ZA 101.04.1 Introduction to Energy Recovery Ventilation (Part 1)

25 minutes

Estimated duration to complete this Learning Segment

Zehnder Academy Learning Path

This segment is part of the training for:

Zehnder America Certified Comfosystems **SPECIFIER**

Zehnder America Certified Comfosystems **INSTALLER**

Zehnder America Authorized Comfosystems **TECHNICIAN**

Zehnder America Authorized Comfosystems **DEALER**

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Knowledge Level:

Introductory

The equations presented at this level are only for demonstration (not for memorization).

Recommended prerequisites:

- ZA101.01 IAQ Basics
- ZA101.02 Basic Principles of Ventilation
- ZA101.03 Introduction to Ventilation Standards

LEARNING OBJECTIVE(S)

By the end of this course participants will be able to…

1. Recognize the “energy penalty” that comes with ventilation
2. Review the common technologies used for energy recovery
3. Distinguish between the recovery capabilities of an HRV and an ERV
4. Define recovery efficiency and identify the contributing factors

Learning Objective 1

Recognize the “energy penalty” that comes with ventilation

Ventilation and Comfort

In 101.02 - Basic Principles of Ventilation, we concluded that natural ventilation with windows isn't practical year-round in most climates. Too often, the outdoor air is either too hot, humid or cold for comfort.

Opening the windows for fresh air while continuing to run the heat or AC for comfort seems foolish.

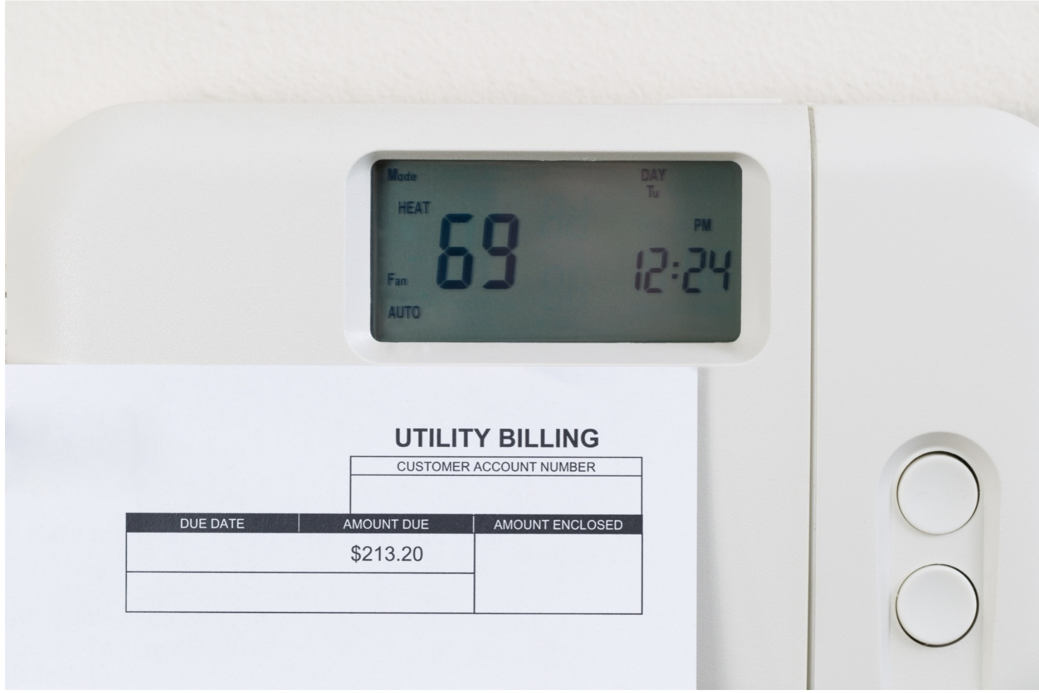
Unfortunately, in some cases mechanical ventilation is really no different...

Ventilation Energy Penalty

All ventilation, whether natural or mechanical, brings outdoor air into the house and will usually change the temperature and humidity of the house.

This requires additional heating or cooling energy, which can be estimated with a pretty simple calculation.

The result of this calculation is the "energy penalty" of ventilation.



Calculating Energy Penalty

The amount of heating or cooling energy (in BTUs per hour) required to condition the ventilation air can be roughly calculated with the following equation...

$$BTU/h = 1.08(Q_{cfm})(\Delta T_F)$$

(for introductory purposes only)

...where…

1.08 is an accepted multiplier related to air's ability to carry heat at a certain density.

Q_{cfm} is the ventilation rate in cfm.

ΔT_F is the temperature difference in degrees Fahrenheit between outdoor air temp and the indoor set point on the thermostat.

Cold Climate Example

100 cfm of outdoor air to meet ventilation requirements.

Outdoor = 22F and thermostat set to 72F (ΔT of 50F).

The equation would be…

$$\text{BTU/h} = 1.08(100)(50) = 5{,}400 \text{ (or 1.6 kW)}$$

This is enough to impact the size of the heating system required to condition this house.

And depending on the specific climate it could account for over 100 gallons of heating oil every year.

Hot Climate Example

100 cfm ventilation

Outdoor = 92F and thermostat set to 72F (ΔT of 20F)

BTU/h = 1.08(100)(20) = 2,160 (633 W)

The smaller ΔT results in a smaller energy penalty than the cold climate example.

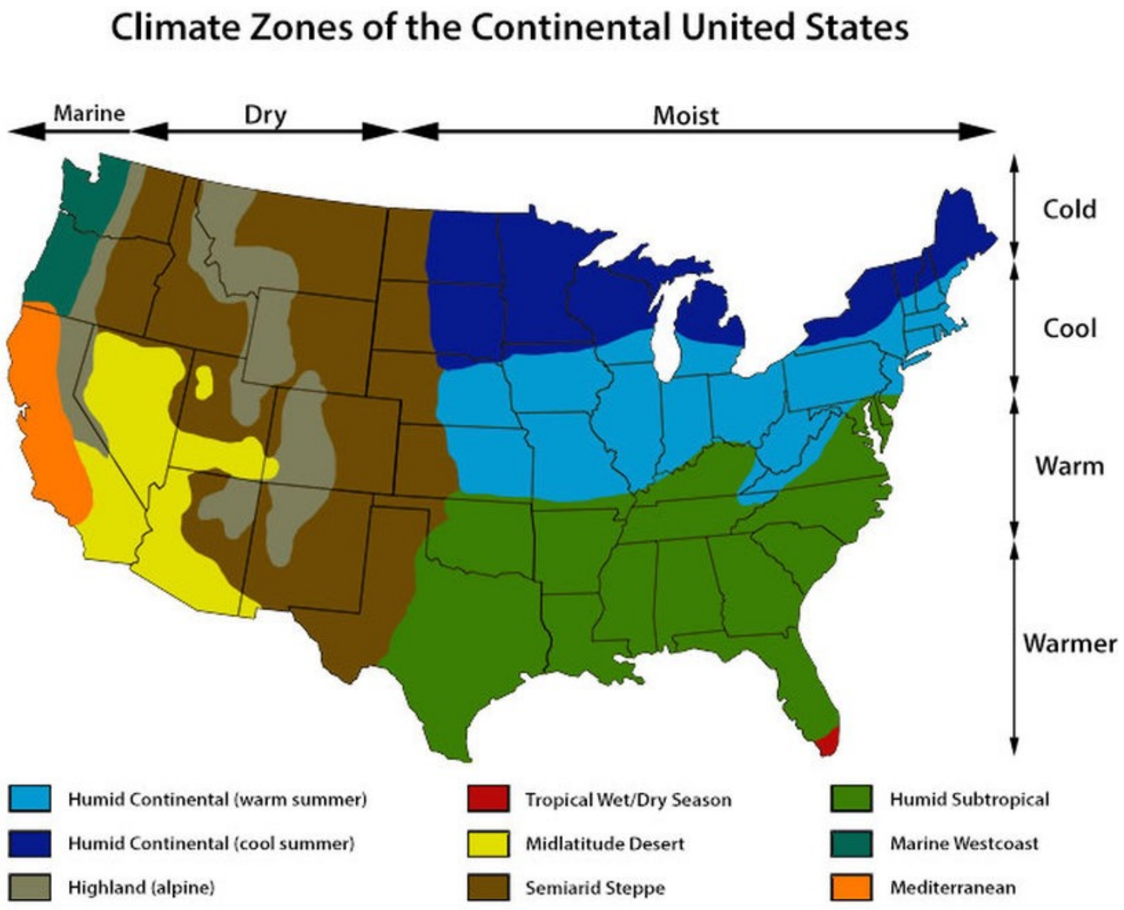
This may or may not change the size of the cooling system, but it could still account for hundreds of dollars in extra electricity to run the AC.

And we haven’t even discussed the humidity…

Ventilation and Humidity

Some climates have very humid outdoor air. In some cases100 cfm of ventilation could introduce almost 200 pints per day (PPD) of moisture.

A dehumidifier sized to remove that moisture would require about 1.5kW of electricity (hundreds of dollars per year).



Recovering the Energy Penalty

Ventilation for good indoor air quality can cost far more in energy than the electricity it takes only to run a fan.

What if there was a way to recover most of that lost energy while maintaining the healthy benefits of ventilation and the comfort of heating and cooling?

Energy Recovery Ventilation is the way!

Knowledge Check

Learning Objective 1

Recognize the “energy penalty” that comes with ventilation

What is the “ventilation energy penalty”?

A. The energy it takes to heat or cool the outdoor air used to ventilate the building.

B. A fine imposed by ASHRAE when you don’t follow the ventilation requirements.

C. The electricity it takes to run fans or blowers during very hot weather.

D. The energy it takes to complete online training in ventilation.

Knowledge Check

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Learning Objective 2

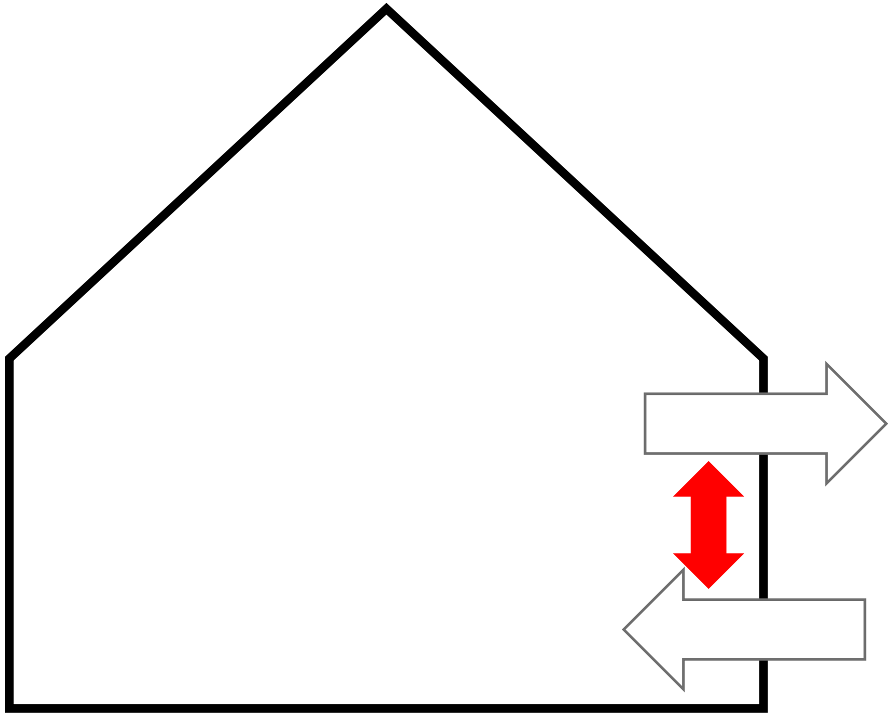
Review the common technologies used for energy recovery

Energy Recovery Ventilation

An energy recovery ventilation system is a balanced ventilation system that includes both supply and exhaust fans.

The system efficiently transfers energy between the supply and exhaust air streams.

This helps reduce the “energy penalty” of additional heating and/or cooling.

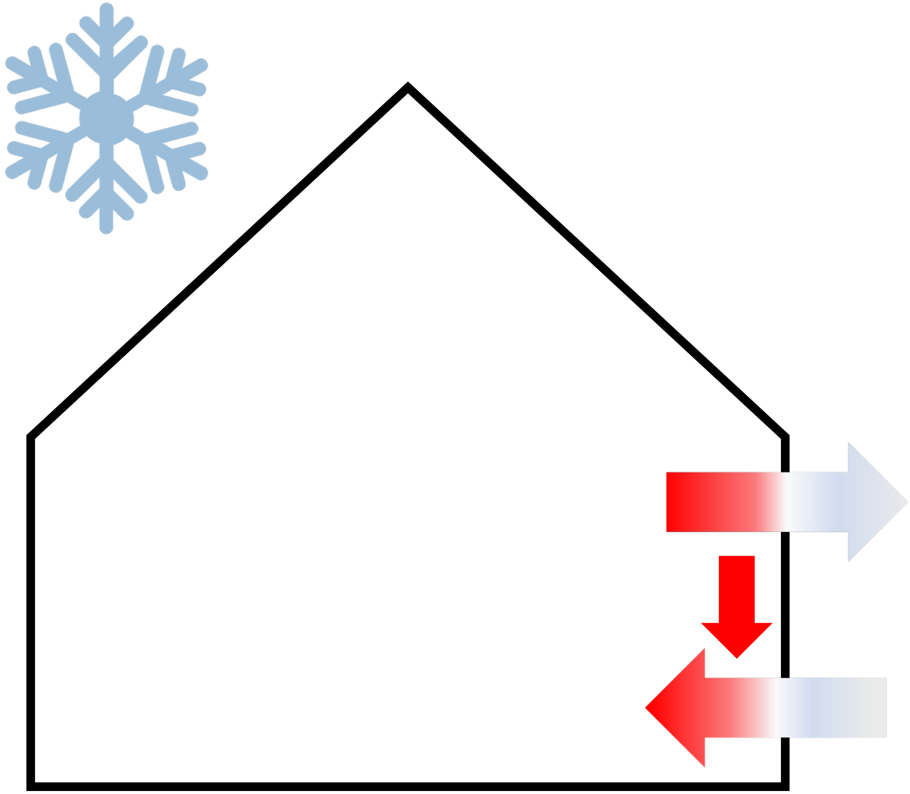


Energy Recovery Ventilation in Winter

In cold weather, energy is recovered from the exhaust air before it's expelled outdoors.

The recovered energy is transferred to the supply air before it is distributed to the indoor living spaces.

This helps keep the heat inside.

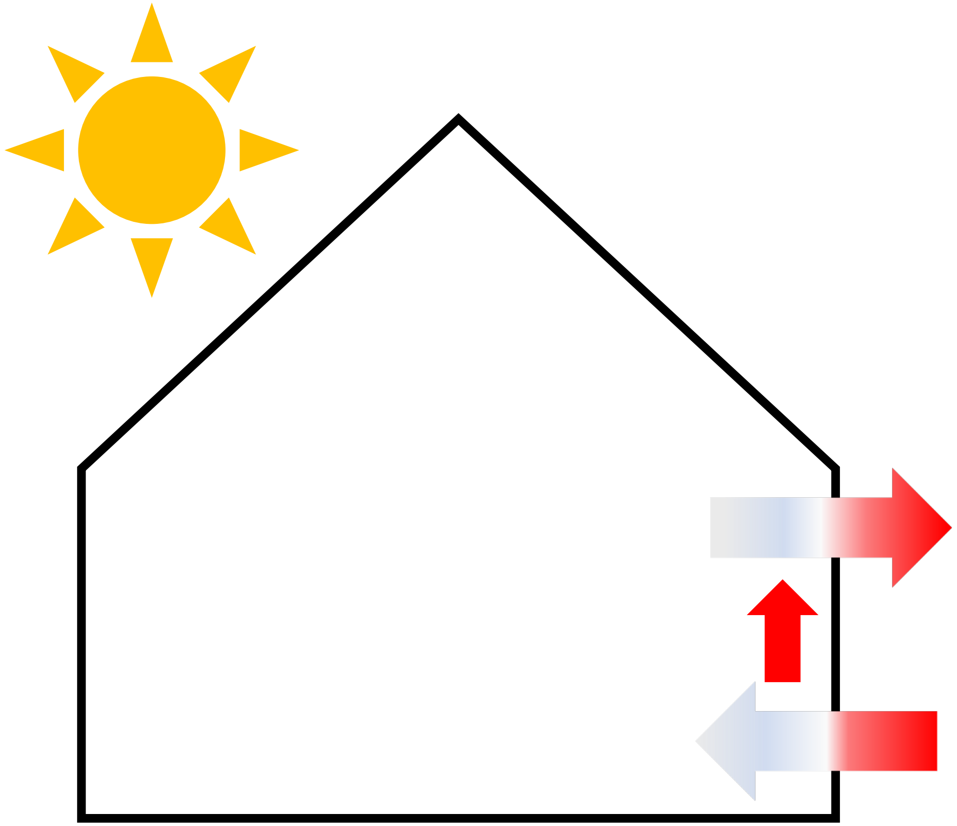


Energy Recovery Ventilation in Summer

In hot weather, energy is recovered from the supply air before it's distributed to the indoor living spaces.

The recovered energy is transferred to the exhaust air so it can be expelled outdoors rather than added to the house.

This helps keep the heat outside.



Energy Recovery Technologies

There are different types of energy recovery technologies, but they are all designed to accomplish the same basic goal...transfer energy from one ventilation air stream to another.

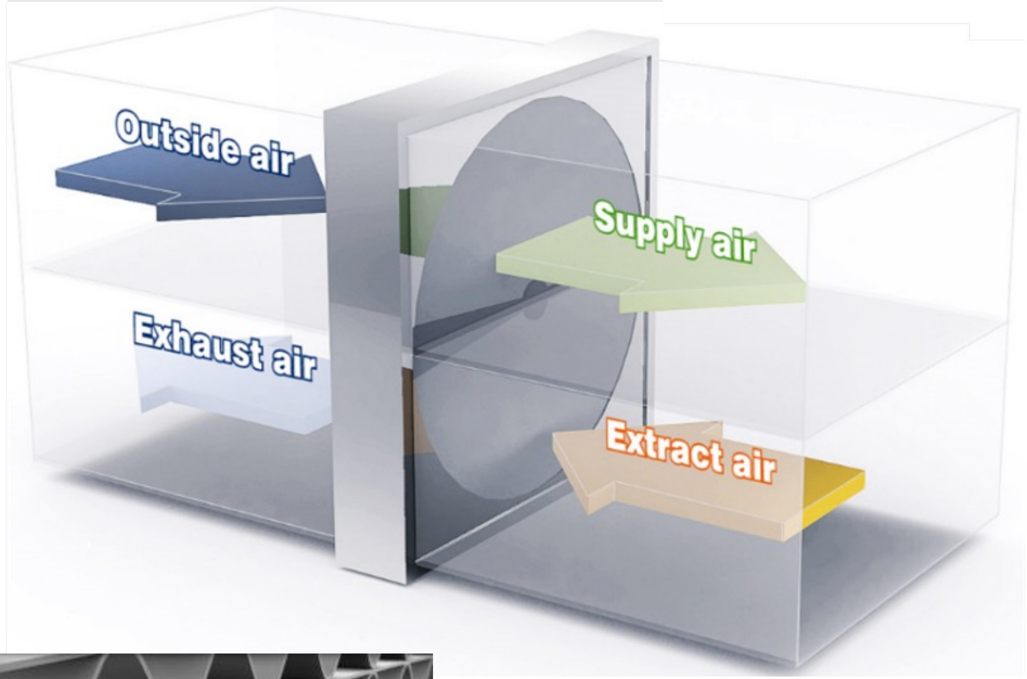
We shall briefly review these four types…

1. Rotary heat exchanger
2. Refrigerant-based heat pump
3. Hydronic run-around loop
4. Fixed-plate heat exchanger

Rotary Heat Exchanger

In North America, rotary heat exchangers are more common in large commercial applications; however, they do exist in smaller residential-sized systems.

The main component in a rotary heat exchanger is an air-permeable wheel, usually made of some corrugated media, whether metal or plastic, which is sometimes coated.



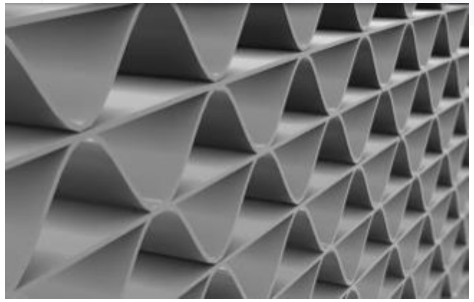
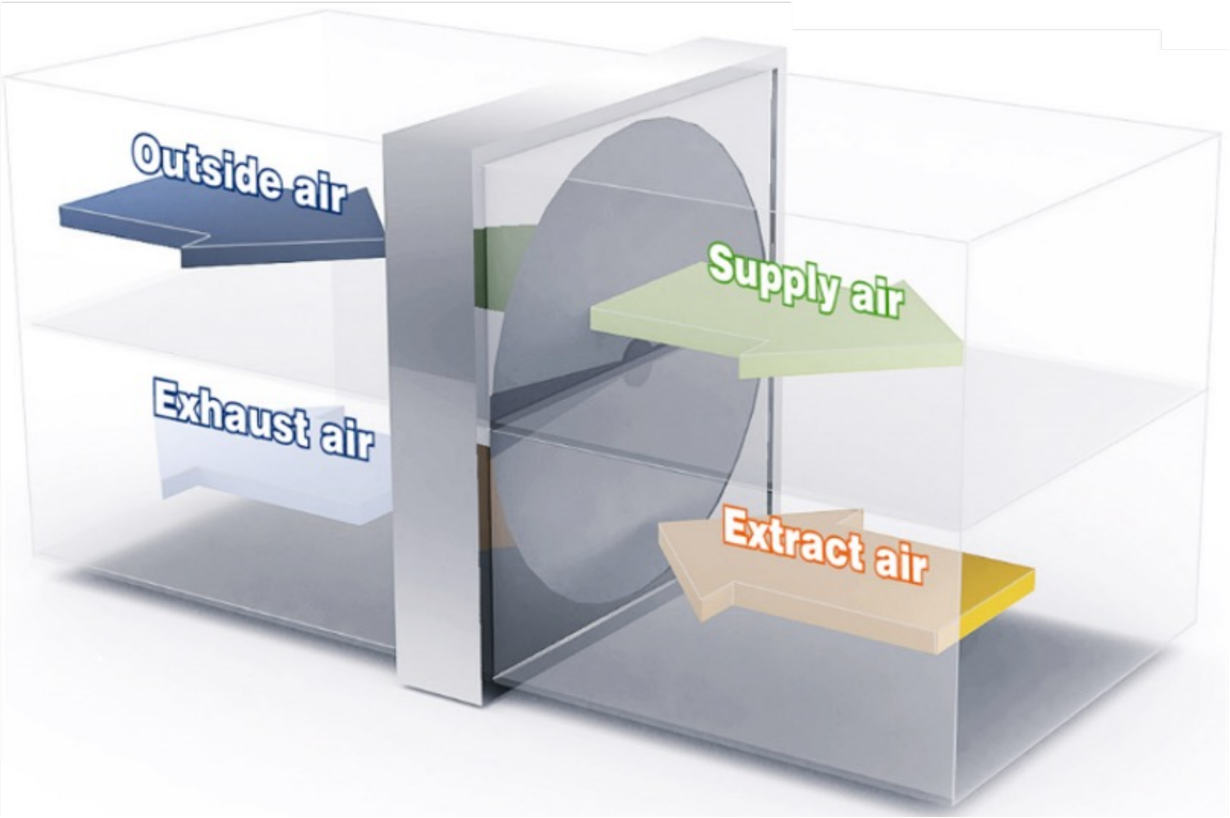


Photo Credit:
ÖSTBERG GROUP AB

Rotary Heat Exchanger

The wheel is positioned so that half of it is in the supply air plenum and half is in the exhaust air plenum.

As the wheel rotates, each segment of the wheel will pass alternately through the supply plenum and the exhaust plenum.



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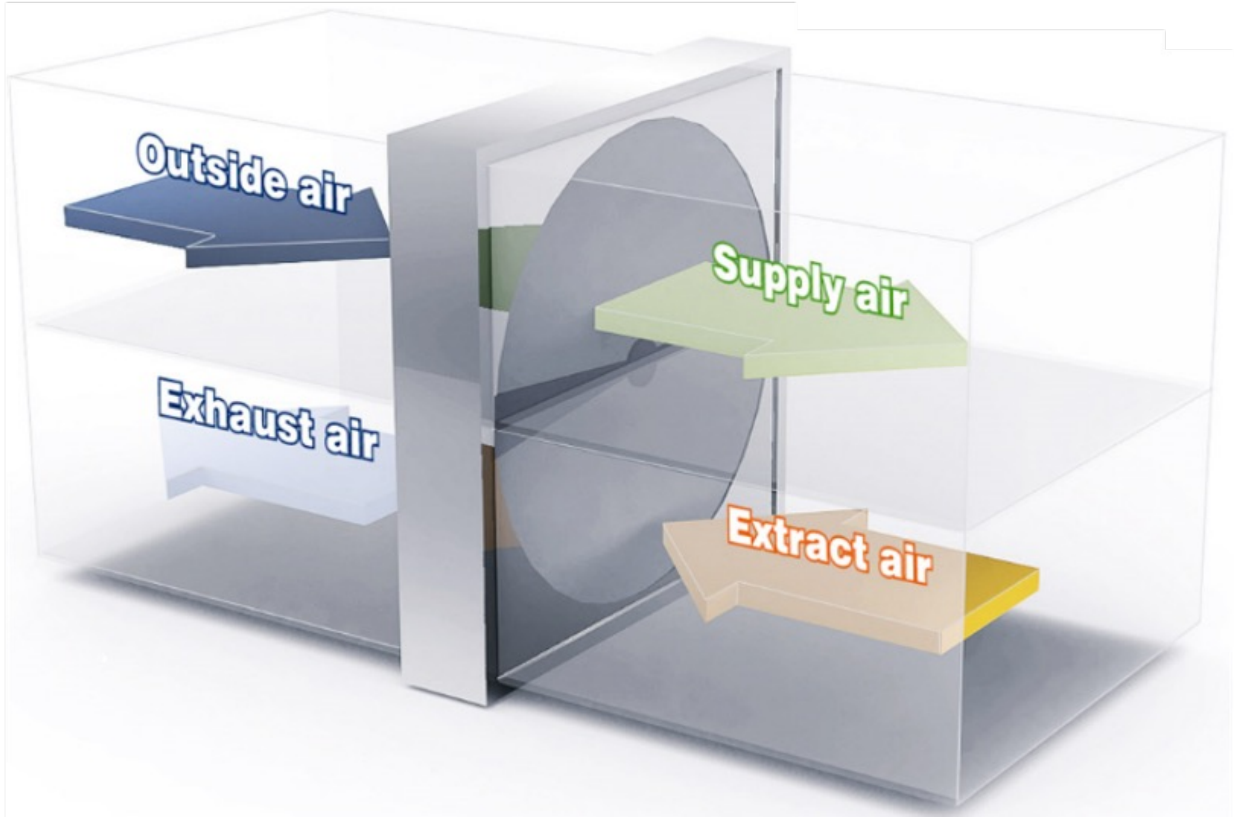
Rotary Heat Exchanger

The warmer air stream (depending on the season) will give up a portion of its energy to the wheel as it flows through the media

As the wheel rotates, the warmed media will rotate to the other plenum where the cooler air will pass through it and be warmed, recovering energy.



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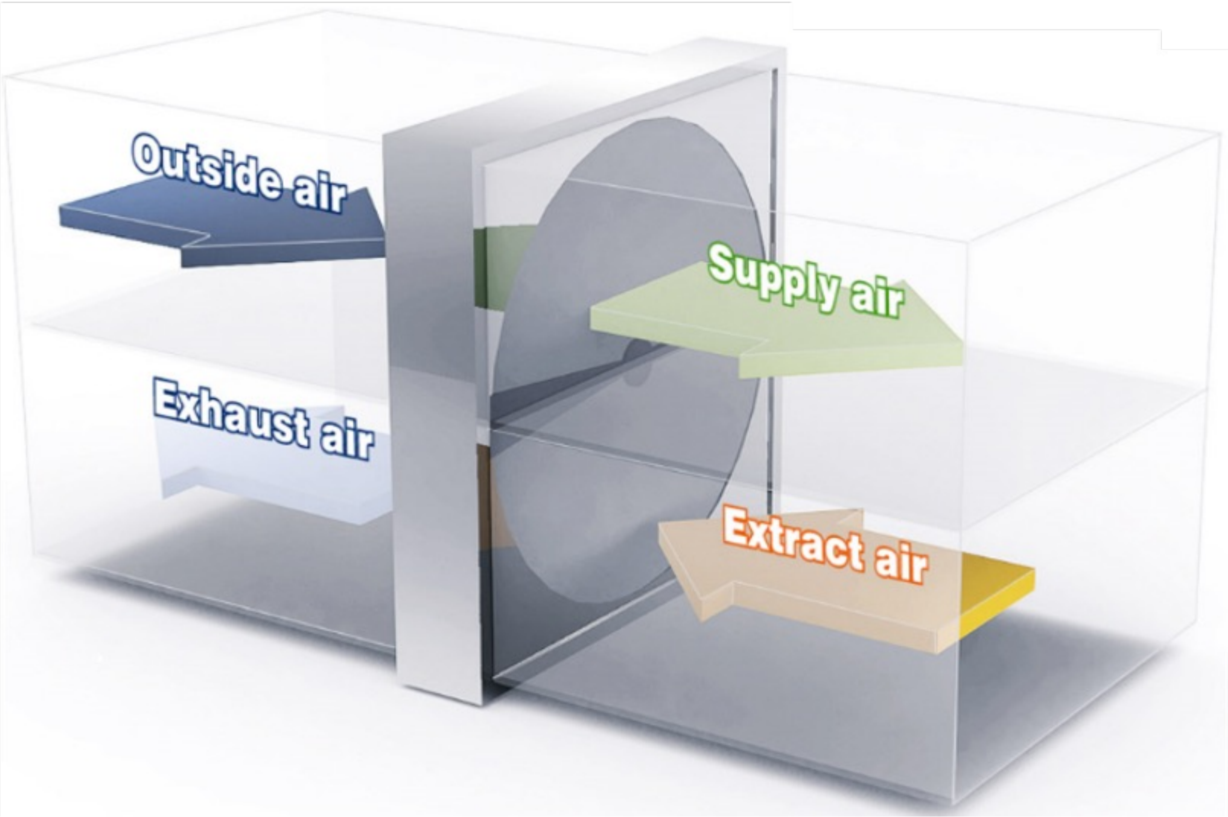
Rotary Heat Exchanger

Rotary heat exchangers are a widely used and proven technology.

Their limited use in single-family homes may be due to their performance advantages at larger scales and perceptions about moving parts and cross contamination.



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Knowledge Check

Rotary heat exchangers are named for…

A. ...the way they swirl the supply and exhaust air together.

B. ...the fact that they need to be removed and installed backwards seasonally.

C. ...the way the air is rolled into the house on wheels.

D. ...the wheel that transfers heat from one air stream to another.

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Heat Pump Use

Heat pumps essentially collect heat from one location and release it in another. This technology has been used in homes for more than 100 years.

A refrigerator is a heat pump, collecting heat from inside the box and releasing it outside.

An AC is a heat pump, collecting heat from inside the home and releasing it outside.

Heat pumps can also be used to heat homes, collecting heat from outside the home and releasing it inside.

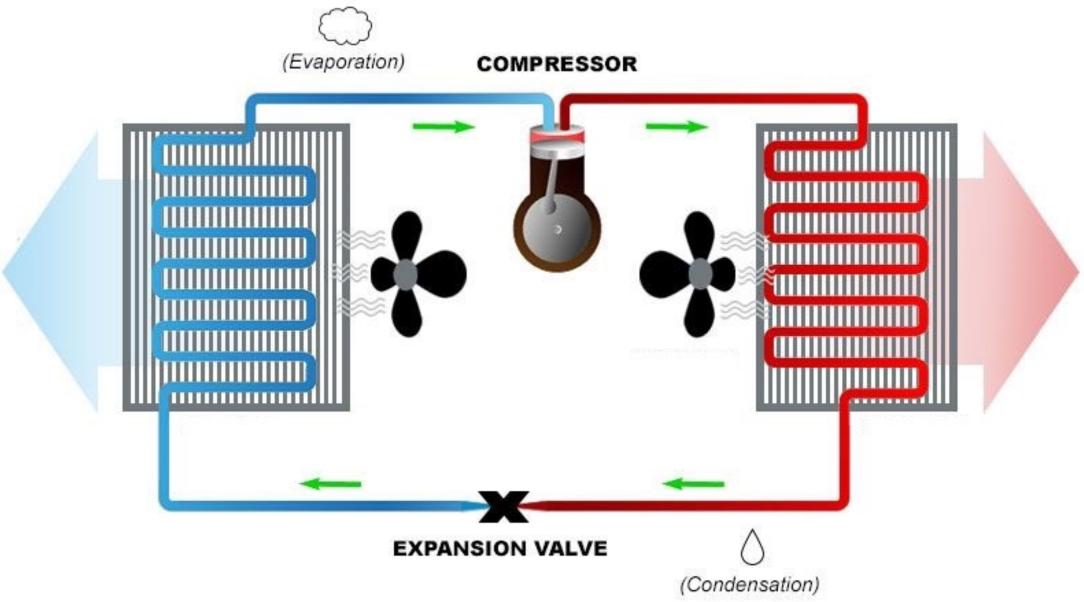


Photo Credit: Carrier

Heat Pumps and Ventilation

In the case of a heat pump recovery ventilator, the heat is collected from either the supply or exhaust airstream and then released to the opposite airstream. The cycle can be reversed to match the seasons.

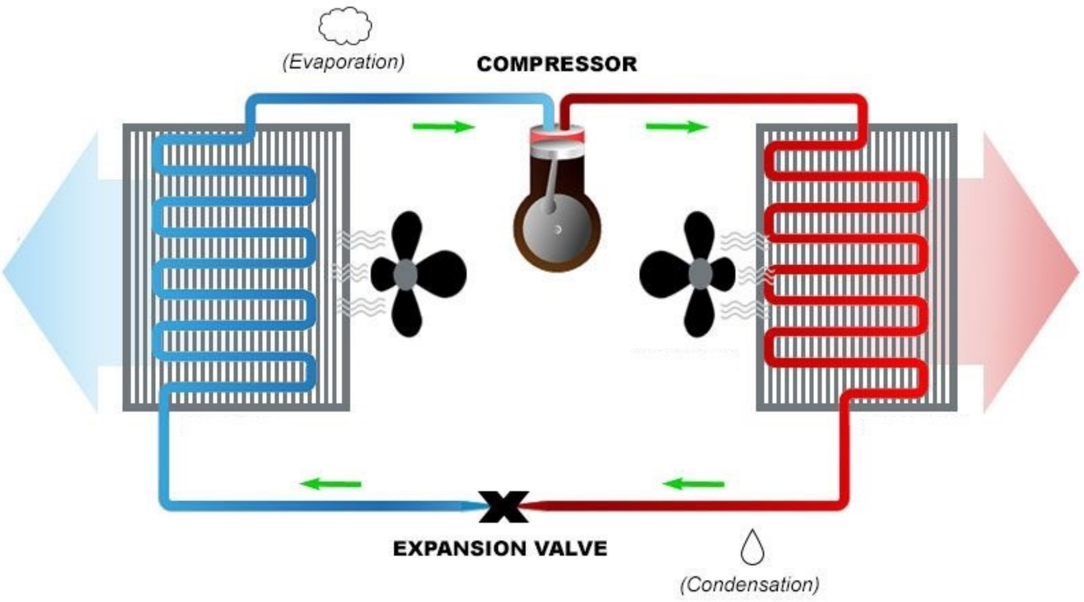


Photo Credit: Carrier

Refrigerant-based Heat Pump

Heat pump technology is based on a closed-loop refrigeration cycle that relies on the latent energy of evaporation and condensation to collect and then release heat.

Liquids absorb heat when they change state from liquid to gas. Gases give off heat when they change state from gas to liquid.

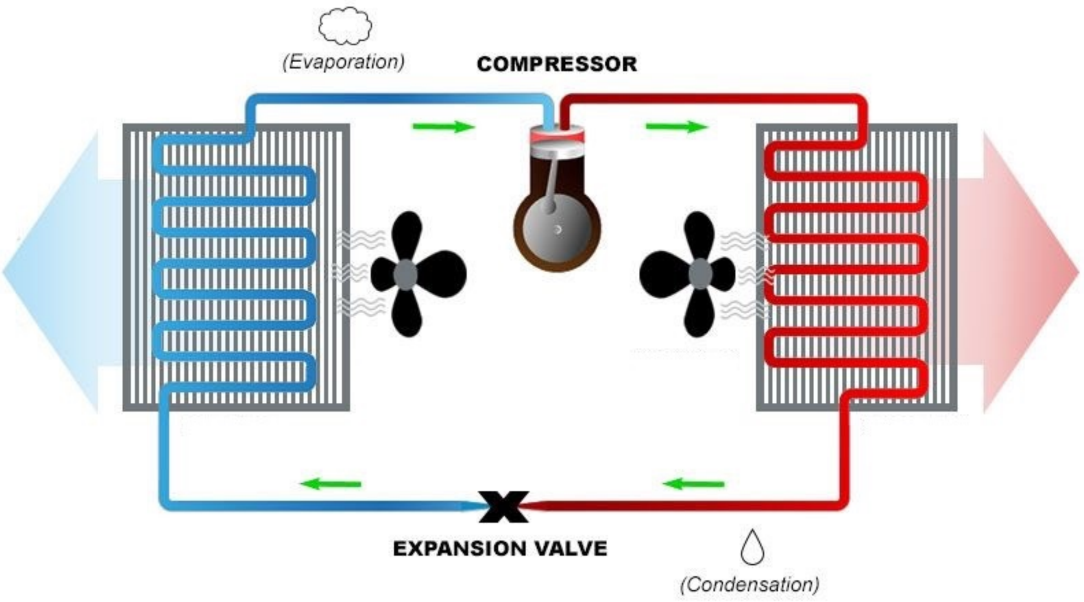


Photo Credit: Carrier

Refrigeration Cycle

1. The refrigerant is pressurized as a gas by the compressor
2. The refrigerant then passes through the condenser coil, where it condenses into a liquid and gives off its heat to the air stream being blown across the coil
3. Next the refrigerant flows through the expansion valve, where it is restricted and drops to low pressure

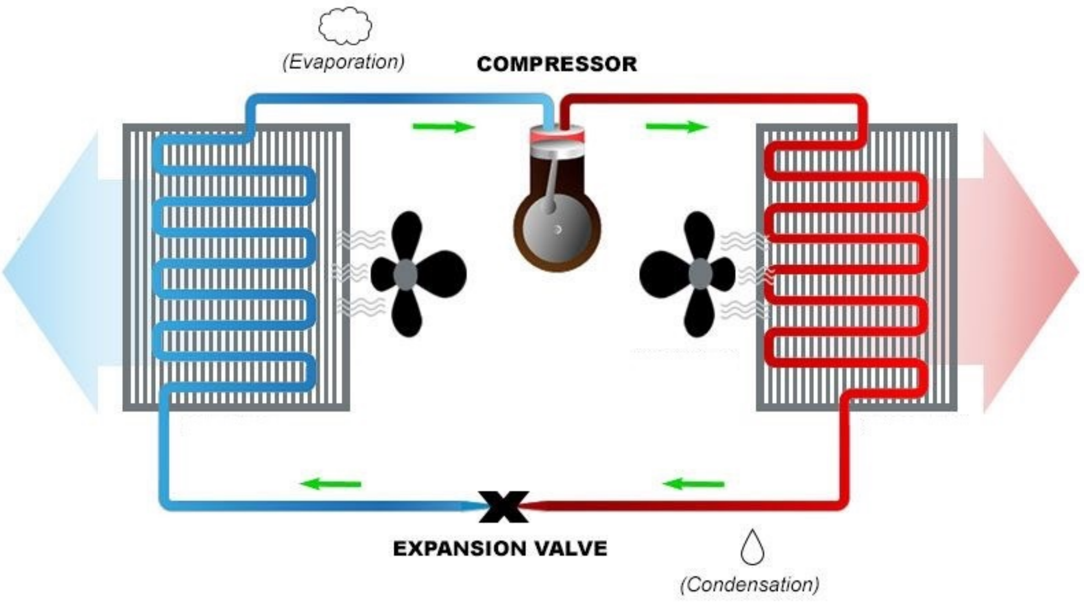


Photo Credit: Carrier

Refrigeration Cycle

4. The refrigerant then passes through the evaporator coil, where it absorbs heat from the air stream being blown across the coil. This changes the refrigerant back into a low-pressure gas
5. The refrigerant returns to the compressor and the cycle is repeated

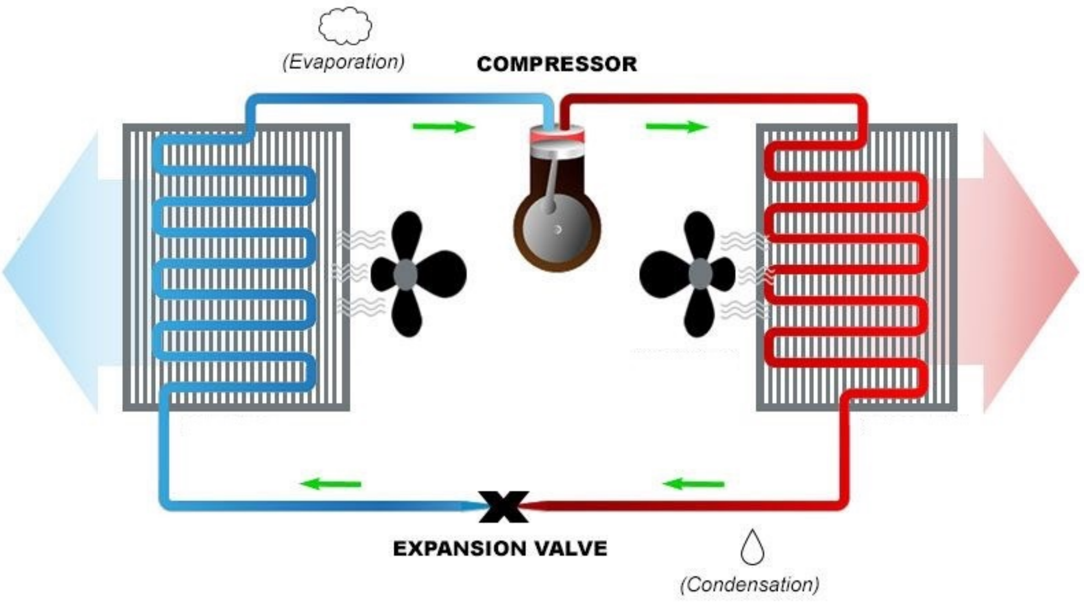


Photo Credit: Carrier

Heat Pumps and Ventilation

Although heat pumps can move more watts in heat than they consume in electricity (commonly 3:1), they still consume more electricity than a passive energy recovery device, include more moving parts, are noisier, and require refrigerants that can leak and be detrimental to the environment.

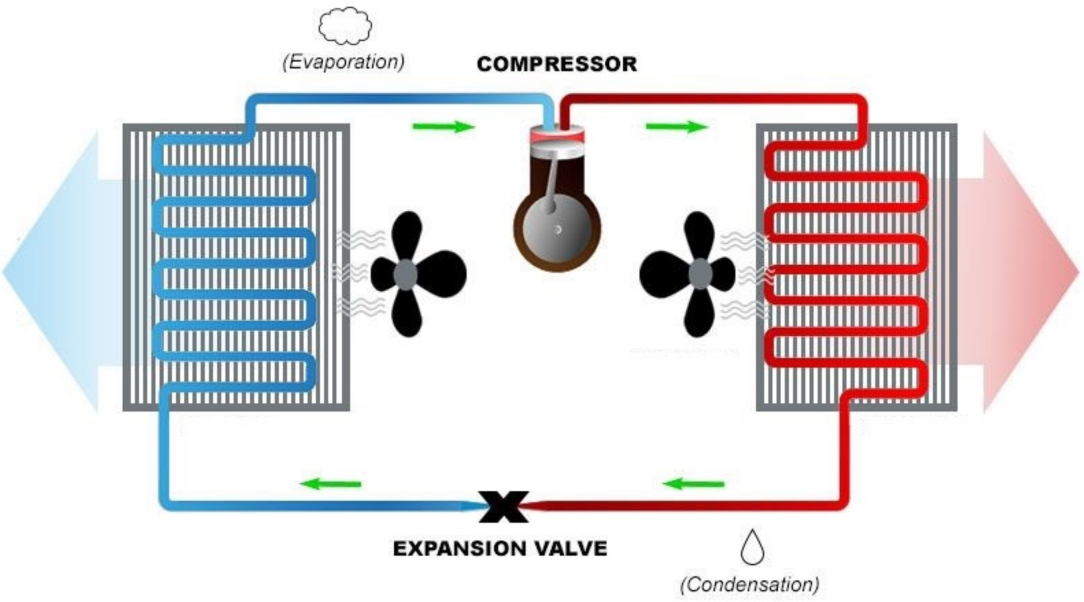


Photo Credit: Carrier

Knowledge Check

How is a heat pump used to transfer heat between supply and exhaust air streams?

A. The compressor pump motor heats up while it runs and tempers the cold air.

B. A refrigeration cycle with evaporation and condensation transfers heat between the supply and exhaust air streams.

C. Heat is collected from the refrigerator and pumped into the exhaust air.

D. Heat is collected from the refrigerator and pumped into the supply air.

Knowledge Check

How is a heat pump used to transfer heat between supply and exhaust air streams?

A. The compressor pump motor heats up while it runs and tempers the cold air.

B. A refrigeration cycle with evaporation and condensation transfers heat between the supply and exhaust air streams.

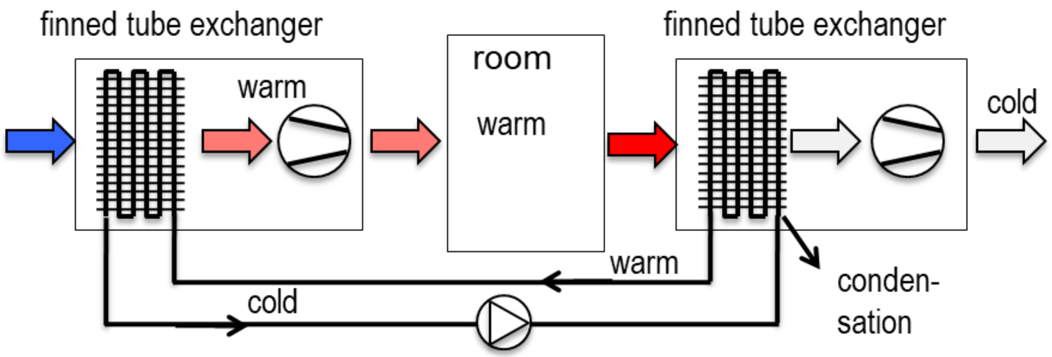
C. Heat is collected from the refrigerator and pumped into the exhaust air.

D. Heat is collected from the refrigerator and pumped into the supply air.

Hydronic Run-Around Loop

A hydronic (or glycol-filled) run-around loop is sort of a simplified version of a heat pump.

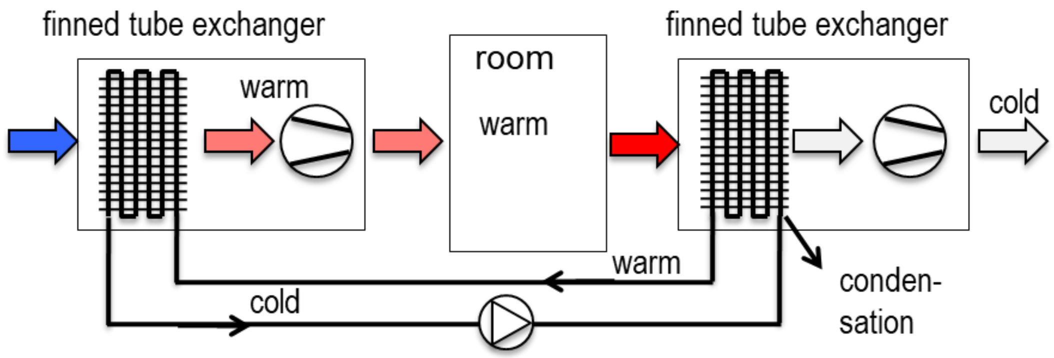
Rather than using refrigerant under pressure, water with antifreeze is simply pumped around in a loop like it would be in a heating system.



Hydronic Run-Around Loop

The supply and exhaust airstreams each run across their own hydronic heat exchanger coil, moving heat between the air and the liquid loop.

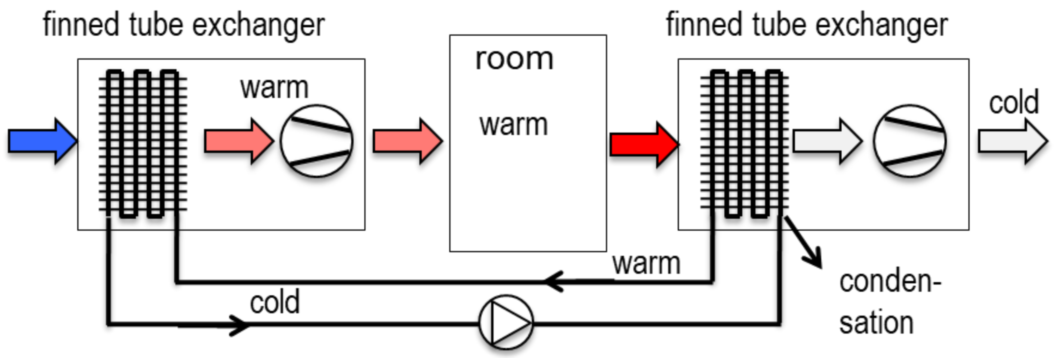
Heat from the warmer air stream enters the loop through one coil, travels around to the other coil and warms the other airstream as it passes.



Hydronic Run-Around Loop

Although a hydronic run-around loop is a simple, relatively low-cost way to recover energy, it's not as effective at capturing energy as some other technologies.

Also, because it requires the addition of a pump and plumbing to the air handling system, there are additional maintenance concerns in the long run.



Knowledge Check

Which of the following is true?

A. A hydronic run-around loop is similar in some ways to a heat pump.

B. A hydronic run-around loop has no moving parts.

C. A hydronic run-around loop is the most effective energy recovery ventilation system.

D. A hydronic run-around loop can never give you a straight answer.

Knowledge Check

Which of the following is true?

A. A hydronic run-around loop is similar in some ways to a heat pump.

B. A hydronic run-around loop has no moving parts.

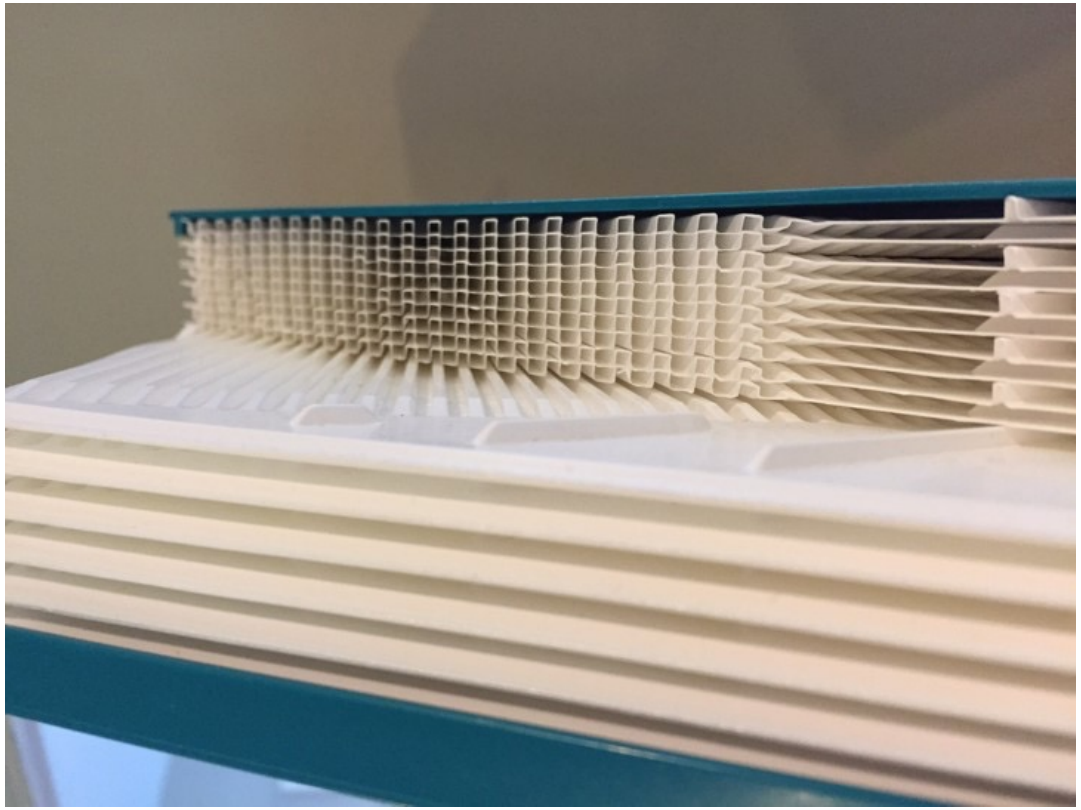
C. A hydronic run-around loop is the most effective energy recovery ventilation system.

D. A hydronic run-around loop can never give you a straight answer.

Fixed-Plate Heat Exchanger

A fixed plate heat exchanger uses no moving parts to transfer energy between the supply and exhaust air stream.

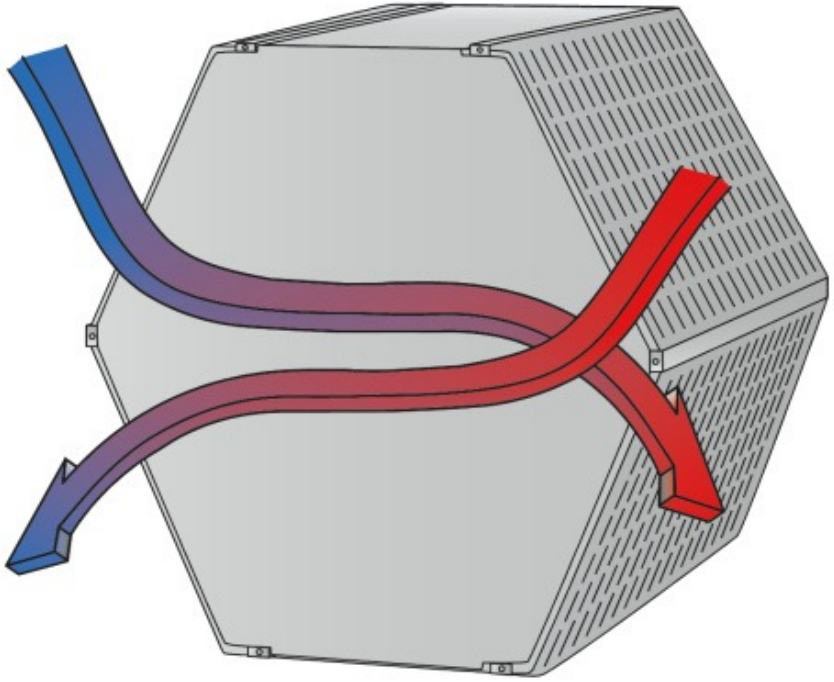
Very thin plates (either plastic or metal) are stacked together into a wafer-like heat exchanger. Ridges in the plates form channel-like openings that are oriented so that both supply and exhaust air can be directed into different sides of the heat exchanger without ever mixing.



Fixed-Plate Heat Exchanger

As air passes through the heat exchanger, the energy in the warmer air stream moves across the thin plates and is picked up by the cooler air stream.

Depending on the size and shape of the heat exchanger and the speed of the air moving through, very high energy recovery can be achieved.



Fixed-Plate Energy Recovery Ventilators

Due to the simplicity of a fixed-plate heat exchanger it can be combined into a cabinet that includes the supply and exhaust fans, filters and controls to create a relatively compact appliance.

Fixed-Plate Energy Recovery Ventilators

Energy Recovery Ventilators have only two separate air streams flowing through them (outdoor air entering the building and indoor air leaving the building).

However, both air streams have two duct connections; an entrance to and exit from the ERV. So, there are a total of four duct connections…

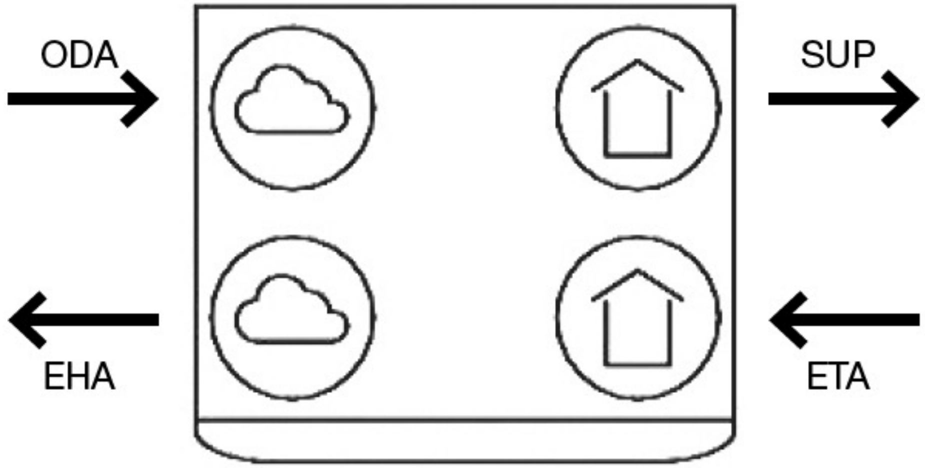
ERV Duct Connections

Outdoor Air (ODA)
Carries unconditioned fresh air from outside to the heat exchanger

Supply Air (SUP)
Carries tempered fresh air from the heat exchanger to the rooms

Extract Air (ETA)
Carries conditioned stale air from the rooms to the heat exchanger

Exhaust Air (EHA)
Carries stale air from the heat exchanger to the outside



Fixed-Plate Energy Recovery Ventilators

Fixed-plate heat exchangers are the most common type used in residential ventilation systems, and they are the only type currently offered by Zehnder America.

So, from this point forward, we will only be discussing fixed-plate type heat exchangers.

Knowledge Check

A fixed-plate heat exchanger…

A. ...has no moving parts.

B. ...is manufactured from previously broken plates.

C. ...can achieve very high heat recovery effectiveness.

D. Both A and C above.

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A fixed-plate heat exchanger…

A. ...has no moving parts.
B. ...is manufactured from previously broken plates.
C. ...can achieve very high heat recovery effectiveness.
D. Both A and C above.

ZA 101.04.1 Introduction to Energy Recovery Ventilation (Part 1)

Thank you for completing Part 1 of this Learning Segment.

When you're ready, please continue to Part 2.