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

Analysis of Standards Options for Whole House Fans

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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 residential whole house fans.

2 Product Description

Whole house fans are high air volume (1000-8000 cubic feet per minute (cfm)) exhaust fans mounted in the ceiling of residences for the purpose of providing cooling and fresh air. Operated in the summer when outdoor temperatures are lower than indoor temperatures, they draw air into the house through open windows and exhaust warmer house air directly into the attic. When operated through the night, whole house fans can cool building mass as well as indoor air, and can displace next-day air conditioner operation, thereby shifting energy use to off-peak periods. They also improve comfort by increasing air movement.

Whole house fans are normally supplied with a gravity or motor-operated shutter that seals the ceiling opening when the fan is not operating. At least one manufacturer provides insulated shutters, but most are uninsulated metal. Fans are propeller type, and may be either direct-drive or belt-driven. Nominal propeller diameters are 24", 30", and 36" for most products, although other sizes also are manufactured.

Available controls include manual switches, timers, and speed controls. Automatic controls to initiate fan operation when the outdoor temperature is lower than the indoor temperature are not used because unattended fan operation (with windows closed) could result in back-drafting of combustion appliances and fireplaces.

Although studies have shown that mechanical ventilation can result in significant cooling energy savings and reduced cooling demand (Parker, 1992), whole house fans are not currently eligible for Title 24 credits. Current residential compliance tools do not demonstrate energy savings for mechanical ventilation cooling because natural ventilation benefits are overly optimistic. Lack of persistence due to manual fan operation may be a sufficiently valid reason to make whole house fans ineligible for Title 24 credits.

A 1988 study (Springer, 1988) completed for the Sacramento Municipal Utility District (SMUD), documents the installed efficacy of seven fans. Fan efficacy ranged from 0.051 to 0.077 Watts/cfm (average of 0.066), with no trend between efficacy and cost. Data from eight additional fans were found for this analysis. The combined sample of 15 fans averaged 0.066 Watts/cfm (ranging from 0.051 to 0.088), apparently indicating no significant changes in the design and component selection of these fans over the past 15 years. Brand names include Certainteed, Dayton, Broan, Emerson, Cool Attic, Patton, and Kenmore brands.

Two potential problems related to whole house fans are dust and noise. By introducing large amounts of outdoor air into the house, added dust can accumulate. Noise produced by many whole house fans can be bothersome and can cause their use to be limited, particularly during sleeping hours. The SMUD study showed a large variability in noise levels, with those fans that produce "pure tone" noise as being least desirable. Speed controls can be used to mitigate noise.

Figure 1 shows a belt-drive fan. Direct-drive fans directly couple the motor to the fan blades, but otherwise appear similar to Figure 1. The fan blades typically have a flat profile (no air foil) and number from two to four. Motors are generally permanent split capacitor-type. A relatively new product that uses electrically operated insulated shutters mounted above two direct-drive fans is shown in Figure 2. This fan is designed to fit between rafters or trusses spaced 24" apart.

Figure 1: Typical Belt-Drive Whole House Fan

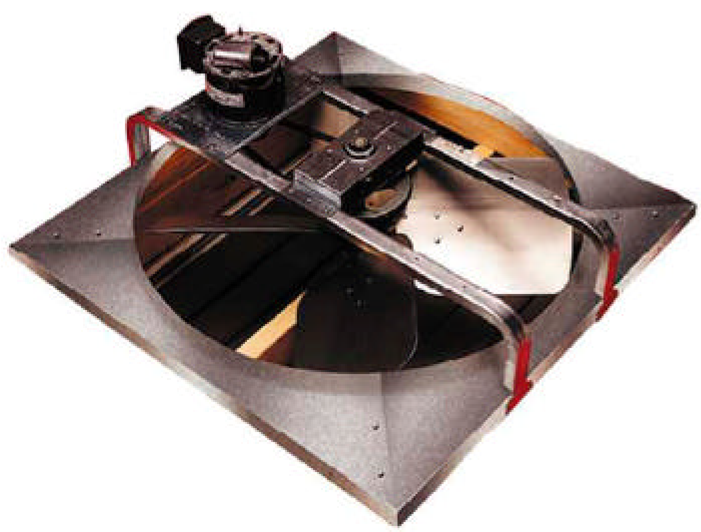


Figure 2: Dual Whole House Fan with Insulated Shutters

3 Market Status

3.1 Market Penetration

The Energy Information Administration last collected data on whole house fans in 1993, when they estimated that 4.2% of households had one (EIA, 1995). According the Pacific Gas and Electric Company (PG&E) Residential Energy Survey (PG&E, 1994), about 5.9% of the homes in PG&E territory have whole house fans. Since this appears to be the best available data, we have extrapolated on a statewide basis to arrive at an estimate of 680,000 California homes with whole house fans. The Residential Energy Survey also shows that whole house fan saturation has been increasing steadily with over 9% of new houses in PG&E territory now having one (See Table 1).

Table 1: Fraction of Households with Whole House Fans by Year of Construction

1989–94	1979–88	1970–78	1960–69	1950–59	1940–49	Before 1940
9.1%	7.3%	6.4%	4.9%	5.2%	3.8%	2.7%

3.2 Sales Volume

Available market surveys do not distinguish between whole house fans and other ventilation fans, so current sales volume cannot be directly estimated without conducting a detailed survey of manufacturers. Most fans are probably sold through home improvement retailers and installed either by retrofit contractors or owners. Since bathroom ventilators are required by building codes, they represent the majority of fan sales. If annual fan sales for both new and retrofit applications represent an estimated 10% of the existing inventory, then annual sales are estimated at roughly 68,000 units. This represents less than 5% of annual residential ventilation fan sales (which includes bath and kitchen fans).

3.3 Market Penetration of High Efficiency Options

Only one manufacturer claims that their fan is energy efficient. However, although this fan has a motorized shutter that is much more effective than conventional louvers, the fan itself has one of the lowest efficiencies (higher Watts per CFM). That some whole house fans have higher efficiency than others is most likely by happenstance. Since they are already marketed as energy-saving devices, manufacturers have little motivation to differentiate their products from others based on efficiency. Opportunities for improving efficiency are noted below in Section 4.3.

4 Savings Potential

4.1 Baseline Energy Use

No published studies describing average or typical whole house fan usage patterns have been identified. Usage varies with weather conditions and user behavior. Under ideal conditions the fan would be operated as soon as the outdoor temperature is a few degrees lower than indoor temperature and would be shut off either when the desired temperature is achieved or in the morning as the outdoor temperature approaches the indoor temperature. Actual usage is affected by the occupant's ability to be present at these times, and by concerns about noise, security (open windows), and comfort.

A conservative estimate of operation would be four hours per day during each of the three summer months, or 360 hours per year. The 1988 SMUD study assumed seven hours per day over a five-month cooling season, or 1050 hours per year. For a typical 6000 cfm fan operating at 0.0660 Watts/cfm, average full speed power demand would be 396 Watts. Applying this power rating to the operating hour estimates yields annual energy usage varying from 143 to 416 kWh per year. On a statewide basis, this amounts to 97 to 283 GWh of annual usage.

4.2 Proposed Test Method

The Heating and Ventilating Institute (HVI) publishes a test standard for certifying exhaust fans, HVI-916, which applies to whole house fans as well as smaller ventilators such as bathroom fans. This voluntary test standard measures airflow rate, sound levels, and power at 0.1" external static pressure, and can be used to develop efficiencies in units of Watts per cfm. However, manufacturers certifying their fans are only required to list airflow and sound in the certification directory, so current information on the efficiency of whole house fans is limited. Currently whole house fans from three manufacturers (Broan, Broan-Nutone, and Marley) are listed in the HVI directory[1], although none of them currently list power demand.

Fans tested under HVI-916 should be tested with manufacturer-provided louvers. Although air leakage and thermal conduction through the louver when the fan is not operating may compromise the thermal integrity of the building envelope, there are no standards for evaluating these effects, and we are not proposing they be considered in this standard.

4.3 Efficiency Measures

Means of improving whole house fan efficiency include the use of efficient motors, efficient fan blades and venturis, and low-pressure drop louvers or shutters. Manufacturers may apply any combination of these measures to achieve the required efficiency. Belt-drive fans operate at lower speeds which can result in higher efficiency and lower noise levels, but belts typically require semi-annual maintenance.

4.4 Standards Options

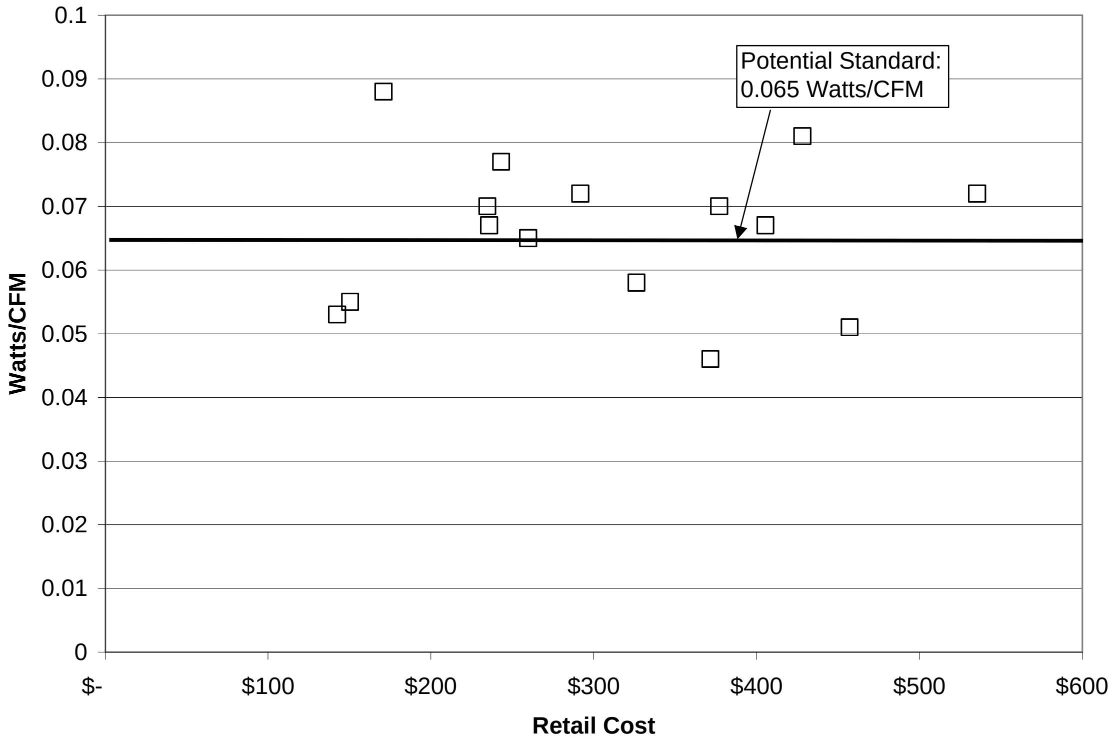
Figure 3 plots airflow efficiency (Watts/cfm) and retail cost data for the 15 fans evaluated in this report. The data clearly show the lack of statistically significant correlation between efficiency and cost for the fans tested. Based on the available data, we find that 0.065 Watts per cfm represents an efficiency level defining a reasonable standards level. Since some of the lowest cost fans surpass this level, there cannot be a strong economic factor impeding other more expensive fans from achieving this efficiency level.

[1] Certified Home Ventilating Products Directory, HVI 911, October 2002.

4.5 Energy Savings

As shown in Figure 3, nine of the 15 fans would not meet the proposed 0.065 Watts/cfm efficiency level. If these nine fans achieved the proposed efficiency level, the average demand reduction would be 30 Watts, resulting in 11 to 31 kWh per year savings based on the range in operating hours assumed in this study. Converting the entire stock of fans to compliant fans would result in statewide savings of 7 to 21 GWh/year.

Figure 3: Fan Airflow Efficiency vs. Retail Cost



5 Economic Analysis

5.1 Incremental Cost

According to the limited sample analyzed for this study, fans compliant with the proposed 0.065 Watts/cfm level are on average, $25 cheaper than the non-compliant fans. Similar to ceiling fans, marketing factors have a much greater influence on retail price than design features that directly affect energy use.

5.2 Design Life

Exhaust fans are projected to have a service life of 6 to 18 years[2]. An average life of 12 years was used to estimate the cost effectiveness of this proposed standard.

[2] Appliance Magazine, September 2000

5.3 Life Cycle Cost

Applying this present value electricity cost to the projected energy savings results in present value costs savings of $12 to $33 per fan depending on annual fan operating hours.

Table 2: Analysis of Customer Net Benefit

Design Life (years)	Annual Energy Savings (kWh)	Present Value of Energy Savings*	Incremental Cost	Net Customer Present Value**
12	11 to 31	$12 to $33	$0	$12 to $33

*Present value of energy savings calculated using a Life Cycle Cost of $1.075/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

Components such as efficient motors are widely available and should not be a limiting factor in their production. Any redesign of the airflow path through the unit should not adversely affect the size and/or configuration of the fans.

6.2 Existing Standards

There are no existing standards regulating the energy efficiency of whole house fans sold in California. The Heating and Ventilating Institute (HVI) test standard for exhaust fans, HVI-916, includes a test method for “Whole House Comfort Ventilators” and develops the airflow and power ratings needed for the proposed standard, but HVI testing and certification is currently voluntary.

7 Recommendations

Given the relatively small projected savings, and the lack of robust data on typical operating schedules, we do not feel that a standard level is justified at this time. We recommend that whole house fans sold in California be tested according to HVI-916 and their airflow efficiency in W/cfm listed. This would open the door for a possible standard level at a future time, and would also provide useful information to consumers.

8 Bibliography

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