PRODUCT APPLICATION GUIDE | ENERGY RECOVERY

OPTIMIZING EXHAUST AIR ENERGY RECOVERY

So many different energy recovery technologies, energy codes and standards, and building types. What is the best way to select the right device for the application? The intent of this application guide is to provide understanding of the most commonly used options, how they work, and the best fit for each.

WHAT IS EXHAUST AIR ENERGY RECOVERY

Exhaust air energy recovery is a useful solution to provide affordable ventilation for high outdoor air commercial and institutional applications. In commercial HVAC units, the energy recovery components pre-treat outside air by exchanging the energy from the exhaust air to help reduce overall operating costs. When outside air temperatures are warm, energy recovery devices pre-cool and dehumidify the incoming air. Conversely, when outside air temperatures are cool, energy recovery devices humidify and pre-heat the incoming air.

Two of the most common technologies in the energy recovery market are:

- Enthalpy Wheel
- Enthalpy Core

Although codes and standards such as ASHRAE 90.1 dictate when exhaust air energy recovery must be provided, understanding the composition, design, and efficiency of the different technologies can help inform which will be the best option for an application. This guide will discuss the above technologies which are commonly used in the packaged rooftop HVAC market. Other exhaust air energy recovery options include regenerative plates and sensible-only technologies such as aluminum flat plates, energy wheels, heat pipes.

HOW DO THESE DEVICES WORK

ENTHALPY WHEELS – ALUMINUM OR POLYMER

Construction and Performance

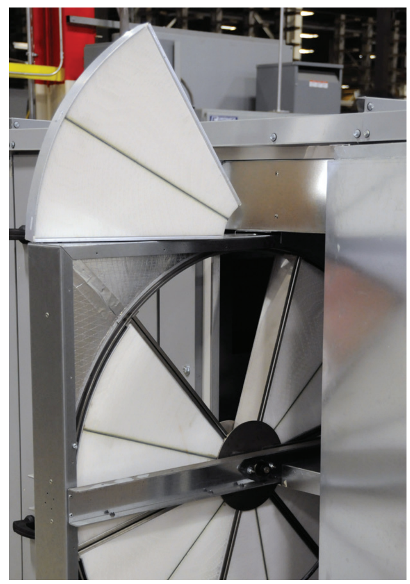
Enthalpy wheels are the most efficient and widely available energy recovery technology in the packaged rooftop market with the capability to transfer both sensible and latent energy. Energy recovery wheels work by rotating a thermal mass between an exhaust airstream and an outside airstream. They require a heat transfer media with a desiccant for latent energy transfer, a drive system to rotate the wheel, and circumferential and radial seals to limit airflow between airstreams. Typical total effectiveness is 65-80% when the supply and exhaust airflows are balanced. In most packaged rooftop units, higher face velocities (800 feet/minute) typically result in effectiveness on the lower end of that range.

There are two primary types of enthalpy wheel media: polymer and aluminum. Both have the capability to transfer latent energy by applying a desiccant to the wheel. Polymer wheels feature a silica gel desiccant embedded into the polymer substrate. An aluminum wheel most commonly uses a molecular sieve desiccant that is bonded to the surface.

Maintenance

Enthalpy wheels should be protected on both airstreams with MERV-8 or higher filters. With proper filtration, the wheel media should be inspected on an annual basis and cleaned if required. Polymer wheels are provided in removable pie-shaped segments as shown at right, which can be cleaned with a detergent bath. Aluminum wheels up to seven feet in diameter are usually provided as one piece that can be vacuumed in place or purged with compressed air. Larger aluminum wheels are provided in segments.

It is critical that motors, belts, and seals be inspected at regular intervals and adjusted as necessary to control cross leakage and maintain performance. A wheel that is not rotating recovers no energy.



Segmented polymer wheel can be removed in pieces if needed for maintenance

Applications

Enthalpy wheels offer the greatest savings in high percentage outside air applications, especially in humid climates. Typical applications are classrooms, dormitories, office buildings, labs, and hotels.

ENTHALPY CORES – POLYMER OR FIBER

Construction and Performance

Like an enthalpy wheel, an enthalpy core transfers both sensible and latent energy. Enthalpy cores have a total effectiveness range of 50-65%. Enthalpy cores are typically manufactured as a corrugated and layered hydroscopic polymer or fiber membrane. The supply and exhaust airstreams travel through the separated corrugated pathways and the energy transfer occurs through the membrane. This results in a lower cross leakage rating than enthalpy wheels, typically less than 1%, between the supply and exhaust airstreams. Enthalpy cores require lower face velocity (300 feet/minute) than wheels to achieve energy code-mandated performance with an acceptable air pressure drop. As a result, the size of a packaged unit is typically larger with an enthalpy core for a given airflow.

Enthalpy core heat exchangers are easy to maintain with no moving parts

Maintenance

With no moving parts, maintenance of the enthalpy core is lower compared to the enthalpy wheel. Enthalpy cores should be protected on both airstreams with MERV-8 or higher filters. Annual maintenance is recommended to clean the core's surfaces to ensure that debris does not accumulate and block the airstreams. Polymer cores are water washable and can be cleaned in place with a low velocity water source. Fiber material cores must be vacuumed to remove debris. The overall maintenance is low and the ability for the core to continuously provide the designed energy recovery capability remains high throughout the life of the device.

Applications

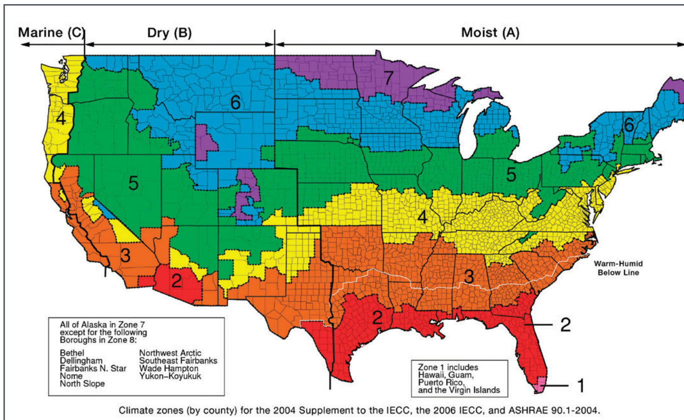
Although the cores have a lower total effectiveness when compared to a wheel, their total effectiveness meets most state energy codes, and they are popular in buildings where there is limited or no onsite maintenance staff. The core technology is most commonly found in applications such as schools, dormitories, offices, and nursing homes. In addition, with low cross leakage ratings, the core technology is recommended for bathroom exhaust and locker room applications as well.

WHEEL VS. CORE PERFORMANCE

CATEGORY	ENTHALPY WHEEL		ENTHALPY CORE	
Heat Transfer Medium	Aluminum	Polymer	Fiber	Polymer
Total Performance	70-85%	70-85%	50-60%	55-65%
Internal Pressure Drop	Moderate		High	
Exhaust Air Transfer Ratio (EATR)	3-5%		0-1%	
Maintenance	Moderate Belts and motors need regular inspection		Low No moving parts, annual inspection	

WHY IS EXHAUST AIR ENERGY RECOVERY USED

The requirement for exhaust air energy recovery promotes energy efficient design where certain favorable criteria exist. It first appeared in ASHRAE 90.1-1989 as more of a suggestion than a defined requirement. In the revisions since it was first introduced, specific guidelines have been included for when energy recovery is required and a minimum efficiency has been set. The current standard considers the supply airflow and outside airflow of the system, the climate where the project is located, and the annual operating hours to determine if energy recovery is required.



Climate zone map of the United States

ENERGY STANDARDS AND CODES

Energy codes are a part of the building codes in each U.S. state governing the minimum requirements for energy efficient construction of new buildings, additions, and retrofits. The requirement for exhaust air energy recovery is mandated in these standards and codes. The two most common sources included in state building codes are:

- ASHRAE 90.1, Energy Standard for Buildings Except Low Rise Residential Buildings
- International Energy Conservation Code (IECC)

ASHRAE 90.1 and IECC are updated every three years. There are a few states with no energy codes, and some states or cities that create their own requirements, but most adopt one of these two standards. Adoption of new versions of the codes is often slow, so the requirement in many states may be several versions behind.

Two tables are provided in the ASHRAE 90.1 and IECC standards/codes to show whether the supply airflow of a system requires energy recovery: one for systems operating less than 8,000 hours per year, and one for systems operating 8,000 hours or more per year. As might be expected, more systems meet the energy recovery requirement when they operate 8,000 hours or more annually. The tables are entered using the percentage of outside air and the ASHRAE Climate Zone for the site. Where energy recovery is prescribed, an enthalpy recovery ratio (ERR) of 0.5 is required, defined as the change in the outdoor air enthalpy divided by the difference between the return air entering enthalpy and outside air entering enthalpy. There is also a list of exceptions to the requirement for various spaces that have specific energy recovery requirements detailed in other sections of the code.

TABLE 6.5.6.1-1 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Less than 8000 Hours per Year

	% Outdoor Air at Full Design Airflow Rate							
Zone	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
1B, 2B, 5C	NR	NR	NR	NR	≥26,000	≥12,000	≥5,000	≥4,000
6B	≥28,000	≥26,500	≥11,000	≥5,500	≥4,500	≥3,500	≥2,500	≥1,500
1A, 2A, 3A, 4A, 5A, 6A	≥26,000	≥16,000	≥5,500	≥4,500	≥3,500	≥2,000	≥1,000	>0
7, 8	≥4,500	≥4,000	≥2,500	≥1,000	>0	>0	>0	>0

NR - Not Required

TABLE 6.5.6.1-2 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Greater than or Equal to 8000 Hours per Year

	% Outdoor Air at Full Design Airflow Rate							
Zone	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
3C	NR	NR	NR	NR	NR	NR	NR	NR
1B, 2B, 3B, 4C, 5C	NR	≥19,500	≥9,000	≥5,000	≥4,000	≥3,000	≥1,500	>0
1A, 2A, 3A, 4B, 5B	≥2,500	≥2,000	≥1,000	≥500	>0	>0	>0	>0
4A, 5A, 6A, 6B, 7, 8	>0	>0	>0	>0	>0	>0	>0	>0

NR - Not Required

Two tables are provided in the ASHRAE 90.1 and IECC standards to show where exhaust air energy recovery is required

The latest version of ASHRAE 90.1-2022 contains one significant change that impacts mainly northern climates. If a space is not actively humidified, and cooling enthalpy recovery is exempted in the Climate Zone, the energy recovery device may now be sensible only, with the requirement being a Sensible Energy Recovery Ratio of 60% for non-transient dwelling units and 50% for all other spaces. This change recognizes that during winter in colder, drier climates, if the space is not actively humidified, there will be little to no latent energy to recover when the dry outdoor air is introduced to the space.