Title
Summary of Workshop: Barriers to Energy Efficient Residential Ventilation

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Summary of Workshop:
Barriers to Energy Efficient Residential Ventilation
Held on January 10, 2008
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Introduction

The purpose of this Building America workshop was to bring together a few interested participants to discuss the issues associated with implementing energy efficient ventilation in homes. The workshop was held on January 10 at DOE Headquarters and the following people attended:

Attendance List

The workshop participants represented a wide range of interests:

- **Building America Teams**
  - BIRA, IBACOS, CARB, IHP, BSC
- **Industry**
  - HVI, Panasonic, Fantech
- **Labs**
  - NREL, NIST, ORNL, LBL
- **Federal Agencies**
  - DOE, EPA

The following people gave presentations at the workshop

- John Talbott
- Steve Emmerich
- Bob Hendron
- Srikanth Puttagunta
- Subrato Chandra
- Joe Lstiburek
- Ola Wettergren
- Don Stevens
- Eric Werling
- Jeff Christian

The remaining people also attended

- Bruce Baccei
- Duncan Prahl
- Steve Bolibruck
- Brad Oberg
- David Springer
- Ron Judkoff
- Margo Thompson
- David Price
- Terry Logee
- George James
- James Lyons
Background

The purpose of ventilation is to provide fresh (or at least outdoor) air for comfort\(^2\) and to ensure healthy indoor air quality by diluting contaminants. Historically, people have ventilated buildings to provide source control for combustion products, objectionable odors and to control high indoor moisture generation. Currently, a wide range of ventilation technologies is available to provide ventilation in dwellings including both mechanical systems and more sustainable technologies. Most of the existing housing stock in the U.S. uses infiltration combined with window opening to provide ventilation. Sometimes this results in over-ventilation with subsequent energy loss or under-ventilation and potentially poor indoor air quality. Recent residential construction methods have created tighter, less energy-consuming building envelopes that create a potential for under-ventilation. Infiltration rates in these new homes average a third to a quarter of the rates in existing stock. As a result, new homes often need mechanical ventilation systems to provide acceptable indoor air quality or to meet current ventilation standards.

Because of the effects it has on health, comfort, and serviceability, indoor air quality in homes is becoming of increasing concern to many people. According to the American Lung Association a number of factors within our homes have been increasingly recognized as threats to respiratory health. The Environmental Protection Agency lists poor indoor air quality as one of the largest environmental threat to our country. Asthma is the leading serious chronic illness of children in the U.S. Construction-defect litigation and damage are on the increase in new houses and some of this increase is related to indoor air quality problems such as moisture. Residential ventilation can address many of these indoor air quality problems.

Traditionally residential ventilation was not a major concern because policy makers believed that, between operable windows and envelope leakage, people were getting enough outdoor air. However, recent research has shown that these days the majority of occupants do not open windows sufficiently from the point of view of satisfying ventilation requirements, such as ASHRAE 62.2. ASHRAE is in the process of publishing an addendum to ASHRAE 62.2 removing the exception allowing operable windows to meet the whole-house mechanical requirements. Over the past three decades, houses have become much more energy efficient. At the same time, the types of materials used in furniture, appliances, and building materials in houses have changed. People have also become more environmentally conscious, not only about the resources they were consuming but about the environment in which they live.

ASHRAE Standard 62.2 is a standard for ventilation for acceptable indoor air quality in low rise residential buildings that (together with its companion Standard 62.1 for all

\(^2\) Comfort in an IAQ context means acceptable perceived air quality and not principally thermal comfort. This includes control of irritating substances and objectionable odors.
other buildings) represents the current standard for setting ventilation rates. Like all ASHRAE standards 62.2 is continually updated with the next version expected to be published in 2010.

ASHRAE Standard 62.2 has requirements for whole-house ventilation, local exhaust ventilation, source control, and system requirements. The standard assumes that infiltration contributes 2 cfm/100 sq. ft. (0.1 L/s/m$^2$) of floor area. In addition to this infiltration, the prescriptive part of the standard requires whole-house mechanical ventilation rate given by Equation 1:

\[
Q(cfm) = 0.01A_{floor}(\text{ft}^2) + 7.5(N + 1)
\]

\[
Q(L/s) = 0.05A_{floor}(m^2) + 3.5(N + 1)
\]

Where Q is the required ventilation rate, $A_{floor}$ is the house floor area and N is the number of bedrooms. For most houses the ventilation rate requirements of Equation 1 must be met by mechanical ventilation.

Standard 62.2 also requires local mechanical exhaust in kitchens and bathrooms. Kitchens must have the capacity to exhaust at least 100 cfm (50 L/s) through a range hood or provide 5 kitchen air changes per hour. Bathrooms must have the capacity to exhaust 50 cfm (25 L/s) or have 20 cfm (10 L/s) of exhaust continuously.

**Energy Efficiency**

Standard 62.2 sets minimum requirements for ventilation but does not address the energy required to provide that ventilation. Infiltration and ventilation typically account for 1/3 to ½ of the space conditioning load. As houses get more efficient both the infiltration and the sensible load through the envelope get reduced.

In tight, energy efficient homes, such as those from Building America, the ventilation load becomes a larger fraction of the total load. While the ventilation load in the absolute may be substantially smaller than the infiltration load in a typical home, reducing the ventilation load becomes more and more a priority in the quest for higher efficiency levels.

A special problem exists in the more humid climates. As the sensible load decreases through better building envelopes, the latent load from both ventilation and internal sources becomes a larger and larger fraction of the total load. Conventional air conditioning equipment may not be able to handle such a low sensible-heat ratio especially during shoulder seasons.

Regardless of the climate, however, there is a need to provide whatever ventilation is deemed acceptable in an energy efficient manner. There have been various reports on how to do this with the most commonly considered systems.
Workshop Objectives

The objectives for this workshop were to bring together those with different viewpoints on the implementation of energy efficient ventilation in homes to share their perspectives. The primary benefit of the workshop is to allow the participants to get a broader understanding of the issues involved and thereby make themselves more able to achieve their own goals in this area.

In order to achieve this objective each participant was asked to address four objectives from their point of view:

- **Drivers for energy efficient residential ventilation**: Why is this an important issue? Who cares about it? Where is the demand: occupants, utilities, regulation, programs, etc? What does sustainability mean in this context?

- **Markets & Technologies**: What products, services and systems are out there? What kinds of things are in the pipeline? What is being installed now? Are there regional or other trends? What are the technology interactions with other equipment and the envelope?

- **Barriers to Implementation**: What is stopping decision makers from implementing energy-efficient residential ventilation systems? What kind of barriers are there: technological, cost, informational, structural, etc. What is the critical path?

- **Solutions**: What can be done to overcome the barriers and how can/should we do it? What is the role of public vs. private institutions? Where can investments be made to save energy while improving the indoor environment?

Ten participants prepared presentations for the workshop. Those presentations are included in sections at the end of this workshop report.

These presentations provided the principal context for the discussions that happened during the workshop. Critical path issues were raised and potential solutions discussed during the workshop. As a secondary objective we have listed key issues and some potential consensus items which resulted from the discussions.

Key Issues

A key theme that appeared repeatedly was that a major barrier was having the decision maker understand the value proposition for implementing energy efficient ventilation. What this value proposition is depends strongly on who the decision maker is. Builders, contractors, manufacturers, consumers and public interest groups have very different views on the costs and benefits of energy efficient ventilation.

Another broad issue was that energy efficient residential ventilation is a compound concept. That is, the case for having ventilation at all must be considered first. Once
that is done the energy efficient aspect of it follows a similar path to other residential energy efficiency features. The most energy intensive part of ventilation requirements such as 62.2 is the whole-house mechanical ventilation because of the energy requirement to provide and, more importantly, the energy required to condition that air.

Another broad issue was that most decision makers were getting mixed messages from the “expert” community and were therefore unlikely to make substantial investments. That is, it appears to them that there is no consensus on whether to ventilate, how much to ventilate etc. and therefore there was little reason to change unless they themselves perceived a key problem.

**Builders**

Builders were a key group, well represented by the Building America teams present as well as NAHB. The general sense was that builders were primarily motivated to ventilate to reduce their risk. This included risks of call-backs and risk of litigation. Thus durability is part of the motivation. It was also felt that builders would respond to customer demand to provide these benefits, but that there was currently not much demand.

Builder concerns also depended on the market segment of the builders. The low-cost oriented builders would not likely implement energy efficient ventilation (or ventilation of any kind) unless required to by code. The more value-added builders would implement energy efficient ventilation if the got sufficient value through perceived quality improvements in their product. That is, if the builder had some way of showing that his product was better, met some higher quality level or was in some was differentiated he would be willing to invest in it.

Some Building America participants believe that the current 62.2 rates are too high for Building America houses in hot, humid climates. As a result their builder partners provide whole house mechanical ventilation in hot-humid climates that are significantly below the current 62.2 rates. This approach has led to low ventilation and low associated ventilation energy but very few homeowner complaints in hundreds of homes built to date with these types of positive pressure whole house ventilation system over the last decade. While the lack of complaints does not necessarily indicate acceptable IAQ, limited data suggests good RH control with this strategy. Data is lacking, however, on how such a strategy impacts contaminants such as VOCs, particulates, toxic compounds, radon, formaldehyde, etc.

Because of the infiltration credit built into 62.2 some BA participants and their builder partners view 62.2 as a barrier to building tight homes. Some groups outside of ASHRAE have interpreted the standard to mean that if the building is tighter than the
default infiltration credit, the mechanical ventilation needs to be increased and/or no energy benefit can be taken. ASHRAE has formally clarified that no such thing is required, but the barrier remains.

Some also view ASHRAE Standard 62.2 as a barrier to energy-efficient ventilation because it does not properly credit the performance differences among various mechanical ventilation systems. For example, balanced systems (e.g. Heat Recovery Ventilators) interact differently with the building than do unbalanced systems (e.g. continuous supply). Similarly systems that distribute the air differently (e.g. fan integrated systems vs. single point exhaust) should in principle provide different levels of performance.

The issues raised above of contaminants of concern, energy efficient humidity control, minimum rates, the role of infiltration, air distribution impacts, and system interactions are all open issues requiring further investigation before they can be reliably adopted by builders.

**Consumers**

It was felt that few consumers understood the issues associated with ventilation and indoor air quality enough to make informed choices and therefore to supply demand for the market. Consumers may generally assume that health concerns are already provided by any house they buy in the same way the structural safety concerns are taken care of. Many consumers apparently believe that when they are told they have an “HVAC” system, they actually get ventilation.

There was a general belief that consumers would want good indoor air quality and good ventilation, but did not know what that meant or how to ask for it. From the consumer standpoint ASHRAE Standard 62.2 is enabling because it specifies minimum ventilation. Unless codes require the use of 62.2, however, consumer education is needed for them to be able to actually get energy efficient ventilation.

**Manufacturers / Ventilation Industry**

The manufactures were represented by two past chairman of the Home Ventilating Institute each also presenting their own companies. The manufacturers of ventilation products have been developing appropriate equipment for the change in the market. Many more products are available to meet the sound and air flow requirements of ASHRAE Standard 62.2. The industry felt that the rates of ASHRAE Standard 62.2 were too low based on medical studies and supports a higher mechanical ventilation rate.

A key industry issue is getting good information into hands of decision makers including consumers. This information includes the value of IAQ and the associated
need for ventilation as well as the different implications of meeting these needs in different ways. The industry felt was capable of providing systems and equipment information to its customers.

Public Sector

DOE, EPA and the National Labs represented the public sector. The public sector was seen as being the best able to answer R&D questions regarding minimum requirements and system performance. The public sector also is the key player in setting performance specifications that would allow labeling or certification or other means of allowing the market to show that particular pieces of equipment and/or systems could provide value. The public sector could play a role of facilitator and independent third party.

From the public health perspective of organizations such as EPA, it is not surprising that improving RH control, in highly controlled homes in hot, humid climates has led to fewer comfort complaints, since odors and RH are the most common comfort complaints. However, there are many pollutants (e.g. formaldehyde, other VOC's, radon, ozone) that will not be controlled by this strategy, pose significant long term health risks, and which are often characterized by the lack of symptoms that can be easily discerned as comfort issues. The focus on reducing ventilation rates to allow effective RH and odor control in hot/humid climates is at best a partial and temporary solution. It may reduce comfort complaints (and some RH related health risks), while ignoring, and very likely increasing other health risks that are not being measured. Furthermore, reducing ventilation air is only one way of tackling the RH problem in hot/humid climates. Dehumidification is a viable strategy for controlling indoor humidity that does not sacrifice other aspects of indoor air quality. Like ventilation, humidity control is a building service that may require energy and so energy-efficient options must be explored.

Summary and Recommendations

The participants did not have time to come to consensus on specific recommendation, but the list below reflects recommendations coming from multiple sources at the workshop.

- Builders need simple, preferably single, solutions that are easily implementable
- More research is needed on the ventilation science, looking at minimum requirements, contaminants of concern (including humidity), regional issues and exposure. Much of the data justifying higher ventilation rates have come from Scandinavian countries. This may not be applicable to hot-humid climates where high vent rates can cause high humidities and dust mites and mold and other IAQ
problems. What is the right vent rate that optimizes energy usage, eliminates moisture problems and keeps VOCs to acceptable levels?

- 3rd party labels or ratings should be developed/expanded to facilitate evaluation and implementation of energy efficient strategies

- Risk assessment and IAQ analyses should be done evaluating moisture as a pollutant. This could be extended to other outdoor air contaminants as well.

- To address barriers and other key issues mentioned above, several areas of work relating to ASHRAE Standard 62.2 (or similar codes and standards) were identified as needing further development:
  - Trade-offs between minimum ventilation rate and air distribution systems
  - Role of infiltration
  - Minimum rates
  - Role of air cleaning/filtration
  - Material emission reduction (e.g. low emission furnishings)
  - Regional requirements
  - Alternative compliance mechanisms including “the IAQ method” of 62.1
  - Differences between new and existing homes

- A significant recommendation of the group was the need for a study to determine the relationship between contaminant levels, ventilation rates and house properties. Such a study would be large in scope and likely involve several institutions so that energy, indoor air quality, cost and sustainability concerns could be properly addressed.

- Another recommendation was to look at moisture as a special kind of contaminant. Moisture is special because a) for hot humid climates is both indoor and outdoor, b) it can be a comfort problem when too high or too low, c) it is not itself a contaminant but can enable contamination when it allows materials to become too damp, d) it has a special kind of “air cleaning” in the form of AC operation and/or dehumidification.

The workshop provided an excellent venue to exchange information regarding the implementation of energy efficient residential ventilation. The net outcome was felt to be positive and worth repeating. It was generally felt that any future such workshop would benefit from more input from the indoor air quality community.

While much of this workshop is generally applicable to most residential occupancies, the focus was on new, single-family homes. Issues specific to HUD-code homes, multifamily buildings, or existing homes were not discussed in any significant way.
 Discussion

- Standards can be both drivers and barriers
- ASHRAE Standards landscape (handout) includes segmentation of purposes
- Critical segmentation is energy conservation vs. IAQ i.e., ASHRAE 90.2 vs. 62.2. A "no more than" standard vs. a "no less than" standard.

Other ASHRAE Standards

- 136 Residential Air Change: is subsumed into 62.2
- 119 Residential Leakage Standard could be subsumed? Maybe not
- 119 is an Energy Conservation Standard with due consideration of IAQ
- "After-build compliance" is an issue with 119
- New revision committee for 119
- The hope for Standard 189 Sustainable Buildings

SUMMARY

- Many Standards relate/contribute to the objective of energy efficient ventilation.
- Although segmentation of purposes is inevitable, development of consensus on each purpose is still important
- Drivers are not in place to allow standards to deliver EERV (as compared to SEER 13)

ASHRAE 62.2 Residential

- Generally lower ventilation requirement.
- Infiltration is credited in two ways:

$$ V_{OA\ 62.2} = 7.5 \ (Nbr\ +1) + 0.01 \ A $$

and excess credit

$$ V_{OA\ 62.2} = \frac{1}{4} \ (\text{Measured\ Leakage} - 0.02 \ A) $$

ASHRAE 62.2 Intermitent Operation

$$ Q_{r} = \frac{Q_{v}}{(1 - f)} $$

Where

- $Q_{r}$ = fan flow rate
- $Q_{v}$ = ventilation air requirement (from Table 4.1)
- $e$ = ventilation effectiveness (from Table 4.2)
- $f$ = fractional on-time.

ASHRAE 62.2 Mass Continuity Effects
ASHRAE 62.2 Residential

TABLE 4.2 Ventilation Effectiveness for Intermittent Fans

<table>
<thead>
<tr>
<th>Daily Fractional On time, f</th>
<th>Ventilation Effectiveness, e</th>
</tr>
</thead>
<tbody>
<tr>
<td>f &lt;= 35%</td>
<td>0.33</td>
</tr>
<tr>
<td>35% &lt;= f &lt; 60%</td>
<td>0.50</td>
</tr>
<tr>
<td>60% &lt;= f &lt; 80%</td>
<td>0.75</td>
</tr>
<tr>
<td>80% &lt;= f</td>
<td>1.0</td>
</tr>
<tr>
<td>If fan runs at least once every three hours e = 1.0</td>
<td></td>
</tr>
</tbody>
</table>

ASHRAE 62.2 Single and Multiple Fan Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Fan#1 actual cfm (creditable cfm)</th>
<th>Fan #2</th>
<th>Fan #3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>One 60 cfm continuous fan</td>
<td>60 (60)</td>
<td></td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Two 30 cfm continuous fans</td>
<td>30 (30)</td>
<td>30 (30)</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>One 120 cfm intermittent fan @ 50% runtime, controlled to operate every three hours</td>
<td>120 (60)</td>
<td></td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>One 240 cfm intermittent fan @ 50% runtime, no cycle control</td>
<td>240 (60)</td>
<td></td>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>

ASHRAE 62.2 Multiple Fans

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Fan#1</th>
<th>Fan #2</th>
<th>Fan #3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two 60 cfm intermittent fans each @ 50% runtime, controlled to operate once every three hours</td>
<td>60 (30)</td>
<td>60 (30)</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Two 120 cfm intermittent fans each @ 50% runtime, no cycle control</td>
<td>120 (30)</td>
<td>120 (30)</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>One 55 cfm continuous, two local 100 cfm, 50 cfm, deemed to run 10% no cycle control</td>
<td>55 (55)</td>
<td>100 (3.3)</td>
<td>50 (1.6)</td>
<td>60</td>
</tr>
</tbody>
</table>

ASHRAE 62.2 2007 proposed addendum

<table>
<thead>
<tr>
<th>Fractional On-Time</th>
<th>Cycle Time (hours)</th>
<th>0 to 6</th>
<th>8</th>
<th>12</th>
<th>24</th>
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<tbody>
<tr>
<td>0.1</td>
<td>10.0</td>
<td>11.5</td>
<td>15.4</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>5.0</td>
<td>5.6</td>
<td>6.6</td>
<td>*</td>
<td></td>
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<tr>
<td>0.3</td>
<td>3.3</td>
<td>3.6</td>
<td>4.0</td>
<td>*</td>
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</tr>
<tr>
<td>0.4</td>
<td>2.5</td>
<td>2.6</td>
<td>2.8</td>
<td>5.4</td>
<td></td>
</tr>
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<td>0.5</td>
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<td>2.1</td>
<td>2.2</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>1.7</td>
<td>1.7</td>
<td>1.8</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>0.7</td>
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<td>1.4</td>
<td>1.5</td>
<td>1.6</td>
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</tr>
<tr>
<td>0.8</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
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</tr>
<tr>
<td>0.9</td>
<td></td>
<td></td>
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<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

ASHRAE 136 Effective Air Change for Residential

$$A_E = (\text{Balanced Fan Flow} + \left(\frac{\text{Infiltration Flow}}{A_E}\right) + \left(\frac{\text{Unbalanced Fan Flow}}{A_E}\right))^0.5$$

$$A_E = 8760 \left(\sum_{i=1}^{n} \left(\frac{\tau_i}{A_E}\right)\right)^0.5$$

where

- $\tau_i$ = the time per year for which the particular combination of operating fans is used to calculate $A_E$ has no effect (hours per year)
- $n$ = the number of time periods in the year with different values of $A_E$

Summary and Conclusions

- When does two plus two equal four? Nearly never.
- Why are there different Mathematical Expressions across these Standards? 62.1 vs. 62.2 (appropriate differences)
- 62.2 vs. 136 (different perspectives)
- Are all these differences the end of the world? No
ASHRAE STANDARD 62.2-2007

Ventilation and Acceptable Indoor Air Quality for Low-Rise Residential Buildings

Steven J. Emmerich
Chair, ASHRAE SPC 62.2
January 2008

INTRODUCTION

- **Purpose** This standard defines the roles and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality in low-rise residential buildings.
- **Scope** Single-family houses and multi-family structures of three stories or fewer

PRIMARY REQUIREMENTS

- Whole Building Ventilation
  - Mechanical system meeting Section 4 or “other methods” when approved by LDP
- Local Exhaust
  - Fans in Kitchens and Baths
- Other Requirements
  - Limited Source Control
- Air-Moving Equipment
  - Sound and other requirements

MECHANICAL VENTILATION REQUIREMENT

- Limited Exceptions
- Control System
- Intermittent Operation Permitted
- Climate-Based System Restrictions
- Includes a Default Infiltration Credit (2 cfm/100 sq. ft.)

LOCAL EXHAUST

- **Kitchens**
  - 100 cfm (50 l/s) capacity or
  - 5 h⁻¹ continuous

- **Bathrooms**
  - 50 cfm (25 l/s) capacity or
  - 20 cfm (10 l/s) continuous

OTHER REQUIREMENTS

- No Transfer Air from Adjacent Units, Garages, etc.
- Instructions & Labeling
- Clothes Dryers: Exhausted to Outside
- Net Exhaust Limit for Combustion Appliances
- Air Handlers in Garages Must be Sealed
- Windows for Additional Ventilation Capacity
- Minimum Filtration
- Ventilation Openings

DRAFT FOR REVIEW
**AIR-MOVING EQUIPMENT**

- Sound ratings
- Airflow ratings
  - Duct sizing or flow measuring
- Dampers in Multi-Branch Exhaust Ducting

**Other 62.2 stuff**

- Appendix A: Operations and Maintenance
- Appendix B: HVAC Systems
- User’s Manual for 62.2-2004 (to be revised)
- Companion Guideline 24P – completed first public review with minimal comments

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**Barriers to Implementation of Energy Efficient Residential Ventilation**

- Standard 62.2 is a driver for residential ventilation.
  - Via codes/green programs
- Is it a barrier to energy efficient residential ventilation?
  - Energy efficiency not in scope
  - Very modest ventilation rates
  - Allows intermittent
  - Contains very few limitations on system type
  - Does not credit “better systems”
  - Assumes a default infiltration but no tightness requirement
  - Allows “alternative ventilation” but has no specifics for natural ventilation
Presentation by Bob Hendron

Barriers to Energy Efficient Ventilation

Drivers for energy efficient residential ventilation
- Zero Energy Homes and other programs targeting very large energy savings
- Less valuable in houses without adequate source control measures
- Less necessary in leaky houses
- Occupant comfort and health
- Occupant pocketbook

Markets & Technologies
- Common systems in Building America houses
  - Central fan integrated supply (more common in hot/mixed climates)
  - Continuous/timed point exhaust (upgraded bath fan or dedicated system) (more common in cold climates)
  - HRV with ducted supply (more common in dry climates)
  - ERV with ducted supply (more common in humid climates)

(Perceived) Barriers to Implementation
- Policy-driven source control
- NHI risk assessment
- Source control guidelines
- First cost
- Effect on comfort (cold drafts, dryness, noise)
- Lack of adequate performance metrics
  - Net ventilation rate
  - Net effect on whole house energy use
  - Distribution of air throughout house
  - Technically imperfect consensus standards
  - Not required by most codes

Solutions
- Better source control
- Better integration with house design
- Ducted/distributed ventilation systems
- Technically sound test methods and performance metrics tailored to residential buildings
- Comprehensive performance data for alternative ventilation systems
- Improved demand controlled systems
- Fully integrated heating/cooling/ventilation/dehumidification systems

Bob Hendron
National Renewable Energy Laboratory
LBNL Ventilation Workshop
Jan 10, 2008
Presentation by Srikanth Puttagunta

HOME VENTILATION
Balancing Energy Use and IAQ

Drivers for energy efficient residential ventilation

Why is it important?
- prevent sick building syndrome as homes are built tighter
Where is the demand?
- certification programs, such as
  - Energy Star (RYSERDA)
  - LEED for Homes
  - Florida Green Home Standard
  - EarthCraft Homes
Healthy Homes
- increase in asthmatic children
What does sustainability mean in this context?
- sustaining a person's health rather than sustaining the built environment.

What's out there?

Strategies:
- exhaust only
  - exhaust fan with control or continuous
- supply only (AHU integrated)
  - AirCycler or Honeywell Y8150
- balanced (AHU integrated or dedicated)
  - Heat Recovery Ventilator (HRV)
  - Energy Recovery Ventilator (ERV)

What are regional trends?

Trends primarily based on cheapest option while accounting for
humidity levels as moisture can contribute to health
problems associated with mold, moisture can seep into the
walls and woodwork causing dry rot and other structural
problems, and moisture can lead to musty odors and
condensation in walls and on windows.

Colder climates: typically exhaust only
Humid climates: typically supply only or ERV
Mixed climates: typically exhaust only or HRV
Canada: requires that a ventilation system be installed in
every new dwelling. HRVs have become most popular due to
the requirement that there be a method of introducing
replacement air.

Barriers to Implementation

Exhaust Only
pros: simple, low cost, low energy
(Panasonic WhisperGreen 50 cfm fan - 4.8 W)
cons: not distributed (for larger homes),
forced infiltration, shouldn't be used if
the home contains atmospheric
heating equipment or wood stoves.

Barriers to Implementation

Supply Only
pros: well distributed
cons: energy cost, energy usage highly
dependent on AHU motor

Balanced
pros: heat recovery, humidity control
cons: first cost, maintenance

Exhaust Ventilation Testing

Solutions

Better exhaust fans
Panasonic WhisperGreen
- SmartFlow™ Optimum CFM Technology — allows the fan to
  operate at a constant CFM regardless to an extent of the ducting
  of the exhaust
- DC Motor Technology — creates a motor that is 75% - 400% more
  energy efficient than the minimum ENERGY STAR® requirements
- CustomVent™ Variable Speed Control — allows the fan
to run at a lower level until required to increase to a maximum
level when the switch is turned on. A delayed off timer returns the
fan to the minimum CFM level after a period of time set by the user.
Solutions (cont’d)

Ventilation control based on an indicator (CO₂) rather than or in addition to ASHRAE 62.2, which prescribes rates based on a combination of experimental data, psychological considerations, subjective evaluations and professional judgment.

ERVs with ECM motors.

Building America Research

A side-by-side comparison of three ventilation strategies in Chicago, IL.

Energy Recovery Ventilation
Air Cycler
Supply Ventilation
Exhaust-Only Ventilation (2 bathrooms)

Evaluating Distribution

Carbon Dioxide Concentrations

Ventilation Power Consumption

The installed furnace fans consumed 712 Watts; CARG recommended ECM reduce fan for the study. Table header

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Electricity kWh/yr</th>
<th>Gas Therms/yr</th>
<th>Total Ventilation Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERV + Air Handler</td>
<td>4308/1899</td>
<td>51/-9</td>
<td>$390/$184</td>
</tr>
<tr>
<td>Air Cycler</td>
<td>3714/1304</td>
<td>12/54</td>
<td>$379/$165</td>
</tr>
<tr>
<td>Exhaust Only</td>
<td>263</td>
<td>76</td>
<td>$76</td>
</tr>
<tr>
<td>ERV, No Air Handler</td>
<td>595</td>
<td>13</td>
<td>$68</td>
</tr>
</tbody>
</table>

Conclusions

- All systems provided similar fresh air distribution.
- Exhaust-Only strategy cost 50% less to operate – with lowest first cost
- Hypothetical ERV with separate ductwork is most efficient – with highest first cost
- Need to check actual flow of systems (flows often <50% of stated flows) and check controls (timer settings & other specialized controls)
Presentation by Subrato Chandra

BAIHP Ventilation Approaches
Ken Fonseca, Dennis Sterer, Subrato Chandra
January 10, 2008

Topics
- Approach for site built and modular housing in hot humid climates— not covering HUD code housing
  - Production houses w/o active dehumidification
  - Homes w/ dehumidification

Ventilation
- Quiet bath fans and Cooktop vented to outside.
- Mechanical whole house ventilation is also provided.

Kitchen Exhaust / Fireplace Venting

Positive Pressure Ventilation
- This is desirable in our climate.
- These homes use 4" or 5" ducts from outside to the return air plenum with manual damper and filtered at the inlet. Ventilation is provided only when the compressor / furnace runs (Fan on auto)

OA Intake from back porch
Filter Backed Grill Covering the OA Intake
OA Intake Duct in Soffit

DRAFT FOR REVIEW
Great Location for OA Intake is ceiling of entry porch

OA Duct connection to Return Air Plenum

Inspect, Test, Rate

- Perform Periodic Site Inspections, Tests And Rate Each Home (~HERS 60 to 70)
- Provide Feedback To Builder
- Qualifies for $2,000 federal tax credit

Data from 102 houses (ACH50)

Duct Leakage to Outside

House Pressurization

HERS Index

Whole House Vent Rate

DRAFT FOR REVIEW
Vent Rate as % of 62.2

Notes
- Provided ventilation = runtime*vent rate + kitchen and bath vent+ dryer vent + operable windows. Total has not been measured in these homes.
- In over 500 homes with this type of ventilation system no reported complaints about odor
- Interior T and RH Data on ~100 homes is planned this year, 50 BA and 50 non BA
- Data from one home in Ft. Myers area (south FL) next

T and RH data for New Generation Homes by Kingon
- 2451 sq. ft. - Family of 4
  - No zoning
  - 32 cfm runtime vent
  - Vented attic
  - Ft. Myers, FL

Homes with Dehumidification
- Stalwart Homes, Panama City, North FL
- Palm Harbor Home Prototype, Siesta Key, South FL

PHH Gen-X Solar IBS 2007 Home
Site Relocation to Siesta Key, FL

Solar panels (PV and DHW) on the south roof.
Next Steps for Siesta Key Home

- Complete all work and commission the system
- Instrument and monitor starting ~March 2008
Presentation by Joe Lstiburek

Building Science
Ventilation

Why (Builder)?
Risk-Durability
Risk-Comfort
Risk-Health

Why (Rest of Us)?
Risk-Health
Comfort
Durability

Technology

Build Tight - Ventilate Right
Build Tight - Ventilate Right
How Tight?
What's Right?

Best
As Tight as Possible - with -
Balanced Ventilation
Energy Recovery
Distribution
Source Control - Spot exhaust ventilation
Filtration
Material selection

Air Barrier Metrics
Material 0.02  l/(s·m²) @ 75 Pa
Assembly 0.20  l/(s·m²) @ 75 Pa
Enclosure 2.00  l/(s·m²) @ 75 Pa
0.35  cfm/ft² @ 50 Pa
0.25  cfm/ft² @ 50 Pa
0.15  cfm/ft² @ 50 Pa
Barriers - Policy
ASHRAE 62.2
HERS/RESNET

Barriers - Technology
ECM
Supplemental Dehumid

Barriers - Cost
Exhaust $100
Exhaust + Dist $150
Supply + Dist $150
Spot + Ex/Sup + Dist $450
Balanced/ER $1,000

ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.01 cfm per square foot of conditioned area.
Occupancy is deemed to be the number of bedrooms plus one.

Occupant Rate + Building Rate

\[ Q(v) = \text{Ventilation Rate} \]

\[ Q(\text{fan}) = Q(v) \cdot C(d) \]

\[ C(d) = \text{Distribution Coefficient} \]

System Type

<table>
<thead>
<tr>
<th>System Type</th>
<th>Demand 1.0 kwh/\text{cub. ft/hr}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust only (CAE)</td>
<td>0.5</td>
</tr>
<tr>
<td>Exhaust + Distribution (DSS) + stand-alone, with supply (CAE)</td>
<td>1.25</td>
</tr>
<tr>
<td>Exhaust + Distribution (DSS) + stand-alone, with supply (CAE)</td>
<td>1.25</td>
</tr>
<tr>
<td>Exhaust + Distribution (DSS) + stand-alone, with supply (CAE)</td>
<td>1.25</td>
</tr>
<tr>
<td>Exhaust + Distribution (DSS) + stand-alone, with supply (CAE)</td>
<td>1.25</td>
</tr>
<tr>
<td>All other systems</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Radiant heat

Exhaust air

Outside air

Exhaust air

Outside air

Exhaust air

Outside air
Residential Ventilation in North America
January -08
Ola Wettergren
Pres. of Fantech and Kanalflakt
Past Chair of HVI

Topics
- Drivers for energy efficient residential ventilation
- Markets & Technologies
- Barriers to implementation
- Solutions

Drivers for energy efficient residential ventilation

Chain of decision makers:
Consumer, Architect, Contractor, Builder. Code official etc. All need to be influenced.

Highest hindrances are Consumers and Builders. Consumers need to understand the need for ventilation. Builders, because they do not understand the need for ventilation.

We therefore need to increase the understanding of the need for ventilation.

Drivers for energy efficient residential ventilation

Codes and regulations: Not to prescribe ventilation, ventilation is not required for the users or the occupants. This is due to indoor air quality.

Preliminary calculations to be done to determine ventilation demand for air quality guidelines. New strategies: EnergyPlus, HVI, LEED, etc.

Consumer ignorance on ventilation.

HVI position on ASHRAE 62.2

Standards for minimum residential ventilation rates have been established by ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) for achieving appropriate environmental air quality. The rate takes into account a combination of mechanical fans and air leakage into the home (infiltration). Infiltration varies from home to home and changes with weather conditions. Therefore, HVI recommends using mechanical fans (not infiltration) for the total rate required to ensure that the minimum ASHRAE ventilation rates are met.

Why ventilation?
- Health
- Productivity
- Comfort
- Durability

90% of our time is spent indoors - 90% of the air we breathe is therefore indoor air.

Why ventilation? - Health

The Värmland study (Sweden)
- 4000 children followed
- "Why do children become allergic?"
- 40% of 4-year-olds have some form of allergy.

Risk factors:
- Poor indoor climate
- Smoking
- Short period of breast feeding
- More than one risk factor gives large increase
**Why ventilation? - Productivity**

Technical University of Denmark

![Graph showing the relationship between outdoor air rate and text typing speed](image)

**Why ventilation? – Health & Productivity**

The Massachusetts Study

Is performance affected by vent rate?

- Minimum requirement = 50% higher absenteeism due to sickness
- Annual loss = 400 dollars per person

Higher ventilation rates give healthier people

---

**Why is this an issue now?**

![Bar chart showing air exchange rate in homes](image)

To the average consumer, IAQ is:

- Temperature
- Odor
- Humidity

The average consumer thinks ventilation is:

- Extraction from the HVAC system

---

**Markets & Technologies - Exhaust only**

- Extraction through the use of fans
- Outdoor air via slot valves, windows, leaks
- Only limited filtration possible

*Common system – cheap to install, but not energy efficient*

---

**Markets & Technologies – Heat Exch.**

- Good
- Better
- Best

---

DRAFT FOR REVIEW
To get Consumers to Want and Pay for more Energy Efficient Ventilation they need to understand why.
Presentation by Don Stevens

PHEC Research & Development

Barriers to Implementation of Energy Efficient Residential Ventilation

Don Stevens
National Research & Development Manager
Panasonic Home and Environment Co.
January 10, 2008

Drivers for En Eff Res Ventilation

- Global warming/carbon reduction
- Poor IAQ in homes
- Rising cost of utilities
- Increased use of man-made construction products

Markets and Technologies

- Utility programs
- Energy Star
- LEED for Homes and other Green programs
- Single Family
- Low-Rise and High-Rise Multifamily
- New and existing homes and apartments

Markets and Technologies

- Fans (supply or exhaust)
  - Using less energy (as low as 5 watts)
  - Getting quieter (400+ HVI models < 1.0 sone)
- Integrated central systems
  - With airhandler (timer, HRV/ERV)
  - With dehumidifier
  - With water heater (HPWH)
- Balanced systems
  - ERV, HRV, other

Markets and Technologies

- DC motors
  - 4.7 watts @ 30 cfm
  - 5.2 watts @ 40 cfm
  - 6.8 watts @ 50 cfm
  - 7.6 watts @ 60 cfm
  - 8.9 watts @ 70 cfm
  - 11.3 watts @ 80 cfm
- Set continuous flow 30-70 cfm (52.2)
- Kick to high of 80 for settable time

Barriers to En Eff Res Ventilation

- Lack of consumer information
- Lack of designer information
- Lack of contractor information
- Perceived high first cost
- Perceived high operating cost

Lack of consumer information

- Consumers do not understand the need for residential mechanical ventilation
- IAQ is generally odorless, tasteless, and invisible to the occupant
- Consumers somewhat understand the intangible values of “Green” building but generally are hung up on reducing energy costs

Lack of consumer information

- Consumers think their HVAC system takes care of the Ventilation requirements
- Consumers think that any new electrical load is a negative and so must be avoided.
- Consumers are aware of outdoor pollution but not aware that the air in the home may be much worse

DRAFT FOR REVIEW
<table>
<thead>
<tr>
<th>Lack of consumer information</th>
<th>Lack of designer information</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Consumer awareness is starting to improve but mostly because of press about mold damage and “sick building” issues</td>
<td>• The majority of residential building designs are not created or reviewed by an engineer or an architect and are often “value engineered” to minimize the first costs</td>
</tr>
<tr>
<td></td>
<td>• The majority of the residential architects were not trained in energy efficient design or the value of mechanical ventilation for residential buildings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lack of designer information</th>
<th>Lack of contractor information</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The USGBC LEED program has raised this awareness for nonresidential buildings and the hope is that the LEED for Homes program will do the same for residential building design</td>
<td>• The building community is just now becoming aware of the need for mechanical ventilation</td>
</tr>
<tr>
<td>• The EPA Energy Star Homes program still does not require mechanical ventilation – it is just now offering an “IAQ Package” as an option</td>
<td>• The Model Codes from ICC still do not require mechanical ventilation in the kitchen, the bathroom (if a window is present), or the whole building for IAQ</td>
</tr>
<tr>
<td></td>
<td>• The Building America program and local programs have raised the awareness</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lack of contractor information</th>
<th>Perceived high first cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Residential installation contractors still do not know how to properly install fans and so create lots of low-performing installations because of poor ducting and terminal devices, even when using excellent equipment</td>
<td>• Designers, builders, and consumers often are unwilling to try designed ventilation because of the perception that it will cost more upfront (and it often does)</td>
</tr>
<tr>
<td>• Panasonic trying to improve this with online training for installers through “Panasonic Ventilation University”</td>
<td>• It is very difficult to quantify the avoided costs of poor IAQ as a way to offset the higher first cost</td>
</tr>
<tr>
<td>Perceived high first cost</td>
<td>Perceived high operating cost</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>• People often look for a dedicated system that costs a lot when an upgraded bath fan can do the job</td>
<td>• Consumers are concerned that their already-high utility bills will be impacted by the operating cost of the installed mechanical ventilation system</td>
</tr>
<tr>
<td><img src="image" alt="Image of a bathroom fan" /></td>
<td>• Manufacturers try to minimize the added electrical load of the fan motor and/or the added HVAC load caused by the ventilation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perceived high operating cost</th>
<th>What do we need?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Wide variety of ventilation approaches use different amounts of energy</td>
<td>• INFORMATION</td>
</tr>
<tr>
<td>– Some equipment can provide the necessary ventilation with a continuously operating fan at 62.2 rates at 5-10 watts while others use the installed airhandler to ventilate intermittently at a much higher rate while drawing 300-500 watts</td>
<td>• INFORMATION</td>
</tr>
<tr>
<td>– HRV/ERV products can recover some of the outgoing energy into the incoming air, but the higher pressure drop across the core uses more energy</td>
<td>• INFORMATION</td>
</tr>
<tr>
<td><img src="image" alt="Image of a bathroom ventilation system" /></td>
<td>• INFORMATION</td>
</tr>
</tbody>
</table>
Why is ventilation important?

Ventilation is linked to health outcomes:
- Higher ventilation rates are associated with reduced health risks and increased productivity in offices & schools (insufficient research in homes)
- Exposure to some indoor pollutants is linked to chronic and acute health impacts (cancer, asthma, etc.) and we know effective ventilation can reduce concentrations/exposures

Who cares about ventilation?

1. Consumers care about IAQ & Health
   - They spend >$1 Billion annually on “air cleaning” products
   - > 20 Million asthmatics
2. Building professionals are concerned about IAQ risks (callbacks, litigation, etc.)
3. Manufacturers care about ventilation product/system sales

Why is energy-efficient ventilation important?

1. Because of these barriers, professionals don’t promote, sell, & specify ventilation systems
2. If energy-efficient ventilation & dehumidification systems become available and cost competitive, professionals will be more likely to promote adoption
3. So, improving energy efficiency of ventilation solutions is critical to market adoption.

Barriers to Implementation

What is stopping decision makers from implementing energy-efficient residential ventilation systems?

1. Cost Competition (better, efficient systems cost more)
2. Trade & Professional Myths (partial truths, misunderstood & perpetuated):
   - “Energy penalty” of ventilation
   - Ventilation increases RH
   - No complaints = good IAQ
3. Lack of Training
   - Some assume inadequate benefits of ventilation or how to sell it
   - Others don’t understand how to properly design & install systems (fear of change)
4. Lack of Consumer Demand
   - Consumers don’t realize they don’t have adequately controlled ventilation (the V in HVAC)
   - They often believe ventilation wastes energy

What is the critical path?

1. Increase Value Proposition (for consumers & builders)
2. Encourage Competition (to get prices down)
3. Increase Training Opportunities for Sales & Trades

Solutions

1. Strategies to overcome the barriers:
   - Promote market transformation (e.g., the ENERGY STAR Indoor Air Package)
   - Consumer Benefits Messaging
   - Demonstrate that new technologies work
   - Research to better understand/quantify risk reduction/benefits of Ventilation & Sourf
2. Some technologies we’d like to see more of:
   - Improved controls for ventilation systems, including better integration with HVAC
   - Improved equipment for handling latent loads

Proposed Research

- Inter-agency study to assess pollutant source concentrations in new homes & the effects of mechanical ventilation

- EPA: David Price; DOE: Terry Logee; HUD: ?

- Objectives:
  - Analysis of new/existing data on indoor pollutant levels, envelope tightness, ventilation rates, and IAQ
  - Modeling of pollutant concentrations/ventilation rates
  - Initial Hazard Assessment for ventilation rates
  - Field Assessment of target pollutants over range of ventilation rates & climates
  - Estimation of ventilation energy consumption for climate zones

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Ventilation issues in the pursuit of ZEH in the Mixed Humid Climate

Jeff Christian
Oak Ridge National Laboratory

Building America Team Meeting/Ventilation workshop
January 10, 2008

Total VOC measurement results for nZEH and conventional houses

Summer Temperature (°F) and %RH in 2005

ZEH5 a 2-story 2600 ft² walkout

Precooling helps reduce peak cooling

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34% of Peak Cooling due to ventilation

19% of Peak Heating due to ventilation

Like to examine the moisture impacts in houses with different levels of hygroscopic buffering

- Several papers at the Envelopes 10 conference
- Wood interiors have greater hygroscopic buffering potential

ZEH 2: collected CO₂ data for awhile

Leeds interest and sustainable material selection interest should

- Result in less source pollutants, 62.2 should give credit for homes that do a more thought full trim out with less air quality containment sources

Dehumidifying Heat Pump Water Heater

- Has potential to reduce latent loads in ZEHs
- Smart water heater recharge during high RH moments