


# Mechanical Ventilation Strategies and Solutions

Energy OutWest  
Scottsdale, AZ

Paul Raymer  
ASHRAE 62.2 Member, Chair HVI IAQ Committee, LEED IEQ TASC, NAHB IAQ & Water Task Group,  
Chief Investigator for Heyoka Solutions

June, 2008



## Heyoka Solutions


- Developer and manufacturer of ventilation equipment and controls;
- Located on Cape Cod, Massachusetts;
- Members of ASHRAE, Building America, HVI, NESEA, RESNET and US Green Building Council (USGBC);
- LEED for Homes IEQ TASC and NAHB Green Building Standard IEQ Advisory Committee, and ASHRAE 62.2 SSPC.

Paul H. Raymer  
Falmouth, MA 02540    866-389-8578    [www.HeyokaSolutions.com](http://www.HeyokaSolutions.com)




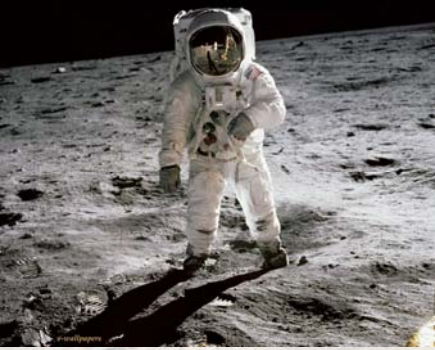

## Ventilation

- Ventilation should be a controlled movement of air through the house;
- The purpose of the ventilation system is to control odors, contaminants and indoor levels of moisture;
- The ventilation system must not adversely affect the building envelope or the operation of other mechanical systems;
- Both the building and the occupants need fresh air.



## Why Ventilate?


- Humidity - mold, mildew, etc.
- CO<sub>2</sub> – people breathing
- Cigarette smoke and other gases
- Pressure

## What is Ventilation?


The movement of air -

- Air for cooling;
- Air for appliances;
- Air for people to breathe.




- House and occupants need a ventilation system for fresh air and the expulsion of pollutants;
- Spot ventilation systems like bath fans and range hoods need draft air;
- Atmospheric combustion appliances need draft air;
- Decorative appliances like fireplaces need draft air;
- Cleaning appliances like central vacuums need draft air.

If these things can't happen simultaneously without interfering with each other, the house is too tight.




## Fan Terms


- CFM – cubic feet per minute;
- Static pressure – resistance to flow;  
Measured "WC or Pa (Pascal);
- Sone – linear measurement of sound;
- HVI (Home Ventilating Institute) and HRAI (Heating Refrigeration and Air Conditioning Institute of Canada).



## How to read a fan box.






- Fan Model #
- Air Flow and Sound Rating 70 CFM and 4 Sones
- "For baths up to 65 sq. ft. other rooms to 85 sq. ft."
- Ceiling or wall installation
- UL
- HVI




## Can a house be too tight?

Yes.

A house is too tight if it negatively affects the comfort and health and living activities of the occupants.




## It doesn't take much

1 Pascal




- Typical natural draft furnaces, boilers, and water heaters have venting problems with pressures exceeding 5 to 7 pascals;
- Conventional fireplaces start having problems at 3 pascals.

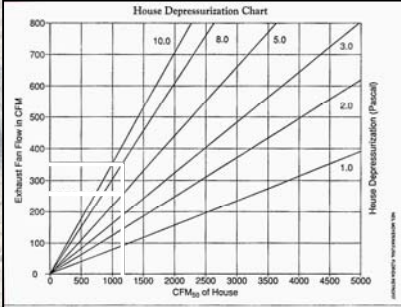



### How do you know if it's too tight?

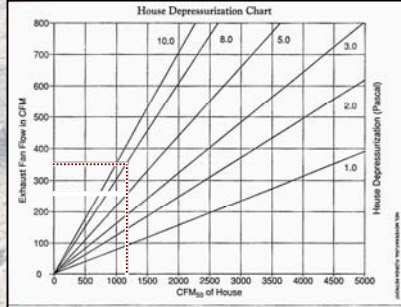

- Measure it



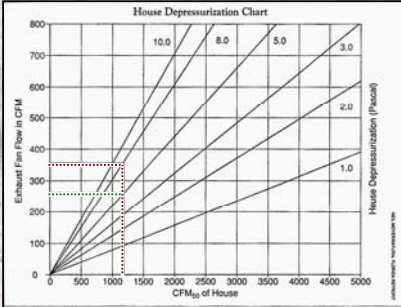


Well insulated, new house, blower door tested to 1,200 cfm<sub>50</sub>


Adding a 350 cfm kitchen fan would depressurize the house to 8 Pascals.


To limit that to 5 Pascals this house would leak 260 cfm. Need to add a hole to make up the difference.  $350 - 260 = 90$  cfm  
 $CFM = \text{Area of the vent} \times \Delta P^0.5$   
 Area of the vent =  $90 / 5 = 40$  sq. in. 7 inch diameter hole

- Or add balancing air.



Note: An HRV or ERV is designed to be a balanced system and not a source of make-up air for any other device.



## Air Flow Considerations and House Pressures



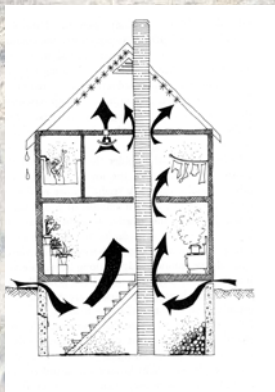
A residential ventilation system is more than just a bathroom fan or a range hood.



## Other parts of a residential ventilation system



## The wonders of air pressure

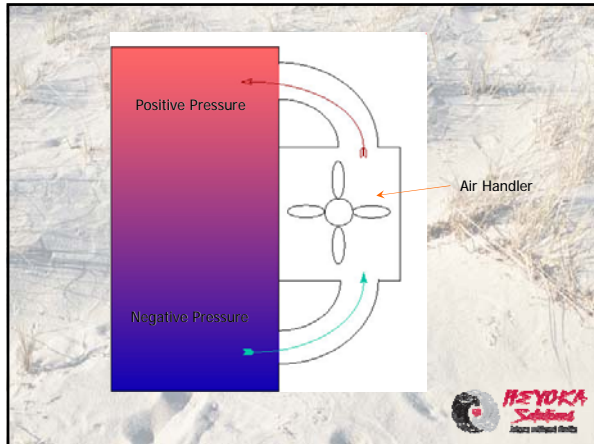


Thanks to Charlie Wing  
"From the Walls In"



- Forced air heating and cooling systems should circulate an equal volume of air to and from the conditioned spaces, keeping the air pressure in the house neutral.
- If the house is under positive pressure, air will be pushed out of the conditioned space.
- If the house is under negative pressure, unconditioned air will be sucked in.





- Air leaks or holes in supply ducts allow air to escape before it is delivered to the conditioned space;
- Because of this unbalanced condition, more air is taken out by the return ducts, putting the house under negative pressure.
- If the ducts run through the attic, the system is attempting to air condition the outdoors!

- Air leaks or holes in the return ducts pull less air from conditioned spaces;
- More air is supplied than is returned, putting the house under positive pressure.

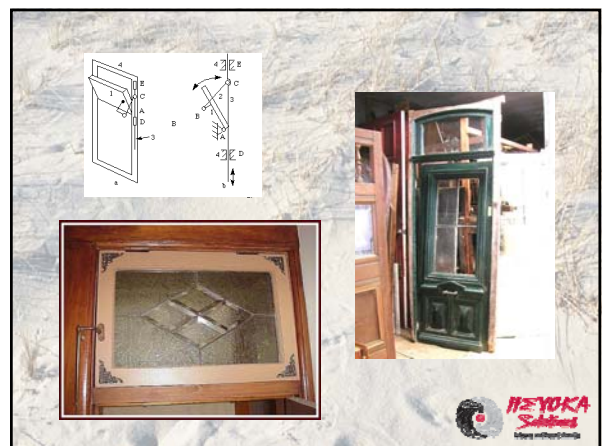
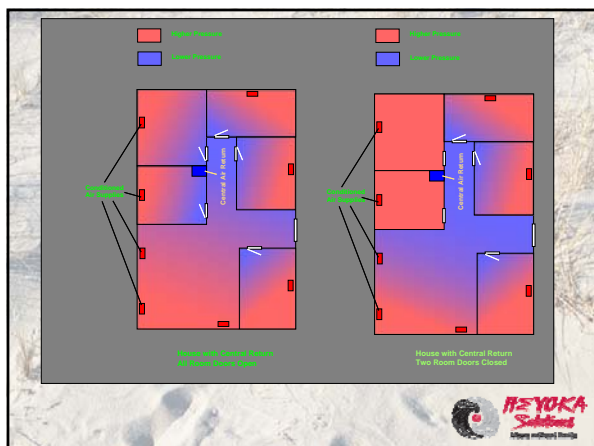
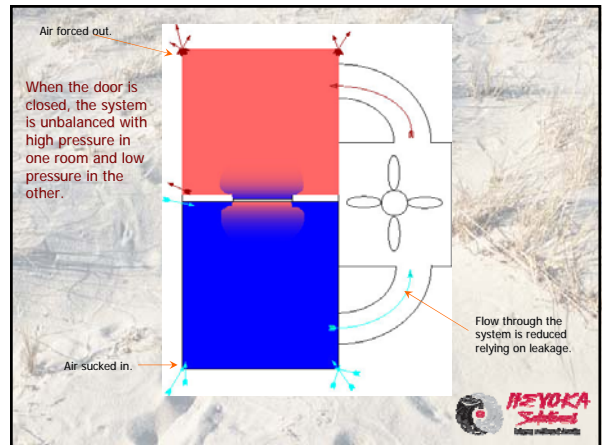
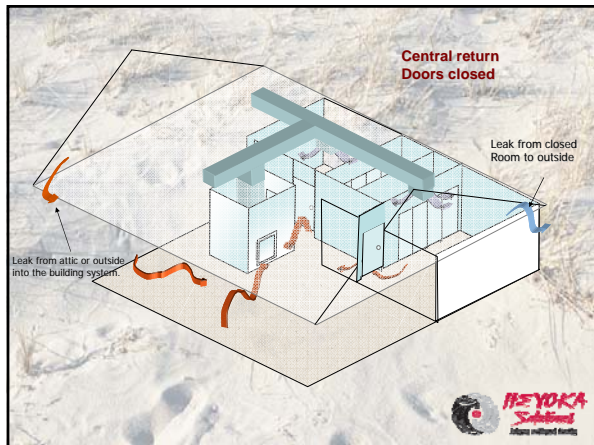
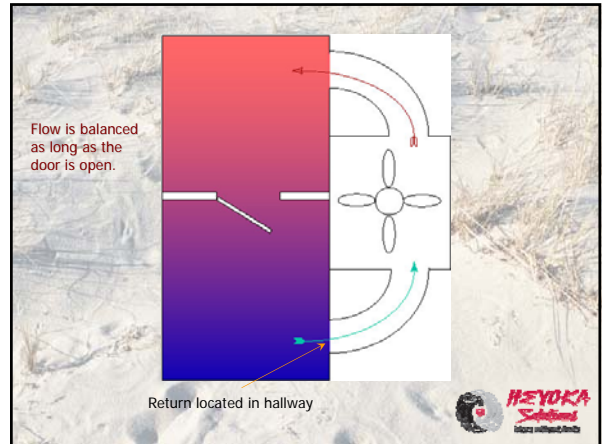
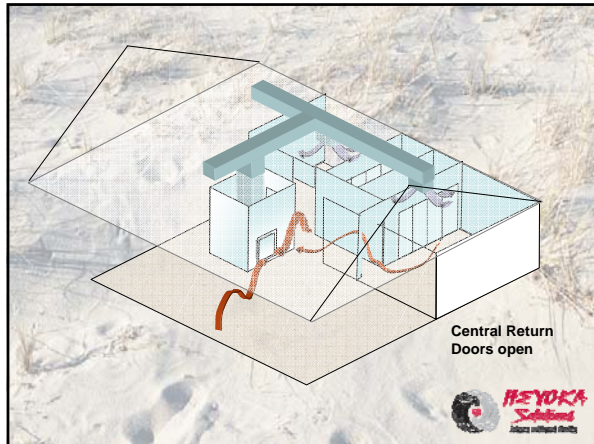
## Who cares?

We're talking about tiny numbers.

Infiltration is slow – damage takes place over an extended period. Like a slow drip.

Unbalancing can even occur by simply closing a room door!

Mechanically induced infiltration dwarfs natural infiltration.





Goal: keep pressure across the wall less than 2.5 Pascals

Hole on each side of the wall covered by a grille.

Allows air in the wall cavity to be drawn in as well.

For 2.5 Pascals:  
 Area in sq. inches = CFM/.83

100 cfm into the room  
 $100/.83 = 120.5$  sq in.  
 Need 10" x 12" opening

**MEYOKA Solutions**  
Helping you succeed. Period.



Grilles on either side of the wall with a wall sleeve.

**MEYOKA Solutions**  
Helping you succeed. Period.

Privacy insert in wall sleeve impedes light and sound transfer.

**MEYOKA Solutions**  
Helping you succeed. Period.



Offset grilles offer privacy.

High Pressure (Supply)      Low Pressure (Return)

Air in the cavity is drawn in. Flow is limited by the narrowest wall dimension – usually 3.5".

Slot under the door.

High Pressure (Supply)      Low Pressure (Return)

Low resistance, clear path. Limited privacy. Can be restricted by carpeting.

For 2.5 Pascals:  
Area in sq. inches = CFM/2

100 cfm into room  
 $100/2 = 50$   
30 inch door  
 $50/30 = 1.67"$  cut under door



Jumper duct.

High Pressure (Supply)      Low Pressure (Return)

For 2.5 Pascals:  
Duct diameter required = square root of the CFM

100 cfm into room  
Sq rt of 100 = 10  
10" diameter duct



If you know the flow rate: shortcuts to calculating the wall opening size.

- Wall opening with grilles:  
Area in Square inches = CFM/.83
- Slot (no grilles):  
Area in square inches = CFM/2
- Flexible jumper duct with grilles = square root of the cfm

**If you don't know the flow rate:**

- For square or rectangular inlets, determine the area and double it to determine the approximate flow into the room.  
Example: A 4" x 12" grille probably allows 96 cfm into the room.
- Determine the relief opening accordingly.



- If the inlet is round, square the diameter and double it to determine the approximate flow rate.  
Example: An 8" diameter grille could allow  $(8 \times 8) \times 2 = 128$  cfm into the room.
- Determine the relief opening accordingly.

Note that these are just approximations. It is far better to know or measure the flow.



**Some devices that can be used to measure low pressure differentials:**



Bacharach 13-7019  
MZF gauge approx  
\$250



Bacharach 13-3000D  
Drafrite Draft gauge  
approx \$130



Dwyer Model 460  
Air Meter approx \$30



Testo 512  
Digital Manometer  
Approx \$810



Testo 506  
Pocket Manometer  
Approx \$180



Energy  
Conservatory  
DG 700



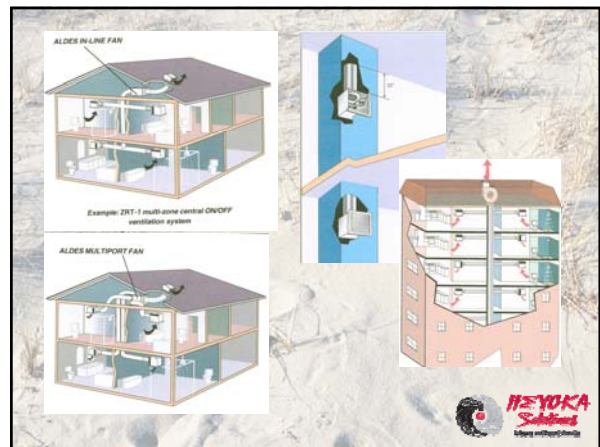
**System Design and Controls**

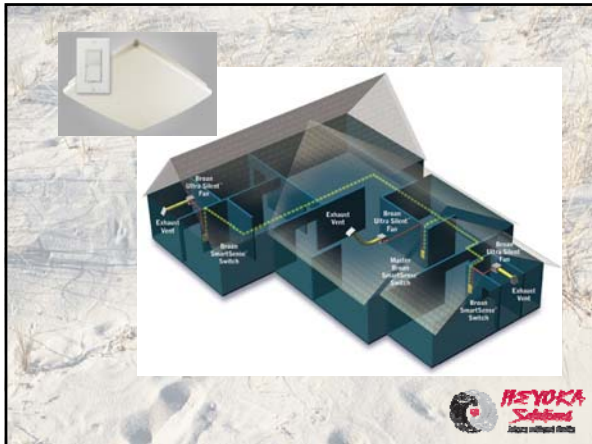


**System Design**

- Natural/passive ventilation;
- Exhaust or Supply only ventilation;
- Mechanically balanced ventilation;
- Mechanically balanced ventilation with heat or energy recovery.

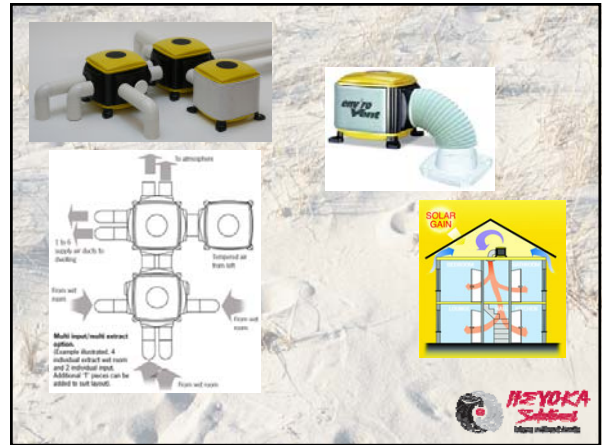






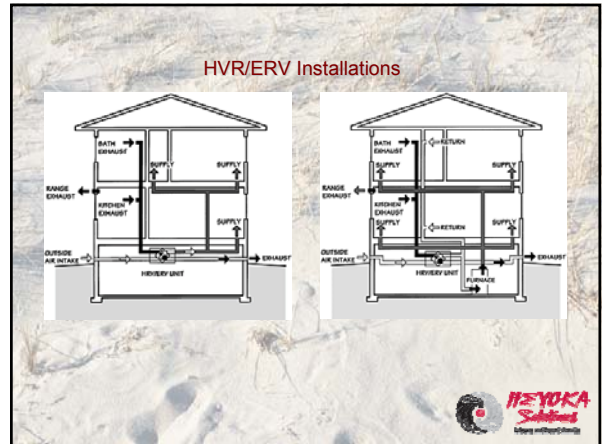
A multi-port supply system can be used to duct fresh air to bedrooms where people spend the most time. It should be able to filter and condition the air.

Fresh air into the return side. Distribution through air handler.



### Heat or Energy Recovery Ventilators

The Fresh Air Solution



## Why use which?

- Number of bathrooms and layout of the house;
- Financial considerations;
- Existing systems;
- Owner preferences;
- Owner participation.



## Overview of controls

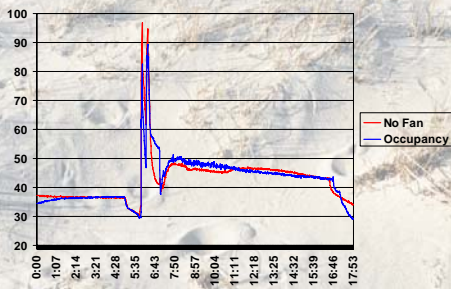
- Wall switch



- Motion Control



## Occupancy/Motion Detector



## Overview of controls (cont.)

- Humidity Control



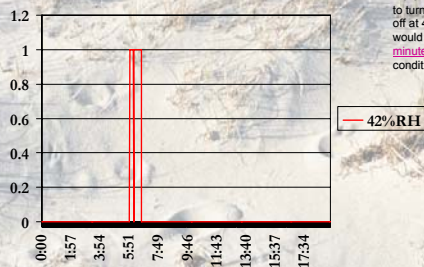
Electro-mechanical



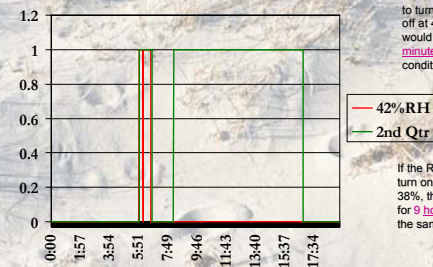
Electronic



## Fan Run w/Humidity Control w/2% Hysteresis



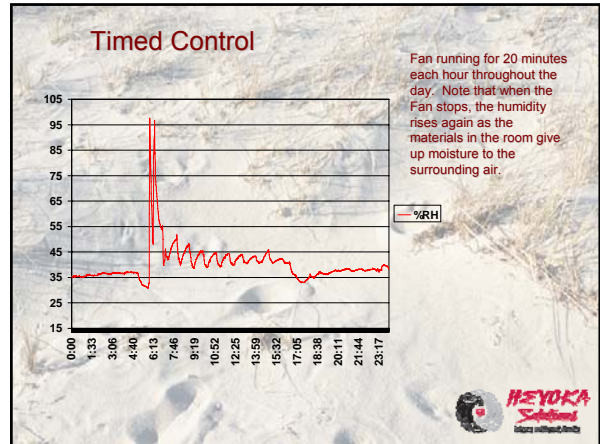
## Fan Run w/Humidity Control w/2% Hysteresis



## Overview of controls (cont.)

- **Timers**

Electronic and electro-mechanical



## HRV/ERV controls

Maintenance and filter change indicators are critical to health and performance.

End of Part 1  
Stay tuned for Part 2

Thanks for listening

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[www.HeyokaSolutions.com](http://www.HeyokaSolutions.com)

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## Other ventilation issues & systems.

## Radon systems



Fantech



RadonAway

Fans use backward curved, motorized impellers



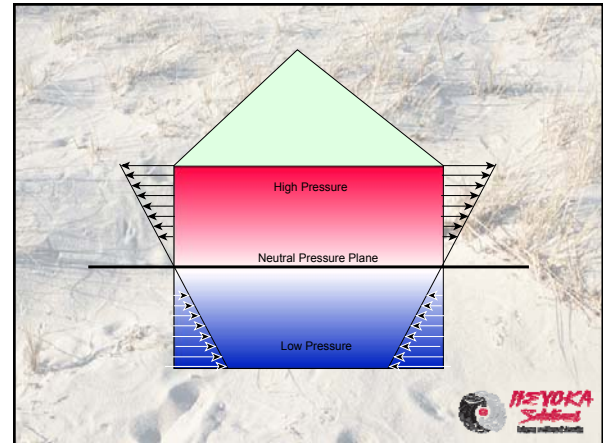
## Radon systems

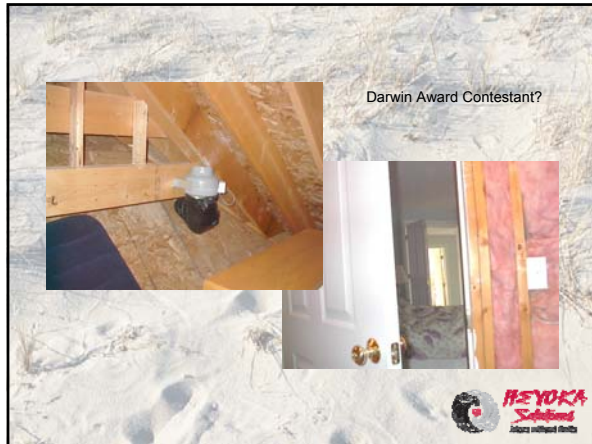


<http://www.radonwisconsin.com/>



## Attached Garages






**LEED for Homes EQ Credit 10.3**

Minimize Pollutants from Garage and/or  
Install an exhaust fan in the garage (1 point)  
that is rated for continuous operation.  
Non-ducted – 70 cfm or greater;  
Ducted – 100 cfm or greater.  
Can be run continuously or control with an  
occupant sensor, light switch, garage door opening-closing mechanism,  
carbon monoxide sensor, or equivalent.

**NAHB Green Building Standard**  
801.4.2 "Install an exhaust fan in the garage" (They have eliminated this  
in the final draft.)

Mechanical Code requirement of 100 cfm/car



**HEYOKA Solutions**  
Indoor Air Quality Experts

**Whole House Comfort Ventilators**

- Whole house comfort ventilators are NOT whole house ventilation systems;
- WHCV are for cooling;
- Whole house ventilation systems are for fresh air for breathing.

**HEYOKA Solutions**  
Indoor Air Quality Experts



This is NOT a Whole House Comfort Ventilator.  
This is an attic fan.



This is NOT a whole house fan.  
This could be a central ventilation system  
for fresh air for people.

**HEYOKA Solutions**  
Indoor Air Quality Experts

**Whole House Comfort Ventilators**



**HEYOKA Solutions**  
Indoor Air Quality Experts

A few bath fan  
installation details:

**HEYOKA Solutions**  
Indoor Air Quality Experts





## What the heck is GREEN building anyway?

“Green building is the practice of:

- increasing the efficiency with which buildings and their sites use and harvest energy, water, and materials;
- reducing building impacts on human health and the environment;
- through better siting, design, construction, operation, maintenance, and removal during the complete building life cycle.”

Wikipedia.org



## ASHRAE Greenguide

... a green/sustainable building design is one that achieves high performance, over the full life cycle, in the following areas:

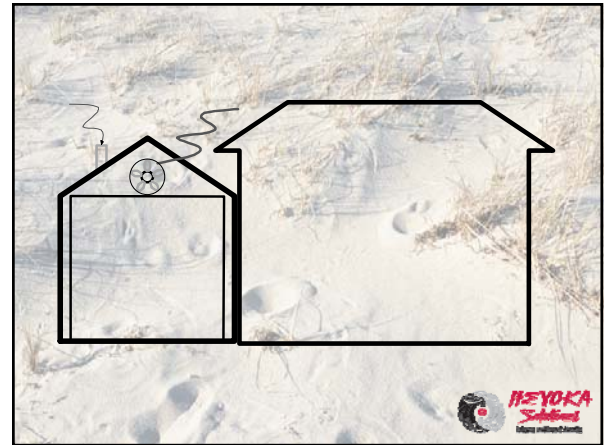
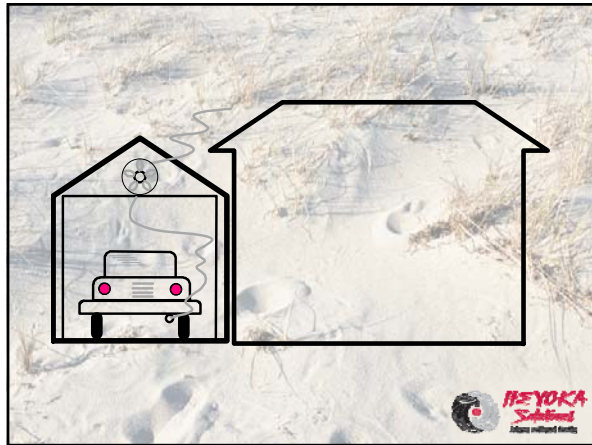
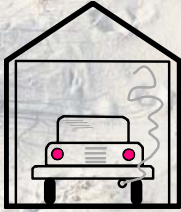
- Minimizing natural resource consumption . . .
- Minimizing emissions . . .
- Minimizing discharge of solid waste and liquid effluents . . .
- Minimal negative impacts on site ecosystems.
- Maximum quality of indoor environment, including air quality . . . .



Green building is “holistic” building  
– thinking it all the way through.



What are you trying to do and how would you like it to happen?



## Green Building: Riding the wave with Good Ventilation

- Role of ventilation in LEED for Homes;
- Role of ventilation in Energy Star with the Indoor Air Package;
- Ventilation in NAHB Green Building Guidelines;
- Ventilation in Green Communities and Health House;
- Lot of other GREEN programs like: Global Green, Green Built, Inc. (Michigan), Build Green Program of Kansas City, Green Energy Ohio, EcoBuild of Memphis, Wisconsin Green Built Home, etc.



Comparing Green Building Guidelines and Healthy Homes Principles:  
A Preliminary Investigation

The National Center for Healthy Housing  
April 2006

[http://www.centerforhealthyhousing.org/Green\\_Analysis.pdf](http://www.centerforhealthyhousing.org/Green_Analysis.pdf)



## ANSI/ASHRAE 62.2-2007

“This standard applies to spaces intended for human occupancy within **single-family houses and multifamily structures of three stories or fewer** above grade, including manufactured and modular houses. This standard does not apply to transient housing such as hotels, motels, nursing homes, dormitories or jails.”



## 62.2

- Sizing Table 4.1a is provided based on 7.5 cfm/person plus 1 cfm/100 ft<sup>2</sup> of conditioned space;
- 62.2-2007 assumes 2 people in the master bedroom like ASHRAE 62-1989;
- Table 4.1a reduces ventilation of larger residences compared to old 0.35 ACH method.



**Whole Building Ventilation Requirements  
Table 4.1a (cfm)**

Number of Bedrooms	0-1	2-3	4-5	6-7	>7
<1500 ft <sup>2</sup>	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 ft <sup>2</sup>	105	120	135	150	165



## 62.2

- This level of ventilation is intended to be provided continuously whenever the building is occupiable.
- This can be supply ventilation, exhaust ventilation, or balanced ventilation.
- This level of ventilation was set including a default credit of 2 cfm/100 ft<sup>2</sup> for infiltration.



## LEED for Homes

Ventilation integrated with IEQ  
Must achieve 6 points in IEQ

Two paths –

(Path 1) Energy Star with IAP (13 points) plus additional ventilation options

- Enhanced local exhaust (2 points)
- 3<sup>rd</sup> party testing (2 points)
- Better/Best air filters (2 points)
- Indoor contaminant control (2 points)

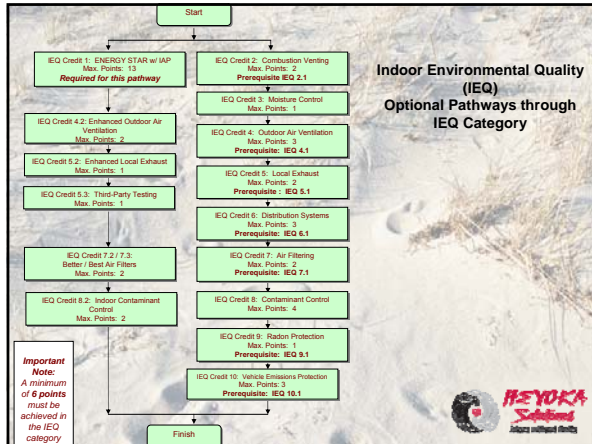


## LEED for Homes (cont)

(Path 2) Including nine credits for a max total of 21 points including:

- Combustion venting;
- Moisture control;
- Outdoor air ventilation;
- Local exhaust;
- Distribution systems;
- Air filtering;
- Contaminant control;
- Radon protection;
- Vehicle emissions protection.





### ENERGY STAR INDOOR AIR PACKAGE Specifications, version 2

**Ventilation**

4.15 Provide mechanical whole-house ventilation meeting all ASHRAE 62.2 requirements. The following requirements shall be visually verified:

- Whole house mechanical ventilation system & controls installed to deliver prescribed outdoor air ventilation rate (62.2 section 4), including ventilation restriction in 62.2 section 4.6 (i.e. max 7.5 cfm/100 sq.ft.) for "Warm-Humid" climates as defined by IECC Figure 301.1; AND
- Transfer air (i.e. air from adjacent dwelling units or other spaces such as garages, crawlspaces, or attics) shall not be used to meet ventilation requirements (62.2 section 6.1); AND
- Air inlets shall be located a minimum of 10 ft. from contaminant sources (62.2 section 6.8); AND
- Airflow tested to meet rated fan airflow (at 0.25 in. w.c.), or ducts sized per requirements of 62.2 Table 7.1 and/or manufacturer's design criteria (62.2 section 7.3).

**Notes:**

- Outdoor air ducts connected to the return side of an air handler shall be permitted as supply ventilation only if manufacturer's requirements for return air temperatures are met (i.e., air shall be tempered to maintain minimum 60 degree F continuous air flow across furnace heat exchanger).
- The ventilation restriction for "Warm-Humid" climates is not applicable when Energy Recovery Ventilators (ERV's) or whole-house dehumidification are installed, per manufacturer's instructions.

4.16 Provide local mechanical exhaust ventilation to outdoors in each bathroom and kitchen, meeting ASHRAE 62.2 section 5 requirements. In addition, all bathroom ventilation fans shall be ENERGY STAR qualified unless multiple bathrooms exhausted with a multi-port fan.

4.17 Clothes dryers shall be vented to outdoors.

**Exception:**  
• Specific condensing dryers, equipped with condensate drain.

## ENERGY STAR, Indoor Air Package, & Green Building

### Green Home Staircase

**Energy Efficiency**

- Envelope
- Distribution
- Equipment
- Lighting
- Appliances

**IAQ and Durability**

- Moisture/Mold
- Soil-gas Control
- Pest Mgt.
- HVAC
- Combust. Safety
- Materials
- Commissioning

**Resource Efficiency**

- Site Planning
- Water
- Materials
- Waste Mgt.
- Renewables

**ENERGY STAR w/Indoor Air Package Green Buildings**

## Making it Visible: VENTILATION messaging

**Involvement Questions:**

- "Does your house ever feel stuffy?"
- "Did you realize that typical home HVAC systems don't include Fresh Air Ventilation?"

**How to Demonstrate Value:**

- "All our homes are equipped with high efficiency whole-house fresh air ventilation."
- "Plus we include over a dozen advanced heating and cooling system features to improve comfort and system effectiveness."

Leave a features comparison checklist and/or Benefits label(s) in utility room.

**Enterprise**  
CELEBRATING 25 YEARS + 1982-2007

Enterprise Community Partners Green Building Program The Green Communities Initiative is intended to help "mainstream" green building and sustainable development in the affordable housing industry. By 2009, Green Communities will provide \$550 million in Green Grants, financing, and equity investment to create 8,500 affordable rental and for-sale homes nationwide.

The Green Communities criteria are aligned with the LEED (Leadership in Energy and Environmental Design) Green Building Rating System®. The US Green Building Council, through LEED, strongly supports the Green Communities initiative. In addition, the Green Communities criteria reflect and are compatible with leading state and local green building programs.

[www.greencommunitiesonline.org](http://www.greencommunitiesonline.org)

### 7-6 Ventilation MANDATORY

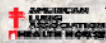
Except for Moderate Rehab

**How**  
Install a ventilation system for the dwelling unit that provides 15 cubic feet per minute of fresh air, per occupant.

**Intent**  
Optimal ventilation improves indoor air quality by providing fresh air to the living space on a regular basis.


**Things to Consider**

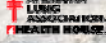
- Design the ventilation system to take maximum advantage of regional climate characteristics in order to help cut down on energy costs.
- Natural ventilation is acceptable in "paradise" climates defined under ASHRAE 62.2 Exceptions to 4.1.
- Specify a mechanical whole-house ventilation system per ASHRAE 62.2 and the EPA Energy Star with Indoor Air Package Specifications.

 **American Lung Association Health House®**


The Health House program provides quality information for home builders and home owners regarding home design, construction, renovation and operation with a focus on healthy indoor air quality. Health House seeks to build a unique blend of sound medical science integrated with proven building science in a format understandable to both homebuilders and homeowners.

[www.healthhouse.org](http://www.healthhouse.org)



 **American Lung Association Health House®**

- HVAC system designed according to Manual J
- Ventilation (Final performance test): "Continuous people ventilation should be at least 1.0 cfm per 100 square feet of floor area plus at least 15 cfm for the first bedroom and 7.5 cfm for each additional bedroom.
  - The ventilation system shall be capable of providing 2 times this amount;
  - Minimum 45 cfm
  - Outdoor air shall be distributed to or exhaust air drawn from at least three locations including all bedrooms;
  - Select fans that are quiet, energy efficient, and long lasting;
  - For surface mounted fans, sound should be < 1.5 sones;
  - Power should be < 0.5 watts per cfm ( 1 watt/cfm for HRV);
  - Flows rated at 0.2 inches WC shall be used to meet the people ventilation rates."



 **Global Green**

**"Results"**  
Global Green's unique approach merges innovative research, cutting-edge community based projects and targeted advocacy that:



- Educates hundreds of millions of people annually
- Leverages billions of dollars for environmental initiatives
- Implements ground-breaking environmental policy"

**Green Built, Inc.**  
A project of the Home & Building Association of Greater Grand Rapids (HBAGGR), Green Built, Inc. supports home construction practices that incorporate environmentally friendly site development, water conservation, energy efficiency, waste reduction, and other green practices.

**COORDINATES**  
Home and Building Association of Greater Grand Rapids  
2021 44th St. SE  
Grand Rapids, MI 49508  
United States



**Green Built Home Wisconsin**  
<http://www.greenbuilthome.org/>






**Mechanical Systems**

- ☐ 44. High efficiency whole house fan installed with R-38 min. insulated cover.
- ☐ 45. Two properly supported ceiling fans installed (ENERGY STAR label encouraged).
- ☐ 46. Ceiling fan pre-wires provided in habitable rooms (min. 2 prewires not including bedrooms).
- ☐ 47. (2) Heat Recovery Ventilator (HRV) installed.  
List manufacturer \_\_\_\_\_
- ☐ 48. (3) Energy Recovery Ventilator (ERV) installed.  
List manufacturer \_\_\_\_\_


**Indoor Air Quality**

- ☐ 15. (4) House meets American Lung Association Health House standards.
- ☐ 16. Automatic tub/shower room fan controls such as timers or humidistats.
- ☐ 17. Bath fans installed with smooth ducting with short, straight runs.
- ☐ 18. Spring loaded, weather stripped fan dampers installed.



 **National Association of Homebuilders**

- 802.1 Ventilation systems to comply with ASHRAE 62.2-2007 (proposed)
- 802.1.1 Local mechanical exhaust ventilation to outdoors in each bathroom and kitchen meets ANSI/ASHRAE 62.2-2007 section 5;
- 802.1.2 Bathroom exhaust fan is provided with an automatic timer or humidistat;
- 802.1.3 Kitchen range and bathroom exhaust are verified to specification. Ventilation airflow is tested to meet the rated fan airflow (at .25 in. w.c.) or duct(s) sized per requirements of 62.2, table 7.1 and/or the manufacturer's installation instructions (ANSI/ASHRAE Standard 62.2-2007, section 7.3).
- 802.1.4 Exhaust fans are ENERGY STAR
- 802.2.1 Whole building ventilation meets the requirements of ANSI/ASHRAE Standard 62.2-2007, section 4:
  - (1) Exhaust or supply fans) - 7 points
  - (2) Exhaust exhaust and supply fans - 9 points
  - (3) Heat-recovery ventilator - 10 points
  - (4) Energy-recovery ventilator - 10 points
- 802.2.2 Ventilation airflow is tested to meet the rated fan airflow (at 0.25 in. w.c.) or duct(s) sized per requirements of 62.2, Table 7.1 and/or the manufacturer's installation instructions (ANSI/ASHRAE Standard 62.2-2007, section 7.3).



**VENTILATION AND THE GREEN BUILDING OPPORTUNITY Useful web addresses:**

- [www.hvi.org](http://www.hvi.org)
- [www.usgbc.org](http://www.usgbc.org) (link to LEED for homes through this)
- [www.affordablecomfort.org](http://www.affordablecomfort.org)
- [www.nahb.org](http://www.nahb.org)

**National Association of State Energy Officials  
State & Territory Energy Offices**

- <http://www.naseo.org/members/states.htm>

**U.S. Dept. of Energy - Energy Efficiency and Renewable Energy State Energy Office Contacts:**

- [http://www.eere.energy.gov/state\\_energy\\_program/seo\\_contacts.cfm](http://www.eere.energy.gov/state_energy_program/seo_contacts.cfm)



## References (cont)

- [www.energystar.gov](http://www.energystar.gov)
- ASHRAE 62.2 standard:  
[www.ashrae.org/publications/detail/16090](http://www.ashrae.org/publications/detail/16090)
- Publications referred to in Session at Comfortech:  
Comparison of various programs  
[http://www.centerforhealthhousing.org/Green\\_Analysis.pdf](http://www.centerforhealthhousing.org/Green_Analysis.pdf)
- [www.greencommunitiesonline.org](http://www.greencommunitiesonline.org)
- [www.healthhouse.org](http://www.healthhouse.org)
- <http://www.greenbuilthome.org>



## Green Program Summary

- All Green building programs have ventilation requirements – Get to know ANSI/ASHRAE 62.2-2007 and Energy Star with IAP;
- Bad ventilation installations can cause problems and result in expensive callbacks;
- “Snake oil” or “Band Aid” solutions will come back to bite you;



## Verification Testing

(or How do you know it really works?)

Simple stuff:

Paper	Fan draws it up at:
Single ply paper tissue	>30 cfm
Single ply paper towel	>60 cfm
“20 lb” copier paper	>110 cfm



## Verification Testing

(or How do you know it really works? Cont.)

Simple stuff – CMHC “Calibrated Garbage Bag”:



[http://www.cmhc-schl.gc.ca/en/co/maho/yohoyohe/inaiqu/inaiqu\\_003.cfm](http://www.cmhc-schl.gc.ca/en/co/maho/yohoyohe/inaiqu/inaiqu_003.cfm)



## Verification Testing

(or How do you know it really works? Cont.)

Simple stuff – CMHC “Calibrated Garbage Bag”:

Time to deflate small “green” bag (Glad 66 x 91 cm)	CFM
1 second	50 cfm
5 seconds	30 cfm
12 – 13 seconds	10 cfm



Vane anemometer \$479



Hot wire anemometer \$699



Balometer \$1306

Evaluation of flow hood measurements for residential register flows

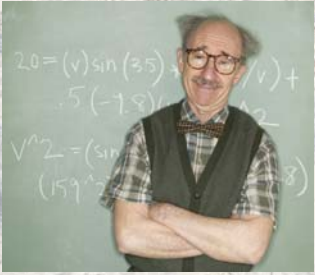
<http://epb.lbl.gov/publications/lbnl-47382.pdf>





Duct blaster with DG700 (and a cardboard box)

<http://www.energyconservatory.com/products/products2.htm>



Thanks for listening

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