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?
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

January  Feb  Mar  Apr  May  Jun  Jul  Aug  Sept  Oct  Nov  Dec
1971-2000

© TBS, LLC, DJ & Co, 2014
Average Monthly Precipitation
Burlington, Vermont

Inches

January February March April May June July August September October November December

1971-2000

rssWeather.com
Burlington Climate Dew Pt. Graph

Online source:
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://rcmzerenergy.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

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

- Pollutant
- Warm Air & Moisture
- Other Stuff?

Original Courtesy Camroden Associates.
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

Groundwater (liquid)
Air From Soil (water vapor)
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 as a system
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

“Kickout”

Slope grade away

Stone drip edge
Enhanced thermal conductivity

*GeoPerformX* tube to extract heat
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
Wall Moisture Control

Exterior

0°  68°

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
Double Stud Wall

Courtesy rcmzeroenergy.com
Dense Pack Cellulose & Rock Wool Batt

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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
Mechanical Ventilation Strategies
Ventilation - Albany, NY

Too Leaky

Very Tight

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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

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

Owner must want to use
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

IMC and ASHRAE 62.2
Quality Bath Fans

Courtesy Fantech
Local Exhaust at All Sources

Courtesy rcmzeroenergy.com

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Good Idea...
Bath Fan Delay Switch

Timer and Off-delay Controls for unattended moisture removal

Courtesy Ametek NCC

Courtesy Broan
Kitchen Exhaust Hood Fan

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

Passive Makeup air.

Courtesy rcmzeroenergy.com
Kitchen Exhaust Fan & Exit

Courtesy rcmzeroenergy.com
Kitchen & Dryer Exhaust Make Up

Courtesy rcmzeroenergy.com
Plan for Laundry & Dryer Exhaust

Filter Box

Booster Fan Access

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

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

INSIDE

Fresh Air to Room

Fixed Partition and Spacer Plates (proprietary resin composite media)

Stale Room Air

OUTSIDE

Stale Room Air (exhausted to outside)

Outside Air
Balanced ventilation systems can provide good distribution
Operated on low & intermittent

Courtesy rcmzeroenergy.com
Supplies from HRV

- Upper Level Living/Dining Supply
- Lower Level Multi-Purpose Room Supply
- Upper Level Master Bedroom Supply
- HRV
- HRV Fresh Air Intake
- Lower Level Bedroom Supplies
- Upper Level Den Supply
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

Operated on low normally, high intermittently

Courtesy Harold Turner
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

Return air registers

Stale Air exhaust

HRV

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
Air in on West side, out on North

Courtesy rcmzeroenergy.com
Prevent Odors in HVAC System?

- Wet filters
- Dirt/mold on liner
- $\text{H}_2\text{O}$ 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”
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

*Diagram showing components of a condensing furnace including Primary Heat Exchanger, Secondary Condensing Heat Exchanger, Combustion Air Intake, Burners, Gas Valve, Combustion Air Exhaust, Inducer Motor, Blower, Condensate Drain Trap, and High Efficiency Condensing Furnace.*
Oil fired semi-sealed combustion

Exhaust

Combustion air

Vacuum relief valve

Courtesy Dave Johnston & Company
Powered Make-up Air

Single Family Homes

Multi-Family Homes

Commercial Buildings

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
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 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

Raining?

AC “On”

Courtesy rcmzeroenergy.com
Over One Year

Indoor Humidity (%RH)

AC “ON”

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
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”.

Result: Power Usage
Build Tight
Ventilate Right!

✓ Improved Comfort
✓ Reduce Energy Use
✓ Fewer Moisture Problems
✓ Better Indoor Air Quality
Thank You
Please fill our your evaluations

www.rcmzeroenergy.com
www:turnerbuildingscience.com
www:hlturner.com

www.thousandhomechallenge.com