Cold Climate Exhaust Ventilation Research in High Performance Homes

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Ventilation Research

Side-by-side comparison of three ventilation strategies in identical ENERGY STAR homes.

• Energy Recovery Ventilation
• Air Cycler Supply Ventilation
• Exhaust-Only Ventilation

All commissioned to deliver 60 CFM continuously (equivalent, per ASHRAE 62.2).
Evaluating Distribution

House 1: ERV
CO₂ Distribution

Date & Time

Carbon Dioxide Concentration (ppm)

Outdoors
Living Room
Master BR
Second BR
Carbon Dioxide Concentrations

Winter 2004-2005
CO₂ Concentrations

Percent of Readings

CO₂ Concentration [ppm]

1 - ERV
2 - Air Cycler
3 - Exhaust Only
<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>1899</td>
<td>-9</td>
<td>$184</td>
</tr>
<tr>
<td>Air Cycler</td>
<td>1304</td>
<td>54</td>
<td>$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>
RDI Prototype Home
Colrain, MA

Two Panasonic WhisperGreen fans running continuously at 40 CFM, 6 Watts.
NREL Tracer Gas Results

Equivalent Ventilation Rate (ACH)

Test Case
- Exhaust On, Doors Closed
- Exhaust On, Doors Open
- Natural, Doors Closed
- Exhaust On, Doors Closed, Window crack

Legend:
- Living/Kitchen/Dining
- Master Bedroom
- Master Bathroom
- Bedroom 2
- Bath
- Bedroom 3
RDI’s Wisdom Way Solar Village
Heating System

- **Design Loads**
  - 10,000 – 12,000 Btu/h

- **Room Heaters:**
  - **Lo:** 10,200 Btu/hr
  - **Hi:** 16,000 Btu/hr
  - 83% AFUE
  - Sealed Combustion
HVAC System – First Floor
HVAC System – Second Floor
Tracer Gas Testing

- Case 4 Case 2
- RAOA, hr⁻¹
- Doors Open
- living room
- kitchen
- SW BR
- SE BR
- NE BR
- bath
Tracer Gas Testing

![Graph showing RAOA, hr⁻¹ for different rooms and conditions]

- **Doors Open**
  - living room: 0.35
  - kitchen: 0.32
  - SW BR: 0.33
  - SE BR: 0.30
  - NE BR: 0.28
  - bath: 0.25

- **Doors Closed (Fan OFF)**
  - living room: 0.18
  - kitchen: 0.15
  - SW BR: 0.12
  - SE BR: 0.10
  - NE BR: 0.08
  - bath: 0.05
Tracer Gas Testing

![Graph showing RAOA, hr\(^{-1}\) for different conditions and rooms.](image)

- **Doors Open**
  - Living room: 0.35
  - Kitchen: 0.33
  - SW BR: 0.32
  - SE BR: 0.31
  - NE BR: 0.30
  - Bath: 0.34

- **Doors Closed (Fan OFF)**
  - Living room: 0.25
  - Kitchen: 0.22
  - SW BR: 0.20
  - SE BR: 0.18
  - NE BR: 0.16
  - Bath: 0.24

- **Doors Closed (Fan ON)**
  - Living room: 0.30
  - Kitchen: 0.27
  - SW BR: 0.25
  - SE BR: 0.23
  - NE BR: 0.21
  - Bath: 0.29
Comfort Tests & Monitoring

• Chief concern is temperature in upstairs bedrooms without direct conditioning;

• Short-term testing with NREL in Feb 2009 (when tracer gas testing done);

• Temperature monitoring of 4 occupied homes during winter of 2009-2010;

• Utility bills reviewed.
Heating Comments

- No comfort complaints from occupants of 4 monitored homes;
- Heating system savings ($4,000 - $5,000) allowed for added envelope costs ($7,000 - $10,000);
- Very little or no use of supplemental heaters in bedrooms;
- Gas space heating costs ≈ $200 - $400;
- Design loads are comparable to normal internal gains.
Ventilation Gaps

- When and how much distribution/mixing is really necessary?
- HVAC for smaller loads, lower air flows
- Filtration
- Implications of maintenance (or lack thereof)
- Role for air inlets or trickle vents?
- Wider understanding of when and where exhaust-only ventilation is (and is not) appropriate.