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RESNET Atlanta

Ventilation: Effective Strategies and Lessons Learned

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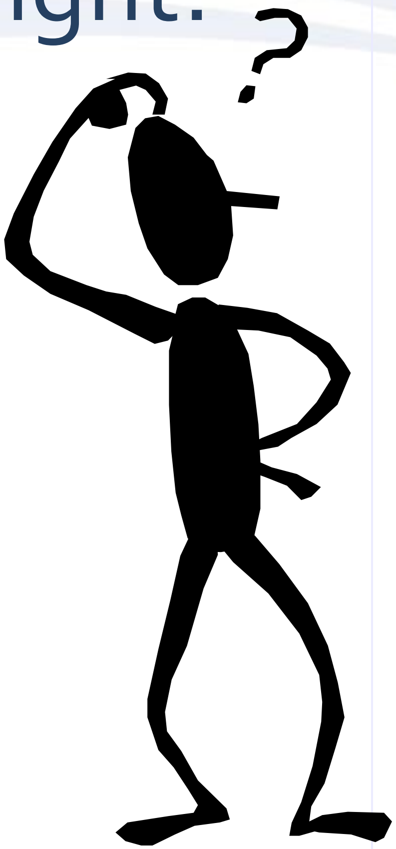
Let's Review

- A house has got to breathe, right? Why?
  - Fresh indoor air
  - Outdoor air quality/allergies
  - Moisture Control
- You want me to do what?
- Why not just let it leak?



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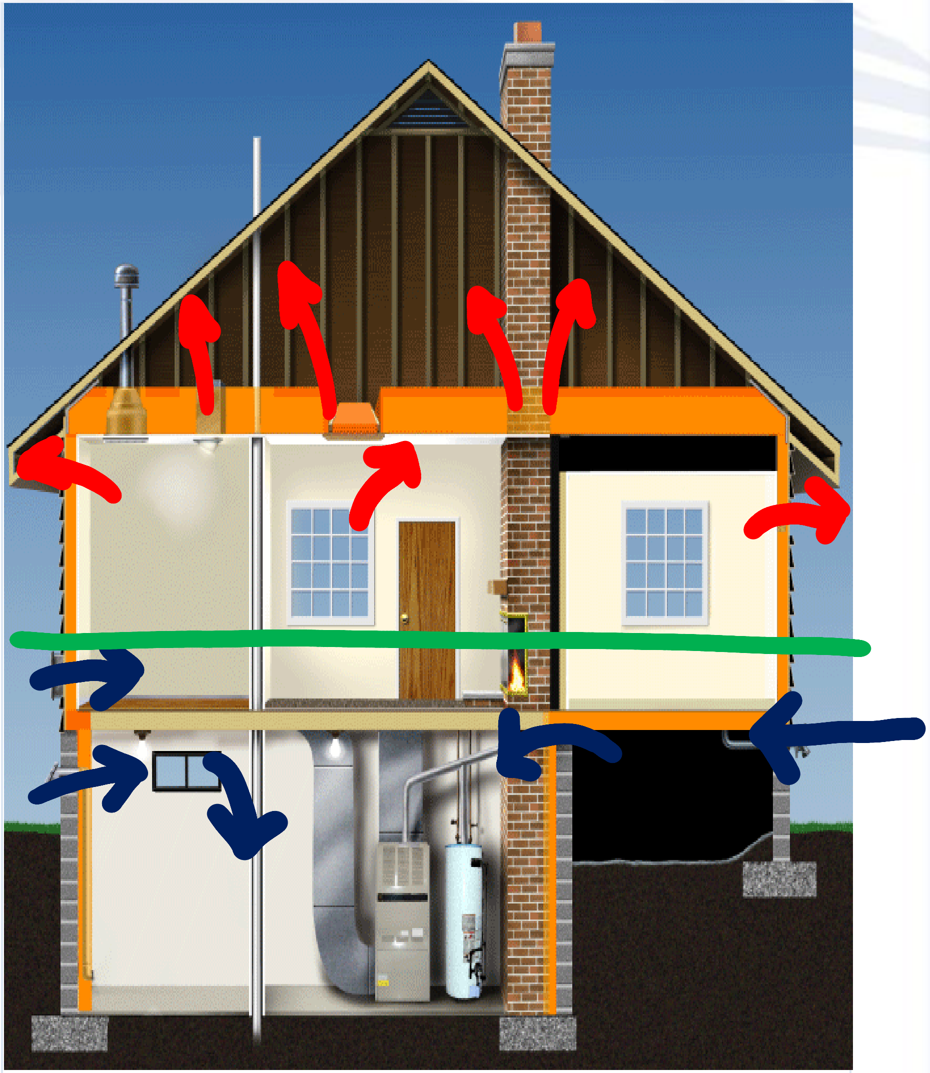
Infiltration Driving Forces

- Stack effect
- Pressure created by height and temperature difference
- Neutral pressure plane is at height where holes don't leak
- Infiltration below / Exfiltration above
- The further from the neutral pressure plane the higher the leakage – up or down



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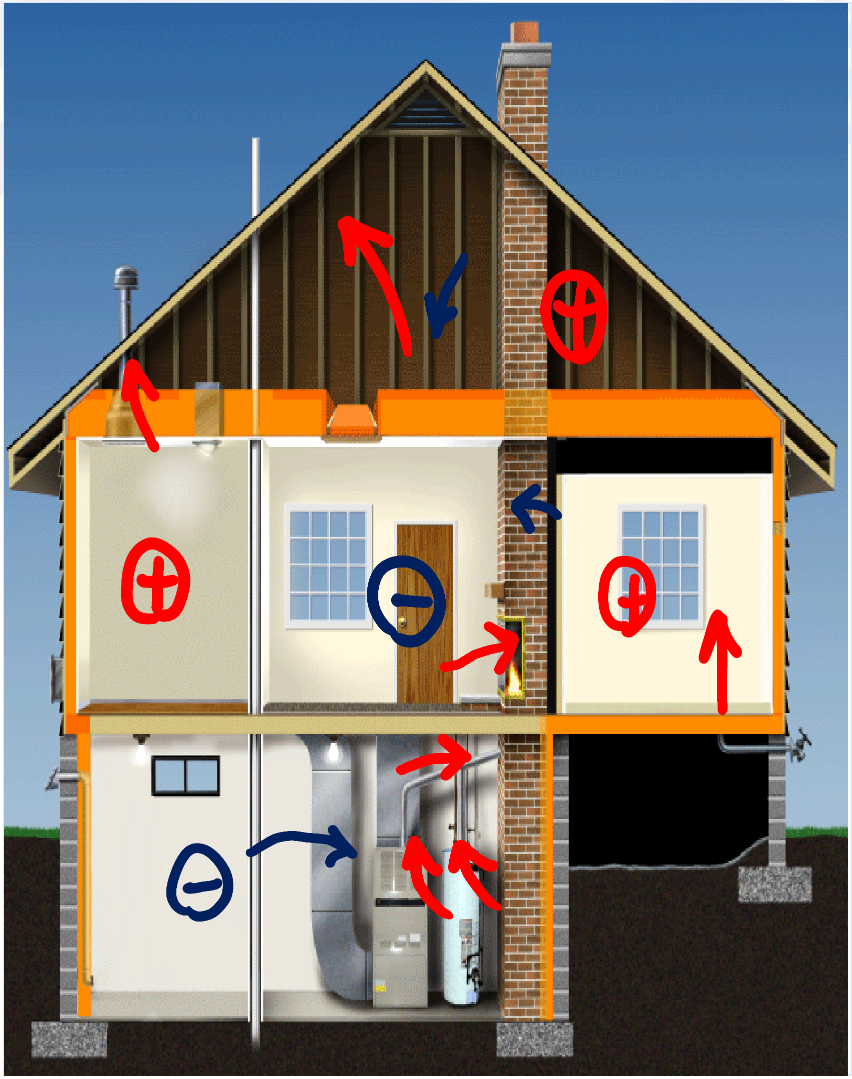
Infiltration Driving Forces

- Wind
- Stronger in winter
- Sensitive to location
  - Building height
  - Orientation
  - Shielding

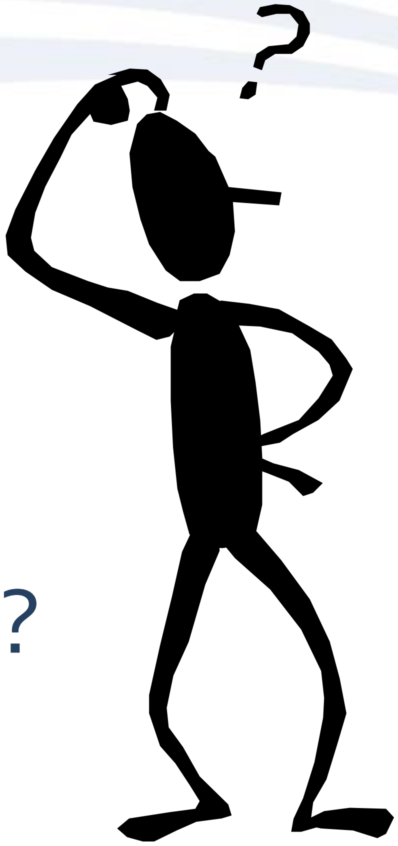
Infiltration Driving Forces

- Mechanical leakage
- Supply and Return leaks pressurize and depressurize
- Same with unbalanced air flow
- Combustion depressurizes
- Exhaust air depressurizes
  - Clothes dryers
  - Kitchen fans



So Many Questions

- How much air do you need?
  - How much air do you get?
  - Where does it come from?
- How big a hole do you leave?
- Where do you put the hole?
- Can the air hurt us or the house?



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Solution!

- Let’s connect the hole to a duct so we know where it’s going (or coming from)
- Let’s hook up a fan so we know how much air we are moving
- Let’s eliminate all of the other holes that we don’t need or want

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ASHRAE 62.2/ENERGY STAR

Whole-Building Ventilation

Required Ventilation Rate (cfm) =

(0.01 x Conditioned Floor Area) + 7.5 x (bedrooms + 1)

Example (2,000 sq. ft., 4 bedroom house)

Ventilation rate = (2000 x 0.01) + (7.5 x 5) = 58 cfm

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ASHRAE 62.2/ENERGY STAR

Whole-Building Ventilation

- Exhaust only, supply only or balanced system
- Local exhaust fans can be used
- Outdoor air can be supplied to the return of an air handler if the air meets manufacturer's return air temperature criteria
- "Fan On" as a control strategy OK with ASHRAE but not ENERGY STAR

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ASHRAE 62.2

Intermittent vs Continuous Flow

- Intermittently operated systems permitted, but ventilation rates must be increased if:
  - cycle time is greater than 4 hours and
  - fractional on time is less than 100%
- Intermittently operated systems must be larger to overcome off cycles and reduced ventilation effectiveness
- Oversized systems cost more money, make more noise and can decrease comfort – why go there?

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Net Pressurization

- Limitations for extreme weather conditions
  - < 7.5 cfm/100 sf net exhaust in hot humid climates
  - < 7.5 cfm/100 sf net supply in very cold climates
- Conditions that cause problems will exist in these climates, but more on this later.

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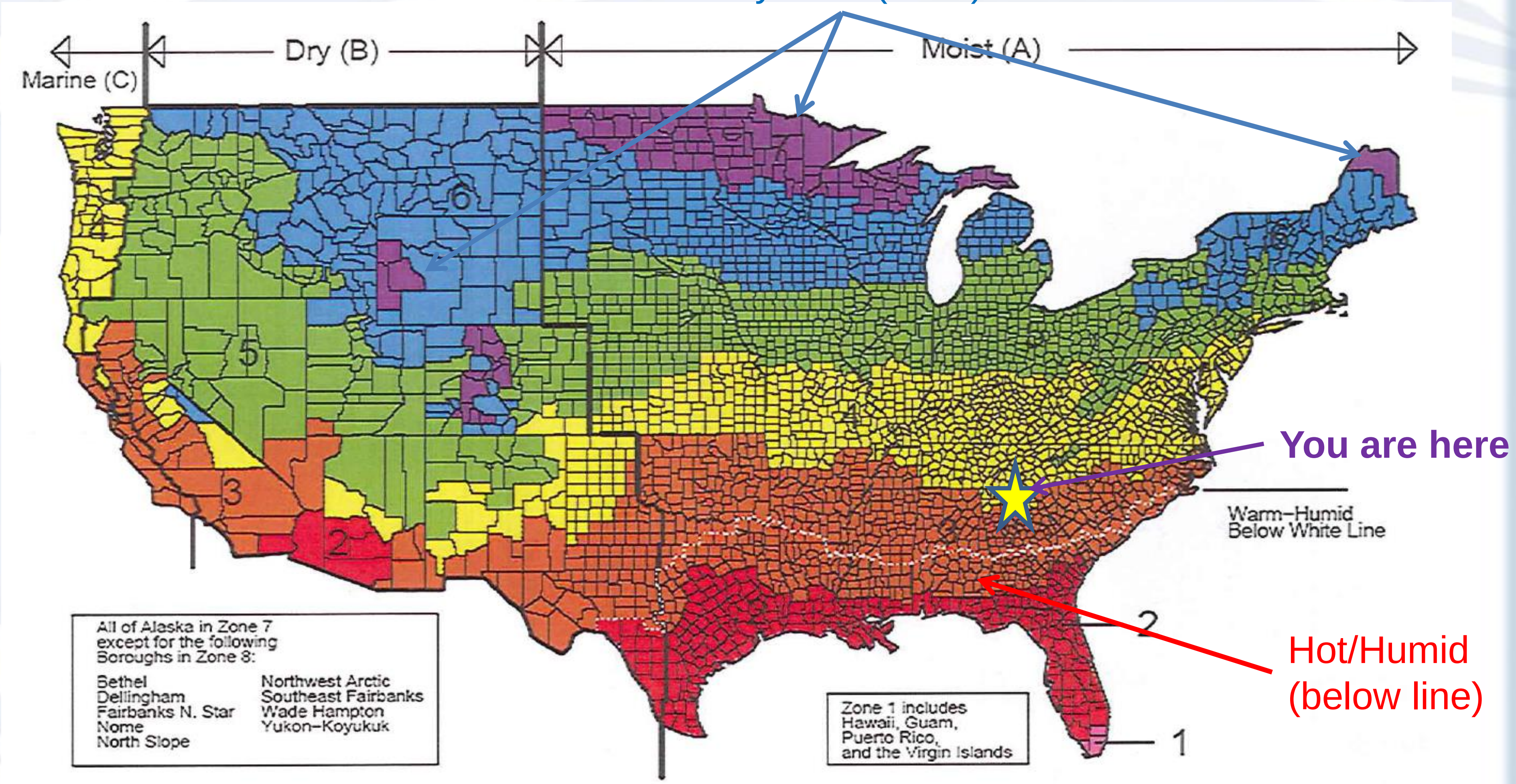
ASHRAE 62.2

Very Cold (CZ 7)



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Local Exhaust

- Measured air flow <u>or</u>
- Prescriptive exhaust duct sizing
  - Duct size, type (smooth/flex), length and number of elbows determined by rated airflow and required airflow
    - Now an option for ENERGY STAR kitchen exhaust

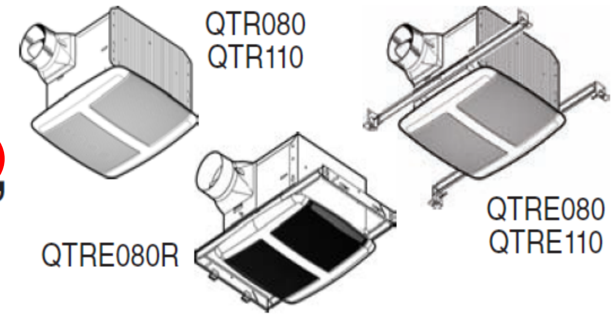
Fan Ratings

BROAN

SPECIFICATION SHEET

QTR / QTRE SERIES FANS

MODELS QTR050F, QTR080, QTR110, QTRE080, QTRE080R, QTRE110



Ultra-quiet, high performance bath fan with a modern-styled grille.

FEATURES

BLOWER:

- Plug-in, permanently lubricated motor - engineered for continuous operation
- Dynamically balanced centrifugal blower wheel for quiet, efficient performance
- Low RPM for quiet operation
- Resilient anti-vibration motor mounts (QTR080 only)

HOUSING:

- Rugged, 26 gauge, galvanized steel construction
- Polymeric, 4" round duct connector with tapered sleeve

TYPICAL SPECIFICATION

Ceiling Ventilator shall be Broan Model QTR050F (QTR080) (QTR110) (QTRE080) (QTRE080R) (QTRE110).

Ceiling Ventilator shall have corrosion resistant galvanized steel housing. It shall be ducted to a roof or wall cap using 4" round ductwork.

Blower assembly shall be removable, have a centrifugal-type blower wheel and a permanently lubricated motor designed for continuous operation.

Non-metallic damper/duct connector shall be included.

Air delivery shall be no less than 50 (80) (110) CFM and sound level no greater than 0.4 (0.8) (1.0) (1.3) (1.5) Sones. All air and sound ratings shall be certified by HVI.

Ceiling ventilator shall be Energy Star® qualified and have an energy efficient permanent split capacitor motor (Models QTRE080, QTRE080R & QTRE110 only).

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Fan Ratings – read the small print

HVI PERFORMANCE

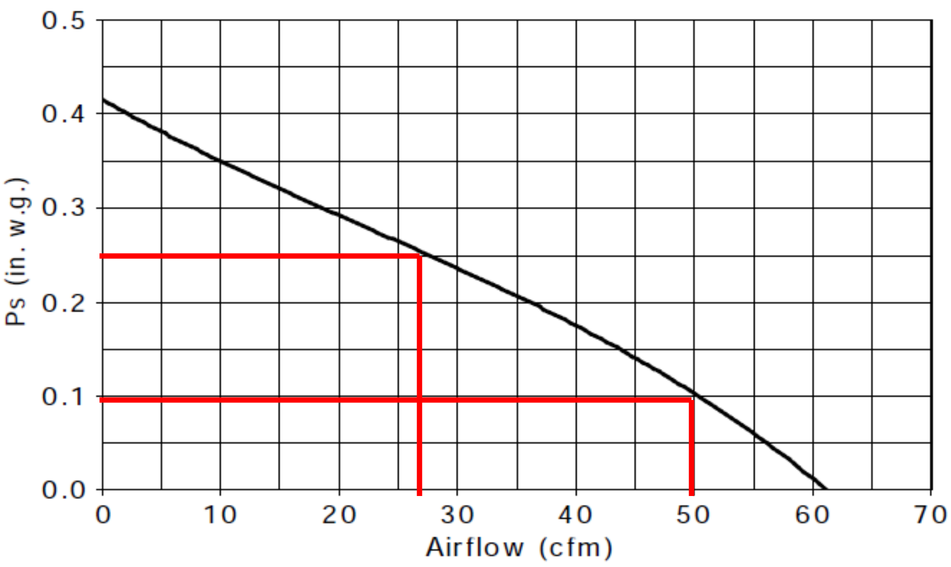
Model	Static Pressure (Ps)	CFM	Sones	Fan Watts
QTR050F	0.10	50	0.4	
	0.25	28		
QTR080	0.10	80	1.0	
	0.25	66		
QTR110	0.10	110	1.5	
	0.25	98		
QTRE080 QTRE080R	0.10	80	0.8	28.2
	0.25	55		
QTRE110	0.10	110	1.3	36.3
	0.25	89		

® 2100 HVI CERTIFIED

HVI-2100 CERTIFIED RATINGS comply with new testing technologies and procedures prescribed by the Home Ventilating Institute, for off-the-shelf products, as they are available to consumers. Product performance is rated at 0.1 in. static pressure, based on tests conducted in a state-of-the-art test laboratory. Sones are a measure of humanly-perceived loudness, based on laboratory measurements.

AIR FLOW PERFORMANCE

MODEL QTR050F



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Fan Ratings – read the small print

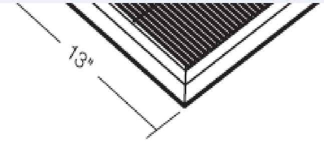
warranty on other parts.

Typical Specifications:

Ventilating fan shall be of the ceiling mount, ENERGY STAR rated type, with no less than 50 CFM and no more than 0.3 sone as certified by the Home Ventilating Institute (HVI) at 0.1 static pressure in inches water gauge. Power consumption shall be no greater than 4.3 watts and ENERGY STAR rated with efficiency rating of no less than 12.4 CFM/watt. The motor shall be fully enclosed with brushless DC motor engineered to run continuously. Power rating shall be 120v/60Hz. Duct diameter shall be no less than 4". Fan shall be UL and cUL listed for tub/shower enclosure when used with GFCI branch circuit wiring. Fan shall be California Title-24 compliant.

DC Motor Technology:

- When fan faces static pressure, its speed is automatically increased to ensure that the desired CFM is not compromised, which allows the fan to perform as rated.

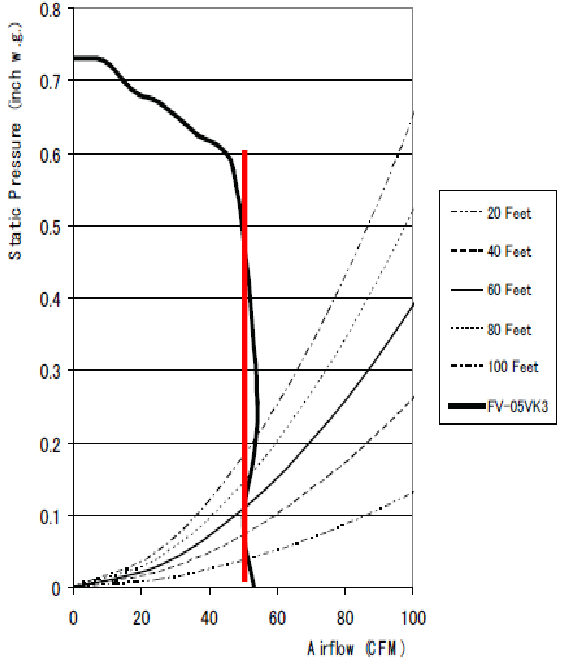


Specifications:

	FV-05VK3	
Static Pressure (inches w.g.)	0.1"	0.25"
Air Volume (CFM)	50	54
Noise (sones)	<0.3	0.3
Power Consumption (Watts)	4.3	7.5
Energy Efficiency (CFM/Watts)	12.4	7.7
Speed (RPM)	749	1101
ENERGY STAR Rated	Yes	
Washington State VIAQ Code	Yes	
California Title 24	Yes	

As of 1/11

Fan Curve FV-05VK3



For Complete Installation Instructions Visit www.panasonic.com/building

cULus 2100 HVI CERTIFIED

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Option 1 – Exhaust

- Local exhaust for bathrooms and kitchen
- One bathroom fan used as exhaust only whole-house ventilation system
  - Example: 2000 SF, 4 Bedrooms, 2 ½ Baths, 150 SF Kitchen
    - Whole House Ventilation = (2000 x 0.01) + (5 x 7.5) = 57.5 cfm
    - 80 CFM ENERGY STAR bath fan set at 60 CFM continuous in hall bath
    - Kitchen Exhaust = 100 cfm hood <u>or</u>
    - 5ACH x 150 SF x 9 FT / 60 min/hr = 113 CFM general exhaust (will probably require 150 CFM fan)
    - 80 CFM bath fan in master bath to run on switch or 50 CFM bath fan with controller set to 20 CFM continuous

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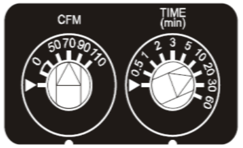
Option 1 – Exhaust

- Ventilation Control - intermittent/continuous
  - Switch mounted (third party)
    - Intermatic
    - Tamarack

  - Fan mounted
    - Panasonic
    - Broan/Nutone

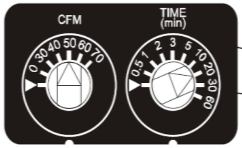
SWITCH INDICATION

FV-13VKM3
FV-13VKS3



Switch indications on blower unit

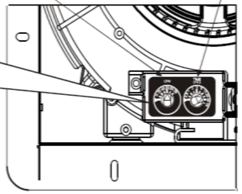
FV-08VKM3
FV-08VKS3



Switch indications on blower unit

Low speed air volume preset switch

High/Low delay time preset switch



Low speed air-volume preset switch positions

FV-13VKM3 FV-13VKS3	Air volume [CFM]	0		50	70	90	110
FV-08VKM3 FV-08VKS3		0	30	40	50	60	70

Factory setting : FV-13VKM3/FV-13VKS3: 70CFM; FV-08VKM3/FV-08VKS3: 50CFM.
Position "0" : Fan stop.
Position "▶" : use for factory test only.
High/Low delay time preset switch positions

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Option 1 – Exhaust

- Least expensive to install
- Does not require extensive design consideration – no distribution system required
- Lowest power draw

- No energy recovery or humidity control
- No control of fresh air quality
  - Can't be filtered
  - Source unknown
- House depressurization can contribute to moisture problems in hot humid climates

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Option 2 – Supply

- Local exhaust for bathrooms and kitchen
- Outside air tied into HVAC return air duct with damper and controller
  - Example: 2000 SF, 4 Bedrooms, 2 ½ Baths, 150 SF Kitchen
    - Whole House Ventilation = (2000 x 0.01) + (5 x 7.5) = 57.5 cfm
    - min. 6" outside air duct with motorized damper, controller. Limit outside air to maintain RA within manufacturer specs.
    - Kitchen Exhaust = 100 cfm hood <u>or</u>
    - 5ACH x 150 SF x 9 FT / 60 min/hr = 113 CFM general exhaust (will probably require 150 CFM fan)
    - 80 CFM bath fan in both baths to run on switch or 50 CFM bath fan with controller set to 20 CFM continuous

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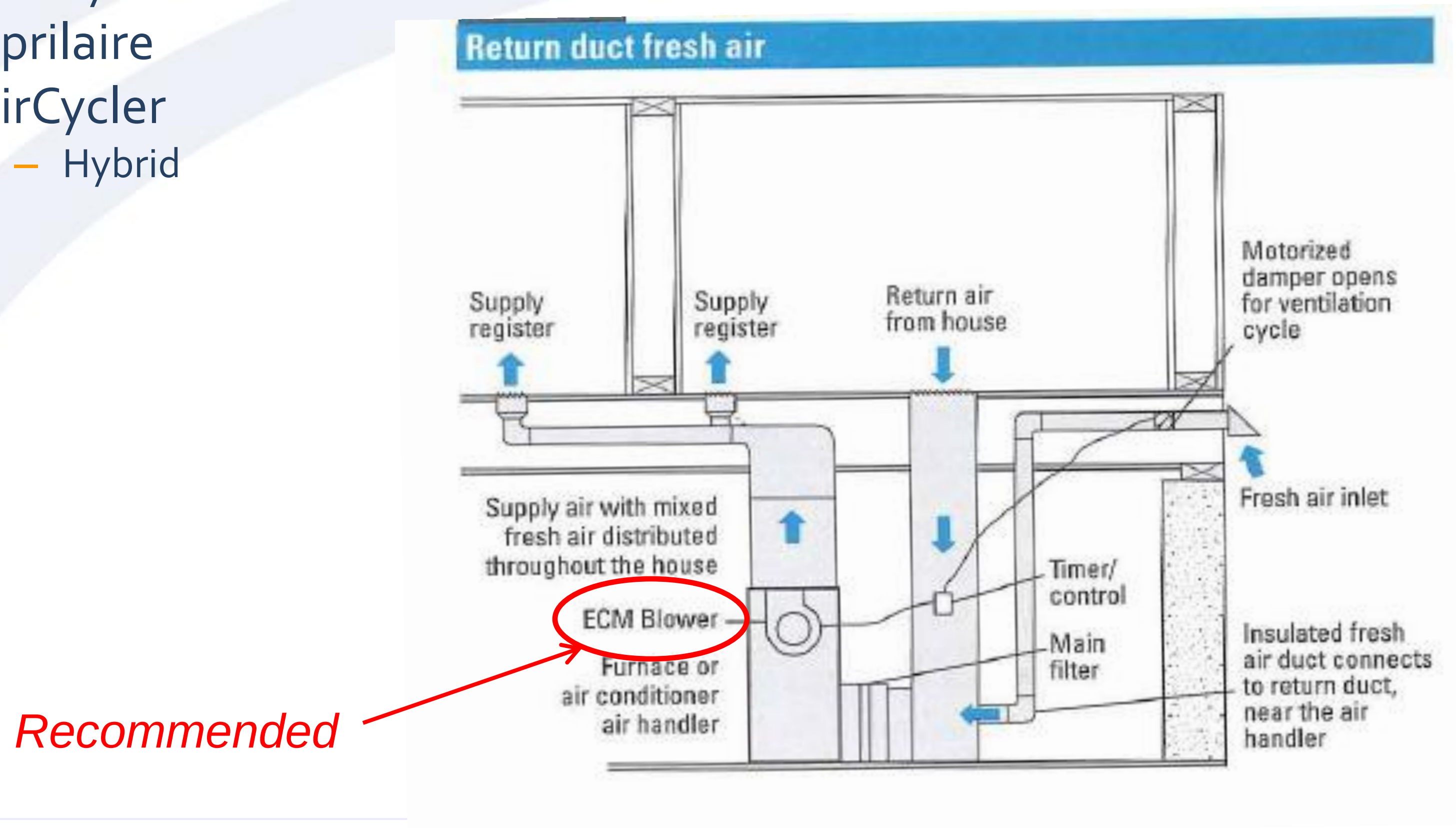
Option 2 – Supply

- Controller operates blower and damper
  - Available Control Products in Marketplace
    - Honeywell
    - Aprilaire
    - AirCycler
      - Hybrid



Option 2 – Supply

- Low installed cost
- Limited distribution system required
- Fresh air from known location
- Fresh air filtered prior to distribution
- Fresh air tempered or conditioned prior to distribution

- No energy recovery or humidity control
- Temperature of blended return air must be considered
- House pressurization can contribute to moisture problems in very cold climates
- Highest cost to operate – better with ECM blower
- Potentially lowest cost to operate as a hybrid

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Option 3 – Balanced with Energy/Heat Recovery

- Local exhaust for bathrooms and kitchen
- Exhaust/Outside air through ERV/HRV tied into HVAC return air duct
  - Example: 2000 SF, 4 Bedrooms, 2 ½ Baths, 150 SF Kitchen
    - Whole House Ventilation = (2000 x 0.01) + (5 x 7.5) = 57.5 cfm
      ERV/HRV sized to meet or exceed
    - Kitchen Exhaust = 100 cfm hood <u>or</u>
      5ACH x 150 SF x 9 FT / 60 min/hr = 113 CFM general exhaust
      (will probably require 150 CFM fan)
    - 80 CFM bath fan in both baths to run on switch or 50 CFM bath fan with controller set to 20 CFM continuous

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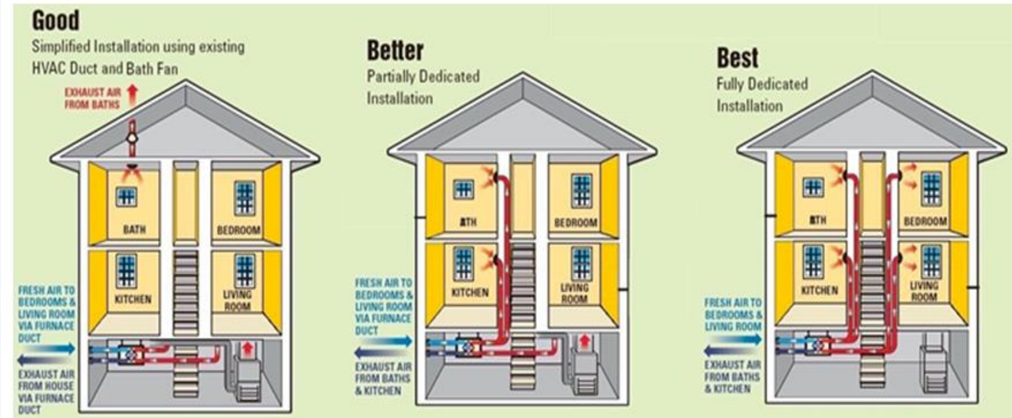
Option 3 – Balanced with Energy/Heat Recovery

- Reduced sizes/cost now available
- HRV controls temperature of outside air
- ERV controls humidity as well
- Complexity of distribution system highly variable



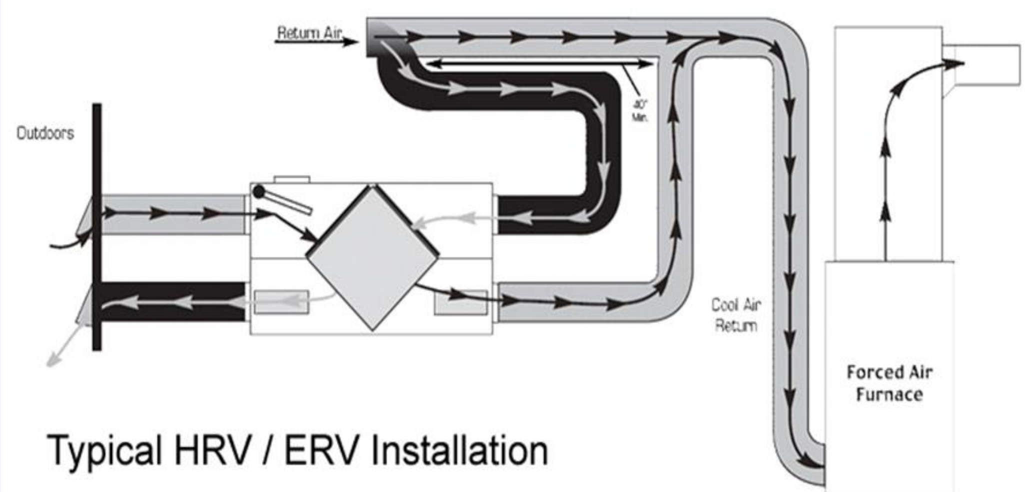


Diagram Courtesy of IAQsource.com

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Option 3 – Balanced with Energy/Heat Recovery

- Fresh air from known location
- Fresh air filtered prior to distribution
- Fresh air tempered or conditioned prior to distribution
- Reduces cost of re-conditioning ventilation air
- Energy Recovery controls humidity winter and summer

- Highest installed cost
- Distribution system required
- Largest space requirements

- House is under neutral pressure

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Performance – How do we know it works?

Plan: Fan Selection & Duct Sizing

- Manufacturers Fan Rating data
- ACCA Manual D Calculations (probably not needed)
- ASHRAE 62.2 Prescriptive Tables

Verify: Actual Flow Rates

- Post installation testing

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Manufacturer's Data: Rated Airflow

- Fan Specifications
  - Rated @0.1 or @0.25 in wc?
- Panasonic FV-08VQ5 (nominally 80 CFM fan)

FV-08VQ5		4" Duct (Standard)	
Ventilation Fan Characteristics (HVI Certified Data)	Static Pressure (inches w.g.)	0.1	0.25
	Air Volume (CFM)	80	62
	Noise (sones)	<0.3	0.4
	Power Consumption (Watts)	14.7	14.5
	Energy Efficiency (CFM/Watts)	5.8	4.5
	Speed (RPM)	829	1089
	Current (amps)	0.12	0.12
	Power Rating (V/Hz)	120/60	
	ENERGY STAR rated	Yes	

As of 06/10

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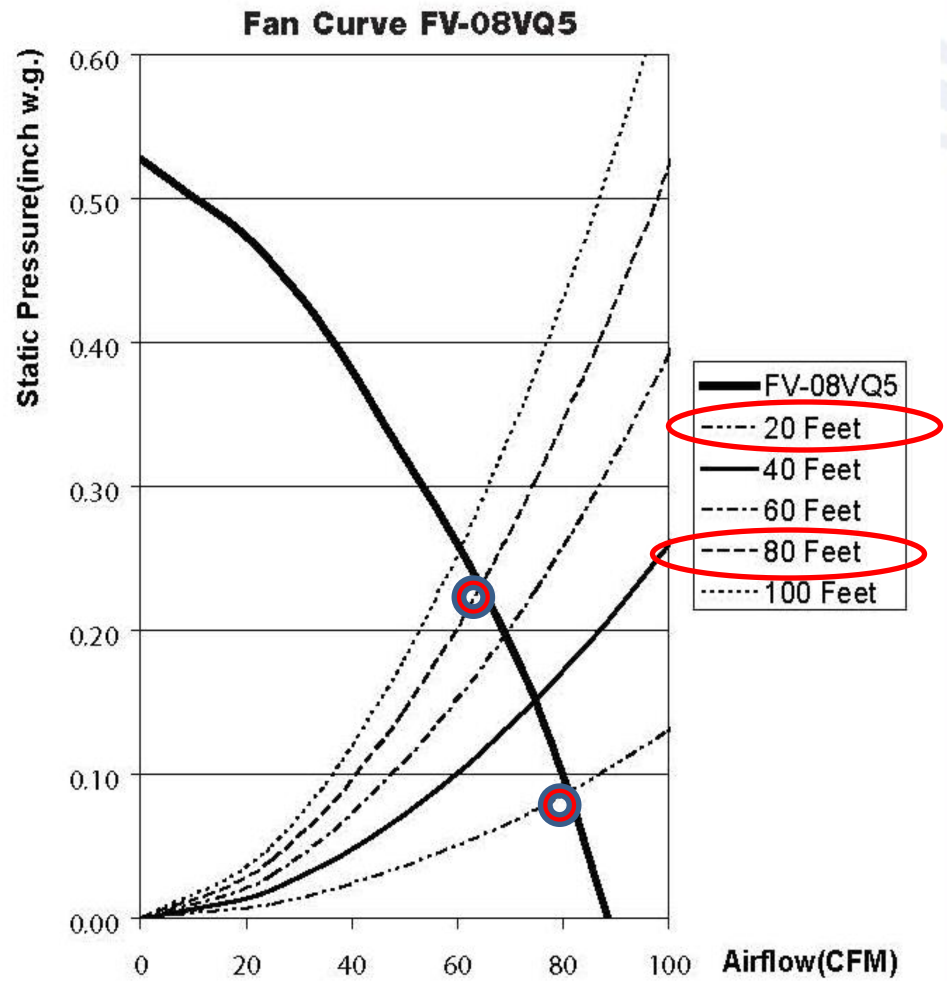
Manufacturer's Data: Fan Curve

- Standard is 4" hard metal duct
- Using Ductulator
- 80 CFM through 4" duct:
  - Friction rate of 0.4 in wc/100 ft
  - @ 0.1 in wc this allows for 25 ft of duct run
- 62 CFM through 4" duct
  - Friction rate of 0.25 in wc/100 ft
  - @ 0.25 in wc this allows for 100 ft of duct run
- Fan Curve is conservative and has reduced length of run by about 20%



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ASHRAE 62.2 Prescriptive Comparison

TABLE 7.1 Prescriptive Duct Sizing

Duct Type	Flex Duct					Smooth Duct				
Fan Rating cfm @ 0.25 in. w.g. (L/s @ 62.5 Pa)	50 (25)	62	80 (40)	100 (50)	125 (65)	50 (25)	62	80 (40)	100 (50)	125 (65)
Diameter, in. (mm)	**Maximum Length, ft (m)**									
3 (75)	X		X	X	X	5 (2)		X	X	X
4 (100)	70 (27)	43	3 (1)	X	X	105 (35)	77	35 (12)	5 (2)	X
5 (125)	NL		70 (27)	35 (12)	20 (7)	NL		135 (45)	85 (28)	55 (18)
6 (150)	NL		NL	125 (42)	95 (32)	NL		NL	NL	145 (48)
7 (175) and above	NL		NL	NL	NL	NL		NL	NL	NL

This table assumes no elbows. Deduct 15 ft (5 m) of allowable duct length for each elbow.
NL = no limit on duct length of this size.
X = not allowed, any length of duct of this size with assumed turns and fitting will exceed the rated pressure drop.

ASHRAE 62.2-2007

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Manufacturer's Data: Duct Runs

GENERAL SAFETY INFORMATION

1. Do not install this ventilating fan where interior room temperature may exceed 104°F (40°C).
2. Make sure that the electric service supply voltage is AC 120V, 60Hz.
3. Follow all local electrical and safety codes, as well as the National Electrical Code (NEC) and the Occupation Safety and Health Act (OSHA).
4. Always disconnect the power source before working on or near the fan, motor, junction box.
5. Protect the power cord from sharp edges, oil, grease, hot surfaces, chemicals or other objects.
6. Do not kink the power cord.
7. Do not install the unit where ducts are configured as shown in Fig. A.
8. Provide make up air for proper ventilation.

Fig. A

Field Results….

Unit #	Kitchen Fan Flow Rate
1201	25 CFM
1202	45 CFM
1203	75 CFM
3201	90 CFM
3202	106 CFM
3203	101 CFM

What went wrong ???

- Actual field conditions were different:
  - Damper got sealed in place at exterior wall
  - Interior damper taped in place at factory
  - Added an elbow to change location of exterior grille
  - Exterior hood was not available in 5" transitioned up to 6"

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Field Conditions….

Many things can go wrong

- Field variations in ducting (obstructions, architectural opinions)
- Factory tape on fan damper
- Stuck dampers
- Multiple dampers
- Ceiling radiation dampers
- Flex vs. Hard Duct
- Crushed flex duct
- Various types of outlets (4" v 6", wall caps, soffit caps, roof caps)
- Tight building structure reduces air flow
- Different duct configurations (turbulence)
- Different testing methods/conditions produce different results

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Recommendations

1. Specify a fan with the same size collar as duct (fans with 6" collars are available)
2. Don't transition duct/cap sizes
3. Ensure there is enough spare capacity to accommodate field issues that arise
4. Specify a fan with a variable speed motor that will provide the required CFM over a range of static pressure

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Back to Net Pressurization

- From Recent Experience
  - Extreme weather does exist in Climate Zones 3-6 (summer 2013/winter 2014 in NE)
  - Risk level is lower, but the damage can be the same
  - Condensation problems experienced during hot/wet period during early summer 2013
    - MF Buildings
    - HVAC systems installed in floor ceiling assemblies
    - Exhaust ventilation
    - Relatively tight construction

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Back to Net Pressurization

- From Recent Experience (cont.)
  - Conclusions
    - Continuous depressurization during extreme weather resulted in high moisture
    - Floor systems leaky relative to rest of envelope
    - Small dwelling units more likely to be oversized for A/C
    - Uninsulated ductwork lowered temperature/increased RH in floor assembly and became condensing surface
    - Tight ducts may be contributing factor

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Back to Net Pressurization

- From Recent Experience (cont.)
  - Recommendations
    - Insulate all ducts in floor assemblies
    - Pay more attention to floor assembly leakage – good application for spray foam
    - Stand-alone dehumidification
    - Make ceiling intentionally leaky to the inside (fire rated)??
    - Eliminate unbalanced exhaust only systems

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First Cost Considerations

- Exhaust Fan/Controller
  - Equipment cost about $200
  - No additional installation with integral controller
  - Careful ducting required
- Supply Air Control/Damper/Transformer
  - Equipment Cost <$200
  - Additional duct/installation cost
  - Location / clearance of fresh air inlet must considered

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First Cost Considerations

- Hybrid Supply/Exhaust
  - Equipment Cost <$400 with an ENERGY STAR fan
  - Additional duct/installation cost
  - Location / clearance of fresh air inlet must considered
- ERV/HRV
  - Equipment Cost $500-$1200
    - Small (40 CFM) standalone from Panasonic online for <$400
  - Additional duct/installation cost variable depending on complexity of system
  - Space for installation and connection to duct systems may be a factor

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Case Study

1200 SF Townhouse – interior unit

- 2 stories, 2 Bedrooms
- Minimum ventilation requirement = 12 + 3*7.5 = 34.5 CFM
- Infiltration – 833 CFM50
- Estimated Operating Cost - $1,300 yr
  including $230 service charges and Philadelphia rates
- Ventilation Comparisons
  - None
  - 2 exhaust fans (ESTAR PSC and ECM)
  - Air Cycler with PSC and ECM air handlers
  - Compact ERV
  - Traditional ERV

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Case Study

System Type Vent Rate Hours/Day Power	None	Exhaust 40 CFM 24 15W	Exhaust 40 CFM 24 5W	Air Cycler w/PSC 40 CFM N/A 300 W	Air Cycler w/ECM 40 CFM N/A 200 W	Air Cycler w/ECM 40 CFM N/A 125 W	Compact ERV 40 CFM 24 23 W	Ducted ERV 60 CFM 16 94 W
Heat Energy (MMBtu/yr)								
Infiltration	6.6	2.9	2.9	2.9	2.9	2.9	6.6	6.6
Ventilation	0	6.1	6.1	6.1	6.1	6.1	2.1	1.3
Total	**6.6**	**9**	**9**	**9**	**9**	**9**	**8.7**	**7.9**
Cool Energy (MMBtu/yr)								
Infiltration	-0.1	0	0	0	0	0	0	0
Ventilation	0	-0.1	-0.1	-0.1	-0.1	-0.1	0	0
Total	**-0.1**	**-0.1**	**-0.1**	**-0.1**	**-0.1**	**-0.1**	**0**	**0**
Design Heat Load (kBtu/hr)								
Infiltration	2.5	1.1	1.1	1.1	1.1	1.1	2.5	2.5
Ventilation	0	2.3	2.3	2.3	2.3	2.3	0.8	0.5
Total	**2.5**	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**	**3.3**	**3**
Design CoolLoad (kBtu/hr)								
Infiltration	1.1	0.3	0.3	0.3	0.3	0.3	1.1	1.1
Ventilation	0	1.7	1.7	1.7	1.7	1.7	0.6	0.4
Total	**1.1**	**2**	**2**	**2**	**2**	**2**	**1.7**	**1.5**

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Case Study

System Type Vent Rate Hours/Day Power	None	Exhaust 40 CFM 24 15W	Exhaust 40 CFM 24 5W	Air Cycler w/PSC 40 CFM N/A 300 W	Air Cycler w/ECM 40 CFM N/A 200 W	Air Cycler w/ECM 40 CFM N/A 125 W	Compact ERV 40 CFM 24 23 W	Ducted ERV 60 CFM 16 94 W
Heat Cost/yr ($)	198	225	227	194	205	213	220	203
Cool Cost/yr ($)	87	91	89	111	104	98	91	97
Vent Fan Cost/yr ($)	0	20	7	266	178	111	31	86
Total Cost/yr ($)	**285**	**336**	**323**	**571**	**487**	**422**	**342**	**386**
HERS Index	**63**	**65**	**64**	**74**	**70**	**68**	**65**	**65**

Note: Air Cycler as a "hybrid" supply/exhaust not included. In theory, operating cost would be less than for a comparable exhaust system due to less runtime of the exhaust fan. HERS index predicted to be equal or better than exhaust.

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Case Study

Conclusions

- Ventilation can cost as little as $40/year (that's $0.11 a day)
- For installation and operating cost, you can't beat a good bath fan
- It's all about fan power draw – even with an ERV
- Air cycler more expensive to operate ($140 – $180/year), but …
  - Source of air is known
  - Ventilation is distributed
  - Hybrid adds installation cost but major reduction operating cost
- Compact ERV is good option for small homes
  - low first cost
  - simple ducting
  - known air source
  - good operating cost

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New Technology

Can high tech save you money?

- ECM bath fans (Panasonic, Broan, Nutone)
  - Save operating costs
  - Precise airflow under a variety of conditions
  - Reliable delivery where verification is required
    - Whole house and exhaust for LEED and ENERGY STAR
    - Reduce/eliminate call backs for failed tests
  - With or without controls
- ECM motors in ERVs (Honeywell)
  - Save operating costs – its all about the motor
  - Precise/adjustable airflow
  - Save callbacks when verification is required
- Supply air control/Hybrid systems/
- Exhaust systems with passive inlets

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Thank you!!

Questions?

Contact me

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