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APPLIANCE & PLUG LOADS

ROOM AIR CLEANER

SWAP008-01

CONTENTS

MEASURE NAME

Room Air Cleaner

STATEWIDE MEASURE ID

SWAP008-01

TECHNOLOGY SUMMARY

A room air cleaner is a portable, electric appliance that removes fine particles, such as dust, smoke, and pollen, from indoor air using a number of methods including filtration, radiation, or heat sterilization. People typically purchase air cleaners because someone living in the home has a sensitivity (allergy or otherwise) and requires the air to be free of particulate matter. Purchase patterns are seasonally driven by the allergy season (spring and fall).[1]

Portable air cleaners generally contain a fan to circulate the air and use one or more of the air cleaning devices discussed above. Portable air cleaners may be moved from room to room and used when continuous and localized air cleaning is needed. Products are generally run continuously during specific times of year, or even some cases run continuously throughout the entire year.

The effectiveness of a portable air cleaner in reducing airborne pollutants is measured by the clean air delivery rate (CADR). The CADR is a measure of a portable air cleaner delivery of contaminant-free air, expressed in cubic feet per minute.

MEASURE CASE DESCRIPTION

The measure case specification is based upon the ENERGY STAR specification for room air cleaners, which measures energy efficiency with a clean air delivery rate (CADR) to watt ratio. Specifically, the measure case air cleaner is specified as a model that exceeds the minimum ENERGY STAR specification by 30% or that exceeds the minimum ENERGY STAR specification by 50%.

Measure Case Specification

Product Type	Efficiency (CADR/W)	Idle Power Draw (W)	Source
ENERGY STAR + 30%	2.6	0.6	ENERGY STAR. 2011. "ENERGY STAR® Program Requirements Product Specification for Room Air Cleaners: Version 1.2." Effective July 20, 2011.
ENERGY STAR + 50%	3.0	0.6	

[1] Energy Solutions. 2015. "Analysis of Incremental Measure Costs for the Retail Products Portfolio." Memorandum submitted to Brian Smith, Pacific Gas & Electric Company.

BASE CASE DESCRIPTION

The base case air cleaner model specified below exceeds the minimum ENERGY STAR specification of 2.0 CADR/W.

Base Case Specification

Efficiency (CADR/W)	Idle Power Draw (W)	Source
2.2	0.7	EMI Consulting. 2016. "2016 PG&E Retail Products Platform (RPP) - Air Cleaner Laboratory Research Results." Memorandum submitted to PG&E.

CODE REQUIREMENTS

This measure is not governed by State or federal standards.

Applicable State and Federal Codes and Standards for Room Air Cleaners

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20	None.	n/a
CA Building Energy Efficiency Standards – Title 24	None.	n/a
Federal Standards	None.	n/a

NORMALIZING UNIT

Each.

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector 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.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
Normal replacement	UpDeemed	Res
Normal replacement	DnDeemed	Res
Normal replacement	DnDeemDI	Res
New construction	UpDeemed	Res
New construction	DnDeemed	Res

Measure Application Type	Delivery Type	Sector
New construction	DnDeemDI	Res

Eligible Products

Eligible products must meet the efficiency (CADR/W) requirements specified in the Measure Case Description.

Eligible Building Types

This measure is applicable in any residential building type of any vintage.

Eligible Climate Zones

The measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

This measure is not explicitly excluded from any building type, vintage or climate zone.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Appliance and plug loads (AppPlug)

ELECTRIC SAVINGS (kWh)

The annual electric unit energy saving (UES) is calculated as the difference between the baseline and measure case unit energy consumption (UEC).

The air cleaner UEC (baseline or measure case) is a function of the capacity (CADR), the efficiency of the unit (CADR per watt), the power draw in idle mode, and the number of hours in each mode (active and idle).

$$UEC = \frac{P_A \times T_A + P_I \times T_I}{1000} \times PLF \times IEM_{elec}$$

$$P_A = \frac{Cap}{Eff}$$

$UEC =$ *Unit energy consumption (kWh)*
$P_A =$ *Power draw in active mode (W)*
$T_A =$ *Number of hours per year spent in active mode*
$P_I =$ *Power draw in idle mode in (W)*

T_I = *Number of hours per year spent in idle mode*
Cap = *Capacity of air cleaner (CADR)*
Eff = *Efficiency of air cleaner (CADR/W)*
PLF = *Part-load factor, a weighted average of how often partial-load fan settings are use and percentage of power draw vs. power draw at full speed.*
IEM_{elec} = *HVAC interactive effects multiplier, electric*
1000 = *Conversion factor to change from watt-hours to kilowatt-hours.*

The key parameters for these calculations are detailed below.

Device Modal Power Draw. The air cleaner active mode power draw (in watts) is based on the air cleaner size (in terms of CADR) divided by its efficiency (CADR per watt). Average air cleaner size within each size bin was determined based on internet retailer sales data collected by the Northwest Energy Efficiency Alliance for five major retailers in September through December 2014.[2] The sales-weighted average size was calculated for each size bin, provided in the table below.

Other than data from the EPA Appliance Savings Calculator, there is little publicly available meter data on air cleaner idle power draw. Therefore, in 2016, Pacific Gas and Electric (PG&E) funded a laboratory testing study on a sample of 13 non-ENERGY STAR certified air cleaners. The average tested efficiency of 2.2 CADR/W and 0.7 W standby power draw are used for base case assumptions. All active and idle power draw assumptions are provided in the following table.

Air Cleaner Power Efficiency and Power Draw Assumptions

Product Type	Size Bin (CADR)	Sales-Wtd Avg Size (CADR)	Efficiency (CADR/W)	Idle Power Draw (W)	Active Power Draw (W)	Source
Base Case	< 100	70.3	2.2	0.7	32.0	EMI Consulting. 2016. "2016 PG&E Retail Products Platform (RPP) - Air Cleaner Laboratory Research Results." Memorandum submitted to PG&E.
	100 – 150	132.2			60.1	
	> 150	240.5			109.3	
ENERGY STAR + 30%	< 100	70.3	2.6	0.6	27.0	ENERGY STAR. 2016. "Savings Calculator for ENERGY STAR Qualified Appliances." "appliance calculator.xls." Last updated October 2016. See "Air Purifier Calcs" tab.
	100 – 150	132.2			50.8	
	> 150	240.5			92.5	
ENERGY STAR + 50%	< 100	70.3	3.0	0.6	23.4	ENERGY STAR. 2016. "Savings Calculator for ENERGY STAR Qualified Appliances." "appliance calculator.xls." Last updated October 2016. See "Air Purifier Calcs" tab.
	100 – 150	132.2			44.1	
	> 150	240.5			80.2	

[2] The source for this data has not been located.

Hours of Operation. Hours of operation assumptions were drawn directly from the PG&E Air Cleaner Hours of Use Research Results.

Air Cleaner Hours-of-Operation Assumptions

Mode					Source
Active	Idle	Sleep	Off	Total	
3,641	3,787	0	1,332	8,760	EMI Consulting. 2016. "2016 PG&E Retail Products Platform (RPP) - Air Cleaners Hours of Use Research Results." Memorandum submitted to PG&E.

Part-Load Factor. The part-load factor (PLF) is a weighted average of 1) how often partial-load fan settings are in use and 2) the percentage of power draw versus power draw at full speed. The PLF was derived from data from two separate research efforts conducted by PG&E: a customer survey research on air cleaner usage habits, and laboratory testing on a sample on non-ENERGY STAR certified air cleaners.

Data Used to Derive Part-Load Factor

Parameter	Air Cleaner Fan Speed Setting			Source
	Low	Med	High	
% of users who utilize each fan speed setting	0.30	0.50	0.20	EMI Consulting. 2016. "2016 PG&E Retail Products Platform (RPP) - Air Cleaners Hours of Use Research Results" Memorandum submitted to PG&E.
Power draw as % of power draw at full speed	0.59	0.63	1.00	EMI Consulting. 2016. "2016 PG&E Retail Products Platform (RPP) - Air Cleaner Laboratory Research Results." Memorandum submitted to PG&E.

Interactive Effects. Heating, ventilating and air conditioning (HVAC) interactive effects refers to the change in HVAC energy usage due to the installation of energy-savings measures that directly change electric energy use within the conditioned space of a building. Interactive effective multipliers are developed and maintained by the California Public Utilities Commission (CPUC) Energy Division and its team of consultants via building simulation techniques that incorporate results from building site surveys, field measurements, laboratory tests, and facility billing data analysis. Interactive effects multipliers for the air cleaner measures were developed only for residential the sector and vary by IOU service territory.

The interactive effects factors were selected for “IOU territory” (weighted by climate zone) and the “Existing” building vintage. The factors for the utilities were used for the appropriate service territory. The table below maps each California climate zone to an IOU service area to identify the appropriate saving value for each California climate zone.

Climate Zone-IOU Service Area Mapping

Program Administrator	Climate Zone
SCE	CZ06, CZ08, CZ09, CZ10, CZ13, CZ14, CZ15, CZ16
PG&E	CZ01, CZ02, CZ03, CZ04, CZ05, CZ11, CZ12
SDG&E	CZ07

PEAK ELECTRIC DEMAND REDUCTION (KW)

It is assumed that this measure operates within the Database of Energy Efficient Resources (DEER) peak period of 4 p.m. to 9 p.m. on weekdays.[3] Peak demand reduction is calculated as the difference between the baseline and measure case active mode power draw, multiplied by the coincident demand factor (CDF). The resultant values are then multiplied by the demand interactive effects multiplier.

Active Mode Power Draw. The calculation of air cleaner power draw is summarized in Electric Savings.

Coincident Demand Factor. The CDF was estimated from an air cleaner hours of use study conducted in 2016 that analyzed data collected via an online survey with residential customers in the PG&E service territory. The study was conducted for the period of 2 p.m. to 5 p.m. on weekdays. There is currently no available data to estimate an updated CDF for the period of 4 p.m. to 9 p.m.

Interactive Effects Multiplier. HVAC interactive effects refers to the change in HVAC energy usage due to the installation of energy-savings measures that directly change electric energy use within the conditioned space of a building. Interactive effective multipliers are developed and maintained by the Energy Division of the California Public Utilities Commission (CPUC) and its team of consultants via building simulation techniques that incorporate results from building site surveys, field measurements, laboratory tests, and facility billing data analysis. Interactive effects multipliers for the air cleaner measures were developed only for the residential sector and vary by IOU service territory.

Peak Demand Reduction Inputs

Parameter	Value	Source
Coincident demand factor	0.319	EMI Consulting. 2016. "2016 PG&E Retail Products Platform (RPP) – Air Cleaner Hours of Use Research Results". Memorandum submitted to Pacific Gas and Electric (PG&E). December 29. Page 15.

The table below maps each California climate zone to an IOU service area to identify the appropriate saving value for each California climate zone.

Climate Zone-IOU Service Area Mapping

Program Administrator	Climate Zone
SCE	CZ06, CZ08, CZ09, CZ10, CZ13, CZ14, CZ15, CZ16
PG&E	CZ01, CZ02, CZ03, CZ04, CZ05, CZ11, CZ12
SDG&E	CZ07

GAS SAVINGS (THERMS)

The gas unit energy savings (UES) of a measure case air cleaner is based solely on the estimated change of gas consumption as reflected by a gas HVAC interactive effects multiplier. As shown, the gas UES is equal to the product of the interactive effects multiplier and the electric UES.

$$UES_{therms} = (UES_{kWh}) \times (IE_{gas})$$

[3] California Public Utilities Commission (CPUC). 2018. *Resolution E-4952.* October 11. Op 1.

UES_{kWh} = *Annual electric unit energy savings (kWh/yr)*

IE_{gas} = *Gas interactive effects multiplier*

Note that the gas interactive effective multipliers are negative and reflect the slight increase in gas space heat usage as a result of the installation of this measure.

The table below maps each California climate zone to an IOU service area to identify the appropriate saving value for each California climate zone.

Climate Zone-IOU Service Area Mapping

Program Administrator	Climate Zone
SCE	CZ06, CZ08, CZ09, CZ10, CZ13, CZ14, CZ15, CZ16
PG&E	CZ01, CZ02, CZ03, CZ04, CZ05, CZ11, CZ12
SDG&E	CZ07

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. EUL is often, but not always, derived from measure persistence or retention studies. 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.

The EUL specified for a room air cleaner are specified below. This EUL value is utilized in the U.S. EPA Appliance Calculator the product lifetime for room air cleaners. Insofar as the RUL is only applicable to the first baseline period for a retrofit measure with an applicable code baseline, it is not applicable for this measure.

Effective Useful Life and Remaining Useful Life

Parameter	Room Air Cleaner	Source
EUL (yrs)	9.0	ENERGY STAR. 2016. "Savings Calculator for ENERGY STAR Qualified Appliances." "appliance calculator.xls." Last updated October 2016. See "Air Purifier Calcs" tab.
RUL (yrs)	n/a	-

BASE CASE MATERIAL COST ($/UNIT)

The base case material cost for equipment *delivered via direct install* is equal to $0.

The estimation of the base case material cost for *all other delivery types* follows the approach to estimate measure case costs, as summarized in Measure Case Material Cost.

MEASURE CASE MATERIAL COST ($/UNIT)

Measure case material costs for *all delivery types* were estimated from a hedonic price model that utilized web-scraped ("web harvested") data from eight online retailers yielded 516 initial product models and approximately 110 initial attributes.[4]

Hedonic price models are often used to estimate the contribution of specific characteristics (including energy efficiency) to the product price. This is the method utilized in the 2010-2012 Ex Ante Measure Cost Study[5] to identify key drivers of price and determine the fraction of price explained by specific variables (such as energy efficiency). As outlined in Young et al.,[6] the key drivers of cost may be unrelated to energy efficiency. In this modeling approach, the incremental measure cost (IMC) is defined as the fraction of cost difference between the program-qualified (measure case) and base case model that can be attributed to energy efficiency. For example, if the measure is an ENERGY STAR product and the base case is a non-ENERGY STAR product, IMC is defined as the fraction of incremental cost that can be attributed to an ENERGY STAR product. The IMC may be different for various models, and therefore a weighted average is calculated across multiple model-specific IMC values to establish an overall IMC for the product category.

The results of the hedonic price model indicate that ENERGY STAR-qualified air cleaners are estimated to cost 41% more than non-qualified products. Because the coefficient of the 'ENERGY STAR' term in the model was highly statistically significant (p=0.008), the IMC model estimate is accepted (rather than the null hypothesis that the IMC is equal to $0.00).

This approach and the results for air cleaners is detailed and fully documented by Energy Solutions in its 2016 memorandum to Pacific Gas and Electric Company.[7]

BASE CASE LABOR COST ($/UNIT)

The base case labor cost for equipment *delivered via direct install* is equal to $0.

This measure is delivered through the retail channel and therefore installation and labor costs, if any, are assumed to be borne by the end user. Thus, the base case installation labor cost for *all other delivery types* is equal to $0.

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[4] This analysis is part of a broader effort to understand the dynamics between product attributes and price. A web harvesting approach was initially utilized by the Statewide IOU Codes and Standards team to identify key drivers of product costs for LED lamps from 2012-2014 and was presented at the ACEEE Summer Study Conference in 2014.

[5] Itron, Inc. 2014. *2010-2012 WO017 Ex Ante Measure Cost Study Final Report.* Prepared for the California Public Utilities Commission.

[6] Young, D., M. McGaraghan, N. Dewart, D. Hopper, P. Borocz, F. Kaser, et al. (Energy Solutions). 2014. "Leveraging Big Data to Develop Next Generation Demand Side Management Programs and Energy Regulations." Proceedings of the 2014 ACEEE Summer Study on Energy Efficiency in Buildings, 11-332. Washington, DC: American Council for an Energy Efficient Economy (ACEEE).

[7] Energy Solutions. 2015. "Analysis of Incremental Measure Costs for the Retail Products Portfolio." Memorandum submitted to Brian Smith, Pacific Gas & Electric Company.

MEASURE CASE LABOR COST ($/UNIT)

The measure case labor cost for equipment *delivered via direct install* will be derived as the average installation cost submitted by one or more implementation contractors. The actual installation cost can vary by contractor, the date when the work occurred, and by the volume of each specific contractor's business. Contractor costs are confidential information and are based upon contractually agreed upon pricing as established in their purchase order with the program administrator. Therefore, the program administrator program tracking systems are the only source for the labor installation cost data. The program administrator will utilize the actual program cost to evaluate the cost-effectiveness of the measure.

For *all other delivery types*, a high efficiency model does not require additional installation labor compared to a base case model. Since this measure is applicable for normal replacement and new construction installations, the base case and measure case model installation costs are expected to be the same for the customer and thus not estimated for the incremental cost analysis.

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. This NTG was established specifically for residential products incentivized at the midstream delivery channel.

Net-to-Gross Ratios

Parameter	Value	Source
NTG Ratio	0.20	California Public Utilities Commission (CPUC), Energy Division. 2015. "Workpaper Disposition for PGECOAPP128 Revision 0 Retail Products Platform." December 15. Page 8.

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. The GSIA rate for the room air cleaner measure is specified in **Error! Reference source not found.**. This GSIA rate is the current "default" r ate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment

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

NON-ENERGY BENEFITS

Non-energy benefits for this measure have not been quantified.

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. This measure is not included in the Database for Energy Efficient Resources (DEER), thus the only parameters drawn from DEER are noted below.

DEER Difference Summary

DEER Item	Comment
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 Version	n/a
Reason for Deviation from DEER	DEER does not contain information on energy use or savings for an energy-efficient electric or gas commercial convection oven measure.
DEER Measure IDs Used	n/a
NTG	Source: The value of 0.20 stipulated in the 2015 RPP disposition. An NTG does not exist, thus the NTG-ID: *Res-sAll-mRfg-DG* is used as a proxy.
GSIA	The value of 1.0 is associated with GSIA ID: *Def-GSIA*
EUL/RUL	Source: The EUL of 9 years is associated with EUL ID: *Res-AirCleaner.* The EUL for this measure is not in DEER.

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Submission Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	11/30/2017	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: PGECOAPP128, Revision 6 (January 30, 2018) PGECOAPP128, Revision 3 (March 29, 2017) Consensus reached among Cal TF members.
	12/31/2018	Jennifer Holmes Cal TF Staff	Revisions for submittal of Version 01