Codes and Standards Enhancement Initiative
For PY2004: Title 20 Standards Development

Draft Analysis of Standards Options For Portable Room Air Cleaners

Prepared for:
Gary B. Fernstrom, PG&E

Prepared by:
Davis Energy Group
Energy Solutions
May 6, 2004

This report was prepared by Pacific Gas and Electric Company and funded by California utility customers under the auspices of the California Public Utilities Commission

Table of Contents

1 Introduction

The Pacific Gas and Electric Company (PG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report covers standards and options for portable room air cleaners.

2 Product Description

Portable room air cleaners refer to plug-in, portable air cleaners ranging in size from desktop models to portable air cleaners that are advertised as whole house models. The Association of Home Appliance Manufacturers (AHAM) defines these products as follows:

An electric cord-connected appliance with the function of removing particulate matter from the air and which can be moved from room to room.

Central ducted HVAC in-line air cleaning devices are not included in this analysis. Portable air cleaners typically consist of a cabinet, sometimes with wheels, that contains one or more air filters[1], a fan and motor that draw air through the filter(s), and controls to regulate the fan speed and indicate the condition of the filter media. Air cleaner capacity claims are typically expressed in terms of the floor area of the space they are designed to adequately clean based on some combination of the air changes per hour and the air cleaning performance of the model. Air cleaners range in capacity from 50 to over 1200 square feet, with 200 to 450 square feet being the most common capacity range. Their power demand ranges from 34 to 350 watts with most models demanding less than 160 watts.

Figure 1: Example of a Portable Room Air Cleaner

[1] One or more filters are used in most but not all models.

There are several models of air cleaners on the market that use electrostatic forces to clean the air instead of, or in addition to, a filter media to trap particles. In these models, air passes through an electrical field, sometimes with the help of a fan, charging suspended particles. These charged particles are subsequently attracted to nearby, oppositely charged collection plates where they are trapped until the unit is cleaned manually. Some units do not use a fan to draw air particles into the air cleaner. The absence of a fan results in a quiet, energy-efficient unit, but Consumer Reports, which periodically compares room air cleaner performance and energy consumption, also found that such units are largely ineffective at reducing airborne particles (Consumer Reports, 2002). By contrast, a model that uses a fan and filter in conjunction with electrostatic technology was evaluated by Consumer Reports and out-cleaned the other 15 models tested. While "passive" air cleaners will do extremely well in terms of energy efficiency, the findings of Consumer Reports underscores the need to view energy consumption in relation to reasonable cleaning efficacy and capacity ratings.

Portable room air cleaners can also use negative ionization to purify air. Air cleaners using negative ionization emit negatively charged ions into the air, which stick to positively charged particles such as pollen, dust and smoke. These heavier particles fall to the ground and can be captured and removed through vacuuming and dusting. Like the electrostatic precipitator model described above, the ionizing air cleaners appear to use very little energy (e.g., 6 watts). No ionizing models appeared to be rated or evaluated by Consumer Reports. Without efficacy data these products could not be included in the analysis.

Many portable room air cleaners are listed in the AHAM Directory of Certified Room Air Cleaners. AHAM certifies these products according to a standardized measurement system known as the Clean Air Delivery Rate (CADR). CADR, measured in cubic feet per minute, indicates how well an air cleaner reduces three pollutants: tobacco smoke, dust and pollen. Accordingly, each product listed with AHAM has three individual CADRs[2]. Although the AHAM directory lists a recommended room size provided by the manufacturer, AHAM does not certify this number.

On March 17, 2004, ENERGY STAR issued a final draft of its Program Requirements for Room Air Cleaners and is currently accepting stakeholder comments on the draft.

3 Market Status

3.1 Market Penetration

We initially estimated air cleaner saturation in California based on the shipment information discussed in the following section, and design life information from ICF Consulting, which is under contract by the US EPA to research portable room air cleaners. Based on a design life of between eight and nine years and US shipment information for the last nine years (Appliance Magazine, 2000), we estimated that there are approximately 18 million units in use in the US market. We then assume that approximately 15%, or 2.7 million air cleaners, are found in California households and

[2] Due to the different characteristics of each pollutant, an independent CADR is assigned to each pollutant based on test results. A separate test is conducted for each of the three pollutants.

business (12% of U.S. households are in California but an additional proportion attributed to longer allergy season, higher air quality problems, and higher health consciousness commonly associated with Californians was assumed). Recently we received a summary of survey research conducted by NFO Worldwide Research for AHAM, where 936 households were surveyed in 2002, which states that:

- Almost one-third of households surveyed own an air cleaner
- Two-thirds of those households that own an air cleaner have only one air cleaner; the rest have two or more air cleaners

If truly representative, these survey findings might suggest a product saturation of over four million in California since there are almost 12 million households in the State. In view of the shipments data reported by *Appliance Magazine* below, which does not appear to support the survey findings, and our lack of more detailed information about the AHAM survey sample representativeness, we use the more conservative saturation estimate calculated above rather than that calculated from the AHAM survey data.

3.2 Sales Volume

According to *Appliance Magazine's Statistical Review (Appliance Magazine, 2000),* US shipments of portable room air cleaners have fluctuated somewhat over the past decade. Table 1 below shows sales data from 1990 through 1999.

Table 1. U.S. Shipments of Portable Room Air Cleaners, 1990-1999

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Shipment (millions)	2.1	2.0	2.1	2.1	2.4	2.5	2.6	1.7	1.7	2.1

Source: Appliance Magazine Statistical Review, May 2000.

In the year 2000, 1.65 million portable room air cleaners were shipped in the United States (Clark, 2001). The average annual shipment from 1990 through 2000 is 2.1 million units. If we assume the same percentage of units as above, then approximately 15% of 2.1 million—or 310,000—air cleaners are sold annually into the California market.

3.3 Market Penetration of High Efficiency Options

No model-by-model shipment data was available to use in estimating shipment weighted efficiency performance, so a more qualitative assessment of the relative market penetration of high efficiency products was used. We developed a sample including 23 products for which we were able to obtain power and efficacy (CADR) data. Research indicated that Honeywell, Holmes, Whirlpool, Bemis, and Hamilton-Beach/Proctor-Silex collectively represent about 85% of market share (Jiambolvo, 2001). If the products sold by these larger manufacturers tended toward the high end of the efficiency spectrum one could infer that high efficiency products have a substantive market share. However, we found their products to vary considerably relative to each other and the other products in the dataset, in terms of the selected efficiency metric, CADR/watt. When ranked from most efficient to least efficient, we found that:

- The four Honeywell products in our dataset all ranked in the *bottom* half;
- The three Holmes products ranked in the *top* half;
- The two Whirlpool products ranked in approximately the *top* quartile;
- The two Bemis products both ranked in the *bottom* 10%.

(There were no Hamilton-Beach/ Proctor-Silex products in our dataset.)

Based on conversations with company engineers, salespeople, and other claims, two manufacturers, Blueair and Panasonic, appeared to be the only manufacturers promoting their products as energy efficient compared to other comparable air cleaners. When we compared the CADR/watt of these two manufacturers' products with the other products in our dataset, the Blueair model ranked in the top five percent and the six Panasonic models for which we had data ranked in the bottom 60%. Blueair represents less than five percent of market share. Given this distribution of product efficiencies and the limited attention to energy efficiency in product promotional materials, we conclude that the penetration of high efficiency air cleaners in California is likely to be modest.

4 Savings Potential

4.1 Baseline Energy Use

Baseline energy use is determined by multiplying the demand of an air cleaner at each setting by the total annual hours of operation at that setting. In determining power draw of a single air cleaner, we drew upon two articles by Consumer Reports, and data from original market research, which included searches of manufacturer Web sites and calls to manufacturers and dealers. From these sources, we collected either average power (Consumer Reports provided only average values) or both high and low speed power (directly from manufacturers) for products for which efficacy data (CADR) was available. High-speed power demand ranged from 68 to 264 watts in our sample. Low speed power ranged from 15 to 180 watts. From this sample, we determined the hypothetical average power rating for the sample was 91 watts based on the premise that the air cleaners are operated on high fan speed 50% of the time and low fan speed 50% of the time, a premise consistent with Consumer Reports' methodology.

The second key factor is operating time at each power setting. This requires behavior data for total hours of use annually, and typical speed settings during use. The research conducted by NFO Worldwide Research for AHAM in 2003 provides the following data regarding air cleaner ownership and usage:

- Three-quarters of households surveyed use their air cleaner all year round, and three-quarters of these owners operate their air cleaner every day
- One-quarter use it only during allergy season, and one-third of these owners operate their air cleaner every day

- 38% of air cleaner owners run their units 24 hours per day, and 44% of the owners surveyed run their units 8 hours or fewer per day
- On average, households run their air cleaners 13.6 hours on a typical day during the season in which they are using the air cleaner
- Three-quarters of users reported running their air cleaners on medium or low fan speed
- Air cleaners are operated on high fan speed 14% of the time, medium fan speed 41% of the time, low fan speed 33% of the time, and automatic 12% of the time.

Prior to the availability of the above-mentioned AHAM data, we surveyed approximately two-dozen resources, including Consumer Reports, Appliance Magazine, the American Lung Association, numerous manufacturer-published owners manuals, various allergy and asthma associations, and a number of academic researchers. None had any research data on typical use patterns, but many—including several manufacturers—recommended that portable room air cleaners be run constantly for best results. Marla Sanchez, a researcher at Lawrence Berkeley National Laboratory, had estimated three hours per day in a research paper addressing numerous home appliances (LBNL, 2002). Sanchez's information, however, was based on an interview with Emerson Electric in which Emerson provided a range from three to 24 hours per day.

In the absence of any additional data, we rely on AHAM's data regarding typical usage patterns of households with portable room air cleaners. Based on the findings above, we assume that approximately three-quarters of the portable room air cleaners in California are used 12 months out of the year, while one-quarter are used during allergy season. We assume that allergy season is six months long in California, including late spring, summer and early fall when pollen and dust are of the greatest concern and, incidentally, during peak demand season. We calculated the number of hours the typical air cleaner is used per year, based on air cleaner usage statistics summarized below from the AHAM study.

Table 2. Frequency of Air Cleaner Usage

Usage Bins	Year Round Users	Allergy Season Only Users
Everyday	74%	34%
5-7 times a week	10%	18%
3-4 times a week	8%	14%
1-2 times a week	5%	7%
Once a week or less	4%	27%

In calculations, we take the mid-point of each usage range and for the once a week or less category we use a value of 0.8 days per week.

In our own dataset for products for which high and low speed power values were known, we calculated that air cleaners set at high speed demanded on average 2.5 times as much power at high speed as they do at low speed. We then used this ratio to estimate high and low values for the sub-sample of products obtained from Consumer Reports, which did not provide high and low values. For the sake of simplicity, we further assume that the power demanded while operating at medium fan speed is exactly halfway between the power required at high and low speeds, or (2.5x+x)/2, which equals 1.75x, where “x” equals the low speed power.

We next take the AHAM survey results for relative frequency of use at each setting and evenly distribute the proportion of automatic setting between the other three settings. This yields the following speed settings assumptions used in the subsequent calculations: air cleaners are run at high speed 18% of the time, medium fan speed 45% of the time, and low fan speed 37% of the time, or (0.18*2.5x)+(0.45*1.75x)+(0.37*x), or 1.61x. In our sample of products, “x” was calculated to be 52 watts. This suggests an approximate weighted average power of 83 watts when in use for the average operating air cleaner in our sample, which we presume to be representative of the units in service in California.

Thus, based on the usage behavior and demand assumptions above, we estimate that the average portable room air cleaner uses approximately 305 kWh per year. Peak demand is calculated assuming that just over half of units are run during the peak demand period. Again, the values for this sample are not weighted to reflect actual market share for each model because shipment-weighted performance data were not available.

Based on the above assumptions, we estimate that California’s 2.7 million units collectively use approximately 637 GWh, annually. Additionally, those units would represent a coincident peak demand of 87 MW.

4.2 Proposed Test Method

There appears to be no generally accepted test method of determining energy consumption of air cleaners. AHAM has developed standard ANSI/AHAM AC-1-2002, *Association of Home Appliance Manufacturers Method for Measuring Performance of Portable Household Electric Cord-Connected Room Air Cleaners*, which measures air cleaning efficacy expressed as Clean Air Deliver Rate (CADR) but not energy consumption. We propose a test method based largely on AC-1-2002 with additional steps added to measure energy consumption. It should be noted that ENERGY STAR is in the process of developing a test methodology that builds on AC-1-2002, as well. We do not recommend this test method, however, as it considers only measurements at high-speed settings. Immediately below, we summarize the AC-1-2002:

The AC-1-2002 measures a portable room air cleaner’s effectiveness at removing three pollutants- dust, tobacco smoke, and pollen particulate matter- from a room. The air cleaner to be tested is set to “high” and placed in a 1,008 cubic foot test chamber and the pollutant is introduced. Initially, the natural decay rate is measured and recorded while the room air cleaner is off. The natural decay rate is the natural attenuation of suspended particulate matter as a result of naturally settling and deposition on wall surfaces with no active filtration. Following that, the pollutant is reintroduced to the chamber, the air cleaner is turned on the high-speed setting (only) and particle concentration data is recorded over time yielding a “measured decay rate”, which includes both the natural decay rate and the rate of reduction in number of suspended particles resulting from use of the air cleaner. Each pollutant is tested separately and particle concentration data is recorded for 10 to 20 minutes, depending on the pollutant type. The CADR is calculated by multiplying the volume of the test chamber times the difference between the measured decay rate and the natural decay rate:

$$CADR = V\ (k_m - k_n)$$

where,

V = volume (cubic feet)

k_m = measured decay rate ($min.^{-1}$)

k_n = natural decay rate ($min.^{-1}$)

The result is three individual ratings in cubic feet per minute—one rating for the removal of each pollutant.

The CADR is proportional to the recommended room area that can be adequately filtered by the air cleaner, and consumers are encouraged to compare CADR numbers within the context of the recommended room size. AHAM recommends that the CADR be at least two-thirds of the area of the room in square feet. (In other words, if the room is 900 square feet, AHAM recommends choosing an air cleaner with a CADR of 600). The higher the CADR for tobacco smoke, pollen and dust for the same size area, the faster the unit filters the air.

Additional Test Method Steps

Several additional steps should be added to the AC-1-2002 test method to allow for measurement of average power demand. As with the ENERGY STAR draft test method, prior to taking any power measurements, the air cleaner should be run for 48 hours without filters to "break in" new units. Consistent with Energy Star and to simplify the testing, only one particulate, dust, should be used in the incremental testing. A given air cleaner often has different CADR scores for each type of particulate.

The power demanded by a portable room air cleaner should be measured thirteen times at one-minute intervals starting two minutes following the beginning of the test for removing dust particulate matter (step 6.2.3.4 in AC-1-2002). Three readings can be thrown out as "outliers", leaving 10 power measurements in the dataset, from which to calculate an average value. Two sets of such instantaneous power measurements should be taken: One set while the unit is operating at high speed, and the other while the unit is operating at low speed. Please note that neither AC-1-2002 nor the ENERGY STAR method includes testing at any speed other than the highest speed. As most usage occurs at speeds lower than the highest speed, it is important that the test method should allow for measurement at low speed settings.

For the highest speed set of measurements, the air cleaner should be set with options set at maximum level (filter check indicator, fan control, etc). At the low speed setting all option settings should be set at the minimum level. The expanded test procedure should measure both CADR (dust) and power demand at both high and low settings. A normalized efficacy (CADR per watt) can then be calculated.

We note that for this standards proposal, the CADR/watt metric is based on only the high speed CADR divided by the average of high and low speed power measurements.

Because it was not part of the AHAM test procedure, low speed CADR was not listed by manufactures and thus a standard proposal based on the high and low speed CADR and high and low speed power was not possible in this proceeding.

Nonetheless, the expanded AHAM test method should include a low speed CADR measurement and this data should be reported to the Energy Commission and used to develop a more comprehensive standards proposal in a future proceeding. Thus, future efficacy ratings (CADR/watt) would be an average CADRS at high and low settings, similar to the power rating, which is an average power of high and low speed settings and would provide the most realistic assessment of real-world cleaning and efficiency performance.

4.3 Efficiency Measures

In the course of our research, only two manufacturers were identified that claimed to incorporate design features that make their products more energy efficient. (Many manufacturers referred to their models as energy-efficient, but this appeared to be a reference to the relatively modest wattage requirements of the appliance on an individual basis and independent of efficacy relative to other products).

The first manufacturer, Blueair, uses a “new, patented technology” called HEPASilent, a “HEPA-like” polypropylene fiber filter that ionizes smaller particles (Blueair, 2001). In addition, Blueair uses a “very high quality, stainless steel, German-made … fan and motor”. The second manufacturer that advertised an efficient design of their air cleaners is Panasonic. Panasonic incorporates a “micro-dust sensor” or an interval timer into some of its units[3]. The micro-dust sensor is an infrared sensing device that detects particulate matter and adjusts the fan setting to the optimum speed for filtering out that level of particulate matter. The timer runs the unit for 20 minute intervals, followed by 20 minutes of off-time, and so on. Unfortunately, efforts to contact the engineers at Blueair and Panasonic for further technical information or incremental cost data were not successful.

4.4 Standards Options

There are no mandatory energy efficiency standards for portable room air cleaners in the United States. As noted, however, a voluntary program for air cleaners is being developed by the ENERGY STAR program. ENERGY STAR has circulated a final draft of their Program Requirements for Room Air Cleaners and is accepting comments from interested parties until May 7, 2004. ENERGY STAR requires that room air cleaners meet a specification of greater than or equal to 2.0 CADR/watt, using the CADR for dust and testing for energy use only at high speed. ENERGY STAR aims to capture the top 25% of units on the market.

Unlike ENERGY STAR, the power ratings proposed to support the standards in this analysis are an average of high and low speed as outlined in Section 4.1. Thus, ENERGY STAR’S CADR per watt target cannot be compared with the proposed CADR per watt in this report.

[3] Panasonic Website (www.Panasonic.com)

In this analysis, a standard option substantially less rigorous than the proposed ENERGY STAR specification is analyzed. We select a standard option of greater than or equal to 2.7 CADR/watt because approximately half of our sample appears to meet this standard based on the methodologies described above.[4] As shown in the Appendix, the sample of 23 products shows a range of 0.8 to 10 CADR/watt.

Energy savings from the proposed standard were calculated as follows. As noted earlier, 305 kWh per year is the baseline average energy use, based on 23 portable room air cleaners for which we collected power and CADR data. For each product with an efficiency of less than 2.7 CADR/watt, a new value equal to the standard was inserted, which assumes that manufactures will improve the energy efficiency of failing units just enough to meet the standard. Recalculating the average power rating for the 23 products, average energy use would be 236 kWh per year.

Table 3 below, shows the technical potential unit savings, percentage savings, and statewide energy and peak demand savings from implementation of the proposed standard option.

Table 3. Estimated Savings for Proposed Standard

Standard	Projected Savings (%)	Per Unit Annual Savings (kWh)	First Year Statewide Savings (GWh)	First Year Peak Demand Savings (MW)	Full Replacement Statewide Annual Savings (GWh)	Full Replacement Peak Demand Savings (MW)
>= 2.7 CADR/W	23%	69	22	4	187	32

5 Economic Analysis

5.1 Incremental cost

To assess the impact of efficiency standards on retail product costs, we evaluated the correlation among retail prices, power and cleaning efficacy (Figure 2 below). The air cleaning efficacy/power (CADR/watt) was graphed against the listed price of 20 portable room air cleaners for which we had all the necessary data. We found no significant correlation between CADR/watt and price, suggesting that energy-efficient units do not cost significantly more than inefficient units. Any correlation that might exist between price and efficiency is disguised by the more significant costs associated with features (i.e. brand, appearance, control features, etc.)

We also found no correlation between life cycle filter replacement costs and power consumption (Figure 3 below), leading us to anticipate no incremental cost associated with filters designed for higher efficiency portable room air cleaners.

[4] Using the CADR for dust at high speed only with power measured at high and low speeds.

Figure 2. CADR/Watt vs. Price for 20 Portable Room Air Cleaners

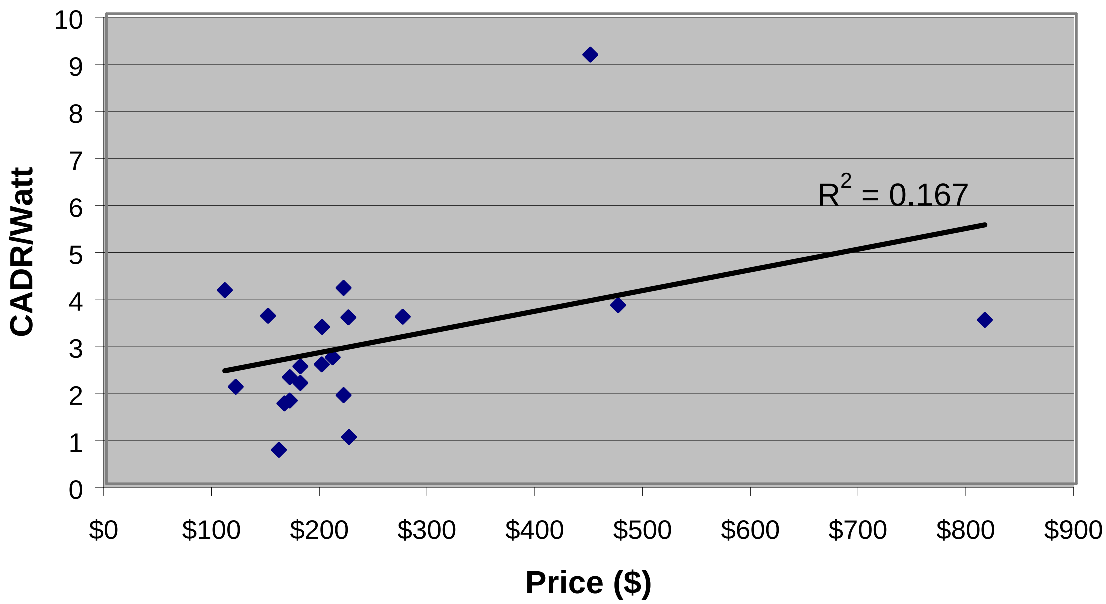
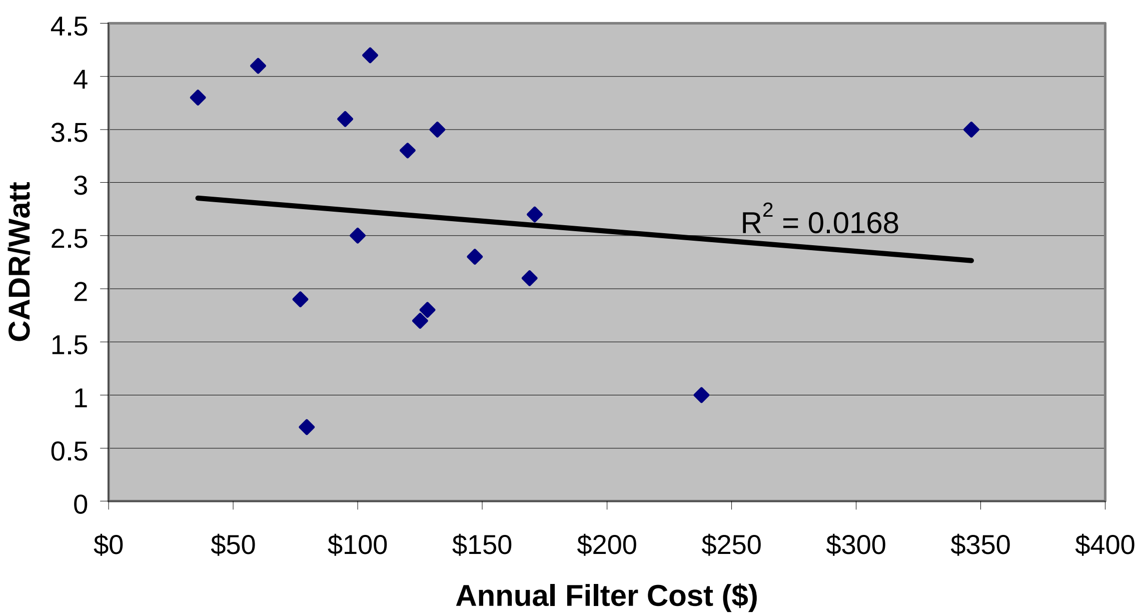


Figure 3. CADR/Watt vs. Annual Filter Cost for 16 Portable Room Air Cleaners



Despite this analysis, we concede that it is possible that with all other options and features held constant, there may be an incremental cost associated with increasing the efficiency of non-complying models. To estimate this cost, we considered motor efficiency improvements, the simplest opportunity to model in this analysis. We assessed the incremental cost of moving from a shaded pole motor to a permanent split capacitor

(PCS) motor. Based on a quick survey of literature and several calls to motor manufactures and distributors, we assume an incremental cost of $10 for this efficiency measure. This measure could almost double the motor efficiency (e.g. 30% to 50% efficiency).

5.2 Design life

ICF Consulting research suggests that the design life of portable room air cleaners is 8.5 years (Clark, 2001). We round this to a lifetime of eight years in order to remain conservative and simplify the analysis of present value of electricity savings. Interestingly, current products use up to two to three times their purchase price in electricity over their life.

5.3 Life cycle cost

Table 4, below, shows the life cycle cost of a single portable room air cleaner under the proposed standard using assumptions provided above.

Table 4. Life Cycle Cost

Proposed Standard	Design Life (years)	Annual Energy Savings (kWh)	Present Value of Energy Savings* ($)	Incremental Cost, Retail ($)	Customer Net Present Value** ($)
>= 2.8 CADR/watt	8	69	$54	$10	$44

* Present value of energy savings calculated using a life cycle cost of $0.778/kWh (CEC, 2001)
** Positive value indicates a reduced total cost of ownership over the life of the appliance.

6 Acceptance Issues

6.1 Infrastructure Issues

A variety of manufacturers produce air cleaners, but a handful controls most of the market. At least two manufacturers appear to be promoting their units as high efficiency, indicating that there is market demand for more efficient products with comparable cleaning performance. Simple, additional measurements can be added to existing industry test methods to allow collection of data necessary to support this standards proposal.

6.2 Existing Standards

There appear to be no energy efficiency standards for portable room air cleaners in the United States. As noted, ENERGY STAR is in the process of developing the first voluntary specification for portable room air cleaners at a level significantly more rigorous than proposed in this CASE report.

7 Recommendations

We recommend that the CEC establish minimum efficiency performance standards for air cleaners. We propose a standards level of greater than or equal to 2.7 CADR/watt, when measured and calculated in accordance with Section 4.1 above. The power rating is to be an average of high and low speeds; the CADR is to be tested while the unit is set on "high" only. The standard should read:

"*The ratio of CADR for dust at the high power setting to the average power of the high and low power settings shall not be less than 2.7 CADR/watt, where CADR is measured only at full speed setting and where the power is determined by the average of high and low speed settings.*"

Furthermore, we recommend the CEC adopt ENERGY STAR'S standby power requirement: The portable room air cleaner must use less than or equal to 2 Watts while in standby mode to activate secondary consumer features. Standby power must be tested in accordance with the Standby Power test procedure outlined (based on the International Electrotechnical Commission Standard 62301, Ed. 1.0) in the ENERGY STAR program requirements and eligibility criteria.

In addition, we recommend that the CEC require testing and listing of portable room air cleaners in accordance with test methods described in Section 4.1 above.

As noted in the test procedure discussion, we recommend that the AHAM test procedure be expanded to measure CADR at low speed for a future proceeding. It was not clear from our research whether CADR is proportional to speed setting given the different air cleaning technologies employed. The Commission should, therefore, assess CADR/watt ratings under both high CADR/watt only and high and low CADR/watt to determine whether it needs to revise the proposed standard in a future rulemaking in order to encourage better overall efficiency.

8 References

Appliance Magazine. 2000. *Appliance Magazine Statistical Review (47th Annual Report),* May 2000, p. 65.

AHAM. 2003. *2003 Directory of Certified Room Air Cleaners.* Edition 2- April 2003. Association of Home Appliance Manufacturers.

ANSI/AHAM AC-1. 1988.. AHAM Standard Method for Measuring Performance of Household Electric Air Cleaners. Association of Home Appliance Manufacturers.

California Energy Commission (CEC), 2001. *2001 Update, Assembly Bill 970 Appliance Efficiency Standards Life Cycle Cost Analysis*. P400-01-028, Table 12A. Sacramento, CA. California Energy Resources Conservation and Development Commission..

Clark, Robin (ICF Consulting). 2001. Personal Communication, May 24, 2001.

Consumer Reports. 2002. *Clearing the Air: Portable Room Air Cleaners*, February 2002 (http://www.consumerreports.org).

Jennifer (Blueair sales office). 2001. Personal Communication, Oct. 24, 2001.

Jiambalvo, John (under contract to ICF Consulting). 2001. Personal Communication, November 20, 2001.

Lawrence Berkeley National Laboratory (LBNL). (2002). http://enduse.lbl.gov/Projects/ResMisc.html (Appendix D, Table 1)

Panasonic. 2001. www.Panasonic.com

Rose, Bleys W. 1989. *Clearing the Air on Air Cleaners*, Home Energy Magazine, March/April 1989.

9 Appendix

Portable room air cleaner sample market and performance data

CADR Source: AHAM Directory (April 2003)
Source high/low W: Manufacturer Web sites
Source average W: ConsumerReports.org Feature Report: Ratings Room air cleaners: The tests behind the ratings (Feb 2002)- data on 16 models, we d/n incl. Ionic Breeze for reasons outlined in our report
CADR/watt: This is CADR for dust tested on high, but watts numbers are averages of high and low.

Manufacturer	Brand	Model	Purchase Price	Hi Watts	Low Watts	Watts- backed out from CR, running half hi, half low speed	Watts	Adjusted Wattage (.91x)	CADR (pollen/dust/smoke)	CADR/Watt
Bemis	Bemis	127-001	$159.99	264	180		222	203	160/160/160	0.79
Bemis	Bemis	200-001	$224.99	264	180		222	203	215/220/220	1.08
Honeywell Consumer	Honeywell enviracaire	17000	$199.99/$130			76	76	69	130/130/130	1.87
Panasonic	Panasonic	EH3020		150	80		115	105	200/200/200	1.90
Hunter Fan Company		30375	$170.00			150	150	137	260/260/265	1.90
Panasonic	Panasonic	EH3012		100	35		67.5	62	125/125/125	2.03
Panasonic	Panasonic	F-P20HU1	$239.95/$200	107	55	114	97.5	89	200/215/215	2.41
Panasonic	Panasonic	F-P10HU1	$119.95	68	29		48.5	44	100/100/100	2.26
Honeywell Consumer	Honeywell	13520	$180.00			134	134	123	251/275/287	2.24
Panasonic	Panasonic	EH3015		105	35		70	64	140/150/150	2.34
Honeywell Consumer	Honeywell enviracaire (	17400	$170.00			97	97	89	180/200/220	2.26
Honeywell Consumer	Honeywell enviracaire $	18150	$199.99/$160			60	60	55	135/150/150	2.73
Panasonic	Panasonic	F-P15HU2	$199.95	75	43		59	54	150/150/150	2.78
Sears, Roebuck & Co	Kenmore	83259	$249.99/$170			93	93	85	200/225/250	2.65
The Holmes Group	Holmes	HAP-675	$200.00			90	90	82	300/300/300	3.65
Amway	Amway	E2526	$815.05	110	19		64.5	59	225/225/225	3.82
The Holmes Group	Bionaire	BAP1300	$220.00/$229.00	230		89	89	81	315/315/315	3.87
Sears, Roebuck & Co	Kenmore/Whirlpool	83355/AP4503OHO	$250/$299.99			90	90	82	330/330/330	4.01
The Holmes Group	Holmes/GE	HAP-650/106653	$160/$139.96			63	63	58	225/225/225	3.91
Friedrich	Friedrich	C90-A	$450/$475/$499	90	47	79	79	72	370/325/300	4.50
The Holmes Group	Holmes/GE	HAP-625/106643	$120/$99.96			34	34	31	140/140/140	4.50
Sears, Roebuck & Co	Kenmore/Whirlpool	83353/AP25030HO	$219.99			36	36	33	170/160/155	4.86
Blueair	Blueair	AV501	$449.00	70	15		42.5	39	390/390/380	10.04
			Min	264	180	Avg.	91	83	Average	3.15
			Max	68	15					