Build a Better House

HVAC

Maine Indoor Air Quality Council

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Thank you, program sponsors...























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Building Science Basics

Bulk Water Management

Heat Flow Management

Air Flow Management

Vapor Management

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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



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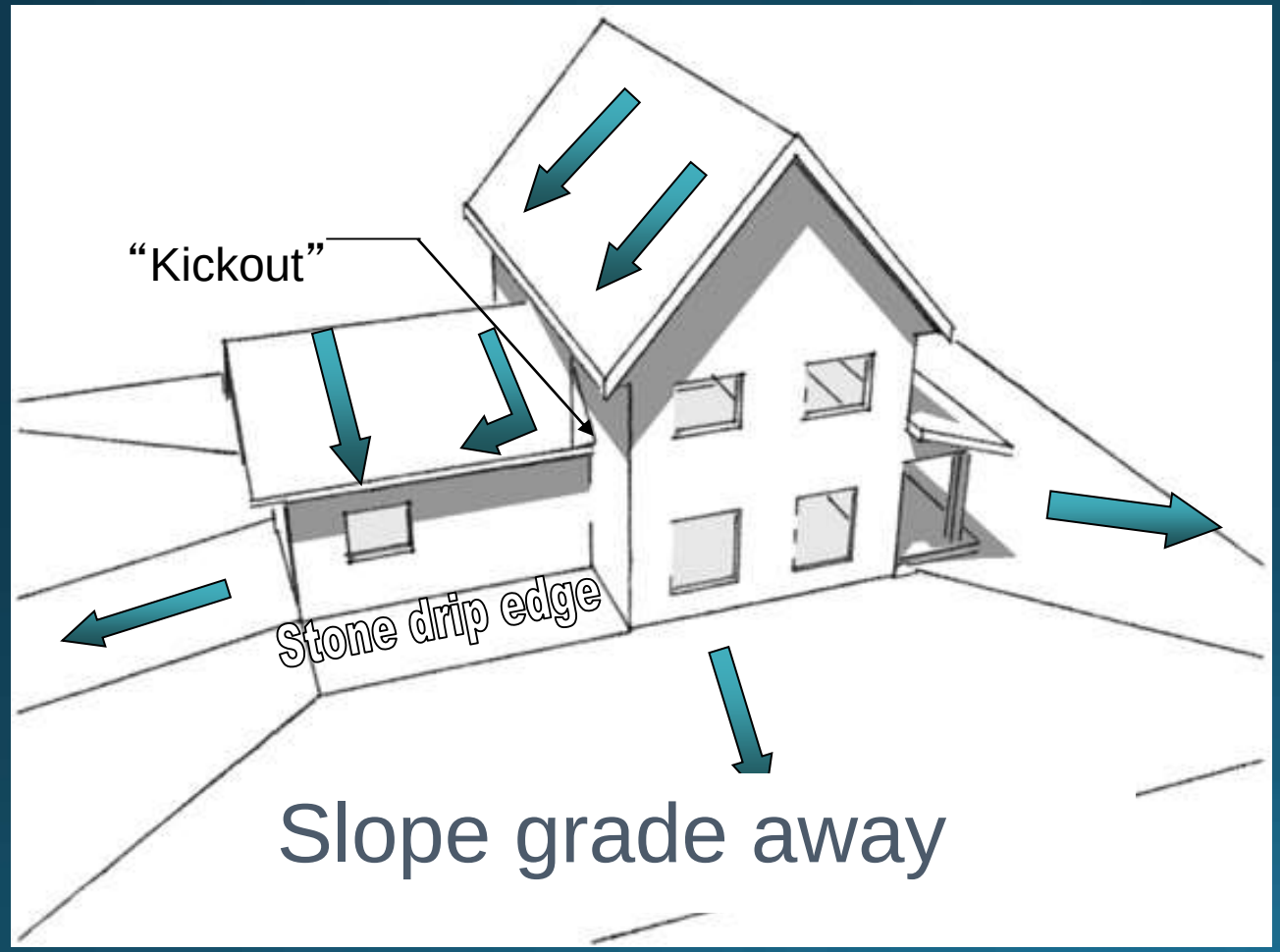
Bulk Water Management



Eave and rake overhangs

Grade slopes away

Flashing

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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

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The House As A System Must

Manage Moisture Vapor & Air Flow

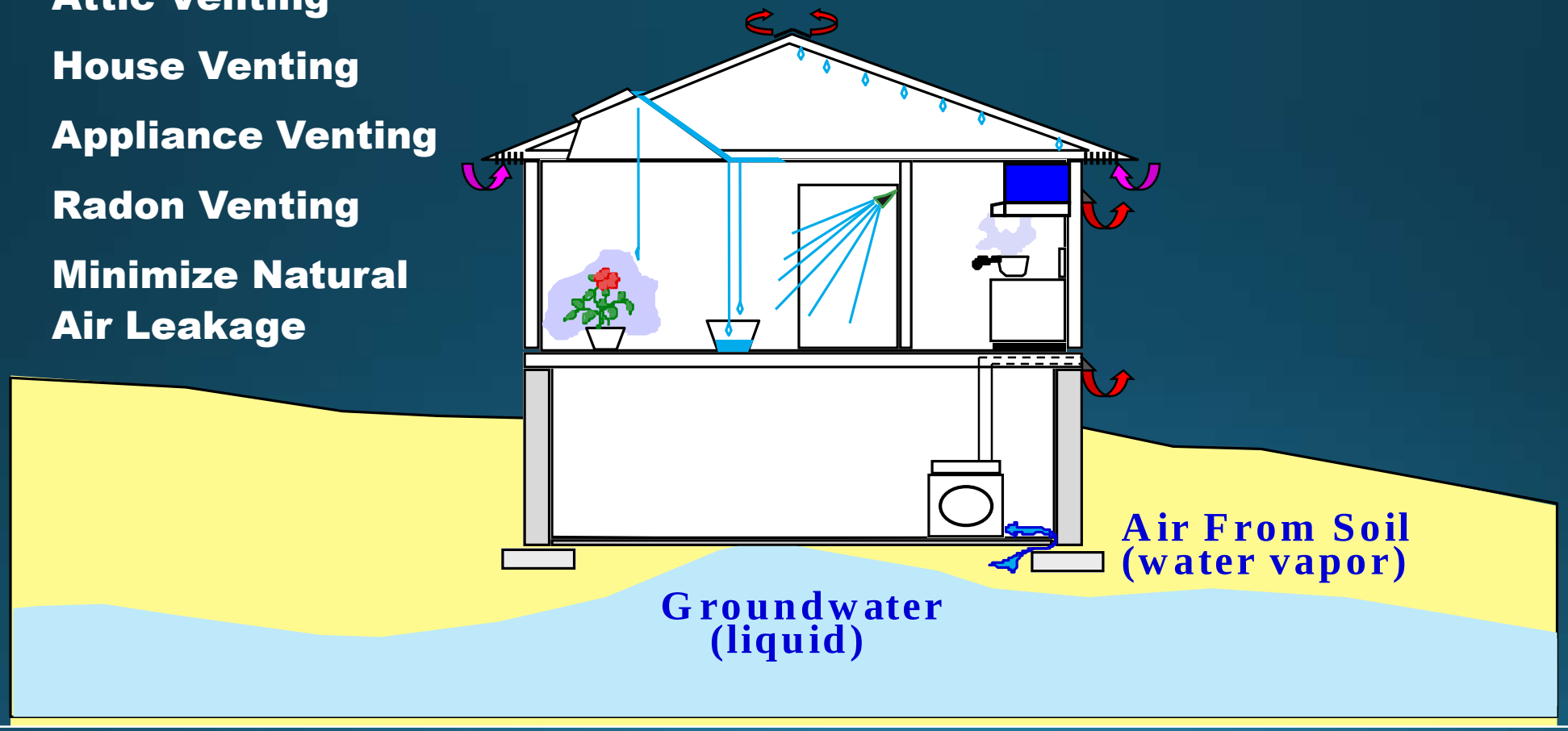
Attic Venting

House Venting

Appliance Venting

Radon Venting

Minimize Natural Air Leakage



Original Courtesy Camroden Associates

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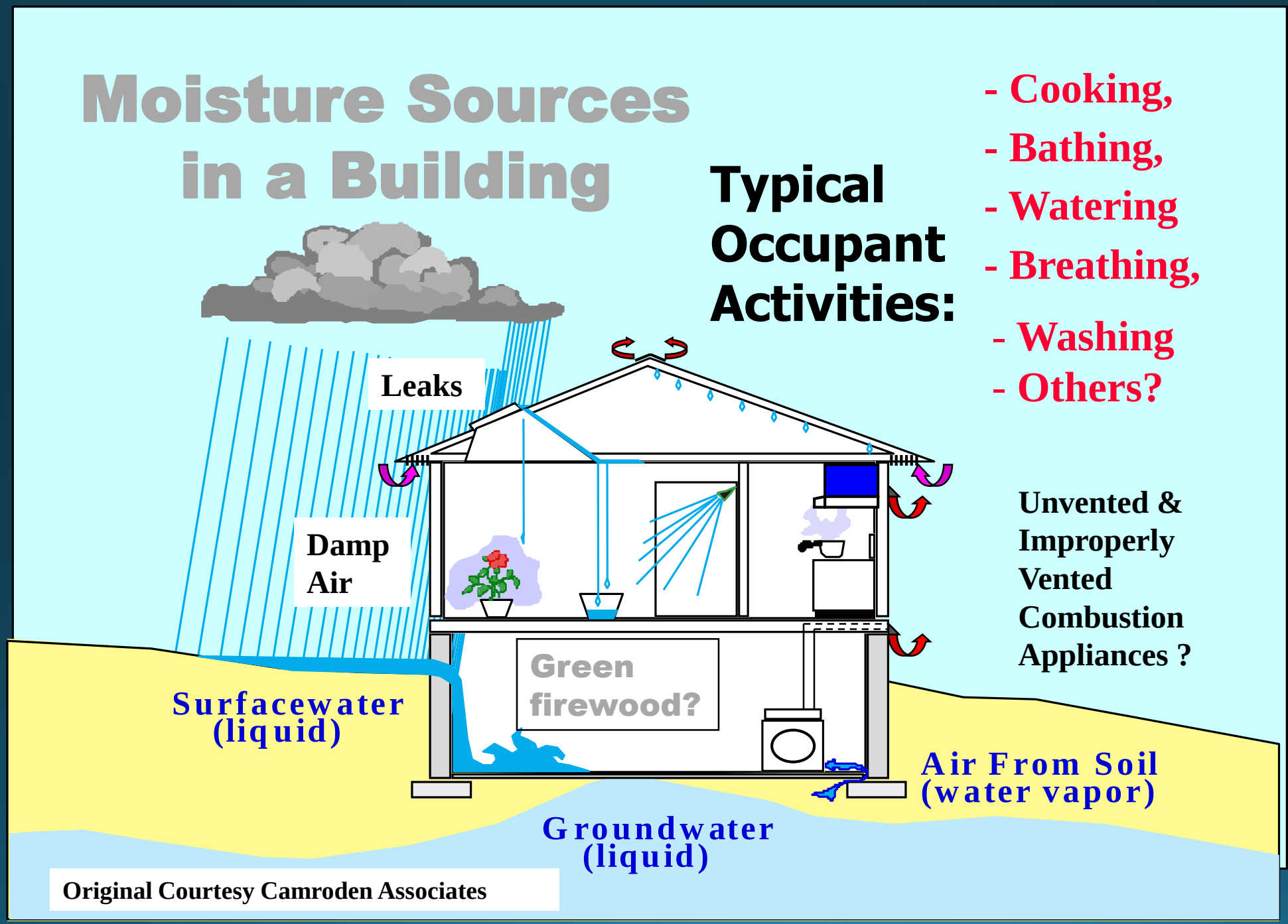
Moisture Sources in a Building



Typical Occupant Activities:

- Cooking,
- Bathing,
- Watering
- Breathing,
- Washing
- Others?

Unvented & Improperly Vented Combustion Appliances ?

Original Courtesy Camroden Associates

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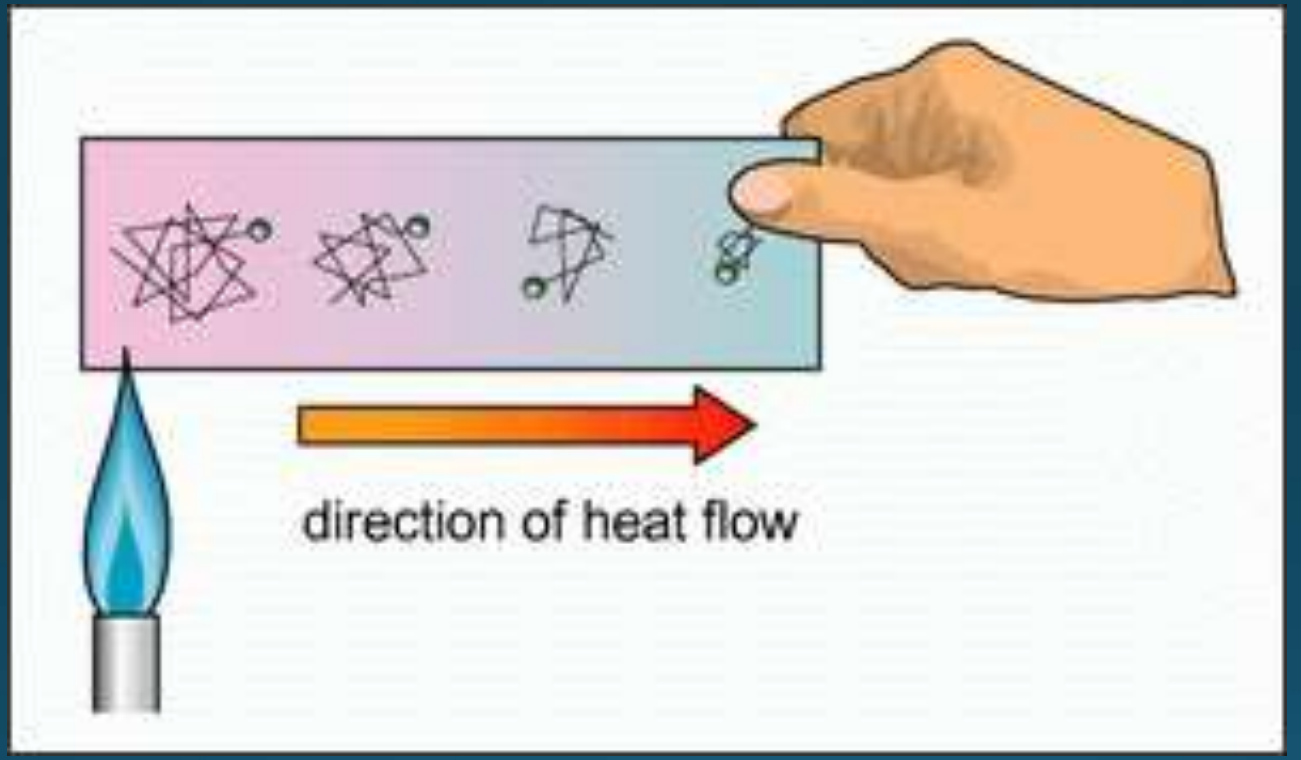
Rules of Heat Flow



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

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

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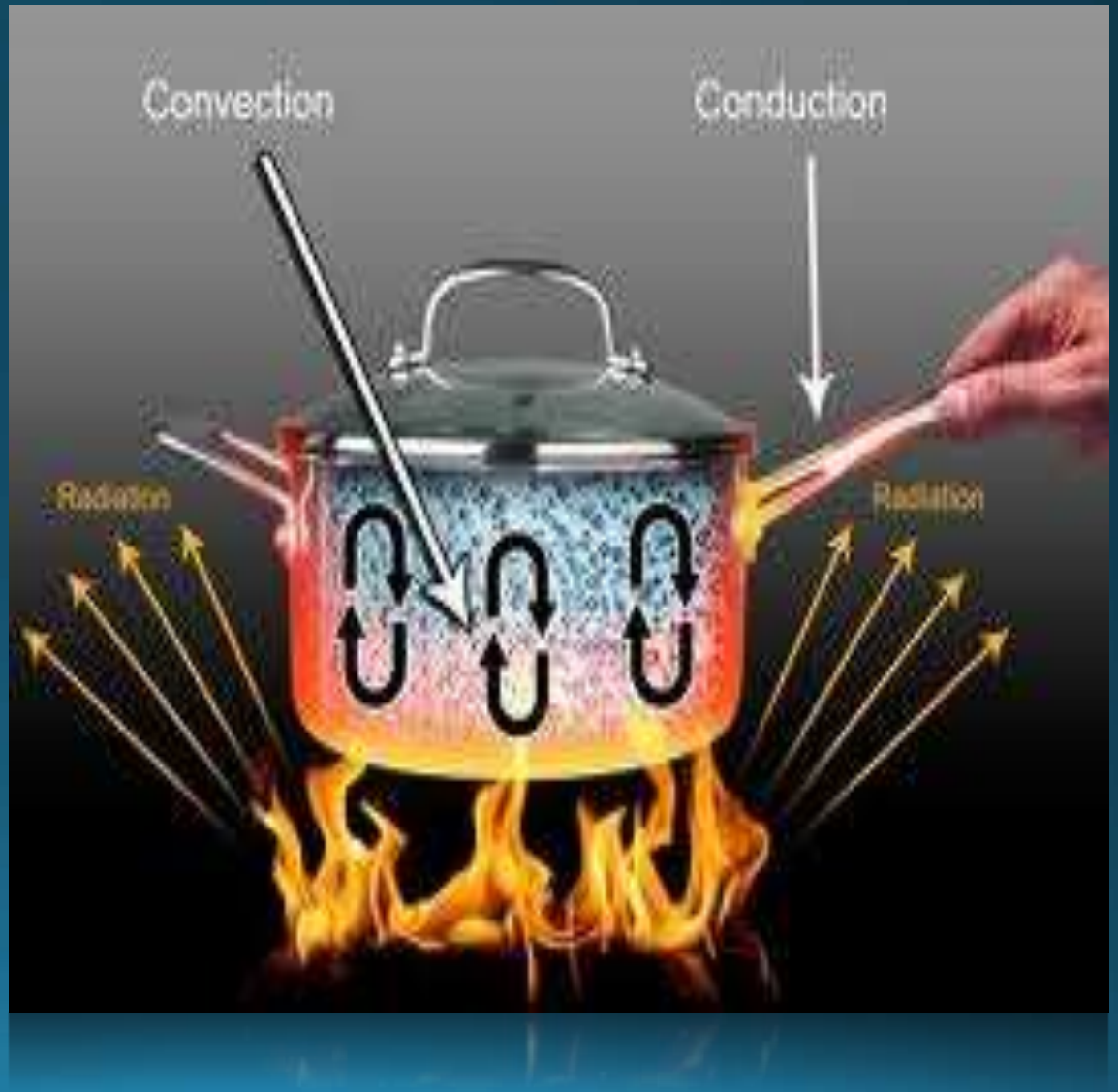
Heat transfer mechanisms

Conduction… molecular excitation without molecular movement

Convection… fluid movement of excited molecules

Radiation… electromagnetic motion of charged particles



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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!

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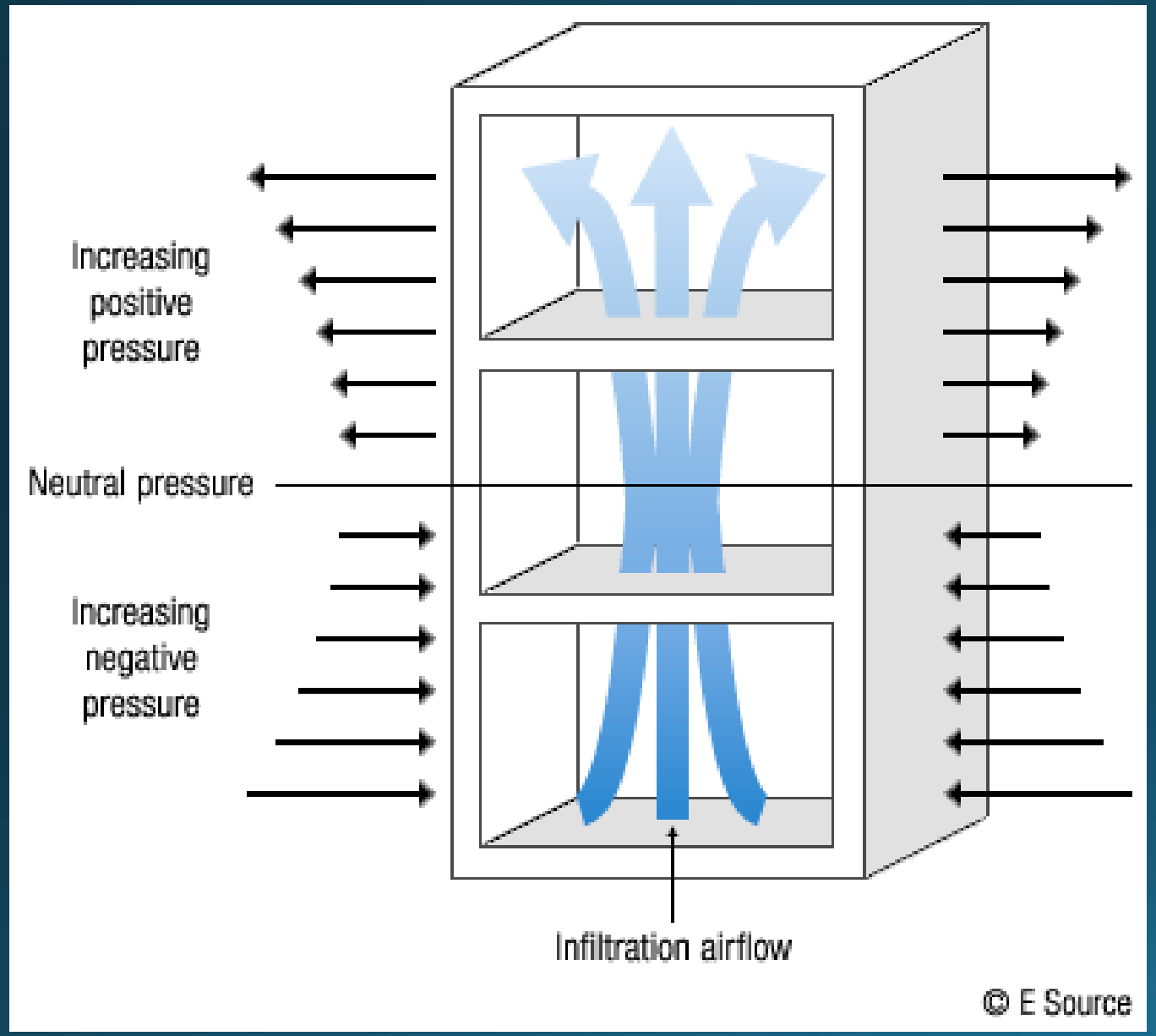
Stack Effect



ST Home Inspections

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

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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

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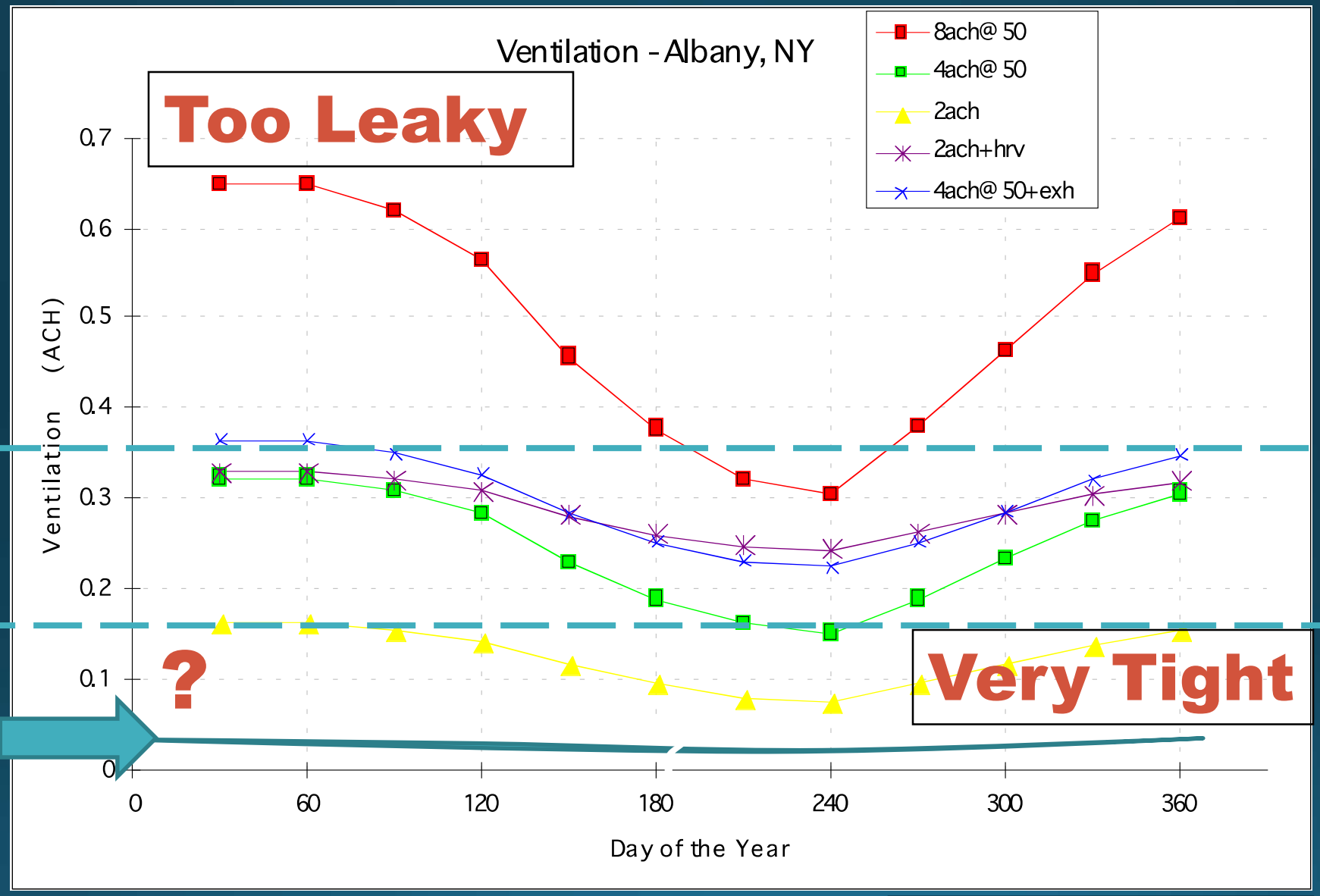

Courtesy Camroden Associates.

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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

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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

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Human Comfort Factors

Metabolic rate

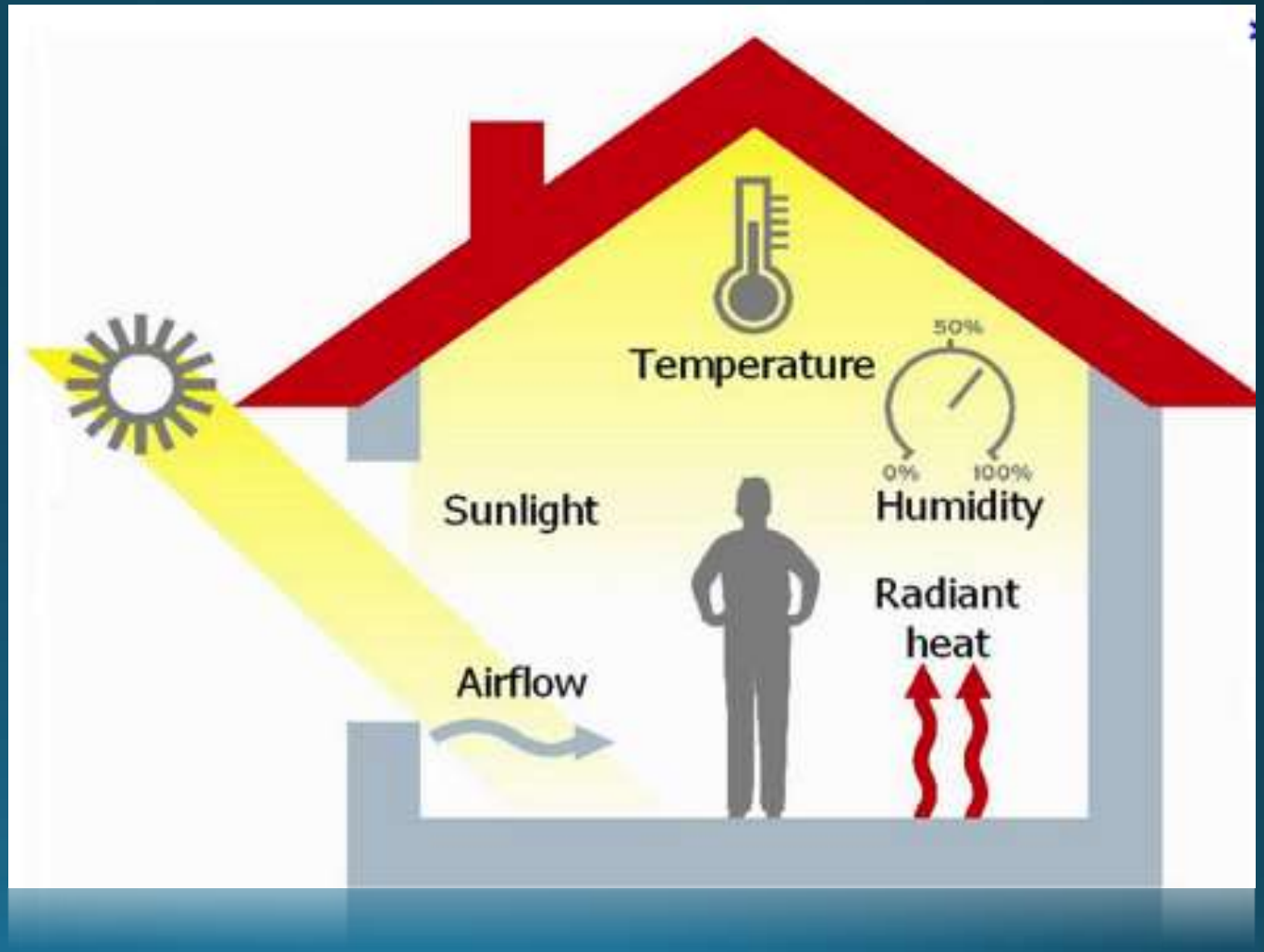
Clothing levels

Air temperature

Radiant temperature

Air velocity

Relative humidity



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Benchmarks of Good Practice

Dry
Clean
Comfortable
Adequate Ventilation
Pest Control



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Benefits
Ventilate Right, Build tight

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



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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/

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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

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“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

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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

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Central HVAC Systems

Require planning for routing ductwork inside the thermal enclosure

If FHA, ducted system facilitates effective air filtration to remove small particulates

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“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

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Ventilation Types



Structural
- *Crawlspace*
- *Roof*
- *Sidewall*

Occupant
- *Spot (Bathroom)*
- *Whole house*

Combustion
- *Boiler and furnace*
- *Wood stove and fireplace*

Appliance
- *Clothes dryer*
- *Cooking stove*

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Basement Systems

To vent, or not to vent?

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Powered crawlspace Venting

Not a good idea

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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

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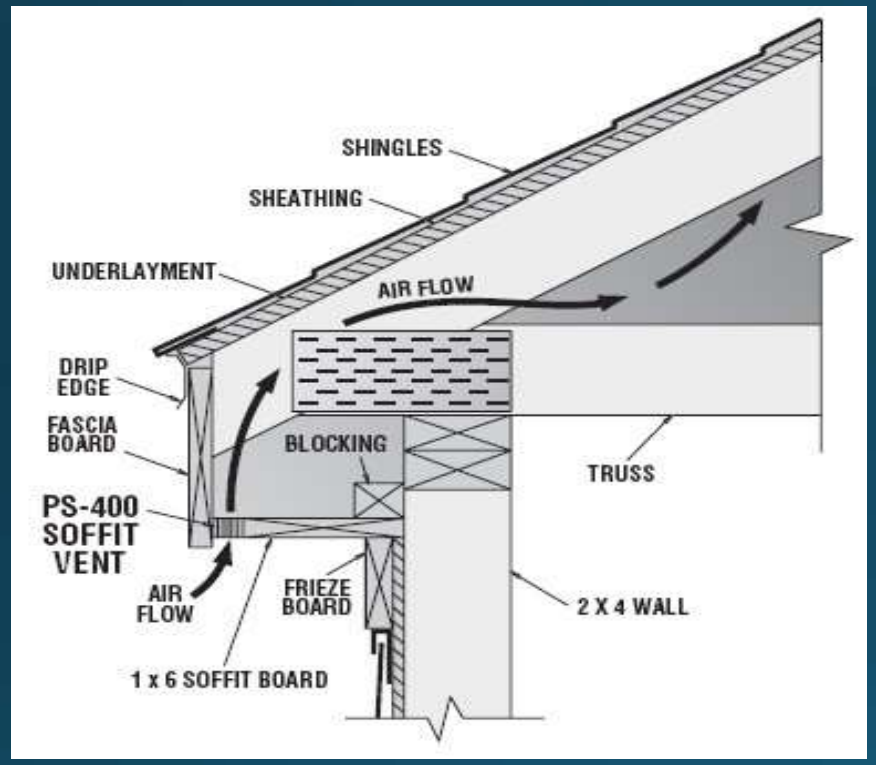
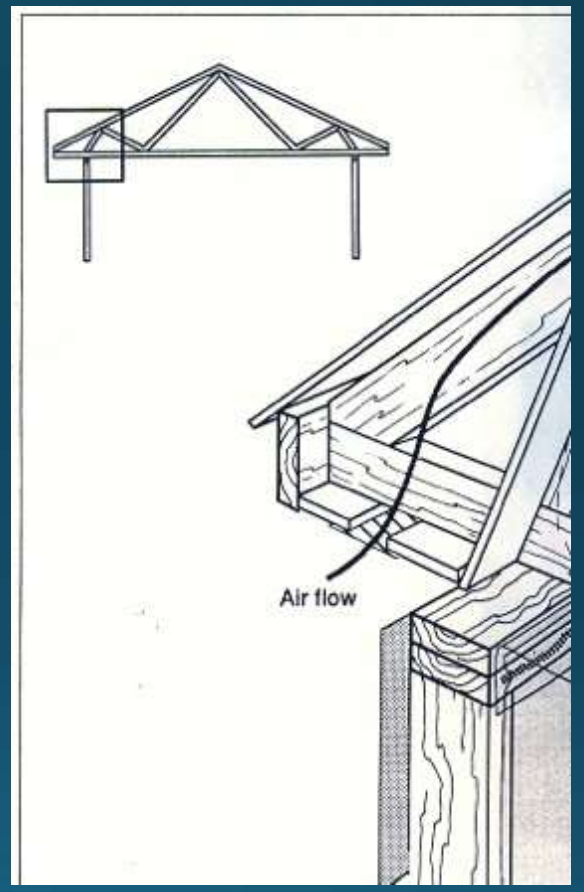
Eave Venting



Very poor detail in this climate

Courtesy easy2diy



Better detail in this climate

Courtesy CHBA

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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

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Attic Hatches?

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

Gaskets required per code





Courtesy Attic Tent

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Most hatches...



...are rarely used

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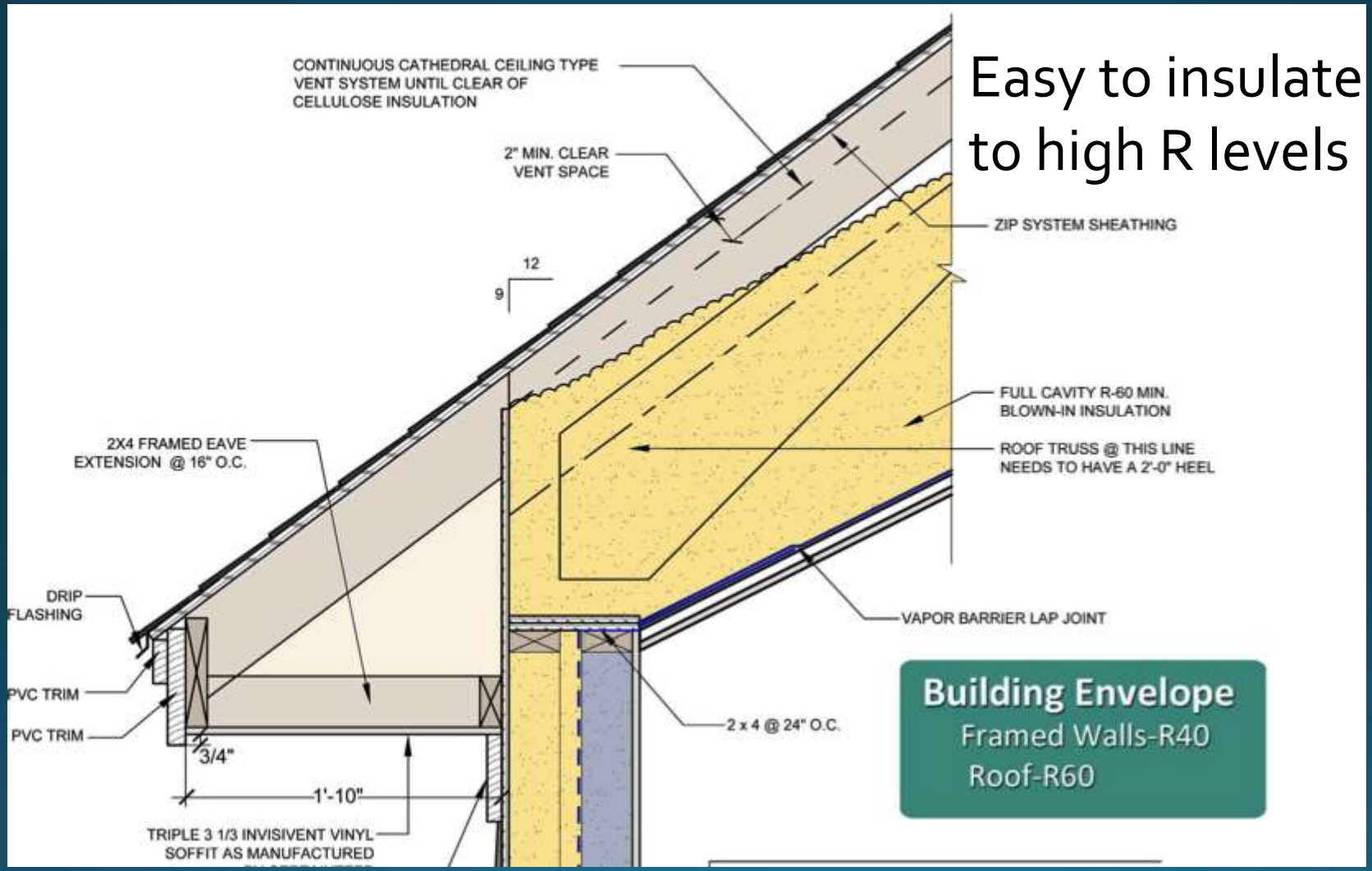
Cold Climate Eave Venting



Easy to insulate to high R levels

Courtesy rcmzeroenergy.com

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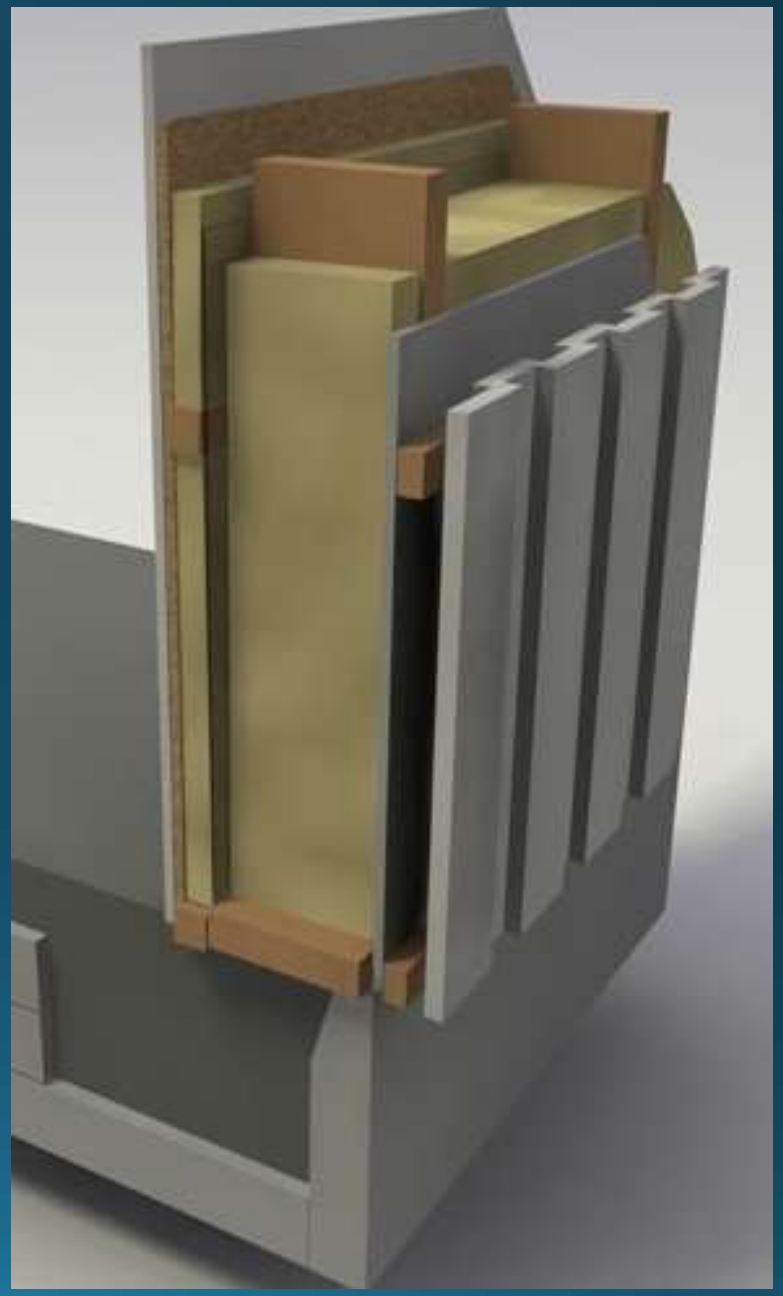
Sidewall Venting for Rain Drainage and Drying



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Why Ventilate? (Occupant Ventilation)

Maintain appropriate humidity

Remove unhealthy pollutants

Increase Comfort

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Lots of air leakage worked well 200 years ago?



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How about the last 70 years?

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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)

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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



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Ghosting



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Excess





Natural Ventilation
Air Leakage

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Unplanned air leakage



Poor attic air sealing and insulation

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Uncontrolled Air Leakage

Courtesy Camroden Associates



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Unintended Airflow

Way Too Much Building Moisture In The Attic





Courtesy Camroden Associates

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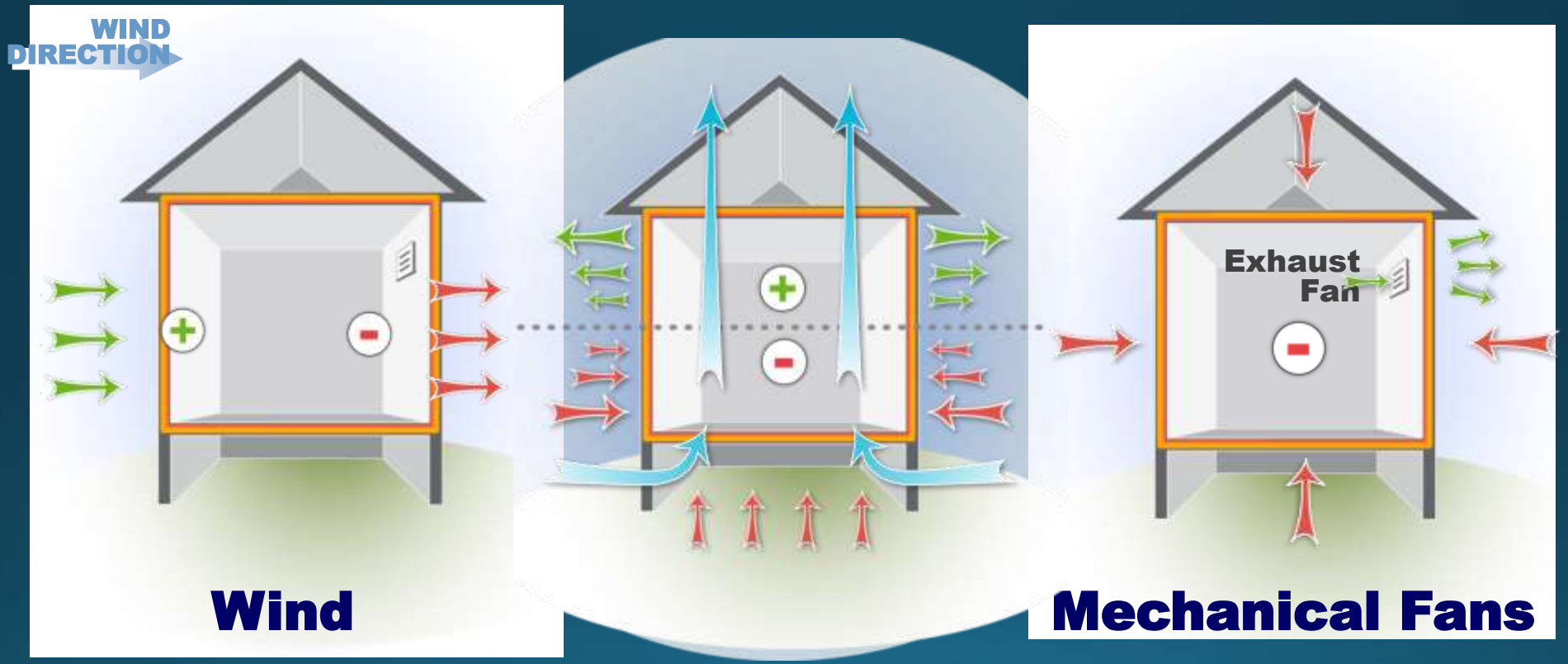
How Much Air? – Delivered How?

What moves air through buildings?



Stack effect - warm air rising

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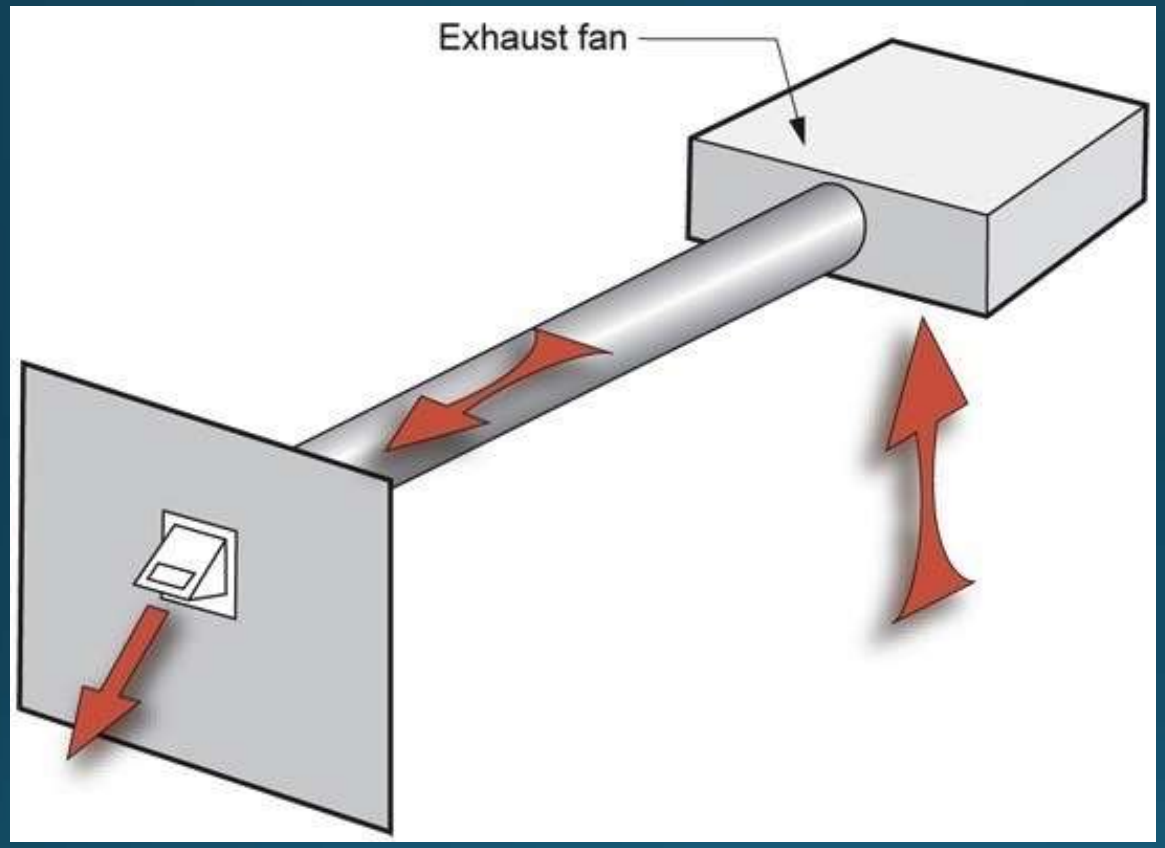

Building Science Corp

Non-distributed exhaust ventilation

local source control, spot ventilate

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Bath exhaust (balanced?)

50 cfm intermittent or 20 cfm continuous



Courtesy Camroden Associates

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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

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



variable speed control with high/low delay timer

Humidity control option

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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

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Now Lots of Quality Bath Fans



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



Courtesy Panasonic

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Combination Light and Fan



Renewaire™ illuminated fan

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Also Good Idea...
Bath Fan Delay Switch



Courtesy Ametek NCC



Courtesy Broan



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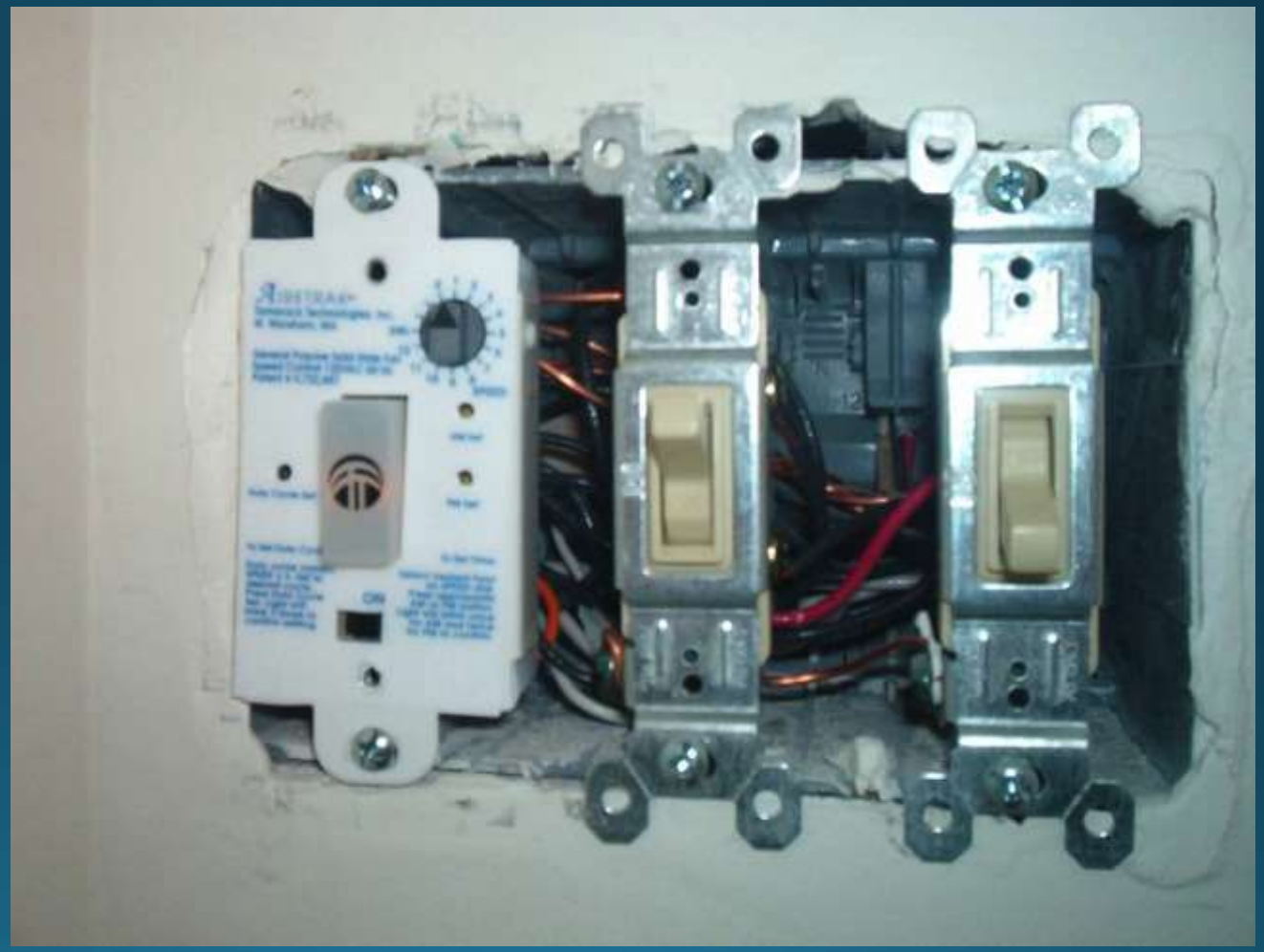
Airetrack™ by Tamarack

A control for whole building intermittent fans

Fan Speed

Built-in Timer

Boost



Courtesy USDOE,eere.energy.gov

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Avoid a bad installation



Courtesy Camroden Associates

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Courtesy Camroden Associates

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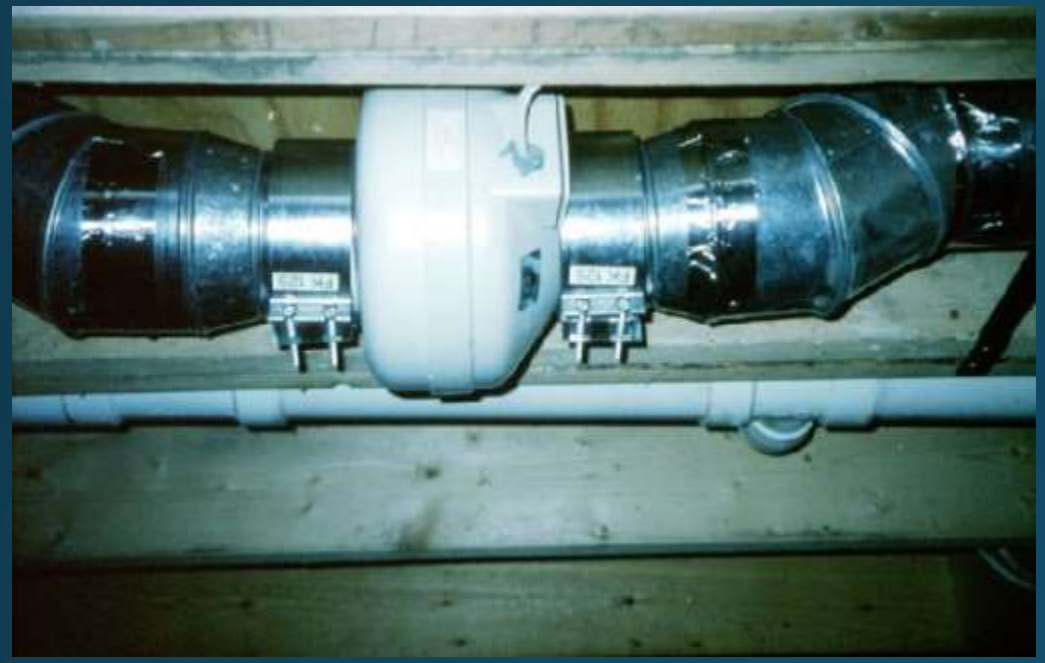

Good Installation: Exhaust fan in basement, vented through rim joist fitting





Courtesy Camroden Associates

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Soler and Palau™ TD Silent



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Unusual technique

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Fifteen minute break

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Kitchen Exhaust Hood Fans



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

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

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Combustion Cooking

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Resistance Cooking

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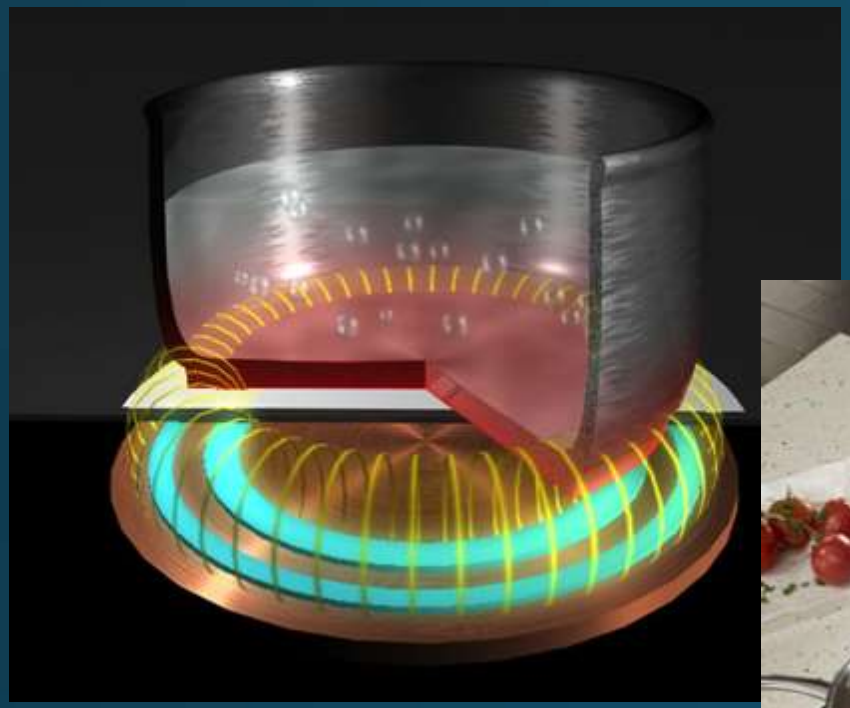
Induction Cooking





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Ventilation is necessary no matter how you cook



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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

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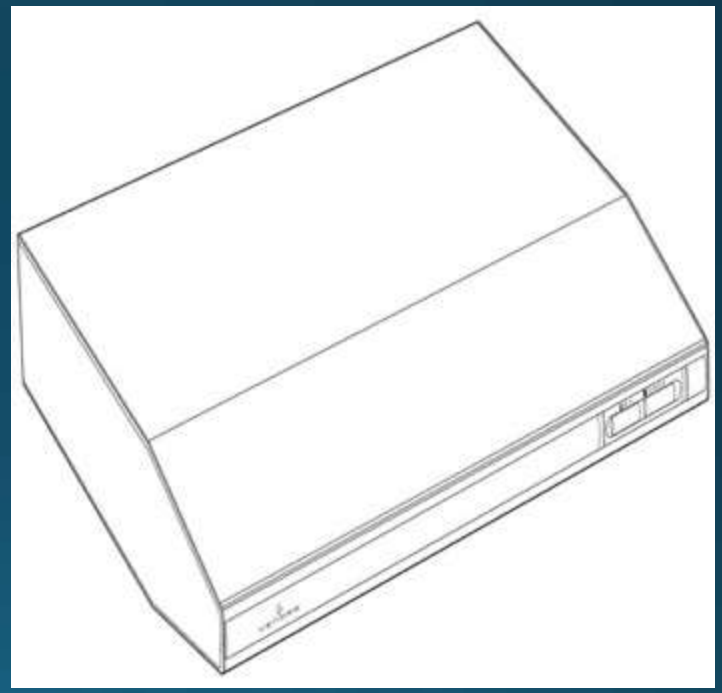
Normal Size: Multi Speed Kitchen Exhaust Fans

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

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Large Kitchen Exhaust Hood Fan



Courtesy rcmzeroenergy.com

400+CFM requires make up air

IRC M1503.4



Skuttle

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900 CFM exhaust, 900 CFM supply



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Dacor™ Pop-up Ventilator



400 – 600 CFM

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Down draft Range ??

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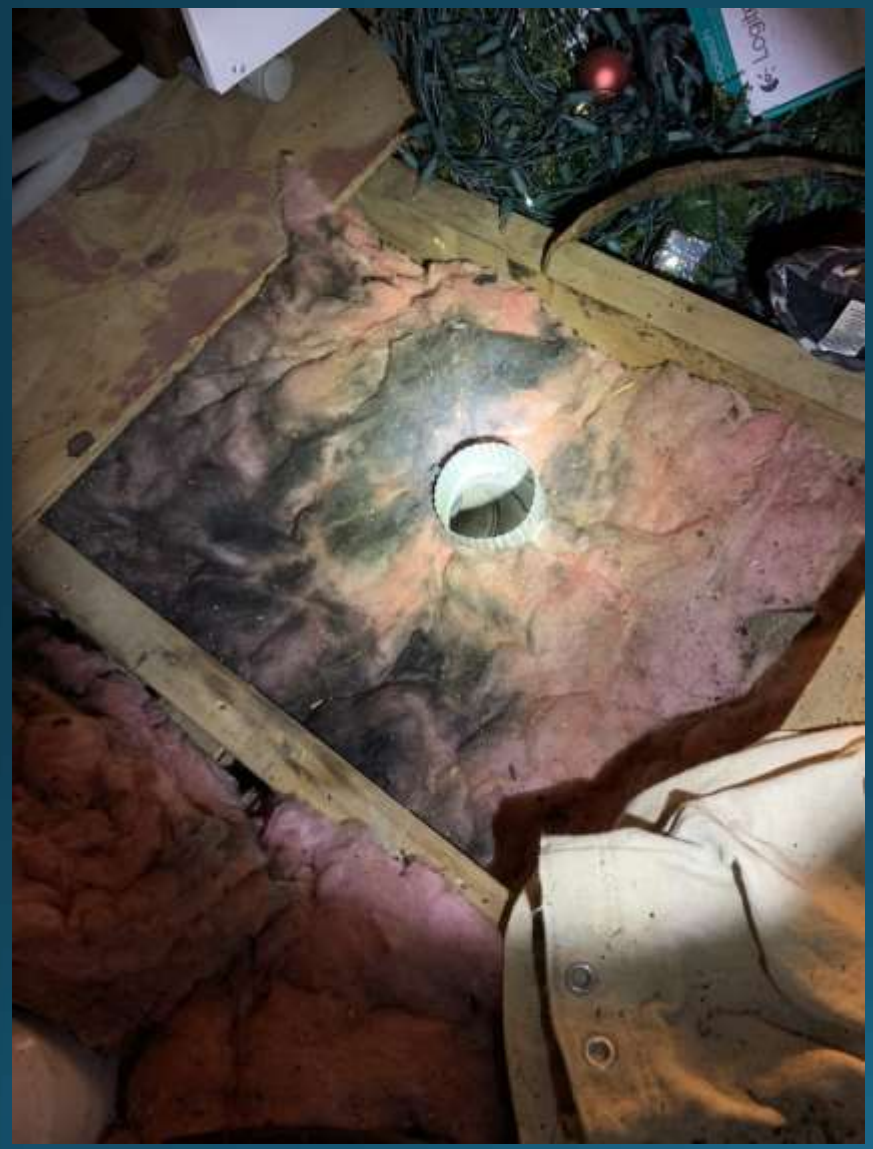

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Kitchen & Dryer Exhaust Make Up





Courtesy rcmzeroenergy.com

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Kitchen Exhaust Fan & Exit





Courtesy rcmzeroenergy.com

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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 <u>planed</u> make-up air, may need distribution.

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

Builder must be able to install





Owner must want to use

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Utilize a soffet for distribution



Directional vanes

MDF and ceiling tiles



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Small diameter duct

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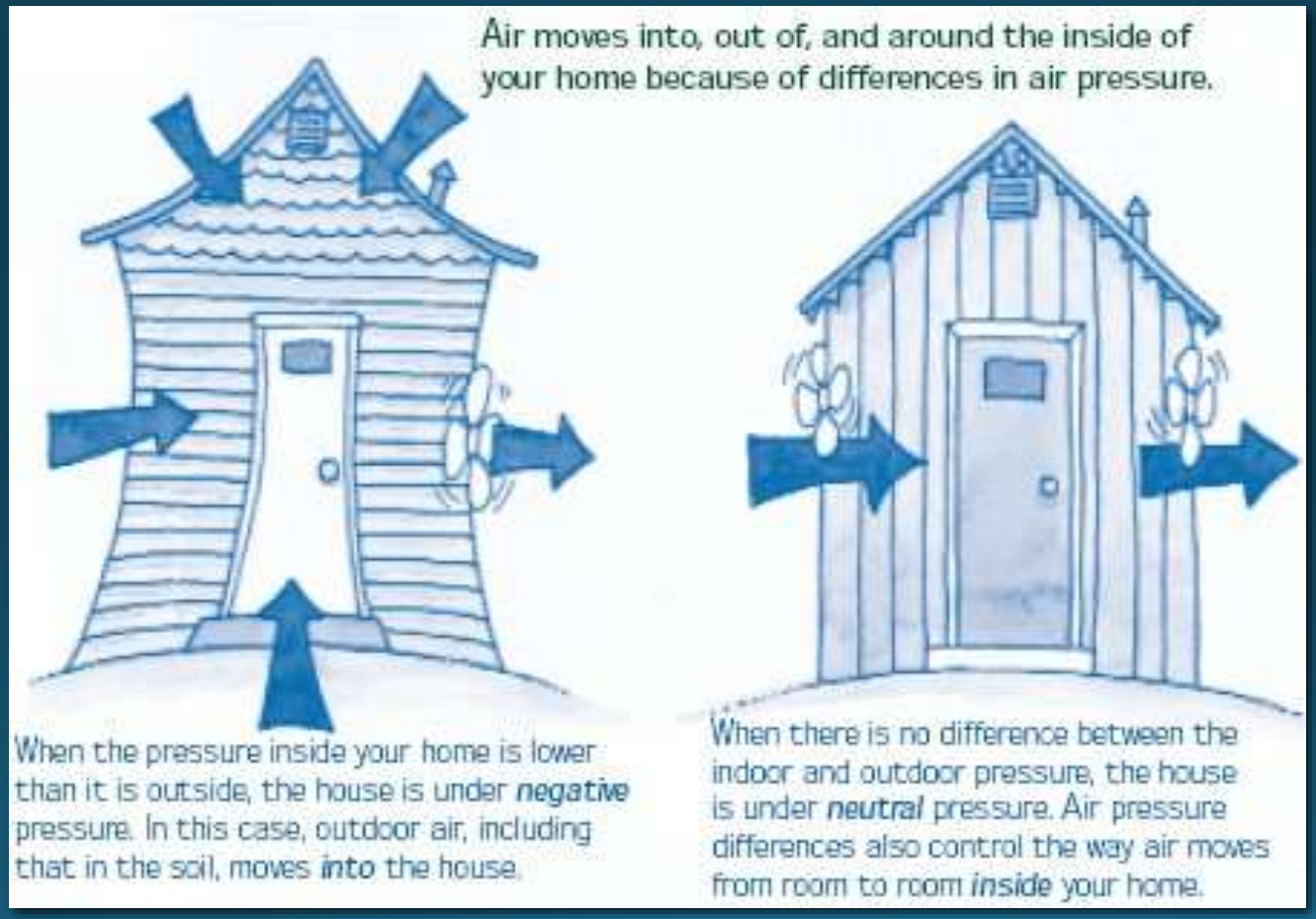
Exhaust ventilation requires some type of *make-up air*



Courtesy NYSERDA

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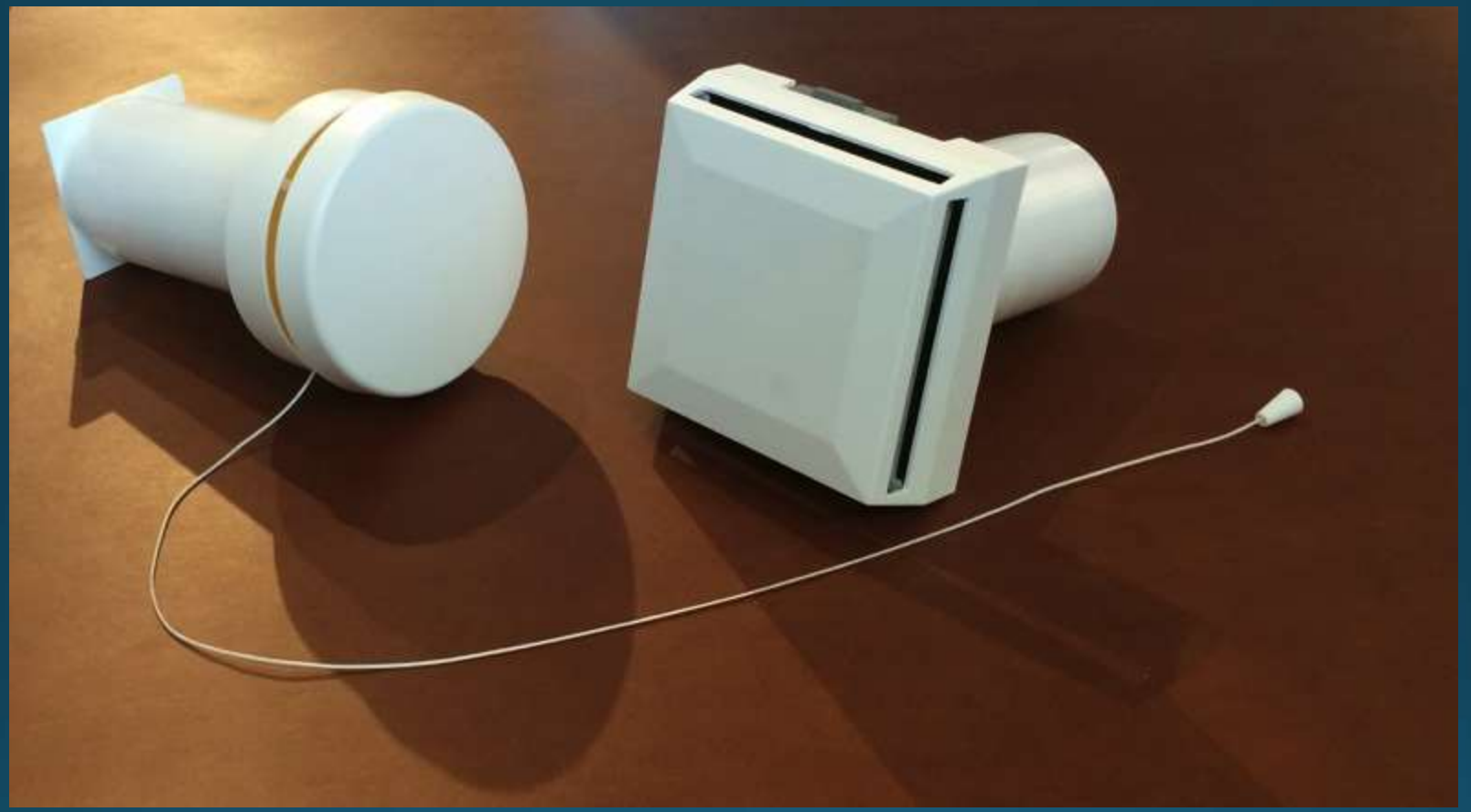

Manual make up air devices ?

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Automatic make up air ?

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Passive manual make up air devices

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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)**

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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

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Home Ventilation Guidance Follow ASHRAE 62.2-2013?

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

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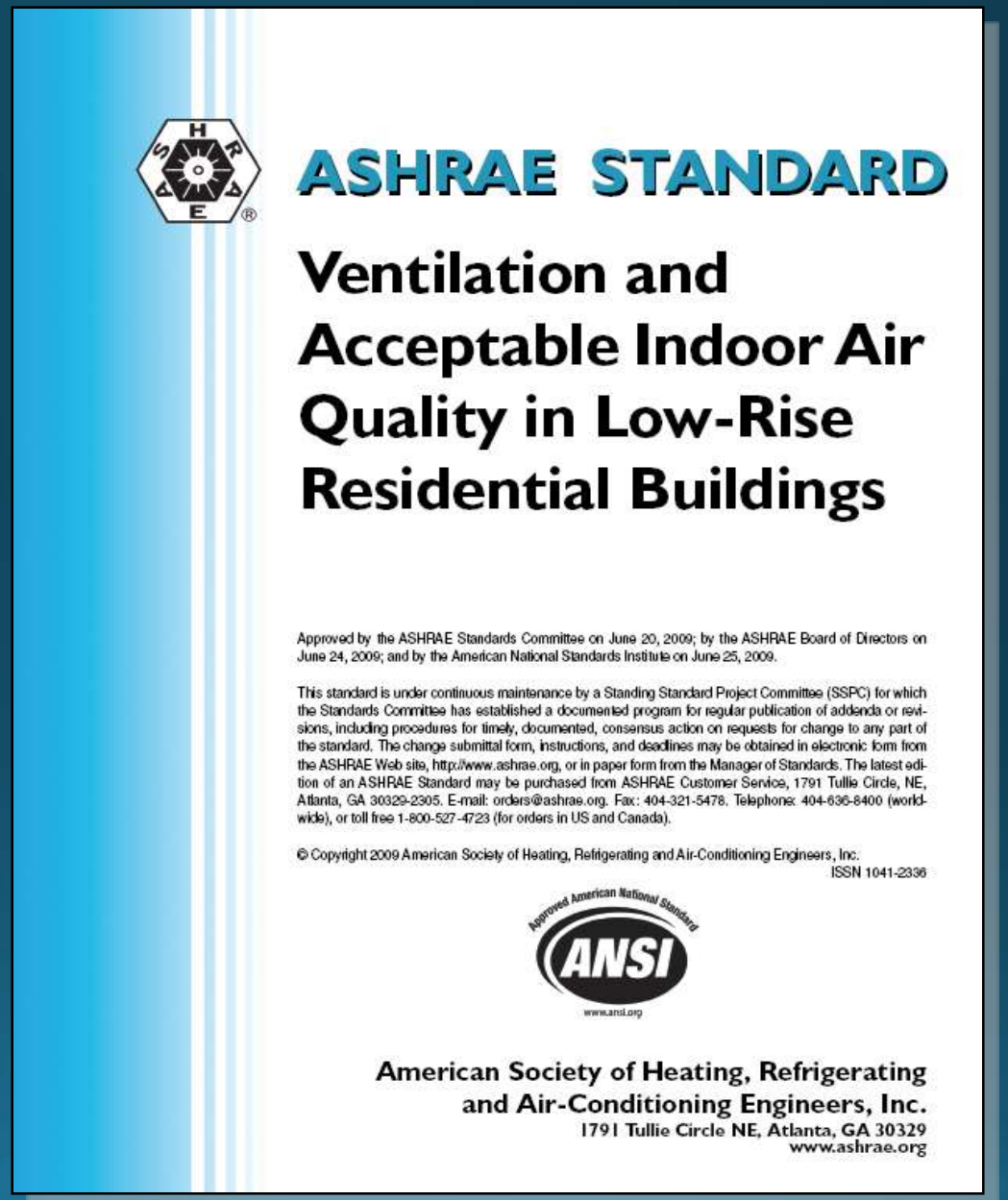
Average installed cost, including controls, no energy recovery: $825 ?

www.ashrae.org



ASHRAE STANDARD

Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 20, 2009; by the ASHRAE Board of Directors on June 24, 2009; and by the American National Standards Institute on June 25, 2009.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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The Engineer's House....???



Courtesy rcmzeroenergy.com

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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)

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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



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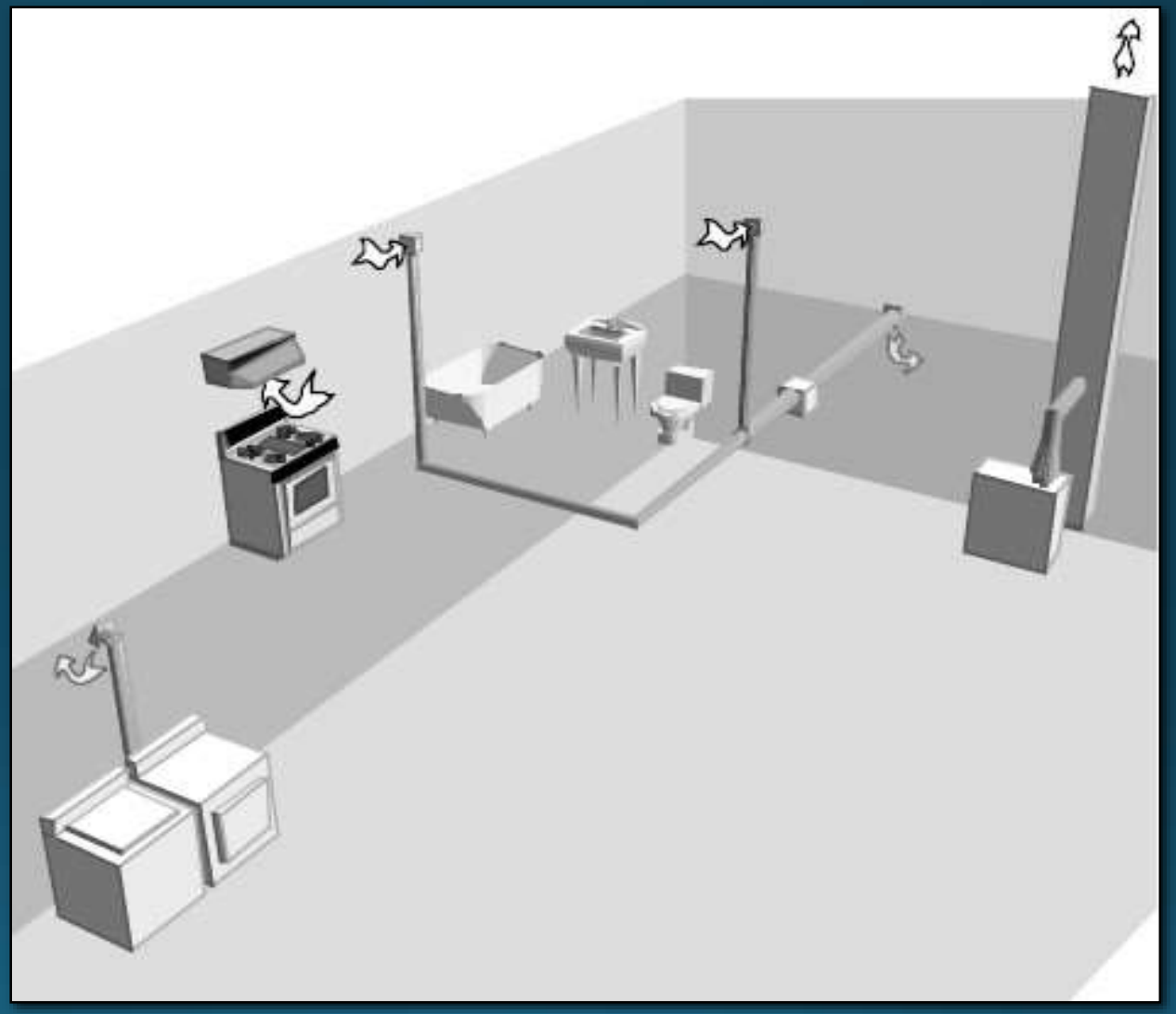
Quiet Central Exhaust Fan?



Courtesy Camroden Associates.

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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

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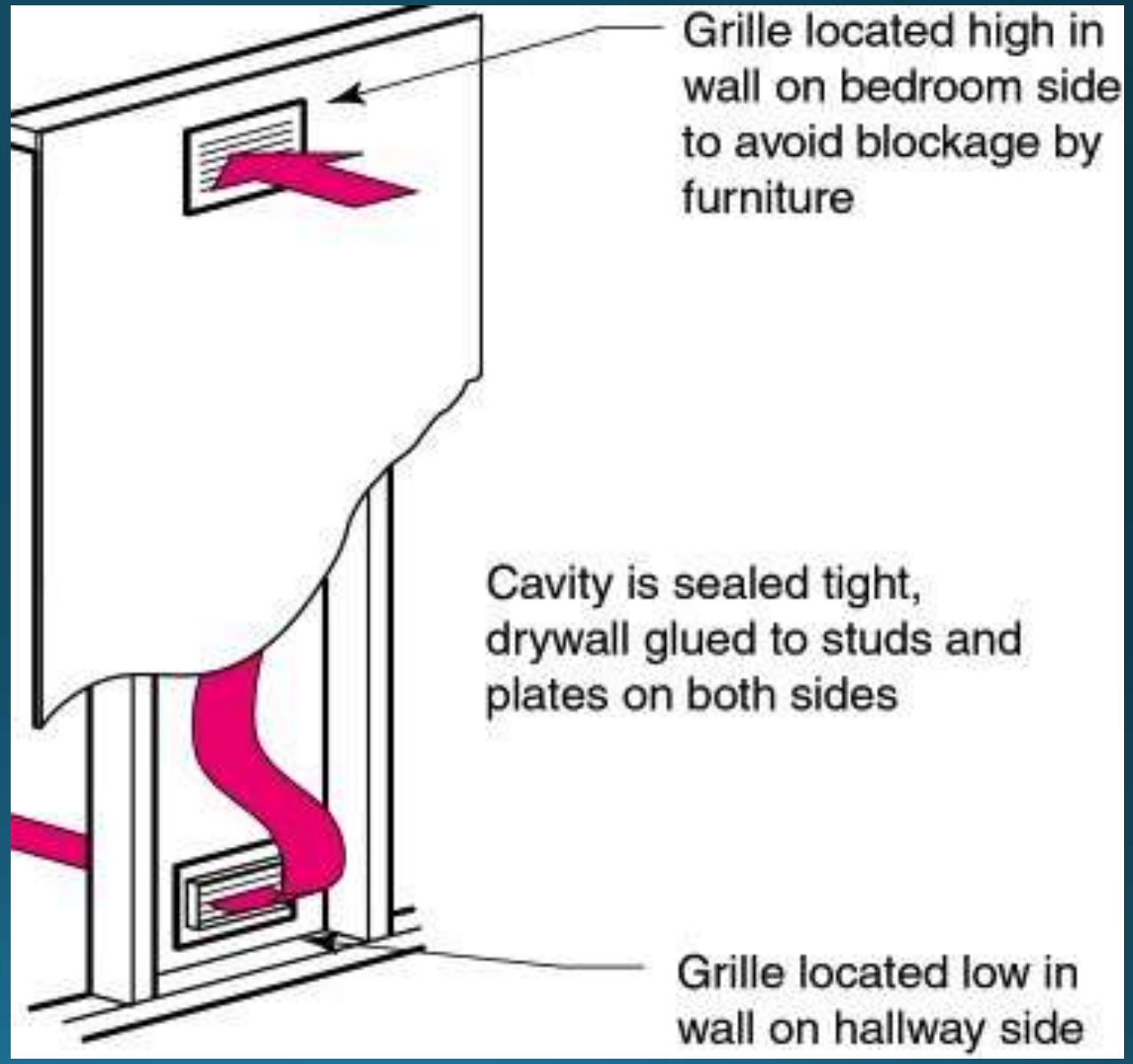
Air Distribution?



Building Science Corp

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Courtesy Camroden Associates.

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Some Residential Control Options

Cycle or Change Speed Based on:

Percent run time

Humidity

Occupancy

Time of day

Others??

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Attached Garage Exhaust Fan?





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Why not “Supply Only” ventilation?

Supply only ventilation would require “make up…vacuum”?

Supply only ventilation would pressurize the building, causing what?

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Balanced Ventilation Systems



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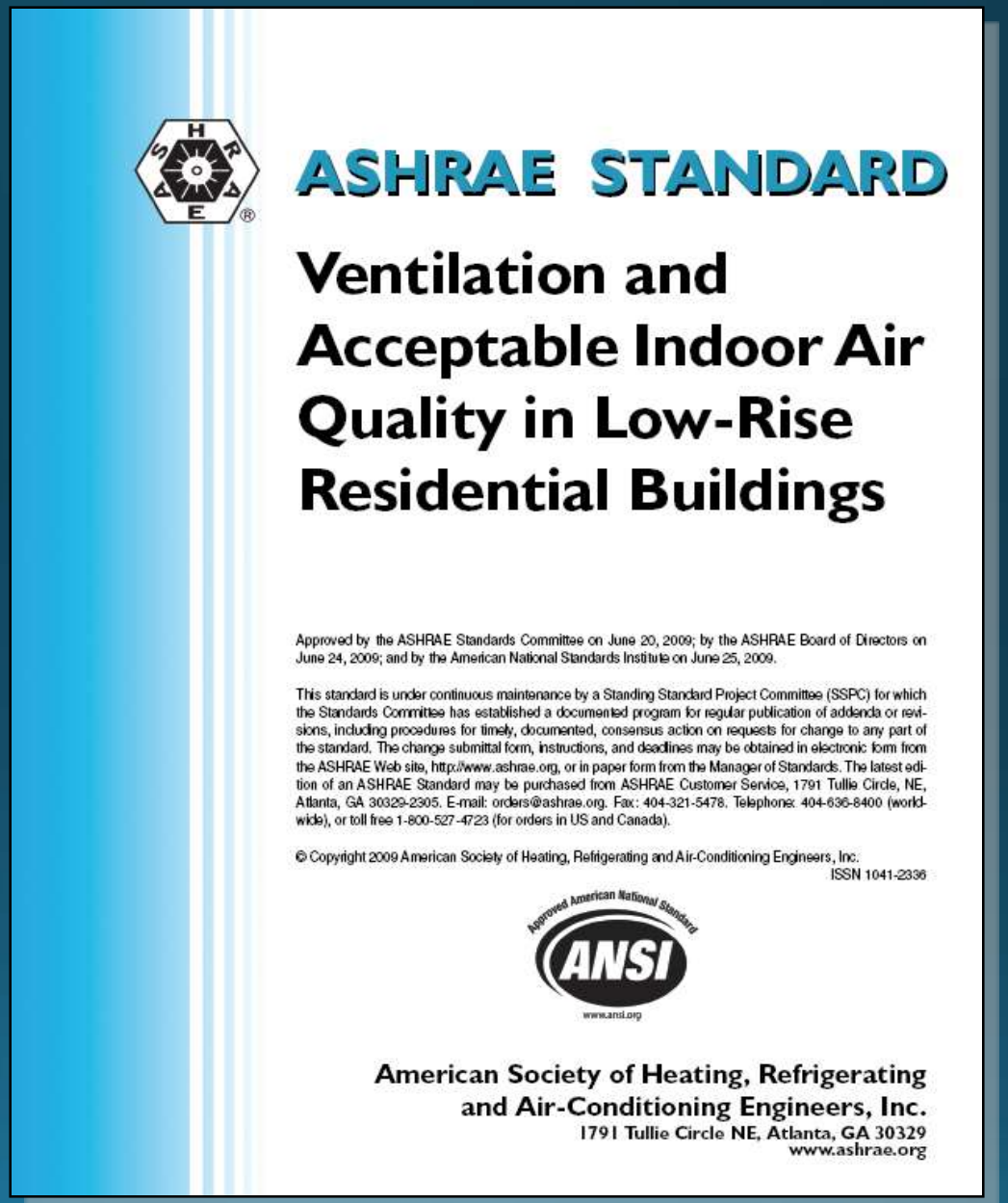
Average installed cost, including controls, *with* energy recovery: $5000?

www.ashrae.org



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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

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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

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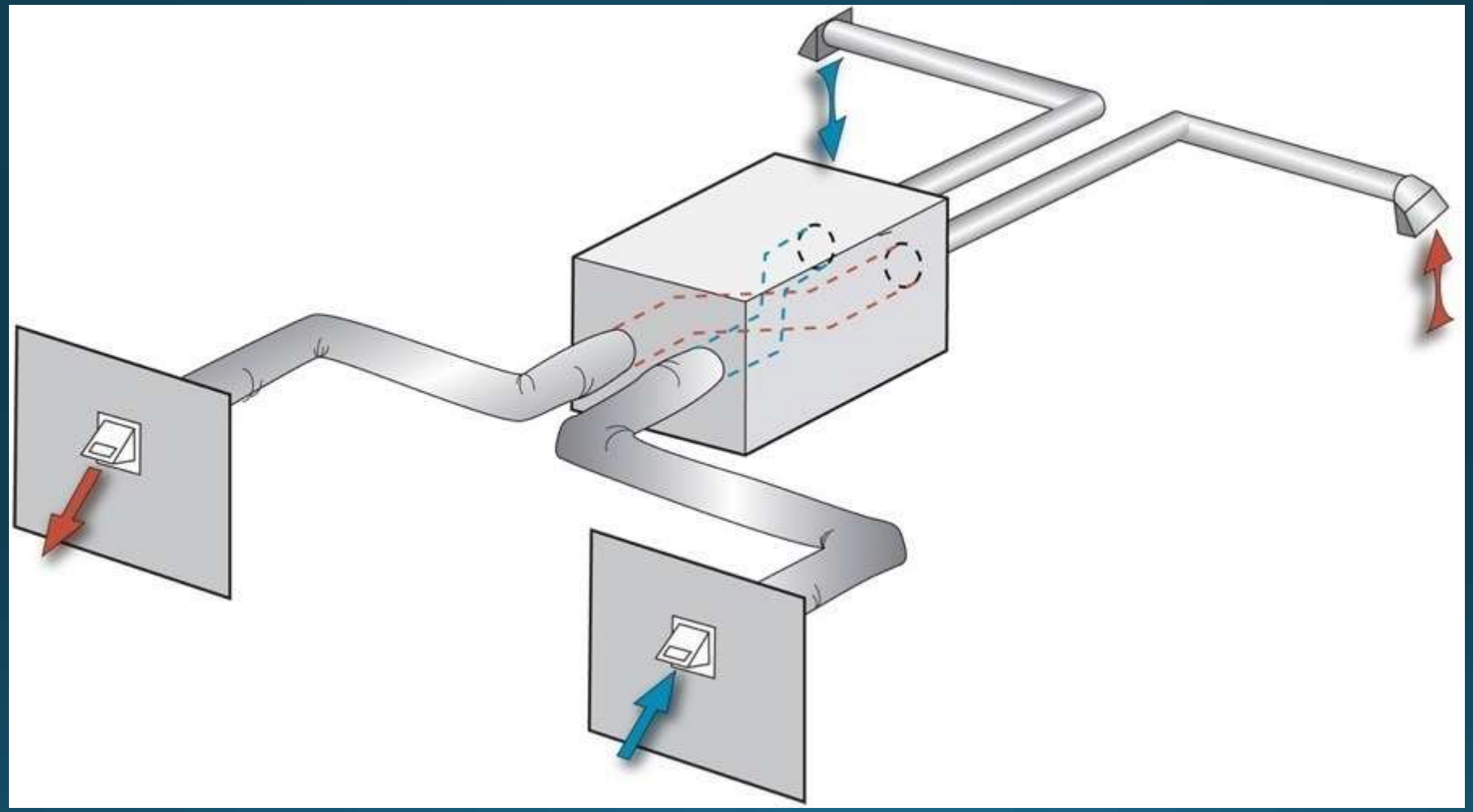
Typical Energy Recovery Ventilation



Building Science Corp

Simplified

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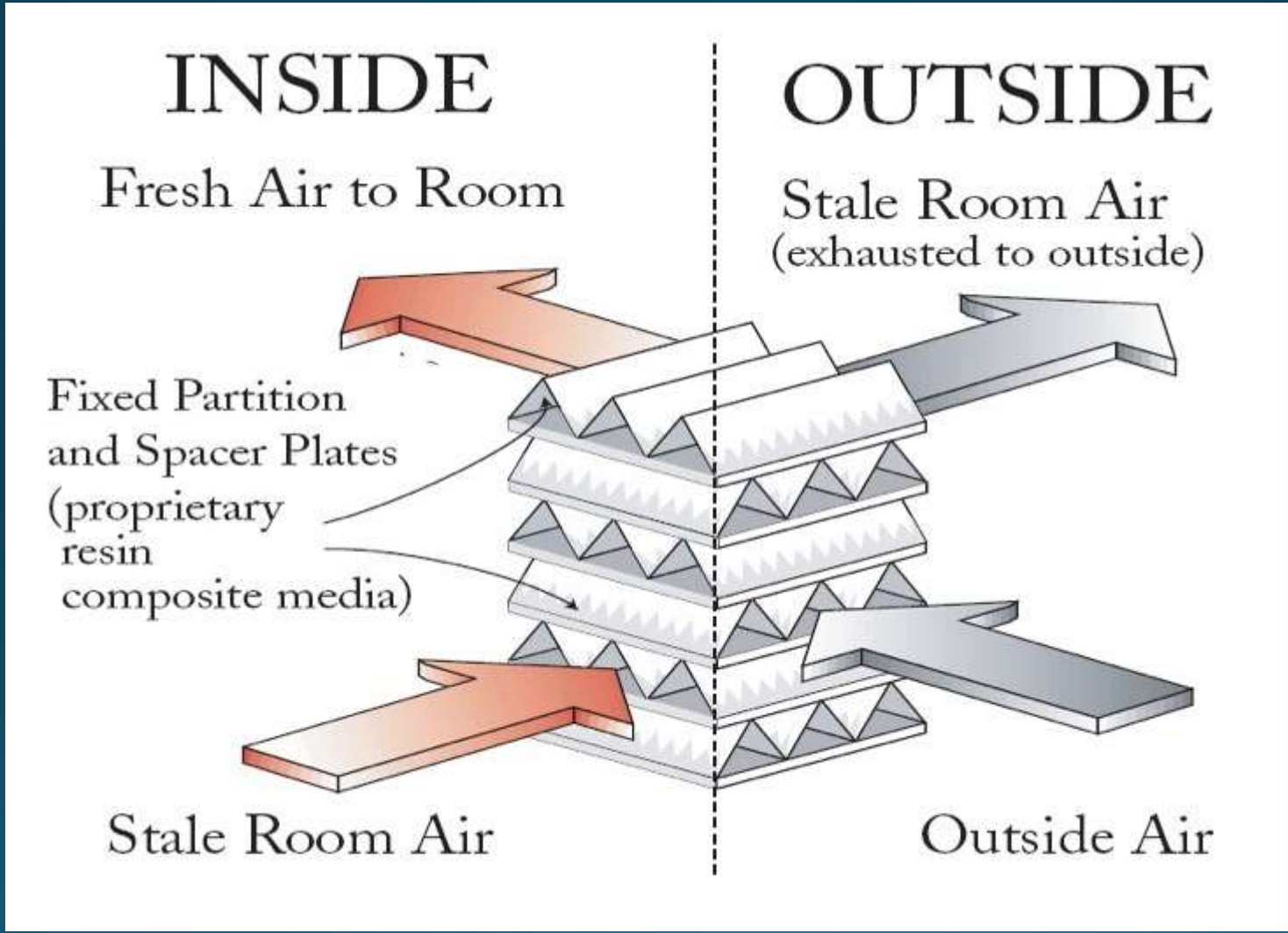
Energy Recovery Units



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Not a New Idea or Product

28 Years in Service

Maintenance: Air filters cleaned annually, 1 blower replaced after 14 years



Courtesy Harold Turner

Operated on low normally, high intermittently

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Now Many Size Units Available From Many Sources

Saves Energy when heating, cooling, controlling humidity

80% efficient

Renewaire™

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108

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



Courtesy Camroden Associates.

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Photo Credit: Alex Wilson

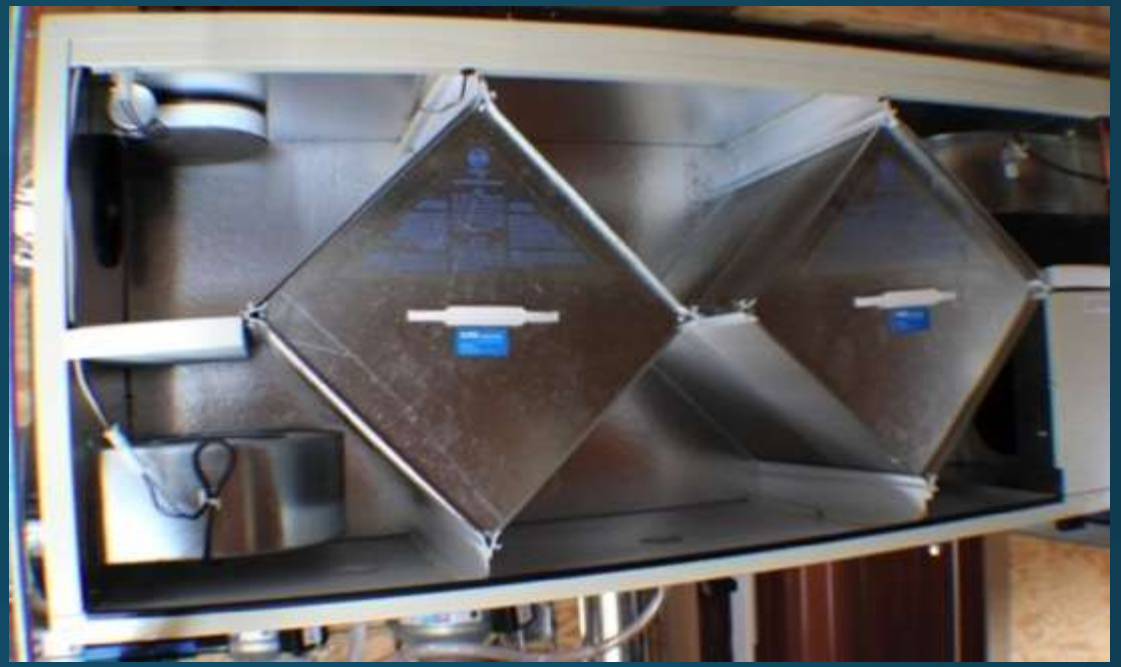

Photo Credits: Harold Turner



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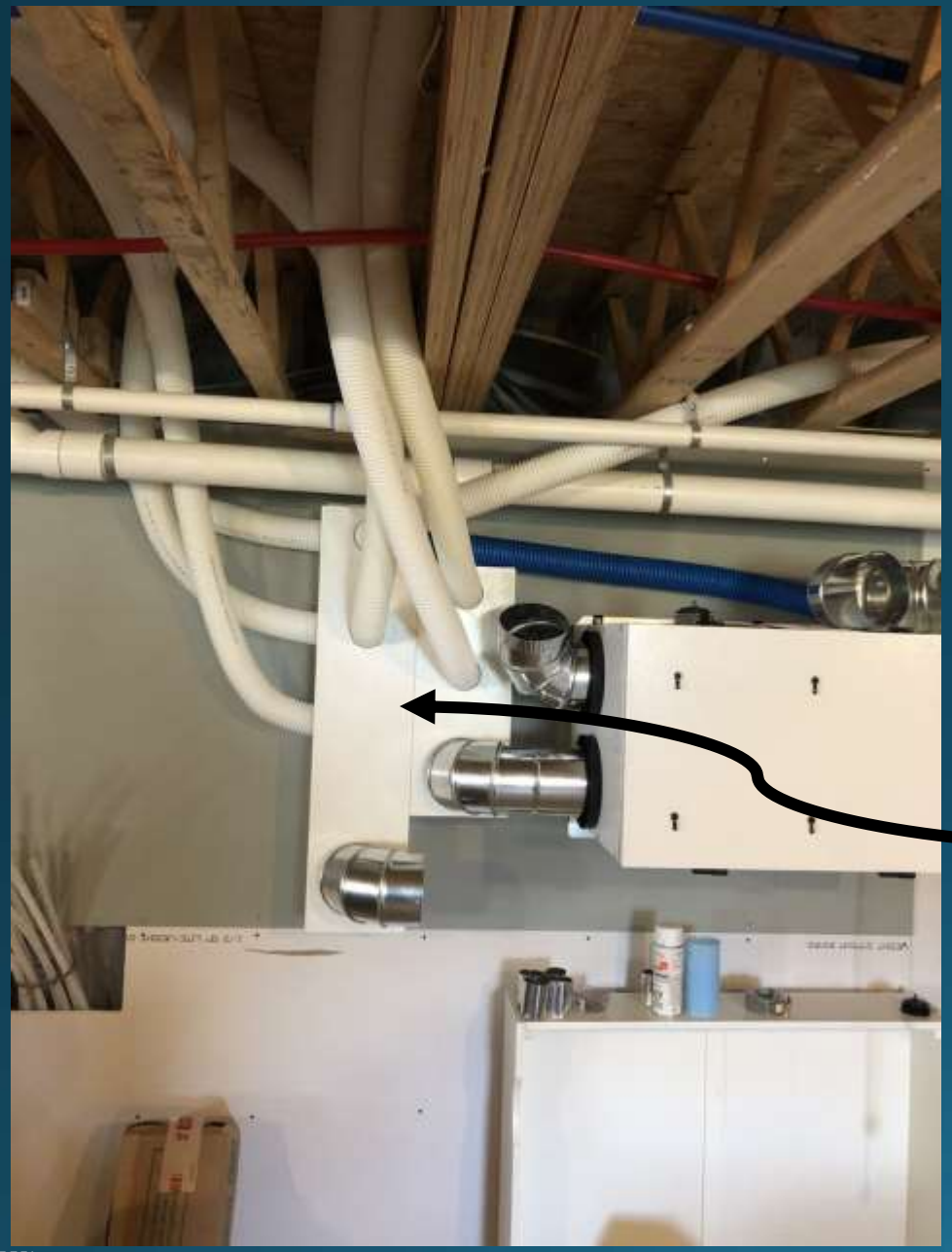
Another version



Site built plena
for supply and exhaust

©2021

Energy Recovery Units
User Friendly Controls





Courtesy Renewaire

Percent Run Time

©2021

Even distribution is important with balanced systems…

©2021

Must be balanced and well located

If HRV or ERV blow “cold” air on the occupants

they will not get used much…
problems ?

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114

Air “in” on West side, “out” on North



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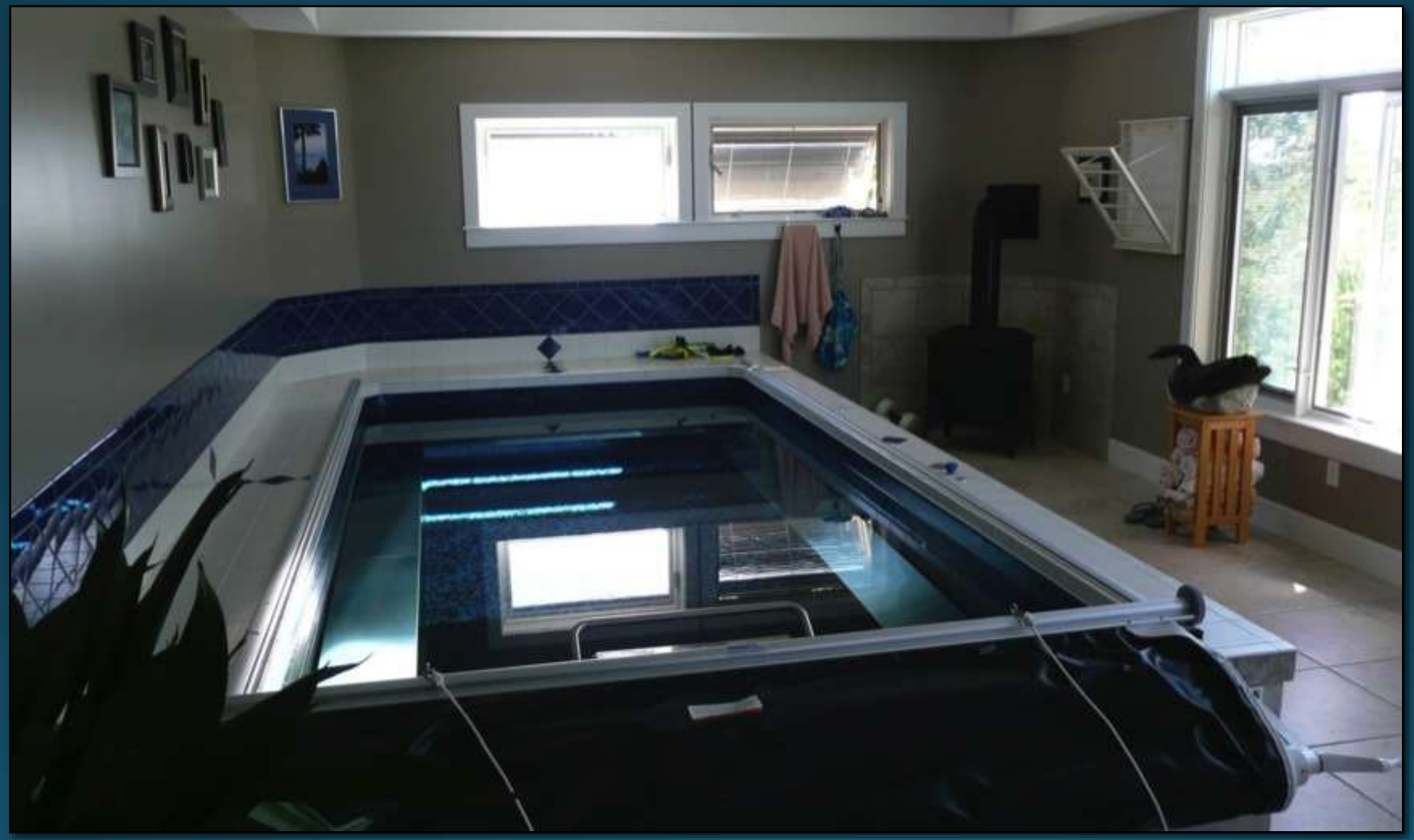
Courtesy rcmzeroenergy.com

Special Ventilation Need : Indoor Pool



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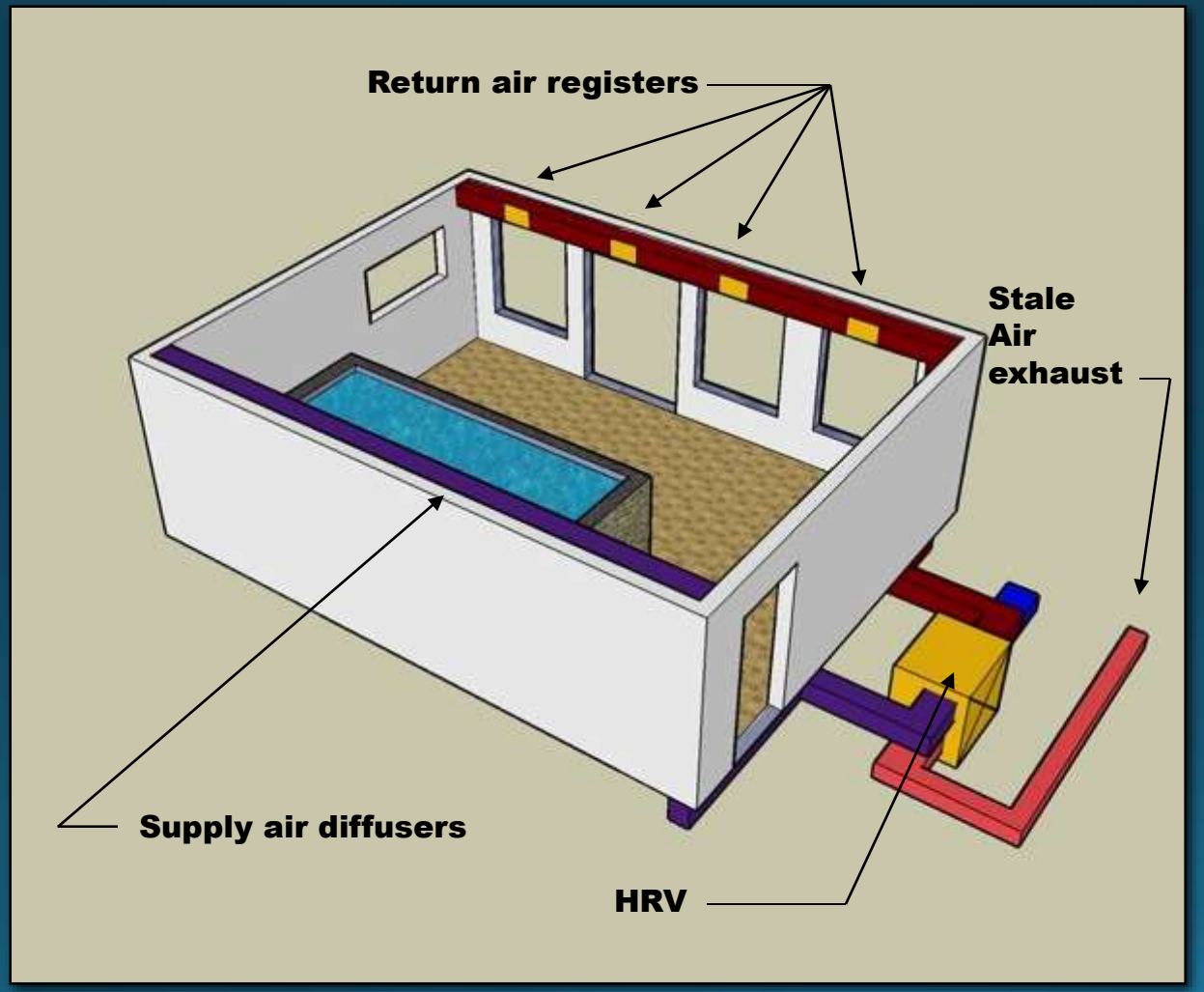
Pool room schematic



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42,000 gallons @ 84° ????



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Or Put Outdoors, Energy Efficient Hot Tub?



©2021

Big dogs

Special requirements !

Code doesn’t account for animals



©2021



TwinFresh™ Comfo

Lunos™



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Whole House Fan?



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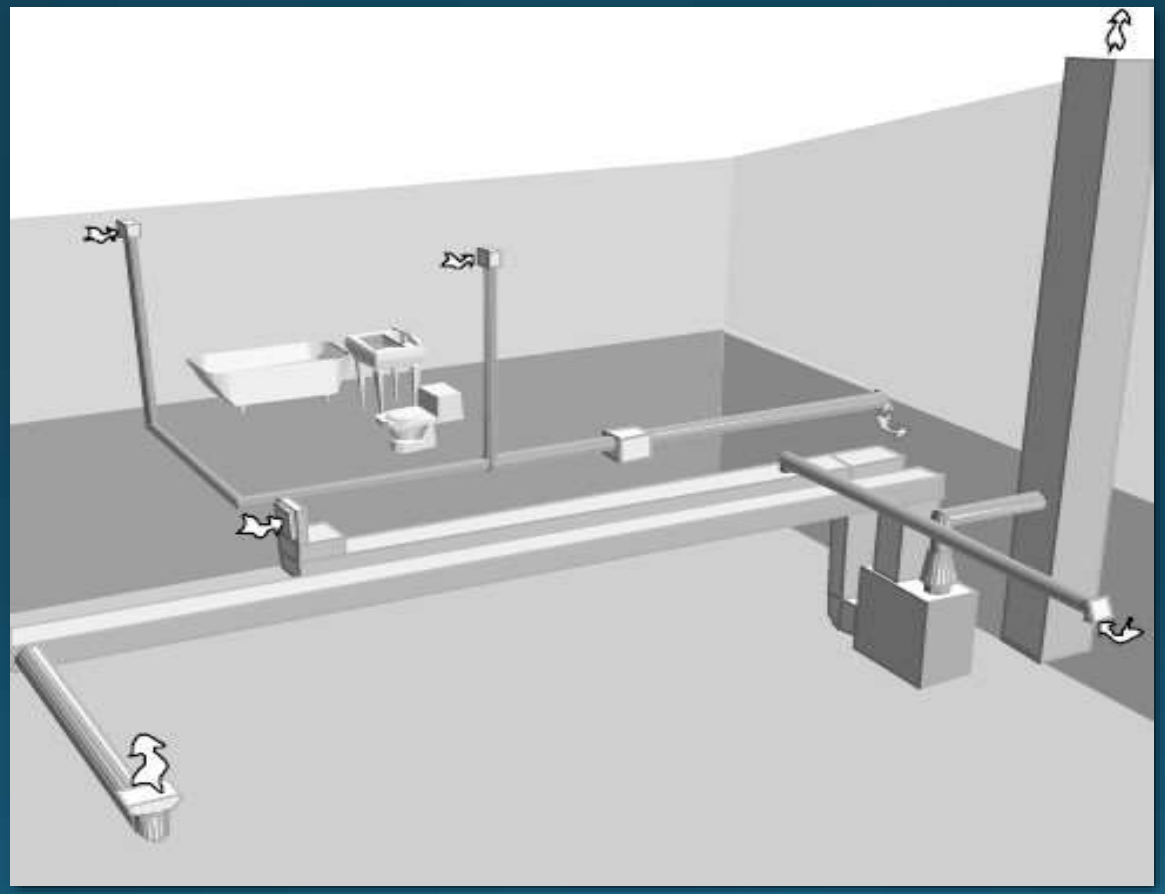
Quiet Central Exhaust With Make-Up Air From Heating System Return



Courtesy Camroden Associates

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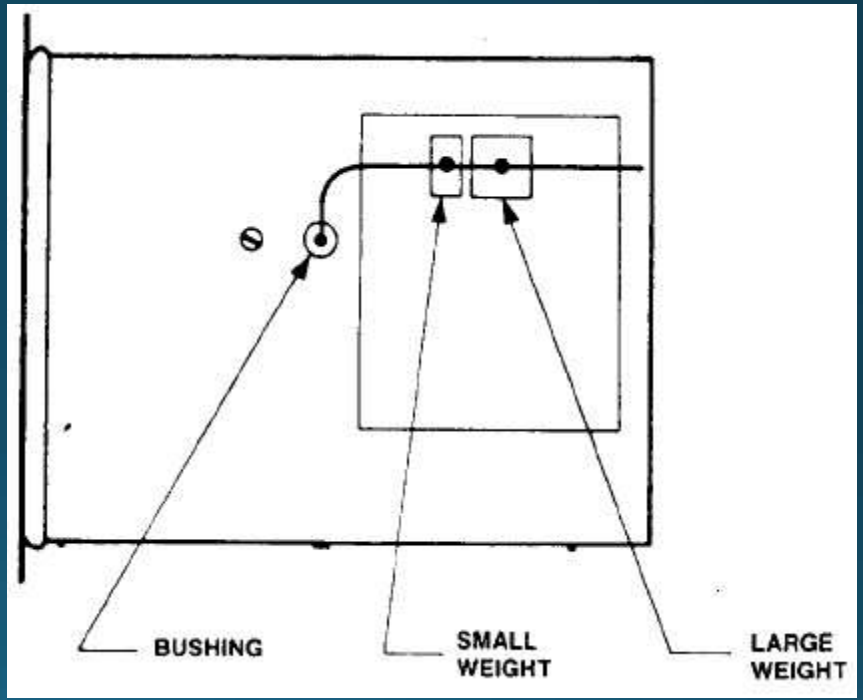
Passive Make-up Air Furnace / AC Kit

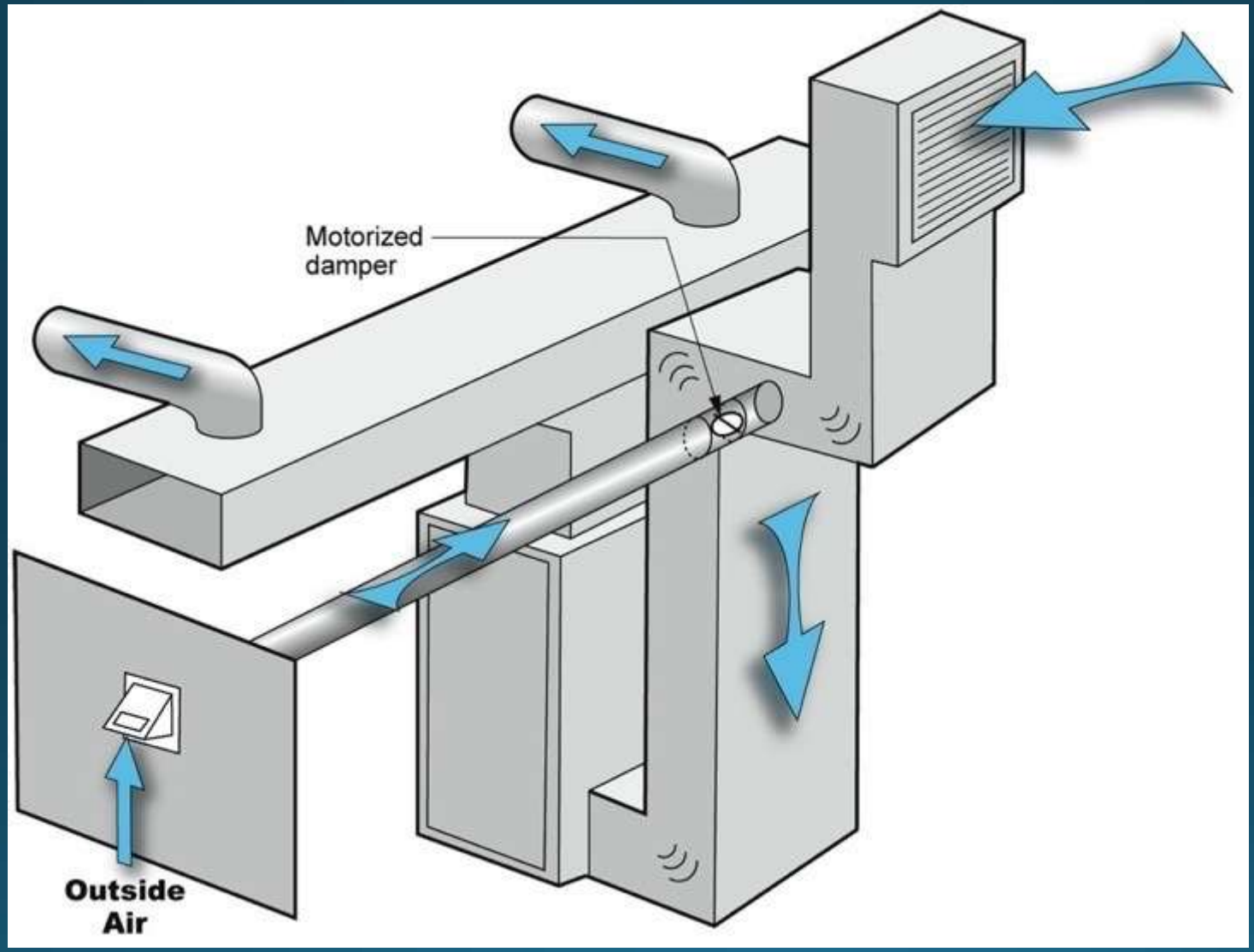


Skuttle™ 216 Make-up Air Control



Courtesy Skuttle

©2021



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Courtesy Camroden Associates



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End of Session One

Up next...

Rick Karg

Residential Energy Dynamics

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Build a Better House

HVAC, Part II



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Thank you, program sponsors...



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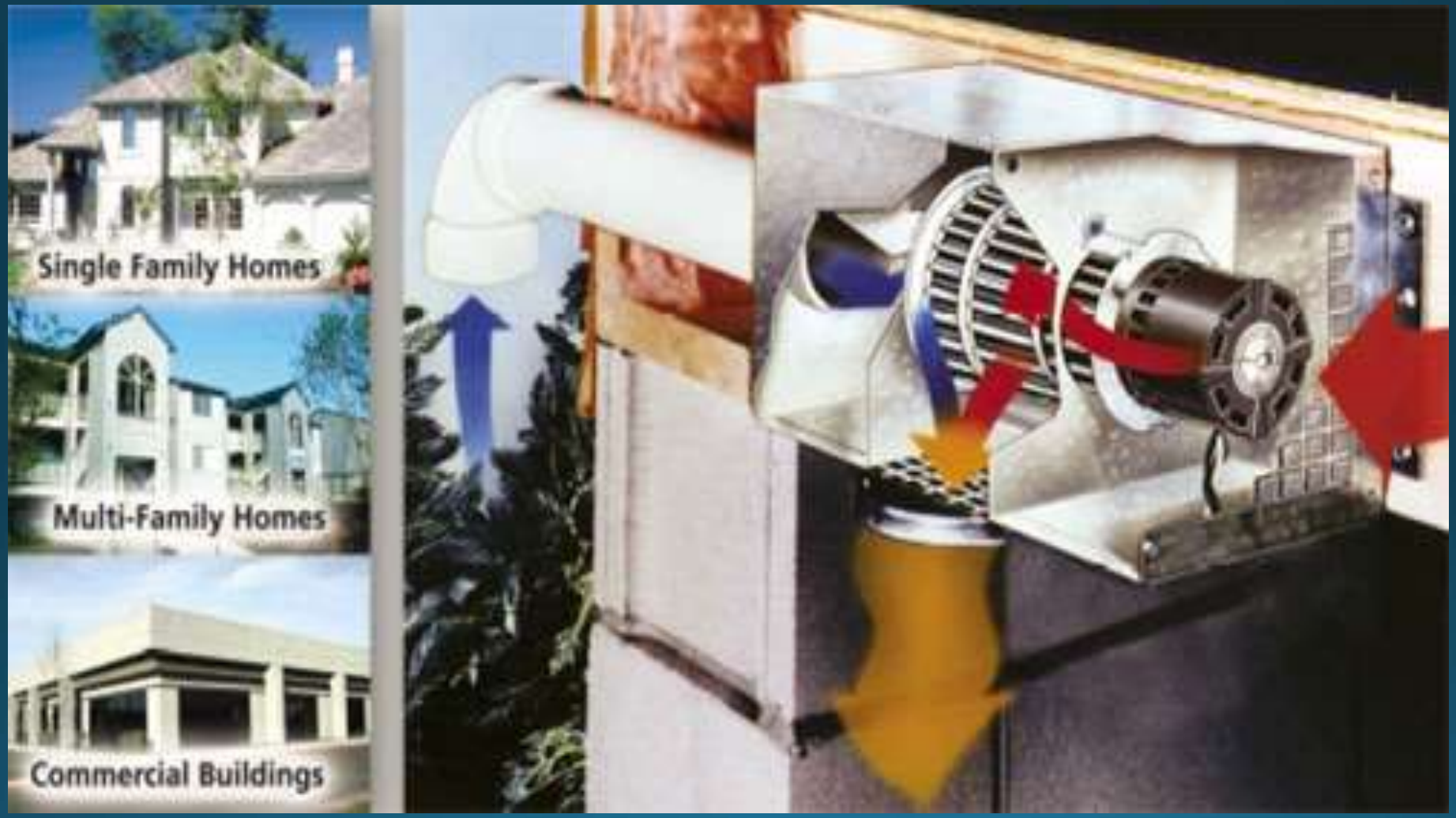
Powered Make-up Air?



Courtesy Tjernlund Inforcer

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Powered Make-up Air



Need a “candy cane”



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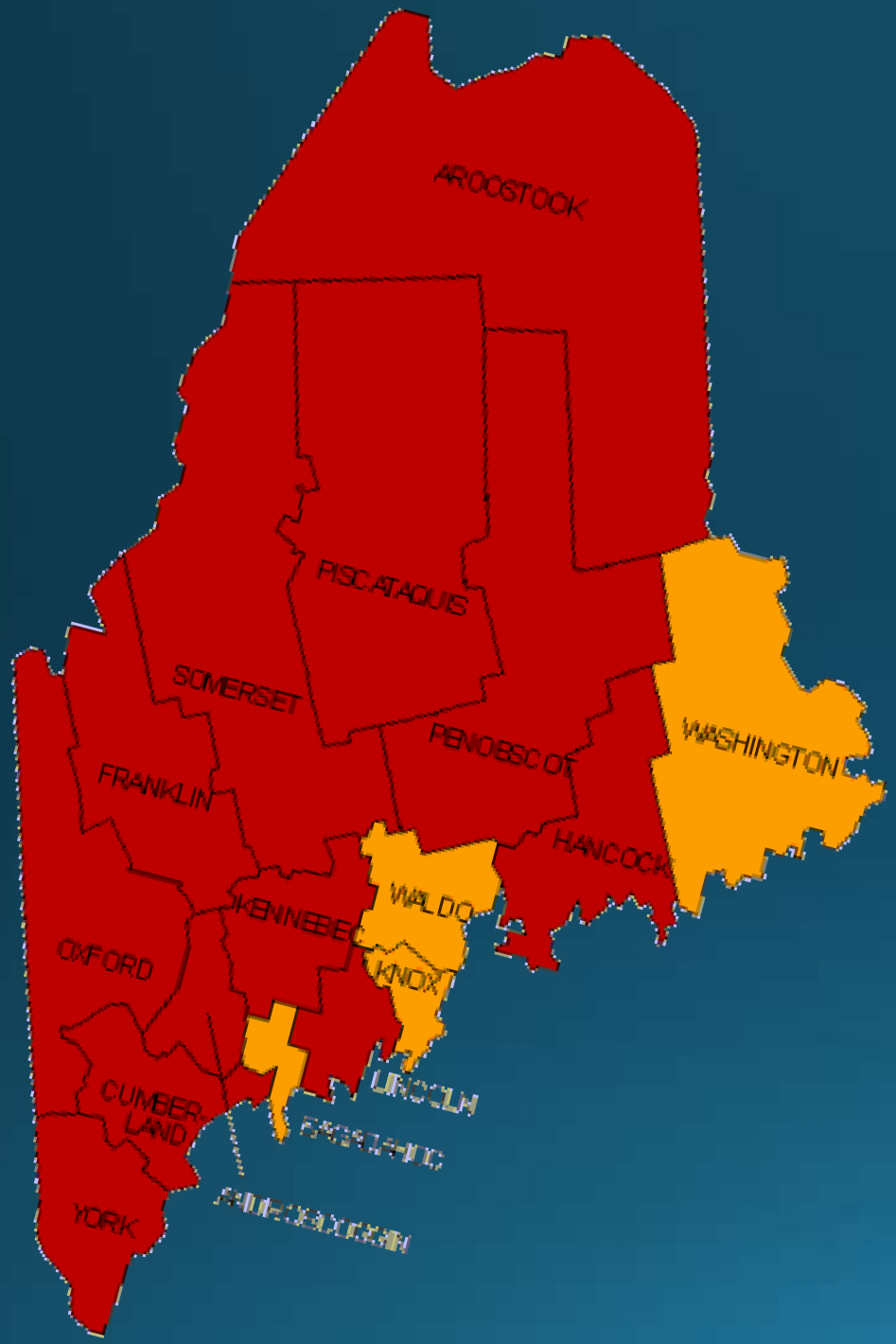

Radon in Maine

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

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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

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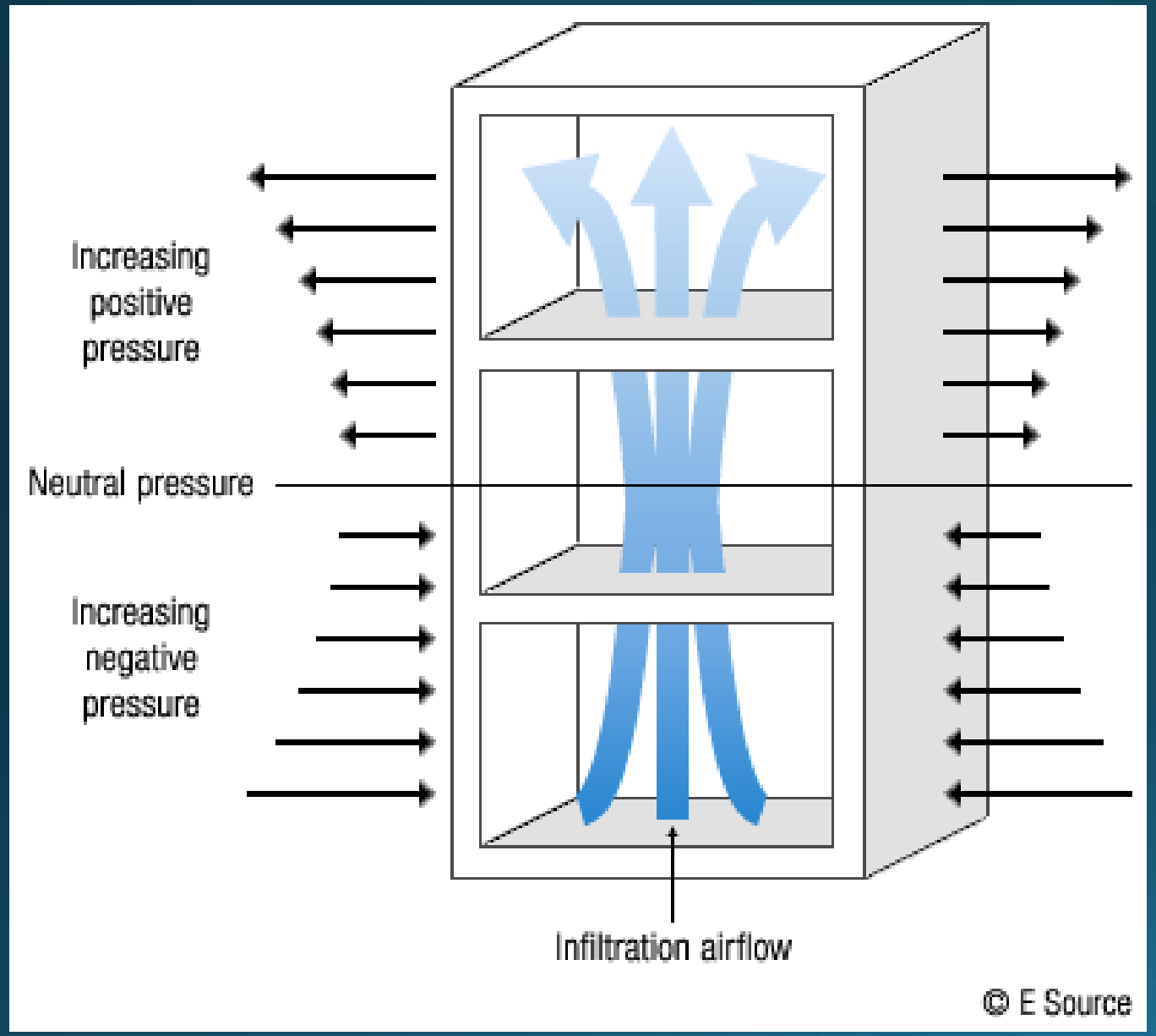
Stack Effect



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

ST Home Inspections

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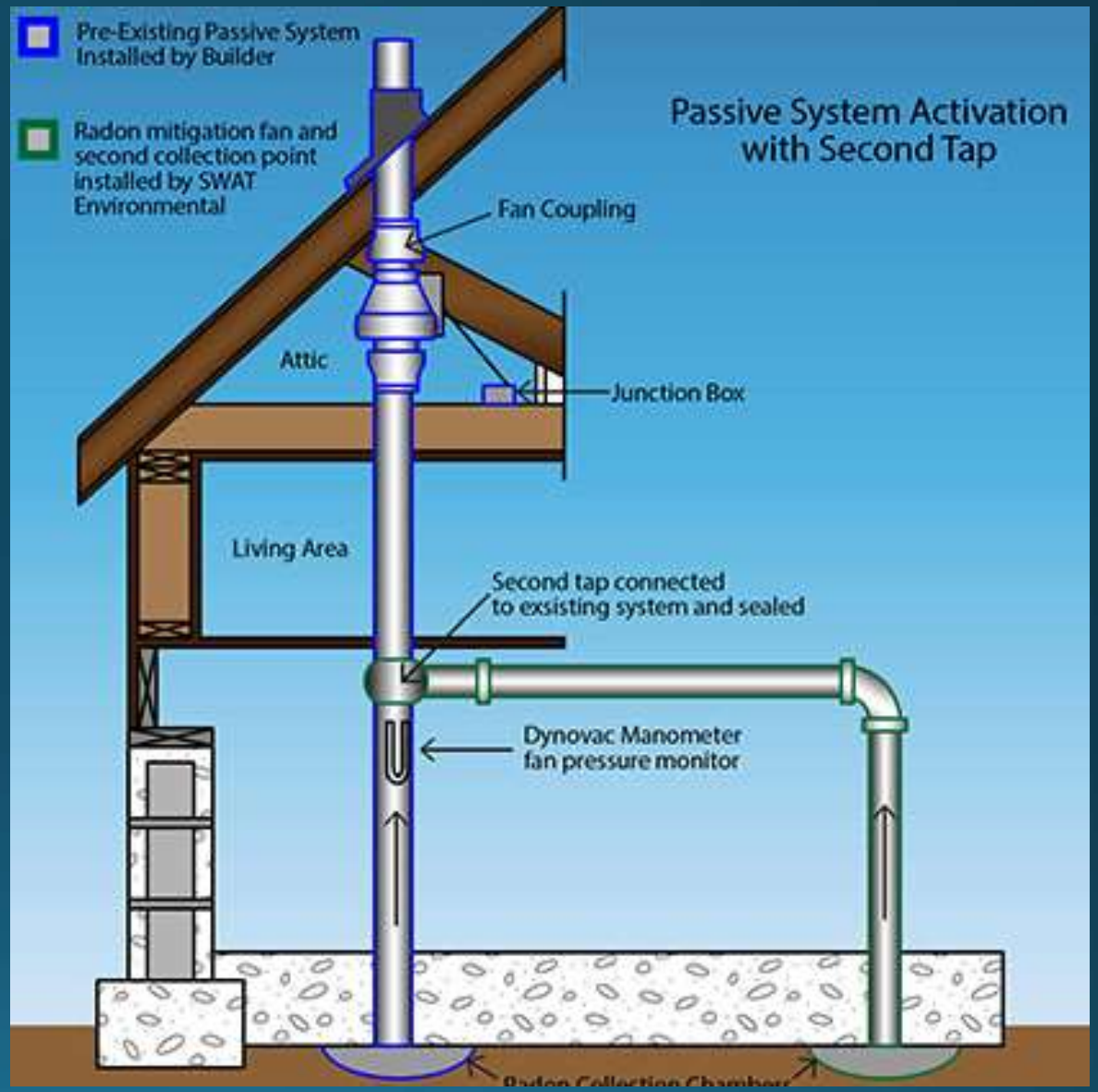
Pressure Manipulation

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



SWAT Radon.com

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Radon Solutions



www.maineradiationcontrol.org

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

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

Helps in radon mitigation



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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

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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



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



Courtesy Camroden Associates

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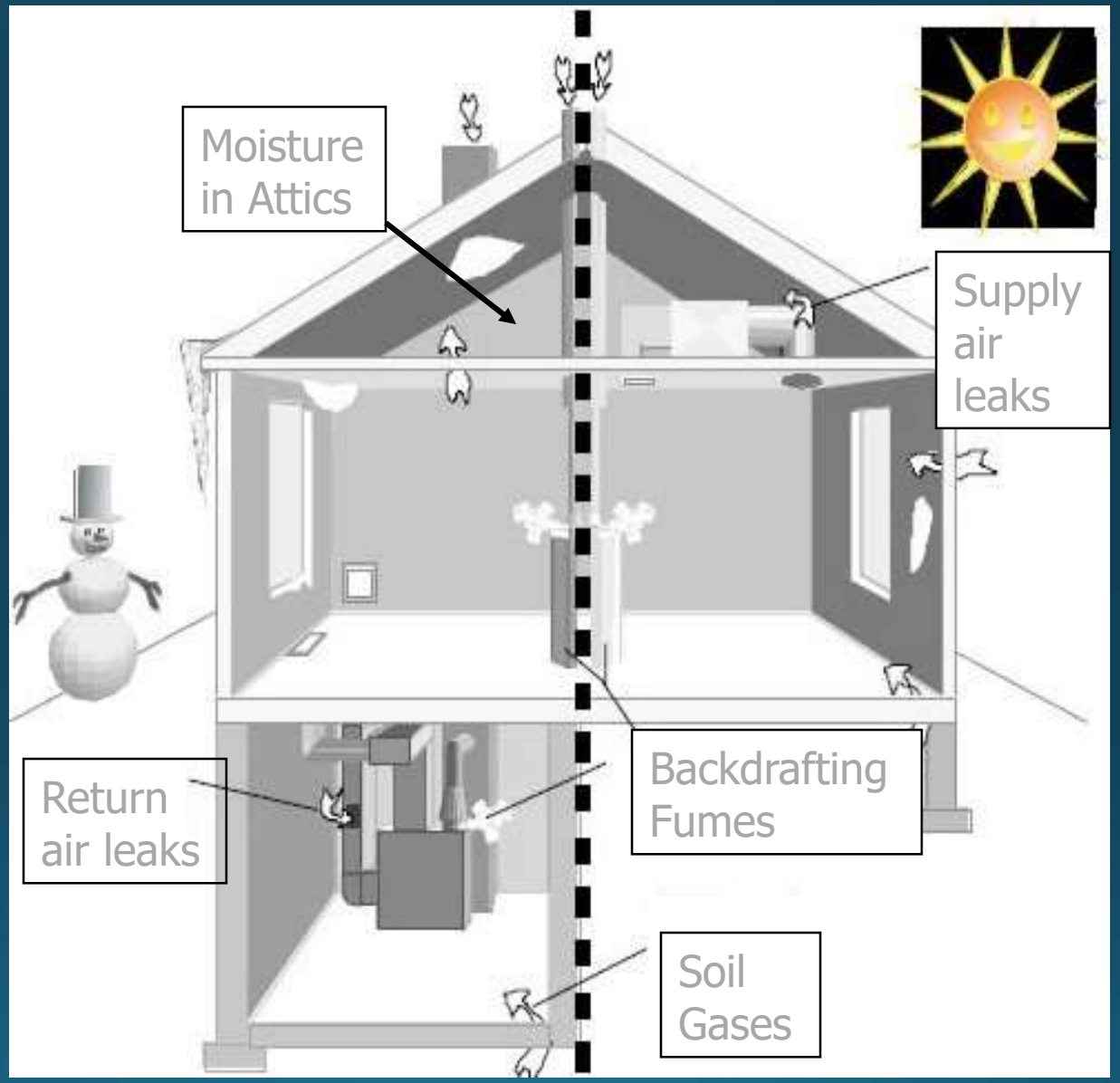
Unintended airflows

lead to various problems

in winter

or summer



Courtesy Camroden Assoc.

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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 ?*



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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!



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What about windows

Note frost at parting rail

ASHRAE 62.2 6.6

Passive Vents?

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Cap and vent sumps

or soil gas, radon, moisture flow into the home



Courtesy Mr. Basement

©2021

Please don’t do this



©2021



Or this

©2021

Or this



©2021

Or this



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



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Measuring Exhaust Air Flow



Courtesy USDOE,eere.energy.gov

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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 RJ Karg Associates and ASHRAE

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

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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

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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

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



Courtesy RED

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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

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Ventilation and Source Control

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Ventilation can’t fix everything



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

We’ve all been in “smoking sections” in restaurants

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Odors in general

The nose knows…





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Limit VOC Sources

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

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“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



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“Ensure combustion appliances do not backdraft when <u>all</u> exhaust appliances are operating simultaneously”



Make-up air ?

ASHRAE 62.2

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Heating

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Burning Wood

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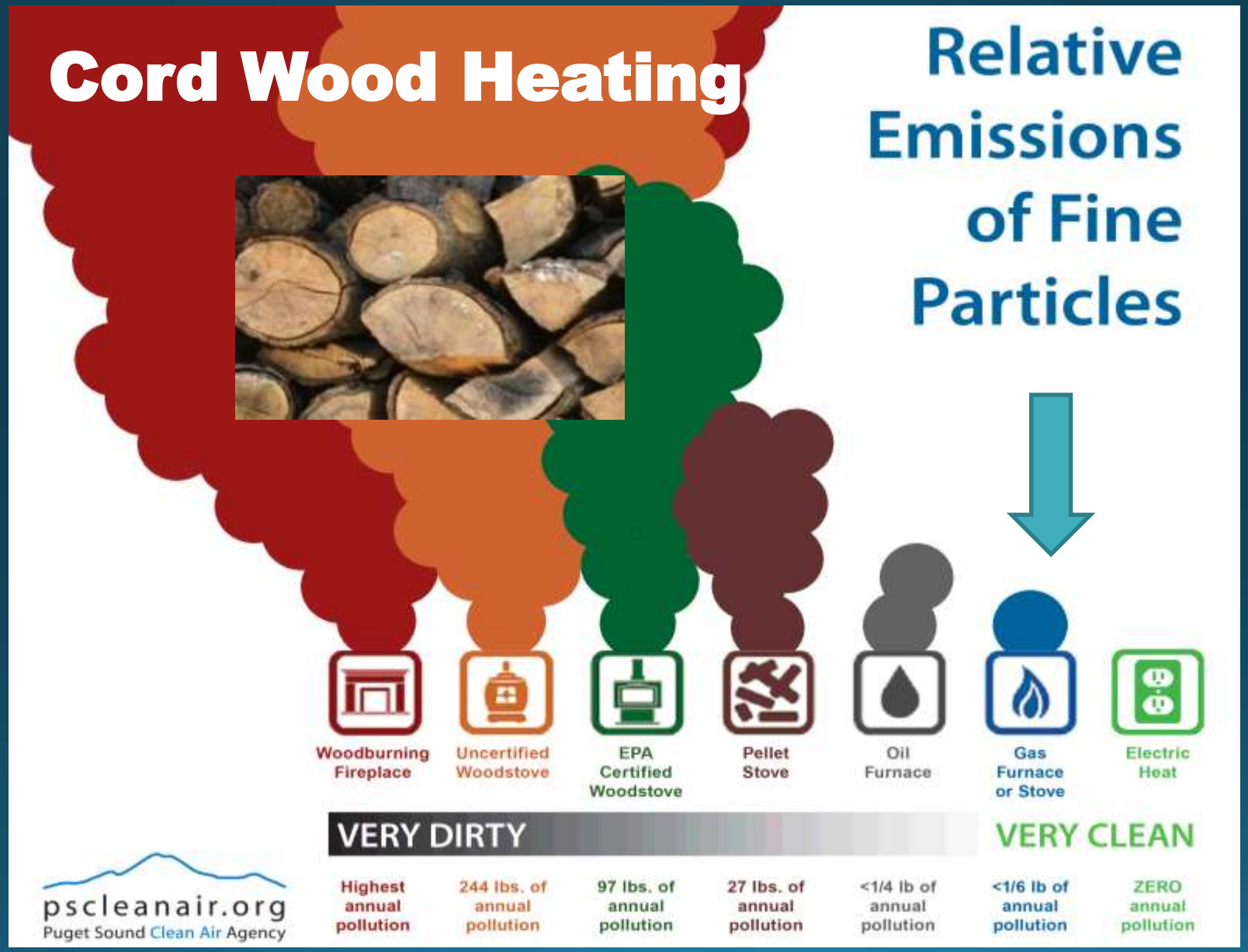
When Burnt



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“Seasonal smoke from outdoor wood fired boilers poses health risk”



UW-Madison

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Most folks
like wood fired
radiant heat

Especially in older
leaky homes

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Removing Particles Air Filtration

This is not an air filter



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Typical MERV 8 filter



Minimum Efficiency Reporting Value

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Particle Filtration Maintenance?



Courtesy Turner Building Science & Design, LLC

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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**

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Normal install of particle air cleaning filter



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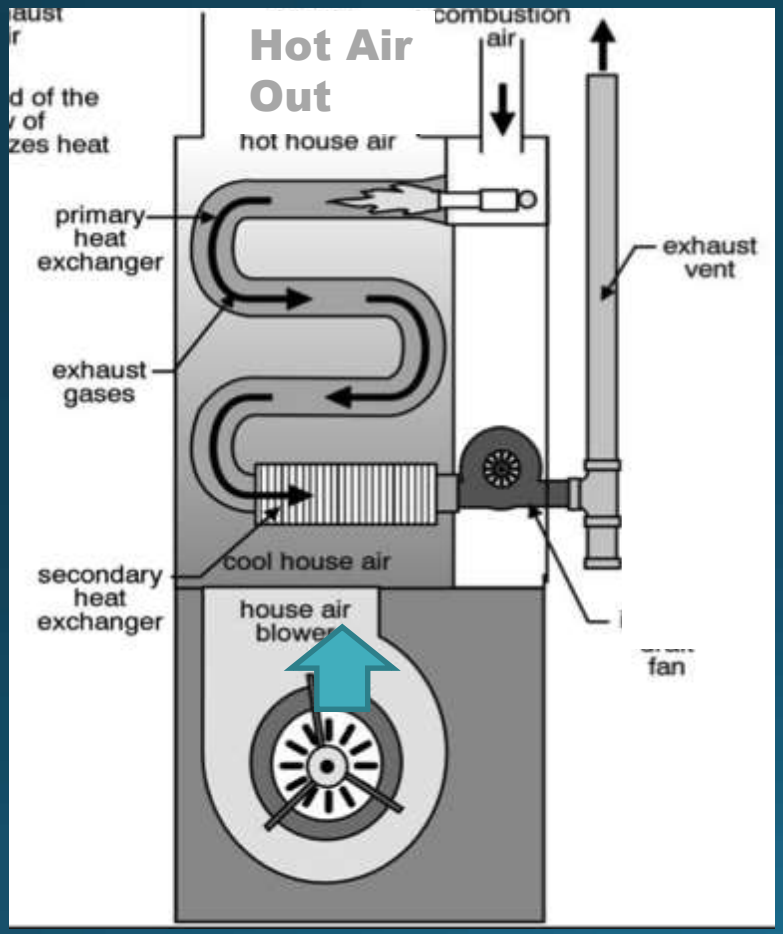
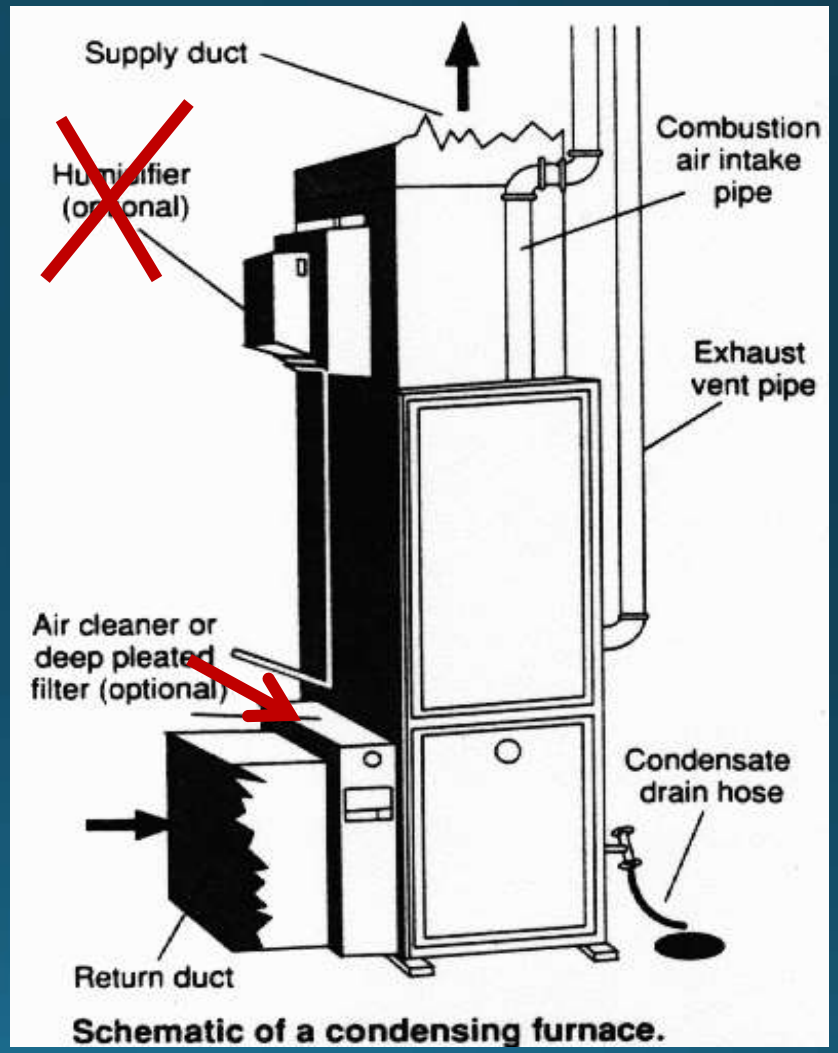
Courtesy: honeywellstore.com/store/images

Get a Modulating Gas Fired Condensing Furnace



Return



Schematic of a condensing furnace.

Add 4 inch pleated filter

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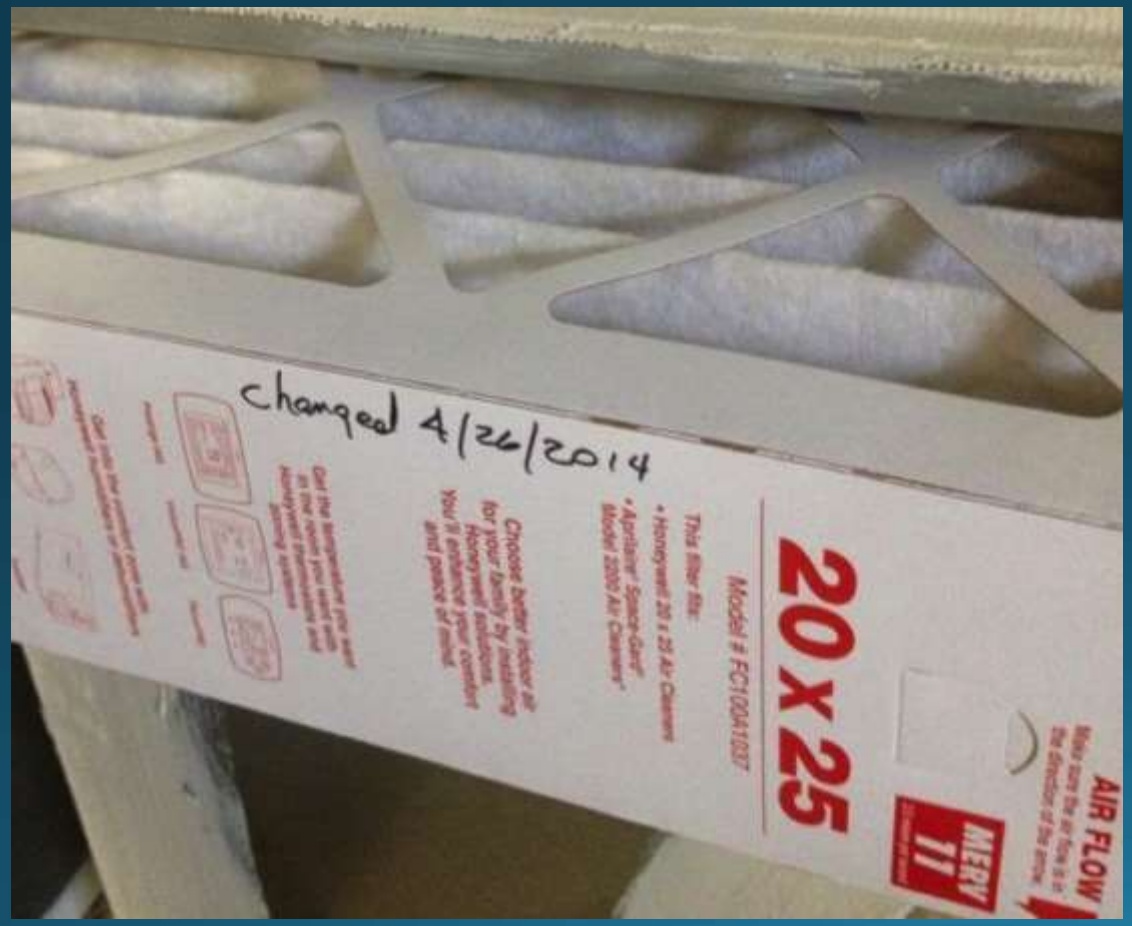
Proper size , fit, and maintenance is important for all air filters, especially high efficiency



Up to 1500 cfm (492 FPM)

$25.00?

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Small particles penetrate very deeply

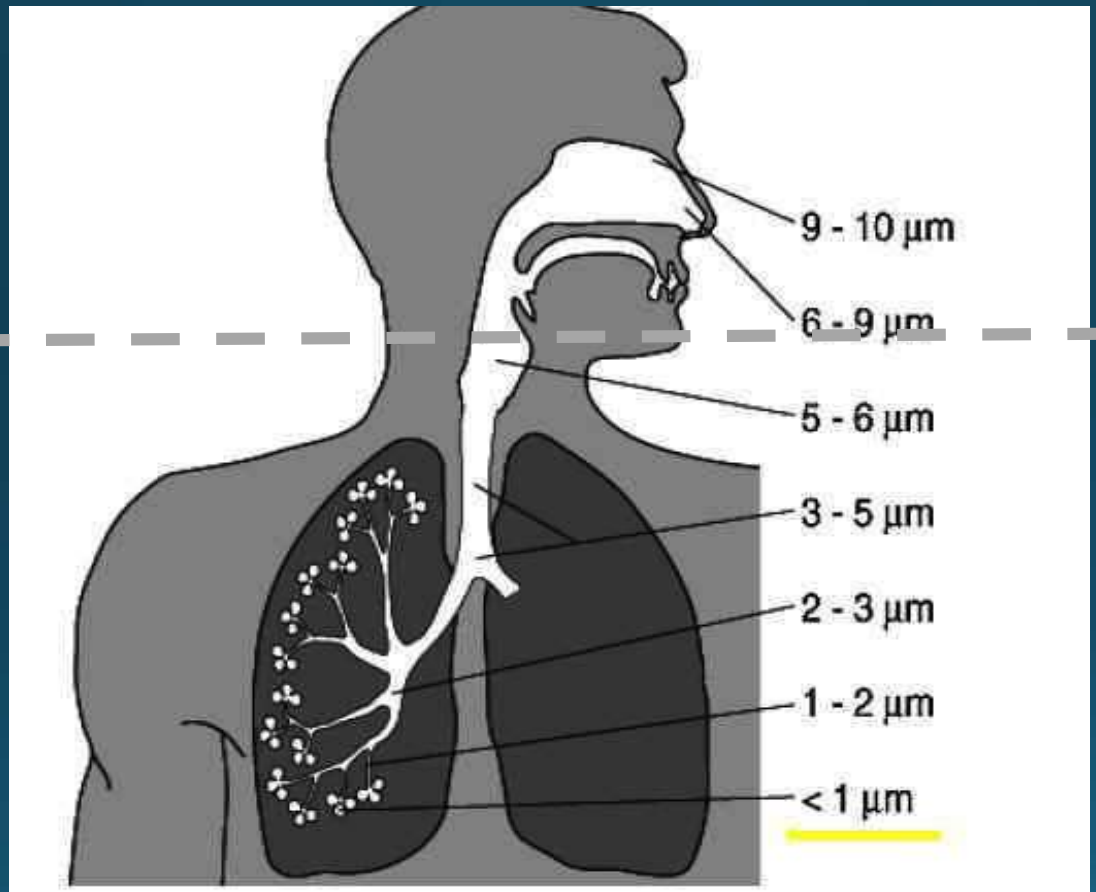

Figure 2 Particle deposition in respiratory system

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

©2021

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



$350 plus install
240 CFM

Courtesy: fantech.net/CM3000



Courtesy: rcmzeroenergy.com

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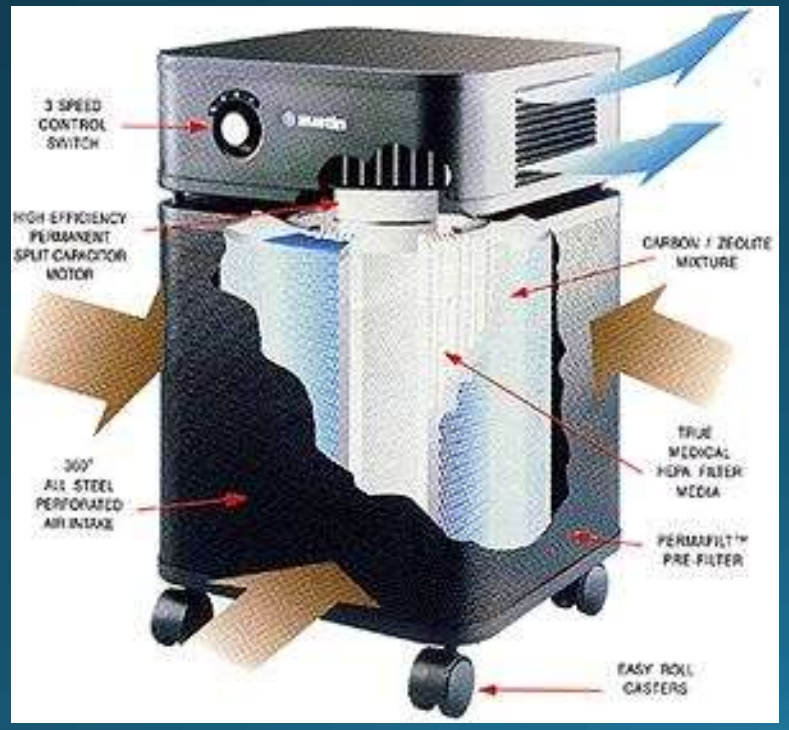
Typical HEPA stand alone room particle air cleaning device (less than $500)



Courtesy austinair



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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

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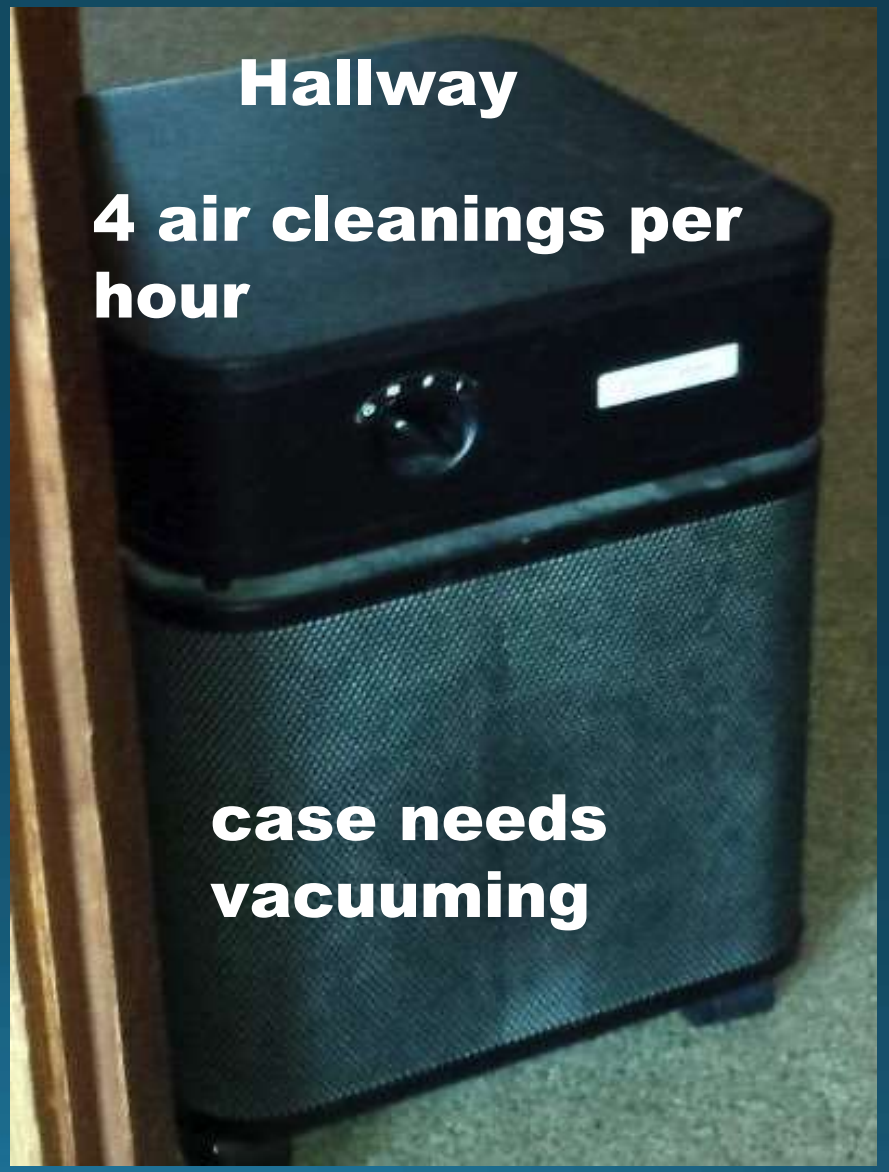
W. Turner our sanctuary bedroom areas,
Medium speed = 125 CFM





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

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Home made particle air cleaners



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Never allowed indoors?

Isolate and vent to the outdoors





Courtesy Camroden Associates

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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**

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Fifteen minute Break

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Efficient?
Legal for heating indoors?





You can’t go wrong with that…

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Window mounted pellet stove?





Manchester, ME

©2021



Atmospheric oil fired forced hot water boiler

Heavy duty and bullet proof 20-30 year life span

AFUE = 86.2%

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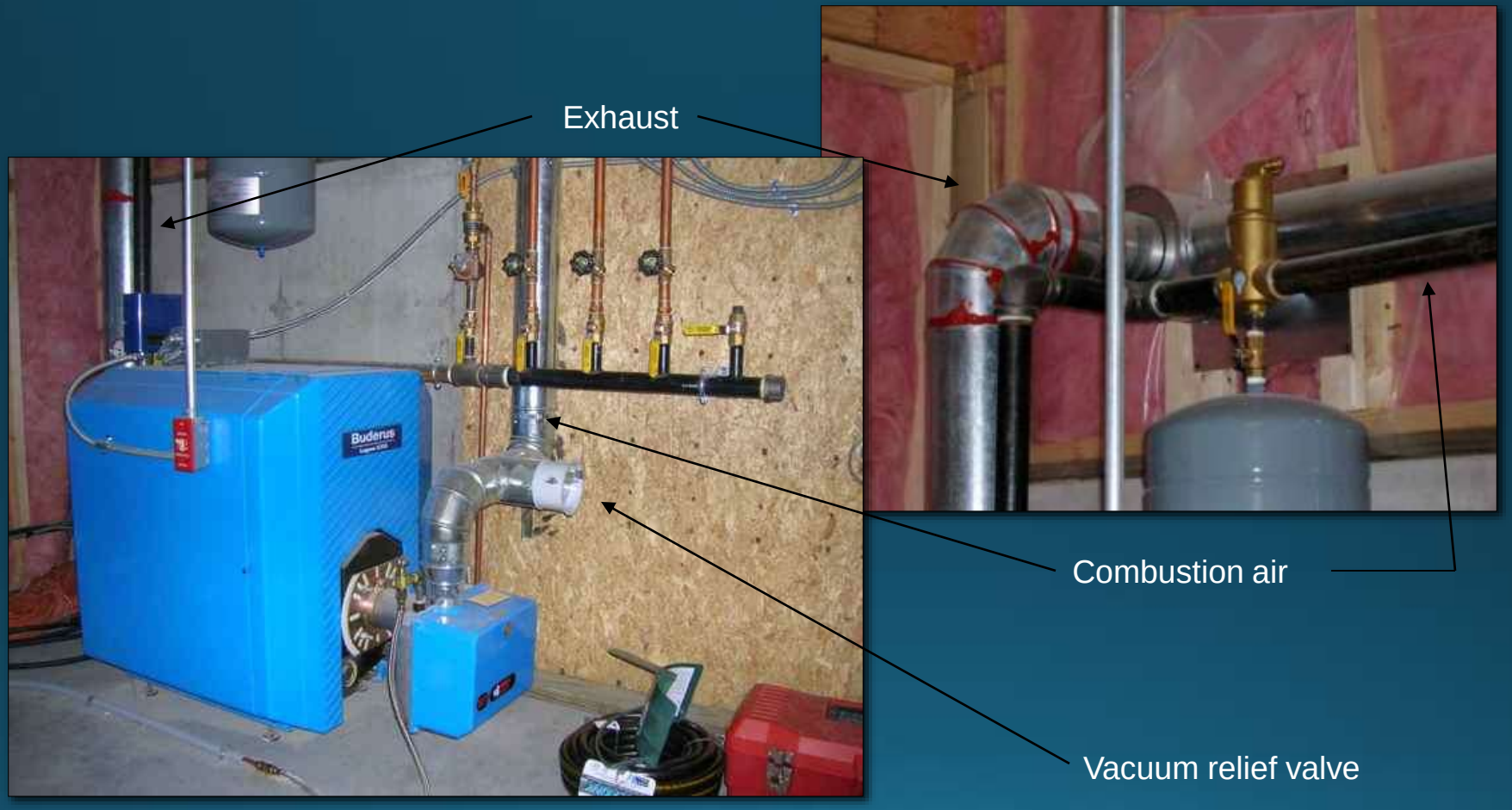
Oil fired semi-sealed combustion?



Non condensing boiler

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Gas or Oil fired Condensing boiler

The plume contains CO_2 and H_2O



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High sulfur exhaust plume



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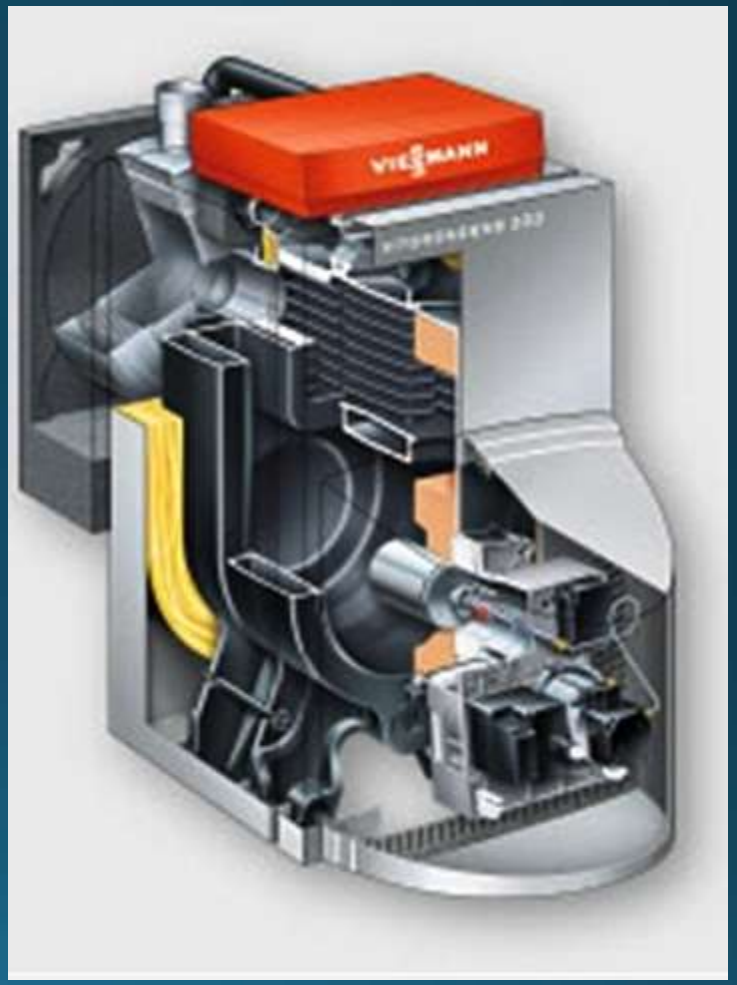
Condensing Oil Fired Boiler



AFUE =88.1%



Vitorondens 200-T 53KW Oil

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Sealed combustion

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

Veissmann™ Vitodens

AFUE = 95%



Condensing boiler

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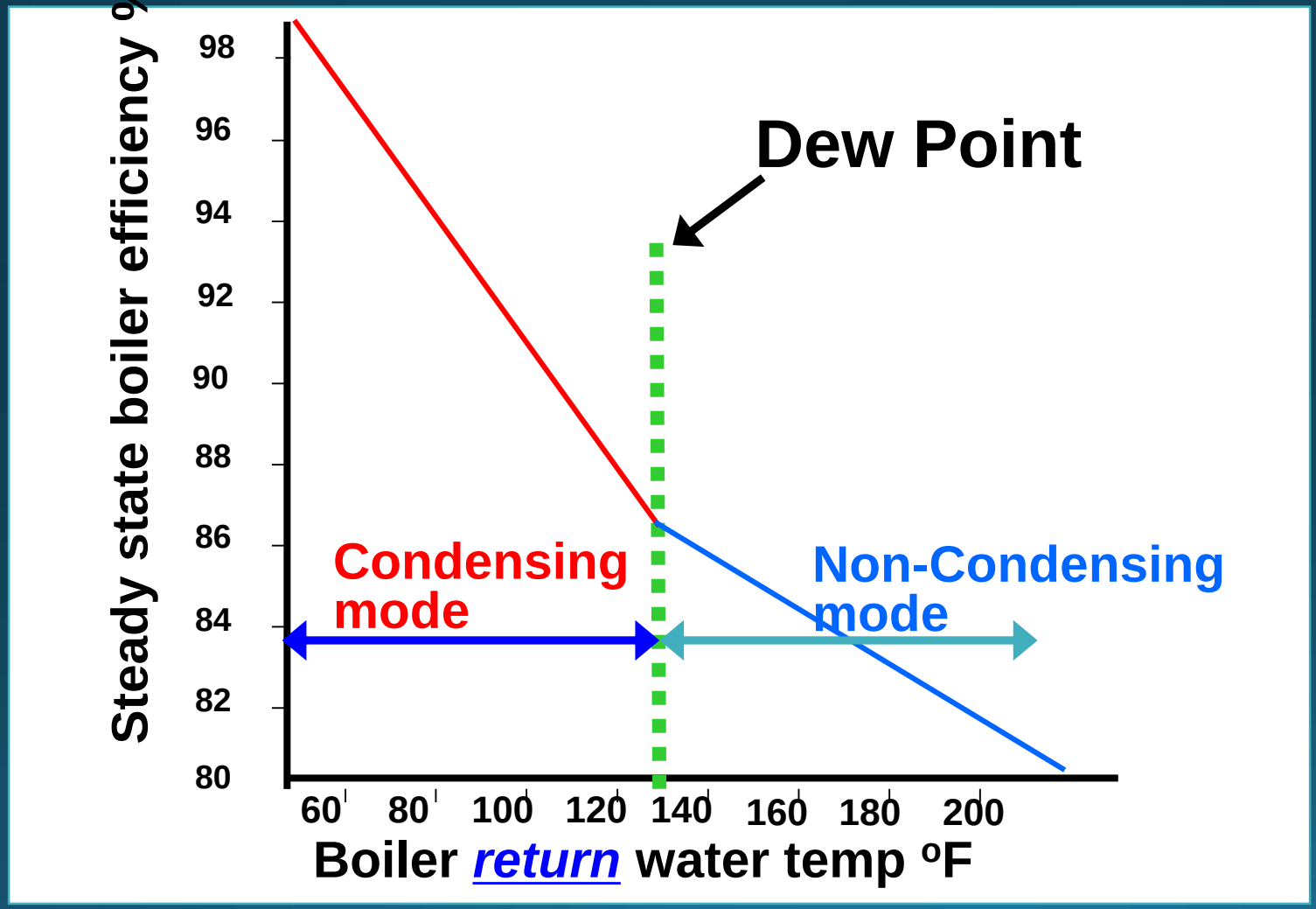
Boiler fuel efficiency



Courtesy ASHRAE

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

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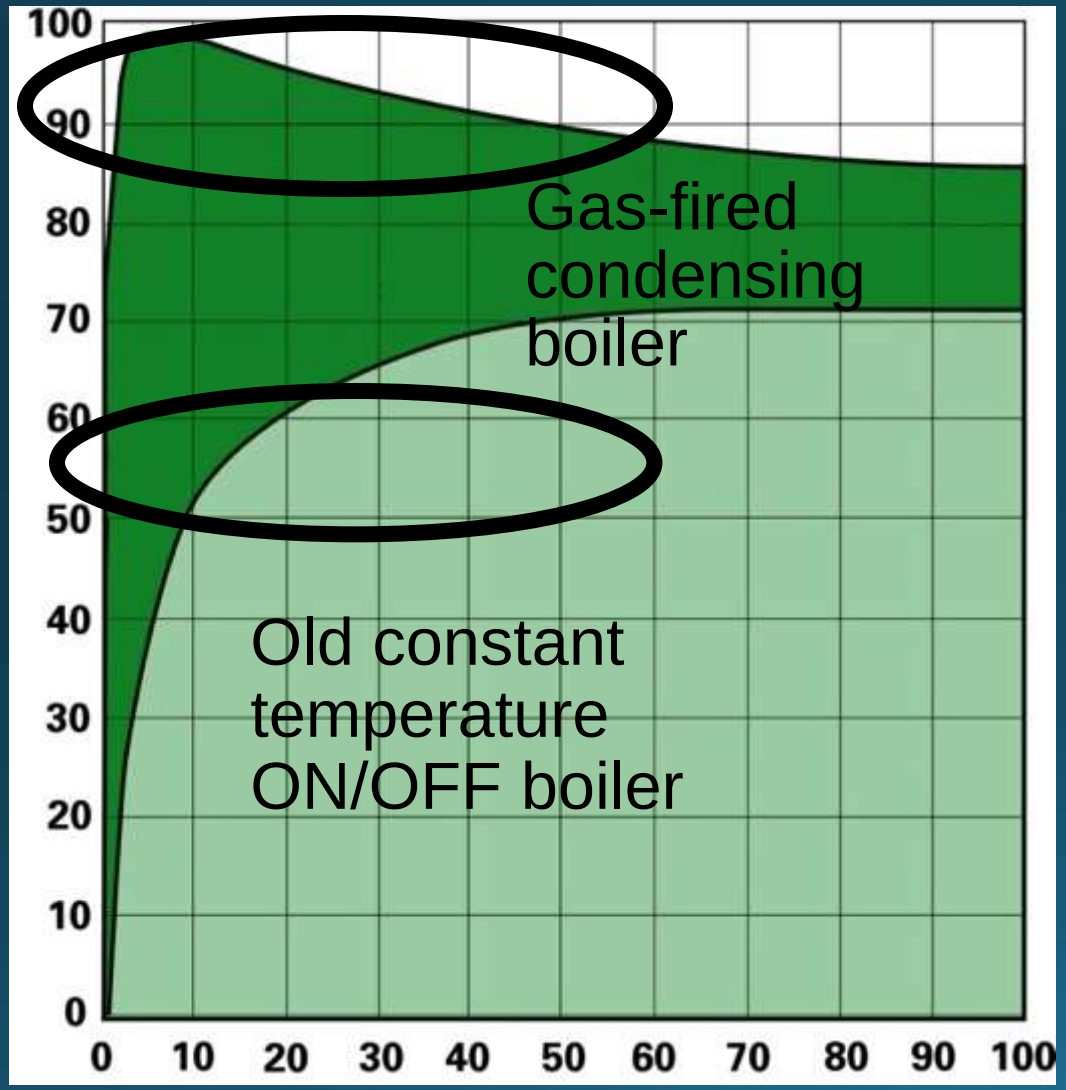

Typical boiler efficiencies

96 %

vs.

56%

Courtesy Viessman

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High Performance Boiler Repairs?

Trained Expertise Available?
Contracted Maintenance?
Stocking Spare Parts?

Who?? How Fast??

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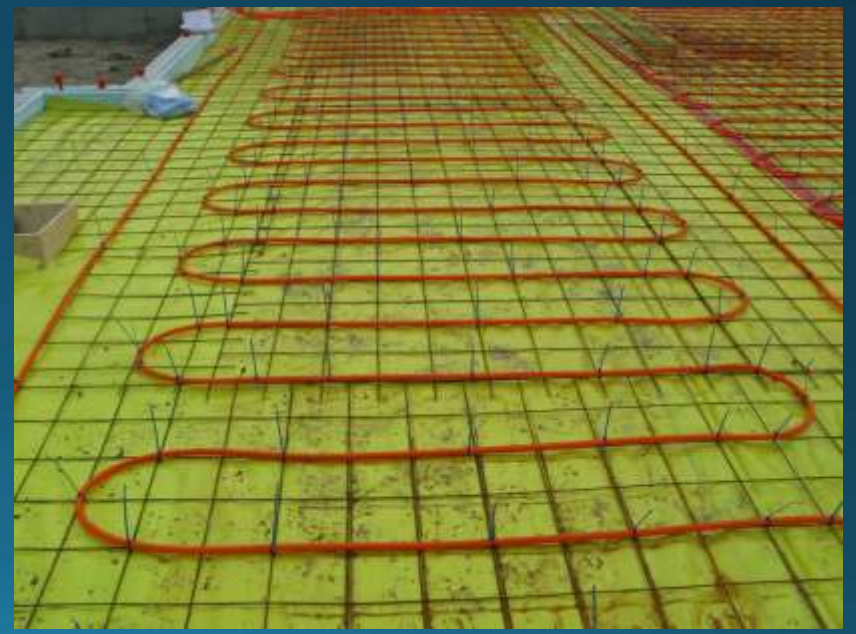
FHW Distribution









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Normal radiator placement

Why?

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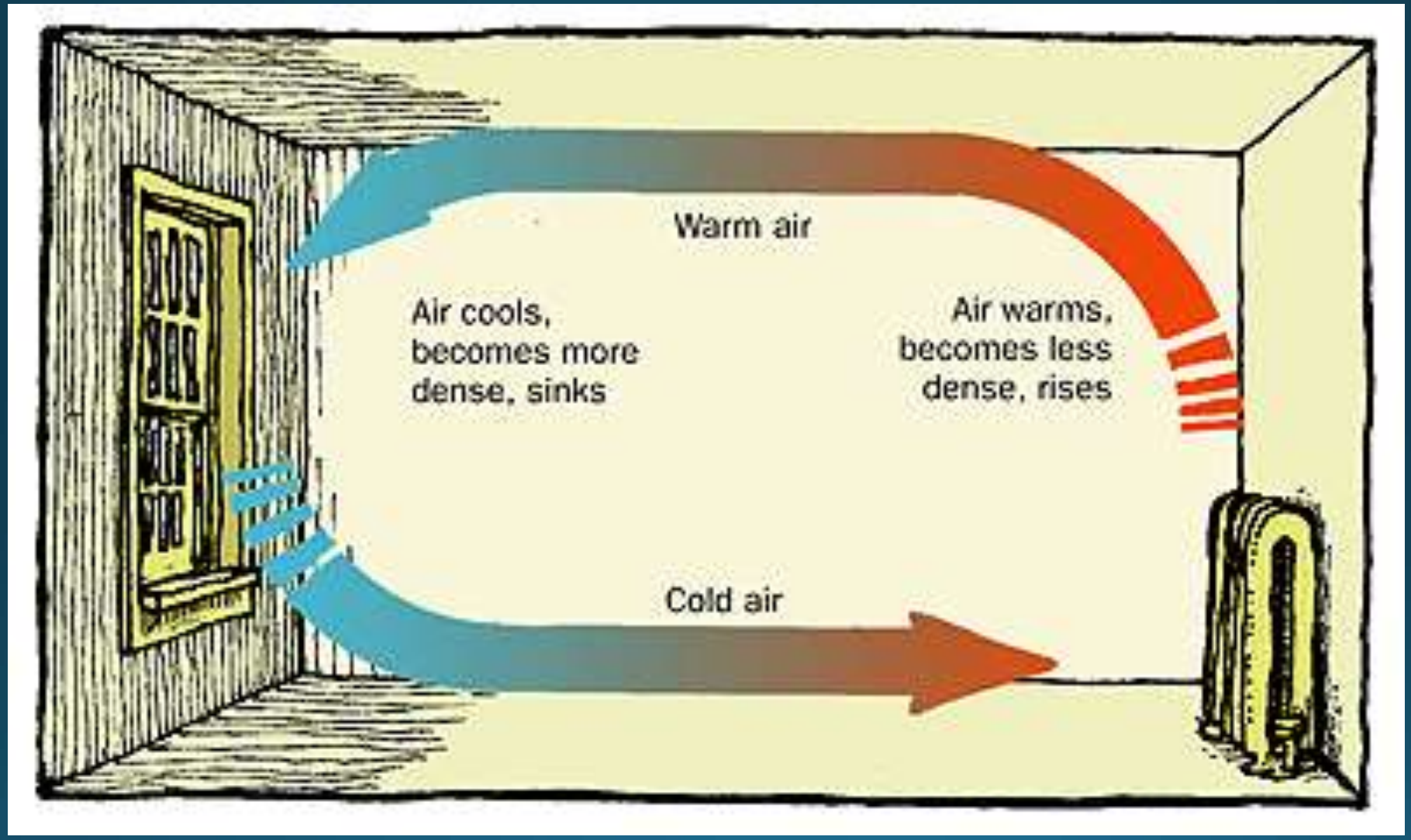
Uncomfortable Convective Loop, cold floor, cold feet



Unusual radiator placement

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CP371 Qmark Radiant Panel



120V 375 watts

Spot heat in bathrooms

Easy repairs?

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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

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Harmonic Noise



Dead quiet

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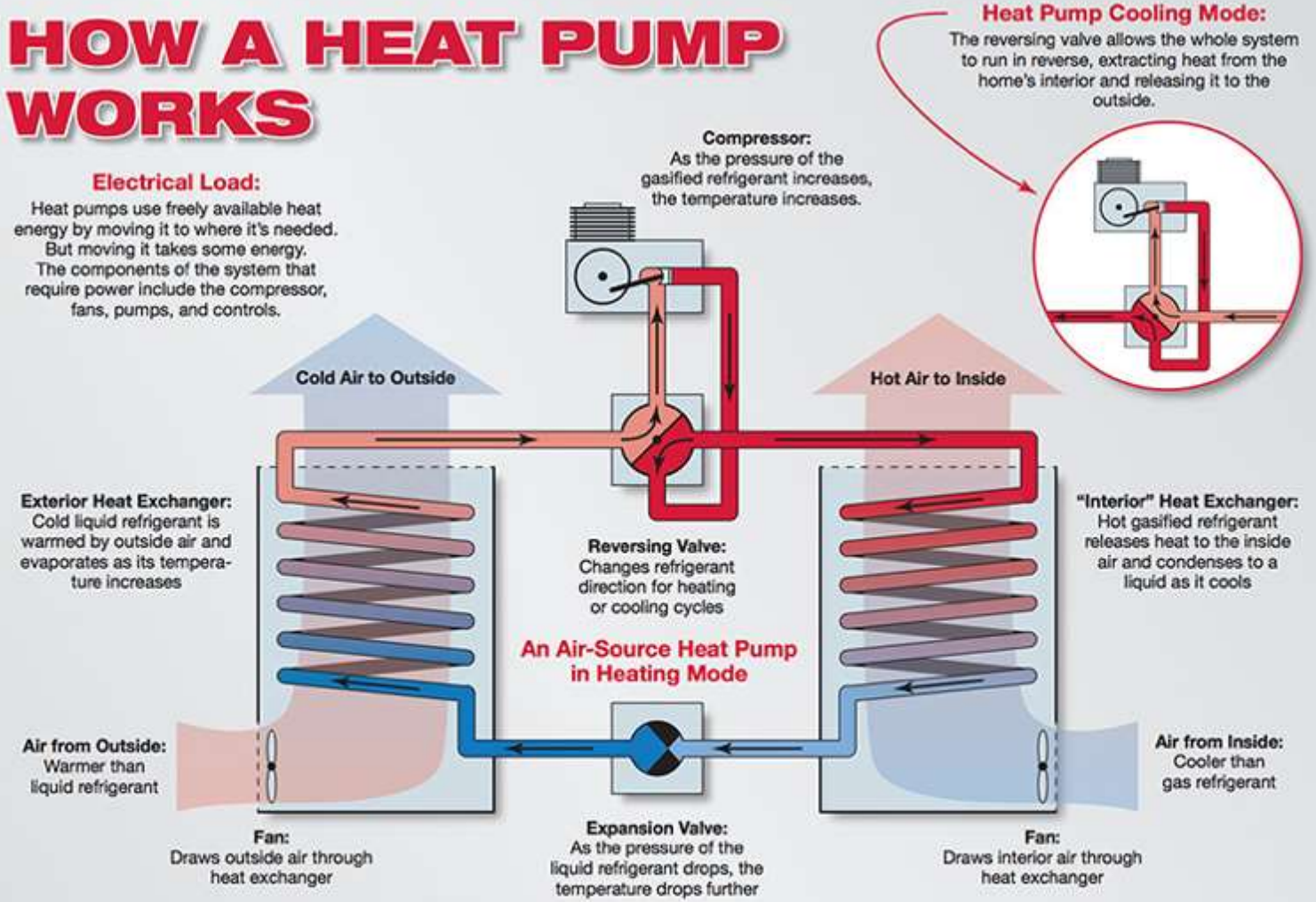
HOW A HEAT PUMP WORKS



Courtesy Homepower Magazine

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Mini-splits





Typically do not have outside air supply



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

May be stand alone or ducted

One head or several heads

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Heat Pump Water Heater

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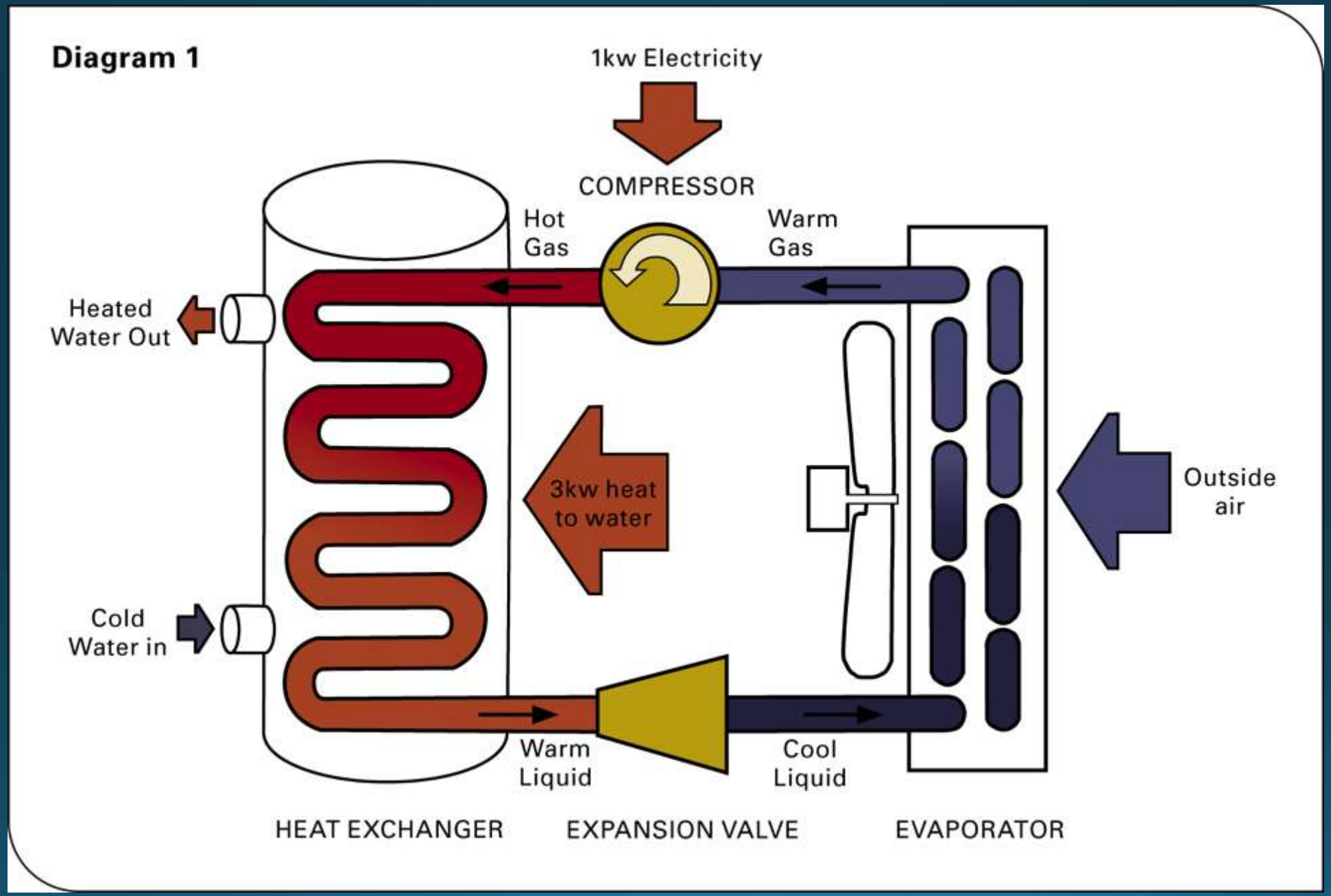


Diagram 1
1kw Electricity
COMPRESSOR
Hot Gas
Warm Gas
Heated Water Out
3kw heat to water
Outside air
Cold Water in
Warm Liquid
Cool Liquid
HEAT EXCHANGER
EXPANSION VALVE
EVAPORATOR

©2021



Sanden SANCO$_2$ Heat Pump Water Heater

©2021



Vented clothes drying!?

©2021

People complained about slow clothes drying

This fell out



©2021





©2021

Non vented dryer

How do condensation dryers work?

1. Ambient (cool) air enters dryer.

2. Ambient air enters heat exchanger and is heated.

3. Ambient air (warm and dry) exits heat exchanger.

4. Process (heated) air enters drum to absorb moisture and dry load.

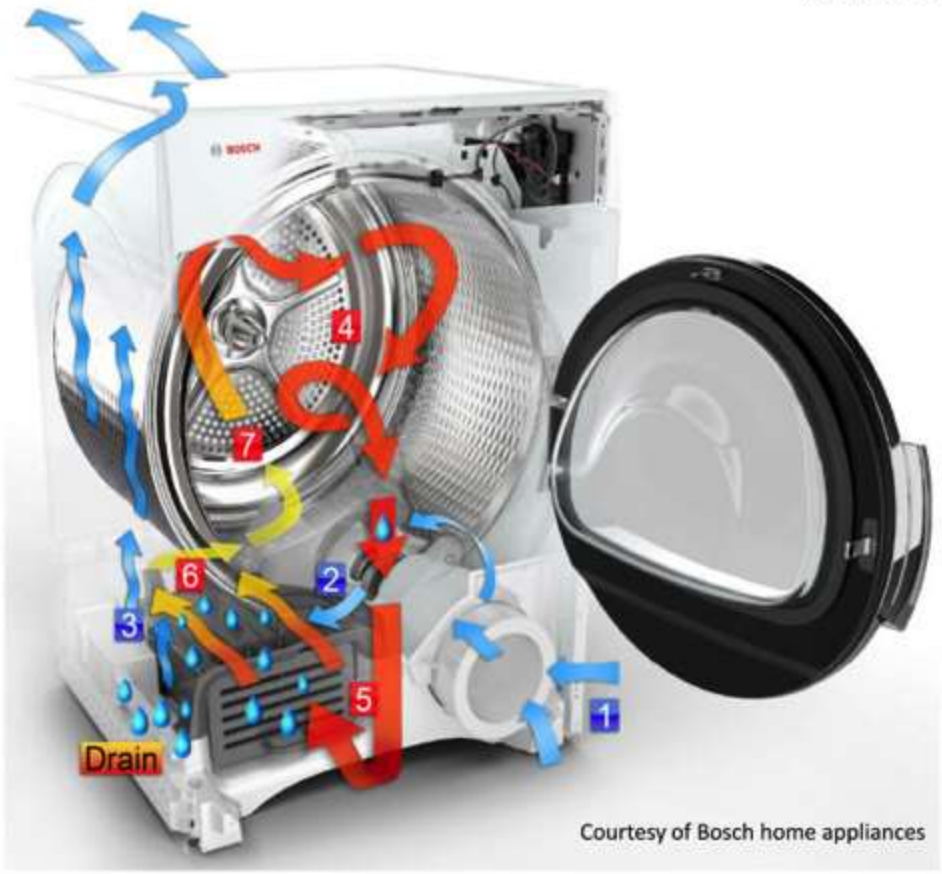
5. Process air (wet) enters heat exchanger, is cooled releasing moisture.

6. Process air (dry) exits heat exchanger.

7. Process air enters heater and is heated up.

Drain. Water is collected and pumped to drain.

BOSCH
Invented for life



Courtesy of Bosch home appliances

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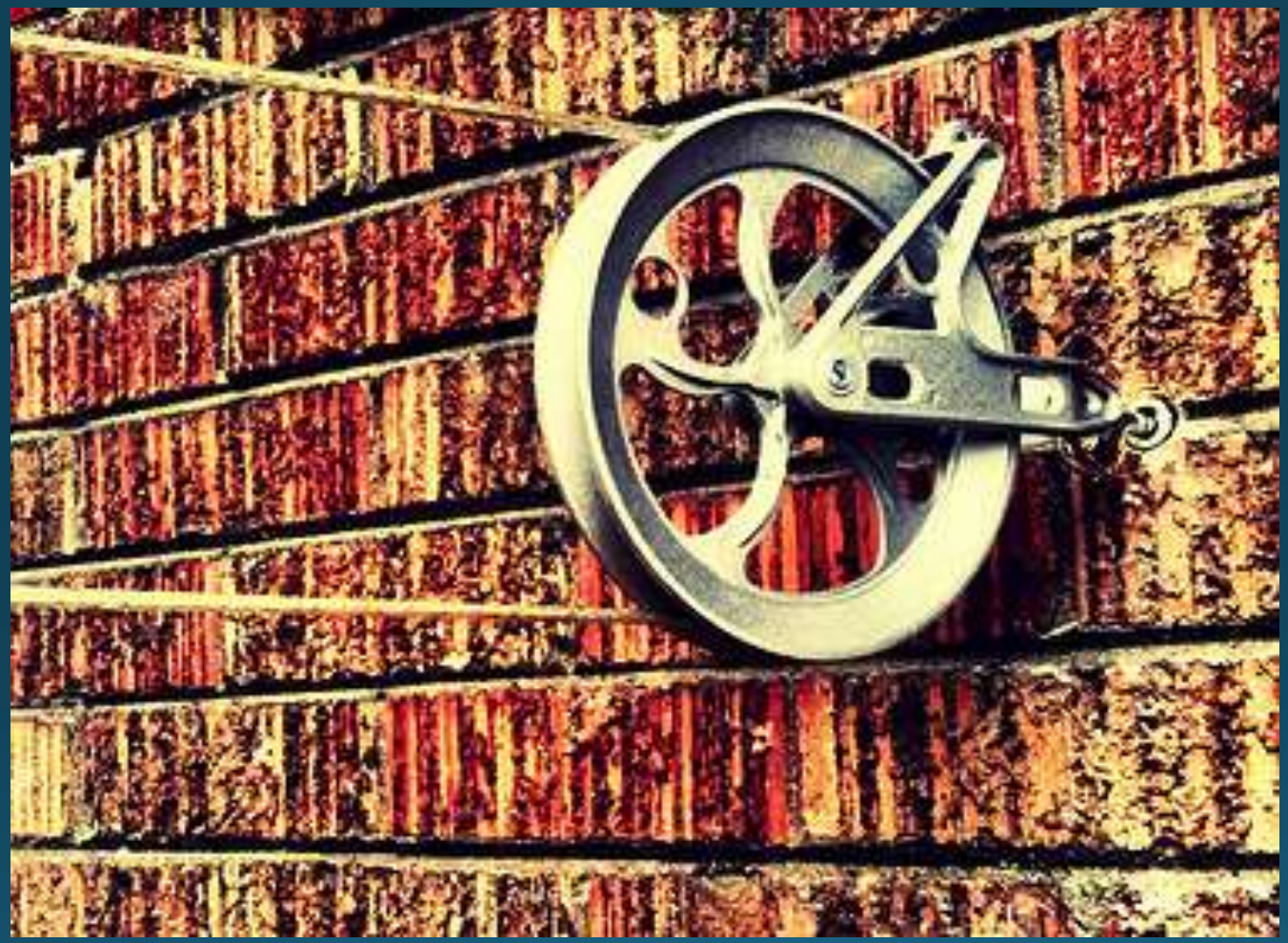

The original unvented dryer

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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

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Some further "Maine Climate Considerations"

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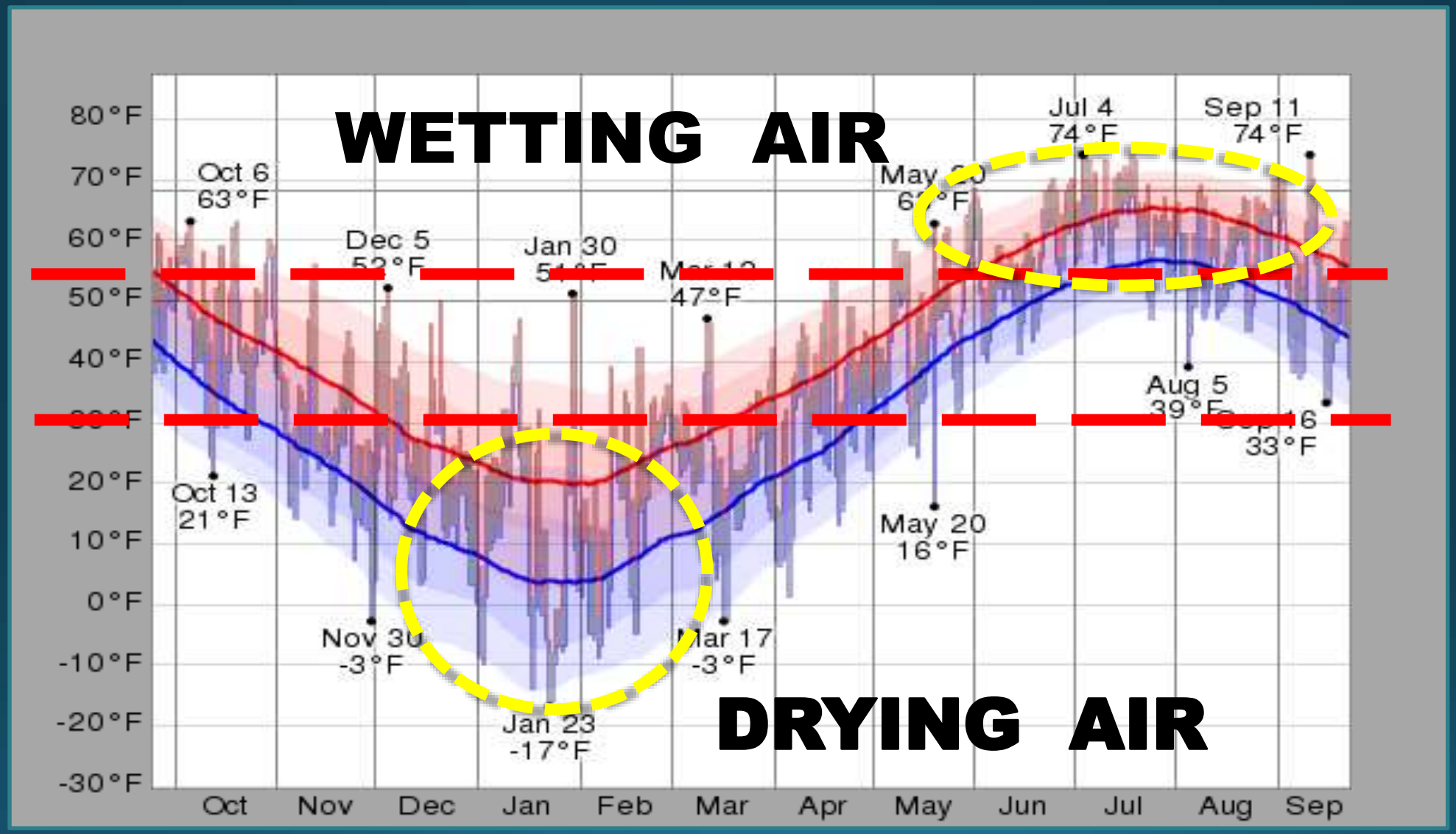
New England Dew Point Climate Graph



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WeatherSpark.com

Outdoor summer ventilation make-up air wets basements



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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%

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Dehumidifiers





Critical operating T°

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Add Humidity?

Aprilaire 800

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

Max 45%
25% when cold

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Builders’ Responsibilities

Radon… knowledge and implementation of ASTM E1465

Radon testing and mitigation are regulated in the State of Maine

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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

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Ventilate Right
Build Tight

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

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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

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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

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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

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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

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End of Session Two

Up next...

Dana Fischer

Mitsubishi Electric

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