are applicable to workpaper technologies for parameter development that reflects professional care, expertise, and experience |
| 9 | Appropriately incorporate DEER assumptions, methods, and values for new or modified existing measures using professional care and expertise |
| 10 | Incorporate cumulative experience into workpaper through inclusion of an analysis of previous activities, reviews, and direction. (ED expects IOUs to immediately incorporate disposition guidance into workpapers to be submitted for formal review) |

[7] The Uniform Workpaper Template is not posted on the DEER website as of 4/21/14, and is currently in Microsoft Access Database format.
[8] Metric 3 is not split among a – d in Attachment 7, however metric 3 was separated into four subcategories in this document for the purposes of identifying individual workpaper development actions to address quality.
[9] "Adequate" is defined in Attachment 7 such that derivations of underlying assumptions of workpaper are easy to understand by the CPUC reviewer.

# Appendix 5 – DEER Resources Flow Chart

Draft DEER
Resources Flow Cha

# References

[1] American Water Works Association Research Foundation, "Residential End Uses of Water," 1999, available at http://www.waterrf.org/PublicReportLibrary/RFR90781_1999_241A.pdf.
[2] KEMA, Inc., "4.6 Clothes Washers," *WO21: Residential On-site Study: California Lighting and Appliance Saturation Study (CLASS 2012)*, November 2014, available at http://www.calmac.org/publications/2014.11_24_WO21_CLASS_Final_Report_Clean.pdf.
[3] Research surveys conducted by the Association of Home Appliance Manufacturers (AHAM) indicate that 22 percent of households purchasing a new clothes washer dispose of their old top-loading clothes washer by giving it away. Other common disposal practices include leaving it at a previous home (16 percent), selling it (11 percent), allowing the retailer to take it (15 percent), and dropping off at a recycling center (10 percent). Association of Home Appliance Manufacturers. "2010 Major Appliance Consumer Research," December 7, 2010. Research Conducted by Bellomy Research. Industry interviews suggest that recyclers re-sell approximately 25 percent of used clothes washers received from residential owners and retailers. Energy Solutions, "Clothes Washer Market Characterization Summary: Task 1 of 3," Prepared for NRDC, December 2010.
[4] Pg. 11. Energy Solutions, "Clothes Washer Market Characterization Summary: Task 1 of 3," Prepared for NRDC, December 2010.
[5] Pg. 3-7. RW Beck and Weston Solutions, *Recycling, Waste Stream Management, and Material Composition of Major Home Appliances* (2005), prepared for Association of Home Appliance Manufacturers (AHAM).
[6] KEMA, Inc., *Appliance Recycling Program Impact Evaluation, Volume 1: Report, Work Order 35* (2014), available at http://www.calmac.org/publications/2010-2012_ARP_Impact_Evaluation_Final_Report.pdf; and National Renewable Energy Laboratory (NREL), *Chapter 7. Refrigerator Recycling Evaluation Protocol* (2013), available at http://energy.gov/sites/prod/files/2013/11/f5/53827-7.pdf.
[7] Appendix J2 to Subpart B of Part 430—Uniform Test Method of Measuring the Energy Consumption of Automatic and Semi-automatic Clothes Washers. 10 CFR Ch. II, Subchapter D.
[8] Table P-2. California Energy Commission, *2014 Appliance Efficiency Regulations* (2014), available at http://www.energy.ca.gov/2014publications/CEC-400-2014-009/CEC-400-2014-009-CMF.pdf.
[9] Pgs. 14-17. KEMA 2014.
[10] Pg. 46. The Cadmus Group, Inc., *Residential Retrofit High Impact Measure Evaluation Report* (2010), available at http://www.calmac.org/publications/FinalResidentialRetroEvaluationReport_11.pdf.
[11] ADM Associates et al., *Evaluation Study of the 2004-05 Statewide Appliance Recycling Program* (2008), available at http://www.calmac.org/publications/EM&V_Study_for_2004-2005_Statewide_RARP_-_Final_Report.pdf.
[12] NREL 2013.
[13] Pg 7-6 and Tables 7.2.1 and and 7.3.1. 2012 Technical Support Document for Residential Clothes Washers, "Chapter 7. Energy and Water Use Determination," available at http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0019-0047.
[14] Pg. 7-6. 2014 Technical Support Document for Commercial Clothes Washers, "Chapter 7. Energy and Water use Determination," available at http://www.regulations.gov/#!documentDetail;D=EERE-2012-BT-STD-0020-0036.
[15] Available at http://websafe.kemainc.com/rass2009/Query.aspx?QType=1&tabid=1.
[16] Pg. 7-20. NREL 2013.
[17] Adapted from Table 10. KEMA, Inc. 2014.
[18] Appendix A. of Decision D. 11-07-030: "*Energy Division believes that gross saving must be established based upon the difference between the recycled unit energy use, if left on the grid rather than being recycled, and any unit that is placed into service in place of the recycled unit. Energy Division believes that in some situations no unit is placed into service in place of the recycled unit and thus the recycled unit UEC equals the savings, UES. The utilities believe the only probable case that should be considered is the case where UEC and UES are equal and that all other cases should not be considered. However, Energy Division believes that in many instances another unit is placed into*

*service in place of the recycled unit thus causing a reduction in the savings from preventing the recycled unit from staying in service. The overall effect of the recommended Energy Division gross savings adjustment is approximately a 40% reduction in savings.*"

[19] Pg. 46. The Cadmus Group, Inc. 2010.

[20] Pg  7-2. 2012 Technical Support Document for Residential Clothes Washers.

[21] Pg. 7-6. 2012 Technical Support Document for Residential Clothes Washers.

[22] Pg. 7-6. 2014 Technical Support Document for Commercial Clothes Washers.

[23] Pg. 7-6. 2012 Technical Support Document for Residential Clothes Washers.

[24] Pg. 7-2. 2012 Technical Support Document for Residential Clothes Washers.

[25] Pg. 7-6. 2012 Technical Support Document for Residential Clothes Washers.

[26] Pg. 7-6. 2014 Technical Support Document for Commercial Clothes Washers.

[27] Pg. 7-6. 2012 Technical Support Document for Residential Clothes Washers.

[28] Pg. 7-6. 2014 Technical Support Document for Commercial Clothes Washers.