Advanced Design Rooftop HVAC Unit

Measure ID: 246
Proposer Name: Mark Firestone
Contact Info: PAE Consulting Engineers
markf@pae-engineers.com
(503)226-2921
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Sector: Industrial
Focus Area: Commercial/Institutional Building Performance, HVAC
Energy System: HVAC & Humidity Control
End Uses: data center, restaurant, retail, office
New or Retrofit: New, Retrofit

Standard Practice:
The packaged rooftop HVAC unit is the most common way to provide HVAC to commercial buildings in the marketplace today. This has been the case for several decades or more, so there is a large market for both new units and replacement units. Actual market penetration is unknown (does anyone have data??).

Typical commercial quality rooftop HVAC units are designed to meet minimum energy code requirements. The market is very competitive and cost-driven, and there is limited incentive to produce units that exceed minimum code requirements. Options for some high efficiency components are available from a limited number of manufacturers.

Description:
The Advanced Design Rooftop HVAC Unit offers improved energy performance over the typical "commercial" rooftop unit by enhancing the performance of individual components and configurations, including fans, coils, filters, dampers, compressors, condensers, controls, and airflow path. Specific enhancements include the following:

• High efficiency fans
• Variable speed fans
• Low pressure drop coils and filters
• Low leakage dampers
• IAQ Damper (measure outside air (OA) flow)
• Variable speed or digital compressor
• Larger condenser
• Water-cooled condenser
• Refrigeration system optimized for part load operation
• DDC controls
• Self diagnostic controls
• Optimizing control sequences: supply air temperature and pressure reset, night purge, optimum start/stop, low temperature air during economizer operation, demand-control ventilation, enthalpy-based economizer,
• Heat recovery: Sensible or total
• Improved fan/duct connections
• Aerodynamic air path (lower velocity, less abrupt turns)
• Additional insulation
• Tighter casing (less leakage)

Development Status:
High efficiency components currently exist, and are typically used in custom-built air handling and air conditioning units. Engineers currently work directly with custom unit manufacturers to design and specify high efficiency units for projects with aggressive energy conservation goals. This equipment is more expensive not only because it is of higher quality, but because it is designed and manufactured in a "one-off" manner. If the market for higher efficiency units was broadened, manufacturing could become more efficient, and costs would drop accordingly.

Target Customer:
Commercial building owners and developers interested in greater energy efficiency and "green building" credentials for enhanced organizational image and marketability.
Need and Benefit:

The rooftop unit is a common, easily applied HVAC solution. The Advanced Design Rooftop HVAC Unit would serve all the same customer needs, with the benefit of being more energy efficient.

Energy Savings:
Energy savings can be grouped into three main categories: Fan Energy, Refrigeration System Energy, and Heating Energy. Energy savings will depend on how many of the enhancements are incorporated into the unit, and also on the application (See Energy Savings Dependencies below). Percentage savings are not additive, but apply to the remaining energy use after each successive enhancement is made. Estimates of the annual electrical energy savings potential (% of total unit energy usage) for individual enhancements are as follows:

- High efficiency fans (2-3%)
- Variable speed fans (5-10%
- Low pressure drop coils and filters (2-3%)
- Low leakage dampers (2-3%)
- IAQ Damper (measure OA flow) (Variable - depends on whether conventional unit over or under-ventilates)
- Variable speed or digital compressor (3-5%)
- Larger condenser (1-2%)
- Water-cooled condenser (3-4%)
- Refrigeration system optimized for part load operation (2-3%)
- DDC controls (5-10%)
- Self diagnostic controls (n/a - maintains persistence of savings over time)
- Optimizing control sequences: supply air temperature and pressure reset, night purge, optimum start/stop, low temperature air during economizer operation, demand-control ventilation, enthalpy-based economizer (5-20%)
- Heat recovery: Sensible or total (10-15%)
- Improved fan/duct connections (2-3%)
- Aerodynamic air path (lower velocity, less abrupt turns) (3-5%)
- Additional insulation (3-5%)
- Tighter casing (less leakage) (3-5%)

For measures that save Heating Energy (Heat Recovery, Demand-Control Ventilation, Tighter Casing), it is assumed the unit has electric heat (heat pump or electric resistance).

Energy Savings Dependencies:
Energy savings will depend on how many of the enhancements are incorporated into the unit, and also on the application. Energy savings will be achieved in all HVAC applications; however, units in the following applications will achieve the greatest energy savings:

Applications with Higher Cooling Ton-Hours: Buildings with high internal loads, or excessive glazing, or low performance glazing, or low performance envelopes, or high percentage outside air (see below) will have a greater portion of their energy use resulting from Refrigeration System Energy. These applications will benefit most from enhancements to the Refrigeration System (Variable Speed or Digital Compressor, Larger Condenser, Water-cooled Condenser, Night Purge, Enthalpy-based Economizer).

Applications with Higher Percentage Outside Air: Buildings such as schools or other high occupant density spaces have a greater portion of their energy use resulting from Heating Energy. These applications will benefit most from enhancements that impact heating such as: Heat Recovery, Demand-Control Ventilation, Tighter Casing.

Cost:
A custom rooftop HVAC unit can be expected to cost 2-3 times as much as a commercial quality rooftop HVAC unit, depending on which of the enhancements are included. Additional costs may result from higher quality components, additional components and controls, and larger size unit casings.

Effective Life:
The effective life of a custom rooftop HVAC unit is at least twice as long as a commercial quality rooftop HVAC unit. Additional lifespan results from higher quality components and greater maintainability.

Energy Performance Specifications:
Many consulting engineers have written specifications to define the components, features and qualities of custom rooftop HVAC units. These specifications are typically several pages or more in length. In addition, drawings are typically provided to detail unit configurations and schedule operating characteristics.

Competing Technologies:
Standard commercial rooftop HVAC units capture most of the market for this technology. The standard units do not compete in terms of energy efficiency, lifespan, or maintainability; however they are significantly less expensive. High end institutional buildings often have custom air handling units of similar technology housed within the building, coupled to chillers and boilers.

Barriers:
The greatest barrier to implementation is initial cost. With financial incentives, this technology could become more cost effective.

Sources and Advocates:
Institutional building owners such as hospitals and universities sometimes apply this technology to their buildings. This technology is also favored by corporate owners who use lifecycle cost analysis in making their purchasing decisions.

NBI (New Buildings Institute) has studied the performance of commercial rooftop units and developed a number of recommendations for how to improve unit efficiency at relatively minimal cost.
http://www.newbuildings.org/technologies/heating-cooling-mechanical-systems

CEE (Consortium for Energy Efficiency) is working on a similar concept for an Advanced Rooftop Unit (ARTU) that contains a number of the features (Improved Outdoor Air Control, Improved Economizer Reliability, Self-Diagnostic Controls, and Fault Tolerant Design).
http://newbuildings.org/sites/default/files/ARTU_ProductDefinitionFinalReport.pdf

Links:
NBI (New Buildings Institute): http://www.newbuildings.org

Refs:
Personal Experience in design and modeling of energy consumption of HVAC systems.

NBI (New Buildings Institute) website.

Prior Work:
None known.

Comment:
FROM JUNE 2010 HVAC TAG RANKING SURVEY RESPONSES:
1. Similar to technology #16 - Premium Ventilation Package for Rooftop Units
2. Determining a savings/rebate method for this is important.
3. Suggest this be merged with #16.
4. "One of the criteria for choosing measures, is whether there is equipment available off the shelf. I understand some manufacturers are offering some, but not all of these features.
This proposal describes some very good things to do, but after such a unit goes through it's development and ""shake out"" I expect some of the features will be ""optimized"" out. It appears to be more of a ""reasearch project"" than a ""program measure.""
From a utility's point of view, it would be easier to provide incentives for equipment that meets established standards; e.g. EnergyStar, or CEE Tier2, etc.

The next proposal, ""Thighter HVAC boxes"" is something that was considered by the industry as a feature of Advanced Design RTUs. Perhaps the ""measures"" should be combined."

Planning Source:
TAG

Updates:
Reviewd D Koenen
Edited A Thompson
Entered A Mountjoy-Venning