To:PG&E

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RE:2016 PG&E Retail Products Platform (RPP) – Air Cleaner Laboratory Research Results

Introduction

The Pacific Gas and Electric Company (PG&E) submitted a workpaper for the Retail Products Platform (RPP) Program in December 2015. In its workpaper disposition the California Public Utilities Commission – Energy Division (CPUC-ED) identified the need for further research to support the unit energy savings (UES) values for room air cleaners.[[1]](#footnote-1) Resultantly, PG&E is currently conducting two distinct but related research efforts on room air cleaners:

1. **Lab testing of non-ENERGY STAR air cleaners to measure power draw and efficiency and determine if any models meet ENERGY STAR criteria.** In this research effort, PG&E has partnered with Intertek, an EPA-certified third-party test lab, to test and meter room air cleaner models that are not ENERGY STAR certified.
2. **Surveys to determine hours of use (HOU) and coincident demand factor (CDF) for air cleaners.** For this effort, PG&E and EMI Consulting are conducting a survey of PG&E residential customers to derive more accurate and reliable HOU and CDF estimates.

*This memo only summarizes the results of the first effort (lab testing).*

The lab testing is being conducted because commission staff were concerned about the lack of data to support the assumption that non-ENERGY STAR models of products included in the RPP program (such as soundbars, air cleaners, and freezers) do not meet ENERGY STAR specification requirements. Staff stated that there needs to be evidence that non-ENERGY STAR products do, in fact, use more energy than ENERGY STAR products. In other words, a product that is not ENERGY STAR certified does not, by default, consume more energy than an ENERGY STAR product. It may be, for example, that ENERGY STAR certification was too costly for the manufacturer, but that the product meets ENERGY STAR requirements nonetheless.

The RPP program incents a portfolio of ENERGY STAR certified products that are sold by retailers to residential customers. Some of these products have federal energy efficiency regulations in place, and all such models are required to be tested to show compliance with federal standards. However, certain plug load devices such as soundbars and air cleaners are not federally regulated, so test data is only available for ENERGY STAR certified models. With limited data available for non-ENERGY STAR certified models, it is difficult to determine whether those models that have not been tested via the certification process have efficiencies below ENERGY STAR specifications. In the research described here, PG&E identified models of non-ENERGY STAR certified air cleaners with high market share and tested them using the applicable ENERGY STAR test protocol. The testing provided key parameters such as power draw and determined whether the selected models meet ENERGY STAR requirements.

Research Questions/Objectives

This purpose of this research was to answer the questions:

* What is the power draw of non-ENERGY STAR certified air cleaners?
* Is the power draw for non-ENERGY STAR models substantially higher than ENERGY STAR certified models?
* Are there models of air cleaners that have not been ENERGY STAR certified, but would meet ENERGY STAR specifications if they were tested?

Summary of Key Findings

* Average active mode power draw of the non-ENERGY STAR models tested is 39.7 W (there is no active mode power draw requirement in the ENERGY STAR specification).
* Average standby mode power draw of the non-ENERGY STAR models tested is 4.1 W (ENERGY STAR maximum is 2 W).
* Average efficiency (for dust) is 1.7 CADR/W (ENERGY STAR minimum is 50 CADR).
* Seven of the thirteen models tested produce less than 50 CADR and would not be considered under the ENERGY STAR specification.
* One of the thirteen models tested meets the ENERGY STAR specification requirements.
* When operating at modes other than the maximum fan setting, the average “low” setting power draw is 59% of the “high” setting power draw and the average “medium” setting power draw is 63% of the “high” setting power draw.

Research Approach

PG&E contracted Intertek, an EPA-certified third-party test lab, to test and meter models selected by PG&E using the methodology discussed below.

Model Selection

Under contract with PG&E, Energy Solutions identified top-selling air cleaner models (both ENERGY STAR and non-ENERGY STAR) by reviewing major retail websites and sorting the products using the “best-selling” sorting option. Each model was then determined to be ENERGY STAR certified or non-ENERGY STAR based by matching its model number to the ENERGY STAR Qualified Products list. This generated a ranked list of top selling non-ENERGY STAR models for each retailer.

At the time of air cleaner model selection, retailers had not yet provided RPP program administrators with sales data for non-ENERGY STAR models of products included in the program. Therefore, to determine the relative market share of each non-ENERGY STAR model, Energy Solutions plotted model rank by retailer website and total retailer sales for ENERGY STAR models to create a regression equation that was used to estimate sales of non-ENERGY STAR models based on website rank (Figure 1).

Figure 1. Example curve fitting of RPP-reported air cleaner sales by top-selling rank

Based on these regression equations, Energy Solutions interpolated the sales of non-ENERGY STAR products based on their website rank, and created a list of non-ENERGY STAR models and their estimated sales volume. From this overall list of non-ENERGY STAR products, Energy Solutions created a shortlist of products comprised of top-selling models with good representation across a variety of manufacturers, retail channels, and product capabilities. The final list of models tested is shown in Table 1.

Table 1: Non-ENERGY STAR Air Cleaners Selected for Testing

|  |  |  |  |
| --- | --- | --- | --- |
| MODELa | RPP Retailer non-energy star Market shareB | | |
| NUMBER OF UNITS SOLD | SALES VOLUME RANKC | % OF SALES |
| 2 | 271 | 1st | 38.0% |
| 5 | 200 | 2nd | 28.1% |
| 12 | 31 | 3rd | 10.8%D |
| 4 | 20 | 6th | 2.8% |
| 7 | 8 | 8th | 1.1% |
| 6 | 3 | 9th | 0.4% |
| 8 | 3 | 9th | 0.4% |
| 11 | 1 | 11th | 0.1% |
| 13 | 1 | 11th | 0.1% |
| 1 | 0 | NA | 0.0% |
| 3 | 0 | NA | 0.0% |
| 9 | 0 | NA | 0.0% |
| 10 | 0 | NA | 0.0% |

A Manufacturer/model information is confidential, but can be provided if requested to the CPUC-ED and/or other utility partners on an as needed basis.

B Market share is based on RPP retailer sales data from January 2015 – November 2016 from the ICF database.

C Out of 34 different non-ENERGY STAR models that are sold by RPP retailers

D Here we have included additional models numbers that only differ by color.

Using the RPP retailer sales data that has since become available, we determined that this list of models represents roughly 82% of non-ENERGY STAR air cleaner market sales.[[2]](#footnote-2) The top three selling models (all of which were tested) represent 77% of non-ENERGY STAR sales. The top ten selling models (seven of which were tested) represent 96% of non-ENERGY STAR sales.

Model Testing

Each model was lab tested in accordance with the test method outlined in the ENERGY STAR Program Requirements Product Specification for Room Air Cleaners.[[3]](#footnote-3)

The following characteristics were collected from manufacturer specifications for each model:

* Manufacturer and model number
* Clean air delivery rate (CADR) for dust, tobacco smoke, and pollen if available

The following data were collected through the testing process:

* Dust-free air delivery rate (cfm) tested under ANSI/AHAM AC-1-2015
* Active mode power consumption
* Standby mode power consumption
* Efficiency in CADR/W (dust)
* Power consumption at multiple fan settings

Research Results

ENERGY STAR Testing

ENERGY STAR test results are shown in the table below.

Table 2: Non-ENERGY STAR Air/ Cleaner Lab Testing Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Modela | Dust-Free Clean Air Delivery Rate (CADR, in cfm) | Dust Efficiency (CADR/W) | Active Mode Power (W) | Standby Mode Power (W) |
| 1 | -1.62b | -0.2b | 10.8 | 0 |
| 2 | 72.2 | 1.3 | 56.4 | 0.1 |
| 3 | -1.9 b | -1.9 b | 49.8 | 45.7 |
| 4 | 68.5 | 1.3 | 52.7 | 0.1 |
| 5 | 60.9 | 1.6 | 38.3 | 0 |
| 6 | 153.6 | 6.7 | 22.8 | 0.4 |
| 7 | 95.7 | 1.2 | 83.2 | 0 |
| 8 | 126.2 | 2.3 | 55.7 | 2.3 |
| 9 | 49.8 | 1.5 | 34.3 | 0 |
| 10 | 3.5 | 0.1 | 59.1 | 2.8 |
| 11 | 49 | 1.4 | 35.1 | 0 |
| 12 | 25.6 | 3.3 | 7.8 | 0.5 |
| 13 | 36.3 | 3.7 | 9.6 | 1.2 |

a Manufacturer/model information is confidential, but can be provided if requested to the CPUC-ED and/or other utility partners on an as needed basis.

b A negative CADR and CADR/W (resulting from the negative CADR) means that the natural decay rate (with the unit off) of the pollutant particles that are injected into the air during the test procedure is faster than the decay rate with the unit on. In more practical terms, the units with negative CADR values don’t have fans and therefore don’t move air. CADR is measured in cubic feet per minute (cfm), and a unit that doesn’t have a fan will not have a meaningful cfm measurement. Units with negative CADR and CADR/W values are not effective at removing particulate matter from the air. However, these units may function perfectly well as air deodorizers and/or may effectively kill microorganisms such as bacteria, viruses, and mold using high heat or UV light. These two units have been removed from the analysis that follows as they don’t conform to the ENERGY STAR definition of air cleaner. No sales of these units were found in the ICF RPP database.

The ENERGY STAR specification requires that air cleaners produce a minimum of 50 CADR, have an efficiency of at least 2 CADR/W and a standby power draw of no more than 2 W. Only one model tested (Model 6) meets all these criteria. This model represents only 0.4% of non-ENERGY STAR sales at RPP retailers. Three other models had efficiencies of at least 2 CADR/W (Models 8, 12, and 13) but either did not produce the minimum 50 CADR (Models 12 and 13) or exceeded the maximum standby power draw (model 8). In addition, eight models (Models 1, 2, 4, 5, 6, 7, 9, and 11) had a standby power draw of less than 2 W, but either did not produce the minimum 50 CADR (Model 1) and/or didn’t meet the minimum efficiency requirement (Models 2, 4, 5, 7, 9, and 11).

As shown in Figure 1 below, the models tested had CADRs (for dust) ranging from 3.5 to 153.6, and an average CADR of 67.4.

Figure 1. CADR (for dust) by Model Tested



Figure 2 shows that the models had efficiencies (for dust) ranging from 0.1 to 6.7 CADR/W and an average efficiency of 2.2 CADR/W.

Figure 2. Efficiency (for dust) by Model Tested



Figure 3 shows that the models tested had active mode power draw ranging from 7.8 to 83.2 W and an average active mode power draw of 41.4 W

Figure 3. Active Mode Power Draw by Model Tested



Figure 4 shows that the models tested had standby power draw ranging from 0 to 2.8 W, and an average standby power draw of 0.7 W.

Figure 4. Standby Mode Power Draw by Model Tested



Power Draw by Fan Speed Testing

Table 3 shows the results of power draw readings for up to 5 available fan speed settings for each model. The last two columns show the estimated “low” and “medium” speed power draws as a percentage of the power draw at the highest speed setting. Models with only one speed setting (1, 3, and 12) are excluded from the analysis. Models with two speed settings have no attributable “medium” speed setting. For models with more than 3 speed settings, the “medium” setting is taken as the average of all settings between the highest and lowest settings.

Table 3: Power Draw at by Fan Speed Setting and Model Tested

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Model | Power Draw (W) | | | | | % of Power Draw at High Fan Speed | |
| **Fan Speed 1** | **Fan Speed 2** | **Fan Speed 3** | **Fan Speed 4** | **Fan Speed 5** | **Fan Setting Low** | **Fan Setting Medium** |
| 1 | 10.8 |  |  |  |  | N/A | N/A |
| 2 | 3.2 | 5.3 | 10.3 | 20.7 | 42.8 | 7% | 28% |
| 3 | 49.8 |  |  |  |  | N/A | N/A |
| 4 | 3 | 5.1 | 9.8 | 19.4 | 40 | 8% | 29% |
| 5 | 26.2 | 30.4 |  |  |  | 86% | N/A |
| 6 | 5.5 | 9.5 | 14.9 |  |  | 37% | 64% |
| 7 | 51.5 | 64 |  |  |  | 80% | N/A |
| 8 | 23.9 | 27.2 | 35.2 | 45.5 |  | 53% | 69% |
| 9 | 20.4 | 24.3 |  |  |  | 84% | N/A |
| 10 | 46.8 | 51 | 55.7 | 58.3 |  | 80% | 92% |
| 11 | 9.2 | 17.8 |  |  |  | 52% | N/A |
| 12 | 2.7 |  |  |  |  | N/A | N/A |
| 13 | 9.9 | 10 | 9.8 |  |  | 100% | 100% |
| **Average** | | | | | | **59%** | **63%** |

Impact of Results on RPP Workpaper

In the RPP workpaper, the unit energy consumption of room air cleaners is calculated using Equation 1 and Equation 2.

Equation 1

Equation 2

Where

UEC = unit energy consumption in kWh

PA = power draw in active mode in watts

TA = number of hours per year spent in active mode

PS = power draw in standby mode in watts

TS = number of hours per year spent in standby mode

Cap = capacity of air cleaner in CADR

Eff = efficiency of air cleaner in CADR/W

1000 = conversion factor to change from watt-hours to kilowatt-hours.

The efficiency of base-case models was assumed to be 1.0 CADR/Watt. The efficiency of basic tier (ENERGY STAR) program-qualified models is 2.0 CADR/Watt, and the efficiency of advanced tier (ENERGY STAR +30%) program-qualified models is 2.6 CADR/Watt. Standby mode power draw was assumed to be 1.0 watt for base-case models, 0.6 watts for basic tier (ENERGY STAR) program-qualified models, and 0.5 watts for advanced tier (ENERGY STAR + 30%) program-qualified models.

Based on the results of this research, we believe **the assumption for the base-case efficiency should be increased from 1 CADR/W to 2.2 CADR/W** (the average of all the non-ENERGY STAR models tested excluding the two units with negative CADR ratings). In addition, **the assumption for the base-case standby power draw should be decreased from 1 W to 0.7 W** (the average of all the non-ENERGY STAR models tested excluding the two units with negative CADR ratings). These changes will result in a negative unit energy savings value for basic tier air cleaners and significantly reduced savings for the advanced tier.

In addition, a part-load factor should be applied to the power draw in active mode (PA) that is calculated as a weighted average of the percentage of users that typically run their air cleaners at each speed setting and the power draw of each speed setting as a percentage of the power draw at the highest setting. This is necessary because the PA currently used in the workpaper (for both baseline and measure-case calculations) assumes that air cleaners are always used with the fan at the highest speed setting. The consumer survey research (the second research item alluded to in the beginning of this memo) shows the following frequency of usage at different speeds: 30% at “low”, 50% at “medium”, and 20% at “high” [[4]](#footnote-4). Our lab testing results show that the models tested draw 59% of the maximum power at “low” speed and 63% at “medium” speed. Thus, we arrive at a part-load factor of 0.69 as shown in the calculation below. This **part-load factor of 0.69 should be applied to the active mode power draw for both baseline and measure-case energy consumption calculations.**

1. In its disposition letter, the CPUC-ED also requested additional research on clothes dryers, soundbars, and research into product-specific market barriers preventing increased adoption of RPP measures. This memo only covers air cleaner research. [↑](#footnote-ref-1)
2. We have removed from the dataset models that do not conform with the ENERGY STAR definition of air cleaner, namely, those models whose primary function is something other than removing particulate matter from the air (i.e. killing bacteria, viruses, and other microorganisms) and those models with a secondary function (i.e. heating, cooling, humidifying, dehumidifying) [↑](#footnote-ref-2)
3. <https://www.energystar.gov/index.cfm?c=archives.air_cleaners> [↑](#footnote-ref-3)
4. To arrive at the 20%/50%/30% split for users who typically use their air cleaners in high/med/low settings, we assumed respondents who use the “auto” setting and those who responded that they don’t know what setting they typically use, both typically use the medium setting. [↑](#footnote-ref-4)