Volume 3: Residential Measures

neren Missouri TRM – Volume 3: Residential Measures Revision Log

ision	Date	Description
	05/30/2018	Initial version filed for Commission approval.
	12/21/2018	Updated "Deemed Tables" with PY2017 Evaluation results per Stipulation and Agreement (File No. EO-2018-0211). Added Demand Response language per Stipulation and Agreement.
	1/01/2020	Updated "Deemed Tables" with PY2018 Evaluation results. Also includes revisions to HVAC measures and multifamily measures, based on feedback from evaluation contractor. This includes updates to Volume 3 of the TRM.
	10/15/2020	Updated “Deemed Tables” with PY19 Evaluation results and other revisions to improve consistency with Deemed tables.
	09/15/21	Updated “Deemed Tables” with PY20 Evaluation results and other revisions to improve consistency with Deemed tables.

Volume 3: Residential Measures

3.1 Appliances

3.1.1 Refrigerator and Freezer Recycling

DESCRIPTION

This measure describes savings from the retirement and recycling of inefficient but operational refrigerators and freezers. Savings are provided in two ways. First, a regression equation is provided that requires the use of key inputs describing the retired unit (or population of units) and is based on a 2013 workpaper provided by Cadmus using data from a 2012 ComEd metering study and metering data from a Michigan study. The second methodology is a deemed approach based on 2011 Cadmus analysis of data from a number of evaluations.[1]

The savings are equivalent to the unit energy consumption of the retired unit and should be claimed for the assumed remaining useful life of that unit. A Part Use Factor is applied to account for those secondary units that are not in use throughout the entire year. The user should note that the regression algorithm is designed to provide an accurate portrayal of savings for the population as a whole and includes those parameters that have a significant effect on the consumption. The precision of savings for individual units will vary. This measure also includes a section accounting for the interactive effect of reduced waste heat on the heating and cooling loads.

This measure was developed to be applicable to the following program type: ERET.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

N/A

DEFINITION OF BASELINE EQUIPMENT

The existing inefficient unit must be operational and have a capacity of between 10 and 30 cubic feet.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The estimated remaining useful life of the recycling units is 8 years.[2]

DEEMED MEASURE COST

Measure cost includes the cost of pickup and recycling of the refrigerator and should be based on actual costs of running the program. If unknown, assume $140 per unit.[3]

LOADSHAPE

Refrigeration RES
Freezer RES

Algorithm

CALCULATION OF SAVINGS

ENERGY SAVINGS

Regression analysis: Refrigerators

Daily energy savings for refrigerators are based upon a linear regression model using the following coefficients:[4]

[1] Cadmus "2010 Residential Great Refrigerator Roundup Program – Impact Evaluation," 2011.
[2] KEMA "Residential Refrigerator Recycling Ninth Year Retention Study," 2004.
[3] Based on average program costs for SCE Refrigerator Appliance Recycling Program. Innovologie, "Appliance Recycling Program Retailer Trial Final Report," a report prepared for Southern California Edison, 2013.
[4] Coefficients provided in May 13, 2016, Cadmus evaluation report; Ameren Missouri Refrigerator Recycling Impact and Process Evaluation: PY2015.

Independent Variable Description	Estimate Coefficient
Intercept	0.5822
Age (years)	0.0269
Pre-1990 (=1 if manufactured pre-1990)	1.0548
Size (cubic feet)	0.0673
Dummy: Side-by-Side (= 1 if side-by-side)	1.0706
Dummy: Single Door (= 1 if single door)	-1.9767
Dummy: Primary Usage Type (in absence of the program) (= 1 if primary unit)	0.6046
Interaction: Located in Unconditioned Space x CDD/365	0.0200
Interaction: Located in Unconditioned Space x HDD/365	-0.0447

$$\Delta kWh_{Unit} = \Big[0.5822 + (Age * 0.0269) + (Pre-1990 * 1.0548) + (Size * 0.0673) + (Side-by-side * 1.0706) + (Single-door * -1.9767) + (Primary\ Usage * 0.6046) + \left(\frac{CDD}{365} * Unconditioned * 0.0200\right) + \left(\frac{HDD}{365} * Unconditioned * -0.0447\right)\Big] * Days * Part\ Use\ Factor$$

Where:

Age = Age of retired unit
Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)
Size = Capacity (cubic feet) of retired unit
Side-by-Side = Side-by-side dummy (= 1 if side-by-side, else 0)
Single-Door = Single-door dummy (= 1 if single-door, else 0)
Primary Usage = Primary Usage Type (in absence of the program) dummy (= 1 if Primary, else 0. If unknown, assume 0.262.[5])
CDD = Cooling Degree Days
= 1678:[6]
Unconditioned = If unit in unconditioned space = 1, otherwise 0. If unknown, assume 0.64.[7]
HDD = Heating Degree Days
= 4486[8]
Days = Days per year
= 365
Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.864.[9]

Deemed approach: Refrigerators

$$\Delta kWh_{Unit} = UEC * Part\ Use\ Factor$$

Where:

UEC = Unit Energy Consumption
= 1181 kWh[10]
Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.864.[11]
ΔkWh_{Unit} = 1181 * 0.864
= 1020 kWh

[5] Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019.
[6] Based on climate normals CDD data, with a base temp of 65°F.
[7] Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019.
[8] Based on climate normals HDD data, with a base temp of 65°F.
[9] Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019.
[10] This value is taken from the 2016 Cadmus evaluation of Ameren Missouri Refrigerator Recycling PY2015.
[11] Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019.

Regression analysis: Freezers:

Daily energy savings for freezers are based upon a linear regression model using the following coefficients:[12]

Independent Variable Description	Estimate Coefficient
Intercept	-0.8918
Age (years)	0.0384
Pre-1990 (=1 if manufactured pre-1990)	0.6952
Size (cubic feet)	0.1287
Chest Freezer Configuration (=1 if chest freezer)	0.3503
Interaction: Located in Unconditioned Space x CDD	0.0695
Interaction: Located in Unconditioned Space x HDD	-0.0313

$$\Delta kWh_{Unit} = [-0.8918 + (Age * 0.0384) + (Pre-1990 * 0.6952) + (Size * 0.1287) + (Chest\ Freezer * 0.3503) + (CDD/365 * Unconditioned * 0.0695) + (HDD/365 * Unconditioned * -0.0313)] * Part\ Use\ Factor$$

Where:

Age = Age of retired unit

Pre-1990 = Pre-1990 dummy (=1 if manufactured pre-1990, else 0)

Size = Capacity (cubic feet) of retired unit

Chest Freezer = Chest Freezer dummy (= 1 if chest freezer, else 0)

CDD = Cooling Degree Days (see table in refrigerator section)

Unconditioned = If unit in unconditioned space = 1, otherwise 0. If unknown, assume 0.67.[13]

HDD = Heating Degree Days (see table in refrigerator section)

Days = Days per year = 365

Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.778.[14]

Deemed approach: Freezers

$$\Delta kWh_{Unit} = UEC * Part\ Use\ Factor$$

Where:

$UEC_{Reitred}$ = Unit Energy Consumption of retired unit
= 1061 kWh[15]

Part Use Factor = To account for those units that are not running throughout the entire year. If available, Part-Use Factor participant survey results should be used. If not available, assume 0.778.[16]

ΔkWh_{Unit} = 1061 * 0.778
= 825 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh_{unit} * CF$$

Where:

ΔkWh_{unit} = Savings provided in algorithm above (not including $\Delta kWh_{wasteheat}$)

CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor[17]

---

[12] Coefficients provided in May 13, 2016, Cadmus evaluation report; Ameren Missouri Refrigerator Recycling Impact and Process Evaluation: PY2015.
[13] Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019.
[14] Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019.
[15] This value is taken from the 2016 Cadmus evaluation of Ameren Missouri Refrigerator Recycling PY2015.
[16] Ameren Missouri Appliance Recycling Impact and Process Evaluation: PY2019.
[17] Based on Ameren Missouri 2016 Loadshape for Residential Refrigeration and Freezer End-Use.

Refrigerators = 0.0001285253
Freezers = 0.0001285253

NATURAL GAS SAVINGS

$$\Delta Therms = \Delta kWh_{Unit} * WHFeHeatGas * \ 0.03412$$

Where:

ΔkWh_{Unit} = kWh savings calculated from either method above, not including the $\Delta kWh_{WasteHeat}$

WHFeHeatGas = Waste Heat Factor for Energy to account for gas heating increase from removing waste heat from refrigerator/freezer
= - (HF / $\eta Heat_{Gas}$) * %GasHeat
If unknown, assume 0

HF = Heating Factor or percentage of reduced waste heat that must now be heated
= 58% for unit in heated space[18]
= 0% for unit in heated space or unknown

$\eta Heat_{Gas}$ = Efficiency of heating system
= 71%[19]

%GasHeat = Percentage of homes with gas heat – see table below.

0.03412 = Converts kWh to therms

Heating Fuel	%GasHeat
Electric	0%
Gas	100%
Unknown	65%[20]

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE:

[18] Based on 212 days where HDD 65>0, divided by 365.25.

[19] This has been estimated assuming that natural gas central furnace heating is typical for Missouri residences. The predominant heating is gas furnace with 48% of Missouri homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey). In 2000, 29% of furnaces purchased in Missouri were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years, so units purchased 16 years ago provide a reasonable proxy for the current mix of furnaces in the state. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows: ((0.29*0.92) + (0.71*0.8)) * (1-0.15) = 0.71.

[20] Based on data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls."

2 Air Purifier/Cleaner

SCRIPTION

air purifier (cleaner) meeting the efficiency specifications of ENERGY STAR® is purchased and installed in place of a model meeting the cur eral standard.

s measure was developed to be applicable to the following program types: TOS and NC.

pplied to other program types, the measure savings should be verified.

FINITION OF EFFICIENT EQUIPMENT

efficient equipment is defined as an air purifier meeting the efficiency specifications of ENERGY STAR® as provided below.

1. Must produce a minimum 50 Clean Air Delivery Rate (CADR) for Dust[21] to be considered under this specification.
2. Minimum Performance Requirement: = 2.0 CADR/Watt (Dust)
3. Standby Power Requirement: = 2.0 Watts Qualifying models that perform secondary consumer functions (e.g., clock, remote control) m meet the Standby Power Requirement.
4. UL Safety Requirement: Models that emit ozone as a byproduct of air cleaning must meet UL Standard 867 (ozone production must exceed 50ppb)

FINITION OF BASELINE EQUIPMENT

baseline equipment is assumed to be a conventional unit.[22]

EMED LIFETIME OF EFFICIENT EQUIPMENT

measure life is assumed to be 9 years.[23]

EMED MEASURE COST

incremental cost for this measure is $70.[24]

ADSHAPE

AC RES

Algorithm

LCULATION OF SAVINGS

ECTRIC ENERGY SAVINGS[25]

$$Energy\ Savings\ (kWh_{Year}) = \{CADR\ \times (1/Eff_{BL} - 1/Eff_{ES}) \times (Hr_{oper}) + (SBBL - SBES) \times (24 - Hr_{oper})\} \times 365/1000\ *$$

ere:

CADR	= Clean air recovery rate for dust
Eff_{BL}	= Clean air recovery rate for dust per watt for baseline unit
Eff_{ES}	= Clean air recovery rate for dust per watt for ENERGY STAR® unit
Hr_{oper}	= Hours per day of operation
SBBL	= Standby for baseline unit
SBES	= Standby for ENERGY STAR® unit
365	= Days/year
1,000	= Conversion factor (Wh/kWh)

easured according to the latest ANSI/AHAM AC-1 (AC-1) Standard.
defined as the average of non-ENERGY STAR® products found in EPA research, 2011, ENERGY STAR® Qualified Room Air Cleaner Calculator.
NERGY STAR® Qualified Room Air Cleaner Calculator.
meren Missouri MEEIA 2016-18 TRM, January 1, 2018.
NERGY STAR® Qualified Room Air Cleaner Calculator.

Term	Value[26]
CADR	157.56
EFF_{BL}	1.00
EFF_{ES}	3.00
Hr_{oper}	16
SB_{BL}	1.00
SB_{ES}	0.391
ISR	94%

MMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh * CF$$

ere:

ΔkWh = Gross customer annual kWh savings for the measure
CF = 0.0004660805

TURAL GAS SAVINGS

TER IMPACT DESCRIPTIONS AND CALCULATION

EMED O&M COST ADJUSTMENT CALCULATION

re are no operation and maintenance cost adjustments for this measure.[27]

ASURE CODE:

neren Missouri Efficient Products Evaluation PY2018

me types of room air cleaners require filter replacement or periodic cleaning, but this is likely to be true for both efficient and baseline units and so no difference in cost is med.

3 Clothes Dryer

SCRIPTION

s measure relates to the installation of a residential clothes dryer meeting the ENERGY STAR® criteria. ENERGY STAR® qualified clo ers save energy through a combination of more efficient drying and reduced runtime of the drying cycle. More efficient drying is achieved thro eased insulation, modifying operating conditions such as air flow and/or heat input rate, improving air circulation through better drum desig ster fans, and improving efficiency of motors. Reducing the runtime of dryers through automatic termination by temperature and moisture sen elieved to have the greatest potential for reducing energy use in clothes dryers.[28] ENERGY STAR® provides criteria for both gas and elec hes dryers.

s measure was developed to be applicable to the following program types: TOS and NC.

pplied to other program types, the measure savings should be verified.

FINITION OF EFFICIENT EQUIPMENT

thes dryer must meet the ENERGY STAR® criteria, as required by the program.

FINITION OF BASELINE EQUIPMENT

baseline condition is a clothes dryer meeting the minimum federal requirements for units manufactured on or after January 1, 2015.

EMED LIFETIME OF EFFICIENT EQUIPMENT

expected measure life is assumed to be 14 years.[29]

EMED MEASURE COST

Dryer Size	Incremental Cost[30]
Standard	$75
Compact	$105

ADSHAPE

cellaneous RES

Algorithm

LCULATION OF SAVINGS

CTRIC ENERGY SAVINGS

$$\Delta kWh = \left(\frac{Load}{CEFbase} - \frac{Load}{CEFeff}\right) * Ncycles * \%Electric$$

ere:

Load = The average total weight (lbs) of clothes per drying cycle. If dryer size is unknown, assume standard.

Dryer Size	Load (lbs)[31]
Standard	8.45
Compact	3

NERGY STAR® Market & Industry Scoping Report. Residential Clothes Dryers. Table 8. November 2011. /www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

sed on an average estimated range of 12-16 years. ENERGY STAR® Market & Industry Scoping Report. Residential Clothes Dryers. November 2011. /www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

st based on ENERGY STAR® Savings Calculator for ENERGY STAR® Qualified Appliances. ://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

sed on ENERGY STAR® test procedures. https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers

CEFbase = Combined energy factor (CEF) (lbs/kWh) of the baseline unit is based on existing federal standards energy factor and adjusted to CEF as performed in the ENERGY STAR® analysis.[32] If product class unknown, assume electric, standard.

Product Class	CEFbase
Vented Electric, Standard (≥ 4.4 ft^3)	3.11
Vented Electric, Compact (120V) (< 4.4	3.01
Vented Electric, Compact (240V) (<4.4	2.73
Ventless Electric, Compact (240V) (<4.4	2.13
Vented Gas	2.84[33]

CEFeff = CEF (lbs/kWh) of the ENERGY STAR® unit based on ENERGY STAR® requirements.[34] If product class unknown, assume electric, standard.

Product Class	CEFeff
Vented or Ventless Electric, Standard (≥ 4.4 ft^3)	3.93
Vented or Ventless Electric, Compact (120V) (< 4.4	3.80
Vented Electric, Compact (240V) (< 4.4 ft^3)	3.45
Ventless Electric, Compact (240V) (< 4.4 ft^3)	2.68
Vented Gas	3.48[35]

Ncycles = Number of dryer cycles per year. Use actual data if available. If unknown, use 283 cycles per year.[36]
%Electric = The percent of overall savings coming from electricity
= 100% for electric dryers, 5% for gas dryers[37]

ng defaults provided above:

Product Class	ΔkWh
Vented Electric, Standard (≥ 4.4 ft^3)	145.7
Vented Electric, Compact (120V) (< 4.4 ft^3)	53.8
Vented Electric, Compact (240V) (<4.4 ft^3)	58.9
Ventless Electric, Compact (240V) (<4.4 ft^3)	74.3
Vented Gas	7.0

MMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh * CF$$

ere:

ΔkWh = Energy Savings as calculated above
CF = Summer peak coincidence demand (kW) to annual energy (kWh) factor
= 0.0001148238

NERGY STAR® Draft 2 Version 1.0 Clothes Dryers Data and Analysis.
deral standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.
NERGY STAR® Clothes Dryers Key Product Criteria. https://www.energystar.gov/index.cfm?c=clothesdry.pr_crit_clothes_dryers
deral standards report CEF for gas clothes dryers in terms of lbs/kWh. To determine gas savings, this number is later converted to therms.
pendix D to Subpart B of Part 430 – Uniform Test Method for Measuring the Energy Consumption of Dryers.
ne hundred percent for electric dryers accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc.). Five percent for gas dryer determined using a ratio of the electric to total savings from gas dryers given by ENERGY STAR® Draft 2 Version 1.0 Clothes Dryers Data and Analysis. Value reported EPA ENERGY STAR® appliance calculator.

ng defaults provided above:

Product Class	ΔkW
Vented Electric, Standard (≥ 4.4 ft^3)	0.0251
Vented Electric, Compact (120V) (< 4.4 ft^3)	0.0092
Vented Electric, Compact (240V) (<4.4 ft^3)	0.0101
Ventless Electric, Compact (240V) (<4.4 ft^3)	0.0128
Vented Gas	0.0012

TURAL GAS ENERGY SAVINGS

ural gas savings only apply to ENERGY STAR® vented gas clothes dryers.

$$\Delta Therm = \left(\frac{Load}{CEFbase} - \frac{Load}{CEFeff}\right) * Ncycles * Therm\_convert * \%Gas$$

ere:

Therm_convert = Conversion factor from kWh to therm
= 0.03413

%Gas = Percent of overall savings coming from gas
= 0% for electric units and 84% for gas units[38]

ng defaults provided above:

ΔTherm = (8.45/2.84 – 8.45/3.48) * 257 * 0.03413 * 0.84
= 4.03 therms

TER IMPACT DESCRIPTIONS AND CALCULATION

EMED O&M COST ADJUSTMENT CALCULATION

ASURE CODE:

ro percent for gas dryers accounts for the fact that some of the savings on gas dryers comes from electricity (motors, controls, etc.). Eighty-four percent was determined us o of the gas to total savings from gas dryers given by ENERGY STAR® Draft 2 Version 1.0 Clothes Dryers Data and Analysis.

4 Clothes Washer

SCRIPTION

s measure relates to the installation of a clothes washer meeting the ENERGY STAR® (CEE Tier1), ENERGY STAR® Most Efficient (CEE or CEE Tier 3 minimum qualifications. If the Domestic Hot Water (DHW) and dryer fuels of the installations are unknown (for example thro tail program), savings are based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provid algorithms can also be used to calculate site-specific savings where DHW and dryer fuels are known.

s measure was developed to be applicable to the following program types: TOS and NC.

pplied to other program types, the measure savings should be verified.

FINITION OF EFFICIENT EQUIPMENT

thes washer must meet the ENERGY STAR® (CEE Tier1), ENERGY STAR® Most Efficient (CEE Tier 2), or CEE Tier 3 minimum qualificat vided in the table below), as required by the program.

FINITION OF BASELINE EQUIPMENT

baseline condition is a standard-sized clothes washer meeting the minimum federal baseline as of March 2015.[39]

Efficiency Level		Top loading >2.5 Cu ft	Front Loading >2.5 Cu ft
Baseline	Federal Standard	≥1.29 IMEF, ≤8.4 IWF	≥1.84 IMEF, ≤4.7 IWF
Efficient	ENERGY STAR®, CEE Tier 1	≥2.06 IMEF, ≤4.3 IWF	≥2.38 IMEF, ≤3.7 IWF
	ENERGY STAR® Most Efficient, CEE Tier 2	≥2.76 IMEF, ≤3.5 IWF	≥2.74 IMEF, ≤3.2 IWF
	CEE Tier 3	≥2.92 IMEF, ≤3.2 IWF	

Integrated Modified Energy Factor (IMEF) includes unit operation, standby, water heating, and drying energy use, with the higher the value e efficient the unit: "The quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer en sumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water en sumption, the energy required for removal of the remaining moisture in the wash load, and the combined low-power mode energy consumpti

Integrated Water Factor (IWF) indicates the total water consumption of the unit, with the lower the value the less water required: "The quot he total weighted per-cycle water consumption for all 67 wash cycles in gallons divided by the cubic foot (or liter) capacity of the clo her."[40]

EMED LIFETIME OF EFFICIENT EQUIPMENT

expected measure life is assumed to be 14 years.[41]

EMED MEASURE COST

incremental cost assumptions are provided below:[42]

Efficiency Level	Incremental Cost
ERGY STAR®, CEE Tier 1	$32
ERGY STAR® Most Efficient, CEE TIER 2	$393
E TIER 3	$454

ADSHAPE

cellaneous RES

Algorithm

---

e http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.
efinitions provided in ENERGY STAR® v7.1 specification on the ENERGY STAR® website.
sed on DOE Chapter 8 Life-Cycle Cost and Payback Period Analysis.
sed on weighted average of top loading and front loading units (based on available product from the California Energy Commission (CEC) Appliance database s://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx) and cost data from Life-Cycle Cost and Payback Period Excel-based analytical tool. See "2015 Clothes her Analysis.xls" for details.

LCULATION OF SAVINGS

CTRIC ENERGY SAVINGS

$$\Delta kWh = \left[\left(Capacity * \frac{1}{IMEFbase} * Ncycles\right) * \left(\%CWbase + (\%DHWbase * \%Electric_{DHW}) + (\%Dryerbase * \%Electric_{Dryer})\right)\right] - \left[\left(Capacity * \frac{1}{IMEFeff} * Ncycles\right) * \left(\%CWeff + (\%DHWeff * \%Electric_{DHW}) + (\%Dryereff * \%Electric_{Dryer})\right)\right]$$

ere:

Capacity = Clothes washer capacity (cubic feet)
= Actual - If capacity is unknown, assume 3.45 cubic feet[43]
IMEFbase = Integrated Modified Energy Factor of baseline unit
IMEFeff = Integrated Modified Energy Factor of efficient unit
= Actual. If unknown, assume average values provided below.
Ncycles = Number of Cycles per year
= 271[44]
%CW = Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)

%DHW = Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)
%Dryer = Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)
$\%Electric_{DHW}$ = Percentage of DHW savings assumed to be electric
$\%Electric_{Dryer}$ = Percentage of dryer savings assumed to be electric

Efficiency Level	IMEFbase		
	Top loading >2.5 Cu ft	Front Loading >2.5 Cu ft	Weighted Average[45]
Federal Standard	1.29	1.84	1.66

Efficiency Level	IMEFeff		
	Top loading >2.5 Cu ft	Front Loading >2.5 Cu ft	Weighted Average[46]
ENERGY STAR®, CEE Tier 1	2.06	2.38	2.26
ENERGY STAR® Most Efficient, CEE Tier 2	2.76	2.74	2.74
CEE Tier 3	2.92		2.92

	Percentage of Total Energy Consumption[47]		
	%CW	%DHW	%Dryer
Federal Standard	8%	31%	61%
ENERGY STAR®, CEE Tier 1	8%	23%	69%

sed on the average clothes washer volume of all units that pass the new federal standard on the CEC database of clothes washer products (accessed on 08/28/2014). If util specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.
eighted average of 271 clothes washer cycles per year (based on 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances sect vest Census Region for state of Missouri): http://www.eia.gov/consumption/residential/data/2009/. See "2015 Clothes Washer Analysis.xls" for details.
lities have specific evaluation results providing a more appropriate assumption for singlefamily or multifamily homes in a particular market or geographical area, then tha ld be used.
eighted average IMEF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of availab ENERGY STAR® product in the CEC database (accessed 08/28/2014). The relative weightings are: 67% front and 33% top for Baseline; 62% front and 38% top for RGY STAR CEE Tier 1; 98% front and 2% top for ENERGY STAR Most Efficient, CEE Tier 2; and 100% front for CEE Tier 3. See more information in "2015 Clothes her Analysis.xlsx."
eighting is based upon the relative top vs. front loading percentage of available product in the CEC database (accessed 08/28/2014).
e percentage of total energy consumption that is used for the machine, heating the hot water, or by the dryer is different depending on the efficiency of the unit. Values ar d on a weighted average of top loading and front-loading units based on data from DOE Life-Cycle Cost and Payback Analysis. See "2015 Clothes Washer Analysis.xls" f ls.

	Percentage of Total Energy Consumption[47]		
	%CW	%DHW	%Dryer
ENERGY STAR® Most Efficient, CEE Tier 2	14%	10%	76%
CEE Tier 3	14%	10%	76%

DHW fuel	$\%Electric_{DHW}$
Electric	100%
Natural Gas	0%
Unknown	43%[48]

Dryer fuel	$\%Electric_{Dryer}$
Electric	100%
Natural Gas	0%
Unknown	90%[49]

ng the default assumptions provided above, the prescriptive savings for each configuration are presented below:[50]

nt Loaders:

	ΔkWH			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ENERGY STAR®, CEE Tier 1	149.3	52.6	96.4	-0.2
ENERGY STAR® Most Efficient, CEE Tier 2	222.1	85.9	132.2	-4.0
CEE Tier 3	243.1	104.8	137.2	-1.1

Loaders:

	ΔkWH			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ENERGY STAR®, CEE Tier 1	149.3	97.0	77.0	24.8
ENERGY STAR® Most Efficient, CEE Tier 2	222.1	132.6	117.1	27.5
CEE Tier 3	243.1	374.4	230.5	42.0

ghted Average:

	ΔkWH			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ENERGY STAR®, CEE Tier 1	149.3	70.6	88.0	9.4
ENERGY STAR® Most Efficient, CEE Tier 2	222.1	80.9	137.5	-3.7
CEE Tier 3	243.1	98.4	143.2	-1.5

e DHW and dryer fuel is unknown, the prescriptive kWH savings based on defaults provided above should be:

ΔkWH

efault assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri. If utilities h
fic evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then they should be used.

efault assumption for unknown is based on percentage of homes with clothes washers that use an electric dryer from EIA Residential Energy Consumption Survey (RECS)
for Midwest Region, data for the state of Missouri. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market o
raphical area, then they should be used.

ote that the baseline savings for all cases (front, top and weighted average) is based on the weighted average baseline IMEF (as opposed to assuming front baseline for fron
ient unit and top baseline for top- efficient unit). The reasoning is that the support of the program of more efficient units (which are predominately front loading) will resul
participants switching from planned purchase of a top loader to a front loader.

Efficiency Level	Front Loaders	Top Loaders	Weighted Average
ERGY STAR®, CEE Tier 1	112.8	89.6	99.0
ERGY STAR® Most Efficient, CEE Tier 2	161.5	136.6	134.3
E Tier 3	424.6	154.8	151.8

MMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh * CF$$

ere:

ΔkWh = Energy Savings as calculated above

CF = Summer peak coincidence factor for measure
= 0.0001148238

ng the default assumptions provided above, the prescriptive savings for each configuration are presented below:

nt Loaders:

	ΔkW			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ENERGY STAR®, CEE Tier 1	0.022	0.008	0.015	0.000
ENERGY STAR® Most Efficient, CEE Tier 2	0.033	0.013	0.020	-0.001
CEE Tier 3	0.037	0.016	0.021	0.000

Loaders:

	ΔkW			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ENERGY STAR®, CEE Tier 1	0.022	0.015	0.012	0.004
ENERGY STAR® Most Efficient, CEE Tier 2	0.033	0.020	0.018	0.004
CEE Tier 3	0.037	0.056	0.035	0.006

ghted Average:

	ΔkW			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ENERGY STAR®, CEE Tier 1	0.022	0.011	0.013	0.001
ENERGY STAR® Most Efficient, CEE Tier 2	0.033	0.012	0.021	-0.001
CEE Tier 3	0.037	0.015	0.022	0.000

e DHW and dryer fuel is unknown, the prescriptive kW savings should be:

	ΔkW		
iciency Level	Front Loaders	Top Loaders	Weighted Average
ERGY STAR®, CEE Tier 1	0.013	0.017	0.015
ERGY STAR® Most Efficient, CEE Tier 2	0.021	0.024	0.020
E Tier 3	0.023	0.064	0.023

TURAL GAS SAVINGS

$$\Delta Therms = \left[\left[\left(Capacity * \frac{1}{IMEFbase} * Ncycles\right) * \left(\left(\%DHWbase * \%Natural\ Gas_{DHW} * R_{eff}\right) + \left(\%Dryerbase * \%Gas_{Dryer}\right)\right)\right] - \left[\left(Capacity * \frac{1}{IMEFeff} * Ncycles\right) * \left(\left(\%DHW_{eff} * \%Gas_{DHW} * \%Natural\ Gas\_DHW * R\_eff\right) + \left(\%Dryereff * \%Gas_{Dryer}\right)\right)\right]\right] * Therm\_convert$$

ere:

$\%Gas_{DHW}$ = Percentage of DHW savings assumed to be Natural Gas
R_{eff} = Recovery efficiency factor
= 1.26[51]
$\%Gas_{Dryer}$ = Percentage of dryer savings assumed to be Natural Gas
Therm_convert = Conversion factor from kWh to therm
= 0.03412

Other factors as defined above.

DHW fuel	$\%Gas_{DHW}$
Electric	0%
Natural Gas	100%
Unknown	57%[52]

Dryer fuel	$\%Gas_{Dryer}$
Electric	0%
Natural Gas	100%
Unknown	10%[53]

ng the default assumptions provided above, the prescriptive savings for each configuration are presented below:

nt Loaders:

	ΔTherms			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ERGY STAR®, CEE Tier 1	0.0	2.2	2.5	4.7
ERGY STAR® Most Efficient, CEE Tier 2	0.0	3.8	3.6	7.4
E Tier 3	0.0	8.1	11.3	19.4

Loaders:

	ΔTherms			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ERGY STAR®, CEE Tier 1	0.0	4.2	1.8	6.0
ERGY STAR® Most Efficient, CEE Tier 2	0.0	5.9	3.1	8.9
E Tier 3	0.0	5.9	3.6	9.6

account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electr r heater with 0.98 recovery efficiency. (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore, r of 0.98/0.78 (1.26) is applied.

efault assumption for unknown fuel is based EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri. If utilities hav fic evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then that should be used.

efault assumption for unknown fuel is based EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of Missouri. If utilities hav fic evaluation results providing a more appropriate assumption for homes in a particular market or geographical area, then that should be used.

ghted Average:

	ΔTherms			
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer
ERGY STAR®, CEE Tier 1	0.0	3.4	2.1	5.5
ERGY STAR® Most Efficient, CEE Tier 2	0.0	6.1	2.9	9.0
E Tier 3	0.0	6.2	3.4	9.6

e DHW and dryer fuel is unknown, the prescriptive therm savings should be:

	ΔTherms		
iciency Level	Front Loaders	Top Loaders	Weighted Average
ERGY STAR®, CEE Tier 1	1.51	2.52	2.11
ERGY STAR® Most Efficient, CEE Tier 2	2.52	3.60	3.71
E Tier 3	5.66	3.70	3.84

TER IMPACT DESCRIPTIONS AND CALCULATION

$$\Delta Water\ (gallons) = Capacity * (IWFbase - IWFeff) * Ncycles$$

ere:

IWFbase = Integrated Water Factor of baseline clothes washer
= 5.92[54]

IWFeff = Water Factor of efficient clothes washer
= Actual - If unknown assume average values provided below

Other factors as defined above.

ng the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:

	IWF[55]			ΔWater (gallons per year)		
Efficiency Level	Front Loaders	Top Loaders	Weighted Average	Front Loaders	Top Loaders	Weighted Average
deral Standard	4.7	8.4	5.92	N/A		
NERGY STAR®, CEE Tier 1	3.7	4.3	3.93	934	3,828	1,857
NERGY STAR® Most Efficient, CEE Tier 2	3.2	3.5	3.21	1,400	4,575	2,532
CE Tier 3	3.2		3.20	1,400	7,842	2,538

EMED O&M COST ADJUSTMENT CALCULATION

.

ASURE CODE:

eighted average IWF of Federal Standard rating for front loading and top loading units. Weighting is based upon the relative top vs. front loading percentage of available r RGY STAR® products in the CEC database.

VF values are the weighted average of the new ENERGY STAR® specifications. Weighting is based upon the relative top vs. front loading percentage of available ENERG R® and ENERGY STAR® Most Efficient products in the CEC database. See "2015 Clothes Washer Analysis.xls" for the calculation.