The Role of Ventilation
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Ventilation and Utility Program Incentives in the Northwest U.S.

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1. Synopsis

Residential ventilation has at least two energy penalties that must be considered when addressing the ventilation levels recommended in ASHRAE Standard 62.

- Energy is required to heat the fresh outside air used for ventilation. In cold climates with high heating costs, an air-to-air heat exchanger can lessen the operating expense.
- Energy is needed for the fan motor used to introduce fresh outside air and/or to exhaust stale indoor air.

This paper will explore the residential ventilation experience in the Pacific Northwest states of the United States regarding the use of heat recovery versus non-heat recovery ventilation systems. It will also discuss the experience of one large private electric utility (1.6 million customers in seven states) in determining utility ventilation program design and incentive programs based on Demand Side Management. It will trace the analysis by the authors of the energy penalties of several ventilation strategies and the level of incentive for low-energy fans that is supportable by the utility in the rate-making process. (Private utilities in the United States are regulated monopolies that must seek approval of state utility regulatory boards for rates, energy conservation programs, and program incentives.)

2. Introduction

The Pacific Northwest region of the United States includes the states of Washington, Oregon, Idaho, and western Montana. The coastal area has a temperate, damp, maritime climate west of the Cascade Mountains; the interior area east of the Cascades and west of the Rockies has a dry, cold, high mountain climate. Approximately 80% of the Pacific Northwest's population lives in the coastal area.

Residential ventilation has been a component of electric utility and governmental agency programs in the Northwest since about 1984 and has been required in residential energy and ventilation codes since 1991. The major complaint from occupants of houses built early in the programs was that the ventilation fans were too loud. Follow-up surveys showed that occupants would not operate a noisy fan even if disabling the fan caused condensation and mold growth in the home. As we have gained experience in residential ventilation, quieter fans have been introduced, and the length of recommended daily operation has grown. But better fans and longer operating times raised concerns about the energy cost of ventilation. This paper will explore one utility's attempts to address these concerns.

History of Ventilation in Utility Energy Efficiency Programs

The northwestern United States is an area with energy codes exceeding almost all other parts of the country. As residential energy codes and electric utility energy efficiency programs became more stringent, ventilation and indoor air quality (IAQ) became critical issues. Unfortunately, due to a lack of consumer knowledge and questionable installation and performance in many ventilation fans and heat recovery ventilation (HRV) units, adequate ventilation levels were often not maintained. Electric utilities marketing energy efficient thermal shell programs often faced customer complaints about stuffy homes and mold growing on walls. Often the problem was customers disconnecting the ventilation systems in their homes due to excessive fan noise. Quite often disconnecting the ventilation system was done despite specific utility guidelines requiring a certain amount of ventilation system run time per day to ensure adequate air exchange and indoor air quality.

The concept of using a controlled, mechanical ventilation instead of natural ventilation was not understood by the majority of consumers and contractors. Many contractors and consumers could not understand the idea of building a house tight and then "punching holes in the walls" to allow fresh air to come in. This lack of education on the part of both consumers and contractors led to inadequate ventilation and unacceptable indoor air quality in many homes. Clearly, a solution was needed.

Importance of Ventilation in Marketing Energy Efficiency

The solution was a combination of increased education for consumers and contractors, as well as the introduction and marketing of new and improved ventilation technologies in the residential marketplace. The increased education component focused first on in-depth technical training on ventilation for utility representatives managing the energy efficient thermal shell programs. This training was supported by a technical booklet on ventilation written for general contractors, with separate sections developed for single family construction and multi-family construction. Explanations of both HRV and non-HRV ventilation systems were provided to address the needs of different climates.

Finally, a less technical consumer brochure was developed to explain the importance of home ventilation and its relation to indoor air quality. Ventilation is a dry topic in residential construction and often not understood well by consumer or contractor. Typically, consumers are more interested in the carpet colors and the type of decorative tile to be installed in the home, while contractors are interested in what helps them sell their homes as fast as possible. Here was another dilemma facing utility marketers: how to make ventilation an integral part of the home construction and buying process. Enter indoor air quality as the marketing tool to ensure adequate ventilation. The elements of ventilation education segued into a successful marketing message for promoting energy efficient home programs to both consumers and contractors. Everyone can relate to concerns about living in a stuffy, stinky, or polluted indoor environment. No one wants to live in an unhealthy indoor environment; no contractor wants the liability of building an unhealthy home. Ventilation is the solution to the IAQ problem.

While utility program technical specifications were changed to require quieter fans, they were still not quiet enough for some customers. The new technical specifications also required longer ventilation system run times, raising the specter of energy penalties. To address the energy penalty and quietness issues, we explored the concept of a nominal utility incentive paid to contractors who installed quiet, energy efficient ventilation fans and HRV systems. The goal was to encourage market transformation so that quiet, energy efficient ventilation fans and HRV systems would become commonplace in the residential home construction marketplace.

3. Research and Analysis of Fan Energy Considerations

In analyzing the costs of providing adequate ventilation for reasonable indoor air quality, we looked at both the energy penalty for heating outside air drawn into the structure and for the fan energy for operating the fan. The cost of electrical energy in the Pacific Northwest averages approximately $.05 per kilowatt-hour, while the United States national average cost is over $.10 per kWh. Given that the majority of the housing in the Northwest is located in a climate that requires less than 5000 heating degree days (°F) per year, the energy penalty for bringing in fresh air typically does not justify the added cost of heat recovery ventilation. In areas where the energy cost is greater and/or the climate is more severe, HRV systems deserve more consideration than we have given them in the maritime Northwest.

Most residential ventilation systems currently installed in the Pacific Northwest use negative pressure ventilation strategies with one or more exhaust fans to pull stale air out of the building. Typically, a quiet (1.5 sone or less), surface-mounted bath fan or a remote-mounted bath fan is controlled by a 24-hour time-of-day timer to provide general ventilation for at least eight hours a day. We refer to this as "whole house ventilation". While ASHRAE Standard 62-1989 generally requires ventilation at 0.35 ACH whenever the house is occupied, we have adopted a setting of eight hours a day as a program- or code-minimum setting for the automatic control.

All the houses built in the Northwest are of fairly tight construction, with a target leakage rate of about 7 air changes per hour at 50 Pascals. Consequently, the houses need mechanical ventilation with a specific strategy for bringing in outside fresh air. Fresh air is introduced either through passive air inlets located in bedrooms and the living space or through an outside air connection to the return air plenum of the forced air furnace. The air inlets are generally Swedish or French through-the-wall inlets or American inlets built into the window frames. The outside air connection to the return air plenum of the forced air furnace relies on negative pressure created by the air handler to pull in outside air and on the air handler fan to move the mixture of household air and outside air to all the rooms of the house.

The major emphasis of our research was to analyze the energy cost of using the air handler in the forced air system, compared to the use of an exhaust fan with inlets, and then to determine if the energy savings of low energy fans could support an incentive from the utility. A major issue addressed was the energy used by the furnace. When the forced air furnace's air handler is used to bring in outside air and deliver it to habitable rooms, the air handler fan's energy use must be analyzed. Field surveys by the authors on behalf of Pacific Power and Light and by Ecotope for the Bonneville Power Administration and the Washington State Energy Office under Cycle III of the Residential Construction Demonstration Program have shown an average wattage of 500 watts for air handler fans in a sample of nearly 30 houses. Wattage ranged as high as 740 watts for a half-horsepower fan and as low as 310 watts for a quarter-horsepower fan. When the air handler is used to supply the outside air, an average load of 500 watts is placed on the home's electrical system with an additional load of 15-100 watts for the exhaust fan.

Some builders and HVAC contractors have tried using variable speed heat pumps to minimize this fan energy penalty. Some of the true variable speed motors can slow down to under 100 cfm, resulting in fairly low wattages. However, as the cfm decreases, the pressure in the duct available for supply and return air movement is reduced as well. In fact, when the cfm is dropped to one-quarter of its former rate, the pressure available in the ducts drops to one-sixteenth, leaving virtually nothing to draw in air from the outside. These systems in fact do not introduce any measurable fresh air at low speed.

When using the furnace air handler to supply outside air for ventilation, it is reasonable to assume that some portion of the eight hours of daily ventilation operating time will coincide with a call for heating. The amount of overlap time will depend on the UA of the house, the climate, the system size, and the thermostat setting. If we assume that over the year one to two hours of the ventilation operating time will in fact coincide with the call for heat, then a conservative estimate is that the air handler would operate for at least six hours a day for ventilation only. At 500 watts, this represents a load of 1,095 kilowatt hours per year just for the air handler operation. The typical 60 watt, whole house fan consumes an additional 175 kwh, resulting in a cost of operation for fan energy alone of 1,270 kwh per year. On the basis of this analysis, Pacific Power and Light stopped allowing the use of the furnace air handler to introduce and distribute outside air for the ventilation system.

If a quiet bath fan controlled by a timer is used with wall or window inlets for passive introduction of fresh outside air, only the exhaust fan energy must be counted. For the typical 60 watt fan, this represents approximately 175 kwh per year. However, over the past year several manufacturers have introduced low energy fans that draw only 12-25 watts. In multifamily buildings, central remote-mounted fans can deliver similar energy savings when one fan ventilates several units in the same building. Pacific Power and Light decided to investigate the potential for offering an incentive to builders who installed low energy fans. One of the considerations was whether the energy savings were worth enough to support an incentive to move builders to the more efficient (and more expensive) fans. The following data summarizes the analysis:

Manu-facturer	Model Number	Cfm at .1" w.g.	Cfm at .25" w.g.	Sone Rating	Wattage	kWh/Yr for 8 hr	kWh/Yr for 24 hr
Surface mounted fans:							
Broan	S90	90	75	1.5	50 w	146 kWh	438 kWh
	314	128	106	1.5	70 w	204 kWh	613 kWh
	360	100	84	1.5	80 w	234 kWh	701 kWh
Fan America	SMV80	80	60	0.8	35 w	102 kWh	307 kWh
	SMV100	100	80	1.2	37 w	108 kWh	324 kWh
	SMV140	120	120	1.5	40 w	117 kWh	350 kWh
NuTone	QT-80	80	63	1.5	60 w	175 kWh	526 kWh
	QT-90	90	85	1.5	75 w	219 kWh	657 kWh
	QT-130	130	100	1.0	120 w	350 kWh	1,051kWh
Panasonic	05VQ	50	31	0.5	12 w	35 kWh	105 kWh
	07VQ	70	52	0.5	15 w	44 kWh	131 kWh
	08VQ	90	70	1.0	17 w	50 kWh	149 kWh
	11VQ	110	88	1.5	19 w	55 kWh	166 kWh
	12VQ	110	60	1.0	20 w	58 kWh	175 kWh
	20VQ	190	130	1.5	31 w	91 kWh	272 kWh
Remote single pickup fans:							
Broan	SP100	120	107	--	50 w	146 kWh	438 kWh
	SP140	160	145	--	85 w	248 kWh	745 kWh
Fantech	F-100	150	140	--	70 w	204 kWh	613 kWh
Kanalflakt	K4	105	90	--	48 w	140 kWh	420 kWh
	K5	143	125	--	50 w	146 kWh	438 kWh

Remote multipoint fans:
Assume 2 story building with 2 bedroom units with 850 square feet (85 square meters) and 1 bath that needs 45 to 50 cfm (21-24 l/s) of whole house fan ventilation.

Manu-facturer	*Model Number*	*Cfm at .25" w.g.*	*Cfm at .40" w.g.*	*Number of units*	*Wattage*	*kWh/Yr for 24 hr operation*
ALDES	VMPK	110 low	110 low	2	72 w	315/unit
		180 high	180 high	3	120 w	350/unit
	MPV200	75-230	75-230	4	90 w	197/unit
	MPV300	200-330	200-330	6	120 w	175/unit
Broan	MP100	106	98	2	50 w	219/unit
	MP140	149	141	2	85 w	372/unit
	MP200	210	200	4	140 w	307/unit
Kanalflakt	EQ180	178	150	2	69 w	302/unit
	EQ375	290	280	4	152 w	333/unit

In the Pacific Northwest, we use the rated flow at 0.25 inches of water gauge (62 Pascals) for surface-mounted fans and 0.4" w.g. (100 Pascals) for remote multipoint fans. When comparing ventilation strategies for buildings, it is obvious that the use of low energy fans has a significant impact on the energy use of the building. For a four bedroom house being ventilated at 80-120 cfm for eight hours a day, the choices might be a NuTone QT-130 or a Panasonic 20VQ to provide the ventilation at 1.0 sones of noise level. The NuTone fan would use 350 kWh per year while the Panasonic fan would use only 91 kWh per year, a savings of 259 kWh. If the ventilation in a multifamily apartment building were being compared, then the choices for two bedroom apartments being ventilated continuously at 50-75 cfm might include a Broan S90 or a NuTone QT-80 in each apartment or a central multipoint fan such as the ALDES MPV300 ventilating six apartments. The Broan fan would use 438 kWh, the NuTone fan would use 626 kWh, and the ALDES multipoint fan would use 175 kWh per apartment. This gives a savings of 263-451 kWh per year per apartment, with the added incentive of no fan noise in the apartment. As can be seen, the low energy fans from Panasonic offer the lowest fan energy cost on a per unit basis. A central multipoint fan such as the ALDES MPV300 fan that ventilates several apartments at once is also quite efficient when compared to the more typical quiet, surface-mounted fan.

On the basis of this analysis of fan energy, Pacific Power and Light Company determined that the current value of the potential saved energy over the life of an exhaust fan operating for at least eight hours daily supported a $50 incentive payment to encourage a builder to install a low energy fan. Because the private electric utility operates as a regulated monopoly in its service area, Pacific Power was required to show the state regulatory commissions in its several-state service area that the avoided cost of the saved energy was greater than the added cost of the ventilation upgrade. Pacific Power was successful in making this case, and the incentive is now in place in four states. For a utility with higher electric rates, a higher incentive could be justified.

4. Summary:

Our experience in the Pacific Northwest is that passive ventilation strategies do not provide adequate ventilation at the time it is needed and that mechanical ventilation is much more dependable and predictable. Electric utilities and government agencies should approach mechanical ventilation with an eye to both the energy penalty of heating the fresh air (or reheating the house) and to the energy penalty for fan motor energy. If energy rates are low and the climate is moderate, the reheat energy penalty is low and therefore the use of heat recovery ventilation is not warranted. The fan energy consideration can be addressed either by requiring a low energy or shared fan or by providing an incentive to encourage the use of low energy fans or shared fans to reduce the fan energy penalty for ventilation. The savings by using low energy fans is significant and should be considered in calculating program, code, and incentive costs.