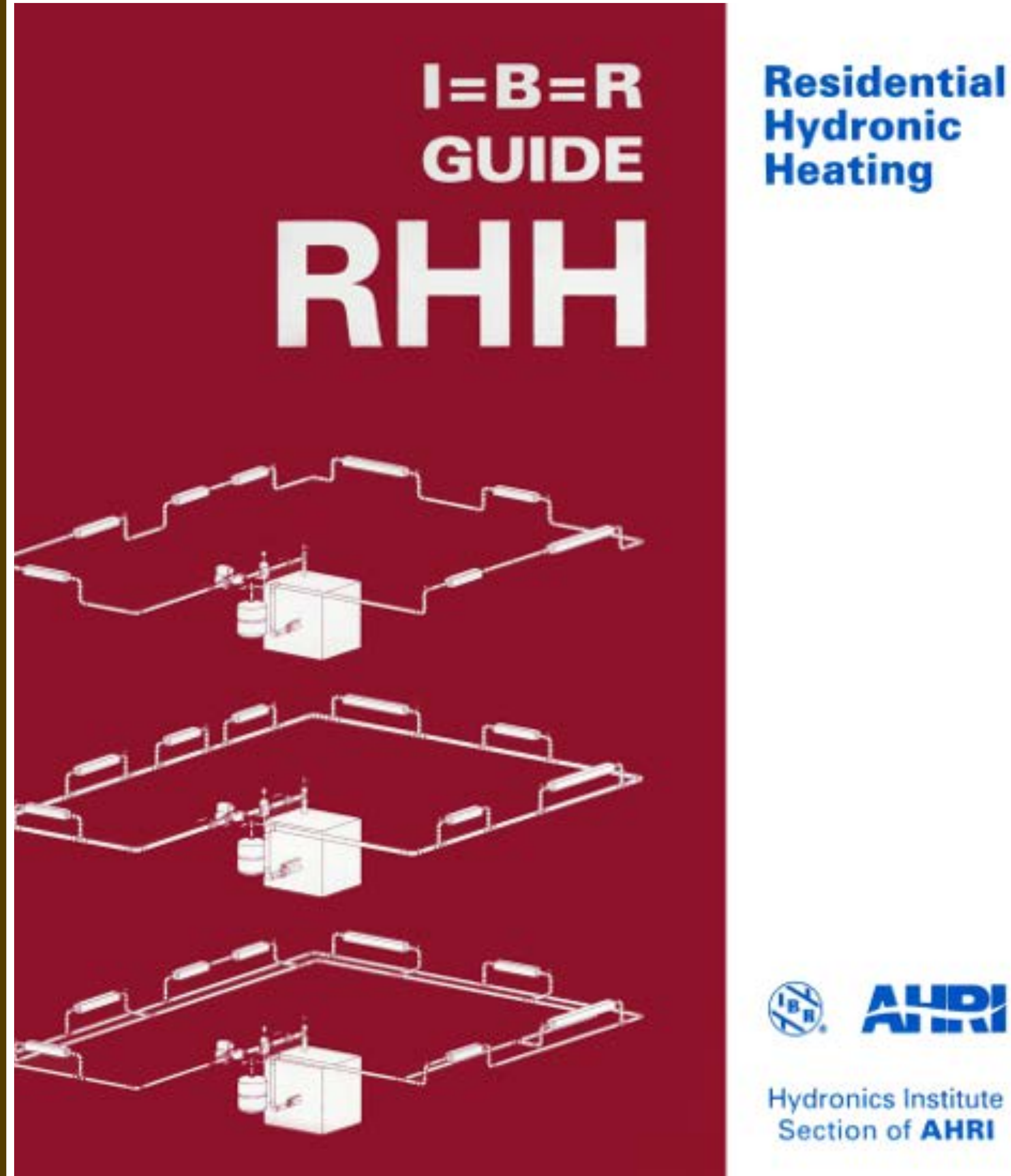
Noise concerns can be addressed with proper grille selection

Hydronic (Hot Water based) Systems present opportunities



Hydronic Heating

Advantages of Hydronic Heating Pipes

=

A ½"pipe delivers the same amount of heat as an

8" x 8"duct.

½"Pipe

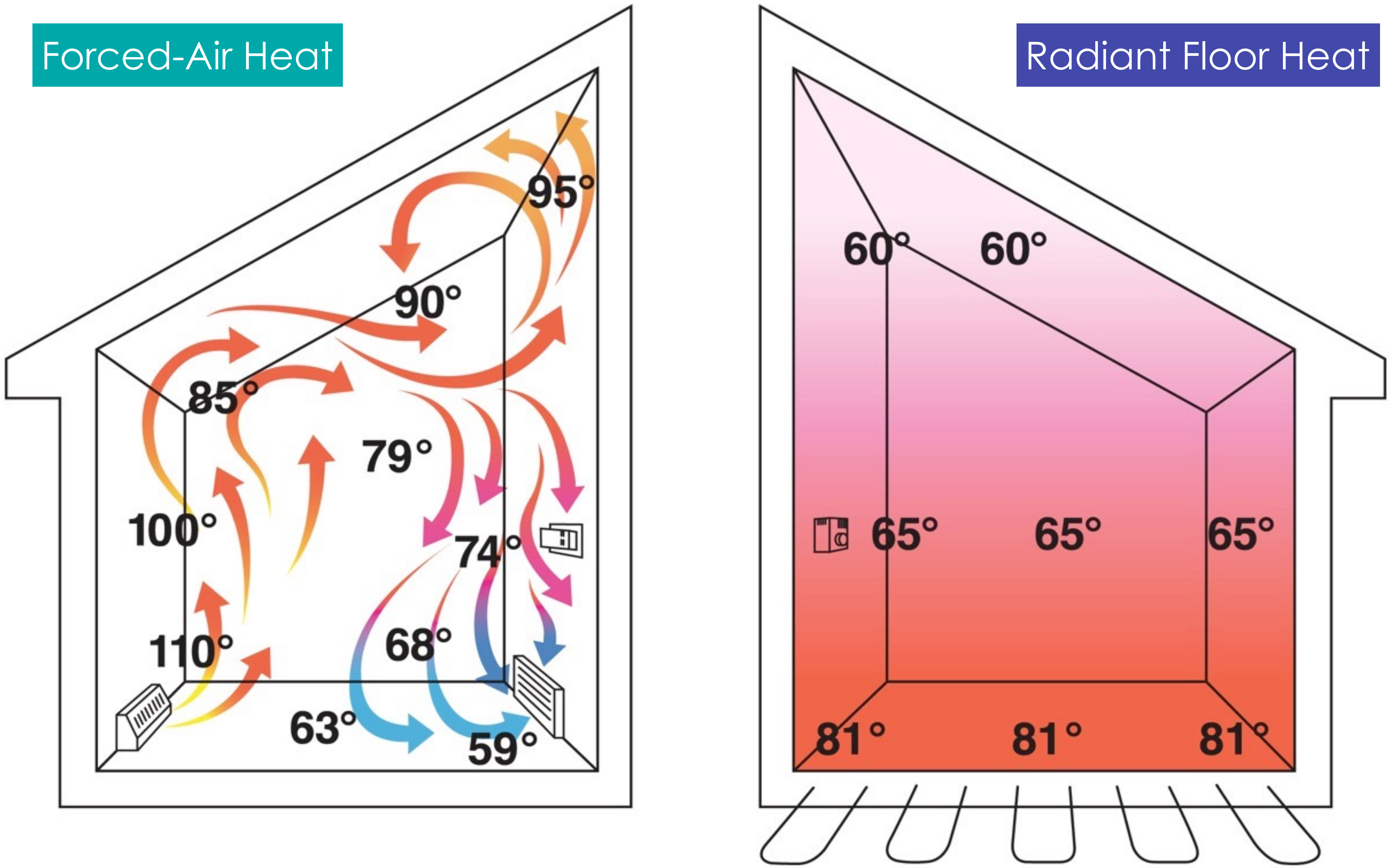
16,000 BTUs/hr
Heat Capacity

8"x 8" Duct

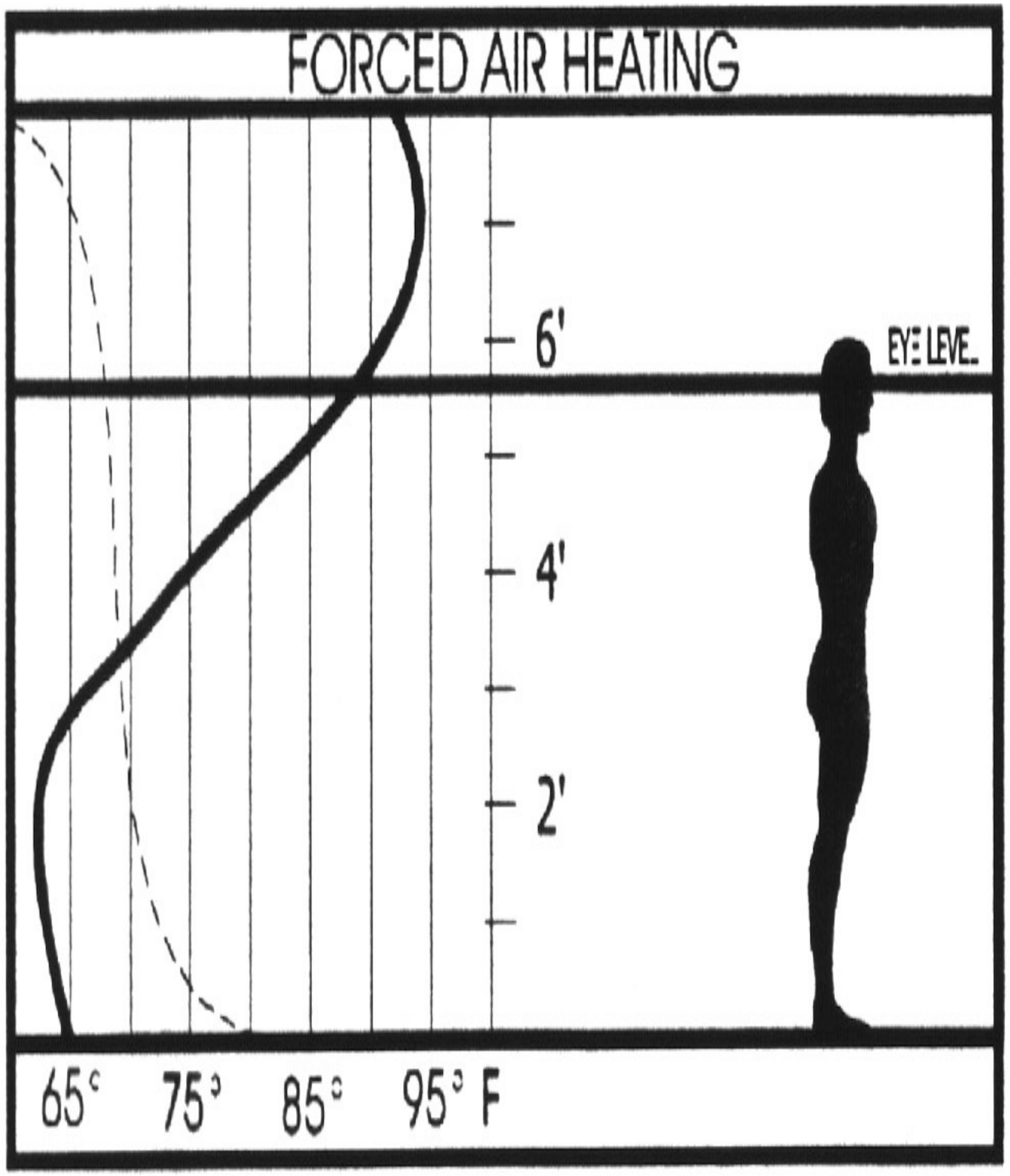
16,000 BTUs/hr
Heat Capacity

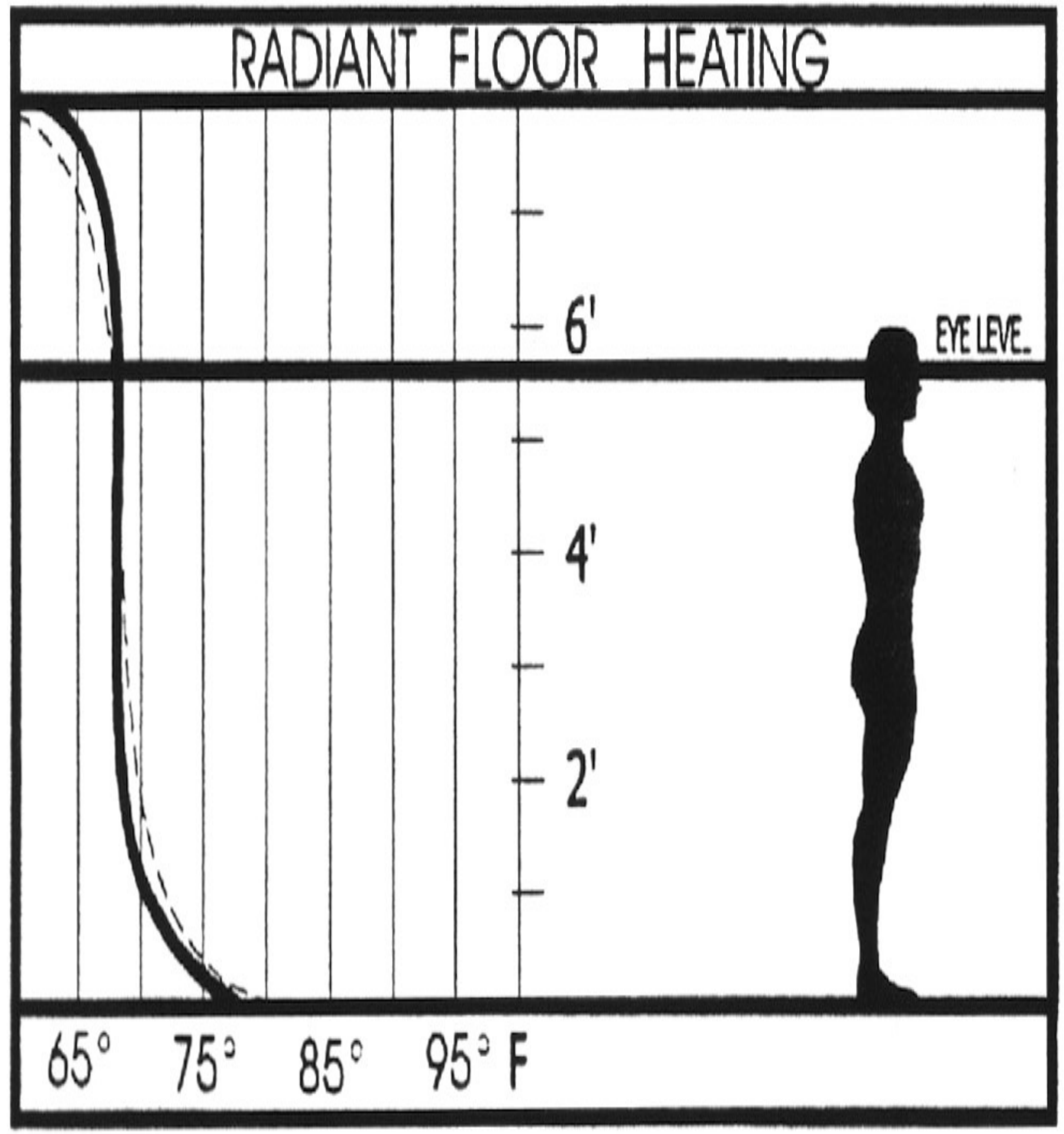
Temperature Gradients

Forced Air vs. Radiant Floor Temperature Distribution



Forced Air vs Radiant Heating Curves
- A good comfort match

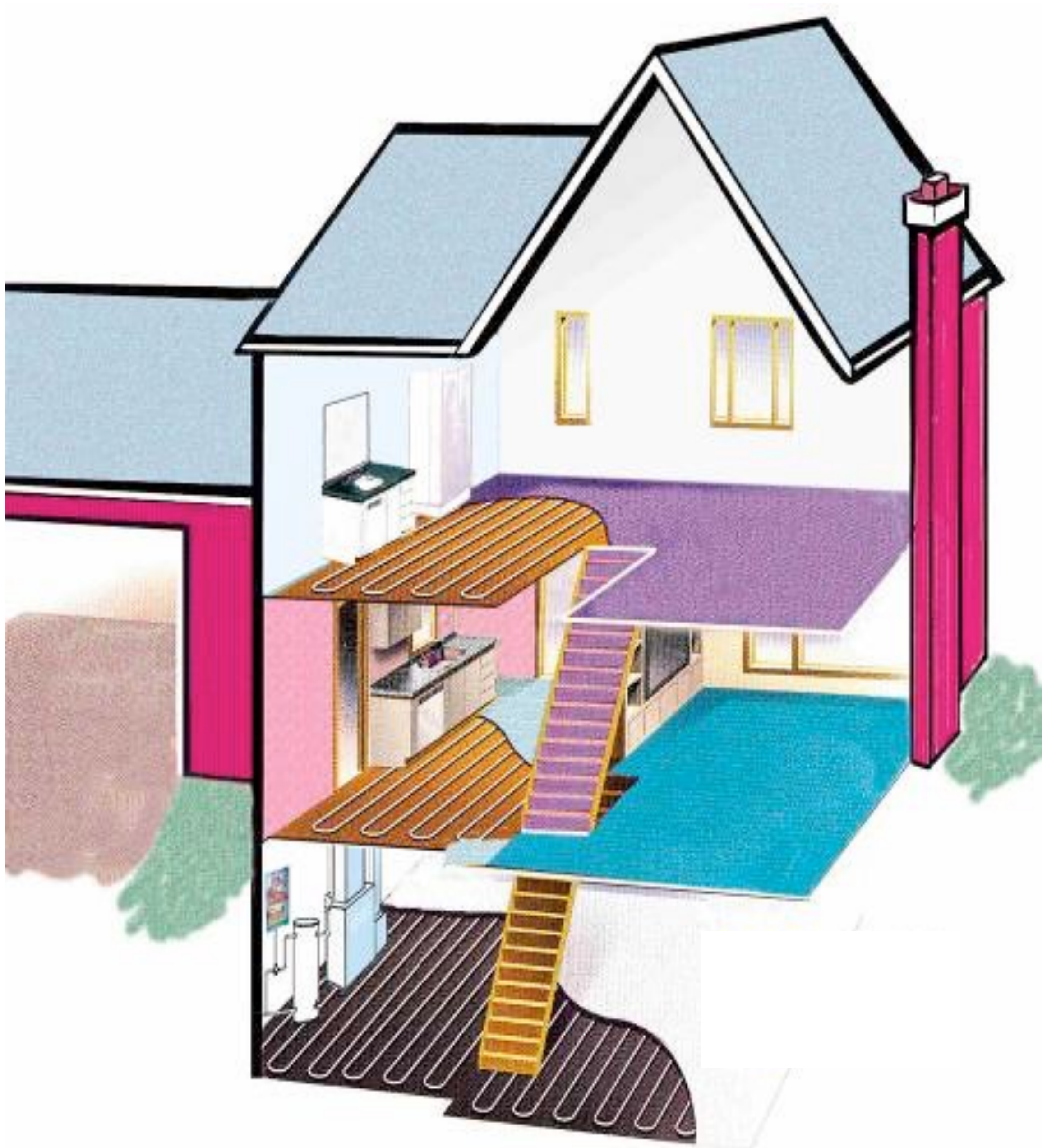




Radiant in-Floor Heat

- Heat surfaces, not air
- Lower noise
- Comfort on concrete floors
- Ideal for basements & “floor warming”
- Requires additional systems for AC, humidity control and filtration

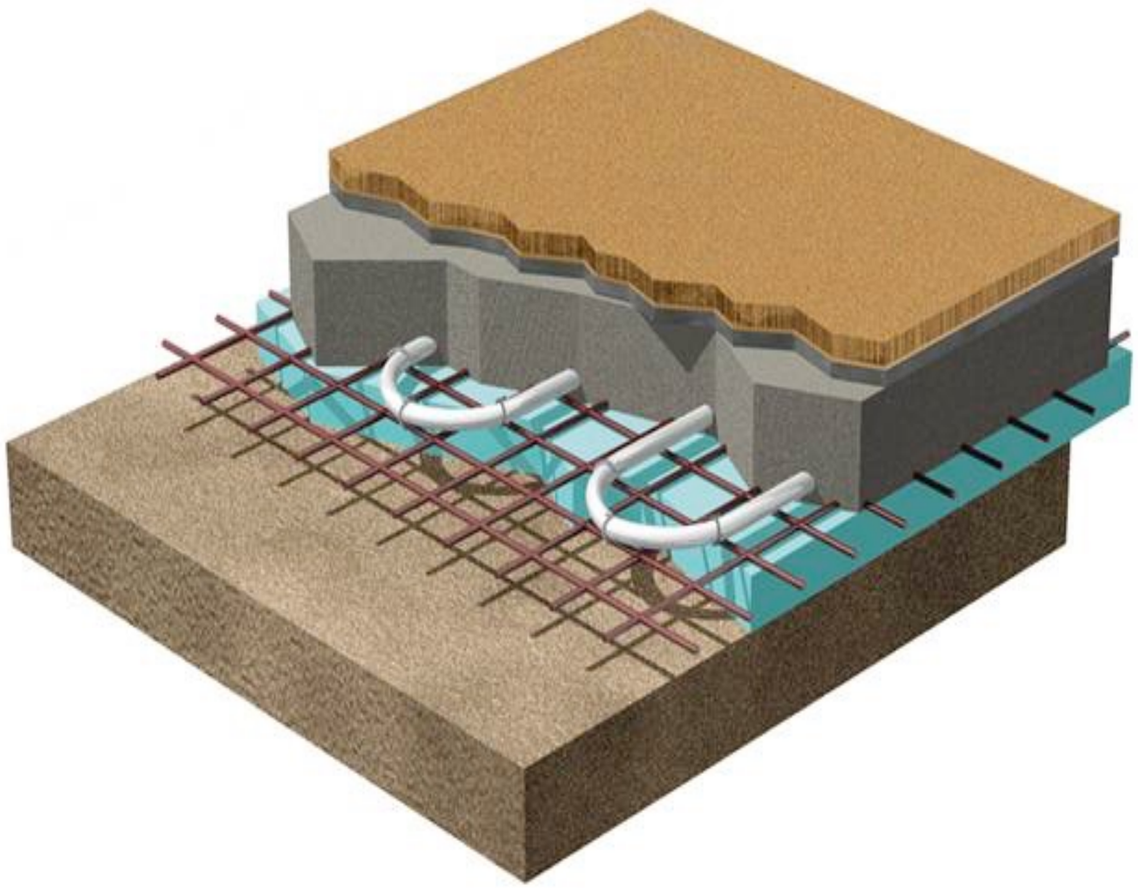
In-Floor Heating

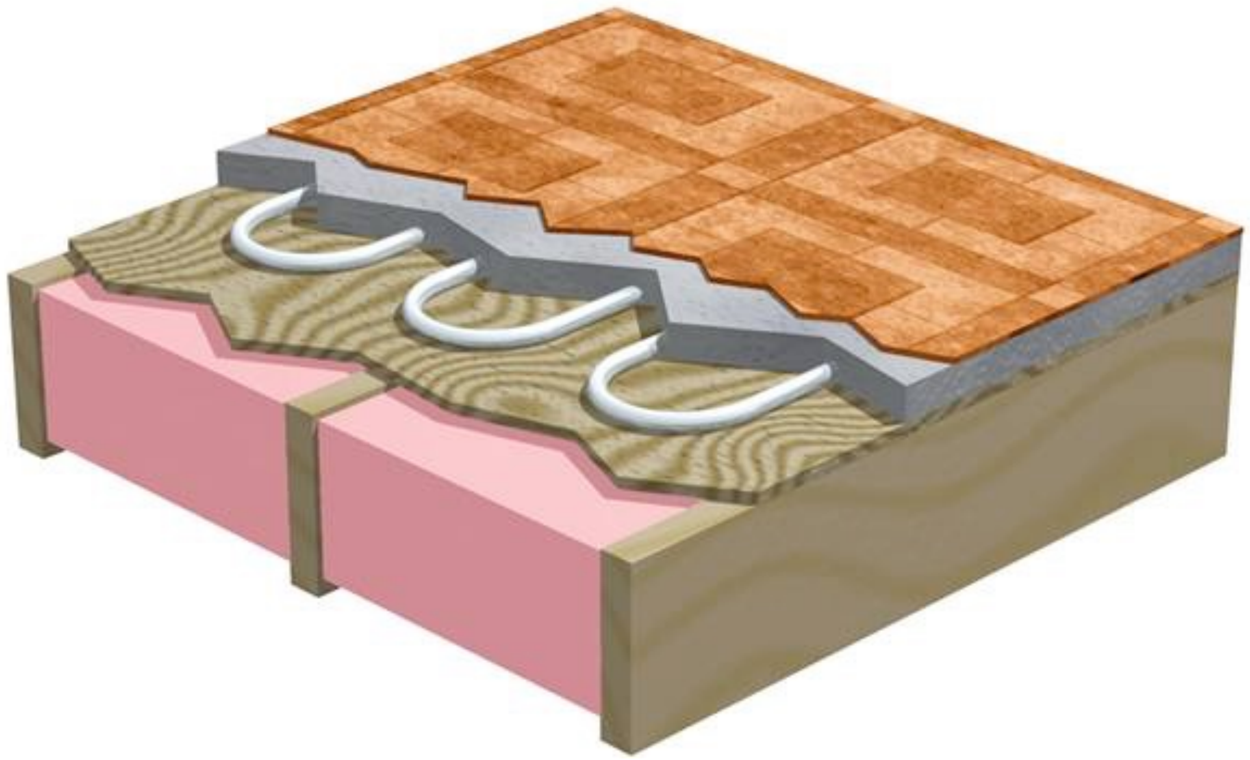


- Perfect in basements & for floor warming
- Hot water can be supplied from a water heater
- Can be more cost effective with rationalized controls and “combining” systems

Radiant heating installation methods

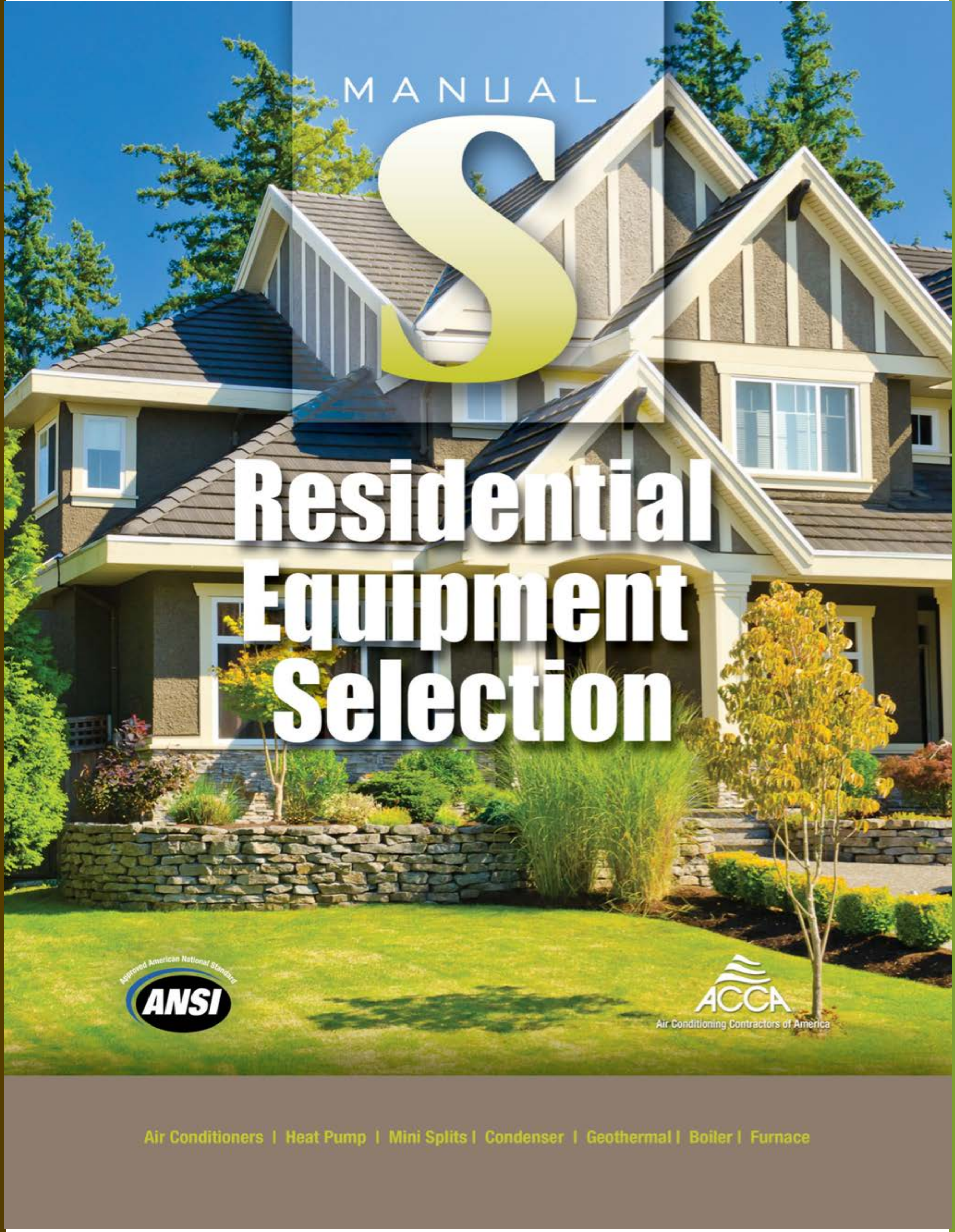
Concrete Slab





Poured Floor Underlayment

Select the right equipment



ACCA Equipment Selection

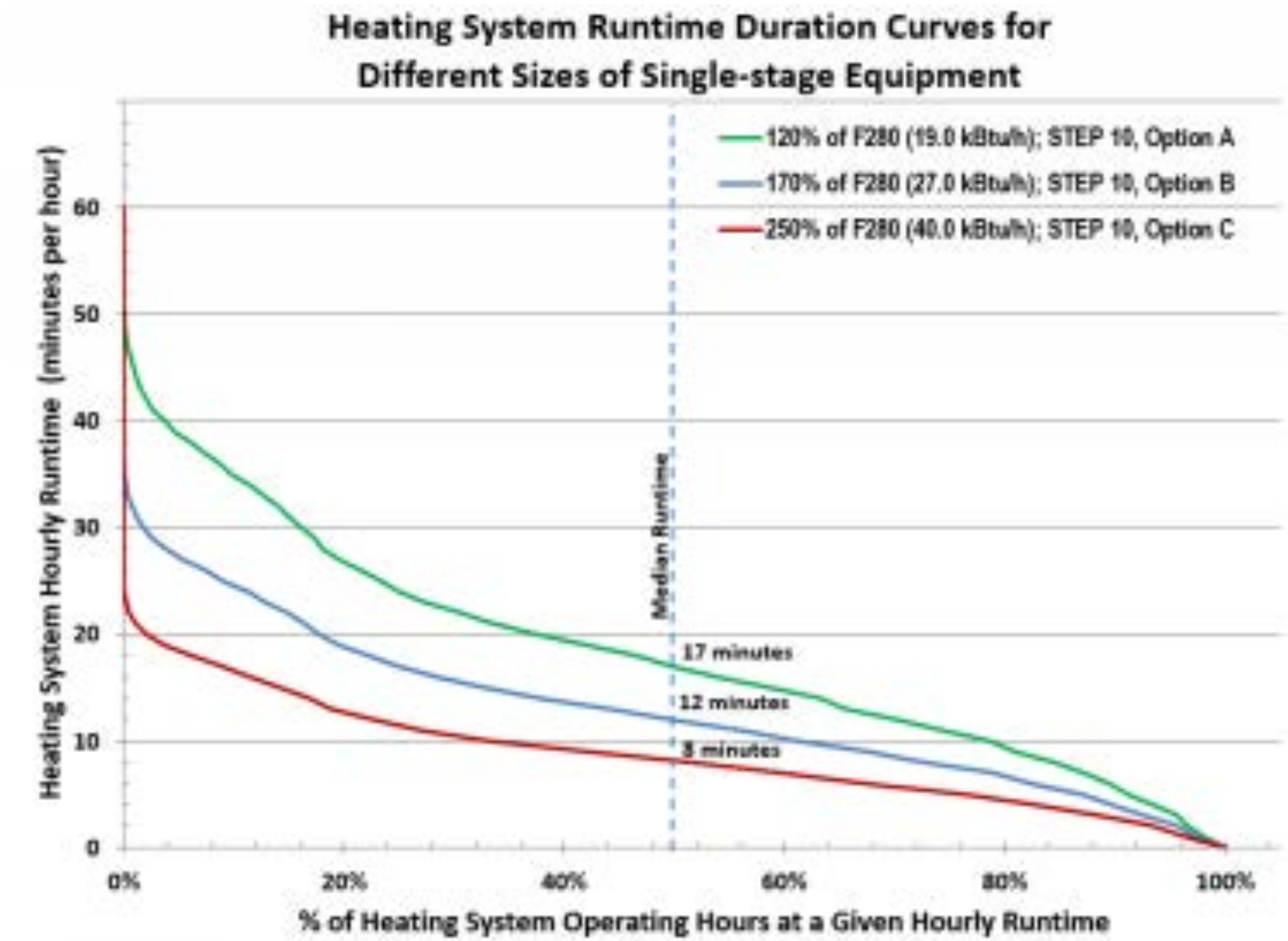


Figure 21: Runtime Duration Curves for Single-Stage Equipment

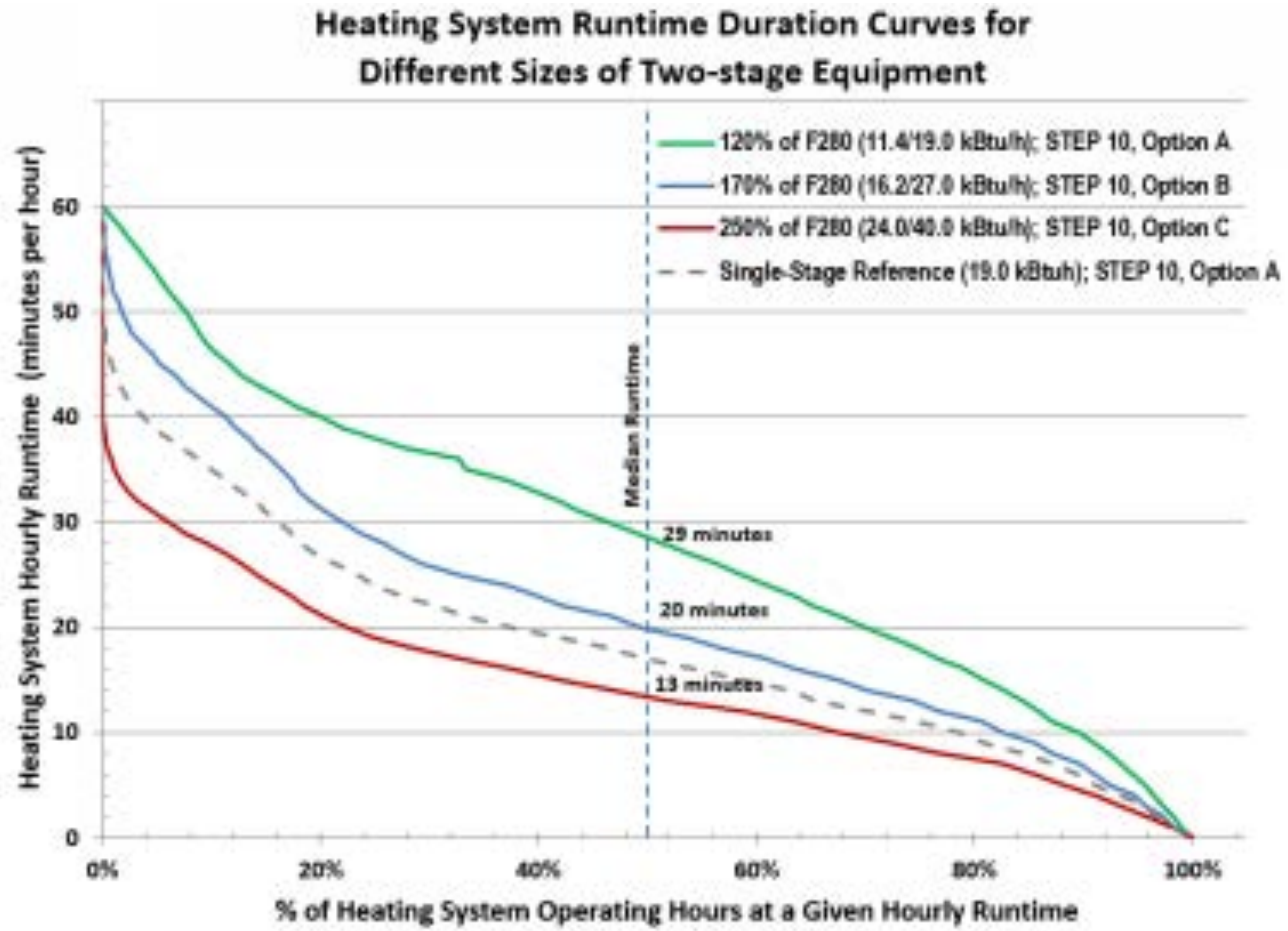


Figure 22: Runtime Duration Curves for Two-Stage Equipment

A STUDY IN EQUIPMENT SELECTION FOR LOW LOAD HOMES

SINGLE STAGE

Table 8: Median and Coldest-day Hourly Runtimes for Single-Stage

Parameter	A-size (120% of F280)	B-size (170% of F280)	C-size (250% of F280)
Median Runtimes	17 minutes per hour	12 minutes per hour	8 minutes per hour
Coldest 5% ON-times	39 minutes per hour	27 minutes per hour	18 minutes per hour
Coldest 5% OFF-times	21 minutes per hour	33 minutes per hours	42 minutes per hour

TWO STAGE

Table 9: Median and Coldest-day Hourly Runtimes for Two-Stage

Parameter	A-size (120% of F280)	B-size (170% of F280)	C-size (250% of F280)
Median Runtimes	29 minutes per hour	20 minutes per hour	13 minutes per hour
Coldest 5% ON-times	54 minutes per hour	45 minutes per hour	31 minutes per hour
Coldest 5% OFF-times	6 minutes per hour	15 minutes per hours	29 minutes per hour

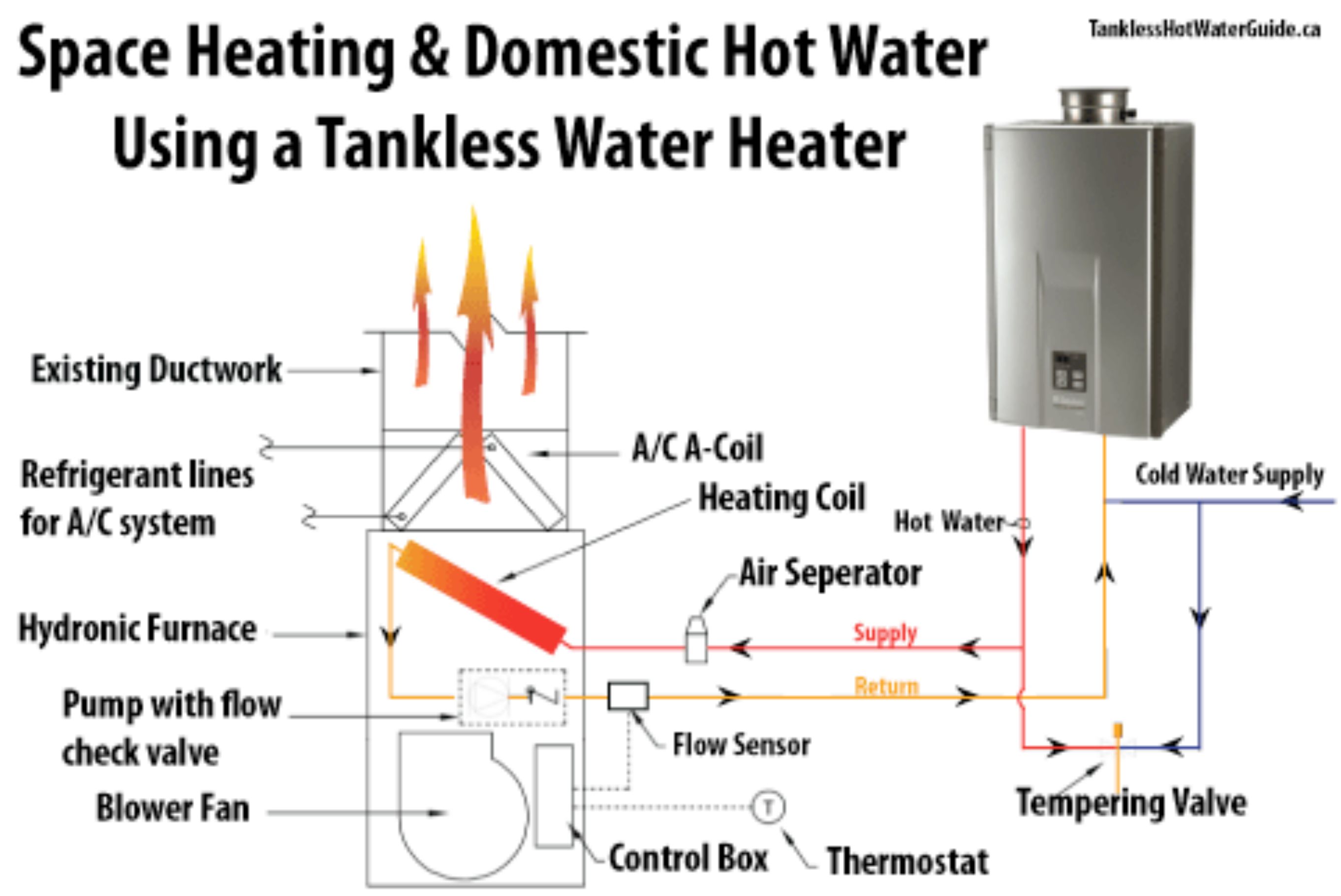
MODULATI NG

Table 10: Median and Coldest-day Hourly Runtimes for Modulating Heating Systems

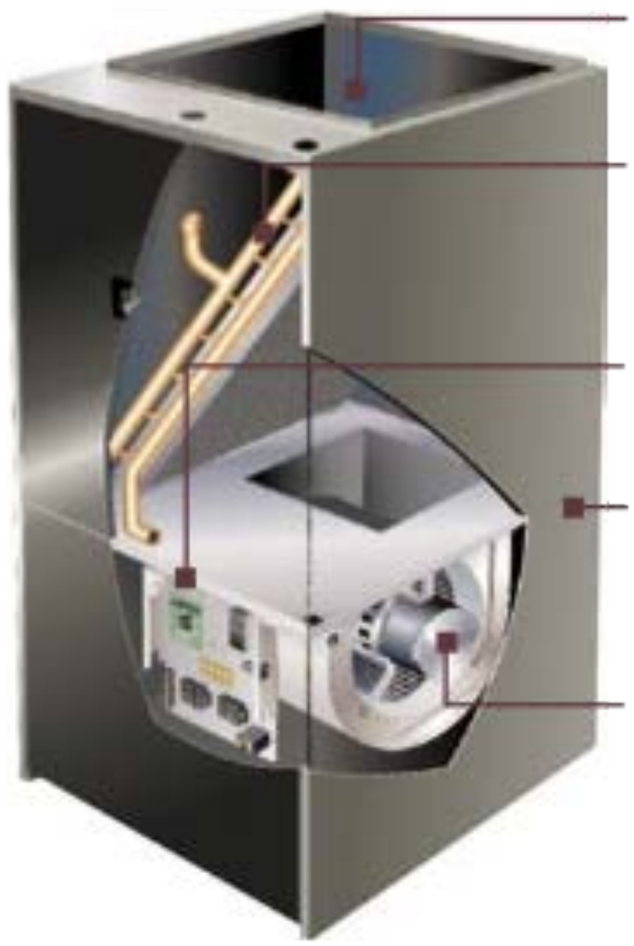
Parameter	A-size (120% of F280)	B-size (170% of F280)	C-size (250% of F280)
Median Runtimes	39 minutes per hour	30 minutes per hour	20 minutes per hour
Coldest 5% ON-times	57 minutes per hour	53 minutes per hour	46 minutes per hour
Coldest 5% OFF-times	3 minutes per hour	7 minutes per hours	14 minutes per hour

Integrated Mechanical Systems

- Invest in one good heat source
- Invest in multiple fuel choices
  - Gas
  - Electric
  - Heat pump
  - Solar
- Priority controls
- Great flexibility, adjustments to:
  - Air flow
  - Water flow
  - Water temperature



Combination Systems



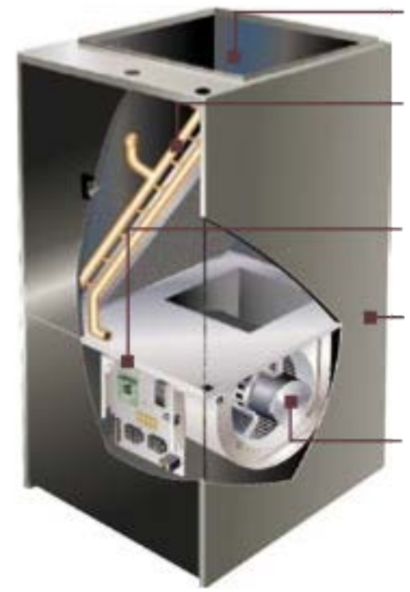
Hot water air handler

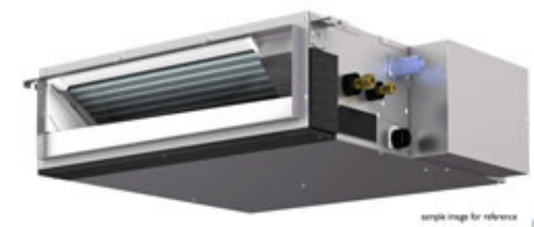
Condensing Water Heater

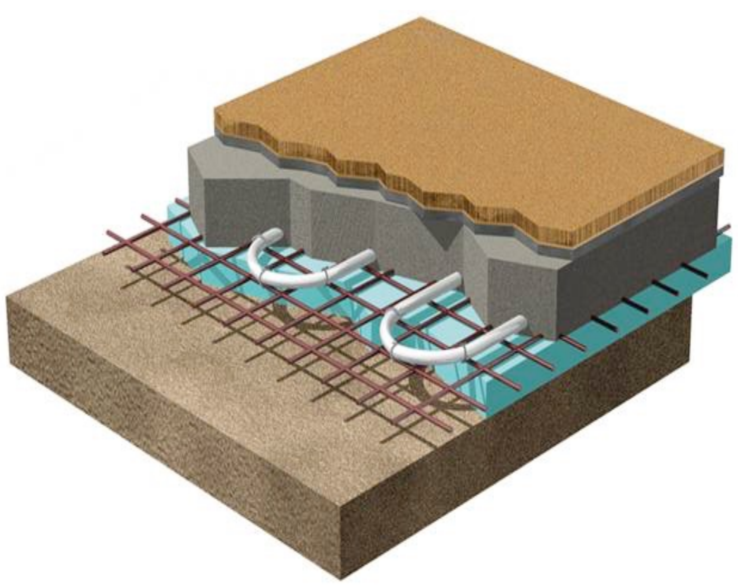
Heating / Cooling Summary

Many Options







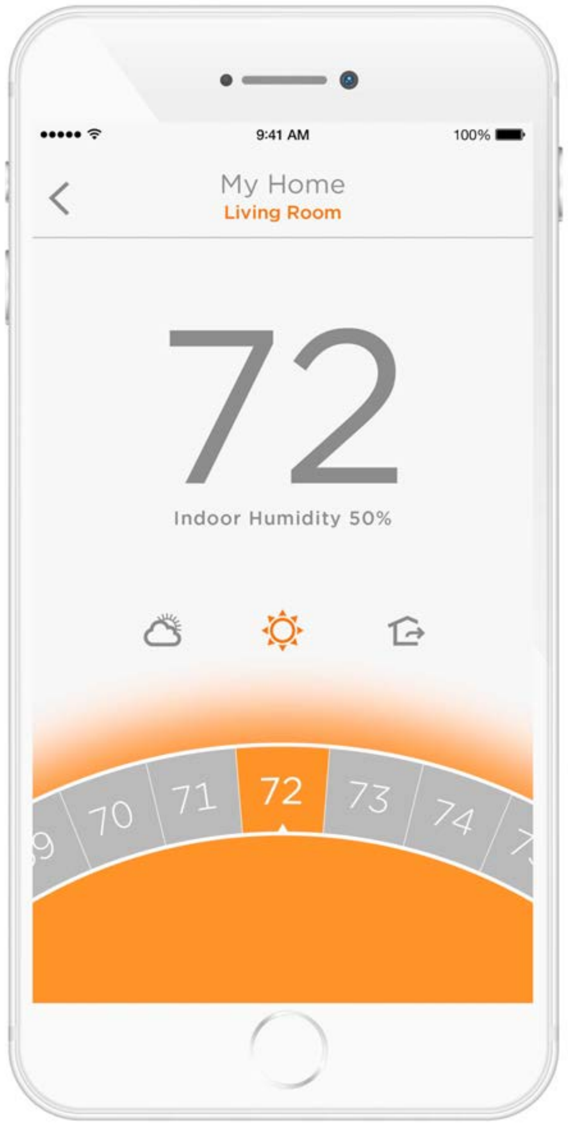

Higher Expectations

Controls

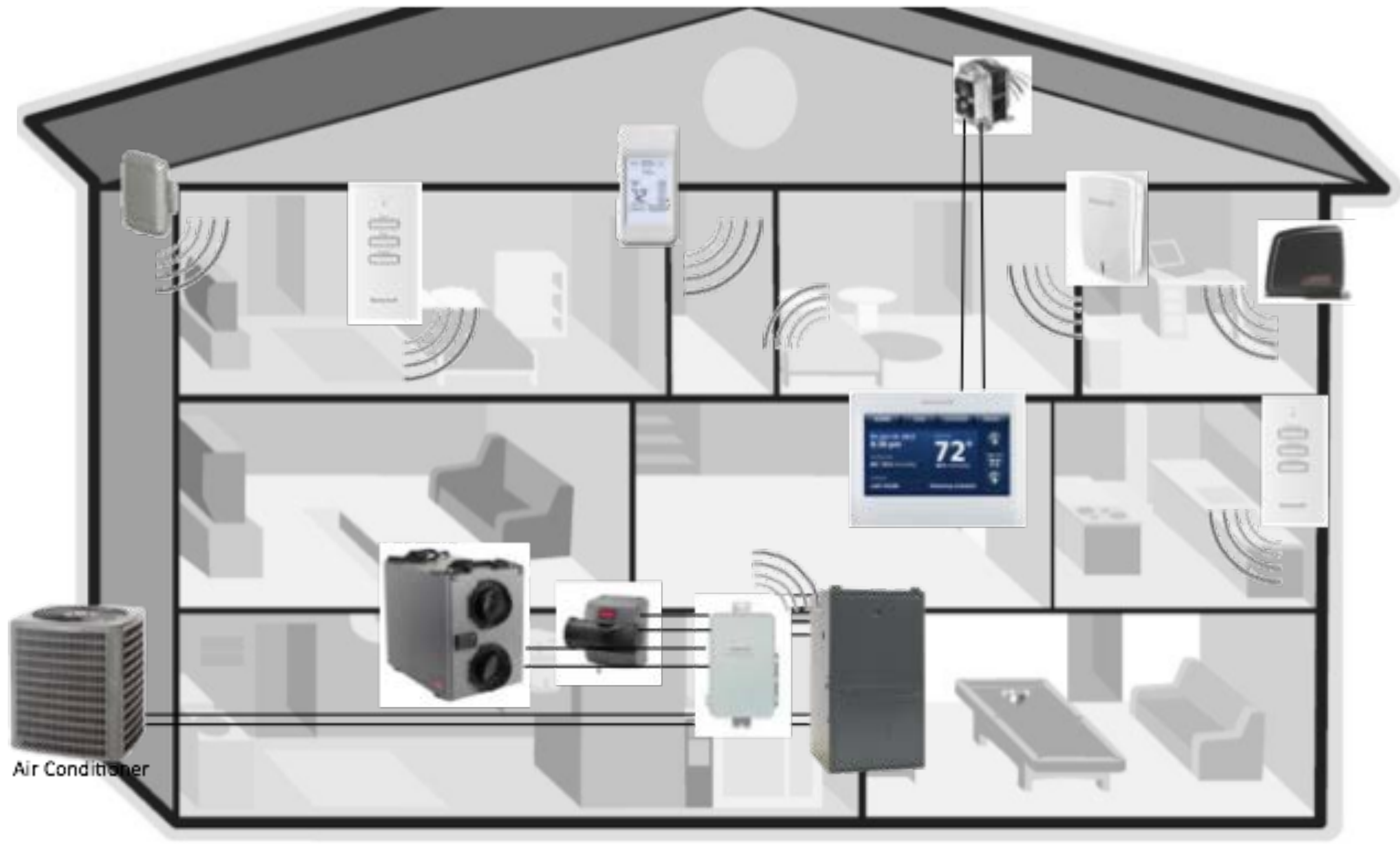
- Controls history

Smarter Controls

- Anticipating change
- Outdoor reset
- Time of use rate decisions
- Programming & integrating functions
- Fan cycles
- Humidification
- Dehumidification
- Ventilation
- Real time diagnostics

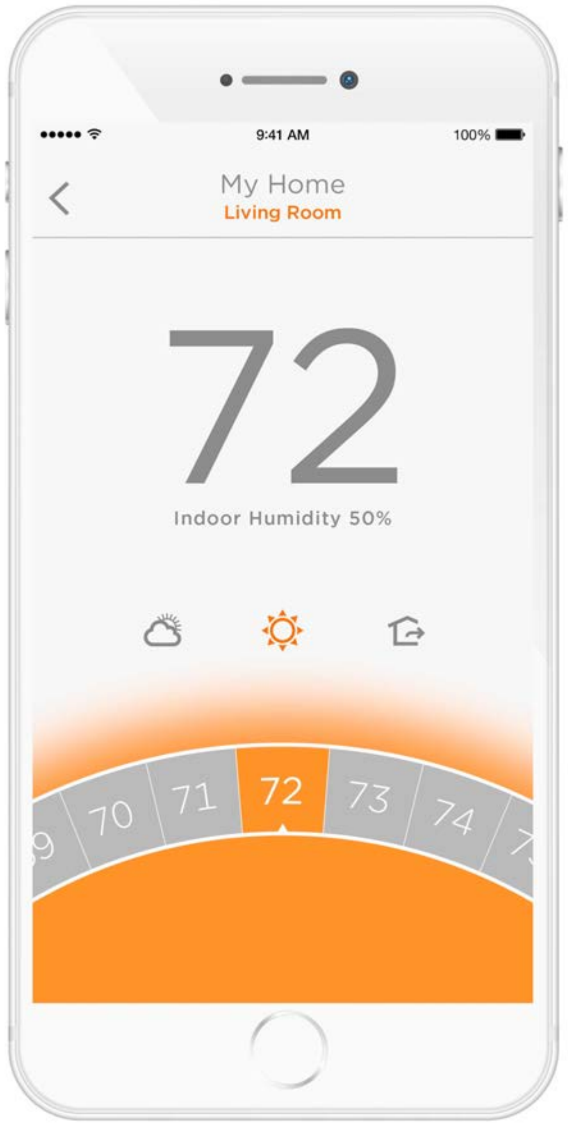


Smarter Controls



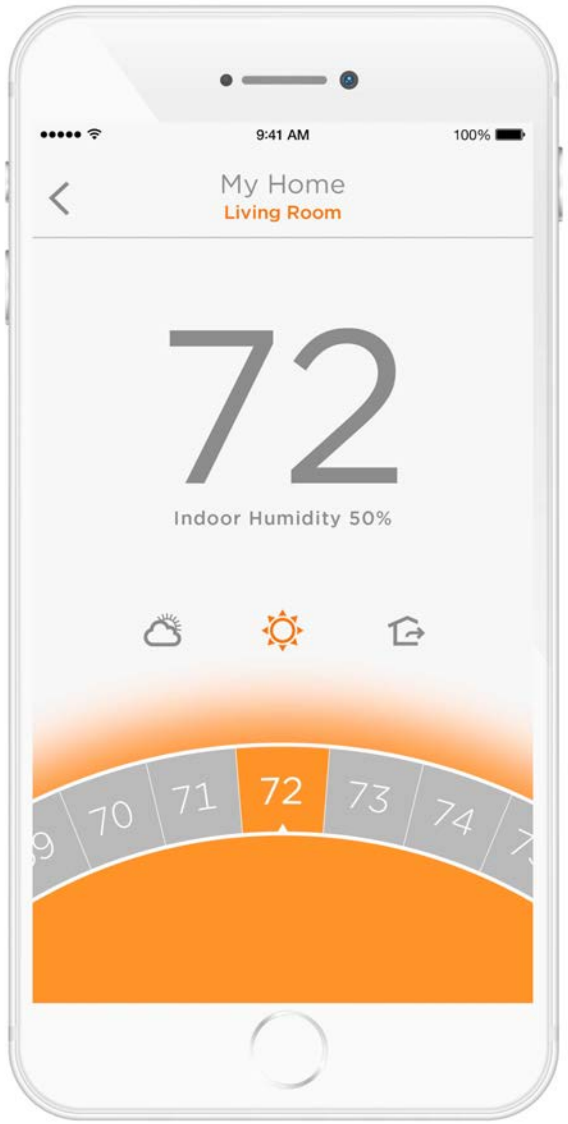
Value Proposition to Builders

- Learning proper sizing
- Real time diagnostics
- Simplifying choices
- Consistent messages
- Responding to buyer trends



Value Proposition to Homebuyers

- Matches their life
- Puts HVAC in their hands
- Empowers better decisions
- Simplifies decisions
- A better connection to comfort
- Discoverable savings



Verification / Commissioning

Testing for performance

Simple Testing Can Help

- Verify performance before the Design Day
- 3-4 measurements
- Matched to the design
- Matched to manufacturer's specifications

Sealing duct work EVEN WHEN ITS ALL LOCATED WITHIN THE HOME.

What's actually happening in the field????

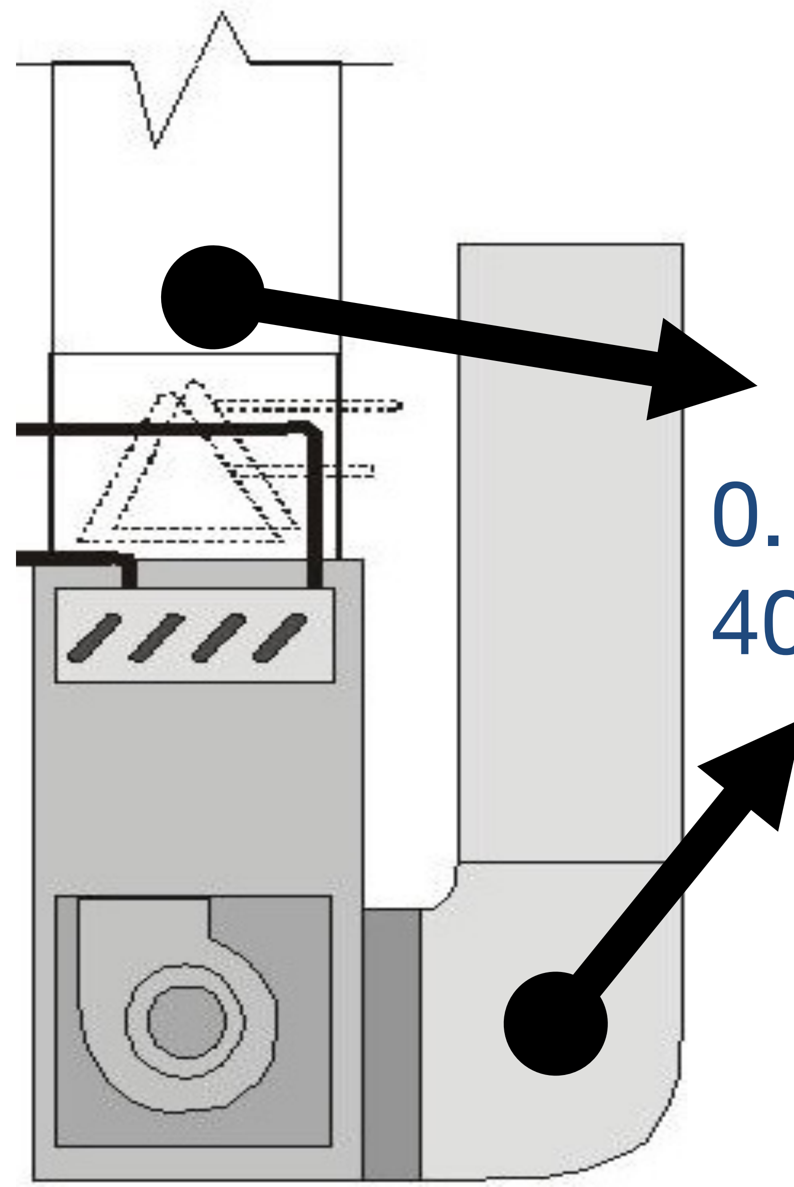
Duct leakage nearly 30-40%-no sealing = Drop in ESP!!!

HTG Field
tested at .04
.05

CLG Field
tested at .05
.09+

	Heating		Cooling	
External static pressure	0.50	in H2O	0.50	in H2O
Pressure losses	0.23	in H2O	0.23	in H2O
Available static pressure	0.27	in H2O	0.27	in H2O
Supply / return available pressure	0.13 / 0.14	in H2O	0.13 / 0.14	in H2O
Lowest friction rate	0.066	in/100ft	0.066	in/100ft
Actual air flow	380	cfm	800	cfm
Total effective length (TEL)	412 ft			

1) Duct pressures



0.15” to 0.25”
40 – 60 Pa

2) Airflow at Air Handler

3) Airflow & Temperatures at Registers

		Design BTU	Design CFM	Design Friction	Dia.
Bed-3	Heat	1700	31	0.1	4"
	Cool	1366	49	0.1	5"

4) Refrigerant Verification

5) Temperature rises

Others

Accurate Temperature & RH

Combustion efficiency / CO

Gas Pressure

Water Pressure

EPA's Indoor air PLUS Program

An excellent opportunity for builders & HVAC contractors

ENERGY STAR

look for EPA Indoor airPLUS QUALIFIED HOMES

- Moisture control
- HVAC: heating, cooling, ventilation, filtration
- Combustion and garage isolation
- Commissioning the building
- Radon control
- Pest barriers
- Healthy building materials

Valuable Resources

ENERGY STAR Certified Homes, Version 3 (Rev. 07)
HVAC System Quality Installation Contractor Checklist [1]

	Builder Verified [5]	Cont. Verified [6]	N/A
2. Heating & Cooling System Design [4,8] **-** *Parameters used in the design calculations shall reflect home to be built, specifically, outdoor design temperatures, home orientation, number of bedrooms, conditioned floor area, window area, predominant window performance and insulation levels, infiltration rate, mechanical ventilation rate, presence of MERV6 or better filter, and indoor temperature setpoints = 70°F for heating; 75°F for cooling.*			
2.1 Heat Loss / Gain Method: ☐ Manual J v8 ☐ 2009 ASHRAE ☐ Other: ________	☐	☐	-
2.2 Duct Design Method: ☐ Manual D ☐ Other: ________	☐	☐	☐
2.3 Equipment Selection Method: ☐ Manual S ☐ OEM Rec. ☐ Other: ________	☐	☐	-
2.4 Outdoor Design Temperatures: [9] Location: ____________ 1%: ___°F 99%:___ °F	☐	☐	-
2.5 Orientation of Rated Home (e.g., North, South): ________________________	☐	☐	-
2.6 Number of Occupants Served by System: [10] ________________________	☐	☐	-
2.7 Conditioned Floor Area in Rated Home: ________________________ Sq. Ft.	☐	☐	-
2.8 Window Area in Rated Home: ________________________ Sq. Ft.	☐	☐	-
2.9 Predominant Window SHGC in Rated Home: [11] ________________________	☐	☐	-
2.10 Infiltration Rate in Rated Home: [12] Summer: _______ Winter:_______	☐	☐	-
2.11 Mechanical Ventilation Rate in Rated Home: ________________________ CFM	☐	☐	-
2.12 Design Latent Heat Gain: ________________________ BTUh	☐	☐	-
2.13 Design Sensible Heat Gain: ________________________ BTUh	☐	☐	-
2.14 Design Total Heat Gain: ________________________ BTUh	☐	☐	-
2.15 Design Total Heat Loss: ________________________ BTUh	☐	☐	-
2.16 Design Airflow: [13] ________________________ CFM	☐	☐	-
2.17 Design Duct Static Pressure: [14] ________________________ In. Water Column	☐	☐	☐
2.18 Full Load Calculations Report Attached [15]	☐	☐	-

Hot Water

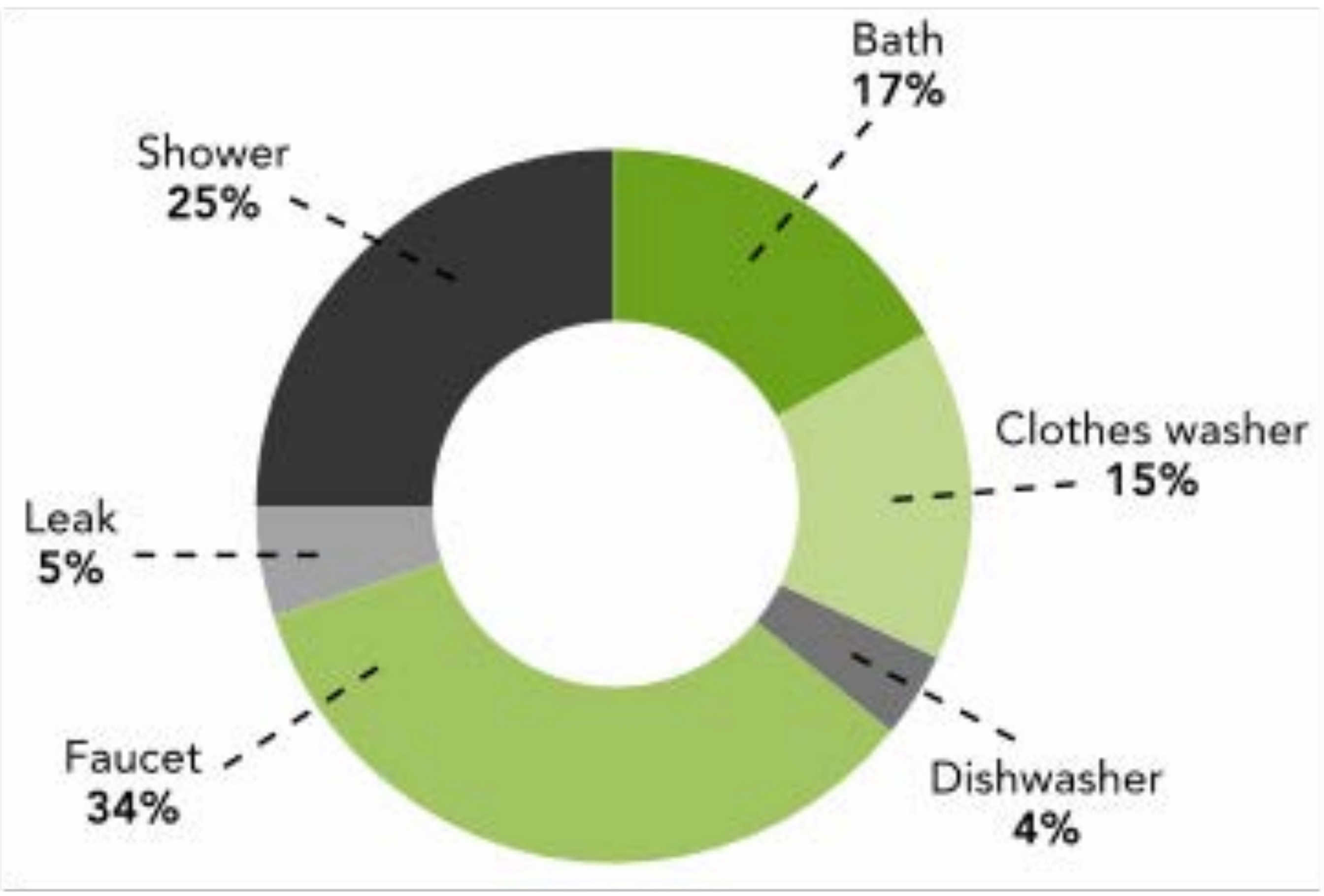

TEMPERED

Expectations have Changed

Hot Water Usage Relevance

- Hot water use is still on its way up
- Wait times are an issue
  - Waste of water
  - Perception of energy waste

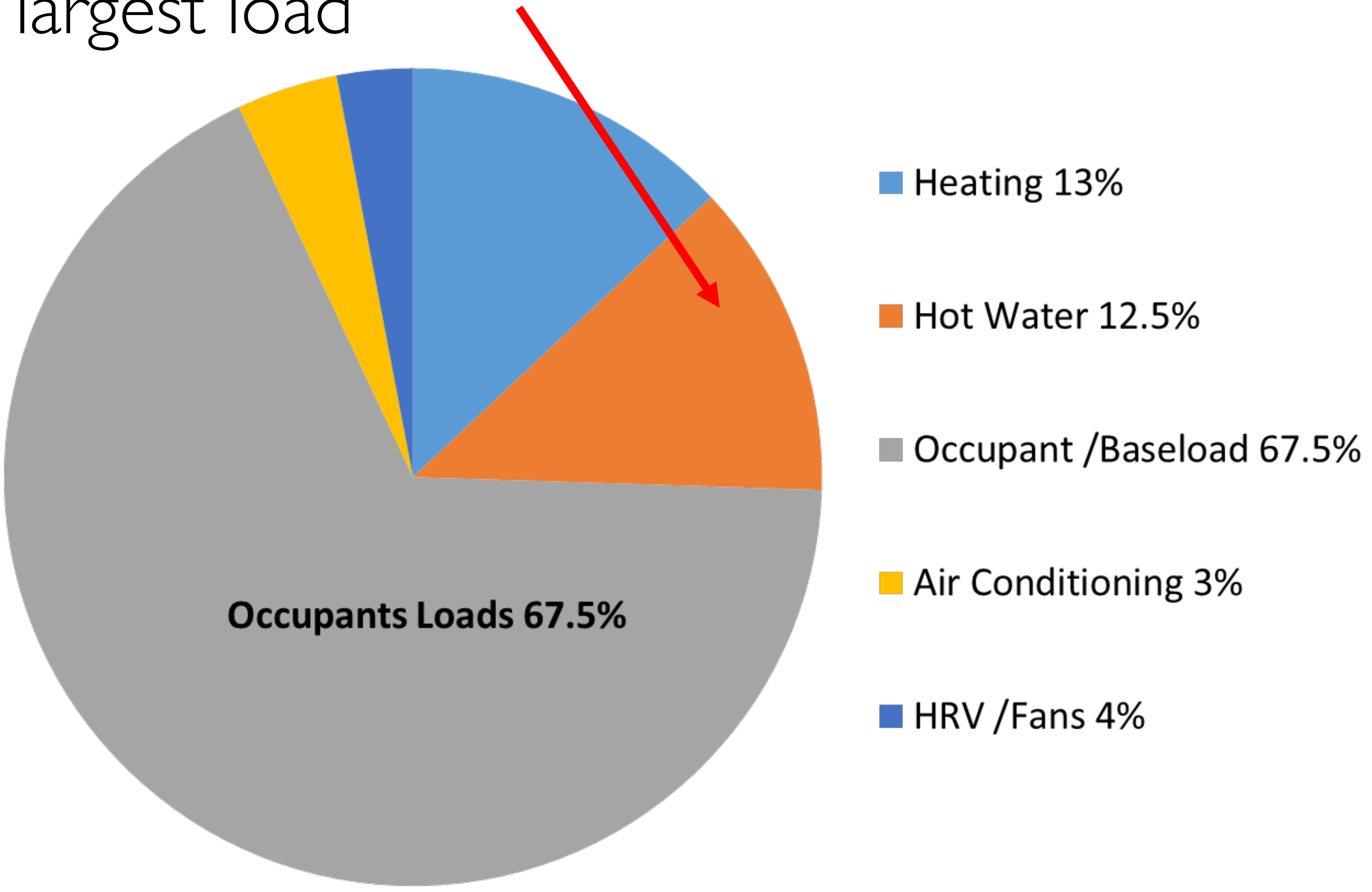
Main uses for household hot water



Source: Canadian Building Energy End-Use Data and Analysis Centre

ZERH'S
DOMESTIC HOT WATER IS A BIG DEAL

- In Net Zero homes DHW is tied with space heating as the 2nd largest load



Regulations have changed

Minimum 2016 Requirements		**Example EF**
Gas	**Storage:** <55 US gal. EF = 0.675 – (gal x 0.0015) >55 US gal. EF = 0.8012 – (gal x 0.00078) **Tankless:** EF = 0.82–(gal x 0.0019)	40 US gal = 0.62 60 US gal = 0.75 Typical = 0.80
Oil	EF = 0.68–(gal. x 0.0019)	50 gal = 0.585
Electric	<55 gal. EF = 0.960–(gal x 0.0003) >55 gal. EF = 2.057–(gal x 0.00113)	40 gal = 0.95 60 gal = 1.98

Hot water is flexible

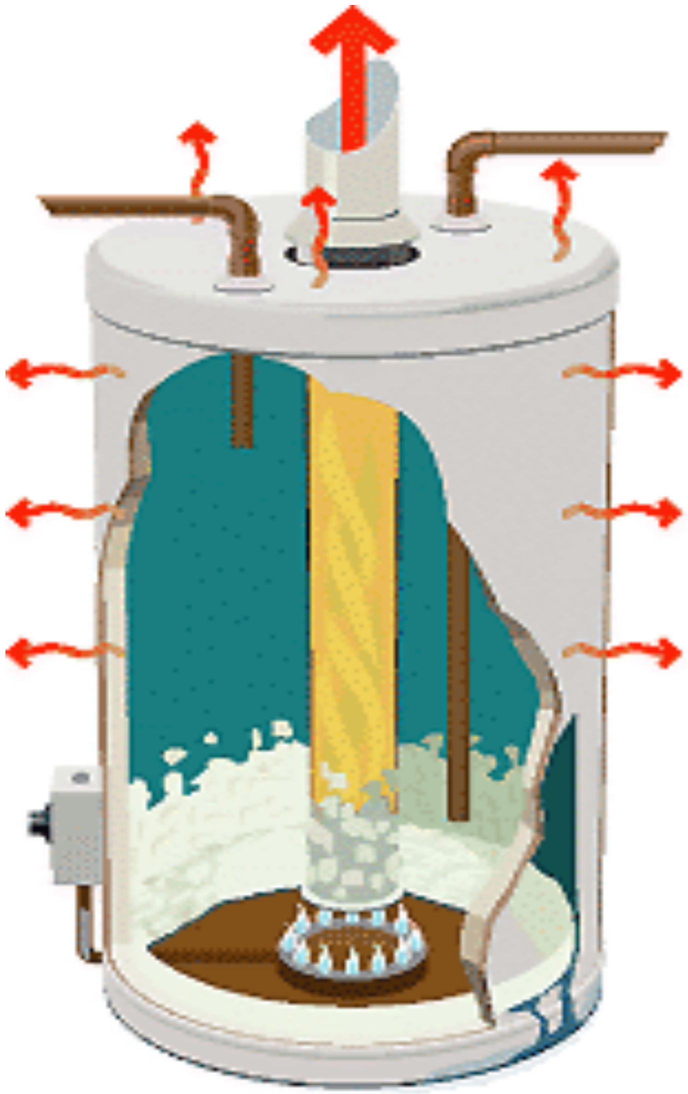
- In-floor
- Air handlers
- Towel warmers
- Radiant panels
- DHW
- Storage

- Oil
- Gas
- Electric
- Wood
- Solar
- Reclaim

What's the Right Choice?

- Fuel access?
- Number of people?
- Patterns of use?
- Space / location limits
- Climate zone?
- Efficiency of the home
- Other mechanicals?
- Expectations of clients?
- Other?

Water Heaters



Traditional Tank
EF < 0.60

Tankless = +0.80

Condensing
water heater =0.86

High Efficiency Condensing Gas Storage Water Heater

Strengths

- Direct vent / sealed combustion
- EFs 0.86+ possible
- Very quick recovery times
- Similar foot print as existing storage
- Similar operational characteristics
- Quiet venter motors
- Well suited for “Combo” space & water heating applications


High Efficiency Condensing Gas Storage Water Heater

Design / Installation Considerations

- Vent lengths to outside
- Decommissioning existing chimney
- Electric power required
- Typically taller unit
- Access to condensate drainage
- Be sure to compare efficiency ratings against alternatives with similar capacities

Tankless Water Heaters

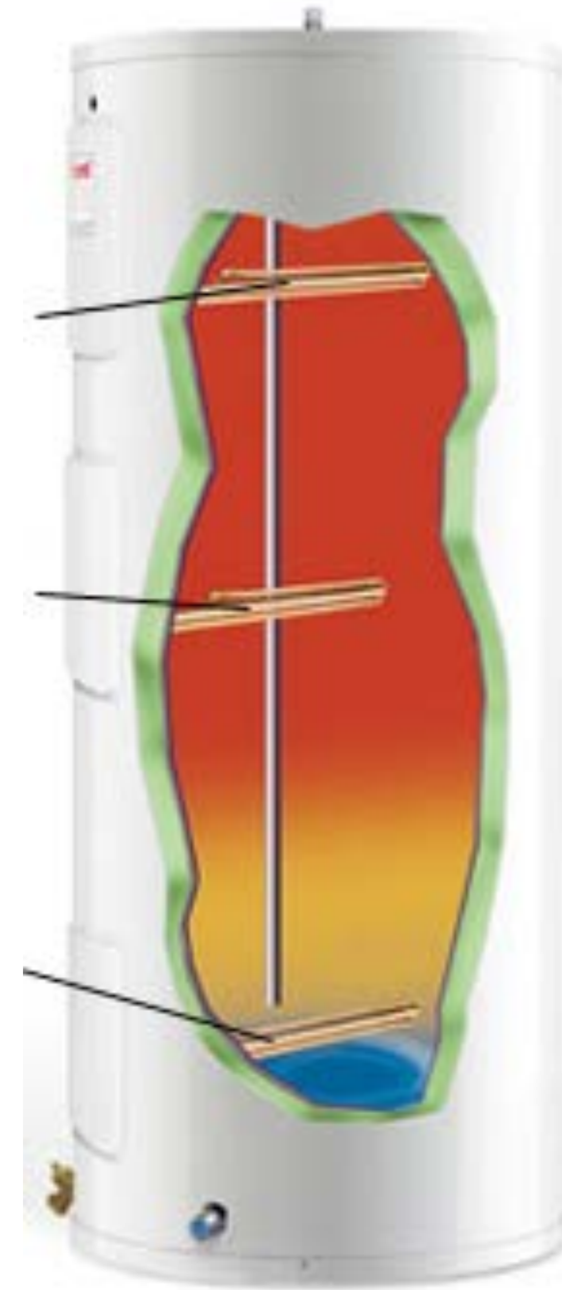
Strengths

- Low stand-by losses
- EFs from 0.80 to high 0.90's possible
- Wall installation frees up floor space
- Continuous supply of hot water
- Great flexibility
  - Point of use temperature controls
  - Locate supplementary units near point of use
  - Combo space & water heating capabilities
- Safe operation with direct venting
- New technologies reduce wait times - recirc. and internal storage tanks

High Efficiency Electric Storage Water Heater

Strengths

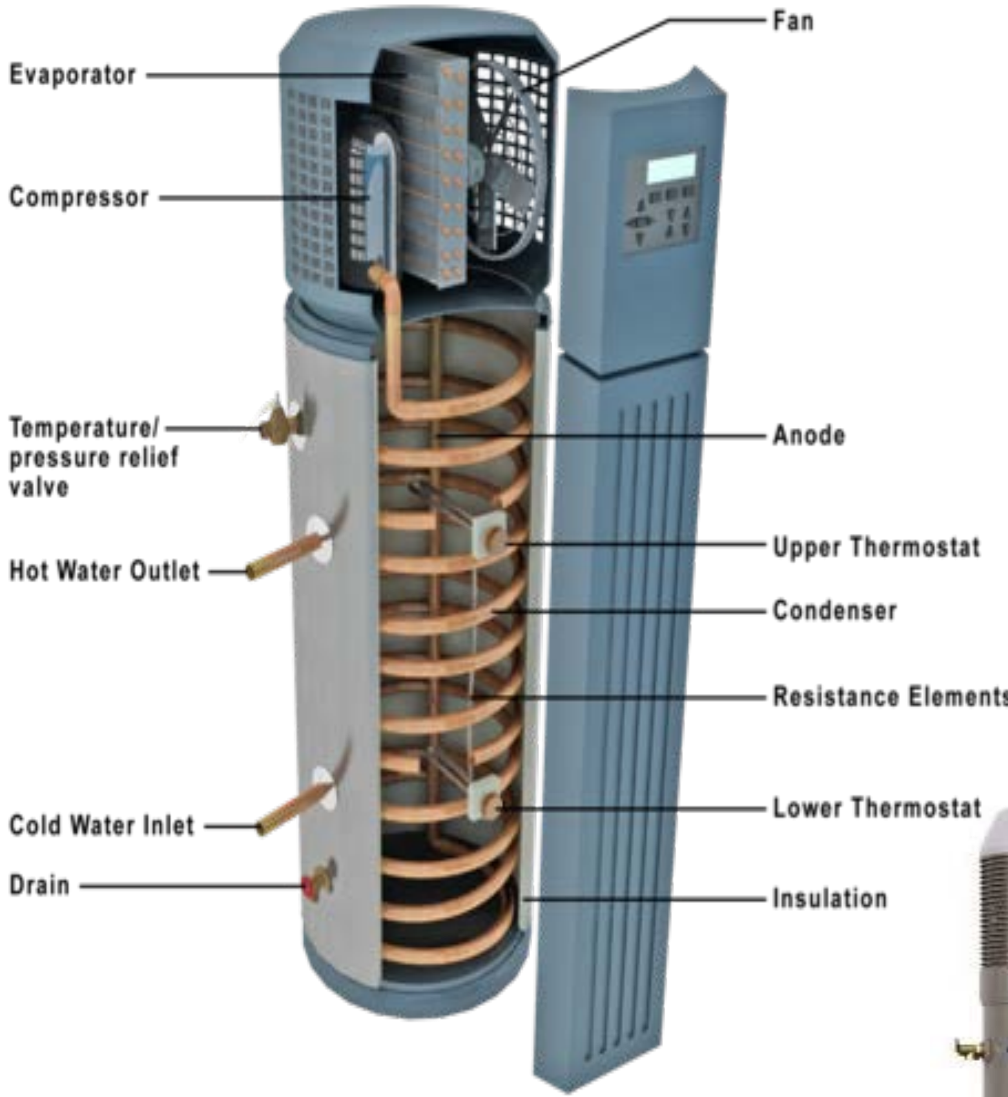
- High levels of jacket insulation
- EFs 0.94+ possible
- Similar foot print as existing storage
- Greater durability:
  - Often better coils & coil arrangement
  - Often better liner & jackets
  - Better drainage for cleaning
  - Combine with time of use controls
- A very simple change-out from existing electric storage tanks



Heat Pump Water Heaters

Strengths

- Very high EFs – 2.30+ possible
- Similar foot print as existing storage
- Provides cooling & dehumidification to the space
- Electric back-up
- Particularly useful in “Net zero-energy” homes to complement solar thermal & solar PV.



Condensing gas vs Air Source Hybrid Hot water: A Net Zero Conundrum

1. Energy Access- Gas, Electrical, etc
2. Occupant expectations
3. Cost of appliance?
4. Gas cost vs electrical?
5. Access to equipment?
6. PV vs ASHWT?!?

VS

97% TANKLESS VS HYBRID HP 2.5 COP

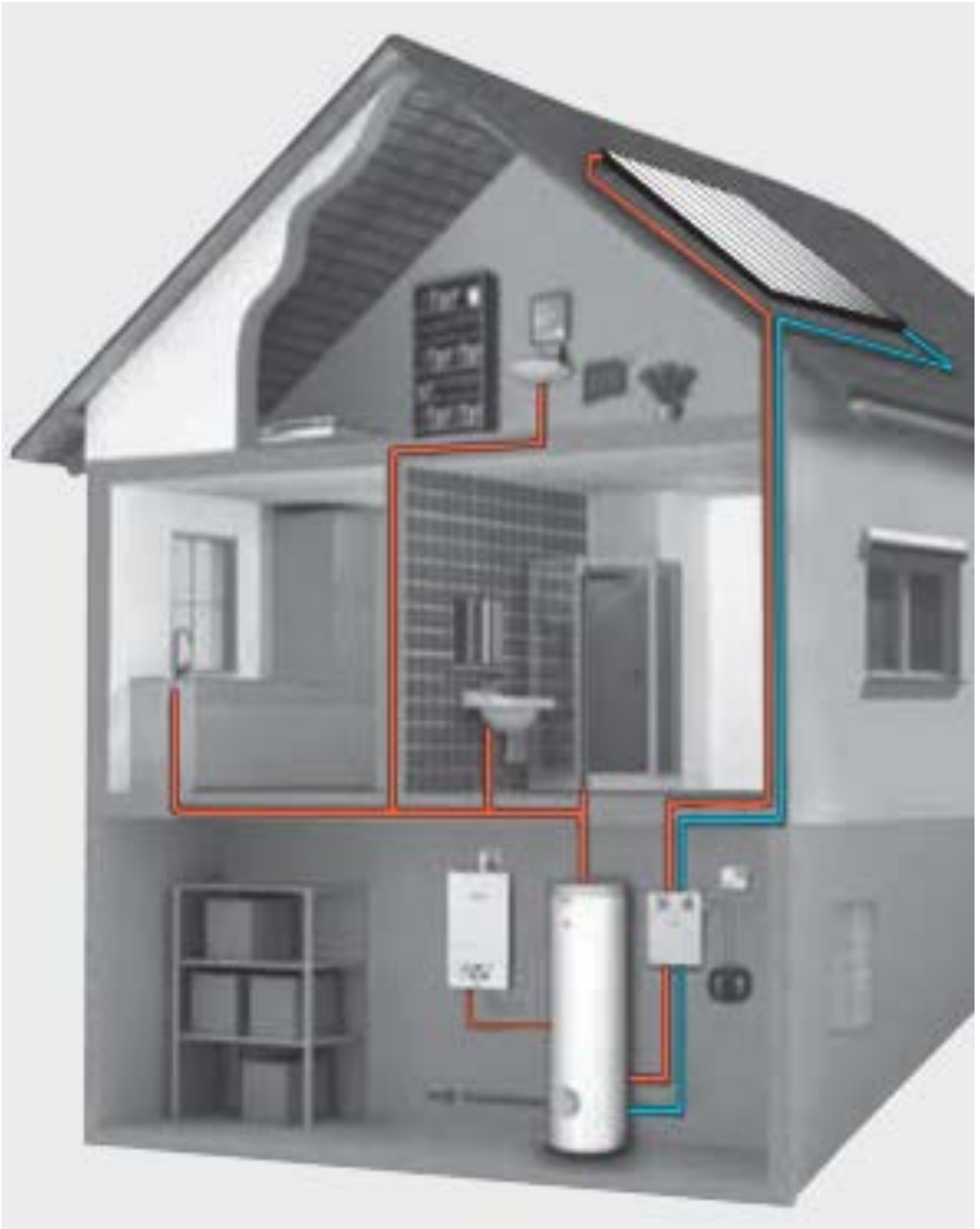
- **HYBRID HP= BETTER HERS RATING /SAVES 5-600KwH ANNUALLY (32 SQFT OF SOLAR PRODUCTION)**
- **GAS= OPERATIONAL COST ANNUALLY SAVES $100 VS HYBRID HP.**

Drain Water Heat Recovery: An ideal match for low load homes.

- INCREASE RECOVERY TIME OF DHW UNIT
- INCREASE EFFICIENCY; 0.67EF + 42%DWHR =COMBINED 0.80EF
- KEY IS TYING TO MULTIPLE SHOWER FIXTURE DRAINS

Solar Thermal Water Heaters

- A great preheat strategy for tankless, storage water heaters & HPWHs – increases their capacity
- 50-60% of annual hot water needs are easily provided
- Excess hot water can be used to heat swimming pools
- Requires freeze protection & annual maintenance



ZERH'S AND HOT WATER: **DISTRIBUTION IS AS IMPORTANT AS EQUIPMENT EFFICIENCY**

- "Must Have" for zero net-energy ready homes
- Based on EPA WaterSense Specifications:
  - No more than 0.5 gallons of water in any piping/manifold between the hot water source and any hot water fixture.
  - No more than 0.6 gallons of water shall be collected from the hot water fixture before hot water delivered.
  - Timer- and temperature-based recirculating systems shall not be used to meet the criteria.

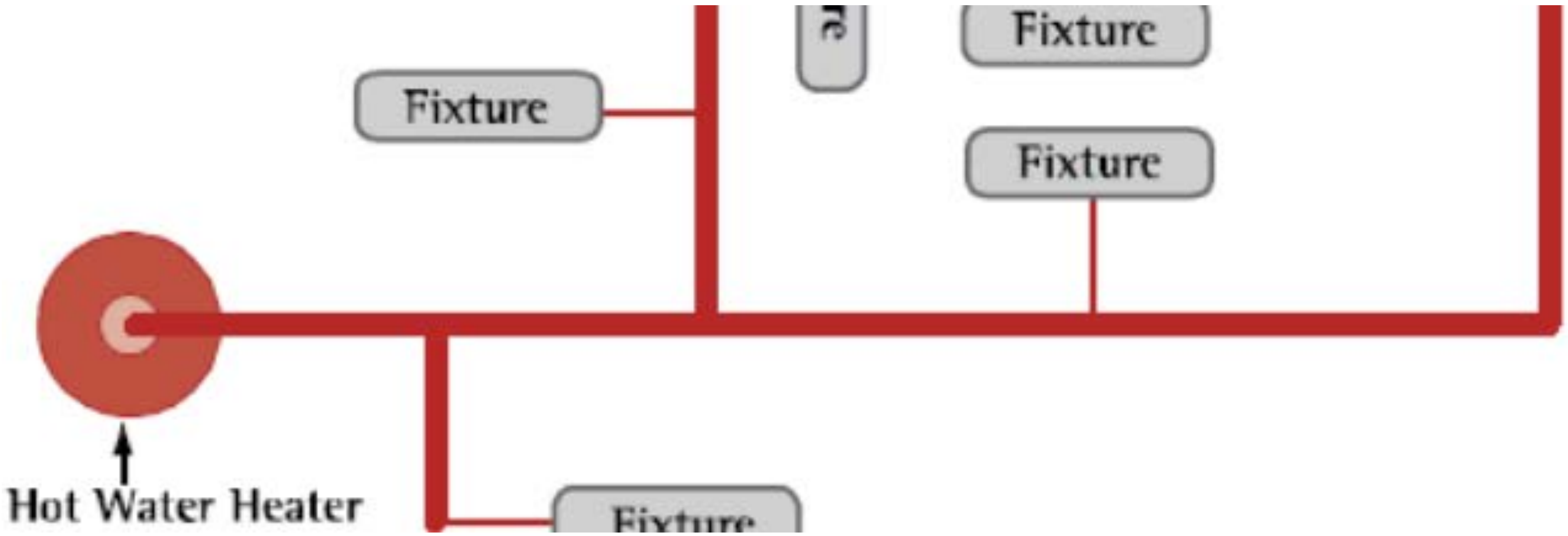
ZERH'S AND HOT WATER: DISTRIBUTION

Good Design =
Energy Savings =
Occupant Satisfaction

- The water/energy matrix is key
- Right sizing PIPE
- Plumbing design prepared ahead of time
- Re-circulation pump

Vol. in Pipe (OZ)	*Min. time-to-tap (secs) at selected flow rates*					
	0.25 gpm	*0.5 gpm*	*1.0 gpm*	*1.5 gpm*	*2.0 gpm*	*2.5 gpm*
24	**45**	**23**	**11**	**8**	**6**	**5**
64	**120**	**60**	**30**	**20**	**15**	**12**
75	**141**	**70**	**35**	**23**	**18**	**14**
300	**563**	**281**	**141**	**94**	**70**	**56**

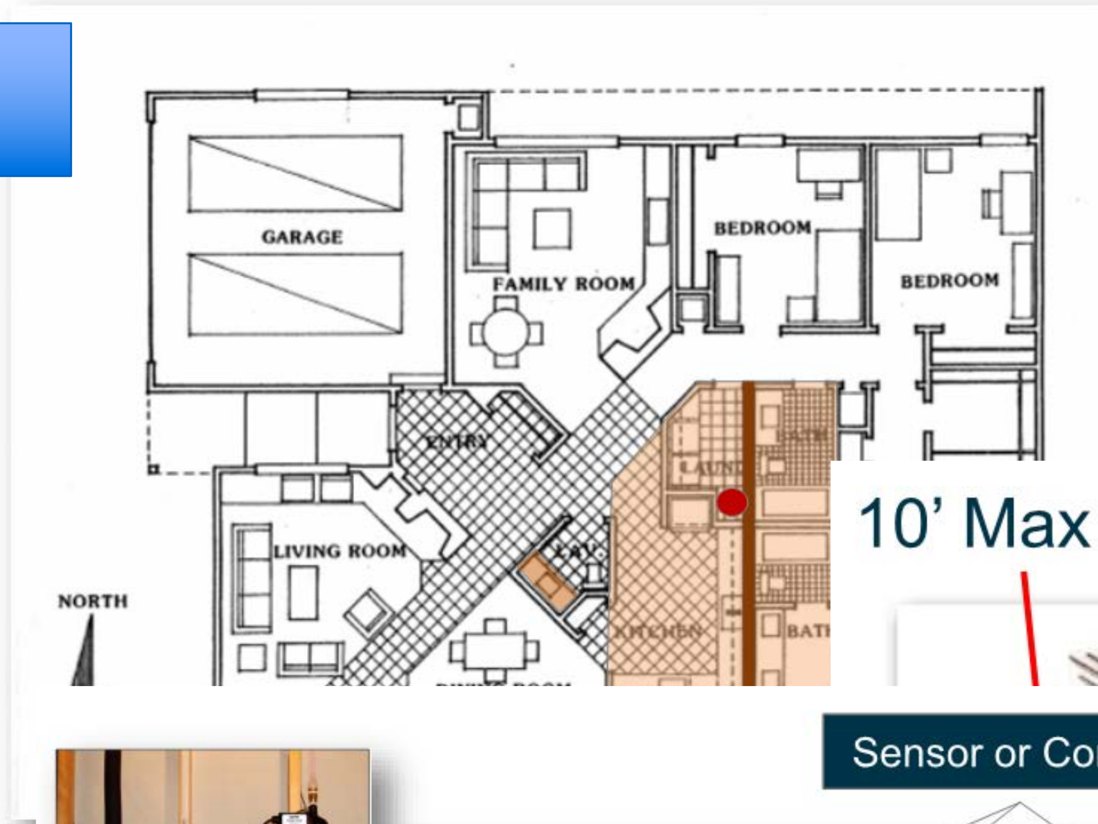
ZERH'S AND HOT WATER: DISTRIBUTION OPTIONS



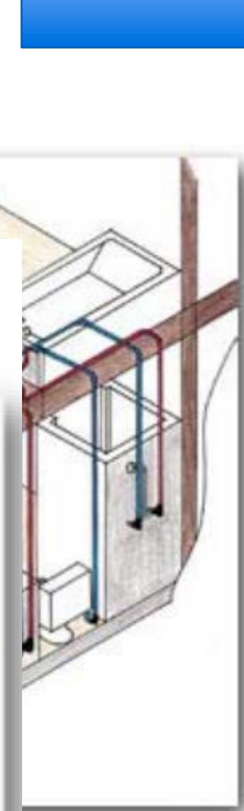
- Core Plumbing Layout (wet wall)
- Manifold System
- Demand Pumping System

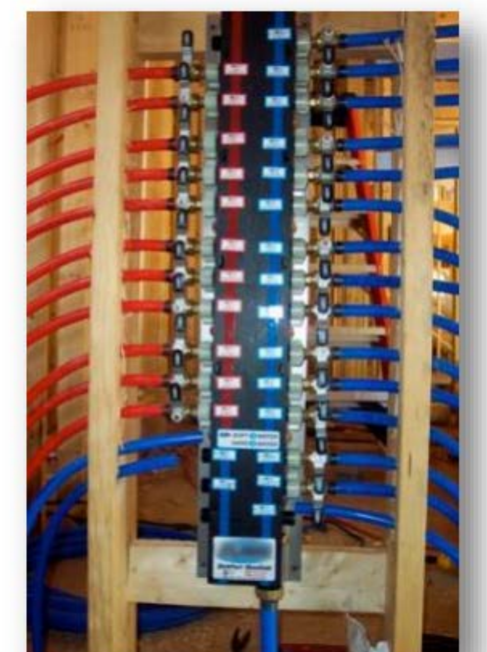
ZERH'S AND HOT WATER: DISTRIBUTION

CORE LAYOUT

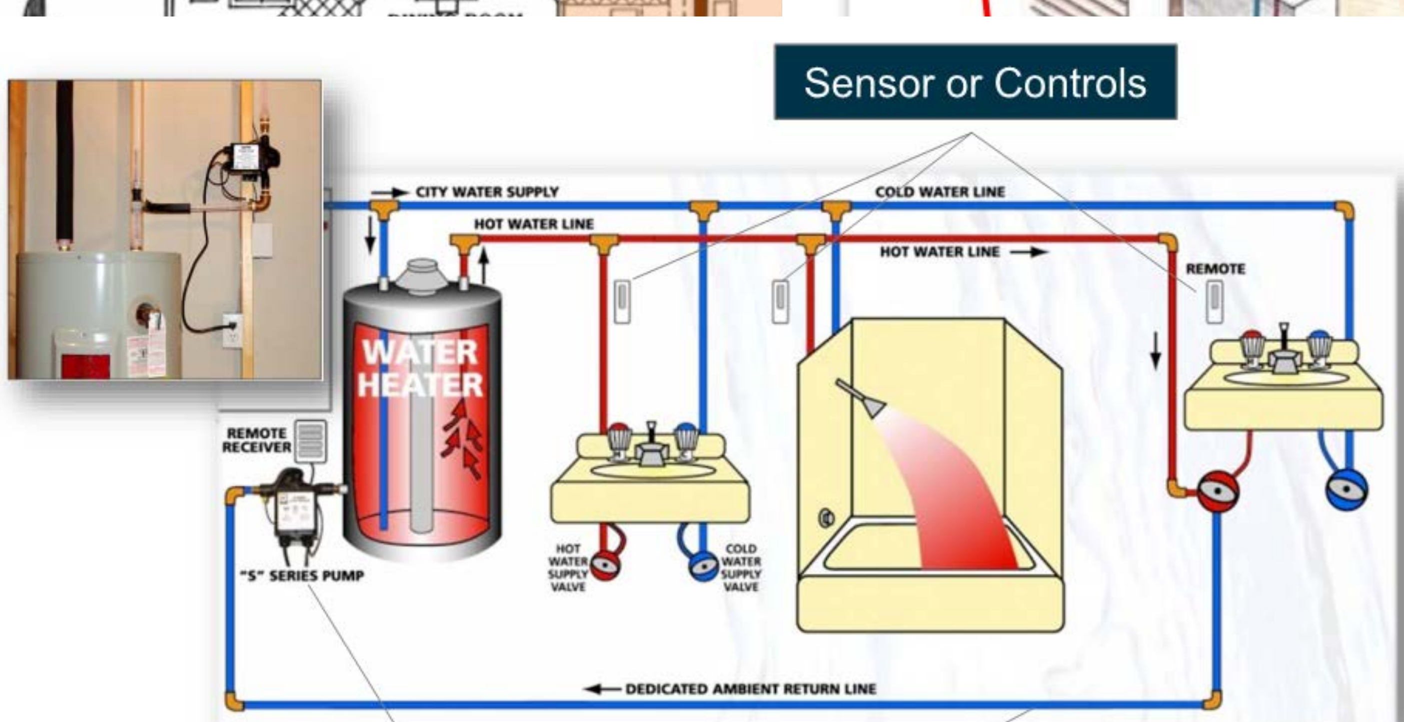


MANIFOLD





DEMAND SYSTEM



Sensor or Controls

Demand Pump

Dedicated Return

IAQ & Ventilation

Indoor Air Quality is Important to our Clients

20% of households have someone with asthma, allergies or respiratory problems

…poor IAQ may cost 10's of billions annually in lost productivity

EPA

Air cleaners are a $1.2 Billion industry

IAQ…Why is it a bigger issue than ever?

Change in the
<u>way we build</u>
-Tighter
-More chemicals
-Air conditioning

Change in the
<u>way we live</u>
-90% of time indoors
-Don’t open windows
-More moisture

Change in
<u>products we use</u>
-Carpets &furnishings
-Cleaners & hygiene
-More “stuff” inside

1. **Remove Pollutants**
2. **Source control**
   - "Seal" or Isolate
   - If you can't remove it find a way to isolate or seal it
3. **Ventilate**
   - Dilute pollutants with "fresh" outdoor air
   - Point source removal
4. **Filter**

IAQ Control Strategies

We have always needed Ventilation

"Light and air as means of preserving the health of the occupants of tenements are just as necessary as running water. Dr. H. M. Biggs, an eminent authority on tuberculosis, testified before the Tenement House Commission

The New York Times

Published: October 13, 1901

Ventilation

Ventilation - a system or means of providing fresh air.

Webster New Collegiate Dictionary

We used to ventilate with windows, now we don’t

All homes need Capacity for Mechanical Ventilation

- To control moisture
- To remove common pollutants
- To ensure good indoor air quality for occupants

Low Load homes and ventilation: More critical then ever

Ventilation system: Let's get a few things straight…

- A ventilation system does NOT provide make-up air.
- A ventilation does NOT provide combustion air.
- Balanced ventilation systems are not affected by opening or closing windows.
- Forced air heating (and cooling) alone does not provide ventilation.
- HRV/ERV's are NOT principally humidification /dehumidification appliances…they are VENTILATION /fresh air appliances

Ventilation & IAQ Systems

How Much Ventilation?

ASHRAE 62.2 - 2010

Whole House - Continuous "Capacity"

Based on # of occupants & size of home

CFM = (# of bedrooms + 1) x 7.5 + (0.01 x cond. ft^2)

OR USE THE TABLE

Floor Area Sq. ft	# of Bedrooms		
	1	2-3	4-5
<1500	30	45	60
1501 - 3000	45	60	75
3001 - 4500	60	75	90
4501 - 6000	75	90	105

Controls moisture and common occupant pollutants

How Much Ventilation?
ASHRAE 62.2 - 2013

Whole House - Continuous “Capacity”

Based on # of occupants & size of home

CFM = (# of bedrooms + 1) x 7.5 + (0.03 x cond. ft^2)

OR USE THE TABLE

Floor Area Sq. ft	# of Bedrooms		
	1	2-3	4-5
<1500	60	75	90
1501 - 2500	90	105	120
2501 - 3500	120	135	150
3501 - 5000	165	180	195

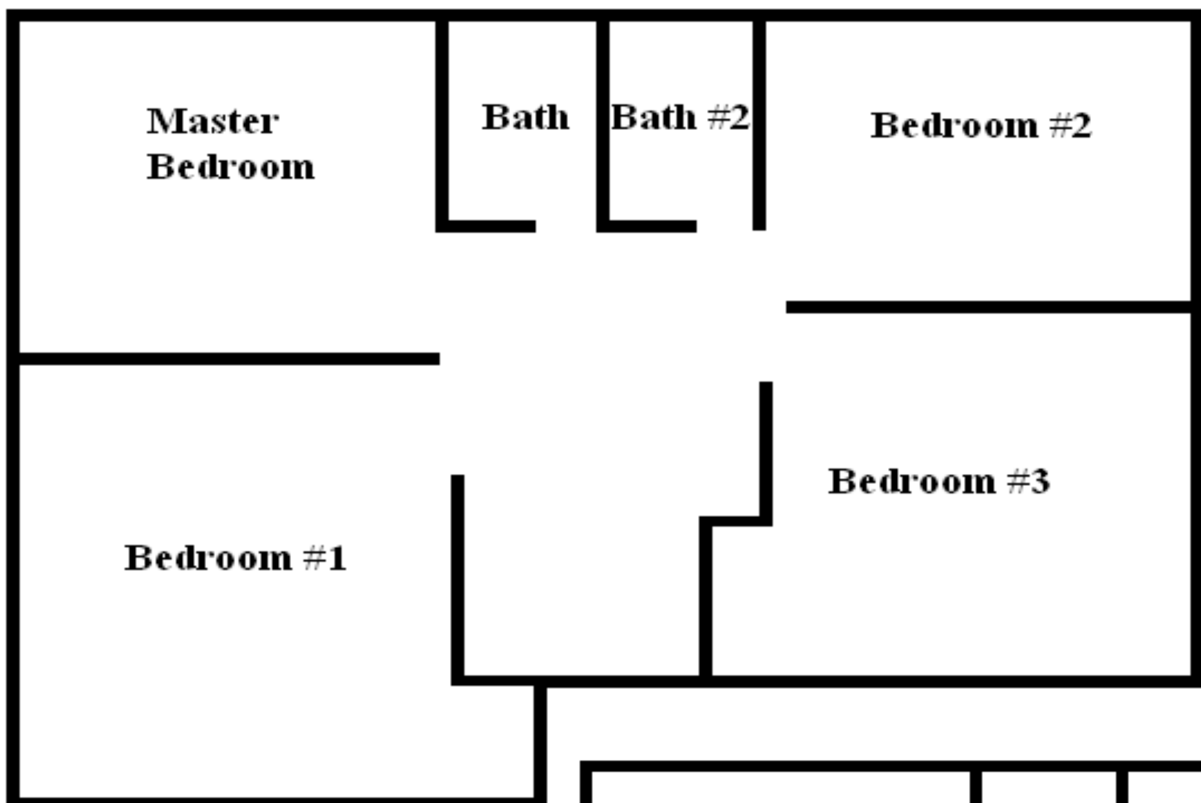
Controls moisture and common occupant pollutants

Ventilation Sizing Example

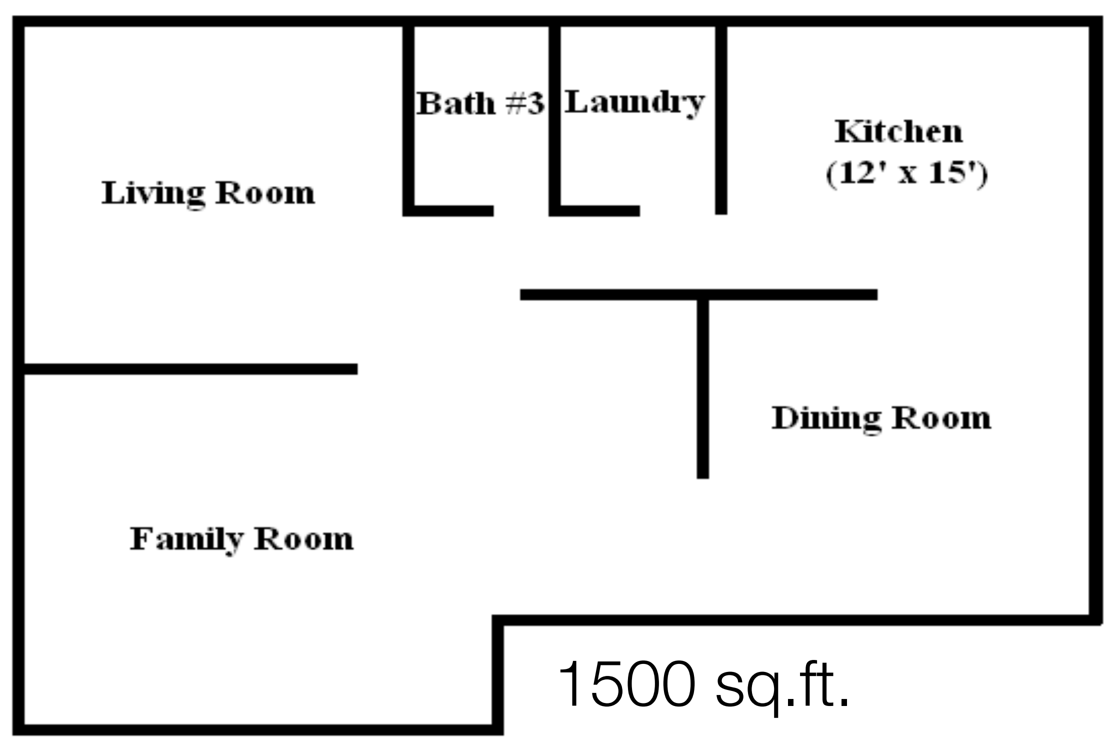
Continuous Capacity

= (4+1) x 7.5 + (0.03 x 3000)

= 128 CFM



1500 sq.ft.



1500 sq.ft.

Local Exhaust Ventilation

ASHRAE 62.2 Minimum Exhaust Flow Rate		
	Continuous	**Intermittent**
Kitchen	60 CFM	100 CFM
Bathroom	20 CFM	50 CFM

HVI Kitchen Range Exhaust Flow Rate		
Location of Range	**Recommended per Linear Ft of Range**	**Minimum per Linear Ft of Range**
Against a Wall	100 CFM	40 CFM
In an Island	150 CFM	50 CFM

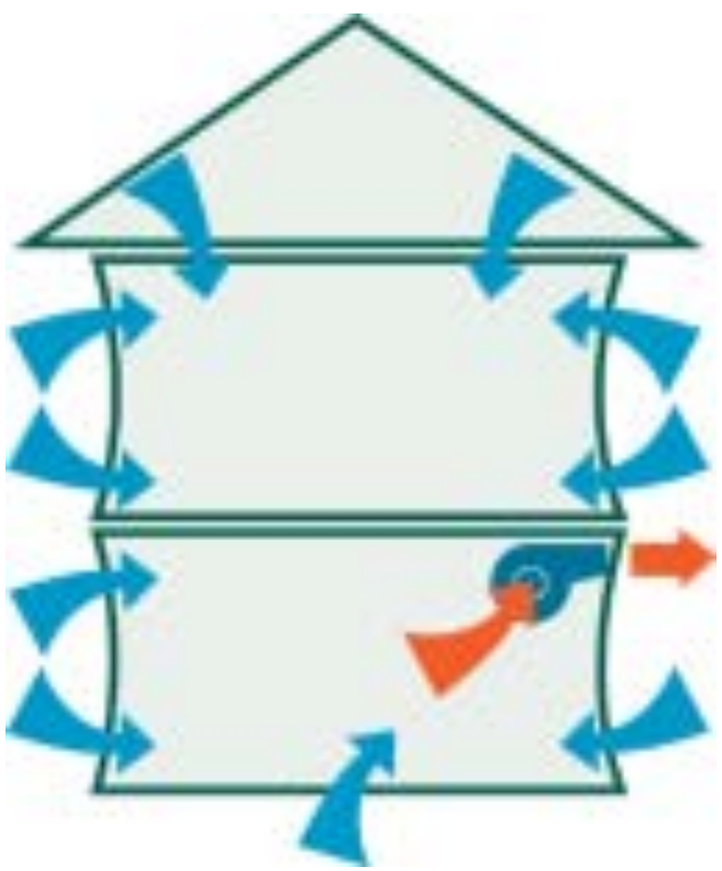
HOME VENTILATING INSTITUTE

For Gas Ranges recommend 100 CFM / 10,000 BTUs of burner capacity

Ventilation Strategies
may impact air leakage patterns

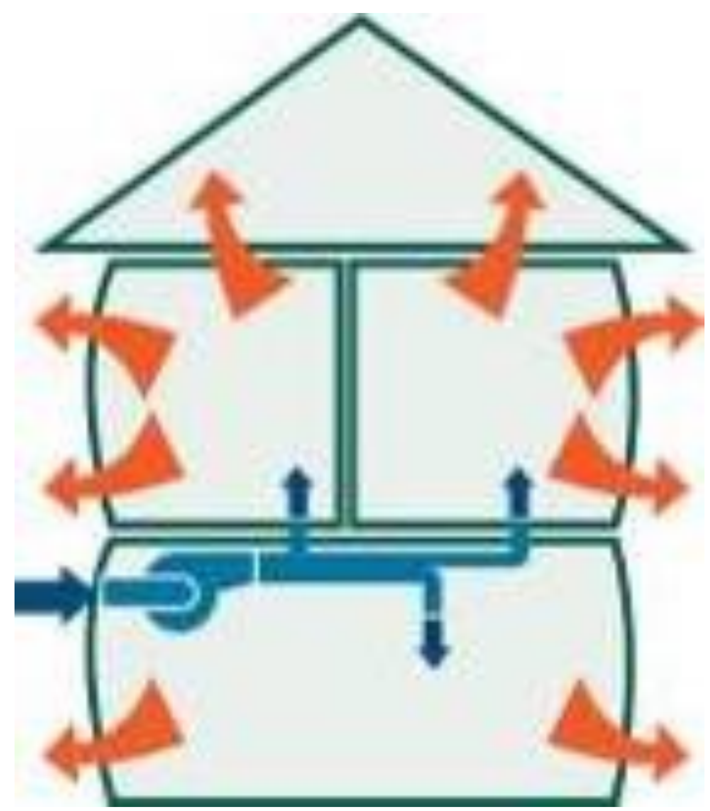
Negative Pressure

- In humid climates can pull moist air into building envelopes



Positive Pressure

- In cold climates can force moist air into building envelopes

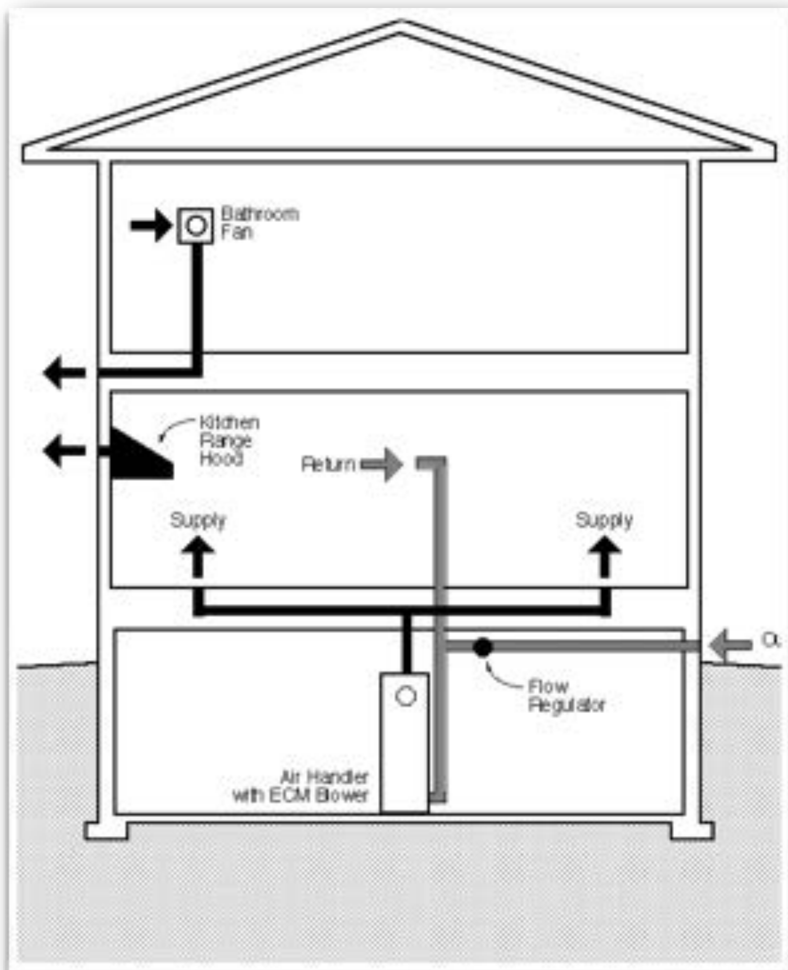


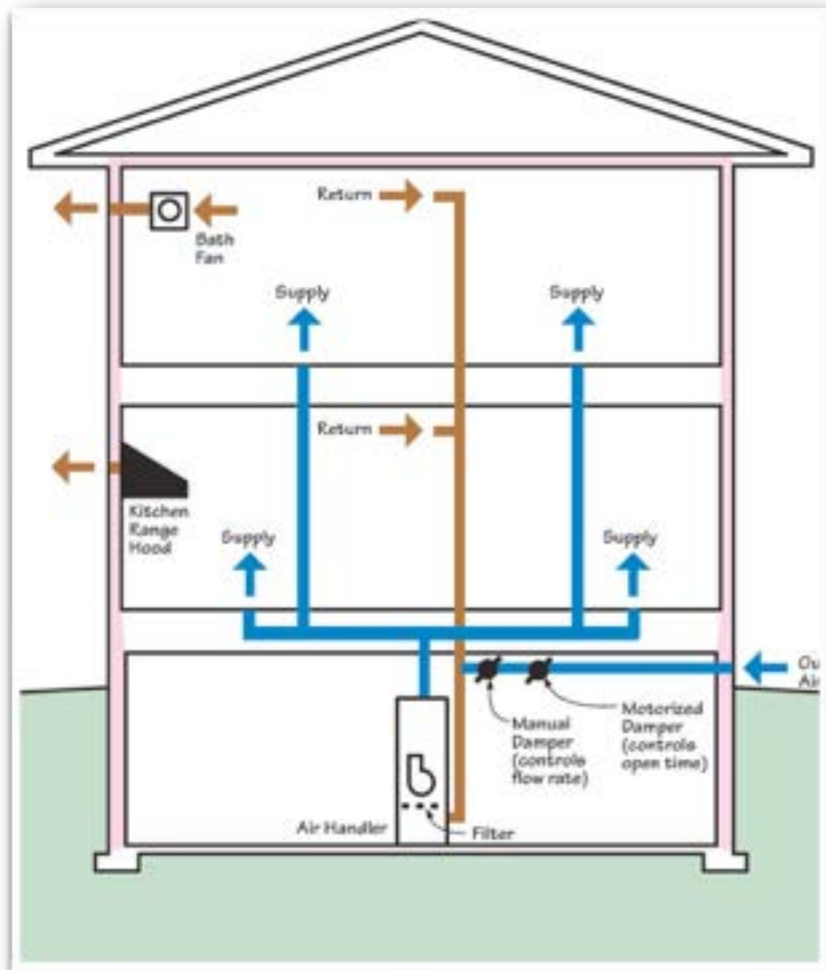
Balanced

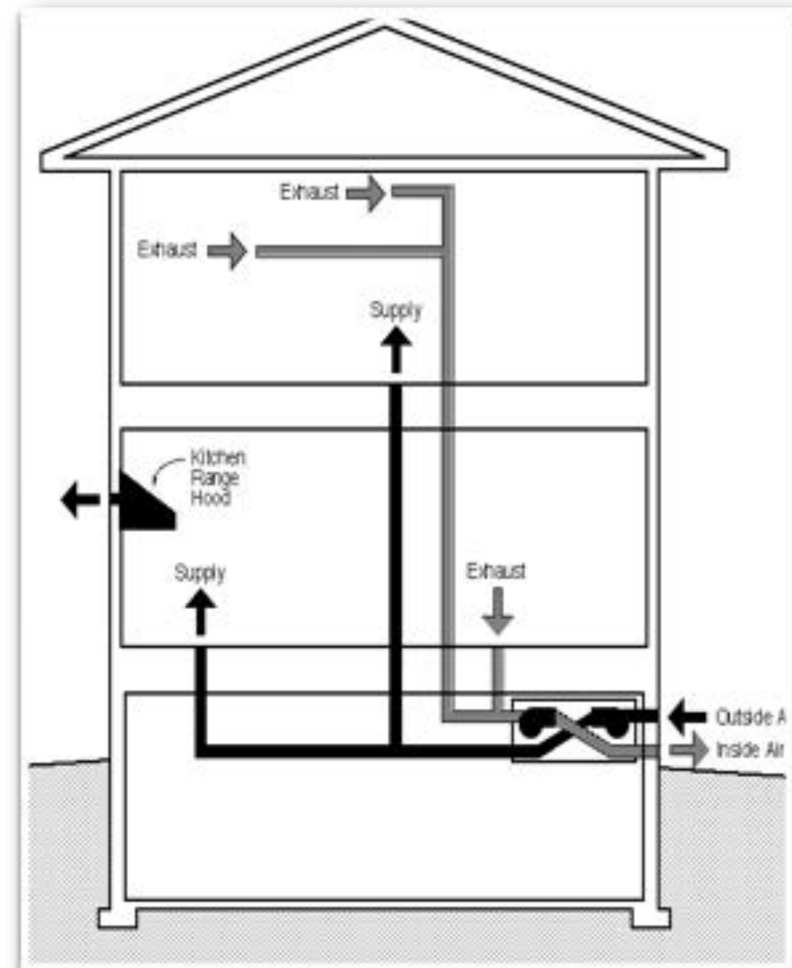
- Best in all climate zones

The tighter the house, the greater the pressure effect

Types of Mechanical Ventilation







Graphic courtesy of Building Science Corporation

Exhaust

Supply

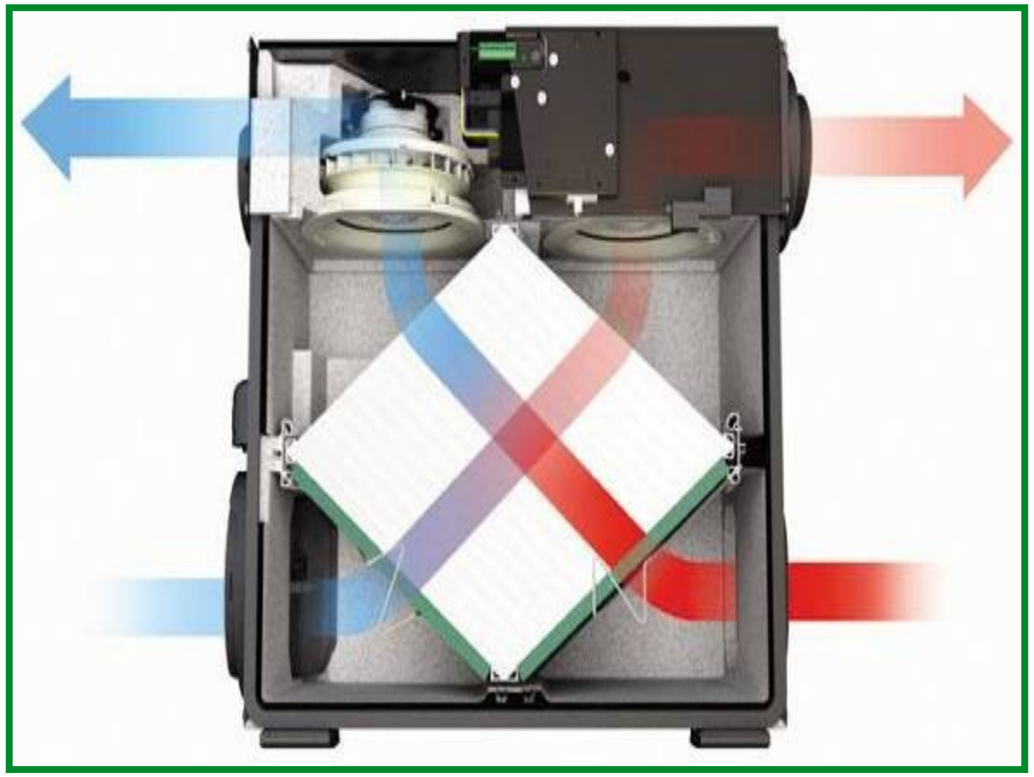
Balanced

Ventilation Opportunities

Quiet Bath & Kitchen Fans
- Quiet
- On timers or automatic control

Central Exhaust Fans
- Ducted from bathrooms
- On timers / controls

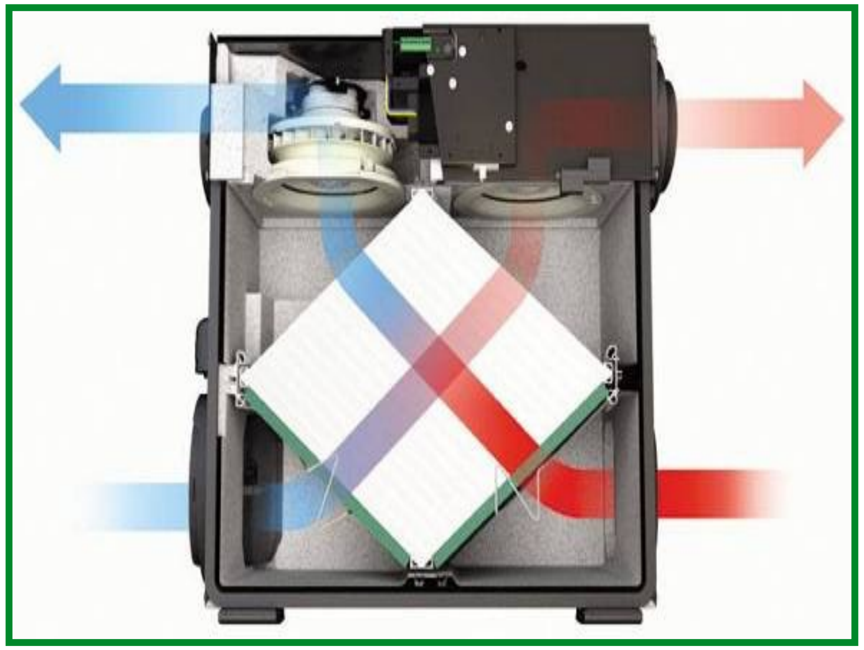
HRVs/ERVs
- Simplified or exhaust ducted
- Good controls



Ventilation Opportunities

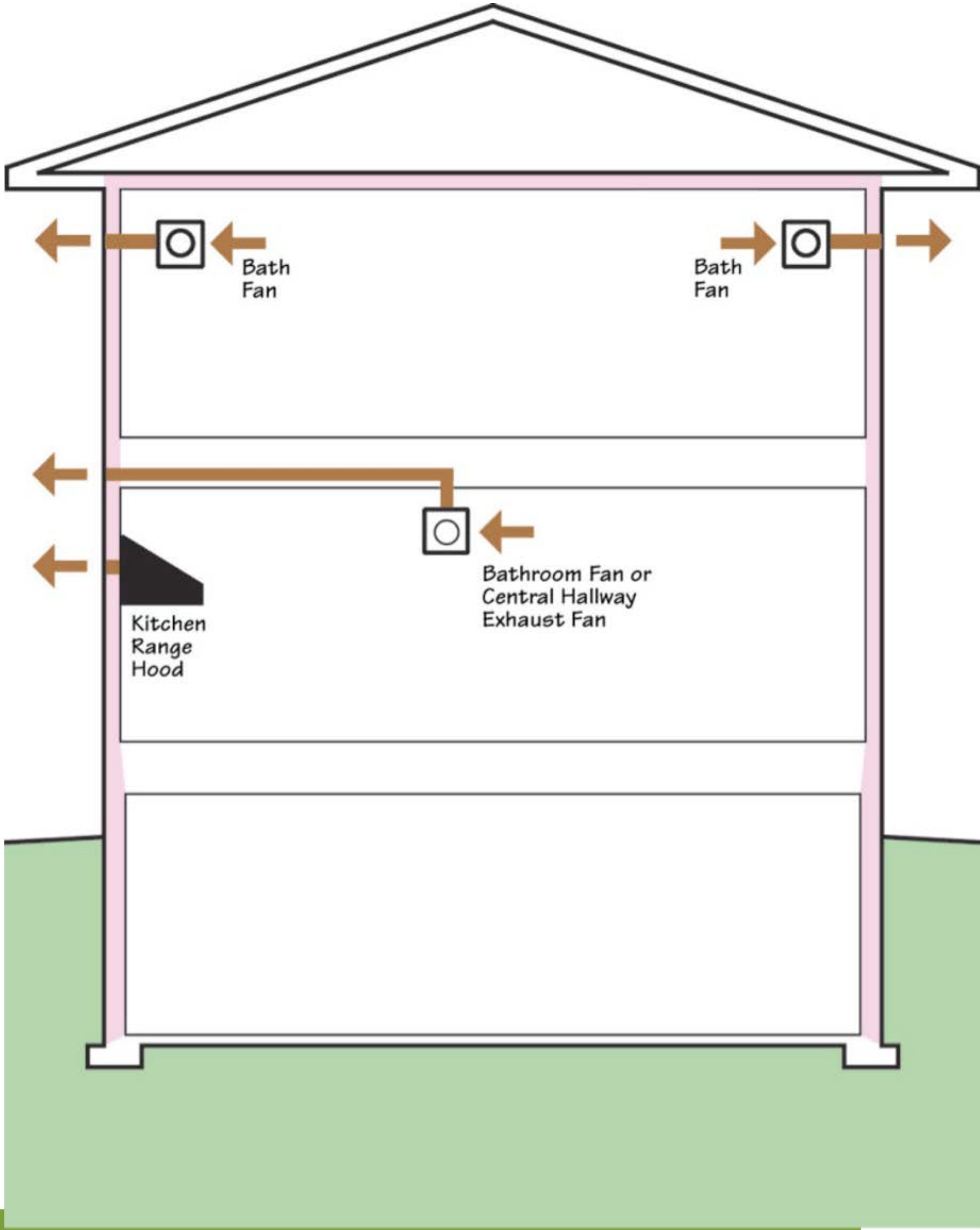
<u>Rated, Tested, Labeled Product</u>

- Always use HVI Certified fans
- Choose ENERGY STAR Qualified Fan and HRVs



Exhaust Only Ventilation

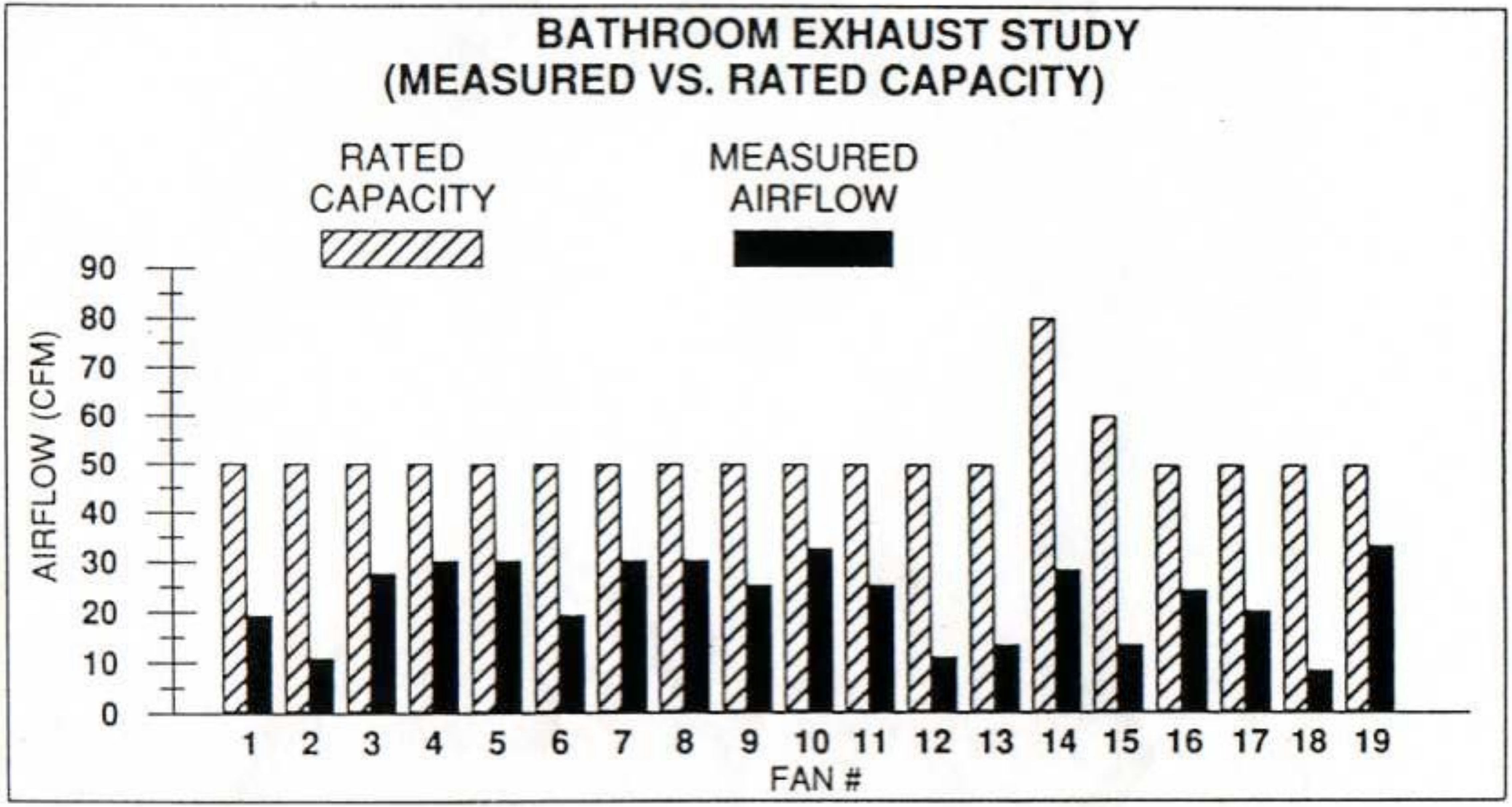
- Specify good quiet fans in bathrooms and kitchen
- Bath fans with sound ratings under 1.5 sones
- Can be used for point source control or general ventilation
- Use timers or other controls to extend usage
- Recall that large exhaust fans can cause negative pressure



Control Strategies for "Continuous" Exhaust

Fan manufacturers have many new, helpful control strategies

- Continuous Low
- High speed occupancy
- Cycle timed



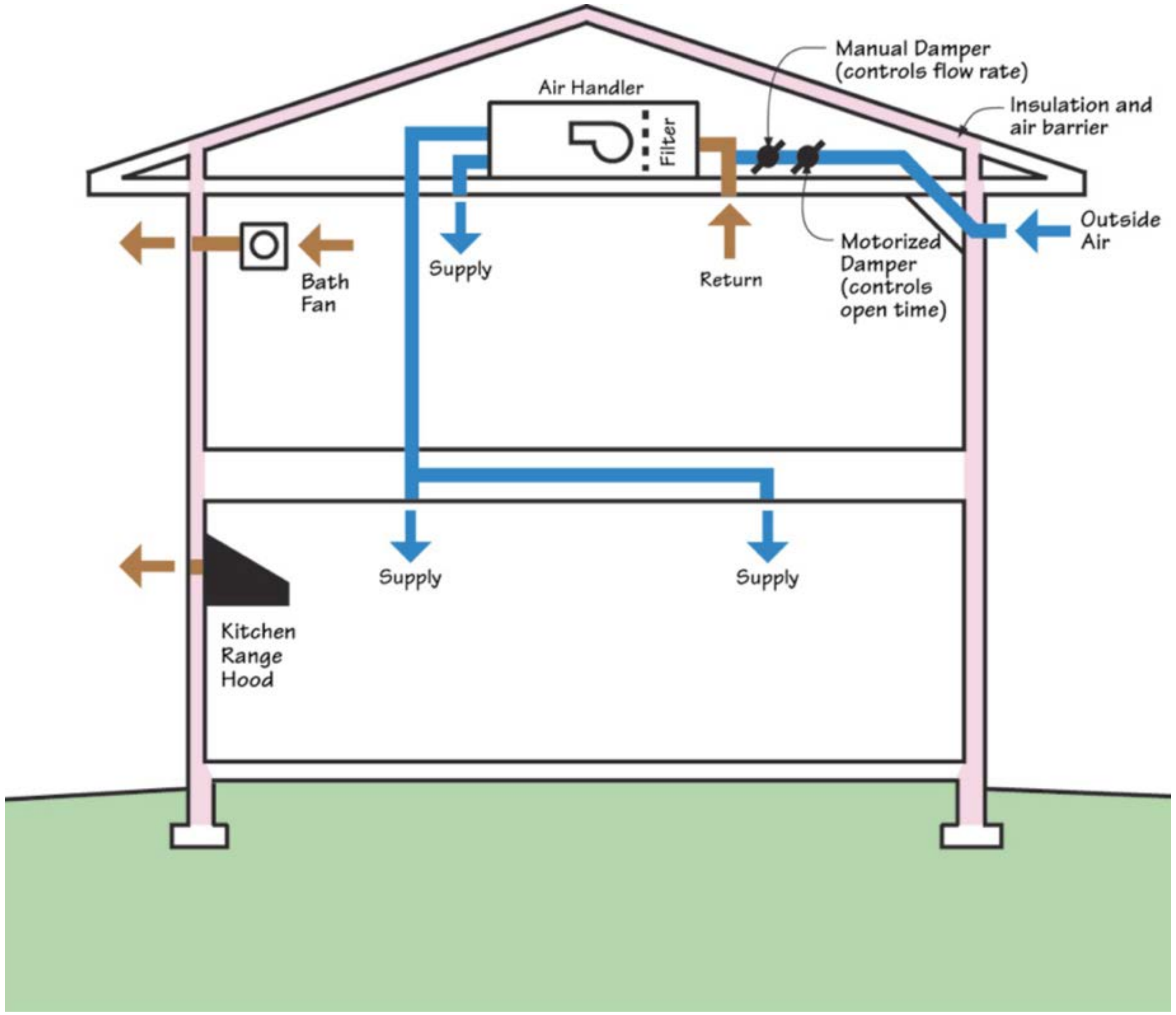
Canadian bathroom exhaust study. *In 26 fans tested (19 shown here), the measured airflow of the installed fan was less than half the rated capacity in nearly every case.*

Supply Only Ventilation

- A fewer air duct into the furnace/air handler - typically 6” dia.

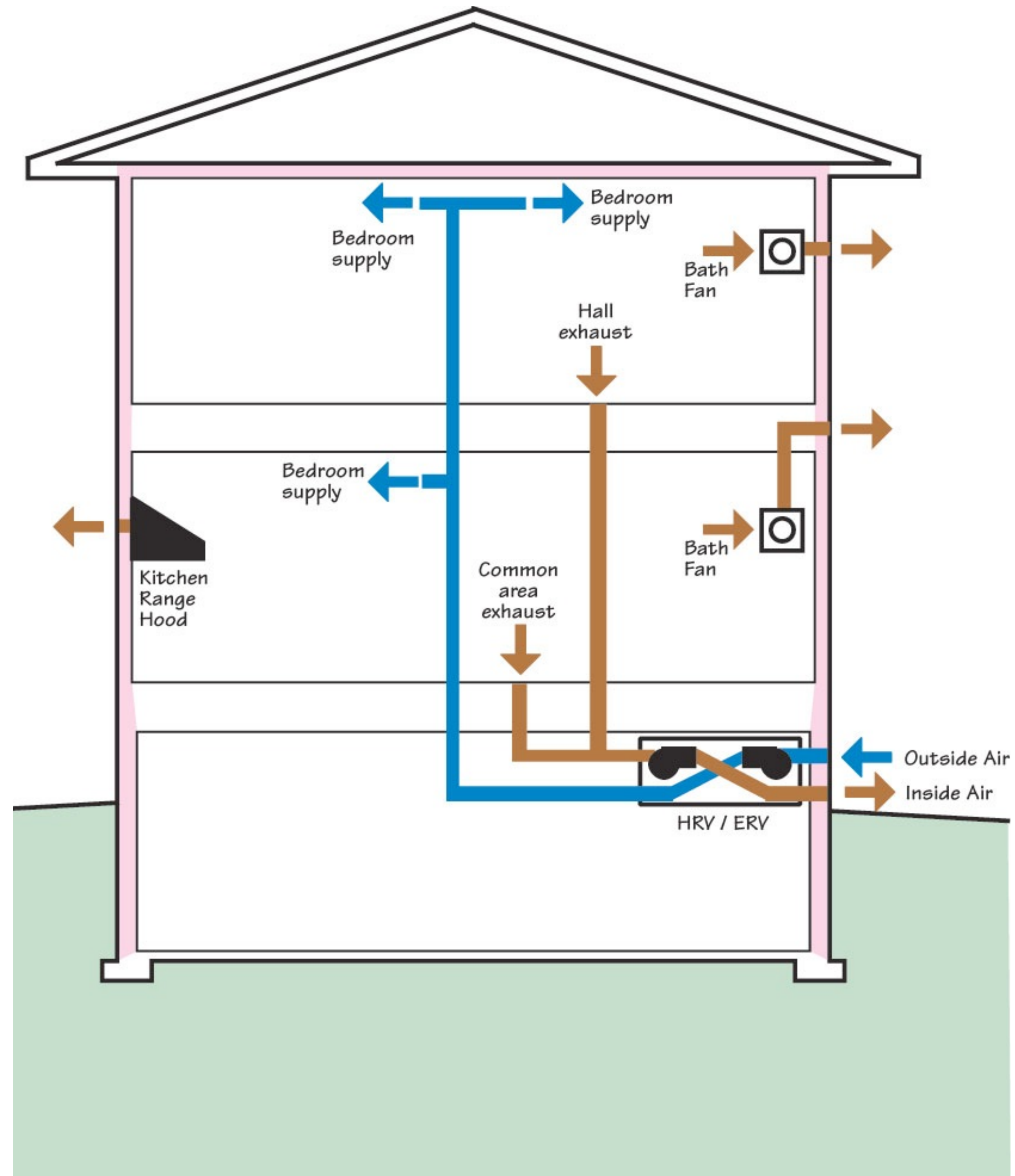
- Use dampers in conjunction with timers to control operation of the ventilation independent of heating & cooling cycles

- New ECM fan motors are very effective



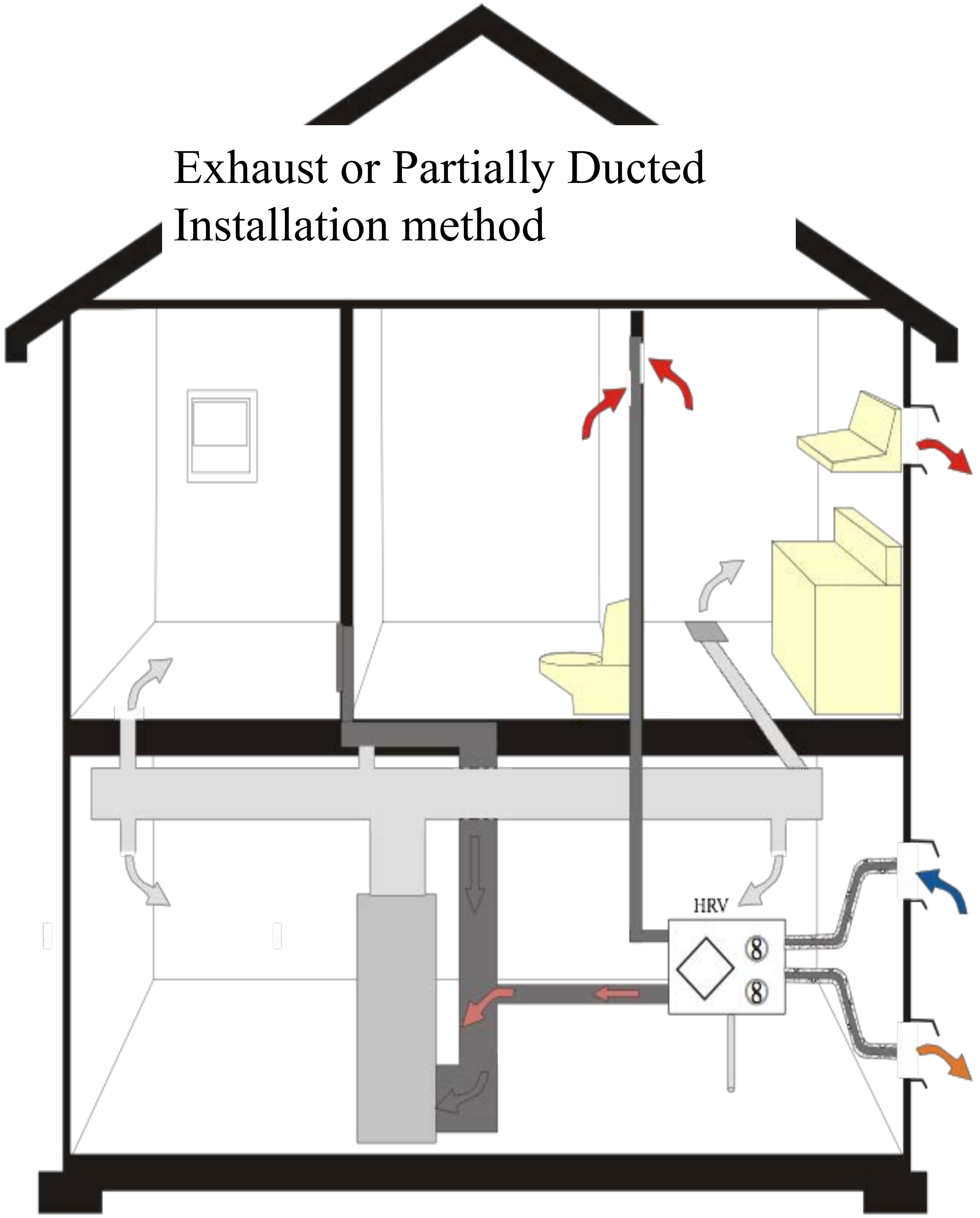
Balanced ventilation with heat or energy recovery

- Remote mounted multiple room pick-up and delivery
- Draw from the common area and supply to all bedrooms
- Central fan integration is also used



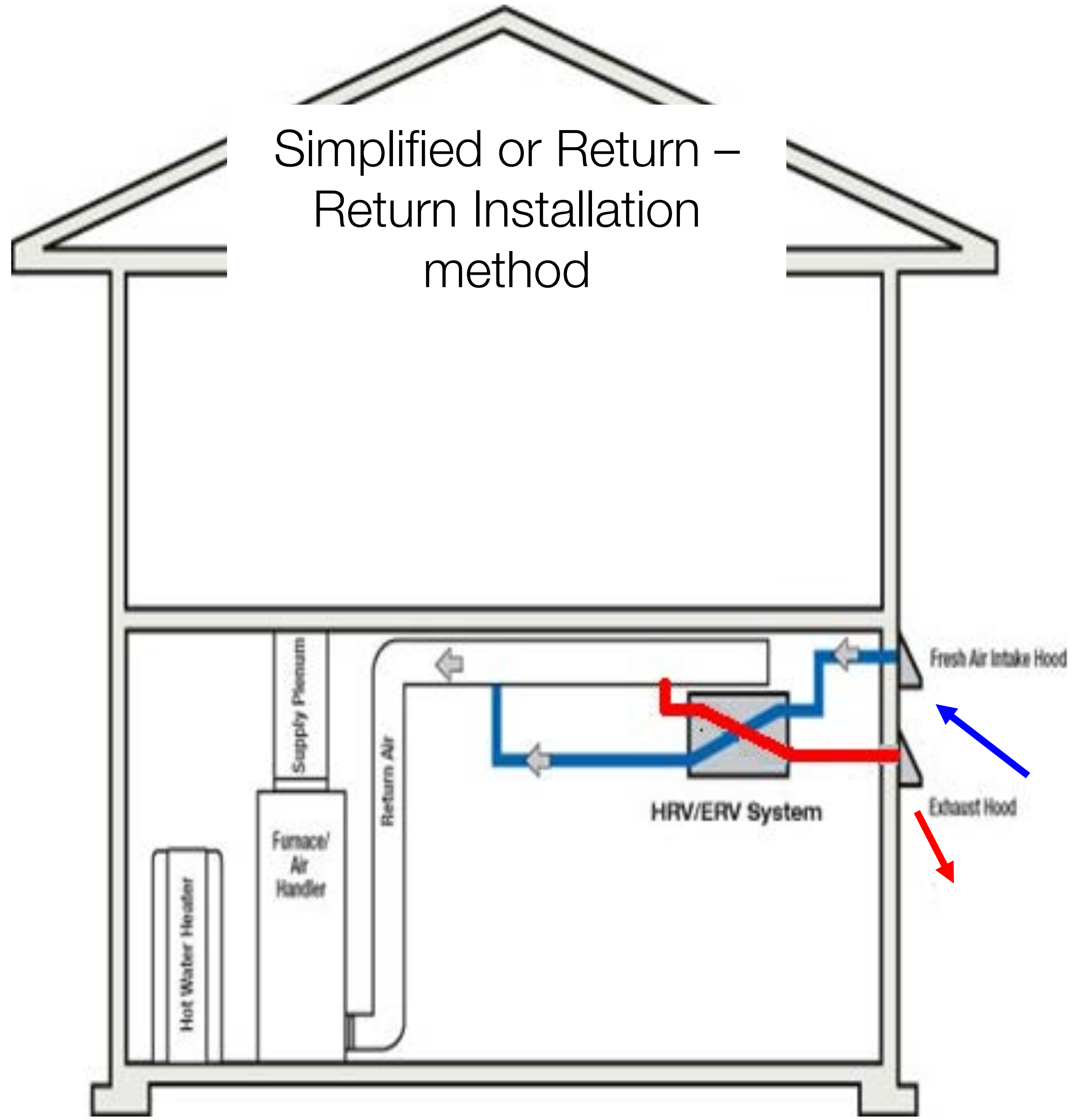
Installation Options

- There are different options for installation depending on application needs
- Often the furnace duct system is used to distribute fresh air
- When possible, run exhaust ducts from bathrooms & kitchens



Balanced Ventilation with Heat Recovery

- HRVs / ERVs for continuous ventilation
- Choose Home Ventilating Institute (HVI) certified
- Select units with the right air flow.



HOME VENTILATING INSTITUTE

Ventilation & High Performance Homes

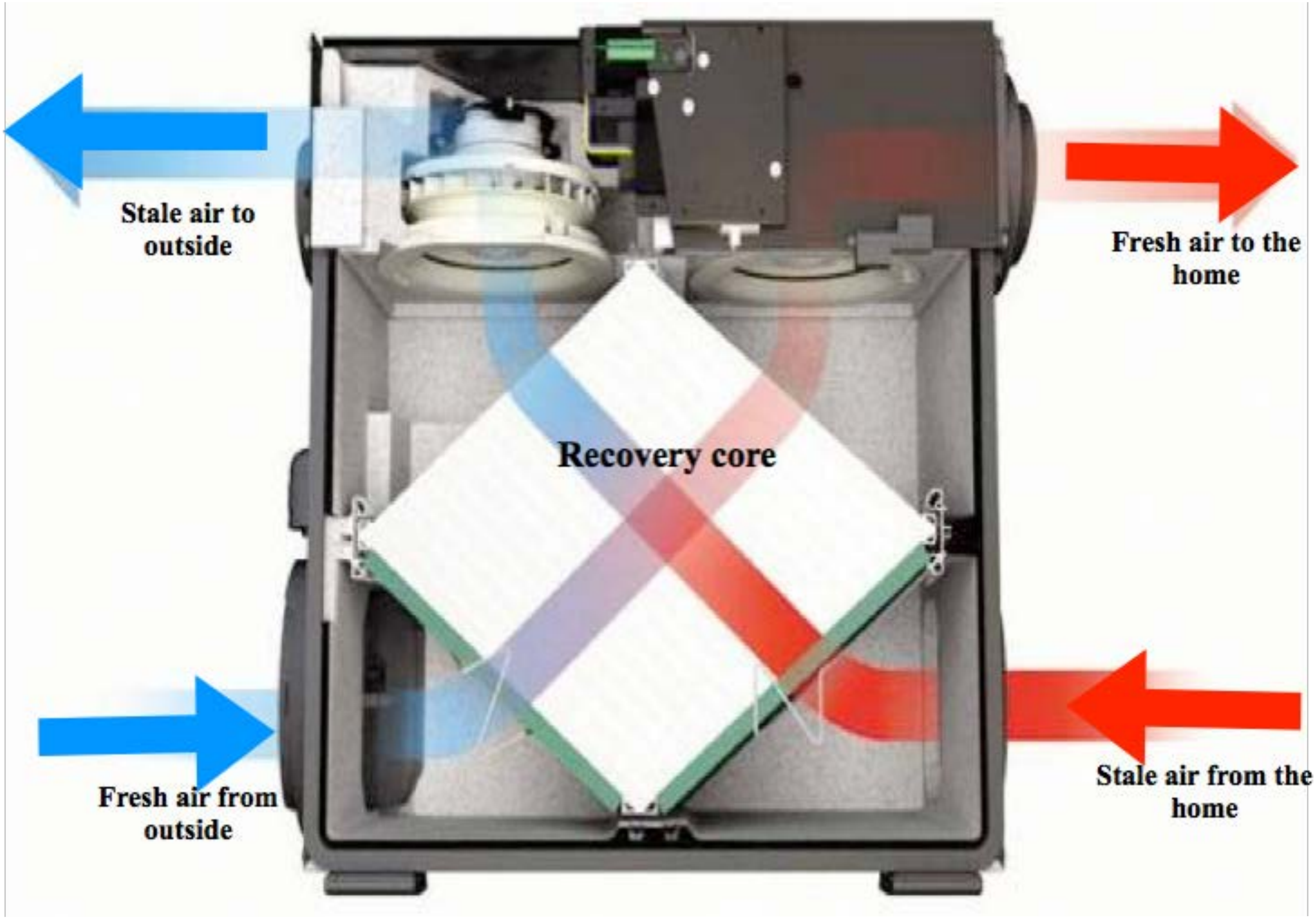
Ventilation is an important part of the House as a System

- Allows for houses to be built tighter
- Provides interior moisture and pollutant control

Ventilation will impact other HVAC systems

- Impact on HVAC load calculations
- Impact on moisture balance
- Impact on house pressures
- Impact on control strategies

The Lungs of the Home



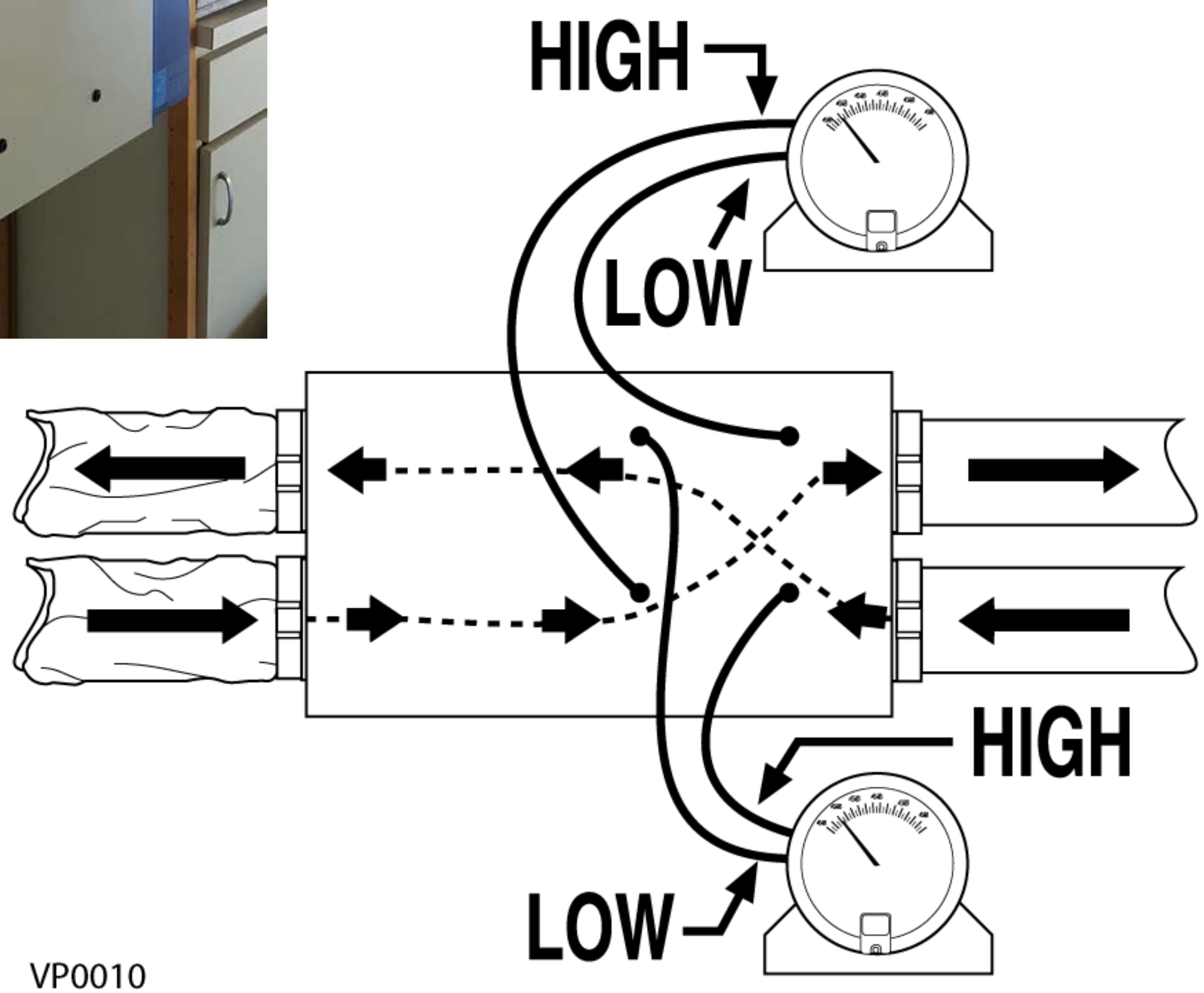
Construction Instruction®

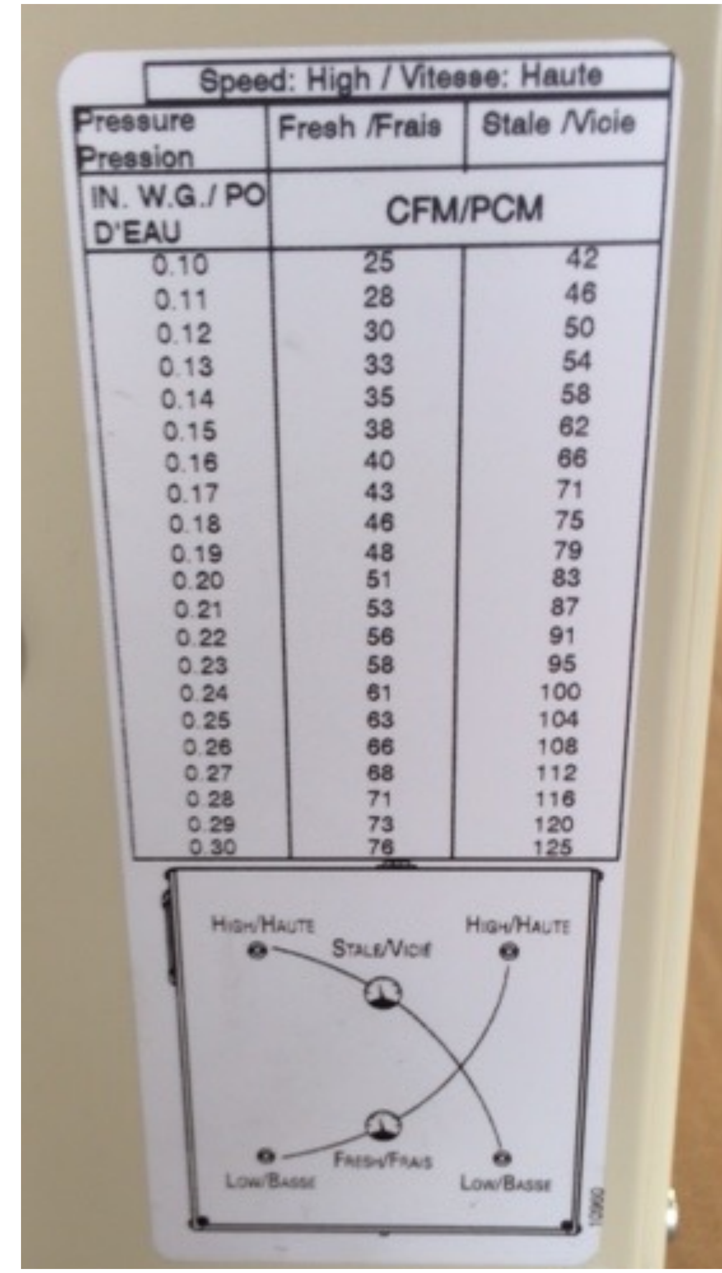
Building Science for Everyone, Everywhere

Energy Recovery Ventilator (ERV) in an Attic

Winter

HRVs / ERVs - Balancing Flows





Speed: High / Vitesse: Haute		
Pressure Pression	Fresh /Frais	Stale /Vicie
IN. W.G./ PO D'EAU	CFM/PCM	
0.10	25	42
0.11	28	46
0.12	30	50
0.13	33	54
0.14	35	58
0.15	38	62
0.16	40	66
0.17	43	71
0.18	46	75
0.19	48	79
0.20	51	83
0.21	53	87
0.22	56	91
0.23	58	95
0.24	61	100
0.25	63	104
0.26	66	108
0.27	68	112
0.28	71	116
0.29	73	120
0.30	76	125

HRVs / ERVs - Balance the Flows

HRV's - ERV's what's the difference?

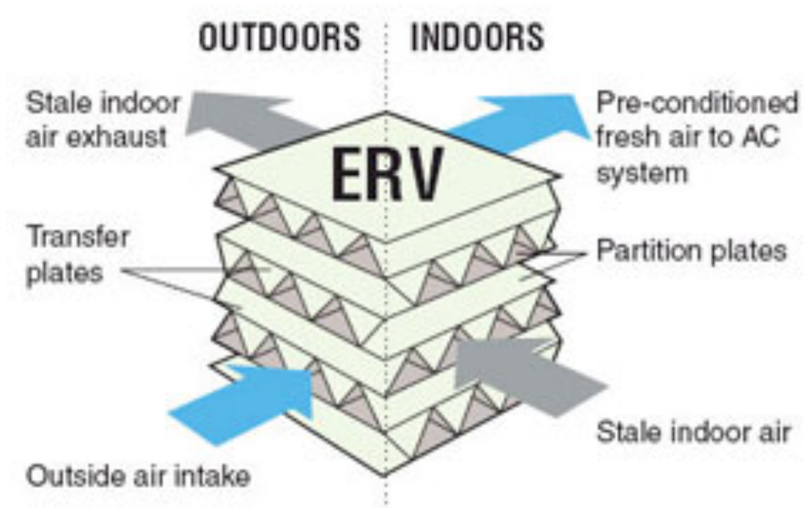
Heat Recovery Ventilation

- Allows transfer of sensible heat or temperature difference

Poly or Aluminum Core

Energy Recovery Ventilation

- Allows both sensible and latent transfer
- Moisture transfer
  - Reduces cooling loads in humid climates
  - Avoids over-drying in winter



Permeable Core

Ventilation Impact on Heat / Cool Loads

75 CFM of ventilation will increase HVAC loads

Cold Weather

At -20 ^{0}F

- Ventilation adds 7300 BTUs to heating loads
- Ventilation can remove up to 7 gallons of water per day

Hot Weather

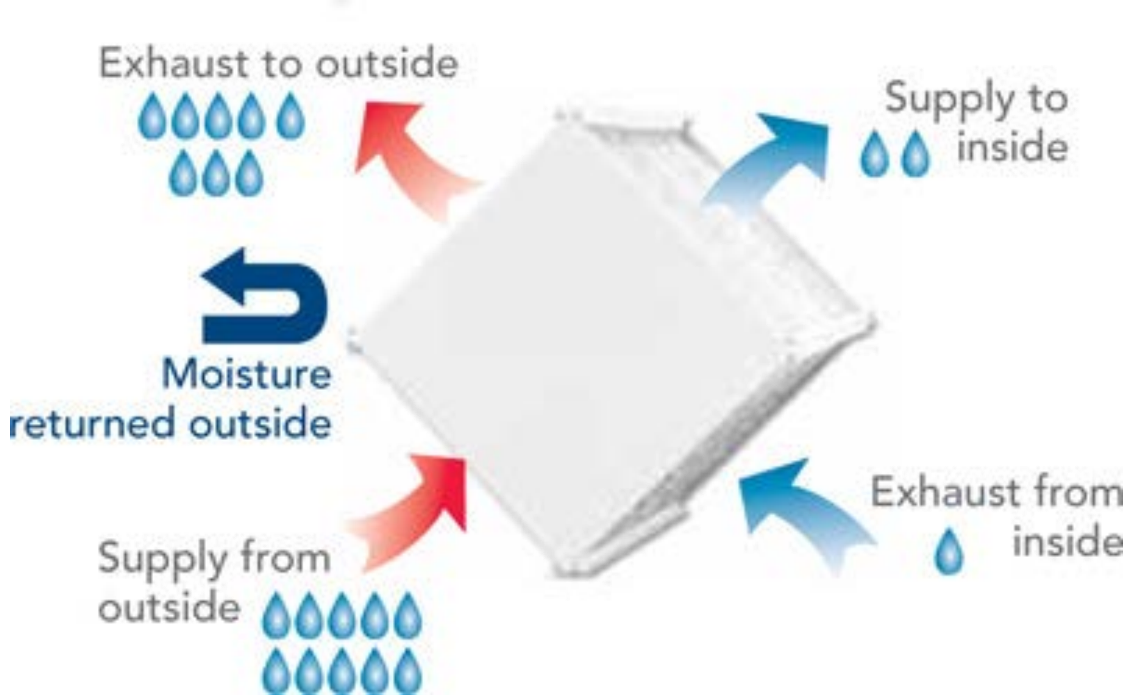
At 105 ^{0}F and dry outside

- Ventilation adds 2500 BTUs (1/5 of a ton) to cooling loads
- At 95 ^{0}F and humid
- Ventilation adds 4500 BTUs (just over 1/3 of a ton) to cooling loads
- 2/3 of this load is latent (moisture)

These loads can be reduced by up to 80% through the use of heat / energy recovery technology

HRV or ERV? A new question for ZERH's

- Increased LATENT (moisture) / SENSIBLE (temperature) ratios loads:
  - Ventilation + "normal lifestyles" – occupant loads
  - From 25:75 to now 40:60
- Healthy range of humidity is critical - winter 35% - 40 %, summer 50% - 55%.
- Presence of AC loads are increasingly- LATENT and can be addressed by ERVs(not HRV's)
- Energy Recovery is 50% - 60%



Ventilation Impact on Moisture Control

- Ventilation tends to:
  - Remove moisture in heating season
  - Add moisture in the cooling season
- Ventilation is helpful in avoiding winter condensation

Avoiding Winter Over-drying

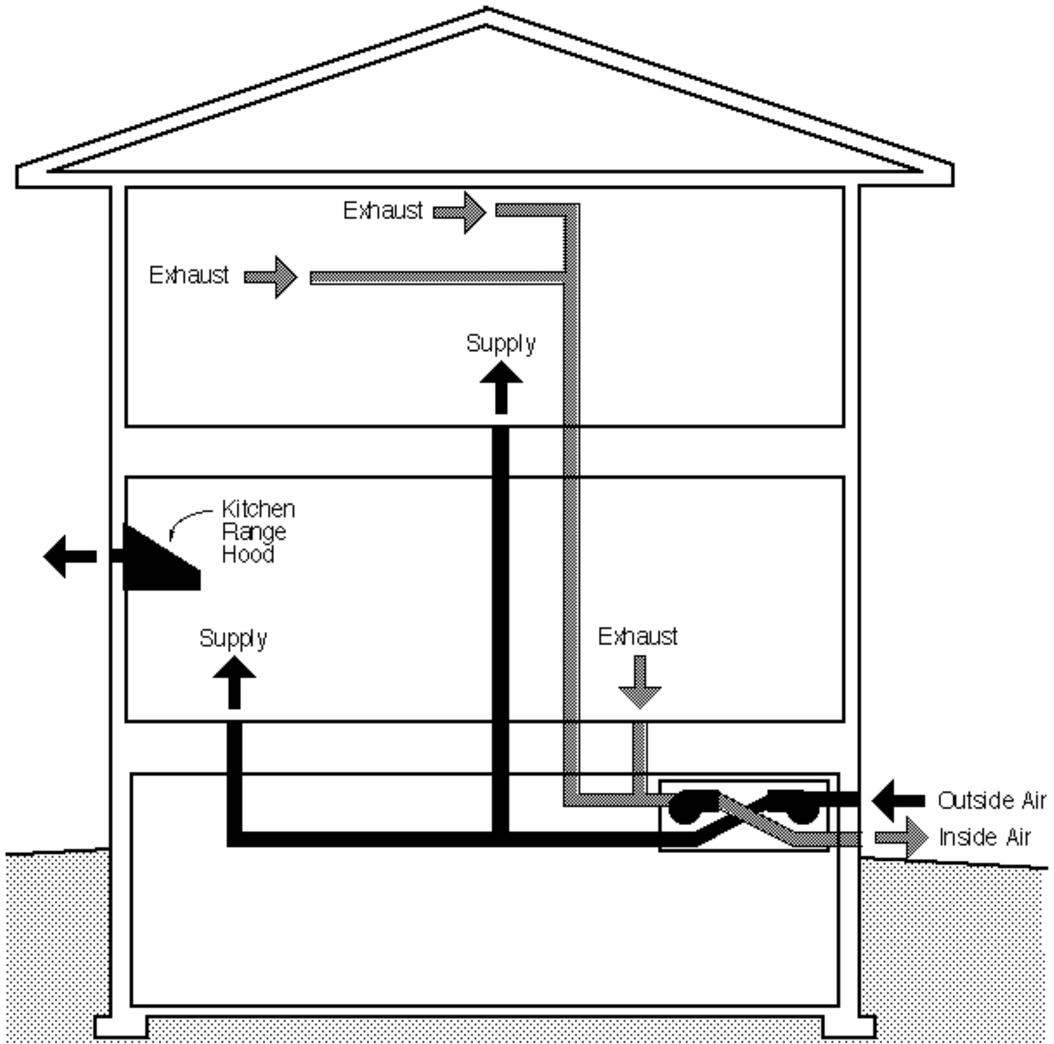
- Provide occupants with controls
- Use ERV technology to recapture moisture
- Add a humidifier

Avoiding Summer Moisture

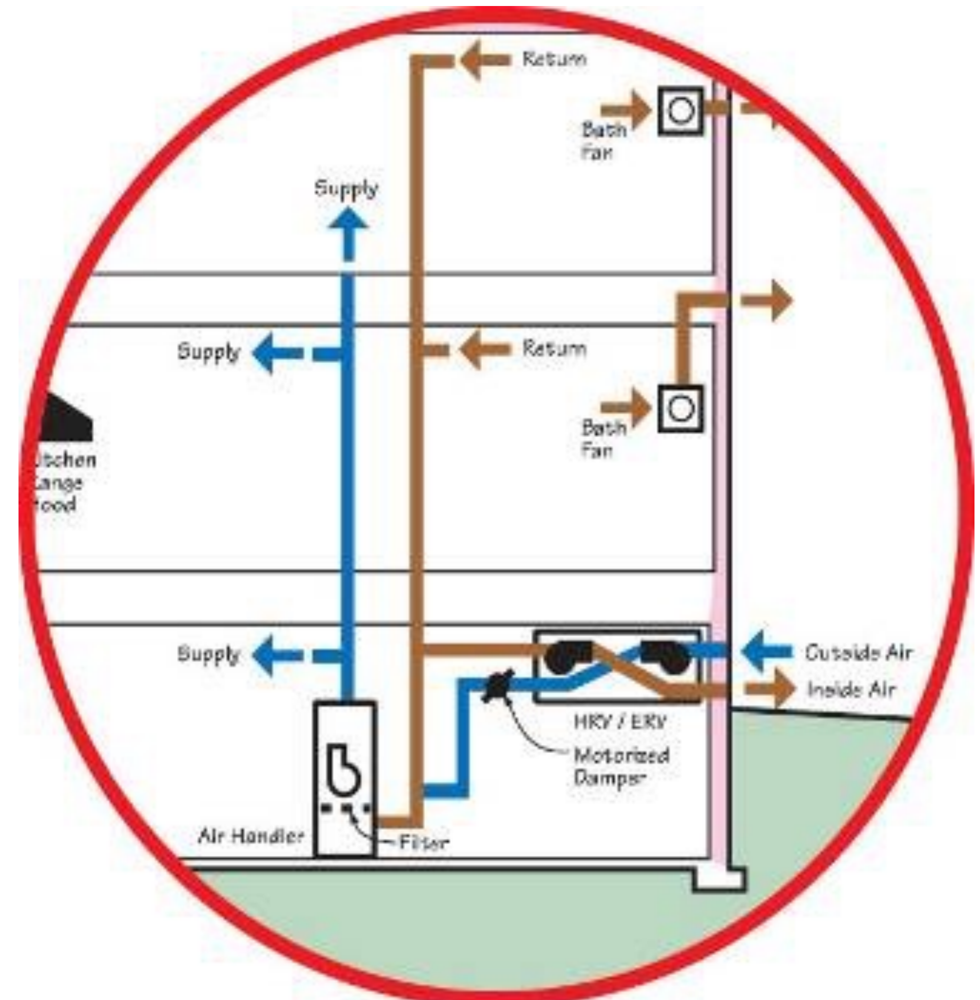
- Provide occupants with controls
- Use ERV technology to reject moisture back outside
- Add a dehumidifier / two stage air conditioner

Comparing Installation Costs – 3000 sq.ft home

Fully Ducted System



Simplified System



ERV System

- Certified Unit, Ducting, Controls
- Kitchen fan, Bath fan (as needed)
- Installation & Verification of air flows

Estimated Cost = $1600- $2200

Ventilation System Decision Matrix

	House tightness	HVAC	Climate	Cost
Exhaust	loose	Non-spillage	Cold, dry	Lowest capital, Higher operating
Supply	loose	Forced air	Hot, humid	Low Capital Higher operating
Balanced	tight	Any	Any	High capital cost Lowest operating

The Cost of Ventilation – 75 CFM continuous

Electric costs Gas heat costs	$0.06 / kW $0.60 / Therm	$0.12 / kW $0.60 / Therm	$0.18 / kW $0.60 / Therm
North (Duluth, MN)	$180/yr	$220/yr	$250/yr
Mixed (Louisville, KY)	$105/yr	$155/y	$195/yr
Hot, Humid (Miami, Fl)	$ 115/yr	$155/yr	$240/yr

The Savings of Ventilation w/ Heat Recovery

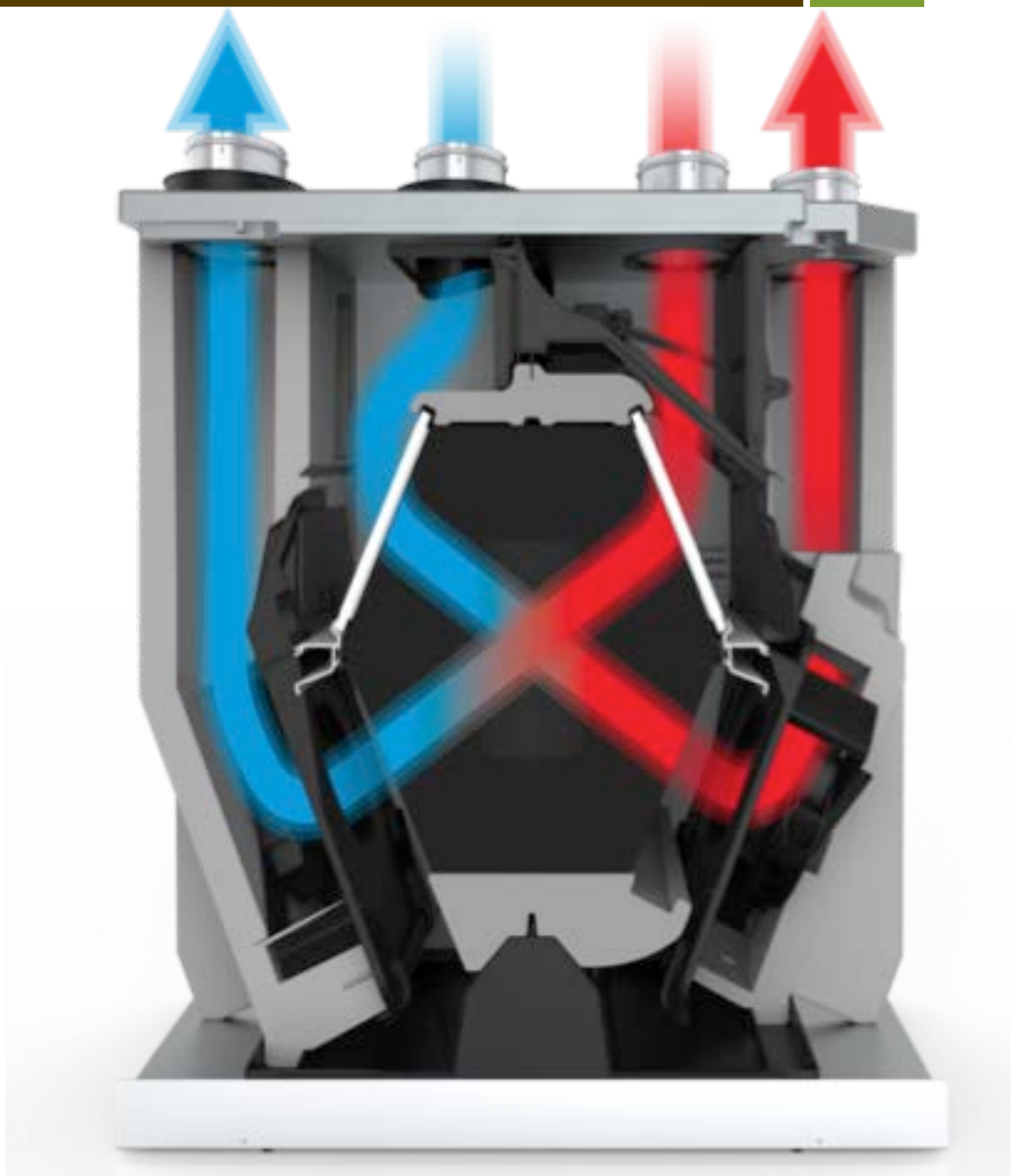
Proper ventilation enables tighter homes

This can save:

- $200 - $250 /yr in the north
- $125 - $175 /yr in mixed climates
- $ 75 - $125 /yr in southern climates
- ECM motors on air handlers, fans and ERVs can help save even more

ZERH's need New Ventilation Innovations:

- SRE up to 84% at -0 C /30 F
- ECM motors – 22 watts
- HEPA filter option
- 200 CFM +



In ZERH's the fan efficacy matters more. New Ventilation Innovations

- ECM or DC brushless fan motors
- 1000+ kWh / yr vs. standard HRV
- For a ZERH(15,000kWh) that is a 6% annual reduction in energy

VENTILATION CONTROL STRATEGIES

Ventilation Controls Matter:

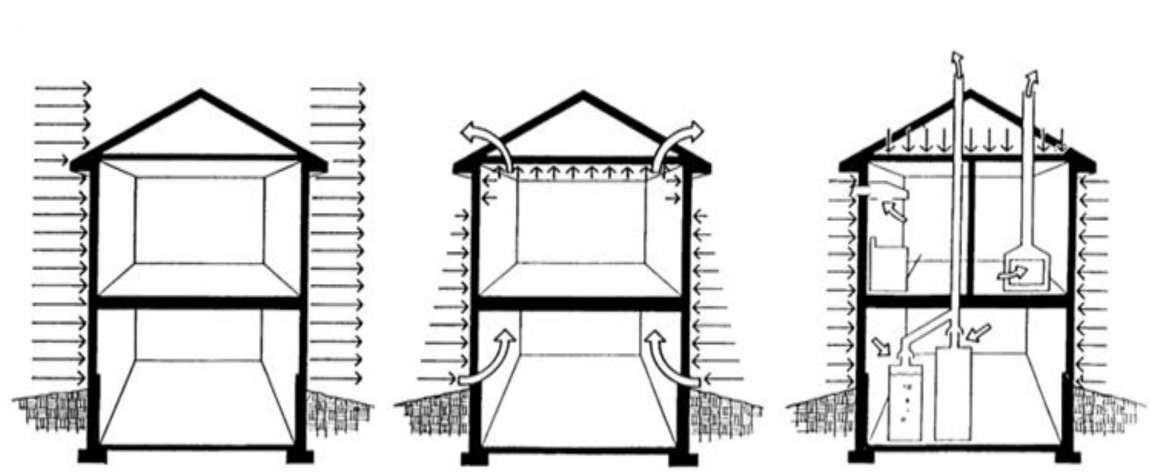
- Timer?
- Dehumidistat?
- “Smart” Controls?

Air tightness and HRVentilation

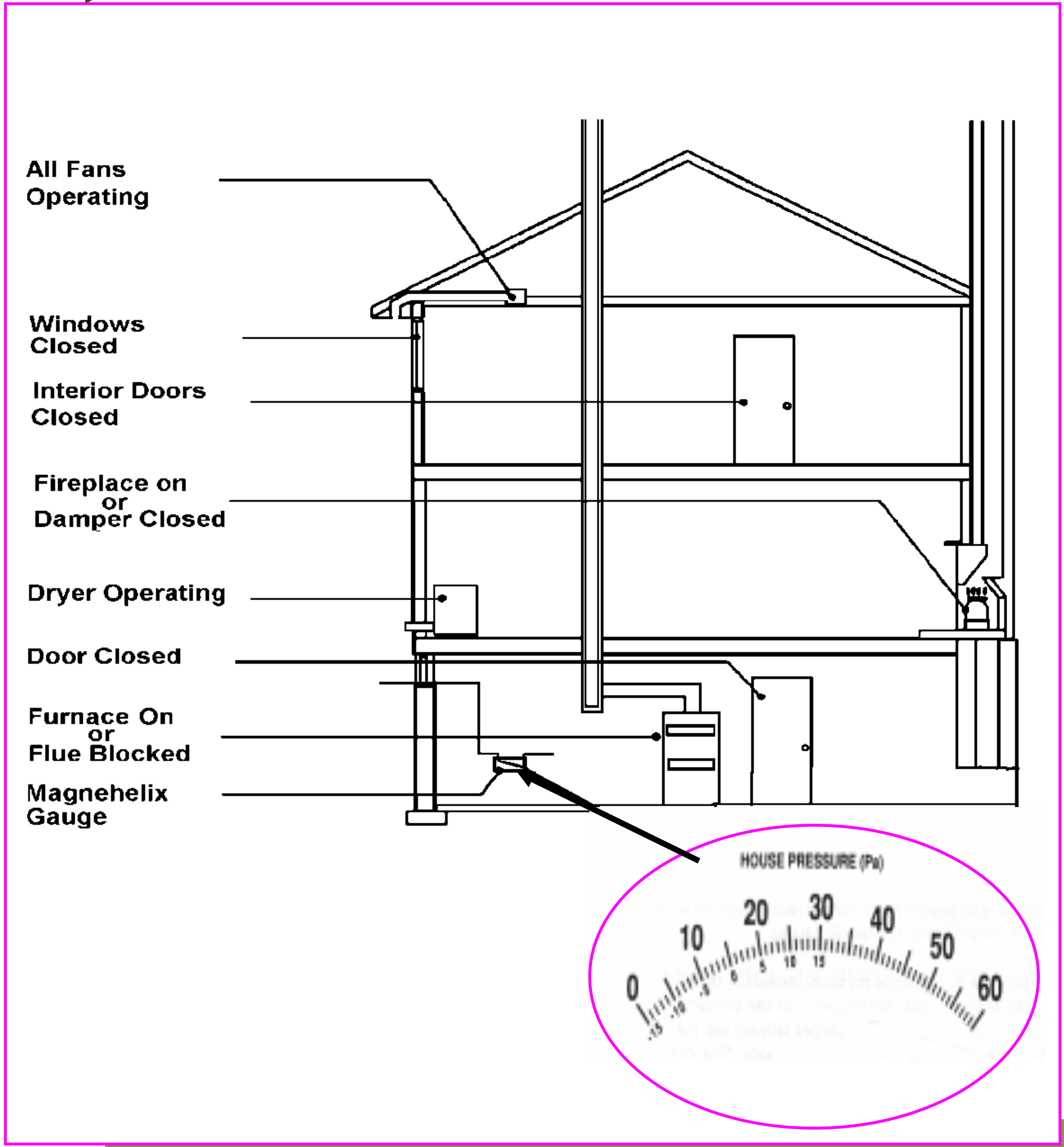
Know the REAL numbers for air tightness! (ACH50,etc)!

Satisfy ventilation with HRV/ERV) -Take advantage of BETTER ventilation design and equipment e.g. balanced ventilation with heat recovery(HRV or ERV).

Combining air tightness AND heat recovery for ventilation will REDUCE the heating and cooling loads further



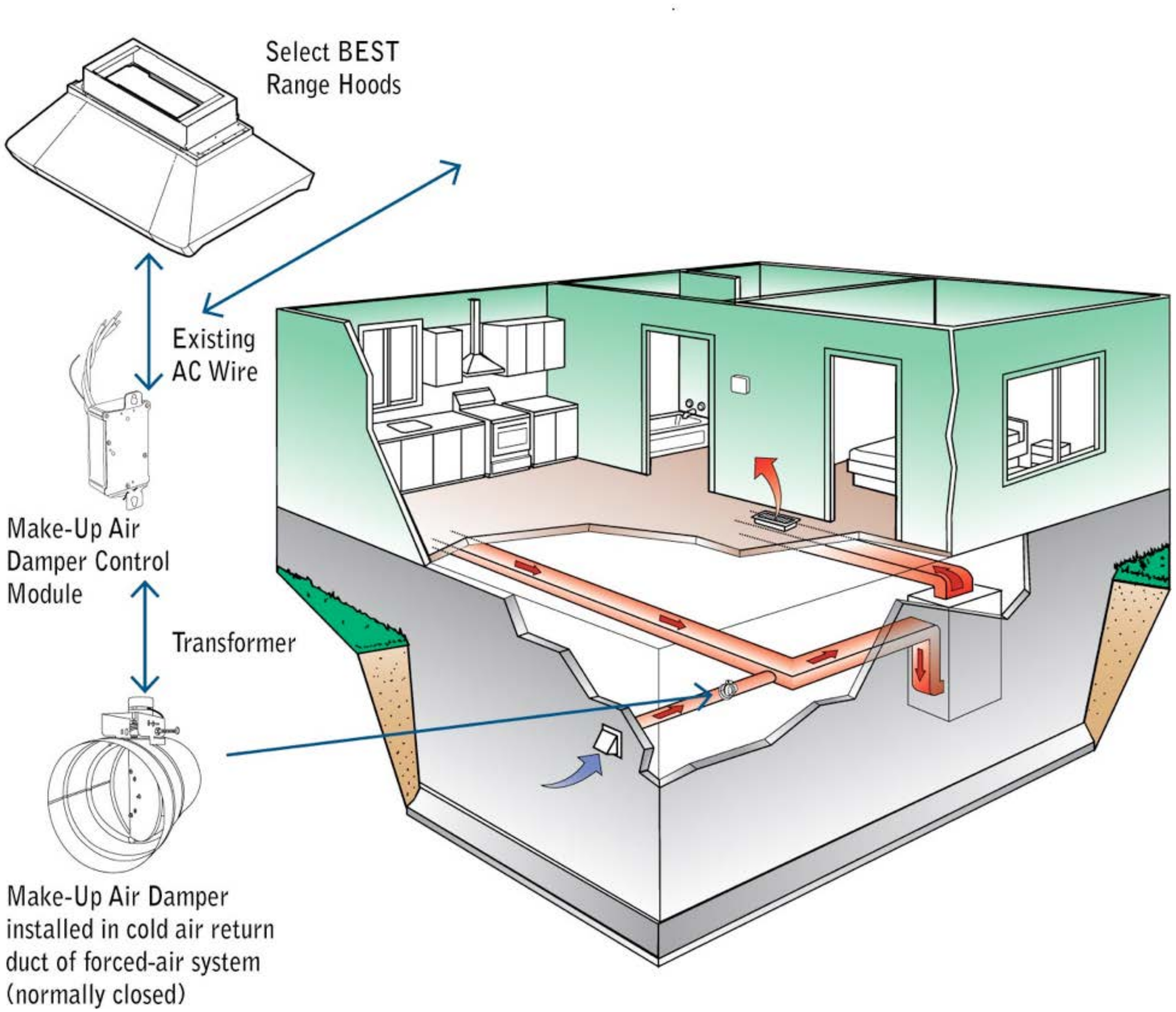
Ventilation Impact on combustion appliances
Testing for depressurization



- Specific concern with natural draft appliances; wood burning fireplaces, gas log sets
- Tight houses with large exhausts can cause negative pressure
- Chimneys can overcome -5 Pa (-0.02"w.g.) pressure
- Test and provide make-up air if required

What about make-up air?

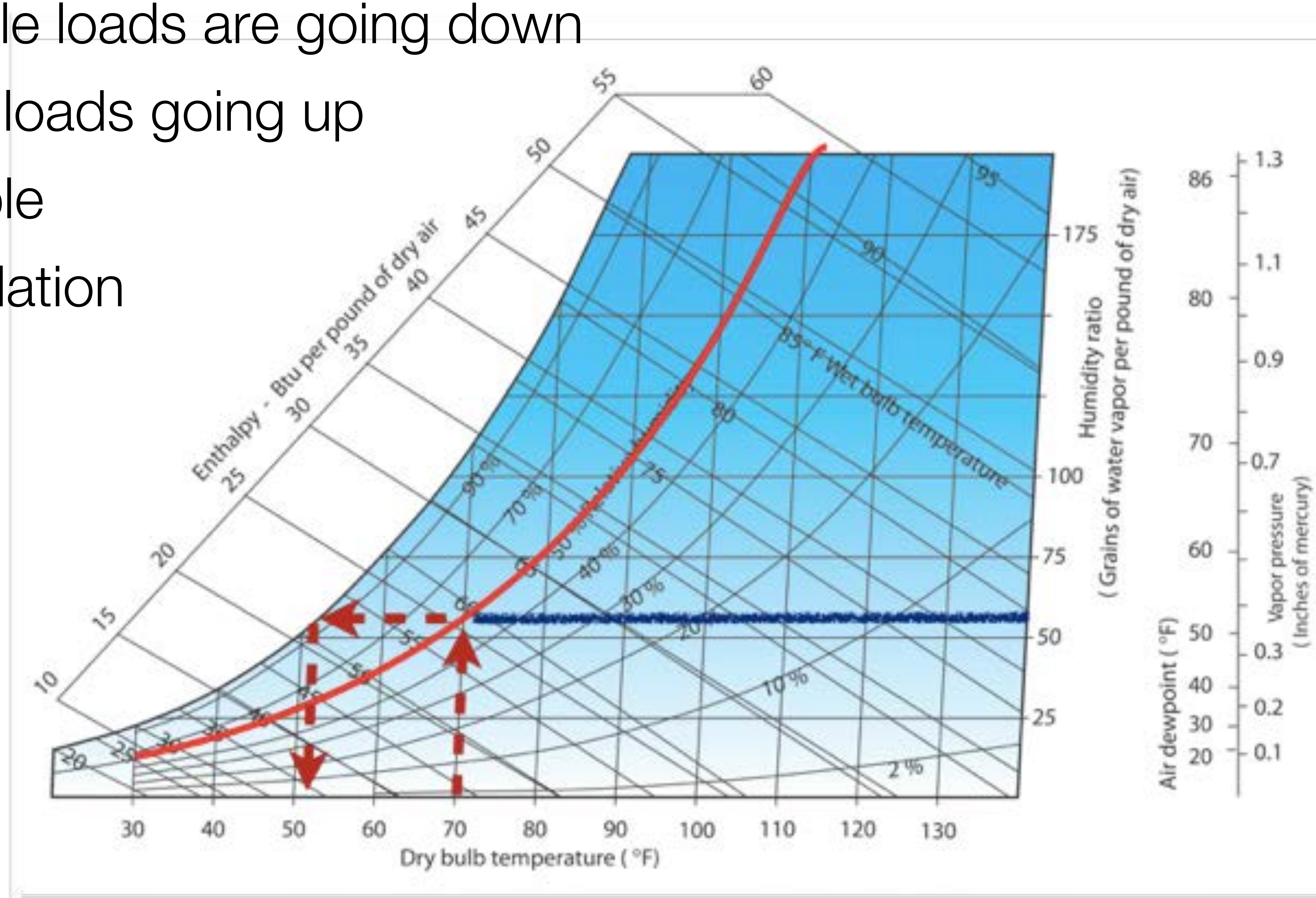
Fan manufacturers have new, helpful strategies



Over 400 CFM ??

Building Science & Moisture control

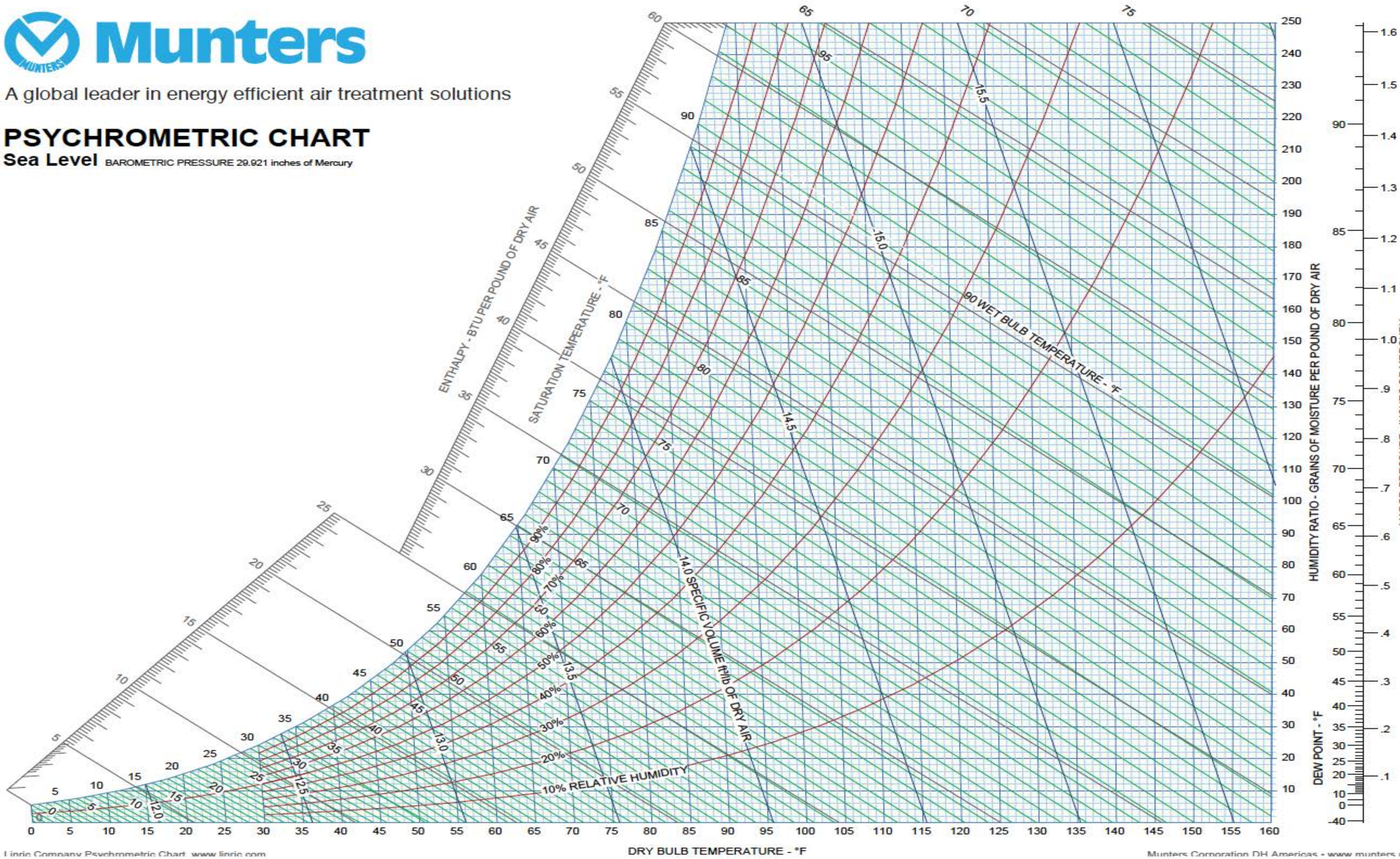
- Sensible loads are going down
- Latent loads going up
  - People
  - Ventilation



Psychrometrics

Understanding the Physics of Air

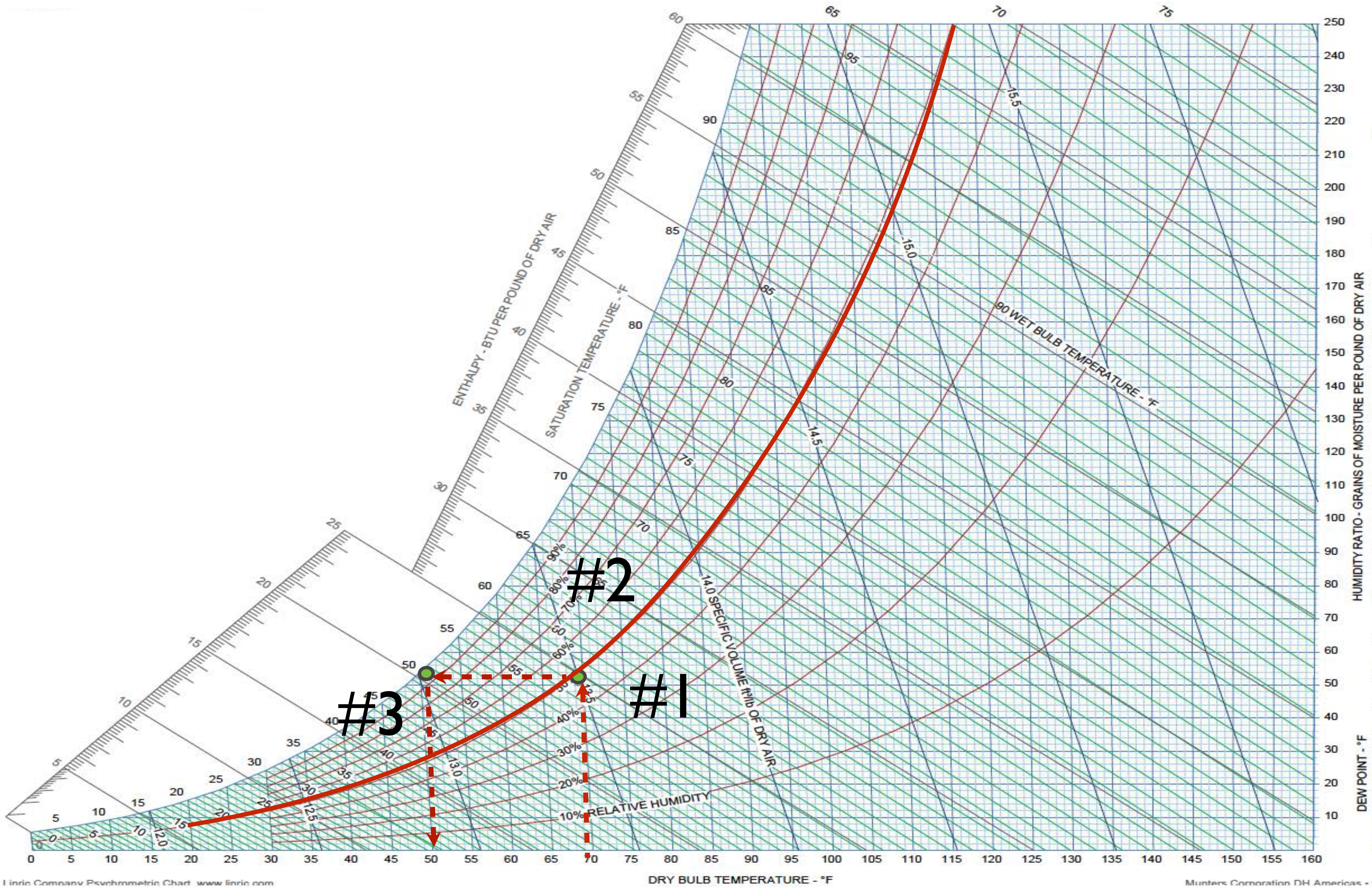
Psychrometric Exercise



a) If indoor air is at 70 F and 50% RH, to what temperature must it be cooled to get condensation? ___50.53 F___ This is the Dew Point

b) If the indoor air was at 30% RH, what would the dew point be? ________________

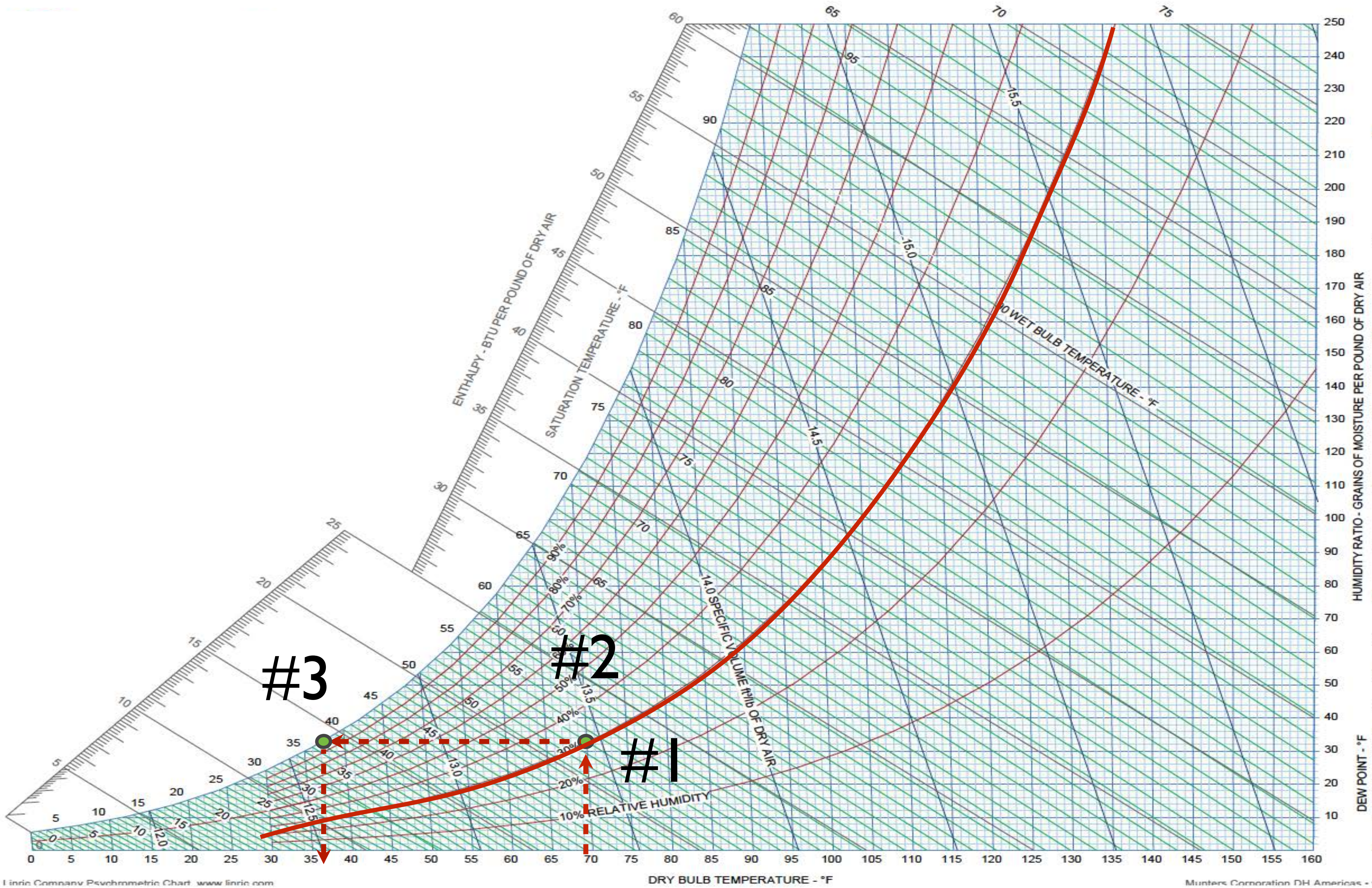
c) What is the dew point of outdoor air at 90 F and 70% RH? ____________________



a) If indoor air is at 70 F and 50% RH, to what temperature must it be cooled to get condensation? ___50.53 F___ This is the Dew Point

b) If the indoor air was at 30% RH, what would the dew point be? ___37.2 F___

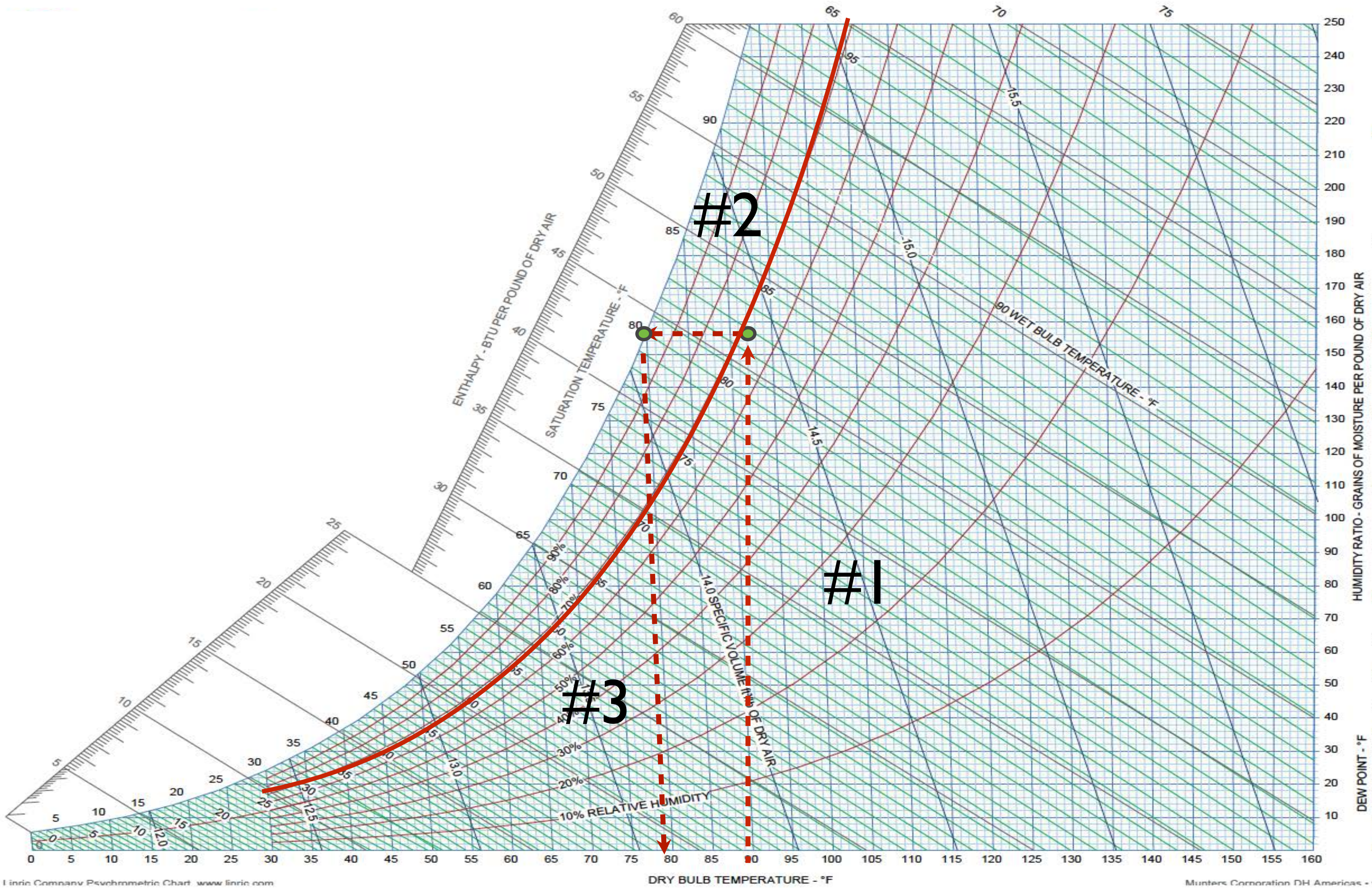
c) What is the dew point of outdoor air at 90 F and 70% RH? ____________



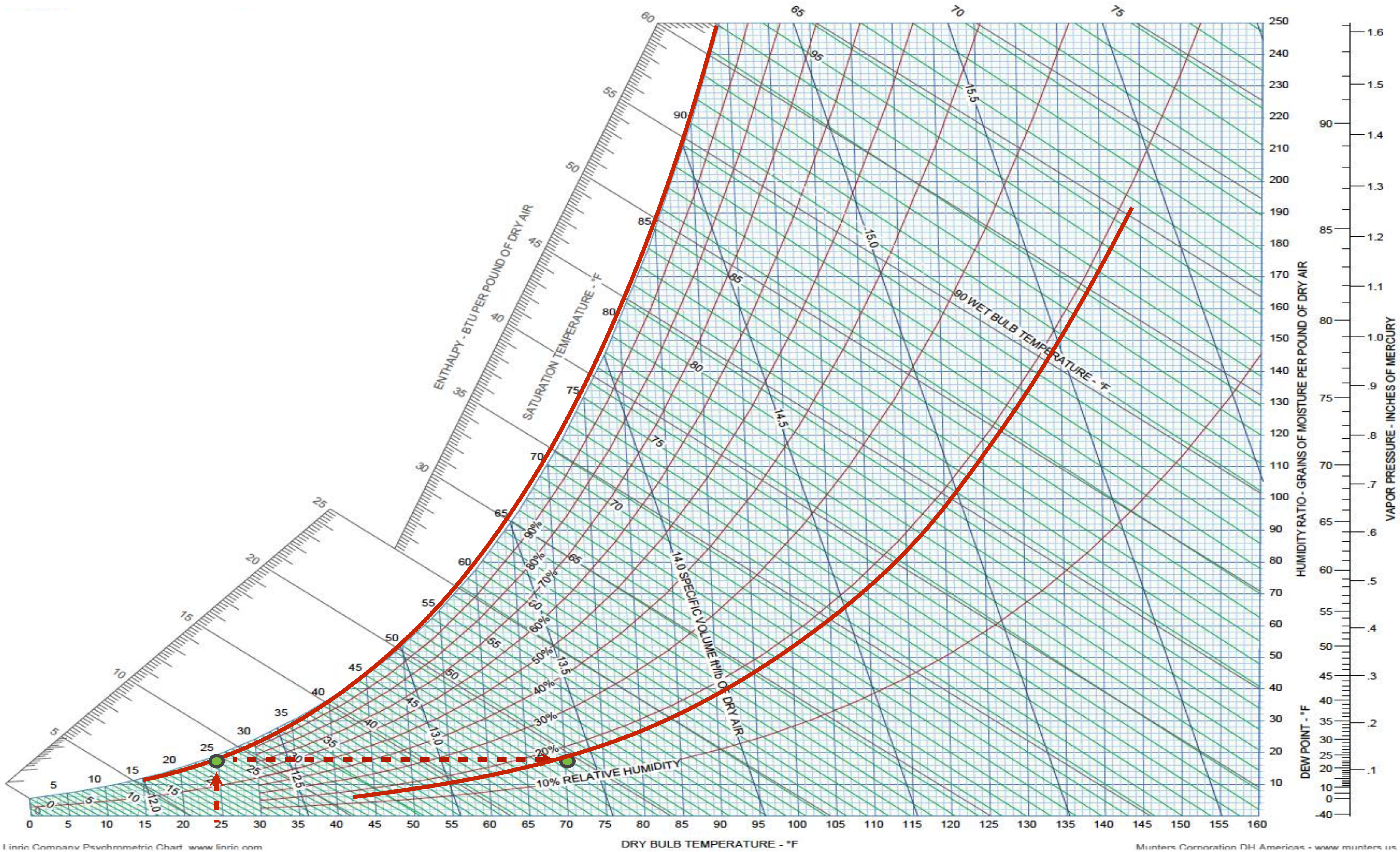
a) If indoor air is at 70 F and 50% RH, to what temperature must it be cooled to get condensation? **50.53 F** This is the Dew Point

b) If the indoor air was at 30% RH, what would the dew point be? **37.2 F**

c) What is the dew point of outdoor air at 90 F and 70% RH? **79 F**



2. If the outside air is 25 F and 100% RH, what will the RH be of the air once it is brought in and warmed up to 70 F? **19.0 %**

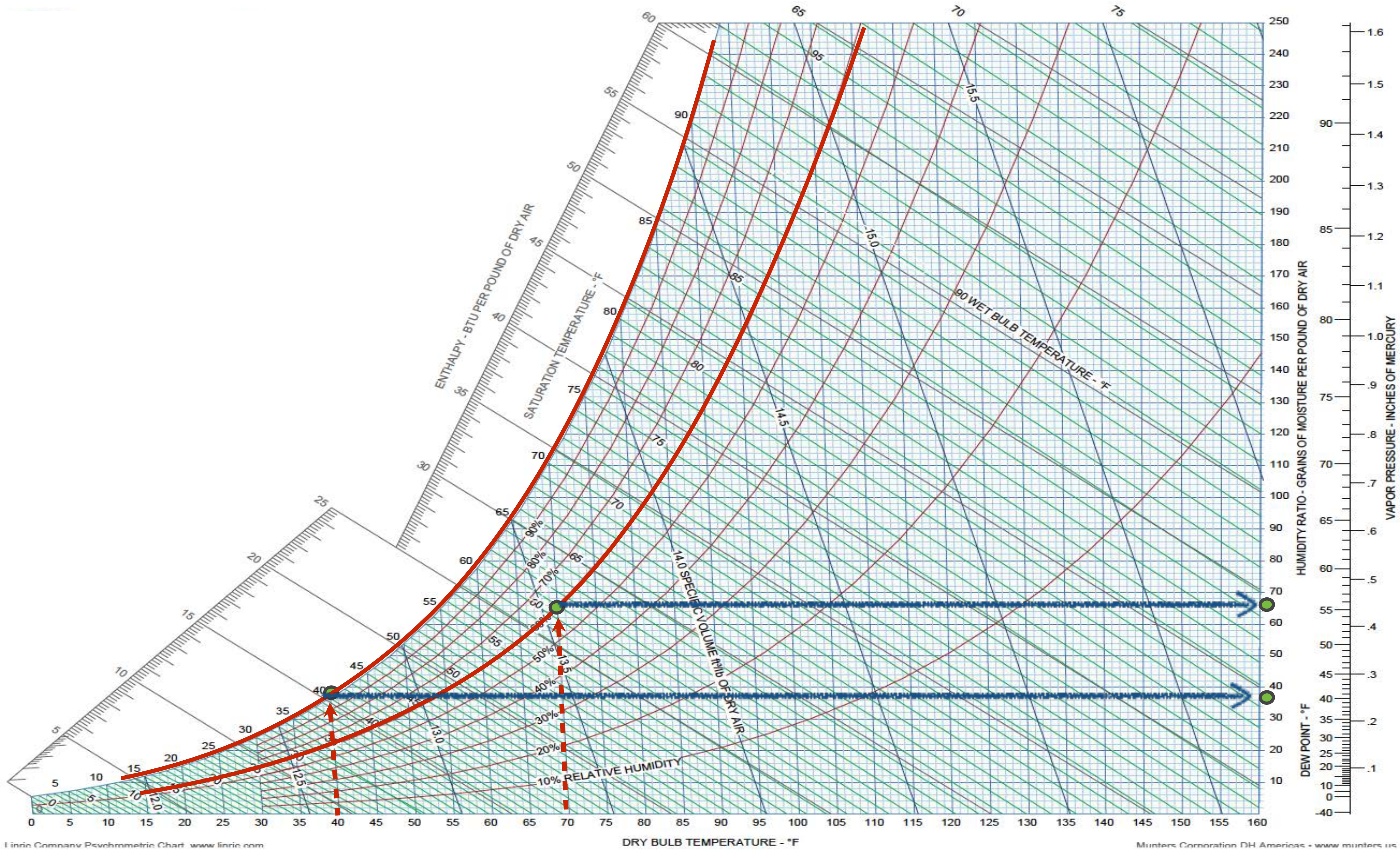


3. Which airstream has more moisture in it:

a) House inside air that is at 70 F and 60% RH Humidity Ratio = 66 Grains

b) Outside air when it is 40 F and raining. Humidity Ratio = 36 Grains

c) Will opening a window or turning on a ventilation system help dry out this house on what appears to be a very wet day? ________________

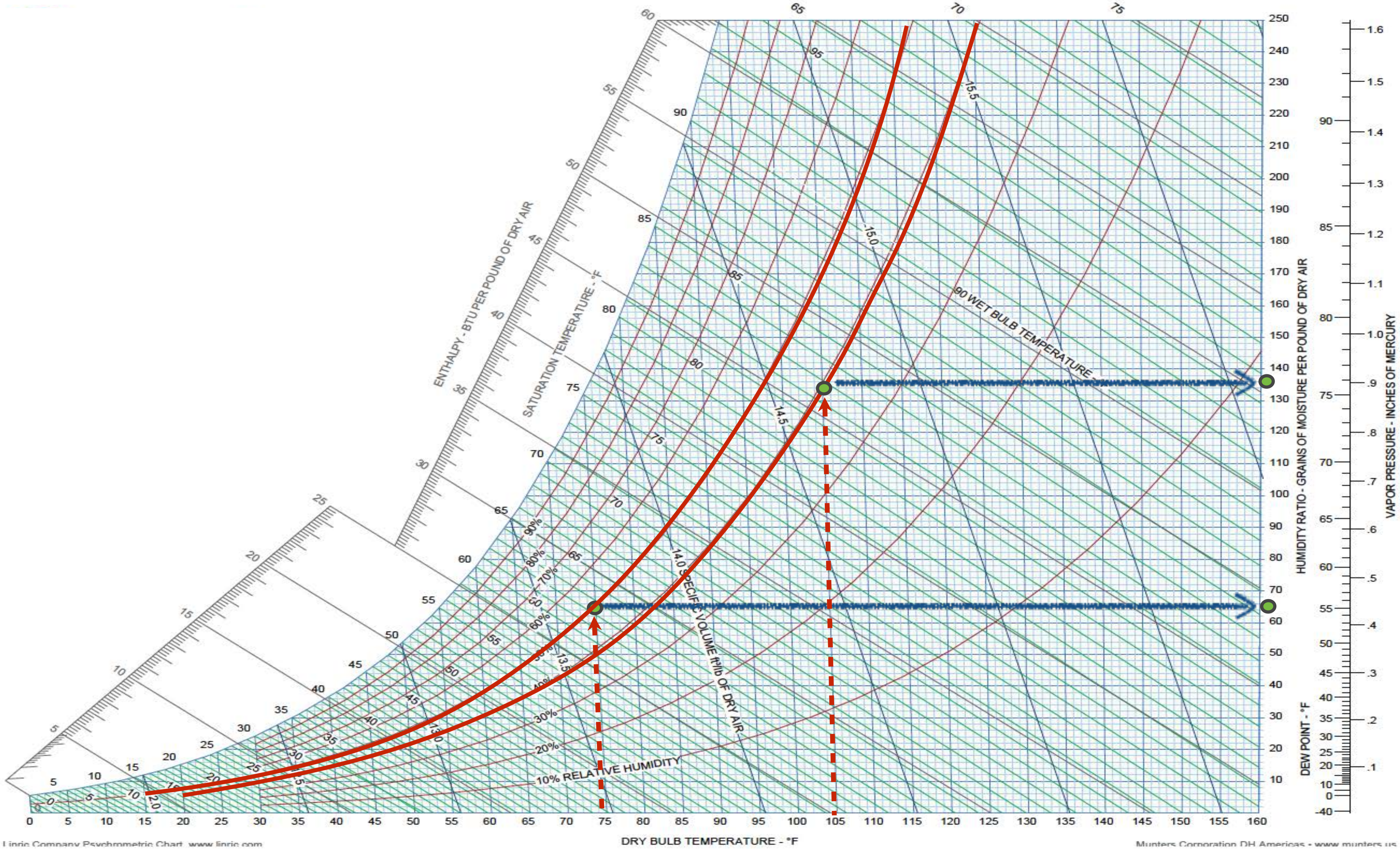


4. Which airstream has more moisture in it:

a) House inside air that is at 75 F and 50% RH Humidity Ratio = **65 Grains**

b) Outside air that is at 105 F and 40% RH Humidity Ratio = **136 Grains**

c) Should we ventilate with outside air at these conditions? __________



The importance of Dehumidification

Sensible loads are down:
- Better windows
- Better walls
- Better ceilings

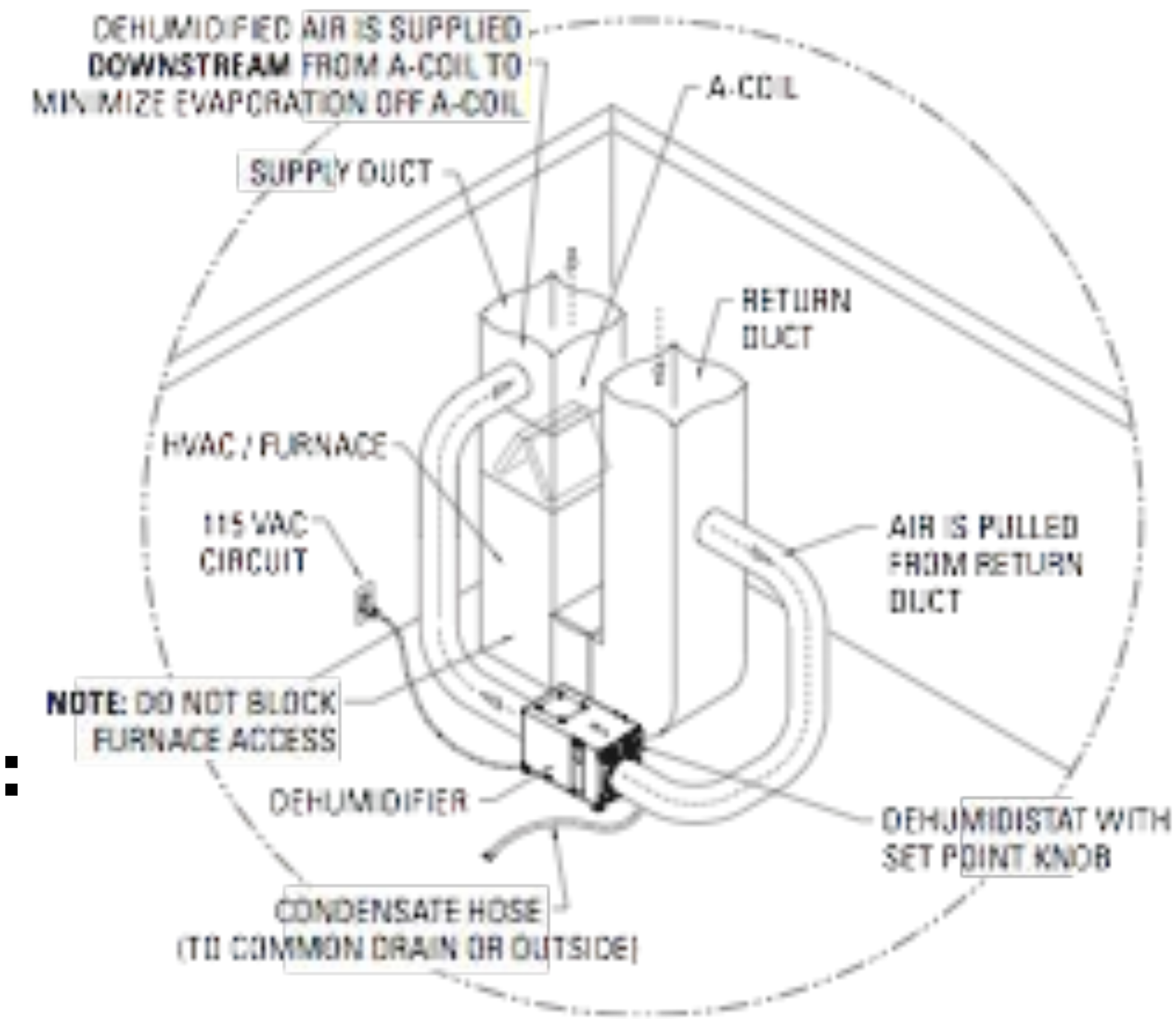
Latent loads are up:
- More time indoors
- More plumbing
- More consistent ventilation

HVAC design must include dehumidification, to supplement air conditioning

Dehumidification Strategies

Strategies:

- 2 stage AC units with humidity controls
- ERVs for ventilation
- Portable dehumidifiers
- Whole house dehumidifiers



Whole House System Advantages:

- High moisture removal capacity
- Up to 120 pints per day
- Can be integrated with AC controls
- May allow downsizing of AC system by 1/2 to 1 ton
- Filtered and drained near the central system

Critical Dehumidification Applications

- Basements in cold climates for spring and fall
- In hot, humid climates to supplement AC & ventilation loads
- **In coastal climates to aid drying of construction moisture**

Humidification Applications

- Winter in cold climates
- Large homes with low occupancy levels

Sizing:

- **Required capacity is a function of:**
  - Air tightness of the home
  - Ventilation strategies
  - Occupancy generation

Filtration

Filtration

Filtration is the 4th of IAQ strategies: Remove, Seal, Ventilate, then Filter

- Filtration at the furnace works and is cost effective
- Commonly located in the return duct of the air handler
- Choose a filter with a rating of MERV 10 or better
- The better the filter, the more it restricts air flow, understand the appliance needs

Filtration Options

<u>1" – 4" Pleated Filters</u>

- MERV 8-12
- May restrict air flow

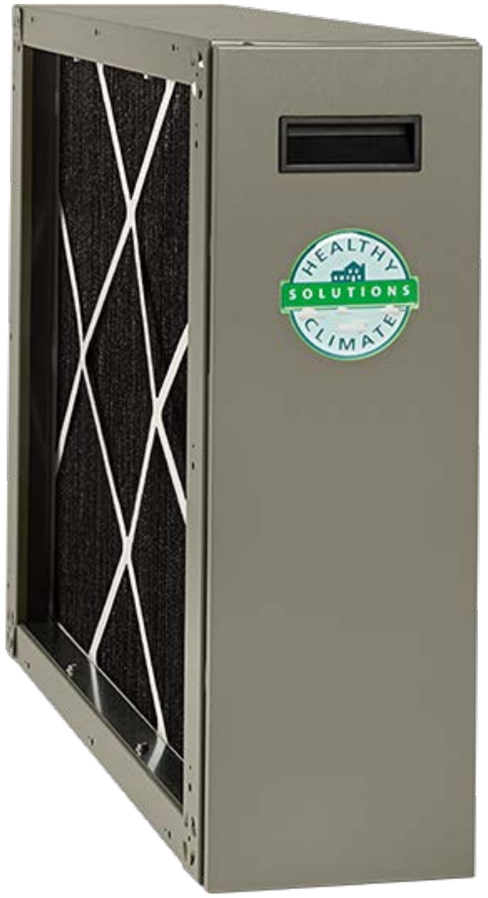
<u>1" Electrostatic</u>

- MERV 6-10
- Simple, washable
- May restrict air flow

<u>Electronic Filter</u>

- No MERV ratings
- Good at removing small particles
- Needs cleaning every 6-8 weeks
- May give off small amounts of ozone

Media Filters offer flexibility



Return Air Grille Filter

Air Handler Cabinet

Consider Pressure Drop across the filter:
Less than 0.2” W.C. should be adequate

Filtration Options

HEPA Filters

- Work to eliminate pollutant sources before spending money on HEPA
- MERV 16-20
- Very restrictive on airflow, they need their own fan system
- Available in ducted or portable units

Water Usage

Water Efficient Fixtures

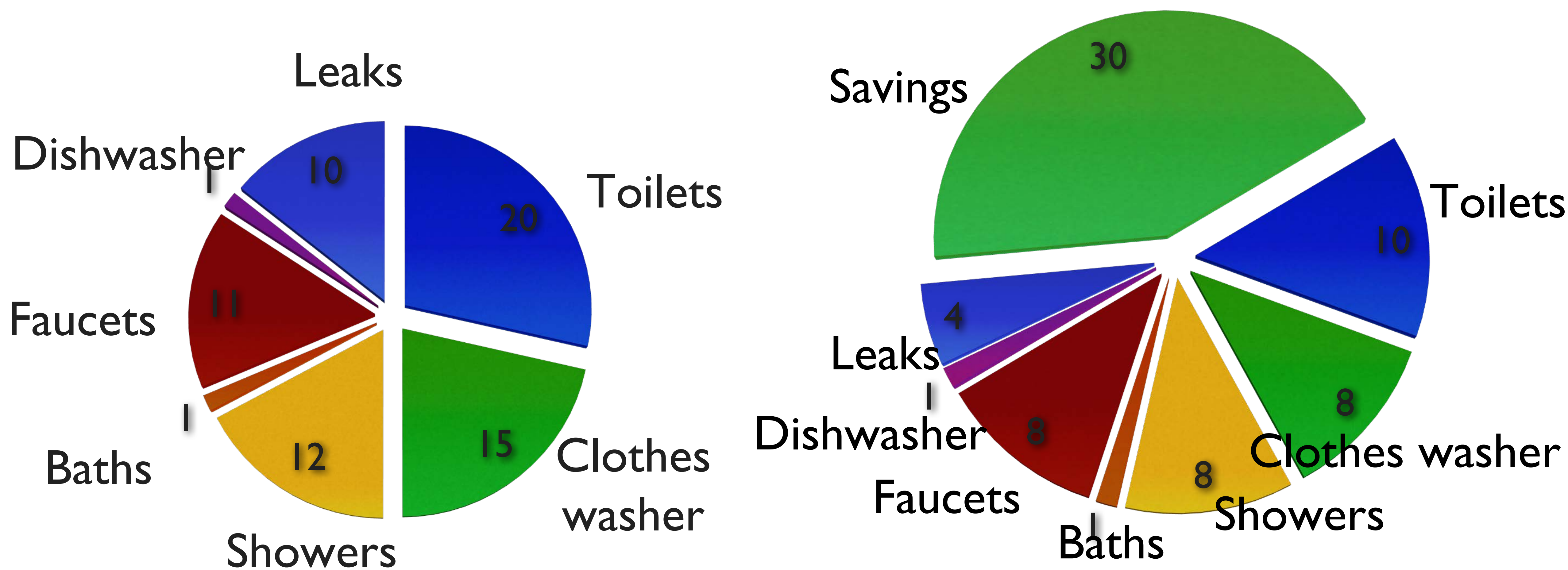
Faucets < 1.8 GPM

Shower heads < 2.0 GPM

Front load washers save 60%

Toilet with < 1.3 Gallons

Typical US Home = 70 gallons per person/day



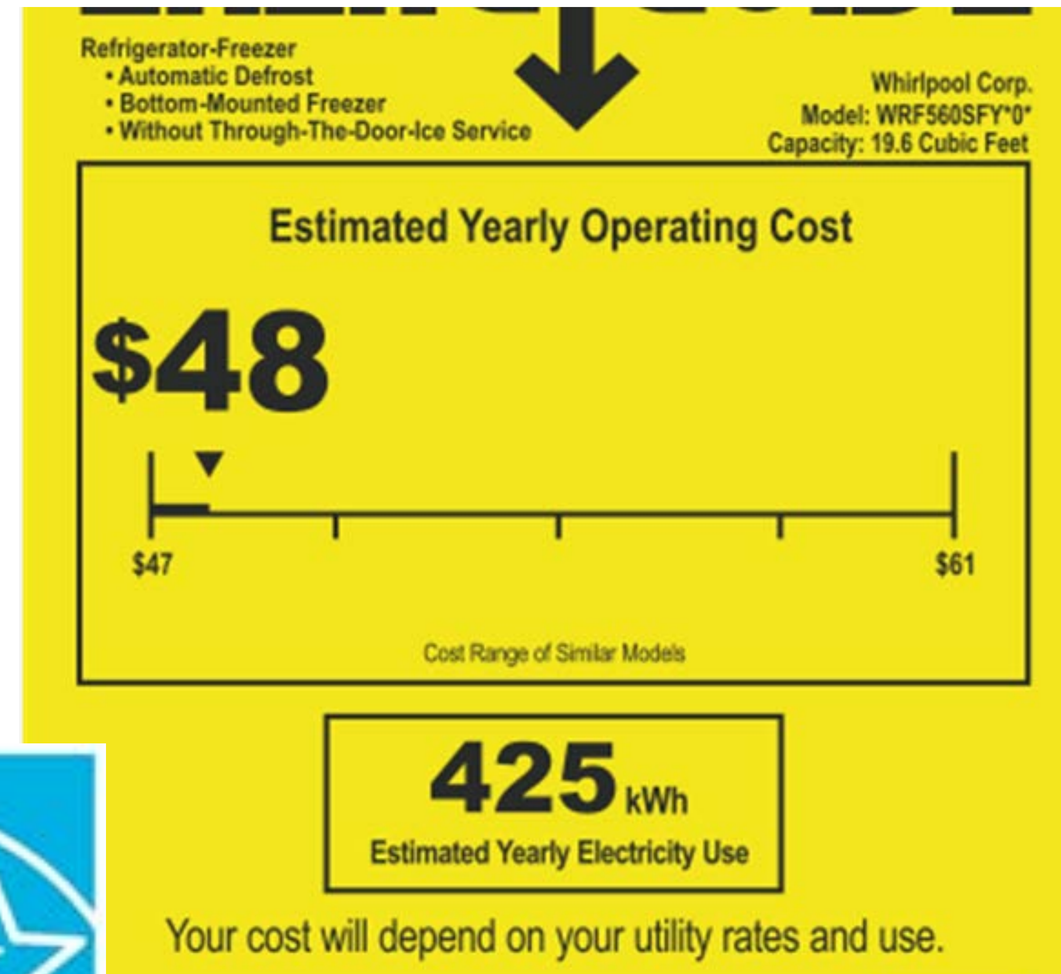
Gallons per person per day

An EPA water efficiency retrofit study indicated the total water use was reduced to 40 gallons per person per day - 39% reduction

Source: Aquacraft, Boulder, CO

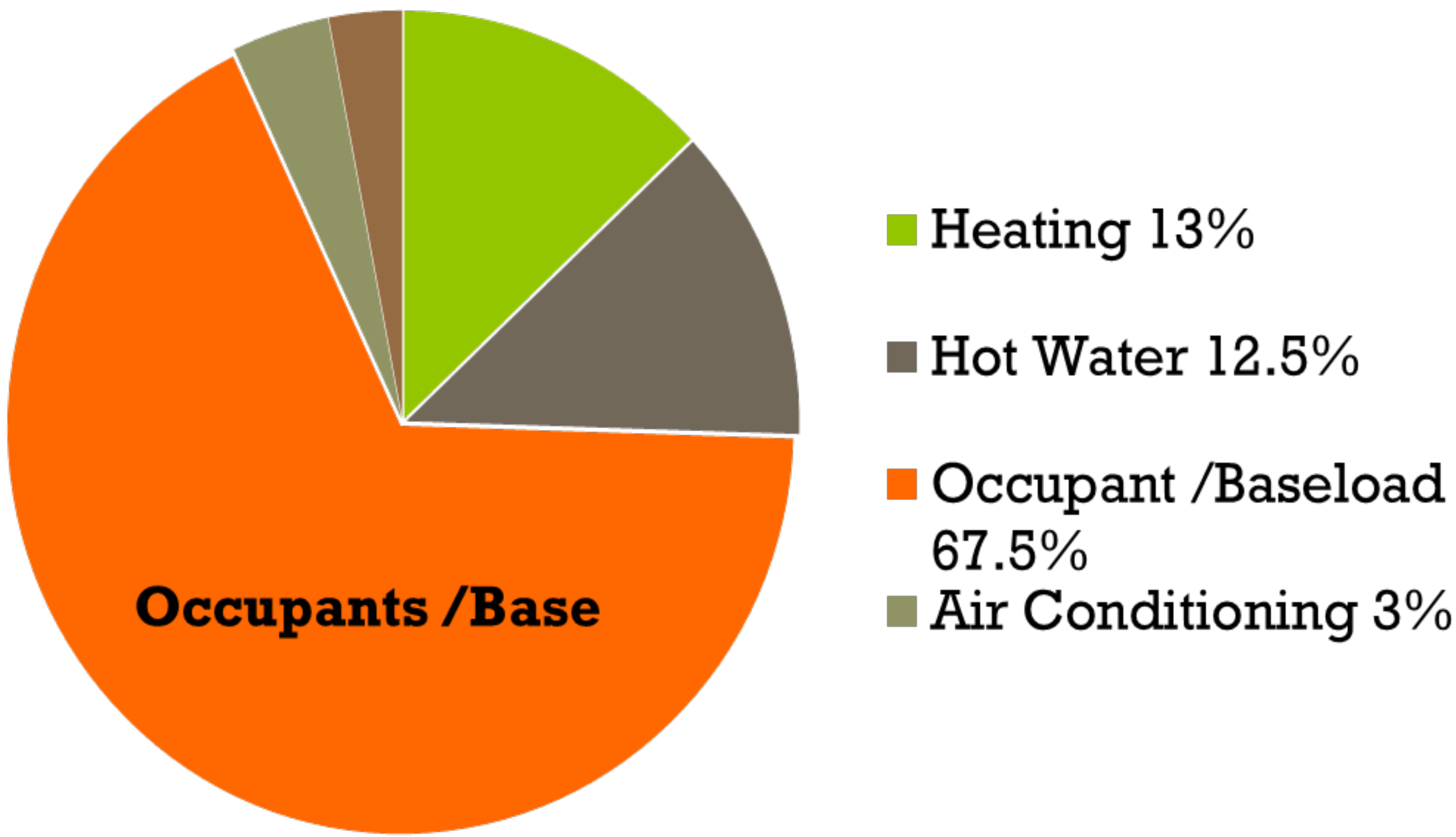
Lighting & Appliances

OCCUPANT PREFERENCES AND APPLIANCES



WHY DO APPLIANCES AND HOUSE OPERATING CONDITIONS MATTER?

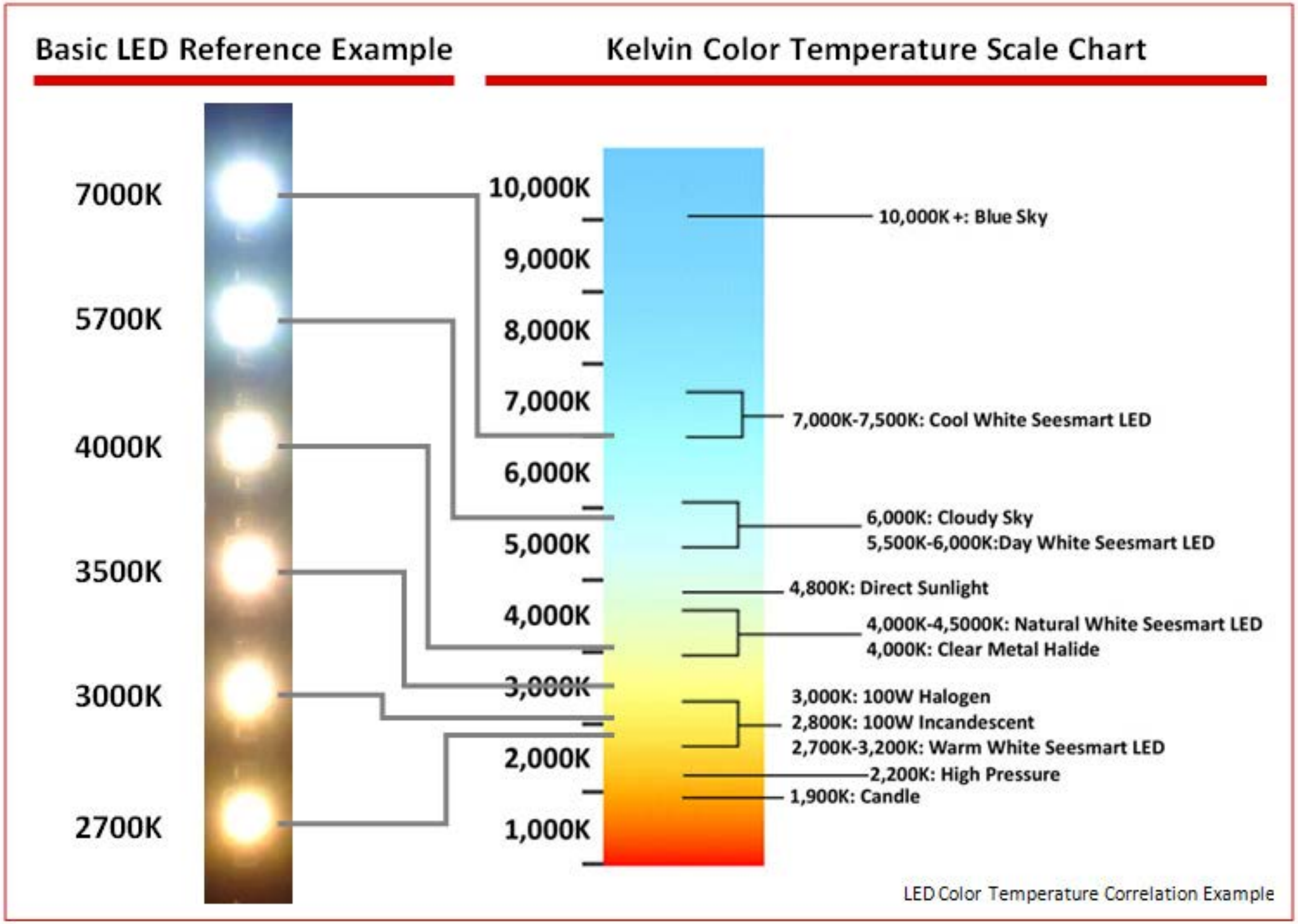
A ZERH LOAD PROFILE (IECC 2021…?)



OCCUPANT BASE LOADS = LIGHTS, APPLIANCES,LIFE-STYLE CHOICES

Lighting-Energy Efficiency
Changes happening every 6 months

Lighting Design
Using color / temperature of light effectively



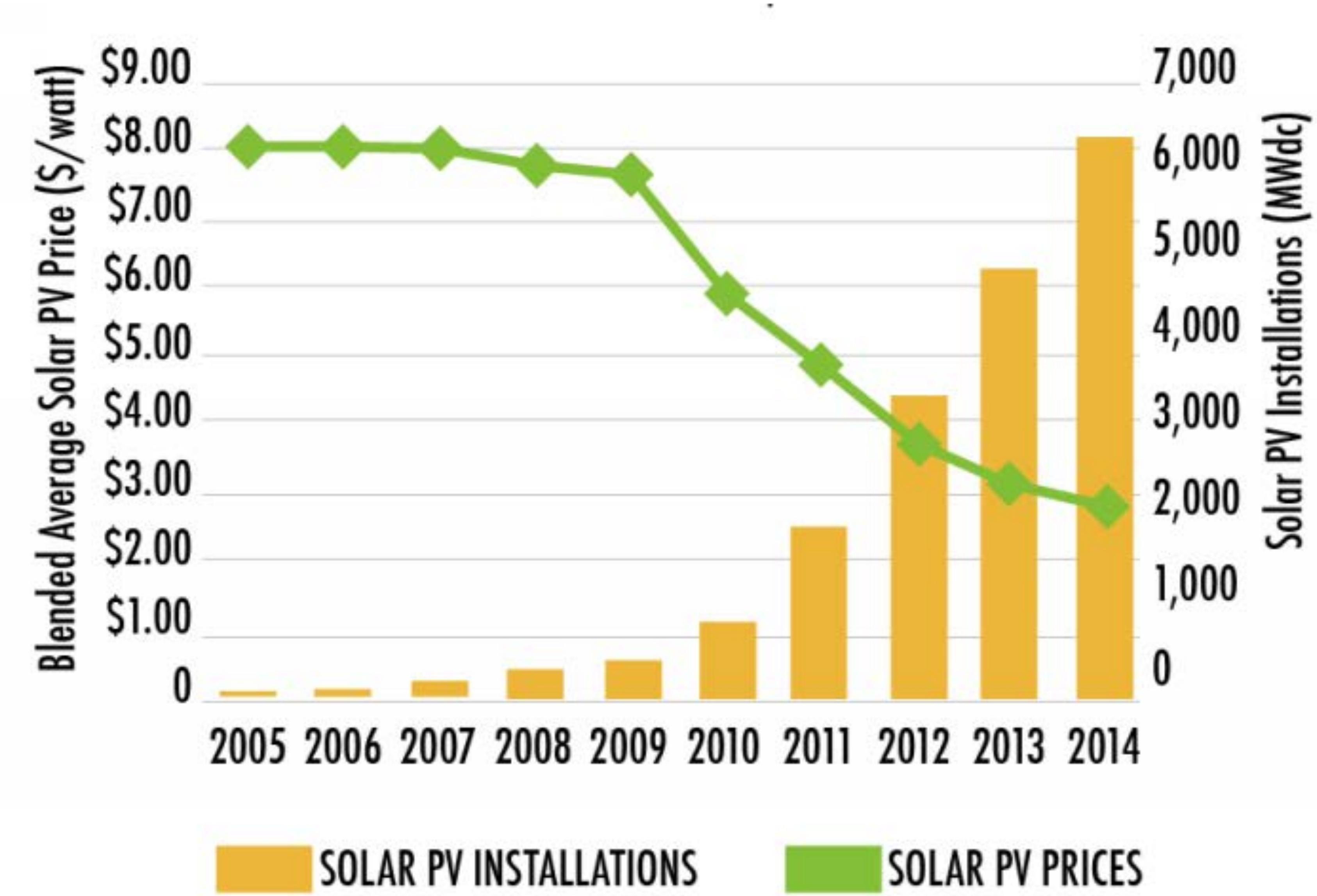
Don’t forget the power of daylighting

Solar

RENEWABLE POWER: SOLAR PV PHOTOVOLTAICS

RENEWABLE POWER: SOLAR THERMAL

RENEWABLE POWER: SOLAR



Source: "*Solar Adds More Than 4 Gigawatts of Capacity in Q3, Marking its Largest Quarter in History, U.S. Solar Market Insight*," Solar Energy Industry Association, Updated Dec. 13, 2016

FIRST THINGS FIRST…

Better initial ROI with Enclosure and Mechanical Upgrades vs SOLAR (Renewables)

If we rely only on solar here is what we get….

PV= $2 to $3 per watt CREATED

Enclosure /Mechanicals = $0.30 to $1 per watt SAVED

SOLAR OPTIONS

PV (PANEL) vs BIPV (INTEGRATED ROOF)

VS

Solar Hot Water

- New “packaged” systems available
- A 2-4 panel system can supplement 50%-90% of DHW needs for a typical family
- Can supplement heating for the house

THE FUTURE LANDSCAPE
HOUSING AND TRANSPORTATION ARE ONE…

NET ZERO COMMUNITIES
A MIX OF CHALLENGES AND OPPORTUNITIES

Really small loads require new infrastructure partnerships and financing options

NET ZERO COMMUNITIES
A MIX OF CHALLENGES AND OPPORTUNITIES

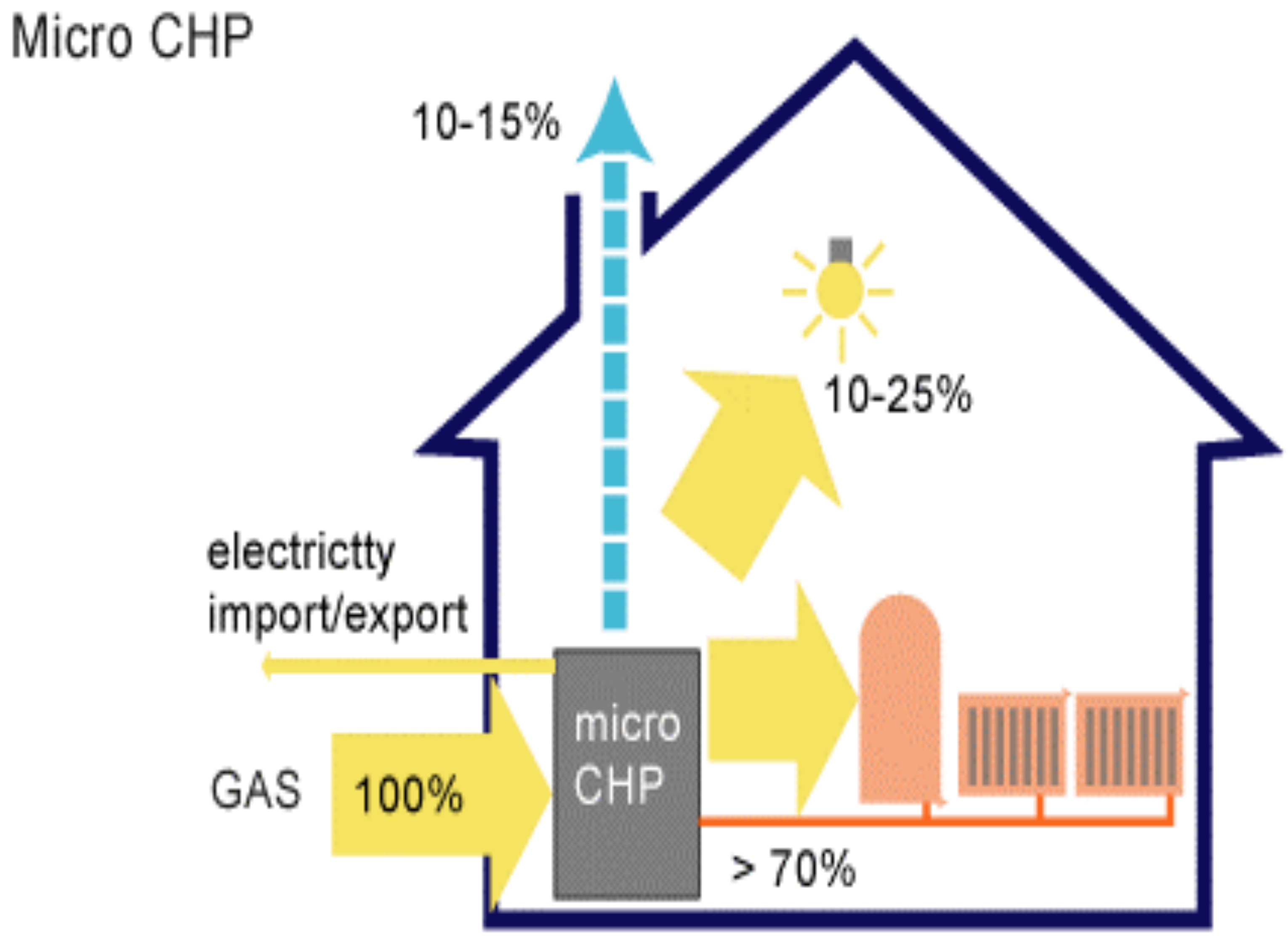
- Grid access for net metering is a HUGE ISSUE .
- Utility administration for net metered homes….What happens if you end the year having produced a surplus of energy?

NET ZERO COMMUNITIES
A MIX OF CHALLENGES AND OPPORTUNITIES

BATTERIES (STORAGE) ANSWERS THE GRID CAPACITY ISSUE

THE FUTURE LANDSCAPE

LOW LOAD- ALL LOADS ARE FAIR GAME
COMBINED HEAT AND POWER



THE FUTURE LANDSCAPE

LOW LOAD- ALL LOADS ARE FAIR GAME
COMBINED HEAT AND POWER

AISIN MicroGen

- Electricity
- Heating
- Cooling

Utility trials in California, Texas, Alberta & Ontario

Technology already moving away from fuel to **fuel-cel**l

THE NET FUTURE LANDSCAPE

MODULARIZATION AND ZERO ENERGY HOMES

What did we accomplish today

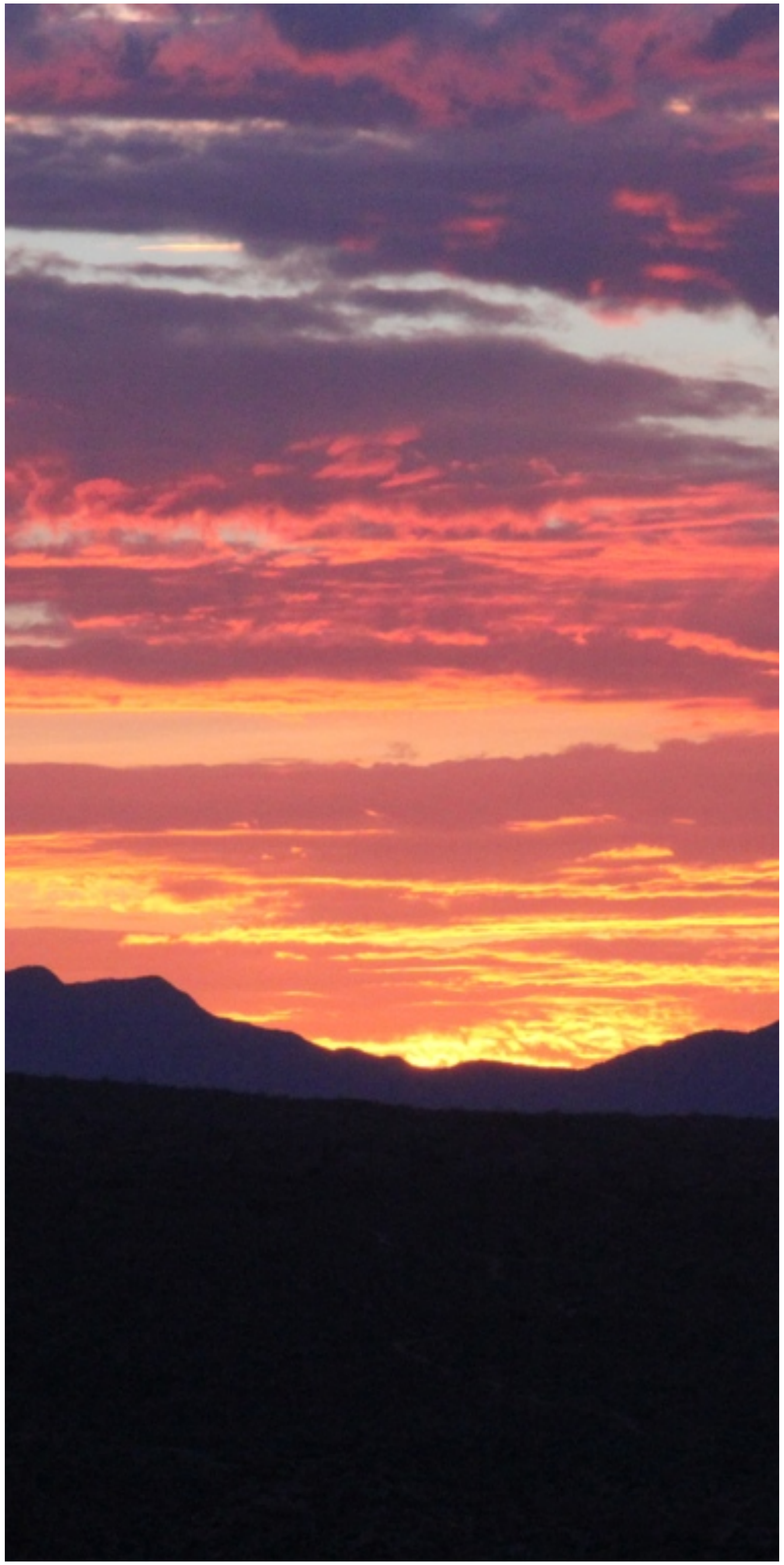
- Safer
- Healthier
- Comfortable
- Durable
- More efficient
- More affordable

What should be on your To Do List?

What Should I Be Doing By Now				
Tasks	**Done**	**This Year**	**3-5 Yrs**	**5-10 Yrs**
All furnaces, waters & gas fireplace DV, PV and/or sealed comb.	☐	☐	☐	☐
94%+ furnaces with ECM / Variable output heating & fan motors	☐	☐	☐	☐
HE water heating – 0.82+ Energy factor	☐	☐	☐	☐
Heat Recovery or Energy Recovery ventilation	☐	☐	☐	☐
Energy Star rated, quiet bath and kitchen fans	☐	☐	☐	☐
"Warm floor" heating where it is needed most –ie. basements	☐	☐	☐	☐
Smaller, properly sized duct work with proper grille selection	☐	☐	☐	☐
18+ SEER AC with dehumidification cycle	☐	☐	☐	☐
Sealed duct work	☐	☐	☐	☐
Dehumidification in basements	☐	☐	☐	☐
MERV 10+ filter effectiveness	☐	☐	☐	☐
High HSPF Air source of ground source heat pumps	☐	☐	☐	☐
Zoned systems	☐	☐	☐	☐
Integrated / remote access / diagnostic controls	☐	☐	☐	☐
Integrated heating and hot water systems	☐	☐	☐	☐
Solar ready homes	☐	☐	☐	☐
Solar water heating	☐	☐	☐	☐
Solar photovoltaics	☐	☐	☐	☐

Summary

- Respect the changes
- Get the sizing right
- Choose high performance
- A systems approach
- Manage moisture
- Identify strategic partners
- Verify performance



Thank You

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BUILDING KNOWLEDGE CANADA INC

	Doug Tarry Homes HVAC Comparison Report					Jan 10th, 2012	
Model	Sq. Ft.	H2K Btu	Current F280 Btu	Model % Over H2K	Furnace Output	Output % Over Model	Output % Over H2K
Morningdale	1442	25,365	44,073	73.76%	45,000	2.10%	77.41%
Kenwood	1685	30,062	49,005	63.01%	68,000	38.76%	126.20%
Livingston	1872	30,784	35,149	14.18%	45,000	28.03%	46.18%
Thornwood	1460	21,988	40,221	82.92%	45,000	11.88%	104.66%
Average	1,669	27,201	41,897	56.29%	49,600	18.08%	83.26%

2275 sq.ft. house – with heat pump

	1982 ERS 70	2012 ERS 81	2020 ?? ERS 88
Heat Loss (BTUs)	78,500 BTUs	37,000 BTUs	25,000 BTUs
Heat Gain (BTUs / Tons)	30,000 BTUs (2.5 Ton)	18,000 BTUs (1.5 Ton)	15,000 BTUs (1.5 Ton)
Annual Energy	47,500 kWh	33,500 kWh	16,500 kWh
Annual Energy $$	$ 5,500	$ 3,200	$ 2,150