Trends in High Efficiency HVAC Packaged Products

May 2012
AGENDA

Packaged commercial HVAC equipment and application overview
Trends in high efficiency commercial packaged products
  Full load mechanical improvement challenges
  The importance of part load efficiency
Technology enablers for energy savings
  Multi-speed technology
Technology enablers for shedding peak load
  Demand Controlled Ventilation
  Energy Recovery
  Thermal Storage in packaged systems
Gas Heat on Packaged units: energy saving strategies (heating)
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Gas Heat on Packaged units: energy saving strategies (heating)
ROOFTOP UNIT OVERVIEW

- Control Box
- Indoor Coil
- Indoor Fan
- Gas Heat
- Base Rail
- Base Pan
- Compressor
- Condenser Coil
AHRI – independent, 3rd party verification of unit performance. Ensures manufacturer’s performance claims are accurate and rated uniformly, enabling fair comparisons.
AHRI CERTIFICATION

Ensuring human comfort, productivity, and safety, while practicing environmental stewardship is the mission of the Air-Conditioning, Heating, and Refrigeration Institute (AHRI). Our 300 member companies produce more than 90 percent of the residential and commercial air conditioning, heating, water heating, and commercial refrigeration equipment made in North America. Through our certification program, standards, advocacy, and other activities, we strive to help save energy, improve productivity, and ensure a better environment.
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Gas Heat on Packaged units: energy saving strategies (heating)
Significant improvements have been made in overall building efficiency as well as Packaged Rooftop Efficiencies.

Significant improvement has also been made for rooftop efficiencies, but we are approaching “Max-Tech” for EER.

source: PNNL ASHRAE 90.1 Determination
EFFICIENCY IMPROVEMENTS

PAC limits shown YAC subtract 0.2
PART LOAD VS FULL LOAD

Historic focus has been on full load efficiency - but that is less than 1% of the operating hours.

Full load is important from peak kW but part load is where most of the hours are.

Also, most units are oversized by at least 10%

Latent control in humid zones contributes to increased power consumption in part load operation.

The plot shows a typical hours load profile for an office building: ambient temperature vs load.
IEER PART LOAD METRIC

The **IEER** is intended to be a measure of merit for the part load performance of the unit.

The equation is:

\[
\text{IEER} = 0.020*A + 0.617*B + 0.238*C + 0.125*D
\]

Where:
- \(A\) = EER at 100% net capacity at design conditions
- \(B\) = EER at 75% net capacity and reduced ambient
- \(C\) = EER at 50% net capacity and reduced ambient
- \(D\) = EER at 25% net capacity and reduced ambient

• The weighting factors were based on an average of the 17 ASHRAE climate zones for several building types.
• It includes the operating hours where the compressor is running and but does not include the hours where only economizers run.
• Each building may have different part load performance due to local occupancy schedules, building construction, building location and ventilation requirements. For specific building energy analysis an hour-by-hour analysis program should be used.
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ULTRA HIGH EFFICIENCY 3-5 TONS

1. Electrical mechanical controls or digital controls

2. High Efficient Direct Drive ECM (x-13) or Belt Drive motor and Variable Frequency Drive (VFD)

3. High efficient direct drive ECM outdoor fan motor aids in unit overall high performance.

4. Two-Stage scroll compressor provides efficient and accurate temperature control. Combined with digital controls system can provide Single Zone VAV logic and operation.
MULTI SPEED INDOOR FAN

ASHRAE Standard Summary:
As of January 1, 2012 all direct expansion Air Conditioners & Air Handlers >110k+ capacity serving single zones shall have two speed or variable speed drive indoor fan control.

At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:
1. Two-Thirds of the full fan speed or,
2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1

(VFD)
Fan Automatically Adjusts To Unit Operation Per New Standard

- 1st Stage Cooling = Fan at 67%
- 1st and 2nd Stage Cooling = Fan at 100%
- Any Heating = Fan at 100%
- Ventilation Only = Fan at 67%
MULTI SPEED INDOOR FAN

Based on annual estimated electric energy savings utilizing Carrier’s Hourly Analysis (HAP) Program v4.6.
Based on cooling and ventilation fan runtime hours using ASHRAE 90.1 office application, default schedule, weather, and building data. Carrier model 48/50TC*D12. All locations except Los Angeles evaluated with a single dry bulb economizer, Los Angeles evaluated with differential enthalpy economizer.
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<th>Packaged commercial HVAC equipment and application overview</th>
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</table>

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ECONOMIZERS

100% Open – all return air is exhausted

Modulated Open – some return air, some OA

No Outside Air

Power Exhaust (if equipped)

Barometric relief/exhaust

Must view this in presentation mode
ECONOMIZERS

Alternate intake options

OA Dampers

Sliding panel
ECONOMIZERS

Tampa, FL

Syracuse, NY

Free cooling opportunities

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Commercial building code requires continuous ventilation when occupied

\[
\text{Building Ventilation for area} + \text{Occupancy Ventilation for people} = \text{Total ventilation rate}
\]

Economizers with DCV can break the OA CFM into these two parts and reduce the ventilation load on the HVAC system, unless required by actual occupancy load.
Purple = “demand controlled”  Green =“constant”  
Difference between the two equates to significant savings.

**Bottom Line… CO2 is a good “people meter”**

People exhale CO₂ at concentrations of 4% (40,000 ppm)

Normal room concentrations are ~ 400 - 1200 ppm

As a gas, CO₂ diffuses and equalizes rapidly throughout a room

CO₂ production by people is very predictable based on activity level…doubling the people in a room will double the CO₂

CO₂ levels will build until an equilibrium level is reached with outside air entering the space
# ECONOMIZERS

Great when then work

<table>
<thead>
<tr>
<th>Typical failure modes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not properly commissioned</td>
<td>Factory installed</td>
</tr>
<tr>
<td></td>
<td>Proper commissioning</td>
</tr>
<tr>
<td></td>
<td>Integrated controls with feedback</td>
</tr>
<tr>
<td>Broken linkage</td>
<td>Gear driven design</td>
</tr>
<tr>
<td>Seized dampers</td>
<td>Gear driven design</td>
</tr>
<tr>
<td>Control system failure</td>
<td>Proper maintenance, fault diagnostics</td>
</tr>
</tbody>
</table>

Source: Jan2007 TAG/Public Interest Energy Research/Architectural Energy/CEC study (CEC-500-2007-006) and Nov2008 TIAX/DOE study of Commercial Building Controls Diagnostics. (TIAX ref no. D0180)

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GEARS VS LINKAGE

Older economizer designs had linkage that broke…turning it into a manual air damper…gear drives should be clearly specified.

Gears  Actuator connected to gear

Linkage will eventually bind & break!
ALARM TOOLS

Get trouble indications where they needs to go:
- The right people - facilities, service, operations
- E-mail, texting, pop-up alarms

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Utilize trending to spot system operational issues
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WHAT IS ENERGY RECOVERY?
WHAT IS ENERGY RECOVERY?

Energy Recovery = the use of exhaust air to partially condition the incoming OA before the evaporator coil

Examples:

Desiccant heat wheel device

Ventilation Air → Exhaust Air

Supply Air → Return Air

Mechanical device (heat pump)

Outside Air → Exhaust Air

Supply Air → Return Air

Mixed Air

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Unit Airflow rear view

Filters protect the wheel on each airstream.

Rooftop Unit

Mixed Air = RA2 + Outdoor Air

Pre-cooled, dehumidified and/or heated Ventilation Air

ERV module

Outdoor Air

Exhaust Air

Supply Air

Return Air

Return Air / Exhaust Air Diverter Dampers

Replaceable Filters

Airflow Sensing Module

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INTEGRATED ENERGY RECOVERY

Operation: Wheel rotates between the incoming outdoor airstream and the building exhaust airstream. Transfers heat and moisture from one airstream to the other.

Result = outdoor air is pre-conditioned, significantly reducing the capacity and energy needed from the mechanical HVAC system.
Desiccants: How Do They Work?

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

Because the vapor pressure in the colder exhaust air stream is lower, the water vapor pressure on the desiccant surface is lower, too. The water is desorbed and exhausted back to the outside.

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

Desiccant opening

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Table shows the typical outside air requirements that will be MANDATORY for a building designed to meet ASHRAE 90.1-2010 and ASHRAE 62.1-2010 requirements.

Exact values can change based on the occupancy and space design.

The energy recovery will impact building designs that need ~25% outdoor air or more.

These applications cover ~ 75% of the industry applications.

Use of ER reduces compliance complexity for designing engineers!

ASHRAE 189 requires ER on applications with 5%-30% OA

<table>
<thead>
<tr>
<th>Building</th>
<th>% OA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary School</td>
<td>75</td>
</tr>
<tr>
<td>Secondary School</td>
<td>69</td>
</tr>
<tr>
<td>Retail</td>
<td>65</td>
</tr>
<tr>
<td>Strip Mall</td>
<td>62</td>
</tr>
<tr>
<td>Hospital</td>
<td>54</td>
</tr>
<tr>
<td>Outpatient Care</td>
<td>50</td>
</tr>
<tr>
<td>Small Office</td>
<td>46</td>
</tr>
<tr>
<td>Restaurant</td>
<td>36</td>
</tr>
<tr>
<td>Fast Food</td>
<td>34</td>
</tr>
<tr>
<td>Large Office</td>
<td>32</td>
</tr>
<tr>
<td>Medium Office</td>
<td>27</td>
</tr>
<tr>
<td>Warehouse</td>
<td>26</td>
</tr>
<tr>
<td>Hotel</td>
<td>23</td>
</tr>
<tr>
<td>Grocery</td>
<td>21</td>
</tr>
<tr>
<td>Motel</td>
<td>20</td>
</tr>
</tbody>
</table>
Requirements by weather zone

Zones 1A thru 6A will require ER on applications with 30% OA at 5,500cfm up to 70% OA at 1,000cfm

ASHRAE CLIMATE ZONES

All of Alaska in Zone 7 except for the following
Bethel
Dillingham
Fairbanks N. Star
Nome
North Slope
Northwest Arctic
Southeast Fairbanks
Wade Hampton
Yukon-Koyukuk

Zone 1 includes
Hawaii, Guam,
Puerto Rico,
the Virgin Islands and
other tropical locations
EFFICIENCY COMPARISON

Energy recovery provides GREAT efficiency benefits when you need it most!

**Graph of CEF vs Application EER (Cooling Mode)**

- **Base Unit Application EER**
- **RTU+ERV System CEF - Tampa**
- **RTU+ERV System CEF - Detroit**

<table>
<thead>
<tr>
<th>Example</th>
<th>Base Rooftop Unit</th>
<th>Base RTU w/integrated Energy Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model:</td>
<td>48PGDC12-A-6</td>
<td>48PGDC12-A-6-T</td>
</tr>
<tr>
<td>Altitude (ft)</td>
<td>0.0 ft</td>
<td>0.0 ft</td>
</tr>
<tr>
<td>CFM</td>
<td>3500</td>
<td>3500</td>
</tr>
<tr>
<td>Ext static press:</td>
<td>0.75&quot;</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>Ventilation Air:</td>
<td>50% or less (economizer)</td>
<td>50% OA (1750 CFM)</td>
</tr>
</tbody>
</table>

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RTU Energy Efficiency Ratio

\[ EER = \frac{\text{Net conditioning capacity of RTU}}{\text{Total electric power by RTU}} \]

ERV Recovered Energy Efficiency Ratio

\[ RER = \frac{\text{Net conditioning recovered by ERV}}{\text{Total electrical power consumed by ERV}} \]

CEF = Combined Efficiency Factor (system EER)

Example:

48HC-24 + Integrated Energy Recovery = System CEF (30 ton system)

\[ \begin{align*}
EER & \quad & RER & \quad & = \text{CEF} \\
12.0 & \quad & 124.69 & \quad & = 17.19
\end{align*} \]

17.19 System EER for a 30 ton total system

Reference: [www.ahrinet.org/Content/FindaGuideline_240.aspx](http://www.ahrinet.org/Content/FindaGuideline_240.aspx)
### CEF EXAMPLES

<table>
<thead>
<tr>
<th>Rooftop Unit</th>
<th>RTU AHRI EER</th>
<th>ERV Wheel</th>
<th>RTU Airflow (CFM)</th>
<th>ERV Airflow (CFM)</th>
<th>Atlanta</th>
<th>Miami</th>
<th>Phoenix</th>
<th>Montreal</th>
<th>Detroit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CEF RER</td>
<td>CEF RER</td>
<td>CEF RER</td>
<td>CEF RER</td>
<td>CEF RER</td>
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<tr>
<td>48HC 17</td>
<td>12.0</td>
<td>ERC-3628</td>
<td>5250</td>
<td>3800</td>
<td>68.67</td>
<td>16.60</td>
<td>80.82</td>
<td>17.59</td>
<td>61.82</td>
</tr>
<tr>
<td>48HC 20</td>
<td>12.0</td>
<td>ERC-3628</td>
<td>5950</td>
<td>3800</td>
<td>68.67</td>
<td>16.01</td>
<td>80.82</td>
<td>16.87</td>
<td>61.82</td>
</tr>
<tr>
<td>48HC 24</td>
<td>12.0</td>
<td>ERC-4646C</td>
<td>7000</td>
<td>5500</td>
<td>76.27</td>
<td>17.19</td>
<td>89.95</td>
<td>18.29</td>
<td>68.73</td>
</tr>
<tr>
<td>48HC 28</td>
<td>11.2</td>
<td>ERC-4646C</td>
<td>8750</td>
<td>5500</td>
<td>76.27</td>
<td>15.38</td>
<td>89.95</td>
<td>16.25</td>
<td>68.73</td>
</tr>
<tr>
<td>50HC 17</td>
<td>12.2</td>
<td>ERC-3628</td>
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<td>61.82</td>
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<td>7000</td>
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<td>17.45</td>
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<tr>
<td>50HC 28</td>
<td>11.4</td>
<td>ERC-4646C</td>
<td>8750</td>
<td>5500</td>
<td>76.27</td>
<td>15.63</td>
<td>89.95</td>
<td>16.53</td>
<td>68.73</td>
</tr>
</tbody>
</table>

* CEF equates to a system EER value

In example cities systems experience up to **6.37 efficiency point boost, with an average increase of 4 points of efficiency!**
### APPLICATION COMPARISON

<table>
<thead>
<tr>
<th>Design Conditions (St. Louis IAP)</th>
<th>High Eff 20 ton 48HCDD24</th>
<th>High Eff 25 ton 48HCDD28</th>
<th>EnergyX® System 48HCDD24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airflow (CFM)</td>
<td>8000</td>
<td>8000</td>
<td>8000</td>
</tr>
<tr>
<td>Ventilation Air (CFM)</td>
<td>4000</td>
<td>4000</td>
<td>4000</td>
</tr>
<tr>
<td>OA (db/wb °F)</td>
<td>95 / 76</td>
<td>95 / 76</td>
<td>95 / 76</td>
</tr>
<tr>
<td>RTU Evap EAT (db/wb °F)</td>
<td>-</td>
<td>85 / 70</td>
<td>85 / 70</td>
</tr>
<tr>
<td>RTU Evap LAT (db/wb °F)</td>
<td>58 / 57</td>
<td>62 / 61</td>
<td>60 / 59</td>
</tr>
<tr>
<td>Total Cooling Capacity (MBH)</td>
<td>325</td>
<td>264</td>
<td>312</td>
</tr>
<tr>
<td>Sensible Capacity (MBH)</td>
<td>215</td>
<td>195</td>
<td>217</td>
</tr>
<tr>
<td>Total Heating Capacity (MBH)</td>
<td>300</td>
<td>251</td>
<td>251</td>
</tr>
<tr>
<td>Unit Efficiency</td>
<td>-</td>
<td>12 EER</td>
<td>11.2 EER</td>
</tr>
</tbody>
</table>

**Effectively doubled heating Capacity with constant gas bill**
ENERGY RECOVERY REBATES

Example: Florida Power & Light

www.airxchange.com/airxchange-technology-utility-rebates.htm

Florida Power and Light offers incentives for its business customers to upgrade their HVAC system and lighting system with energy-efficient equipment.

The individual rebates vary according to system size and efficiency rating; ERV rebates up to $1.35 per CFM. Typical is ~ $0.8 to 0.9 per CFM.

Example: 10 ton High Efficiency Rooftop + EnergyX® System at 2000 CFM ~ $1,840 rebate


- Enthalpy wheel or plate type ERV system which recovers both sensible and latent heat from the building exhaust
- Desiccant or moisture transfer membranes for humidity control
- AHRI certified and listed with 50% net total thermal effectiveness rating
<table>
<thead>
<tr>
<th>Typical failure modes</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unverified performance</td>
<td>Factory integrated and certified</td>
</tr>
<tr>
<td>Poor installation</td>
<td>Factory integrated</td>
</tr>
<tr>
<td>Not properly commissioned</td>
<td>Factory installed Proper commissioning</td>
</tr>
<tr>
<td></td>
<td>Integrated controls with monitoring and feedback</td>
</tr>
<tr>
<td>Poor air balance</td>
<td>Integrated airflow monitoring</td>
</tr>
<tr>
<td>Dirty transfer media</td>
<td>Removable media for clean-ability</td>
</tr>
</tbody>
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INTEGRATED ENERGY RECOVERY

Factory engineered
Factory integrated
ETL listed system
One warranty
One service support team
INTEGRATED ENERGY RECOVERY

Onboard airflow monitoring

Differential pressure sensed across window opening

Correlation between differential pressure and CFM

Intake/exhaust fans modulate
  Backward curved
  Direct drive ECM motors

Drive Actual CFM =
  Commanded CFM

*Aluminum mist filter removed for photo
Ease of Set-Up
Enter:
  Commanded Exhaust
  Commanded Intake

System:
  Modulating fans
  Intake damper
  Onboard airflow monitoring

System works to balance actual and commanded

*Factory integrated system and controls*
INTEGRATED ENERGY RECOVERY

Ease of Service

Easy access door

Filters slide out

Wheel slides out

Segmented wheel for easy cleaning*

*Wheels greater than 25”
EASE OF SERVICE

Segmented wheel facilitates cleaning

1. Segments are removed through access panels
2. Segment is soaked in alkaline cleaner (“409” or “Fantastic”)
3. Segment is rinsed and drained
4. Segment is dried and ready for use
INTEGRATED ENERGY RECOVERY

Factory engineered

Factory integrated

ETL listed system

One warranty

One service support team
SELECTABLE OPTIONS

Economizer option – allows true modulating economizer capability when OA is suitable for free cooling
  • operates as a true wheel bypass damper
  • uses stop/jog operation for wheel

Frost control option – uses exhaust air to defrost the wheel when necessary

Demand Controlled Ventilation - Modulating Integrated Energy Recovery Systems units are compatible with single zone CO2 sensor
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THERMAL STORAGE

The Ice Energy Hybrid Cooling™ Solution

Complements standard air conditioning to be:

- less costly
- more reliable
- green*

By using less expensive, less polluting, nighttime power to create & store cooling for use the next day

*Based on use of nighttime wind energy and lower source emitting generation equipment
THERMAL STORAGE

Interconnecting copper refrigerant supply and return line sets from Ice Bear unit to ice-ready evaporator coil in Carrier RTU

Seth Mohler
303-944-6274
sMohler@CarrierWest.com
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PACKAGED SYSTEMS- HEATING

Challenges

Higher gas efficiency (AFUE)

Opportunities

Energy recovery
High Efficiency Heat pumps
Fan savings
There are significant application differences between commercial and residential.

In commercial, the indoor fan is always on during the occupied period due to ventilation requirements as defined by ASHRAE 62.1.

Commercial applications tend to have much higher cooling loads due to internal plug loads which can be 25 to 30% of the load plus the internal occupancy density is much higher.

Commercial buildings like offices tend to use time of day schedule where the unit is off or setback during the evening where residential tends to be operating at design temperatures during the evening.

Cooling/Heating Changeover temperatures are much lower and cooling dominates the commercial market and heat to cool ratios are lower.
The chart shows a typical Commercial office building load profile and a Residential Load Profile.
Because of the acidic nature of the condensate you cannot drain it on the roof or the ground.

For ground mounted units which is 20 to 30% of the market it would be difficult to drain the condensate as it might be below the level of the sewer lines.

Many commercial codes do not allow it to be drained into the sewer system.

Also heating is used when the ambient is below freezing and the condensate lines and condensate will freeze.
0.10 incremental pressure drop **currently not possible** and will require new technology and increased cabinet sizes.

**Corrosion issues and condensate disposal** are still an issue.

Increasing plug loads and tighter buildings with higher insulation levels the **benefits will continue to decrease**.

Some older buildings may have higher heating loads, but should we develop condensing furnace technology to fix bad buildings or should we fix the buildings with **energy retrofits which will reduce energy more**.
EXAMPLE ENERGY RECOVERY SPEC

1. Energy Recovery Ventilator and Economizer
   a. System Description
      One-piece Energy Recovery Ventilation (ERV) System is an electrically controlled ventilation air pre-conditioner utilizing an AHRI 1060 certified Energy Recovery Cassette to reduce the cooling and heating loads placed on the primary HVAC unit by untreated outdoor air. Building exhaust air shall be introduced to the ERV unit through ductwork. Unit shall be designed as a factory-installed option to be used with packaged rooftop units for use in vertical return applications only.
   b. Quality Assurance
      (1.) Unit shall be designed in accordance with UL Standard 1995
      (2.) Energy Recovery unit shall be ETL tested and certified.
      (3.) Rooftop unit and Energy Recovery unit shall be ETL certified as one single system.
      (4.) Roof curb or curb extension shall be designed to conform to NRCA Standards.
      (5.) Insulation and adhesive shall meet NFPA 90A requirements for flame spread and smoke generation.
      (6.) Unit casing shall be capable of withstanding ASTM No. 141 (Method 6061) 500-hour salt spray test.
      (7.) Unit shall contain ARI 1060 certified Energy Recovery Cassette.
      (8.) Unit shall leakage rates shall be capable of meeting ASHRAE Standard 62.1 requirements for use of class-2 exhaust with class-1 ventilation air.

2. Products
   a. Equipment (Standard)
      (1.) General: The Energy Recovery System shall be a factory assembled, single piece unit. Contained within the unit enclosure shall be all factory wiring with a single, pre-determined point of power input and a single point of 24-volt control wiring.
      (2.) Unit Cabinet
         (1.) Unit cabinet shall be constructed of galvanized steel coated with a pre–painted baked enamel finish.
         (2.) All models shall have hoods installed over outside air intake and exhaust openings. Outside air hood shall have aluminum water entrainment filters.
         (3.) All models have 1-in., 2 pound density fiberglass insulation.
         (4.) Hinged access doors with compression latches shall be provided on all units for access to fans and filters. Hinged doors shall be provided with at least one handle capable of being locked.
         (5.) Exhaust air stream shall have back-draft dampers to prevent air penetration during off cycles.
         (6.) Holes shall be provided in the base rails for rigging shackles to facilitate overhead rigging.
      b. Blowers
         (1.) Blowers shall be direct drive with variable speed motors.
         (2.) Blower wheel shall be made of steel with a corrosion resistant finish. It shall be dynamically balanced, double-inlet type with backward-curved blades.
         (3.) Blower shall be mounted on neoprene vibration isolation pads.
         (4.) Motor shall be high efficiency and have thermal overload protection.
      c. Filter Section
         (1.) Standard filter section shall accept commercially available, 2-in. pleated filter(s).
      d. Controls and Safeties
         (1.) The Energy Recovery Ventilator shall operate in conjunction with rooftop unit fan.
      e. Electrical Requirements
         (1.) All unit power wiring shall enter unit cabinet at a single location.
      f. Energy Recovery Cassette
         (1.) The energy recovery media shall have a minimum of 70% effectiveness at nominal unit airflow.
         (2.) Energy wheel performance shall be ARI Standard 1060 Certified and bear the ARI Certified Product Seal.
         (3.) The energy recovery cassette shall be an UL Recognized component for electrical and fire safety.
         (4.) The wheel shall be coated with silica gel desiccant, permanently bonded without the use of binders or adhesives.
         (5.) Coated wheels may be washable with detergent or alkaline coil cleaner and water.
         (6.) The silica gel shall not dissolve or deliquesce in the presence of water or high humidity.
         (7.) The substrate shall be made of a lightweight polymer and shall not degrade or require additional coatings for application in coastal environments.
         (8.) The wheel polymer layers shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop.
         (9.) The polymer layers shall be captured in a stainless steel wheel frame or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.
         (10.) Energy recovery wheels greater than 19 inches in diameter shall be provided with removable wheel segments.
         (11.) Wheel frame shall be a welded hub, spoke and rim assembly of stainless, plated, and or coated steel and shall be self-supporting without the wheel segments in place.
         (12.) Wheel segments shall be removable without the use of tools to facilitate maintenance and cleaning.
         (13.) Wheel rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.
         (14.) Wheel bearings shall provide an L-10 life of 400,000 hours.
         (15.) Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

2. Special Features (Options and Accessories)
   a. Supply and exhaust air frost control option
      (1.) Factory-installed frost protection module shall sense pressure differential across the energy recovery cassette.
      (2.) Supply blower shall be shut-off if the pressure differential across the energy recovery cassette exceeds an adjustable set point. Blower shall remain off for an adjustable period.
      (3.) Exhaust blower and wheel shall remain in operation in order to remove any frost build-up on the wheel.
   b. Energy Recovery Ventilator maintenance indicator package
      (1.) A factory-installed switch shall monitor Energy Recovery Ventilator blowers and motor amp draw and send a signal to field-supplied 24-v indicator upon amperage surge that maintenance required.
      c. Filter maintenance indicator
         (1.) A factory-installed differential pressure switch shall measure pressure drop across the outside air filter and activate a field-supplied 24-v indicator when airflow is restricted. It shall not interrupt Energy Recovery System operation. Switch set point shall be adjustable.
      d. Energy Recovery Ventilator free cooling with enthalpy and stop/jog control
         (1.) An enthalpy sensor shall prevent the wheel from rotating if the outside air conditions are acceptable for free cooling. Both exhaust and supply blowers will remain on.
         (2.) Stop-Jog-Control shall energize the wheel periodically during the free cooling operation of the Energy Recovery Ventilator to prevent dirt build-up on the wheel.
   e. Economizer Option
      (1.) The economizer shall be integrated in the energy recovery module and shall allow air to bypass the energy recovery wheel for free cooling and fail safe operation. Tilting wheel mechanisms shall not be allowed.
      (2.) The economizer damper shall be motorized with factory installed, 24-volt Belimo actuator.
      (3.) The energy recovery system shall be capable of using the economizer in a free cooling operation.
      (4.) The economizer shall utilize enthalpy sensor controls when in the economizer mode.
   f. CO₂ Sensor
      (1.) The modulating airflow energy recovery unit shall be capable of incorporating a CO₂ sensor for use with Demand Control Ventilation.
      (2.) The CO₂ sensor shall connect to the base rooftop unit’s digital controller.
      (3.) The modulating airflow energy recovery unit shall use at a minimum, a high & low CFM airflow set point when a CO₂ sensor is used.
DIAGNOSTICS REPORTS


Final Report

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ADVANCED HVAC SYSTEMS FOR IMPROVING THE INDOOR ENVIRONMENTAL QUALITY AND ENERGY PERFORMANCE OF CALIFORNIA K-12 SCHOOLS

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