BUILD BETTER TOGETHER

Ventilation and Humidity in High-Performance Homes

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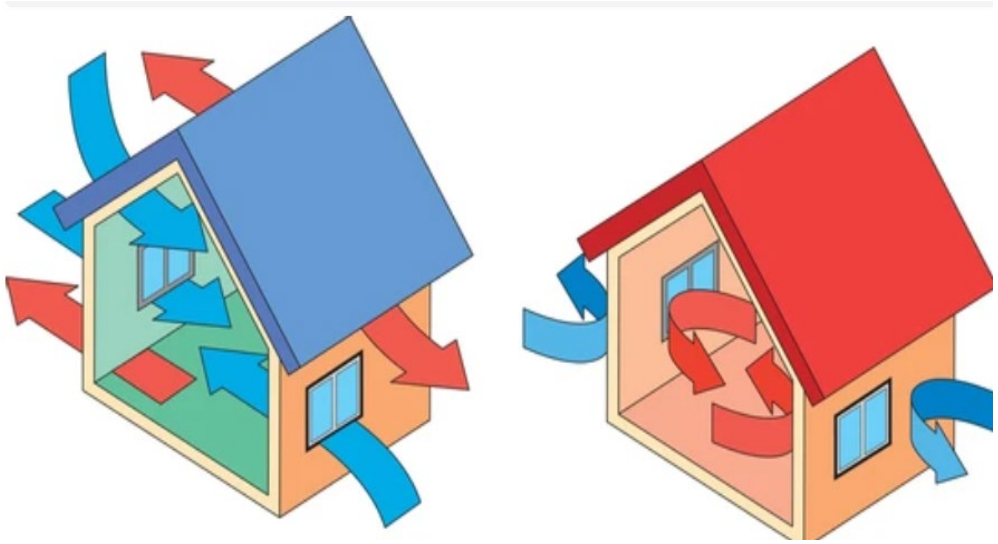
Zehnder America

High-performance Buildings



Airtight and well insulated construction.

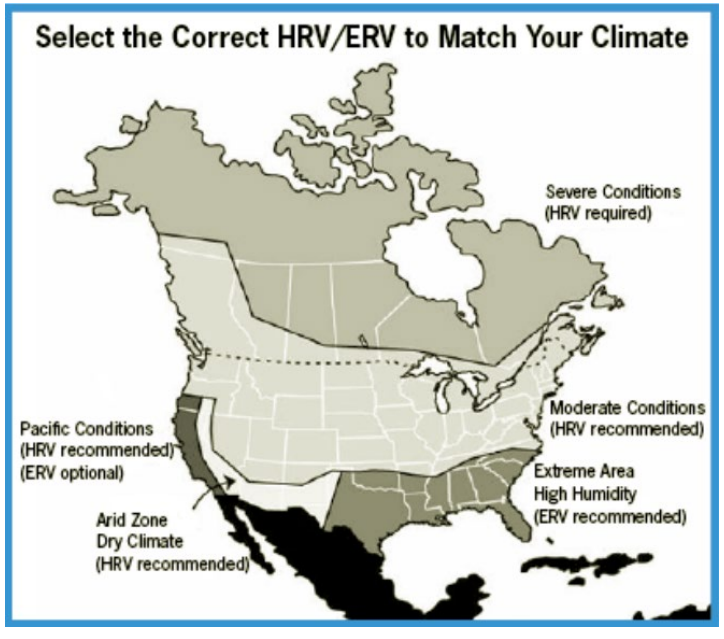
The goal is to create an isolated and fully controlled indoor environment with minimal impact from the outside conditions.

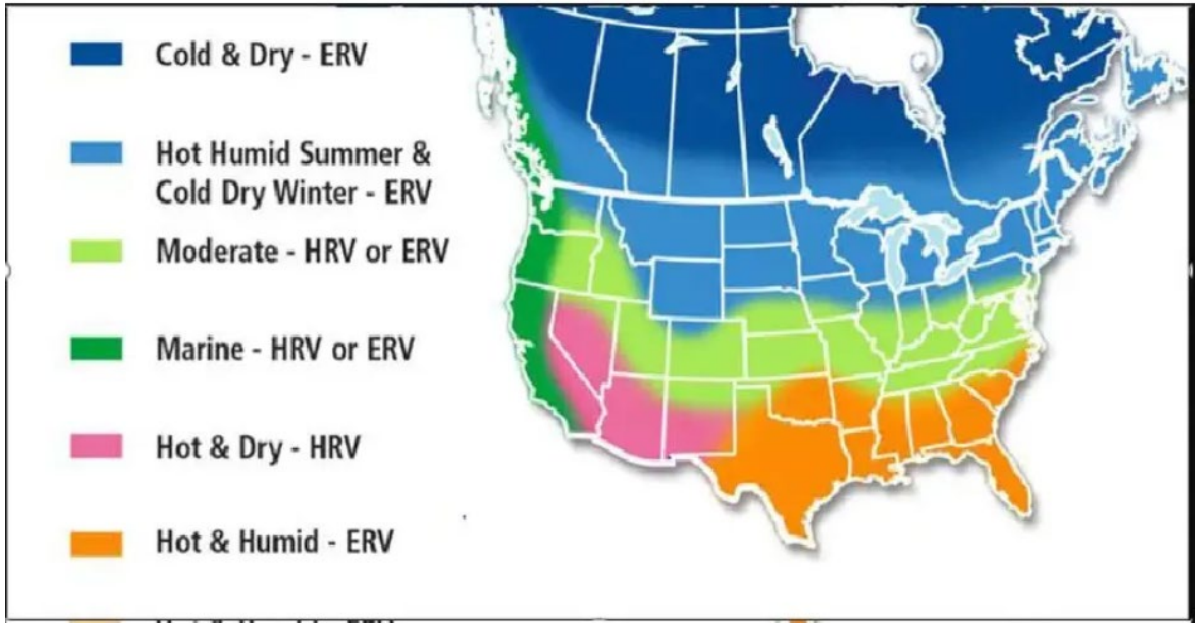
Isolation comes with limited natural ventilation, that’s why these buildings need properly designed controlled ventilation systems to keep the IAQ on a healthy level.

HRV vs. ERV

Ventilation is no longer a question of “if one should be installed”. The main question is “Which do I choose? HRV or ERV?” The concern over the recovery core freezing is not as much of a issue today. Too much outdated and confusing information is available.

Recent studies shows that freezing in cold climates is not such a big issue anymore with ERV’s and their operational details. Using energy modeling software and looking into the energy savings and comfort benefits, the ERV core usage has grown significantly.





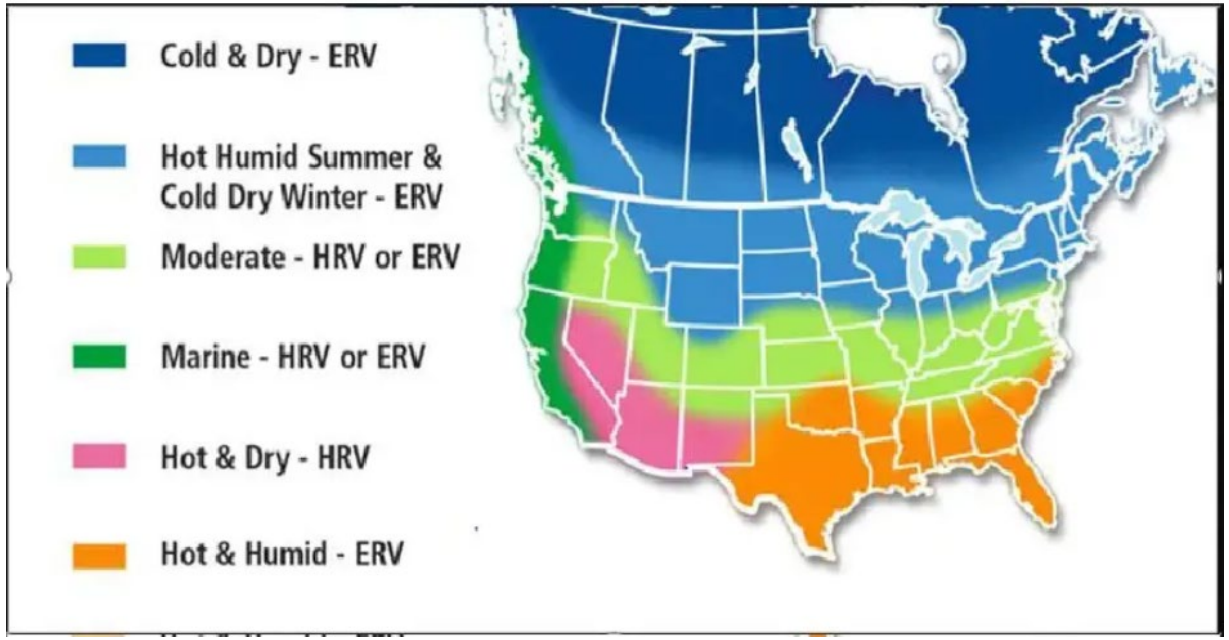
HRV vs. ERV ?

HRV's are more common on the West coast due to lower humidity issues.

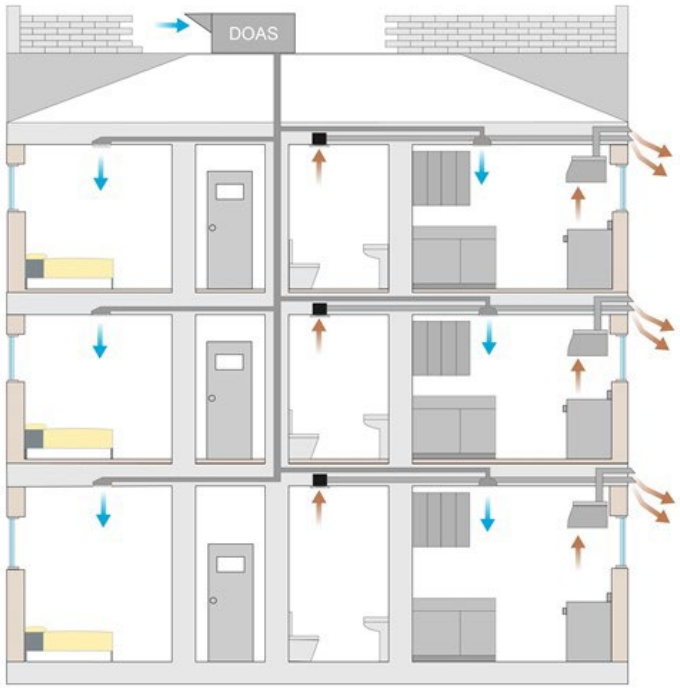
High or low indoor humidity is a problem for every home as we try to keep indoor RH% between 35-55% around 70-75F.

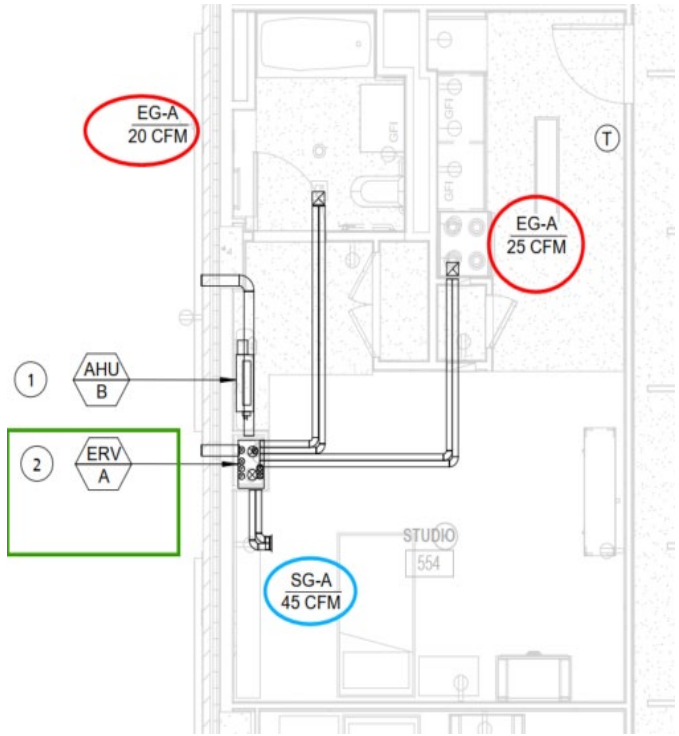
Dry outside condition will dry the house; too much humidity outside will increase the humidity inside. This is our battle with nature, as no core is 100% efficient at this point.

All together, ERV's are significantly reducing this impact, but it comes with some penalties on core efficiency. ERV's core is a little bit less efficient than HRV's.



Mechanical ventilation – energy penalty





Mechanical ventilation uses electrical fans or blowers to move the air in and out of the space.

Ventilation can be supplied by DOAS (Designated Outdoor Air System) or individual unit ventilation.

Depending on the size of the equipment, the capacity of them can vary between 15 CFM to 3,500 CFM (or even more) on multifamily applications.

Normally, these mechanical ventilation equipment operate continuously (24/7), or in some cases, on a scheduled intermittent running time.

Mechanical ventilation – pros. and cons.

Pros:

-Consistency of the airflow rate
-Controllability of the airflow rate
-Filtration opportunity
-Heat and Energy recovery option

Cons:

-Higher initial cost (equipment and labor)
-Cost of operation (electricity)
-Depending on the efficiency, the energy consumption varies
-**Requires maintenance!!! Every system is as good as it is maintained!!!**

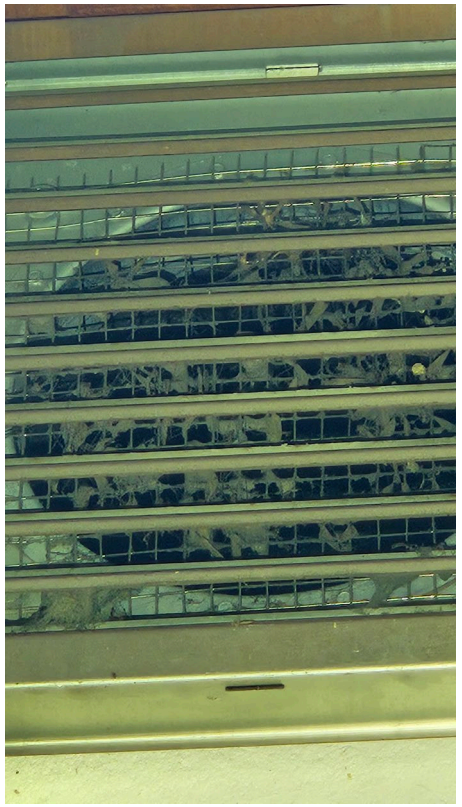
Every system is as good as it is maintained

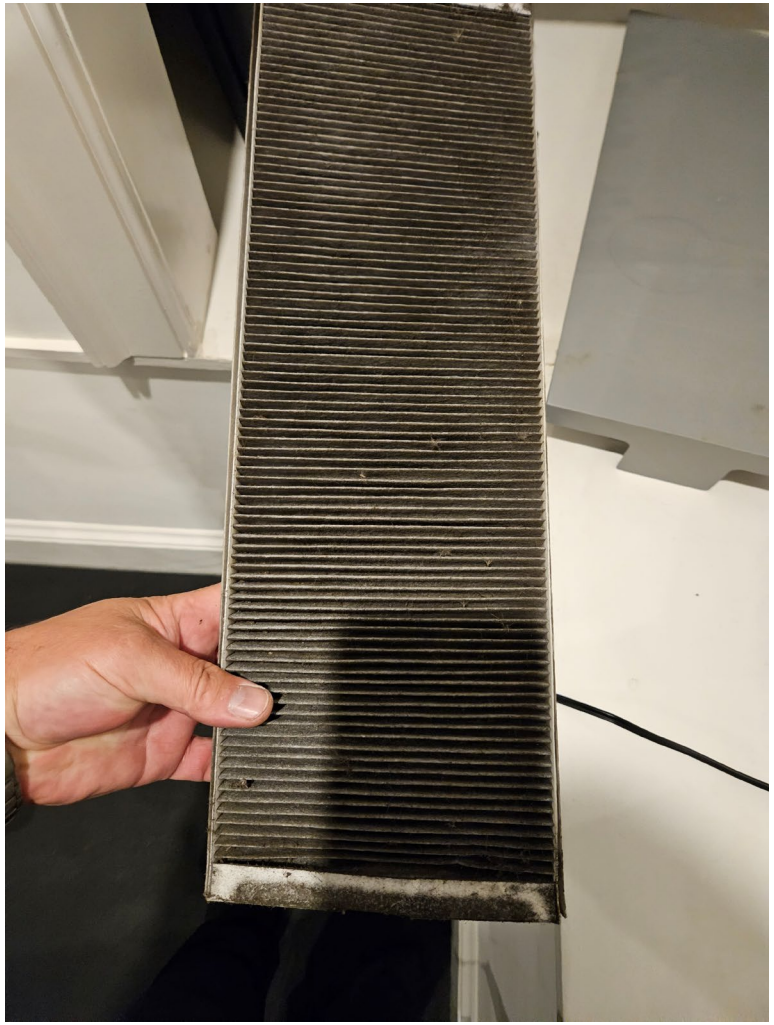
I would like to remind everyone that maintenance is a crucial part of ventilation.

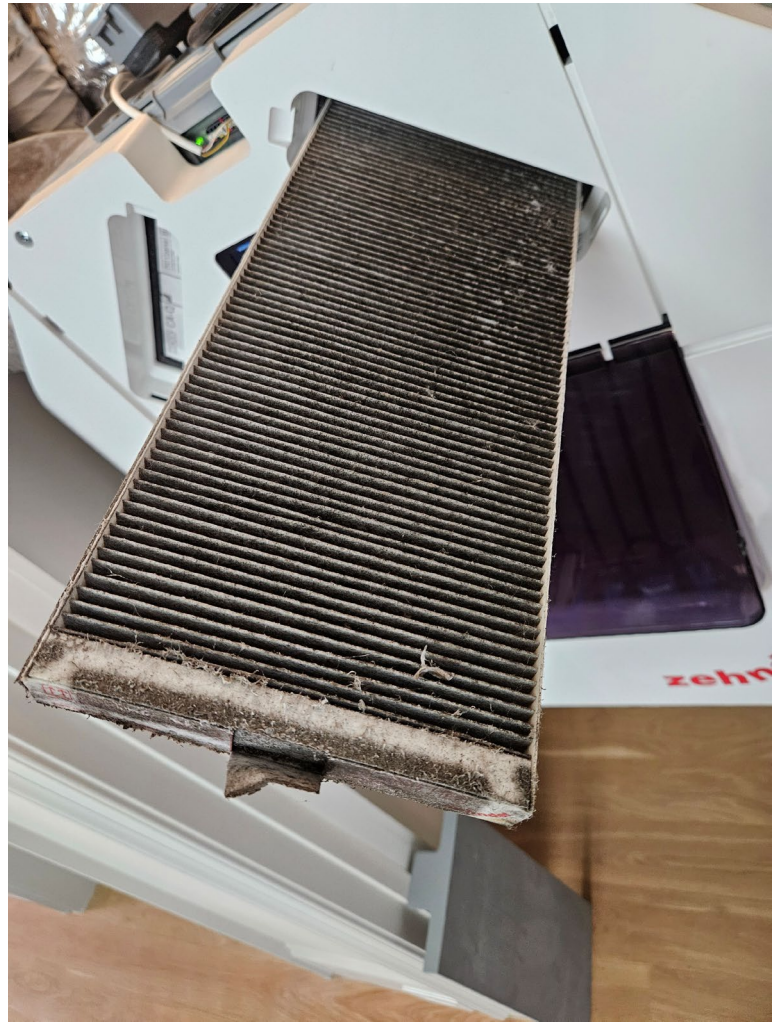
Even the best system is worthless if it is not maintained!!!

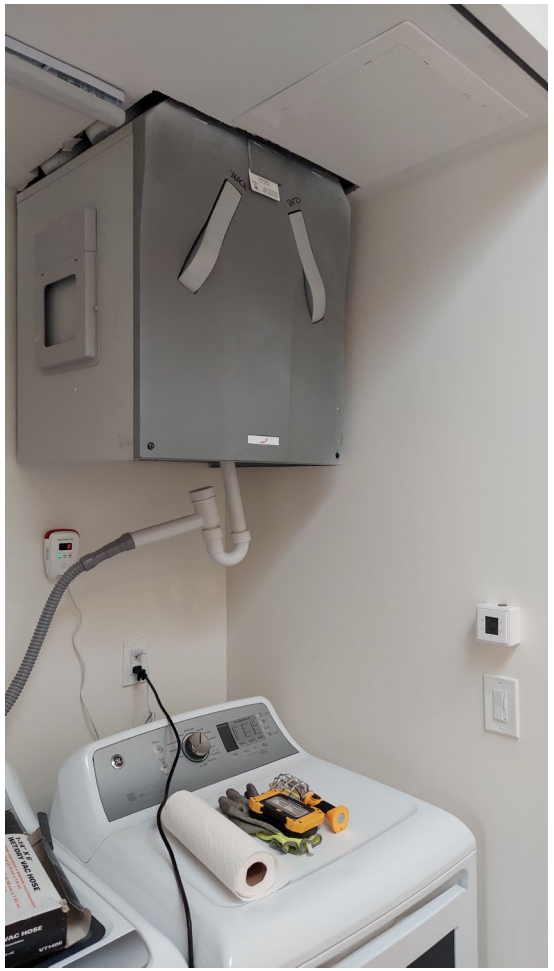
Filters need to be changed when they get dirty. Their lifetime depends on the location of the house.

Annual maintenance is always required if you want to keep the system running.









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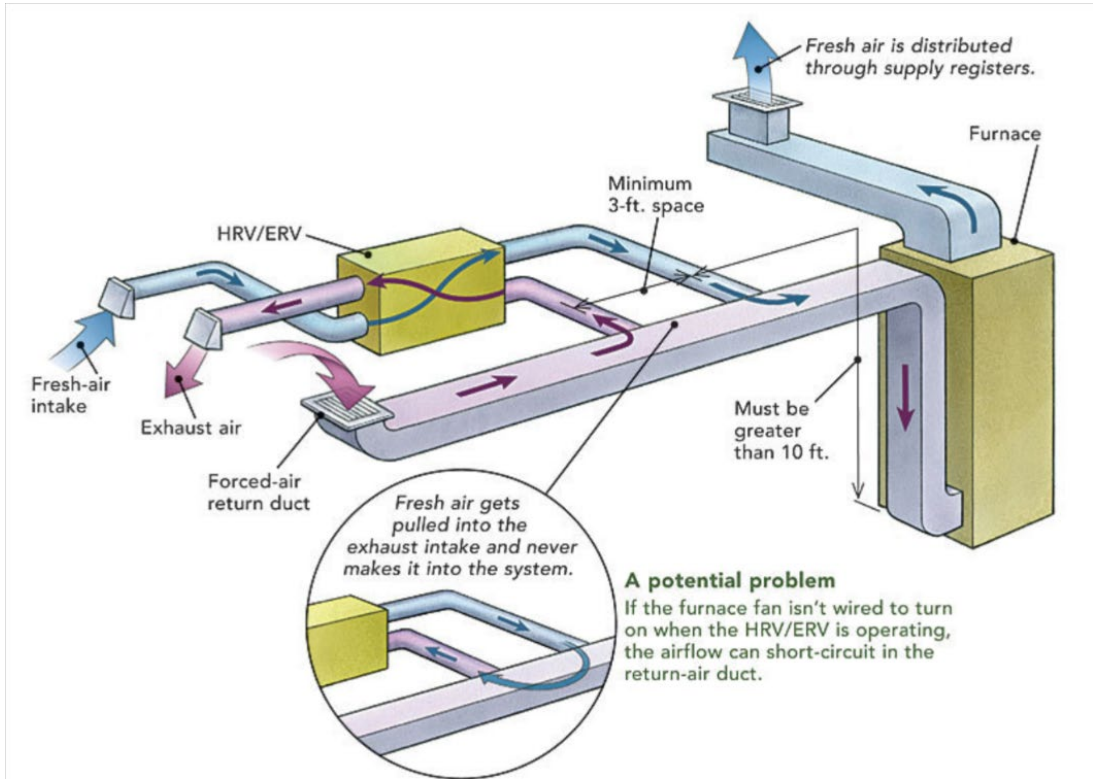
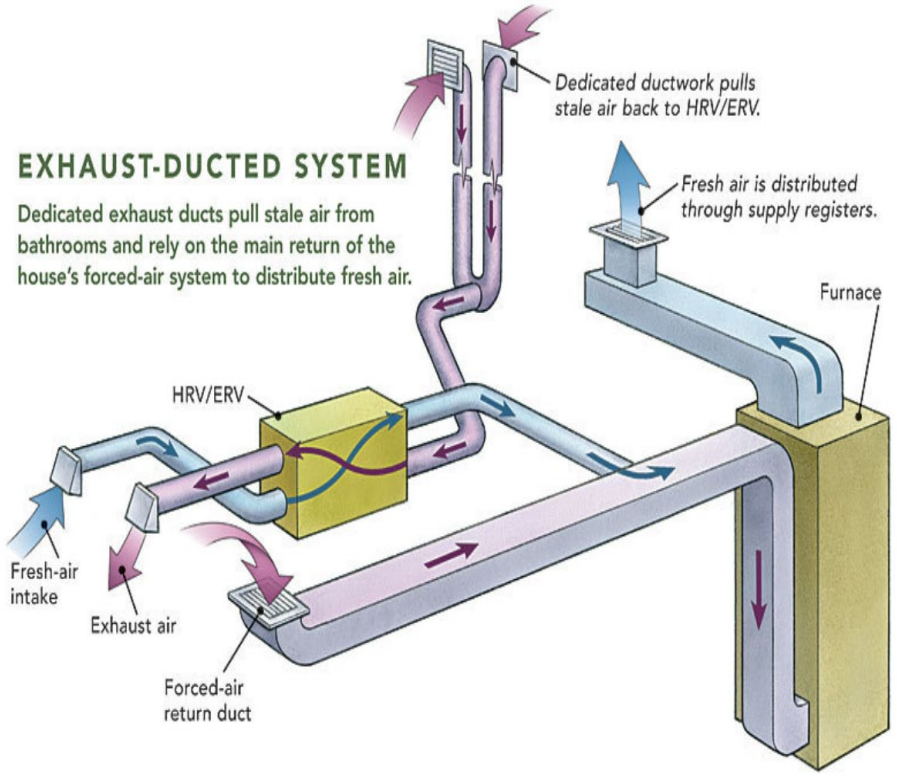
Distribution – Connecting to central ductwork



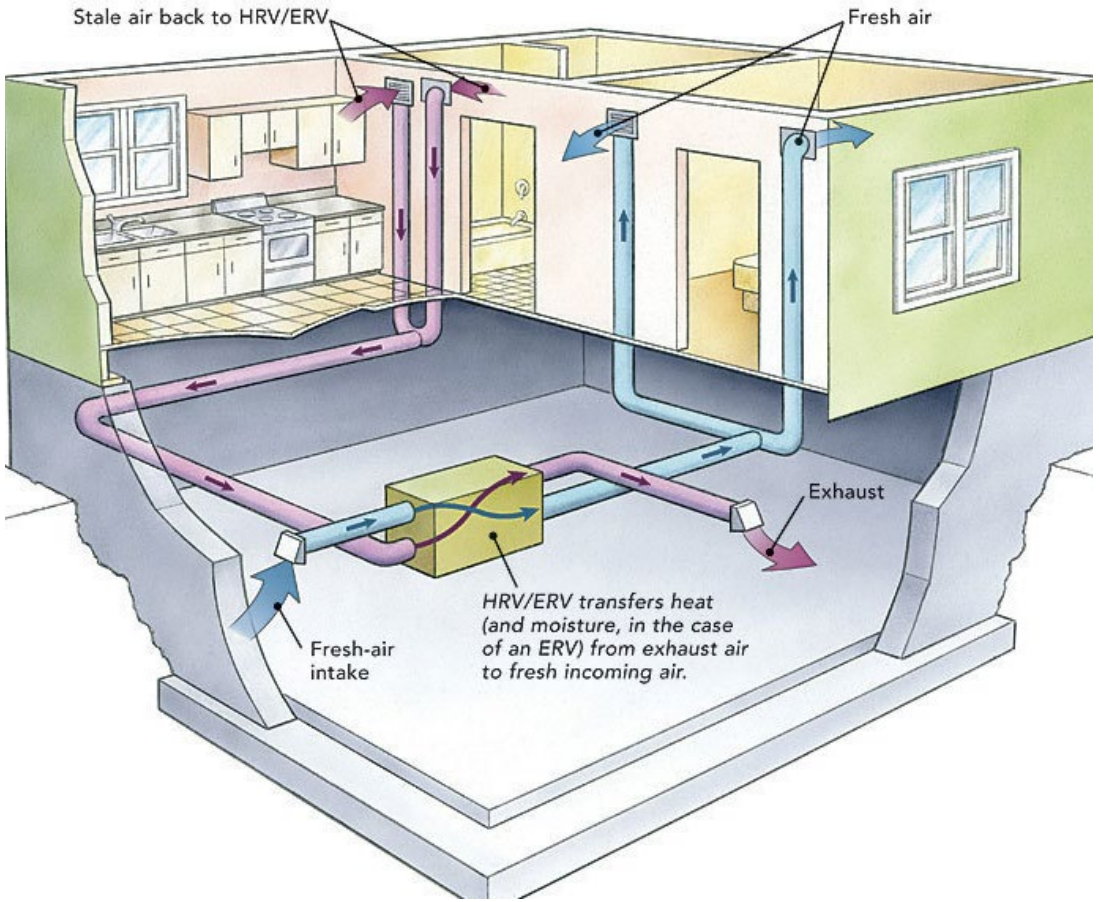
- Most common installation method
- Must follow manufacture's recommendations
- Follow local code requirements for intake locations
- Fresh air is tempered by the central AH (temperature change, dehumidification) – less efficient H/ERV's

Distribution – Local Exhaust distribution only

- Dedicated exhaust ducts !!!
- Better ventilation result
- Must follow manufacture recommendations
- Follow local code requirements for intake locations
- Fresh air is tempered by the central AH (temperature change, dehumidification) – less efficient H/ERV's



Distribution - “Targeted” Distribution Design

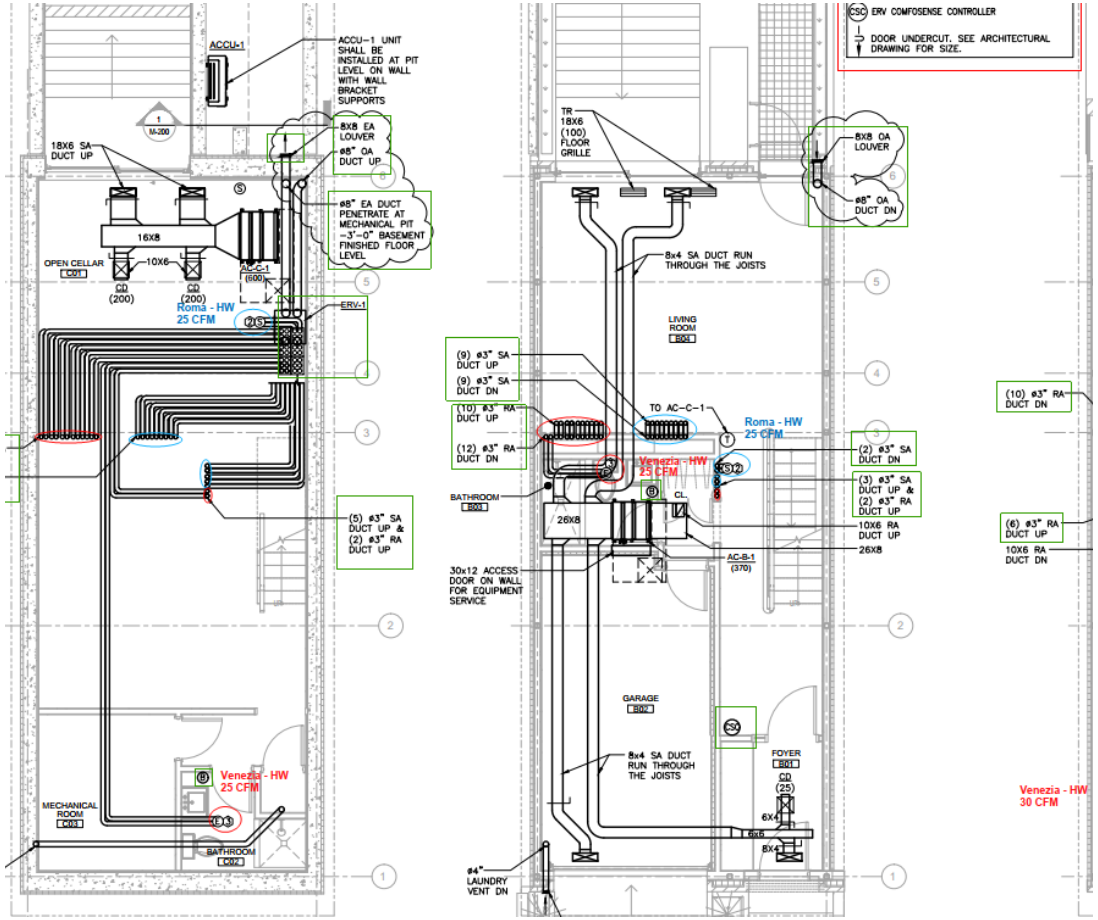


Airtight distribution system is carefully designed to move air properly, to or from, the targeted areas (rooms) to satisfy the requested local and whole house ventilation rates. This is done without negatively impacting comfort or creating noise.

Using a “targeted” distribution system, will remove the polluted air and deliver tempered and filtered fresh air where it is needed.

This is the most common application for passive building design

Ventilation effectiveness



The “effectiveness” of the targeted ventilation is always much better than simple ventilation at central locations.

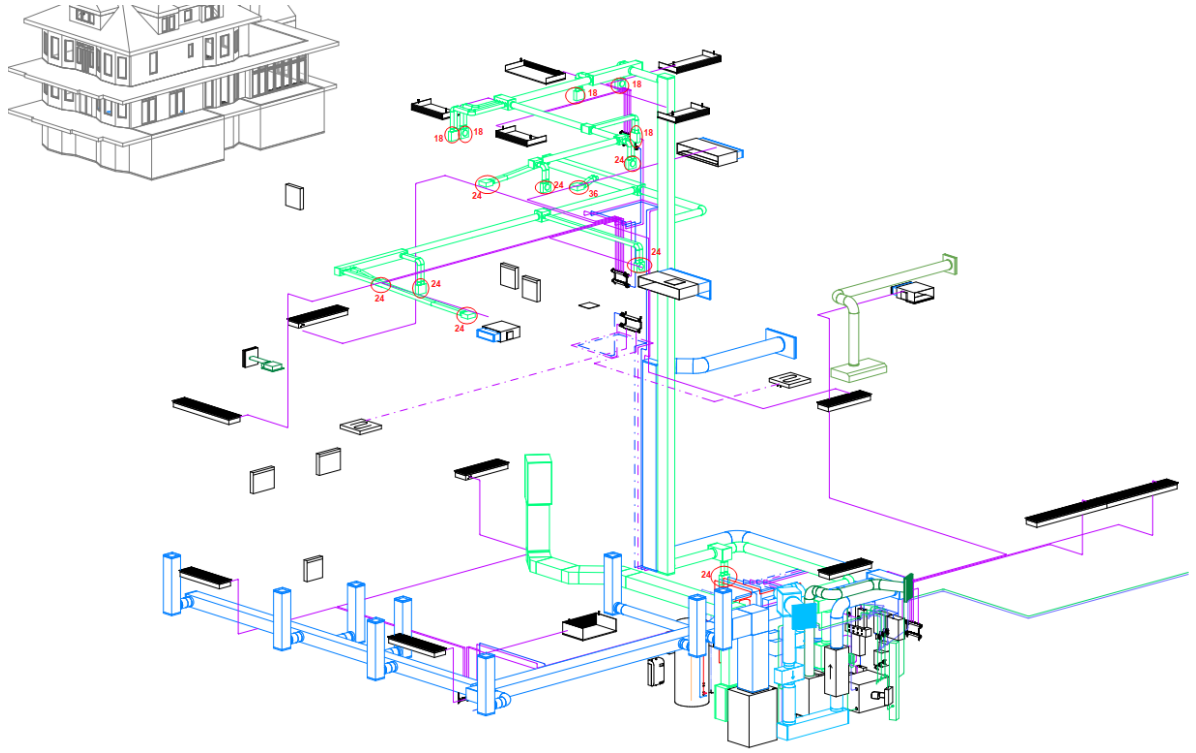
It guarantees the air movement across the entire construction and - if designed properly - should comply with local ventilation code requirements as well.

“Targeted” Distribution System with MEP Design

We are working closely with many MEP firms and architects who understands the Phius approach and believe in our mission with the targeted ventilation design.

Most of the buildings are different but the goal is always the same:

Remove the contaminants, possibly from their source, and introduce fresh filtered air to the living quarters.



Set the airflow rates with commissioning

The commissioning process is the final verification to confirm that your rates are where they should be following the design

- Minimum total continuous supply rate:

15 CFM/occupant required

18 CFM/occupant recommended (WUFI)

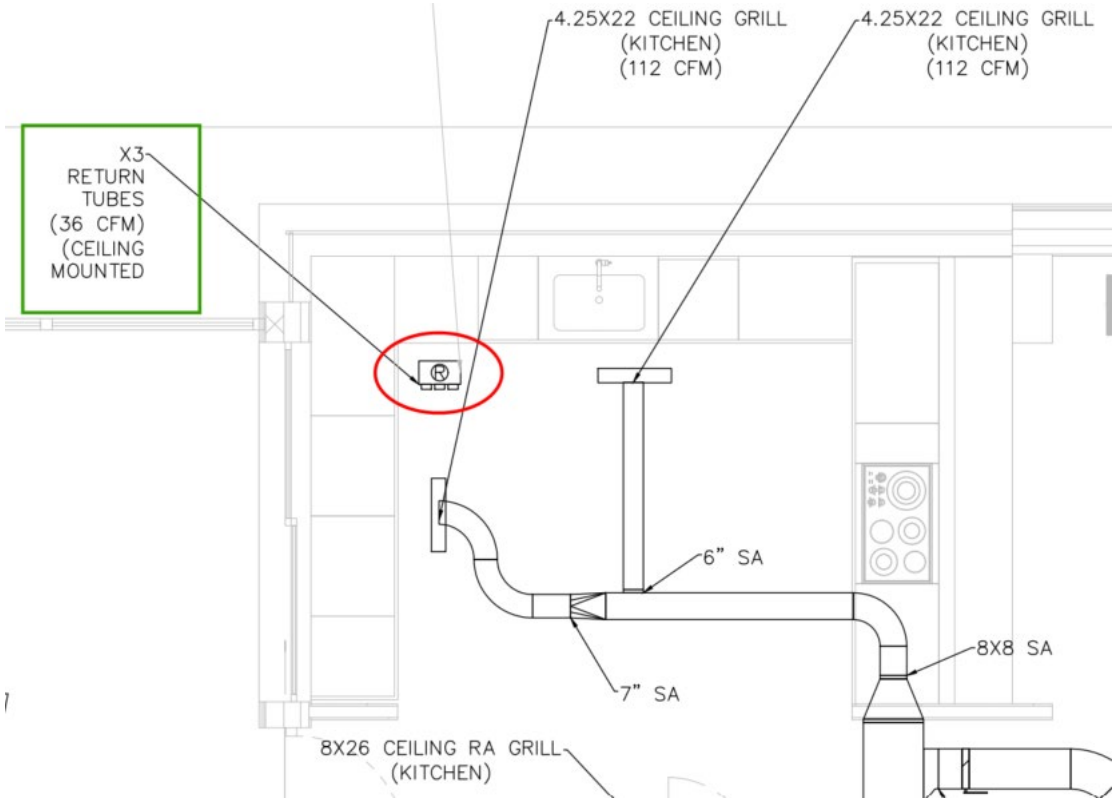
- Minimum total continuous extract rates:

Full bath 20 CFM (< 4 stories)

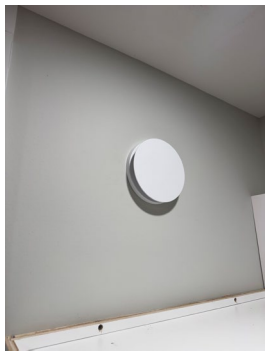
Half bath 20 CFM (< 4 stories)

Kitchen 25 CFM (< 4 stories)

> 4 stories - bath 25 CFM, kitchen 50 CFM



Adjustable airflow rates at the location



Targeted distribution is specifically designed to meet with the Phius requirements, and the system can handle even 1 CFM airflow adjustment.

Use the best option and make it fit for the house design.

It is challenging and sometimes comes with headaches, but there is always a solution.

Filtration

Filtration is a very important part of ventilation.

We always want the best indoor air quality. Proper filtration is the next step after we decide the supply grill location.

Please, think before you install.

Filtration

Advanced systems are using advanced filtration as a basic option.

For better results MERV13 filter should come with every unit. Also, the MERV15 high-performance filter, as well as an active carbon (charcoal) filter should come as an option.

This is almost a necessity in some regions.

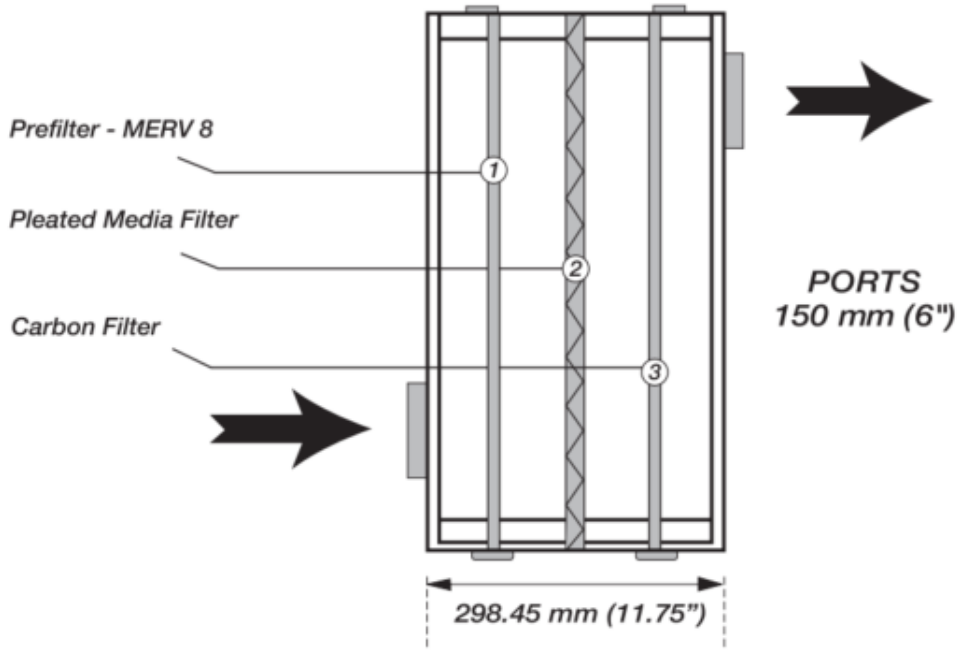
Additional filtration - upstream or downstream?

Additional filters can be applied upstream (before the unit) or downstream (after the unit). Each has its benefits.

Pre-filtration is normally applied using lower quality filter to capture large debris and protect the equipment.

Post-filtration is used to perform precise purification.

A carbon filter can be applied to both



Smart Seasonal Features – Bypass (economizer)

Some H/ERVs also include onboard sensors and seasonal features designed to maximize healthy, comfortable ventilation, while minimizing energy consumption.

Bypass mode (economizer) detects when it's better to ventilate without energy recovery to improve indoor comfort. Like on a cool dry summer evening after a hot day.

This should only be used in certain climates!!!

Modulating Bypass

Smart Seasonal Features – electric pre-heater

Modulating Pre-heater

- Integrated modulating pre-heaters use just enough electricity in winter to maintain continuous, healthy ventilation while avoiding frost that could reduce energy recovery or damage the inside of the heat exchanger.
- No recirculation, always fresh air.

HERV's Recovery Efficiency

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

Recovery efficiency is represented by a recovered percentage of the difference (called 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).

The core recovery efficiency is always less than 100%.

As soon as the outdoor air absolute humidity (AH) is higher than the indoor air AH, ventilation will always introduce additional humidity (without additional dehumidification).

Understanding the numbers

Latent recovery efficiency always calculated with absolute humidity (AH)!!!

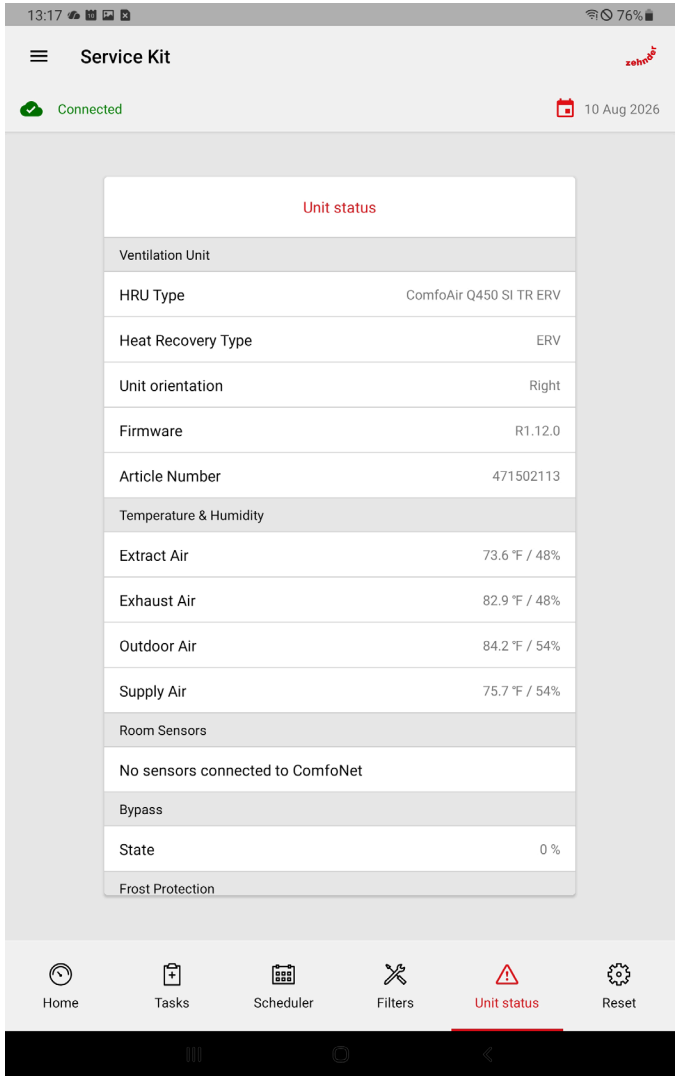
Humid outside - summer

Outdoor 84.2F – 54%RH = 15.525 g/m3

Supply 75.7F – 54%RH = 11.943 g/m3

Extract 73.6F – 48%RH = 9.935 g/m3

Exhaust 82.9F – 48%RH = 13.266 g/m3



Understanding the numbers

Outdoor	15.525 g/m3
Supply	11.943 g/m3
Extract/Inside	9.935 g/m3
Exhaust	13.266 g/m3

Total AH difference between outdoor and indoor

15.525-9.935 = 5.59 g/m3 - #1

Total AH difference between outdoor and supply

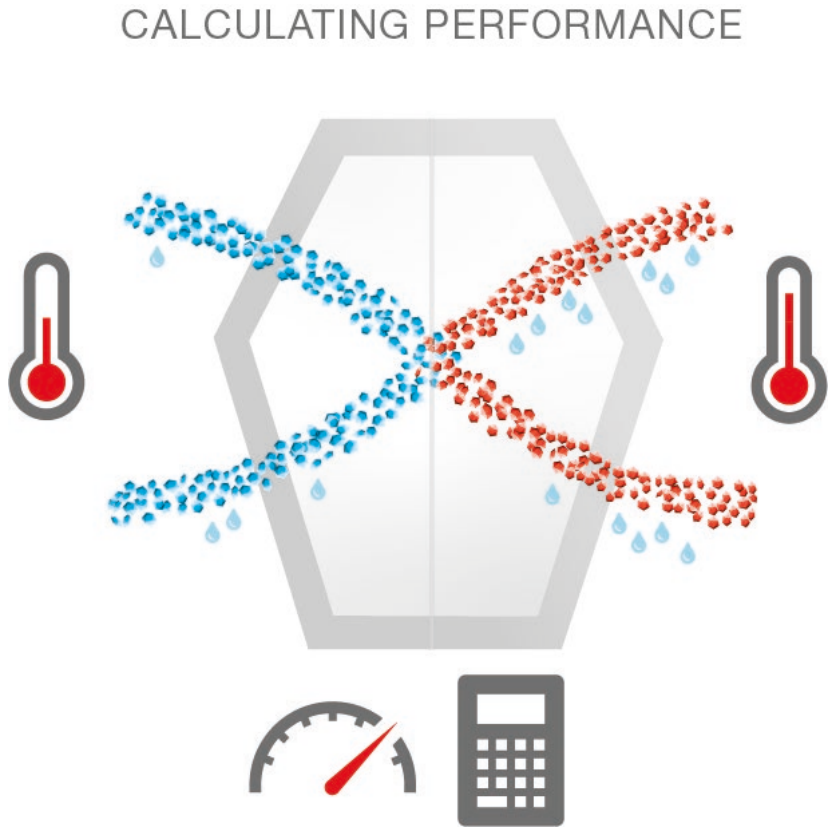
15.525-11.943 = 3.582 g/m3 - #2

Total AH difference between inside and supply – introduced AH

11.943-9.935 = **2.008 g/m3 !!!** - #3

Latent efficiency #2 / #1 3.582/5.59 = 64.1% @ 135CFM

Latent energy loss #3 / #1 2.008/5.59 = 35.9% @ 135CFM



Understanding the numbers

Latent recovery efficiency always calculated with absolute humidity (AH)!!!

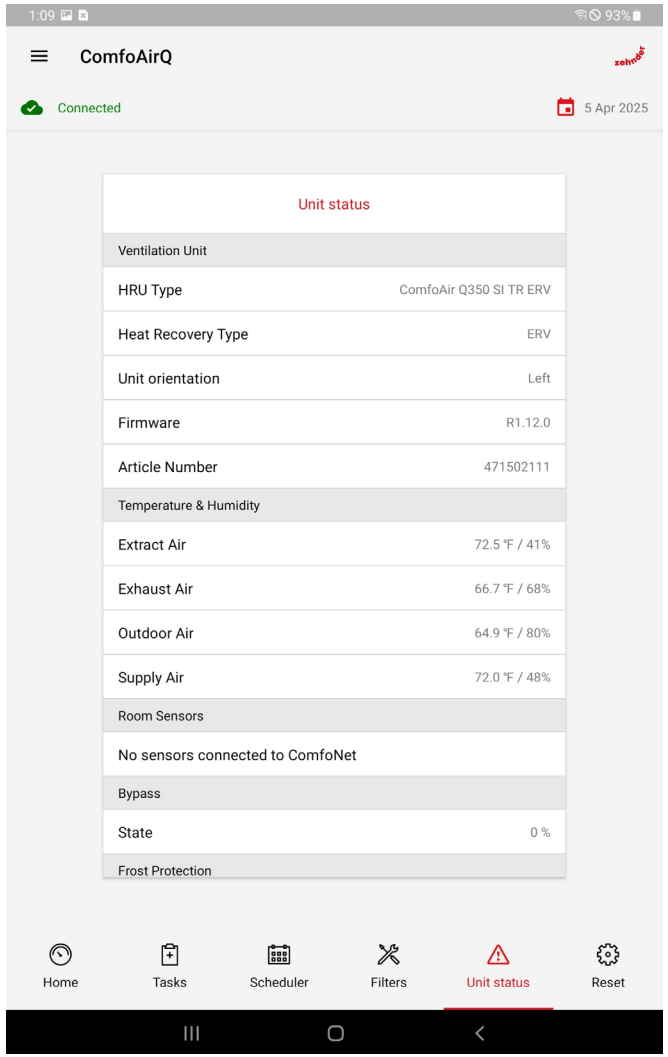
Humid outside - summer

Outdoor 64.9F – 80%RH = 12.497 g/m3

Supply 72.0F – 48%RH = 9.441 g/m3

Extract 72.5F – 41%RH = 8.194 g/m3

Exhaust 66.7F – 68%RH = 11.27 g/m3



Understanding the numbers

Outdoor	12.497 g/m3
Supply	9.441 g/m3
Extract/Inside	8.194 g/m3
Exhaust	11.27 g/m3

Total AH difference between outdoor and indoor

12.497-8.194 = 4.303 g/m3 - #1

Total AH difference between outdoor and supply

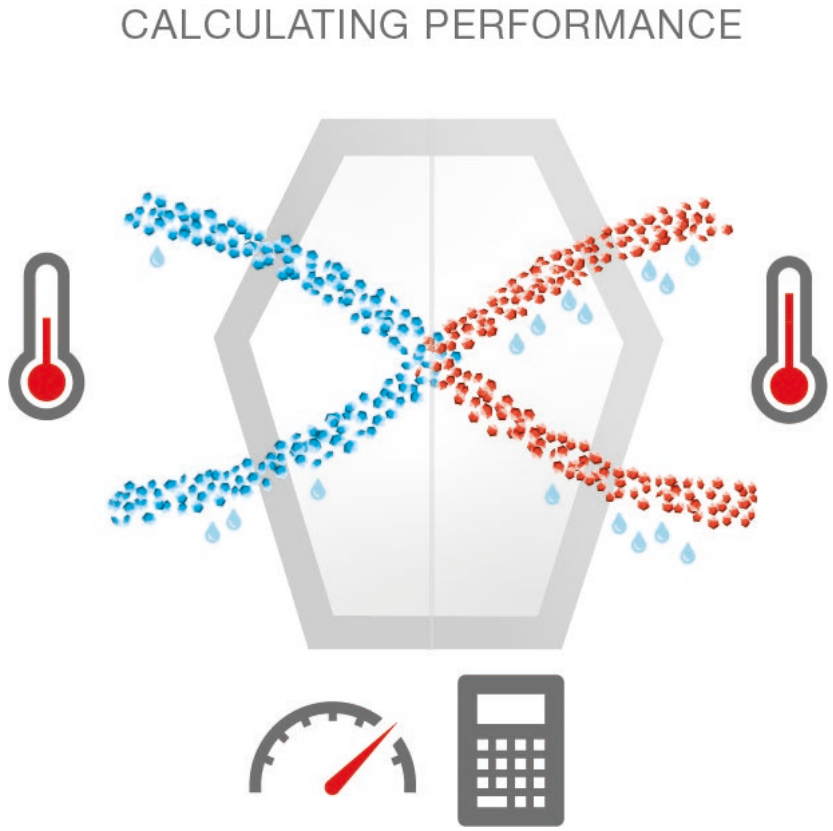
12.497-9.441 = 3.056 g/m3 - #2

Total AH difference between inside and supply – introduced AH

9.441-8.194 = **1.247 g/m3 !!!** - #3

Latent efficiency #2 / #1 3.056/4.303 = 71.1% @ 100CFM

Latent energy loss #3 / #1 1.247/4.303 = 28.9% @ 100CFM



Understanding the numbers

Latent recovery efficiency always calculated with absolute humidity (AH)!!!

Dry outside - winter

Outdoor 31.8F – 73.5%RH = 3.539 g/m3

Supply 66.0F – 40.5%RH = 6.564 g/m3

Extract 71.6F – 40%RH = 7.768 g/m3

Exhaust 40.3F – 75.1%RH = 4.971 g/m3

ELEMENT

ZEHNDER MODEL CAQ450 0°C TEST AT 210 M3/H (58.3 L/S)

AVERAGE VALUES DURING TEST

STATIONS	1 COLD SUPPLY	2 WARM SUPPLY	3 WARM EXHAUST	4 COLD EXHAUST	NET WARM SUPPLY
AIR FLOW std L/S	58.2	58.6	58.9	58.6	58.2
TEMPERATURE °C	-.1	18.9	22.0	4.6	19.0
R.H. %	73.5	40.5	40.0	75.1	
DEW POINT °C	-3.8	5.2	7.8	.5	
HUMIDITY RATIO	.0028	.0055	.0066	.0040	.0055
ENTHALPY KJ/KG	6.9	33.0	38.9	14.5	33.0
ENERGY CONTENT KW	.48	2.32	2.75	1.02	
STATIC PRESSURE Pa	-30	30	-31	33	(Initial)
STATIC PRESSURE Pa	-31	30	-31	33	(Final)

CASE TEMP(D) 20.3°C AMBIENT TEMP 22.0°C TOTAL READINGS 60

H/ERV SURFACE MEASUREMENT	2.35 m²		
CALCULATED EXTERNAL INPUT	.12 KW		
FROM ABOVE AVERAGES	-.19 KW		

CALCULATIONS (ADJUSTED FOR CROSS-LEAKAGE)

SENSIBLE ENERGY RECOVERED	4819 KJ	1.339 KWH	1.339 KW
SENSIBLE ENERGY EXHAUSTED	5622 KJ	1.562 KWH	1.562 KW
SENSIBLE RECOVERY EFFICIENCY	80.2 %		
ADJUSTED SENSIBLE RECOVERY EFFICIENCY	82.0 %		
TOTAL ENERGY RECOVERED	6560 KJ	1.822 KWH	1.822 KW
TOTAL ENERGY EXHAUSTED	8124 KJ	2.257 KWH	2.257 KW
TOTAL RECOVERY EFFICIENCY	77.0 %		
ADJUSTED TOTAL RECOVERY EFFICIENCY	78.2 %		
WATER RECOVERED	.69 Kg		
WATER EXHAUSTED	.97 Kg		
LATENT PERFORMANCE COEFFICIENT	.71		

Understanding the numbers

Outdoor	3.539 g/m3
Supply	6.564 g/m3
Extract/Inside	7.768 g/m3
Exhaust	4.971 g/m3

Total AH difference between outdoor and indoor

7.768-3.539 = 4.229 g/m3 - #1

Total AH difference between outdoor and supply

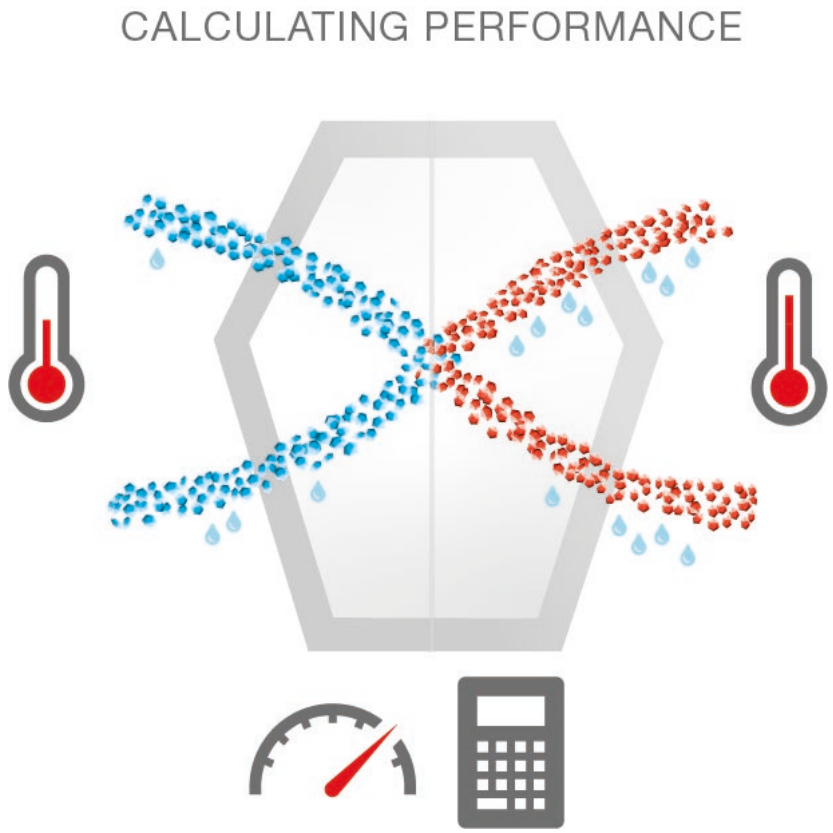
6.564-3.539 = 3.025 g/m3 - #2

Total AH difference between inside and supply – reduced AH

7.768-6.564 = **1.204 g/m3 !!!** - #3

Latent efficiency #2 / #1 3.025/4.229 = 71.5% @ 123CFM

Latent energy loss #3 / #1 1.204/4.229 = 28.5% @ 123CFM



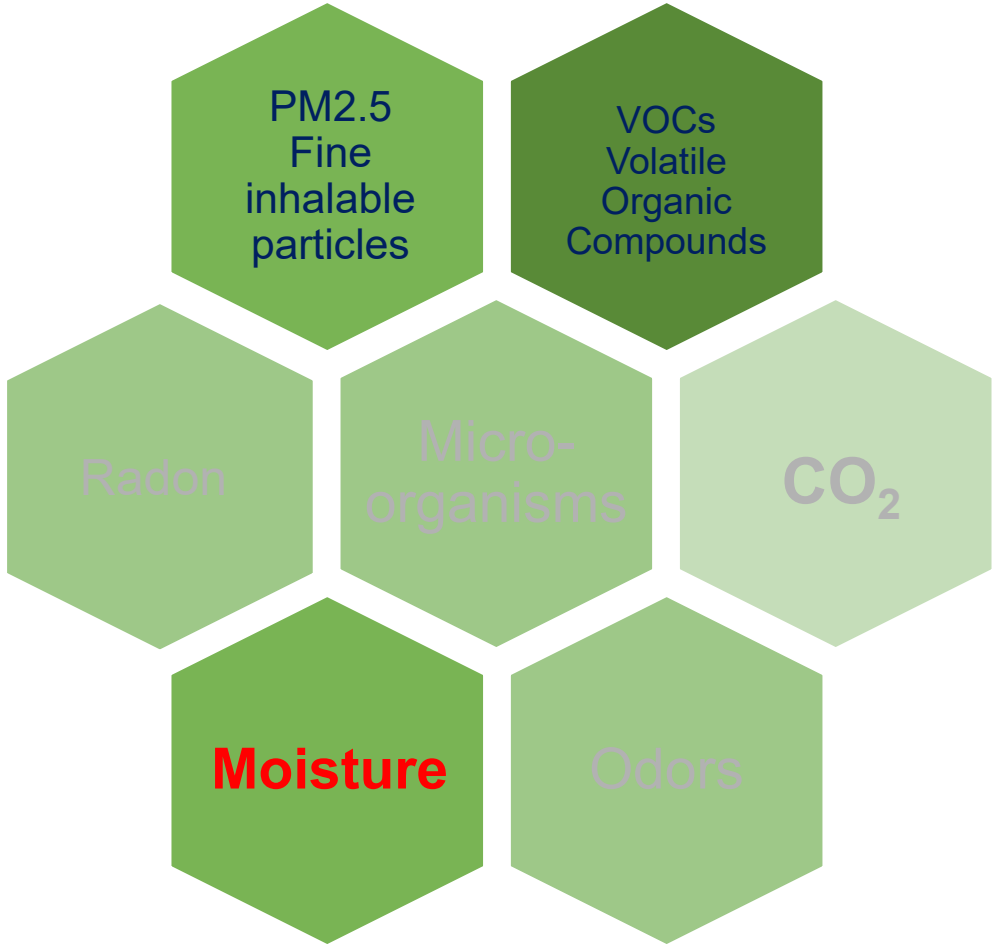
Typical Indoor Air Contaminants

Do you remember these most common contaminants?

Unfortunately, moisture is one of them and it is a major concern when we deal with ventilation.

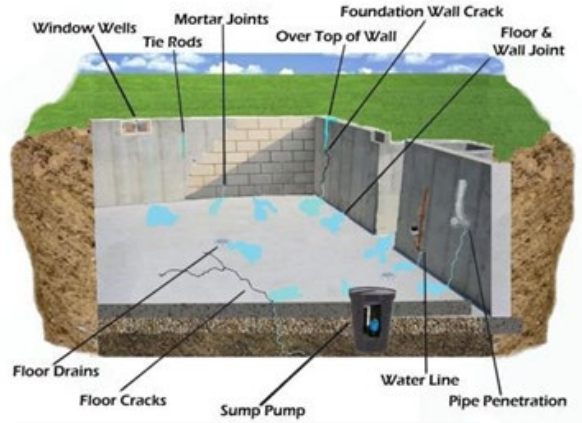
Many high-performance homes with mechanical ventilation could have relative humidity problems.

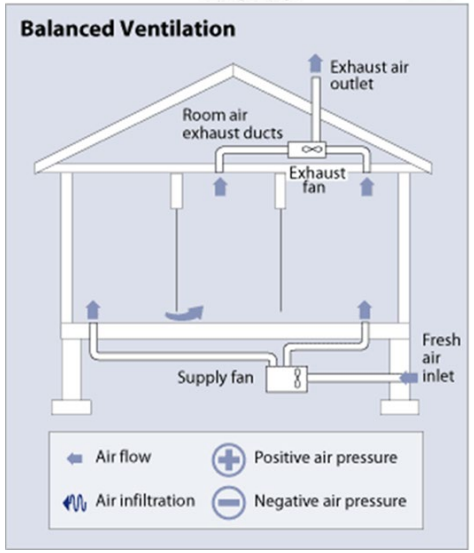
There are multiple reasons why.



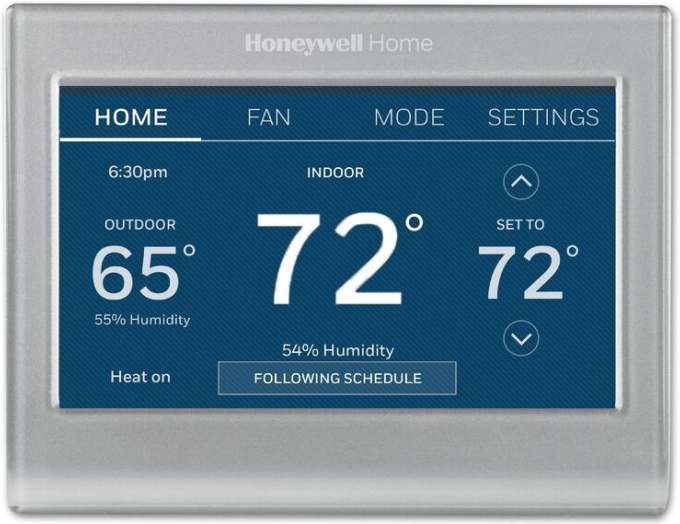
The source of humidity

- Construction material (concrete, paint, spackle, etc.)
- Occupant's living style (plants, fish tank, cooking, steam shower, etc.)
- Ventilation





Why AC's have hard time dealing with high indoor humidity?



Indoor dehumidification is normally based on the operation of the AC system, which in most cases, operates based on the indoor temperature settings. Dehumidification is a simple byproduct of cooling with AC.

Man-J calculation verifies the amount of sensible and latent heat needed to be removed to keep the IAQ on a proper level. Man-S directs us to the right equipment size. Even when all these calculations are done properly, we still could have high-humidity issues. WHY?

High-performance homes are well insulated and airtight. Due to that, they don't gain enough sensible load to operate the AC system long enough to properly remove the latent load. They are technically **short cycled on latent load removal**.

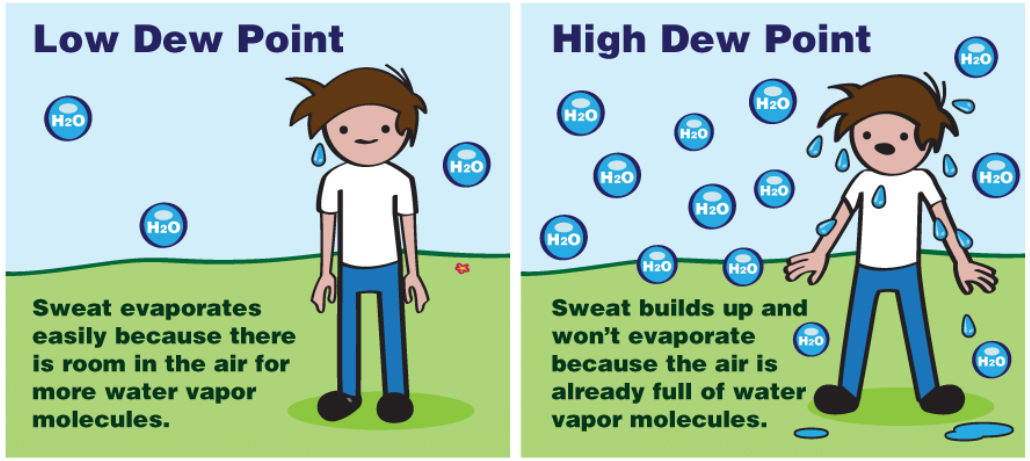
Some systems have "dry mode" option, which works great on latent removal; however, it can overcool the house because the dehumidification is still based on the cold evaporator surface.

High SEER = lower latent load removal

Higher SEER units often have lower latent (moisture) removal capacity because they prioritize sensible cooling (temperature reduction) to achieve efficiency ratings, often resulting in higher Sensible Heat Ratio and lower latent capacity.

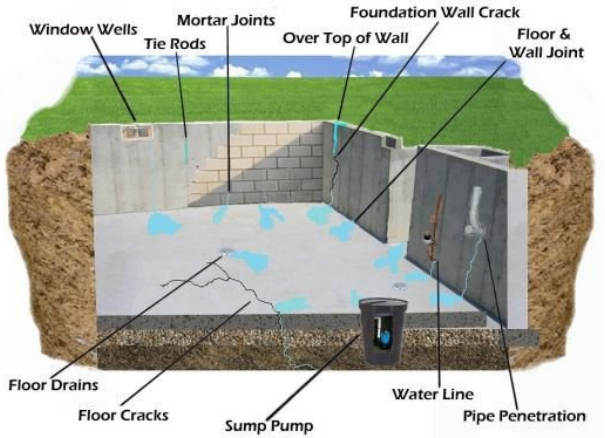
High-efficiency systems (17+ SEER) often use two-stage or variable-speed compressors that run longer at lower speeds, which can improve dehumidification compared to single-stage units.

To compensate for reduced latent capacity, you should have proper system sizing, utilize variable-speed equipment, or install supplemental dehumidification.



Better sensible load removal = Shorter running time = Less latent load removal

What is the best solution to reduce high indoor humidity?



- Reduce the amount of moisture
  - Repair the air and water leaks
  - Lower internal gain of humidity (less plants or fishtanks)
  - Use vented range hood with make-up air system
  - Get the proper mechanical ventilation equipment (ERV)
- **Dehumidification strategy**
  - Design your HVAC system properly
  - Install supplemental whole home dehumidifier

What is the best solution to increase low indoor humidity?

Indoor humidification is normally based on the IAQ requirements and achieved with designed humidification strategy.
Homes, in dry climate zones or during cold winter days, should have a properly designed humification system. This system should keep indoor humidity between 30-45 RH%. Higher humidity level during cold weather condition can cause condensation on cold surfaces by reaching the dew point easier.

What is the future of ventilation?

- Core efficiency is almost maxed out; it is up to (90-95%)
- Fan efficacy is pretty good (4-5 CFM/Watt)

Not much more we can improve on these efficiency details

What is the future of ventilation?

Ventilation requirements should shift towards demand-controlled ventilation

- Demand Ventilation with IAQ sensors across the building – minimal human interaction
- Building automation (BAS) connectivity (ModBus)

When will the code recognize demand ventilation?

Code required ventilation (IRC, IMC) is great to start with, but in high-performance construction homes, it misses a lot of details which can significantly impact the IAQ.

We must start the conversation with code officials about the acceptance of demand-controlled ventilation details as an additional code recognized option.

The actual ventilation level should vary based on the actual IAQ details.

When you need more, you ventilate more. When you need less, you ventilate less! There is no “fit for all” rule, every home is unique.

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