APPLICATION AND DESIGN GUIDELINES

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AIR-TO-AIR ENERGY RECOVERY VENTILATION EQUIPMENT OVERVIEW:

ASHRAE's Terminology of Heating, Ventilation, Air Conditioning and Refrigeration reference book defines Air-to-Air Heat Energy Recovery Ventilation Equipment (AAERVE) as energy recovery components and packaged energy recovery units that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preconditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an air-conditioner (to include air heating, air cooling, air circulating, air cleaning, humidifying and dehumidifying) system.

By utilizing the previously conditioned return/exhaust air to temper the incoming outdoor supply air, an AAERVE (example: packaged unit featuring an Energy Recovery Wheel) can provide several important benefits including:

- Increased energy efficiency for the combined system, defined as Combined Efficiency (CEF)
- Reduced space conditioning energy requirement, defined as Net Building Load
- Reduced equipment size and resulting purchase price due to reduced building load

AAERVE PRINCIPLES OF OPERATION:

Although there are many different types of AAERVE, this document will focus on packaged rooftop units featuring Energy Recover Wheels but the same concept applies to bolt on Energy Recovery Wheels, and Stand Alone Energy Recovery Ventilators. The basic principles of this equipment are very similar to many other types of AAERVE systems.

The Energy Recovery Wheel in the packaged rooftop unit features a coated substance that has the ability to absorb sensible and latent heat energy between two different air streams. The Energy Recovery Wheel rotates, absorbing energy in one air stream and then transferring the energy to the alternate air stream. This process allows the equipment to recover the space conditioning energy from the previously conditioned return/exhaust air and temper the incoming outdoor supply air.

Figure 1 below illustrates the operation of an Energy Recovery Wheel during summer conditions. Notice the cool exhaust air from the occupied space will enter the Energy Recovery Wheel, conditioning the hot entering air. During winter conditions this process reverses and the wheel uses the warm exhaust air to condition the cold incoming outdoor supply air.

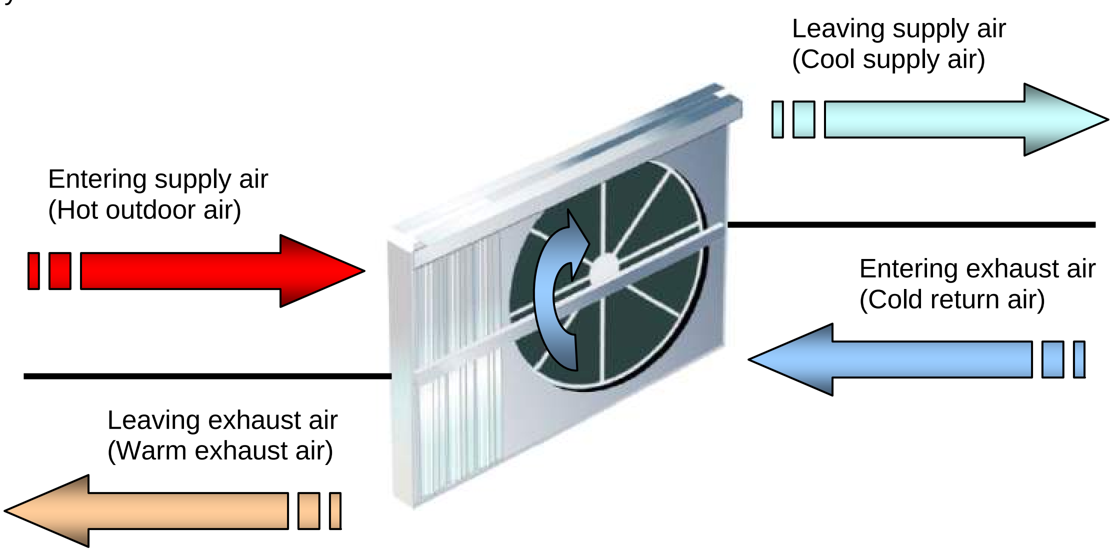


Figure 1 – Energy Recovery Wheel Operation

EFFICIENCY AND PERFORMANCE MEASUREMENT RATINGS:

There are several ways to measure the efficiency and effectiveness of Air-to-Air Energy Recovery Ventilation Equipment. The first measurement, Recovery Efficiency Ratio (RER), applies to the efficiency of the Air-to-Air Heat Exchanger device such as an Energy Recovery Wheel. Another measurement, Combined Efficiency (CEF), applies to the efficiency of the Air-to-Air Energy Recovery Heat Exchanger when combined with an air conditioner such as a packaged rooftop unit. One final measurement, the Net Effectiveness, applies to the amount of energy the Air-to-Air Heat Exchanger can transfer between the exhaust and entering air streams.

Recovery Efficiency Ratio (RER) measures the effectiveness of equipment such as an Energy Recovery Wheel. To calculate this efficiency rating, take the energy savings achieved from reducing the sensible and latent load of the outdoor air by the amount of energy (KW) the Energy Recovery Wheel consumes to accomplish this task. For an Energy Recovery Wheel that rotates in a packaged rooftop unit, energy consumption could occur in the form of a motor to move the wheel and a supply fan to force exhaust air through the wheel. Typical ratings for Energy Recovery Wheels can range as high as 120 RER.

Combined Efficiency (CEF) measures the efficiency of the entire system and is comparable to the traditional Energy Efficiency Rating (EER) typically used with packaged rooftop units. However it is important to note that the CEF and EER ratings are not exact matches. This occurs because manufacturers must use a specific rating scenario to measure EER as prescribed by ANSI/ARI standards while the CEF rating takes into account a user defined rating scenario.

For example, a 20 ton packaged rooftop unit must perform certification rating testing at 95 F DB outdoor air and 80 F DB / 67 F WB entering evaporator air conditions. However, when designing and selecting a packaged rooftop unit featuring an energy recovery wheel the user specifies the design conditions, which typically differ from the ANSI/ARI standard. This allows the user to calculate the actual CEF and Net Effectiveness of the wheel at design conditions.

Net Effectiveness measures how much heat energy a device such as an Energy Recovery Wheel can recover. This measurement will tell the user how well the AAERVE can perform the job under a given set of conditions. For example, an AAERVE with a Net Effectiveness rating of 73% will do a better job of recovering heat energy than a similar device with a Net Effectiveness rating of 65%.

BUILDING LOAD REDUCTION AND UNIT SIZING:

The use of a smaller packaged rooftop unit with an energy recovery wheel is made possible because of the Net Building Load effect. ASHRAE defines this term as the total calculated space conditioning energy required for a building including the impact of energy recovery (total building load minus the total energy recovered from the exhaust air). The Net Building Load applies to both heating and cooling design conditions.

For example, let’s assume the total building cooling load is 200 tons including outside air without an AAERVE. If the AAERVE can reduce the outdoor air load by 75 tons then the Net Building Load will equal 125 tons (200 tons – 75 tons = 125 tons).

The Net Building Load can have a dramatic effect on unit equipment size and energy usage depending on the design conditions. Often times adding an Energy Recovery Wheel to a packaged rooftop unit pays for itself within a very short time period. Please note, an AAERVE can’t recover energy from an unconditioned space (ie morning warm-up or unoccupied space). AAERVEs need to be sized accordingly.

OTHER DESIGN AND SPECIFICATION CONSIDERATIONS:

AAERVE Classifications and Integrated Systems

AAERVE system types include integrated, stand alone, stand alone coupled and unitized. While each system has different benefits and features, there are a couple of key things to note regarding Lennox’s Energence™ 35-50 ton packaged rooftop units featuring an integrated Energy Recovery Wheel:

- Low installation cost because the AAERVE does not require a separate field installation
- Guaranteed performance and trouble free operation at start up due to factory testing and verification[1]

1 Still requires air balance, same as stand alone systems

Frost Control

The AAERVE system should incorporate some type of means or control device for avoiding frost from the air-to-air heat exchanger. For example, Lennox's Energence 35-50 ton units featuring an integrated Energy Recovery Wheel use a thermostat that senses the exhaust air temperature that together with the Prodigy Controller will close the outdoor air damper during cold weather operation, preventing potential frost problems.

System Balancing

Specifying equal (balanced) supply and exhaust airflows will provide the maximum energy recovery for the AAERVE. While unequal airflows will reduce the impact for energy recovery and lessen the effectiveness of the equipment, this may be desirable to meet other design requirement such as building pressurization setpoints.

Economizer Operation

During certain times of the year it may be desirable to bypass the AAERVE and bring in unconditioned outside air. Lennox's Energence 35-50 ton packaged rooftop units feature a bypass damper so the unit can bring in fresh outdoor air without operating the Energy Recovery Wheel. This helps reduce energy consumption and allows the unit to save operating costs by taking advantage of opportunities to use fresh outdoor air for cooling.

Cooling Design Selection Conditions

The ASHRAE Handbook Fundamentals provide three different sets of cooling design conditions. The specified design choice may have an impact on the ability to control indoor humidity and system efficiency. These three design conditions include:

- Dry-bulb/mean wet-bulb data, which prioritizes sensible load
- Wet-bulb/mean dry-bulb data, which prioritizes latent load
- Dewpoint/mean dry-bulb data, which prioritizes humidity ratio

Maintenance and Serviceability

Like all mechanical equipment, Air-to-Air Heat Exchangers require period maintenance and service. Lennox's Energence 35-50 ton packaged rooftop units featuring an integrated Energy Recovery Wheel has several features that make maintenance and service fast and friendly including:

- Removable pie shaped wedges that prevent the entire removal of the wheel for cleaning
- Alternating air flow between exhaust and supply air streams for self cleaning functionality

<u>AAERVE OPERATION EXAMPLE:</u>

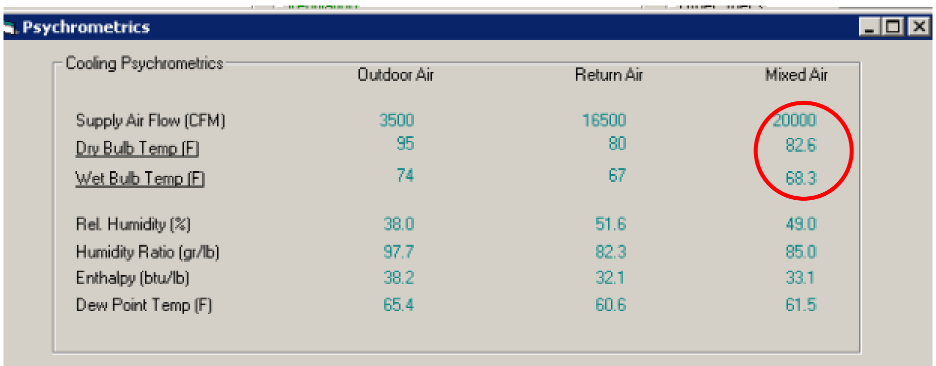
The following example illustrates the performance benefits of utilizing an Energy Recovery Wheel in a packaged rooftop unit. This example prioritizes sensible heat removal.

Design / unit information:

- Outdoor air temperatures: 95º F DB, 74º F WB
- Return/exhaust air temperatures: 80º F DB, 67º F WB
- Internal sensible building load: 35 tons (294,000 Btuh)
- Unit type: Energence packaged rooftop unit
- Supply air: 20,000 CFM
- Outdoor air: 3,500 CFM
- Exhaust air: 3,500 CFM

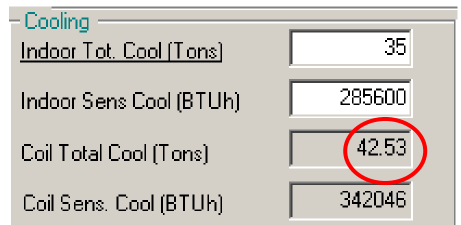
Scenario A: Standard Packaged Rooftop Unit

Utilizing Lennox's Product Selection Software and the information listed above, the program has selected a 40 ton Energence packaged unit. Without an Energy Recovery Wheel, the mixed air temperature entering the evaporator coils is 82.6º F DB and 68.3º F WB. This results in a total coil load of 42.53 tons.


Psychrometrics

Cooling Psychrometrics

	Outdoor Air	Return Air	Mixed Air
Supply Air Flow (CFM)	3500	16500	20000
Dry Bulb Temp (F)	95	80	82.6
Wet Bulb Temp (F)	74	67	68.3
Rel. Humidity (%)	38.0	51.6	49.0
Humidity Ratio (gr/lb)	97.7	82.3	85.0
Enthalpy (btu/lb)	38.2	32.1	33.1
Dew Point Temp (F)	65.4	60.6	61.5

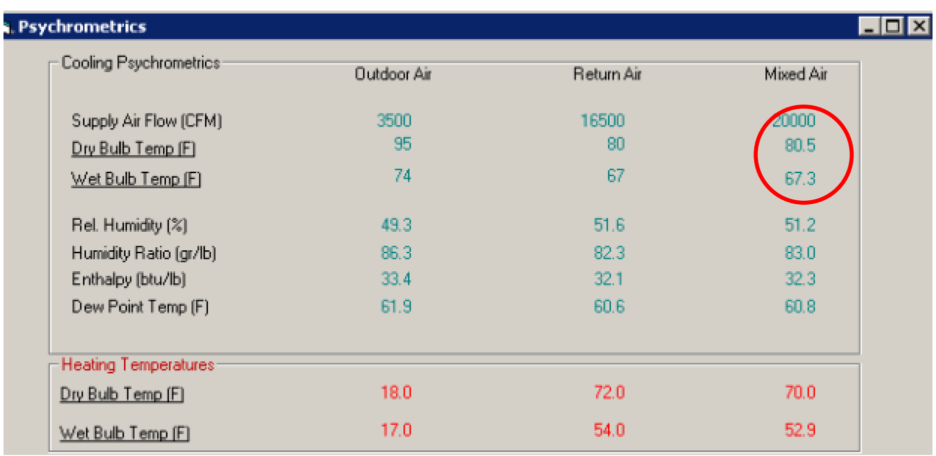

Cooling

Indoor Tot. Cool (Tons)	35
Indoor Sens Cool (BTUh)	285600
Coil Total Cool (Tons)	42.53
Coil Sens. Cool (BTUh)	342046

Scenario B: Packaged Rooftop Unit With an Integrated Energy Recovery Wheel

Utilizing the same product selection software and design parameters and adding in the requirement to also include an Energy Recovery Wheel, the program has now selected a 35 ton Energence packaged unit. The mixed air temperature entering the evaporator coil has dropped to 80.5º F DB and 67.5º F WB. This drop has resulted because the outdoor air leaving the Energy Recovery Wheel and mixing with the return air has been reduced to 82.8º F DB and 68.6º F WB.

The other important item to notice is the total coil load now equals 36.86 tons, a reduction of almost 6 tons. Our Net Building Load for this project equals 36.86 tons (42.53 tons – 5.67 tons = 36.86 tons). The Net Effectiveness for the AAERVE has been rated at 77.4%.

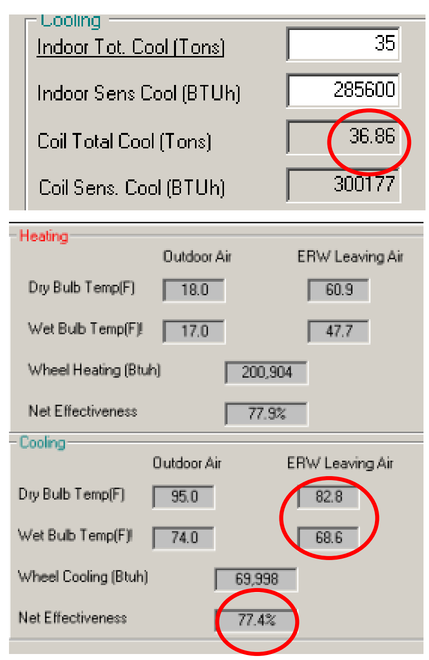

Psychrometrics

Cooling Psychrometrics

	Outdoor Air	Return Air	Mixed Air
Supply Air Flow (CFM)	3500	16500	20000
Dry Bulb Temp (F)	95	80	80.5
Wet Bulb Temp (F)	74	67	67.3
Rel. Humidity (%)	49.3	51.6	51.2
Humidity Ratio (gr/lb)	86.3	82.3	83.0
Enthalpy (btu/lb)	33.4	32.1	32.3
Dew Point Temp (F)	61.9	60.6	60.8

Heating Temperatures

Dry Bulb Temp (F)	18.0	72.0	70.0
Wet Bulb Temp (F)	17.0	54.0	52.9


Cooling

Indoor Tot. Cool (Tons)	35
Indoor Sens Cool (BTUh)	285600
Coil Total Cool (Tons)	36.86
Coil Sens. Cool (BTUh)	300177

Heating

	Outdoor Air	ERW Leaving Air
Dry Bulb Temp(F)	18.0	60.9
Wet Bulb Temp(F)	17.0	47.7
Wheel Heating (Btuh)	200,904	
Net Effectiveness	77.9%	

Cooling

	Outdoor Air	ERW Leaving Air
Dry Bulb Temp(F)	95.0	82.8
Wet Bulb Temp(F)	74.0	68.6
Wheel Cooling (Btuh)	69,998	
Net Effectiveness	77.4%	

References:

1. ASHRAE *Terminology of Heating, Ventilation, Air-Conditioning, and Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

2. ANSI/ARI Standard 1060-2005, *Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment*, 2005, Air-Conditioning and Refrigeration Institute, 4100 North Fairfax Drive, Suite 200, Arlington, VA 22203, U.S.A.

3. ANSI/ARI Guideline V-2003, *Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC Systems*, 2003, Air-Conditioning and Refrigeration Institute, 4100 North Fairfax Drive, Suite 200, Arlington, VA 22203, U.S.A.

4. ANSI/ARI Guideline W-2005, *Selecting, Sizing, and Specifying Packaged Air-to-Air Energy Recovery Ventilation Equipment*, 2005, Air-Conditioning and Refrigeration Institute, 4100 North Fairfax Drive, Suite 200, Arlington, VA 22203, U.S.A.