

**AP P L I ANC E**

H E A T PU M P CL O T H E S D R Y E R , R E S ID E NT I A L , F UEL S UB S T I T UT I O N

SW A P 0 1 4 - 0 1

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# MEASURE NAME

Heat Pump Clothes Dryer, Residential, Fuel Substitution

# STATEWIDE MEASURE ID

SWAP014-01

# EFFECTIVE DATE

12/13/ 2019

# TECHNOLOGY SUMMARY

Residential clothes dryers are designed to dry clothes by tumbling the load in a heated drum to remove moisture through evaporation. Because a horizontal axis of rotation is required to create the tumble action, residential clothes dryers are typically front-loading. Front-loading clothes dryers have an opening on the front of the unit, covered by a door, which gives access to an inner cylindrical drum where the load to be dried is placed. The inner drum is perforated and is surrounded by a larger outer housing which collects the moisture-laden air. The clothes dryer uses electricity to power an electric motor that rotates the drum within the housing, which is contained inside a cabinet. Vanes and/or surface textures may be incorporated into the inner surface of the drum to facilitate separation of the clothing to expose surface areas for drying.

Air is drawn through the drum of the clothes dryer by means of an electrically driven blower. This air stream is heated prior to entering the drum to evaporate the moisture in the clothing. Heating may be provided by an electrically energized resistive element. Alternatively, hot air in the drum may be supplied by means of a gas burner system whose combustion products are directed into the drum by the electrically powered blower.

Some high-efficiency clothes dryers can modulate the amount of heat entering the drum, allowing for settings at lower temperatures. This reduces the amount of energy required to heat the drum but increases the dryer run times. The most efficient electric dryers are heat pump dryers. Heat pump clothes dryers’ work by recirculating the exhaust air back to the dryer after the moisture is removed by a refrigeration-dehumidification system. No heating element is needed. The warm and damp exhaust air of the dryer enters the evaporation coil where it cools down below the dew point, and sensible and latent heat are extracted. The heat is transferred to the condenser coil and reabsorbed by the air in a closed cycle.

Definitions related to clothes dryers include the following:

*Electric Clothes Dryer:* A cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is electricity and the drum and blower(s) are driven by an electric motor(s).

*Gas Clothes Dryer:* A cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is gas and the drum and blower(s) are driven by an electric motor(s).

*Standard Size Clothes Dryer:* A clothes dryer with a drum capacity of 4.4 cubic feet or greater. [1](#_bookmark0)

*Compact Clothes Dryer:* A clothes dryer with drum capacity less than 4.4 cubic feet. [2](#_bookmark1)

*Vented Clothes Dryer:* A clothes dryer that discharges moist, heated air from the cabinet, typically through a duct, to an exterior location. Vented dryers use either an open-loop or a closed-loop system with an internal condenser to remove the evaporated moisture from the heated air. [3](#_bookmark2)

*Ventless Clothes Dryer:* A clothes dryer that routes the moist air from the drum through a heat exchanger which condenses the water vapor from the air. The condensed water is either collected in a removable container for disposal by the user or it is discharged into a drain line. Open-loop dryers will discharge the relatively dry air into the room, while closed-loop dryers do not. Due to the risks associated with combustion byproducts in gas dryers, ventless dryers are all electrically heated. [4](#_bookmark3)

*Combined Energy Factor (CEF)* is a factor used to measure clothes dryer efficiency and uses units of pounds of clothes per kilowatt-hour (lbs/kWh). It is equal to the clothes dryer test load weight in pounds divided by the sum of the standby, off, and active mode dryer energy consumption expressed as kilowatt hours (kWh). The CEF in lbs/kWh is applied to both electric and natural gas dryers. Gas dryer energy consumption in therms is converted to kWh equivalent when calculating CEF[5](#_bookmark4).

# MEASURE CASE DESCRIPTION

The measure case is an efficient, above code, ENERGY STAR Efficient Clothes Dryers using Energy Star Version 1.1 Specification[6](#_bookmark5) List[7](#_bookmark6). Heat pump clothes dryers are cabinet-like appliance designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is electricity and the drum and blower(s) are driven by an electric motor(s). Hot air is created by utilizing a heat pump, which reduces drying time and increases energy efficiency. Heat pumps can be applied to both vented and ventless dryers.

Energy efficiency requirements utilize a Combined Energy Factor (CEF) metric as required by California and Federal Regulations. Minimum qualifying measure efficiencies were set based on the lowest

1 U.S. Environmental Protection Agency (EPA). 2011. *ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryers*. November.

2 U.S. Environmental Protection Agency (EPA). 2011. *ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryers*. November.

3 U.S. Environmental Protection Agency (EPA). 2011. *ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryers*. November.

4 U.S. Environmental Protection Agency (EPA). 2011. *ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryers*. November.

5 US Department of Energy. 2019. “Energy Conservation Program: Test Procedure for Clothes Dryers”. [https://www.federalregister.gov/documents/2019/07/23/2019-15208/energy-conservation-program-test-procedure-for-clothes-](https://www.federalregister.gov/documents/2019/07/23/2019-15208/energy-conservation-program-test-procedure-for-clothes-dryers) [dryers](https://www.federalregister.gov/documents/2019/07/23/2019-15208/energy-conservation-program-test-procedure-for-clothes-dryers)

6 US Department of Energy, Energy STAR. 2011. “Program Requirements Product Specification for Clothes Dryers.” [https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specifica](https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria_0.pdf) [tion%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria\_0.pdf](https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Final%20Version%201.1%20Clothes%20Dryers%20Specification%20-%20Program%20Commitment%20Criteria%20and%20Eligibility%20Criteria_0.pdf)

7 US Department of Energy, ENERGY STAR. List of Certified Products. <https://www.energystar.gov/productfinder/product/certified-clothes-dryers/>

efficiency equipment on the 2019 ENERGY STAR Efficient list[8](#_bookmark7) and exceed California Title 20 and Federal Regulations Standards (see code requirements).

Measure Case Technology Characterization

|  |  |
| --- | --- |
| Equipment | Combined Energy Factor (CEF) |
| Heat Pump Clothes Dryer, Standard Size, Any Voltage | 4.50 |
| Heat Pump Clothes Dryer, Compact Size, 120V | 4.50 |
| Heat Pump Clothes Dryer, Compact Size, 240V | 4.50 |

# BASE CASE DESCRIPTION

The base case is defined as a natural gas clothes dryer. Natural gas clothes dryers are cabinet-like appliances designed to dry fabrics in a tumble-type drum with forced air circulation. The heat source is gas and the drum and blower(s) are driven by an electric motor(s). Gas clothes dryers must be vented.

Baseline CEF draws from Federal Standard 10 CFR § 430.32(h) and can also be found in California Title 20 1605.1(q).[9](#_bookmark8)[10](#_bookmark9) Baseline equipment natural gas clothes dryers are only vented but can be either compact or standard.

Base Case Technology Characterization

|  |  |
| --- | --- |
| Equipment | Combined Energy Factor (CEF) |
| Natural Gas Clothes Dryer | 3.30 |

# CODE REQUIREMENTS

Clothes dryers do not fall under California Building Energy Efficiency Standards (Title 24).

This measure is governed by California Appliance Efficiency Standards (Title 20) and Federal Regulations.

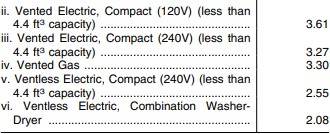
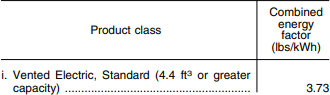
|  |  |  |
| --- | --- | --- |
| Code | Applicable Code Reference | Effective Date |
| CA Appliance Efficiency Regulations – Title 20 (2019) | Section 1605.1(q) | January 1, 2015 |
| CA Building Energy Efficiency Standards – Title 24 (2019) | N/A | N/A |
| Federal Standards | 10 CFR § 430.32(h)  10 CFR § 430.23(d) | January 1, 2011  January 1, 2015 |

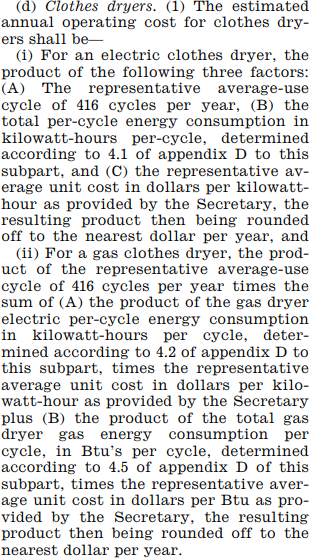
8 Southern California Edison (SCE). 2019. “SWAP014-01 DataSpec 11-7-19.xlsm”, Energy Star list tab

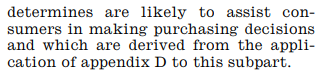
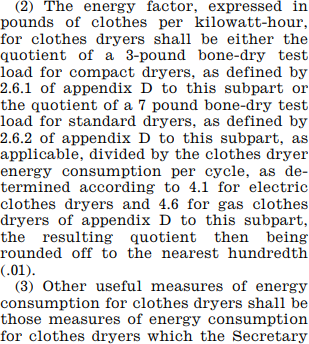
9 US Department of Energy (DOE) 10 CFR § 430.32(h)

10 California Energy Commission (CEC) Title 20 § 1605.1(q)

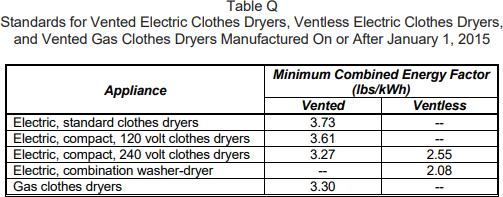
Federal Standard 10 CFR § 430.32(h) Federal Required Minimum CEF Requirements for Clothes Dryers



Federal Standard 10 CFR § 430.23(d) Test Methodology Requirements for Clothes Dryers



Title 20 1605.1(q) California State Minimum CEF Requirements for Clothes Dryers



# NORMALIZING UNIT

Each

# PROGRAM REQUIREMENTS

*Fuel Substitution Test*

Per CPUC Decision 19-08-009 Rulemaking 13-11-005 “Decision Modifying the Energy Efficiency Three- Prong Test Related to Fuel Substitution”, for all fuel substitution measures, the measure must ‘not increase total source energy consumption when compared with the baseline comparison measure available utilizing the original fuel’. Also, the measure ‘must not adversely impact the environment compared to the baseline measure utilizing the original fuel. Fuel substitution calculations were conducted using CPUC’s “Fuel Substitution Calculator” to confirm the measures in this workpaper pass Parts One and Two of the Fuel Substitution Test[11](#_bookmark10).

*Measure Implementation Eligibility*

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

*Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.*

11 Southern California Edison (SCE). 2019. “SWWH025-01 Fuel Substitution Calculator.xlsx”.

Implementation Eligibility

|  |  |  |
| --- | --- | --- |
| Measure Application Type | Delivery Type | Sector |
| Normal Replacement | DnDeemed | Res |
| Normal Replacement | DnDeemDI | Res |
| Normal Replacement | UpDeemed | Res |
| New Construction | DnDeemed | Res |
| New Construction | DnDeemDI | Res |

*Required Documentation for Normal Replacement in Upstream and Mid-Stream Delivery*

For upstream/mid-stream delivery method, the participant baselines are unknown and the spillover effects are unknown. The manufacturer or distributor doesn’t know whether the purchased measure is replacing a gas or an electric baseline appliance. Claimed savings for these delivery types will be adjusted using the ratio of baseline gas appliance to total baseline appliances. These ratios will be determined from (Residential Appliance Saturation Survey (RASS)[12](#_bookmark11). The implementer shall survey 10% of the mid-stream installations, to determine actual gas/electric baseline proportions, and the program administrator shall adjust claimed savings based upon these survey results.” This survey will be conducted monthly, by e- mail. Sample survey question is as follows:

“What was the fuel source of the equipment you replaced?”

1. Gas
2. Electric
3. I don’t know/I’m not sure

In addition, for mid-stream delivery method, the implementer should provide the retailer or distribution location where the product was sold, rated capacity, and proposed building type where the product will be installed (single family, multi-family or mobile homes).

A survey will not be issued for upstream delivery method.

*Required Documentation for Normal Replacement and New Construction in Downstream and Direct Install Delivery*

For downstream deemed and downstream direct-install delivery types, in addition to the standard information such as building type, climate zone, and capacity of the units, the following data must to be submitted with each project application by the project developer:

* What is the existing fuel type for the clothes dryer (electric/gas)?
* Did the site require any electric infrastructure upgrades for the proposed electrification measure? If yes, provide the itemized invoices with infrastructure upgrade costs.
* Did the owner install any other electrification measures at this site? If yes, list the measures and provide the itemized invoices with infrastructure upgrade costs (if any).

12 California Energy Commission. 2010. “2009 California Residential Appliance Saturation Study”.

*Eligible Products*

General Eligibility Requirements

Installed equipment must be an ENERGY STAR Efficient listed heat pump clothes dryer under the Energy Star Efficient Version 1.1 Specification. Measure equipment must exceed minimum efficiency requirements. Existing base equipment must be disposed.

*Eligible Building Types and Vintages*

This measure is applicable for all residential building types (single family, multifamily, and mobile homes).

*Eligible Climate Zones*

This measure is applicable in all California climate zones.

*Incentive Amounts*

Fuel substitution measures face market barriers, including consumer market failures and supplier market failures.[13](#_bookmark12) Deployment of the program may require rebates or financial incentives to participants that exceed the measure cost.[14](#_bookmark13)

# PROGRAM EXCLUSIONS

The fuel substitution measures are not eligible for replacing an existing electric resistance clothes dryer and/or an electric heat pump clothes dryer equipment.

As this is a fuel substitution measure, it is only eligible for replacement of existing gas equipment. This measure is not applicable for new construction installations. However new services, as defined in

*Fuel Substitution Technical Guidance for Energy Efficiency*, are eligible. [15](#_bookmark14) New service measures are only eligible for Downstream and Direct Install application, when:

* Measures are installed in new areas of an existing building,
* Measures are installed in a major renovation of an existing building, or
* Measures are installed in capacity expansions of existing systems to serve existing and/or new load retrofits that require a new energy service.

13 Energy+Environmental Economics. April 2019. “Residential Building Electrification in California <https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf> Consumer economics, greenhouse gases and grid impacts”.

14 Originally defined in D.92-09-080, the dual test was last modified in D.05-04-051

15 California Public Utilities Commission (CPUC), Energy Division. 2019. *Fuel Substitution Technical Guidance, Version 1.1*. October

1. Page 3.

These exceptions will follow the same baseline technology requirements as a Normal Replacement measure application type.

# DATA COLLECTION REQUIREMENTS

Baseline equipment type and fuel source must be verified.

Per CPUC Decision 19-08-009[16](#_bookmark15), building infrastructure costs which include panel upgrades or gas line installations/upgrades required to facilitate these fuel substitution measures shall be collected for all downstream measures.

Per Fuel Substitution Technical Guidance Energy Efficiency, program administrators sponsoring fuel substitution measures should be required to track the instances of building infrastructure upgrades (such as electrical panels and natural gas lines) associated with installation of fuel substitution measures.

Approaches to this data collection should be designed in consultation with Commission staff and the data should be included in energy efficiency annual reports.

# USE CATEGORY

Appliance

# ELECTRIC SAVINGS (kWh)

Energy savings methodology is adopted from Statewide Workpaper ‘SWAP003-01’ Clothes Dryer, Residential. Measure case Combined Energy Factor (CEF) will be drawn from ENERGY STAR Certified Most Efficient Clothes Dryers list (2019) for heat pump clothes dryers.[17](#_bookmark16)

Unit energy savings (UES) is calculated as the difference between the baseline and measure case unit energy consumption (UEC). It is expressed in kWh.

UES = (UECbaseline − UECmeasure)

Factors that affect the UEC of a residential clothes dryer include the efficiency of the dryer, represented by combined energy factor (CEF), the number of cycles per year that the dryer operates, the moisture content of the clothing, and the weight of the clothing dried per cycle.

UEC = �

(cycles × C [lbs])

lbs

× RMCred�

(CEF [ ])

kWh

CEF = Combined Energy Factor [lbs/kwh]

C = Weighting of clothing per cycle in pounds [lbs]

16 California Public Utilities Commission (CPUC). 2019. “Decision 19-08-009 Rulemaking 13-11-005 Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution”. August 1.17 Energy Star Certified Products. 2019. <https://www.energystar.gov/productfinder/product/certified-clothes-dryers/>

17 Energy Star Certified Products. 2019. <https://www.energystar.gov/productfinder/product/certified-clothes-dryers/>

RMCred = Ratio of remaining moisture contents

Cycles are expressed per year for either standard or compact dryers. C is the weight of clothing per cycle for the standard or compact dryer. Combined energy factor (CEF) is the weight of clothing per cycle per total energy usage for the standard or compact dryer. Total energy usage is the combination of the active mode energy usage and the standby energy usage.

CEF =

C [lbs]

�EActive Cycle + EStandby�

EActive Cycle = Dryer energy during active drying cycle EStandby = Standby dryer energy

Remaining moisture content (RMCred) is the result from the remaining moisture content of the clothes prior to drying (RMCw,D2), the remaining moisture content of clothes after drying (RMCd,D2), and the remaining moisture content of the clothes washed in an ENERGY STAR washer (RMCw,EnergyStar).

RMC

red

= RMCw,D2 − RMCd,D2

RMCw,EnergyStar − RMCd,D2

RMCw,D2 = Remaining moisture content after washing machine from DOE Appendix D Test Procedure RMCd,D2 = Remaining moisture content after dryer from DOE Appendix D Test Procedure

RMCw,Energy Star = Remaining moisture content after washing machine for EnergyStar compliant washers

The inputs to the dryer calculations are specified below.

|  |  |  |
| --- | --- | --- |
| Performance Input | Value | Source |
| Cycles Per Year – Standard Dryer | 283 | U.S. Department of Energy (DOE). 2011. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment – Residential Clothes Dryers and Room Air Conditioners.* Prepared by Navigant Consulting, Inc.  and Lawrence Berkeley National Laboratory. |
| Cycles Per Year – Compact Dryer | 251 | U.S. Department of Energy (DOE). 2012. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers*. Prepared by Navigant Consulting, Inc. and Ernest Orlando Lawrence  Berkeley National Laboratory. |
| Weight of Clothing Per Cycle – Standard Dryer | 8.45 | U.S. Department of Energy (DOE). 2012. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers*. Prepared by Navigant Consulting, Inc. and Ernest Orlando Lawrence  Berkeley National Laboratory. |
| Weight of Clothing Per Cycle – Compact Dryer | 3.00 | U.S. Department of Energy (DOE). 2012. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers*. Prepared by Navigant Consulting, Inc. and Ernest Orlando Lawrence  Berkeley National Laboratory. |
| RMCw,D2 | 57.5% | Code of Federal Regulations at 10 CFR 430, Appendix  D2 |

|  |  |  |
| --- | --- | --- |
| RMCd,D2 | 1.75% | Code of Federal Regulations at 10 CFR 430, Appendix D2 |
| RMCw,ENERGY STAR | Standard: 35%  Compact: 38% | U.S. Department of Energy (DOE). 2012. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers*. Prepared by Navigant Consulting, Inc. and Ernest Orlando Lawrence  Berkeley National Laboratory. |
| Percent of Compact Dryers Paired with Compact or Standard Washers | Standard: 27.6%  Compact: 72.4% | Hamilton, M. and A. Salazar (EMI Consulting, Inc.). 2016. “2016 PG&E Retail Products Platform (RPP) – Clothes Dryer Research Results.” Memorandum for Pacific Gas & Electric. December 30. |

Remaining Moisture Content (RMC). As per the disposition of the California Public Utilities Commission (CPUC) Energy Division issued on December 15, 2015, pending additional evaluation of the efficiency washers paired with dryers, savings calculations assume that the remaining moisture content prior to drying the load is equal to the remaining moisture content of a load washed in an ENERGY STAR clothes washer that meets the lowest current ENERGY STAR criteria.[18](#_bookmark17) Subsequently, in December 2016, EMI Consulting, under contract with PG&E, published a memo presenting research on the topic. In particular, a survey of residential customers in the PG&E service territory found that each ENERGY STAR clothes dryer in the study sample was paired with an ENERGY STAR clothes washer.[19](#_bookmark18) According to the 2012 DOE Technical Support Document for residential clothes washers, the use of a 2016 ENERGY STAR-rated clothes washer results in a remaining moisture content of approximately 35% for standard sized washers and 38% for compact washers.[20](#_bookmark19) For compact clothes dryers, the RMCred value is weighted between the values for both Standard and Compact Washers to account for the percent of compact dryers paired with each washer type.

Gas Baseline UEC is initially calculated in the units of kWh as described in the UEC equations above. Gas dryers consume mainly natural gas but also use some electrical energy for equipment like motors, fans, and controls. To account for this, the electrical energy consumption of the gas dryers was estimated in the following way:

* + Based on the ENERGY STAR Market and Industry Scoping Report for Residential Clothes Dryers[21](#_bookmark20) dryer motors rotate both the fans and drums and draw between 200 to 300 watts typically. This analysis uses an average value of 250 watts for the motor and assumes that the motor accounts for all the electrical consumption for gas dryers.
  + Using cycle length (minutes) from ENERGY STAR and average power of 250 watts, the estimated energy (kWh) per cycle is found for all products in the ENERGY STAR list. The total motor energy

18 California Public Utilities Commission (CPUC), Energy Division. 2015. “Workpaper Disposition for PGECOAPP128 Revision 0 Retail Products Platform.” December 15. Page 2.

19 Hamilton, M. and A. Salazar (EMI Consulting, Inc.). 2016. “2016 PG&E Retail Products Platform (RPP) – Clothes Dryer Research Results.” Memorandum for Pacific Gas & Electric. December 30.

20 US Department of Energy (DOE). 2012. *Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers.* Prepared by Navigant Consulting, Inc. and Ernest Orlando Lawrence Berkeley National Laboratory. Table 7.2.1.

21 US Environmental Protection Agency (EPA). 2011. “ENERGY STAR Market & Industry Scoping Report Residential Clothes Dryers”. Table 2.

per year is found by multiplying the energy per cycle by the number of cycles per year for each dryer based on its size (compact or standard).

* + The total motor energy per year is divided by the ENERGY STAR Estimated Annual Energy Use for each product to find the percentage of energy used by the motor. An average value of 11% was found for all gas dryers on the list.
  + The 11% of total energy use was subtracted from the baseline dryers UEC prior to converting from kWh to therms to separate out the electrical and gas consumption.

See the table below for baseline Gas Consumption and refer to the energy calculations for more details on the analysis[22](#_bookmark21).

Baseline Unit Energy Consumption without HVAC IE

|  |  |  |  |
| --- | --- | --- | --- |
| Type | CEF | Unit Electrical Energy (kWh) | Unit Gas Energy (Therms) |
| Gas Dryer, Any Size, Vented | 3.30 | 46.77 | 12.69 |

Measure Heat Pump Clothes Dryer UEC calculations assume the same CEF across vented and ventless, 120V and 240V, and standard and compact heat pump clothes dryers within the ENERGY STAR list for Most Efficient products. For each instance the measure case UECs were calculated:

Measure Unit Energy Consumption without HVAC IE

|  |  |  |
| --- | --- | --- |
| Type | CEF | kWh |
| Heat Pump Clothes Dryer, Standard Size, Any Voltage | 4.50 | 316.94 |
| Heat Pump Clothes Dryer, Compact Size, Ventless 120V | 4.50 | 106.32 |
| Heat Pump Clothes Dryer, Compact Size, Ventless 240V | 4.50 | 106.32 |

HVAC Interactive effects are applied to energy use that occurs within a conditioned space and are not applied to energy use that occurs in unconditioned spaces. The updated UES values based on HVAC IE are weighted based on the percent of dryers located in conditioned and unconditioned spaces[23](#_bookmark22). The UES values were adjusted for interactive effects using the DEER internal gain fractions shown below.

Interactive effects apply in full to the UES of ventless dryers and to 20% of the UES of vented dryers. The factor of 20% was adopted from the Database of Energy Efficient Resources (DEER) values for the internal gain fractions for residential appliances.

Because interactive effects factors specific to clothes dryers were not available, HVAC interactive effects factors for screw-in lamps were applied to the clothes dryer measure savings. Interactive effects were drawn from DEER2020-Res-InLtg Res-Indoor-Screw interactive effects table for existing vintage, residential building types for all climate zones. As the lighting HVAC IE are based on electrical impact values (kWh), the UES values used to calculate the HVAC interactive effects are calculated using UES in kWh per year. The HVAC IE is then added to the relevant UES for each fuel (kWh and therms).

22 Southern California Edison. “SWAP014-01 MeasureDataSpec 10-25-19.xls”.

23 Hamilton, M. and A. Salazar (EMI Consulting, Inc.). 2016. “2016 PG&E Retail Products Platform (RPP) – Clothes Dryer Research Results.” Memorandum for Pacific Gas & Electric. December 30.

Application of Interactive Effects

|  |  |  |
| --- | --- | --- |
| Dryer Location | % of Dryers | Source |
| Conditioned Space | 66.1% | Hamilton, M. and A. Salazar (EMI Consulting, Inc.). 2016. “2016 PG&E Retail Products Platform (RPP) – Clothes Dryer Research Results.” Memorandum for Pacific Gas & Electric. December 30. |
| Unconditioned Space | 33.9% |

DEER Internal Gain Fractions of Clothes Dryers[24](#_bookmark23)

|  |  |  |  |
| --- | --- | --- | --- |
| Dryer Fuel Type | Internal Gains | | |
| Sensible | Latent | Total Heat Gains |
| Clothes Dryer - Electric | 0.15 | 0.05 | 0.20 |

# DEMAND REDUCTION (KW)

In accordance with the requirements of the CPUC Fuel Substitution Technical Guidance, for Energy Efficiency, October 31, 2019, there will not be any peak demand reduction or penalty towards peak demand goal achievement from fuel substitution measures.[25](#_bookmark24)

# GAS SAVINGS (THERMS)

Methodology for calculation of Therms savings is the same as the calculation of electric savings [kWh]. However, the UEC calculation inputs are different and are listed below.

|  |  |  |
| --- | --- | --- |
| Performance Input | Value | Source |
| Cycles Per Year – Standard Dryer | 274 | US Department of Energy (DOE). 2011. Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment – Residential Clothes Dryers and Room Air Conditioners. Prepared by Navigant Consulting, Inc.  and Lawrence Berkeley National Laboratory. |
| Weight of Clothing Per Cycle - Standard | 8.45 | US Department of Energy (DOE). 2012. Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers. Prepared by Navigant Consulting, Inc. and Ernest Orlando Lawrence  Berkeley National Laboratory. |
| RMCw,D2 | 57.5% | Code of Federal Regulations at 10 CFR 430, Subpart B, Appendix D2 |
| RMCd,D2 | 1.75% | Code of Federal Regulations at 10 CFR 430, Subpart B,  Appendix D2 |
| RMCw,ENERGY STAR | 35% | US Department of Energy (DOE). 2012. *Technical Support Document: Energy Efficiency Program for*  *Consumer Products and Commercial and Industrial* |

24 California Public Utilities Commission (CPUC), Energy Division. 2015. “Workpaper Disposition for PGECOAPP128 Revision 0 Retail Products Platform.” December 15. Page 5.

25 California Public Utilities Commission. 2019. “Fuel Substitution Technical Guidance for Energy Efficiency”.

|  |  |  |
| --- | --- | --- |
|  |  | *Equipment: Residential Clothes Washers*. Prepared by Navigant Consulting, Inc. and Ernest Orlando Lawrence  Berkeley National Laboratory. |

HVAC Interactive in conditioned spaces have a therms impact as well. These impacts are calculated similar to the electric energy HVAC IE. Refer to the HVAC electric energy section for details.

# LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

Effective Useful Life (EUL) and Remaining Useful Life (RUL) for clothes dryers are available in DEER.

Effective Useful Life and Remaining Useful Life

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | EUL ID | Value | Source |
| EUL (yrs) | Appl-EffCD | 12.0 | Appliance Magazine. 2013. “The U.S. Appliance Industry: Market Value, Life Expectancy & Replacement Picture 2013.” January. Page 9.  California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update\_2014-02-05.xlsx.” |
| RUL (yrs) | Appl-EffCD | 4.0 | California Public Utilities Commission (CPUC). 2014. “DEER2014-EUL-table-update\_2014-02-05.xlsx.” |

# BASE CASE MATERIAL COST ($/UNIT)

Base case costing was obtained through online price research from various retailer websites in the fourth quarter of 2019. As the baseline represents any existing standard efficiency gas dryer, costing was standardized by excluding only ENERGY STAR qualified natural gas clothes dryers. See cost spreadsheet for additional details.[26](#_bookmark25)

Standardized Baseline Cost

|  |  |  |
| --- | --- | --- |
| Technology | Standardized Average NGCD Cost | Sample Count |
| Natural Gas Clothes Dryer (NGCD) | $869.14 | 205 |

26 Southern California Edison (SCE). 2019. “SWAP014-01 Clothes Dryer Pricing.xlsx”.

# MEASURE CASE MATERIAL COST ($/UNIT)

Heat pump clothes dryers were based on approved equipment in the ENERGY STAR Most Efficient 2019 listings. Clothes dryers that comprise these listings are the best in class for energy savings. Measure case costing for these heat pump clothes dryers was obtained through online price research from various retailer websites in the fourth quarter of 2019. Sample size of the measure case is significantly smaller than the base case due to the lower number of appliances that make the ENERGY STAR Most Efficient listings. See cost spreadsheet for additional details.[27](#_bookmark26)

Standardized Measure Cost

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Technology | Size | Voltage | Average HPCD Cost | Sample Count |
| Heat Pump Clothes Dryer (HPCD) | Compact | 120 | $1,399.00 | 6 |
| Heat Pump Clothes Dryer (HPCD) | Compact | 240 | $1,248.08 | 28 |
| Heat Pump Clothes Dryer (HPCD) | Standard | Any | $1,507.63 | 14 |

Infrastructure Costs. For a natural gas dryer to heat pump dryer conversion infrastructure upgrades would include a capping off the natural gas line, closing vents if measure case is unvented, and possibly the addition of a 208/240 power outlet. Existing gas dryers will likely already be using a 120V outlet, so outlet costs are only applicable to measure cases which do not use 120V power. These infrastructure costs were estimated using RSMeans Online data[28](#_bookmark27) and online retailer costs. RSMeans hourly labor rates for a residential electrician[29](#_bookmark28) were used to estimate labor costs. See the table below for details and the cost calculations for more details.[30](#_bookmark29)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description of Work | Labor Hours | Labor Cost | Material Cost | Total Cost |
| Cap Existing Gas Line w/ Brass Plug for Natural Gas lines. | 0.250 | $16.89 | $4.00 | $20.89 |
| Demolish Existing Vent | 0.727 | $49.11 | $0.00 | $49.11 |
| Dryer outlet, 30 amp-240 volt receptacle, 20' of wiring | 1.401 | $94.64 | $63.50 | $158.14 |
| Total cost | 2.378 | $160.63 | $67.50 | $228.13 |

27 Southern California Edison (SCE). 2019. “SWAP014-01 Clothes Dryer Pricing.xlsx”.

28 2019 RSMeans Electrical Cost Data

29 RSMeans Residential Labor Rates, https://[www.rsmeansonline.com/References/LABORRATE/2-](http://www.rsmeansonline.com/References/LABORRATE/2-) Year%202019%20Labor%20Rates/Residential%20Labor%20Rates.PDF , “Residential Labor Rates.pdf”

30 Southern California Edison. “SWAP014-01 Pricing 10-24-19.xlsx”

# BASE CASE LABOR COST ($/UNIT)

For all delivery types, an electric model does not require additional installation labor compared to a base case gas model. Base case and measure case model installation costs are expected to be the same for the customer and thus is not estimated for the incremental cost analysis. Though infrastructure costs should still be considered.

# MEASURE CASE LABOR COST ($/UNIT)

For all delivery types, an electric model does not require additional installation labor compared to a base case gas model. Base case and measure case model installation costs are expected to be the same for the customer and thus is not estimated for the incremental cost analysis. Though infrastructure costs should still be considered.

# NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. The NTG for fuel substitution measures was stipulated in Decision 19-08-009, *Decision Modifying the Energy Efficiency Three-Prong Test Related to Fuel Substitution,* issued by the California Public Utilities Commission (CPUC).[31](#_bookmark30) “When a fuel substitution measure passes the Fuel Substitution Test, it shall be included in the cost-effectiveness analysis of the portfolio with a net-to-gross (NTG) ratio assumption of 1.0, until such time as evaluated NTG information is available, when the assumption shall be updated on a prospective basis.”

Net-to-Gross Ratios

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Source |
| NTG – ID FuelSubst-Default | 1.0 | California Public Utilities Commission. 2019. Decision 19- 08-009. And  California Public Utilities Commission. 2019. Fuel Substitution Technical Guidance for Energy Efficiency. |

# GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method.

Gross Savings Installation Adjustment Rates

|  |  |  |
| --- | --- | --- |
| Parameter | GSIA | Source |
| Def-GSIA | 1.0 | California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy*  *Efficiency Policy Manual Version 5*. Page 31. |

31 California Public Utilities Commission (CPUC). 2010. *Decision 19-08-009 in the Order Instituting Rulemaking Concerning Energy Efficiency Rolling Portfolios, Policies, Programs, Evaluation, and Related Issues (R.13-11-005).* Issued August 5. OP 1.

# DEER DIFFERENCES ANALYSIS

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

DEER Difference Summary

|  |  |
| --- | --- |
| DEER Item | Comment / Used for Workpaper |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | N/A |
| Reason for Deviation from DEER | DEER 2019/2020 database does not include heat pump clothes dryer measures |
| DEER Measure IDs Used | N/A |
| NTG | Source: DEER. The NTG of 1.0 is associated with NTG ID: FuelSubst-Default |
| GSIA | Source: DEER. The GSIA of 1.0 is associated with GSIA ID: *Def-GSIA* |
| EUL/RUL | Source: DEER. EUL of 12 and RUL of 4. EUL\_ID: Appl-EffCD |

# REVISION HISTORY

Measure Characterization Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision Number | Date | Primary Author, Title, Organization | Revision Summary and Rationale for Revision Effective Date and Approved By |
| 01 | 11/8/19 | Brandon Yamasaki, TRC | First draft of workpaper. |
| 5/1/20 | Jesse Manao, SCE | * Fixed ElecImpactProfile misspelling in Energy Impact tab. * Added PGE & SCG Implementation IDs in Implementation tab. * Modified InstallHours and LaborRate in Cost tab from "0" to Blank. |
|  | 11/30/2021 | Akhilesh Endurthy, Solaris-Technical, LLC. | Addendum to report refrigerant avoided cost calculations in compliance with Resolution E-5152. |