August 9, 2007

To: Chris Gekas, California Energy Commission
1516 Ninth St, MS 25, Sacramento CA 95814-5512

RE: Importance of limiting residential ventilation fan energy consumption in Title 24

Dear Mr. Gekas,

This is a comment on the 2008 changes to California's Title 24 residential energy code, specifically regarding the electrical energy consumption of fans used to ventilate homes.

As a residential building scientist and ventilation consultant, I understand the need to install mechanical ventilation systems in tight homes to ensure adequate indoor-outdoor air exchange whenever windows are closed, for reasons of health and indoor air quality. However, because mechanical ventilation is an additional – and continuous – electrical end use in new homes it is also important to maximize the efficiency of ventilation fans.

My concern is that most builders will choose between the two systems that are cheapest and easiest for them to install, without considering the long-term costs of fan operation. Those are exhaust and 'forced-air supply' ventilation, and while many exhaust fans are energy-efficient, the use of forced-air fans to ventilate homes is not. Exhaust fans that are designed for continuous ventilation of homes use about **0.25 W/cfm** of delivered outdoor air, while 1,000+ cfm forced-air fans – which are not designed for continuous ventilation – use **at least 5.0 W/cfm** of delivered outdoor air – assuming that a 500 W forced-air fan introduces 50-100 cfm of outdoor air whenever it operates. The potential impact of this 'order of magnitude efficiency gap' on energy and peak demand should not be ignored.

You have already received comments from at least two manufacturers of forced-air fans and/or controls who admit their systems won't meet the current proposed fan energy limit of **1.2 W/cfm**, yet want to ensure their systems can be installed in CA without penalty. (The 1.2 W/cfm limit is necessary and reasonable to accommodate balanced HRVs.)

I am not selling and have no personal financial interest in any ventilation system. I do advocate using the most efficient and effective residential ventilation systems possible, and there are plenty of those available, including not only exhaust and balanced heat recovery, but also efficient supply ventilation that is independent of the forced-air fan. **I urge you to maintain the fan energy limit of 1.2 W/cfm** in the energy calculations, and to account for actual fan W/cfm outdoor air with the performance approach is used.

There is no reason to forego energy efficiency to achieve residential indoor air quality, and to do so would be a step backwards for the Building Energy Efficiency Standards.

Supporting information is on the following pages. Thank you for your consideration.

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1) This table shows a simple 'back of the envelope' calculation of the difference between operating an efficient ventilation fan continuously and a typical forced-air fan intermittently – to ventilate a home.

	Efficient exhaust fan, continuously operated	Typical residential forced-air fan, operated for 15 minutes of every non-conditioned hour for ventilation
Ventilation (outdoor air) provided, cfm	100	100
W	25	500
W/cfm	0.25	5.0
Hours of operation per year	8,760	Estimate 1,400 (= (8,760 – heating hours – cooling hours) / 4)
kWh per year	**197**	**700**

Multiplying the difference of 500 kWh/yr by about 100,000 new CA homes per year suggests that about **50,000 MWh per year could be avoided by not using forced-air fans to ventilate California homes.**

2) The following is an excerpt from my 2004 U.C. Berkeley master's thesis titled *Effect of Building Airtightness and Fan Size on the Performance of Mechanical Ventilation Systems in New U.S. Houses: A Critique of ASHRAE Standard 62.2-2003.* Some excerpted text is highlighted for emphasis.
The full document is available at: http://repositories.cdlib.org/cedr/cbe/hvac/Roberson_thesis2004/

Forced-Air Supply Ventilation

Because of the need to distribute supply ventilation air to living and bedrooms through ductwork, some builders use the forced-air conditioning system fan and ductwork (which is present in any home with central air-conditioning) to distribute ventilation air as well. Such 'forced-air supply' or 'forced-air integrated' ventilation systems depend on operation of the forced-air fan to pull outdoor air into the forced-air duct system and distribute it to all rooms with a supply register. Compared to installing a separate supply ventilation fan and ductwork, it is much cheaper and easier for builders to install a 6" supply duct between an exterior wall (i.e., outdoors) and the forced-air duct system.

However, there are several significant problems with using a forced-air fan to provide ventilation. The first problem is that fresh air is needed all the time, while conditioning is not, so the forced-air fan must operate regularly for ventilation even if the thermostat does not call for heating or cooling. Yet because forced-air fans are designed to move roughly ten times as much air as is needed for ventilation (~1,000 vs 100 cfm, respectively), their operating costs are correspondingly larger, and the fact that the fan must operate more often further increases costs. One way to keep forced-air supply operating costs from being prohibitively expensive is to operate a high-efficiency variable-speed forced-air fan at low speed for ventilation; however, the better fans are also more expensive, so production builders use another option, which is to operate typical forced-air fans intermittently.

For example, the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) sponsors the Building America Program, which attempts to improve the energy-efficiency of new homes by collaborating with and changing the construction practices of production homebuilding companies. Building America sponsors several independent but related teams, each with its own strategy for demonstrating building strategies that save energy *at no net added cost to production builders*. One of Building America's teams is the Building Science Consortium, led by Building Science Corporation (BSC), and one BSC engineer "is the exclusive licensee of the applicable patents" to the accessory control (~$125 each, $200 installed) needed to operate a forced-air fan intermittently at regular intervals for ventilation (Rudd 2004). Not surprisingly, forced-air supply ventilation systems using this particular control device are installed in virtually all new homes built by production homebuilding companies working with Building Science

Corporation within the Building American Program (EDU 1997, Barley 2001, Andrews 2002, EERE 2004, Rudd 2004). In fact, in spite of the inherent inefficiency of operating a forced-air fan even intermittently for ventilation, Rudd and his company recommend his product for use not only with forced-air supply ventilation, but also in conjunction with other types of ventilation systems, including continuous exhaust, supply, and balanced heat recovery (EDU 1999, Rudd 2004).

The Building America Program is doing its best to reconcile the need for ventilation of new homes with the current resistance of builders, the lack of public awareness on this issue, the ambiguity of ventilation standards (described below), and the dearth of home mechanical ventilation systems that are both affordable and effective. According to one program employee (Barley 2002):

> "(M)ost homebuyers are not fully aware of IAQ (indoor air quality) issues and whole-house ventilation requirements, and are thus not willing to pay the incremental cost of improved systems. Because the applicable standards do not require these improvements, lower-performance systems are often installed despite the best intention of engineering teams."

Nevertheless, from homeowners' or occupants' perspective (whether they realize it yet or not), there are other significant potential disadvantages to using a forced-air fan for ventilation. These are described elsewhere (Jackson 1991, Roberson et al 1998) but summarized here, with help of a Department of Energy document (US DOE 2002). Of forced-air integrated ventilation, it says:

> "To be most effective, heating and cooling ductwork must be airtight or located within the conditioned space of the house. Several design issues must be addressed, the solutions to which often come at the cost of increased system complexity.
>
> "Ventilation systems that use the air-handler fan tend to provide the most mechanical ventilation in the winter, when the cost of tempering outside air is highest and it is least needed because natural ventilation is usually greatest.
>
> "Ventilation systems that use the air handler fan also tend to provide the least mechanical ventilation when it is most needed…(which is why a non-thermostatic fan control is needed.)
>
> "Running a large air-handler fan can be noisy and expensive. One solution is to use a more expensive variable-speed air-handler fan that operates at low speed when heating or cooling is not needed. This approach may require a motorized damper to keep the ventilation rate nearly constant when the fan operates at different speeds. Another solution is to use a smaller, separate fan to pull outdoor air into the ductwork and distribute it throughout the house.
>
> Duct systems that distribute heated and cooled air effectively when the air flow rate is 800 cfm or more may distribute is poorly when the flow rate is dropped to 100 cfm of less."

In addition, not only is intermittent ventilation much less effective in controlling indoor pollutants, but it also does not maintain indoor pressurization, which is a key advantage of supply ventilation. The entire duct system should be within conditioned space because if not, when it leaks, "outdoor" air is as likely to come from wherever the return ducts are located (e.g., the attic, basement, garage) as from the supply air duct, and conditioned air is as likely to be distributed to wherever the supply ducts are located (e.g., the attic, basement, garage) as to the living area. Also, if supply duct leakage to outside exceeds return duct leakage (i.e., if more air leaks out of the supply ducts than leaks into the return ducts), the house can be depressurized—rather than pressurized—by the fan.

In any case, the expense of operating even a relatively efficient forced-air fan at intervals for ventilation is still higher than that of operating a quiet, efficient, right-sized supply ventilation fan continuously (Wray et al 2000).

END OF EXCERPT, AND COMMENT