
Ameren
MISSOURI

Understanding IAQ and Ventilation

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Energy Code Resources

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Energy Code Resources

Missouri Residential Building Energy Code Construction Practices Study:
https://energy.mo.gov/energy-codes/missouri-residential-building-codes-study
For additional information on other DOE Field Studies and participating states, please visit https://www.energycodes.gov/compliance/energy-code-field-studies.
Additional education resources are available at www.southfaceonlinetraining.org.

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About Southface

- *Building a Regenerative Economy, Responsible Resource Use & Social Equity Through a Healthy Built Environment for All*

www.southface.org

- Mike Barcik – Technical Principal
- mikeb@southface.org

Ventilation White Paper

- About 12 pages – summarizes concepts and presents strategies
- Focus is on Hot-Mixed Humid climates, but concepts work everywhere

GEORGIA ENERGY CODE HELP DESK

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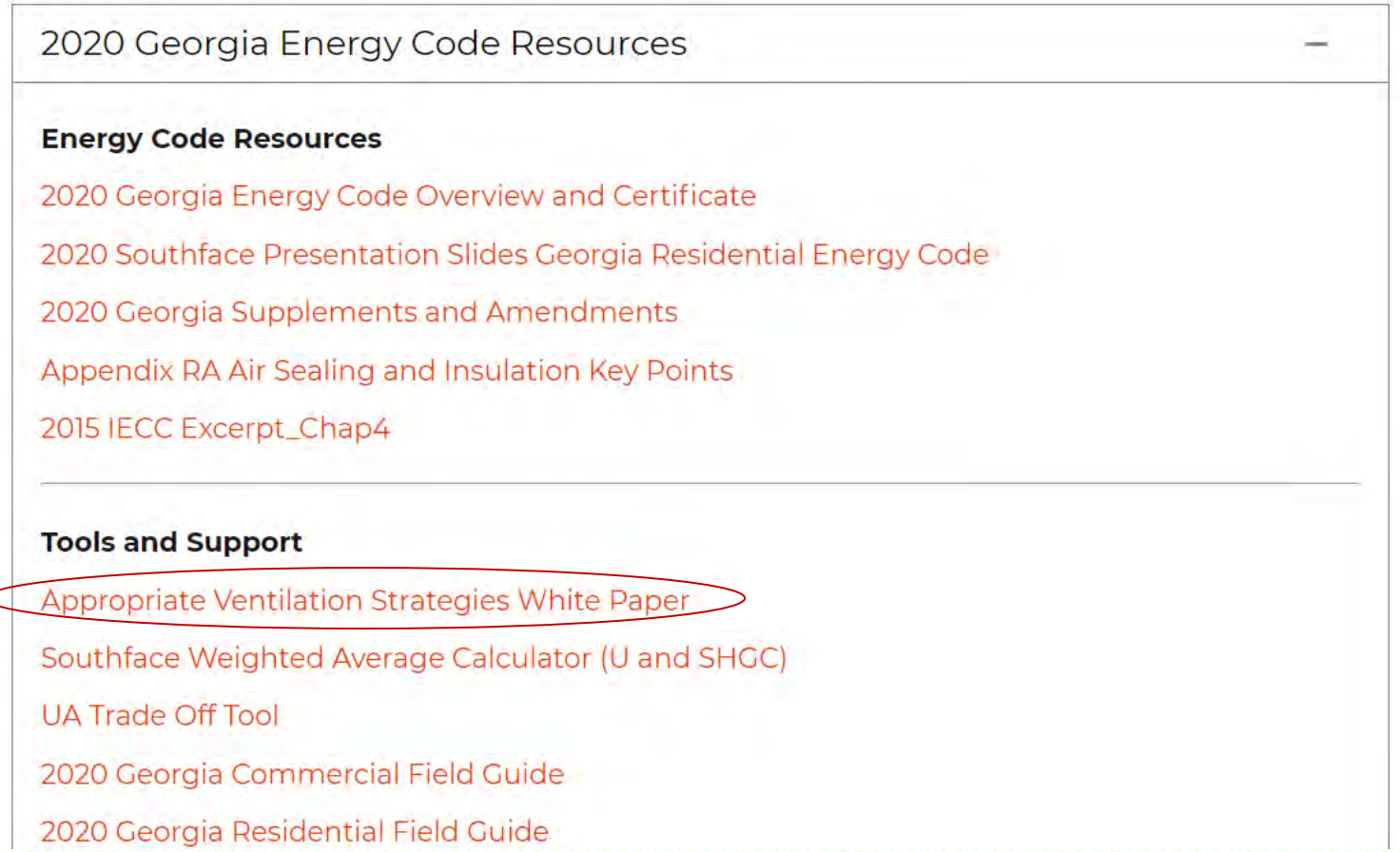


The House as a System

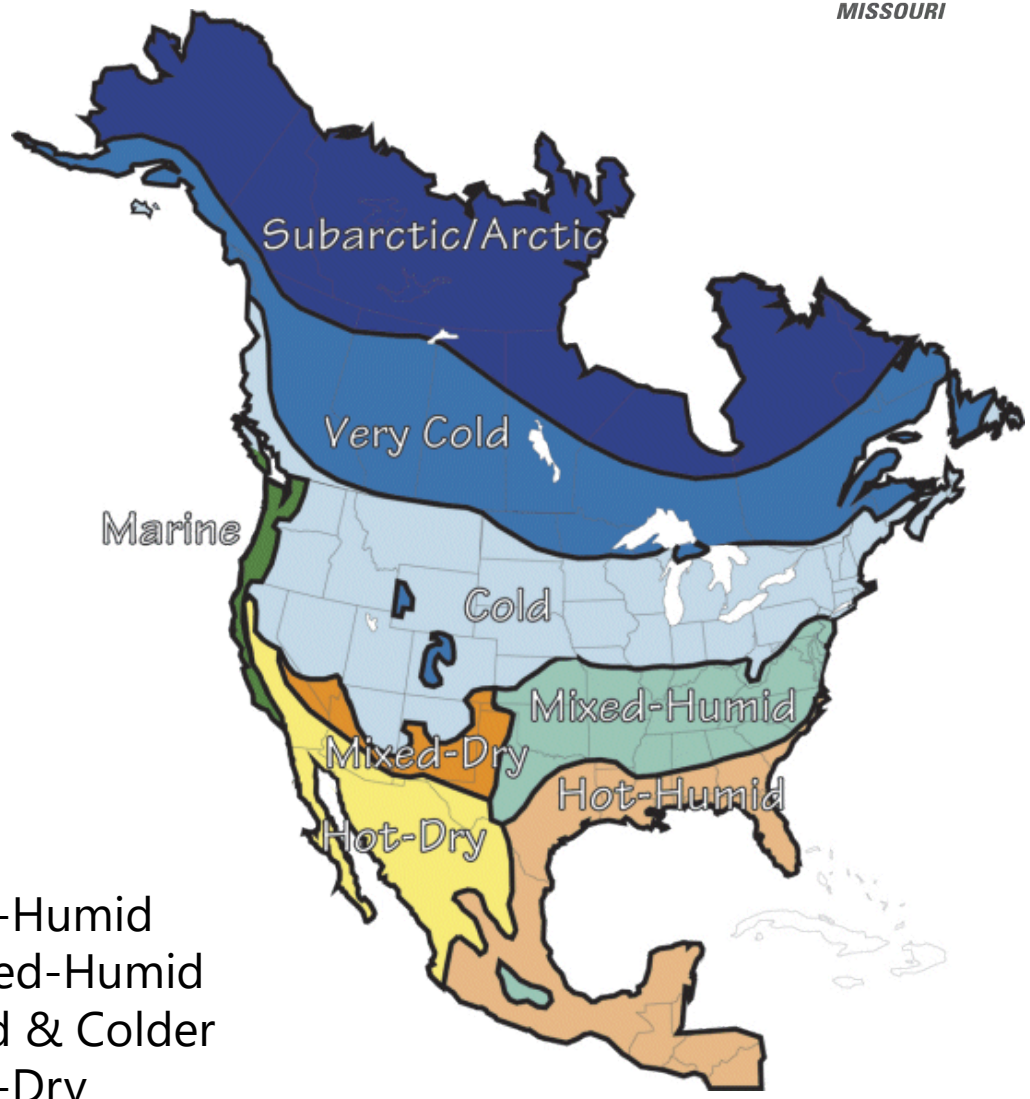
A house is a system made up of interrelated parts:

- The site and neighboring homes
- The weather barrier
- The building thermal envelope
- Space conditioning
- Lighting & appliances & plumbing
- Ventilation

- All efficiency measures should take occupants into account (e.g., air sealing & ventilation)

Building Science:

- Employ scientific principles from a variety of fields that govern building performance
- Optimize building performance and understand, predict, prevent and correct building failures
- Systems approach to houses
- Physics of:
  - **Heat:**
    Flows from hot to cold
  - **Air:**
    Flows from high pressure to low
  - **Moisture:**
    Flows from wet to dry
    (liquid and vapor)



A. Hot-Humid
B. Mixed-Humid
C. Cold & Colder
D. Hot-Dry
E. Mixed-Dry
F. Marine

Learning Objectives

- Summarize the key concepts of IAQ
  1. Pollutant source control
  2. Pollutant separation from the occupants
  3. Ventilation to dilute pollutants with outdoor air
  4. Capture pollutants with filtration
- Determine how ventilation fits into the hierarchy of Indoor Air Quality
- Calculate ventilation rates based on the IRC and ASHRAE 62.2 approaches
- Identify strategies for achieving fresh air
- Compare & contrast ventilation methods for different climate zones & assess which ventilation strategies are appropriate for Hot/Mixed Humid and other climates
- Build the perfect ventilation system

"Indoor air quality is important to the health of my son, who has allergy related asthma. Since moving into our new EarthCraft home, he's really improved."

Ventilation Trivia

Who said it?

"I am certain that no air is so unwholesome as air in a closed room that has been often breathed… and not changed."

- Benjamin Franklin

Is it possible to build a house “too tight”?

Where do those “fresh” air changes come from?

ATTIC

Insulation fibers, dust, coal soot, rodent scat

OUTSIDE

Pollen, auto fumes, dust, moisture

GARAGE

Carbon monoxide, pesticides, gasoline, fertilizers

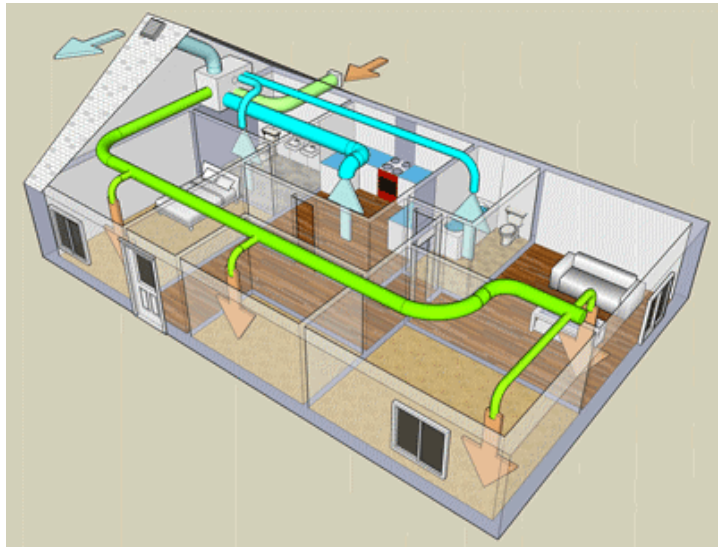
CRAWLSPACE

Mold, dust, lead, radon, moisture, termiticide

Build tight, Ventilate right

Definitions

- **Ventilation** – fresh air provided for the people in the house
- (Not attic ventilation, or crawlspace or garage ventilation, etc.)
- **Infiltration** – random air exchanges occurring in unknown amounts, times and locations



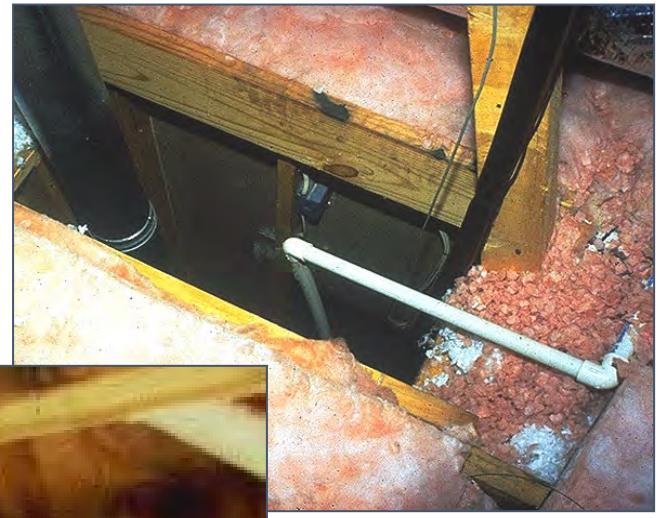
- Air Changes does not equal healthy house…

Ventilation versus Infiltration

- Can’t we just let the house “breathe?”

Ventilation is controlled and intentional introduction of outside air (O.A.)

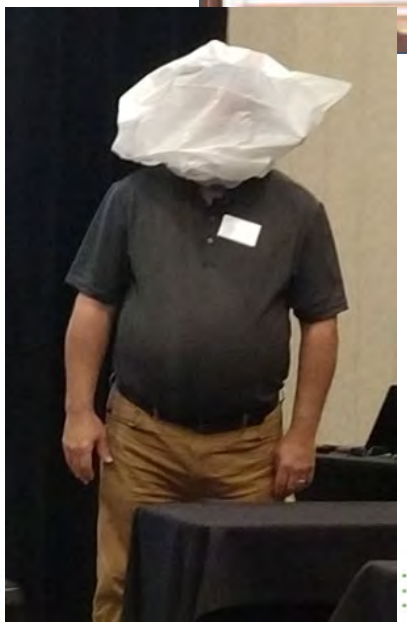
Infiltration… isn’t



Why Ventilate?

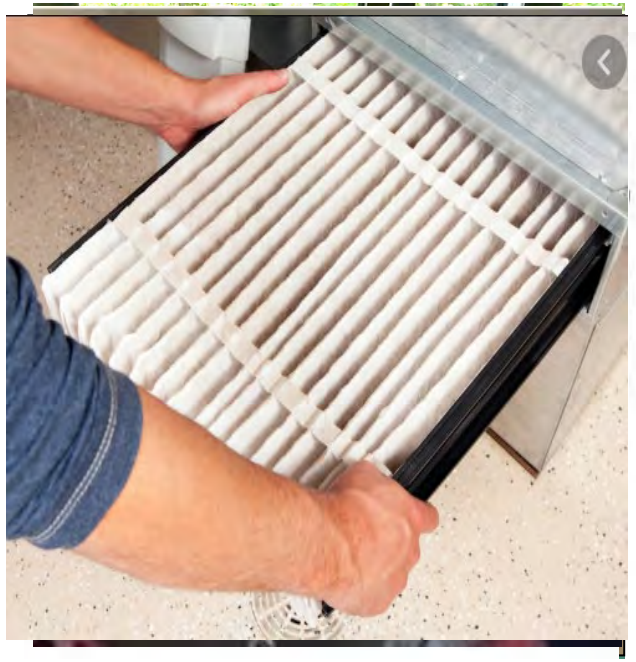
Can’t we just open windows?

- Security
- Dust, pollen, humidity, etc.
- Pests
- Noise
- Action required
- People need fresh air regularly!



SOME KEY IAQ RECOMMENDATIONS

- Understand people have the biggest impact on IAQ
- Keep home dry (& mold free); dehumidify as needed
- Avoid emitting large amounts of contaminants in home
- Ventilate when emitting (cleaning, hobbies, chemicals in consumer products)
- Use spot ventilation (kitchen, bath, toilet exhaust, laundry, clothes closet)
- NO UNVENTED COMBUSTION APPLIANCES!!! (no people air for combustion air)
- Use natural ventilation when outdoor conditions are “clean”
- Have tight envelope and ducts; close house when outdoors is polluted
- Check radon and formaldehyde
- Use efficient variable speed AHU motor (ECM)
- Install good (thick, pleated) AHU filter with no leaks or bypass; (confirm low ΔP)



INDOOR POLLUTANT SOURCES

Biological agents

Chemicals

Combustion

Outdoor Pollutant Sources

Quiz Question

- Which of these factors has the greatest impact on indoor air quality in a typical home?

A. Pets

B. Cleaning products

C. People

D. Volatile Organic Compounds

Steps to good Indoor Air Quality

1. Eliminate (remove pollutant source)
2. Separate (seal or contain pollutants)
3. **Ventilate** (dilute pollutants)
4. Filter (clean and remove pollutants)

"Pollutants need a Pathway to People…"

"…and are Pushed by Positive Pressure!"

Pollutant source control

Pollutant source control means not bringing the pollutant indoors and/or identifying & removing it from an existing home:

- Removing shoes at the front door
- Selecting no VOC paints and adhesives
- Choosing carpets with CRI Green Label (no Red List materials)
- Specifying plywood and particle boards with no added urea-formaldehyde glues
- Installing reclaimed finishes (flooring)
- Eliminating an unvented gas space heater
- Upgrading a water heater to direct vent
- Not burning incense or scented candles

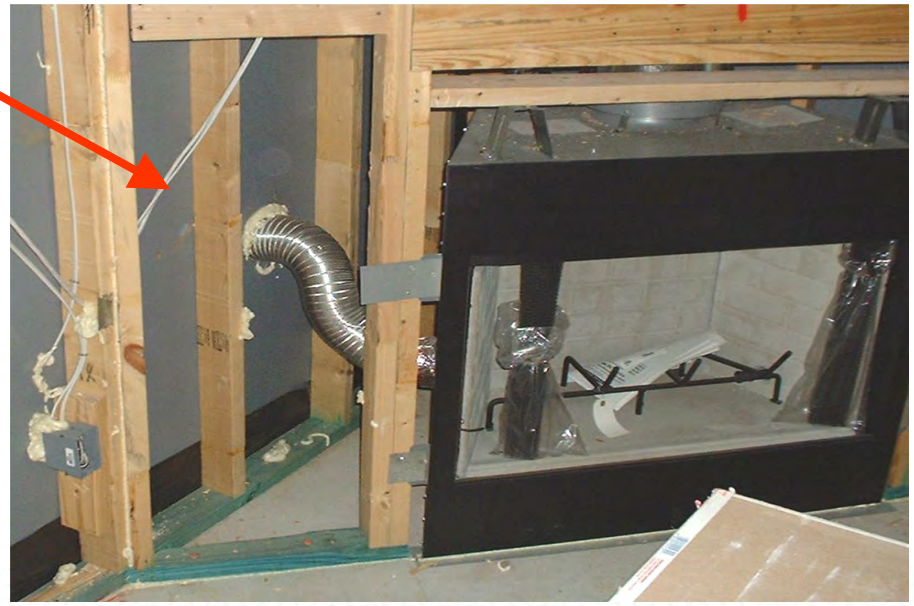
Pollutant separation

Pollutant separation focuses on keeping the pollutants from getting to the occupants:

- Air sealing the garage to house junction to prevent CO and other emissions from entering the home
- Running an exhaust fan in the garage that operates on an occupancy sensor
- Applying a water-based sealant on particle boards that could off-gas
- Allowing new furnishings to “acclimate” in an outdoor space (such as a vented garage or carport)
- Sealing ductwork located in a vented crawlspace (or attic, or garage, etc.)
- Separate air provided to combustion appliances

Combustion Moisture & IAQ

- All fireplaces & other combustion equipment should be provided with:
  1. a flue pipe vented to outdoors
  2. outside combustion air supply
- No unvented gas appliances!



Why filters matter

Answer:

A 1" filter is mainly there to protect the mechanical equipment. It isn't really there for human health.

Even higher quality 1" filters can't do much better. As filters load up, they actually work better, however they greatly impact air flow and strain the HVAC system.

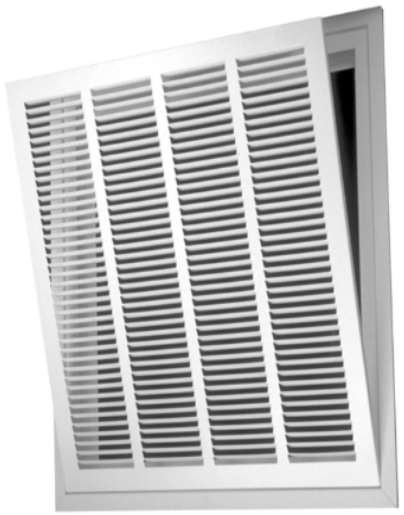
Outcome:

If you want to catch particles that affect human health (~2.5 microns), use a thicker (deeper) pleated filter.

Filters

- Change every leap year?
- El Cheapo vs. HEPA filters
- Want thicker, pleated filters
- Don’t accept installs that prohibit easy filter access
- Seal filter access covers

Practical Pleat



“Filter Lock” uses magnets to seal access

www.filtrationmfg.com

www.anykindoffilter.com

“AKF003” is discount code

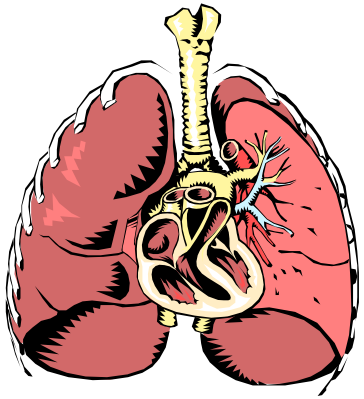
Quiz Question

- Which is the last line of defense against indoor air quality issues?

A. Eliminate (remove pollutant source)
B. Separate (seal or contain pollutants)
C. Ventilate (dilute pollutants)
D. Filter (clean and remove pollutants)

What's the Purpose of Ventilation?

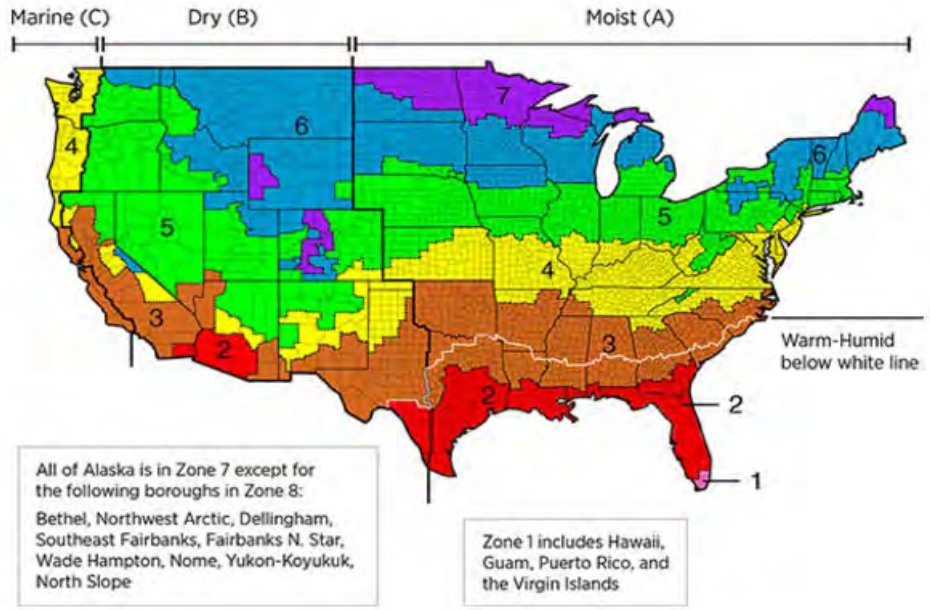
- Provide fresh air for the occupants
- Dilute pollutants



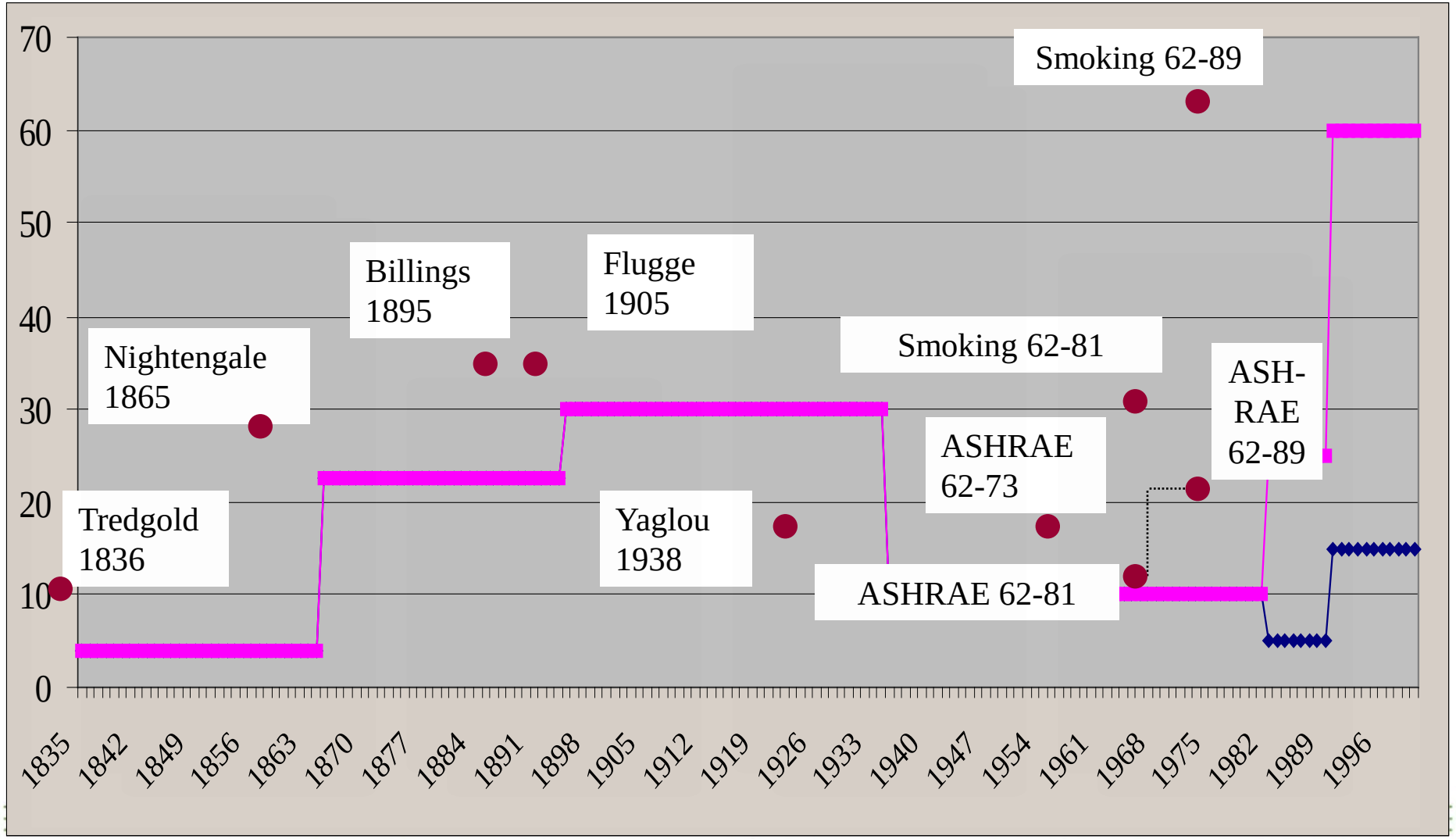
VENTILATION PRACTICALITY

"Perfect can be the enemy of Good"

- Houses are tight (and getting tighter)
- Fresh air is important – we want good ventilation!
- We don't know exactly how much
- We don't all agree on how to best ventilate
- What works in some places isn't necessarily good in other places

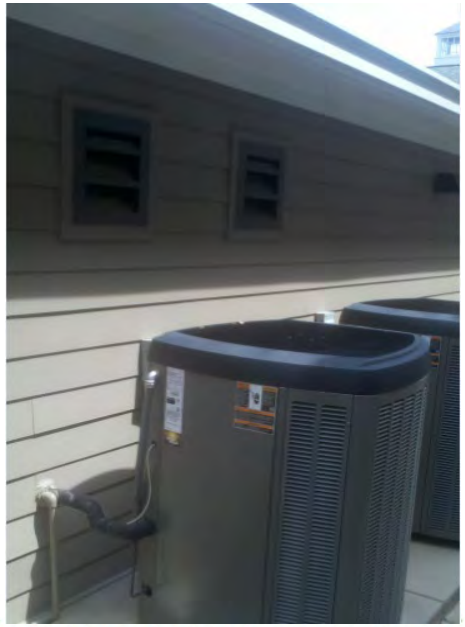


Historical Minimum Ventilation Rates (cfm/person)



Commercial: Rules for Good Ventilation

- Bring in outdoor air from a clean source
- Provide filtered and dehumidified outdoor air to the breathing space
- Vary amount of ventilation based on the number of occupants and process loads
- Design systems to separate ventilation & space conditioning
- Use heat/energy recovery to reduce system size and ventilation energy costs



General Observations

- Certain IAQ and ventilation issues are subjective
- Industry experts do not all agree
- Occupant behavior plays a large role
- Code compliance is combination of IRC/IECC
- Ventilation requirements formerly would vary depending on type of construction – 62.2-2016 onward considers “dwelling units” located in any size building
  - Single family or multifamily
  - New construction or renovation

ASHRAE doesn’t specify where the air comes from
and
Ventilation is very much a function of the occupant’s:
Behavior (activity levels, etc.)
Lifestyle (cooking, bathing)
Smoking (habits)

62.2 - Good Indoor Air Quality is a Goal

- *Acceptable indoor air quality* is a term defined in §3, Definitions, to mean air that is neither irritating nor unhealthy.
- Indoor air that is not acceptable is air that
  1. smells bad
  2. contains irritating contaminants, such as pollen or other allergens
  3. contains contaminants at concentrations that might have harmful health effects
- Unacceptable indoor air can have one, two, or all three of these characteristics.

The standard prescribes mechanical ventilation, building envelope recommendations, and other measures intended to provide residential indoor air quality that is acceptable for human health and comfort.

3. DEFINITIONS

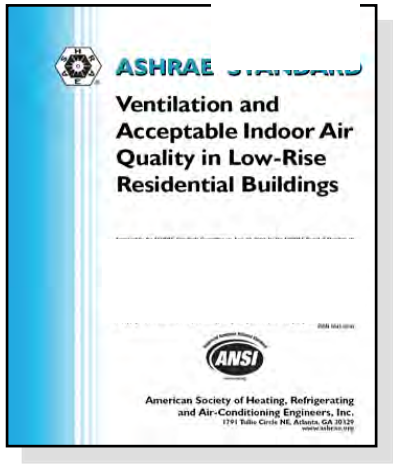
acceptable indoor air quality: air toward which a substantial majority of occupants express no dissatisfaction with respect to odor and sensory irritation and in which there are not likely to be contaminants at concentrations that are known to pose a health risk.

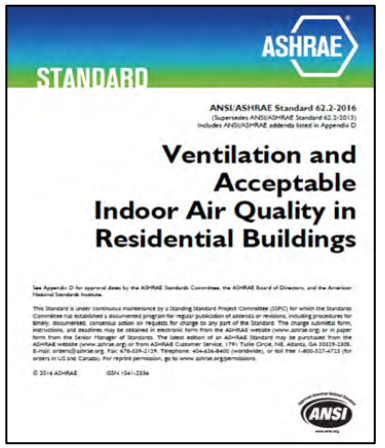
The history of ASHRAE Standard 62

- ASHRAE 62 - 1989 (old!)
- Whole house: 0.35 $ACH_{Natural}$ or 15 cfm per person
- Kitchen: 100 cfm intermittent
  or 25 cfm continuous or operable window
- Bath: 50 cfm intermittent
  or 20 cfm continuous or operable window

This study was based on odor (though not necessarily wrong)

These are still in effect in the code today!





ASHRAE 62.2-2004, 07, 10

7.5 cfm per person PLUS

1 cfm for every 100 s.f. of conditioned space

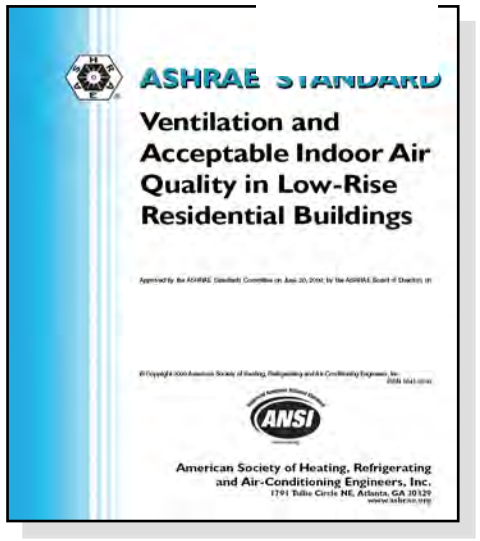
ASHRAE 62.2-2013, 16, 19

7.5 cfm/person + 3 cfm / 100 s.f.

$$Q_{fan} = Q_{tot} - Q_{inf}$$

ASHRAE 62.2-2010 Single Family Ventilation

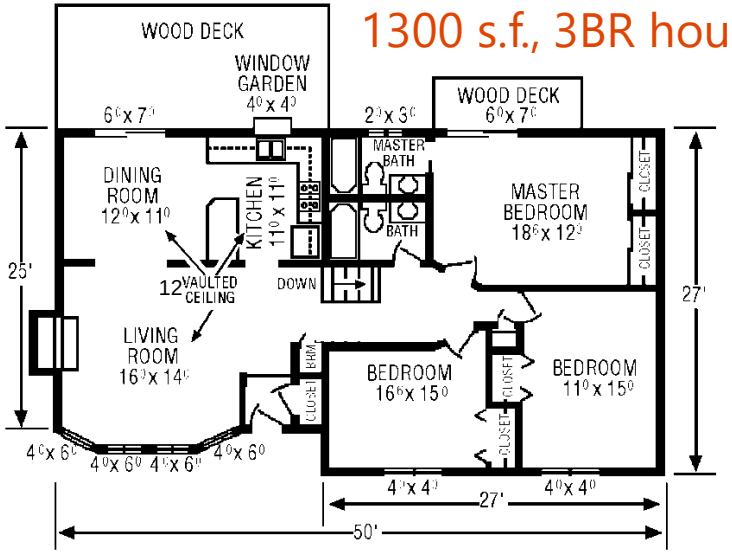
$$CFM_{fan} = (0.01 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$



OR

Floor Area (ft^2)	BEDROOMS				
	0 - 1	2 - 3	4 - 5	6 - 7	>7
< 1500	30	45	60	75	90
1501 – 3000	45	60	75	90	105
3001 – 4500	60	75	90	105	120
4501 – 6000	75	90	105	120	135
6001 – 7500	90	105	120	135	150
> 7500	105	120	135	150	165

ASHRAE 62.2-2010 Single Family Example – small house



1300 s.f., 3BR house

ASHRAE 62.2-2010:

3 Bedrooms = 4 people
4 people x 7.5 cfm / person = 30 cfm
30 cfm + 13 = <u>43 cfm</u>

ASHRAE 62.2 - 2010

$$CFM_{fan} = (0.01 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$

OR

Floor Area (ft^2)	BEDROOMS				
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> 7500	105	120	135	150	165

ASHRAE 62.2-2010 Single Family Example – large house

5200 s.f.,
5 BR house

ASHRAE 62.2-2010:

5 Bedrooms = 6 people
6 people x 7.5 cfm / person = 45 cfm
45 cfm + 52 = <u>97 cfm</u>

ASHRAE 62.2 - 2010

$$CFM_{fan} = (0.01 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$

OR

Floor Area (ft^2)	BEDROOMS				
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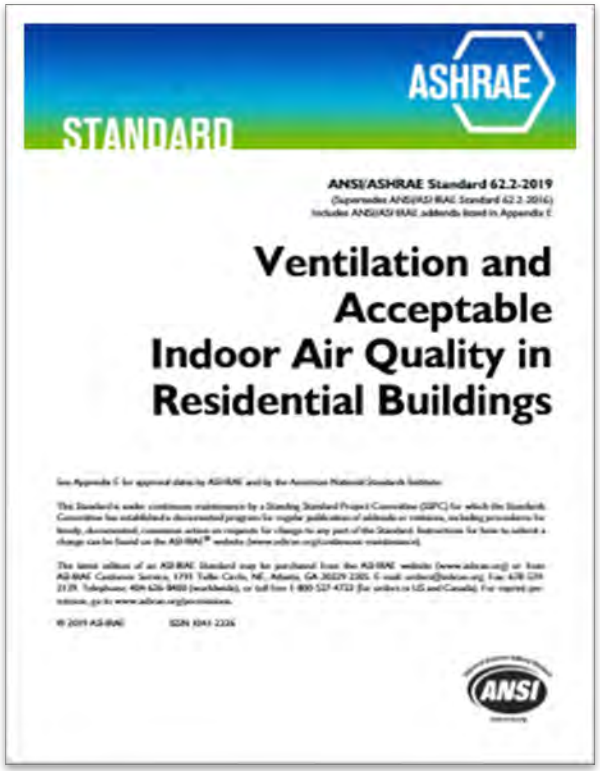
ASHRAE 62.2-2016 Ventilation rates



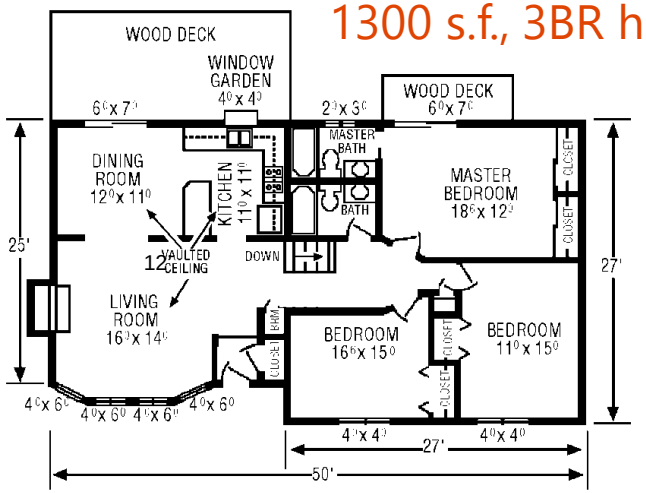
$$CFM_{fan} = (0.03 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$

Table 4-1a (I-P) Ventilation Air Requirements, cfm

	Bedrooms				
Floor Area, ft^2	1	2	3	4	5
<500	30	38	45	53	60
501 to 1000	45	53	60	68	75
1001 to 1500	60	68	75	83	90
1501 to 2000	75	83	90	98	105
2001 to 2500	90	98	105	113	120
2501 to 3000	105	113	120	128	135
3001 to 3500	120	128	135	143	150
3501 to 4000	135	143	150	158	165
4001 to 4500	150	158	165	173	180
4501 to 5000	165	173	180	188	195

ASHRAE 62.2-2016 Single Family Example – small house

1300 s.f., 3BR house



ASHRAE 62.2-2016:

3 Bedrooms = 4 people
4 people x 7.5 cfm / person = 30 cfm
30 cfm + 39 = 69 cfm

ASHRAE 62.2 - 2016

$$CFM_{fan} = (0.03 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$

OR

Table 4-1a (I-P) Ventilation Air Requirements, cfm

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ASHRAE 62.2-2016 Single Family Example – large house

5200 s.f.,
5 BR house

ASHRAE 62.2-2016:

5 Bedrooms = 6 people
6 people x 7.5 cfm / person = 45 cfm
45 cfm + 156 = <u>201 cfm</u>

ASHRAE 62.2 - 2016

$$CFM_{fan} = (0.03 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$

OR

Table 4-1a (I-P) Ventilation Air Requirements, cfm

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3501 to 4000	135	143	150	158	165
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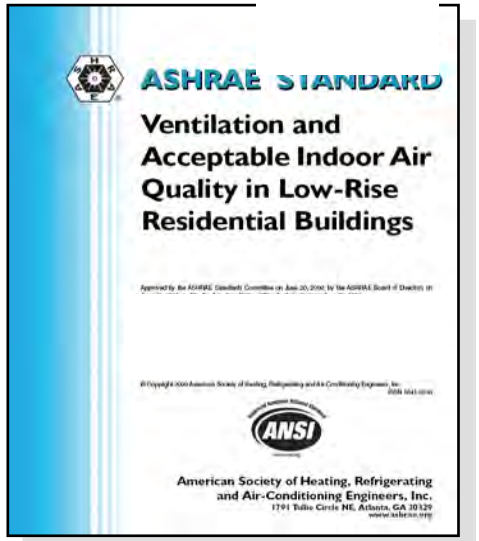
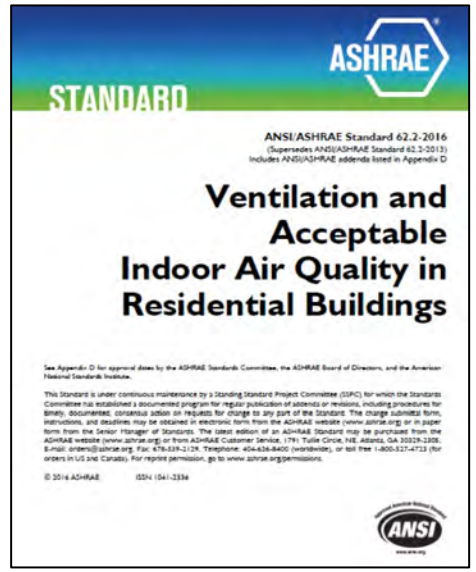
Variable Ventilation rates





RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor[a]	4	3	2	1.5	1.3	1.0

4.5.1 Short-Term Average Ventilation. To comply with this section, a variable ventilation system shall be installed to provide an average dwelling-unit ventilation rate over any three-hour period that is greater than or equal to Q_{fan} as calculated using Section 4.

Quiz Question

- According to ASHRAE 62.2-2010/2016, how much CFM per person must be added to the total calculation?

A. 7.5 CFM

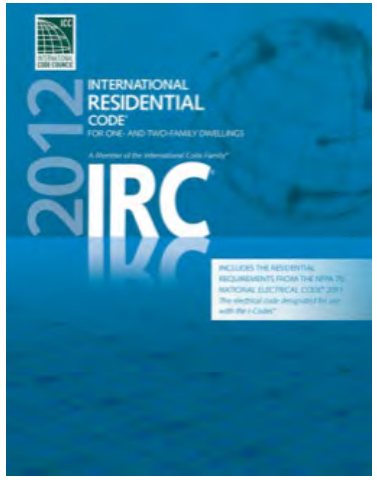
B. 15 CFM

C. 25 CFM

D. 50 CFM

2012 IRC Ventilation requirements

- Ventilation is REQUIRED
- For any home tighter than 5 ACH50



R303.4 Mechanical ventilation. Where the air infiltration rate of a dwelling unit is less than 5 air changes per hour when tested with a blower door at a pressure of 0.2 inch w.c (50 Pa) in accordance with Section N1102.4.1.2, the dwelling unit shall be provided with whole-house mechanical ventilation in accordance with Section M1507.3.

R303.5 Opening location. Outdoor intake and exhaust openings shall be located in accordance with Sections R303.5.1 and R303.5.2.

R303.5.1 Intake openings. Mechanical and gravity outdoor air intake openings shall be located a minimum of 10 feet (3048 mm) from any hazardous or noxious contaminant, such as vents, chimneys, plumbing vents, streets, alleys, parking lots and loading docks, except as otherwise specified in this code. Where a source of contaminant is located within 10 feet (3048 mm) of an intake opening, such opening shall be located a minimum of 3 feet (914 mm) below the contaminant source.

For the purpose of this section, the exhaust from *dwelling* unit toilet rooms, bathrooms and kitchens shall not be considered as hazardous or noxious.

R303.5.2 Exhaust openings. Exhaust air shall not be directed onto walkways.

2012 IECC Ventilation requirements

- Ventilation is REQUIRED:
- For most of country (CZ 3-8), < **3 ACH_{50}**
- For CZ 1-2, < 5 **ACH_{50}**

Between ‘12 IECC and ‘12 IRC, whole house mechanical ventilation is now mandated everywhere!

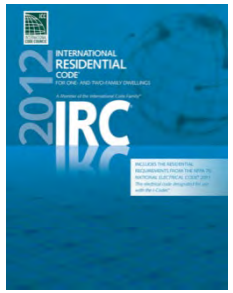
TABLE R402.4.1.1
AIR BARRIER AND INSULATION INSTALLATION

COMPONENT	CRITERIA*
Air barrier and thermal barrier	A continuous air barrier shall be installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed. Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.
Walls	Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. The junction of the top plate and top of exterior walls shall be sealed. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Knee walls shall be sealed.
Windows, skylights and doors	The space between window/door jambs and framing and skylights and framing shall be sealed.
Rim joists	Rim joists shall be insulated and include the air barrier.
Floors (including above-garage and cantilevered floors)	Insulation shall be installed to maintain permanent contact with underside of subfloor decking. The air barrier shall be installed at any exposed edge of insulation.
Crawl space walls	Where provided in lieu of floor insulation, insulation shall be permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.
Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.
Narrow cavities	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air tight, IC rated, and sealed to the drywall.
Plumbing and wiring	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air sealed boxes shall be installed.
HVAC register boots	HVAC register boots that penetrate building thermal envelope shall be sealed to the sub-floor or drywall.
Fireplace	An air barrier shall be installed on fireplace walls. Fireplaces shall have gasketed doors.

2012 IRC is Based on ASHRAE 62.2-2010

- 2012 takes the 62.2-2010 table only

Floor Area (ft^2)	BEDROOMS				
	0 - 1	2 - 3	4 - 5	6 - 7	>7
< 1500	30	45	60	75	90
1501 – 3000	45	60	75	90	105
3001 – 4500	60	75	90	105	120
4501 – 6000	75	90	105	120	135
6001 – 7500	90	105	120	135	150
> 7500	105	120	135	150	165



2018 added the formula

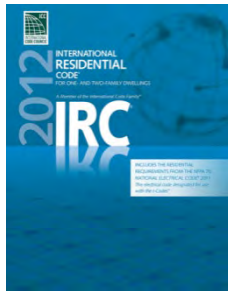
$$CFM_{fan} = (0.01 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$

2012-18 IRC important considerations

- CFMs are based on design and not on verified flow measurements

SECTION M1507
MECHANICAL VENTILATION

M1507.1 General. Where local exhaust or whole-house mechanical ventilation is provided, the equipment shall be designed in accordance with this section.



2012 INTERNATIONAL RESIDENTIAL CODE®

M1507.4 Local exhaust rates. *Local exhaust* systems shall be designed to have the capacity to exhaust the minimum air flow rate determined in accordance with Table M1507.4.

TABLE M1507.4
MINIMUM REQUIRED LOCAL EXHAUST RATES FOR ONE- AND TWO-FAMILY DWELLINGS

AREA TO BE EXHAUSTED	EXHAUST RATES
Kitchens	100 cfm intermittent or 25 cfm continuous
Bathrooms-Toilet Rooms	Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous

For SI: 1 cubic foot per minute = 0.0004719 m^3/s.

M1507.3 Whole-house mechanical ventilation system. Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1507.3.1 through M1507.3.3.

M1507.3.1 System design. The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered to provide supply ventilation.

M1507.3.2 System controls. The whole-house mechanical ventilation system shall be provided with controls that enable manual override.

M1507.3.3 Mechanical ventilation rate. The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate of not less than that determined in accordance with Table M1507.3.3(1).

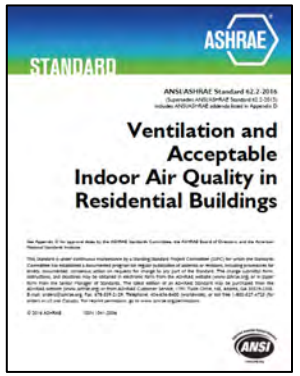
Exception: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25-percent of each 4-hour segment and the ventilation rate prescribed in Table M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2).

IRC vs 62.2-2016 Basic Example - 3 BR, 1400 s.f.

- Use IRC Table
- (Originally from ASHRAE 62.2-2010)

45 CFM Continuous

Floor Area (ft^2)	BEDROOMS				
	0 - 1	2 - 3	4 - 5	6 - 7	>7
< 1500	30	45	60	75	90
1501 – 3000	45	60	75	90	105
3001 – 4500	60	75	90	105	120
4501 – 6000	75	90	105	120	135
6001 – 7500	90	105	120	135	150
> 7500	105	120	135	150	165



Use ASHRAE 62.2-2016 Formula

72 CFM Continuous

$$CFM_{fan} = (0.03 \times A_{floor}) + (7.5 \times (\#\ bedrooms + 1))$$

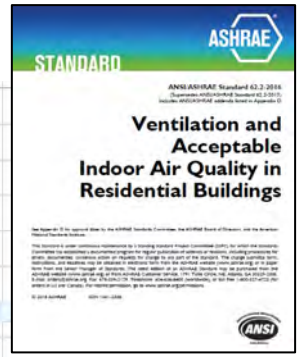
3 cfm/100 ft^2 + (7.5 x (*# bedrooms* + 1))

= *42 CFM + 30 CFM =* ***72 CFM*** *continuous*

62.2-2016 Ventilation Calculator

EarthCraft Single Family Ventilation Calculator based on ASHRAE 62.2-2016			3	Blue fields - entry required
			4	Green fields - entry optional
OPTIONAL: Back out your CFM50:				
Enter the Volume:	12000	cubic feet		
Enter target ACH50:	5			
Estimated CFM50:	**1000**	cfm50		
Enter Floor Area:	1400	sq. feet		
Enter # Bedrooms:	3			
Enter Building Height:	9.0	feet	(e.g., 17' for 2 story)	
Enter Avg Ceiling Height	9.00	feet	(used to calculate volume only)	
Conditioned Volume	12600	cubic feet		
Enter Blower Door CFM50:	1050	cfm50		
ACH50	5.00	ACH	(for reference/comparison only)	
Enter Location wsf:	0.46		(use Chart from Appendix B) =>	
Qtot	72		Starting Ventilation Amount	
			(before adjusting for infiltration)	
---Hidden slides determine Qinf---				
Qinf	26.2	cfm	(infiltration CFM that will be credited)	
Qinf, limit	48		(maximum that could be subtracted)	
Enter Aext	1		(for single family, assume Aext = 1)	
Qfan	45.8	cfm		

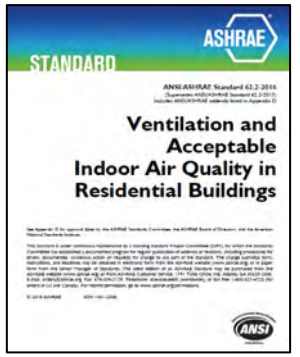
$$Q_{fan} = Q_{tot} - Q_{inf}$$



ASHRAE 62.2-2016 Appendix B wsf Values for Georgia

wsf	Weather Station	Latitude	Longitude	State
0.37	Alma Bacon County AP	31.53	–82.50	Georgia
0.40	Brunswick Golden Is	31.25	–81.47	Georgia
0.40	Brunswick Malcolm McKinnon AP	31.15	–81.38	Georgia
0.38	Albany Dougherty County AP	31.53	–84.18	Georgia
0.36	Valdosta Wb Airport	30.78	–83.28	Georgia
0.41	Macon Middle Ga Regional AP	32.68	–83.65	Georgia
0.39	Warner Robins AFB	32.63	–83.60	Georgia
0.41	Augusta Bush Field	33.37	–81.97	Georgia
0.46	Atlanta Hartsfield Intl AP	33.63	–84.43	Georgia
0.37	Fulton Co Arpt Brow	33.77	–84.52	Georgia
0.39	Dekalb Peachtree	33.87	–84.30	Georgia
0.35	Fort Benning Lawson	32.35	–85.00	Georgia
0.39	Columbus Metropolitan Arpt	32.52	–84.95	Georgia
0.40	Marietta Dobbins AFB	33.92	–84.52	Georgia
0.40	Athens Ben Epps AP	33.95	–83.33	Georgia
0.38	Rome R B Russell AP	34.35	–85.17	Georgia
0.40	Hunter AAF	32.00	–81.15	Georgia
0.36	Moody AFB/Valdosta	30.97	–83.20	Georgia
0.40	Savannah Intl AP	32.12	–81.20	Georgia

62.2-2016 Ventilation Calculator



RED

Reset Print

ASHRAE 62.2-2016 Ventilation

New or existing construction: Existing

Dwelling unit is: Detached

Use infiltration credit: Yes

Closest weather station: United States / Georgia / Dekalb Peachtree

Weather and shielding factor [1/hr] = 0.39

Floor area [ft2] 2200

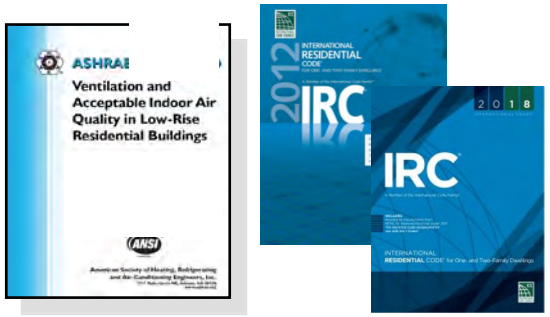
Number of occupants: 5

Dwelling height [ft] 9

Measured leakage @ 50Pa [CFM] 2000

Use Advanced Blower Door Inputs

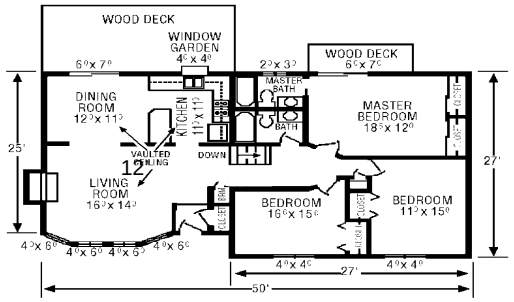
Summary of ventilation rates



RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor[a]	4	3	2	1.5	1.3	1.0

62.2-2010 & IRC '12-18

7.5 cfm/person + 1 cfm/100 ft^2

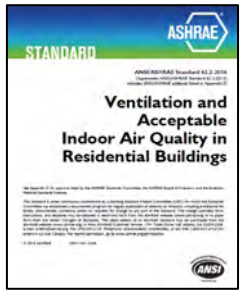


1300 s.f., 3BR house

43/45 cfm
formula/table

(5,200 s.f., 5BR)

97/105 cfm
formula/table



62.2-2016

7.5 cfm/person + 3 cfm/100 ft^2

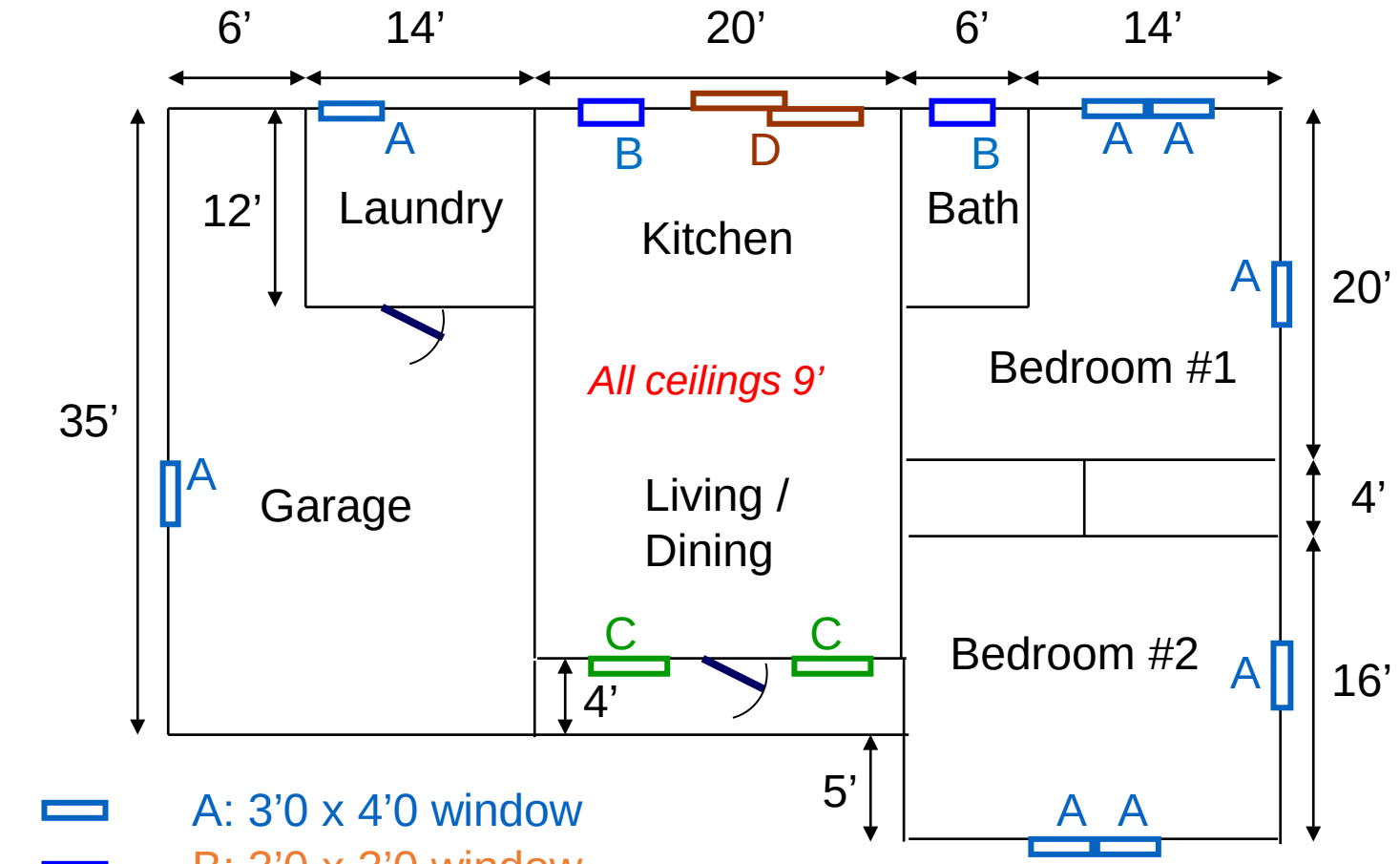
69 cfm*

201 cfm*

4.5.1 Short-Term Average Ventilation. To comply with this section, a variable ventilation system shall be installed to provide an average dwelling-unit ventilation rate over any three-hour period that is greater than or equal to Q_{fan} as calculated using Section 4.

** Before Q_{inf} adjustments for BD result*

Quiz Question: Simple House



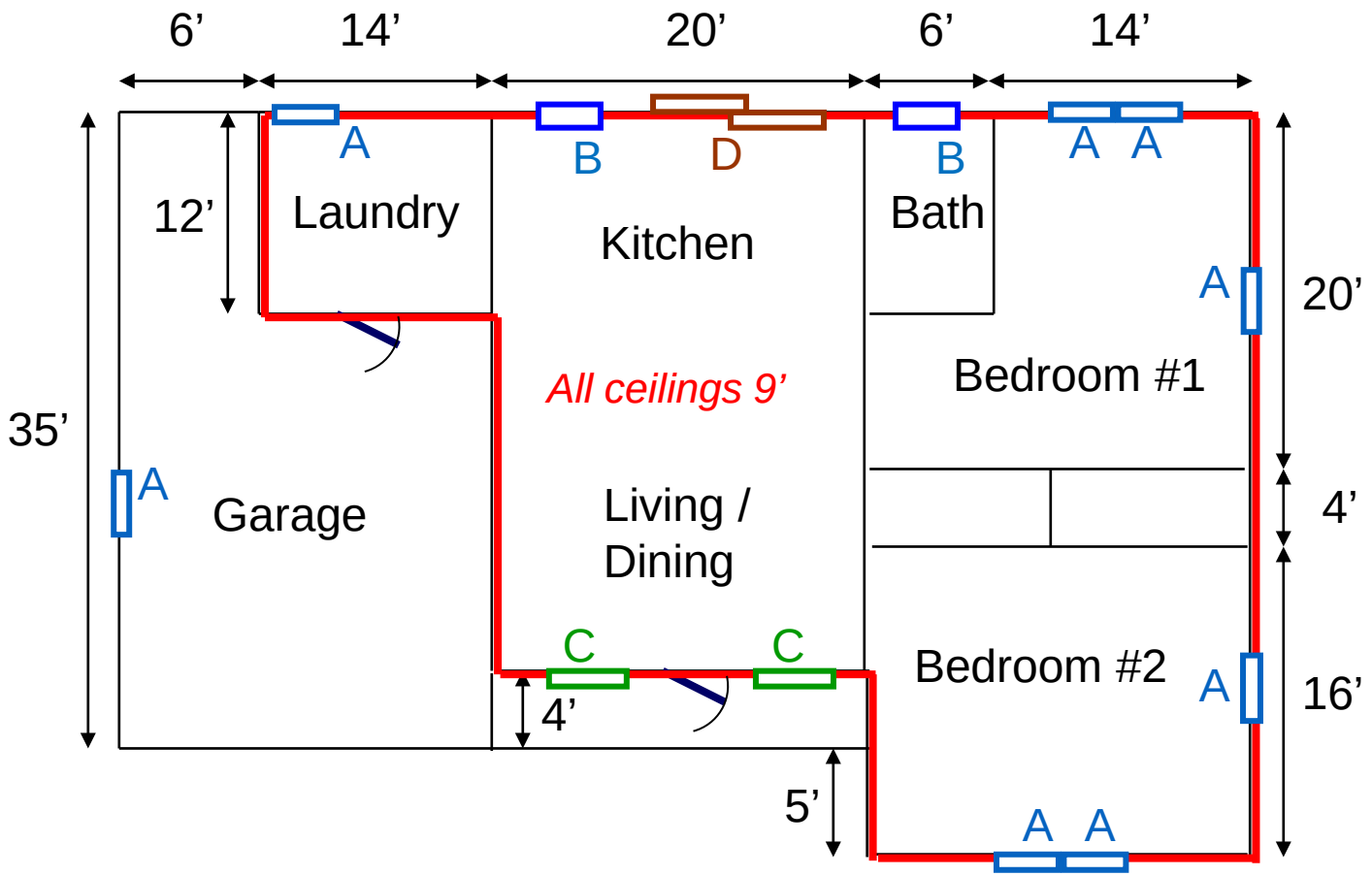
A: 3’0 x 4’0 window

B: 3’0 x 3’0 window

C: 5’0 x 4’0 window

D: 6’0 x 6’8 (Sliding Glass Door)

Quiz: 1588 sq. ft. Simple House



A: 3’0 x 4’0 window

B: 3’0 x 3’0 window

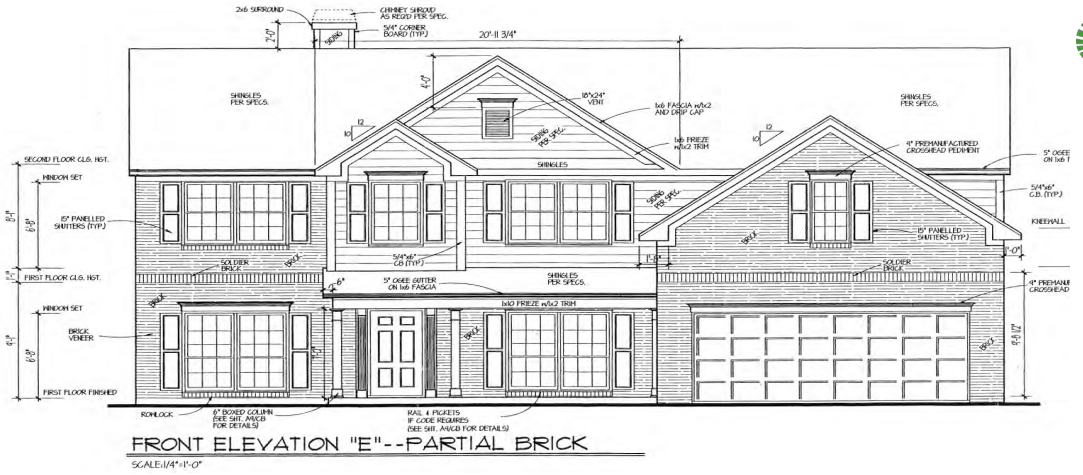
C: 5’0 x 4’0 window

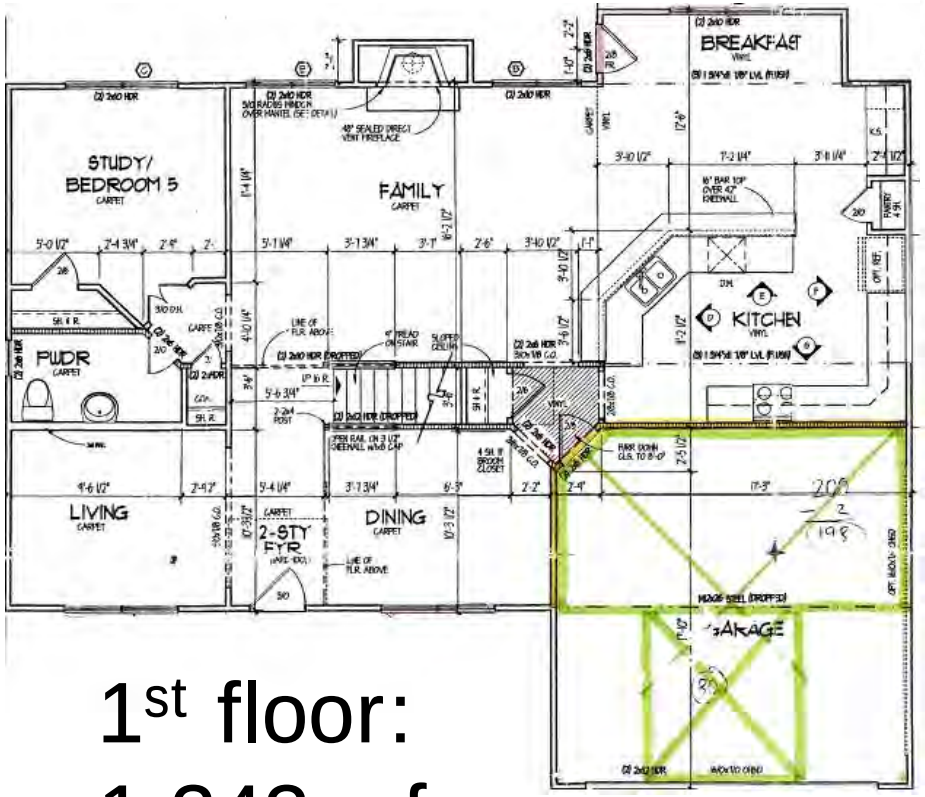
D: 6’0 x 6’8 (Sliding Glass Door)

By IRC/IECC, how much Ventilation?

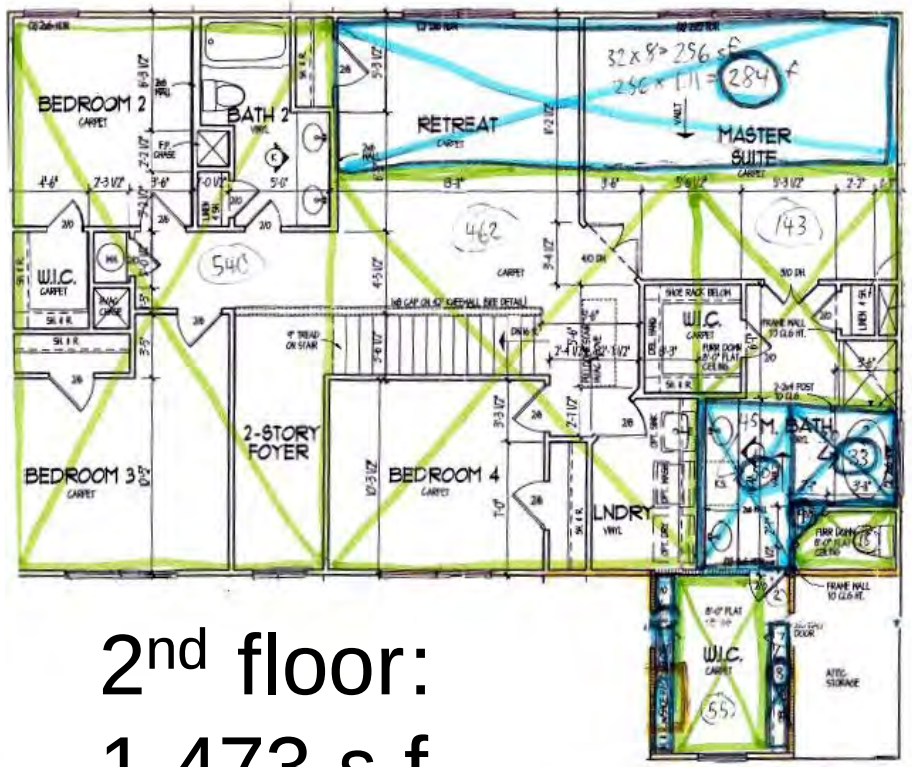
- Floor Area:
  12x14 +
  20x31 +
  20x40 =
  1,588 sq. ft.
- Two Bedrooms
- 16 + (2+1)x7.5 = 39 cfm

Acme 5 BR Home, 2816 sq. ft.



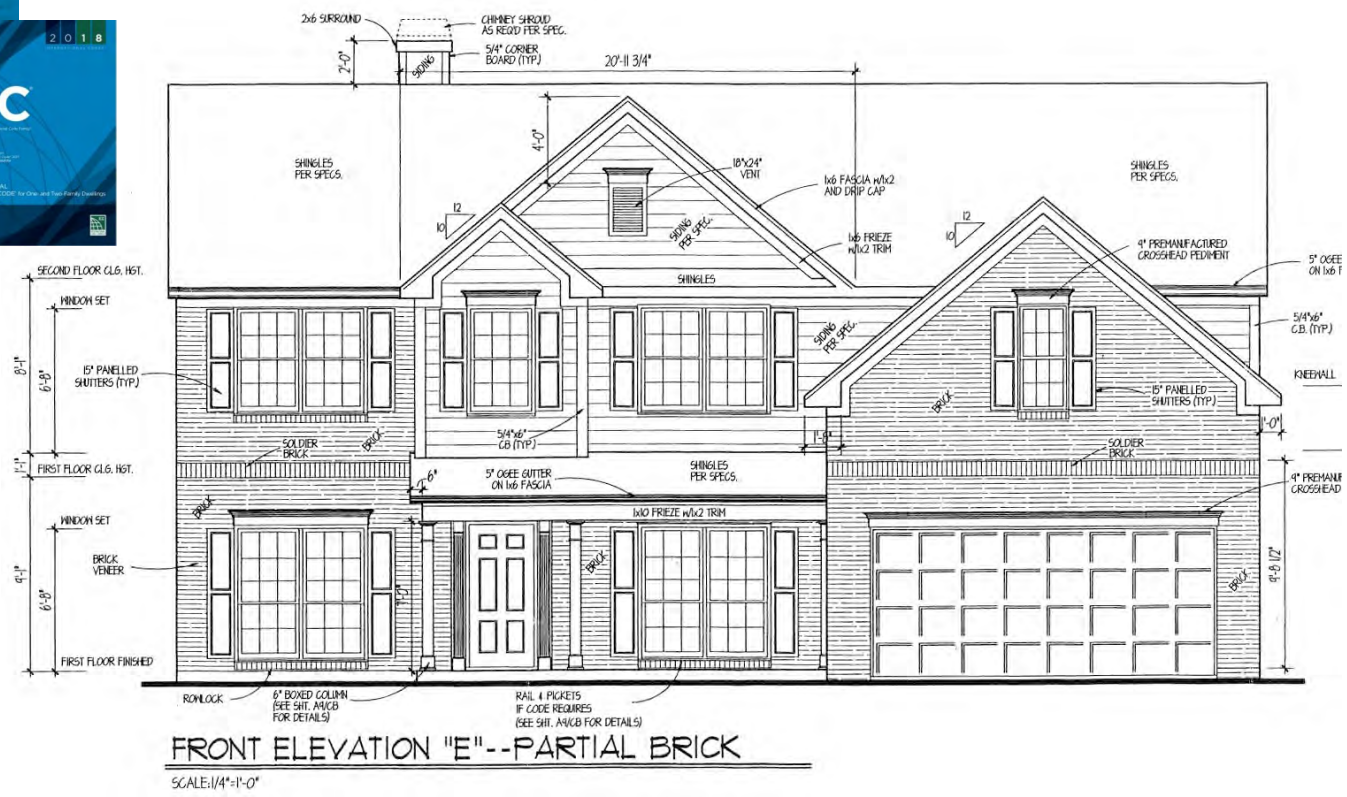


1st floor:
1,343 s.f.



2nd floor:
1,473 s.f.

Quiz Question “Acme” 5 BR Home, 2816 sq. ft.



How much Ventilation?

- Floor Area:
  1343 +
  1473 =
  2,816 sq. ft.
- Five Bedrooms
- 28 + (5+1)x7.5 = 73 cfm

Part 1 Summary

- Ventilation is only a part of achieving good IAQ
  1. Eliminate pollutants
  2. Separate pollutants
  3. Dilute (flush with ventilation)
  4. Filter to catch particles (thick, pleated!)
- ASHRAE 62.2-2010: [7.5/person + 1/100 s.f.]
- IRC is based on above (62.2 -2010) (intermittent ventilation is acceptable)
- ASHRAE 62.2-2016: [7.5/person + 3/100 s.f.]
  - Adjustments allowed for BD test results, existing fans
- ASHRAE 62.2 requires verifying the CFM

Part 2 Ventilation Strategies

Strategies for whole house Ventilation

- Exhaust only
  - Single or multiple ventilation fans
- Supply only
  - Outside air into building
    - Outside air into AHU return plenum
    - Inline supply fan
- Balanced
  - Fan in/fan out
  - Energy/Heat Recovery

Exhaust Only

- Usually a larger CFM, quieter bath exhaust fan with controller / timer switch
- Ventilation layout and installation is critical to airflow
  - Upsize fan to be sure of airflow
  - If 55 cfm is required, spec 70 cfm fan

Exhaust Only

- **Positives:**
- Inexpensive to buy and operate, especially with DC motor; runs continuously
- If quiet, occupant might not unplug it

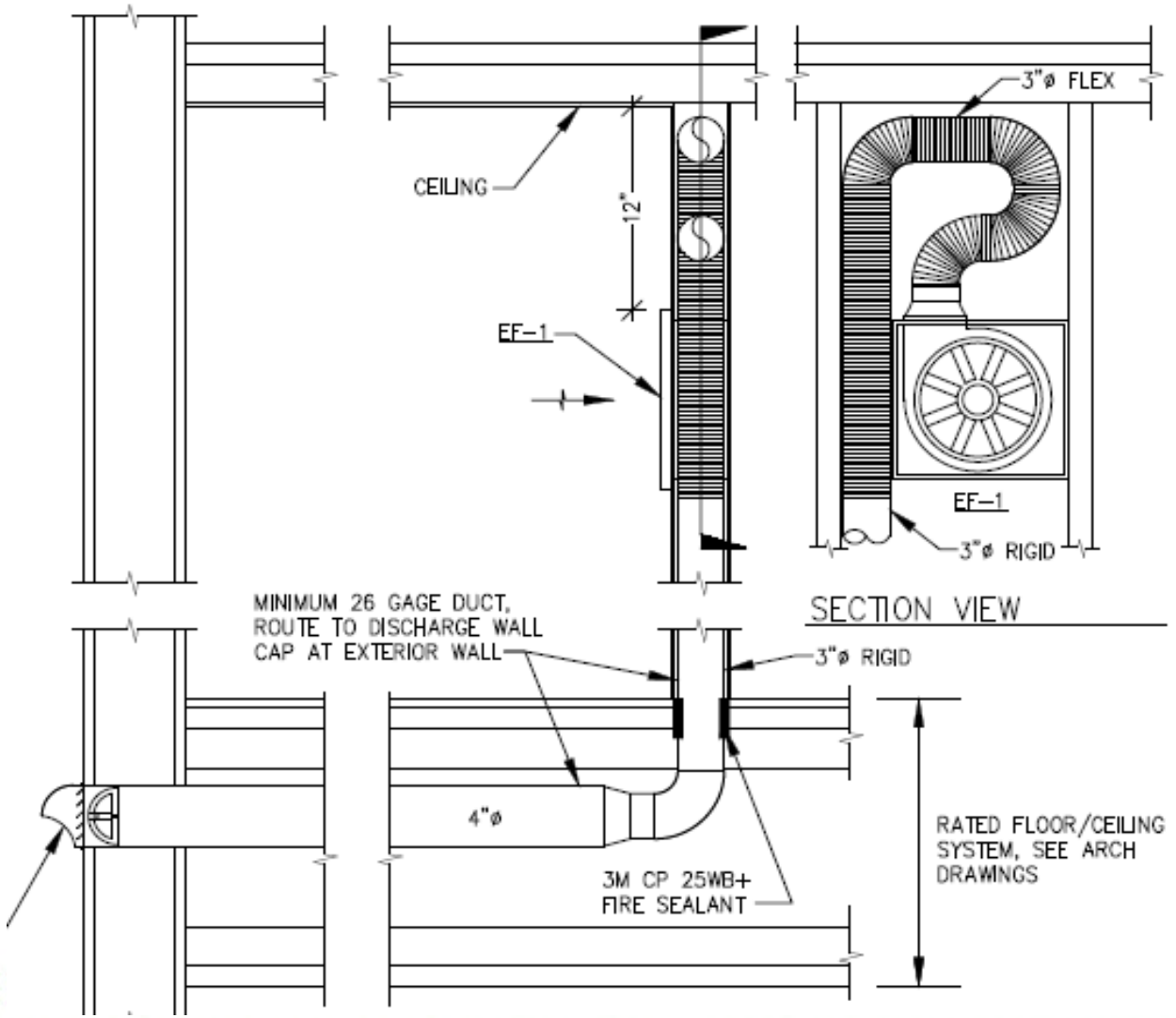
Negatives

- Negative pressure pulls unconditioned air from largest, most available holes and leaks
- How will incoming air be filtered and conditioned?
- Potential combustion safety issues
- Moisture

Ventilation Ducting Matters!

Never use 3” duct!

- Our “real world” concerns…



Duct Sizing

- Recommend upsizing the duct diameter from the fan
- Round metal is best; minimal flex is okay
- Minimize turns (two 45's are much better than two 90's)
- No smaller than ½" mesh bird screen at termination

FIELD DUCT SIZING CHART

ROUND DUCT SIZE ESTIMATE

Flexible Duct		Round Metal Pipe	
Duct Size	Design Airflow	Duct Size	Design Airflow
5"	50	5"	50
6"	75	6"	85
7"	110	7"	125
8"	160	8"	180
9"	225	9"	240
10"	300	10"	325
12"	480	12"	525
14"	700	14"	750
16"	1000	16"	1200
18"	1300	18"	1500
20"	1700	20"	2000

Flex duct = .05" on most metal duct calculator Round metal pipe = .06" on most metal duct calculators

RECTANGULAR DUCT SIZE ESTIMATE

Design CFM	Duct Height - Net inside dimension in inches									
	4"	CFM	6"	CFM	8"	CFM	10"	CFM	12"
60	6x4	60	4x6	90	4x8	120	4x10	150	4x12
90	8x4	110	6x6	160	6x8	215	6x10	270	6x12
120	10x4	160	8x6	230	8x8	310	8x10	400	8x12
150	12x4	215	10x6	310	10x8	430	10x10	550	10x12
180	14x4	270	12x6	400	12x8	550	12x10	680	12x12
210	16x4	320	14x6	490	14x8	670	14x10	800	14x12
240	18x4	375	16x6	580	16x8	800	16x10	950	16x12
270	20x4	430	18x6	670	18x8	930	18x10	1100	18x12
300	22x4	490	20x6	750	20x8	1060	20x10	1250	20x12
330	24x4	540	22x6	840	22x8	1200	22x10	1400	22x12
		600	24x6	930	24x8	1320	24x10	1600	24x12
		650	26x6	1020	26x8	1430	26x10	1750	26x12
		710	28x6	1100	28x8	1550	28x10	1950	28x12
		775	30x6	1200	30x8	1670	30x10	2150	30x12
40	21/2 x10			1300	32x8	1800	32x10	2300	32x12
70	21/2 x14			1400	34x8	1930	34x10	2450	34x12
150	21/2 x30			1500	36x8	2060	36x10	2600	36x12
		100	31/2 x14			2200	38x10	2750	38x12
		220	31/2 x30			2350	40x10	2900	40x12
								3050	42x12

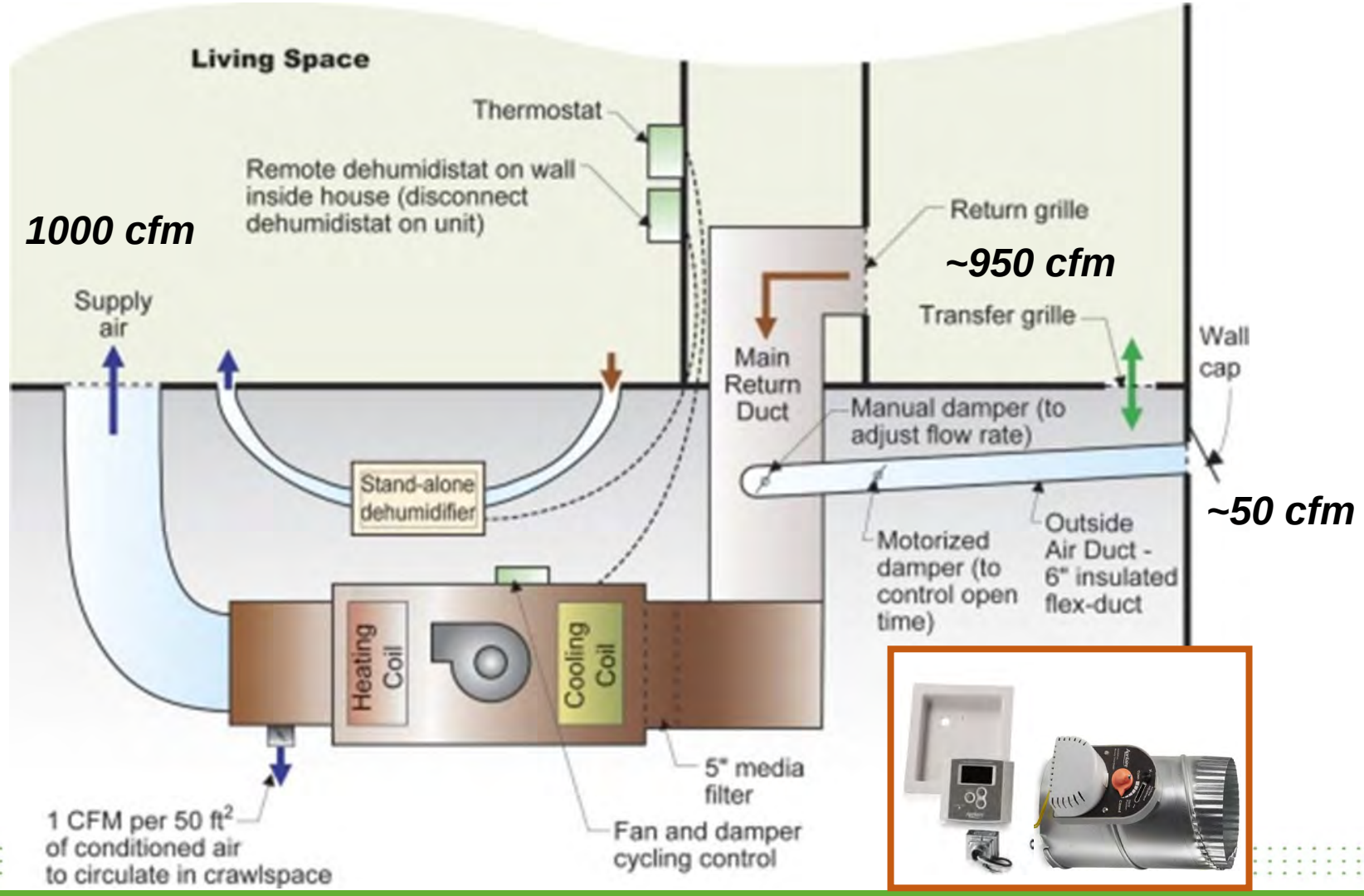
Rectangular sheet metal duct = .07" on most metal duct calculators

Supply Only

- Vent from outside to house or return plenum
- Air needs to be filtered
- Need manual (balancing) damper, motorized damper and timer or controller
- Insulate vent duct

Supply - Positive Pressure Ventilation

Positive ventilation supplied via outside air ducted to return



Supply Only with HVAC

Positives:

- If designed & installed correctly, this approach should supply the intended ventilation CFM
- Air can be filtered and pre-conditioned
- Slight positive pressure inside house keeps pollutants at bay (good in humid climate zones)
- Ventilation air is well mixed and distributed throughout house by duct system
- Mitigates combustion safety issues
- Fairly easy to retrofit

Negatives

- Energy penalty of using big fan to bring in a small amount of air (affects HERS Index)
- In MF, may yield inadequate air flow due to low pressure in HVAC closet – consider a shroud
- Size of vent duct affects run-time
- More pieces to design, install, operate
- Exterior vent placement with filtration

Code considerations for Supply Only

- **R403.6 Mechanical ventilation (Mandatory)**
- The building shall be provided with ventilation that complies with the requirements of the International Residential Code or International Mechanical Code, as applicable, or with other approved means of ventilation. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating.

  R403.6.1 Whole-house mechanical ventilation system fan efficacy. Fans used to provide whole-house mechanical ventilation shall meet the efficacy requirements of **Table R403.6.1.**

  Exception: Where an air handler that is integral to tested and listed HVAC equipment is used to provide whole-house mechanical ventilation, the air handler shall be powered by an electronically commutated motor.

TABLE R403.6.1
WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM FAN EFFICACY[a]

FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
HRV or ERV	Any	1.2 cfm/watt	Any
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

Supply Only With In-Line Fan + Sensor based controls

- **Positives:**
- Likely to have correct ventilation cfm that is filtered & from known source
- Low initial and operating cost
- Can be set to under ventilate during “bad” conditions (too hot, too cold, too humid, too dry)

QUFRESH BY Air King
Patents Pending

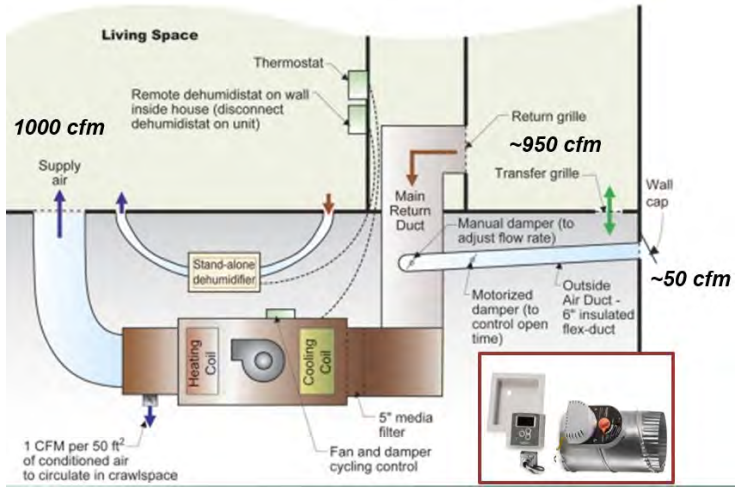
Negatives

- No dehumidification
- No energy recovery

HVI CERTIFIED PERFORMANCE				
MODEL	DUCT SIZE	STATIC PRESSURE	SPEED	WATTS
QFAM	6"	0.2	40 CFM	12.9
			50 CFM	13
			60 CFM	15.1
			70 CFM	17.1
			80 CFM	19.5
			90 CFM	21.8
			100 CFM	26.3
			110 CFM	27.5
			120 CFM	30.1

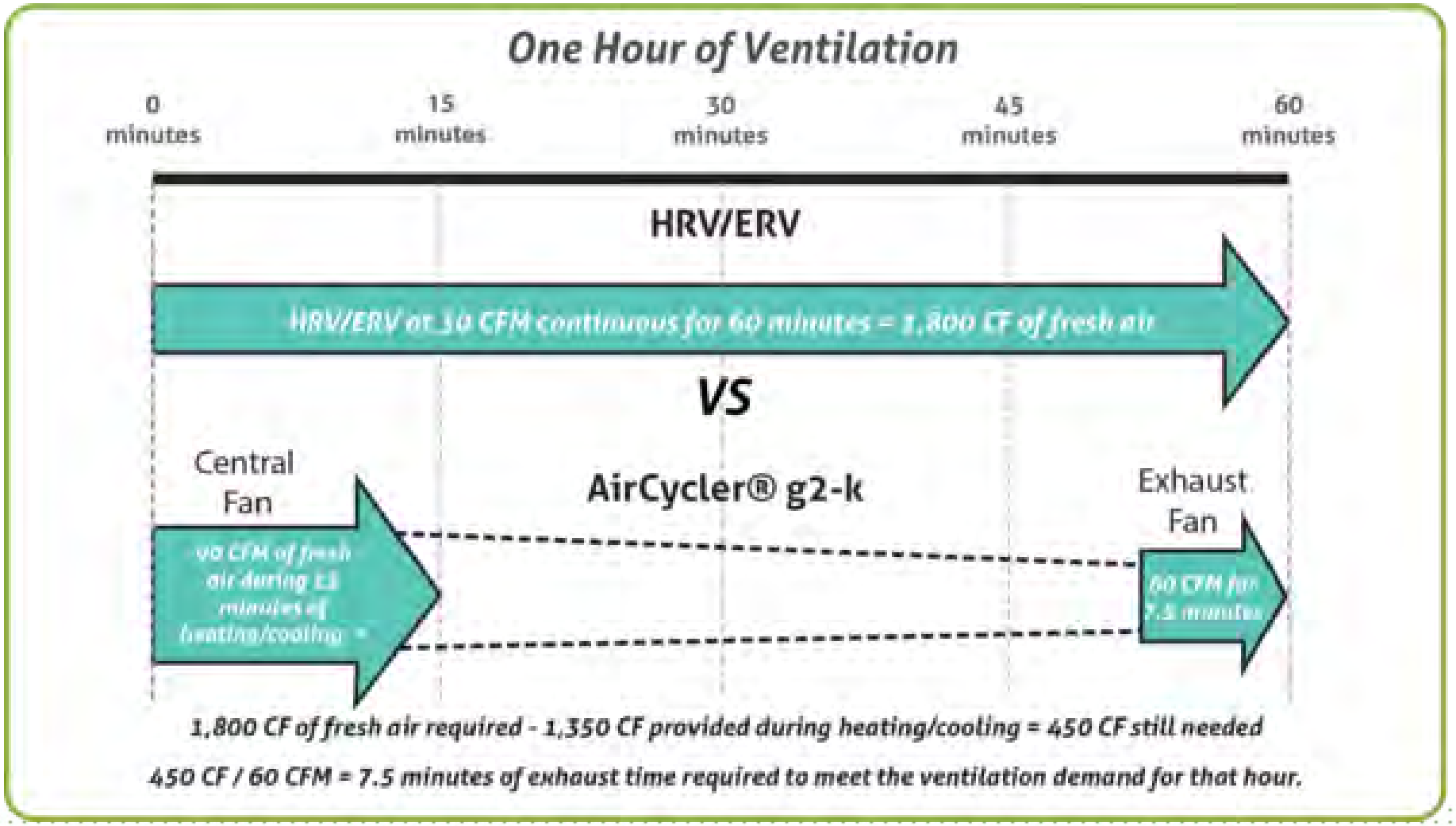
Hybrid approach

- Uses exhaust fan with intake air controlled by electric damper
  - Doesn't necessarily contribute to pressure imbalances inside house
  - Air needs to be filtered
  - Insulate vent pipe
- Controls that monitor hood, dryer, bath fan runtime and reduce ventilation accordingly



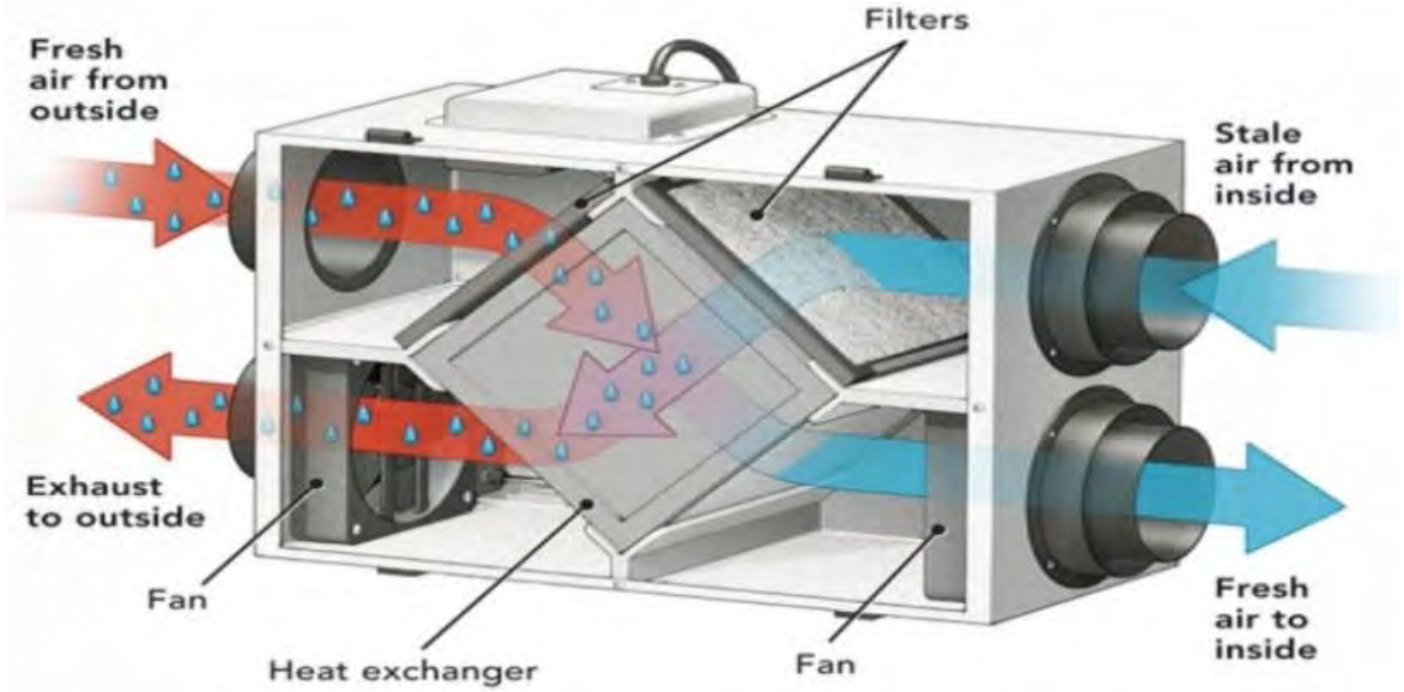
Hybrid approach

AirCycler® SIMPLE VENTILATION SOLUTIONS



Balanced - ERV/HRV

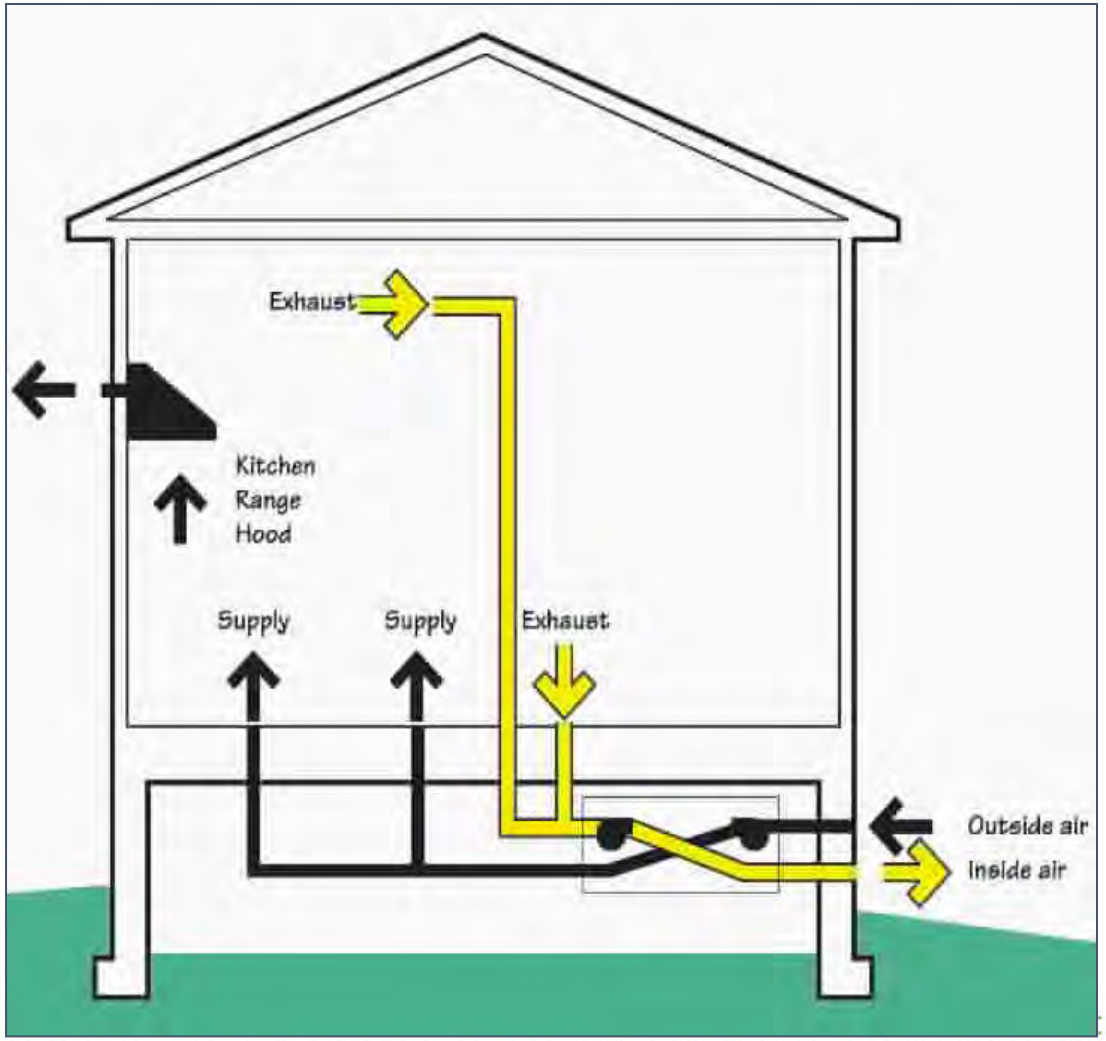
- Doesn’t contribute to pressure imbalances inside house
- Tempers humidity and temperature of incoming air
- Can be tied into duct system, best when independently ducted



Balanced Ventilation

- Energy Recovery Ventilator (ERV) – transfers both:

1. Heat (Sensible)
2. Moisture (Latent)

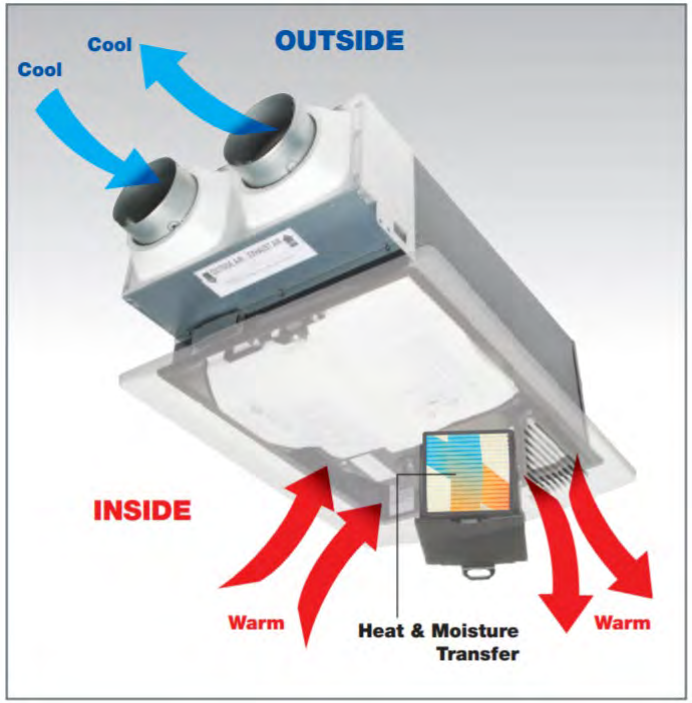


Balanced ERV - Spot Unit

- **Positives:**
- Doesn't create pressure imbalances
- Low energy use
- Relatively low cost
- Ease of set-up & operation
- 2 pipe design, lower installed cost

Negatives

- Low moisture transfer
- Distribution?



Balanced ERV – Whole house unit

- **Positives:**
- Doesn’t create pressure imbalances
- Low energy use
- Good mixing, so-so moisture transfer
- 4 ports, can be tied into duct system

Negatives

- Removes some of the OA moisture but ultimately still adds humidity
- Higher cost

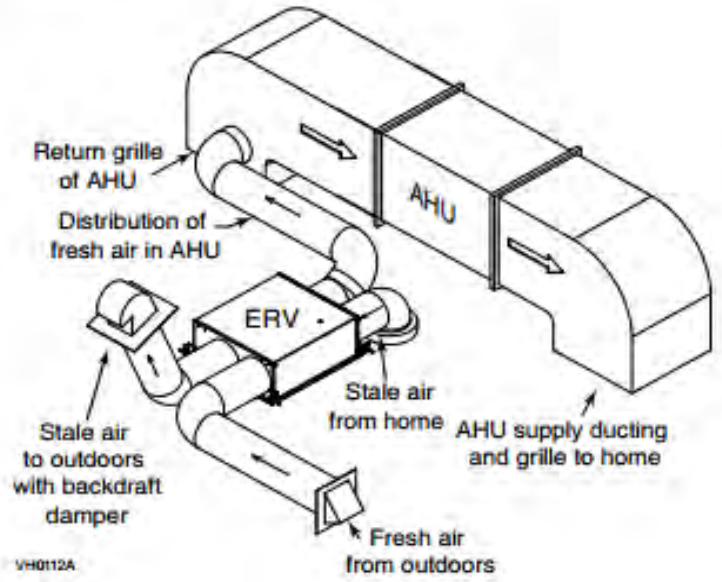
Balanced ERV- Installation Options

- Independently ducted system is best
- Can tie into return duct of main system (don't connect to both supply and return)

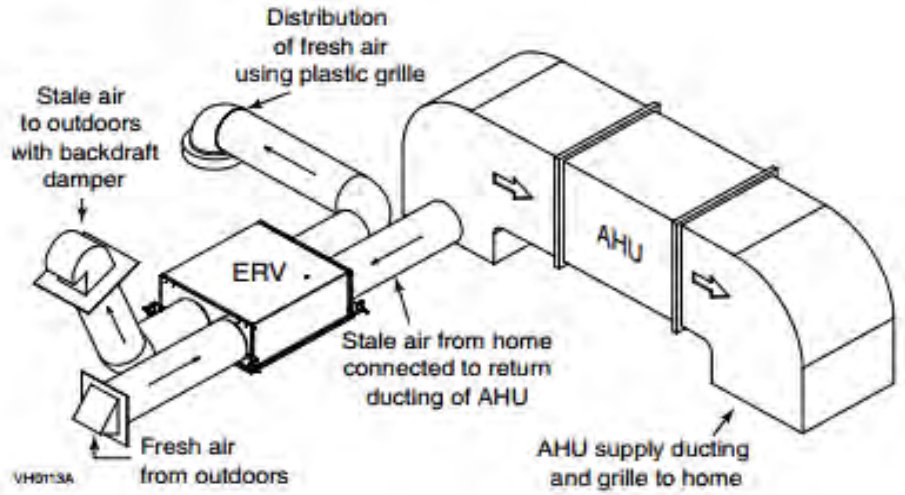
Combining with an AHU

Recommanded configurations
When the distribution of fresh air from the ERV is connected to the return of an AHU (such as in the image below, on the left), the connection should be done **as close as possible from the AHU return grille** to ensure proper functionning of the built-in fresh air damper.

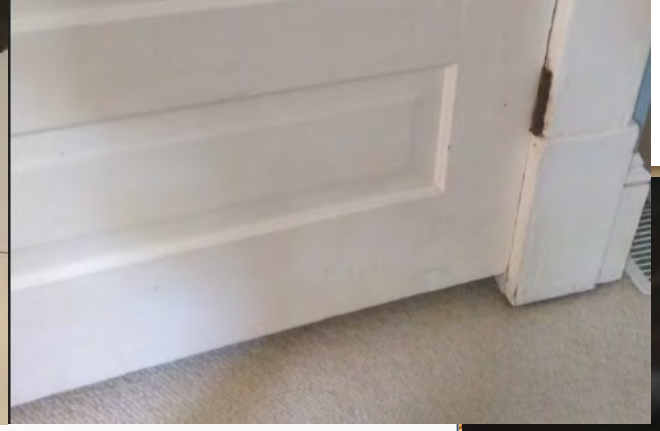
OPTION 1

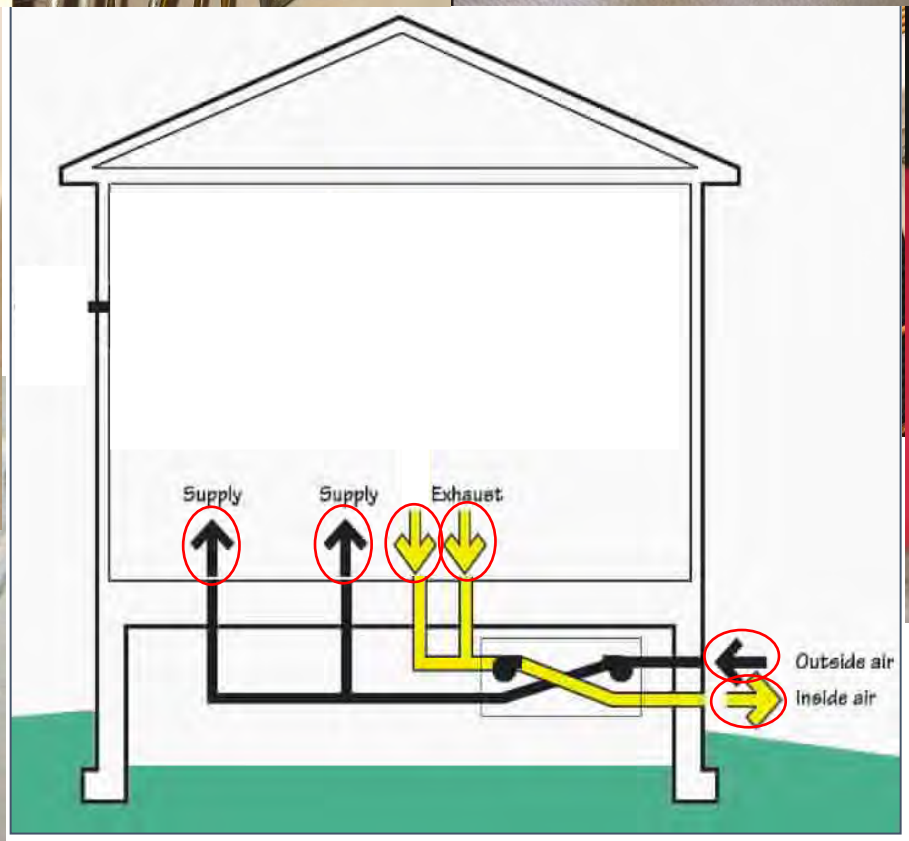


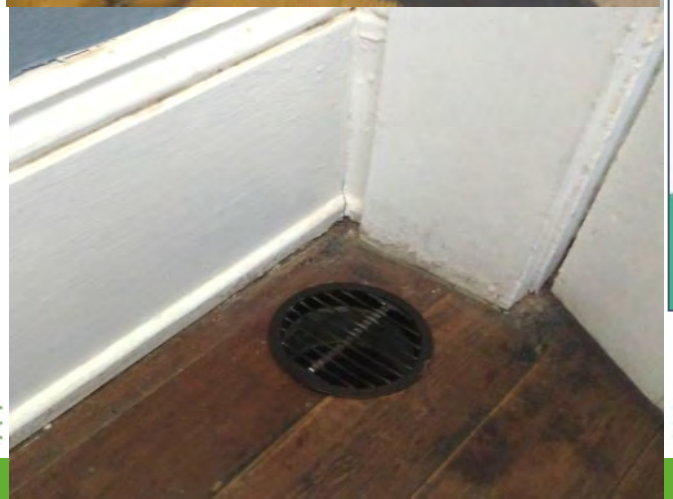
OPTION 2



ERV Retrofit







What is New(er) with Ventilation?

- Mini-splits are becoming more established in the market
- ERV's have gotten much more affordable
- ECM for variable speed AHU's
- "Smart" ventilation controls with sensors for temperature, moisture, particulates, etc.
- Loads have shifted
  - High performance homes don't need as much cooling
  - Homes need drying
- In-wall dehumidifiers for MF
- Ventilation dehumidifiers

HVAC and Moisture

- Don’t expect HVAC to fix bad envelope moisture issues
- Remember Psychrometrics
  - “It ain’t the heat, it’s the humidity”
  - Southern weather example
- HVAC controls can help
  - Humidistat
  - Variable speed blower
  - Variable capacity equipment (staged or variable speed compressors)

Ventilation - What could possibly go wrong…?

- Occupant doesn’t run AC or dehumidifier
  - No fans to move air
- Ventilation system is turned off
- Outside air not conditioned leading to moisture issues (mold/mildew)
- Lack of proper maintenance

Summer Temperature Example

Find 82°F and 80% Relative Humidity.

Record the grains: 132

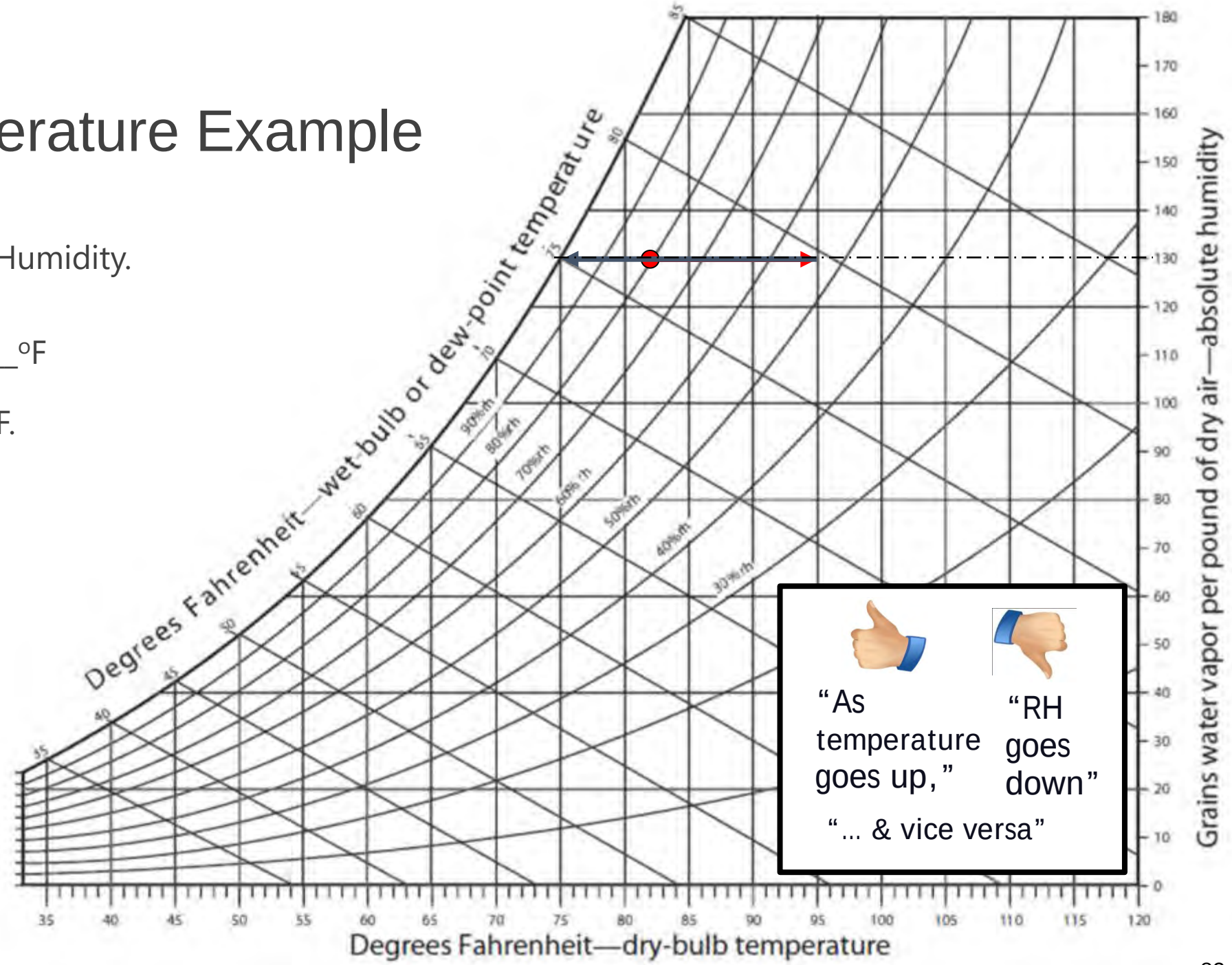
What is the Dew Point? 75 °F

This air is then heated to 95°F. What happens to the relative humidity? ↓

What is the RH? 53 %

This air is now cooled to 75°F. What happens to the relative humidity? ↑

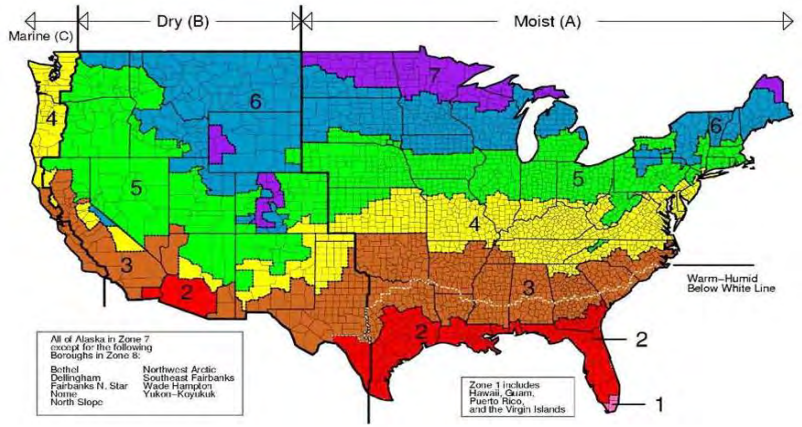
What is the relative humidity? 100 %



HVAC and Moisture

Manual J – calculates Sensible + Latent cooling loads (Sensible + Latent = Total)
Manual S – select equipment that can satisfy both sensible and latent loads (i.e., don't size based on Total Load)

Atlanta, GA									
Bin Temperature	70-75	75-80	80-85	85-90	90-95	95-100	100-105	105-110	Total
# of Hours of Occurrence	1188	880	620	361	172	23	2	0	3246
	37%	27%	19%	11%	5%	1%	0%	0%	
	83%			**17%**					
Manual J Design, Load based on Temperature					92°	99 gr/lb			
ASHRAE Humidity Design, Load based on Moisture					82°	133 gr/lb			
Approximate Extra Moisture Added per 100 CFM Of O.S.A.					3.9 pts/hr	or	93.9 pts/day		



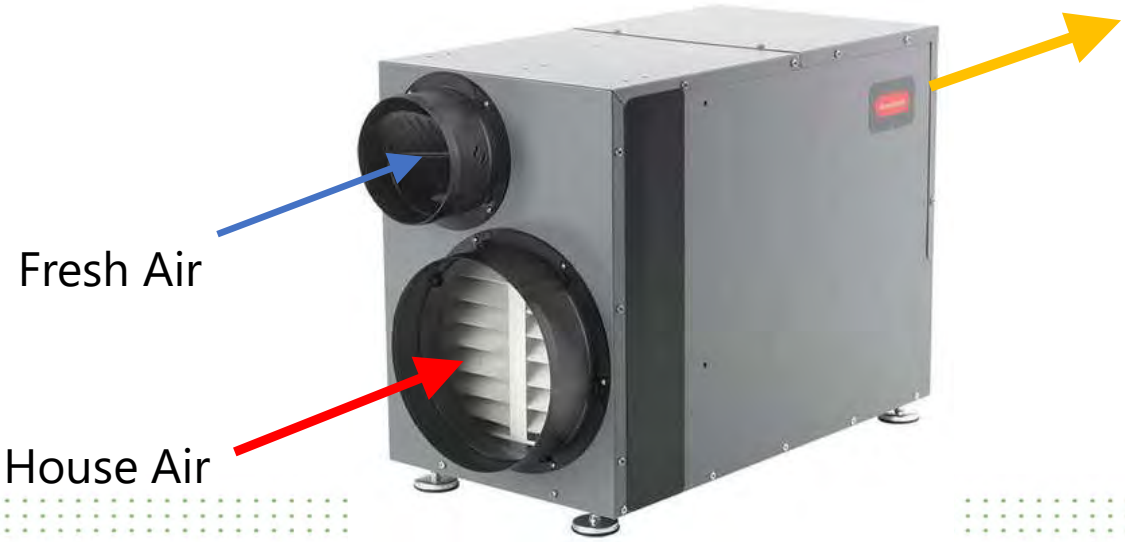
Mixed Air (filtered, dehumidified)

Fresh Air

House Air

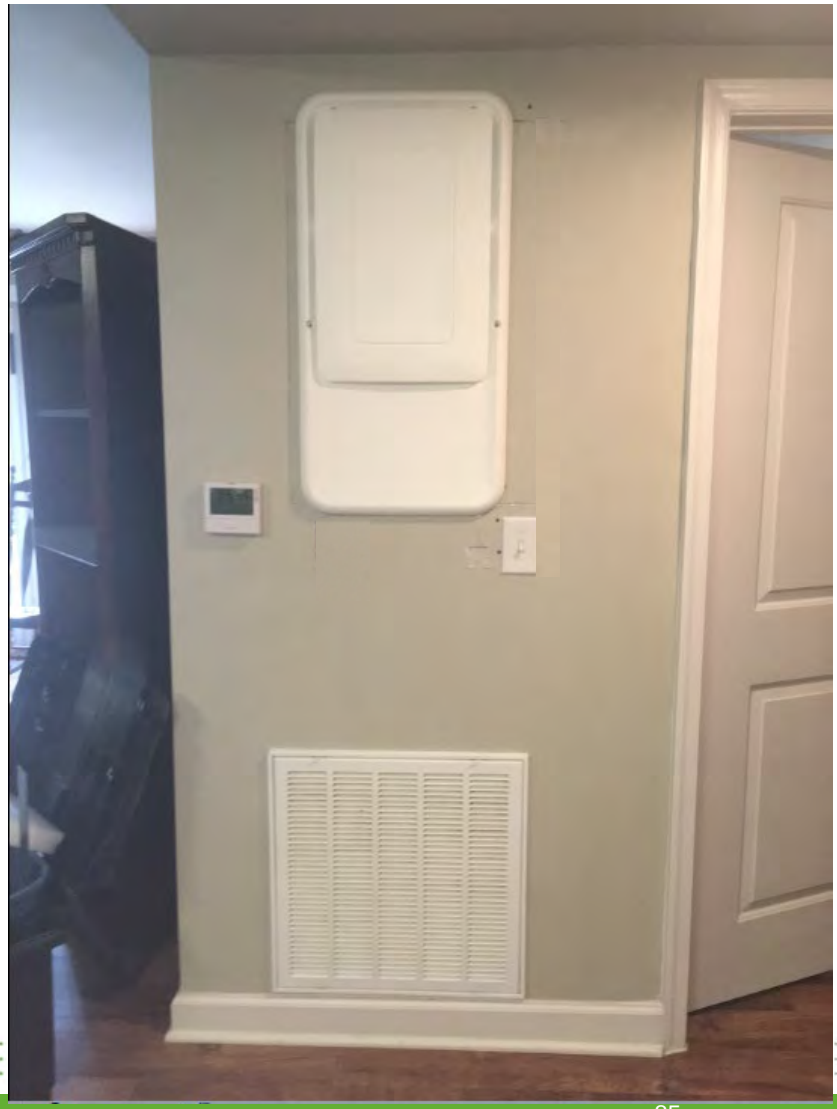
Supply Only – Ventilating Dehumidifier

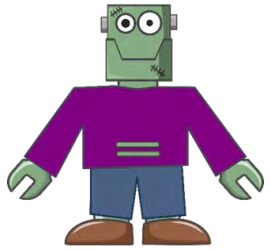
- Pulls air from house and from outside
- Filters & mixes two streams
- Dehumidifies as needed
  - 70 to 100+ ppd
  - Ideal for efficient houses with lower sensible loads but similar latent loads



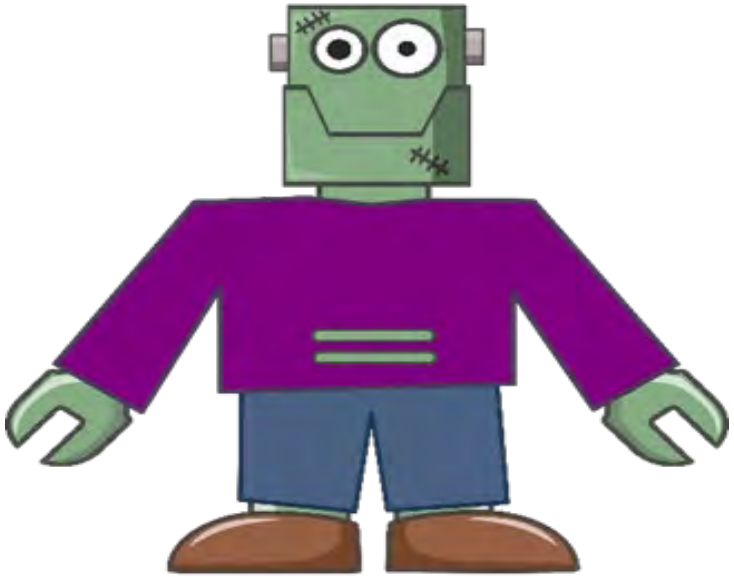
Supplemental Dehumidification

- Stand alone
- Innovative Dehumidifier
  - In-wall
  - Tamper-resistant
  - 25 ppd
- UltraAire MD33
  - 33 ppd
  - In-wall
  - Easier install

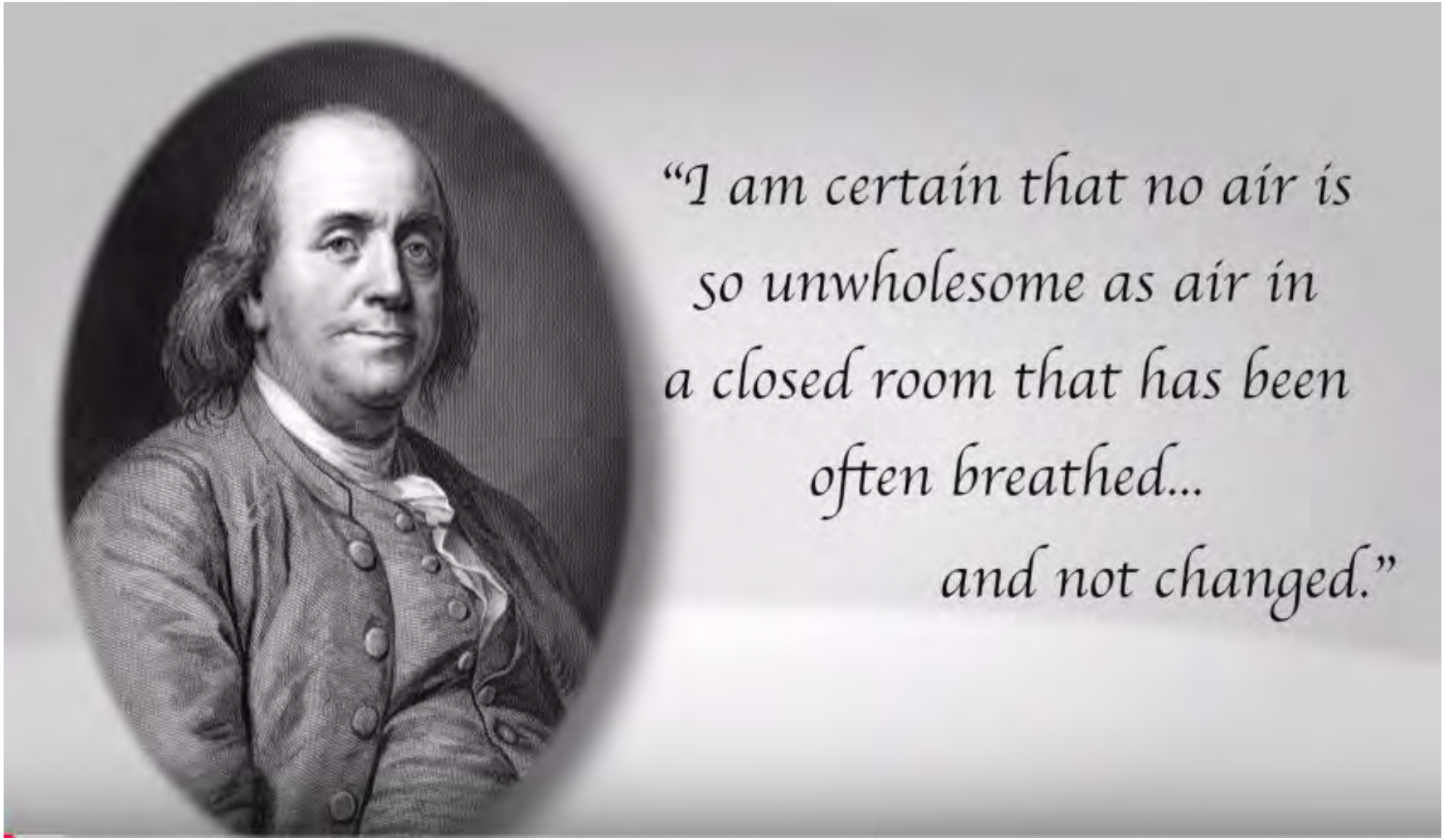




What's the best ventilation system?



- Smart, sensor-based control –
  - Temperature, moisture, plus other pollutants,
  - Adjusts based on conditions and activity
  - Alerts when needed
- Energy recovery - Preconditions entering fresh air with energy of exhausted air
- Supplemental dehumidification - Can assist with house drying as well as incoming fresh air
- Quality filter - Accessible for easy cleaning/replacement
- Want:
  - Low 1st cost + low operating cost
  - Easy to install + tested to verify airflow
  - Easy to maintain + alerts if maintenance issue occurs


"I am certain that no air is
so unwholesome as air in
a closed room that has been
often breathed...
and not changed."