Work Paper WPSCGREAP080718A

**Revision 0**

**Southern California Gas Company**

**Residential Ozone Laundry Retrofits**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | TBD |
| **Measure Description** | Installation of an ozone generator system on an existing or new residential clothes washer for single-family or multi-family (in unit) applications |
| **Base Case Description** | Residential clothes washer meeting the January 1, 2018 federal appliance standards (standard >1.6 cu.ft., top load: IMEF 1.57, IWF 6.5 front load: IMEF 1.84, IWF 4.7).[[1]](#endnote-1)  Applicable for both existing equipment and code/standard equipment, with energy savings projected above code/standard equipment. |
| **Units** | Each |
| **Energy Savings** | *Single-Family*   * Gas Water Heater: 4.0 Th/yr. savings (range of 3.1-4.6 Th/yr.), -1.4 kWh/yr. savings, 0.000 kW savings * Electric Water Heater: 0.0 Th/yr. savings, 91 kWh/yr. savings (range of 70-105 kWh/yr.), 0.012 kW savings (range of 0.010-0.014 kW)   *Multi-Family (In-Unit)*   * Gas Water Heater: 3.0 Th/yr. savings (range of 2.3-3.5 Th/yr.), -1.0 kWh/yr. savings, 0.000 kW savings * Electric Water Heater: 0.0 Th/yr. savings, 68 kWh/yr. savings (range of 53-79 kWh/yr.), 0.009 kW savings (range of 0.007-0.011 kW)   Refer to Excel Calculation Attachment for full energy savings by Climate Zone (affected by mains temperature) |
| **Full Measure Cost ($/unit)** | Estimated $300 per unit |
| **Incremental Measure Cost ($/unit)** | Estimated $300 per unit, retrofit measure |
| **Effective Useful Life** | Estimated 10 years EUL based on similar underlying ozone generator technology for commercial version (PGECOAPP123 R6, August 2017)[[2]](#endnote-2) |
| **Measure Installation Type** | New Construction (NC), Add-on Equipment (AOE) |
| **Net-to-Gross Ratio** | 0.70 (DEER NTGR ID: All-Default<=2yrs) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 12/19/2018 | Jim Young (Navigant Consulting, Inc.) | Original work paper |
|  |  |  |  |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Installation of an ozone generator system on an existing or new residential clothes washer for single-family or multi-family (in unit) applications |
| Existing Condition | N/A |
| Code/Standard | Residential clothes washer meeting the January 1, 2018 federal appliance standards (standard >1.6 cu.ft., top load: IMEF 1.57, IWF 6.5 front load: IMEF 1.84, IWF 4.7).i  Applicable for both existing equipment and code/standard equipment, with energy savings projected above code/standard equipment. |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  |  |  | Residential Ozone Laundry Retrofit (Gas) |
|  |  |  |  | Residential Ozone Laundry Retrofit (Electric) |

*Measure Requirements*

* **Eligibility requirements**: The clothes washer must be designed for residential use only, with a volume ≥ 1.6 cubic feet. The household must have a water heater using natural gas or electricity energy source.
* **Implementation and installation requirements**: Applicable for single-family and multi-family (in unit) building segments; Not applicable for multi-family (common area). No more than one unit can be rebated per household.
* **Documentation requirements:** Proof of purchase must be provided and include all the following:
  + **Ozone Laundry System:** manufacturer’s name and equipment make and model number for ozone system, retailer information, equipment cost, and invoice/receipt with payment in full,
  + **Clothes Washer:** Manufacturer’s name and equipment make and model number for clothes washer.

## 1.2 Technical Description

Ozone laundry systems are a retrofit equipment package that is added to new or existing residential clothes washing appliances. The system can effectively clean clothes without the use of hot water or detergents, and this can provide significant energy and cost savings to households by decreasing the associated water heating energy consumption and purchase of laundry detergents, bleach, fabric softener, and other consumables. Reducing the amount of consumed laundry detergents and related products provides the primary economic benefits for consumers, with energy savings providing a modest benefit.

The ozone laundry system installs on a wall near the clothes washer and connects with the cold-water inlet hose for the clothes washer. The on-board ozone generator converts oxygen (O2) into ozone (O3), which is mixed and diffused into the inlet water supply for the clothes washer. The ozone generator carries a very small electricity consumption during operation, estimated less than 2 kWh per year. The ozone cleans clothing by chemically reacting with soils in cold water, breaking down the soils into smaller molecules that become water soluble, and then released by the linen through normal washer cycle agitation. Any remaining ozone naturally converts back into regular oxygen, and localized ozone concentrations remain below prescribed safety levels. Ozone systems are suitable for cleaning clothing after everyday use or light stains, and require pre-treatment or detergents for heavily stained clothes.

Commercial customers with on-premise laundry facilities (e.g., hotels, fitness centers, healthcare facilities) have successfully employed the technology for several years [PGECOAPP123 R6, August 2017]ii, and IOUs have offered third-party energy efficiency programs for commercial customers. The market for ozone laundry technology is less mature for residential applications, with several small vendors offering products in recent years. In 2015-2016, the Gas Technology Institute (GTI) conducted a demonstration of a residential ozone laundry systems in 12 Nicor Gas customers’ homes in Illinois, followed by a second round of field testing in subsequent years. This work paper uses data collected from the 2015-2016 field testing as the basis for the unit energy savings estimate (50% hot water savings, range of 0-100%), applied to code/standard residential clothes washers. These savings are varied by the 16 California climate zones and water heater type (natural gas, electricity).

This is an emerging technology (ET) with limited performance history as part of utility energy efficiency programs for the residential market.

## 1.3 Installation Types and Delivery Mechanisms

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |
| Add-on Equipment (AOE) | Above Customer Existing | N/A | EUL | N/A |

This measure is identified as AOE, Add-on Equipment with an assumed code/standard baseline from latest federal appliance standard (January 1, 2018) for standard (>1.6 cu.ft.) residential clothes washersi, with a weighted average of top and front load models from CLASS.[[3]](#endnote-3)

* Top load: IMEF 1.57, IWF 6.5
* Front load: IMEF 1.84, IWF 4.7.

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| New Construction | The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential). |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Direct Install | The program implements energy efficiency measures for qualifying customers, at no cost to the customer. |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Up-Stream Incentive | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, to encourage the manufacture, provision, or distribution of an efficient measure. The incentive may or may not be passed on to the end-use customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | No |
| DEER Operating Hours | No |
| DEER Request Prototypes | No |
| DEER Version | No |
| Reason for Deviation from DEER | DEER does not contain this type of measure. Savings calculation based on calculations in support of federal appliance standards, and energy savings results from field testing. |
| DEER Measure IDs Used | None |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| All-Default<=2yrs | All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years | Res | Any | Any | 0.70 |

This is an emerging technology with limited performance history as part of utility energy efficiency programs for the residential market. IOUs have offered ozone laundry programs for commercial customers for several years [PGECOAPP123 R6, August 2017)ii and no programs to date have targeted the residential market. This will be a new technology with no previous history in IOU programs.

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

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

**Effective and Remaining Useful Life**

Limited information exists on the longevity of residential ozone laundry systems. This work paper estimates a 10 years EUL based on similar underlying ozone generator technology for commercial version (PGECOAPP123R6, August 2017).ii The ozone laundry system can be installed across multiple clothes washer lifetimes (DEER estimate of 11-year EUL, 3.7-year RUL).[[4]](#endnote-4)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| OzoneGen | Residential Ozone Laundry Retrofit | Res | AppPlug | 10 | N/A |

### 1.4.2 Codes and Standards Analysis

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 20 (2018)[[5]](#endnote-5) | Section 1605.1, Table P-2: Standards for Residential Clothes Washers | January 1, 2018 |
| DOEi | Code of Federal Regulations, 10 CFR 430.32(g)(4) | January 1, 2018 |

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

The California Appliance Efficiency Regulations (Title 20) require that all residential clothes washers manufactured on or after the dates indicated below must meet the minimum efficiency requirements for IMEF and IWF.v

|  |  |  |  |
| --- | --- | --- | --- |
| **Residential Clothes Washers** | **Clothes Container Compartment Capacity (ft3)** | **Minimum Integrated Modified Energy Factor**  **(Effective January 1, 2018)** | **Maximum Integrated Water Factor  (Effective January 1, 2018)** |
| **Standard Top-Loading  Clothes Washers** | ≥ 1.6 ft3 | 1.57 | 6.5 |
| **Standard Front-Loading  Clothes Washers** | ≥ 1.6 ft3 | 1.84 | 4.7 |

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

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

### 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information1.5.1 2012 California Lighting and Appliance Saturation Study (CLASS)iii

This measure is applicable for both top-load and front-load clothes washers, with front-load clothes washers generally offering lower energy and water consumption. California and federal appliance standards define separate efficiency baselines by clothes washer type (Section 1.4.2), and the energy savings of this measure is directly related to the assumed baseline efficiency. The 2012 California Lighting and Appliance Saturation Study (CLASS) conducted on-site observations of California homes to understand a variety of factors, including clothes washer type. The study estimated the following clothes washer market characteristics for California homeowners: 27.2% horizontal axis (front-load), 67.9% standard (top-load), and 4.8% stacked (assumed top-load). Stacked washers are assumed to be combination or stacked washer-dryer models, which are designed for closets or narrow areas, and typically have top-load clothes washer directly connected to a clothes dryer. The energy calculation section applies a weighted average for front-load and top-load clothes washers to obtain averaged values. The data is available on the CLASS Web Tool, under the question: Category 21. Washing Machine, Report Type 0.4 Type of Washer.

### 1.5.2 2015-2016 Nicor Gas Field Study and 2017 Analysis for SoCalGas

GTI monitored 12 Illinois homes in Nicor Gas territory over several months to measure clothes washer hot and cold water consumption, both before and after installing the ozone system. The host sites included a mix of front load washers and top load washers to achieve a range of approximately 10 to 40 gallons of water consumption per load. One month of baseline monitoring was completed and three or more months of monitoring with the ozone system in operation, with a few exceptions. The demonstration captured detailed information including laundry usage patterns, load size, clothes washer type and efficiency, inlet water temperatures, hot water and cold water flow rates, temperature selections, ozone generator consumption, and other factors. GTI installed the ozone laundry system and instructed the occupants on how they could modify their wash/rinse cycle selections and effectively clean their clothes. Energy savings are based on the observed difference in hot water consumption before and after installing the ozone system. The GTI-Nicor study estimates an average per-cycle hot water reduction of 50% when using the ozone system. Half of the sites achieved >90% hot water savings when using the ozone laundry system, with savings directly related to user cycle selections and habits.

GTI conducted a sensitivity analysis for SoCalGas to adapt field data from the GTI-Nicor study to the Southern California market and demographics, and evaluate the impact of different modeling scenarios that vary number of laundry cycles, inlet water temperature, savings percentage, etc. Much of the methodology and assumptions of this analysis are included in the methodology for this work paper. A copy of the analysis spreadsheet is included in the attachments, and the report for the sensitivity analysis is available upon request.[[6]](#endnote-6)

## 1.6 Data Quality and Future Data Needs

Limited data is available on the hot water savings from ozone laundry systems for residential applications, although both the underlying market and technology are well known. Clothes washer energy consumption and market characteristics are well documented as part of U.S. Department of Energy appliance standards, U.S. Environmental Protection Agency’s ENERGY STAR specification program, IOU energy efficiency programs, and other industry resources. Similarly, the core ozone generator technology is an established energy efficiency measure within commercial ozone laundry systems, with demonstrated hot water savings of 86% in the work paper PGECOAPP123 (range of 22%-100%R6, August 2017).ii

Further field research and evaluation of programs would help determine the expected energy savings percentage over a wider population for residential ozone laundry retrofits. One field test approach could combine limited on-site monitoring with a larger sample group using diary logbooks and surveys. Each participating home would receive an ozone laundry system and record their cycle settings and laundry patterns during the pre- and post-installation periods. A subset of this group would have on-site monitoring to verify the change in hot water consumption. Energy savings would be based on the observed difference in hot water consumption and cycle selections before and after installing the ozone system.

# Section 2. Calculation Methodology

Energy savings estimates for this measure are calculated through the following key components:

* Average hot water consumption per clothes washer cycle
* Annual water heater energy consumption for clothes washer hot water use
* Hot water reduction percentage of ozone system
* Annual ozone generator electricity consumption
* Peak demand savings.

The baseline energy consumption and savings values differ for single-family and multi-family homes based on the estimated clothes washer cycles per year for each segment. Full calculation details and key assumptions are contained in the attached calculation spreadsheet.

Beyond energy savings, this measure can provide significant economic cost savings to households by decreasing the purchase of laundry detergents, bleach, fabric softener, and other consumables. Reducing the amount of consumed laundry detergents and related products provides the primary economic benefits for consumers, with energy savings providing a modest benefit. The economic results are summarized below with full calculation details and key assumptions contained in the attached calculation spreadsheet.

Average Hot Water Consumption per Cycle

Discussed in Section 1.5.1, CLASS 2012 provides estimates for clothes washer market saturation: 27.2% front-load and 72.8% top-load (including stacked as top-load).iii The latest federal appliance standards for clothes washers estimates the per cycle hot water consumption for different clothes washer types and efficiency levels. Within the Life-Cycle Cost Spreadsheet for 2012 Technical Support Document "Energy and Water Use" tab[[7]](#endnote-7), the per cycle hot water consumption estimates are:

* 5.5 gal/cycle for top load washers with efficiency levels IMEF 1.57, IWF 6.5, and
* 2.0 gal/cycle for front load washers with efficiency levels IMEF 1.84, IWF 4.7.

The weighted average of these values and the CLASS market saturation estimate provides 4.5 gallons of hot water per cycle for a baseline clothes washer meeting federal and state appliance standards.

Annual Water Heater Energy Consumption

The baseline energy consumption for the clothes washer is based on the average hot water consumption per cycle (calculated above), inlet and outlet water temperature, water heater recovery efficiency, and number of annual clothes washer cycles. The equation describes the calculation methodology for natural gas and electric water heaters:

Q = Annual water heater energy consumption (Therms, kwh)

V = Volume of hot water per cycle (gallons / cycle)

ρ = Density of water (lbs / gallon) – 8.34 lbs/gal

c = Specific heat of water (Btu/lb-°F) – 1.0 Btu/lb-°F

T\_out = Outlet temperature from water heater (°F) – 124.2 °F

T\_in = Inlet temperature to water heater (°F) – Varies with climate zone, range 51.4 °F to 75.5 °F

η = Water heater recovery efficiency (%) – natural gas 77%, electric 98%

N = Annual clothes washer cycles (cycles / year) – 258 cycles / year for single-family, 194 for multi-family (in-unit)

f = Conversion factor to final energy consumption – natural gas: 100,000 Btu per 1 Therm, electricity: 3,412 Btu per 1 kWh

The volume of hot water per cycle is calculated in the previous subsection. Outlet temperature assumption based on DOE 2014 residential water heater test procedure final rule.[[8]](#endnote-8) Inlet temperature estimates based on annual average mains water temperature by climate zone in DEER. The water heater recovery estimates for natural gas and electric water heaters use assumptions within DEER. The annual clothes washer cycle estimates of 258 cycles/year for single-family and 194 cycles/year for multi-family (in-unit) based on U.S. Energy Information Administration (EIA) 2015 Residential Energy Consumption Survey (RECS) data.[[9]](#endnote-9) The remaining assumptions are engineering constants.

Hot Water Reduction Percentage of Ozone System

Discussed in Section 1.5.2, the GTI-Nicor data suggests that users with an ozone laundry system reduce per-cycle hot water use by 50% compared to baseline clothes washer operations. The water heating energy savings are found by multiplying the annual water heater energy consumption by this 50% value.

Annual Ozone Generator Electricity Consumption

The ozone system uses a small amount of electricity to generate ozone for use during the wash cycle. The GTI-Nicor data recorded ozone generator electricity consumption during the monitoring period, and estimated 5.3 Wh/cycle. This value projects to 1.4 kWh/year assuming 258 cycles/year for single-family homes.

Peak Demand Savings

The peak demand savings (kW) for residential ozone laundry systems is directly related to the annual electricity savings (kWh), as shown in the equation below. The coincident demand factor (CDF) of 0.05 assumes the estimate within the ENERGY STAR clothes washer work paper (PGECOAPP127 R4, December 2017)iv based on DOE Building America research.

= Peak demand savings (kW)

= Annual electricity savings (kWh)

CDF = Coincident demand factor – 0.05

Average Annual Energy Savings

The Excel Calculation Attachment provides the calculated energy savings by climate zone (affected by mains temperature) and water heater type (natural gas, electric). The values below represent simple averages and range of natural gas and electricity savings across climate zones assuming 50% hot water reduction:

*Single-Family*

* Gas Water Heater: 4.0 Th/yr. savings (range of 3.1-4.6 Th/yr.), -1.4 kWh/yr. savings, 0.000 kW savings
* Electric Water Heater: 0.0 Th/yr. savings, 91 kWh/yr. savings (range of 70-105 kWh/yr.), 0.012 kW savings (range of 0.010-0.014 kW)

*Multi-Family (In-Unit)*

* Gas Water Heater: 3.0 Th/yr. savings (range of 2.3-3.5 Th/yr.), -1.0 kWh/yr. savings, 0.000 kW savings
* Electric Water Heater: 0.0 Th/yr. savings, 68 kWh/yr. savings (range of 53-79 kWh/yr.), 0.009 kW savings (range of 0.007-0.011 kW)

**Economic Benefits**

The annual economic benefits for this measure include both energy savings from hot water reduction and decreased use of laundry detergent and other consumables. The table below summarizes the calculated annual cost savings and simple payback for this measure for single-family homes, with full details contained in the Excel Calculation Attachment. This analysis uses statewide residential energy cost estimates from EIA for 2017, and laundry consumable estimates from Jet.com based on an average per load cost from major brands (July 2018). Measure cost of $300 based on review of major online retailers for the PureWash Pro product (July 2018).

Annual Cost Savings and Simple Payback

|  |  |  |  |
| --- | --- | --- | --- |
| **Water Heater Type - Benefits Type** | **Measure Cost** | **Annual Cost Savings** | **Simple Payback** |
| Natural Gas - Energy Only | $300 | $4.59 | > EUL |
| Natural Gas - Energy + Detergent | $300 | $44.05 | 6.8 |
| Electricity - Energy Only | $300 | $17.23 | > EUL |
| Electricity - Energy + Detergent | $300 | $56.69 | 5.3 |

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

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

# Section 4. Costs

## 4.1 Base Case Cost

Since this is a AOE measure, the base case cost is zero.

## 4.2 Measure Case Cost

Estimated measure case cost of $300.00 based on review of major online retailers for the PureWash Pro product (Accessed July 2018). Online retailers advertise prices ranging from $269.00 to $300.00, with MRSP of $349.00. The ozone laundry system is designed for do-it-yourself (DIY) installation, and requires mounting the integrated unit, plugging in a power cord, and attaching the cold water inlet hose for the clothes washer (similar to a garden hose). Due to this design, there is no data to support a cost of labor to install. The measure labor cost is assumed to be zero. The Excel Calculation Attachment summarizes the available cost information for this measure.

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| AOE | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| NEW/NC | $300 | $300 | N/A |
| AOE | $300 | $300 | N/A |

# Attachments

Attachment A - Res Ozone Laundry Retrofit Measure Upload Sheet 08-23-18.xlsx.

Attachment B - GTI-Nicor-Residential Ozone Summary Calcs – 08-23-18.xlsx

Attachment C - DEER-WaterHeater-Calculator TMains.xlsx (Mains Water temperature by Climate Zone and Month, CZ2010 weather files for 2013 Title-24)

# References

1. Code of Federal Regulations Title 10: Energy, Part 430 – Energy Conservation Program for Consumer Products, Subpart C – Energy and Water Conservation Standards., 10 CFR 430.32(g)(4). Accessed July 26, 2018. Retrieved from <https://www.ecfr.gov/cgi-bin/text-idx?SID=86e70cbc87e5af18caca2e5c205bd107&mc=true&node=se10.3.430_132&rgn=div8> [↑](#endnote-ref-1)
2. Ozone Laundry Nonresidential Work Paper (PGECOAPP123 R6, August 2017) [↑](#endnote-ref-2)
3. DNV GL. 2012 California Lighting and Appliance Saturation Survey (CLASS). CLASS Web Tool. Accessed July 2018. Retrieved from <https://webtools.dnvgl.com/projects62/Default.aspx?tabid=190> [↑](#endnote-ref-3)
4. Residential ENERGY STAR Clothes Washer Work Paper (PGECOAPP127 R4, December 2017) [↑](#endnote-ref-4)
5. California Energy Commission, Title 20. Public Utilities and Energy, Division 2. State Energy Resources Conservation and Development Commission, Article 4. Appliance Efficiency Regulations. May 2018. CEC-140-2018-002. Retrieved from <http://www.energy.ca.gov/2018publications/CEC-140-2018-002/CEC-140-2018-002.pdf> [↑](#endnote-ref-5)
6. Scott, S., Sweeny, M. (2017, August 9). Analysis of Residential Ozone Technology in Southern California. Prepared for Navigant Consulting, Inc. on behalf of SoCalGas. Available upon request. [↑](#endnote-ref-6)
7. U.S. DOE. Residential Clothes Washer Rulemaking. Life-Cycle Cost Spreadsheet for 2012 Technical Support Document. "Energy and Water Use" tab. Posted July 6, 2012. Accessed July 2018. Retrieved from <https://www.regulations.gov/document?D=EERE-2008-BT-STD-0019-0044> [↑](#endnote-ref-7)
8. U.S. DOE. Residential and Commercial Water Heaters Test Procedures Rulemaking. Final Rule 10 CFR Part 430, RIN 1904-AC53. Posted June 2014. Accessed July 2018. Retrieved from <https://www.energy.gov/sites/prod/files/2014/06/f17/rwh_tp_final_rule.pdf> [↑](#endnote-ref-8)
9. U.S. EIA. 2015 RECS Survey. Table HC3.1 Appliances in U.S. homes by housing unit type, single-family detached and apartment (5 or more unit building). Updated May 2018. Retrieved from <https://www.eia.gov/consumption/residential/data/2015/index.php?view=characteristics#appliances> [↑](#endnote-ref-9)