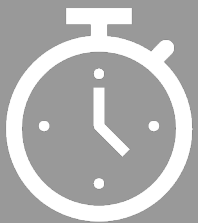


ZA 101.04.2 Introduction to Energy Recovery Ventilation (Part 2)



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

Zehnder America Authorized
Comfosystems 
DISTRIBUTOR

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
- ZA101.04.1 Introduction to Energy Recovery Ventilation (Part 1)

**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 3

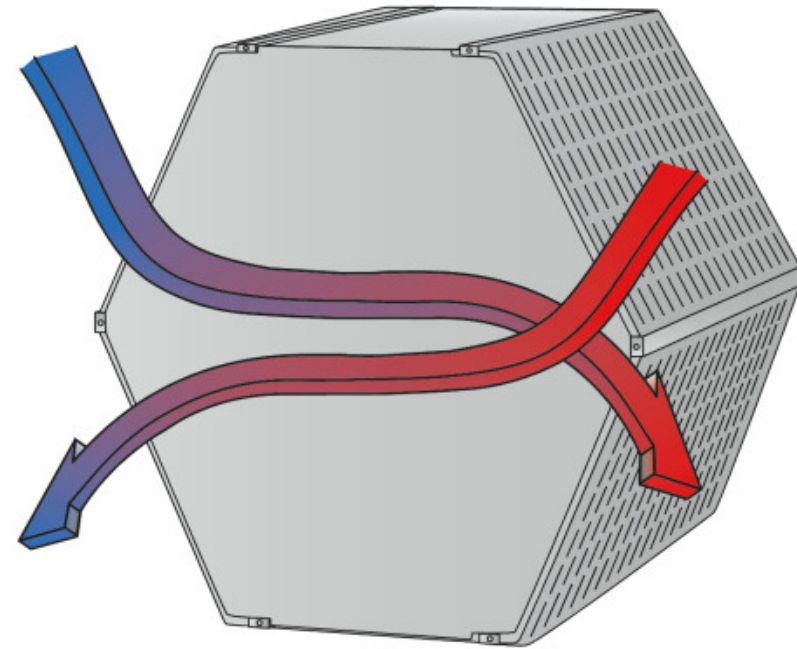
Distinguish between the recovery capabilities of an HRV and an ERV

HRV and ERV

Until now, we have used the term “energy recovery” in a generic way. Before going further, we should make some distinctions...

- “Energy recovery”
- “Heat recovery”

These terms are used commercially to describe systems with a similar function, but they have important differences.



HRV and ERV

HRV = Heat Recovery Ventilator

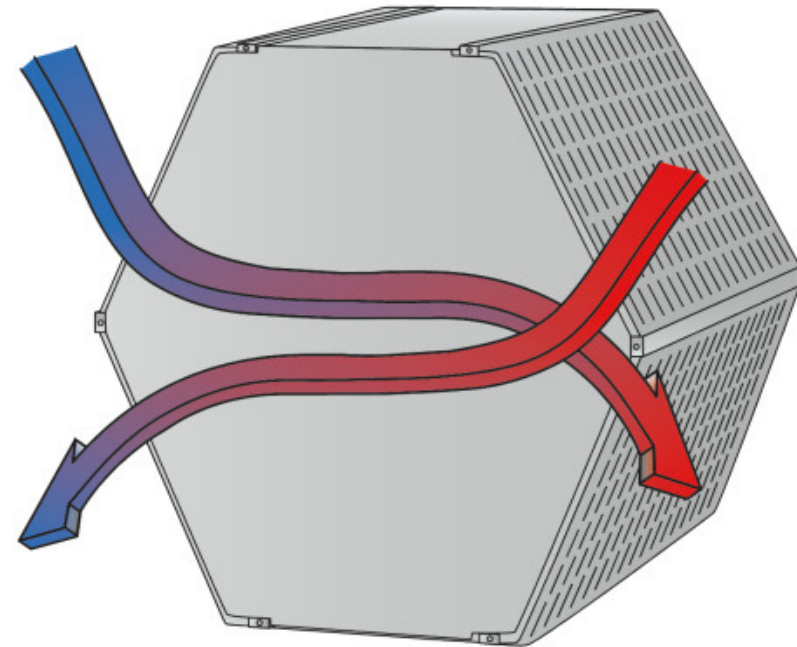
ERV = Energy Recovery Ventilator

Very slight differences that affect their ability to transfer certain qualities of the energy in the air.

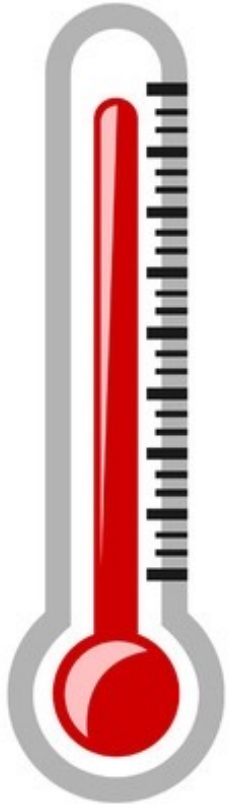
Put in common terms...

- An HRV transfers “heat”.
- An ERV transfers both “heat and humidity”.

Let us take a closer look at “heat” ...



What is Heat?



Heat seems like a simple concept... It is what makes the line rise in the thermometer, right?

Yes, but that is only one aspect of heat, “sensible heat”.

HVAC engineers refer to two different categories of heat...

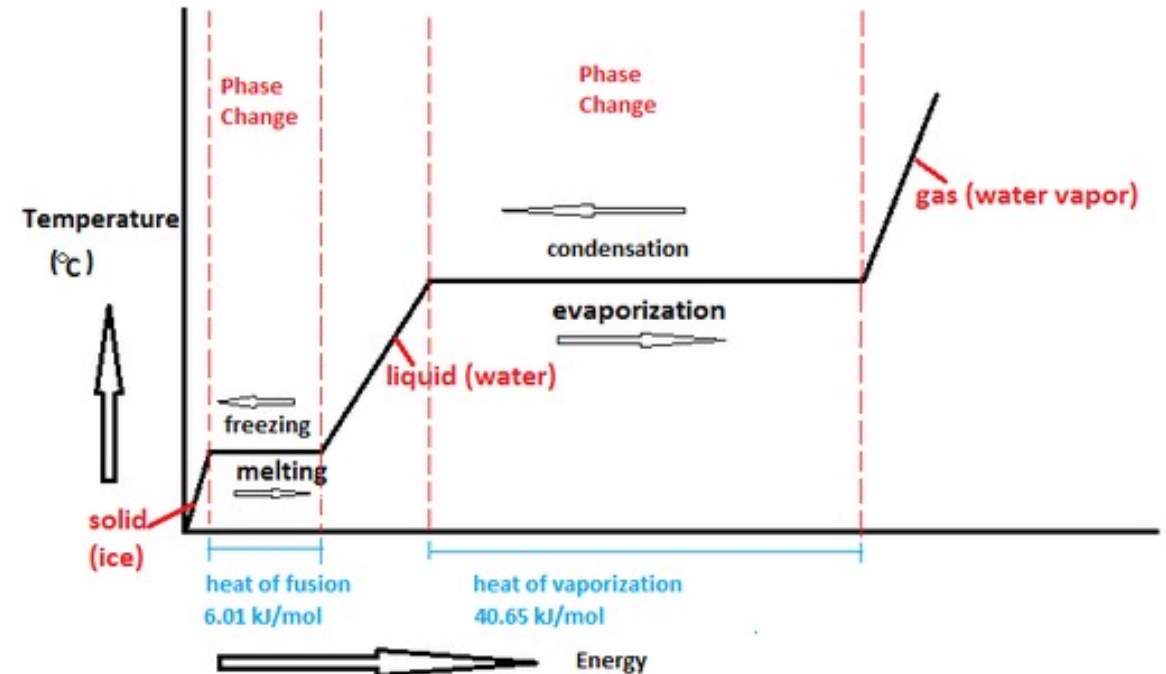
- “sensible heat” (seen on the thermometer)
- “latent heat” (carried in humidity)

Understanding Latent Heat

In the HVAC world, “latent heat” is related to humidity.

Latent heat is the energy required to change water from one state to another.

In HVAC comfort systems this is the phase change back and forth between liquid and gas (either condensation or evaporation).

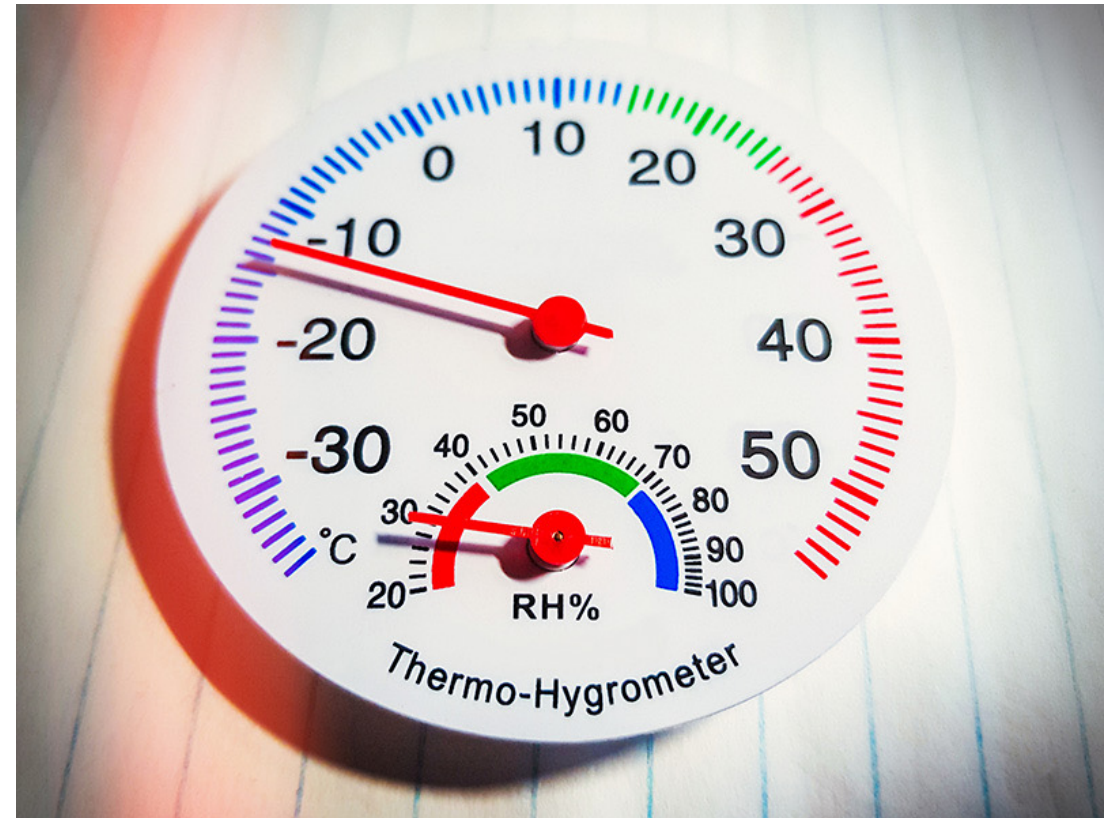


Cawang, CC BY-SA 3.0 <<https://creativecommons.org/licenses/by-sa/3.0/>>, via Wikimedia Commons

Sensible and Latent Heat

The average non-technical person knows “sensible heat” as what’s registered as temperature on the thermometer.

They know “latent heat” as some measure of humidity - commonly expressed in terms of “relative humidity” (RH).



HRV and ERV

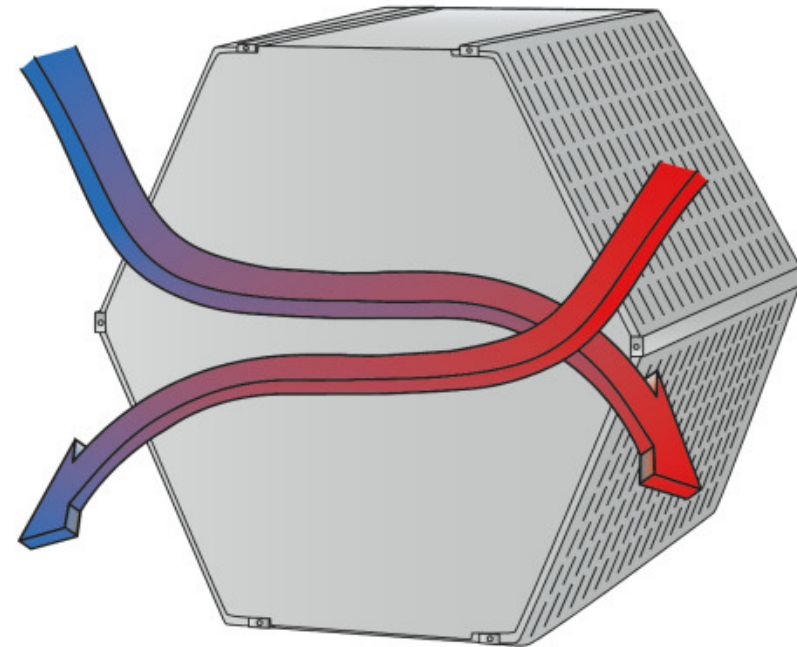
HRV = Heat Recovery Ventilator

Recovers “sensible” heat
(temperature)

ERV = Energy Recovery Ventilator

Recovers “sensible” and “latent” heat
(temperature and humidity)

These terms will become important
later.

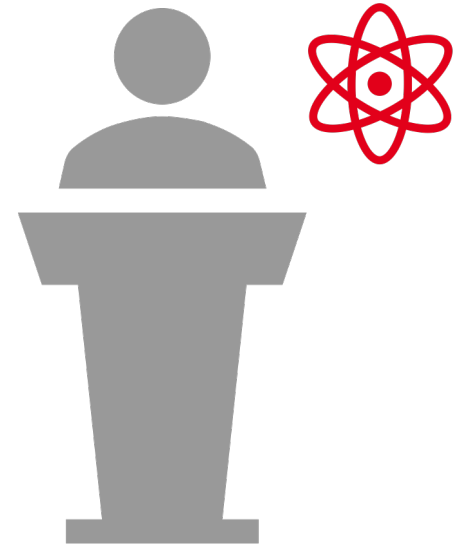


Enthalpy?

An ERV may sometimes be called an “Enthalpy Recovery Ventilator”. Or it may be said to have an “enthalpy exchanger” rather than a heat exchanger.

Nerdy physicists use the word enthalpy technically to describe the “internal energy of a system plus the product of pressure and volume.”

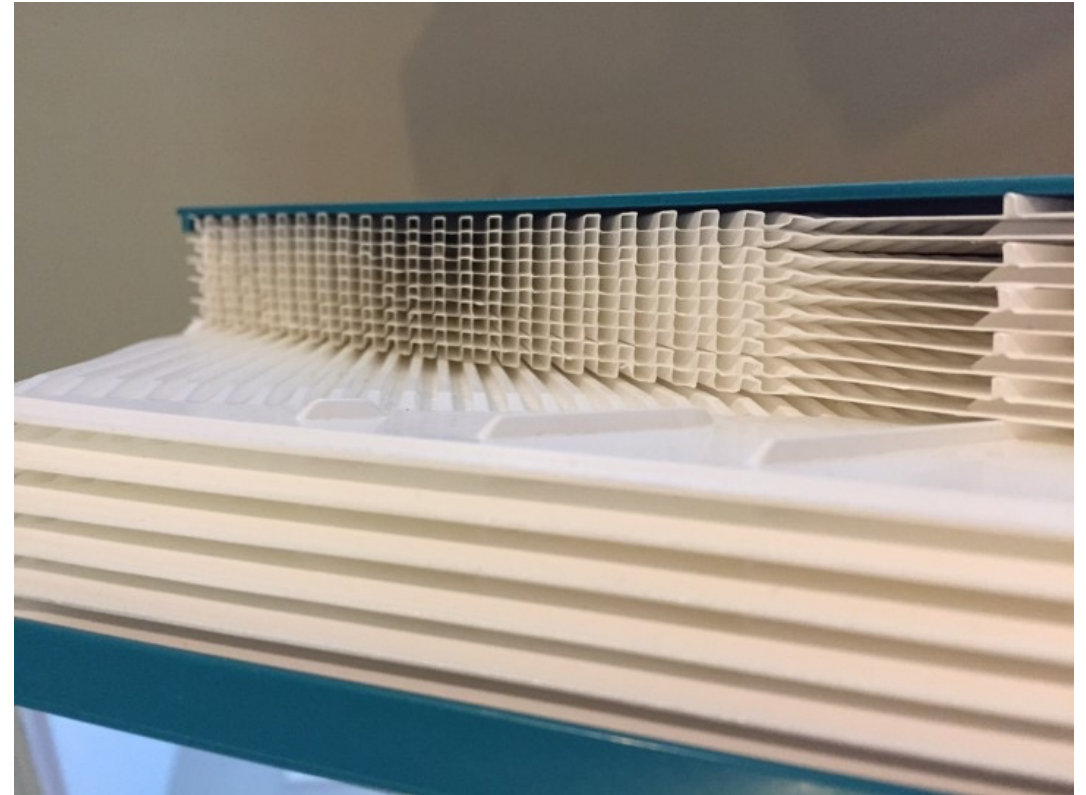
But HVAC people commonly use the word enthalpy to refer to heat and humidity or to the total energy of sensible heat and latent heat.



HRV Features and Capabilities

The fixed plates in an HRV exchanger are very thin, but they're solid and impermeable to water vapor.

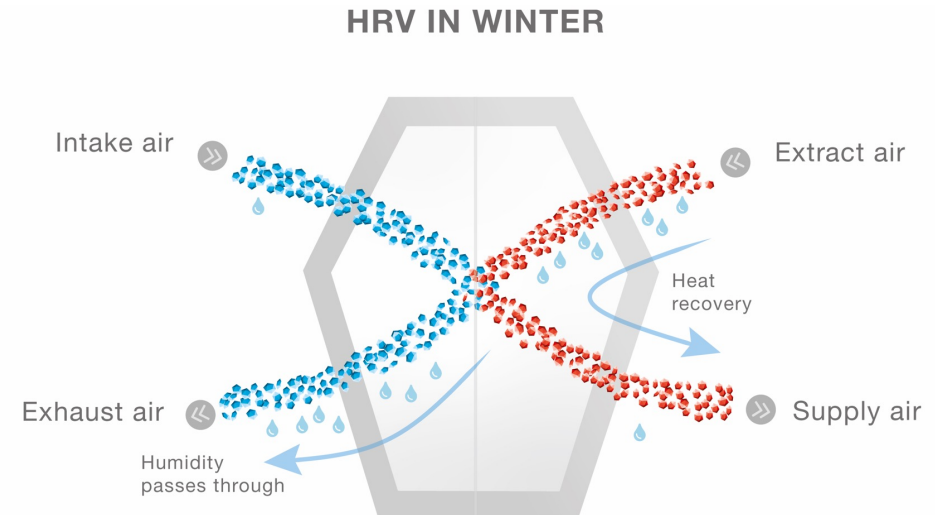
Sensible heat (warmth) can move by conduction across the plate from the warmer side to the cooler side, but any water vapor (humidity) will not transfer across the plate.



HRV in Winter

In general, winter air is not only cold, but relatively dry.

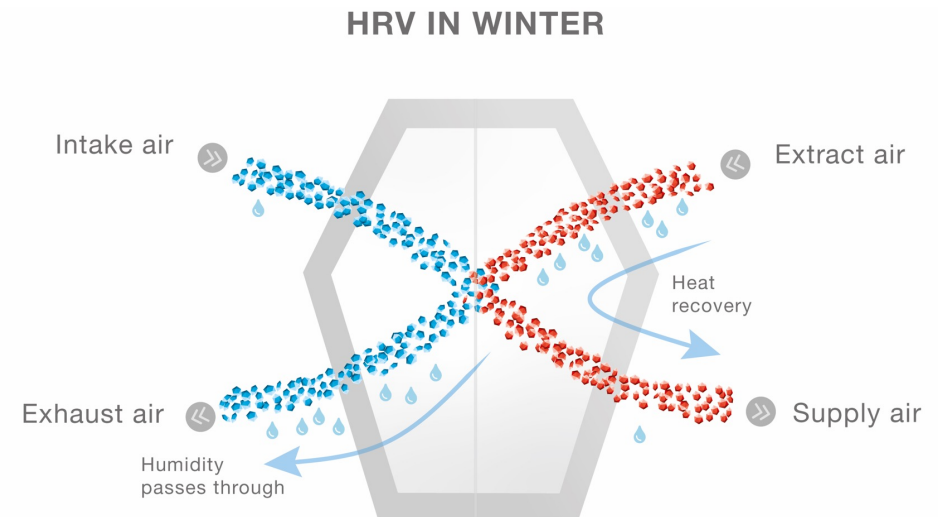
Meanwhile the indoor air has been heated and usually has higher humidity in comparison to the outdoor air (because people give off moisture when we breathe, as do activities like cooking and washing).



HRV in Winter

As the Extract air moves through the heat exchanger core, much of its sensible heat (warmth) is transferred across the plates to the cold incoming Supply air.

There isn't any mechanism that does this. It's just a thermodynamic reality. Heat naturally moves to cold, in this case by conduction through the plate material.

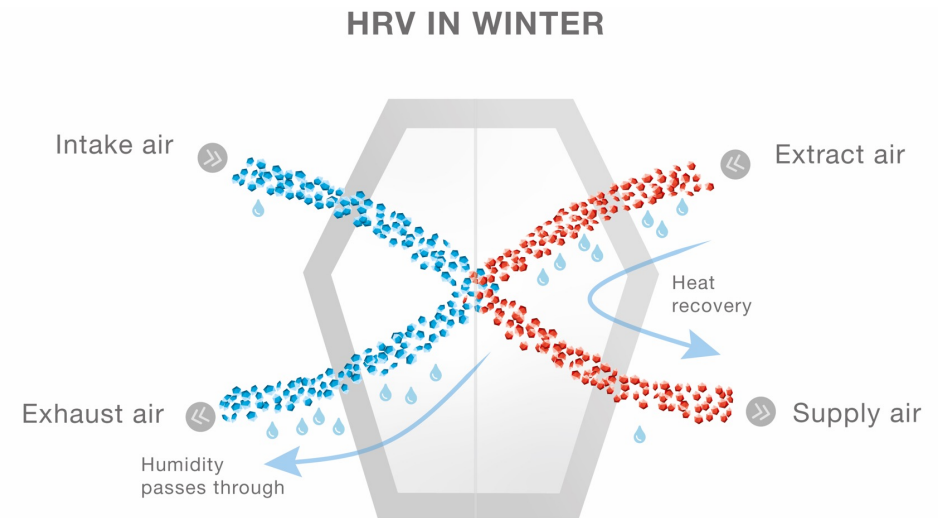


HRV in Winter

Notice that the moisture in the air is not recovered in the exchanger.

The moisture in the Extract air is expelled with the pollutants in the Exhaust air.

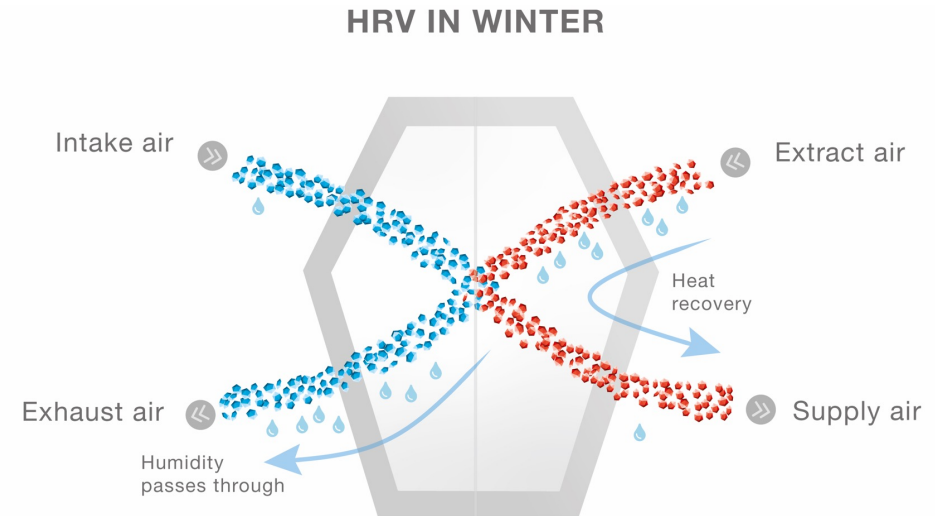
Whatever amount of moisture is in the Outdoor (intake) air is transferred through the exchanger to the Supply air.



HRV in Winter

The Supply air has recovered much of the heat from the exhaust air, so it's no longer cold like the outdoor air.

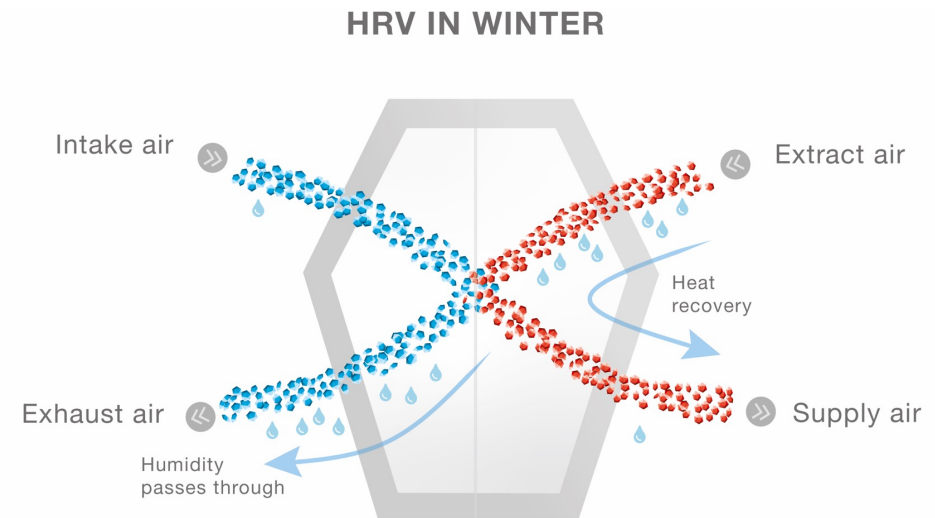
The heat transfer is never 100%, so the Supply air will be a little cooler than the indoor temperature, but with proper air distribution that won't be noticed.



HRV in Winter

While the Supply air is near room temperature, it is also dryer, because the HRV plates don't allow for moisture recovery. The interior of the house will get drier if the HRV runs continuously.

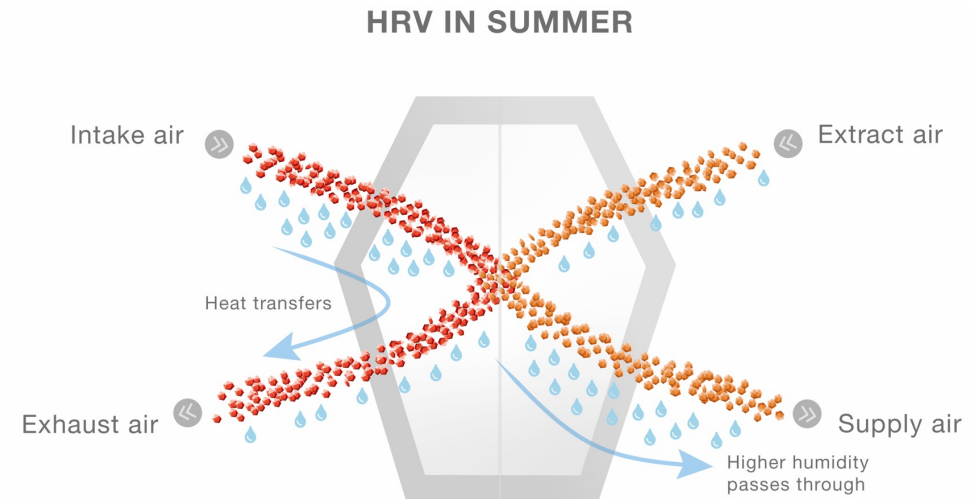
Because the Exhaust air has given up its heat, but still contains all the indoor moisture, it will develop some condensation. For that reason, an HRV always needs a drain in cold weather.



HRV in Summer

In general, summer air is not only hot, but often humid.

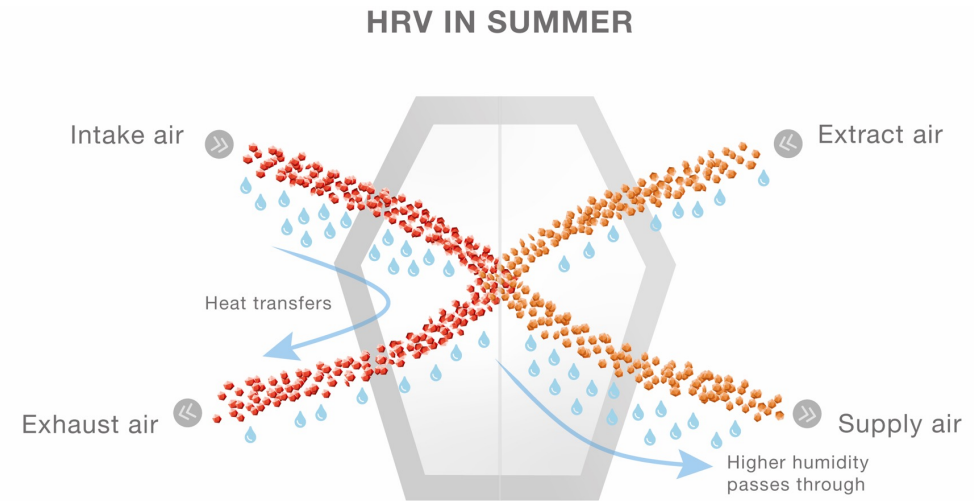
Meanwhile, in many homes the indoor air has been cooled with AC and has less humidity in comparison to the outdoor air.



HRV in Summer

As the Outdoor (intake) air moves into the heat exchanger, it's loaded with summer heat and humidity. The Extract air coming from the house is cool and dry (assuming AC).

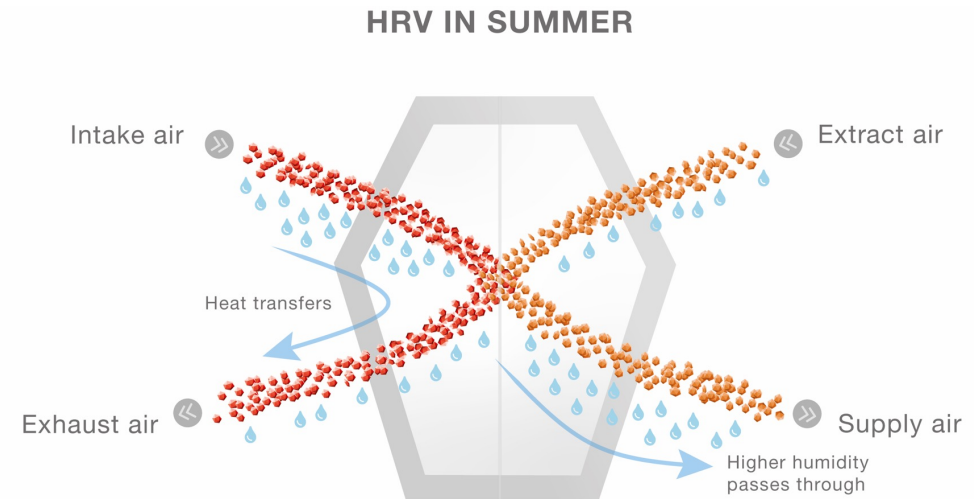
As the Extract air passes through the exchanger, it "recovers" heat from the outdoor air and exhausts it back outdoors along with the indoor pollutants.



HRV in Summer

After the Outdoor (intake) air gives up much of its heat in the exchanger it is supplied to the house at near room temperature (just a little warmer).

Again, because the HRV does not allow for moisture transfer, all the outdoor humidity is introduced to the house. This humidity will need to be taken care of by AC or dehumidification.



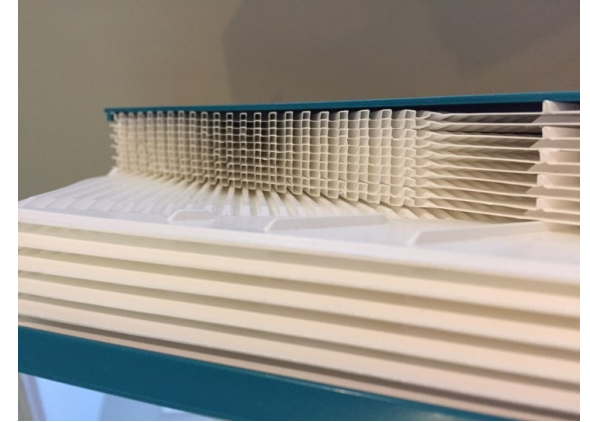
ERV Features and Capabilities

The fixed plates in an ERV exchanger are different than in an HRV.

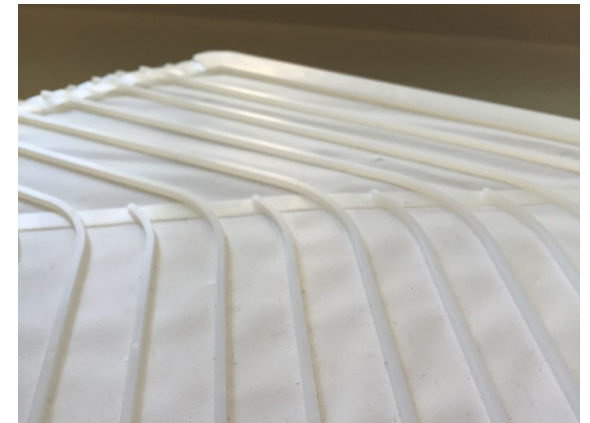
Rather than solid material formed into ridges, ERV plates are made of a porous membrane attached to a plastic grid that forms the channels that guide the airflow.

The membrane allows both sensible heat (warmth) and latent heat (humidity) to pass from one air stream to the other.

HRV Plates



ERV Membrane



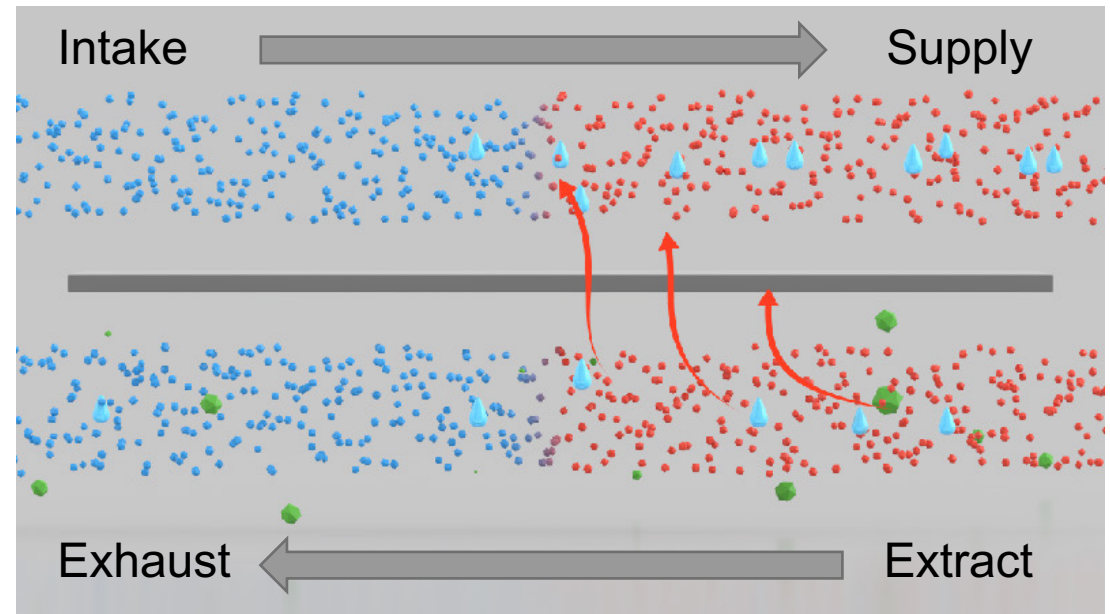
ERV Features and Capabilities

Here is an enlarged illustration of a single membrane layer in the ERV.

As in an HRV, sensible heat moves from the warmer to the cooler air stream.

Also, water vapor moves across the membrane from the more humid to the drier air stream.

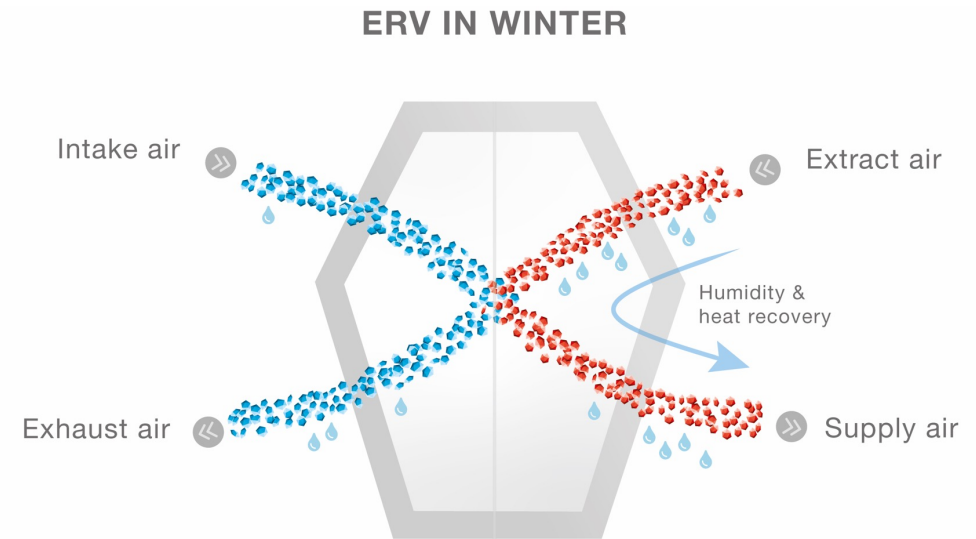
The membrane allows water vapor, but not pollutants (shown as icky green stuff) to transfer.



ERV in Winter

Just as in the HRV, sensible heat from the warm extract air is recovered by the cold intake air so that it can be supplied to the house at near room temperature.

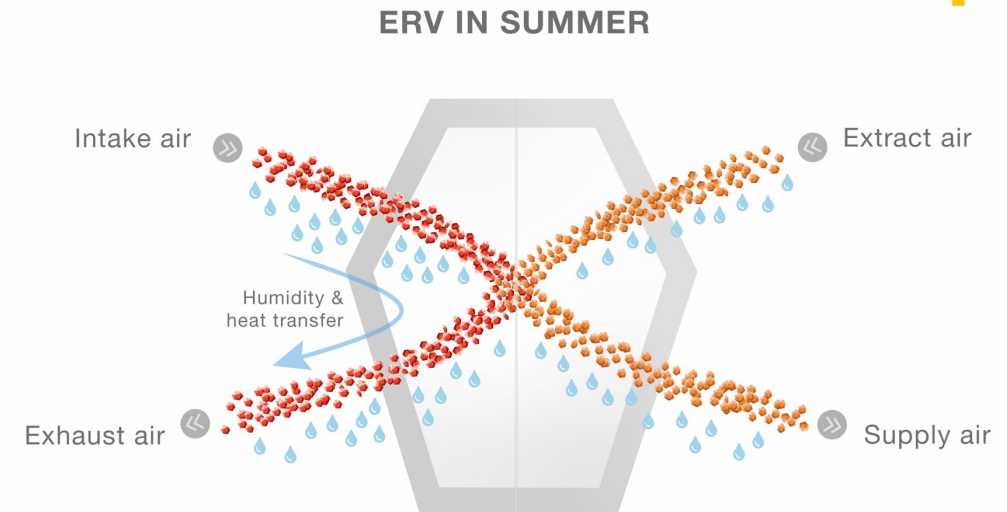
But the ERV also allows moisture to be recovered by the intake air. This has the added advantage of not drying out the inside of the house so fast in winter.



ERV in Summer

The advantage of an ERV in humid summer weather is that both warmth and humidity in the Outdoor (intake) air are partially transferred in the exchanger and exhausted outside with the pollutants.

Again, the transfer (or recovery) of sensible and latent heat are never 100%, so there will still be some humidity in the supply air, but not nearly as much as with an HRV.



(In some climates, a dehumidifier may still be required even with an ERV.)

HRV vs. ERV?

Some general comments (at this introductory level)...

In most cases, an ERV is more desirable than an HRV because of the ERV's ability to help manage moisture levels in the supply air.

Exceptions:

- Specific climates
- High-density occupancy
- Prioritizing sensible recovery effectiveness



Knowledge Check

Learning Objective 3

Distinguish between the recovery capabilities of an HRV and an ERV

An ERV recovers...

- A. ...humidity, but not warmth.
- B. ...warmth, but not humidity.
- C. ...both latent and sensible heat.
- D. ...latent heat, but not sensible heat.



Knowledge Check

Learning Objective 3

Distinguish between the recovery capabilities of an HRV and an ERV

An ERV recovers...

- A. ...humidity, but not warmth.
- B. ...warmth, but not humidity.
- C. ...both latent and sensible heat.**
- D. ...latent heat, but not sensible heat.

Learning Objective 4

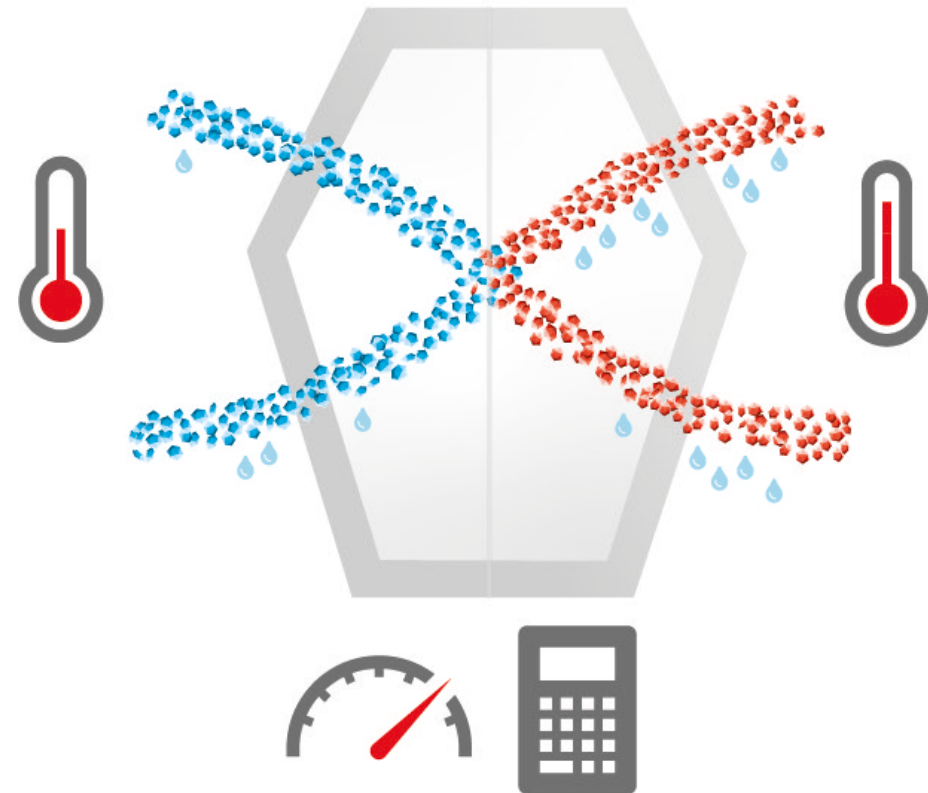
Define recovery efficiency and identify the contributing factors

Performance Matters

It's important to be able to quantify the sensible/latent recovery of an HRV/ERV...

- To compare HRV/ERV models.
- To ensure supply air will be comfortable.
- To be able to calculate the avoided heating and cooling costs (energy penalty saved).
- To help properly size other mechanical systems.

CALCULATING PERFORMANCE



What is Recovery Efficiency?

“Recovery efficiency” describes how effective an HRV/ERV is at recovering energy.

Recovery efficiency is represented by a percentage of the difference (delta or Δ) between the energy in the outdoor air and the indoor air.

Sensible Recovery Efficiency (SRE)

The recovered percentage of ΔT (the difference in temperature).

Latent Recovery Efficiency (LRE)

The recovered percentage of ΔH (the difference in humidity).

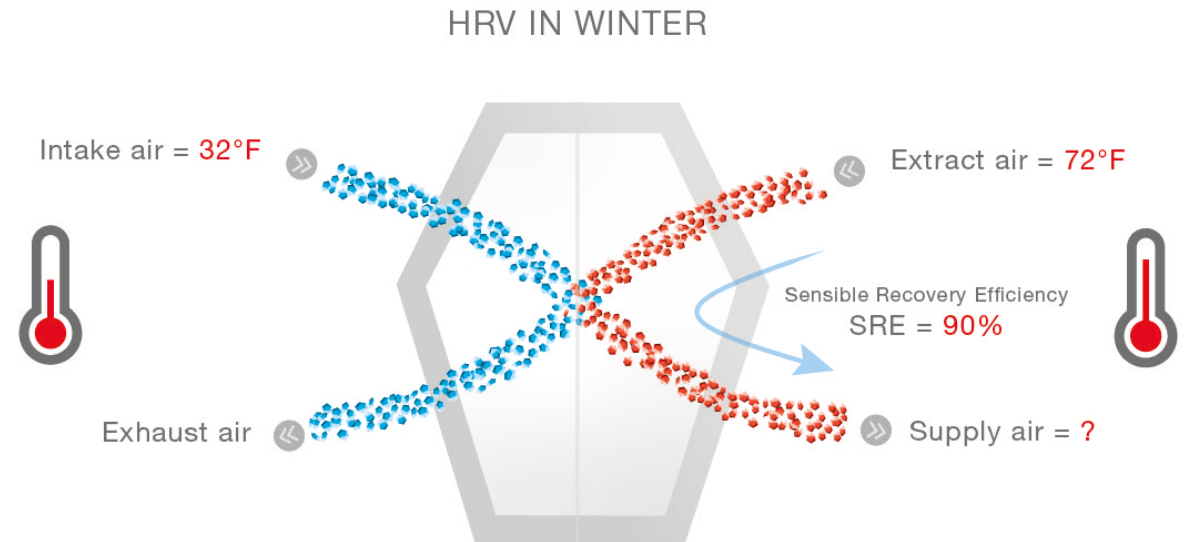


Calculating Supply Air Temperature

One example of using recovery efficiency is to determine the temperature of an HRV or ERV's Supply Air to the interior rooms.

When we know the outdoor and indoor temperatures and the rated SRE of the heat exchanger, we can predict the Supply Air temperature.

(SRE is often tested and published by the manufacturer but should also be available as tested by 3rd party labs or agencies.)

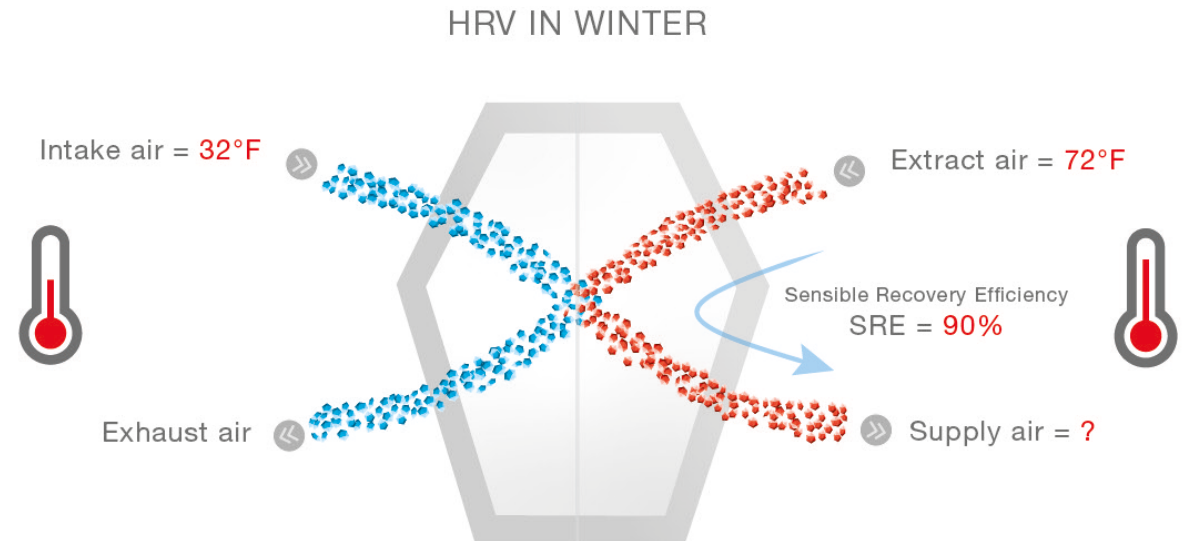


Calculating Supply Air Temperature

As an example, let's look at an HRV operating in winter...

Information we know:

- Temperature of Outdoor Air (T_{ODA}) = 32°F
- Temperature of Extract Air (T_{ETA}) = 72°F
- Rated SRE = 90%



Calculating Supply Air Temperature

****For demonstration only****

First let's determine our ΔT ...

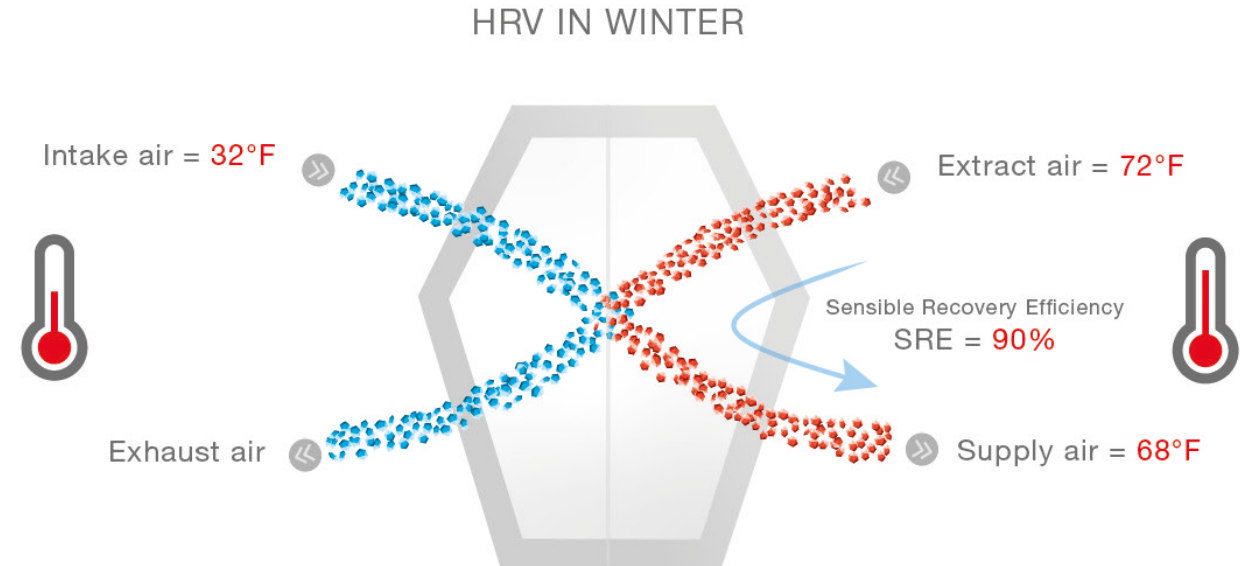
$$\Delta T = T_{ETA} - T_{ODA} = 72^{\circ}\text{F} - 32^{\circ}\text{F} = 40^{\circ}\text{F}$$

Now we can calculate our Supply Air temperature (T_{SUP})...

$$T_{SUP} = \text{SRE}(\Delta T) + T_{ODA}$$

$$T_{SUP} = 0.90(40^{\circ}\text{F}) + 32^{\circ}\text{F}$$

$$T_{SUP} = 36^{\circ}\text{F} + 32^{\circ}\text{F} = \mathbf{68^{\circ}\text{F}}$$





Knowledge Check

Learning Objective 4

Define recovery efficiency and identify the contributing factors

What is ΔT ?

- A. A point in time.
- B. Delta T, the difference between exhaust time and supply time.
- C. Delta T, the difference between Outdoor Air temperature and Extract Air temperature.
- D. None of the above



Knowledge Check

Learning Objective 4

Define recovery efficiency and identify the contributing factors

What is ΔT ?

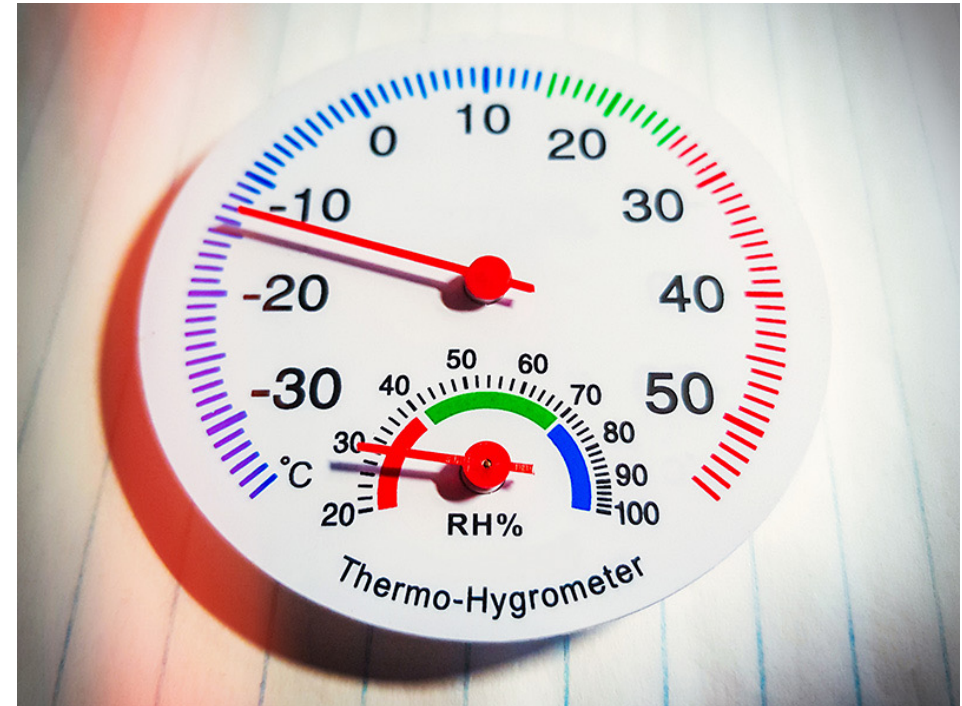
- A. A point in time.
- B. Delta T, the difference between exhaust time and supply time.
- C. Delta T, the difference between Outdoor Air temperature and Extract Air temperature.**
- D. None of the above

Calculating Supply Air Humidity

Predicting the amount of humidity in the Supply Air is slightly more complicated than predicting the temperature, but it can be done.

To do so requires knowing the indoor and outdoor humidity in terms of Absolute Humidity.

Most lay people are more familiar with Relative Humidity (RH) or Dew Point (DP), so some translation to Absolute Humidity (AH) may be necessary.

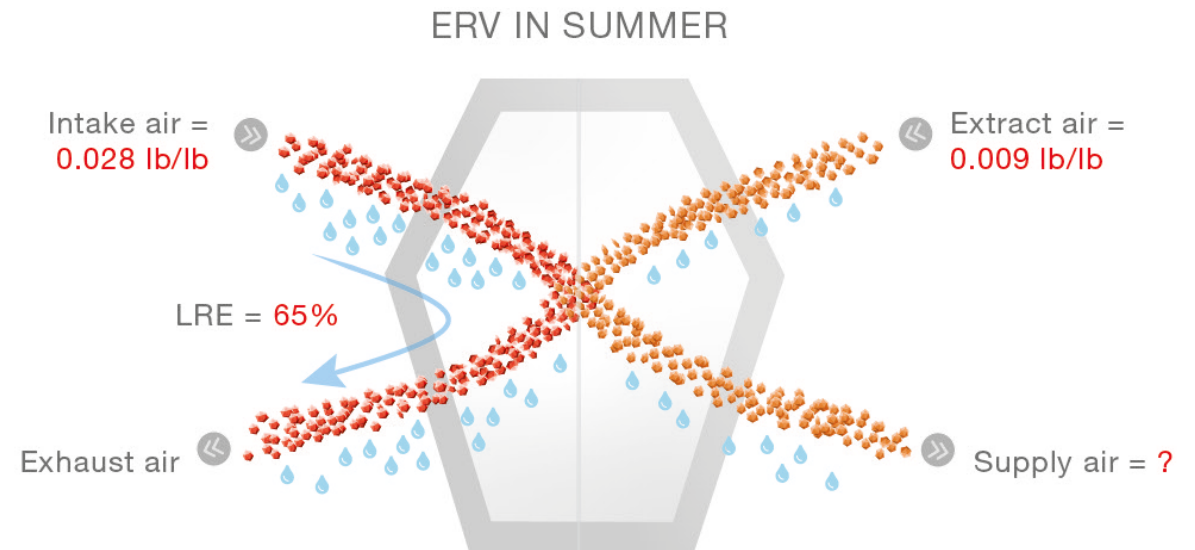


Calculating Supply Air Humidity

When we know the outdoor and indoor humidity ratios and the rated LRE of the heat exchanger, we can predict the Supply Air humidity.

This will help predict comfort as well as inform the mechanical designer about other system requirements.

(Just as with SRE, LRE is often tested and published by the manufacturer but should also be available as tested by 3rd party labs or agencies.)

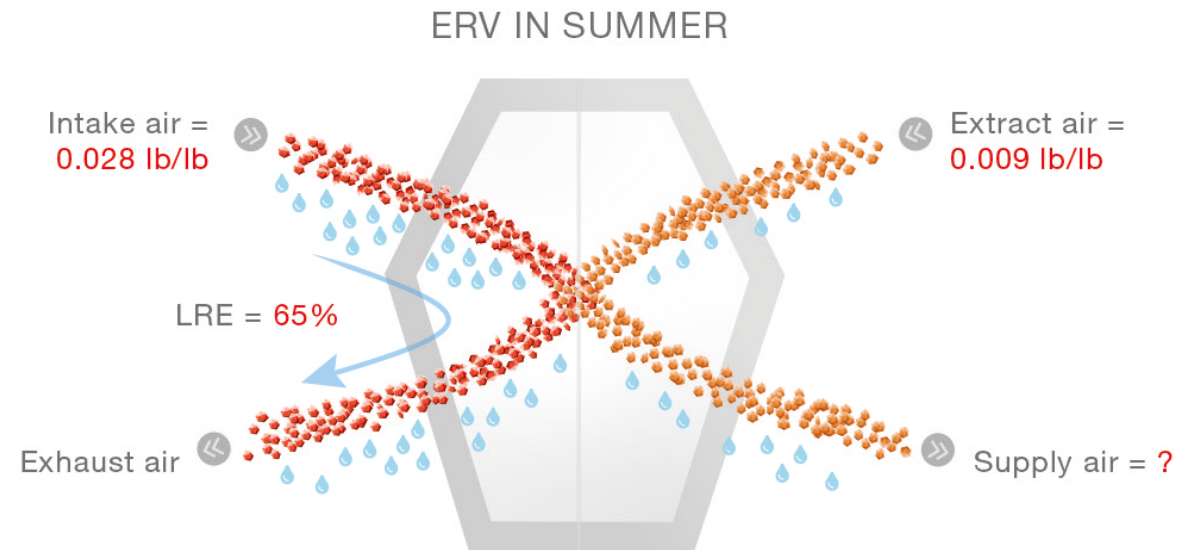


Calculating Supply Air Humidity

As an example, let's look at an ERV operating in summer...

Information we know:

- Humidity ratio of Outdoor Air (H_{ETA}) = 0.028 lb/lb
- Humidity ratio of Extract Air (H_{ODA}) = 0.009 lb/lb
- Rated LRE = 65%



Calculating Air Supply Humidity

****For demonstration only****

First let's determine our ΔH ...

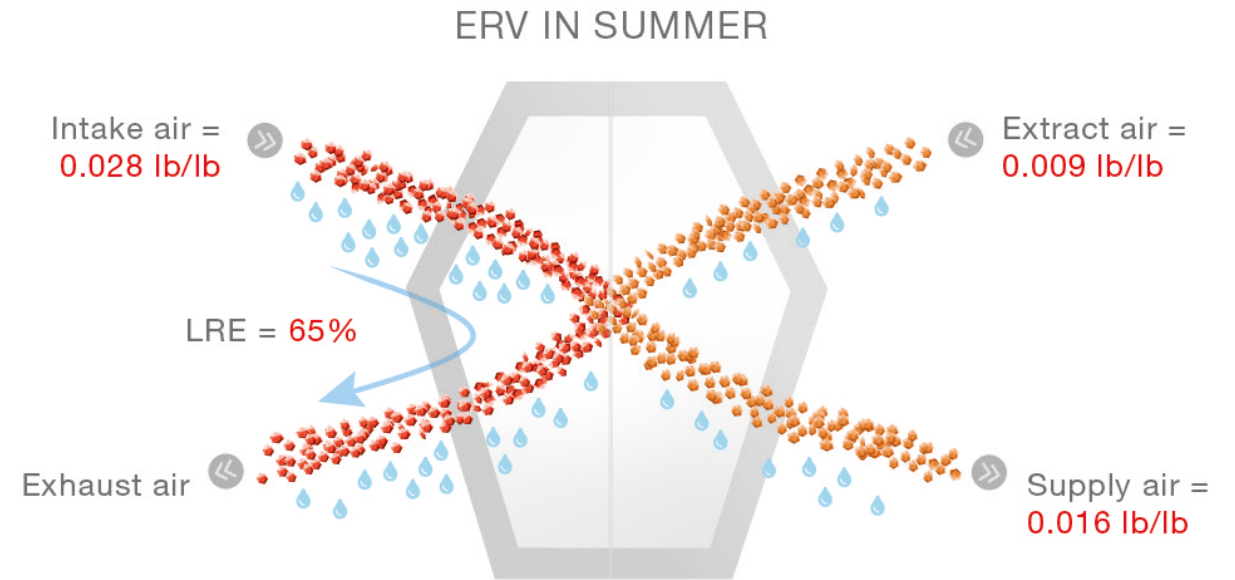
$$\Delta H = H_{\text{ODA}} - H_{\text{ETA}} = 0.028 \text{ lb/lb} - 0.009 \text{ lb/lb} = 0.019 \text{ lb/lb}$$

Now we can calculate our Supply Air humidity (H_{SUP})

$$H_{\text{SUP}} = H_{\text{ODA}} - \text{LRE}(\Delta H)$$

$$H_{\text{SUP}} = 0.028 \text{ lb/lb} - 0.65(0.019 \text{ lb/lb})$$

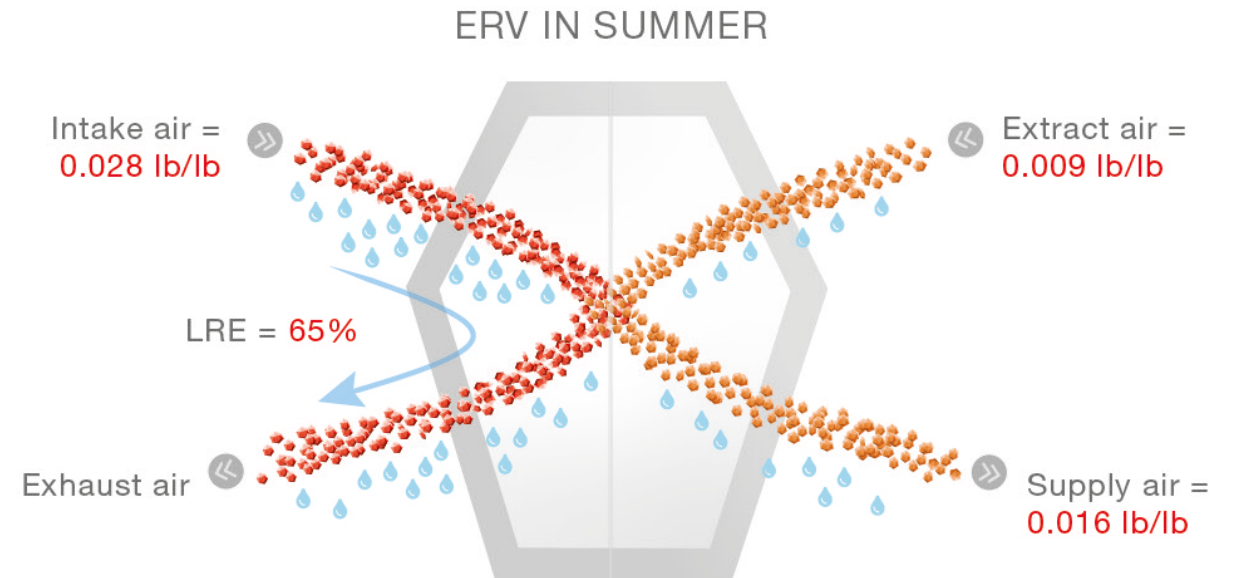
$$H_{\text{SUP}} = 0.028 \text{ lb/lb} - 0.012 \text{ lb/lb} = 0.016 \text{ lb/lb}$$



Calculating Air Supply Humidity

Knowing that the Supply Air humidity will be 0.016 lb/lb may not be immediately helpful to a layperson, so converting to Relative Humidity (RH) might be helpful.

If we also calculate the ERV's Supply Air temperature (just as we did earlier for the HRV), we can also use a psychrometric chart or psychrometric calculator to convert the Supply Air humidity ratio and temperature to RH.

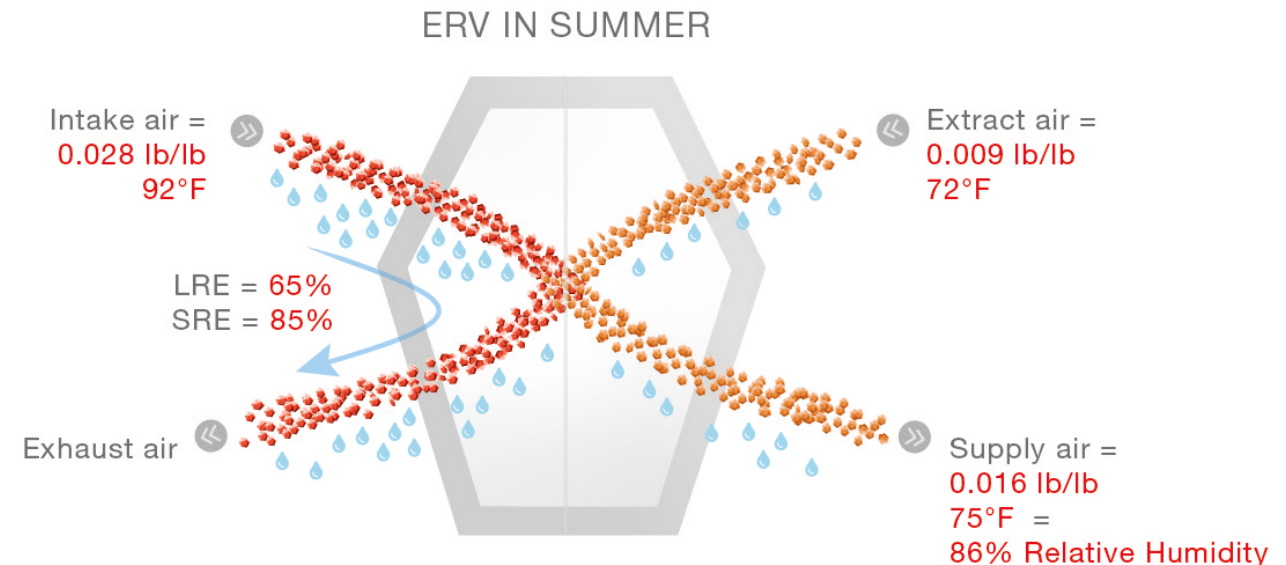


Supply Air Relative Humidity

In this case, the Supply Air will be at 86% RH.

That would be uncomfortable by itself, but it's just a small volume of air that will mix with the larger volume of dryer air that's been conditioned in the house.

In very humid climates, adding a dehumidifier may be necessary to keep long-term humidity in check, even when using an ERV.





Knowledge Check

Learning Objective 4

Define recovery efficiency and identify the contributing factors

Calculating the humidity in the Supply Air...

- A. Is impossible.
- B. Requires knowing the absolute humidity in both the outdoor and indoor air.
- C. Requires knowing the Supply Air temperature if the humidity is to be expressed as RH.
- D. Both B and C above



Knowledge Check

Learning Objective 4

Define recovery efficiency and identify the contributing factors

Calculating the humidity in the Supply Air...

- A. Is impossible.
- B. Requires knowing the absolute humidity in both the outdoor and indoor air.
- C. Requires knowing the Supply Air temperature if the humidity is to be expressed as RH.
- D. Both B and C above**

Recovery Performance Factors

How efficient can an H/ERV be?

The percentage of energy that an H/ERV can recover varies widely depending on several factors. To simplify, let's look at these factors in two categories...

- H/ERV unit design
- Operating conditions



Recovery Performance Factors

The ability of the H/ERV to recover energy is dependent on the total exposure the air has to the heat exchanger plates or membranes.

This total exposure is dependent on the amount of surface area of the plates or membranes as well as the duration of exposure.

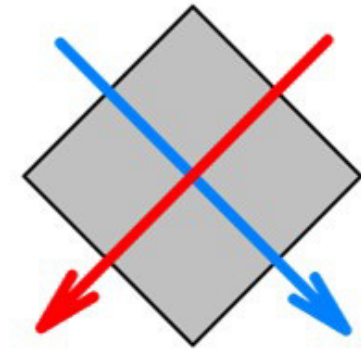
Exposure is important both in the unit design and operating conditions.



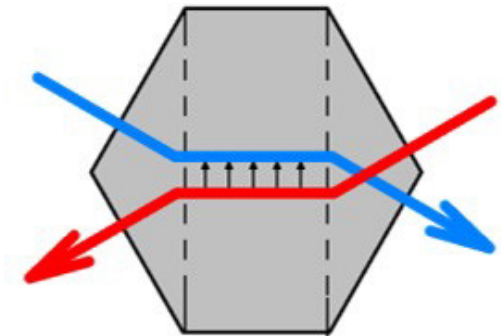
Design: Heat Exchanger Core Shape

Square “cross-flow” heat exchangers arrange supply and exhaust air channels at right angles to each other. This means that any supply air channel is crossing a return channel at only one point. That limits the duration of exposure.

Hexagonal “counter-flow” heat exchangers align the channels so that a supply air channel and return air channel will be adjacent to each other across a long section of the core. That provides more duration of exposure and greater recovery effectiveness.



CROSS-FLOW
HEAT EXCHANGER



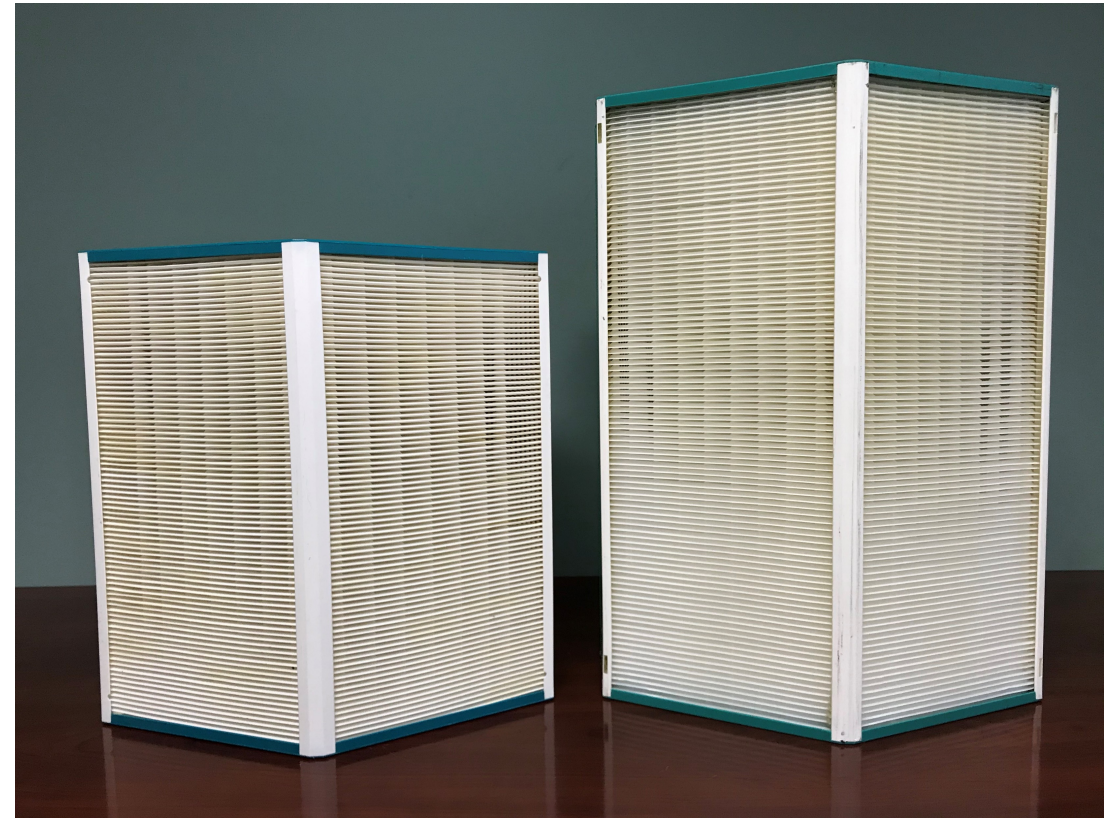
COUNTER-FLOW
HEAT EXCHANGER

Design: Core Height

Core height is determined by how many heat exchanger plates/membranes are stacked together.

More layers = more total surface area for heat transfer. A taller core will have greater energy recovery potential for the same air flow than a smaller core.

A smaller H/ERV might fit better in a small mechanical room, but providing more space for a larger H/ERV will allow for better performance and more long-term energy recovery (and savings).

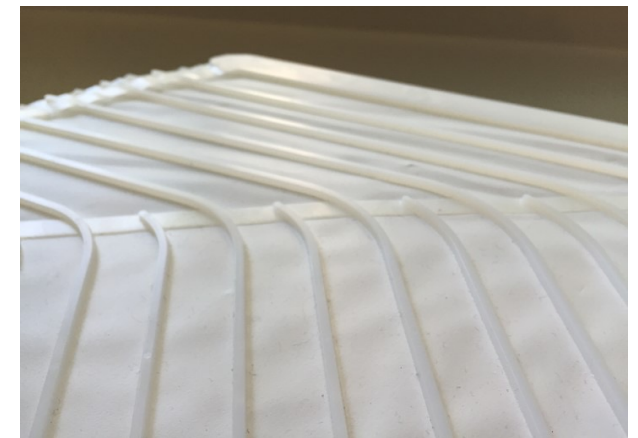
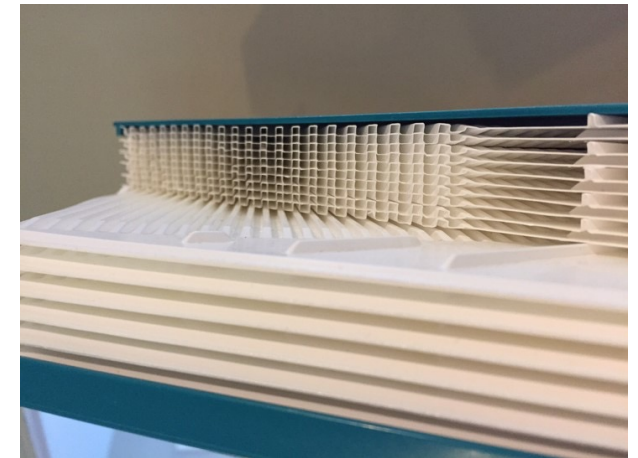


Design: HRV plate vs. ERV membrane

We've looked before at the difference between HRV and ERV fixed plates. This difference in design affects performance.

The rigid material of the HRV plates allows for channels to be molded into the material. Just like the ridges on a potato chip give it a better hold on creamy dip, the channels in the HRV plate give it more surface area for effective heat exchange.

On the other hand, the ERV membrane is flatter and smoother. This is necessary to provide latent (humidity) recovery, but it usually means that sensible recovery effectiveness is reduced (maybe around 6% - 7%).

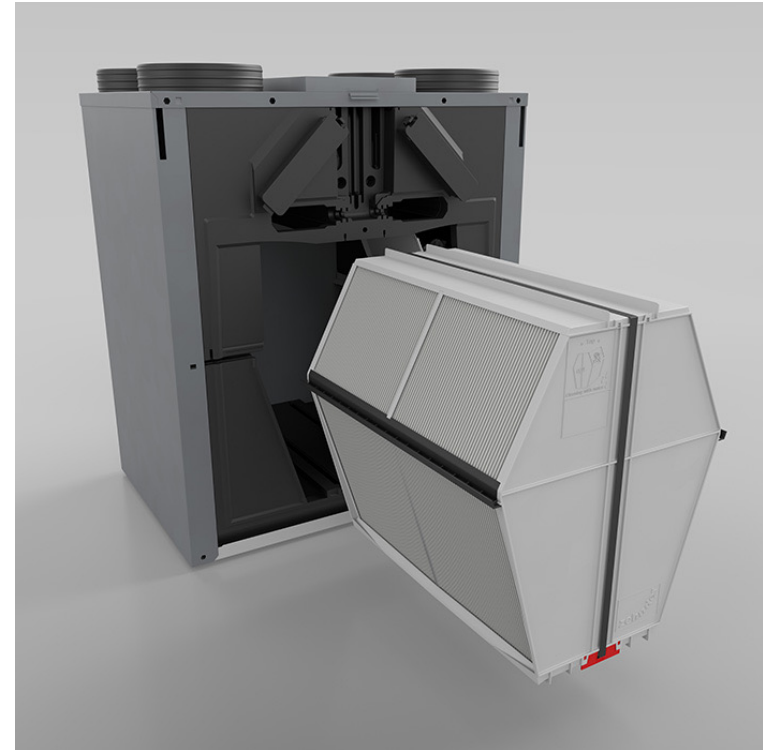


Design: H/ERV Cabinet Insulation and Airtightness

The four air channels inside the H/ERV need to be well insulated from each other and from the mechanical room environment.

Air leakage around the core will not only contaminate the incoming fresh air with polluted exhaust air, but it may also compromise the energy recovery that's been accomplished.

A well-detailed interior with close-fitting tolerances is an important factor in maximizing the H/ERV performance.





Knowledge Check

Learning Objective 4

Define recovery efficiency and identify the contributing factors

Which of the following affect energy recovery performance in an H/ERV?

- A. Heat exchanger core geometry and size.
- B. Plate or membrane configuration.
- C. Airtight H/ERV cabinet.
- D. All of the above



Knowledge Check

Learning Objective 4

Define recovery efficiency and identify the contributing factors

Which of the following affect energy recovery performance in an H/ERV?

- A. Heat exchanger core geometry and size.
- B. Plate or membrane configuration.
- C. Airtight H/ERV cabinet.
- D. All of the above**

Conditions: Flow Rate

Hard-core fun seekers can endure a “polar plunge” for a few minutes, but any longer than that puts warm-blooded humans at risk for hypothermia. That’s because there’s more heat transfer with longer duration of exposure.

The same is true when adjusting fan speeds on an H/ERV. The faster the air moves through the heat exchanger, the lower the energy recovery.

This is simply because the flow rate determines the duration of exposure the air has with the plates/membranes. The faster the air is moving, the less time is available for energy transfer.



Speed 1



Speed 2

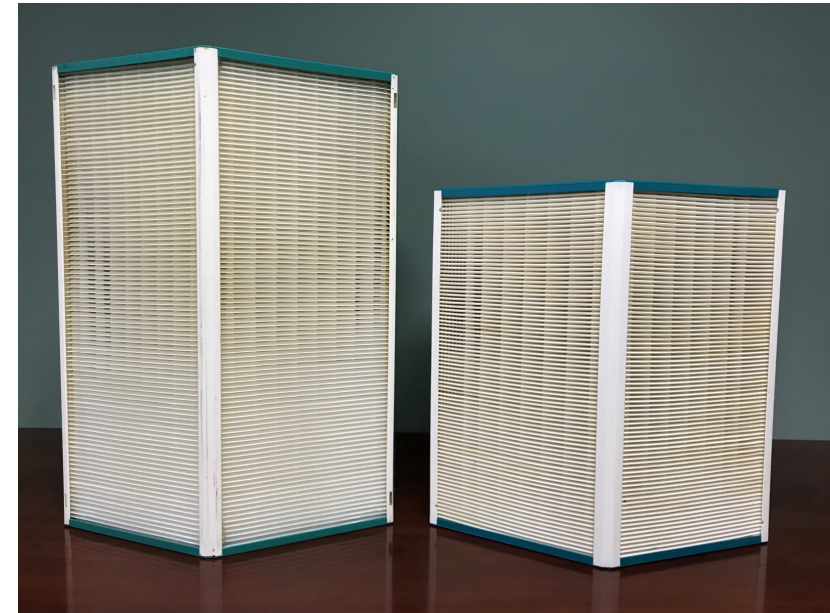


Speed 3

Conditions: Flow Rate

This illustrates an important system design consideration...

Selecting a smaller unit that must run closer to its max speed to deliver the same air flow as a larger unit means the air will be pushed faster across a smaller surface area, resulting in less total exposure and poorer recovery performance.



Conditions: Installation

Intake and exhaust ducts running from the H/ERV to the exterior through conditioned parts of the building need to be well insulated and air-sealed during installation.

If not, they will either leak or provide a path for heat gain or heat loss inside the building. That defeats the purpose of energy recovery.

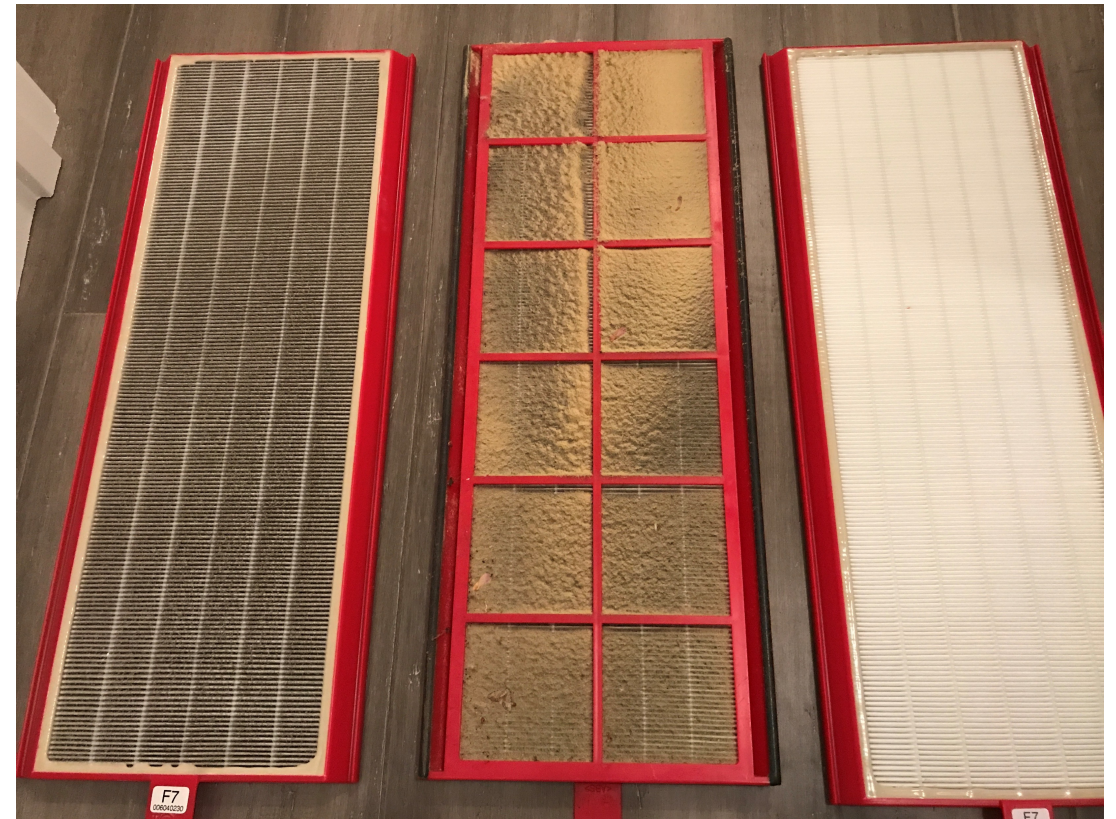


Conditions: Maintenance

A poorly maintained H/ERV system will also have degraded energy recovery performance.

Polluted filters may restrict air flow, influencing the supply/exhaust balance and requiring the fans to work harder.

Eventually, dust may even begin to coat the fans and the air channels within the heat exchanger.



Conditions: Cold Temperatures

Winter conditions with an HRV can also be a factor in heat recovery performance.

As pointed out earlier in this lesson, the humidity in the Exhaust Air will condense inside the heat exchanger core of an HRV.

Most of the water will drop out of the core into a drainage pan inside the cabinet, but some will remain on the plates inside the core, resulting in a lower recovery effectiveness.

This is made even worse if the Outdoor Air temperature is so cold the core begins to fill with frost.





Knowledge Check

Learning Objective 4

Define recovery efficiency and identify the contributing factors

What operating conditions will impact the energy recovery performance of an H/ERV?

- A. Any conditions that change the temperature of the outdoor air.
- B. Any conditions that change the temperature of the exhaust air.
- C. Any conditions that change the total exposure of the air to the heat exchanger plates.
- D. Any conditions that change the size of the mechanical room.



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ZA 101.04.2 Introduction to Energy Recovery Ventilation (Part 2)

Thank you for taking this Learning Segment. We hope you found it informative.

Please explore Zehnder Academy's other course offerings and continue to grow your professional expertise.

