Build a Better House

HVAC

Maine Indoor Air Quality Council

Thank you, program sponsors...

Northeast Laboratory Services
Turner Group
RenewAire
TC Hofford Basement
Mitsubishi Electric
Fresh Air
DuPont
Green & Healthy Maine Homes
Performance Building Supply
AGD

Building Science Basics

Bulk Water Management

Heat Flow Management

Air Flow Management

Vapor Management

Rules of Moisture Movement

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



Bulk Water Management



Eave and rake overhangs

Grade slopes away

Flashing

Ground Water

Keep basements dry...

Warm or cold,

but DRY

Site work

Drainage

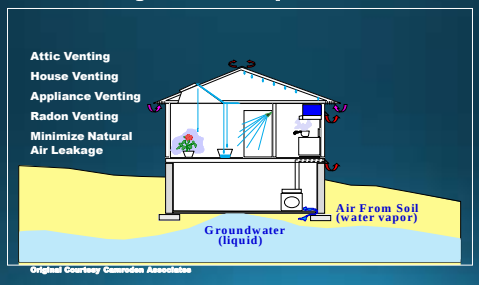
Foundation construction



Courtesy P &K Sand &Gravel Inc.

Ventilation can't fix everything… go to the source

The House As A System Must
Manage Moisture Vapor & Air Flow



7

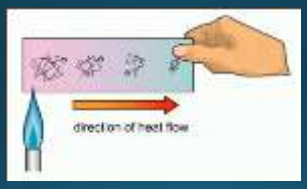
Moisture Sources in a Building

Typical Occupant Activities:
- Cooking,
- Bathing,
- Watering
- Breathing,
- Washing
- Others?



8

Rules of Heat Flow



Heat will always flow from warmer to cooler, or more to less

With no external energy, molecular vibrations slow down until equilibrium is reached

9

Heat transfer mechanisms

Conduction… molecular excitation without molecular movement

Convection… fluid movement of excited molecules

Radiation… electromagnetic motion of charged particles



10

Rules of Air Movement

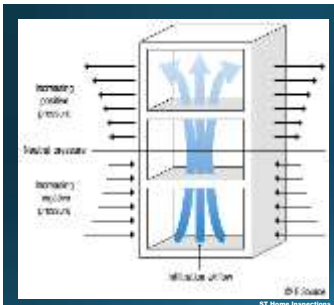


Air moves from high pressure to low pressure

Drivers include
- *Stack effect (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!

11



Stack Effect

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

12

Natural air leakage alone doesn't work well in today's homes

High natural envelope leakage (ELA):

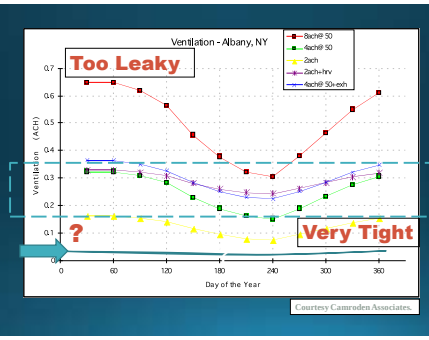
Way too much ventilation & dryness below freezing, not enough when it's much above freezing

No predictable rate unless tested

High heating costs

Drafts are uncomfortable

13



14

Air Leakage Evaluation Performance Assessment

ACH @ cfm50

- **> 5 is not air tight**
- **< 3 is 2015 code, is a good job**
- **< 1 really good job**
- **< 0.6 takes lots of meticulous effort!**

Can also look at CFM @50 Pascals

IECC 402.4.2.1…less than 3 ACH



15

Rules of Vapor Transport

Water vapor will always move from areas of higher concentration to areas of lower concentration

Drivers include...

Vapor pressure differential

Permeability of substrate

Air movement

16

Human Comfort Factors

Metabolic rate

Clothing levels

Air temperature

Radiant temperature

Air velocity

Relative humidity



17

Benchmarks of Good Practice

Dry
Clean
Comfortable
Adequate Ventilation
Pest Control



18

Benefits
Ventilate Right, Build tight

Improve comfort
Reduce energy use
Eliminate moisture problems
Provide clean indoor air
Increased resilience



Maine Uniform Building and Energy Code

IRC…Int'l Residential Code
IBC…Int'l Building Code
IECC…Int'l Energy Conservation Code, or…
ASHRAE 90.1
IEBC…Int'l Existing Building Code
ASHRAE 62.1 and ASHRAE 62.2
ASTM E-1465



http://www.maine.gov/dps/bbcs/

Maine Building Codes

Mechanical Ventilation Rates

Kitchen Exhaust…100cfm intermittent, 25cfm cont.

Bathroom Exhaust…50cfm intermittent, 25cfm cont.

Whole house… .35ACH ?

Kitchen and Bath can be a part of the whole house system

"Quality" Construction Exceeds the Codes

"Compliance" is minimum standard

"Beyond" exceeds standards, and includes redundancy

Avoid over-complication… make it easy for folks in the field

There are two ways to provide HVAC…

Central type systems, tempering the entire volume of the house

"Space" type systems, tempering only those places in need

Central HVAC Systems

Require planning for routing ductwork <u>inside</u> the thermal enclosure

If FHA, ducted system facilitates <u>effective air filtration</u> to remove small particulates

"Space" HVAC Systems

Result in simpler systems, cost less than central systems, may have noise associated with them

Do not provide effective filtration to remove small airborne particulates

Ventilation Types



Structural
Crawlspace
Roof
Sidewall

Occupant
Spot (Bathroom)
Whole house

Combustion
Boiler and furnace
Wood stove and fireplace

Appliance
Clothes dryer
Cooking stove



Basement Systems

To vent,
or
not to vent?



Powered crawlspace Venting

Not a good idea

Attic/Roof Venting

Keeps the roof cold in winter

Lets small amounts of night time accumulating moisture leave from the attic space

House 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



Very poor detail in this climate

Courtesy [illegible]



Better detail in this climate

Courtesy CHBA

Attics/Roof Venting

Use air chutes, don't wash insulation with cold air, and don't restrict air flow to the ridge or gable vent



Courtesy Owens Corning

Attic Hatches?

Need to prevent heated air and moisture from entering uninsulated or cold attics

Gaskets required per code





Courtesy Attic Tent



Most hatches…



…are rarely used

Cold Climate Eave Venting



Easy to insulate to high R levels

Courtesy rcmzeroenergy.com



Sidewall Venting for Rain Drainage and Drying





Why Ventilate? (Occupant Ventilation)

Maintain appropriate humidity

Remove unhealthy pollutants

Increase Comfort

37

Lots of air leakage worked well 200 years ago?



38



How about the last 70 years?

39

Low Ventilation + Chronic Wetting = Mold

Damp and wet basements, bathrooms, windows, and attics often have mold and decay

May or may not be a ventilation problem

Mold is a known allergen and an Asthma Trigger

Maine has one of the highest Childhood & Adult Rates in the US (ALA ME)

40

Low Ventilation

and *unintended* airflows

Signs &Symptoms

Moisture/ice or mold on windows or other surfaces

Ghosting from dust

Lingering odors

Combustion odors/fumes

Moisture in attics



41

Ghosting



42

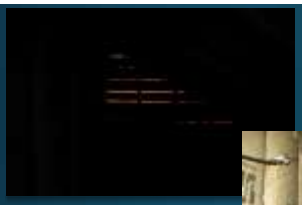
Excess





Natural Ventilation Air Leakage

43

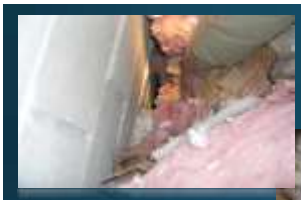


Unplanned air leakage



Poor attic air sealing and insulation

44



Uncontrolled Air Leakage

Courtesy Camroden Associates



45

Unintended Airflow

Way Too Much Building Moisture In The Attic



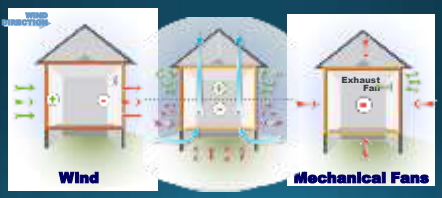


Courtesy Camroden Associates

46

How Much Air? – Delivered How?

What moves air through buildings?

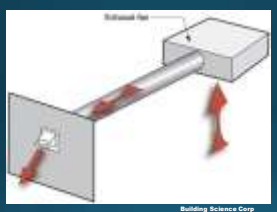


Wind **Mechanical Fans**

Buoyancy

Stack effect - warm air rising

47



Building Science Corp

Non-distributed exhaust ventilation

local source control, spot ventilate

48

Bath exhaust (balanced?)

50 cfm intermittent or 20 cfm continuous



Courtesy Camroden Associates

Std. 62.2
As a Minimum: 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

Quality *Set-able* Continuous? Minimum Flow Bath Fans



variable speed control with high/low delay timer

Humidity control option

RenewAire™ S & P V-Series Ventilation Fans

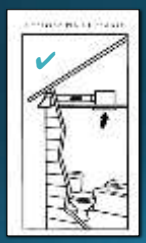
Economical and effective exhaust ventilation for bathrooms, utility rooms and other spot exhaust applications



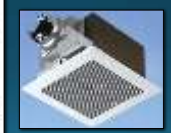
Lowest power consumption of any fan line in the industry
Recess ceiling mount

Designed for continuous low level operation
"Is it on?" quiet

Now Lots of Quality Bath Fans

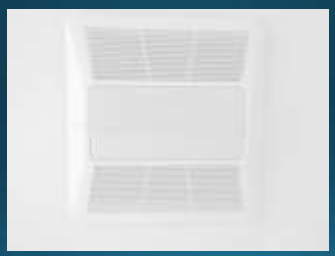


Whole building ventilation may be provided by bathroom or kitchen fan.



Courtesy Panasonic

Combination Light and Fan



Renewaire™ illuminated fan

Also Good Idea...
Bath Fan Delay Switch



Courtesy Amtek HCG



Courtesy Broan



Airetrack™ by Tamarack
A control for whole building intermittent fans

Fan Speed

Built-in Timer

Boost



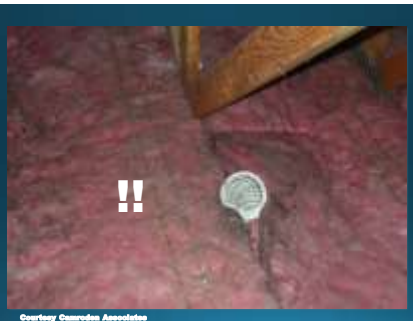
Courtesy USDOE,eere.energy.gov



Courtesy Camroden Associates



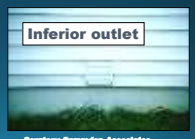




Courtesy Camroden Associates







Good Installation: Exhaust fan in basement, vented through rim joist fitting

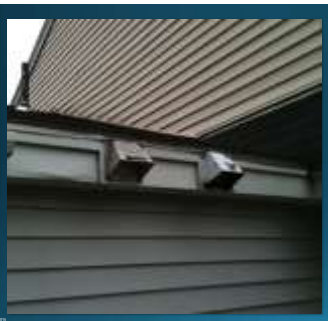
Courtesy Camroden Associates

61

Soler and Palau™ TD Silent



62



Unusual technique

63

Fifteen minute break

64

Kitchen Exhaust Hood Fans



Recommended: 100 CFM "exhaust", (no hair greasers), <u>or</u> Continuous exhaust 5 ACH of kitchen volume.

IMHO: always use quiet exhaust vent hood on all cook stoves

65



Combustion Cooking

66



Resistance Cooking

67

Induction Cooking





68

Ventilation is necessary no matter how you cook



69



Exhaust the kitchen range
-100 cfm inter. or 25 cfm continuous IRC (ductless allowed)
- 100 cfm inter. or 5 ach continuous (if less, range hood must be used) ASHRAE 62.2 (ductless not allowed)



Courtesy Camroden Associates

70

Normal Size: Multi Speed Kitchen Exhaust Fans

Venmar Signature SL
IAQ Range Hood
75, 160, or
270 CFM High

40 CFM
Continuous Low
(less than 1 sone)

17 watts power on low
http://freshairventilation.net/
http://www.swillistonsales.com/



Courtesy Venmar

71

Large Kitchen Exhaust Hood Fan



Courtesy rcmzeroenergy.com

400+CFM requires make up air

IRC M1503.4



Skuttle

72

900 CFM exhaust, 900 CFM supply



73

Dacor™ Pop-up Ventilator



400 – 600 CFM

74



Down draft Range ??

75



76

Kitchen & Dyer Exhaust Make Up





Courtesy rcmzeroenergy.com

77

Kitchen Exhaust Fan & Exit





Courtesy rcmzeroenergy.com

78

Mechanical Ventilation

Accomplished with: Ducted or non-Ducted

Energy recovery unit or units

Small multi speed exhaust fans

Ducted Central Exhaust?

***Clearly labeled* Automatic Control with timer and override**

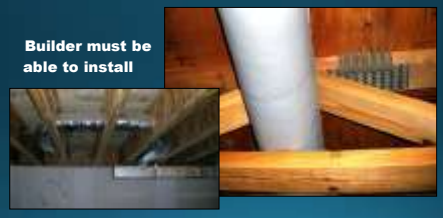
or connected with heating/cooling system?

All need planed make-up air, may need distribution.

79

Systems must be quiet, easy to operate and maintain, and economical

Builder must be able to install



Owner must want to use

80

Utilize a soffet for distribution

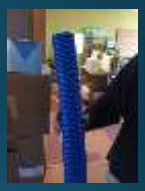


MDF and ceiling tiles

Directional vanes

81

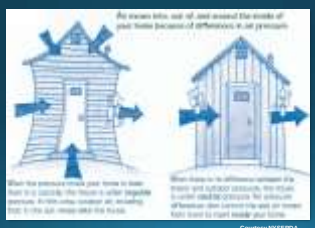




Small diameter duct

82

Exhaust ventilation requires some type of *make-up air*



Courtesy NYSERDA

83



Manual make up air devices ?

84



Automatic make up air ?

85





Passive manual make up air devices

86

Mechanical Ventilation: 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 and distribution (exhaust air out, makeup air in)**

87

Maine "Code" Home Ventilation Guidance

Follow ASHRAE 62.2-2013

(ASHRAE) American Society of Heating, Refrigerating, and Air Conditioning Engineers

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

www.ashrae.org

1-800-527-4723

88

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

89

Average installed cost, including controls, no energy recovery: $825 ?

www.ashrae.org



90

The Engineer's House….???



Courtesy rcmzeroenergy.com

Std. 62.2 "Whole House Ventilation Requirement"

noise less than one sone

Energy Recovery Ventilator or Continuous Exhaust Fan When Occupied

Operate when house is closed up and occupied

Can be provided by the "low speed" of 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 now due to sealed combustion or all electric homes



Quiet Central Exhaust Fan?



Courtesy Camroden Associates.

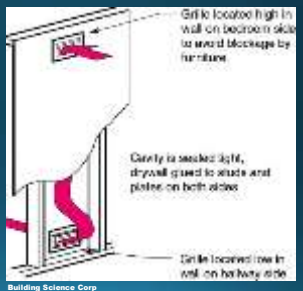
Well distributed ventilation??

Rooms distant from exhaust point will be poorly ventilated, if at all

Indoor pollutants and moisture can build up

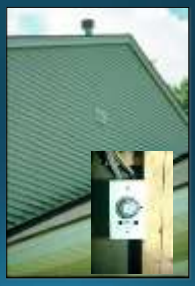
Undercutting doors seldom serves as distribution method

Air Distribution?



Building Science Corp





Courtesy Camroden Associates.

Some Residential Control Options

Cycle or Change Speed Based on:

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

Attached Garage Exhaust Fan?





Why not "Supply Only" ventilation?

Supply only ventilation would require "make up…vacuum"?

Supply only ventilation would pressurize the building, causing what?

Balanced Ventilation Systems

Average installed cost, including controls, *with* energy recovery: $5000?

www.ashrae.org



Definitions

Balanced Ventilation… exhaust and supply (make up air) that neither pressurize nor depressurize a building

Air to Air Heat Exchanger… designed to transfer heat (and moisture?) between two air streams

Heat Recovery Ventilator (HRV)… only transfers sensible heat only; no humidity transfer occurs

Energy Recovery Ventilator (ERV)… transfers sensible heat and humidity (latent heat) from one air stream to another

Importance of Recovery Ventilation

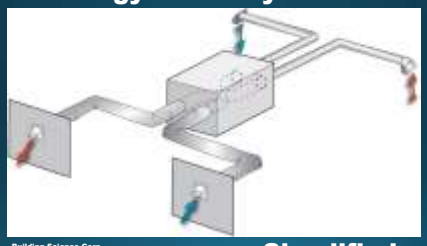
" 1/2 of global energy is used in buildings.

And half of heating/cooling cost is caused by ventilation when it is done by the "open window" method

Ventilation recovery is the most cost-efficient, sustainable, and quickest way to reduce energy consumption & provide better IAQ"

Excerpt from Wikipedia

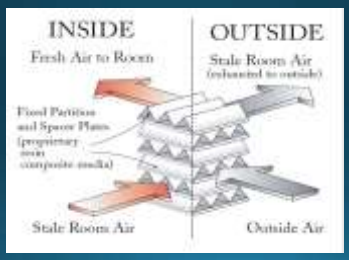
Typical Energy Recovery Ventilation



Building Science Corp

Simplified

Energy Recovery Units



Not a New Idea or Product

28 Years in Service

<u>Maintenance:</u> Air filters cleaned annually, 1 blower replaced after 14 years



Courtesy Harold Turner

Operated on low normally, high intermittently



Now Many Size Units Available From Many Sources

Saves Energy when heating, cooling, controlling humidity

80% efficient

Renewaire™

Balanced ventilation systems provide good distribution (unless the exhaust and outdoor air are both ducted to a furnace distribution system)



Courtesy Camroden Associates.

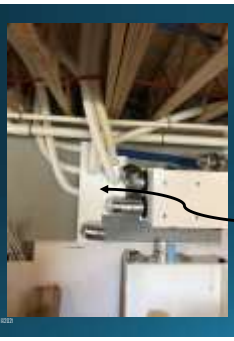


Photo Credit: Alex Wilson



Photo Credits: Harold Turner





Another version

Site built plena for supply and exhaust

Energy Recovery Units User Friendly Controls





Courtesy Renewaire

Percent Run Time

Even distribution is important with balanced systems…

Must be balanced and well located

If HRV or ERV blow "cold" air on the occupants

they will not get used much…
problems ?

Air “in” on West side, “out” on North

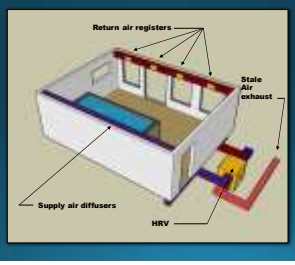


Courtesy rcmzeroenergy.com

Special Ventilation Need : Indoor Pool



Pool room schematic





42,000 gallons @ 84° ????



Or Put Outdoors, Energy Efficient Hot Tub?



Big dogs

Special requirements !

Code doesn’t account for animals





Lunos™



TwinFresh™ Comfo





Whole House Fan?



Quiet Central Exhaust With Make-Up Air From Heating System Return

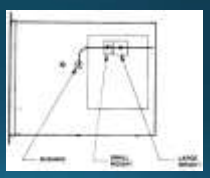


Courtesy Conredon Associates

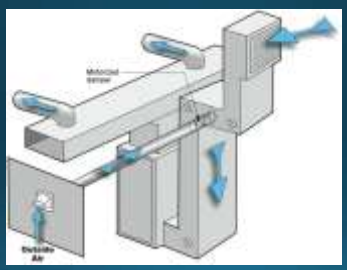
Passive Make-up Air Furnace / AC Kit



Skuttle™ 216 Make-up Air Control



Courtesy Skuttle



Building Science Corp





Courtesy Conredon Associates



End of Session One

Up next…

Rick Karg

Residential Energy Dynamics

Build a Better House

HVAC, Part II

Maine Indoor Air Quality Council

Thank you, program sponsors...

Northeast Laboratory Services

Turner Group

RenewAire

TC Hufford Basement

Mitsubishi Electric

DuPont

Fresh Air

Green & Healthy Maine Homes

Performance Building Supply

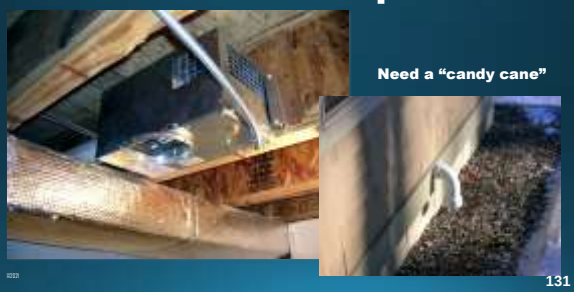
AED

Powered Make-up Air?



Courtesy Tjernlund Inforcer

Powered Make-up Air



Need a "candy cane"



Radon in Maine

High radon potential
Likely 4 pci and above
Moderate radon potential
Likely 2-4 pci

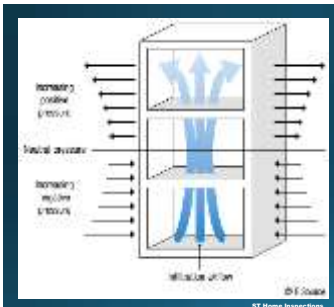
The Maine Radon Section recommends that ALL homes be tested for radon. One in three homes tested exceed guidelines. Mitigation recommended if 4.0 or higher, and should be considered if between 2-4.

www.maineradiationcontrol.org for more information

Radon and "Ventilation"

"Dilution" through continuous ventilation is a marginally successful method of radon exposure reduction

Containment through pressure manipulation, i.e. sub-slab depressurization, is a highly successful radon mitigation method



Stack Effect

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

Pressure Manipulation

ASTM E 1465 08

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



Radon Solutions

Radiation Control Program

www.maineradiationcontrol.org

Radon resistant construction minimizes radon entry and increases success rate of sub-slab depressurization

***Always* Install VDR and insulation prior to concrete placement**

Helps in radon mitigation



Health and Ventilation

Damp houses
- Moisture damage in the envelope, mold exposure may contribute to health problems

Pollutant accumulation
- Contaminants in home can lead to a range of health effects

Back drafting *(unintended airflow)*
- Combustion products from unplanned airflows can lead to illness and death

Backdrafting (draft reversal)

Air moves down the chimney and into the room

Typical contributing factors:

- **Cold chimney**
- **Atmospheric venting**
- **Lack of make-up air**
- **Large exhausts**
- **Wind/exit geometry**
- **Renovations which do not address combustion safety**



139

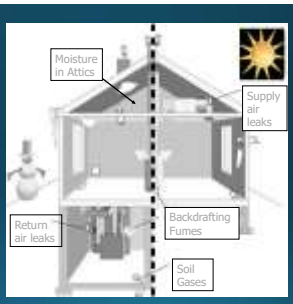
When combustion devices spill fumes into the house it can be hazardous



Courtesy Camroden Associates

140

Unintended airflows lead to various problems in winter or summer



Courtesy Camroden Assoc.

141

Modern performance issues can become complicated

- **No Backdrafting (Sealed Combustion or no combustion)**
- **Planned Range Hood**
- **Planned Make-up Air**
- **Planned Bath Room Exhaust**
- **Vented Dryer ?**
- **Planned Air Filtration?**
- **Dehumidification?**
- **Low VOC Finishes?**
- **Planned wind/exit geometry**
- **Attached Garage Exhausted?**
- **Others?** ***Operated & Maintained Correctly ?***



142

Today's homes need *controlled* ventilation (Who's responsible?)

Building America national home data 600+ US homes

- **Typical measured ACH_{50} = 3-5**
- **4 ÷ (20) = air changes hour < .2**
- **"ELA" less than 1 sq. Foot**

Most New Homes are built fairly tight…

Ventilate them right!



143



What about windows

Note frost at parting rail

ASHRAE 62.2 6.6

Passive Vents?

144

Cap and vent sumps

or soil gas, radon, moisture flow into the home



Courtesy Mr. Basement

145

Please don't do this



146



Or this

147

Or this



148

Or this



149

Even with supplied terminations, moist exhaust is drawn back into attic



150



151

Measuring Exhaust Air Flow



Courtesy USDOE,eere.energy.gov

152

How Much Air, Whole House ?

Whole Building Ventilation Requirement Cubic Feet per Minute (new homes, continuous fan operation)			
Floor Area (ft^2) of Conditioned Space	Number of Bedrooms		
	0 - 1	2 - 3	4 - 5
< 1500	30	45	60
1501 – 3000	45	60	75
For homes larger than 3000 ft^2 and homes with more than five bedrooms, see ASHRAE Standard 62.2-2003, Table 4.1a.			

Courtesy R.J Karg Associates and ASHRAE

Sec. 4.1.3 If old building, tested to be leaky, may be reduced by 50%.

153

Calculating Required if 62.2 – 2010

Base formula, step by step:

Multiply the number of bedrooms + 1 or the number of people by 7.5 CFM per person:

4 people * 7.5 CFM/person = 30 CFM

Calculate 1 CFM per 100 square feet of floor area:

1500 ft^2/100 ft^2 per required CFM = 15 CFM

Add them together:

30 CFM + 15 CFM = 45 CFM continuous

Courtesy USDOE,eere.energy.gov

154

That's complicated!

CFM calculation options:

Appendix B of Ventilation Chapter in *Workforce Guidelines for Home Energy Upgrades*, DOE/NREL, 2011(details of the required math).

ZipTest Pro[3] for the Texas Instruments TI-89 calculator (R.J. Karg Associates).

ResVent 62.2 for the iPhone, iPad, and iPod touch (R.J. Karg Associates).

http://www.residentialenergydynamics.com/REDCalcFree/Tools/ASHRAE6222013

TECTITE from the Energy Conservatory, updated end of 2011.

Courtesy USDOE,eere.energy.gov

155

http://www.residentialenergydynamics.com/REDCalcFree/Tools/ASHRAE6222013



Courtesy RED

156

Cost-effectiveness of Energy Recovery

Compare cost-effectiveness of exhaust only vs. HRV in a cold climate.
Annualized cost = Installed cost/lifetime + annual operational costs + annual heating (or cooling) penalty.

Fan Type	Installed Cost	Lifetime (yrs)	Operational cost/yr	Heating penalty/yr[1]	Total annualized cost
Exhaust only, 20 CFM	$400	10	$30	$110	$ 180 **(Client pays $140)**
HRV, 20 CFM	$1,500	10	$60	$55	$ 265 **(Client pays $115)**

[1]Based on electric heat at $0.11/kWh in a 6,500 HDD climate. HRV assumed to reduce heat loss through fan by 50%.

Courtesy USDOE,eere.energy.gov

Ventilation and Source Control

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…





Limit VOC Sources

No VOC Paint
No Stink Carpet
Tile or Concrete Flooring
Area Rugs
Others?

"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



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



Make-up air ?

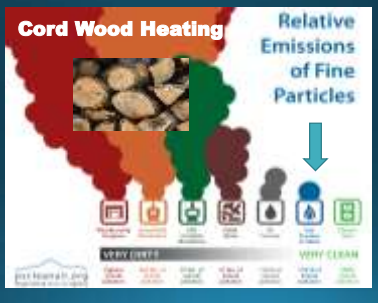
ASHRAE 62.2

Heating



Burning Wood

When Burnt



"Seasonal smoke from outdoor wood fired boilers poses health risk"



UW-Madison



Most folks like wood fired radiant heat

Especially in older leaky homes

Removing Particles Air Filtration

This is not an air filter



Typical MERV 8 filter



Minimum Efficiency Reporting Value

Particle Filtration Maintenance?



Courtesy Turner Building Science & Design, LLC

Typical residential furnace higher efficiency particle filter for new or retrofits in some furnaces



Questions

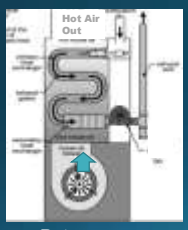
- Filter Eff. Curve
- Pressure Drop
- Power Consumption
- Life of Filter
- Periodic Cost

Normal install of particle air cleaning filter

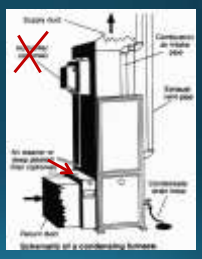


Courtesy: honeywellstore.com/store/images

Get a Modulating Gas Fired Condensing Furnace



Return



Add 4 inch pleated filter

Proper size , fit, and maintenance is important for all air filters, especially high efficiency

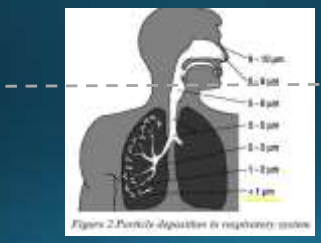


Up to 1500 cfm (492 FPM)

$25.00?

175

Small particles penetrate very deeply



Courtesy:http://www.cleanairhouston.com/test-page.htm

176

Ducted HEPA particle air cleaning device On building supply air (my brother's net zero home)



Courtesy: fantech.net/CM3000



Courtesy: rcmzeroenergy.com

177

Typical HEPA stand alone room particle air cleaning device (less than $500)



Courtesy austinair



178

Creating a Sanctuary Room

1. Size as recommended:
   AHAM clean air performance rating

2. Questions to seek answers to:
   - Filter Eff.
   - Flow Rate
   - Power Consumption
   - Noise Level
   - Life of parts
   - Cost

Size In ____Air Changes Per Hour

179

W. Turner our sanctuary bedroom areas, Medium speed = 125 CFM





http://www.thousandhomechallenge.com/case-studies

Maine Antique

180

Home made particle air cleaners



Never allowed indoors?

Isolate and vent to the outdoors





Courtesy Camroden Associates

No "Scented Candles" In Glass Jars Indoors



Nanoparticle source	Concentration (nanoparticles/cm^3)
Pure wax candle	241,500
Radiator	218,400
Cigarette	213,300
Frying meat	150,900
Heater	116,800
Gas stove	79,600
Scented candles	69,600
Vacuum cleaner	38,300
Air freshener spray	29,900
Ironing a cotton sheet	7,200

Table 1. *Measured concentrations of nanoparticles resulting from various common indoor household activities, after [124].* **Nanomaterials and nanoparticles: Sources and toxicity Cristina Buzea*(1), Ivan I. Pacheco Blandino**(2), and Kevin Robbie***(1), Biointerphase, vol.2, issue 4 (2007) p 17-172**

Fifteen minute Break



Efficient?
Legal for heating indoors?





You can't go wrong with that...

Window mounted pellet stove?





Manchester, ME



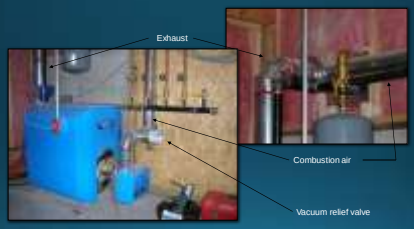
Atmospheric oil fired forced hot water boiler

Heavy duty and bullet proof 20-30 year life span

AFUE = 86.2%

187

Oil fired semi-sealed combustion?



Non condensing boiler

188

Gas or Oil fired Condensing boiler

The plume contains CO2 and H2O



189

High sulfur exhaust plume



190

Condensing Oil Fired Boiler



AFUE =88.1%



Vitorondens 200-T 53KW Oil

191

Sealed combustion

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

Veissmann™ Vitodens

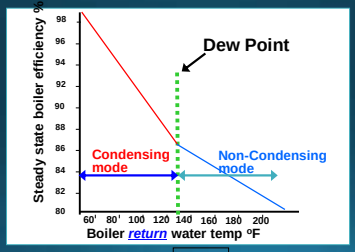
AFUE = 95%



Condensing boiler

192

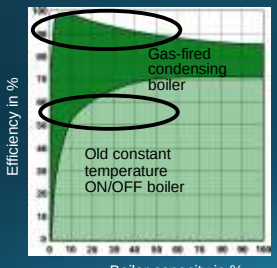
Boiler fuel efficiency



193

So why switch to far more complicated condensing boilers and furnaces?

194



Typical boiler efficiencies

96 % vs. 56%

195

High Performance Boiler Repairs?

Trained Expertise Available?
Contracted Maintenance?
Stocking Spare Parts?

Who?? How Fast??

196





FHW Distribution





197



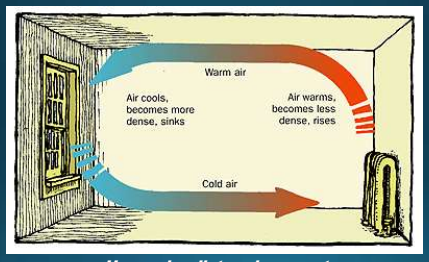


Normal radiator placement

Why?

198

Uncomfortable Convective Loop, cold floor, cold feet



Unusual radiator placement

199

CP371 Qmark Radiant Panel



120V 375 watts

Spot heat in bathrooms

Easy repairs?

200

Heat Pump Efficiency

Heat pumps deliver 3-4 units heat per one unit energy

Gas fired boilers deliver 0.9 units heat per one unit energy

201

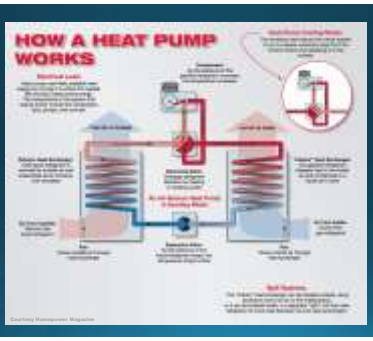


Harmonic Noise



Dead quiet

202



203

Mini-splits





Typically do not have outside air supply



204

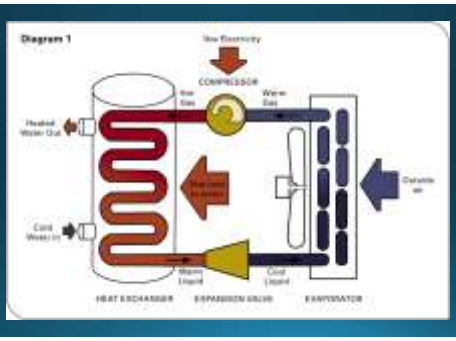
Heat Pumps Must Be Sized Properly, goal run and modulate, *not on/off*

May be stand alone or ducted

One head or several heads



Heat Pump Water Heater





Sanden SANCO$_2$ Heat Pump Water Heater



Vented clothes drying!?

People complained about slow clothes drying

This fell out







Non vented dryer





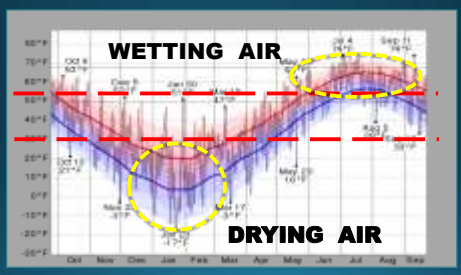
The original unvented dryer

Additional Req. 62.2 2007

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

Some further "Maine Climate Considerations"

New England Dew Point Climate Graph



WeatherSpark.com

Outdoor summer ventilation make-up air wets basements



217

Summer Basement Solution

Humidity control

Monitor with hygrometers

Use a basement dehumidifier *set up to run without needing attendance, with a drain*

Maintain relative humidity below 50%

218



Dehumidifiers



Critical operating T°

219



Add Humidity?

Aprilaire 800

Requires outdoor T° sensor to lower Humidification Rate as T° drops

Max 45%
25% when cold

220

Builders' Responsibilities

Radon… knowledge and implementation of ASTM E1465

Radon testing and mitigation are regulated in the State of Maine

221

Builders' Responsibilities

Ventilation… knowledge and implementation of ASHRAE 62.2, IRC, IECC

Ignorance of current standards and "best practices" does not provide immunity from legal action

222

Ventilate Right Build Tight

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

Additional Questions & Comments

Maine Indoor Air Quality Council
www: maineindoorair.org

David Johnston
djohn2054@gmail.com

Turner Building Science, LLC
www:turnerbuildingscience.com

Maine Radiation Control Program
www.maineradiationcontrol.org

A good resource

Building America Best Practices Series Volume #12
Builders Challenge Guide to 40% Whole-House Energy Savings in the Cold and Very Cold Climates:

http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/cold_climate_guide_40percent.pdf

Chapters: 6,7,8, (13 has checklists)

Building America Solutions Center

https://basc.pnnl.gov/building-components#selection

Tight Ducts
HVAC Quality Installation
Ventilation
Filtration
Pressure Balancing
Efficient Controls
Dehumidification in Hot and Humid Climates
Ducts in Conditioned Space

Another good resource

- *http://www.mainestar.us*
- *Wes Riley, MaineStar LLC, (class handout 2015)*
- *MaineStar 2012- New Home Standards*
  - *New Home Certification Stds. Pdf file*
- *http://energy.gov/eere/buildings/zero-energy-ready-home*

End of Session Two

Up next…

Dana Fischer

Mitsubishi Electric