Appropriate Ventilation Strategies for Homes (in Mixed-Hot Humid Climates) – by Mike Barcik v2.2

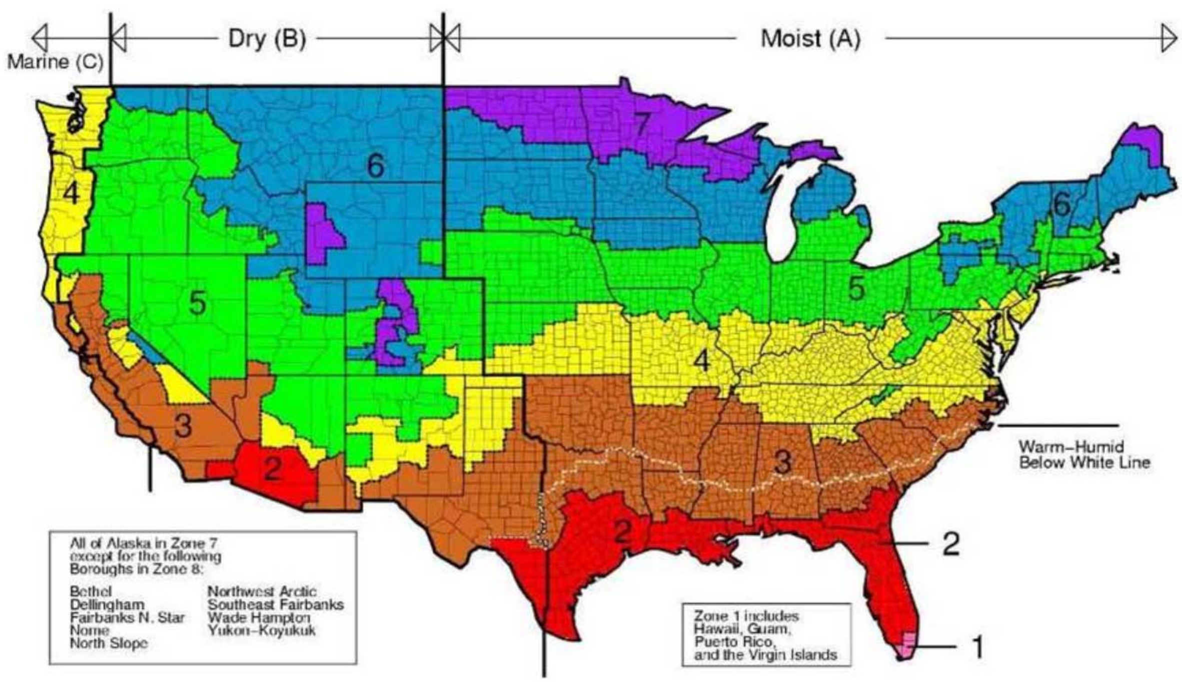
Mike is a technical principal / senior engineer with Southface and has conducted thousands of workshops on energy codes, green building and high performance homes and commercial buildings.

Why Do We Need Ventilation?

Buildings are tight and getting tighter thanks to better energy code implementation and the extensive use of sheet-good materials and more careful attention to sealing penetrations during construction. Tighter buildings offer significant energy savings plus better control of the indoor environment. In contrast, air leakage into and out of an older, leakier building results in drafts, poor comfort, high energy bills and greater risk of moisture problems. Often this air leakage originates from undesirable places that have less healthy air than outdoors including attics, crawlspaces and attached garages.

The House Is a System

Tightening a house to control unwanted pollutant entry and save energy is both desirable and mandated by code. The 2012 International Residential Code (IRC) and all later versions requires a whole house mechanical ventilation system for any home that is blower door tested to < 5 Air Changes per Hour at 50 Pascals (ACH_{50}). While first appearing as an option to "prove" proper air sealing in the 2009 International Energy Conservation Code (IECC), blower door testing became mandatory in the 2012 IECC and beyond. The energy code thresholds of < 3 ACH_{50} for climate zones 3-8 and < 5 ACH_{50} for Climate Zones 1-2 clearly intend that every home will be constructed relatively tightly and will also require a whole house mechanical ventilation system.



In short, since the 2012 versions of the IRC and IECC were published, the best practice of having to "build tight and ventilate right" has finally been codified. Indeed, section 403.6 of the 2015 IECC explicitly requires the home to meet ventilation requirements.

> **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.

Discussion of Indoor Air Quality (IAQ)

Proper IAQ begins with an understanding of airborne pollutants and how they can be detrimental to human health. Pollutants can come from inside or outside of the building and can be natural or manmade in origin.

Common indoor air pollutants in homes include biological pollutants (mold spores, dust mites, bacteria, viruses, pollen, animal dander); combustion pollutants (including carbon monoxide, nitrous oxides, and particulate matter); volatile organic compounds (VOC's) emitted due to "off-gassing" from many paints, glues and finishes found in building materials, as well as carbon dioxide (CO2), radon and other gasses. While water isn't itself a pollutant, water vapor brought in through air leakage can lead to condensation and rot while high relative humidity spurs mildew and mold growth which adversely impacts building durability as well as health.

In order of importance, the four strategies of dealing with pollutants include:
1. Elimination, 2. Separation, 3. Ventilation, and 4. Filtration

Eliminating the pollutant is the best strategy because then it is prevented from impacting the occupants. Examples might be choosing no-VOC paints, carpeting and cabinetry when finishing a house. *Separation* is next best on the list of strategies – it involves isolating the pollutant away from the occupants, such as having a sealed slab to deter radon entry or a well-sealed or detached garage to keep garage pollutants from entering the home. Third on the list is *Ventilation* which serves to provide both fresh oxygen for the inhabitants and also to dilute or flush out the pollutants with typically cleaner air from outdoors. Finally, a better (e.g., thicker, pleated, higher MERV) *filter* may be employed to capture certain particles that would otherwise be breathed into the occupant's lungs.

As a reminder, air sealing actually helps prevent pollutants (and pests!) from entering into a home. Ventilation is needed because *people* live in the home and need to breathe fresh air. This now tight, properly ventilated home offers the best of all worlds – exemplary comfort and efficiency as well as a healthy indoor environment.

How Much Ventilation Is Needed?

The American Society for Heating Refrigeration and Air Conditioning (ASHRAE) has Standard 62.1 for commercial buildings and 62.2 for residential. The 62.2 standard uses a two part rule to determine the amount of ventilation required based on house size and number of occupants.

Since for new construction the number of occupants isn't known, the amount of cubic feet per minute (cfm) needed is derived based on the number of bedrooms + 1. For many past iterations, up to and including ASHRAE 62.2-2010, the formula for ventilation was as follows:

Ventilation (cfm) = (conditioned floor area) x 0.01 + (# bedrooms + 1) x 7.5 (62.2-2010)

From this formula a chart was created (which tends to round up):

Floor Area (ft^2)	# of 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

The chart only (and not the formula) was incorporated into the 2012 IRC to determine a home's required ventilation. For example, a 3 bedroom 1,400 s.f. home would require: 14 + 30 = 44 cfm continuous via the formula and 45 cfm from the chart.

The 2016 version of ASHRAE 62.2 has acknowledged greater occupant health associated with increased ventilation; the formula is adjusted to now be based on 3% of the floor area (instead of 1%):

Ventilation (cfm) = (conditioned floor area) x 0.03 + (# bedrooms + 1) x 7.5 (62.2-2016)

For the 1,400 s.f. home discussed above, the new amount of ventilation would be 42+30 = 72 cfm.

However, for new homes that are blower door tested, this number can be adjusted using a calculator such as the RED tool (www.residentialenergydynamics.com) or a ventilation spreadsheet (example below). Basically, if the house is blower door tested and is very tight, the required full amount of ventilation is not adjusted.

However, if the home's blower door test is only moderately tight, say closer to ~5 ACH_{50}, the amount of ventilation can be reduced to account for a certain amount of natural air change due to infiltration. In the example shown below, the ventilation required would be reduced from 72 cfm down to ~46 cfm.

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

Many beyond code programs reference ASHRAE 62.2-2016. Interestingly, regardless of which ventilation standard / code is used, for the majority of homes the amount of ventilation is usually a number between 40 - 120 cfm.

Does Ventilation Have To Be Continuous?

Both ASHRAE and the IRC allow for intermittent ventilation. In short, the system can bring in twice the amount for 1/2 the time, three times the amount for 1/3 of the time, and so on. ASHRAE 62.2-2016 permits additional adjustment and simply requires that the entire equivalent amount of air changes will occur during a 3-hour period.

For the example above, a ventilation system may supply 45 cfm continuously, 90 cfm for half of the time, 135 cfm for a third of the time and so on. See the excerpt from the IRC below.

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 INTERNATIONAL RESIDENTIAL CODE® 509

What Other Ventilation Code Requirements Are There?

The code requires local (spot) ventilation bath fans to be 50 cfm and kitchen exhaust hoods to be 100 cfm (for intermittent, on-demand operation). Note that as per the IRC, hoods over 400 cfm require make-up air. Spot ventilation fans are important in that they remove moisture and odors at the source. Proper ducting and termination of these devices is critical and enhanced control options for these fans include humidistat and pre-set timer controls to ensure adequate runtimes.

Select an exhaust fan that can provide the required airflow at realistic conditions. It is recommended that an external static pressure of 0.25" w.c. is used (which is much more like real world installations) and not at the often unrealistic 0.1" w.c. In addition, the energy code requires ventilation fans to have a certain minimum efficacy (cfm/W). Virtually all ENERGY STAR rated fans will easily comply and often offer extremely low sone (quiet) operation.

For single family homes, ASHRAE 62.2-2016 requires a readily accessible manual ON-OFF control that is labeled to indicate the system's function.

How Can Ventilation Be Done?

Quite simply, whole house ventilation can be achieved by sucking air out of a house (creating a negative pressure), blowing air into a house (delivering positive pressure) or doing both simultaneously which creates a neutral (balanced) pressure. There are advantages and disadvantages to each of these approaches.

Exhaust only – tends to offer the lowest first cost as well as low operating cost. Arguably, a spot ventilation bath fan that is controlled to run continuously could satisfy whole house mechanical ventilation requirements.

However there are several major downsides to this strategy – first that a building located in a humid climate should not be kept under a continuous negative pressure due to moisture concerns; second that while the amount of air leaving the building occurs through a known location (the exhaust fan duct), the replacement air comes from unknown, often undesirable locations and cannot be filtered; third, that combustion appliances could be more easily backdrafted, and finally, that the mixing of this “fresh” air can be dubious. When operating, the unconditioned outdoor air will be sucked into the building due to the negative pressure. For these reasons, many building scientists in humid climates prefer to utilize exhaust fans for intermittent spot ventilation purposes only.

Supply only – can vary in both first cost and operational cost depending on which approach is used. Supplying outdoor air has one major advantage, the fresh air is pulled in from a known location and can easily be filtered before being introduced and distributed throughout the home. When operating, conditioned air will be pushed out of the building due to the positive pressure (which is desirable in a humid climate). The majority of commercial buildings in humid climates ventilate in this manner.

Supply only systems can be as simple in concept as a bath fan running in the opposite direction (e.g., an inline supply fan). This air can be delivered directly into the dwelling unit or distributed via the existing duct system. The fan can be a dedicated supply fan or the main air handling unit (AHU) blower. In some cases the fan is integrated with a dehumidifier, while in some products the ventilation device has temperature and moisture sensors to adjust the airflow during times when outdoor conditions are “bad” (set by the user, these could be too hot or cold, too humid or too dry).

Balanced systems – recognize that for every cubic foot of air that enters a building, another one must leave. Rather than rely on building pressure to suck in unconditioned air (exhaust) or push out conditioned air (supply), these balanced systems incorporate two separate air streams to both push and pull air at the same time. These two air streams are not mixed, however they can easily be run through a core type heat exchanger so that the energy of the stale, exhausted air can pre-condition (pre-heat, pre-cool/dry) the energy of the fresh, incoming air. These systems offer excellent mixing of the ventilation air into the home and while they require more complex ducting, have become more affordable in recent years. Their operating cost is somewhat offset due to the recovered energy from the heat exchanger.

Hybrid systems – offer a combined strategy such as having a controller operate a (secondary) bath exhaust fan to make up the required ventilation whenever the (primary) main air handling unit has not experienced enough run time due to moderate outdoor conditions.

Where Should the Fresh Air Intake Be Located?

The outside air intake should be located far from pollutant sources, ideally at least 10 to 15’. Examples of outdoor source contaminants include standing water, vehicle exhaust, garbage cans, pet areas, combustion flue gases, roofing materials, plumbing stacks, HVAC condensing units and so on. Generally it is desirable to pull the outdoor air from a high location, such as an intake at the ceiling of a porch or a gable end wall.   In some cases, especially if the intake is easily accessible, the fresh air may be filtered at the source of the intake and in all cases a ½” mesh bird screen is advisable.

What about Natural Ventilation? Can’t We Just Open Windows?

Opening windows is a viable way to potentially save energy and use natural driving forces such as wind and stack effect (warm air rising) to induce air changes. The challenge is that this strategy works best in a specifically designed structure in a usually more temperate (less humid) climate. It also involves active homeowner participation on a regular basis (opening windows and shutting off HVAC equipment and then closing windows and turning equipment back on) and issues such as dust, noise, pollen, insects, air pollution and security concerns are left unresolved. Coupled with the fact that the driving forces are often highly variable, it is difficult for natural ventilation to solely be a consistent whole house ventilation strategy, particularly in Mixed-Hot Humid climates.

What Are Appropriate Strategies for Mixed-Hot Humid Climates?

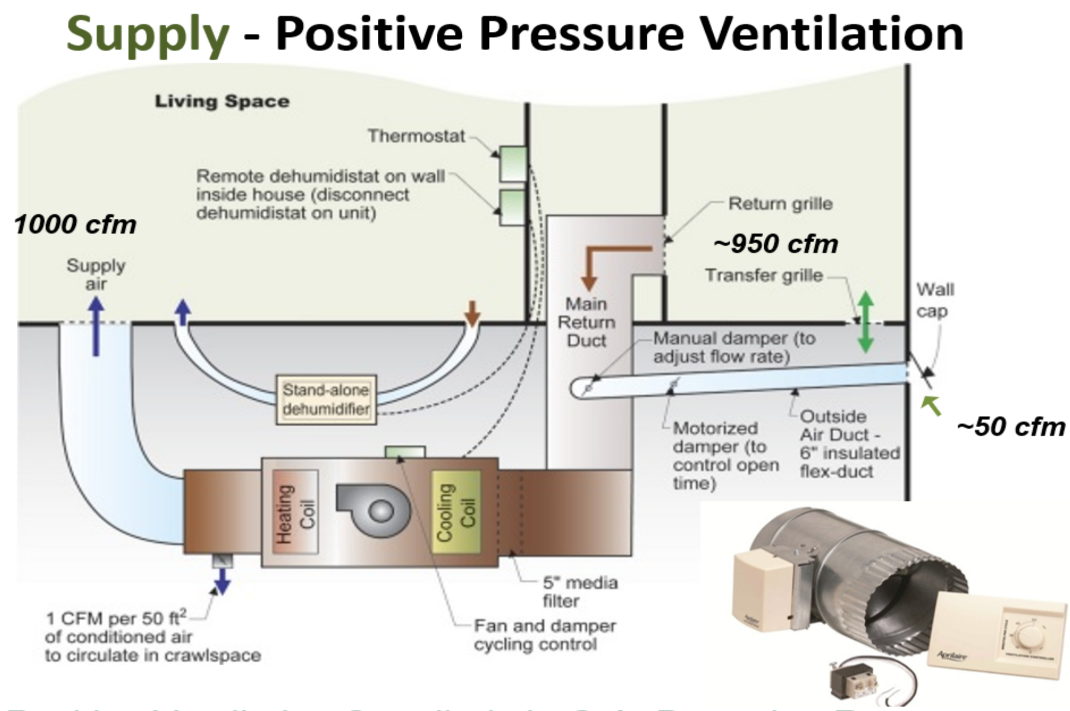
The perfect whole house mechanical ventilation system would have a low first cost, be inexpensive to install, operate quietly with very low energy and at negligible cost, involve minimal maintenance and do an excellent job of providing fresh, filtered outdoor air to the building occupants throughout the living space. Constructing a home in “Humidity-Land” encourages the use of either positive pressure or balanced strategies in order to keep a building from being sucked negative all the time (however, intermittent spot ventilation is still an important strategy). The following five strategies, while not perfect, can certainly be considered viable.

1. Outside Air Ducted Into the Return.

Sometimes referred to as Central Fan Integrated Supply (CFIS), this setup involves adding an approximately 6” fresh air duct from the outside into the return duct. It requires a fresh air intake, balancing damper, motorized damper and controller, and preferably a more efficient AHU blower motor known as an ECM (electrically commutated motor) – this is a requirement of the 2015 IECC. There are a number of controller manufacturers including AirCycler, AprilAire, Honeywell, etc.

This system requires a ducted return (common in most homes with central HVAC systems) and has the proven track record of having been used in commercial buildings for many years as well as many homes in more recent years. It offers exceptional mixing of the fresh air into virtually every room in the house and is designed to operate intermittently.

For example, consider a home needing 50 cfm for 20 minutes out of each hour. If the thermostat was calling for heating or cooling, the controller would simply piggyback by opening the motorized damper for 20 minutes during the normal heating or cooling cycle and then close the damper after the 20 minutes had elapsed. Compared to simply connecting an outdoor air duct into the return, the controller and motorized damper prevents over-ventilating on extreme hot or cold days. If the outdoor conditions are mild, the system tracks that no AHU activity occurred in the last 40 minutes and turns on just the blower and opens the damper for 20 minutes of fresh air and then shuts everything off; this action prevents under-ventilating on a mild day.



Positive Ventilation Supplied via O.A. Ducted to Return

Images from BuildingScience.com and AprilAire

This system is relatively inexpensive but has one downside both in an energy model as well as the real world – the energy required to run the large AHU blower to effectively move relatively few cfm can be costly. As a result, when ventilating using this strategy, the 2015 IECC requires the fan to have a more efficient (albeit more expensive) ECM blower motor to help offset this liability. For savings, this variable speed fan should generally be configured to operate on low speed during times of only ventilating. In addition, proper outdoor air ducting with minimal restrictions is usually necessary to guarantee adequate fresh air flow rates.

2. Inline Supply Fan with Temperature and Moisture Sensor Controls

An inline supply fan is similar to an exhaust fan running backwards – it is relatively inexpensive to both purchase and operate and uses little energy to run continuously. However, a supply fan just dumping raw, ambient air into a dwelling unit is not necessarily the best idea and the smart sensor-based controls can help address this.

Pioneered by AirKing, the QuFresh is an inline supply fan with a built-in filter as well as temperature and moisture sensors. Designed to run continuously and using very little energy, when the conditions are "good", the user can set the parameters for "bad" (e.g., temperature above 90°F or below 40°F, or humidity above 65% RH or below 30% RH). If the conditions are "bad" the unit cycles off for 15 minutes, runs for 5 minutes and then retests. Once the conditions are "good" again, the unit goes back into continuous mode.

QUFRESH BY Air King

Patents Pending

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

Note that while this simple unit can be configured to supply into the existing ductwork, it does not perform any energy recovery such as pre-heating, cooling or dehumidification. However, this concept of a sensor based control that adjusts the ventilation depending on the actual outdoor conditions represents the future of ventilation and several manufacturers (Broan, Panasonic, AprilAire, etc.) are delivering similar products.

3. Ventilating Dehumidifiers

Made by companies such as AprilAire, Honeywell and Thermastor, ventilating dehumidifiers often pull air from two places – the house itself plus the outdoors – before delivering supply air into the home. When operating, the system mixes and filters both the outside air as well as some of the house air. It then controls the moisture level via a humidistat which operates the integrated dehumidifier.

While more expensive, these devices offer excellent moisture control not just for the fresh air but also for the house itself. Frustratingly, it is difficult for energy models to properly capture this added latent cooling (moisture removal) benefit, however the impact is nevertheless significant. Particularly in newer, more efficient homes with relatively low cooling loads, these units can handle a significant portion of the moisture load which frees up the main air conditioner to focus on the much easier sensible (temperature) cooling. It is common for dehumidifiers to actually somewhat increase the temperature of the air supplied into the house, although their output is significantly drier air.

When properly sized using the code required Manual J methodology, air conditioners are sized for the nearly hottest day of the year (the summer outdoor design temperature for a location is the value at which the temperature is exceeded only 1% of the hours of the summer). Oversizing is a frequent problem and results in an air conditioner's inability to run long enough to properly dehumidify – for this reason variable capacity air conditioning equipment is highly desirable. From the data below for Atlanta GA, note that even a right-sized air conditioner is technically oversized most of the hours of the summer.

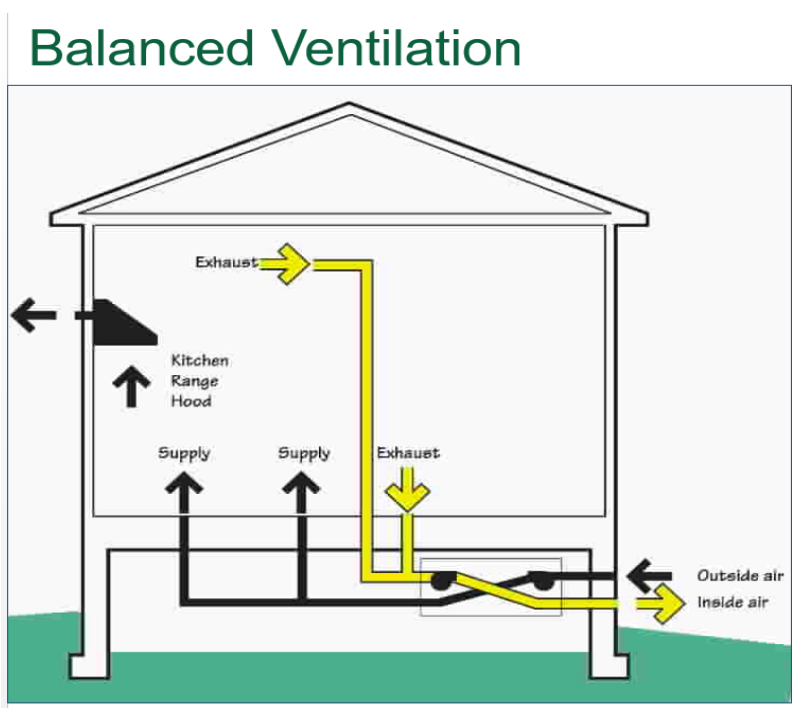
It's Not the Heat, It's The Humidity..

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

The statistical weather data shows that an Atlanta air conditioner is sized for an outdoor temperature of 92-95°F. However, for the majority (83%) of the hours of the summer, the outdoor temperature is actually below 85°F. Also, note that the peak moisture load of 133 grains occurs at 82°F; this is 33% more moisture than the 99 grains that occurs at the design temperature of 92°F. The takeaway is that, more than ever, houses need drying even when they don't need cooling and a dedicated dehumidifier may be the best choice for a modern, efficient home in a Mixed-Hot Humid climate.

4. Energy Recovery Ventilators (ERV's)

An energy recovery ventilator puts the home under balanced pressure and utilizes the energy of the exhaust airstream to pre-condition the fresh, incoming air. ERV's have been around for some time but have become more mainstream and affordable in the last few years.



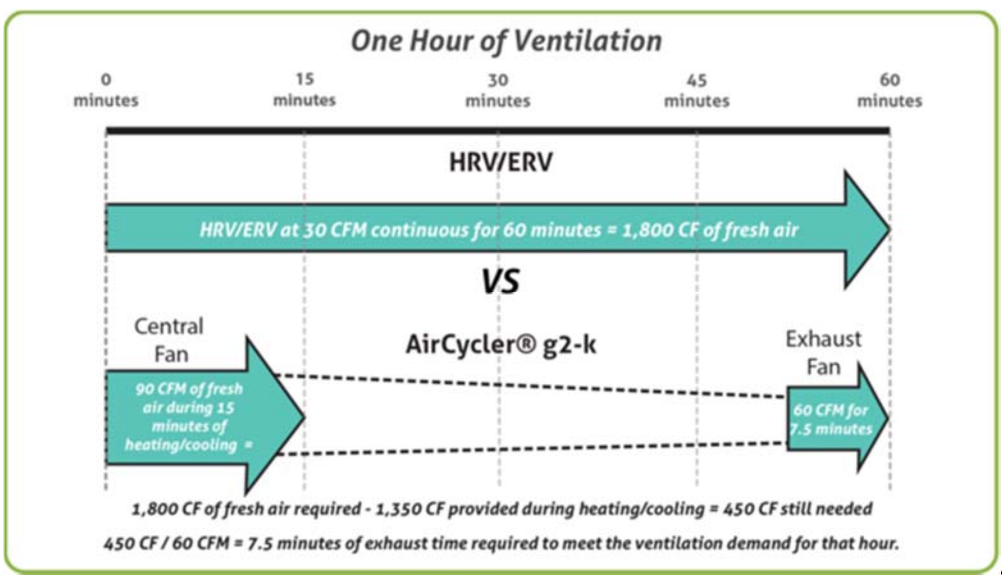
Energy Recovery Ventilator (ERV) – transfers both heat (Sensible) and moisture (Latent)

ERV's can run continuously or on an intermittent basis. They can be ducted independently (preferred) or be tied into either the supply or return side of the main duct system (but not both sides since the air can bypass around the dormant AHU causing short cycling and poor mixing to occur!). ERV's are generally low energy to operate and do a decent job of transferring heat but only a so-so job of transferring moisture (removing approximately half of the moisture needed during humid outdoor conditions).

ERV's do not dehumidify in the summer! In fact, on a humid day, the outdoor air being brought in is always going to add some moisture to the house (however it will be less moisture than if it were just dumped into the home since the outgoing airstream will pick up some of the fresh air's moisture and deliver it back to the outdoors). Some ERV's are being coupled with sensor based controls to cycle during high outdoor moisture load conditions.

5. Hybrid Systems

As an attempt to mitigate the energy penalty of using the big AHU blower to bring in ventilation air when the outdoor conditions are mild and do not require much HVAC runtime, a modification to CFIS is available. Essentially, controls by manufacturers such as AirCycler allow the normal (thermostatically controlled) air handler runtime to bring in "piggybacked" ventilation during periods of heating and cooling runtime. The controller then augments this by running the exhaust fan to "make up" the cfm required after an insufficient AHU runtime, thus creating a hybrid operation.



AirCycler

This hybrid approach means the house may, at times, experience positive, neutral or negative pressure. During moderate weather, running a low-energy exhaust fan to create the remaining air changes instead of running the main AHU fan offers significant energy savings and still provides the necessary volume of air to satisfy the ventilation standard on a regular basis.

Newer hybrid options such as offered by Field Controls offer capability of monitoring up to 4 exhaust appliances (multiple bath fans, clothes dryer, range hood, etc…) and reducing whole house ventilation system run times accordingly. These more sophisticated controls offer 30-minute cycle vs 60-minute cycle which creates shorter but more frequent OA cycles and better parallel run time of the main HVAC system (resulting in a more even introduction of fresh air and improved dehumidification. They also feature temperature and moisture (enthalpy) control capability.

What's The BEST Ventilation Strategy for a Mixed-Hot Humid Climate?

It's wise to acknowledge that at certain times the outdoor air may not be optimal to ventilate with and unless extensive filtration or dedicated conditioning is employed, it may be better to shut the ventilation off and coast (or at least throttle back to a reduced amount). The best ventilation device for a Mixed-Hot Humid climate is likely a dehumidifier coupled with an ERV that utilizes sensor based controls.

Beyond just temperature and humidity, sensors can be utilized to detect for occupancy as well as for pollutants such as smoke in wildfire prone areas or ground level ozone for urban smog days. This "one-size-fits-all" device doesn't truly exist yet and the closest approximations are expensive but it does illustrate the probable future of smart ventilation and the need to operate intelligently during a variety of indoor and outdoor conditions.

Finally, some form of indoor air "traffic light" with multiple sensors that detect a number of indicator pollutants and displays an IAQ status (e.g., Green, Yellow, and Red with audible alarm) may someday become available to help both monitor IAQ and also help control the ventilation system.

Ventilation Resources:

Weatherization (WAP) Standard Work Specifications (SWS)

ASHRAE 62.2

AprilAire

Honeywell

Thermastor

AirKing

Broan/NuTone/Venmar

Field Controls

Panasonic

EPA IAQ Plus Program

Foobot

Purple Air

Build Equinox - CERV

Other IAQ sensors