Energy Recovery Ventilation

Proper ventilation is essential for maintaining good indoor air quality, yet it places an additional burden on cooling and heating equipment, which must condition air that will soon be exhausted from the building. Energy recovery ventilation (ERV) systems recover cooling or heating energy from the exhaust airstream and transfer it to the intake (outside) airstream, saving energy and potentially improving humidity control as well. The magnitude of these benefits varies depending on climate, but geographic locations with hot, humid summers like Florida are ideal for ERV systems.

What Is ERV?

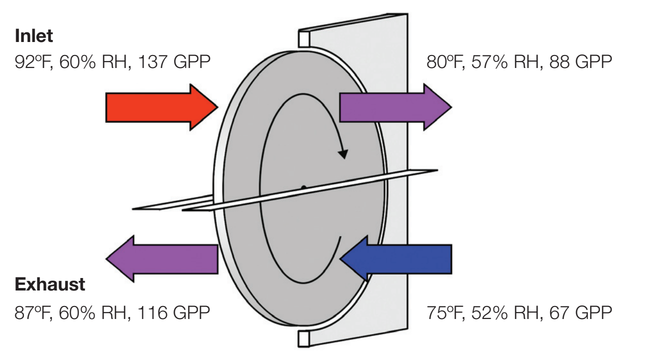
ERV can transfer two types of heat: sensible and latent. Sensible heat refers to the heat content of the air itself, which can be measured with a standard thermometer. Latent heat is the amount of energy that is required to evaporate water into water vapor (humidity) and is required to remove that water from the water vapor via condensation. Latent heat can be measured by a wet-bulb thermometer. Ventilation systems that transfer both sensible and latent heat (total enthalpy) are referred to as ERV, while those that only transfer sensible heat are called heat recovery ventilation (HRV). ERV has the ability to modify humidity levels; HRV does not. Typically, HRV systems do not meet the 50 percent energy recovery effectiveness required by the International Energy Conservation Code (IECC) of 2009 and ASHRAE 90.1. ERV devices include enthalpy wheels and fixed-plate heat exchangers.

Enthalpy wheels. An enthalpy wheel is composed of a matrix of heat- and moisture-adsorbing material, like a desiccant, which rotates between the incoming outside air and outgoing exhaust air ducts (Figure 1).

In the cooling season, as the wheel rotates, it removes water vapor from the moist outside air and transfers it to the dry, conditioned exhaust air that is leaving the building. Simultaneously, the wheel pre-cools the hot incoming outside air and transfers that heat to the cool, conditioned exhaust air. By pre-cooling and dehumidifying the hot, humid intake air, the enthalpy wheel reduces the load on the refrigerant compressor, saving electrical energy. Under part-load conditions, the wheel speed can be reduced, or a bypass duct can be employed to lessen the load on the fans and reduce energy consumption. Enthalpy wheels are among the most common types of ERV systems and typically yield high effectiveness values. For heat transfer systems like ERV, effectiveness refers to the efficiency with which heat is moved from one place to another. Enthalpy wheels can have total effectiveness values as high as 75 percent or more, but proper cleaning and maintenance (at least once a year) are essential to ensure that the enthalpy wheels don't become fouled, as this can reduce heat transfer efficiency and increase the pressure drop in the ductwork. Similar to enthalpy wheels, rotary heat wheels transfer sensible heat only and are available for lower-humidity applications.

Fixed-plate heat exchangers. Unlike enthalpy wheels, fixed-plate heat exchangers don't employ any moving parts. By driving intake and exhaust air through an alternating series of parallel plates that are separated and sealed, heat is effectively transferred between the two airstreams (Figure 2).

Fixed-plate heat exchangers are available in a number of different configurations (two common options are horizontally or vertically oriented plates) and can be made to transfer moisture as well as heat by using semipermeable materials to separate the airstreams. However, many plate heat exchangers instead use materials like aluminum or plastic that only result in sensible heat transfer and, therefore, yield lower net savings.



Notes: F=Fahrenheit; GPP=grains of water per pound of dry air; RH=relative humidity.

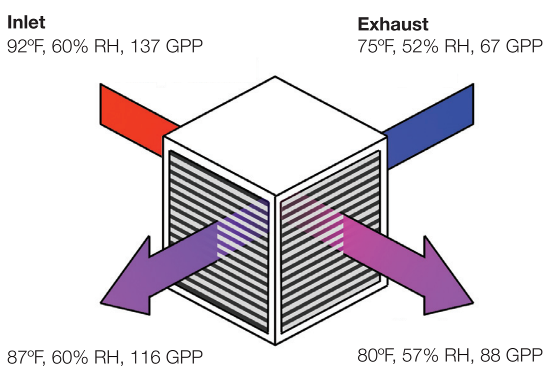
Figure 1: Mechanics of an enthalpy wheel. With high heat-transfer effectiveness, enthalpy wheels are ideal for saving energy, but they can also increase the pressure drop in HVAC ductwork, requiring additional fan energy.

The total energy effectiveness of plate heat exchangers varies from unit to unit based on factors like size and configuration, but it's possible to find units with effectiveness values that are comparable to those of enthalpy wheels. Additionally, because no moving parts are involved, fixed-plate heat exchangers may be able to save additional energy when compared with an enthalpy wheel while also yielding lower maintenance costs. However, it's important to maintain a clean air supply when using a fixed-plate heat exchanger.

Codes and Standards

ASHRAE Standard 90.1 and IECC-2009 are the basis for most HVAC-related building codes in the United States. Both require the incorporation of an ERV system when an individual fan system has a design supply air capacity of 5,000 cubic feet per minute or greater and minimum outside air supply of 70 percent or greater of the design supply air quantity.

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) provides certification of ERV devices in order to ensure that the products will perform as claimed by the manufacturer. To see if a product has been certified by AHRI, you can search through the organization's online directory.



Notes: F=Fahrenheit; GPP=grains of water per pound of dry air; RH=relative humidity.

Figure 2: Configuration of a fixed-plate heat exchanger. As with enthalpy wheels, a bypass duct may be employed under part-load conditions to reduce fan energy consumption.

Benefits of ERV

ERV provides multiple benefits to building operators and occupants.

Reduce HVAC energy consumption. ERV systems save energy by reducing the need to cool or heat outside air. Although fan energy consumption tends to remain unchanged or even increase if the ERV system increases drag in the ductwork, the cooling and heating savings generally far outweigh any increase in fan energy consumption.

Reduce peak demand. HVAC systems are some of the biggest contributors to peak electricity use—times during the day when the utility is required to produce the most energy and when rates are highest. By reducing the need for cooling and heating, an ERV system can help lower a building's peak demand, thereby lowering your electric bill even further by requiring less power during times when rates are highest.

Improve humidity control. Because ERV systems are able to pre-dry incoming ventilation air, they can also help to improve humidity control. ASHRAE and others have documented a growing discrepancy between building humidity load and air-conditioner sensible heat ratio (the ability of the HVAC unit to dehumidify the air). Improved building energy efficiency has decreased sensible cooling loads (for example, heat produced by inefficient lighting and plug loads), while latent loads (including occupant respiration and moist ventilation air) have remained essentially the same. HVAC units are now required to remove more latent heat than they were designed for, leading to higher indoor humidity levels. ERV systems can mitigate these conditions, providing a benefit to building operators and occupants alike.

Provide appropriate ventilation. In some cases, buildings may not be bringing in enough outside air for proper ventilation. By reducing the energy needed by the HVAC system to condition outside air, ERV systems can encourage building operators to increase the amount of outside ventilation air and improve indoor air quality. Additionally, ERV systems can allow building operators to meet updated building codes with a minimal corresponding increase in energy consumption.

Cost-Effectiveness of ERV

ERV systems are well established, and installed costs are relatively stable. However, savings can vary widely depending on the region and the settings used. A recent study conducted at Purdue University shows favorable economics for ERV systems in a variety of buildings. This study investigated savings in five types of buildings across the country—a restaurant, a retail store, a school, an office, and an auditorium—using a detailed simulation model. Simple payback periods for retrofit installations of enthalpy wheels were found to range from two to five or more years in hot and humid climates. However, ERV installations in new construction projects can yield much shorter payback periods as a result of downsizing the cooling and heating equipment in response to lower ventilation loads.

To obtain savings estimates specific to Florida's climate, the simulation was run a second time for this report using data from eight cities in Florida (Table 1). The results indicate that ERV can be a particularly effective strategy in Florida retail stores, restaurants, and auditoriums, with average annual HVAC cost savings of around 16 percent.

As with all building equipment, it's important to properly maintain and commission an ERV system, both to maximize savings and to ensure that they persist over the life of the unit.

Buildings That Are Good Candidates for ERV

In general, buildings that make the best candidates for energy recovery ventilation are distinguished by the following.

Moderate to extreme cooling or heating climates. Given that ERV can reduce the conditioning load from ventilation, buildings in climates where a lot of energy is required to heat or cool the outdoor air stand to benefit the most, whereas those in climates where little conditioning is required or where economizer operation is common will save less. Facilities with large refrigeration loads, such as supermarkets, will also benefit from the reduced humidity load that the display cases would otherwise have to remove.

Large ventilation requirements. Buildings that require large amounts of outdoor air are likely to be good candidates for ERV because they will have correspondingly higher cooling and heating loads due to ventilation. For this reason, buildings that are open for only a few hours per day are unlikely to be good candidates for ERV and might be better off using timers to shut off ventilation fans during unoccupied hours.

New construction. ERV systems can be more easily integrated into new buildings where they can be designed from the beginning to work with the ductwork. Additionally, because ERV systems reduce the cooling and heating load on the HVAC system, much of this equipment can be downsized, yielding lower up-front costs and larger energy savings. For instance, a 21,000-square-foot school in Florida that used an enthalpy wheel to help meet its 45-ton HVAC design load was able to save $25,000 in up-front costs (and $6,000 per year) simply as a result of downsizing its new HVAC system. With that said, costs and savings can vary from site to site based on factors like local climate; the size, type, capacity, and complexity of the ERV unit; and the HVAC system to be installed. Although some rules of thumb exist for estimating installed costs and reductions in HVAC tonnage, these are of limited accuracy. The best way to assess these criteria is to use a simulation tool like the U.S. Environmental Protection Agency's ERV Financial Assessment Software Tool (click the EFAST Download and Installation link in the Contents list) or vendor-provided calculators like those found on the Airxchange, RenewAire, and AAON websites.

	Office			Restaurant			Retail store			School			Auditorium		
Location	Energy (%)	Demand (%)	**Total savings (%)**	Energy (%)	Demand (%)	**Total savings (%)**	Energy (%)	Demand (%)	**Total savings (%)**	Energy (%)	Demand (%)	**Total savings (%)**	Energy (%)	Demand (%)	**Total savings (%)**
Daytona	6.0	6.3	**6.1**	5.3	18.6	**10.1**	7.4	18.9	**11.7**	7.0	13.2	**9.9**	9.1	20.4	**16.0**
Jacksonville	6.2	4.7	**5.5**	4.8	20.5	**10.6**	7.2	20.4	**12.3**	7.2	14.4	**10.7**	11.9	24.3	**19.5**
Key West	9.2	7.4	**8.3**	15.1	23.4	**17.6**	15.3	21.8	**17.4**	13.2	16.0	**14.4**	14.9	26.4	**21.7**
Miami	7.9	7.0	**7.5**	10.6	22.0	**14.2**	12.2	20.8	**15.0**	10.9	14.0	**12.3**	14.0	22.2	**18.8**
Orlando	6.5	8.3	**7.4**	7.3	20.3	**11.9**	9.2	20.8	**13.4**	8.0	13.6	**10.6**	12.2	22.6	**18.5**
Tallahassee	5.2	4.2	**4.7**	4.1	16.7	**8.8**	6.6	17.8	**10.8**	6.0	10.6	**8.2**	7.8	22.9	**17.3**
Tampa	7.1	6.7	**6.9**	8.4	21.6	**13.1**	10.1	21.3	**14.2**	8.9	15.0	**11.8**	13.0	24.4	**19.9**
West Palm Beach	7.5	6.6	**7.1**	10.2	22.2	**14.2**	11.4	22.5	**15.2**	9.9	15.8	**12.5**	13.3	23.5	**19.4**

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Notes: Energy savings are measured in kilowatt-hours; demand savings are measured in kilowatts; and total savings are measured in dollars. Gas savings are excluded from this table.

Table 1: Percentage of annual HVAC energy cost savings from enthalpy wheels. Although savings will depend heavily on actual occupancy patterns, the relatively larger percentage of savings in auditoriums, restaurants, and retail stores highlights these types of facilities as good choices for ERV systems.