The ABCs of ERVs

Why Now?

Technology

Standards & Codes

Energy Savings Software Programs
Energy Recovery Ventilation

1. The ABCs of ERVs
2. Why Now?
3. Technology
4. Standards & Codes
5. Energy Savings Software Programs

The ABCs of ERVs

• Ventilation with Energy Recovery

  **E** – Energy
  **R** – Recovery
  **V** – Ventilator

• KEY QUESTION – How much outside air is required?
The ABCs of ERVs

- Designed to provide energy savings in mechanical ventilation systems
- Recycle energy from the building’s exhaust air to pre-treat the outside air / ventilation air
- Pre-conditioning the outside air reduces the load that the HVAC unit must handle, and hence the required capacity of the mechanical equipment

The ABCs of ERVs

- Pre-condition ventilation air
- Reduce the outside air load requirement
- Reduce cooling and heating requirements
- Lower HVAC equipment operating costs
The ABCs of ERVs

Fresh Outside Air

HVAC

Exhausted
Condition Building Air

Exhaust Fan

Condition building Air

Building

The ABCs of ERVs

Fresh Outside Air

ERV

Condition building Air

Building
The ABCs of ERVs

• ERV Benefits:
  – Reduces summer electrical peak load demand
  – Provides savings in both summer cooling and winter heating operations
  – Enhances humidity control
  – Allows for a reduced HVAC refrigeration system

• SHORT PAYBACK PERIOD – with multiple years of continued operating savings

### Table: ERV Models

<table>
<thead>
<tr>
<th>Model</th>
<th>A/C Reduction (Tons)</th>
<th>Refrigeration (BTU/hr)</th>
<th>Heat Reduction (BTU/hr)</th>
<th>Summer (DFR / WFR)</th>
<th>Winter (DFR / WFR)</th>
<th>Payback (Years)</th>
<th>ROI %</th>
<th>Annual Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 EVAA bolt-on</td>
<td>1.0</td>
<td>31,367</td>
<td>62.2 / 68.7</td>
<td>41.8 / 33.8</td>
<td>4.6</td>
<td>22</td>
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<tr>
<td>500 EVCC</td>
<td>1.4</td>
<td>43,961</td>
<td>78.4 / 65.7</td>
<td>56.1 / 44.6</td>
<td>3.1</td>
<td>32</td>
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<tr>
<td>1000 EVCD</td>
<td>2.6</td>
<td>80,611</td>
<td>79.7 / 66.4</td>
<td>50.4 / 41.2</td>
<td>1.6</td>
<td>167</td>
<td>$1,400</td>
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<tr>
<td>2000 EVED</td>
<td>5.3</td>
<td>163,748</td>
<td>79.5 / 66.3</td>
<td>50.9 / 41.6</td>
<td>1.6</td>
<td>63</td>
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<tr>
<td>2500 EVED</td>
<td>6.2</td>
<td>194,101</td>
<td>80.3 / 66.8</td>
<td>47.8 / 39.3</td>
<td>1.1</td>
<td>91</td>
<td>$2,100</td>
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<tr>
<td>3000 EVHF</td>
<td>7.9</td>
<td>245,774</td>
<td>79.4 / 66.4</td>
<td>51.5 / 41.7</td>
<td>1.1</td>
<td>91</td>
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<tr>
<td>4000 EVHD</td>
<td>10.8</td>
<td>331,501</td>
<td>79.4 / 66.2</td>
<td>51.7 / 42.1</td>
<td>0.6</td>
<td>157</td>
<td>$4,160</td>
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<tr>
<td>5000 EVKG</td>
<td>13.3</td>
<td>409,900</td>
<td>79.5 / 66.3</td>
<td>51.1 / 41.7</td>
<td>0.6</td>
<td>167</td>
<td>$5,550</td>
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<tr>
<td>6000 EVLG</td>
<td>16.5</td>
<td>505,827</td>
<td>79.1 / 66.0</td>
<td>53.0 / 42.9</td>
<td>0.9</td>
<td>111</td>
<td>$6,570</td>
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<tr>
<td>7000 EVKD</td>
<td>18.0</td>
<td>554,912</td>
<td>80.0 / 66.6</td>
<td>49.0 / 40.3</td>
<td>0.4</td>
<td>250</td>
<td>$6,570</td>
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<td>8000 EVLD</td>
<td>20.6</td>
<td>635,832</td>
<td>79.9 / 66.6</td>
<td>49.1 / 40.4</td>
<td>0.3</td>
<td>333</td>
<td>$7,580</td>
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<tr>
<td>9000 EVMD</td>
<td>24.8</td>
<td>755,867</td>
<td>79.2 / 66.0</td>
<td>52.6 / 42.8</td>
<td>0.4</td>
<td>250</td>
<td>$9,750</td>
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<tr>
<td>10000 EVMD</td>
<td>25.4</td>
<td>783,645</td>
<td>80.1 / 66.8</td>
<td>48.2 / 39.8</td>
<td>0.4</td>
<td>250</td>
<td>$9,150</td>
<td></td>
</tr>
<tr>
<td>12,000 EVMD</td>
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<td>943,255</td>
<td>80.2 / 66.6</td>
<td>48.0 / 40.0</td>
<td>0.1</td>
<td>1000</td>
<td>$11,100</td>
<td></td>
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<tr>
<td>14,000 EVMD</td>
<td>36.9</td>
<td>1,121,163</td>
<td>79.9 / 66.4</td>
<td>49.3 / 40.8</td>
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<td>200</td>
<td>$13,600</td>
<td></td>
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<tr>
<td>16,000 EVMD</td>
<td>42.6</td>
<td>1,295,721</td>
<td>79.7 / 66.3</td>
<td>50.0 / 41.3</td>
<td>0.4</td>
<td>250</td>
<td>$16,000</td>
<td></td>
</tr>
<tr>
<td>18,000 EVMD</td>
<td>46.5</td>
<td>1,414,388</td>
<td>80.2 / 66.6</td>
<td>48.0 / 40.0</td>
<td>0.3</td>
<td>333</td>
<td>$16,700</td>
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</tr>
<tr>
<td>20,000 EVMD</td>
<td>51.4</td>
<td>1,560,067</td>
<td>80.3 / 66.6</td>
<td>47.5 / 39.7</td>
<td>0.1</td>
<td>1000</td>
<td>$18,300</td>
<td></td>
</tr>
</tbody>
</table>
The ABCs of ERVs

- ERV Component Types
  - Rotary Heat Exchanger / Wheels
  - Plate Heat Exchanger / Core
  - Heat Pipe Heat Exchanger
  - Run Around Coils
- HRV - Sensible Energy Only
- ERV - Total Energy / Enthalpy Recovery

Energy Recovery Ventilation

1. The ABCs of ERVs
2. Why Now?
3. Technology
4. Standards & Codes
5. Energy Savings Software Programs
Why Now?

- Energy Recovery Ventilation equipment sales will grow at a 15% annual rate over the next five years*
- The marketplace will go from $325 million in 2006 to $780 million in 2012*
- The marketplace is divided into three segments
  - Stand Alone
  - Air Handling Units
  - Packaged DX Systems

* Frost & Sullivan Study, 2006

Market Trends by Product Segment

Note: All figures are rounded. Base Year 2006. Source: Frost & Sullivan
Why Now?

- Market Drivers
  - ASHRAE Standard 62.1 - Ventilation for Acceptable Indoor Air Quality
  - Backbone of International Mechanical Code (IMC), LEED Green Building Rating System, and local ventilation codes
  - ASHRAE Standard 90.1 - Energy Standard for Buildings (except Low-Rise Residential)
    - Backbone of International Energy Conservation Code (IECC), LEED, and Local Energy Codes

Evolution of Minimum Ventilation Rates
Why Now?

- **Standard 90.1-2007**
  - ERV threshold is 70% outside air in a 5000 supply CFM system
- **Standard 90.1-2010**
  - Threshold becomes region and system size specific (see map)
  - Must be 50% enthalpy recovery effectiveness
  - Must have bypass or other control to permit economizer operation
Why Now?

- **Standard 189.1**
  - Design of High-Performance Green Buildings
  - Joint standard w/ ASHRAE, USGBC, IESNA
  - Must have 60% enthalpy recovery effectiveness
  - Likely to become LEED prerequisite
  - Written in code language
  - Acceptable compliance path for International Green Construction Code (IgCC)

### Table 6.5.6.1 A Energy Recovery Requirement (IP)

<table>
<thead>
<tr>
<th>Zone</th>
<th>3B, 3C, 4B, 4C, 5B</th>
<th>1B, 2B, 5C</th>
<th>6B</th>
<th>1A, 2A, 3A, 4A, 5A, 6A</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Supply Fan CFM</td>
<td>NR</td>
<td>NR</td>
<td>≥11000</td>
<td>≥5500</td>
<td>≥2500</td>
</tr>
<tr>
<td>% Outside Air at full design cfm</td>
<td>≥30% and &lt; 40%</td>
<td>≥40% and &lt; 50%</td>
<td>≥50% and &lt; 60%</td>
<td>≥60% and &lt; 70%</td>
<td>≥70% and &lt; 80%</td>
</tr>
</tbody>
</table>

- Written in code language
- Acceptable compliance path for International Green Construction Code (IgCC)
LEED: How does using an ERV help?

- **EA Credit 1 - Optimized Energy Performance**
  - Using an ERV allows downsizing of the HVAC unit and results in higher system efficiency

- **EQ Credit 2 - Increased Ventilation**
  - Ventilation rates can be increased without significant energy penalty

- **EQ Credit 1 - Outdoor Air Delivery Monitoring**
  - ERV controls can monitor the ventilation airflow and issue a low limit alarm
  - The ventilation airflow can be modulated based on space CO₂ levels

- **EQ Credit 7.1 - Thermal Comfort: Design**
  - Using an ERV shifts much of the system latent load off the HVAC unit

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### Table 7.4.3.8 Energy Recovery Requirement (I-P)

<table>
<thead>
<tr>
<th>Zone</th>
<th>3B, 3C, 4B, 4C, 5B</th>
<th>1B, 2B, 5C</th>
<th>6B</th>
<th>1A, 2A, 3A, 4A, 5</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Supply Fan Flow CFM</td>
<td>≥10% and &lt; 20%</td>
<td>≥20% and &lt; 30%</td>
<td>≥40% and &lt; 50%</td>
<td>≥50% and &lt; 60%</td>
<td>≥60% and &lt; 70%</td>
</tr>
<tr>
<td>% Outside Air at Full Design Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3B, 3C, 4B, 4C, 5B</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>1B, 2B, 5C</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>≥26000</td>
</tr>
<tr>
<td>6B</td>
<td>≥25000</td>
<td>≥11000</td>
<td>≥5500</td>
<td>≥4500</td>
<td>≥3500</td>
</tr>
<tr>
<td>1A, 2A, 3A, 4A, 5</td>
<td>≥30000</td>
<td>≥13000</td>
<td>≥4500</td>
<td>≥3500</td>
<td>≥2000</td>
</tr>
<tr>
<td>7, 8</td>
<td>≥4000</td>
<td>≥5000</td>
<td>≥2500</td>
<td>≥1000</td>
<td>≥0</td>
</tr>
</tbody>
</table>
Why Now?

Energy Recovery Benefits
A Value Added Investment

• Achieve occupant comfort (code required / proper ventilation rate / improved IAQ)
• Minimize energy costs / increase HVAC system efficiency

Identifying Potential Recovery Applications

When to Use ERV
• Anywhere constant air changes are required and humidity control (latent capacity) is an issue
• When large quantities of ventilation air are desired
• When long-term energy cost are more important then first cost
• When there is a need to expand beyond the typical RTU operational characteristics:
  - More latent vs. sensible capability
  - Higher system efficiencies
  - Lower energy consumption
  - More stages of operation
Identifying Potential Recovery Applications

Candidates for Recovery
- Retail
- Schools
- Offices
- Theaters
- Fitness Centers
- Gymnasiums
- Hospitals
- Restaurants
- Nursing Homes

"Clean" Exhaust Air

High Levels of Ventilation Air

Energy Recovery Ventilation

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Airstream Designations

- Return Air from space
- Supply Air to conditioned space or HVAC Unit
- Exhaust Air to outside
- Outdoor Air (Ventilation)
- Recovery Device

Summer Ventilation Effectiveness

Effectiveness = \[ \frac{\Delta T \text{ of one airstream}}{\Delta EAT \text{ of the two airstreams}} \]

Exhaust: 91°F (79.4 wb)  
Return: 75°F (62.6 wb)  
Outdoor Air: 95°F (79 wb)  
Supply: 78.5°F (66 wb)

Effectiveness = \[ \frac{95.0°F - 78.5°F}{95.0°F - 75.0°F} = 0.825 \]
### Winter Ventilation Effectiveness

Effectiveness = \( \frac{\Delta T \text{ of one airstream}}{\Delta EAT \text{ of the two airstreams}} \)

**Diagram:**
- Exhaust: 22°F
- Outdoor Air: 10°F
- Return: 70°F
- Supply: 58°F
- Effectiveness = \( \frac{58.0°F - 10.0°F}{70.0°F - 10.0°F} = 0.80 \)

### Impact of Unequal Flows

**Graph:**
- Effectiveness (%)
- Flow Ratio = \( \frac{\text{Exhaust Air}}{\text{Ventilation Air}} \)
- Points: 80%, 70%, 60%
Ideal Arrangement is Manifolded Airstreams

Inline Recovery Device

Exhaust Air

Ventilation Air

Parallel Heat Transfer

50% Maximum Theoretical Efficiency

\[
\frac{70 - 40}{70 - 10} = \frac{30}{60} = 50\%
\]
Counterflow Heat Transfer

100% Maximum Theoretical Efficiency

\[
\frac{70 - 10}{70 - 10} = \frac{60}{60} = 100\%
\]

Leakage

Exhaust Air | Return Air
---|---
Ventilation Air | Supply Air
Leakage

Carryover characteristics:
- **EATR** is exhaust air transfer (from exhaust to supply) or “cross leakage”
  - Remember – air transferred from exhaust to supply is air that has never left the building
  - Where effective purge is required suggest <1% EATR. (Biohazard and toxics should not use wheels - coil runaround is recommended)
- **OACF** is the ratio of outdoor air to supply air
  - Used for fan sizing in higher pressure air handling applications due to seal leakage and purge volume

\[
\text{EATR} = \% \text{ of SA flow from RA} \\
\text{OACF} = \frac{\text{OA flow}}{\text{SA flow}}
\]

Exhaust Air Transfer Ratio (EATR)

- **EATR** = .4%
- 4980 cfm
- 5000 cfm
- 5020 cfm
- 5000 cfm
- 5020 cfm
**Outdoor Air Correction Factor (OACF)**

\[ \text{OACF} = \frac{5420 \text{ cfm}}{420 \text{ cfm}} = 1.08 \]

**Exhaust Air**

- 5400 cfm
- 4980 cfm

**Ventilation Air**

- 5420 cfm
- 5020 cfm

**EATR = .4%**

**NOT RECOMMENDED**

**Blow-Thru and Draw-Thru**

- **Exhaust Air**
  - Return Air Fan
  - Maximum leakage

- **Ventilation Air**
  - Supply Air Fan

**NOT RECOMMENDED**
Purge Design

- A portion of the outside air stream is used to flush out the contaminated return air still contained in the flutes of the wheel.
- Purge assures no re-entrainment.
- Reduces cross transfer of exhaust air (EATR) from a normal 5-10% in to 0%.
- MicroMetl's EATR (without purge) is 0-3%.

However, purge is not required...
- In comfort conditioning.
- When observing ASHRAE 62 ‘classes of air.’

Fan Positioning

Fan arrangement determines carryover potential. Air flows from a high pressure system to low pressure system.

<table>
<thead>
<tr>
<th>Blown-thru SF + Draw-thru EF =</th>
<th>Blow-thru SF + Blow-thru EF =</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Carryover</td>
<td>Carryover</td>
</tr>
</tbody>
</table>

Draw-thru SF + Draw-thru EF = No Carryover*  
*with proper purge
Enthalpy Wheel vs. Sensible Heat Wheel

Total Energy Recovery

\[ E_s = \frac{W_s (X_1 - X_2)}{W_{\text{min}} (X_1 - X_3)} \]

Supply Effectiveness = \( E_s = \frac{T_2 - T_1}{T_3 - T_1} \)  
(Supply Energy Transfer) 

W = Mass Flow  
Y = Dry Bulb, Humidity, Enthalpy

Desiccants: How Do They Work?

Water vapor in outdoor air stream is adsorbed on the desiccant.

Desiccants are man made materials with pore openings to adsorb certain type of vapors and gases.

Because the water vapor pressure in the colder exhaust air stream is lower, the water vapor pressure on the desiccant surface is decreased, so the water is de-sorbed and exhausted back to the outside.
Desiccant – Silica Gel

Adsorption of Various Desiccants
Determination of Frosting

-5.0° F db
75.0° F db
45% rh

Frost Occurrence – Enthalpy Wheel vs. Sensible Plate

Frost Occurrence – Enthalpy Wheel vs. Sensible Plate
Frost Control

**Wheel Frost Control**
- Required for cold climates
- Function of outdoor temperature and indoor RH
- Enthalpy wheel has the lowest frost threshold

**Frost Control Methods**
- **OA Electric Pre-heater**
  - An electric pre-heater elevates the entering air temperature
- **ERV Wheel VFD**
  - If frost build-up is detected the wheel rotational speed is reduced to allow the wheel to defrost
- **Frost Protection**
  - OA blower shuts off if frost build-up is detected, allowing exhaust air to defrost the wheel
- **Low Temperature lock-out**
  - ERV shuts down below frost threshold

### Frost Threshold Temperature (°F)

<table>
<thead>
<tr>
<th>Indoor Air RH</th>
<th>Indoor Air Dry Bulb Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70°F</td>
</tr>
<tr>
<td>20 %</td>
<td>-14</td>
</tr>
<tr>
<td>30 %</td>
<td>-3</td>
</tr>
<tr>
<td>40 %</td>
<td>5</td>
</tr>
<tr>
<td>50 %</td>
<td>12</td>
</tr>
<tr>
<td>60 %</td>
<td>18</td>
</tr>
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</table>

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**Filtration Requirements**

- Filter in Ventilation Air
- Filter in Exhaust Air
- Recovery Device
Why Correct Humidity Is Important

Humidity Buildup at Part Load

<table>
<thead>
<tr>
<th>Load Condition</th>
<th>Design Load Sunny Day</th>
<th>Part-Load Condition</th>
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</thead>
<tbody>
<tr>
<td>Occupancy</td>
<td>100%</td>
<td>20%</td>
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<tr>
<td>Outdoor Air Condition</td>
<td>95 db, 76 wb</td>
<td>80 db, 71 wb</td>
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<tr>
<td>Supply Air Cfm</td>
<td>15,000</td>
<td>15,000</td>
</tr>
<tr>
<td>Cooling Coil Dewpoint</td>
<td>53.5°F</td>
<td>65.5°F</td>
</tr>
<tr>
<td>Room Conditions</td>
<td>75 db</td>
<td>75 db</td>
</tr>
<tr>
<td></td>
<td>48% rh</td>
<td>71% rh</td>
</tr>
</tbody>
</table>
Issues with Bringing in Outside Air

- Increased quantity of ventilation air greatly increases the load on the rooftop air conditioner.
- Conditioned space is typically controlled by a dry bulb thermostat.
- Occupants will be forced to “chase the humidity” by lowering the set point of the room’s thermostat.
  - Result is gross overcooling of the space and a “cold and clammy” condition.

Reduced Operating Range

- Range of ventilation air conditions introduced to the HVAC unit is significantly reduced.
- HVAC unit cooling system can be downsized and will operate at a higher sensible heat ratio (less dehumidification required), which is typical of most packaged DX rooftop units.
- HVAC unit heating system can be downsized or possibly even eliminated.

“Weather Compressor”
Reduced Unit Sizing

<table>
<thead>
<tr>
<th>Atlanta, Georgia</th>
<th>Cooling Design Day</th>
<th>Dehumidification Design Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature</td>
<td>93.9 wb / 74.8 wb (41% RH)</td>
<td>82.0 db / 76.4 wb (78% RH)</td>
</tr>
<tr>
<td>Return Air Temperature</td>
<td>75.0 db / 62.5 wb (50% RH)</td>
<td>75.0 db / 62.5 wb (50% RH)</td>
</tr>
<tr>
<td>RTU Only</td>
<td>RTU w/ ERV</td>
<td>RTU Only</td>
</tr>
<tr>
<td>Mixed Air Temperature</td>
<td>80.7 db / 66.6 wb</td>
<td>76.0 db / 63.5 wb</td>
</tr>
<tr>
<td>Mixed Air Moisture Content</td>
<td>59.2 dp / 75.4 gr</td>
<td>56.3 dp / 67.8 gr</td>
</tr>
<tr>
<td>Leaving Air Temperature</td>
<td>55.0 db / 54.0 wb</td>
<td>55.0 db / 54.0 wb</td>
</tr>
<tr>
<td>Gross Total Capacity</td>
<td>384.2 mbh</td>
<td>279.1 mbh</td>
</tr>
<tr>
<td>Gross Sensible Capacity</td>
<td>271.7 mbh</td>
<td>230.3 mbh</td>
</tr>
<tr>
<td>Gross Latent Capacity</td>
<td>102.5 mbh</td>
<td>48.8 mbh</td>
</tr>
<tr>
<td>Sensible Heat Ratio</td>
<td>0.733</td>
<td>0.825</td>
</tr>
<tr>
<td>Reduction in Total Capacity</td>
<td>--</td>
<td>27.4 %</td>
</tr>
<tr>
<td>Reduction in Sensible Capacity</td>
<td>--</td>
<td>15.2 %</td>
</tr>
<tr>
<td>Reduction in Latent Capacity</td>
<td>--</td>
<td>52.4 %</td>
</tr>
</tbody>
</table>

• Capacity based on 10,000 cfm, 30% OA

Superior Humidity Control

ASHRAE Research Project (1254-RP, TC 8.11)

– Compared 17 system variations including conventional DX, Subcooling Reheat, Hot Gas Reheat, Dual Path, ERV, DCV, Desiccant Reheat and other hybrid combinations
– Simulations run for 7 space types (Office, Retail, Theater, Restaurant, School(2), Motel) in 10 cities (Miami, Houston, Shreveport, Ft Worth, Atlanta, Washington, St Louis, NYC, Chicago, Portland)
– Base DX w/ ERV and/or Dual Path w/ ERV gave superior results:
  • Best system for Minimum Energy Cost and Lowest Life Cycle Cost for Office, Retail and Motel application in ALL CITIES
  • For Schools was best system for Minimum Energy Cost in 15 of 20 cases, and Lowest Life Cycle Cost in 18 of 20 cases
  • Lowest Life Cycle Cost for Theater and Restaurants in 18 of 20 cases
Energy Recovery Ventilation

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3. Technology – Exchanger Types
4. Standards & Codes
5. Energy Savings Software Programs

Run Around Loop

Supply (ventilation) Air Stream  Exhaust Air Stream

Interconnecting Fluid Piping  Expansion Tank  Circulation Pump  3-way Mixing Valve

55 to 65 % sensible effectiveness – no latent recovery
Heat Pipes

Humid Outside Air

Exhaust Air

Supply Air

Return Air

Partitioned area between air streams

Condenser Side

Evaporator Side
Heat Pipe Section

45 to 65% sensible effectiveness – no latent recovery

Fixed & Membrane Plates
**Counterflow and Crossflow**

- Alternating layers of plates
- Form two separate but adjacent air passages
- Counter-flow or cross-flow designs
- Transfers heat between airstreams
- Generally sensible only (aluminum plates)
- Latent with vapor-permeable plates

**Plate Exchanger Crossflow**

50 to 80% sensible effectiveness – latent possible
Fixed & Membrane Plates

- Can be used in many applications where wheels cannot; including hospitals, nursing homes, day care facilities, and toilet exhaust in Chicago
- Can be plastic, paper, or metal
- Core are available to recover sensible only or total enthalpy (sensible + latent)
- Fewer moving parts vs. wheels
- Higher pressure drop vs. wheels
- Generally more expensive than wheels

Energy Wheel

- Support Frame
- Wheel Matrix
- EXHAUST AIRSTREAM
- SUPPLY AIRSTREAM
- Purge
Directionally Oriented Media

- Dimples in filament
- Approx. 0.45 per inch
- Airflow path between filament dimples

Energy Wheel Operation

- 10 and 60 rev/min
- 50 to 85 % total effectiveness

- Supply Air
- Ventilation Air
- Exhaust Air
- Return Air
- Supply Air
Segmented Wheel Cleaning

- Segment is cleaned with non-acid based coil cleaner or alkaline detergent solution
- Segment is rinsed and drained
- Segment is dried and ready for use

Technology Comparison

<table>
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<tr>
<th></th>
<th>5000 CFM</th>
<th>450 FPM</th>
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<tbody>
<tr>
<td>MBH Total</td>
<td>57.4</td>
<td>104.7</td>
<td>207.6</td>
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<tr>
<td>Efficiency Total</td>
<td>19.8</td>
<td>36.1</td>
<td>71.7</td>
</tr>
<tr>
<td>RERT Total</td>
<td>33.05</td>
<td>37.58</td>
<td>119.10</td>
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</tbody>
</table>
Energy Recovery Ventilation

1. The ABCs of ERVs
2. Why Now?
3. Technology – Mating Options
4. Standards & Codes
5. Energy Savings Software Programs

Ventilation Connected to Conditioned Space – DOAS
Bypass Damper Control

Cross-Section of Stacked AHU

Exhaust Air

Return Air

Outdoor Air

Supply Air

Bypass Damper
Custom AHU with Cores

- Outdoor Air Intake
- Return Air
- Supply Air
- Cooling Coil
- Exhaust Air

Duct Mounted

- ERV wheel section in frame – no cabinet

- Exhaust Air
- Ventilation Air
DOAS RTU with Energy Recovery

- Packaged Dedicated Outdoor Air Units (DOAS)
- Recovery Wheel

Standard RTU & Energy Recovery

Rooftop Unit

Transition

ERV
**Standard RTU & Energy Recovery**

- ERV transitioned to the RTU’s horizontal return duct
- Allows for standard RTU economizer
- Requires separate RTU and ERV curbs

**Standard RTU & Energy Recovery**

- ERV transitioned to the RTU’s vertical return duct via drop-in damper box
- Allows for standard RTU economizer
- Requires separate RTU and ERV curbs
RTU Combination Curb

- ERV is transitioned to the RTU’s vertical return duct through the curb
- Allows for standard RTU economizer
ERV is Providing Outside Air to HVAC Unit.

ERV Shut Off, No Outside Air.
**RTU Combination Curb**

- Cost effective method of providing a RTU with an ERV
- Retro-fit or factory install
- Optional economizer and power exhaust function

**RTU Integrated**

- Cost effective method of providing a RTU with an ERV
- Retro-fit or factory install
- Optional economizer and power exhaust function
RTU Integrated

Common Features – Packaged ERV

- Direct drive – variable speed– ECM motors
- High Efficiency Fans – 80%
- Ability to select airflow (high static) / Wheel Effectiveness (high recovery rate)
- Double-wall insulation
- Long warranties on heat exchanger (5-10 yrs)
- Custom paint colors
Common Features – Packaged ERV

- Maintenance Indicators
- Economizer Functions
- Motorized O/A – E/A Dampers
- Frost Protection
- Electric Preheat
- CO2/VOC Space Sensor Controlled Operations
- Self-balancing and OA CFM Monitoring
- DDC Controls & Open Protocol
Airxchange Construction Details

- Used by about 80% of ERV cabinet manufacturers
- All wheels are ARI 1060 Certified
- G90 steel frame
- Stainless steel hub and rotating components
- Permanently lubricated bearings
- Removable, polymer media segments for easy cleaning outside of the unit
- Desiccant imbedded in media
- Urethane stretch belt
- Fractional hp motor
- Five year warranty

Electrically Commutated Motors (ECM)

- EC motors have integrated electronic controls that allow them to function like a VFD
- EC motor/fan combinations are twice as efficient as traditional motor blower combinations with belts and pulleys (up to 80% efficient versus 40%)
- EC motors have a longer average life than traditional motors (10+ years)
- EC motors generate less noise than traditional motors
- EC Motors use up to 30% less energy than traditional motors
Energy Recovery Ventilation

1. The ABCs of ERVs
2. Why Now?
3. Technology
4. Standards & Codes
5. Energy Savings Software Programs

Standards & Codes

ARI 1060 – Performance Rating for Energy Recovery Ventilation Equipment

- ARI Certification
  - Only ERV components that have been independently tested can have this seal. Tested “In accordance with...” is not permissible
  - Where rebates are available, may require certification to apply
  - Will be required by ASHRAE 90.1, addendum E when adopted

ARI 1060-2005 covers Air-to-Air Energy Recovery Ventilation Equipment
• Provides minimum ventilation rates and indoor air quality
• Section 5.17 added with version 62.1-2004 to limit air recirculation based on classification of air types. Classifies the “quality” of air you will be exhausting from the space and using for energy recovery. Controlling recirculation is the goal
• The use of energy recovery allows for air to be reclassified based on dilution

ASHRAE Standard 62.1-2004

ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality

- Class 1: Air with low contaminant concentration, low sensory-irritation and inoffensive odor.
  - Offices, classrooms, churches, break rooms, corridors, conference room, etc.
- Class 2: Air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors. Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.
  - Rest rooms, dining rooms, locker room, commercial laundry, warehouses, etc.
- Class 3: Air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
  - Refrigeration machine rooms, daycare sickroom, general chemical/biological labs, soiled laundry storage, kitchens, dry cleaners, pet shops, etc.
- Class 4: Air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered harmful.
  - Chemical storage, paint booths, printing equipment, kitchen grease hoods, laboratory hoods, etc.
5.17.2.2 Energy Recovery. Class 2 air may be re-designated as Class 1 air in the process of recovering energy when it is diluted with outdoor air such that no more than 10% of the resulting air stream is Class 2 air. Class 3 air may be re-designated as Class 1 air in the process of recovering energy when it is diluted with outdoor air such that no more than 5% of the resulting air stream is Class 3 air.

This long awaited response to the “toilet exhaust” issue has been available for 5 years. Also included in recent versions IMC.
Energy Savings Software Programs

- Many manufacturers have free performance software available
  - Determine the conditions of the ventilation air
  - Economic report for operating savings
  - ERV System Effect – combined efficiency of packaged RTU and ERV

Establishes a method of calculating the energy efficiency of applied ERV components and of HVAC systems utilizing such components at selected operating conditions.

Also provides guidance on proper sizing of cooling and heating equipment when such energy recovery components are applied.

CEF = \[
\text{Net cooling delivered (ERV + RTU)} \div \text{Total power consumed (ERV + RTU)}
\]

### System Efficiencies

**ARI Guideline V – Applied Efficiency and Performance of Energy Recovery Equipment**

- Establishes a method of calculating the energy efficiency of applied ERV components and of HVAC systems utilizing such components at selected operating conditions.
- Also provides guidance on proper sizing of cooling and heating equipment when such energy recovery components are applied.

**Example Table**

<table>
<thead>
<tr>
<th>Model</th>
<th>CEC</th>
<th>LEED</th>
<th>RES1</th>
<th>RES2</th>
<th>RES3</th>
<th>RES4</th>
<th>RES5</th>
<th>RES6</th>
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<tr>
<td>EVA</td>
<td>123</td>
<td>456</td>
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<td>012</td>
<td>345</td>
<td>678</td>
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<td>234</td>
<td>567</td>
<td>890</td>
<td>234</td>
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<tr>
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<tr>
<td>EWF</td>
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<td>890</td>
<td>234</td>
<td>567</td>
<td>890</td>
<td>234</td>
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</tbody>
</table>

**Equation**

\[
\text{RER} = \text{Return Air Plenum} + \text{Balance of Unitary Air Conditioner}
\]

\[
\text{EER} = 12.2
\]

14 – 18.8 CEF

Net conditioning recovered by ERV
Net conditioning capacity of RTU
Total electrical power consumed by ERV
Total electric power by RTU

CEF = \[
\frac{\text{Net cooling delivered (ERV + RTU)}}{\text{Total power consumed (ERV + RTU)}}
\]
System Efficiencies

Typical CEF using ARI Guideline V

<table>
<thead>
<tr>
<th>Tonnage</th>
<th>ARI - Base Unit EER</th>
<th>Outdoor Air (CFM)</th>
<th>Combined Efficiency (CEF) - &quot;System EER&quot;</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Indianapolis</td>
<td>Atlanta</td>
</tr>
<tr>
<td>5</td>
<td>12.2</td>
<td>600</td>
<td>14.1</td>
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<td>5</td>
<td>12.2</td>
<td>2,000</td>
<td>21.5</td>
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<td>10</td>
<td>12.2</td>
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<tr>
<td>10</td>
<td>12.2</td>
<td>4,000</td>
<td>21.9</td>
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<td>15</td>
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<td>15</td>
<td>11.6</td>
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<td>19.6</td>
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<td>25</td>
<td>11</td>
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<td>50</td>
<td>10.2</td>
<td>20,000</td>
<td>17.4</td>
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<td>100</td>
<td>9.7</td>
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<td>11.7</td>
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<td>100</td>
<td>9.7</td>
<td>30,000</td>
<td>14.9</td>
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</table>

Combined Efficiency (CEF) - "System EER"

ARI - Base

Unit EER

Outdoor Air (CFM)

Combined Efficiency (CEF) - "System EER"

Indianapolis

Atlanta

Houston

Phoenix

Toronto

---

MicroModel Comparison AIRX ERC DESIGN POINT ANALYSIS

<table>
<thead>
<tr>
<th>DESIGN CONDITIONS</th>
<th>Dry Bulb, F</th>
<th>Wet Bulb, F</th>
<th>Psychod. Psychod.</th>
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<tbody>
<tr>
<td>SUMMER, Outdoor</td>
<td>70.00</td>
<td>60.00</td>
<td>30.80</td>
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<tr>
<td>SUMMER, Indoor</td>
<td>70.00</td>
<td>60.00</td>
<td>20.74</td>
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<tr>
<td>WINTER, Outdoor</td>
<td>-10.00</td>
<td>-10.00</td>
<td>-1.90</td>
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<tr>
<td>WINTER, Indoor</td>
<td>70.00</td>
<td>50.00</td>
<td>22.71</td>
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<table>
<thead>
<tr>
<th>PROJECT DATA</th>
<th>EVDD</th>
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<tbody>
<tr>
<td>SUMMER, Outdoor</td>
<td>1440</td>
<td>1440</td>
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<tr>
<td>SUMMER, Indoor</td>
<td>1440</td>
<td>1440</td>
</tr>
<tr>
<td>WINTER, Outdoor</td>
<td>78.08%</td>
<td>78.08%</td>
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<tr>
<td>WINTER, Indoor</td>
<td>70.00%</td>
<td>70.00%</td>
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<table>
<thead>
<tr>
<th>SUPPLY AIR CONDITIONS</th>
<th>Summer</th>
<th>Winter</th>
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<tbody>
<tr>
<td>Dry Bulb Temperature, F</td>
<td>75.00</td>
<td>51.09</td>
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<tr>
<td>Wet Bulb Temperature, F</td>
<td>60.44</td>
<td>41.82</td>
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<tr>
<td>Enthalpy, Btu/Ft³</td>
<td>31.38</td>
<td>16.21</td>
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<tr>
<td>Relative Humidity, %</td>
<td>51.5</td>
<td>42.9</td>
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<table>
<thead>
<tr>
<th>DESIGN LOADS, Btu/h</th>
<th>Summer</th>
<th>Winter</th>
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<tbody>
<tr>
<td>Outside Air, Indoor</td>
<td>32,501</td>
<td>32,501</td>
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<td>Outside Air, Total</td>
<td>62,051</td>
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<table>
<thead>
<tr>
<th>RECOVERED LOADS, Btu/h</th>
<th>Summer</th>
<th>Winter</th>
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<tbody>
<tr>
<td>Sensible Recovered</td>
<td>22,945</td>
<td>21,752</td>
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<tr>
<td>Latent Recovered</td>
<td>22,945</td>
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<td>Total Recovered</td>
<td>45,332</td>
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<table>
<thead>
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<th>Net OA LOAD</th>
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<tr>
<td>16,519</td>
<td>42,104</td>
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<td>3.79</td>
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Ryan R. Hoger
708.670.6383
ryan.hoger@tecmungo.com