INDOOR AIR QUALITY IN A NET ZERO HOME

(COLD CLIMATE) 2-6-14

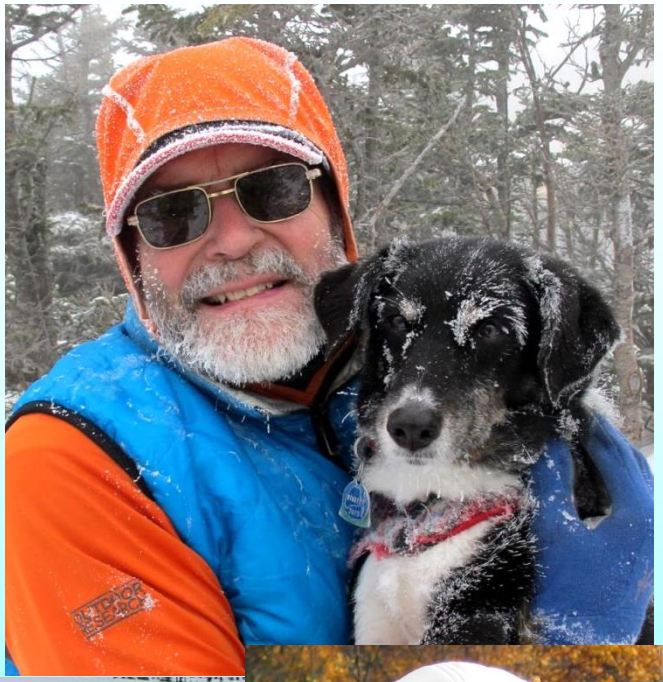
Presented by William Turner, MS, PE
at Better Buildings By Design 2014

Developed by Turner Building Science, LLC
www: turnerbuildingscience.com

Credits to:
Maine Indoor Air Quality Council, Camroden Associates, Dave Johnston & Co., and others.

Who is here, climate zone 6?

Why ?

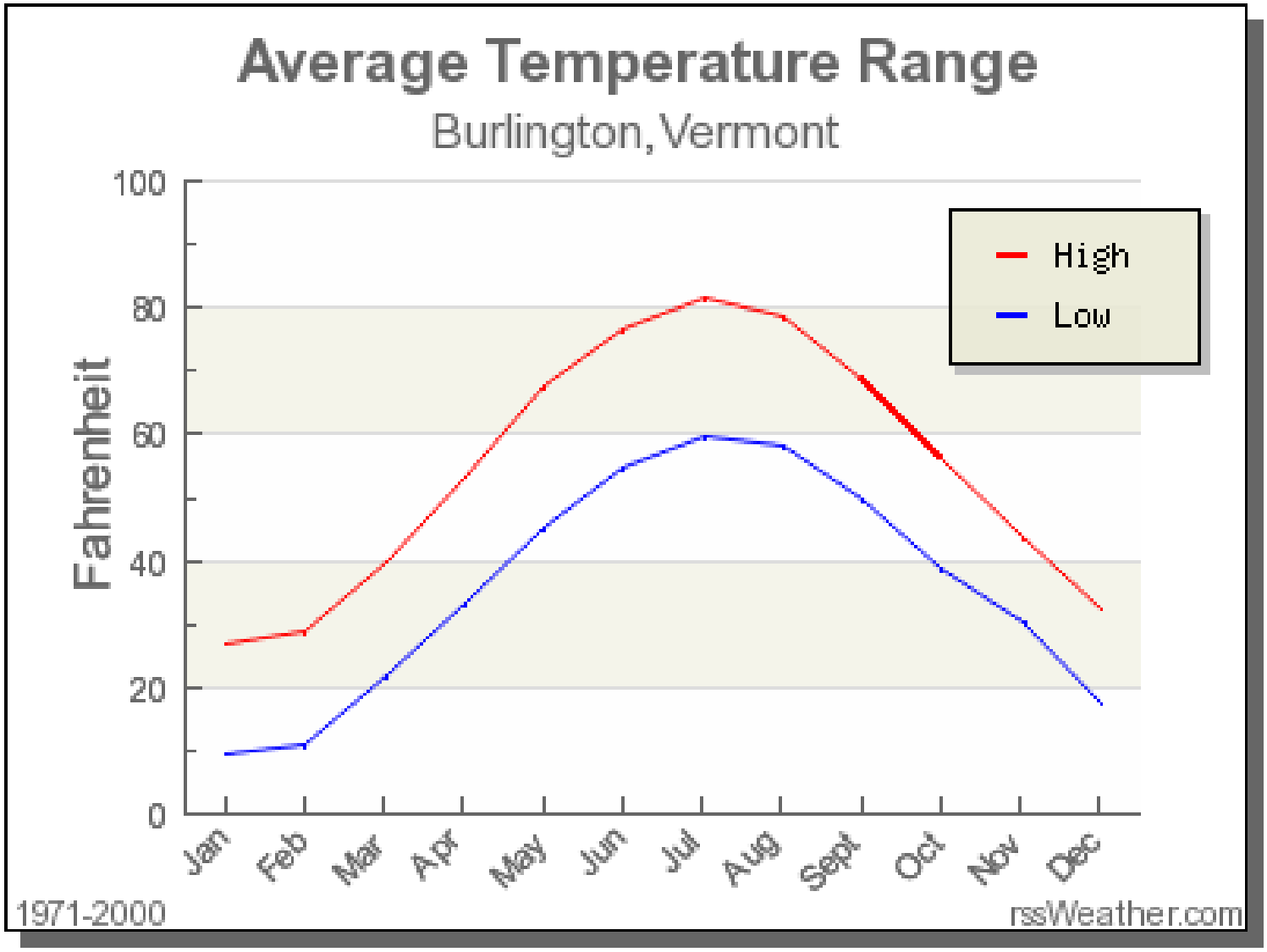


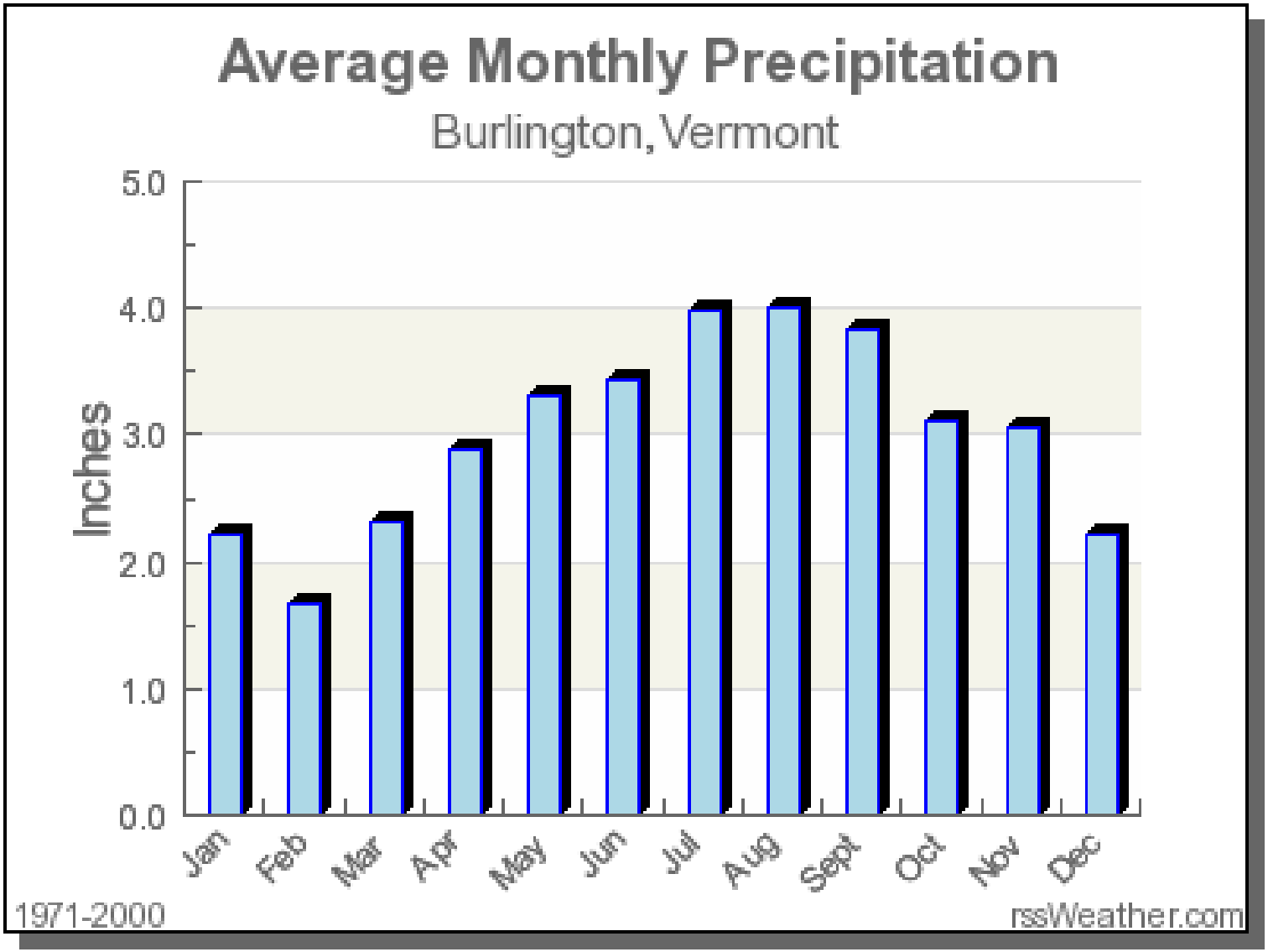
Workshop Topics:

1. Climate, People & IAQ
2. High Performance
3. Ventilation Strategies
4. Source Control Strategies
5. Heating & Cooling Strategies

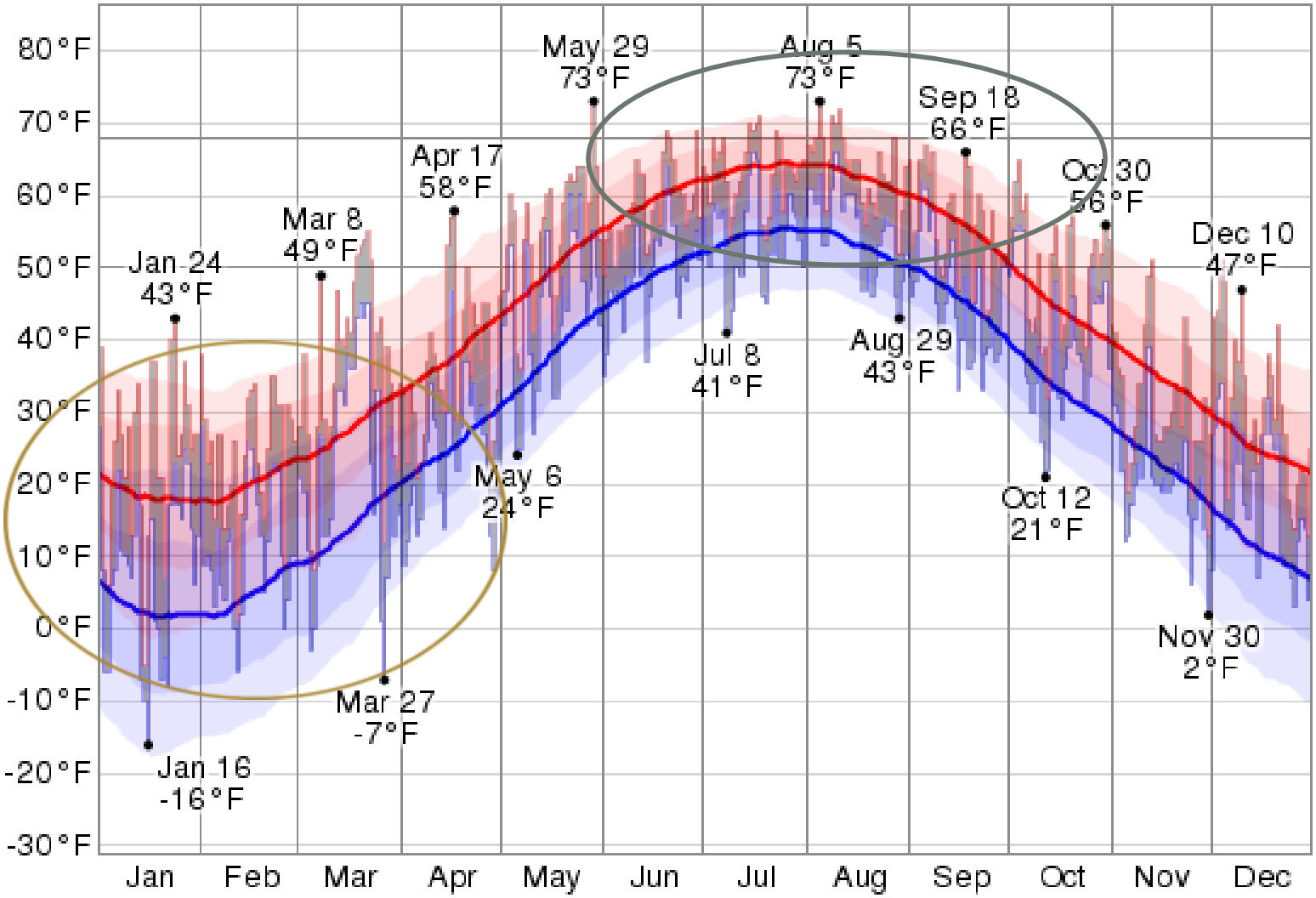
Basic Building Science

Comments and feedback are always welcome


Average Temperature Range
Burlington, Vermont
Fahrenheit
100
80
60
40
20
0
High
Low
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
1971-2000
rssWeather.com


Average Monthly Precipitation
Burlington, Vermont
Inches
5.0
4.0
3.0
2.0
1.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
1971-2000
rssWeather.com

Burlington Climate Dew Pt. Graph

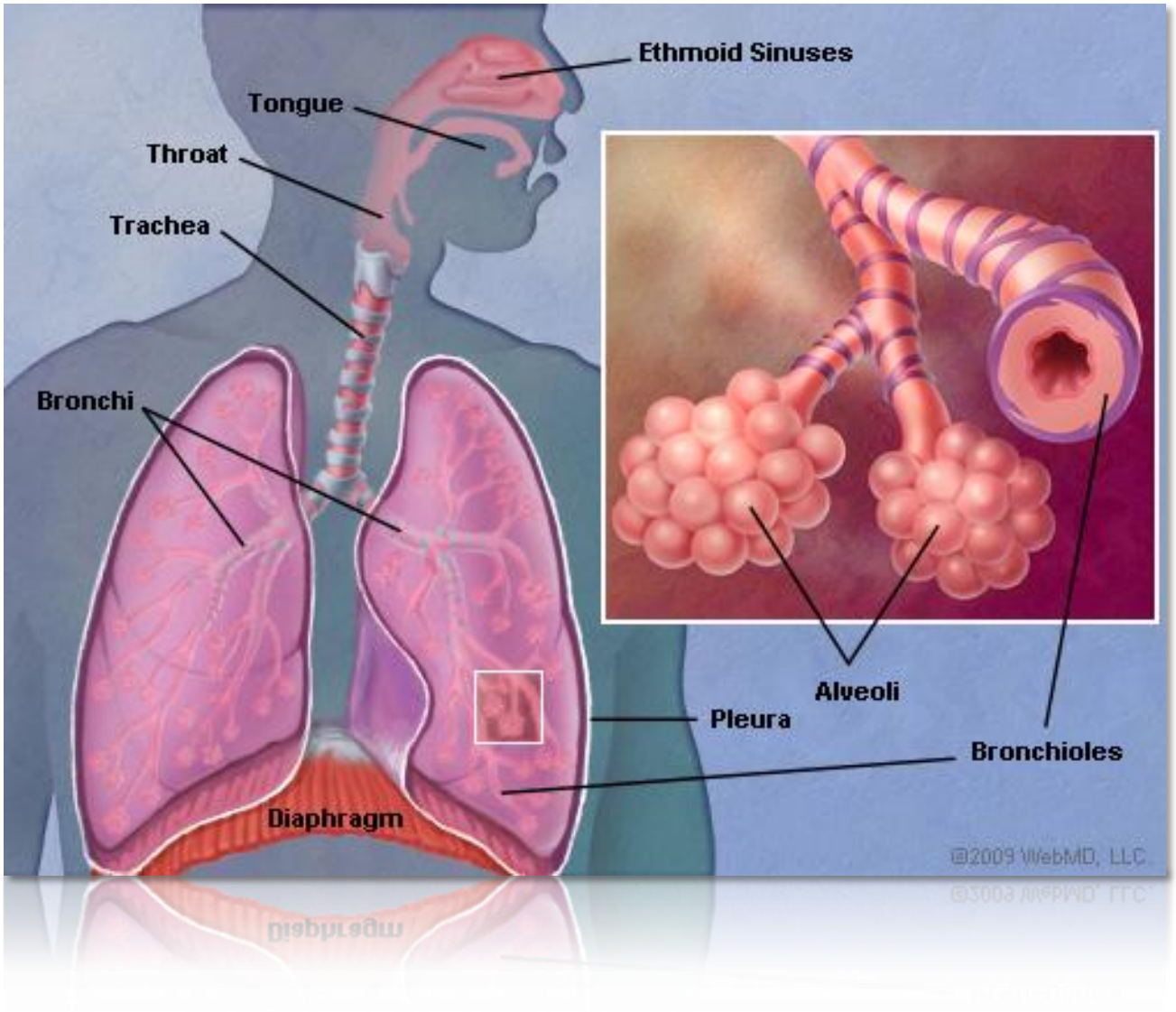


weatherspark.com/history/29818/2012/Burlington-Vermont-United-States

A Few Resources

- ✓MIAQC Checklist For New Home Construction
- ✓Energy Star w. Indoor Air Plus Specifications
- ✓http://rcmzeroenergy.com
- ✓Others you like ?

Human lungs expose about 1/3 of a singles tennis court, about 750 square feet, 1500 miles of passageways



Common IAQ Exposures (Cold & Wet Climate)

- Radon
- Combustion By-products
- Biological Contaminants
- Pets, Vermin, & Pesticides
- VOC's
- Cooking Fumes

- Others?

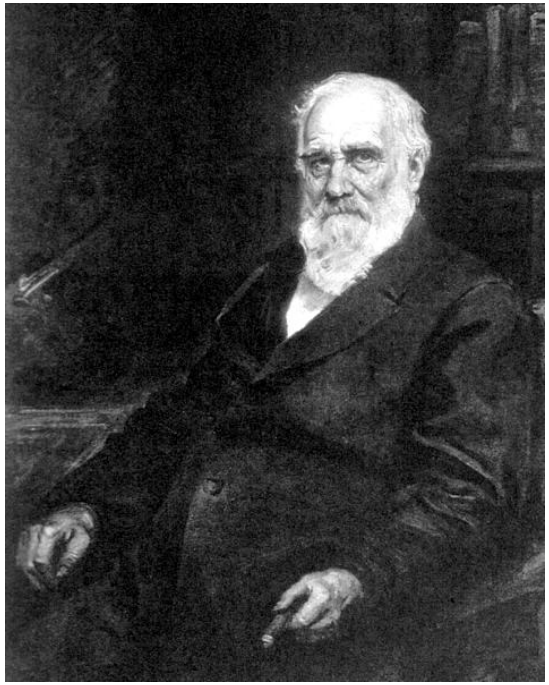
Benchmarks of Good Practice

- ✓Dry
- ✓Clean
- ✓Comfortable
- ✓Adequate Ventilation
- ✓Source Control
- ✓Air Filtration
- ✓Pest Control

The Importance of Source Control

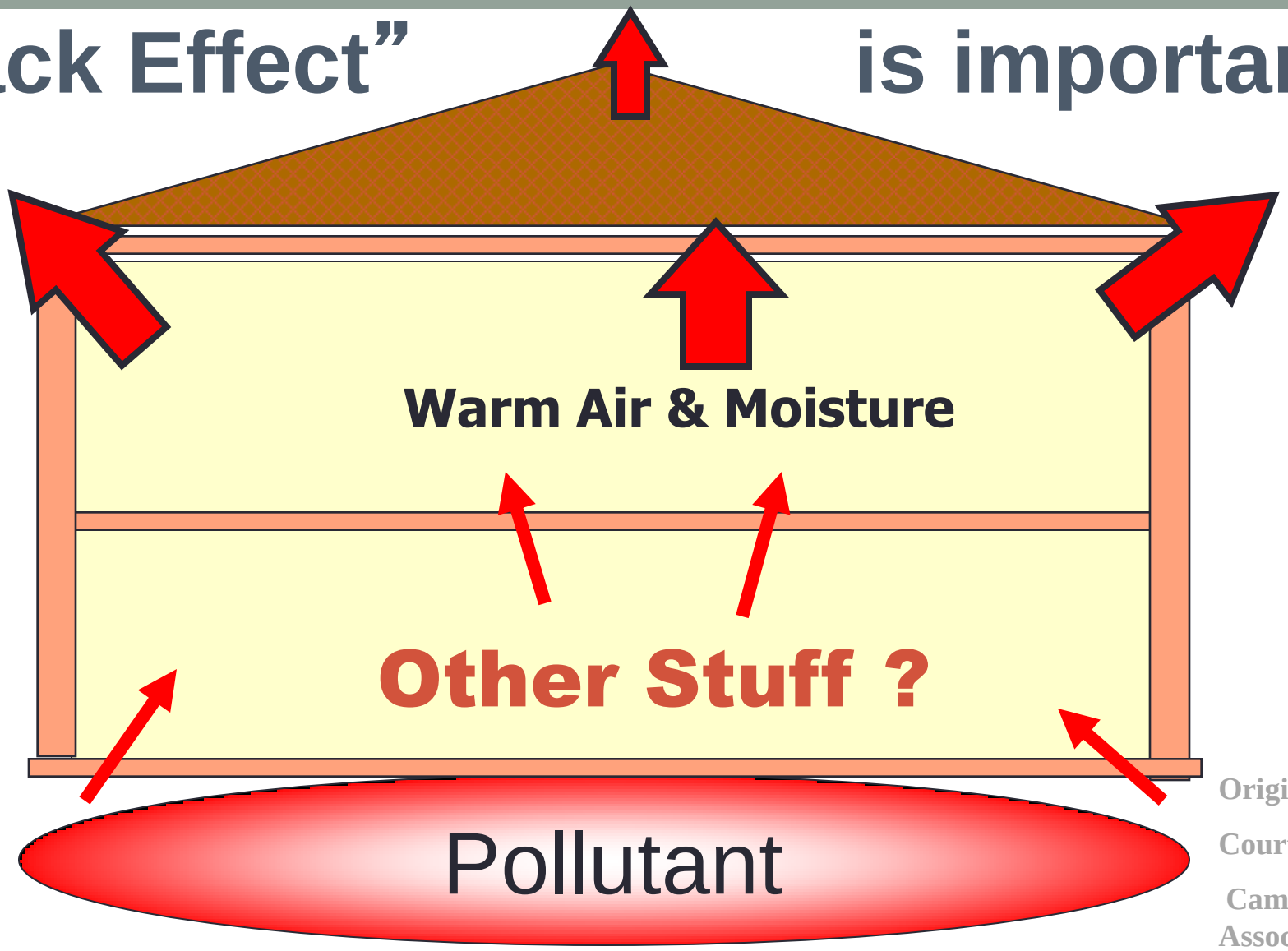
"If there is a pile of manure in a room, do not try to remove the odor by ventilation. Remove the pile of manure."

Max Joseph von Pettenkofer
1818 - 1901



Courtesy Wikipendia

"Stack Effect" is important



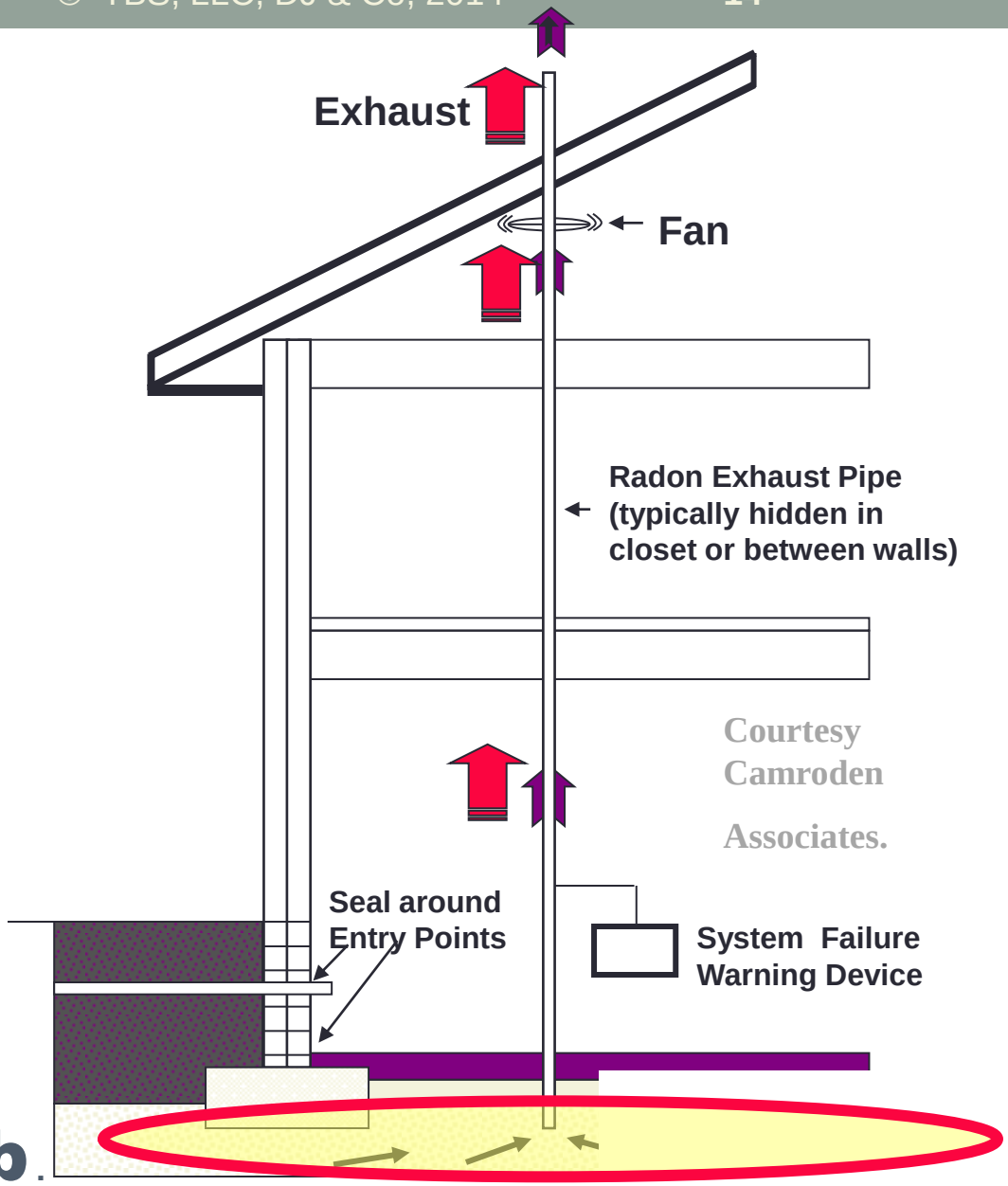
Original Courtesy Camroden Associates.

Soil Gas Pollutants can include Radon, VOCs, Fuels, Methane, etc.

Radon Soil Venting

ASTM E 1465 08

Sub-slab suction reverses the pressure between occupied space and the source by creation of a *negative pressure field* under the slab.



Inexpensive and readily available radon test kits

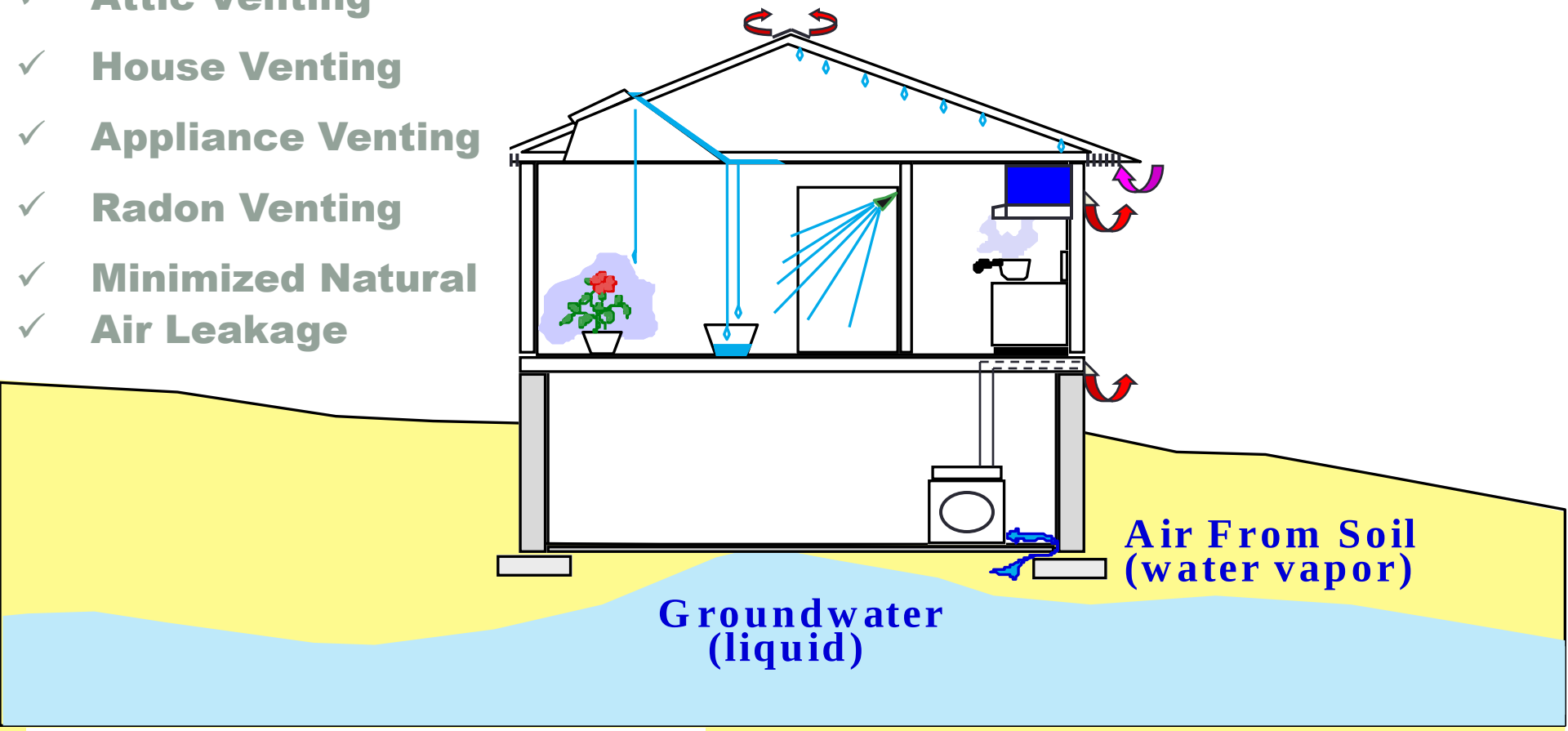
Very important if renovation project includes basement finishing

Must be performed by homeowner or registered tester

The House As A System Must

Manage Moisture & Air Flow

- ✓ Attic Venting
- ✓ House Venting
- ✓ Appliance Venting
- ✓ Radon Venting
- ✓ Minimized Natural
- ✓ Air Leakage



Original Courtesy Camroden Associates

Moisture Rules

- ✓**Moisture flow is from *warm* to *cold***
- ✓**Moisture moves from *more* to *less***
- ✓**Air carries moisture from *high pressure* areas to *low pressure* areas**
- ✓**Gravity pulls water down**
- ✓**Water wicks up**
- ✓**Basement Drainage is critical**

Air Rules

Air moves from *high* pressure to *low* pressure

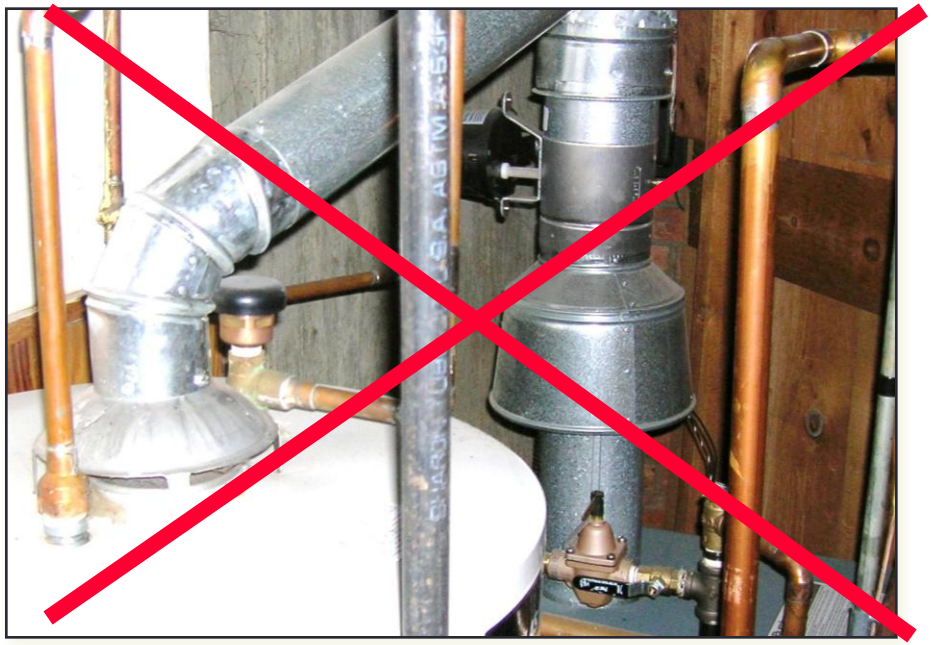
Drivers include

- **Stack effect, (cold air sinks, hot air rises)**
  - ✓**Important long-term**
- **Fans create high and low pressures**
  - ✓**Can overcome stack effect**
- **Wind Effect**
  - ✓**Can overpower both in the short term**

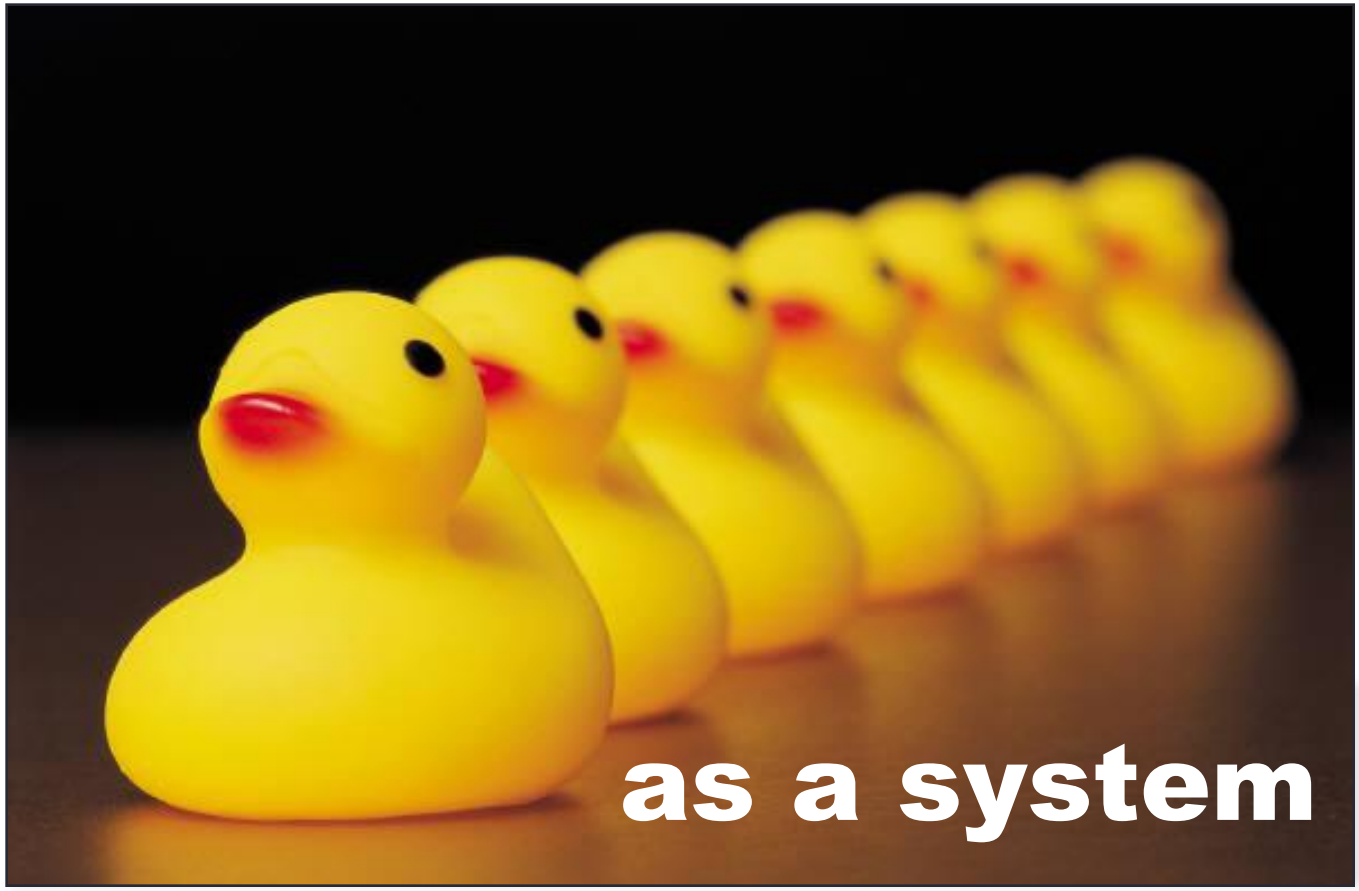
To minimize stack & wind effects & maximize the benefits of small fans…build tight!

Net Zero Assumptions?

- ✓ No Backdrafting (Sealed Combustion or no combustion)
- ✓ Planned Range Hood
- ✓ Planned Make-up Air
- ✓ Planned Exhaust
- ✓ Planned Air Filtration
- ✓ Vented Dryer
- ✓ Low Odor Finishes
- ✓ Low Nap Low Odor Carpets
- ✓ or solid surface floors
- ✓ Planned wind/exit geometry
- ✓ Attached Garage Exhausted
- ✓ Others?



The House Must Work



rcmzeroenergy.com ROSE construction

Building Thermal Envelope

Basement wall R-value...	27
Floor Slab R-value...	22
Wood frame wall...	40
Ceiling...	60
Windows...	4 avg.

Ventilation Rate Capacities

Kitchen...	300cfm hood intermittent, 20cfm cont.
Bathroom...	100cfm intermittent, 25cfm cont.
Whole house...	.35ACH x house volume/60= 230cfm

ACH 50 = 0.6 = 454cfm

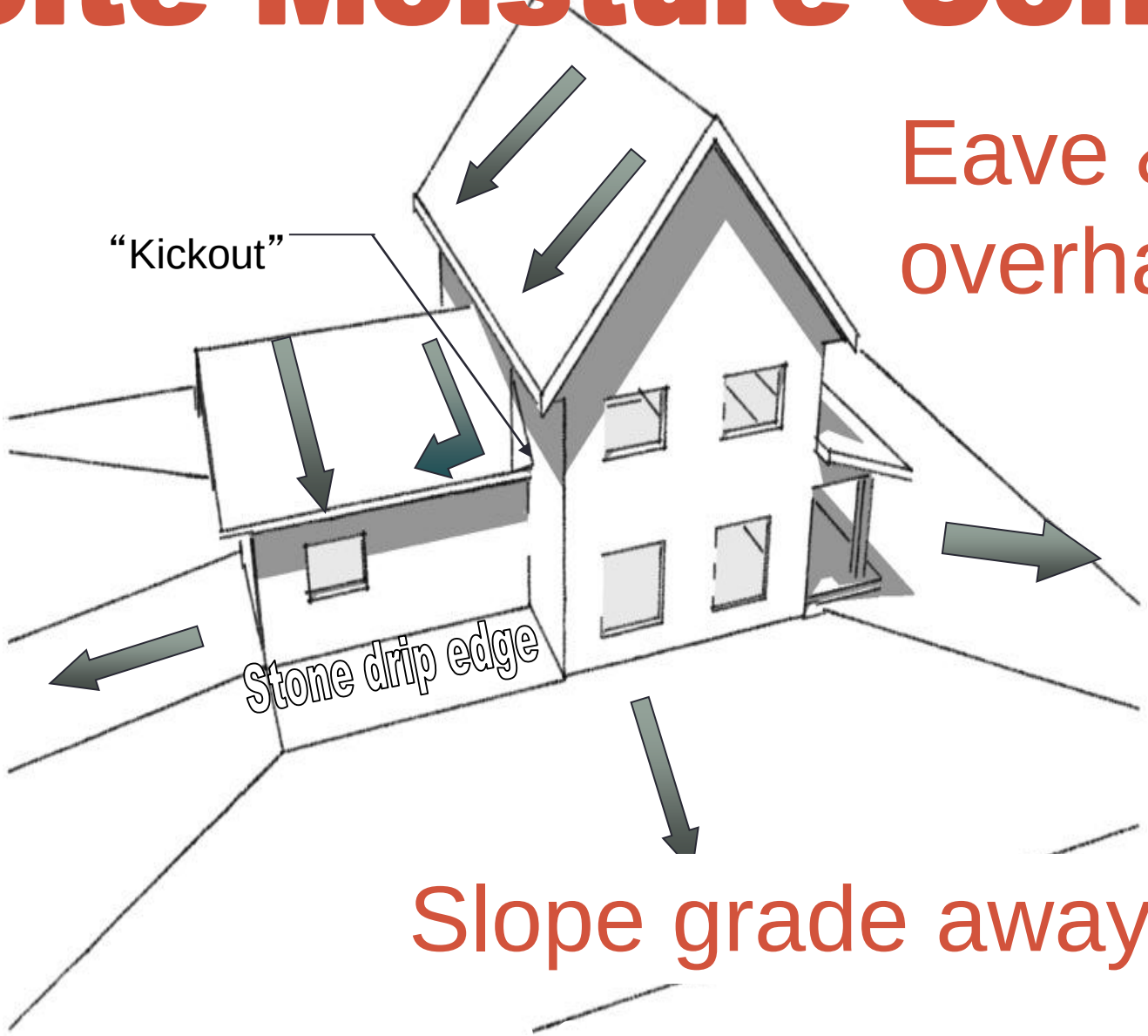
(HERS) Rating Index = 2

Energy Star & Indoor Air Plus Specification Criteria

Lighting Power Density = 0.38 watts/sf

http://rcmzeroenergy.com.com/ROSE-Cottage-Project/energy.html

Site Moisture Control



Eave & rake overhangs

Slope grade away

Geo Exchange & Solar Recharge Located Under Basement Floor

Enhanced thermal conductivity GeoPerformX tube to extract heat

A layer of PEX tubing to store thermal solar heat in the same area as the Geo-exchange Slinky

No Single component wall, roof, or floor systems

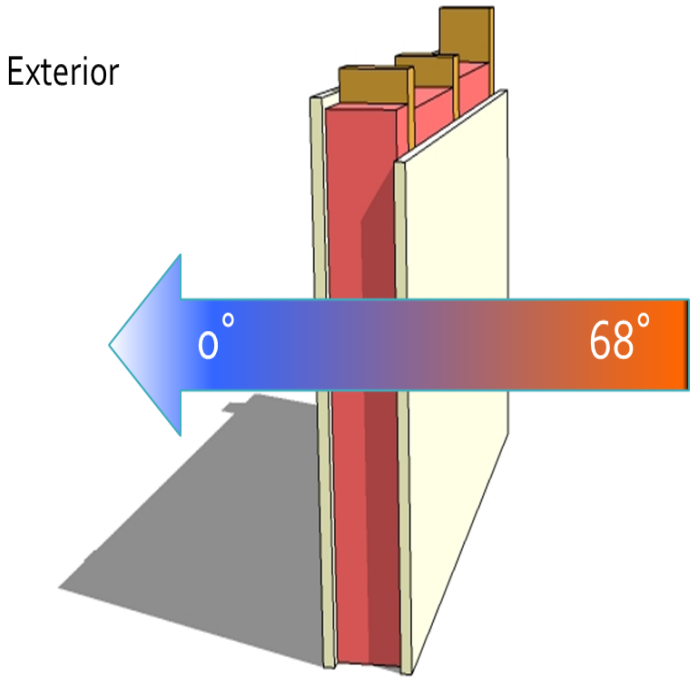
6 inches exp under basement radiant floor

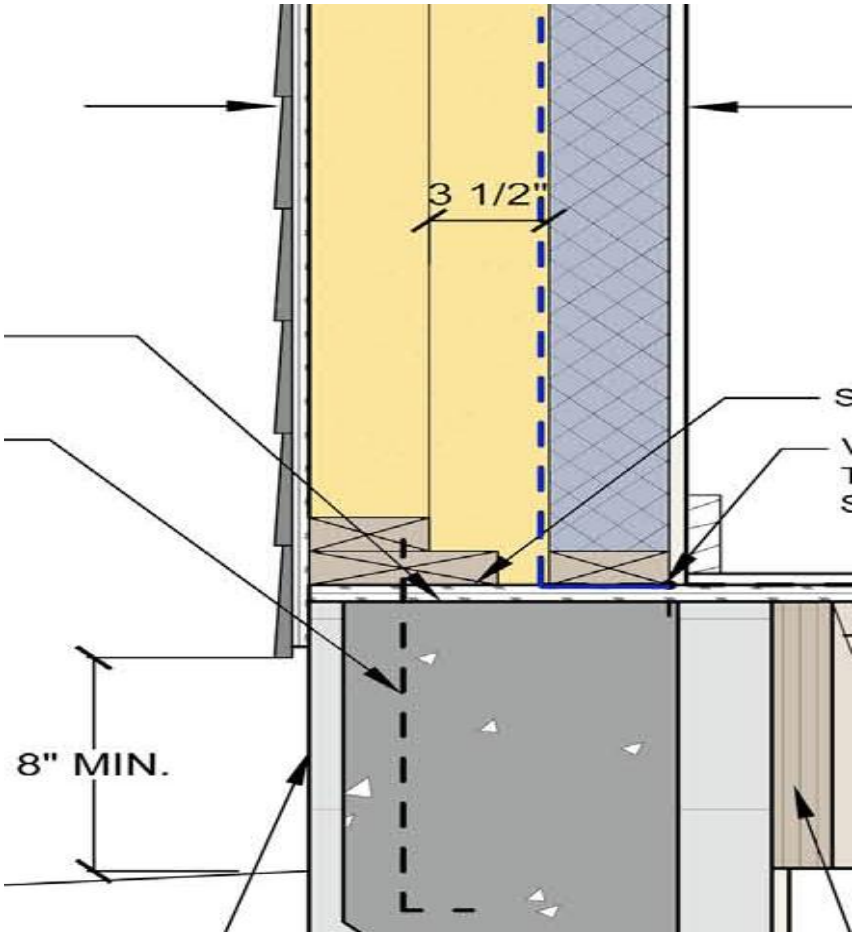
Always
install VDR,
&
insulation
prior to
concrete
placement

Ground Moisture Control

Courtesy rcmzeroenergy.com

Wall Moisture Control





Courtesy David Johnston & Company & rcmzeroenergy.com

Double Stud Wall

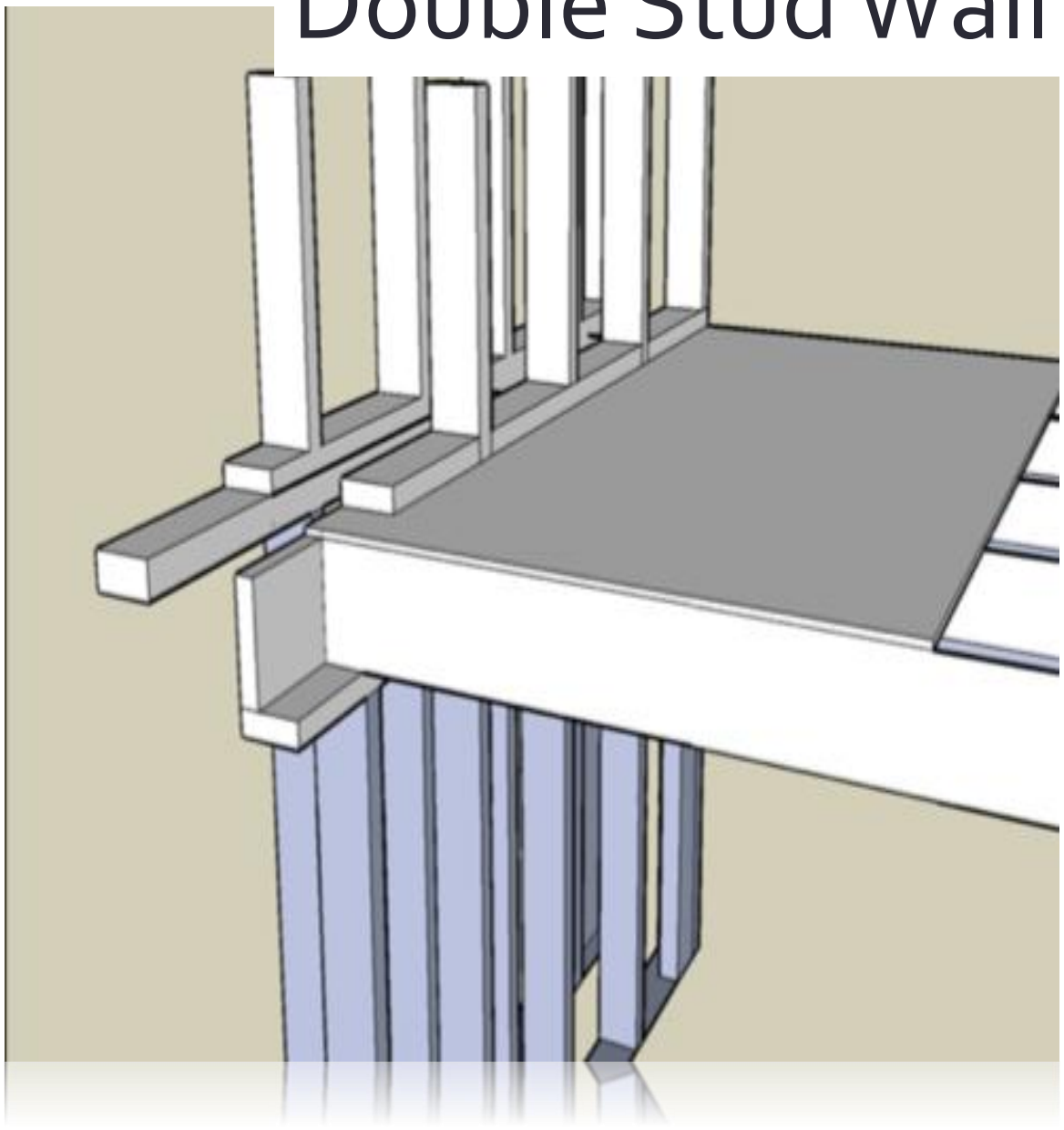
Two 2x4 walls, 3.5" space between

VB applied to *outer* face of *inner* wall

Outer 2/3 dense pack

Inner 1/3 HD batts

Minimal thermal bridging, easy to construct



Courtesy David Johnston & Company

Courtesy rcmzeroenergy.com

Double Stud Wall

Dense Pack Cellulose & Rock Wool Batt

Courtesy rcmzeroenergy.com

Attic/Roof Venting

Keeps the roof cold in winter

lets small amounts of moisture leave from the attic space

Air sealing is critical to keep the amounts of moisture small

IRC R806.2

Minimum Code

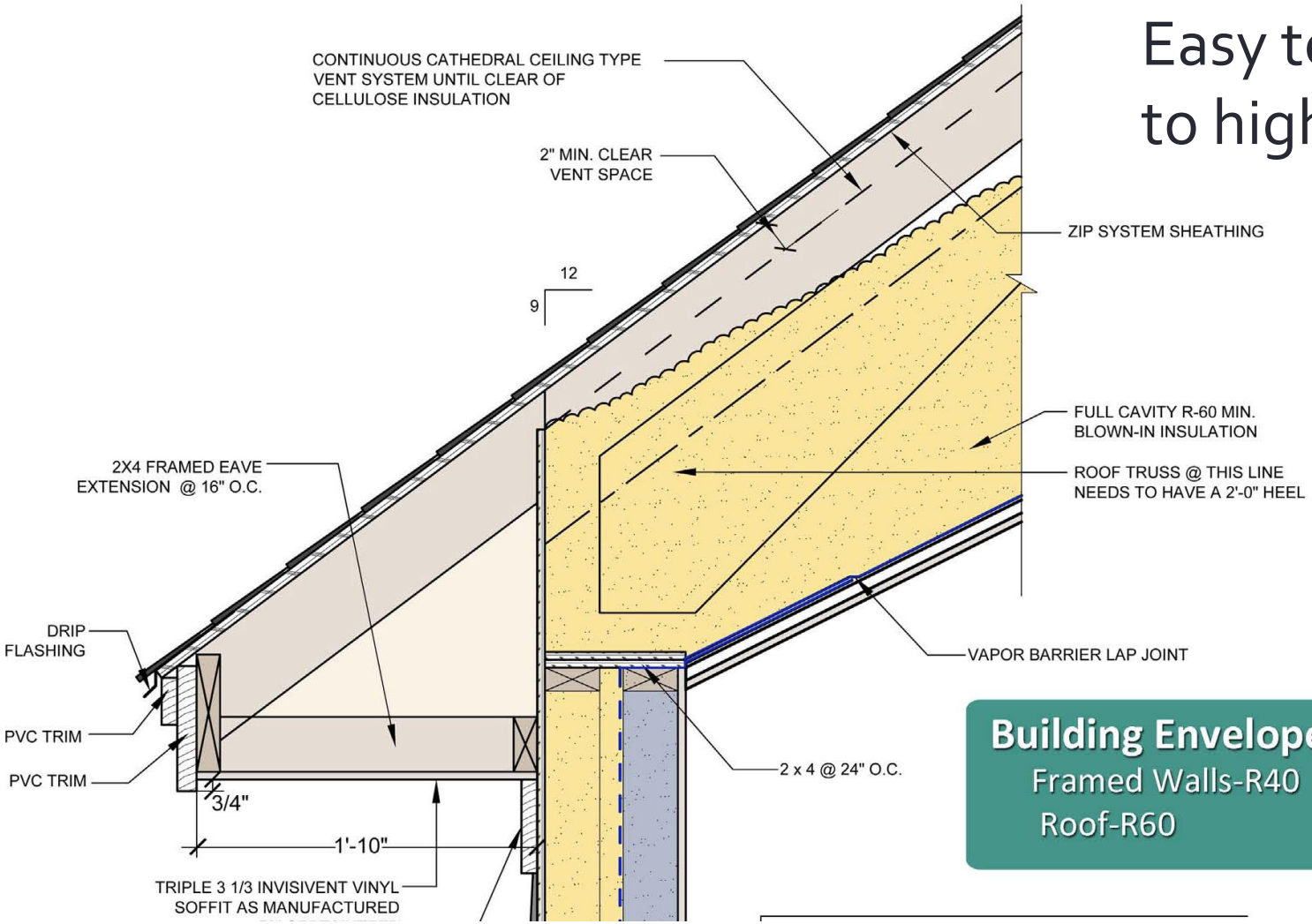
1/150 ratio

With Vapor Retarder <1 perm

1/300 ratio

Eave Venting

Easy to insulate to high R levels

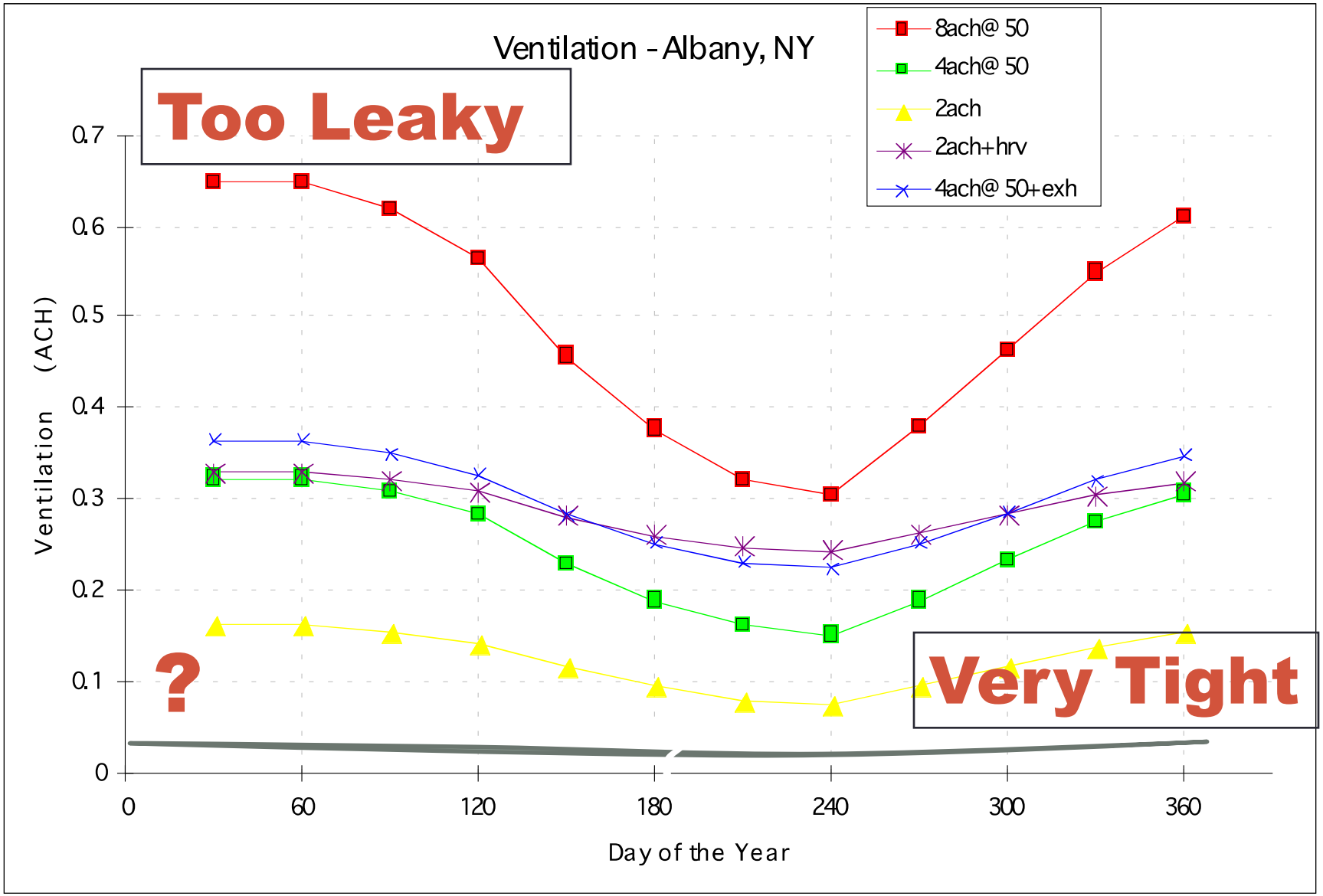


Building Envelope
Framed Walls-R40
Roof-R60

Courtesy rcmzeroenergy.com

Courtesy rcmzeroenergy.com

Mechanical Ventilation Strategies



Courtesy Camroden Associates.

Mechanical Ventilation

Accomplished with

- ✓ Energy recovery unit
- ✓ Small exhaust fan
- ✓ Multiple speed spot exhaust
- ✓ *Clearly labeled* Automatic Control with timer & override

or connected with heating/cooling system?

Home Ventilation Guidance Follow ASHRAE 62.2-2013

(ASHRAE) Std 62.2-2013 "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings"

www.ashrae.org 1-800-527-4723

http://www.waptac.org/WAP-Standardized-Curricula/ASHRAE-62002E2.aspx

ASHRAE, IECC Goals

1) ***Spot ventilate*** **(exhaust) localized pollutant sources**

2) **Provide enough *whole house ventilation* to dilute contaminants that are not localized**

3) **Plan air movement (exhaust air out, makeup air in)**

Systems must be quiet, easy to operate, and affordable

Builder must be able to install

Courtesy Dave Johnston & Company

Owner must want to use

Std. 62.2
Spot Ventilate Bath & Kitchen

Operate on demand

Noise: Less than (3) sones *maximum*

1 Sone - approximately equivalent to a new quiet refrigerator or subdued voice at a range of 3 feet

Bath exhaust (balanced?)

50 cfm intermittent or 20 cfm continuous

Courtesy Camroden Associates

Quality Bath Fans

Courtesy Fantech

Local Exhaust at All Sources

Courtesy rcmzeroenergy.com

Good Idea...
Bath Fan Delay Switch

Courtesy Ametek NCC

Timer and Off-delay Controls for unattended moisture removal

Courtesy Broan

Kitchen Exhaust Hood Fan

Courtesy rcmzeroenergy.com

300 CFM "exhaust", 20 cfm continuous 5 ACH of kitchen volume.

Passive Makeup air.

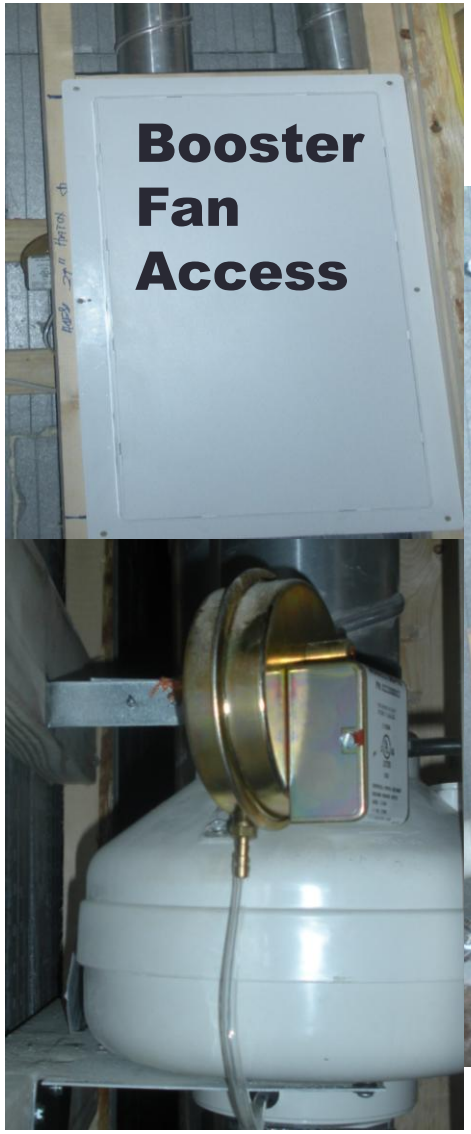
Kitchen Exhaust Fan & Exit

Courtesy rcmzeroenergy.com

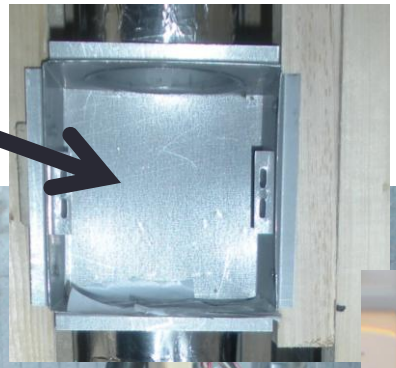
Kitchen & Dryer Exhaust Make Up

Courtesy rcmzeroenergy.com

Plan for Laundry & Dryer Exhaust



Filter Box



Courtesy rcmzeroenergy.com

Std. 62.2 "Whole House Ventilation Requirement"

noise less than one sone

Energy Recovery Ventilator or Continuous Exhaust Fan

- ✓ **Operate when house is closed up and occupied**

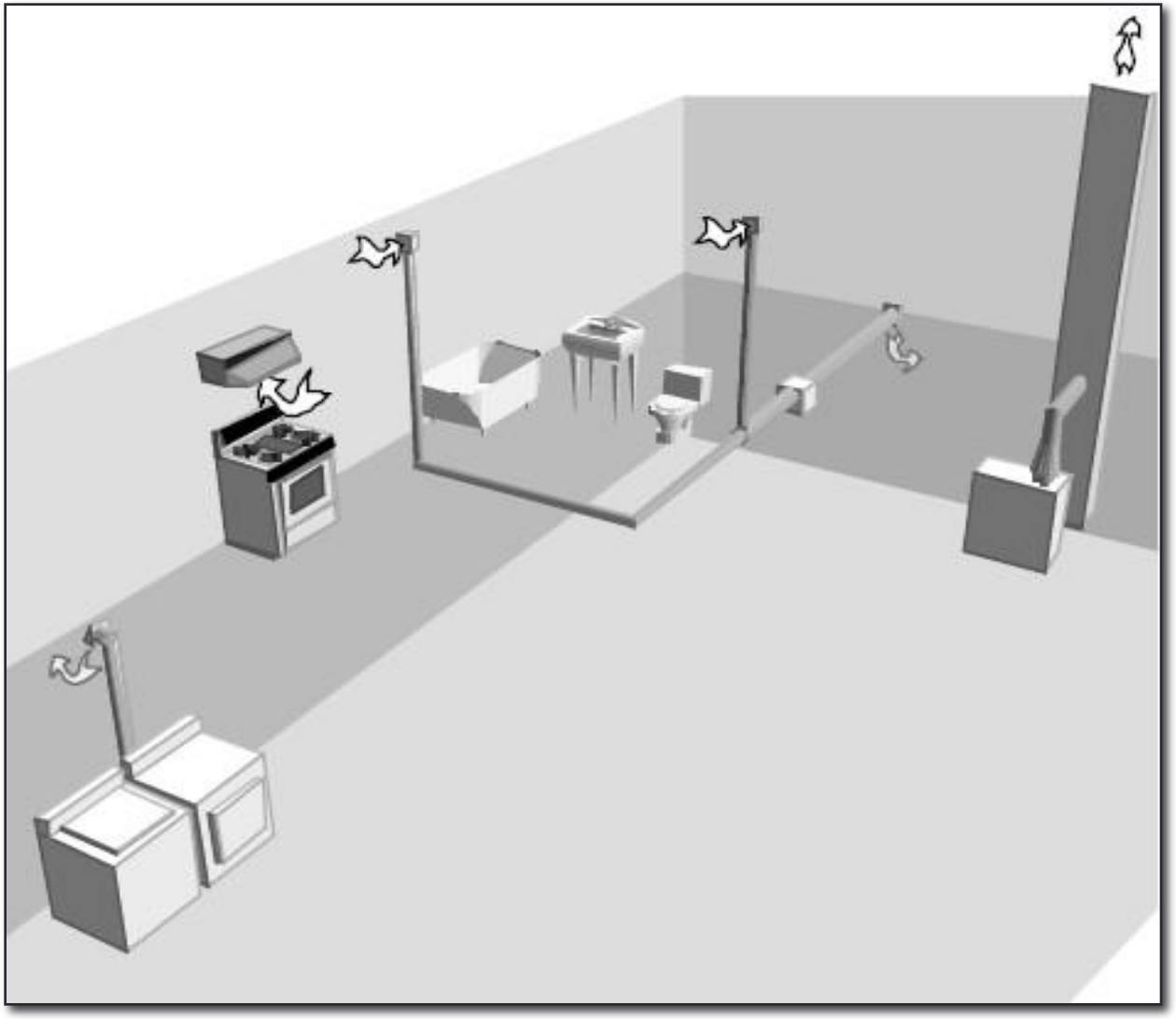
Can be provided by the "low speed" on HRV or ERV, or one or more spot fans in the kitchen (5 ACH) and bathrooms (20 CFM/ Bath)

Reminder: Houses Historically Had Near - Continuous Low Level Basement Ventilation

Loss of near continuous approximate 50 CFM of whole house "exhaust airflow" from the basement into the chimney damper. Loss due to sealed combustion or all electric homes.

Courtesy Dave Johnston & Company

Quiet Central Exhaust Fan



Courtesy Camroden Associates.

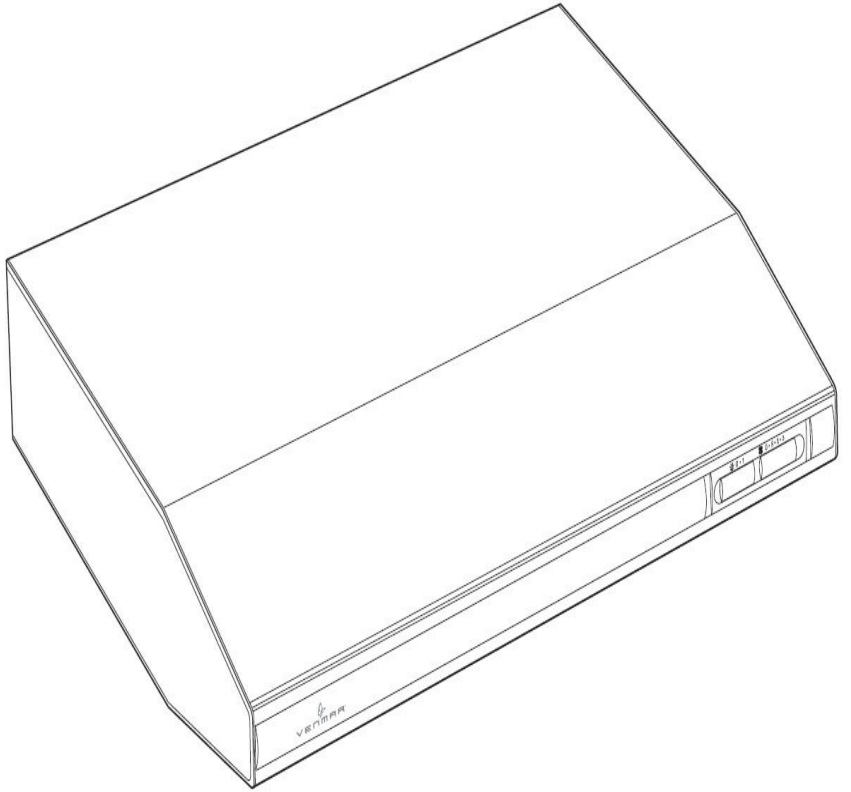
Multi Speed Kitchen Exhaust Fans

Venmar Sig. SL

75, 160, or
270 CFM High

40 CFM
Continuous Low
(less than 1 sone)

19 watts power
on low



Courtesy Venmar

Some Residential Control Options

Cycle or Change Speed Based on:

- ✓ **Percent run time**
- ✓ **Humidity**
- ✓ **Occupancy**
- ✓ **Time of day**
- ✓ **Others??**

Airetrack™ by Tamarack

A control for whole building intermittent fans

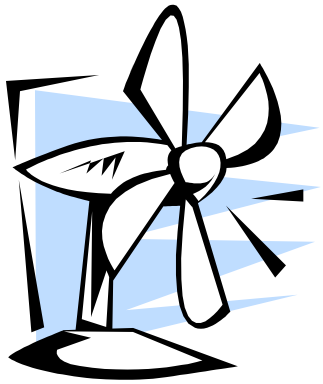
Courtesy Tamarack

Fan Speed: adjustable from 40 to 100% of capacity in 16 increments for background ventilation rate

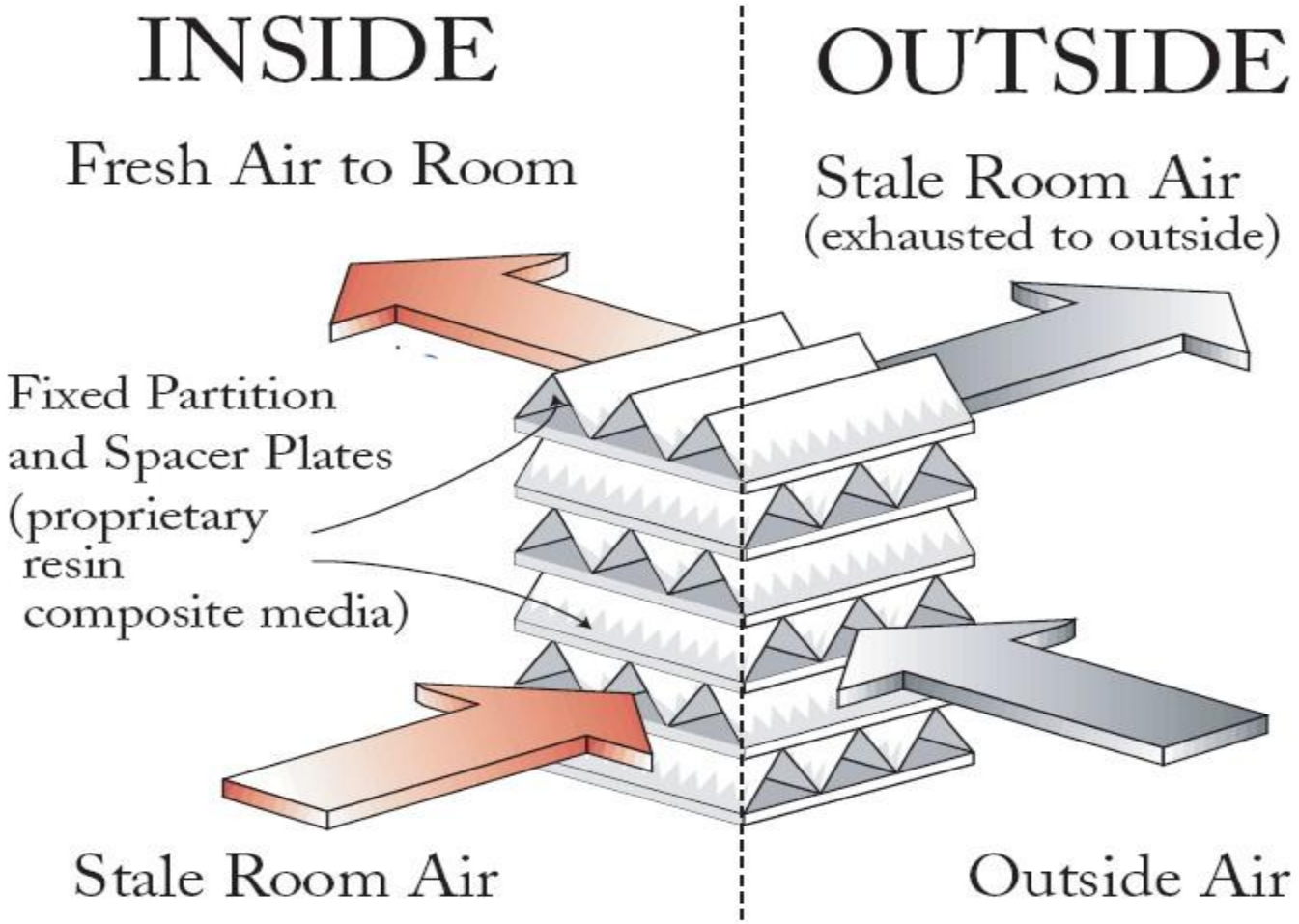
Built-in Timer programmed at installation in multiples of 5 minutes for a 12 or 24 hour cycle

Boost to full speed for 20 minutes by pressing button. Pressing again drops speed to background rate

Balanced Ventilation Systems



Energy Recovery Units



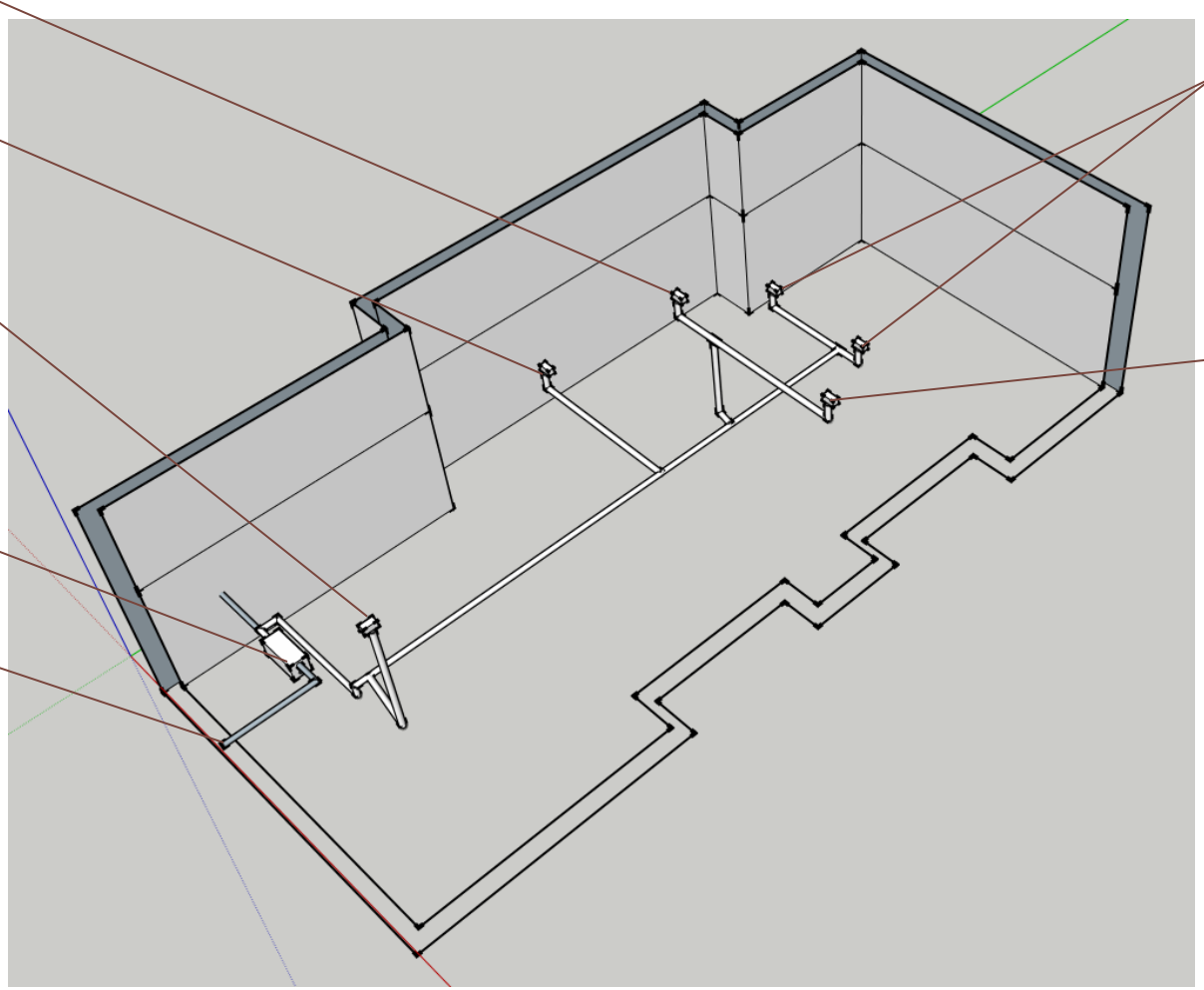
Courtesy rcmzeroenergy.com

Balanced ventilation systems can provide good distribution

Operated on low & intermittent

Courtesy rcmzeroenergy.com

Supplies from HRV



Utilize a soffit for distribution

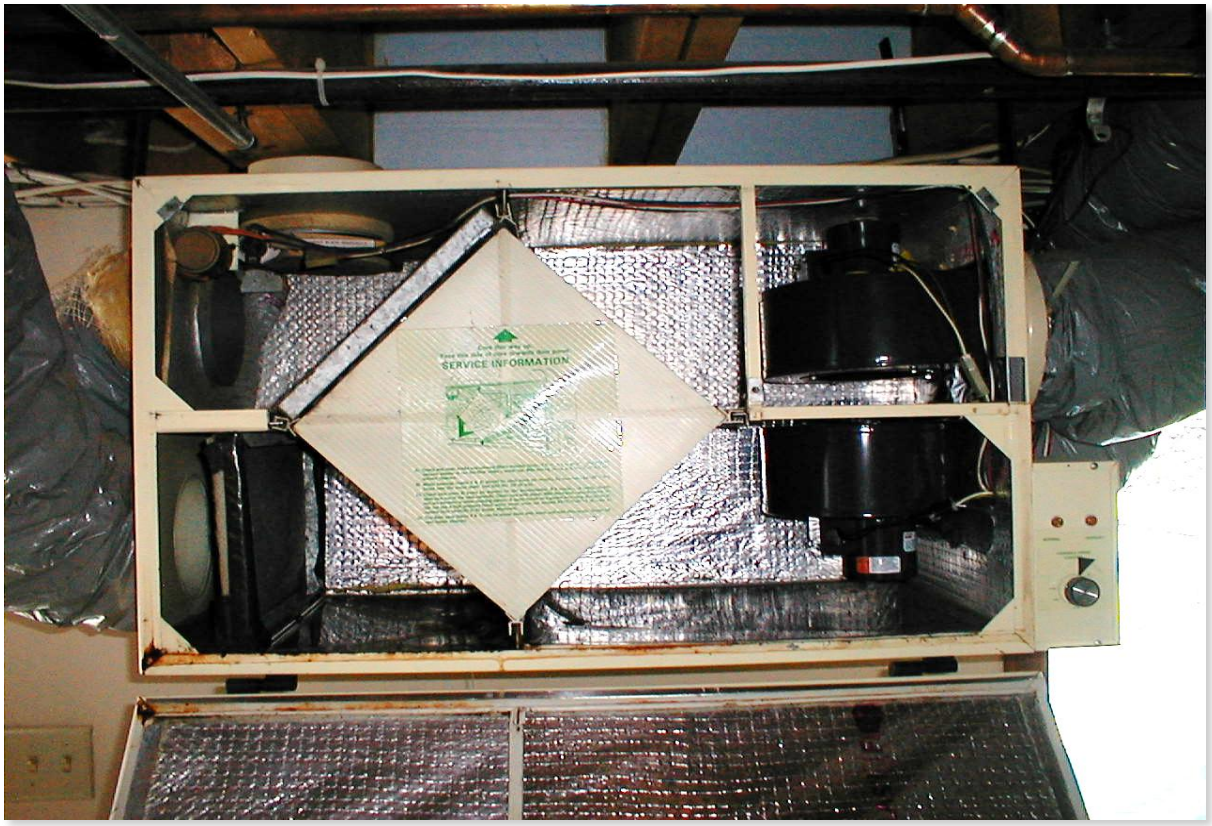
Courtesy rcmzeroenergy.com

Must Be Balanced & well located

If HRV or ERV blow "cold" air on the occupants they will not get used much…

problems **?**

28 Years in Service
Maintenance: Air filters cleaned annually, 1 blower replaced after 14 years



Courtesy Harold Turner

Operated on low normally, high intermittently

Small ERV

50 cfm

Courtesy Air Diagnostics & Engineering Inc.

Special Ventilation ??: Indoor Pool

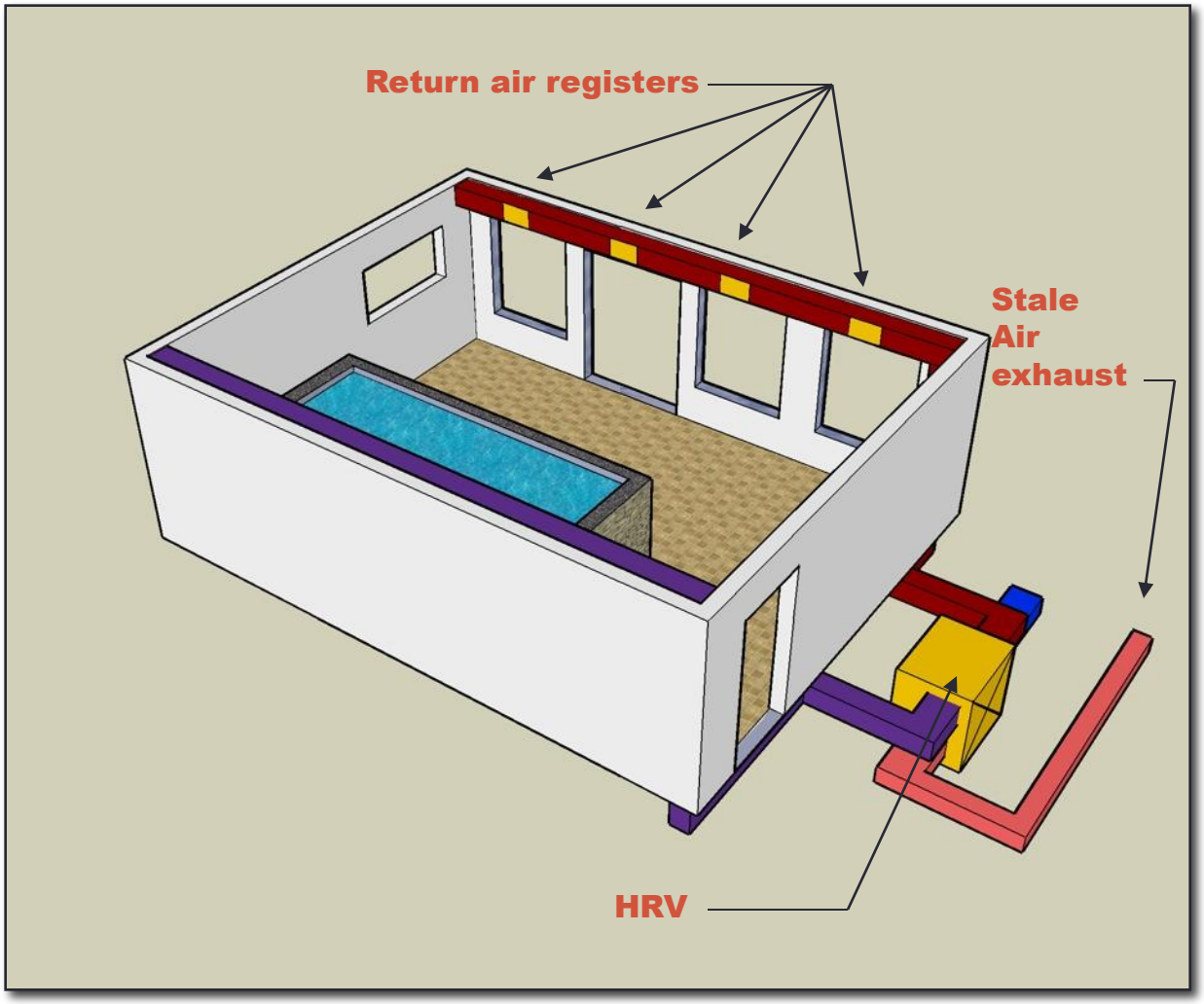
Courtesy Dave Johnston & Company

Planned Ventilation

- 100 CFM heat recovery ventilator
- PCD ductwork
- Supply air vented across pool towards windows
- Return air drawn upwards to wash window surfaces
- % run time, speed, and de-humidistat control
- Supplemental gas heater to raise room temperature above pool temperature prior to pool use

Pool room schematic

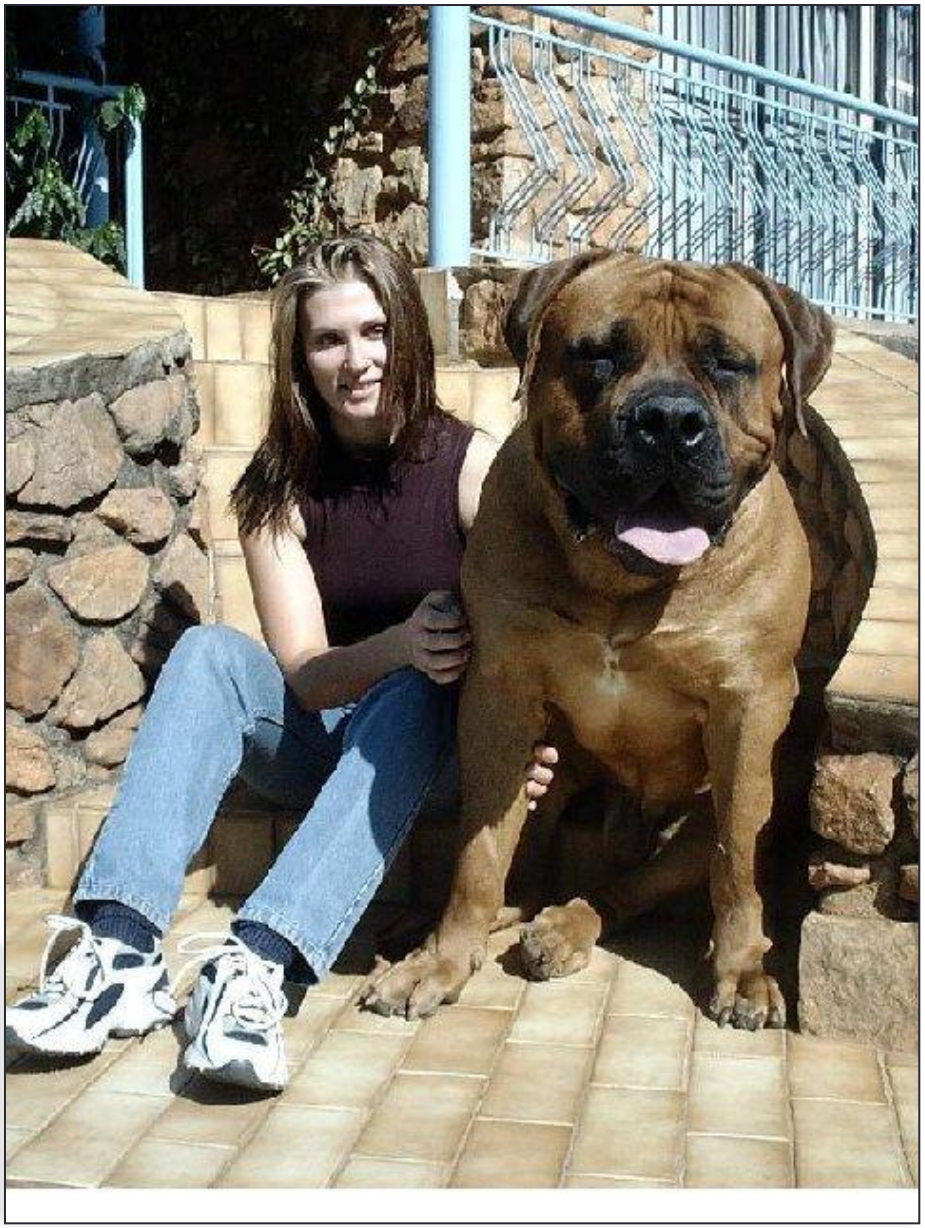
Courtesy Dave Johnston & Company



Big dogs

Special requirements

Code doesn't account for animals



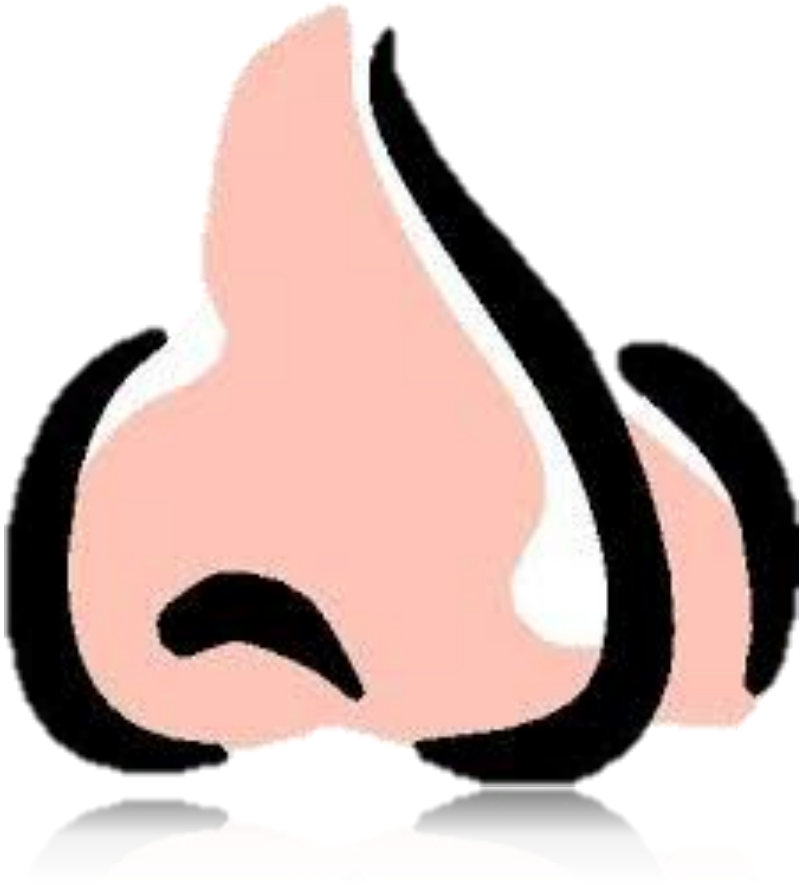
Ventilation can't fix everything

Smoking, Scented Candles, Incense, Plug Ins, etc. are Potential Problems

We've all been in "smoking sections" in restaurants

Odors in general

The nose knows…



VOC's

- ✓No VOC Paint
- ✓Tile or Concrete Flooring
- ✓Area Rugs
- ✓Limited Us of Low VOC Carpets
- ✓Others?

Air Filtration

Minimum Merv 8-11 recommended,

HEPA for 99.97 % at .3 microns desirable

Courtesy Fantech

Courtesy rcmzeroenergy.com

Air in on West side, out on North

Courtesy rcmzeroenergy.com

Prevent Odors in HVAC System?

Wet filters

Dirt/mold on liner

H_2O downstream of cooling coil

Animal nesting?

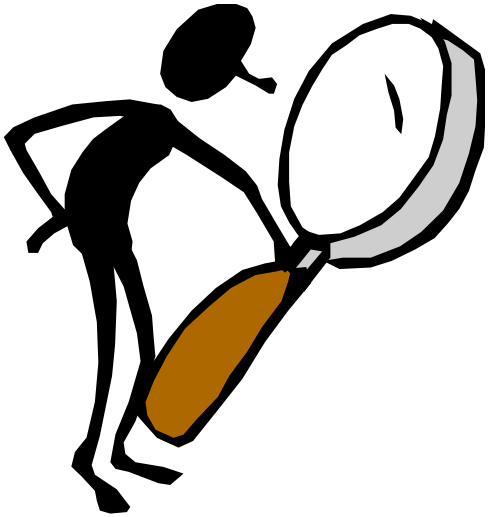
Courtesy Turner Building Science & Design, LLC

2 ton water to water heat pump & 2 ton water to air heat pump

Photo courtesy of George Lavoie Commercial Photography

9 high performance flat plate panels

"Ensure combustion appliances do not backdraft when all exhaust appliances are operating simultaneously"



Make-up air ?

ASHRAE 62.2

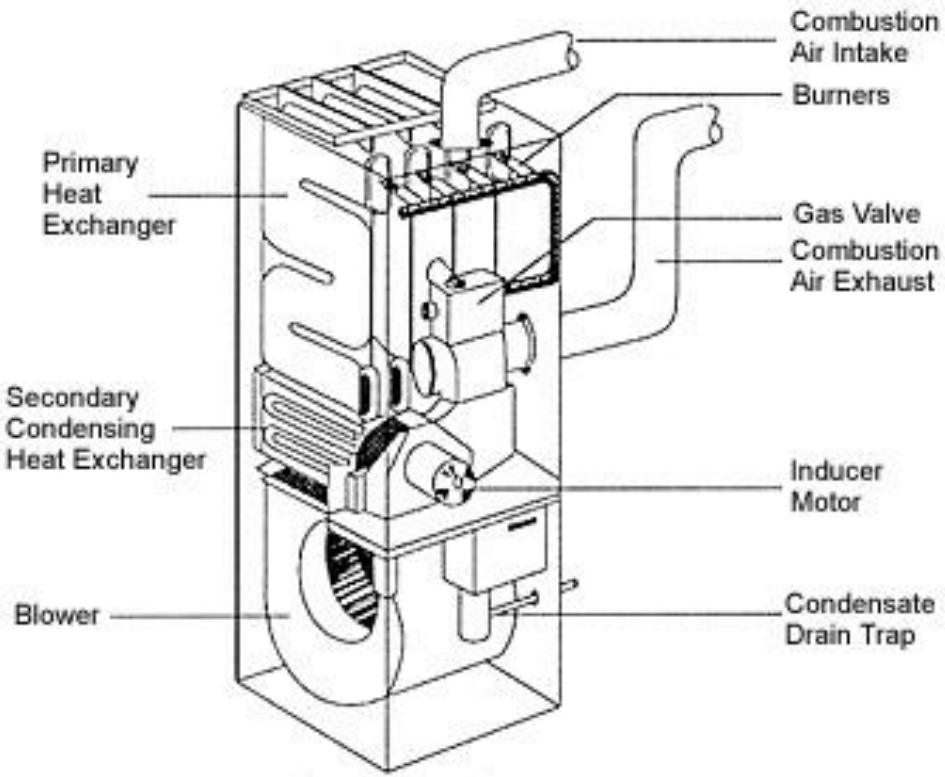
Sealed combustion?

Utilizes outside air for combustion, eliminating backdrafting, poor performance from insufficient combustion

- ✓ Veissmann™ Vitodens

Courtesy Dave Johnston & Company

Condensing Furnace With Make-Up Air From Heating System Return



High Efficiency Condensing Furnace

Courtesy Camroden Associates

Oil fired semi-sealed combustion

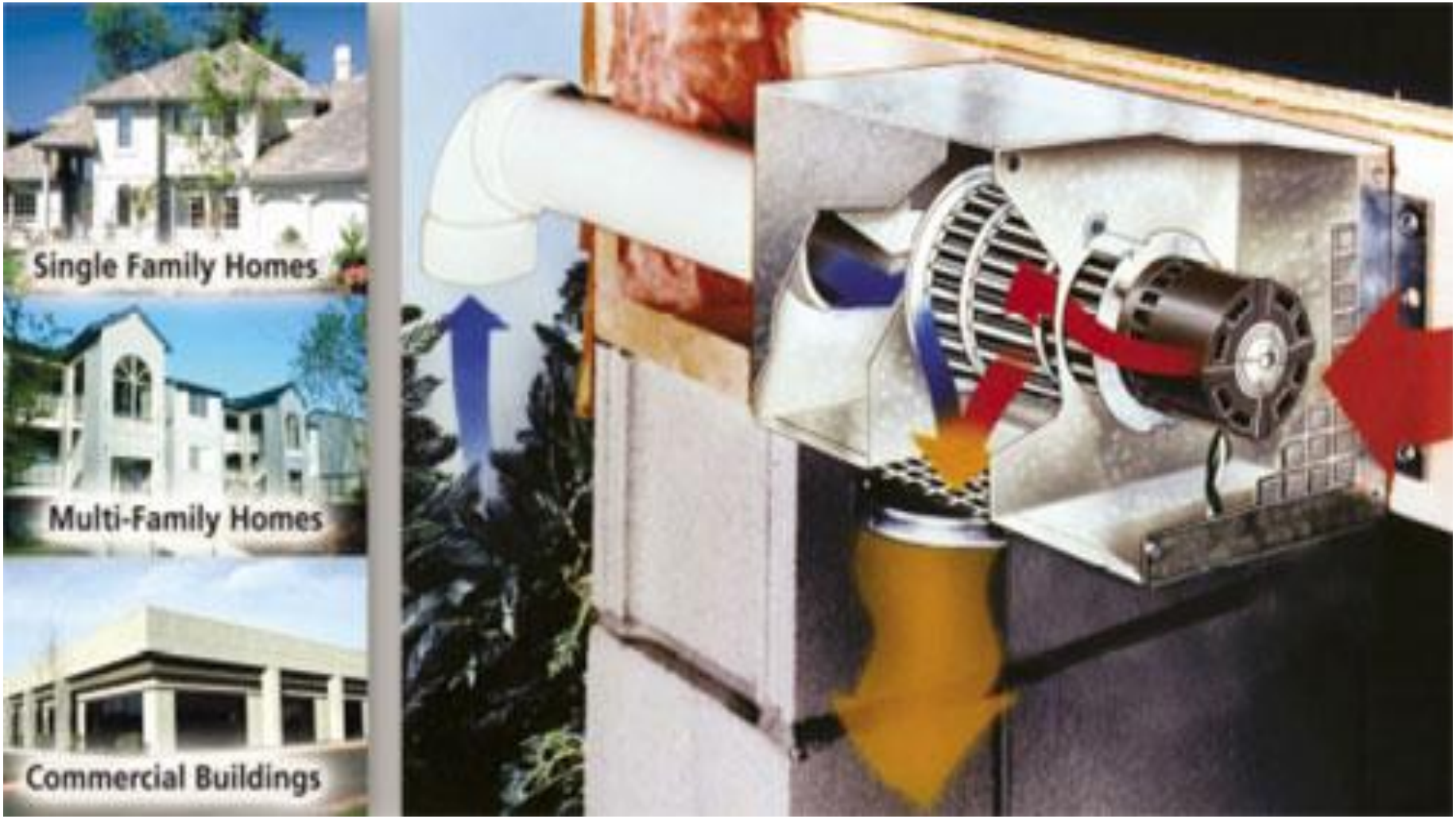
Exhaust

Combustion air

Vacuum relief valve

Courtesy Dave Johnston & Company

Powered Make-up Air



Courtesy Tjernlund Inforcer

Condensing Oil fired boilers??

No. 2 heating oil contains up to 5000 ppm sulfur

Buderus™

High sulfur exhaust plume

Note corroded drip edge

Courtesy Dave Johnston & Company

Exhaust Attached Garage

Common chemicals stored in the garage

Courtesy Dave Johnston & Company

Carbon Monoxide Alarms

- Required in new construction and *permitted* renovations with attached garages or combustion appliances

Additional Req. 62.2 ?

4. Vent drier outside
5. Confirm no backdraft, or power vent
6. Isolate garage with gaskets & sealing
7. Operable windows min 4% of floor area
8. Airtight recess light fixtures & sealing
9. Supply air filters: min. Merv 6
10. Intakes away from sources
11. Prescriptive duct sizing (table)
    (Maximum Length for a Given Diameter)
12. Provide control description & instructions for use & maintenance

We are not done yet…
Some further "Cold Wet" Climate Considerations"

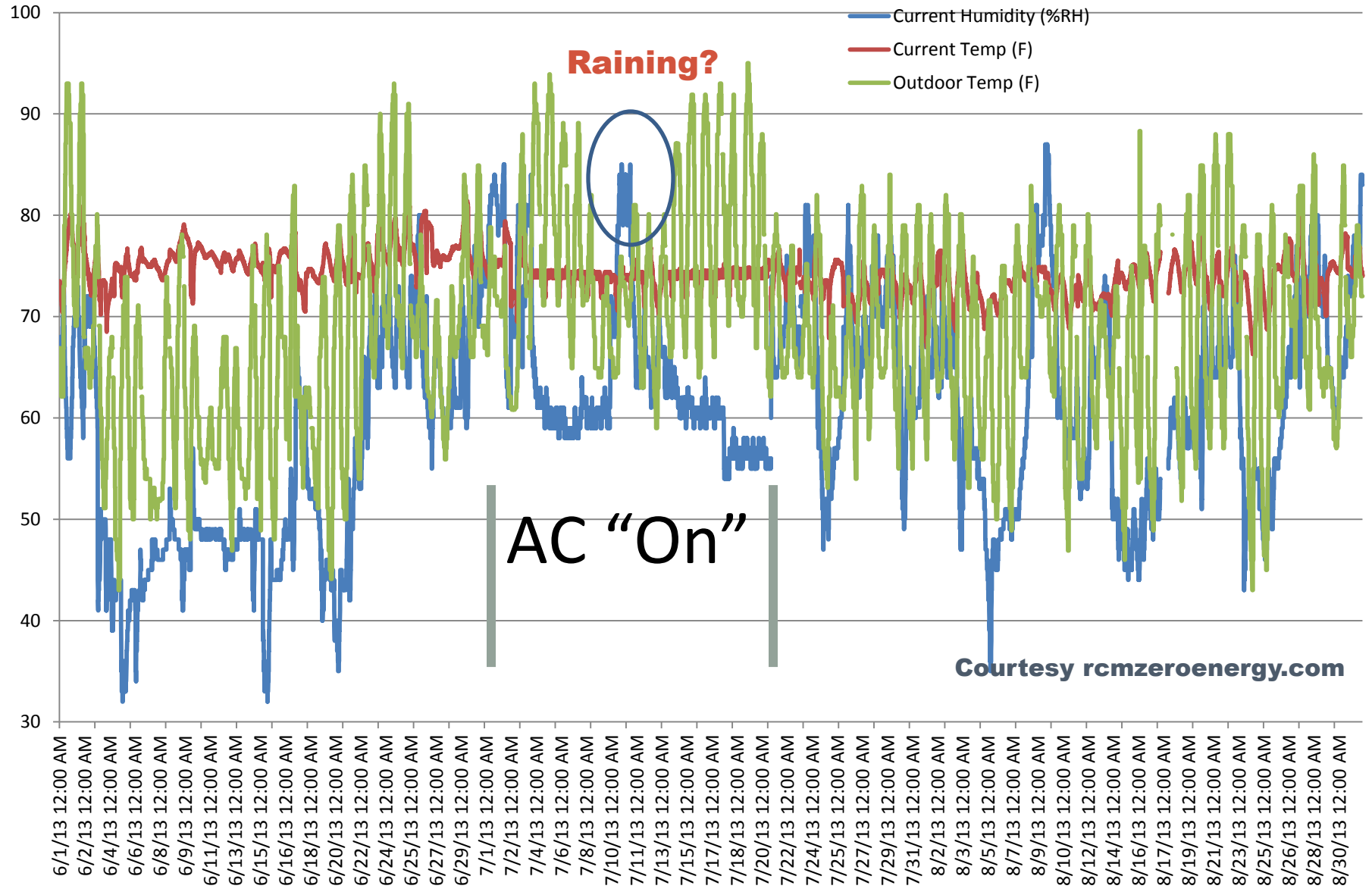
Indoor Humidity

Indoor relative humidity should range between 20% & 40%? during heating, & less than 65%? during the summer season

Watch the windows!

Better too little humidity than too much

Summer


Current Humidity (%RH)
Current Temp (F)
Outdoor Temp (F)
Raining?
AC "On"
Courtesy rcmzeroenergy.com
100
90
80
70
60
50
40
30
6/1/13 12:00 AM
6/2/13 12:00 AM
6/4/13 12:00 AM
6/6/13 12:00 AM
6/8/13 12:00 AM
6/9/13 12:00 AM
6/11/13 12:00 AM
6/13/13 12:00 AM
6/15/13 12:00 AM
6/16/13 12:00 AM
6/18/13 12:00 AM
6/20/13 12:00 AM
6/22/13 12:00 AM
6/24/13 12:00 AM
6/25/13 12:00 AM
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6/29/13 12:00 AM
7/1/13 12:00 AM
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7/31/13 12:00 AM
8/2/13 12:00 AM
8/3/13 12:00 AM
8/5/13 12:00 AM
8/7/13 12:00 AM
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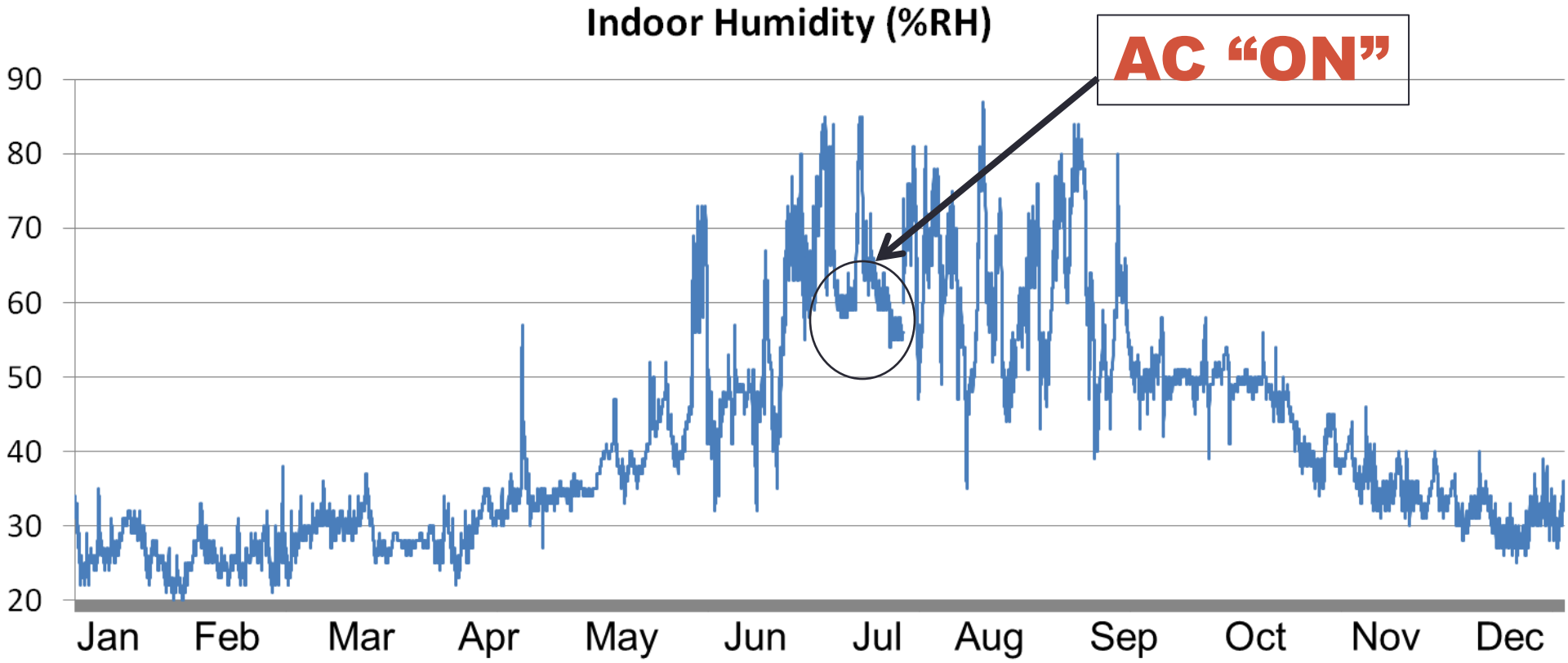
8/12/13 12:00 AM
8/14/13 12:00 AM
8/16/13 12:00 AM
8/17/13 12:00 AM
8/19/13 12:00 AM
8/21/13 12:00 AM
8/23/13 12:00 AM
8/25/13 12:00 AM
8/26/13 12:00 AM
8/28/13 12:00 AM
8/30/13 12:00 AM

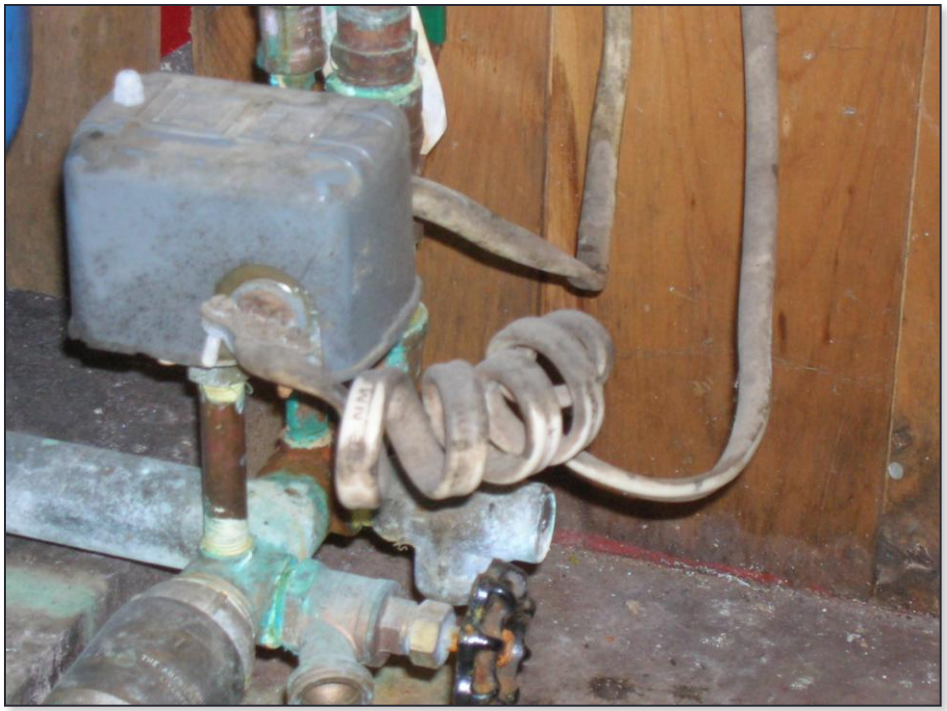
Over One Year



Courtesy rcmzeroenergy.com

Dew point at the water tank?

Humid summer air meets cold surfaces



Particles (dust) provide the food

Courtesy Dave Johnston & Company

Dew point on a tank?

Plan for water management

Courtesy rcmzeroenergy.com

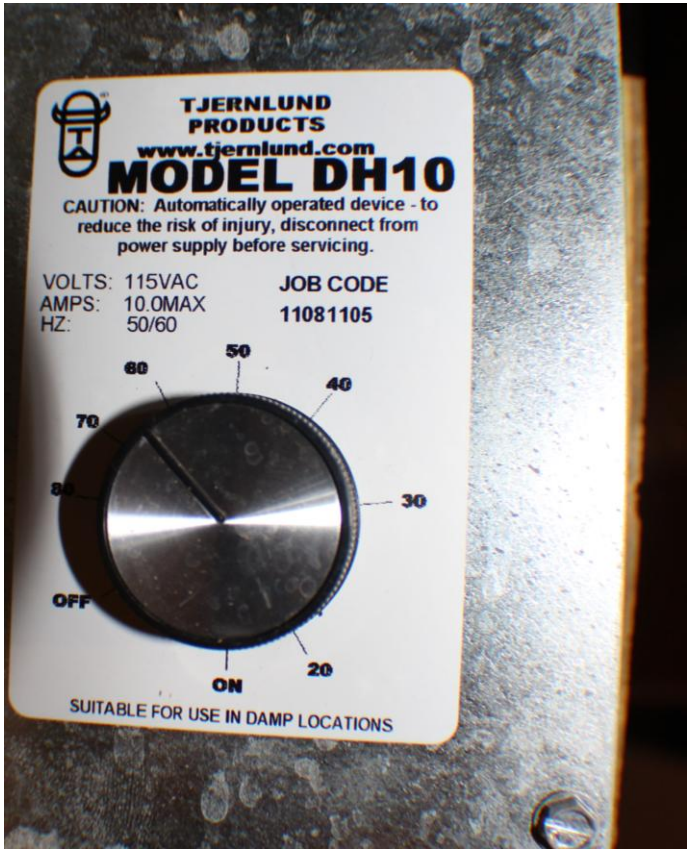
Summer Basement?

Humidity control ?

- ✓ **Monitor with hygrometers**
- ✓ **if needed use a basement dehumidifier *set up to run without needing attendance, with a drain***
- ✓ **Maintain relative humidity below 65%?**

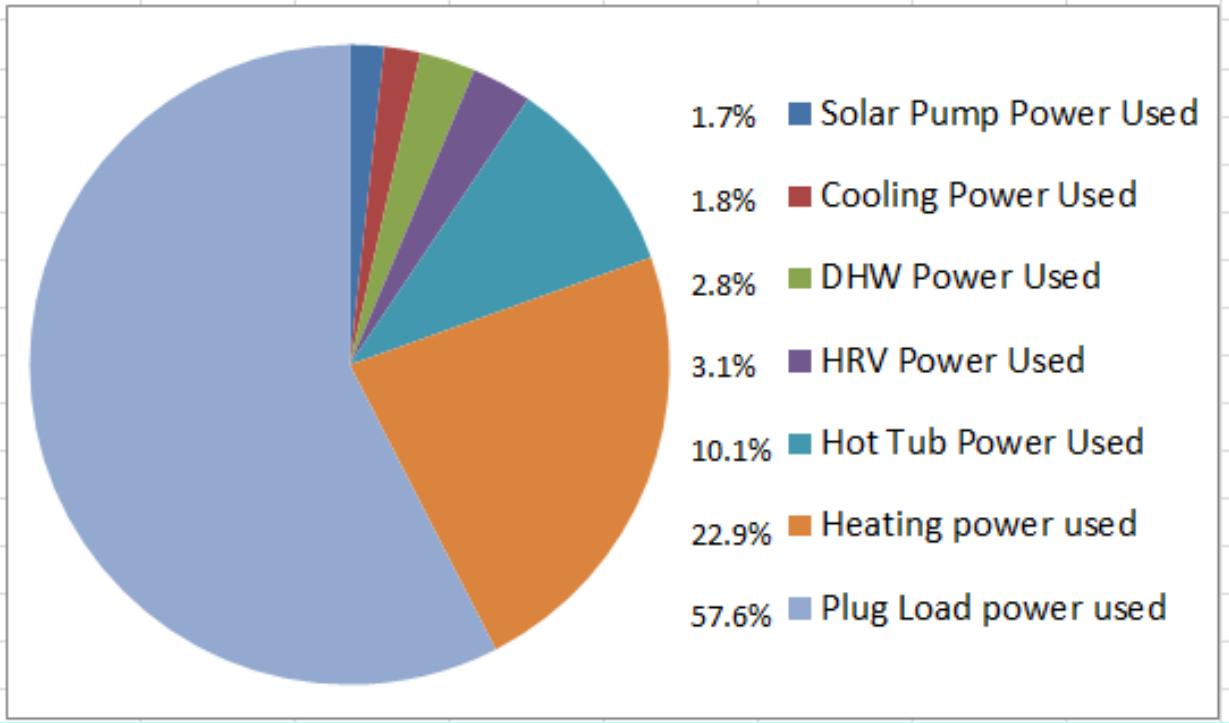
Utility Room Under Spa

Humid summer air meets un-insulated concrete floor



Courtesy rcmzeroenergy.com

Result: Power Usage



Hybrid thermal solar & Geo-Exchange are a “Near-Net-Zero” HVAC solution that make a true net zero energy home practical by adding Photo Voltaic panels. The low KWH of the utilities, allow the home to use ample KWH for a high tech modern lifestyle, without struggling to be “Net Zero”.

Build Tight Ventilate Right!

- ✓Improved Comfort
- ✓Reduce Energy Use
- ✓Fewer Moisture Problems
- ✓Better Indoor Air Quality

Thank You

Please fill our your evaluations

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