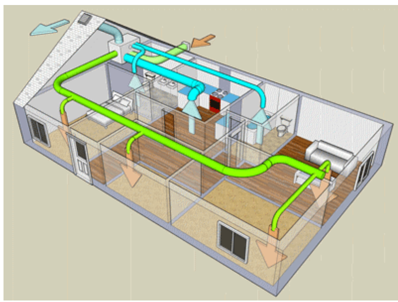
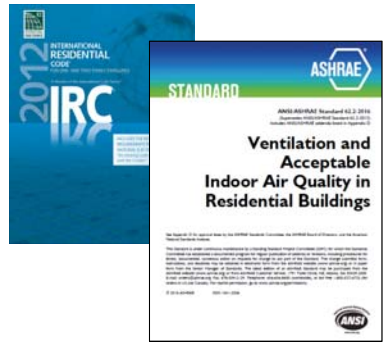
2018 RESNET Conference: Emerging Smart Ventilation Strategies & ASHRAE 62.2-2016



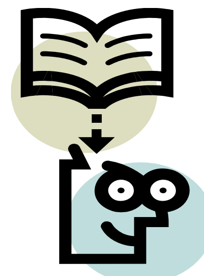
Feb. 26, 2018

Jenna Grygier
&
Mike Barcik

Topics Covered



- Ventilation & Indoor Air Quality
- Using the IRC & ASHRAE 62.2 to determine ventilation requirements
- What strategies have traditionally been used?
- Explaining the concepts of smart ventilation
- Research project details



Brett's Singer's IAQ Recommendations

- Understand people have the biggest impact on IAQ
- Keep home dry (and mold free); dehumidify as needed
- Avoid emitting large quantities 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!!!
- Use natural ventilation when outdoor conditions are "clean"
- Have tight envelope and ducts; close house when outdoors is polluted
- Check radon and formaldehyde (using integrated samplers)
- Install good (thick, pleated) AHU filter with no leaks or bypass; confirm low ΔP
- Use efficient variable speed AHU motor (ECM)

Indoor Pollutant Sources

Biological agents






Chemicals

Combustion




Outdoor Pollutant Sources



Keys to good Indoor Air Quality

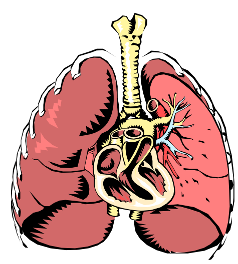
1. Eliminate (remove pollutant source)
2. Separate (seal or contain pollutants)
3. **Ventilate** (dilute pollutants)
4. Filter (clean and remove pollutants)

"Pollutants need a Pathway to People…"

"…and are pushed by positive pressure!"

What's the Purpose of Ventilation?

- Provide fresh air for the occupants

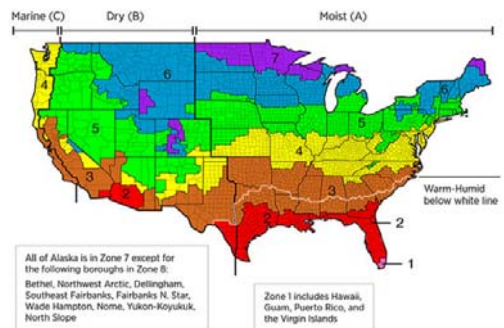


- Dilute pollutants

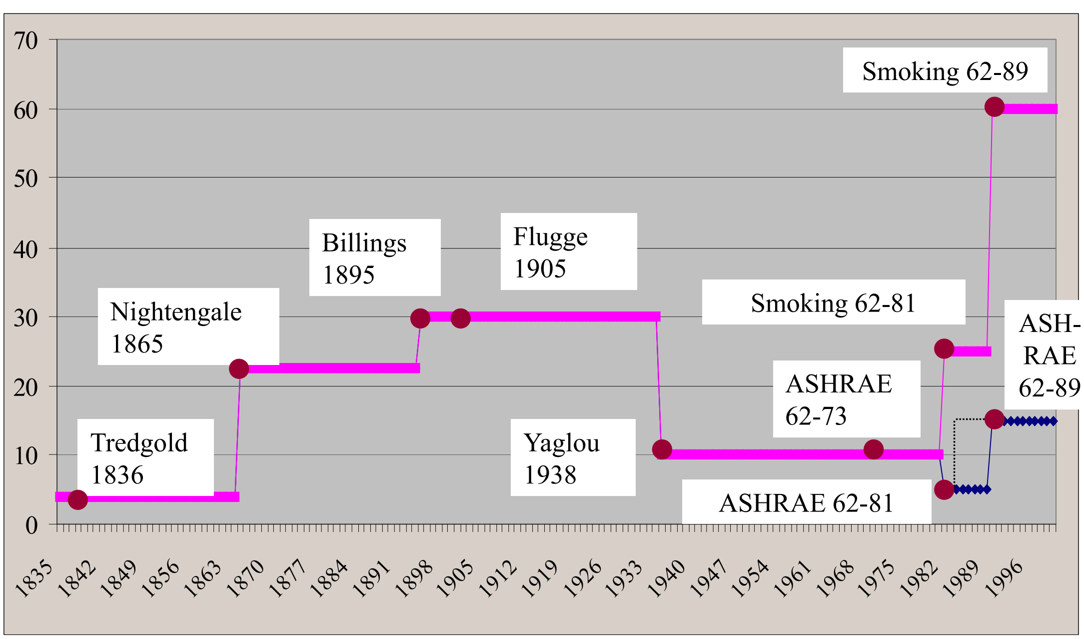
Ventilation Practicality

"Perfect can be the enemy of Good"

- Houses are tight (and getting tighter)
- Fresh air is important – 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)



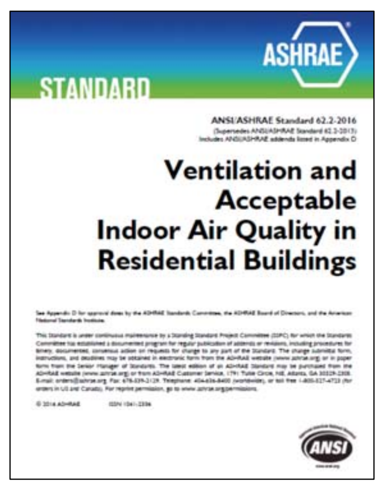
Commercial: Rules for Good Ventilation

- 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
- Designs systems that separate ventilation and space conditioning
- Use heat/energy recovery to reduce system size and ventilation energy costs

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



ASHRAE 62.2-2004,7,10

- 7.5 cfm per person PLUS
- 1 cfm for every 100 s.f. of conditioned space

ASHRAE 62.2-2013,16

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

- Qfan = Qtot - Qinf

Southface

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

2012 IRC requires ventilation if…

- Ventilation is REQUIRED
  - Any home tighter than **5 ACH_{50}**
- Between '12 IECC and '12 IRC, whole house mechanical ventilation is now mandated everywhere!

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 IRC

ASHRAE 62.2 & IRC 2012 Ventilation

- Basically, takes the 62.2-2010 table (but not the formula)

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

For SI: 1 square foot = 0.0929 m^2, 1 cubic foot per minute = 0.0004719 m^3/s.

TABLE M1507.3.3(2)
INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS[a, b]

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

a. For ventilation system run time values between those given, the factors are permitted to be determined by interpolation.
b. Extrapolation beyond the table is prohibited.

2012 IRC

ASHRAE 62.2 & IRC 2012 Ventilation

- CFM's 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.

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 & 62.2-2016 Basic Example – 3 BR, 1400 s.f.

- Use IRC Table

(Originally from 62.2-2010)

- ***45 CFM** continuous*

TABLE M1507.3.3(1) CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTE

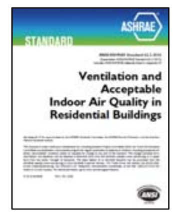
DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

For SI: 1 square foot = 0.0929 m^2, 1 cubic foot per minute = 0.0004719

- 62.2-2016 Ventilation formula:

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

$$= 42\ CFM + 30\ CFM = \mathbf{72\ CFM}\ \text{continuous}$$



62.2-2016 Ventilation Calculator

- Qfan = Qtot - Qinf

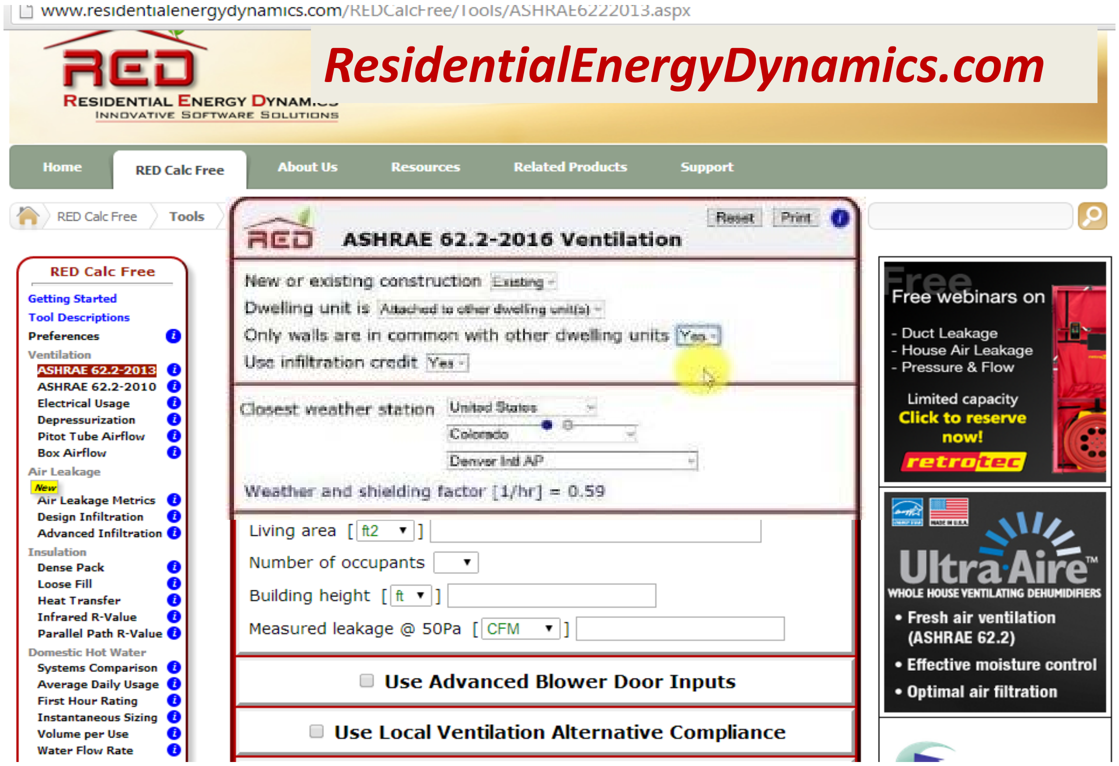
EarthCraft Single Family Ventilation Calculator based on ASHRAE 62.2-2016

	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	

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

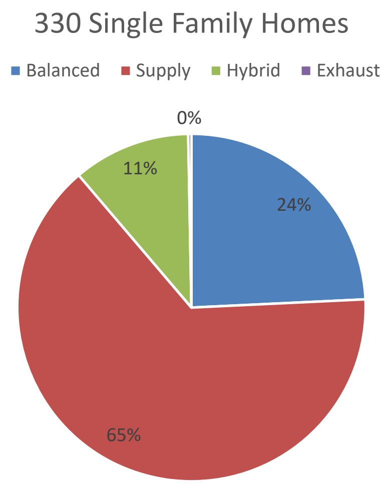
62.2-2016 Ventilation Calculator

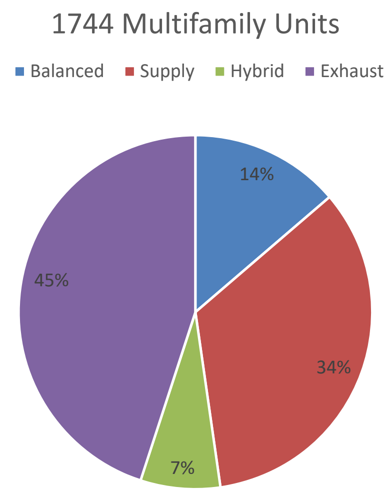


Types of Ventilation

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

What Kind of Ventilation Strategy?

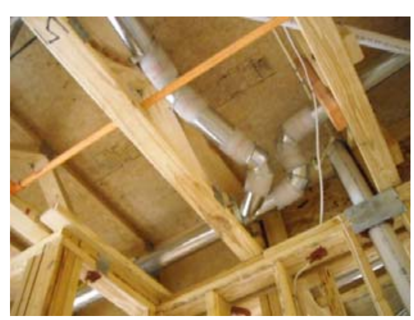




Southface

Exhaust only

- Usually a larger CFM, more quiet bath exhaust fan with 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



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Exhaust only

- Plus- Inexpensive to buy and operate, especially with DC motor; runs continuously
- Plus- If quiet, occupant might not unplug it
- Minus- Negative pressure pulls unconditioned air from largest, most available holes and leaks
- Minus- How will incoming air be filtered and conditioned?
- Minus- Potential combustion safety issues

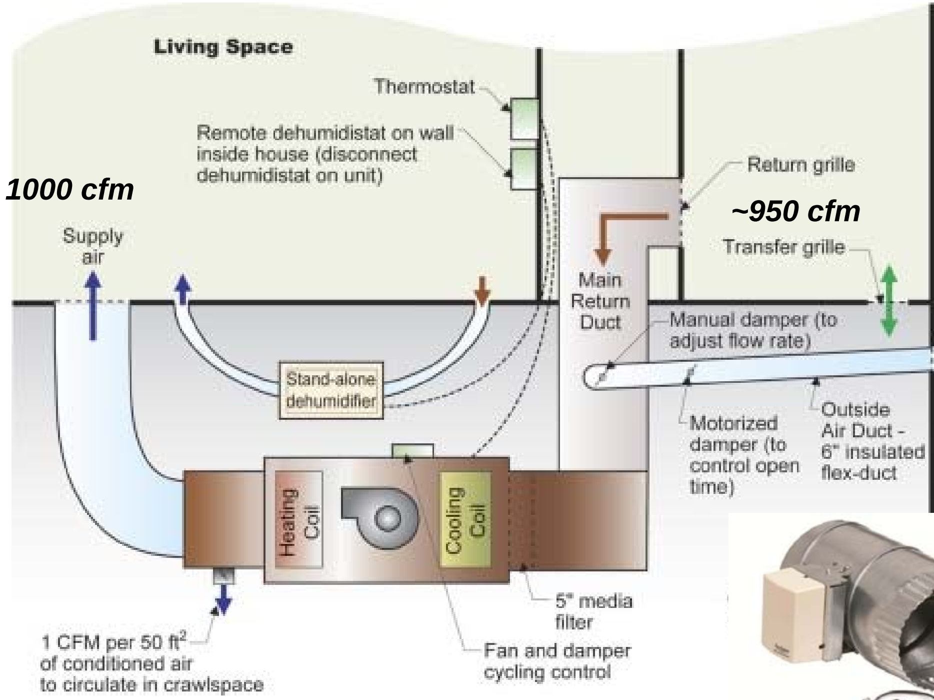
Southface

Supply Only

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

Southface

Supply - Positive Pressure Ventilation



Positive Ventilation Supplied via O.A. Ducted to Return

Supply Only

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

Supply Only

Duct Diameter (in)	Maximum Capacity Flex (cfm)	Maximum Capacity Metal (cfm)
4	25	35
5	45	60
6	70	100
7	100	150
8	150	200

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

Supply Only With In-Line Fan

- Plus- Likely to have correct ventilation cfm
- Plus- Low initial and operating cost
- Minus- Potential moisture issues in HVAC closet

Supply Only With In-Line Fan+

- Plus- Likely to have correct ventilation cfm that is filtered & from known source
- Plus- Low initial and operating cost
- Plus- Can be set to not ventilate during "bad" times (too hot, too cold, too humid, too dry)

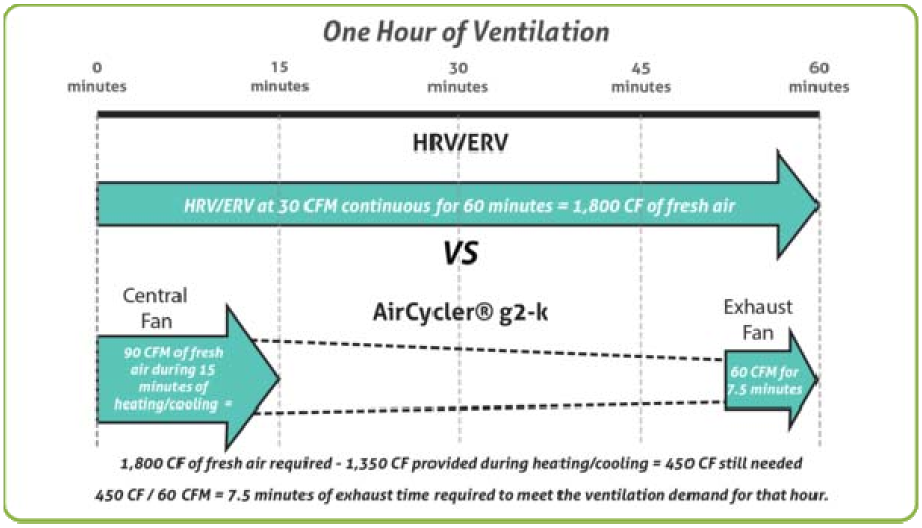
HVI CERTIFIED PERFORMANCE				
MODEL	DUCT SIZE	STATIC PRESSURE	SPEED	WATTS
QFAM	6"	0.2	40 CFM	12.9
			50 CFM	13
			60 CFM	15.1
			70 CFM	17.1
			80 CFM	19.5
			90 CFM	21.8
			100 CFM	26.3
			110 CFM	27.5
			120 CFM	30.1

Hybrid

- 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

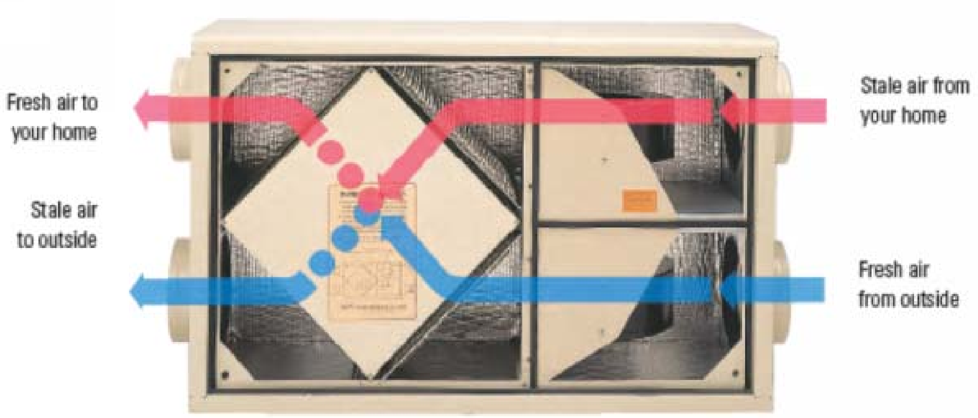
Hybrid

- AirCycler g2/g2-k
  - Install $______?

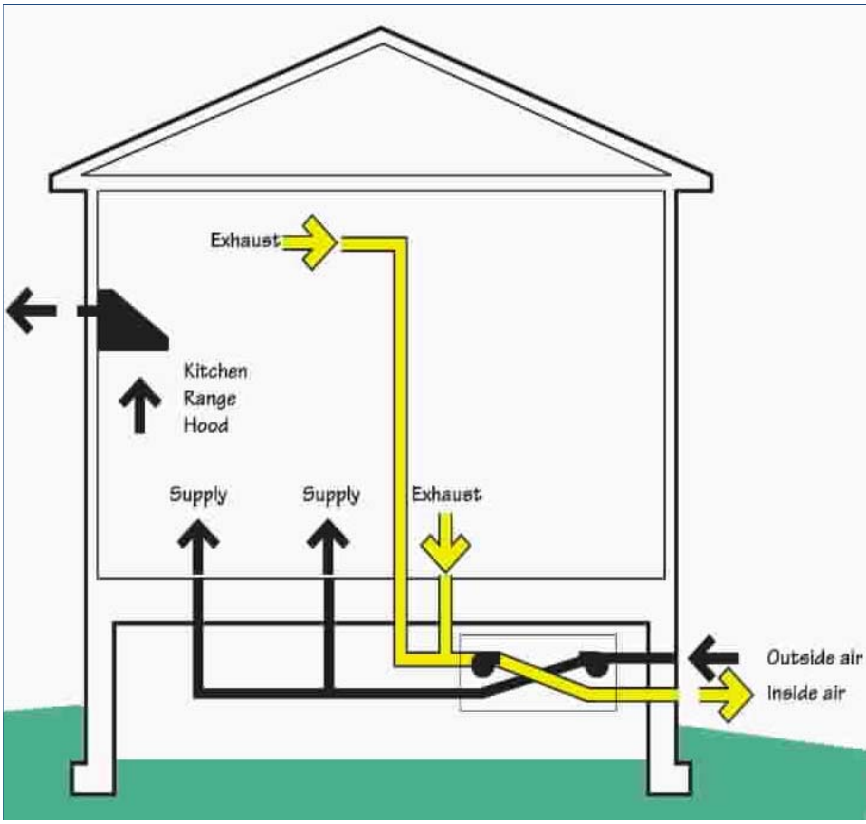


Balanced - ERV/HRV

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



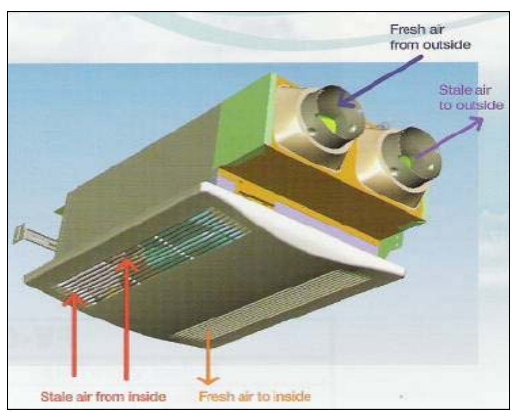
Balanced Ventilation



Energy Recovery Ventilator (ERV) – transfers both heat (Sensible) and moisture (Latent)

Balanced ERV - Spot Unit

- Plus- Doesn't create pressure imbalances
- Plus- Low energy use
- Plus- Relatively low cost
- Plus- Ease of set-up and operation
- Plus- 2 pipe design, lower install cost



- Minus- Low moisture transfer
- Minus- Distribution?

Balanced - ERV-Whole Unit

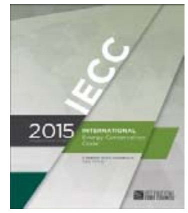
- Plus- Doesn't create pressure imbalances
- Plus- Low energy use
- Plus- Good mixing, decent moisture transfer
- Plus- 4 ports, can be tied into duct system
- Minus- Removes some of the OA moisture but ultimately still adds humidity to house
- Minus- Higher cost

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

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 cooling
  - Homes need drying
- In-wall dehumidifiers for MF
- Ventilation dehumidifiers



R403.6 Mechanical ventilation (Mandatory). The building shall be provided with ventilation that meets 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. Mechanical ventilation system fans shall meet the efficacy requirements of Table R403.6.1.

Exception: Where mechanical ventilation fans are integral to tested and listed HVAC equipment, they shall be powered by an electronically commutated motor.

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)

HVAC and Moisture

It's Not the Heat, It's The Humidity..

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

Dehumidifier/Ventilator

- Pulls air from house and from outside
- Filters & mixes two streams
- Dehumidifies as needed
  - Usually $1,000+
  - 70 to 100+ ppd
  - Ideal for efficient houses with lower sensible loads but similar latent loads

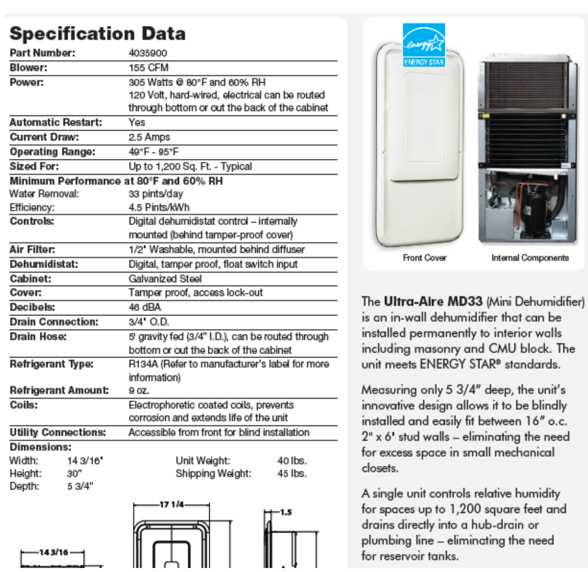
Supplemental Dehumidification

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

Front Cover Internal Components

MF Dedicated Dehumidification

- Ultra-Aire MD33
  - In-wall Dehumidifier



Specification Data

Part Number:	4035900
Blower:	155 CFM
Power:	305 Watts @ 80°F and 60% RH 120 Volt, hard-wired, electrical can be routed through bottom or out the back of the cabinet
Automatic Restart:	Yes
Current Draw:	2.5 Amps
Operating Range:	49°F - 95°F
Sized For:	Up to 1,200 Sq. Ft. - Typical
Minimum Performance at 80°F and 60% RH	
Water Removal:	33 pints/day
Efficiency:	4.5 Pints/kWh
Controls:	Digital dehumidistat control – internally mounted (behind tamper-proof cover)
Air Filter:	1/2" Washable, mounted behind diffuser
Dehumidistat:	Digital, tamper proof, float switch input
Cabinet:	Galvanized Steel
Cover:	Tamper proof, access lock-out
Decibels:	46 dBA
Drain Connection:	3/4" O.D.
Drain Hose:	5' gravity fed (3/4" I.D.), can be routed through bottom or out the back of the cabinet
Refrigerant Type:	R134A (Refer to manufacturer's label for more information)
Refrigerant Amount:	9 oz.
Coils:	Electrophoretic coated coils, prevents corrosion and extends life of the unit
Utility Connections:	Accessible from front for blind installation

Dimensions:

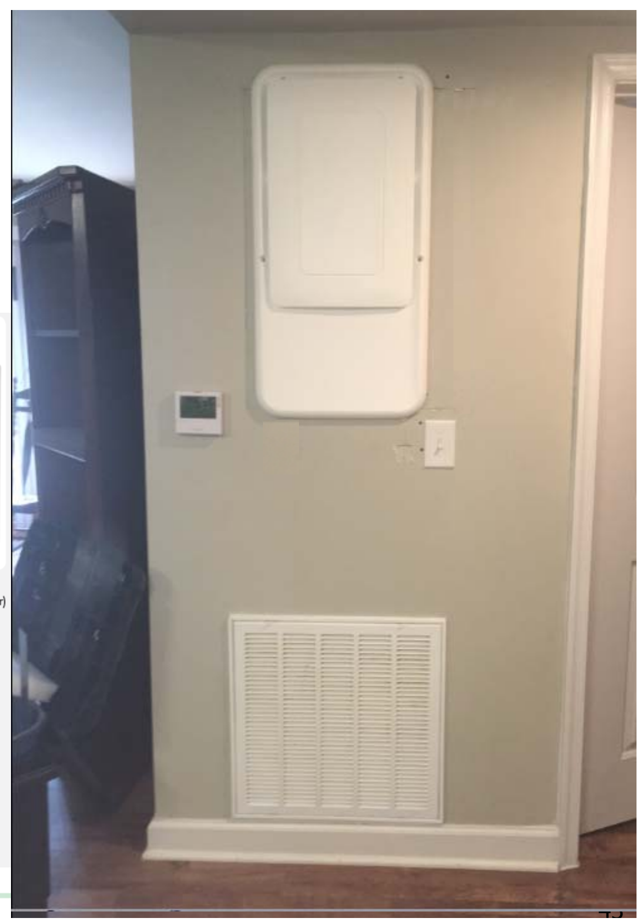
Width:	14 3/16"	Unit Weight:	40 lbs.
Height:	30"	Shipping Weight:	45 lbs.
Depth:	5 3/4"		

Front Cover Internal Components

The **Ultra-Aire MD33** (Mini Dehumidifier) is an in-wall dehumidifier that can be installed permanently to interior walls including masonry and CMU block. The unit meets ENERGY STAR® standards.

Measuring only 5 3/4" deep, the unit's innovative design allows it to be blindly installed and easily fit between 16" o.c. 2" x 6' stud walls – eliminating the need for excess space in small mechanical closets.

A single unit controls relative humidity for spaces up to 1,200 square feet and drains directly into a hub-drain or plumbing line – eliminating the need for reservoir tanks.



V is for Ventilation

- Finally here - Get used to it!
- Spot Ventilation – (spec ENERGY STAR)
  - Kitchens (100 cfm)
  - Bathrooms (50 cfm)
- Whole House Mechanical Ventilation
  - Outside Air ducted to Return (with controller + motorized damper)
  - Energy Recovery Ventilator (ERV)
  - Ventilation Dehumidifier
- Amount IRC: Use chart (based on original 62.2 formula)
- Amount 62.2-2016: (#BR+1) x 7.5 + 3 cfm / 100 s.f.

  [example: 3 BR, 2400 s.f. house = 30+72 = 102 cfm]

  May reduce this amount based on final BD result – Use calculator tool

SMART VENTILATION GOALS

- **Reduce** ventilation **energy** usage and costs below that of an analogous continuously operating system **while maintaining or improving IAQ**
- Interact with the power grid by reducing electricity use during peak demand and eventually allowing grid services such as short-term load shifting

Residential Smart Ventilation: A Review

Gaëlle Guyot[1], Max H. Sherman[2], Iain S. Walker[2] & Jordan D. Clark[2]

[1] Cerema & Savoie Mont Blanc University
[2] Building Technologies and Urban Systems Division

September 2017
(Reference for next 3 slides)

SMART VENTILATION

Uses *the* ***equivalence principle*** to provide response to demand for ventilation rather than a prescribed ventilation rate through variables such as:

- RH and CO_2 (can predict occupancy)
- Occupancy
- Odors
- Pollutant loads (indoor/outdoor)
- Weather conditions
- Predefined schedules
- Utilize equivalence principle

KEY TAKEAWAYS

- Meta-analysis of 38 studies of smart ventilation with controls show ≤60% savings w/o compromising IAQ (and sometimes even improving it). In some cases, -26% savings.
- Occupants rarely aware of IAQ and don't operate systems as recommended
- High disparity of pollutant concentrations between different rooms of a home
- Pollutant sensors may not yet be suitable to be relied upon for residential ventilation

RELEVANT POLLUTANTS FOR SMART VENTILATION

Chronic exposure
- Particulate matter
- Mold and moisture
- Formaldehyde
- Acrolein

Acute Exposure
- Acrolein
- Chloroform
- Formaldehyde
- NO2
- PM2.5

Also important to consider: RH, CO_2, odors, temperatures

FINE PRINT: synthesis of literature disregards the availability and accuracy of corresponding sensors

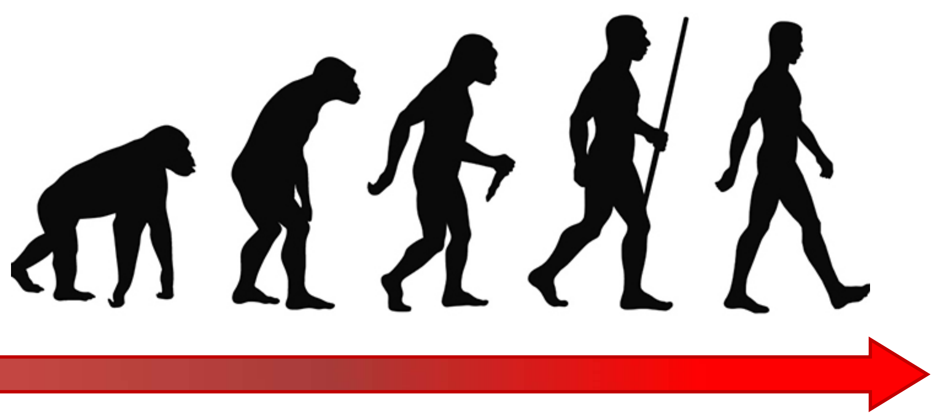
WHAT'S AVAILABLE TO MEASURE IAQ?

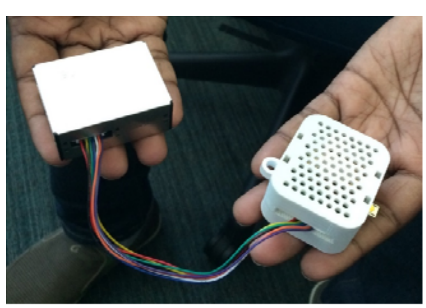
Brett Singer, LBNL 2016

WHAT'S AVAILABLE TO MEASURE IAQ?

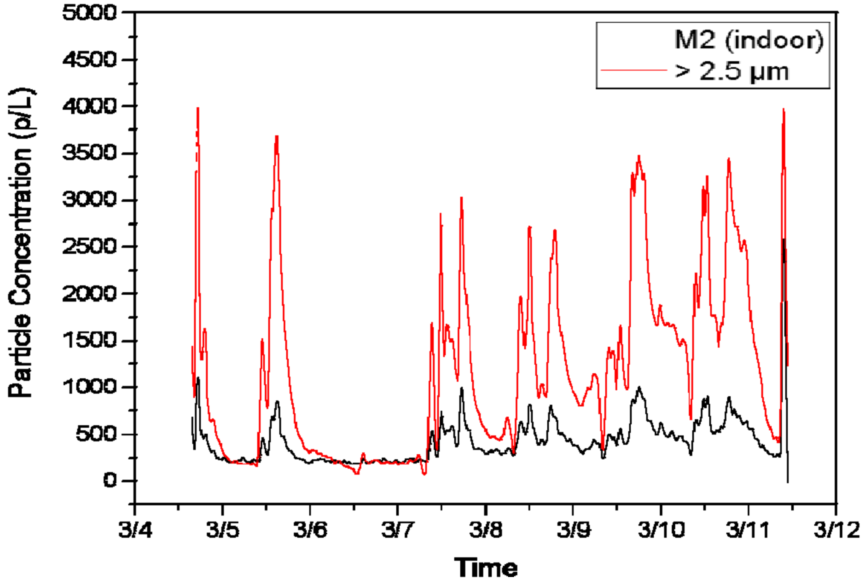
Device	Price	Temp	RH	CO_2	VOC	$PM_{2.5}$	PM_{10}	CO	Ozone	NO_2
Birdi (NA)	$119	●	●	●	●	●				
Koto Air Cubes	$139	●	●	●						
Netatmo	$149	●	●	●						
Speck	$149	●				●				
Airmentor	$183	●	●	●	●	●	●	●		
Awair	$199	●	●	●	●	●	●			
BlueAir-Aware	$199	●	●	●	●	●	●			
Foobot	$199	●	●	●	●	●		●		
Air Quality Egg	$280	●	●			●	●	●	●	
Dylos-DC 1100	$290					●	●			
uHoo (NA)	$299	●	●	●	●	●		●	●	

Brett Singer, LBNL 2016





HOUSE-BUILT SENSOR TEST



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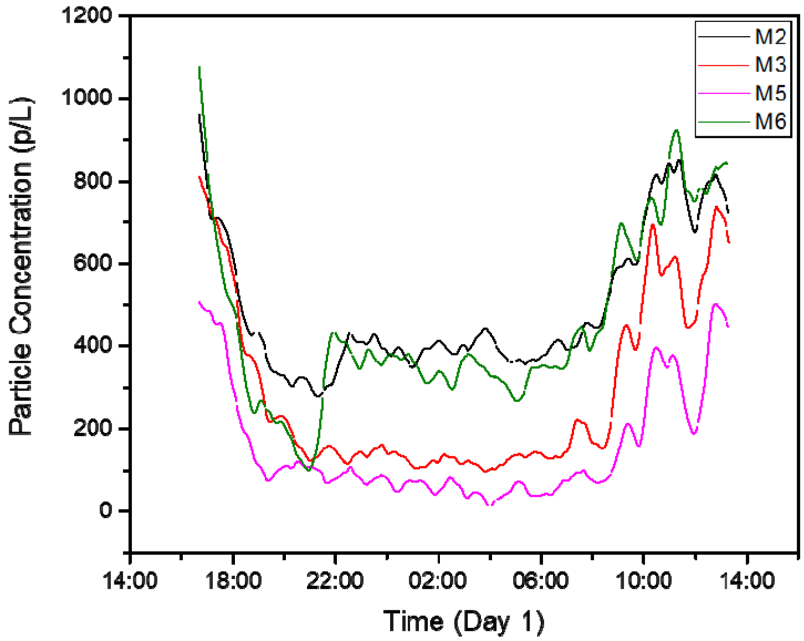
HOUSE-BUILT SENSOR TEST



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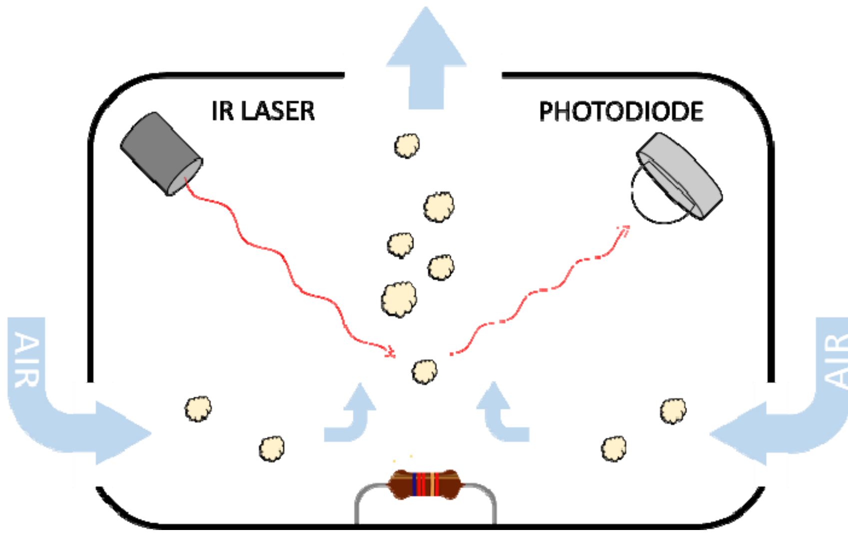
PM SENSOR



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CURRENT RESEARCH

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Southface Energy Institute

Partners
- Underwriters Laboratory
- Beazer Homes
- Center
- Venmar
- Senseware

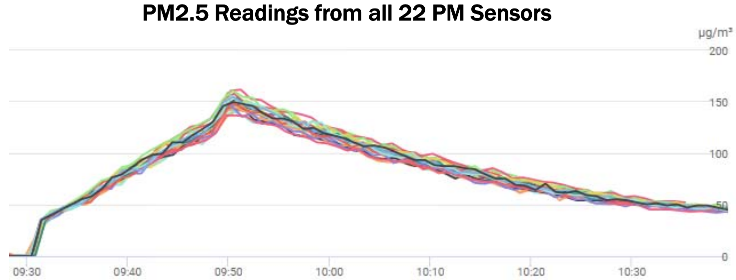
Topic Area
Smarter Indoor Air Quality Solutions

Success Metrics: Develop an ERV field test protocol, and validate that smart-ventilation that considers outdoor air conditions maintain occupant comfort, achieve annual HVAC energy cost savings (compared to central fan integrated supply systems) and agree with newly-developed BEopt models for time-varying ventilation in humid climates.

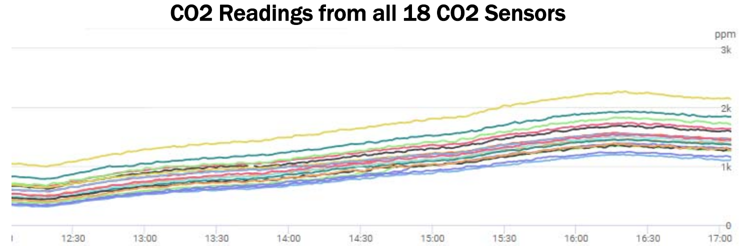
Performance-Based IAQ and Optimized Ventilation

Tested Low-Cost IAQ Sensors in UL Chambers

PM2.5 Readings from all 22 PM Sensors



CO2 Readings from all 18 CO2 Sensors



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Performance-Based IAQ and Optimized Ventilation

- Monitor four new-construction homes in Charleston, SC with “smart” energy recovery ventilators.
- Assess occupant comfort between continuous ventilation and time-varying ventilation modes toggling biweekly.
- Develop ERV field test protocol.
- Examine indoor air quality between the two ventilation methods using low-cost IAQ sensor packages for PM2.5, CO2, T/RH and radon.

BuildingAmerica U.S. Department of Energy

Southface Energy Institute

Partners

- Underwriters Laboratory
- Beazer Homes
- Venmar
- Senseware

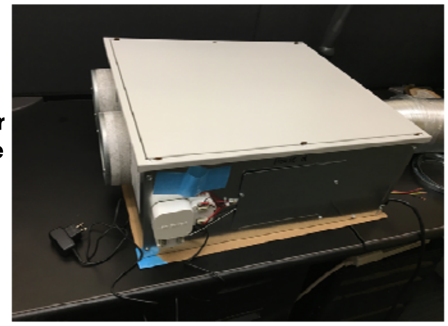
Topic Area

Smarter Indoor Air Quality Solutions

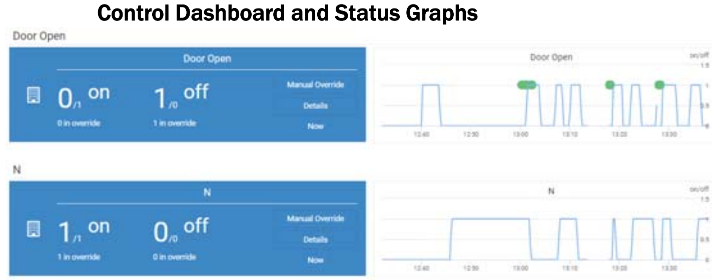
Performance-Based IAQ and Optimized Ventilation

Tested Modified ERVs

ERV Modified by Venmar with Senseware Remote Switch

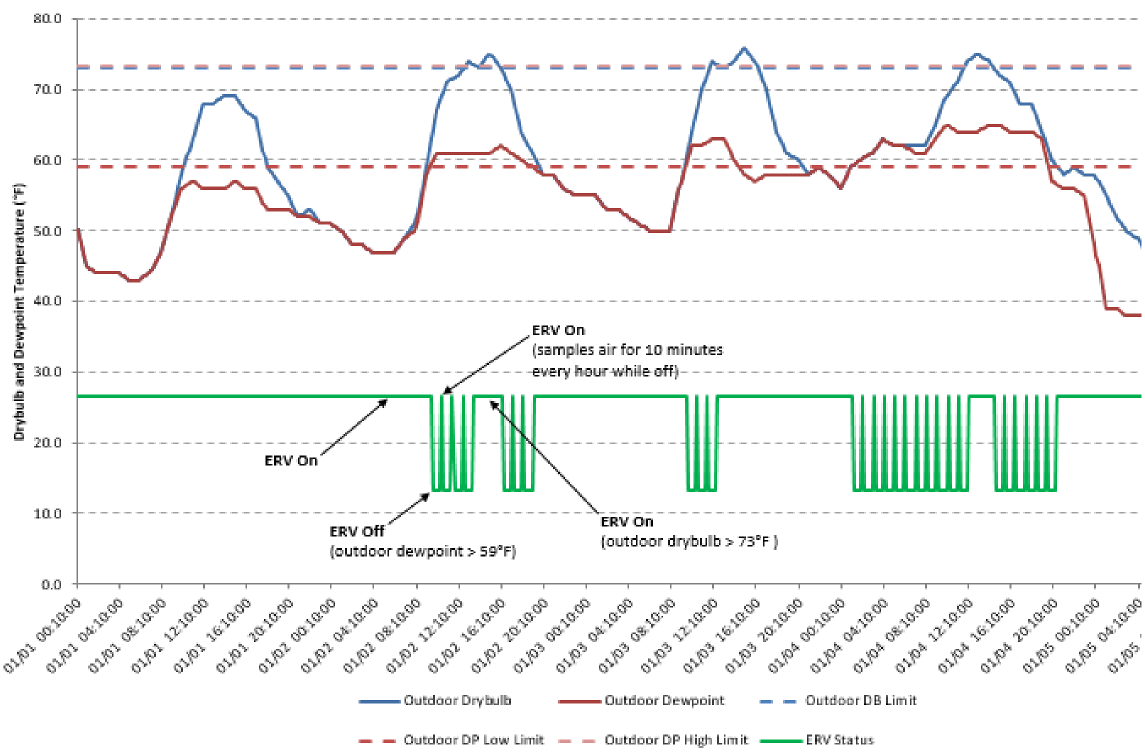


Control Dashboard and Status Graphs



Success Metrics: Develop an ERV field test protocol, and validate that smart-ventilation that considers outdoor air conditions maintain occupant comfort, achieve annual HVAC energy cost savings (compared to central fan integrated supply systems) and agree with newly-developed BEopt models for time-varying ventilation in humid climates.

BEopt Customization



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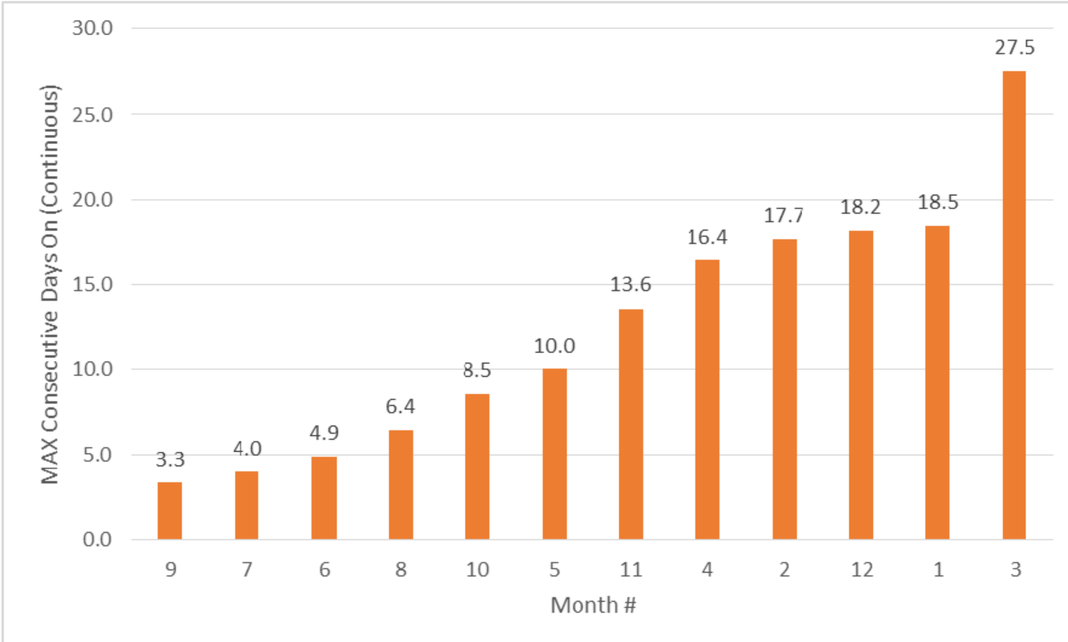
TIME VARYING VENTILATION (WEATHER BASED)



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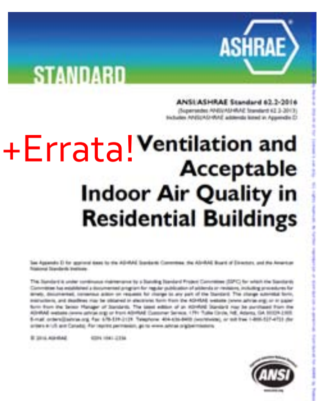
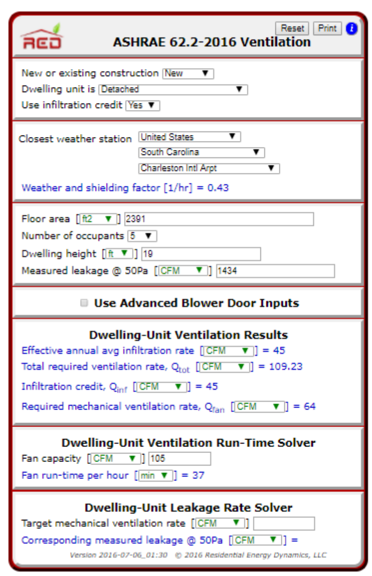
TIME VARYING VENTILATION TOOLBOX





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TIME-VARYING VENTILATION

4.5 Variable Mechanical Ventilation. Dwelling-unit mechanical ventilation systems designed to provide variable ventilation shall comply with Section 4.5.1, 4.5.2, or 4.5.3. Sections 4.5.2 and 4.5.3 also require compliance with Normative Appendix C and require verification with supporting documentation from the manufacturer, designer, or specifier of the ventilation control system that the system meets the requirements of these sections. Where the dwelling-unit ventilation rate varies based on occupancy, occupancy shall be determined by occupancy sensors or by an occupant-programmable schedule.

62.2-2016 SECTION 4 EQUATIONS

Total required ventilation rate

$$Q_{tot} = 0.03A_{floor} + 7.5(N_{br} + 1) \qquad \text{(I-P)} \quad (4.1a)$$

Infiltration credit

(if using single-point blower door test, Addendum I)

$$Q_{inf} = 0.052 \times Q_{50} \times \text{wsf} \times (H/H_r)^z \qquad (4.3)$$

Required Ventilation Rate

$$Q_{fan} = Q_{tot} - (Q_{inf} \times A_{ext}) \qquad (4.6)$$

EXAMPLE

Floor area: 2,390 square feet

CFM50: 1,435 (~4 ACH50)

Bedrooms: 4

ERV Fan Flow: 105 cfm

Q_{tot}=109 cfm

Q_{inf}=45 cfm

Q_{fan}=64 cfm

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EXAMPLE (CONT'D)

Must comply with 4.5.1 or 4.5.2 or 4.5.3

4.5.1. Short term average (any 3 hr. period)

Runtime per hour=Q_{fan}/Fan Capacity

=**64/105=37** min/hr.

For this house and climate in worst case weather condition,
ERV is not capable of providing 37 min/hr. in "smart mode"

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NOW WHAT?

4.5.2 (4.5.2.1 or 4.5.2.2) or 4.5.3

4.5.2.1 Annual Average Schedule. An annual schedule of ventilation complies with this section when the annual average relative exposure during occupied periods is no more than unity as calculated in Normative Appendix C.

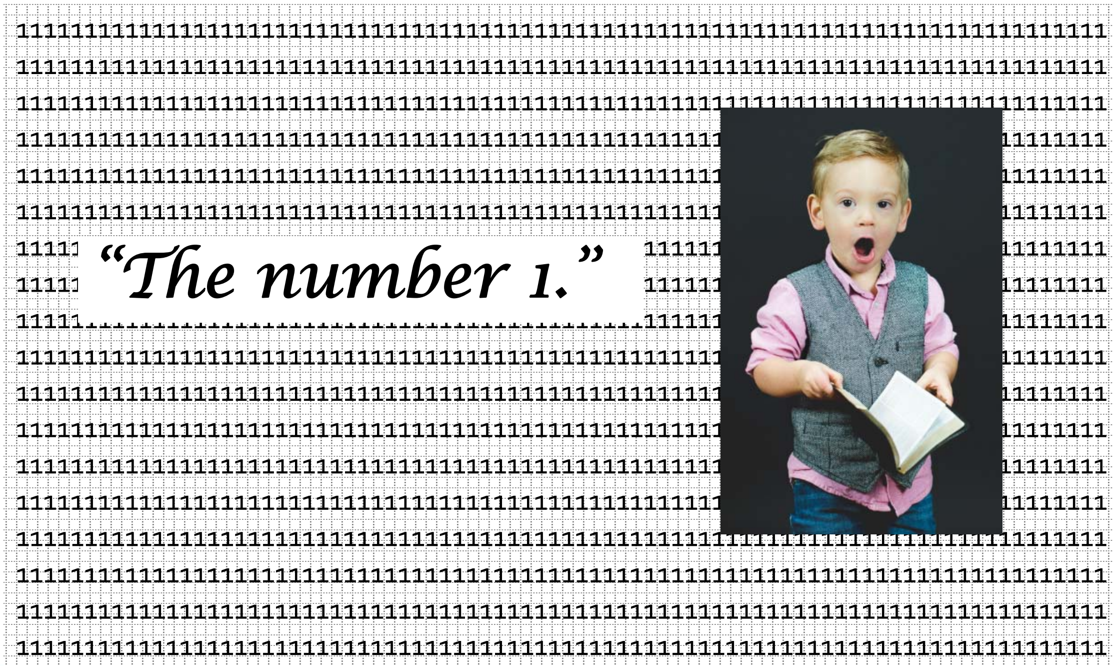
4.5.2.2 Block Scheduling. The schedule of ventilation complies with this section if it is broken into blocks of time and each block individually has an average relative exposure during occupied periods that is no more than unity as calculated in Normative Appendix C.

4.5.3 Real-Time Control. A real-time ventilation controller complies with this section when it is designed to adjust the ventilation system based on real-time input to the ventilation calculations so that the average relative exposure during occupied periods is no more than unity as calculated in Normative Appendix C. The averaging period shall be at least one day but no more than one year and shall be based on simple, recursive or running average, but not extrapolation.

WHAT IS UNITY??

"The state of being united or joined as a whole"

ACTUALLY IN THIS CASE…



APPENDIX C

“**The goal of relative exposure** is to verify that an occupant **using a proposed variable ventilation** system will have **no more annual exposure** to a constant-source contaminant than they would **if a constant total flow** were provided” (User’s Manual)

Peak Exposure Limitation $R_i \leq 5$ (C1.3)

Average relative exposure ≤1

APPENDIX C

For each time step…

- $Q_{inf,i}$ = infiltration rate
- $Q_{fan,i}$=mechanical ventilation rate
- Q_i = total ventilation rate = $Q_{inf,i} + \phi Q_{fan,i}$

  ϕ=1 for balanced systems
- R_i=Relative Exposure
- R_{i-1}=Relative Exposure (previous time step)

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TWO WAYS TO CALCULATE $Q_{inf,i}$

C 2.2.1 "Annual Average Method"	C 2.2.2 "Smaller Time Step Method"
"To calculate $Q_{inf,i}$ use the result from Equation 4.5, Section 4.1.2 Q_{inf}"	C=7400 X ELA (I-P) (C1) C=1050 x ELA (SI Calculate wind driven flow and stack driven flow: Q_w (C4), Q_s (C5) $Q_{inf,\,I} = \sqrt{(Q_w^2 + Q_s^2)}$

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APPENDIX C

C3. RELATIVE EXPOSURE CALCULATION

This section uses the time series of actual ventilation (from Section C2) to calculate the time series of relative exposure.

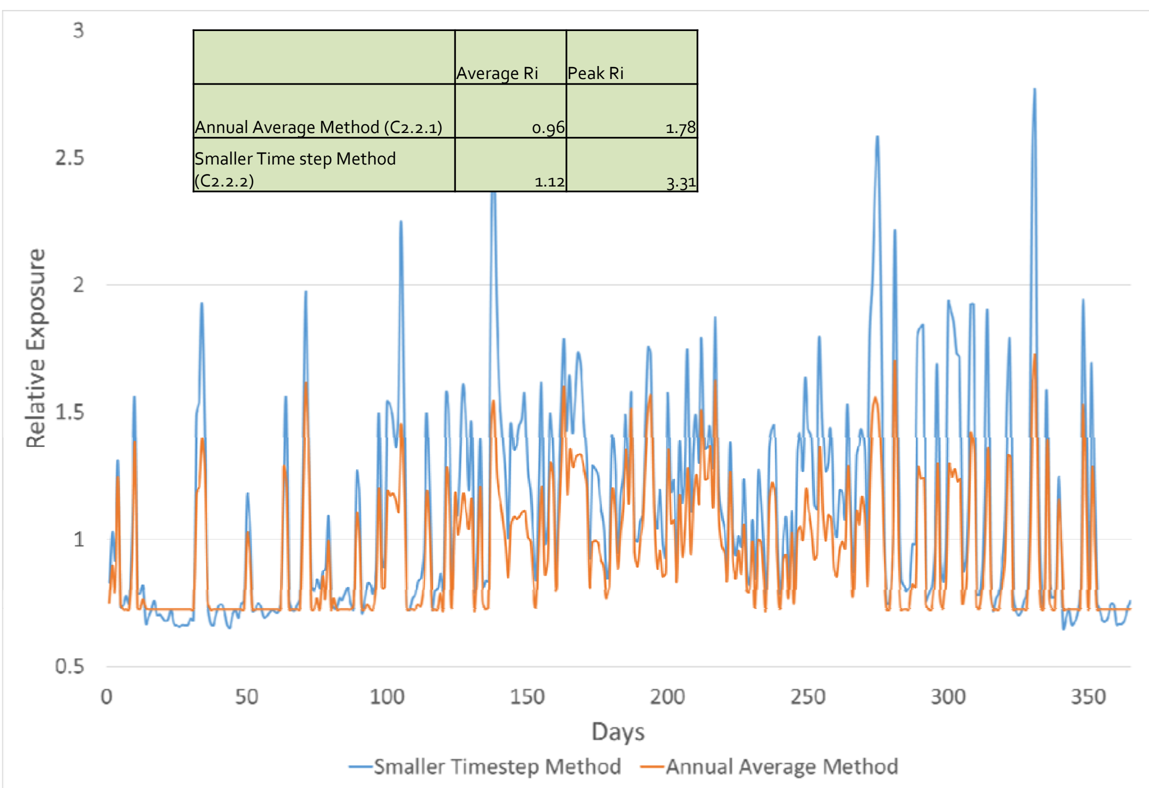
C3.1 Nonzero Ventilation. The relative exposure for a given time step shall be calculated from the relative exposure from the prior step and the current ventilation using the following equation, unless the real-time or scheduled ventilation is zero:

$$R_i = \frac{Q_{tot}}{Q_i} + \left(R_{i-1} - \frac{Q_{tot}}{Q_i}\right) e^{-Q_i \Delta t / V_{space}} \qquad (C9)$$

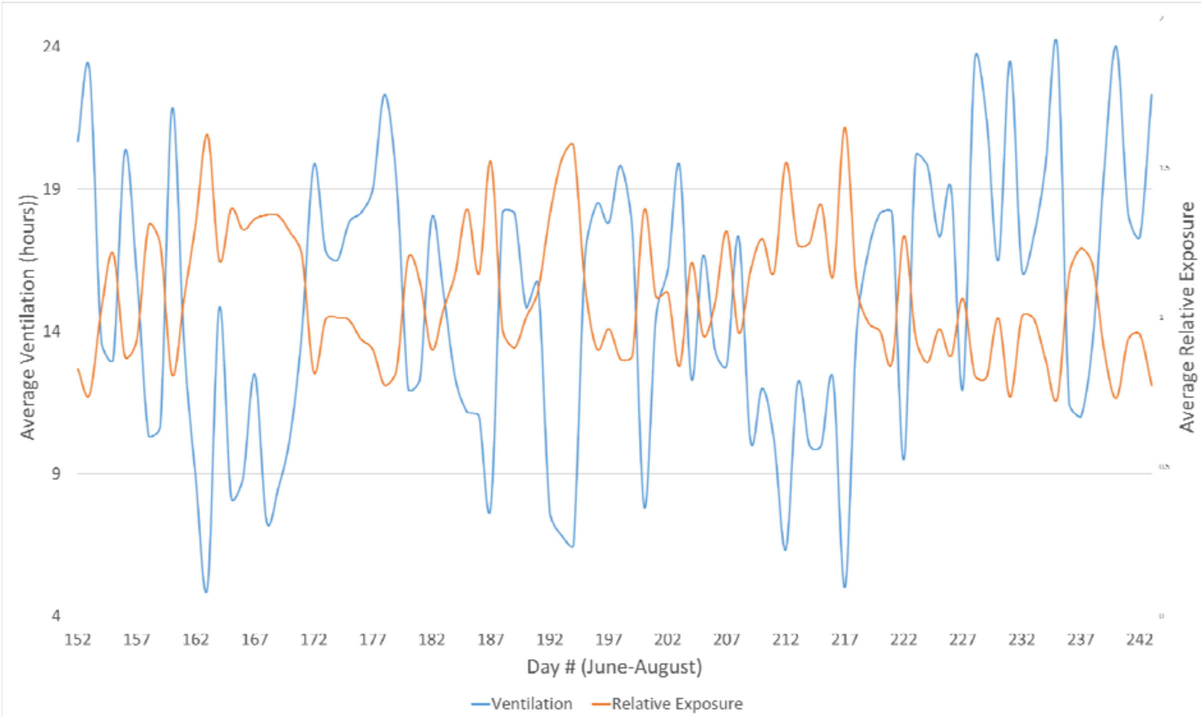
where R_i is the relative exposure for time step i.

C3.2 Zero Ventilation. If the real-time or scheduled ventilation at a given time step is zero then the following equation shall be used:

$$R_i = R_{i-1} + \frac{Q_{tot} \Delta t}{V_{space}} \qquad (C10)$$



	Average Ri	Peak Ri
Annual Average Method (C2.2.1)	0.96	1.78
Smaller Time step Method (C2.2.2)	1.12	3.31



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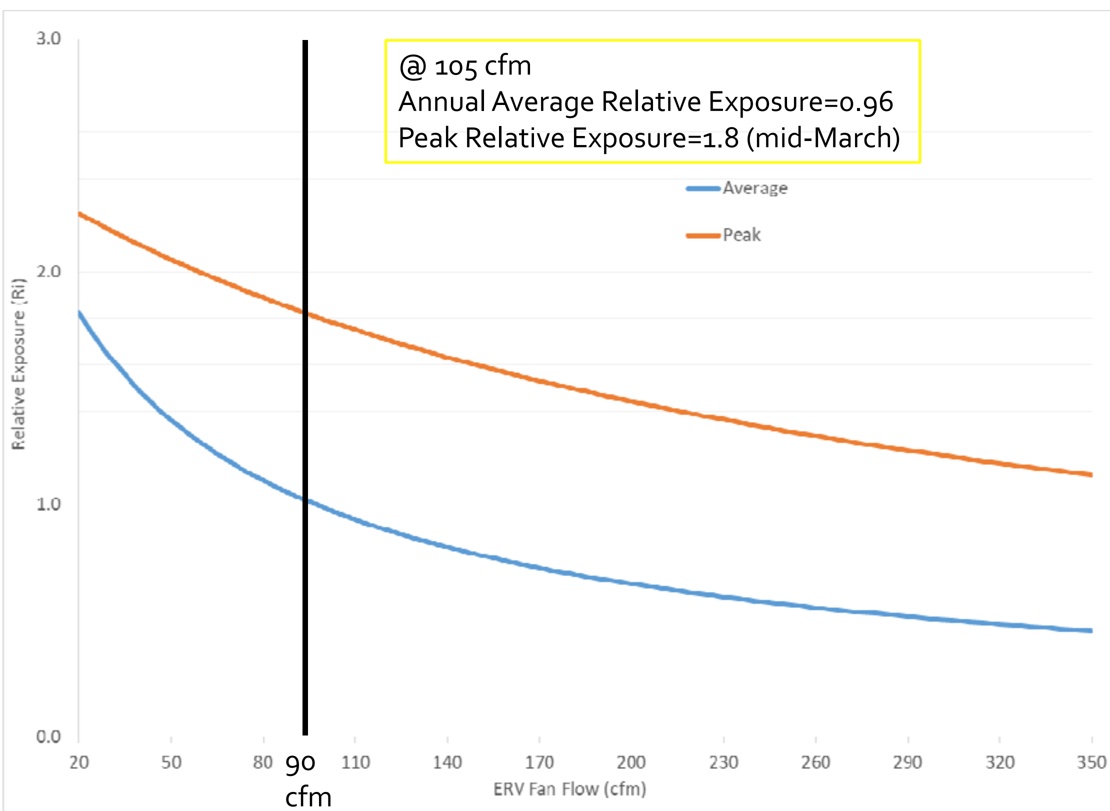

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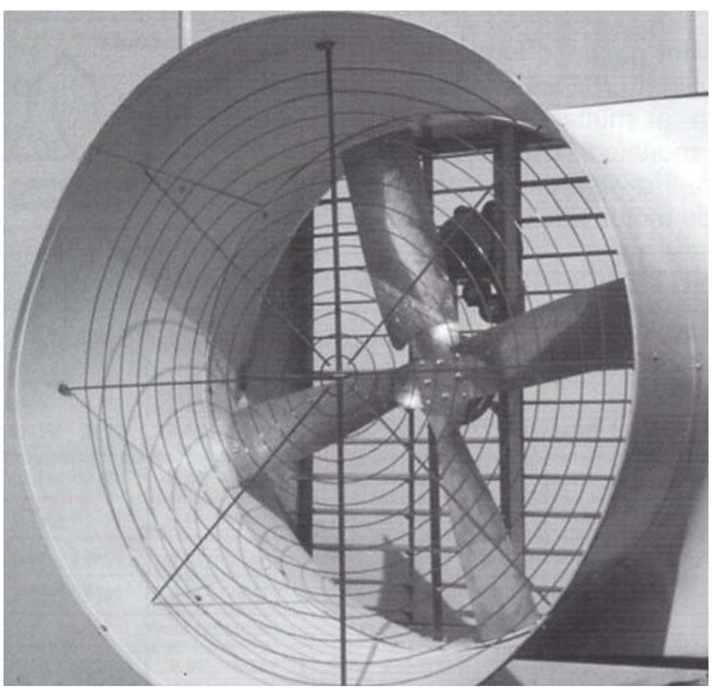
Victory for Smart Ventilation!

- Research underway - Get excited!
  - Constant ERV vs. Time varying
  - IAQ impact of these strategies
  - Energy impact of these strategies (Sensible & Latent impact)
- Proposed for energyplus
- Controls and Sensors
  - on the way (be cautious)

We're Your Biggest Fans!!!



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