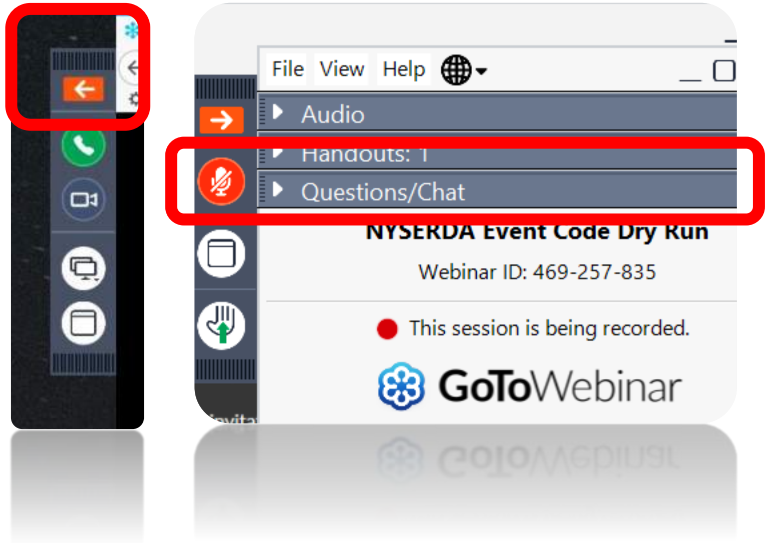
All attendees have been placed on mute.

Use the Question Section on the webinar control panel to ask a question at anytime during the presentation.

Q&A will take place at the end of each segment.

Webinar will be recorded and sent.

Webinar Overview



Submit Responses via PollEverywhere

- Respond at PollEV.com/swa335
- Or text swa335 at 22333 to join, then send your answer

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Take energy efficiency to a new level

Residential New Construction Passive House Multi-family buildings with five units or more

PASSIVE HOUSE INCENTIVE STRUCTURE FOR MULTI-FAMILY (5 UNITS OR MORE)				
Incentive Timing	**Activity**	**Incentive Amount**	**Max Incentive (Per Unit)**	**Max Incentive (Per Project)**
Pre-Construction	Feasibility Study[1]	Up to 100% of Feasibility Study Costs	N/A	$5,000.00
	Energy Modeling[2]	75% of Energy Modeling Costs (Before 90% Design Drawings)	$500.00	$30,000.00
		50% of Energy Modeling Costs (90% Design/50% Construction)	$250.00	$15,000.00
Post Construction	Certification[3]	Up to 100% of Certification Costs	$1,500.00	$60,000.00

1. Feasibility Study will require documentation in the form of a Feasibility Study report and invoice from the Passive House Consultant
2. Incentives will only be awarded prior to 50% Construction Drawings for Passive House projects. No incentives will be granted after 50% Construction Drawing set.
3. Certification may be either through PHIUS, PHI, or EnerPHit certification offerings.

Workshop 3
High Performance Ventilation

Steven Winter Associates, Inc.



Since 1972, Steven Winter Associates, Inc. has been providing research, consulting, and advisory services to improve the built environment for private and public sector clients.

Our services include:

- Energy Conservation and Management
- Decarbonization
- Sustainability Consulting
- Green Building Certification
- Accessibility Consulting

Our teams are based across four office locations:
New York, NY | Washington, DC | Norwalk, CT | Boston, MA

For more information, visit
www.swinter.com

Learning Objectives

Understand the principles of ventilation and air movement

Identify various types of heat recovery ventilation equipment

Describe occupant and building issues resulting from improper ventilation

Develop a successful ventilation system layout plan

Overview of Presentation

5 min break
~2:50 PM

Wrap Up
~4:00 PM

1. High Performance Basics
2. Review the basics of ventilation
3. Identify common layouts and system approaches along with filtration

When poll is active, respond at **pollev.com/swa335**

Text **SWA335** to **22333** once to join

What is your profession?

A. Architect

B. Engineer

C. Contractor/CM

D. Owner/Developer

E. Consultant

F. Other

What is the one thing that you were hoping to learn about today? (hint: link words with an underscore)

Why are We Here

- Push for Building Electrification (Passive House as a pathway)
- Incentives available
- Benefits
  - Drastically lower energy use and operational cost savings
  - Healthy air quality from ventilation systems
  - Consistent and comfortable room temperatures without air drafts
  - Increased natural lighting and quieter acoustic conditions
  - A more resilient and comfortable building

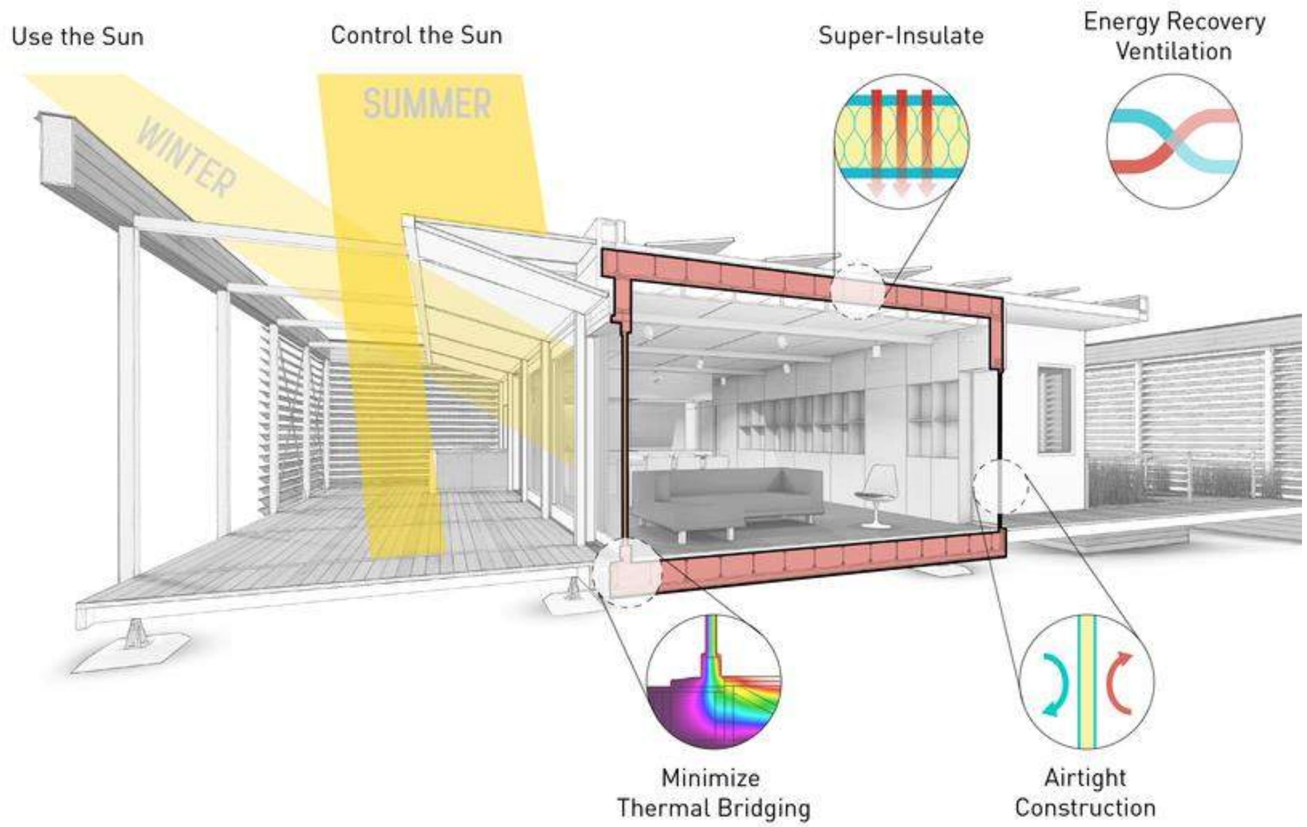
These **Trainings - Each has two parts**

- **Workshop 1:** Continuous Insulation
- **Workshop 2:** Air Sealing and Insulation for Homes
- **Workshop 3:** **High Performance Ventilation Systems for Homes**

High Performance Basics

Goals of High Performance Buildings

- Building durability
- Energy $ reduction
- Optimal thermal comfort
- Superior indoor air quality
- Carbon emissions reductions



The SURE House

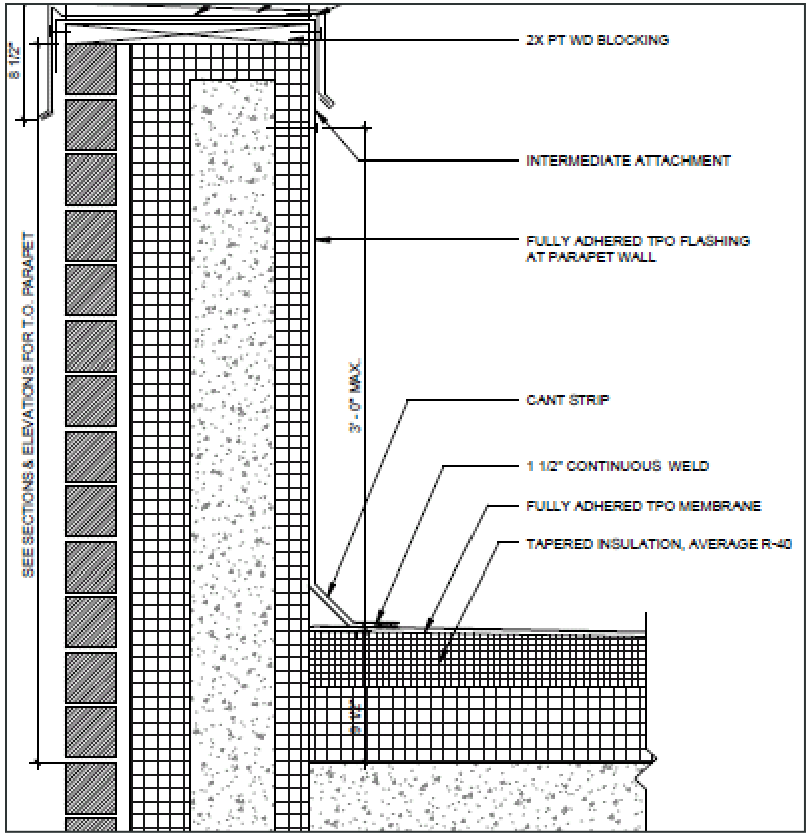
Winner of the 2015 D.O.E. Solar Decathlon

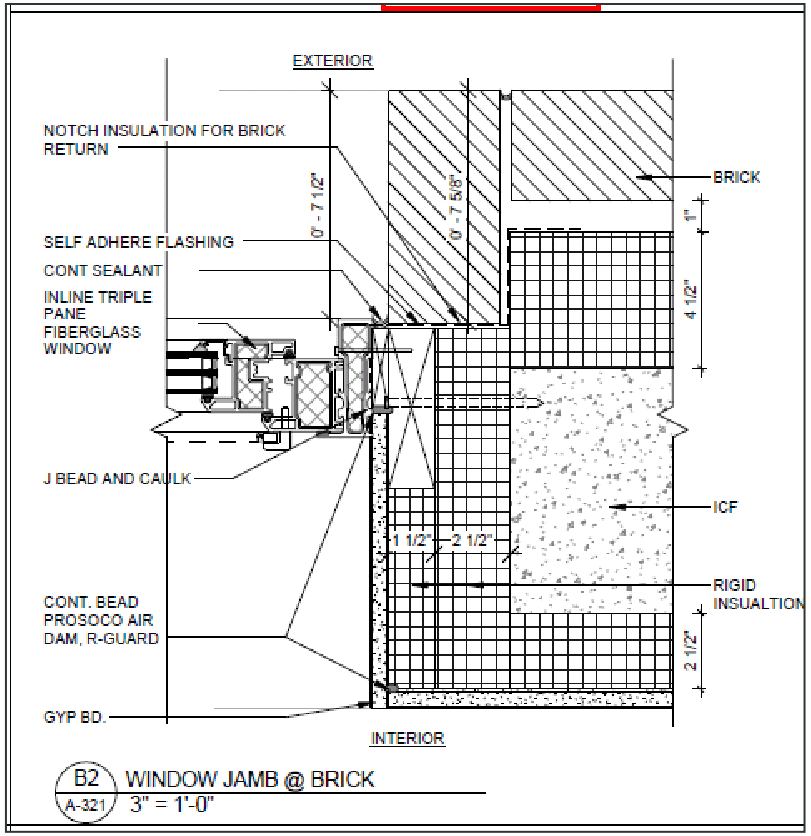
www.surehouse.org

Passive House
as a Pathway to High Performance

- Thermal insulation continuity
- Thermal bridge free construction
- Solar control
- Airtightness
- Balanced mechanical ventilation

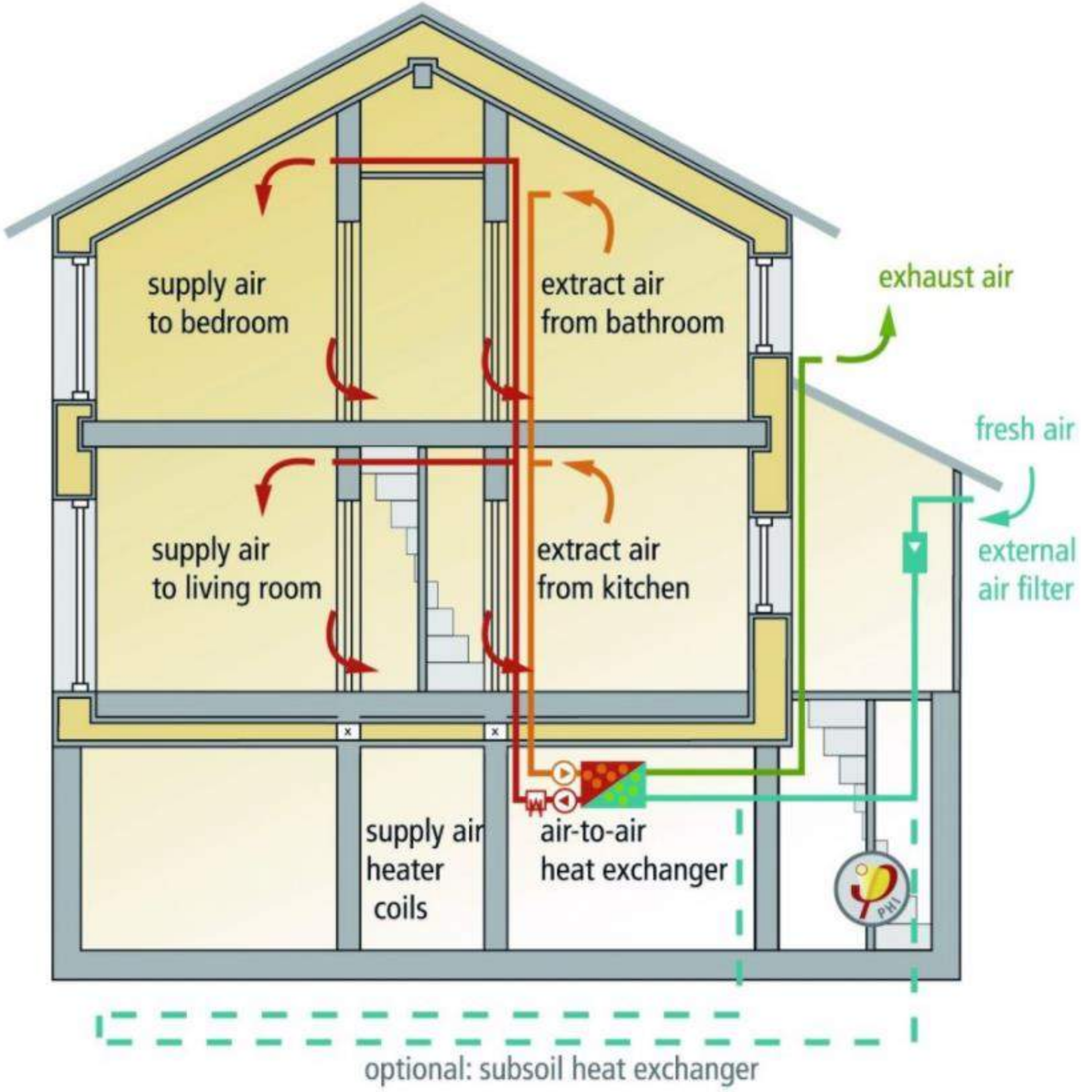
Continuous Insulation





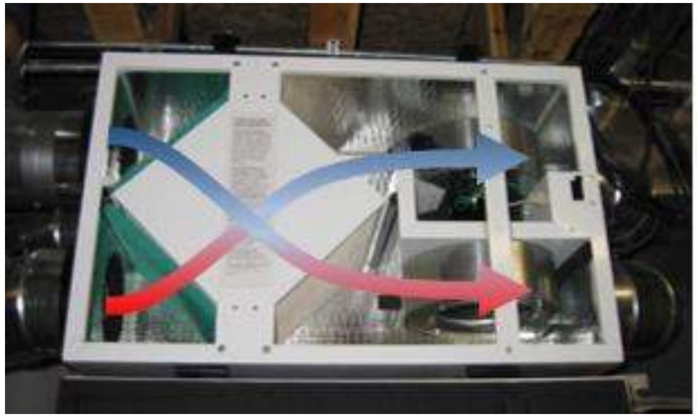
Air-Tightness Blower Door Testing

- Basic Components
  - Gauge (manometer)
  - Shroud
  - Frame
  - Fan



Balanced Ventilation and Heat/Energy Recovery

- Provide fresh, filtered air 24 hours a day
- Heat exchanger +75% Efficient
- Highly insulated and air-sealed ductwork



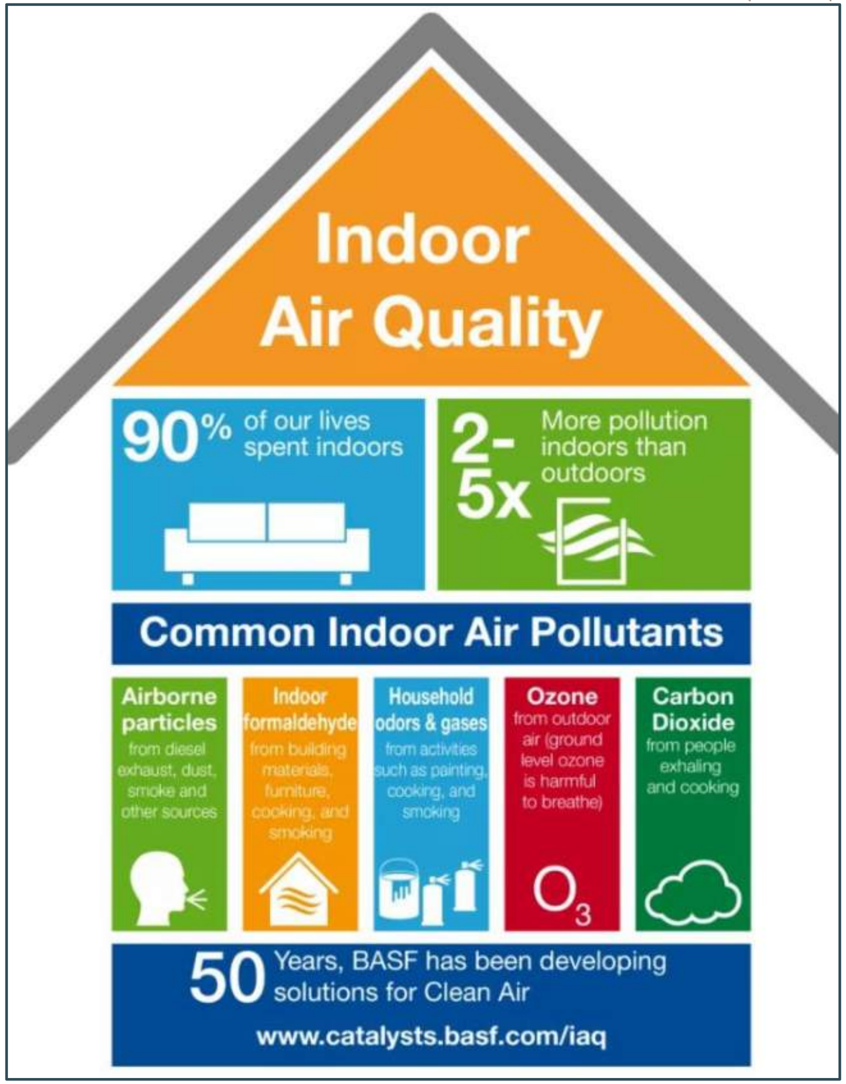
Questions?

Ventilation Basics

IAQ - Indoor Air Quality

Chemical/Substances of Concern include:

- Carbon monoxide
- Tobacco smoke
- Nitrogen dioxide
- Radon
- <u>Certain</u> Volatile Organic Compounds (VOCs)
  - Formaldehyde, benzene, etc.
- PM 2.5 (particulate matter, 2.5 micron range)
- Water
  - Rot, mold and other fungi
- Bacteria, viruses

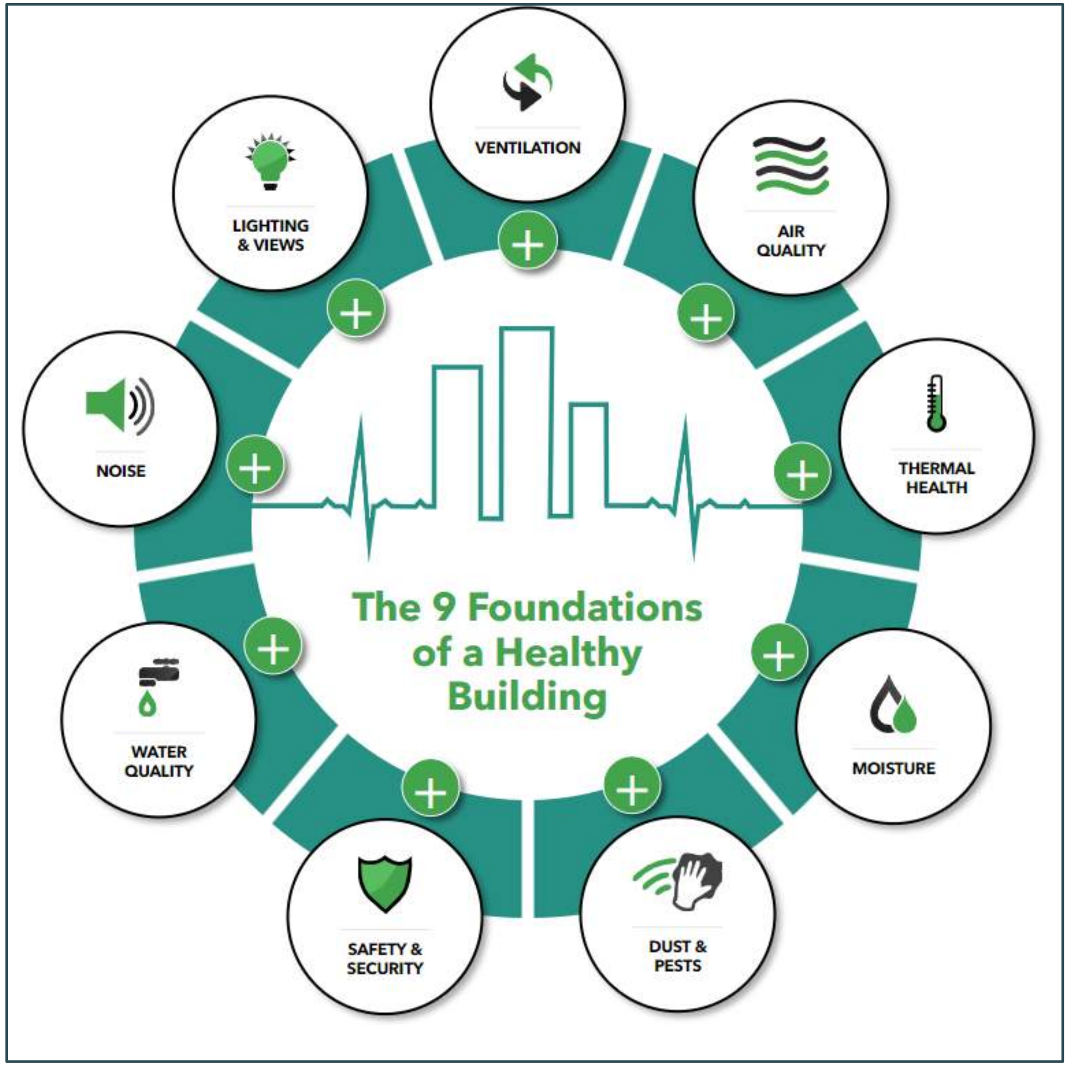


Eight Healthy Home Principles (HUD)

1. Keep it Dry
2. Keep it Clean
3. Keep it Safe
4. *Keep it Well-Ventilated*
5. Keep it Pest-free
6. Keep it Contaminant-free
7. Keep it Well-Maintained
8. Maintain Thermal Control

Nine Foundation of a Healthy Building (Harvard)

1. *Ventilation*
2. Air Quality
3. Thermal Health
4. Moisture
5. Dust & Pests
6. Safety & Security
7. Water Quality
8. Noise
9. Lighting & Views



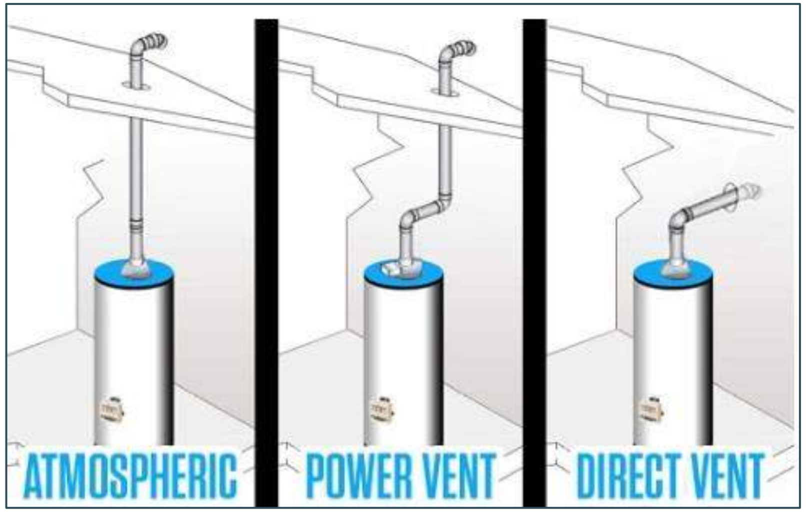
https://9foundations.forhealth.org/

Programs - Resources for Reference

	ENERGY STAR	Indoor Air Plus / PHIUS	Enterprise Green Communities	LEED for Homes	WELL	Fitwel
Environmental Tobacco Smoke			✓	✓	✓	✓
Biological contaminants	✓	✓	✓	✓	✓	✓
Combustion byproducts	✓	✓	✓	✓	✓	
Household products/practices			✓	✓	✓	✓
Toxic materials		✓	✓	✓	✓	✓
Radon		✓	✓	✓	✓	
Safety and security						✓
Diet & Exercise			✓	✓	✓	✓

Beyond Ventilation and Filtration

- Keep water out
  - Precipitation
  - Ground water
  - Plumbing leaks
  - etc.
- Combustion safety, better yet no combustion
- Keep pests out
- Avoid/minimize toxic materials in homes
  - Furniture, coatings, sealants
- Don’t smoke (indoors). Or period.



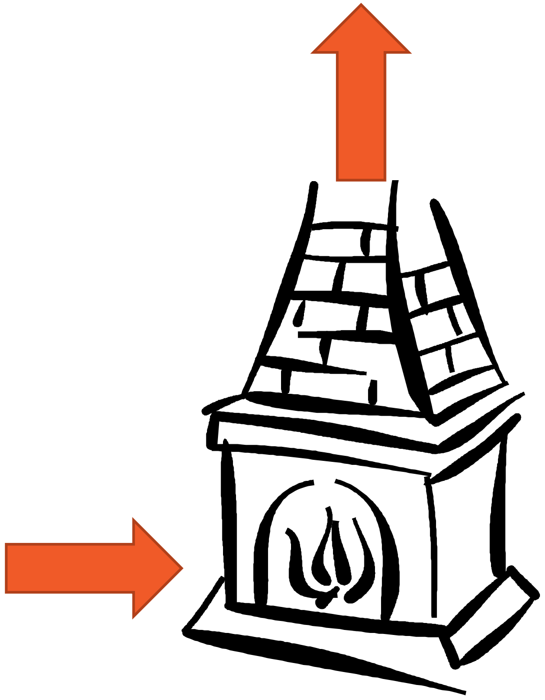
Why Ventilate?

To get contaminants out!

- Efficient homes are more air-tight
- Different materials, new pollutants

We're not talking about:

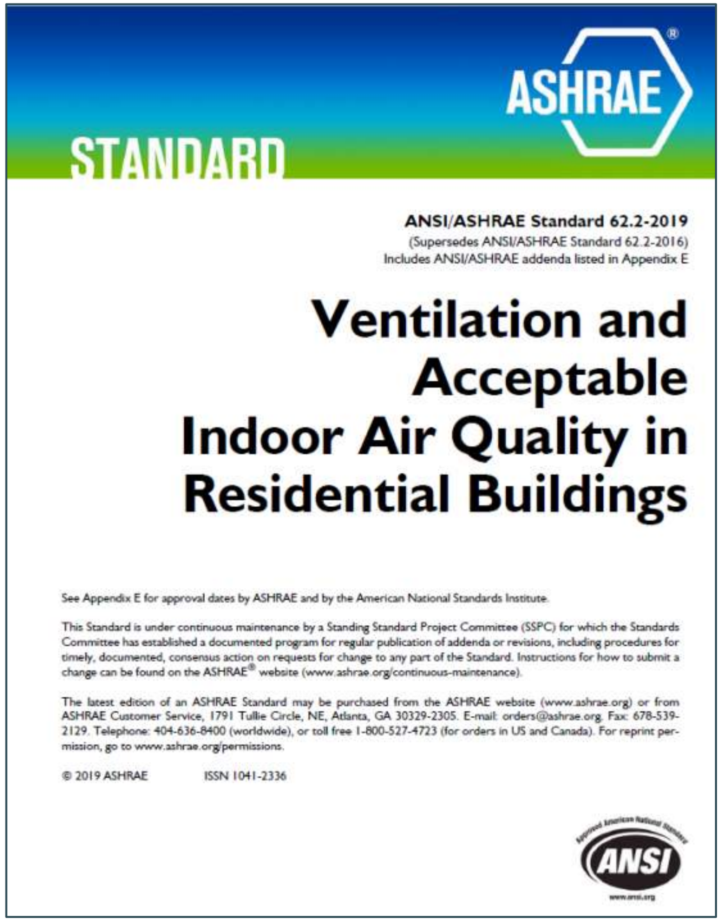
- Combustion venting & Make-up air



(We <u>will</u> talk about possible interactions between ventilation and combustion!)

ASHRAE 62.2

- The standard describes the minimum requirements to achieve acceptable IAQ via dwelling-unit ventilation, local demand-controlled exhaust, and source control.



ASHRAE - Definitions

ASHRAE defines ventilation as: the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.

ASHRAE defines ventilation air as: the minimum amount of outdoor air required for the purpose of controlling air contaminant levels in buildings.

Two Basic Ventilation Areas

- **Dwelling Unit Ventilation** is intended to dilute the unavoidable contaminant emissions from people, from materials, and from background processes.

- **Local Exhaust** is intended to remove contaminants from those specific rooms (e.g. kitchens and bathrooms) that, because of their design function, are expected to contain sources of contaminants.

Local Exhaust - Intermittent

Room	62.2-2019 Requirement
Kitchen	100 cfm vented hood -OR- 300 cfm
Bathroom	50 cfm

*Way oversimplified - actual standard has much more detail.

Local Exhaust - Continuous

Room	62.2-2019 Requirement
Kitchen	5 ach (kitchen volume) Ex: 150 ft^2 kitchen req. ~100 cfm
Bathroom	20 cfm

*Way oversimplified - actual standard has much more detail.

Passive House - Typical Rates

Room	Continuous
Kitchen	25 cfm (boost to 35)
Bathroom	20 cfm

- All exhaust goes through an ERV or HRV – no unbalanced ventilation
- HRV/ERV intakes typically CANNOT be directly over range

Passive House vs. 62.2

It's hard (impossible?) to comply with both!

Range Hoods

- “Ducted” or “Vented means no recirculation
- Many range hoods are recirc, and do not go directly outdoors

Range Hood Best Practices

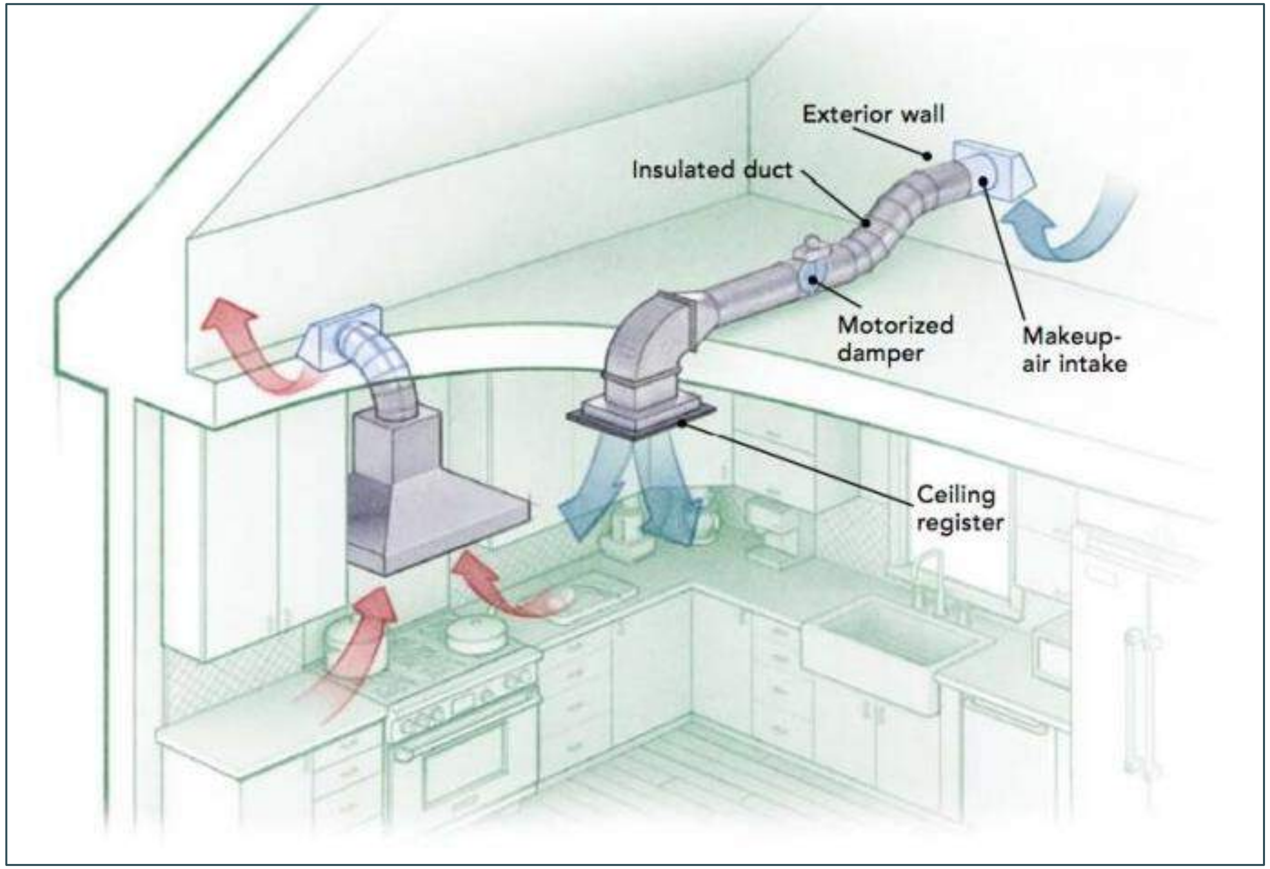
- Cover all burners
  - Use back burners more often
- Capture efficiency (coming soon)
- Quiet and efficient hoods

See "Range Hood Advice from IAQ Researcher:
https://indoor.lbl.gov/news/article/range-hood-advice-indoor-air-quality

Podcast with LBNL: https://www.swinter.com/why-is-kitchen-ventilation-so-important-with-dr-iain-walker-from-lbnl/

Make Up Air with Kitchen Hoods

- Makeup air sometimes required for kitchen hoods > 400 CFM (IRC)
- Do you really need a kitchen hood with flow > 400 CFM?
- You may still need makeup air if < 400 cfm.



Make Up Air with Kitchen Hoods

Before Makeup Air:
-11 Pa worst-case depress.
Range hood: 124 cfm
Bath exhaust: 48 cfm

Non-starter with fireplace (insert)

Added 6” duct with damper tied to range hood.

Worst-case: **-3 Pa**

Common Approaches (Non-PH)

Bath Fans

- ENERGY STAR
- Sound (<1 sone)
- Static Pressure & Flow
- Variable speed is great
- Other controls if desired (e.g. timers, RH sensors)
- <15 Watts

Kitchen Hoods

- ENERGY STAR
- Sound
- Static Pressure & Flow
- Capture Efficiency
  - coming soon...?
- Automatic Controls (senses cooking)

Dwelling Unit Ventilation

"Dwelling-unit ventilation is intended to dilute the unavoidable contaminant emissions from people, materials, and background processes."

(ASHRAE 62.2-2019)

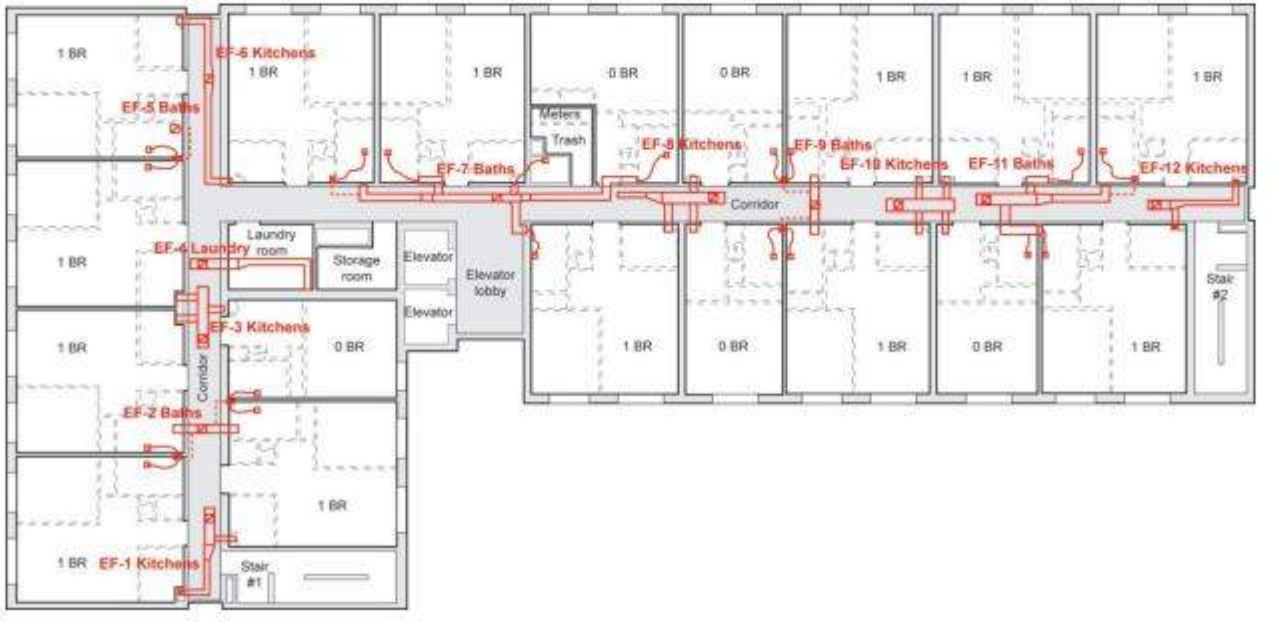
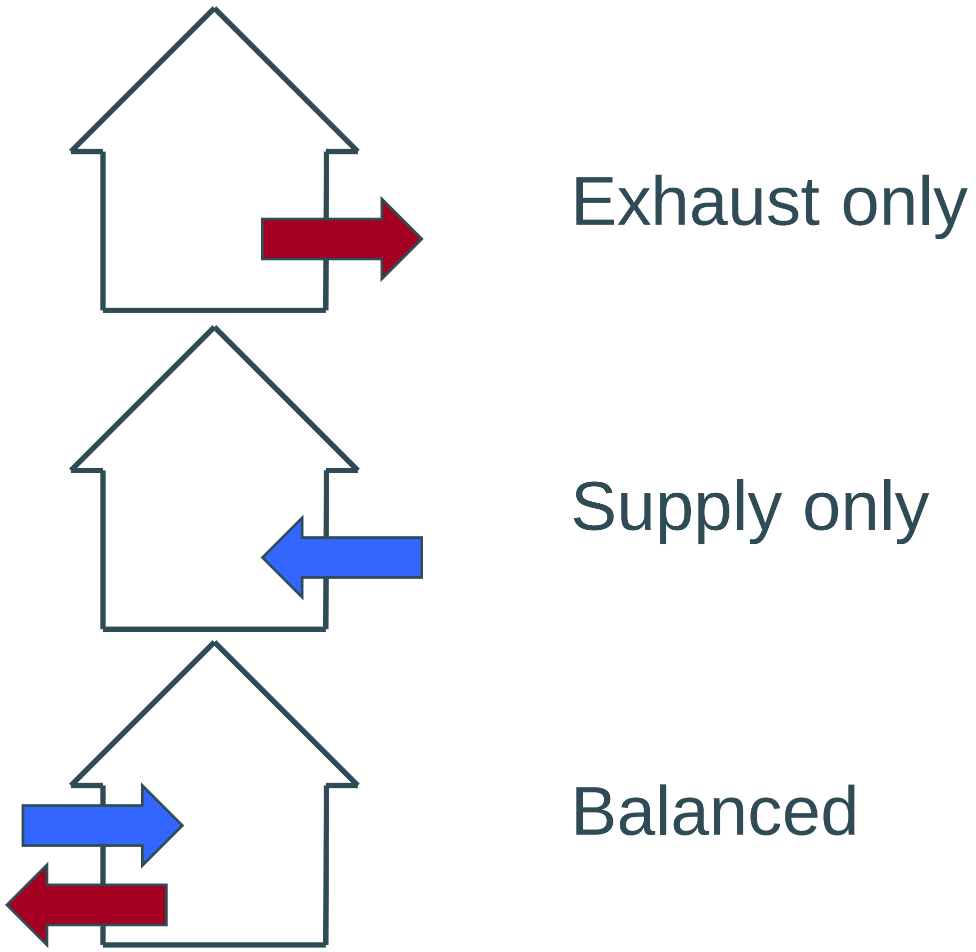


Figure 16. Typical floor plan, showing kitchen/bath exhaust systems and risers

Dwelling Unit / Whole House Ventilation

- Three basic types
- Pros and cons to each
- Code requirements, program requirements, best practices



What type of ventilation system do you typically see on your projects?

A. Exhaust only

B. Supply only

C. Balanced supply and exhaust

D. Not sure

Exhaust Only Ventilation

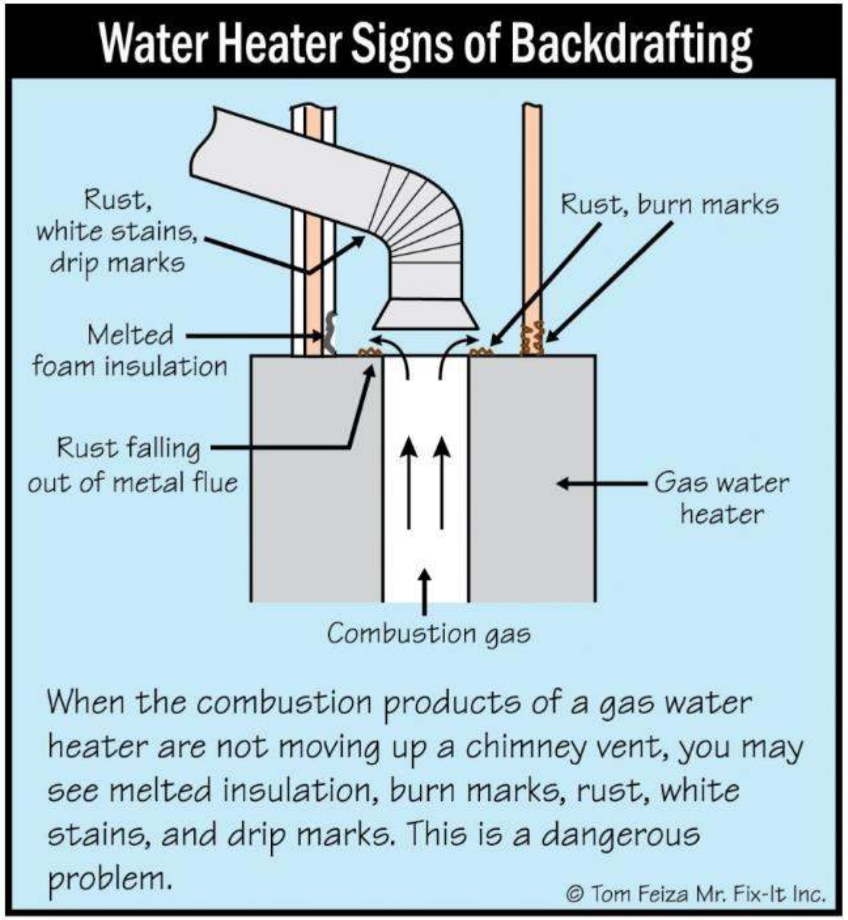
- Efficient bath exhaust fan(s) running continuously or on timer

MAJOR concern with Exhaust Only:

…where does make-up air come from?

Potential Make Up Air Problems

- Combustion – Back drafting
  - (no exhaust only with atmospheric combustion)
- Moldy, nasty crawlspaces/basements
  - Potential Radon concerns
- Attached garages
- Neighbor’s apartment or condo



Exhaust Only Pros & Cons

- Simple!
- Easy installation
- Low cost
- Low maintenance
- Low power
  - (best fans 6-12 Watts)

- Make up air concerns
- Distribution / Mixing

Exhaust Only - Execution

- Assess risks (e.g. backdrafting)
- Evaluate existing systems
  - flow rates, pressures
  - find outlet
- Terminate outdoors
- Efficient ECM product
- Duct runs as short and straight as possible/practical

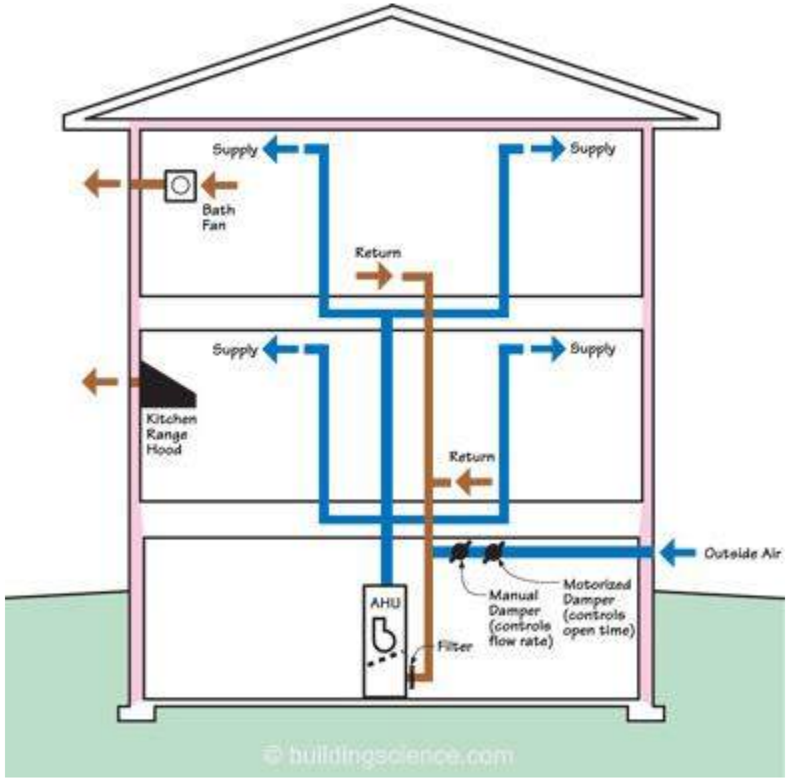
Exhaust Only - Commission

- Verify the flow rates
- Set timer, controls appropriately
- Proper measuring device, especially for low flows

What are some issues that you have seen with exhaust only systems? (hint: link words with an underscore)

Supply Only Ventilation

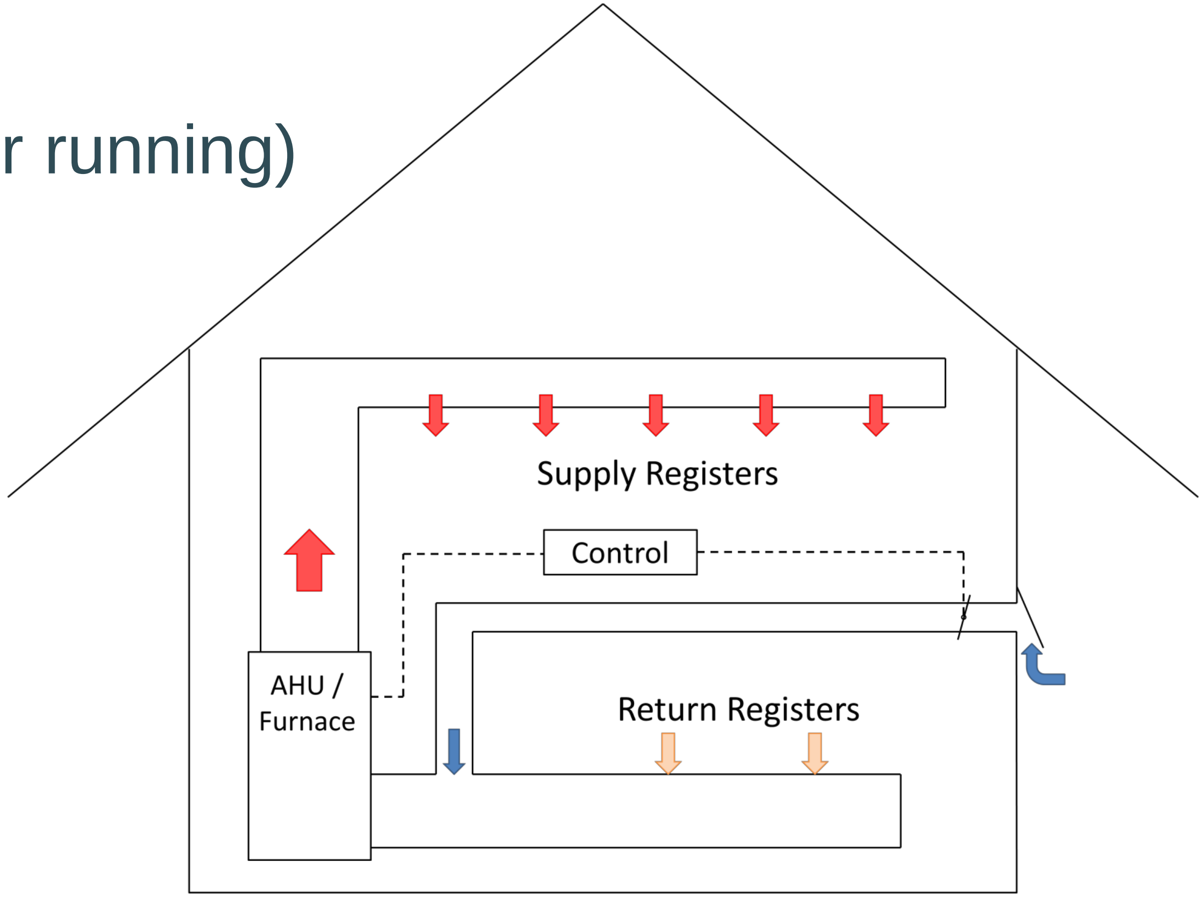
- Supply integrated with central furnace / AC / AHU
  - Central Fan Integrated Supply (CFIS)
- Typically seen by SWA with a booster fan, not through AHU.



Supply Only Ventilation CFIS

Advantages:

- Good distribution (when air handler running)
- Relatively low cost
- Low maintenance



Disadvantages:

- Electricity use of AHU
  - 250 – 1100 Watts
  - Newer equipment is much better!
- Duct leakage losses

Supply Only Ventilation CFIS Implementation

- Only use with efficient furnace fans (ECM, BPM, variable-speed fan motors)
- Need tight ducts!
- Motorized damper wired correctly
- Locate OA intake properly
  - Above snow
  - Away from exhaust
  - Away from other contaminants (e.g. BBQs)

Supply Only Ventilation CFIS Implementation

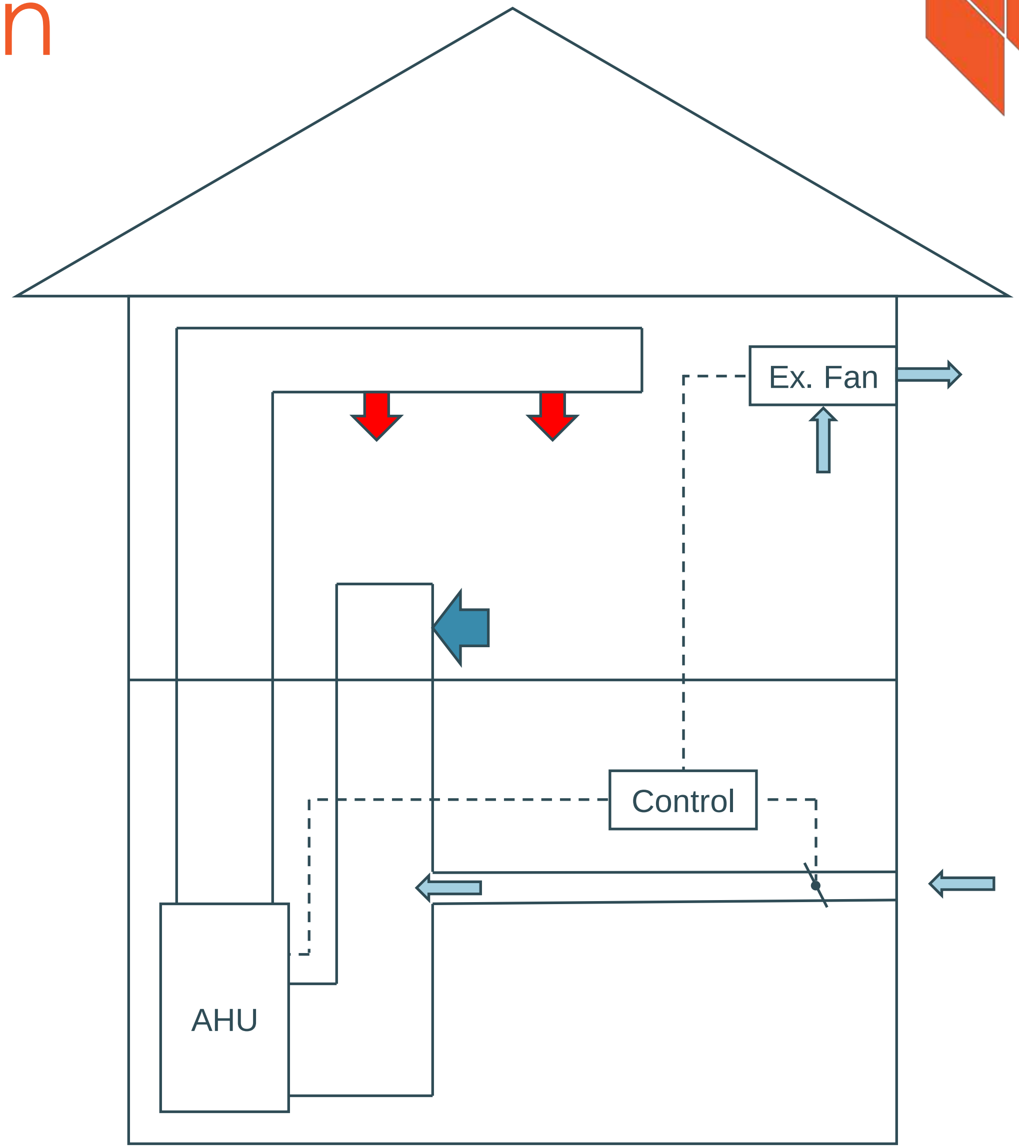
- Check manufacturer data

Be mindful of mixed air temperatures

Outdoor Air Temp.	Max. OA Fraction for Mixed Air >60°F
40 °F	33%
30 °F	25%
20 °F	20%
10 °F	17%
0 °F	14%
-10 °F	13%
-20 °F	11%

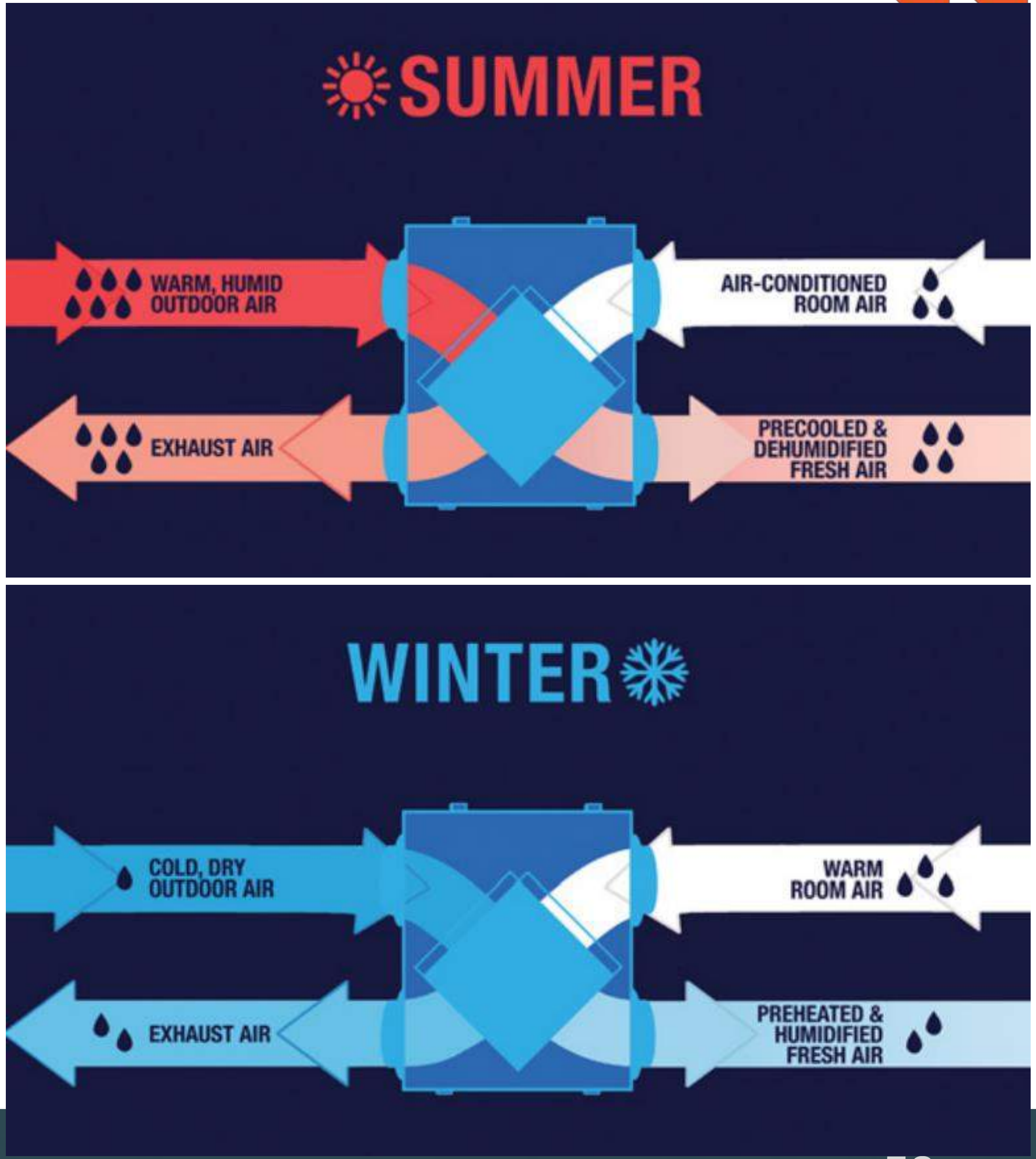
Simple Balanced Ventilation

- Extra controls
- No heat recovery
- Still using AHU fan energy
- Similar concerns to the other CFIS issues
- Can we do better?



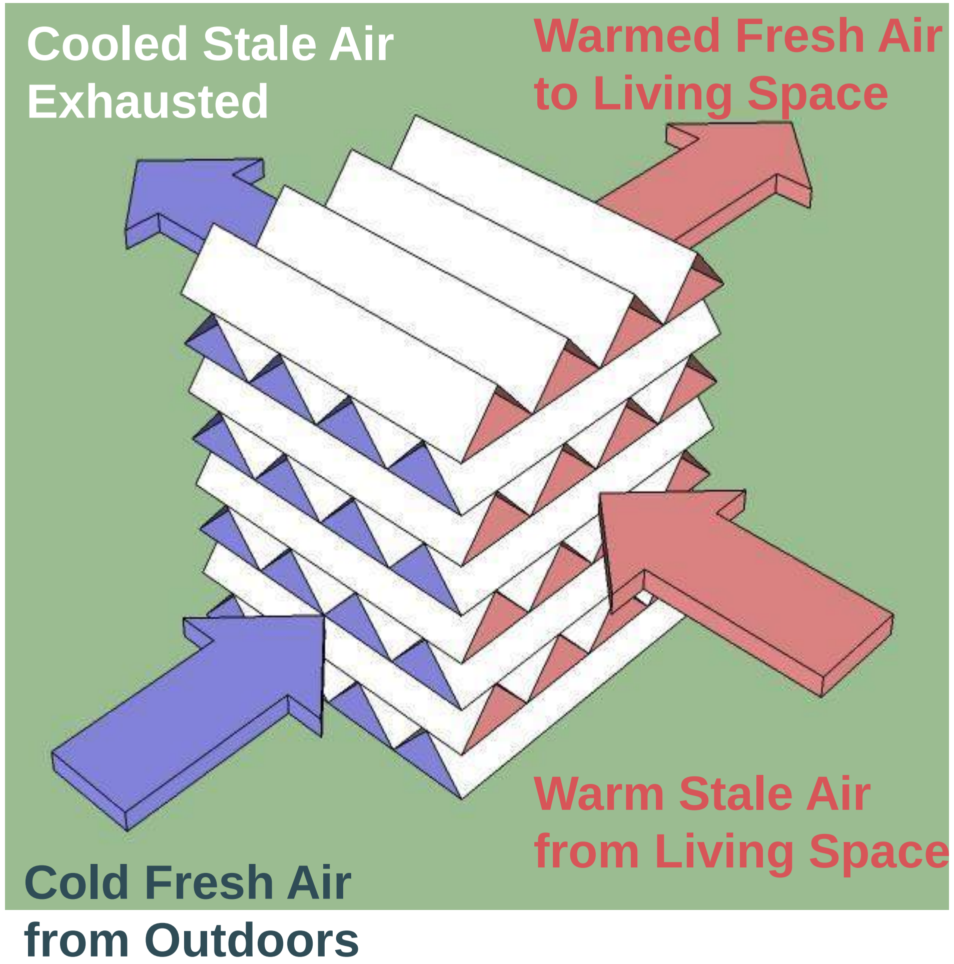
What is an Energy Recovery Ventilator?

- An ERV pre-conditions outdoor air using exhausted indoor air
- Doing so helps recover some of the energy already used to condition the air in the space, which is now being exhausted



Two Main Types

Cross-Flow HX

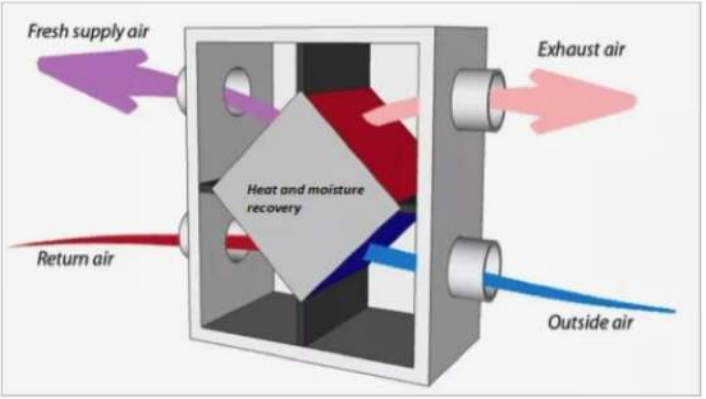


Enthalpy Wheel

Benefits

Benefits:
- Heat recovery
- Balanced ventilation
- Distributed fresh air (often)
- Known source of outdoor air

Disadvantages:
- First cost
- Maintenance
- Integration issues



traditional heat recovery ventilator/CC BY 2.0

Other System Types

- Heat pump energy recovery
- Instead of an ERV exchanger core, the unit uses a high efficiency heat pump to exchange energy between incoming supply and outgoing exhaust air.

Potential Issues

- Missing efficiency data for use in PH modeling
- Mode of operation heating / cooling / ventilation…fresh air continuously?

Options - ERV / HRV

Heat Recovery Ventilator (HRV)

- Sensible heat only (temperature)

Energy Recovery Ventilator (ERV)

- Sensible heat (temperature)
- Latent heat (humidity)
  - Moisture move from high to low, same will be across the heat exchanger

Options - ERV / HRV

ERVs transfer moisture:

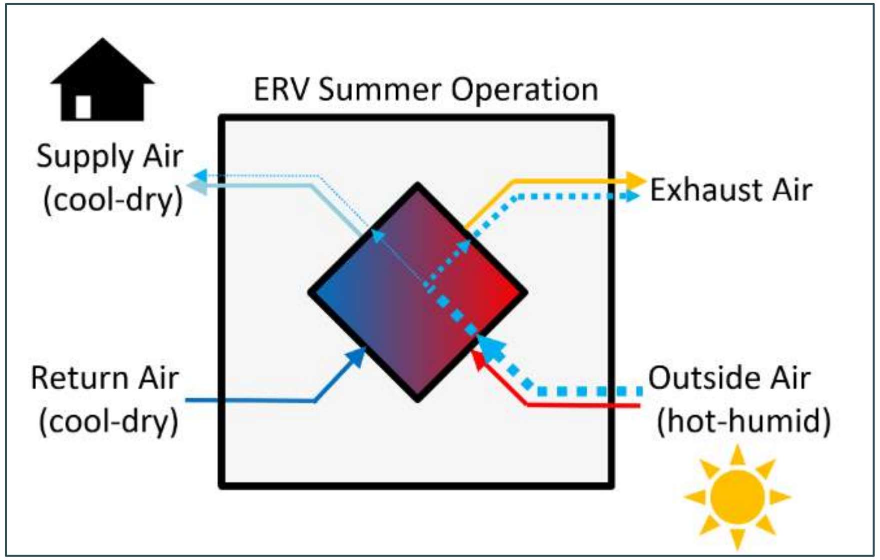
- NOT DEHUMIDIFIERS!

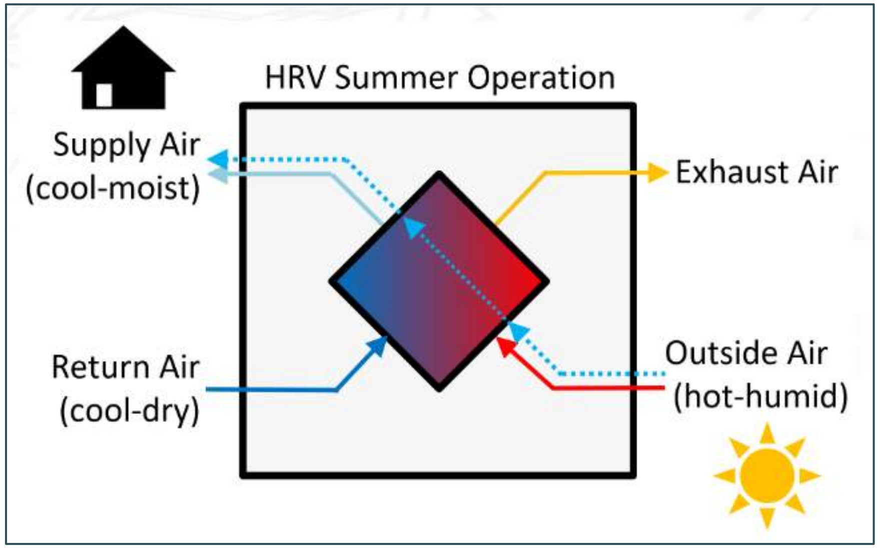
Hot, humid weather:

- ERV can reduce moisture in incoming ventilation air.

Cold climates:

- It depends…

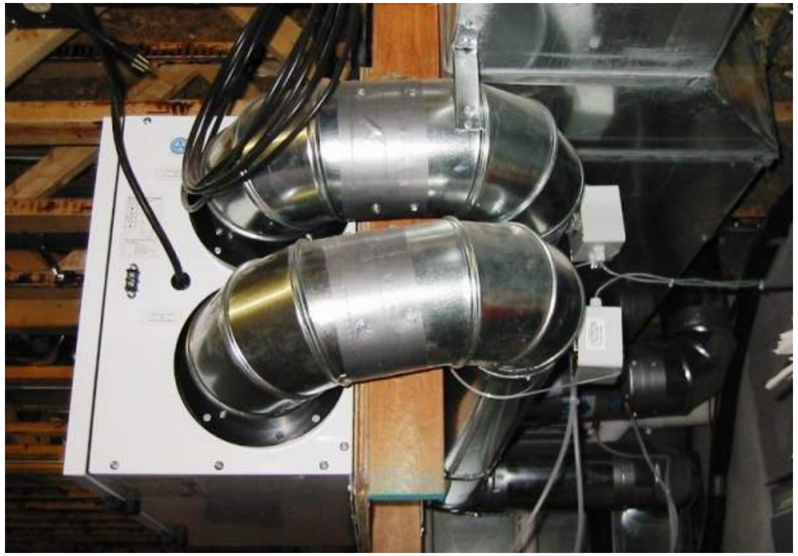




Options - ERV / HRV

- Exhaust from bathrooms?
  ...and kitchens?

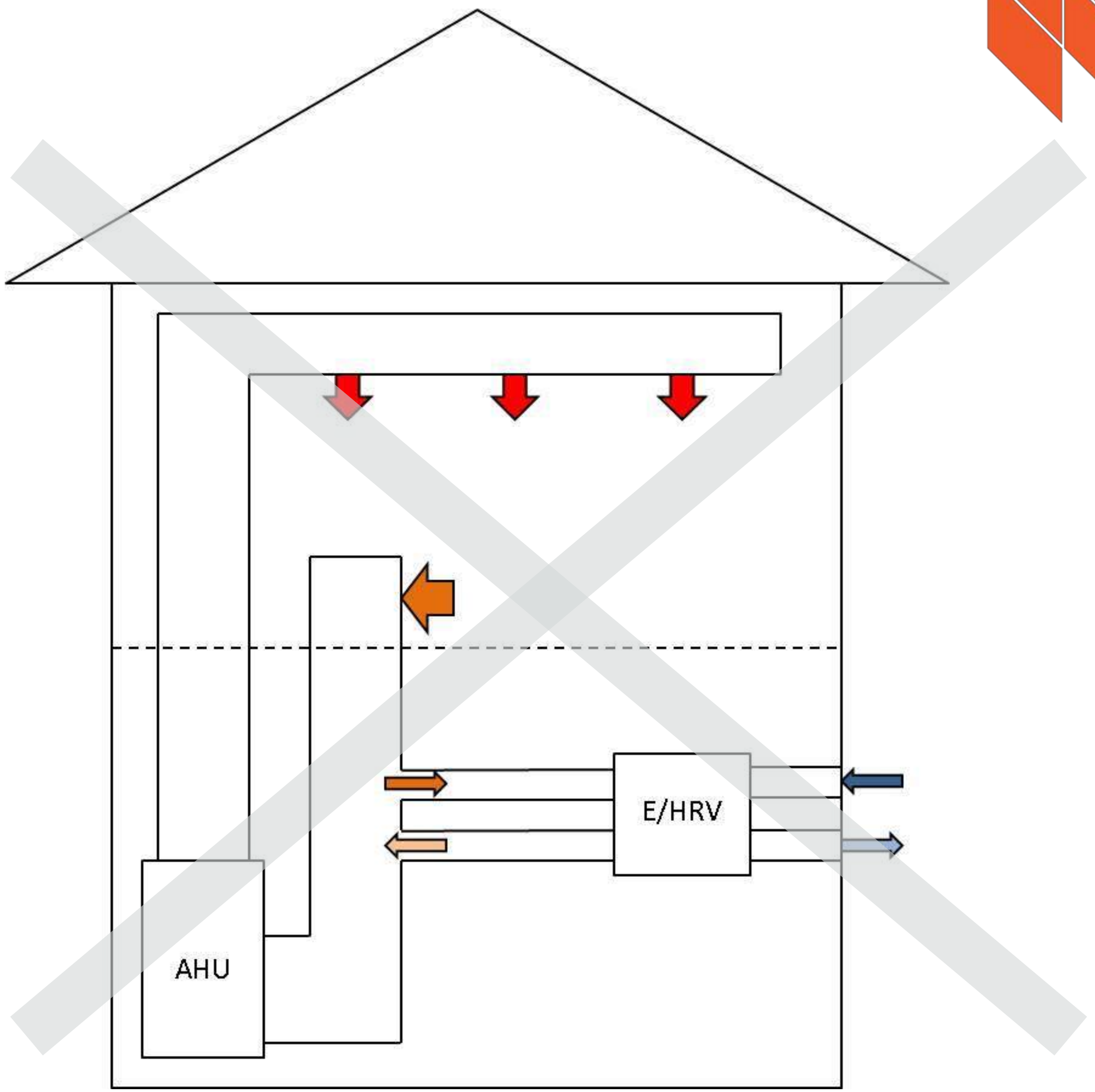
- Integrate with central duct system?



System Layouts

E/HRVs with central AHUs

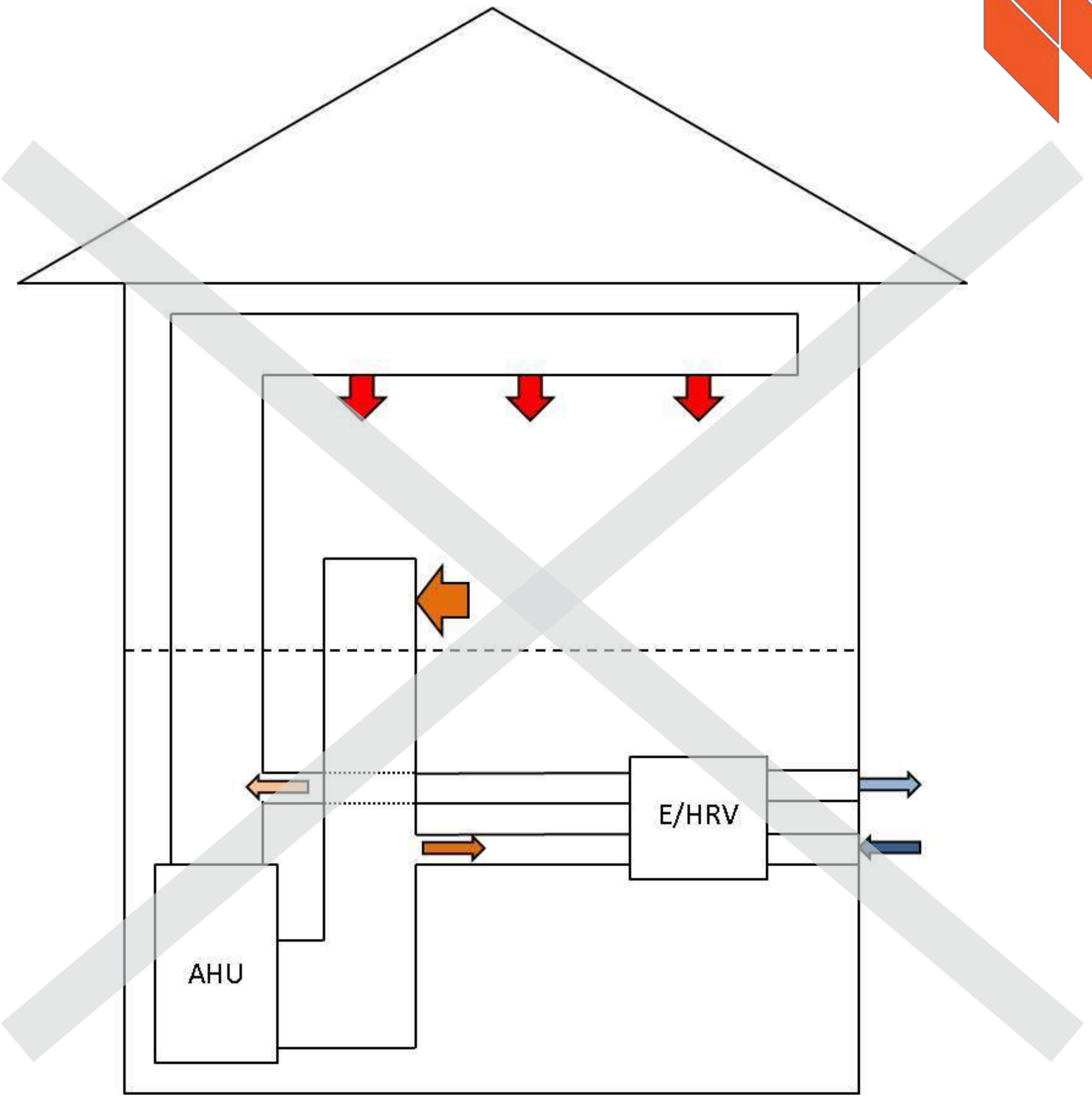
- If the air handler is not on the air will short cycle from the supply to the extract
- Don’t do it



System Layouts

E/HRVs with central AHUs

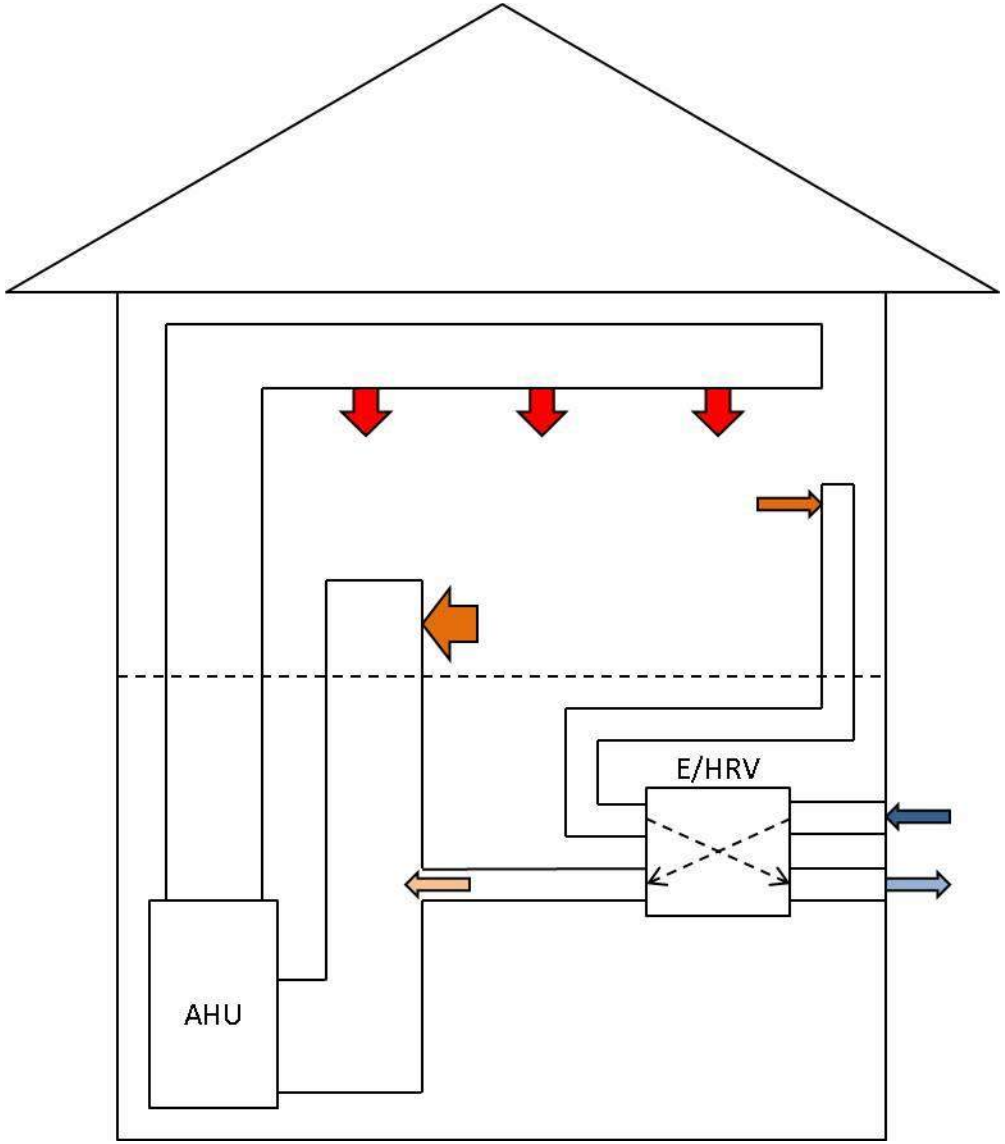
- If the air handler is not on the path of least resistance is back through the air handler to the extract
- Most ERV/HRVs are rated for 2.5 in wc



System Layouts

E/HRVs with central AHUs

- Dedicated ducts for at least one side (supply or exhaust)
- If you do want to duct a HRV/ERV into a central system, separate and dedicate the exhaust from the home
- Still need AHU for supply distribution (extra fan energy)

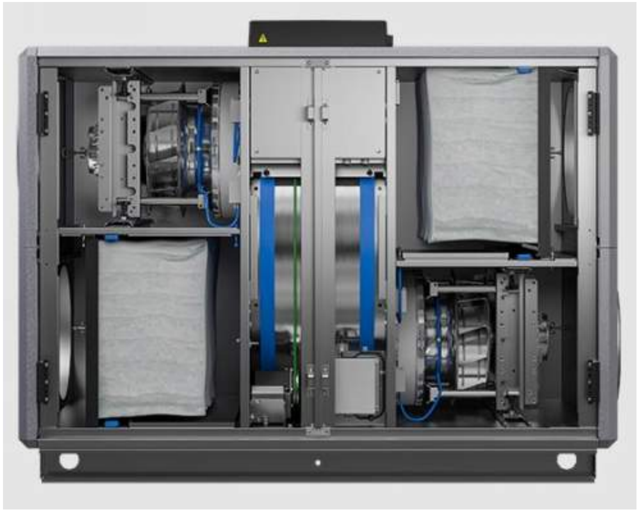


Unitized ERV

- In single family or smaller multifamily applications, small fixed plate ERVs can be used to provide exhaust and ventilation to a single apartment or a few common areas
- They do not usually contain any mechanical heating or cooling components
- Simpler system, but many more filters to change and more envelope penetrations.

Centralized ERVs

- Large ERVs, often with enthalpy wheels, can be located on a roof or mechanical space and ducted to all/most spaces in the building
- This air is typically “neutral” air at ~65-75°F
- More complex equipment and controls, but only one set of filters to maintain and fewer envelope penetrations



Questions?

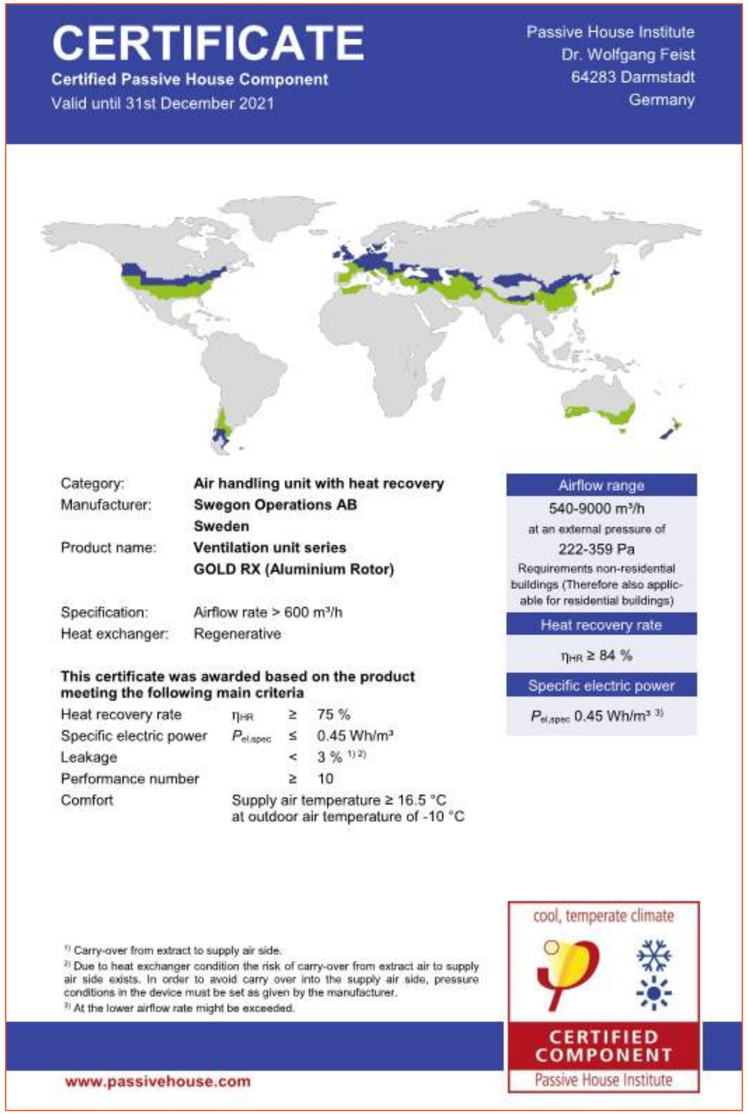
5 Minute Break

Implementing ERVs/HRVs

- Plan duct runs, intake & exhaust
- Make equipment accessible for maintenance!
- Select ERV or HRV
- Determine integration or stand-alone strategy
- COMMISSION! Measure flow rates, adjust controls

Equipment Selections (Unitized)

- Energy recovery > 75%
- Supply > 62°F on winter design day
- Power consumption: 30-50 Watts @ 100-150 cfm
- Fan power efficiency < 0.765 W/CFM.
- Static pressure capability
  - Depends on application/duct system
- MERV 13 filtration on incoming air
- Cost for such equipment starts $800 - $1,000



CERTIFICATE

Certified Passive House Component

Valid until 31st December 2021

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
Germany

Category:	**Air handling unit with heat recovery**
Manufacturer:	**Swegon Operations AB** **Sweden**
Product name:	**Ventilation unit series** **GOLD RX (Aluminium Rotor)**
Specification:	Airflow rate > 600 m³/h
Heat exchanger:	Regenerative

This certificate was awarded based on the product meeting the following main criteria

Heat recovery rate	η_{HR}	≥	75 %
Specific electric power	$P_{el,spec}$	≤	0.45 Wh/m³
Leakage		<	3 % [1) 2)]
Performance number		≥	10
Comfort	Supply air temperature ≥ 16.5 °C at outdoor air temperature of -10 °C		

Airflow range

540-9000 m³/h

at an external pressure of

222-359 Pa

Requirements non-residential buildings (Therefore also applicable for residential buildings)

Heat recovery rate

η_{HR} ≥ 84 %

Specific electric power

$P_{el,spec}$ 0.45 Wh/m³ [3)]

[1)] Carry-over from extract to supply air side.

[2)] Due to heat exchanger condition the risk of carry-over from extract air to supply air side exists. In order to avoid carry over into the supply air side, pressure conditions in the device must be set as given by the manufacturer.

[3)] At the lower airflow rate might be exceeded.

cool, temperate climate

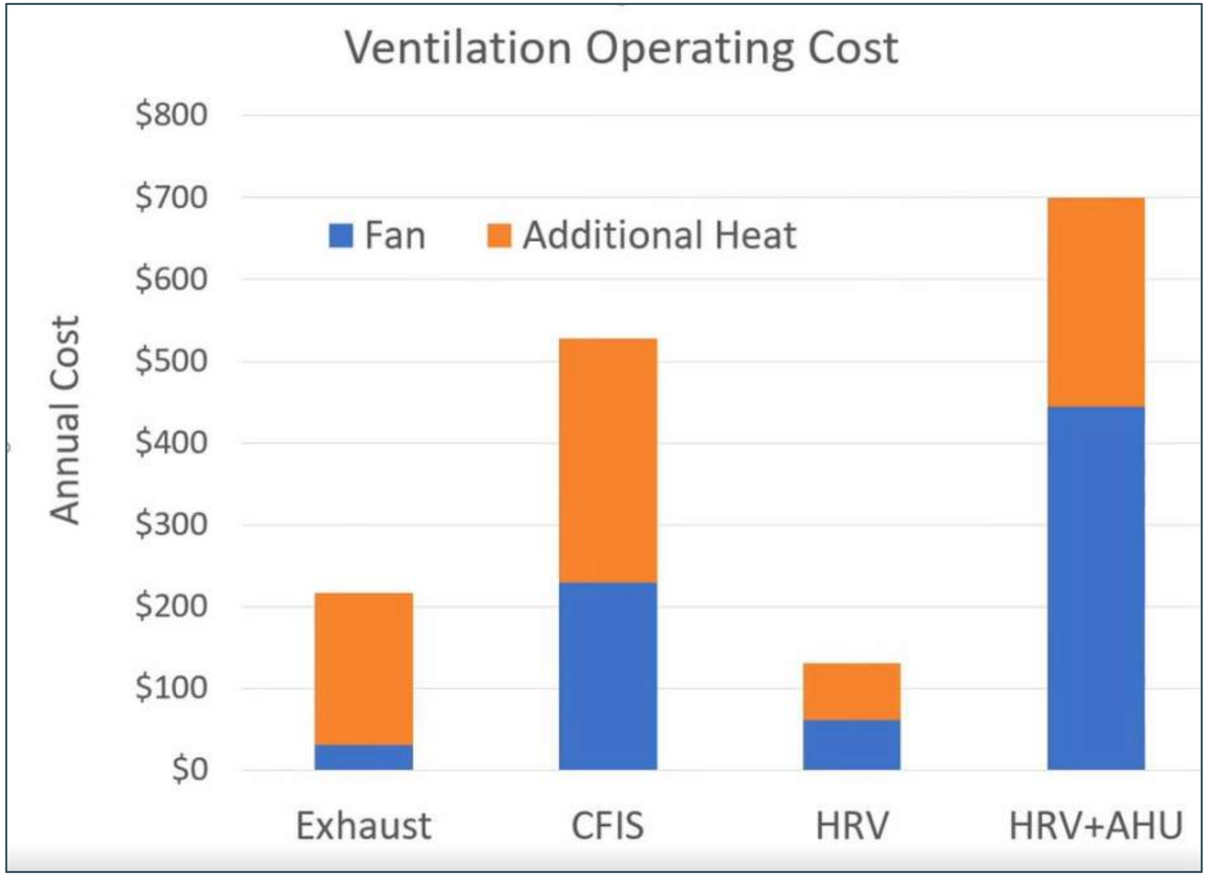
CERTIFIED COMPONENT

Passive House Institute

www.passivehouse.com

Operating Cost Example

- 1,800 ft^2
- 3 Bedroom
- Albany
- ~90 cfm continuously per 62.2-2019



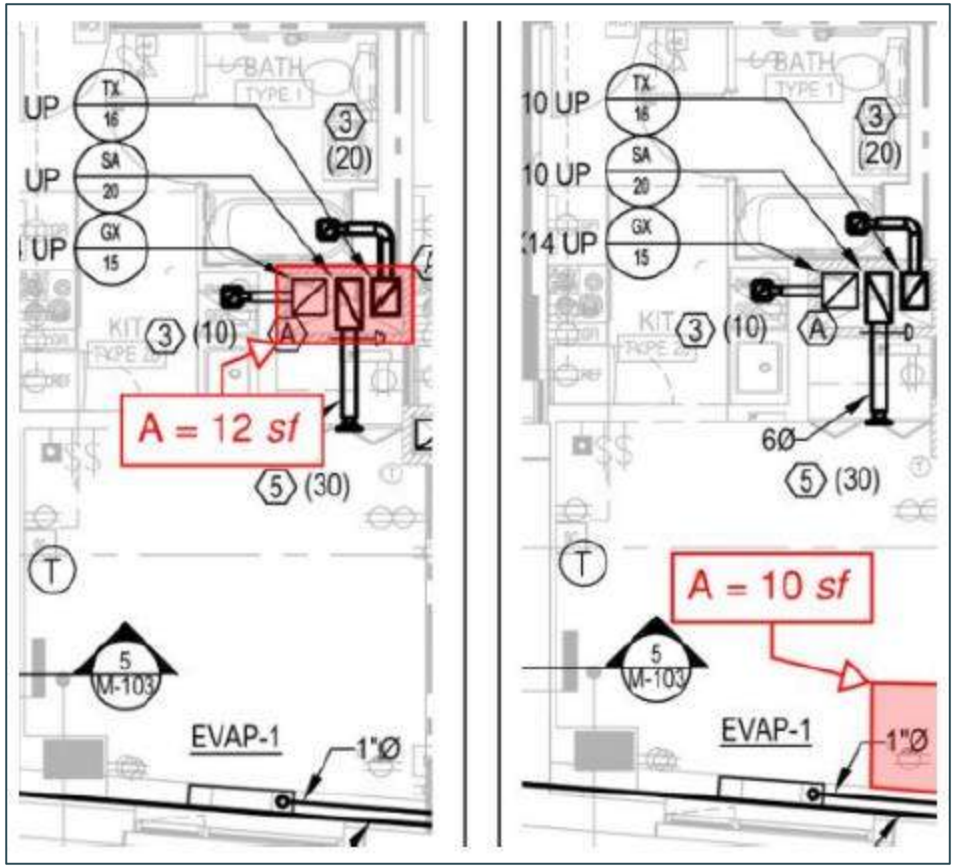
Unitized vs Centralized

Unitized Pros
- On resident's electric meter
- Simple controls

Unitized Cons
- Filter change 2-3 times annually in unit
- Regular exterior vent cleaning
- Two envelope penetrations per apartment

Centralized Pros
- Accessible for maintenance without disturbing tenants
- Only a handful of envelope penetrations

Centralized Cons
- Large vertical risers (take of space)
- Fire-rated and well-sealed risers
- Controls can be more complicated



Decoupling Ventilation from Space Conditioning

- Decoupling allows for smaller capacity heating & cooling equipment, since the ventilation air is pre-conditioned using exhaust air
- The ventilation system can completely turn off during unoccupied periods and allows the space conditioning system to only turn on when there is a call for heating or cooling.
- These changes increase efficiency and greatly simplify controls

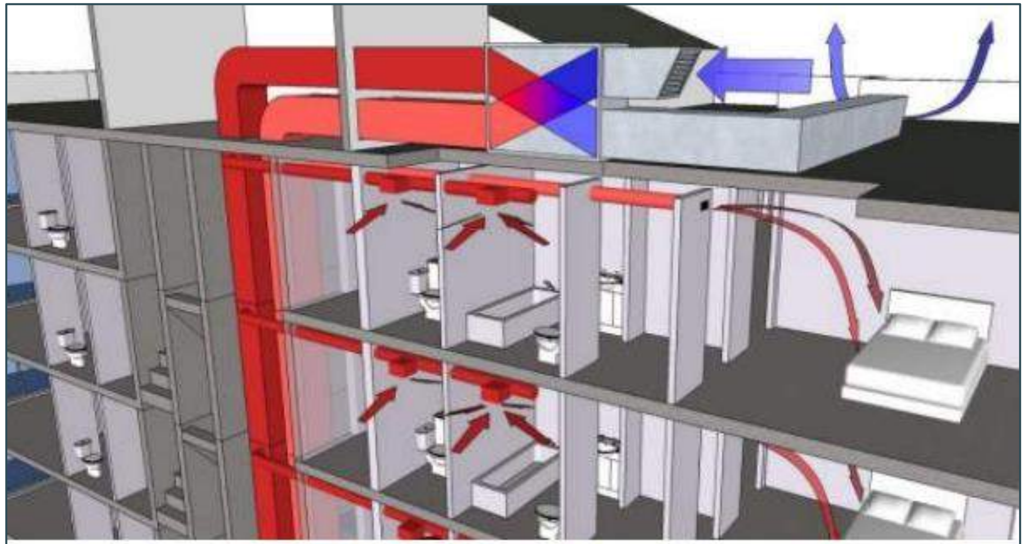
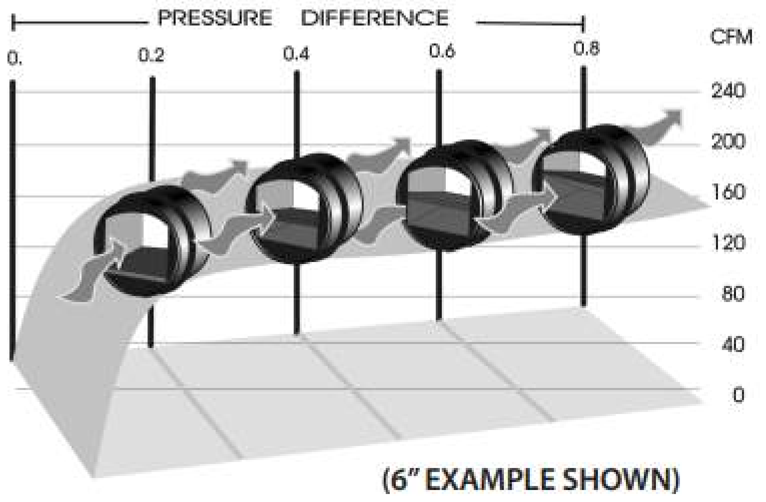


Fig. 4.1 Centralized HRV/ERV with ducted supply and return to each suite.

Air Flow Control

For Constant Flow Systems

- Constant airflow regulator (CAR) dampers
- Contains a mechanism that modulates in response to changing duct pressure to provide a constant flow of air.
- They only provide constant airflow within a specific range of pressures; fan needs to be within range
- Some models have adjustable airflow settings (recommended)
- If the ERV system is intended to have a boost switch, CARs would not be appropriate



ERV Controls

- Some unitized ERVs do not have adjustable speed fans. Choke down with CARs.

- Systems with adjustable fan speed controls need the following properly set up: Airflow set points, static pressure setpoints, supply air temp, airflow at the unit, fan speed settings

- Testing, adjusting, and balancing (TAB) is a crucial part of ensuring ERVs are functioning properly

- As with any HVAC system, duct sealing is necessary to ensure proper operation and optimum efficiency

ERV Sizing

- Engineers and consultants (if applicable) should carefully review ventilation rates to match expected occupancy and space use types
- Equipment sizes could be reduced – reducing first cost and improving efficiency and controllability

VS 3000 RT

Ventilation	Voltage	Flow Range
Heat Recovery Ventilator	208/230 or 480	750 to 3,000 cfm
Energy Recovery Ventilator	208/230 or 480	750 to 3,000 cfm

VS 1000 RT

Ventilation	Voltage	Flow Range
Heat Recovery Ventilator	208 or 240	75 to 1,000 cfm
Energy Recovery Ventilator	208 or 240	75 to 1,000 cfm

Filtration

Filtration
Bottom Line Up Front

- MERV 13 needed to remove meaningful amounts of fine particulates
- MERV 14 is better

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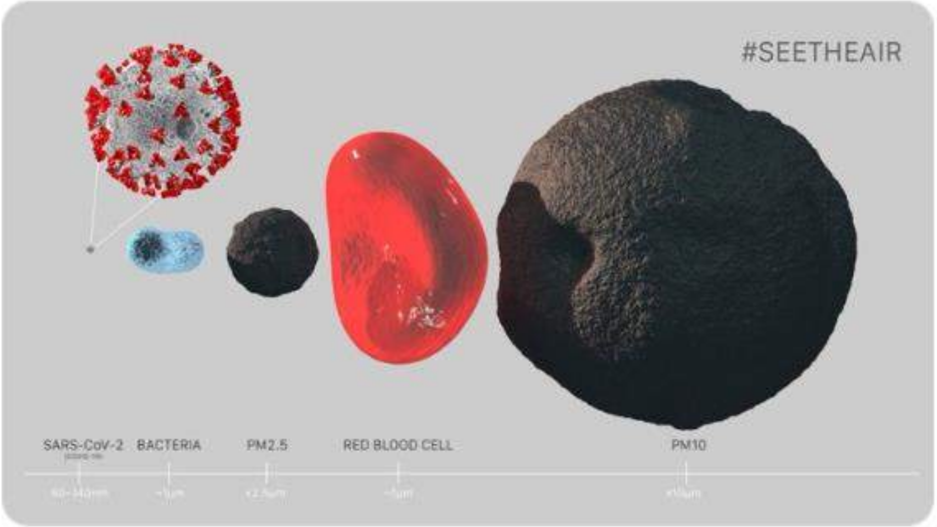
Particulate Matter (PM2.5) Mega Thread 🧵

1/16
What is PM2.5?

Plain English explanation: PM2.5 referees to fine particles with a size of or less than 2.5µm (aka micron). By the way, soot, aerosols, dust, BC are other common terms to call particle pollution.



MERV

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm		
	Range 1 (0.3-1.0)	Range 2 (1.0-3.0)	Range 3 (3.0-10.0)
1	n/a	n/a	E3 < 20
2	n/a	n/a	E3 < 20
3	n/a	n/a	E3 < 20
4	n/a	n/a	E3 < 20
5	n/a	n/a	20 ≤ E3
6	n/a	n/a	35 ≤ E3
7	n/a	n/a	50 ≤ E3
8	n/a	$20 \leq E_2$	70 ≤ E3
9	n/a	$35 \leq E_2$	75 ≤ E3
10	n/a	$50 \leq E_2$	80 ≤ E3
11	$20 \leq E_1$	$65 \leq E_2$	85 ≤ E3
12	$35 \leq E_1$	$80 \leq E_2$	90 ≤ E3
13	$50 \leq E_1$	$85 \leq E_2$	90 ≤ E3
14	$75 \leq E_1$	$90 \leq E_2$	95 ≤ E3
15	$85 \leq E_1$	$90 \leq E_2$	95 ≤ E3
16	$95 \leq E_1$	$95 \leq E_2$	95 ≤ E3

https://www.nafahq.org/understanding-merv/

Covid advice…? Still evolving

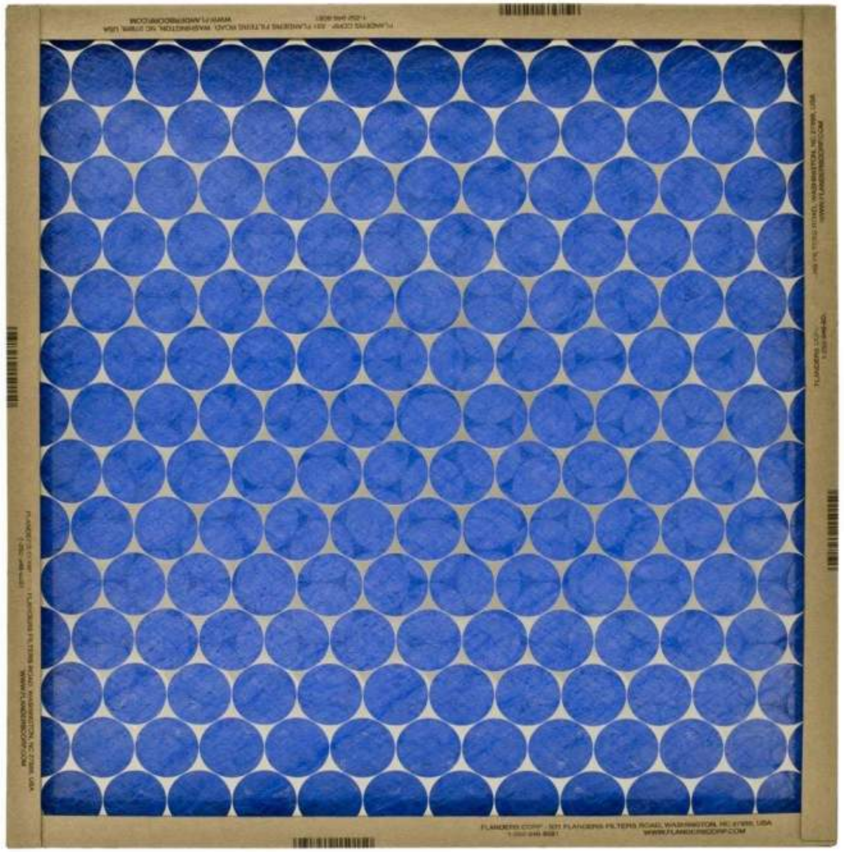
- More ventilation is better
- More/better filtration is better
  - MERV ≥13 are efficient at capturing airborne viruses
  - MERV 14 filters are preferred

+ 3. Since viruses can be carried in the air in aerosol water droplets, will RenewAire units recapture those aerosols, including the viruses?

The RenewAire enthalpy-plate exchanger does not transfer viruses or bacteria between airstreams. The exchanger transfers water vapor in the form of individual molecules absorbed into the membrane, transported across the membrane as bound water molecules, and desorbed into the other airstream. Viruses are much larger and cannot be carried along. However, exchangers and units typically do have small leak paths and if static pressures in the exhaust air compartments of the unit are higher than in the supply, some recapture of exhaust air is possible.

https://www.renewaire.com/about-renewaire/covid-19-response/faqs-renewaire-ervs-and-covid-19/

Skip these



Pleated Media

Filter Media

<u>Charged</u>

"Electret"

- **Efficiency drops over time (charged fibers get covered)**
- Lower **Pressure Drop (PD)**
- **PD** increases a bit over time, but not that much
- Important to **<u>replace</u>** to keep up **removal**

<u>Uncharged</u>

"Mechanical"

- **Efficiency improves over time**
- Higher **PD**
- **PD** increases greatly as filter is loaded
- Important to **<u>replace</u>** to keep **PD** reasonable

Reducing PD

Ruffles

- Much more surface area on pleats
- Especially dense pleats
- ...and deep pleats

Reducing PD

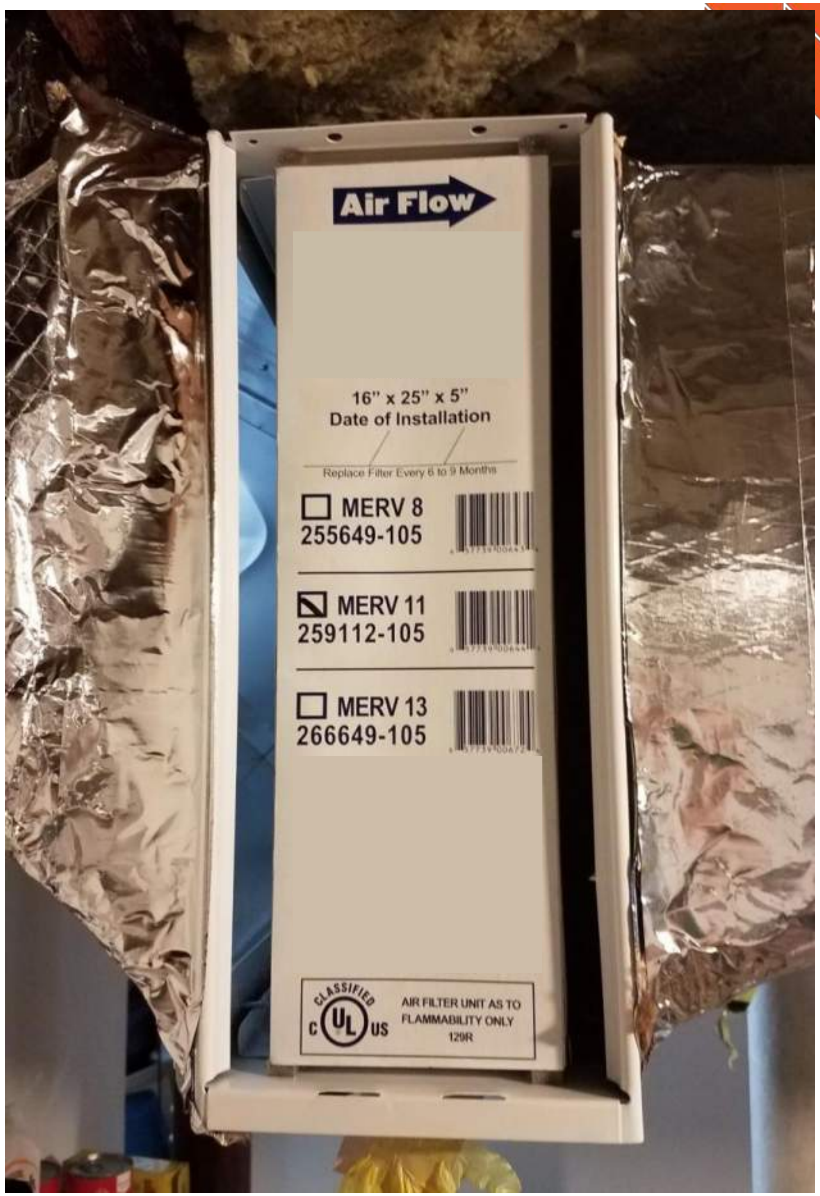
- Thickness / Depth matters (1”, 2”, 4”)

Filtration: Protect Equipment

At least MERV 8? Higher is better….

Bypass

- Many, many documents say bypass is BAD (ASHRAE, ACCA, EPA, etc.)
- Engineered, air-tight filter rack is best.
- Otherwise...



Questions?

What are your final thoughts and takeaways from the presentation today? (hint: link words with an underscore)

Questions & Final Discussion

Join Us for More Trainings!

- **Workshop 1:** Continuous Insulation
- **Workshop 2:** Air Sealing and Insulation for Homes
- **Workshop 3:** High Performance Ventilation Systems for Homes

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