Residential Construction Demonstration Project

Cycle II:

Active Ventilation

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Executive Summary

This report documents the analysis of the performance of natural and mechanical ventilation in Pacific Northwest homes. The analysis was part of Cycle II of the Residential Construction Demonstration Project, sponsored by Bonneville Power Administration (BPA). Since 1986, the Residential Construction Demonstration Project (RCDP) has sponsored the collection of data on energy efficient homes in the Pacific Northwest that comply with these new standards and requirements.

Cycle II of RCDP was conducted between September 1987 and April 1990. It concentrated on energy innovations in homes built to the Super Good Cents specifications. All of the test homes have electric heat and mechanical ventilation systems. Seven different types of active ventilation systems are represented in the homes. Three of these system types are equipped with heat recovery devices, and are represented in approximately a quarter of the test homes.

The potential for both natural and mechanical ventilation was measured. Potential structural leakage was measured by blower door testing. Flow rate and operating time of mechanical ventilation systems were measured with flow hoods and hour meters. Actual ventilation was measured by using a passive tracer gas technique for several weeks during the heating season and at times of normal occupancy.

Combined mechanical and natural ventilation was found to be below 0.35 air changes per hour in 71 percent of the homes. Actual mechanical ventilation fell far short of expectations. This was partially because many system installations failed to deliver the intended air flow rate. A much more important reason was that most occupants operated their systems, at most, only a few hours each day.

Some seemingly likely deterrents to operation appear to have no significant effect. Most people indicated that they had no complaints of drafts or noise and did not ventilate any less because of these effects. Also people who reported great concern over indoor air quality did not ventilate any more than those who indicated very little concern.

Lack of occupant understanding appears to be the dominant reason for under-ventilation. Those who said they neither understood their systems nor knew when to operate them, appeared to use them only briefly as spot ventilators. Occupants who reported the worse relationship with their builders (and presumably had poor communications) operated their systems less. Ironically, occupants who reported the most stale air symptoms (stuffy, too warm, or window condensation) ventilated the least. This suggests that they did not understand that their active ventilation systems could reduce these problems.

By far, the least operation occurred in homes without ducted systems. Three quarters of these homes are ventilated less than 3 hours per day. The systems in these homes are conspicuous because fans are mounted directly in the wall or ceiling. Occupants may be more inclined to switch off these systems because they resemble familiar spot exhaust fans and are apparent by their noise even if they are not bothersome.

The mechanical ventilation time measured by hour meter was consistently less than occupants' estimates of their ventilation time. The discrepancy was greatest for occupants who said they did not understand their systems.

Section 1

Introduction

This report documents the analysis of the performance of natural and mechanical ventilation in Pacific Northwest homes. The analysis was part of Cycle II of the Residential Construction Demonstration Project, sponsored by Bonneville Power Administration (BPA). This report is meant to be used in conjunction with *Residential Construction Demonstration Project, Cycle II: Infiltration and Ventilation in New Electrically Heated Homes in the Pacific Northwest*, prepared by Ecotope Incorporated (Palmiter, Brown, and Bond, 1989) and included as Appendix A.

Background

Modern homes are so well insulated and tightly built that they can no longer rely on leakage alone to provide adequate ventilation. This has led to the development of standards for minimum ventilation and requirements for the installation of mechanical ventilation systems.

Since 1986, the Residential Construction Demonstration Project (RCDP) has sponsored the collection of data on energy efficient homes in the Pacific Northwest that comply with these new standards and requirements. Cycle II of RCDP was conducted between September 1987 and April 1990. It concentrated on homes built to the Super Good Cents specifications. These specifications were developed, in response to the Northwest Regional Power Act, by BPA in partnership with the four northwest states. All Cycle II RCDP homes have electric heat and mechanical ventilation systems.

Study Methods

Data on natural and mechanical ventilation were successfully collected from 190 Pacific Northwest homes. After assessing the data for completeness, data from a reduced number of the homes were ultimately used in the analysis. The number of homes used varied with the different research questions, because each question required different combinations of data. The number was never greater than 160 because only 160 homes have known ventilation system types. Table 1-1 shows the types of mechanical ventilation systems and the number of homes that use each type of system.

Table 1-1. Mechanical Ventilation Systems

System	Intake	Exhaust	No. of Homes	% of Total
AAHXc	Air-to-air heat exchanger integrated with heating system		5	3.9
AAHX	Air-to-air heat exchanger		26	15.5
EAHP	Through-wall vents or make-up air to forced air heating system	Exhaust air heat pump	13	6.2
nHRV1	Through-wall vents or central ducted intake	Designated bathroom, kitchen, or laundry fan	51	30.2
nHRV2	Through-wall vents or central ducted intake	Central ducted exhaust	15	10.1
nHRV3	Through-wall vents or central ducted intake	Separate whole house exhaust fan	6	4.7
nHRV4	Make-up air to forced-air heating system	Designated fan, whole house fan, or central exhaust	44	29.5

The analysis considered the structure, the mechanical ventilation system, and the human occupants of each home as parts of the system. The following parameters were measured:

■ **Air Circulation.** Homes were divided into zones, and the movement of air within and between zones was tested and modeled.

■ **Heat Loss.** The impact on space heating from natural and mechanical ventilation was measured by recording operating time and estimating typical flow rate of mechanical systems, predicting natural infiltration, and calculating the heat loss coefficients for both natural and mechanical ventilation.

At the end of the monitoring period occupants were asked to complete a survey. The purpose of the survey was to compare the reported operating time of mechanical systems with other variables, such as occupants' knowledge of the system, their relationship with the builder, and their concern for indoor air quality.

Section 2

Air Circulation

One measure of ventilation is the amount of air exchange that occurs within and between zones in each home. To calculate zonal air exchange, homes in this study were first divided into zones. Zones consisted mainly of areas that were likely to have similar space heating schedules. For example, each home usually was assigned a bedroom zone, even though the space consisted of separate, isolated (even noncontiguous) bedrooms.

Passive tracer gas testing was used to measure ventilation between zones and between the whole house and outdoor air. This measurement system was developed by researchers at Brookhaven National Laboratories (Dietz, Goodrich, Cote, and Wieser, 1983). It is formally called "AIMS" for Air Infiltration Measurement System, although it is commonly referred to as "PFT testing" because of the perfluorocarbon tracer gases used.

The test method is simple. Tiny capsules called "sources" are placed in the various zones. A minute amount of perfluorocarbon tracer gas diffuses from each of these sources. The concentration of tracer gas in the living space depends partly upon the source's (known) emission rate, but it also varies inversely with the effectiveness of ventilation to dilute or flush tracer gas away.

The concentration of tracer gas is measured by small capillary adsorption tubes (CATS). These are placed in the various zones at different locations than the sources. The CATS adsorb tracer gas in proportion to its concentration in the air. After being exposed for several days or weeks, the CATs are retrieved and taken to a laboratory, where they are analyzed with a gas chromatograph (GC). The mean concentration of tracer gas in the zone during the exposure period is determined from the amount of adsorbed tracer gas.

Finally, laboratory results are input to a mathematical mass balance model to calculate zonal air exchange. Simultaneous equations are written for the mass balance of all tracer gas flavors (unique chemical types) in each zone, and the resulting matrix is solved.

In this project, the resulting zonal PFT data were found to be extremely imprecise. Standard deviations were often greater than their associated parameters. One reason for this imprecision is that all parts of the measurement process have associated errors, such as source emission rate, effect of local turbulence on the CATS, GC errors, gas contamination in sources, and contamination of CATS in transit.

Another reason for the imprecision is that some conditions in the homes were incompatible with the mathematical process used in the model to derive interzonal flows from zonal concentrations. A necessary assumption of the model is that each zone is well mixed. However, the homes were found to have poor intrazonal mixing and strong interzonal coupling, usually because doors in one zone were open to another zone much of the time. Poor intrazonal mixing was the main problem in homes without forced-air distribution systems. Whereas, interzonal coupling was the main problem in homes with forced-air systems.

Interzonal coupling works against the mathematical model by greatly amplifying the effect of measurement errors. Two highly intermixed zones lead to very similar mass balance equations for the two zones, which in turn leads to an "ill-conditioned matrix." Finding a solution is akin to searching for the intersection of two lines that are very nearly parallel and/or coinciding. A very slight error can greatly change the intersection point.

Notwithstanding these problems, the zonal data were sufficient to confirm several reasonable conclusions:

- Houses with forced-air distribution systems show good mixing within and between zones.
- Multistory houses without forced air systems experience strong upward air flow. A forced air system can alter the pattern by recirculating considerable amounts of air from the upper level back into the lower levels.
- Good interzonal mixing occurs when doors are open between zones, regardless of the type air distribution system.
- The concentration of pollutants in zones strongly depends on the location of the pollutant source.

Section 3

Heat Loss

Several tasks were completed in order to assess the impact of ventilation on space heat consumption. These tasks were as follows:

- Recording the amount of time ("on time") that the mechanical ventilation systems were operating, and estimating the typical flow rate of each system
- Calculating the heat loss coefficient of mechanical ventilation systems
- Estimating the amount of natural infiltration, through blower door testing and computer modeling
- Calculating the heat loss coefficient for natural ventilation
- Calculating the combined heat loss coefficient for natural and mechanical ventilation
- Estimating and analyzing the heat loss coefficient percentages produced by conduction and ventilation, and applying percentages to each type of mechanical ventilation system
- Analyzing the effect of mechanical systems on overall ventilation in the homes

Mechanical Heat Loss Coefficient

Mechanical ventilation systems affect the heat loss coefficient (UA) of RCDP homes. To assess this relationship, hour meters were installed on the exhaust ducting to record the operating time of the mechanical ventilation systems. Weekly on-time readings from the meters were multiplied by the most likely flow rate during operation. The hour meters did not distinguish between various fan speeds. To obtain a likely flow rate for multi-speed systems, the control systems were usually configured so that the high speed was used only for spot control and less than an hour per day. Flows were then measured at all fan speeds during the site visits, and the flow used for assessing UA was usually based on the low speed flow for each system.

Some mechanical ventilators were also heat recovery devices. To simplify comparison, it was decided to base ventilation UA only on the amount of air inducted into the houses. In this approach, heat recovered was regarded as a source, not as a credit against ventilation heat loss. This avoids reporting a small mechanical UA that could falsely suggest a lower and less healthful ventilation rate. This method is particularly appropriate for exhaust air heat pumps. Much of their recovered heat goes toward water heating rather than space heating. Also, their heat recovery rate is related to demand and is totally insensitive to indoor/outdoor temperature differential. It should be remembered that AAHXs pay back about 60 percent of the heat loss implied by their UA. During mild weather, EAHPs pay back all the heat lost by inducting outside air. Indeed, they can produce a net gain over the year in milder climates.

Mechanical ventilation UA was computed using Equation 3-1.

Equation 3-1

$$\text{Mech UA} = \text{exflow} \cdot \text{vperday}/24 \cdot C_p \cdot 60 \cdot \rho \cdot (1 - \text{siteelev} \cdot 3.458\text{E-}5)$$

where:

Mech UA	=	Mechanical heat loss coefficient in Btu/hr/°F
exflow	=	Exhaust flow rate during on time in ft ³ /min
vperday	=	Average on time in hr/day
C _p	=	Specific heat of air = 0.24 Btu/lbm/°F
ρ	=	Density of air at sea level and 530 °R = 0.0748 lbm/ft ³
siteelev	=	Site elevation in ft

Natural Heat Loss Coefficient

Natural ventilation was measured by conducting blower door leakage tests and then using a computer model developed by Lawrence Berkeley Laboratories (LBL) to predict natural infiltration (Sherman and Grimsrud, 1980). The Ecotope, Inc., analysis included in Appendix A found that the model significantly over-predicts the effects of wind (Palmiter, Brown, and Bond, 1989). Indeed, the stack effect part of the model, used alone, gave a much better correlation with infiltration measured by tracer gas testing. Average wind speed during the test was low, only 3.7 Mph. Therefore, this analysis used the stack model results along with typical meteorological year data as the natural infiltration predictor for computing UA from natural ventilation.

UA from natural ventilation was computed using Equation 3-2.

Equation 3-2

$$\text{Nat UA} = \text{ACHst} \cdot \text{vol} \cdot C_p \cdot \rho \cdot (1 - \text{siteelev} \cdot 3.458\text{E-}5)$$

where:

Nat UA	=	Natural Infiltration heat loss coefficient in Btu/hr/°F
ACHst	=	ACH computed by the LBL stack model
vol	=	House volume in ft ³
siteelev	=	Site elevation in ft
C _p	=	Specific heat of air = 0.24 Btu/lbm/°F
ρ	=	Density of air at sea level and 530 °R = 0.0748 lbm/ft ³

Combined Ventilation Heat Loss Coefficient

For AAHXs, the combined mechanical and natural ventilation was calculated by simply taking the sum of the two. This method overstates the combined ventilation in exhaust-only houses. Negative pressure induced by exhaust-only systems eclipses part of the natural exfiltration. The degree of eclipsing varies with time, depending on the temperature differential and the amount of induced negative pressure.

In the past, total ventilation was usually calculated by adding in quadrature the unbalanced mechanical flow and the natural ventilation. This method was probably inspired by the knowledge that wind-induced and stack-induced pressure differentials are additive, and their resulting infiltration varies roughly as the square root of pressure differential across any leakage areas. Adding in quadrature, however, is inappropriate when combining natural and mechanical ventilation because the mechanical impetus is a constant-flow phenomenon. Fans exhaust through a dedicated port at a rate nearly independent of other wind and stack driving forces.

A better model is the "add half the mechanical" model. This model stipulates that exhaust ventilation is composed of equal parts of reduced exfiltration and augmented infiltration. Under this concept, combined ventilation equals the natural ventilation (which would occur with fans off) increased by half the fan flow rate. For mechanical ventilation greater than twice the natural ventilation, the entire natural exfiltration would be eclipsed and combined ventilation would equal mechanical ventilation. Figure 3-1 illustrates this theory for a home with 0.25 ACH natural ventilation.

Although it serves as a good approximation, the "add half the mechanical" model is a great over-simplification. A more precise model would account for the vertical distribution of leakage area, time variation of natural ventilation, and nonlinear pressure/flow relationship across leaks. However, because insufficient data are available for a more sophisticated method of combining, the "add half the mechanical" model was used. This method treats natural ventilation as a continuous constant, and treats mechanical ventilation as a constant during on time and as zero during off time.

Equation 3-3 was used to calculate the combined ventilation UA. Because mechanical ventilation is off much of the time in most homes, Equation 3-3 prorates the combined ventilation for on-time hours.

Figure 3-1
Combined Air Changes Per Hour

Equation 3-3

$$u_{\text{acomb}} = [(ACH_{\text{st}} \cdot \text{vol} + 0.5 \cdot \text{exflow} \cdot 60) \cdot v_{\text{perday}}/24 + ACH_{\text{st}} \cdot \text{vol} \cdot (24 - v_{\text{perday}})/24] \cdot C_p \cdot \rho \cdot (1 - \text{siteelev} \cdot 3.458\text{E-}5)$$

or, if $(0.5 \cdot \text{exflow} \cdot 60) > (ACH_{\text{st}} \cdot \text{vol})$ then,

$$u_{\text{acomb}} = [\text{exflow} \cdot 60 \cdot v_{\text{perday}}/24 + ACH_{\text{st}} \cdot \text{vol} \cdot (24 - v_{\text{perday}})/24] \cdot C_p \cdot \rho \cdot (1 - \text{siteelev} \cdot 3.458\text{E-}5)$$

where:

u_{acomb}	=	Combined mechanical and natural ventilation UA
ACH_{st}	=	ACH computed by the LBL stack model
exflow	=	Exhaust flow rate during on time in ft^3/min
v_{perday}	=	Mean ventilation on time
C_p	=	Specific heat of air = 0.24 Btu/lbm/°F
ρ	=	Density of air at sea level and 530 R = 0.0748 lbm/ft ³
siteelev	=	Site elevation in ft

Heat Loss Coefficient Percentages

For all ventilation system types, conduction accounted for an average of 83 percent of the UA, mechanical ventilation accounted for 3 percent, and net natural ventilation accounted for 14 percent. Net natural ventilation is the net effect of natural infiltration after accounting for its interaction with mechanical ventilation. It is derived by subtracting the natural ventilation UA from the combined UA obtained in Equation 3-3. Similarly, net mechanical ventilation can be derived by subtracting the natural ventilation UA from the combined ventilation UA. Table 3-1 shows the various UA percentages for each ventilation system type.

Table 3-1
Heat Loss Coefficient Percentages For Each
Mechanical Ventilation System Type

Ventilation System	UA (Percentage)			Net UA (Percentage)	
	Conduction	Natural	Mechanical	Mechanical	Natural
AAHXo	85.0	13.0	2.0	2.0	13.0
AAHX	80.0	10.8	9.2	9.2	10.8
EAHP	81.4	15.6	5.4	3.0	13.2
nHRV1	82.4	16.6	1.8	0.7	15.8
nHRV2	85.3	14.3	0.7	0.4	14.0
nHRV3	83.5	16.3	0.4	0.2	16.0
nHRV4	84.6	15.1	0.5	0.2	14.8

Percentages in Table 3-1 were first computed for each home. Data from 55 homes were compiled and used in the analysis. The data records for the other homes were incomplete in terms of on-time recordings, mechanical flow, and/or PFT testing. After percentages for these homes were calculated, the means of these percentages were computed for each ventilation system type.

Table 3-1 shows that the gross ventilation for AAHXs is equal to its net counterpart. This is because the AAHXs were assumed to be in balance enough to have no effect on the neutral pressure plane. Natural ventilation is therefore "unaware" of mechanical ventilation and not affected by it.

Figure 3-2 illustrates the UA percentages for each ventilation system. Figure 3-3 illustrates the actual contributions of the UAs by system type.

Figure 3-2
UA Distribution by Ventilation System

Figure 3-3
Heat Loss Coefficient by Ventilation System

Analysis Of Effect Of Mechanical Systems

It is helpful to visualize the effect of the mechanical ventilation systems relative to the same houses if no mechanical systems were installed. Figure 3-4 shows the reduction in natural ventilation UA resulting from the mechanical ventilation systems, based on the "add half the mechanical" combining methodology discussed earlier. This reduction significantly offsets the direct addition of UA by mechanical systems. When making this comparison, one must remember that the AAHXs recover heat, which returns about 60 percent of the heat loss implied by their direct mechanical UA. Similarly, the heat returned by the EAHPs is not directly correlated to their mechanical UA but can approach or exceed the heat loss implied by their mechanical UA.

Figure 3-4
Ventilation UA by Ventilation System

The most striking observation regarding mechanical UA is how small it is. This is due to the very low on time. The low on time of EAHP ventilation was particularly surprising, because EAHPs operate automatically to provide both space and water heat. Furthermore, their setup procedure requires that they be damped down to maximize on time. Only ten sites had EAHPs. They are shown in Table 3-2, along with their on times as measured by an hour meter and/or data logger. Data loggers were used on only three of the EAHP homes (and two AAHX homes). They were installed for special case studies. Their readings were not used in this analysis because they were so few and it was considered inappropriate to mix on time derived by two different types of measurement. Inclusion of the data logger readings would have considerably increased the mean EAHP flow.

Table 3-2
EAHP Mean Daily Operating Time

Home	Hour Meter	Data Logger
101	7.0	
104	2.7	
119	24.0	
120	18.0	
127	2.9	
217	2.3	10.3
222	NA	15.6
405	NA	
456	4.4	
489	NA	16.8

The data loggers recorded air flow hourly, and the data were thoroughly validated. The hour meter and data logger readings differed considerably for the only home (Number 217) that had both instruments. This difference was initially attributed to a failed hour meter, but the hour meter data showed a consistent incremental reading week by week. It was also considered that the hour meter could have been installed on the space heat fan instead of the exhaust fan, but the data logger readings revealed that the heat fan ran almost as much as the exhaust fan. The occupants changed the settings on the unit in spring of 1990 so that the exhaust fan would run continuously. This was still the condition when the data logger was removed in early May 1990.

Three other homes (Numbers 120, 127, and 456) had periods of low or nonoperation, either because of warm weather or extended occupant absence. The other homes showed consistent increments of weekly use. It is not known why some of the homes recorded such low flows. A possibility is that the hour meters may have been installed on the EAHP supply ducts instead of the exhaust ducts.

Section 4

Occupant Interaction with Ventilation Systems

The objective of this portion of the study was to compare the occupant-reported on time to other variables. Each week the occupants reported the on time from hour meters connected to their ventilation systems. They were also asked to estimate their on time and to answer other questions about their ventilation habits, attitudes, and perceptions in a survey at the end of the monitoring period.

It is interesting to compare occupants' estimated on time with metered on time. Seventy-seven homes, with good ventilation metered data, had occupants who thought they could estimate on time on their end-of-monitoring survey. Experience reading the meter did not necessarily give a good feel for ventilation because the meter read a cumulative running time, not a daily mean. The results presented in Figure 4-1 suggest that, collectively by class of ventilation system, occupants slightly overestimated their ventilation time. Individually, some estimates were very different from actual on time. This discrepancy is illustrated by the scatter plot on Figure 4-2 (see page 4-2), which compares each occupant's estimate to the metered data for their home.

Logically, ventilation time and natural infiltration should interact. Low natural infiltration should motivate occupants to run their ventilation systems more. Figure 4-3 seems to suggest this; the greatest operation is in homes below 0.2 ACH. However, further analysis suggests other contributing factors. Figure 4-4 breaks the ventilation down by system type. Stack ACH from the LBL model using local weather station data is used as the measure of natural

Figure 4-1
Measured Ventilation and Occupant Estimated Ventilation

ventilation. From this it is apparent that homes with heat recovery ventilation systems are generally tighter than those without heat recovery. Thus, a better interpretation of Figure 4-3 may be that better built houses are both tighter and have ventilation systems that operate economically and quietly enough to encourage greater usage.

Figure 4-2
Measured Ventilation vs Occupant Estimated Ventilation

Figure 4-3
Ventilation Rate and Tightness

Human factors may be more important than physical characteristics in explaining ventilation time. Occupants who claimed to understand their ventilation systems and to know when to operate them tend to operate them more. This is illustrated in Figures 4-5 and 4-6.

Figure 4-4
Ventilation Rate and Tightness by System Type

Most occupants overestimated their ventilation on time. The over-estimation was less for those occupants who claimed a better understanding of their systems and for those who indicated they had a good relationship with their builder.

Occupants generally use their ventilation systems more if they had a good relationship with their builder, as shown in Figure 4-7.

Figure 4-6
Knowledge of When to Ventilate

Figure 4-7
Relationship with Builder

In turn, good communication between builders and occupants may also lead to better informed occupants, who operate their systems more. Of those who said they understood their systems and knew when to operate them, over 35 percent said they had an excellent relationship with their builder. Of those who did not understand, only 15 percent said they had an excellent relationship with their builder.

One might expect that high concern over indoor air quality would motivate higher ventilation rates, but no clear relationship appears between these two variables. Figure 4-8 shows that many people were highly concerned, but this concern did not motivate them to use their systems more than their less concerned counterparts. In addition, concern over indoor air quality did not translate into any better understanding of the ventilation systems. Roughly 50 percent of occupants who said they understood their systems and knew when to operate them were highly concerned about indoor air quality. The proportion of concerned people who did not understand their systems was also about 50 percent.

Ventilation and perception of comfort could be related. Perception of stale air could lead occupants to use their ventilation systems more. Conversely, stale air could result if occupants did not use them enough. Strong connections were found between low ventilation time and survey responses that indicated that the house was sometimes stuffy or humid or was sometimes too warm on sunny winter days. Table 4-1 shows that low ventilation on time was generally associated with other indicators of discomfort or under-ventilation. This indicates that under-ventilation tends to be the causal factor leading to a perception of stale air. Most notably, occupants reporting stuffiness used their systems a mean of 1.8 hours per day, compared to 5.4 hours per day for their counterparts with no complaints. Occupants reporting that air was sometimes too warm used their systems a mean of 1.2 hours per day, compared to 4.9 hours for their

Figure 4-8
Ventilation Relative to Indoor Air Quality Concern

counterparts. This relationship suggests low occupant understanding of ventilation.

Table 4-1
Correspondence Between Low Ventilation On Time
And Discomfort In The Home

Survey Comment	Mean Ventilation (hr/day)
House sometimes stuffy	1.8
Not stuffy	5.4
Too warm on sunny winter days	1.2
Not too warm	4.9
Dehumidifier used	8.1
No dehumidifier	3.9
Condensation sometimes a problem	4.1
No condensation problem	5.5

Conceivably, noise or drafts can discourage occupants from using their ventilation systems. However, this does not appear to be a strong factor in the low ventilation on time found in this study. Only nine occupants reported that their systems were very noisy and that the noise kept them from using it; only seven occupants reported that drafts were strong and unpleasant in places; and only four said that drafts kept them from using their system.

Section 5

Conclusions

By inference from UA values, mechanical ventilation systems produce very little adverse effect on space heat consumption. The systems that did not recover heat contributed incrementally less than 1 percent to the overall house UA. The contribution was greater for heat recovery systems because of their higher use rate. The greatest amount was from conventionally installed AAHXs, with 9.2 percent of overall house UA. Allowing for heat recovery benefit, they probably added less than 4 percent to space heat load.

The impact on space heat was small because mechanical ventilation systems were greatly underused. While this finding reflects well for space heat, it results in a less healthful indoor environment. Two main reasons may account for this underuse.

One reason is that occupants have control over the systems. Survey comments in conjunction with ventilation system on time seem to suggest that occupants do not fully understand the purpose and operation of their systems. There is a continued need for further occupant education.

Noise may be another reason. Survey responses indicated that noise was only a minor factor in discouraging use. However, the systems sound similar to conventional exhaust fans that have been used for years in bathrooms and range hoods. One heat recovery ventilator manufacturer, Ken Gehring, of the Therma-Stor Products Division of the Dairy Equipment Corporation, believes noise is a greater deterrent than occupant complaints indicate. From anecdotal comments, he has observed that people have long tolerated this noise during spot ventilation as a just price for clearing steam, odors, and smoke. They are used to switching these fans off when the apparent contaminants are cleared. It is hard to forget to turn them off because the noise is a reminder. A noisy fan sounds as if it is straining, wearing itself out, and using energy. Accordingly, it may be premature to dismiss noise as a significant factor in underuse.

Section 6

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