A Paradigm Shift in ERV Technology

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Building Intelligence Group PLLC

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## Existing Buildings and Energy

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing buildings:</strong></td>
<td>4.8 million</td>
</tr>
<tr>
<td><strong>Floor space:</strong></td>
<td>72 billion sq. ft.</td>
</tr>
</tbody>
</table>
| **Floor space per building:** | Mean: 14,700 sq. ft.  
Median: 5,000 sq. ft. |
| **Energy consumed:**  | 6.5 trillion Btus |
Where’s Energy Used?

- HVAC: 40%
- Lights: 28%

Industry: 33%
Buildings: 39%
Transportation: 28%
Commercial: 18%

- Residential: 21%
- 21% Residential
  - Heating: 32%
  - Cooling: 10%
  - Lights: 12%
  - Water Heat: 13%
  - Other: 4%

- Industry: 33%
  - Computers: 1%
  - Cooking: 5%
  - Electronics: 5%
  - Wash: 5%

- Buildings: 39%
  - Computers: 3%
  - Refrigeration: 4%
  - Office Equipment: 7%
  - Ventilation: 7%
  - Water Heat: 7%
  - Cooling: 13%
  - Heating: 16%
  - Other: 10%
Agenda

• Energy recovery basics
  – Ventilation and pressure
  – Special applications
  – Codes and standards
  – Control, applications, and challenges

• Latent vs Total recovery

• Technologies (new and old)

• Advanced polymers

• Economics and applications
Energy Recovery Basics

• Building ventilation is driven by several factors
  – Fresh air for IEQ (typically driven by ASHRAE 62)
  – Make up to compensate for exhaust
  – Need for positive net pressure

• Conditioning outdoor air
  – Drives system design
  – Expensive to operate
  – Often poorly understood
Energy Recovery Basics

- Exhaust air has already been conditioned
  - Energy recovery is intended to reclaim the energy from the exhaust air and to use it to pre-condition make up air
  - Both the sensible and latent heat can be recovered
Sensible Vs Total Recovery
Where to use Energy Recovery?

- Conventional Applications
  - Office buildings
  - Schools
  - Government (airports, libraries, convention centers, museums, etc.)
  - Multi-family housing
- Special Applications
  - Hospital areas requiring isolation
  - Pools and Spas
  - Labs and research environments
  - Industrial applications
  - Grocery and “big box” stores with refrigeration
Why Use Energy Recovery?

• Saves energy
• May reduce project costs
  – Reduce size of boilers, chillers, coils, etc.
  – Requires confidence in ERU performance!
• May be required by code
  – ASHRAE 90.1 2007 (current NC, SC and GA State Code)
  – ASHRAE 90.1 2010
• Can help qualify for LEED, EPACT and Utility Incentives
90.1 2007 Requirements

• Required for AHU’s over 5,000 CFM and OA of greater the 70%
• Must be at least 50% efficient
• Bypass when in economizer
• Exceptions
  – Dirty environments (kitchen hoods, toxic or flammable exhaust, etc.)
  – Spaces with minimal heating and cooling
90.1 2010 Requirements

- Driven by climate zone, AHU size, percent OA (see table 6.5.6.1)
- Must be at least 50% efficient (of enthalpy)
- Bypass when in economizer
- Exceptions
  - Dirty environments (kitchen hoods, toxic or flammable exhaust, etc.)
  - Spaces with minimal heating and cooling
  - Systems that operate less than 20 hours per week
### TABLE 6.5.6.1  Exhaust Air Energy Recovery Requirements

<table>
<thead>
<tr>
<th>Zone</th>
<th>% Outdoor Air at Full Design Airflow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥30% and ≥40%</td>
</tr>
<tr>
<td>3B, 3C, 4B, 4C, 5B</td>
<td>NR</td>
</tr>
<tr>
<td>1B, 2B, 5C</td>
<td>NR</td>
</tr>
<tr>
<td>6B</td>
<td>≥11000</td>
</tr>
<tr>
<td>1A, 2A, 3A, 4A, 5A, 6A</td>
<td>≥5500</td>
</tr>
<tr>
<td>7, 8</td>
<td>≥2500</td>
</tr>
</tbody>
</table>

NR—Not required
Energy Recovery Control

• KISS is the best approach
• Only do recovery when beneficial
  – Outdoor air can be used without recovery for cooling
  – Generally want to bypass (or turn off wheel) when OA is between 50 – 75 degrees
  – Note that wheels need to be periodically “stirred”
• Frost control in cold conditions (below 5 degrees)
• Set up ERU to deal with variable flow
  – Supply and exhaust fans should track each other
  – Option to vary wheel speed
Delivering Energy Recovery

- Dedicated energy recovery unit
- Energy recovery integrated with an air handler
- Dedicated Outdoor Air System (DOAS)
Delivering Energy Recovery
Air Delivery

- Air from an Energy Recovery Unit can go:
  - Directly into the space or return air
  - As tempered outdoor air for an air handler
Energy Recovery Technology

Four Main Options:
- Flat-plate heat exchangers
- Heat wheels
- Run Around Coils
- Heat Pipes
# Energy Recovery Technology

<table>
<thead>
<tr>
<th>Type:</th>
<th>Enthalpy Wheel</th>
<th>Enthalpic Plate</th>
<th>Sensible Plate</th>
<th>Heat Pipe</th>
<th>Run Around Coils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensible Efficiency:</td>
<td>70-90%</td>
<td>60-70%</td>
<td>50-65%</td>
<td>35-55%</td>
<td>30-45%</td>
</tr>
<tr>
<td>Latent Efficiency:</td>
<td>65-80%</td>
<td>35-50%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Benefits:</td>
<td>-Total recovery -Highest efficiency</td>
<td>-Total recovery -Water washable -Freeze tolerant</td>
<td>-Easy to maintain -Consistent performance -Lowest cost</td>
<td>-Low cross contamination</td>
<td>-Zero cross contamination -Separated supply &amp; exhaust</td>
</tr>
</tbody>
</table>
Flat Plate HX

- Sensible only recovery (50-65% sensible efficiency)
- Operation
  - Two airstreams pass in close proximity without mixing
  - Sensible energy transferred through plates
- Benefits
  - Efficient sensible energy transfer
  - Wide air passages – Low pressure drops
  - Low maintenance, no moving parts
  - Easy to clean
  - Consistent performance over time
  - Higher efficiencies than pipes
  - Lower cost than pipes or wheels
- Drawbacks
  - No latent energy transfer
Enthalpic Plate

- Total recovery (50-65% total effectiveness)
- Benefits
  - Sensible and latent recovery with no moving parts
  - AHRI certified performance
  - No cross leakage through the membrane
  - Mold and bacteria resistance
  - Water washable
  - Freeze tolerant
- Drawbacks
  - Size
  - More expensive than a sensible plate
  - New technology
Heat Wheel

- Total recovery (65-85% total effectiveness)
- **Operation**
  - Exhaust and supply air streams flow through wheel
  - Wheel rotates through both airstreams
  - Synthetic or aluminum media transfer sensible heat
  - Integral desiccant transfers latent energy
- **Benefits**
  - Latent energy transfer
  - Higher efficiencies than pipes or plates
  - Short depth dimension
- **Drawbacks**
  - Cross leakage between airstreams
  - Transfers odors and contaminants (especially nicotine)
  - Maintenance of motor, wheel bearings, cleaning
  - Due to leakage & purge, fans must be oversized
  - More expensive than a sensible plate
Run Around coils

- Sensible only recovery (30-45% sensible efficiency)
- Operation
  - 2 coils are piped in a loop, one in the exhaust air stream, one in the supply air stream.
  - Liquid coolant is pumped between the 2 coils to transfer energy
- Benefits
  - No cross contamination
  - Supply and exhaust streams can be in separate locations
- Drawbacks
  - Lower efficiency than pipes, plates or wheels
  - Pump consumes energy
  - Requires glycol to prevent freezing
  - Expensive
  - High pressure drop to achieve moderate performance
Heat Pipe

- Sensible only recovery (35-55% sensible efficiency)
- Operation
  - Exhaust and supply air flows through coil
  - Coil contains refrigerant (closed loop)
  - Refrigerant evaporates and condenses
- Benefits
  - Low cross contamination
- Drawbacks
  - Requires refrigerants – Possibility of leakage
  - Tight fin spacing
    - Higher pressure drop
    - Higher risk of fouling
  - Lower efficiency than plate or wheels
  - More expensive than plates, comparable to wheels
Enthalpic Plate Design Parameters

- Membrane MVTR (Moisture Vapor Transmission Rate)
- Cross Flow versus Counter flow
- Flow Volume, Face Velocity, & Pressure Drop
- Size & Weight
- Air Flow Gap Spacing
- Separator Plate Structure
- Plate to Membrane Seal Process and Materials
- UL-900 Fire Rating
Advanced Permeable Membranes

- Utilizes Nano-technology that is Solid & Non-Porous
- Selective Permeable that Transmits Only certain Substances such as Water Vapor
- Exceptional Diffusion Rate
- Washable or Vacuum Cleaning
- Durable from -40 °F to 160 °F
- Design Flexibility
- Inherent Antimicrobial
- Meets UL-723
Advanced Membrane Construction

Moisture Vapor Transport Channels

Air Flow

Membrane Polymer & Support Substrate
Relative Dynamic MVTR per Modified ASTM F2298-03
Gas Permeability Test

- High moisture vapor transport and trace amount or no gas
ASTM G-21 Fungal Test

Control Sample

Advanced Membrane
AATCC 30 Test III- Mold & Mildew

Control Sample

Advance Membrane Sample

Microscopic growth of *Aspergillus niger* which can only be visible stereoscopically
Fire Safety Requirement

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Flame Spread Index</th>
<th>Smoke Develop Index</th>
<th>Meets UL-723</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advance Membrane</td>
<td>0</td>
<td>20</td>
<td>✓</td>
</tr>
<tr>
<td>Commercial Membrane</td>
<td>55</td>
<td>25</td>
<td>—</td>
</tr>
<tr>
<td>Commercial Membrane</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
## Performance Comparison

<table>
<thead>
<tr>
<th>Type:</th>
<th>Enthalpy Wheel</th>
<th>Advanced Membrane Enthalpy Core</th>
<th>Commercial Enthalpy Core</th>
<th>Commercial Enthalpy Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensible Efficiency:</td>
<td>70-90%</td>
<td>70%+</td>
<td>68%</td>
<td>71%</td>
</tr>
<tr>
<td>Latent Efficiency:</td>
<td>65-80%</td>
<td>60%+</td>
<td>47%</td>
<td>60%</td>
</tr>
<tr>
<td>Total Efficiency:</td>
<td>70-80%</td>
<td>65%+</td>
<td>61%</td>
<td>64%</td>
</tr>
<tr>
<td>Flow Velocity:</td>
<td>300 – 600 FPM</td>
<td>300 – 400 FPM</td>
<td>240 CFM</td>
<td>240 FPM</td>
</tr>
<tr>
<td>Pressure Drop:</td>
<td>0.5” to 1” H₂O</td>
<td>0.5” to 1” H₂O</td>
<td>0.5” to 1” H₂O</td>
<td>0.5” to 1” H₂O</td>
</tr>
</tbody>
</table>
Economics

- First and life cycle costs anticipated to be competitive with wheels
- Potential for further improvements as technology evolves
- More reliable operation can allow for system downsizing – reducing total project costs
Advanced Permeable Membrane

• Benefits
  – Similar performance to wheels
  – No moving parts
  – Anti-microbial
  – No air transfer
  – No condensation
  – Easy to maintain

• Drawbacks
  – Adoption
Recommended Applications

• Replacement for enthalpy wheels
• Evaluate use as a replacement for sensible only solutions
Discussion Questions

• ERV challenges
  – Maintenance / failure
  – Downsizing
  – Economics
  – Applications

• What is needed for adoption?
Contact

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