Welcome

High Performance Mechanicals for
Houses That Work

Energy Design Conference - Duluth, MN

February 21st, 2018

HOUSES THAT WORK
EEBA's Educational Series

HIGH PERFORMANCE HOME SUMMIT 2018
OCTOBER 16-18 | SAN DIEGO, CA

EEBA
Energy & Environmental Building Alliance

Local Sponsor

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CEU's

In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code /1 hour energy** continuing education requirements."

For additional continuing education approvals, please see your credit tracking card.

1.5 EA/PER PART

- EEBA High Performance Mechanicals Part 1
- EEBA High Performance Mechanicals Part 2
- EEBA High Performance Mechanicals Part 3
- EEBA High Performance Mechanicals Part 4

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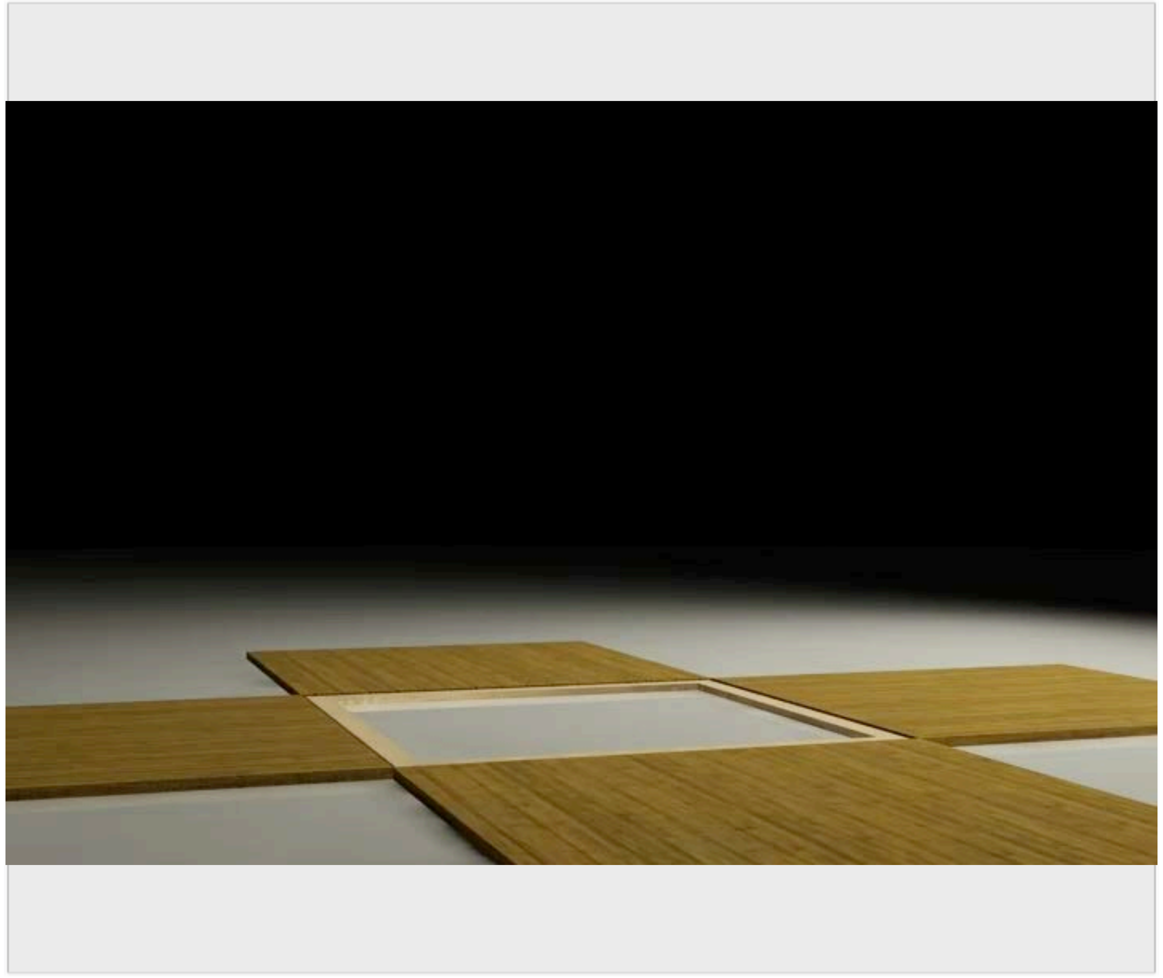
www.constructioninstruction.com

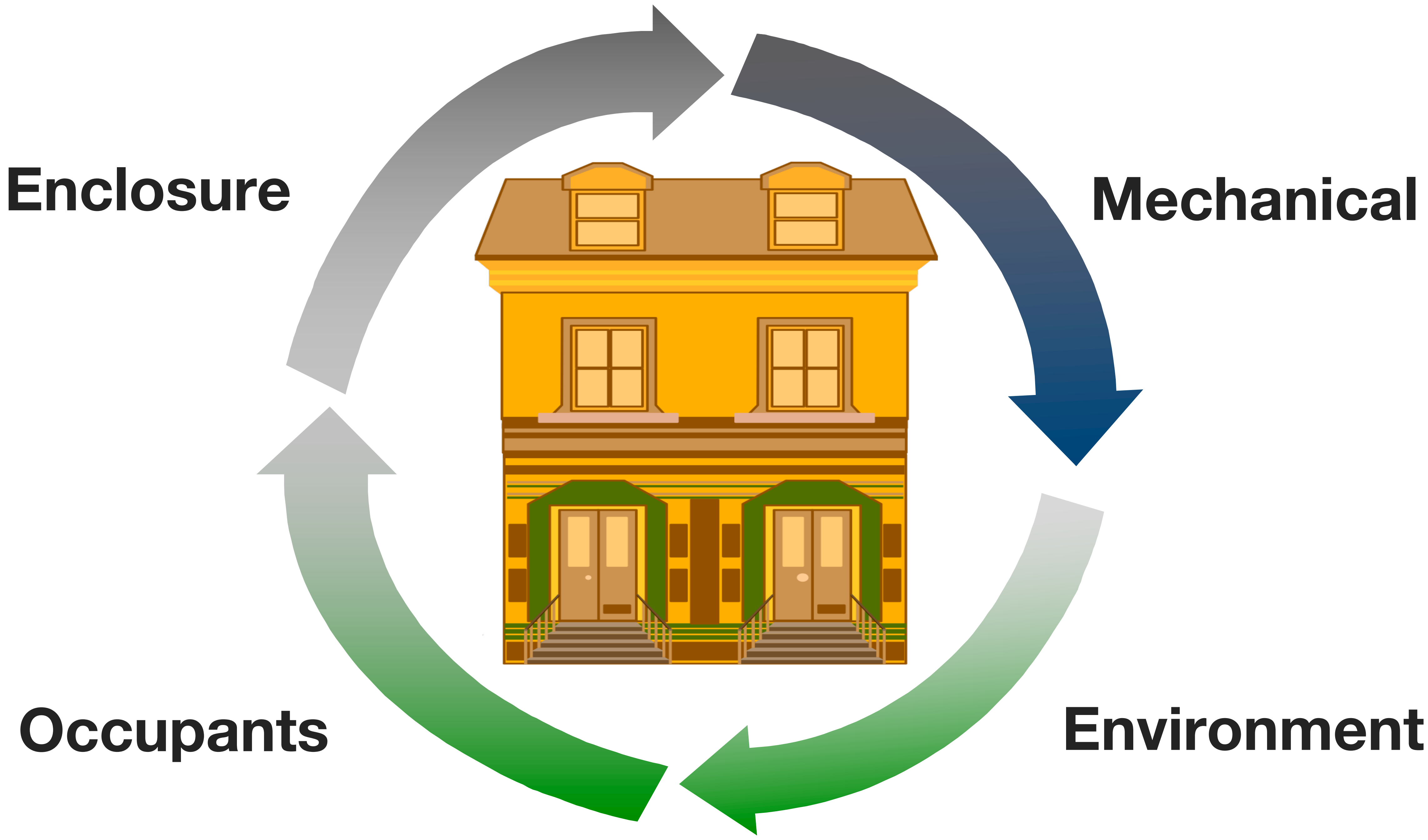


Who's Here?

Topics for Discussion

- What's different in high performance homes?
- The building science connection to mechanical systems
- The right decisions in the right order for all systems
    - The right size
    - Integrated design
    - Equipment alternatives
    - Getting installation right
    - Commissioning
    - Expectation education

How we build has changed
How we live in homes has changed



The original 800-1200 sq.ft starter home

160 MBH

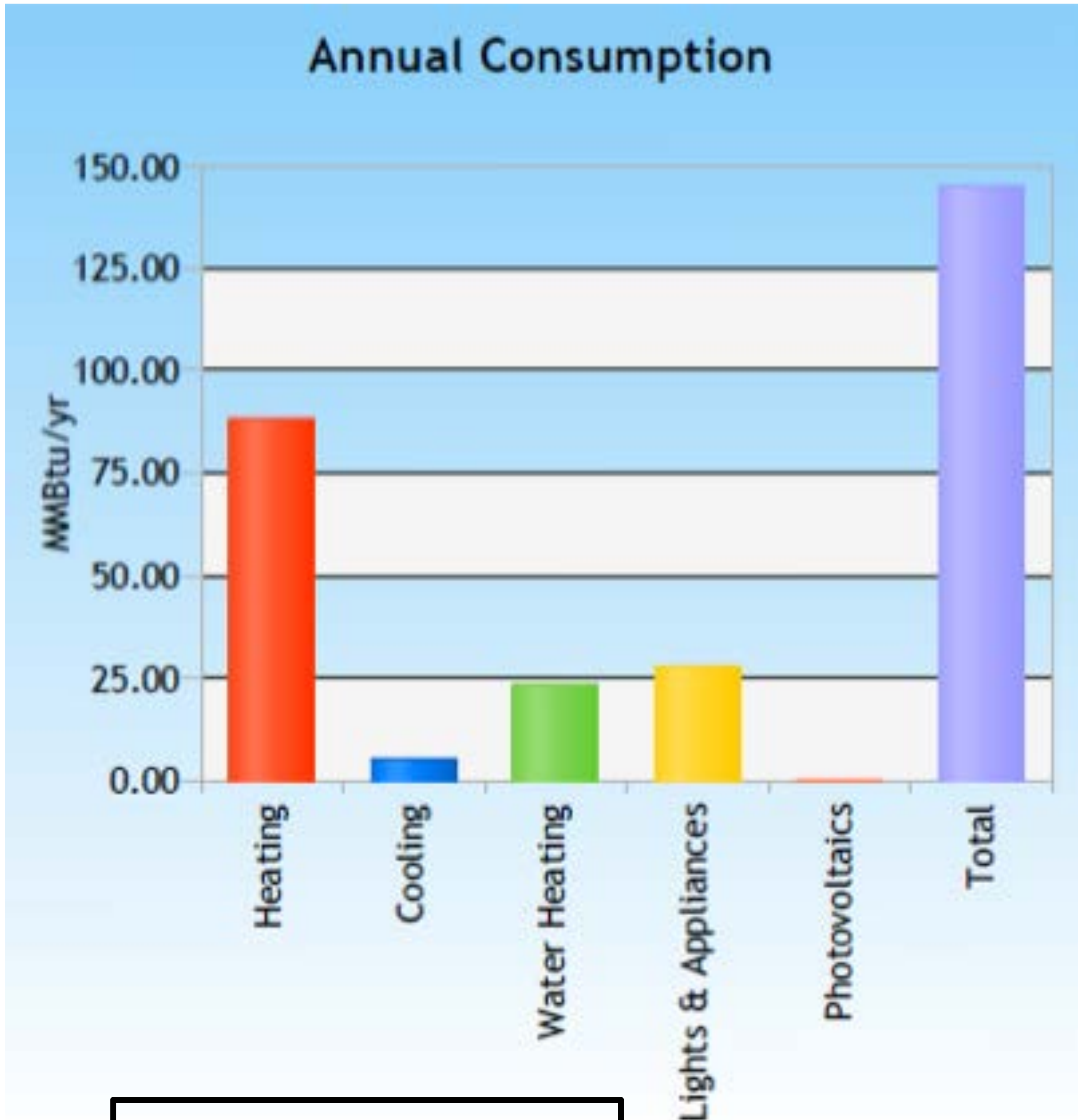
40 MBH

The new 800-1200 sq.ft starter home

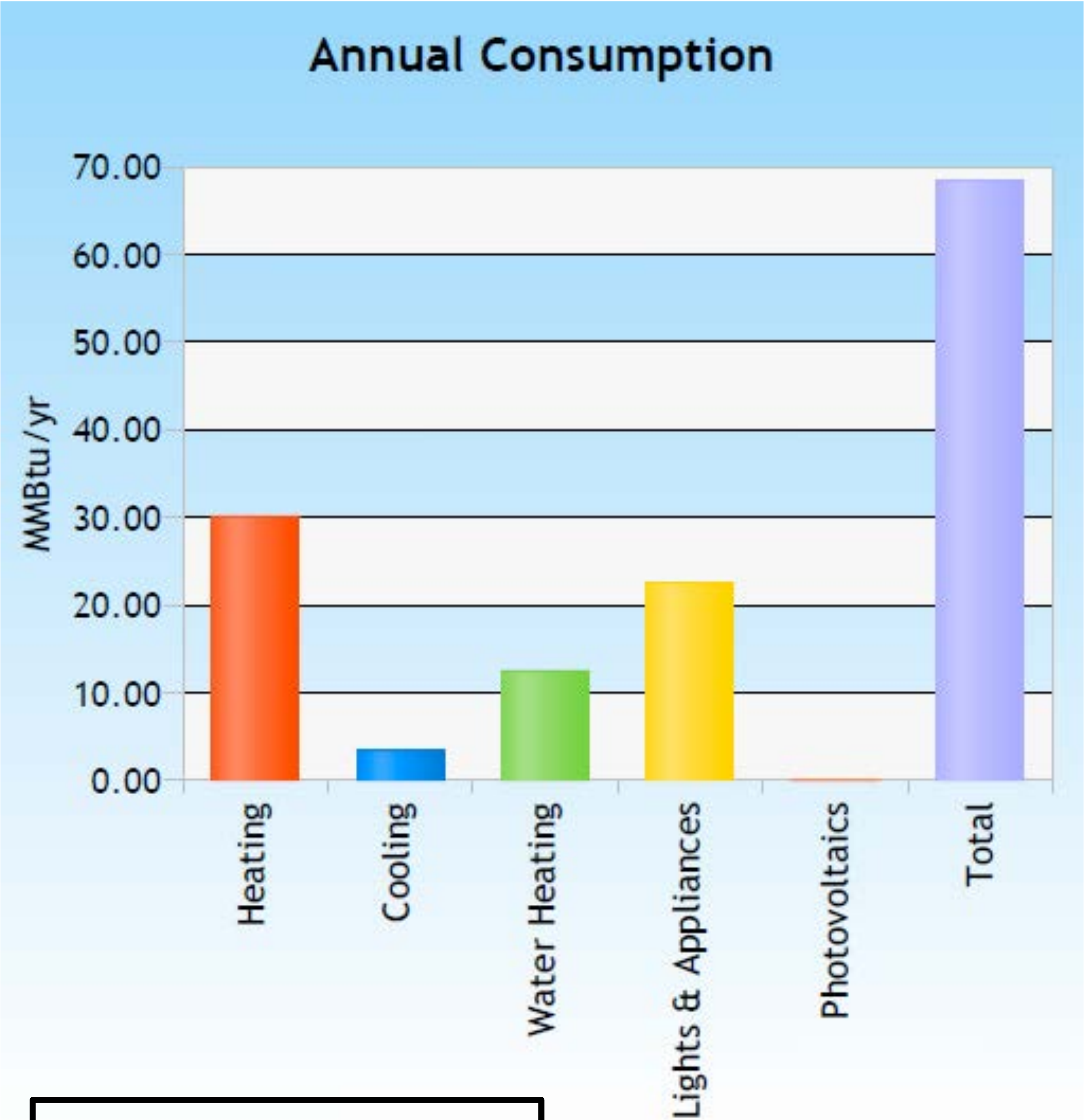
30 MBH

180 MBH

New Mechanical Priorities



HERs 100



HERs 50

Tighter Buildings …… Larger Exhausts

Larger windows …. Opened less

NEW CODES, NEW ZERH, NEW DESIGNS…

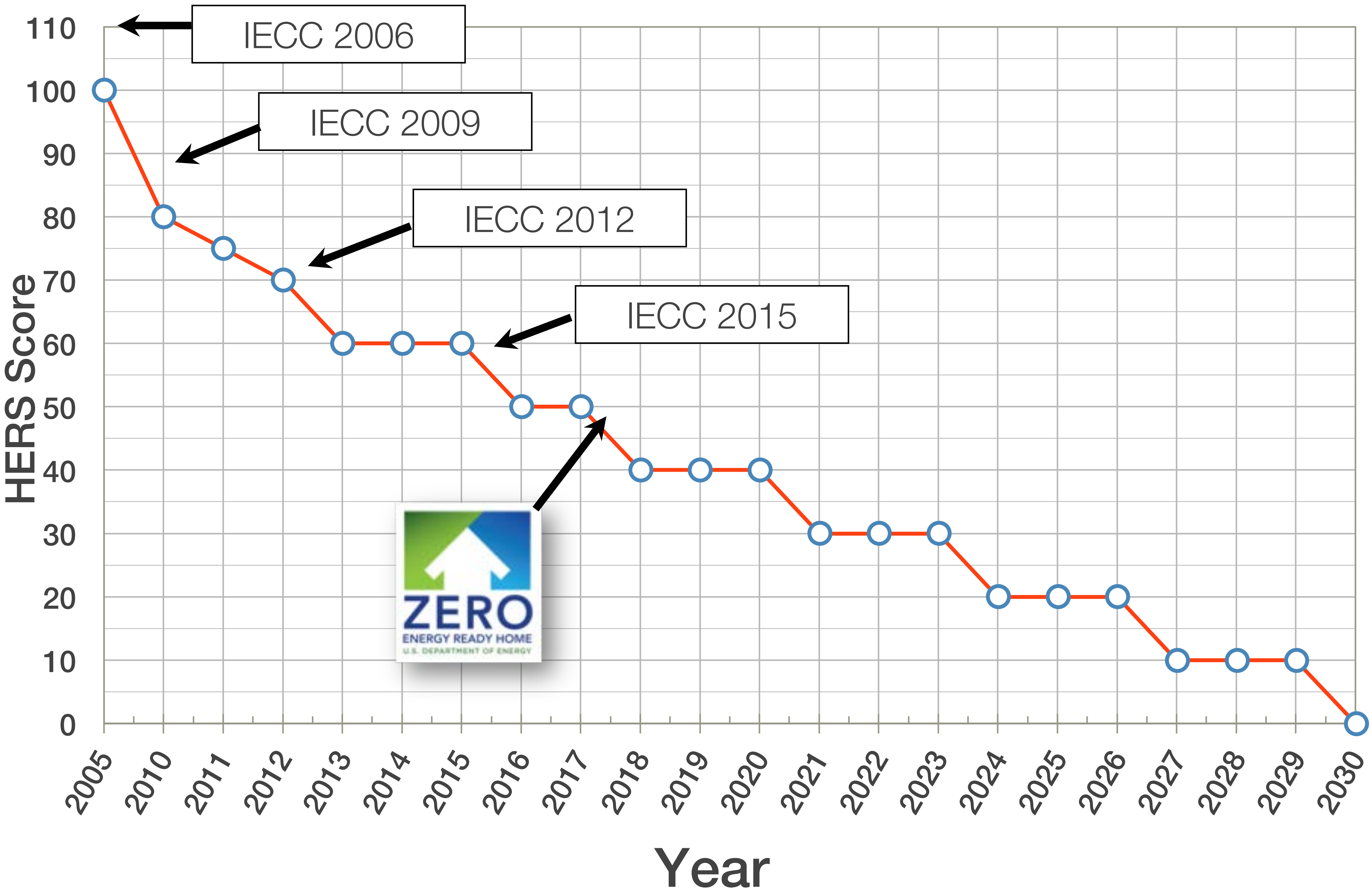
Irrational Enclosure Design = Irrational Mechanical

It's about finding the economical and sustainable balance between Passive vs Active systems (Goldilocks scenario)

Lower sensible loads … higher % latent loads

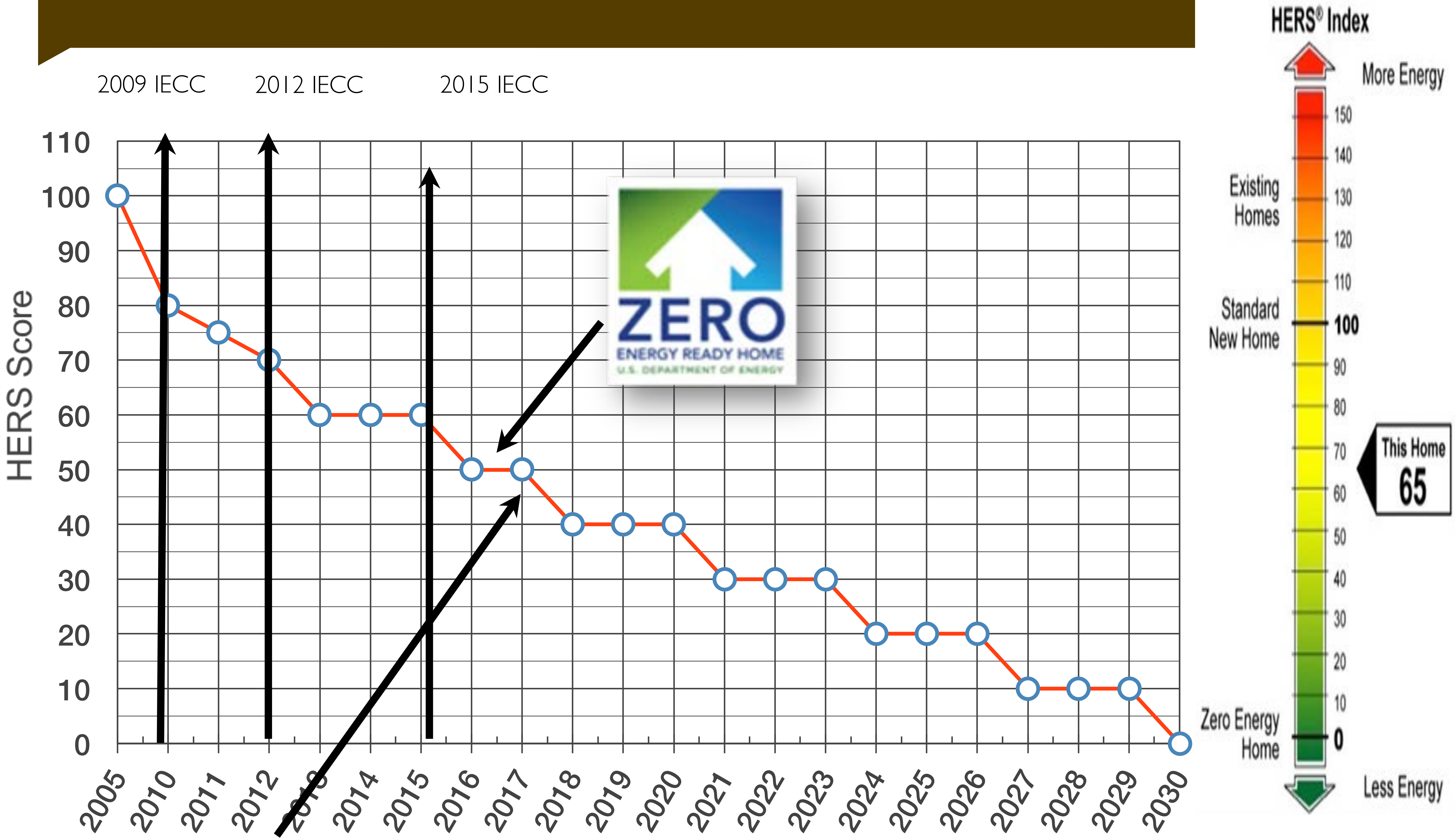
More lights, appliances, hot water

Advanced systems … higher expectations



Codes are Changing - Continual Improvement

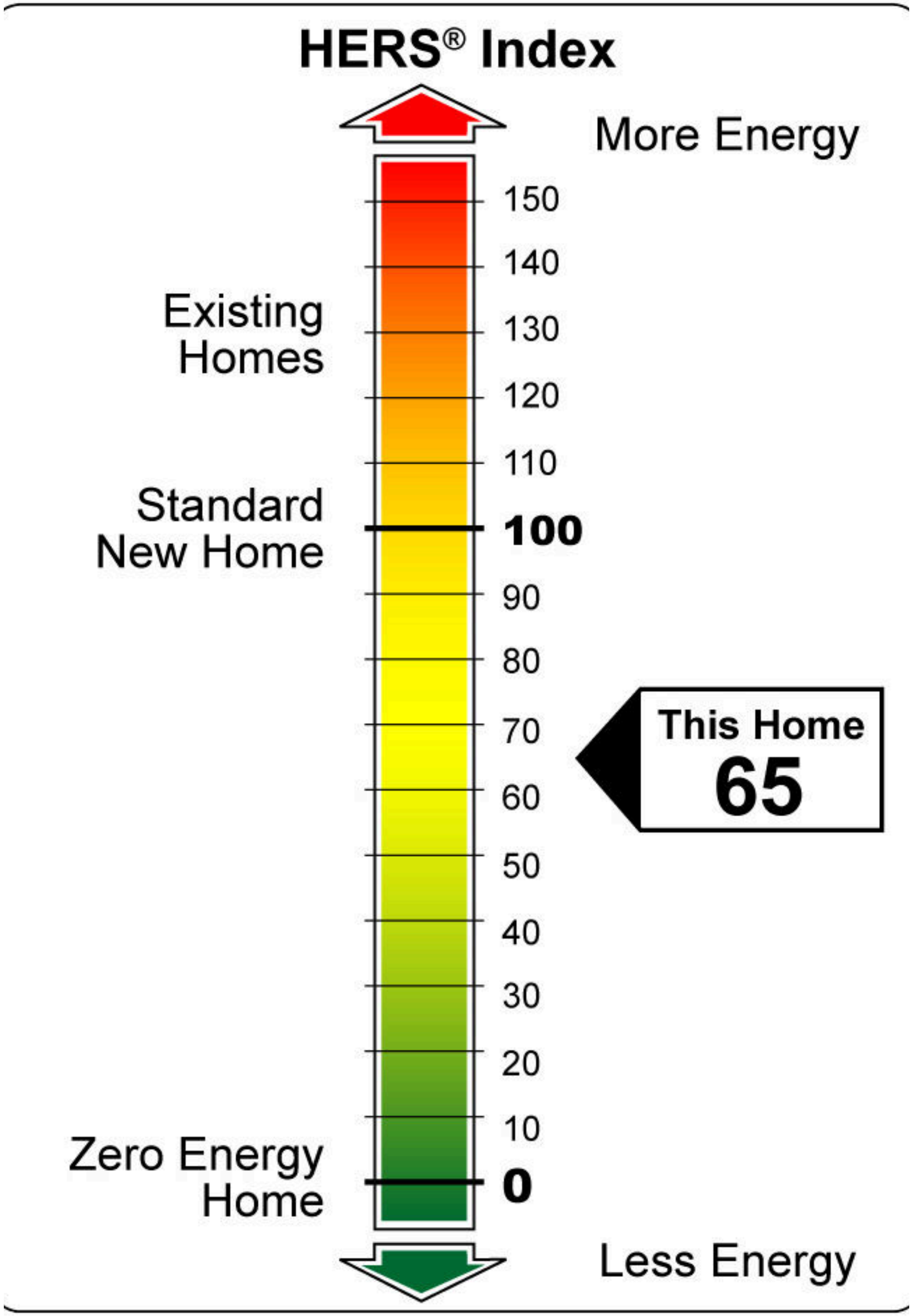
PAST, PRESENT AND FUTURE

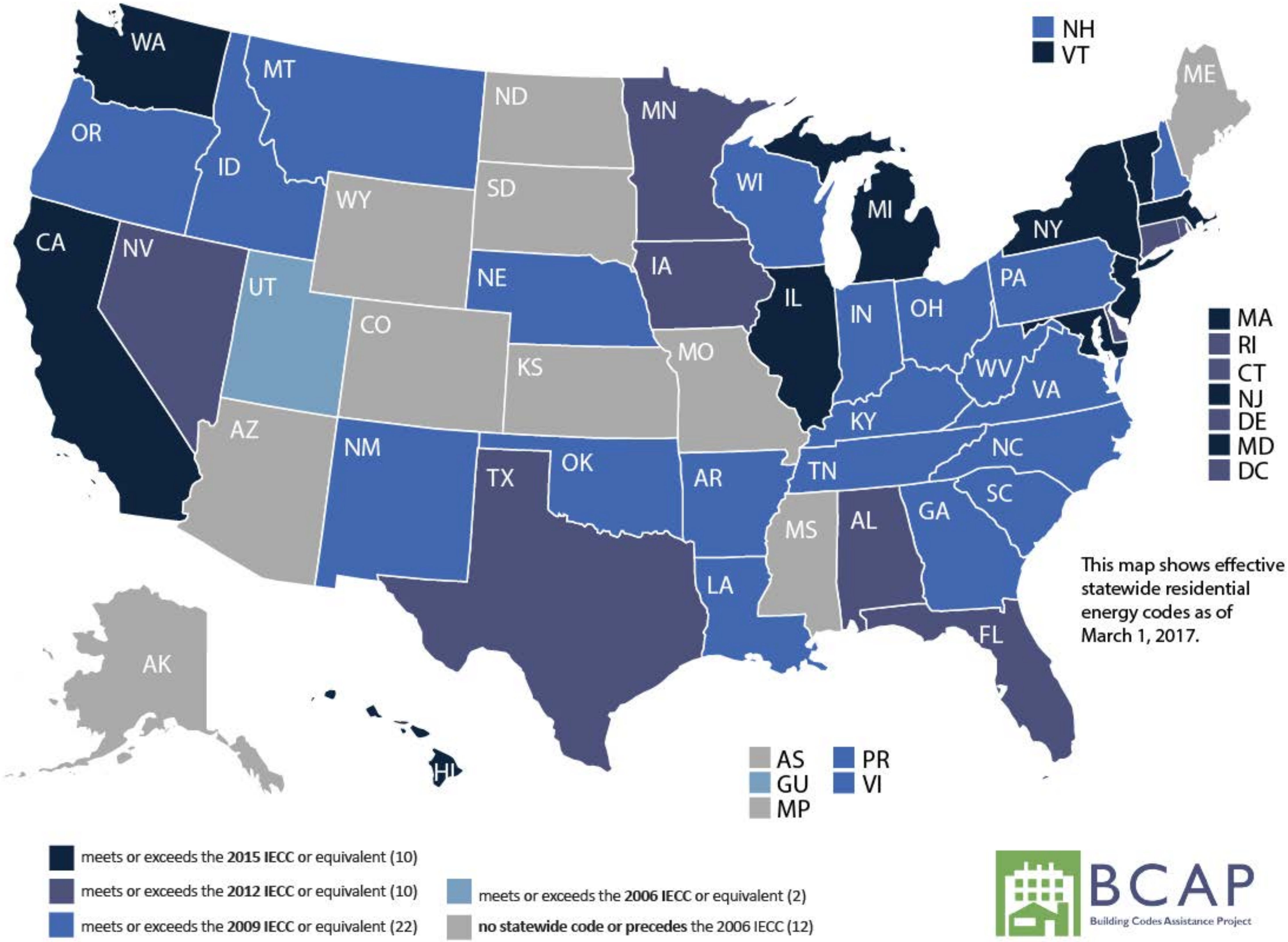


NOTE: Renewable Energy Becomes More Cost Effective

Energy Efficiency Scale

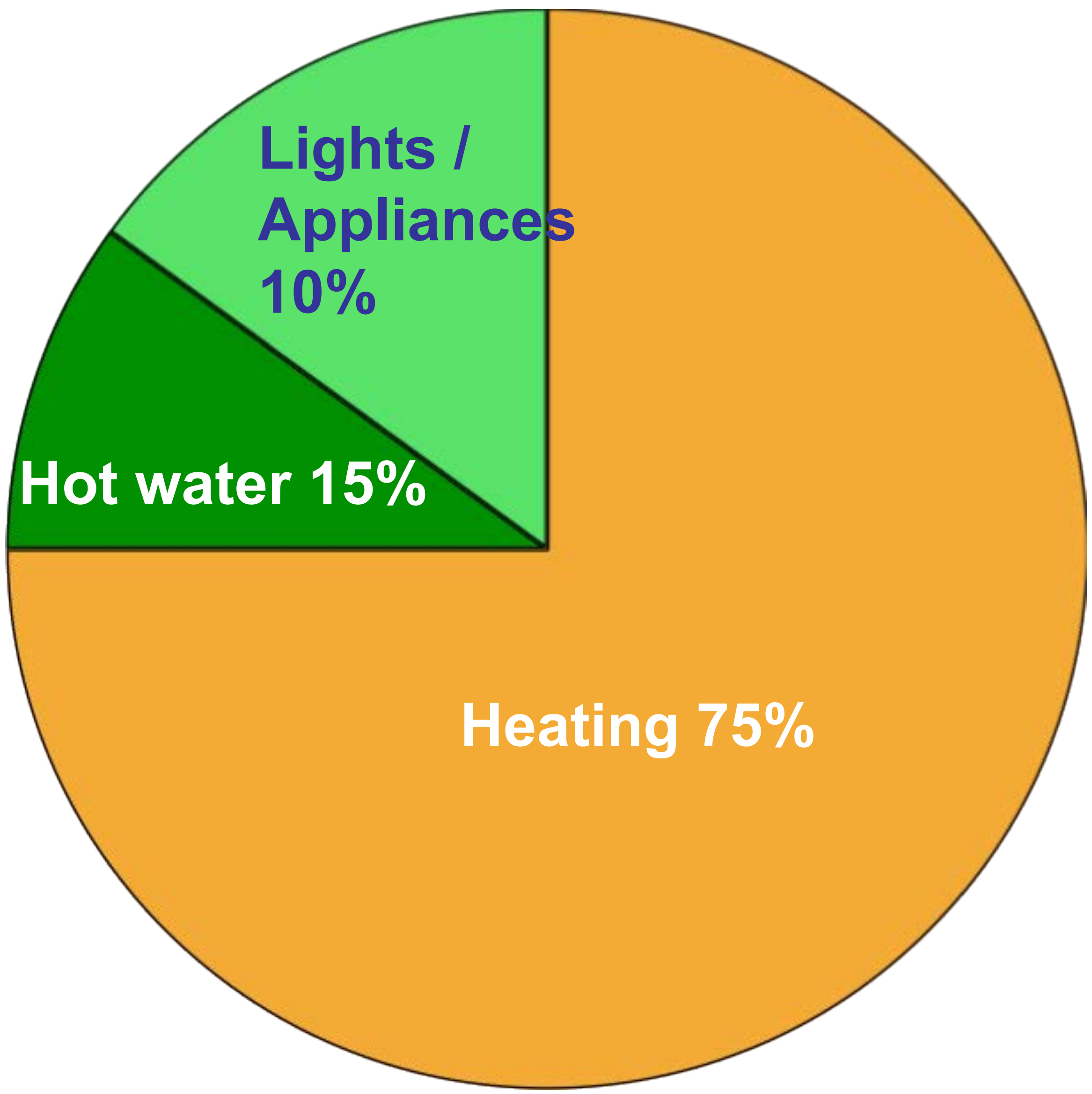
- Every 1 point reduction is equal to a 1% reduction in energy use





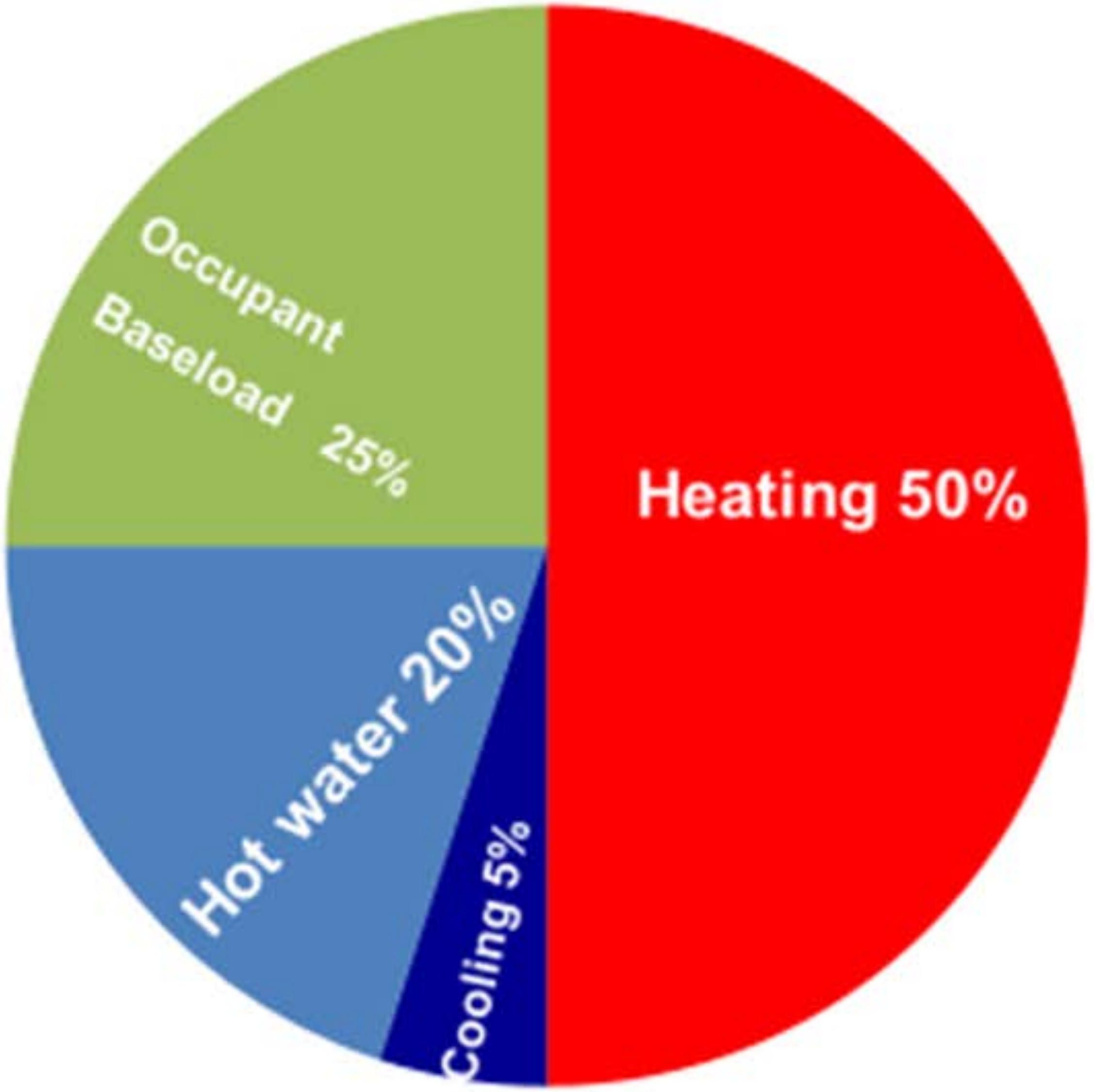
Code adoption as of March, 2017

30 years ago….

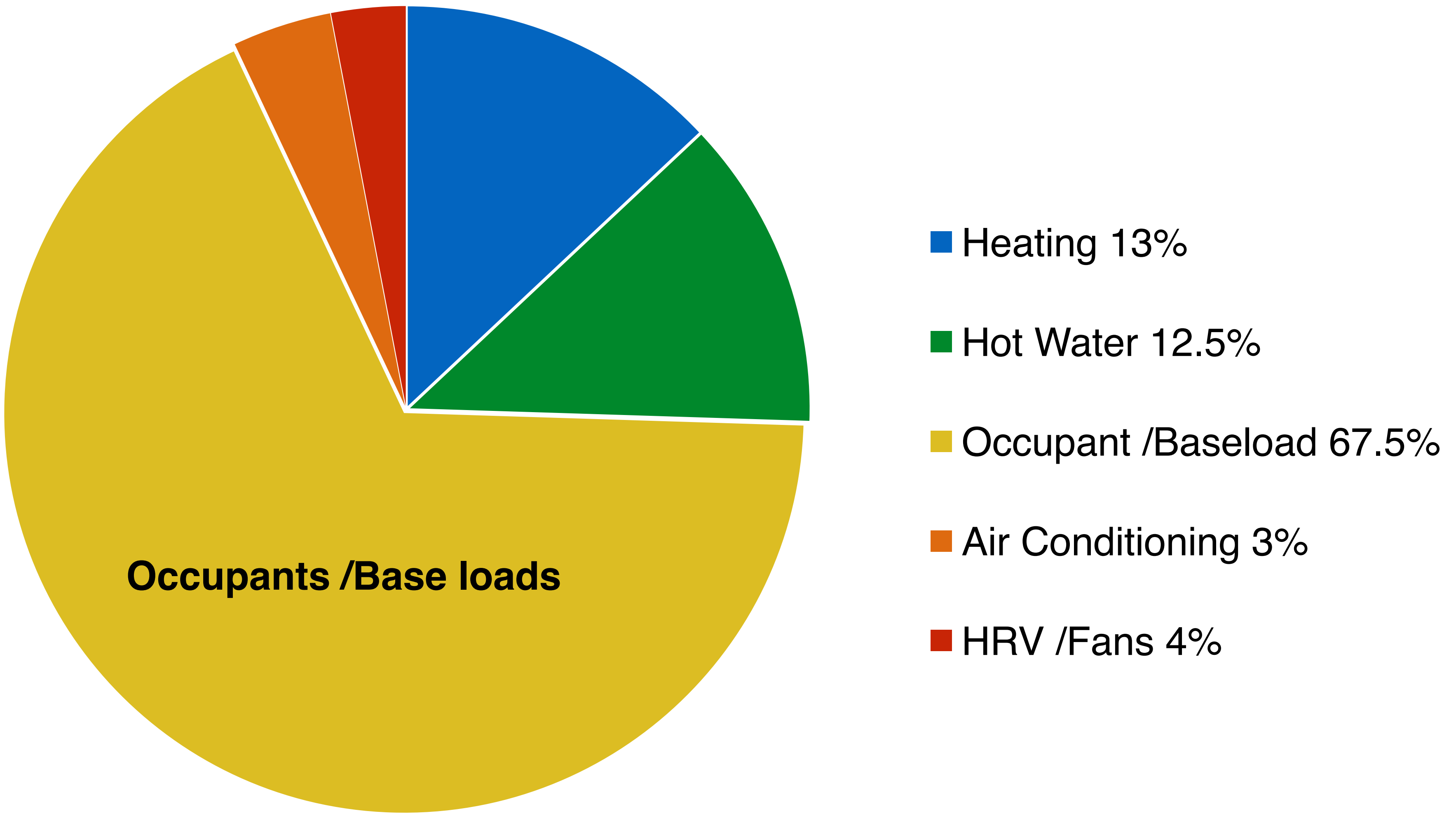


IECC 2015....

SMALLER TOTAL CIRCLE
LOAD PROFILE HAS CHANGED



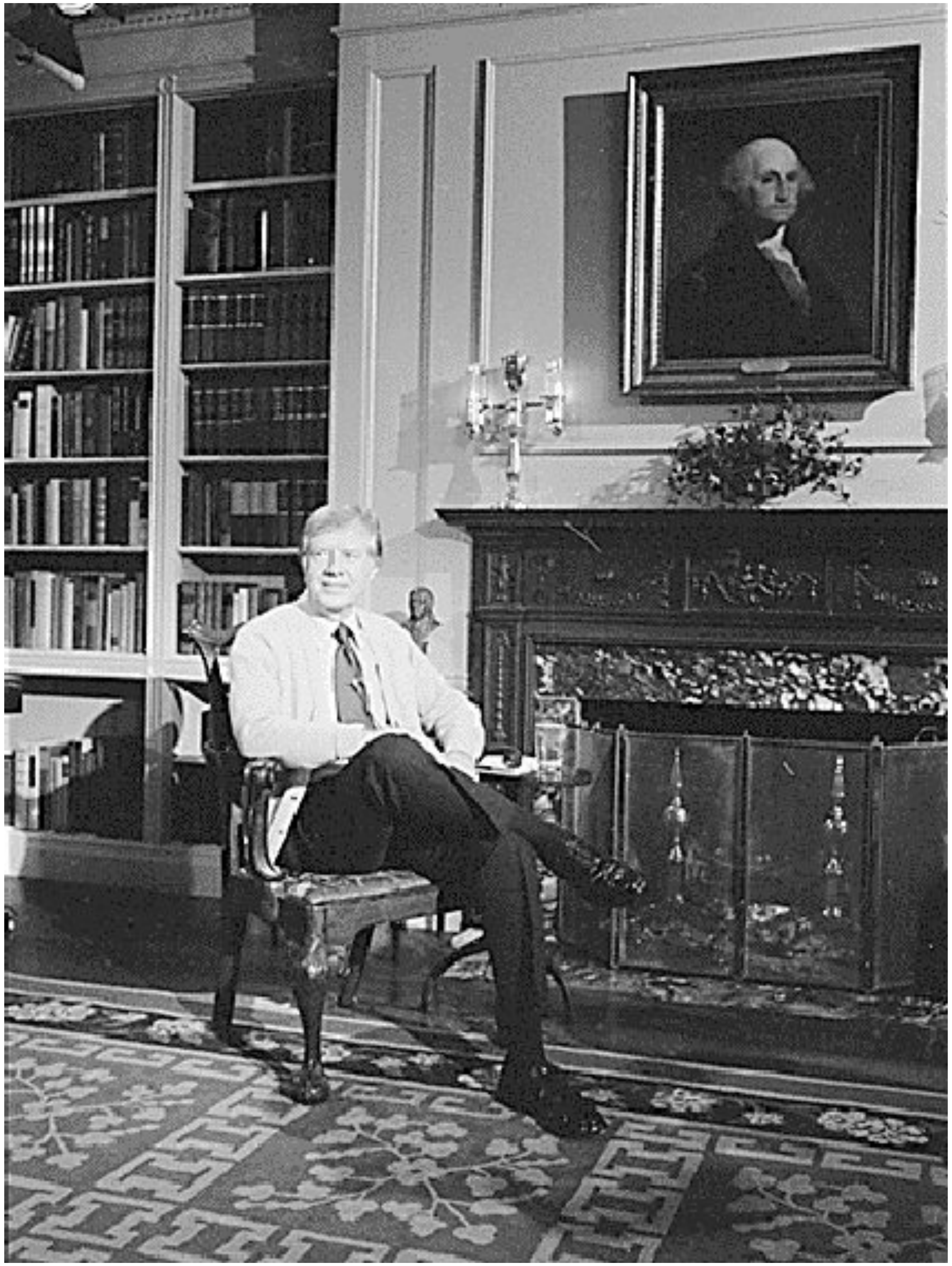
NET ZERO / ZERH….



Are we ready for the changes?

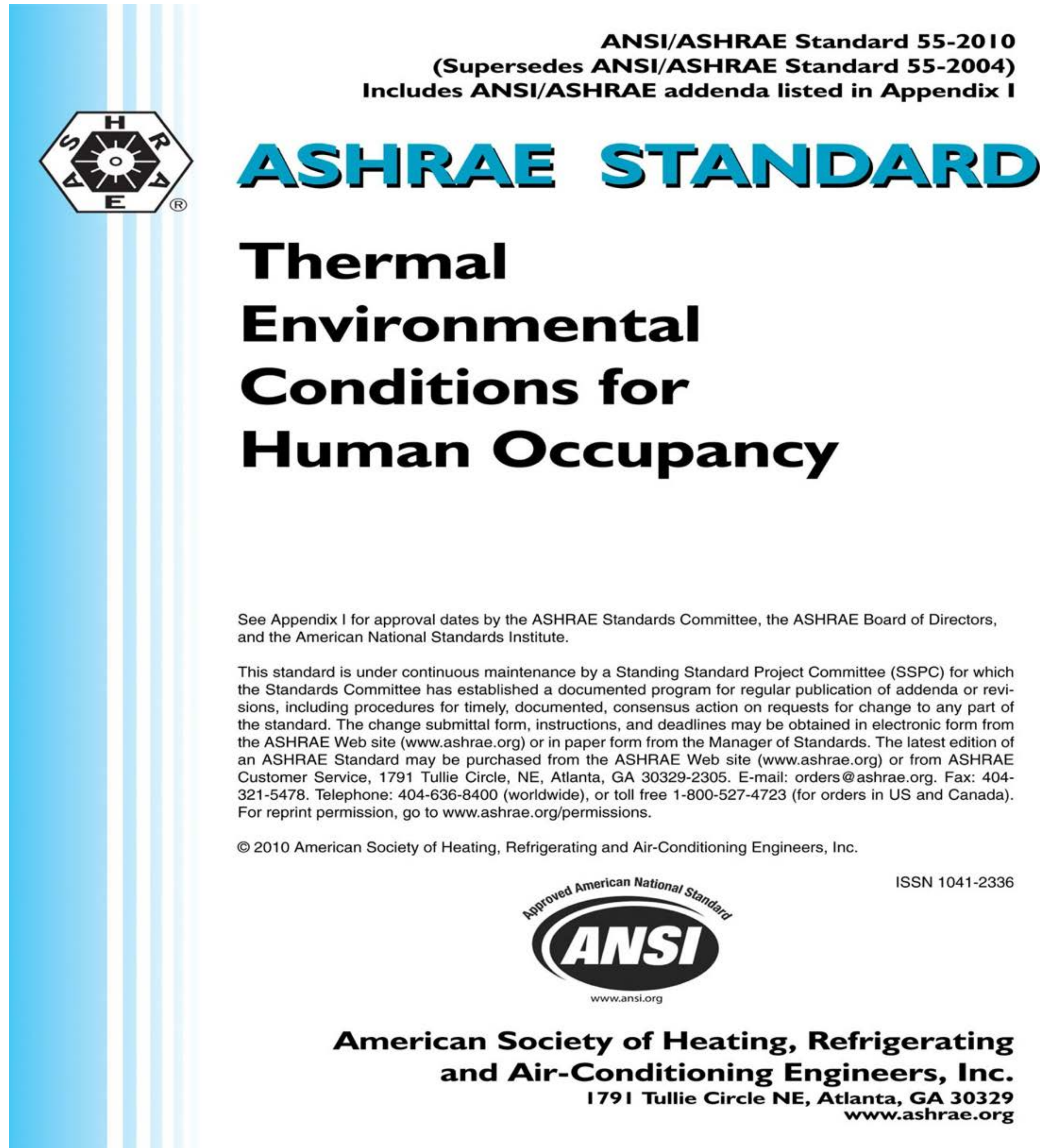
Be Aware…

- Energy Efficiency ≠ Comfort
- Builders typically have more comfort complaints than high bill complaints
- If you can't provide comfort, energy efficiency could be set back 20 years
- Need to remember comfort fundamentals



Let's Start with Defining Comfort

- Air temperature
- Humidity
- Air speed - drafts
- Surrounding surface temperatures
- Gender, age, activities of occupants
- Metabolic rate & clothing



ANSI/ASHRAE Standard 55-2010
(Supersedes ANSI/ASHRAE Standard 55-2004)
Includes ANSI/ASHRAE addenda listed in Appendix I

ASHRAE STANDARD

Thermal Environmental Conditions for Human Occupancy

See Appendix I for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

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 (www.ashrae.org) or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE Web site (www.ashrae.org) or 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). For reprint permission, go to www.ashrae.org/permissions.

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ANSI
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Comfort – Finding the sweet spot

Applies to Operative Temperature

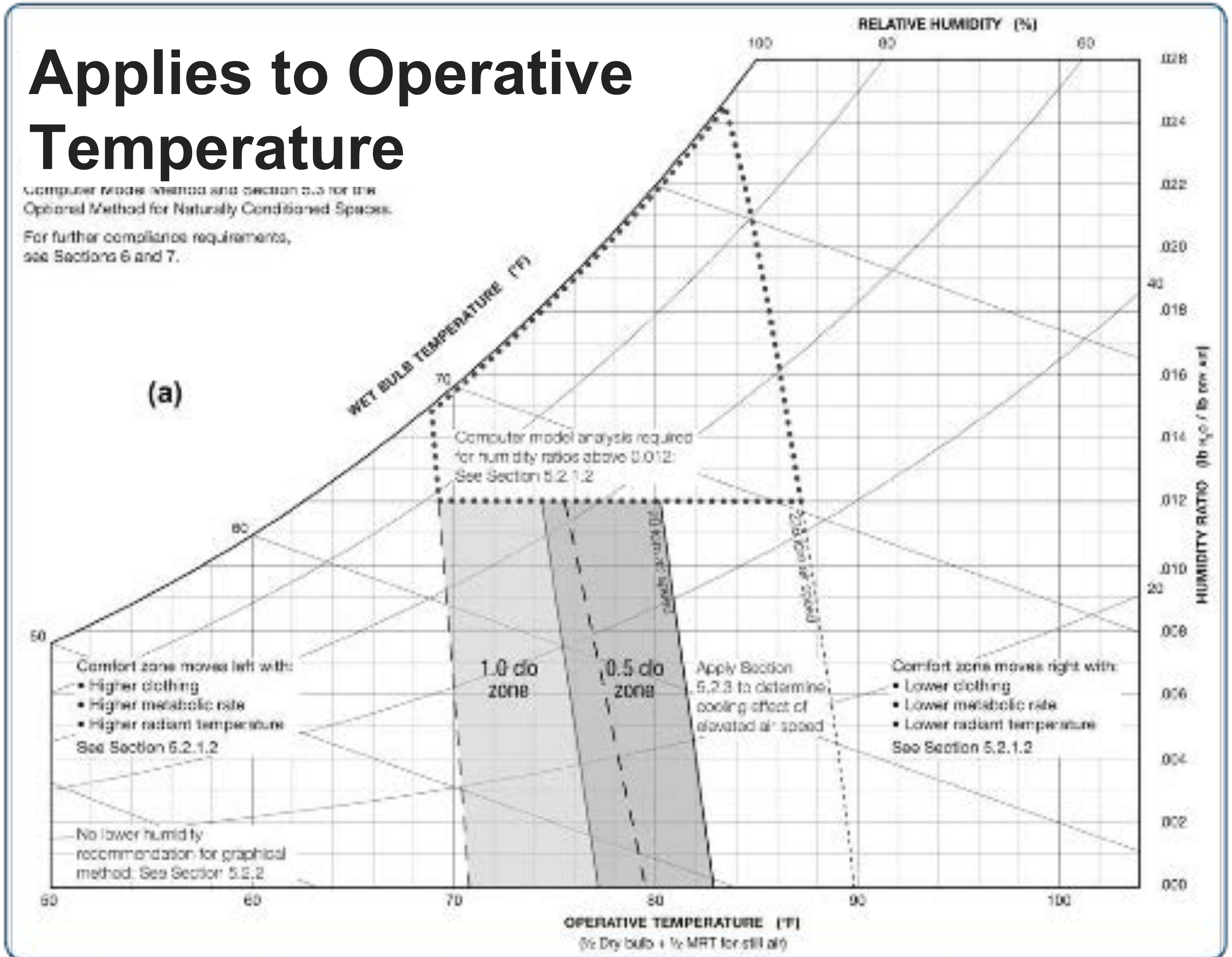


Figure 2: The new Graphic Comfort Zone Method, Figure 5.2.1.1 in Standard 55-2010 (IP version shown).

THERMAL COMFORT DEFINED: ASHRAE 55(40 years old)

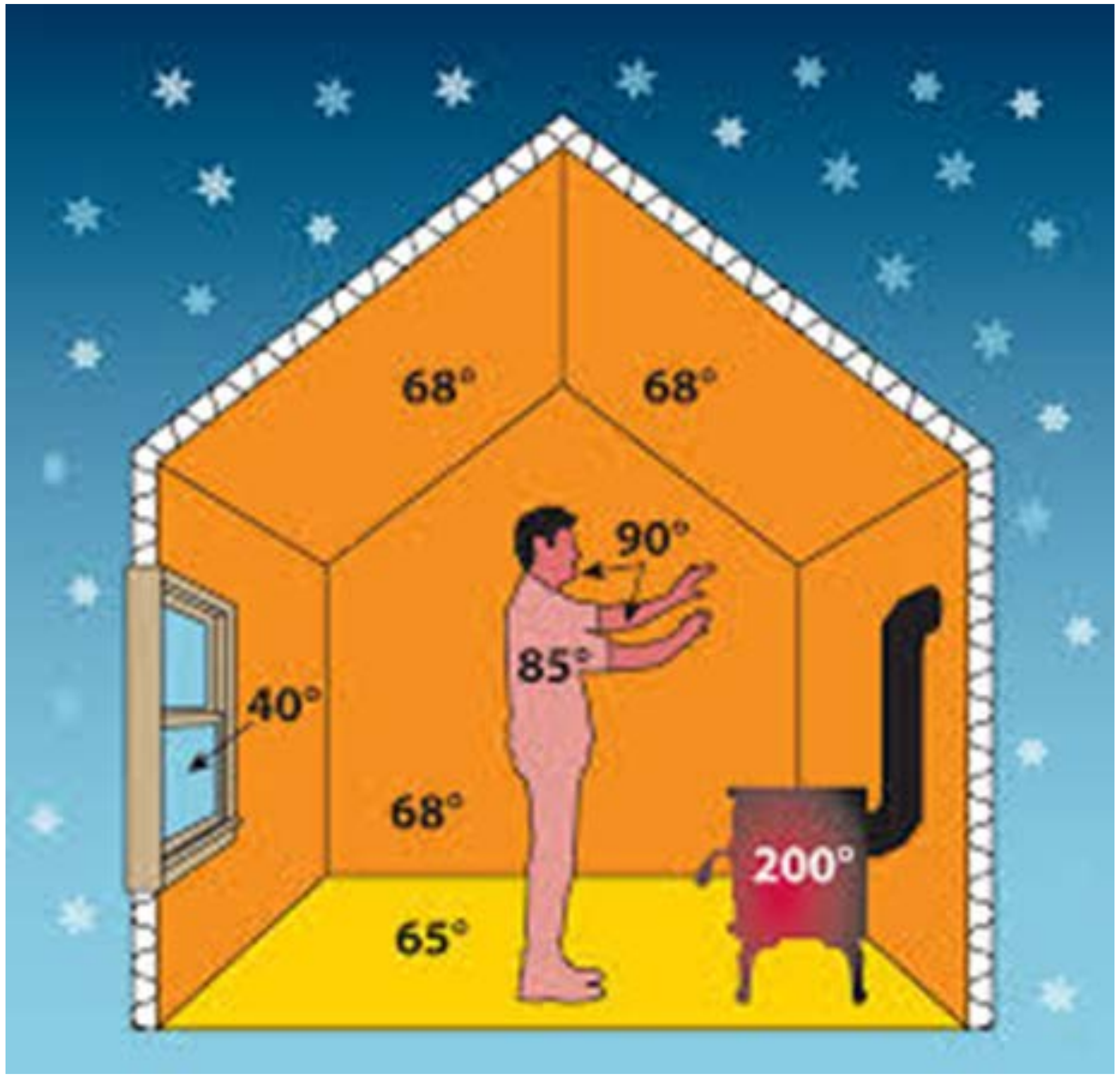
1. Air Temperature(Ambient)
2. Surrounding Surface Temperature(MRT)
3. Humidity

PERSONAL FACTORS:

1. Air movement-Drafts(Air Speed)
2. Occupant Activity AND Sensitivity(Metabolic Rate and Clothing)

ASHRAE 55…."Mean Radiant Temperature"

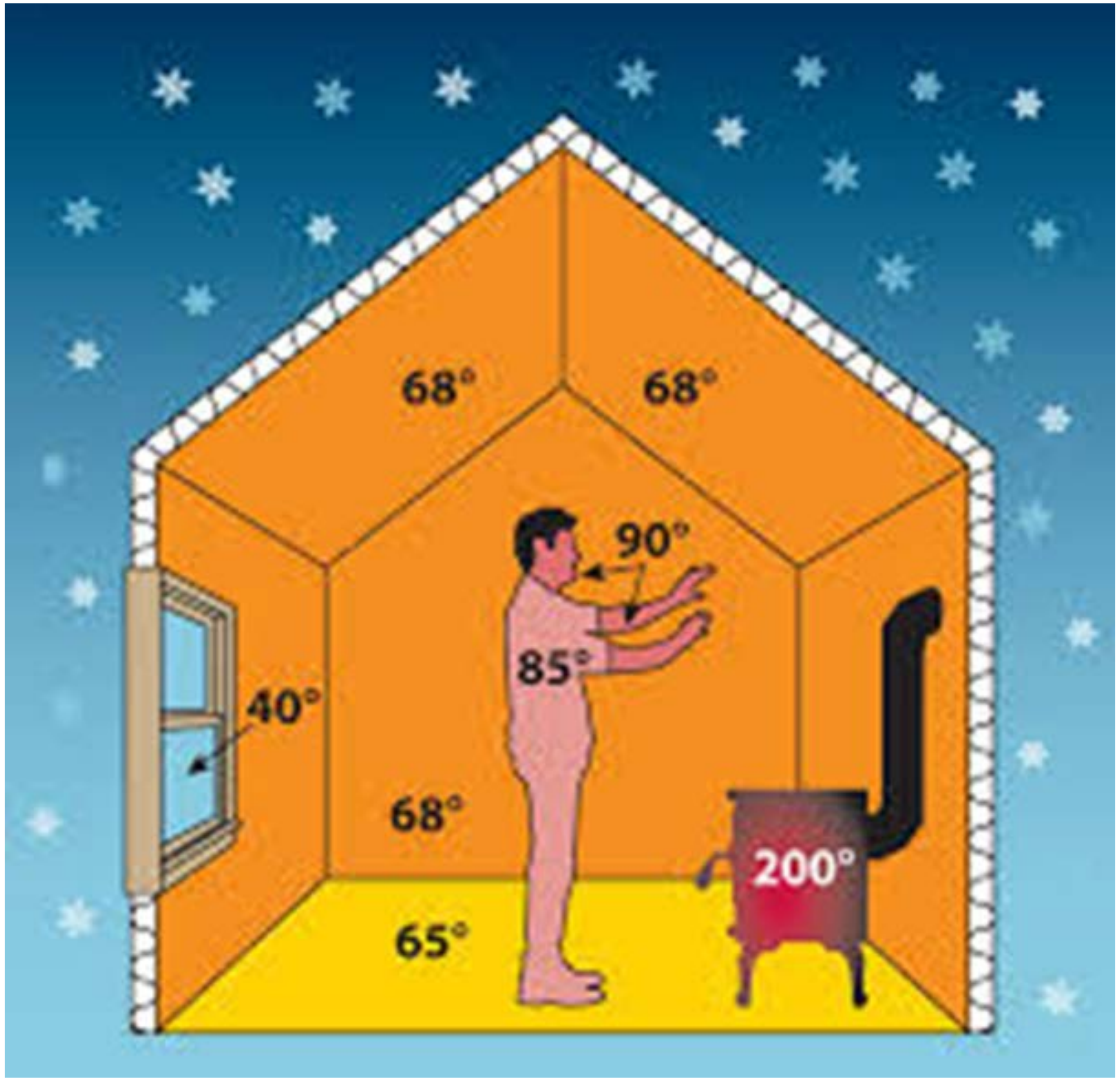
http://comfort.cbe.berkeley.edu/



The Temperatures of the surrounding walls ,floors and windows impacts comfort MORE than air temperature(Thermostat).

How does the body lose (transfer) heat?

- 15% humidity/perspiration
- 35% convection/air movement
- 50% radiation heat exchange.



Operative Temperature

Operative temperature:

- The average of the **mean radiant** and ambient air temperatures, weighted by their respective heat transfer coefficients.
- Thermostats respond to air temperature
- Human **thermal comfort** responds to operative temperature

Can we meet the expectations of our customers?

Residential Single-Zone and Multi-Zone Systems Minimum / Maximum Recommended Values for Comfort and Safety		
Comfort Item	**Heating Season**	**Cooling Season**
Thermostat setpoint (design)	70°F	75°F
Relative humidity (RH)[1]	30% RH maximum (20 – 30% RH is desirable)	55% RH maximum (25 – 50% RH is desirable)
Dry-bulb temperature at the thermostat	Setpoint temperature ±2°F	Setpoint temperature ±3°F (single-zone) Setpoint temperature ±2°F (multi-zone)
Dry-bulb temperature in any conditioned room	Setpoint temperature ±2°F	Setpoint temperature ±3°F (single-zone) Setpoint temperature ±2°F (multi-zone)
Room-to-room temperature differences (i.e., same level)	4°F maximum	6°F maximum (single-zone) 4°F maximum (multi-zone)
Floor-to-floor temperature differences (i.e., different levels)	4°F maximum	6°F maximum (single-zone) 4°F maximum (multi-zone)
Floor temperature (slab floors or floors over unconditioned space)	65°F minimum at 4" above the floor for 70°F thermostat setting [not applicable near outside walls]	----
Air filtration – MINIMUM EFFECTIVENESS[2]	MERV[3] rating of 4 – 6 [Standard disposable media filter]	MERV[3] rating of 4 – 6 [Standard disposable media filter]
Air filtration – BETTER EFFECTIVENESS[2]	MERV[3] rating of 8 – 11 [1-2" residential pleated filter]	MERV[3] rating of 8 – 11 [1-2" residential pleated filter]
Ventilation (outdoor air introduced into the occupied space)	0.35 air changes per hour (ACH) [for any infiltration-ventilation combination]	0.35 air changes per hour (ACH) [for any infiltration-ventilation combination]
Air circulation within room[4]	Size and location of supply outlets selected for optimum heating performance / low resistance return path required for every room	Size and location of supply outlets selected for optimum cooling performance / low resistance return path required for every room

ACCA Comfort Guidelines

Comfort – A starting point

Parameter	Setting	Range
Temperature		
Summer	75 ^{0}F	+/- 3 ^{0}F
Winter	72 ^{0}F	+/- 3 ^{0}F
Humidity		
Summer	50%	+/- 5%
Winter	35%	+/- 5%
Foot Comfort	63 ^{0}F	+/- 3 ^{0}F

Heating & Cooling Systems

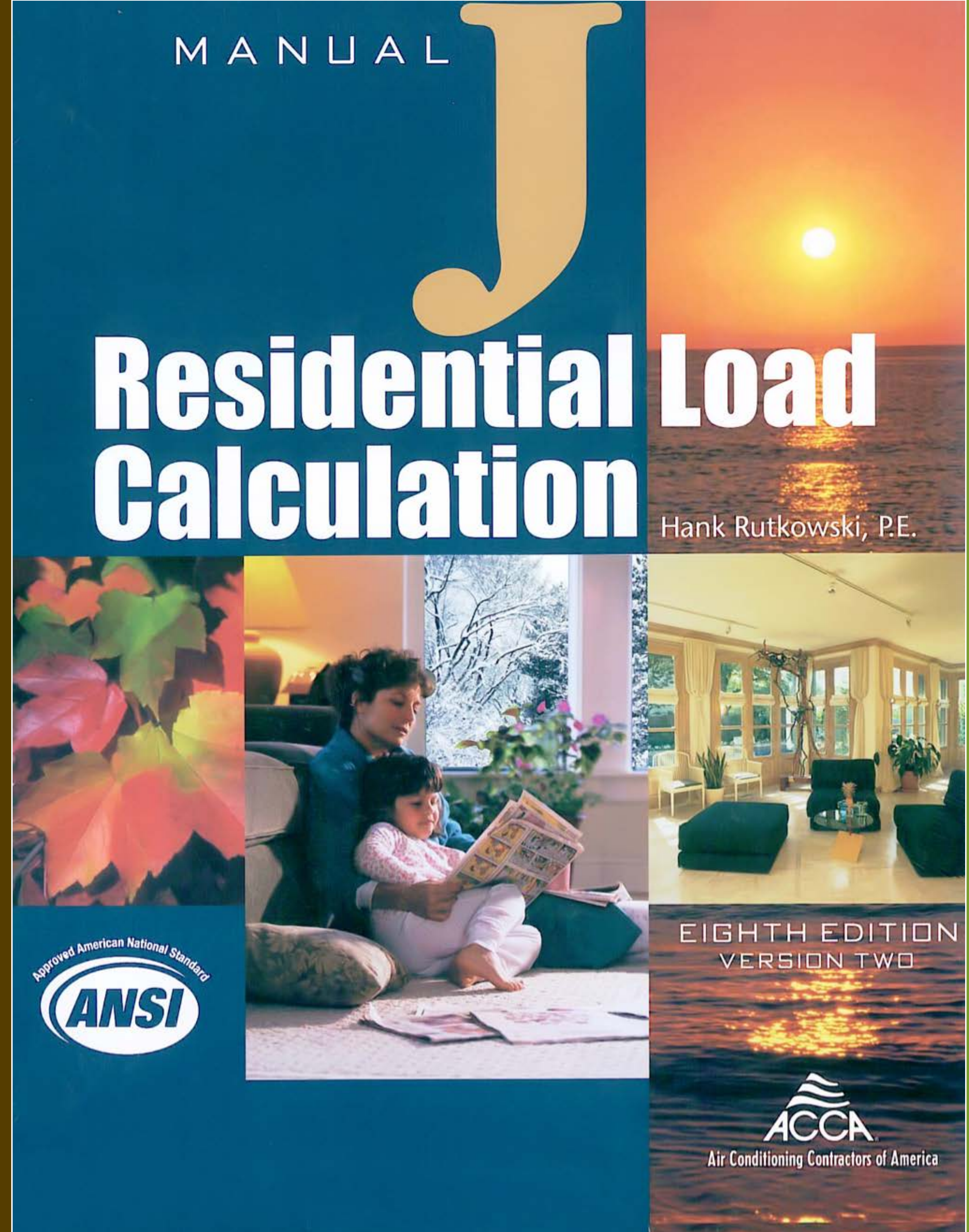
Fuel choices

- Electric
- Gas
- Oil
- Wood
- Solar
- Combinations

Distribution choices

- Central Forced air
- Radiant
  - In-floor
  - Baseboard
- Ductless
- Space heaters

1) Get heating & cooling capacity right



ACCA Sizing Standards

Heat Flow Formulas

Conduction heat flow (through walls, ceilings, floors)

= (Surface Area x Temp. Diff.) / R-value

Radiant flow (through glass)

= Surface area x Solar incidence x **S**olar **H**eat **G**ain **C**oefficient

Heat flow by air (via air leakage or ventilation) - Sensible

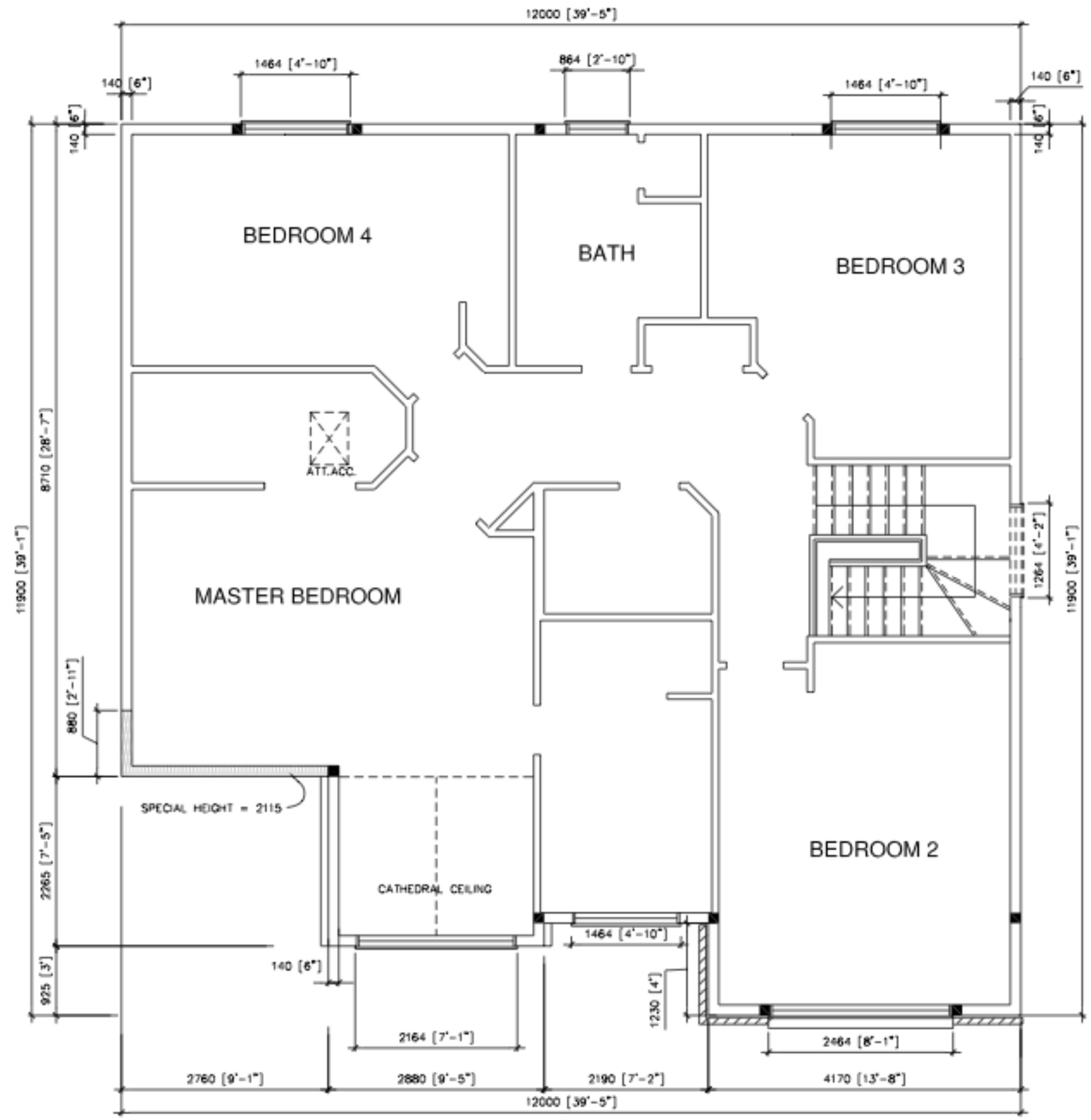
= Volume of air (CFM) x Temp. Diff. x 1.1

HEATING – Get the Size Right

- Do Room-by-Room heat loss & gain calculation

Based on:

- Design Day - Winter
- Conduction losses through enclosure
- Air leakage through enclosure
- Heat losses through ducts in unconditioned space



SECOND FLOOR PLAN

Madison, WI
- design conditions

Condition	ASHRAE 99% / 1%
Winter, design dry bulb (F)	-9°F
Summer, design dry bulb (F)	90°F
Summer, design wet bulb (F)	74.4°F
Degree days-heating	7197
Degree days-cooling	608
Precipitation	31”
Solar incidence - South, July	100

Lets do a one room example

Conductive Heat Loss/ Gain

- 2 exposed walls
- One exposed ceiling
- One window

Radiant Heat Gain (Cooling)

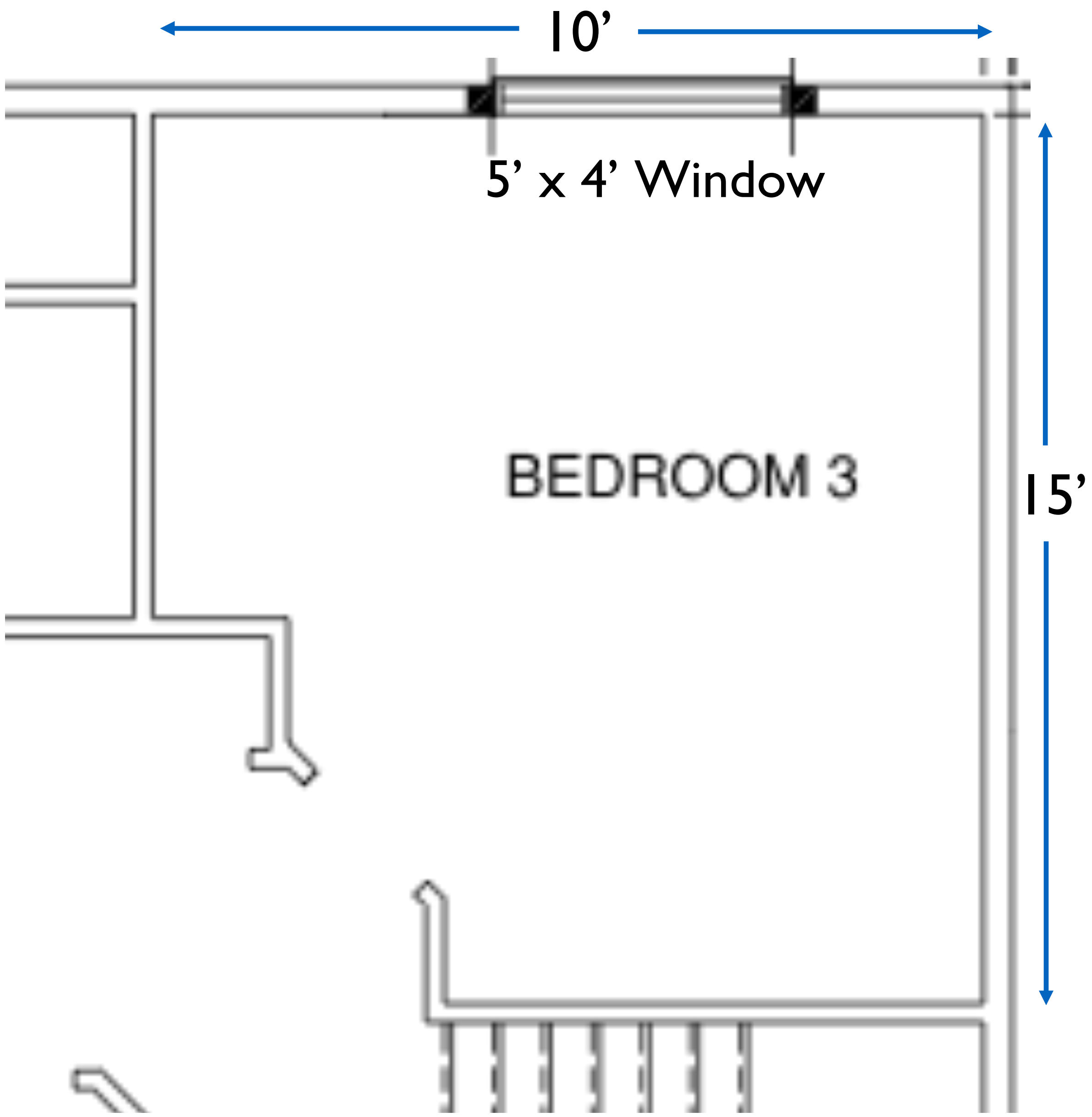
- Solar gain through window

+ Internal loads
+ Air leakage & ventilation

Participants complete the example on your worksheet

Assume 10’ high ceilings

Assume window SHGC = 0.3



HVAC Sizing

Component	Surface area	x	Temp. Diff.	/	R-value	= BTUs/Hr
Ceiling: Winter Summer	________ sq.ft.				R30	
Walls: Winter Summer	_______ sq.ft.				R15	
Windows: Winter Summer	______ sq.ft.				R3	

HVAC Sizing

Component	Surface area	x	Temp. Diff.	/	R-value	= BTUs/Hr
Ceiling: Winter Summer	150 sq.ft.				R30	
Walls: Winter Summer	250 sq.ft.				R15	
Windows: Winter Summer	20 sq.ft.				R3	

HVAC Sizing

Component	Surface area	x	Temp. Diff.	/	R-value	= BTUs/Hr
Ceiling: Winter Summer	150 sq.ft.		60 20		R30	300 100
Walls: Winter Summer	250 sq.ft.		60 20		R15	1000 333
Windows: Winter Summer	20 sq.ft.		60 20		R3	400 133

Solar gain (South) = 20 x 100 x 0.3 SHGC = 600 BTUs/hr

Solar gain (West) = 20 x 160 x 0.3 SHGC = 960 BTUs/hr

HVAC Sizing

Air leakage / ventilation heat loss

= CFM x temp. difference x 1.1

= 60 x 60 x 1.1= 3960 BTUs/hr

Definition - 1.08 is the product of the specific heat (0.24 BTU x Air Density x minutes in an hour (60)

HVAC Sizing

Air leakage / ventilation heat loss

btu/hr = CFM x temp. difference x 1.1

= 60 x 50 x 1.1= 3300 BTUs/hr

Definition - 1.08 is the product of the specific heat (0.24 BTU x Air Density x minutes in an hour (60)

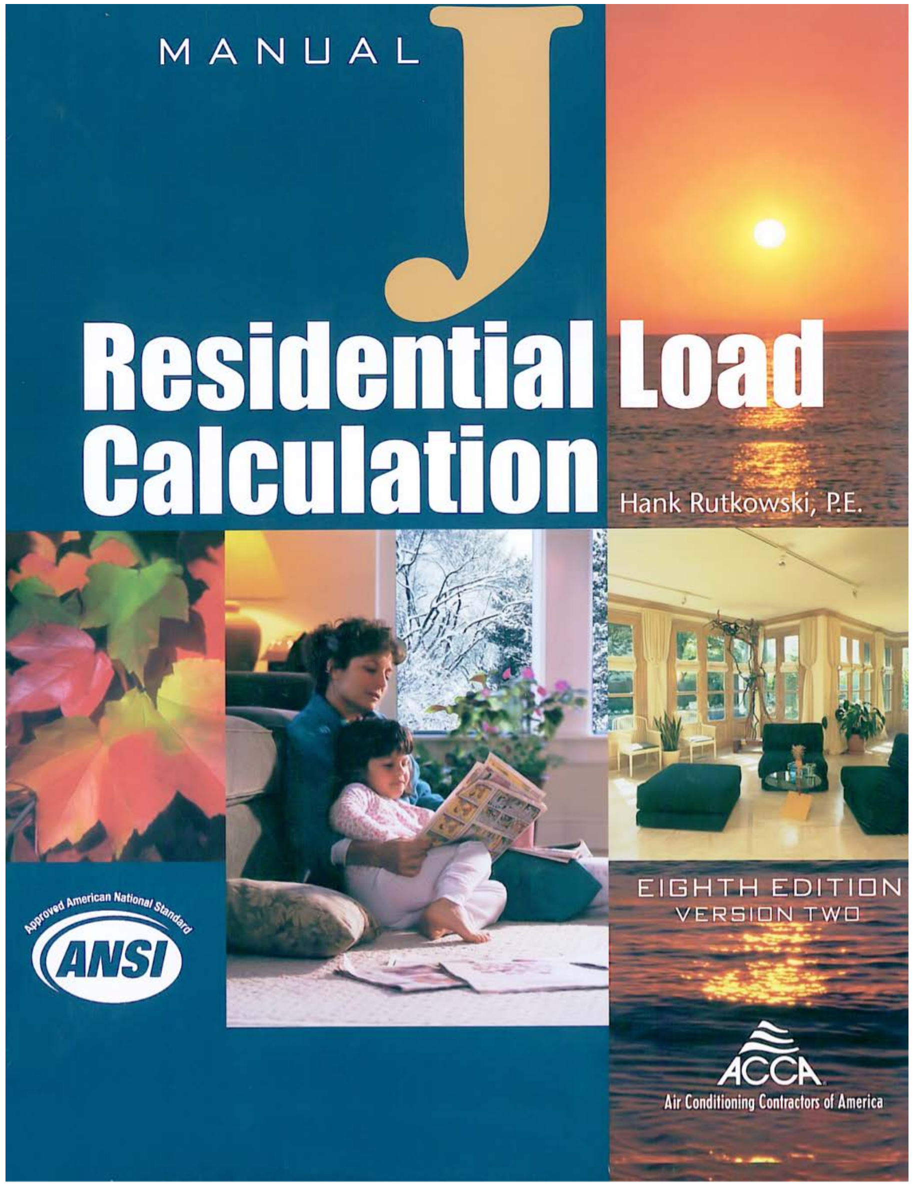
Proper Manual J Calculations

- Numerous software packages exist
- All rely on proper data input and appropriate assumptions

Common Errors:

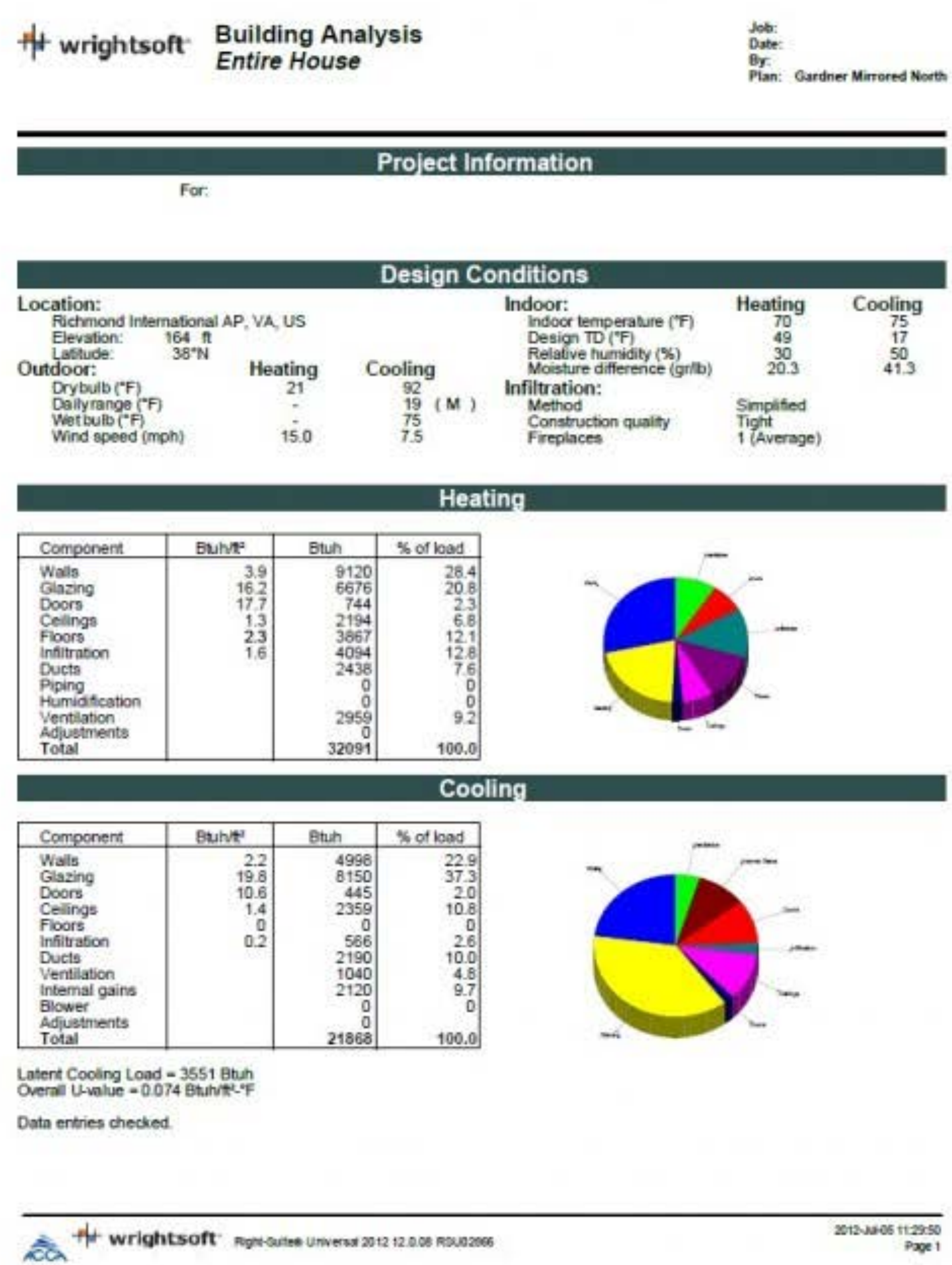
- Fudging design day conditions
- Using default values for air tightness, windows, insulation
- Using improper ventilation rates

Don't tolerate oversizing, Manual J compliant programs have safety factors built in already



Impact of Improper Sizing

- Short cycling
- Poor humidity control
- Poor temperature control
- Noise
- Extra cost for equipment & duct work
- Possibly higher energy bills



wrightsoft **Building Analysis**
Entire House

Job:
Date:
By:
Plan: Gardner Mirrored North

Project Information

For:

Design Conditions

Location:
Richmond International AP, VA, US
Elevation: 164 ft
Latitude: 38°N

Outdoor:	Heating	Cooling
Drybulb (°F)	21	92
Dailyrange (°F)	-	19 (M)
Wet bulb (°F)	-	75
Wind speed (mph)	15.0	7.5

Indoor:	Heating	Cooling
Indoor temperature (°F)	70	75
Design TD (°F)	49	17
Relative humidity (%)	30	50
Moisture difference (gr/lb)	20.3	41.3

Infiltration:
Method: Simplified
Construction quality: Tight
Fireplaces: 1 (Average)

Heating

Component	Btuh/ft²	Btuh	% of load
Walls	3.9	9120	28.4
Glazing	16.2	6676	20.8
Doors	17.7	744	2.3
Ceilings	1.3	2194	6.8
Floors	2.3	3867	12.1
Infiltration	1.6	4094	12.8
Ducts		2438	7.6
Piping		0	0
Humidification		0	0
Ventilation		2959	9.2
Adjustments		0	
Total		32091	100.0

Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	2.2	4998	22.9
Glazing	19.8	8150	37.3
Doors	10.6	445	2.0
Ceilings	1.4	2359	10.8
Floors	0	0	0
Infiltration	0.2	566	2.6
Ducts		2190	10.0
Ventilation		1040	4.8
Internal gains		2120	9.7
Blower		0	0
Adjustments		0	
Total		21868	100.0

Latent Cooling Load = 3551 Btuh
Overall U-value = 0.074 Btuh/ft²-°F

Data entries checked.

wrightsoft Right-Suite® Universal 2012 12.0.08 RSU02666
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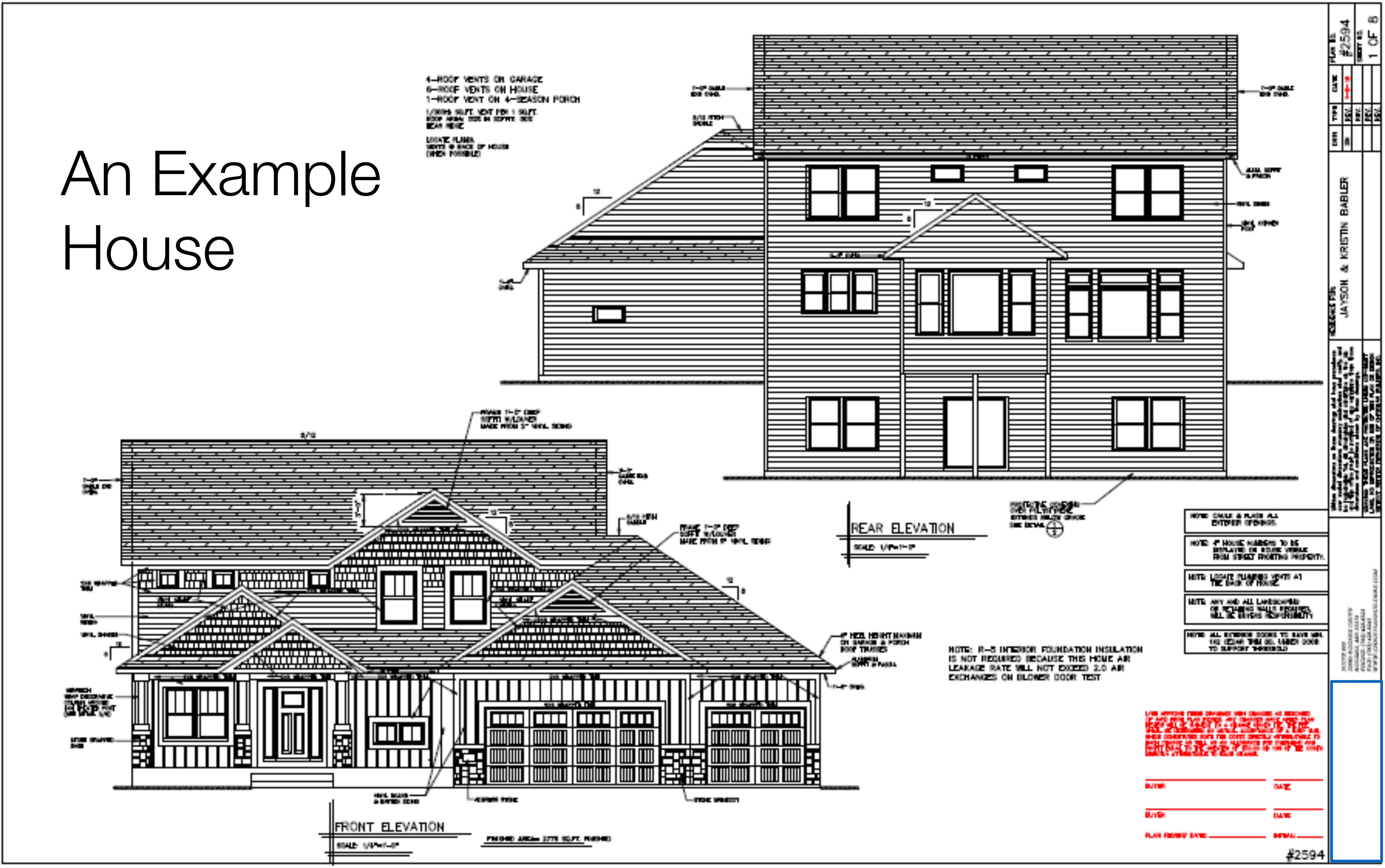
Page 1

An Example House



Example Design Decisions

Parameter	Actual	Traditional
Design Temp (W) Design Temp (S)	-15 ^{0}F 91 ^{0}F	Its cold here: -22 ^{0}F Its getting hotter: 97 ^{0}F
Indoor Design (W) Indoor Design (S)	70 ^{0}F 75 ^{0}F	People are picky: 72 ^{0}F 72 ^{0}F
Orientation	North Front	Worst Case - East Front
Windows	From NFRC label U=0.28, SHGC=0.28 Overhangs used	Default U=0.41, SHGC=0.32 Overhangs not used
Air tightness	Actual 2.0 ACH50	Default 7.0 ACH50
Insulation	R50 ceilings R25 walls R 15 foundation	R44 ceilings R19 walls R 10 foundation
Ventilation	ERV - 75 CFM	Exhaust fans - 75 CFM

An Accurate Manual J

Project Summary
Entire House
Authority Air Designs, LLC.

Job: V505
Date: Feb 09, 2015
By: Joe Colburn
Plan: Beazer Homes

6608 W. 95th Place, Westminster, CO 80021-6422 Phone: (720) 354-8105 Email: Joe@AuthorityAir.com Web: www.AuthorityAir.com

Project Information

For: Justin Wilson, Construction Instruction
3259 Spruce St., Denver, CO 80238
Phone: (719) 337-4749
Web: www.ConstructionInstruction.com Email: Justin@ConstructionInstruction.com

Notes:

Design Information

Weather: Charleston Intl AP, SC, US

Winter Design Conditions

Outside db	30	°F
Inside db	70	°F
Design TD	40	°F

Summer Design Conditions

Outside db	92	°F
Inside db	75	°F
Design TD	17	°F
Daily range	M	
Relative humidity	50	%
Moisture difference	55	gr/lb

Heating Summary

Structure	23079	Btuh
Ducts	2899	Btuh
Central vent (0 cfm)	0	Btuh
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	25977	Btuh

Sensible Cooling Equipment Load Sizing

Structure	22909	Btuh
Ducts	3398	Btuh
Central vent (0 cfm)	0	Btuh
Blower	0	Btuh
Use manufacturer's data	n	
Rate/swing multiplier	0.97	
Equipment sensible load	25545	Btuh

Infiltration

Method		Simplified
Construction quality		Tight
Fireplaces		1 (Tight)
	Heating	**Cooling**
Area (ft²)	2615	2615
Volume (ft³)	23534	23534
Air changes/hour	0.15	0.08
Equiv. AVF (cfm)	88	72

Latent Cooling Equipment Load Sizing

Structure	3518	Btuh
Ducts	525	Btuh
Central vent (0 cfm)	0	Btuh
Equipment latent load	4042	Btuh
Equipment total load	29587	Btuh
Req. total capacity at 0.80 SHR	2.7	ton

Heating Equipment Summary

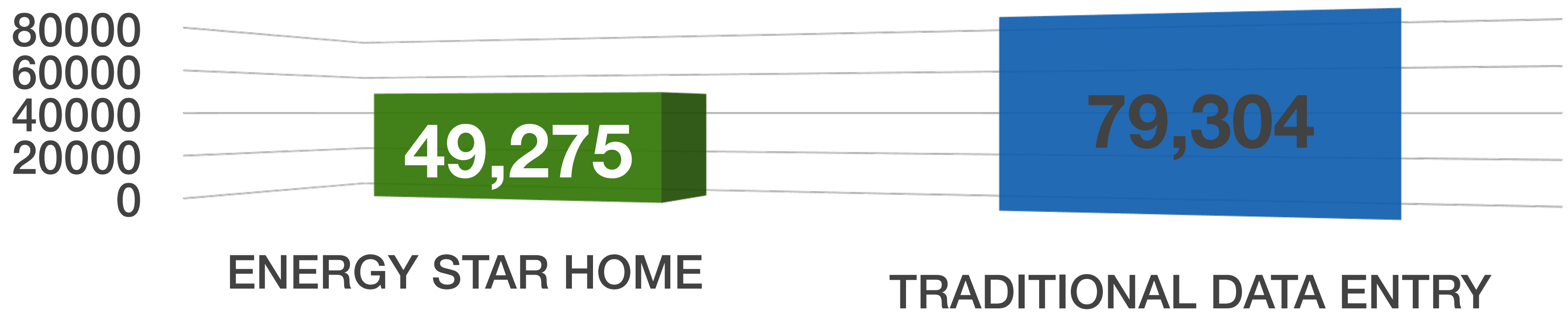
Make	Goodman Mfg.	
Trade	GMVC9 Series	
Model	GMVC950704CX	
AHRI ref	2002232	
Efficiency	96.1 AFUE	
Heating input	69000	Btuh
Heating output	67000	Btuh
Temperature rise	48	°F
Actual air flow	1275	cfm
Air flow factor	0.049	cfm/Btuh
Static pressure	0.80	in H2O
Space thermostat		

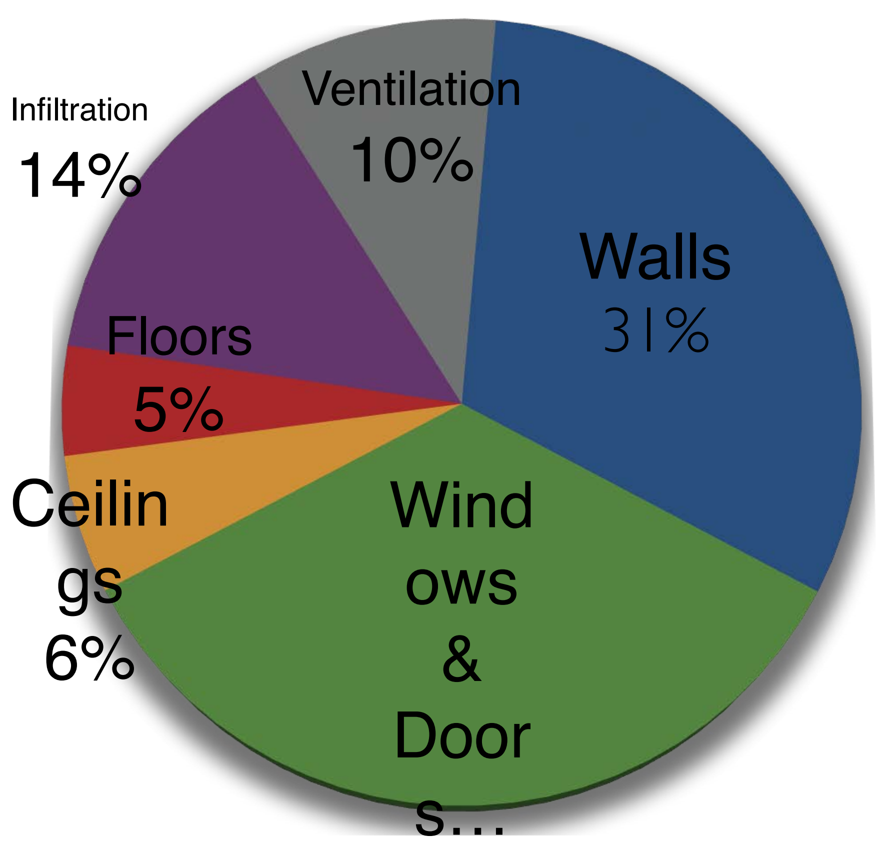
Cooling Equipment Summary

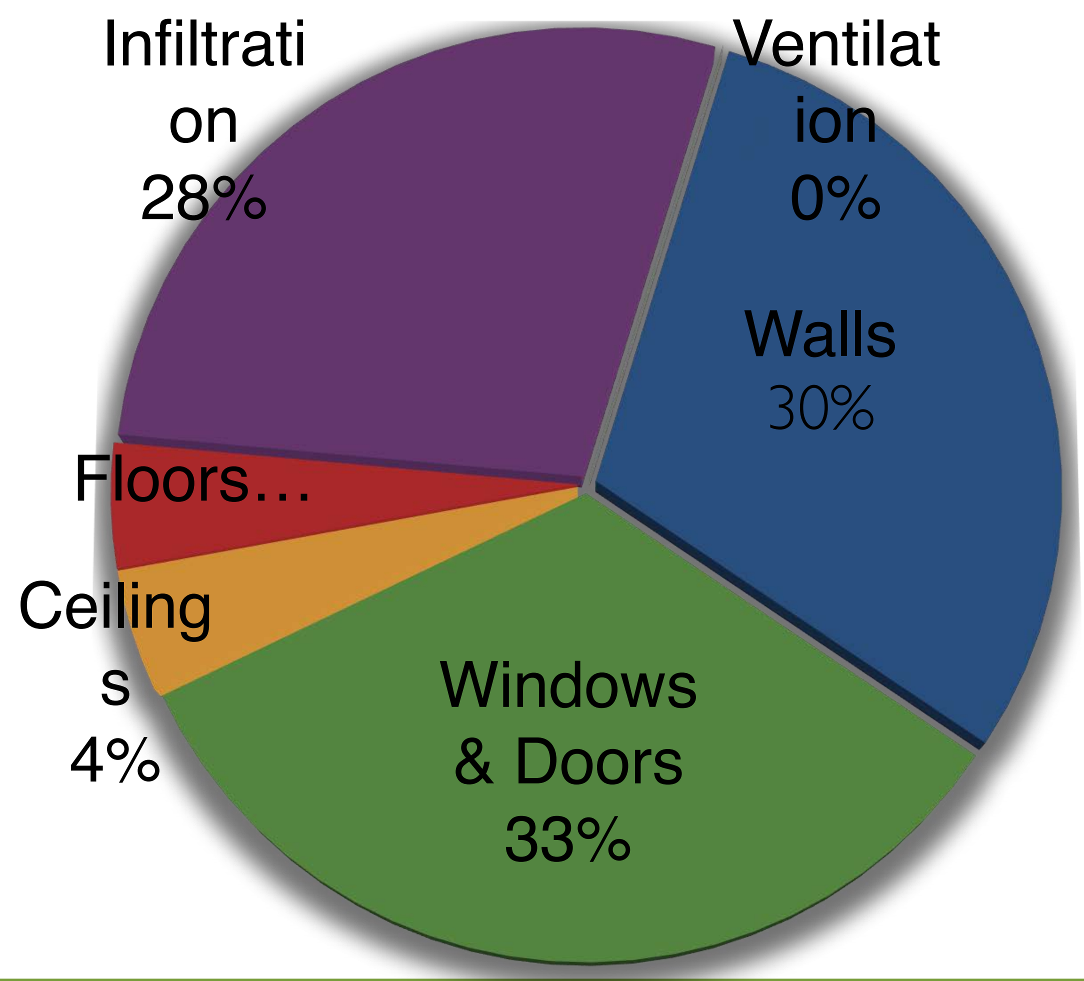
Make	Goodman Mfg.	
Trade	GSX 13 Series	
Cond	GSX160361F	
Coil	CAPF3642C6D	
AHRI ref	5986876	
Efficiency	12.0 EER, 14.5 SEER	
Sensible cooling	27200	Btuh
Latent cooling	6800	Btuh
Total cooling	34000	Btuh
Actual air flow	1275	cfm
Air flow factor	0.048	cfm/Btuh
Static pressure	0.80	in H2O
Load sensible heat ratio	0.87	

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

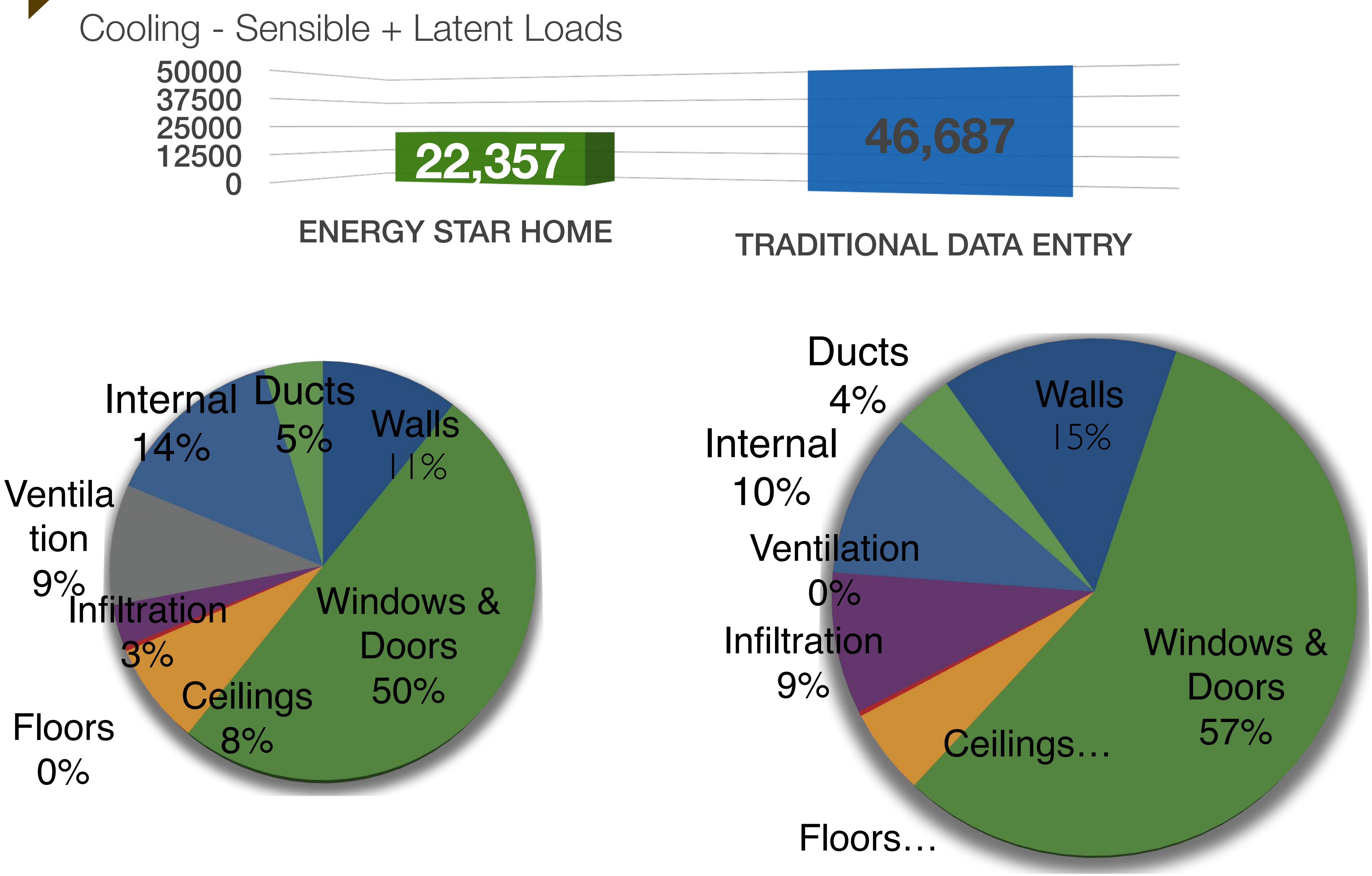
Heating Loads- HP Home Versus Standard

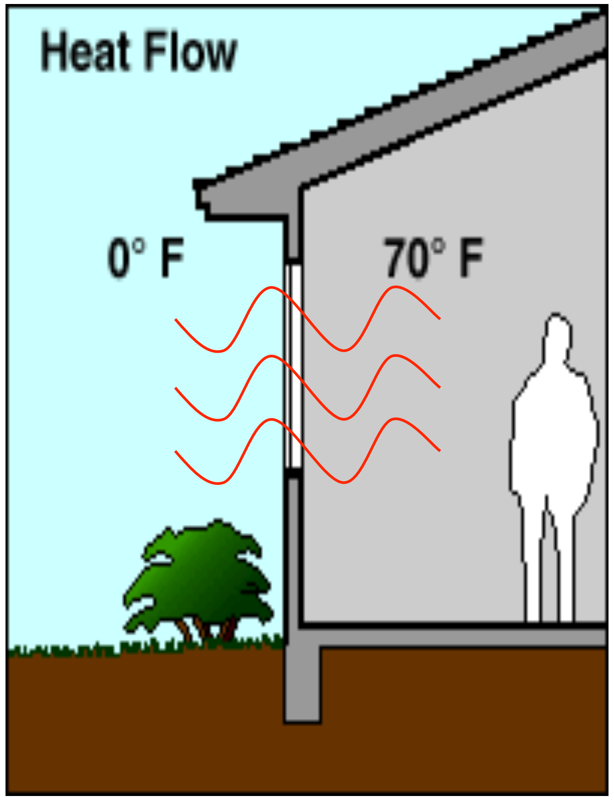






Cooling Loads- HP Home Versus Standard





National Fenestration Rating Council
CERTIFIED

ENERGY PERFORMANCE RATINGS

U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.30	0.36

ADDITIONAL PERFORMANCE RATINGS

Visible Transmittance	
0.59	—

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information.
www.nfrc.org

ENERGY STAR
ENERGY STAR® Qualified in All 50 States

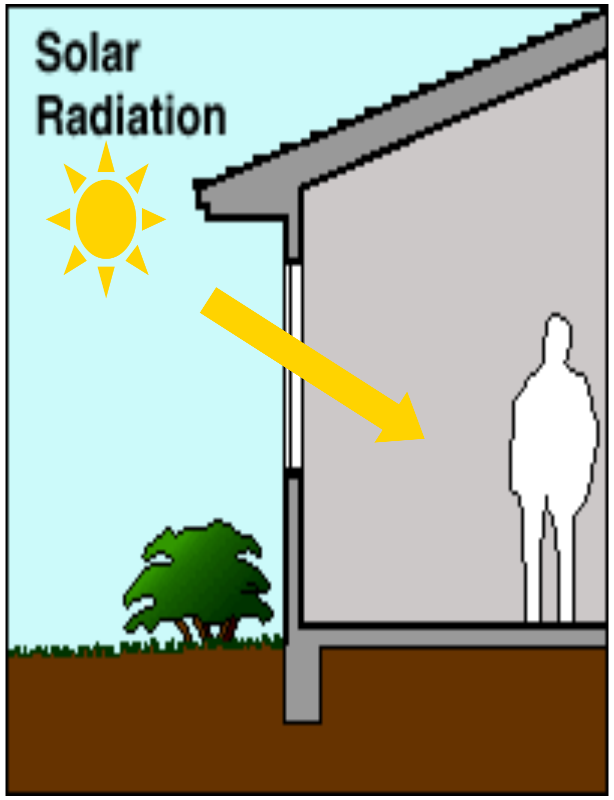
Design Pressure (PSF)
DP 30

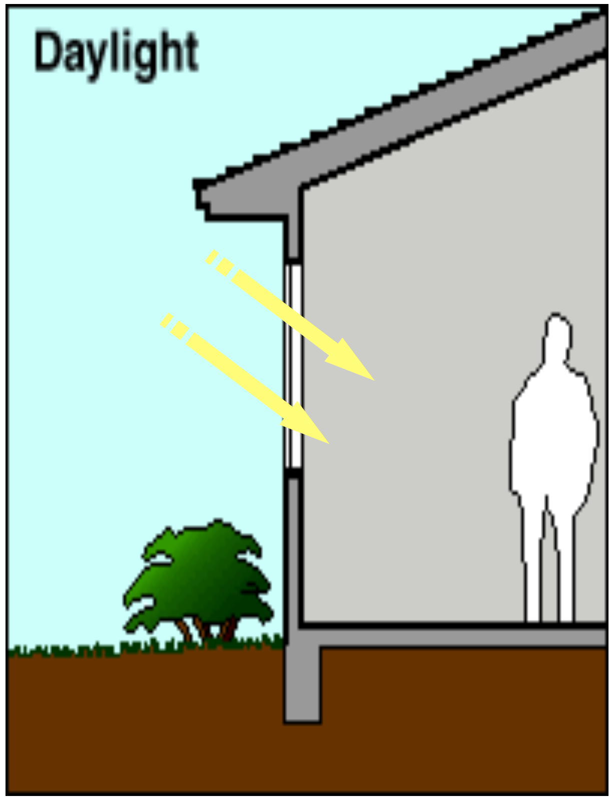
WDMA HALLMARK CERTIFIED
WINDOW AND DOOR MANUFACTURERS ASSOCIATION

F-C50 60" x 72"

Tested to ANSI/AAMA/NWWDA 101/I.S.2-97 or NAFS-1

Meets or exceeds M.E.C., C.E.C., & I.E.C.C. Air Infiltration Requirements WDMA Hallmark Certification Program





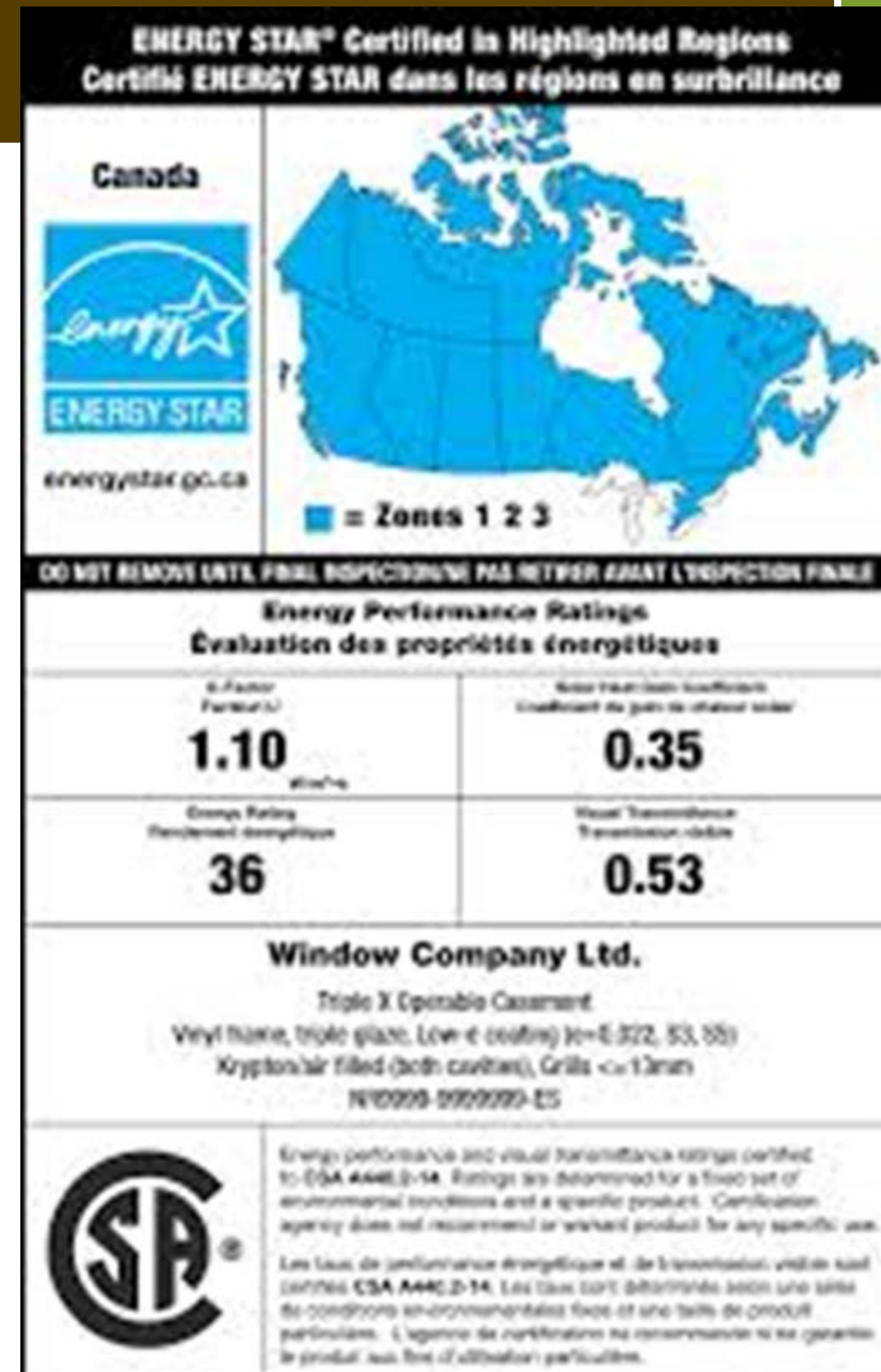
The most 2 important numbers

- **SHGC** indicates how much incident solar radiation is admitted through a window as heat gain. The higher the number, the higher the solar gain.

- **U factor** describes the rate of heat transfer (i.e. how well the window insulates). The lower U factor, the better the window or door insulates.

- **SHGC and U factor** should be chosen carefully to optimize window performance in different climates.

NOTE : SHGC affects 50%+ of most Heat Load calculations(Tonnage)



WHY DUCT SIZING IS INCREASINGLY DRIVEN BY COOLING LOADS…EVEN IN THE NORTH!

- Fastest growing peak load
- Most costly comfort investment in any home
- Trickle down effect: HIGH SHGC WINDOWS = Increasing cooling loads = larger Duct sizing and air handler(furnace blower motor)

Single biggest factor in cooling loads: WINDOWS!(SHGC)

Windows Solar Gain(SHGC) and Air Conditioning

Window Case Study

- **Standard Clear Double Glazed**
- SHGC = .68
- **4.0 Ton AC Unit**

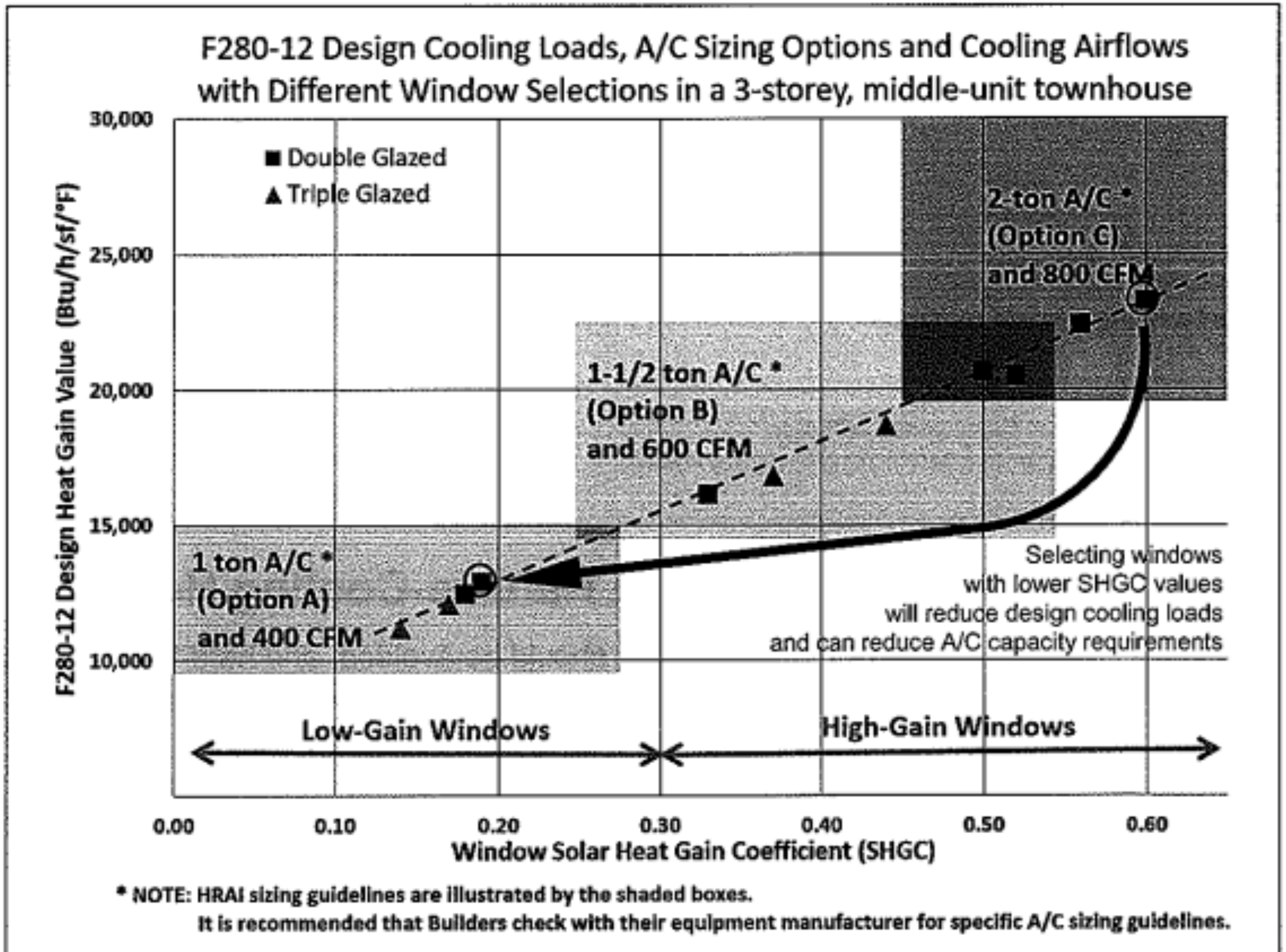
- **Double Glazed Low-e, Low SHGC**
- SHGC = .32
- **2.5 Ton AC Unit….1.5 Ton reduction!**

SHGC AND COOLING LOADS

Amount of Glass in New Homes : More or Less?

2000 or before:	**8 to 10%...**
2010 to 2016:	**12% to 17%....**
2016 New product showing:	**17% to 25%+**

Tread cautiously with higher SHGC. Comfort and Energy implications



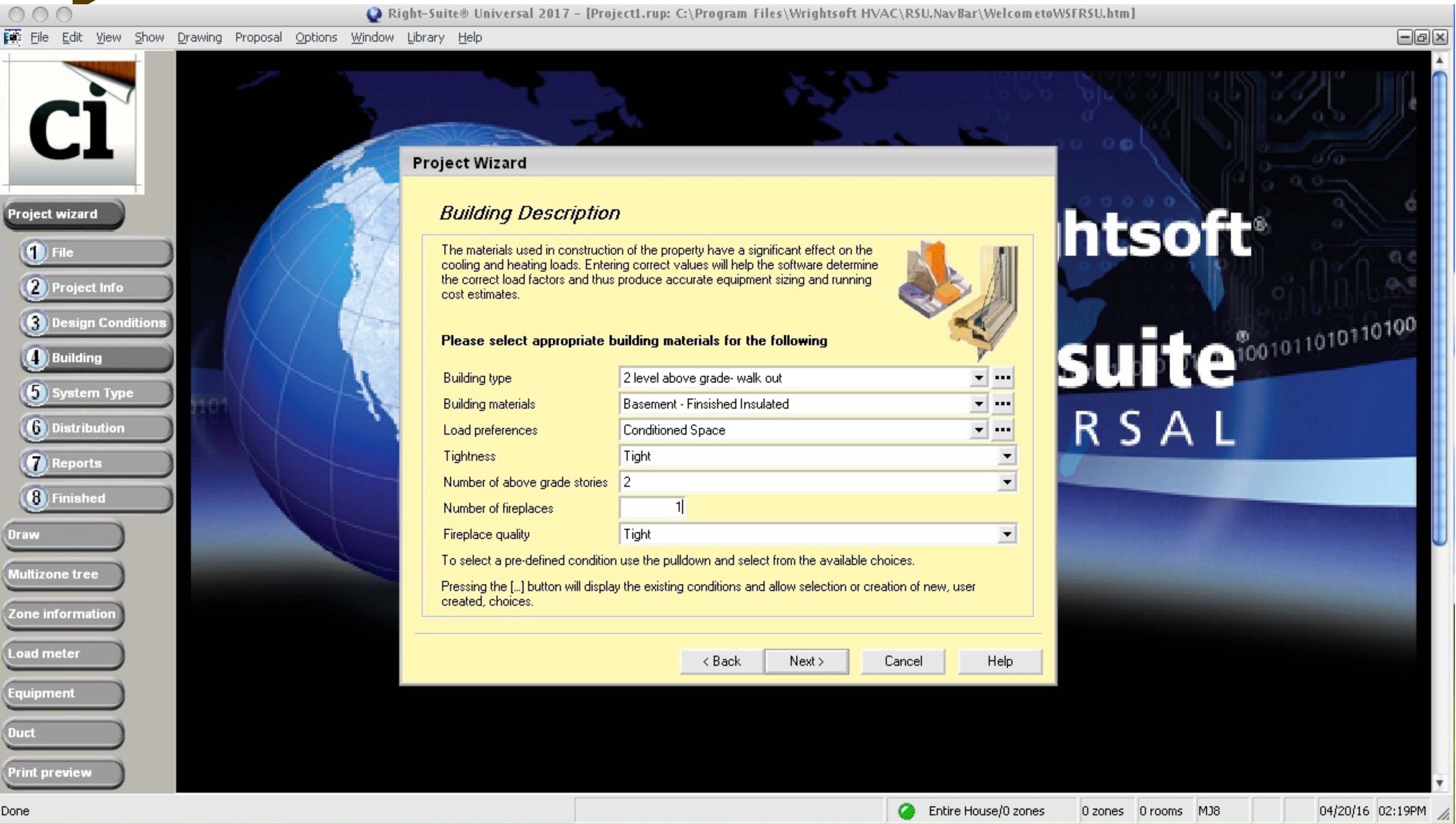
HOW MUCH HEAT/COOLING FOR A LOW LOAD ZERH? (1800 SFT)

HOME TYPE	Load
EXISTING HOME	70,000 Heat 36,000 Cool
2012-2015 IECC BUILT HOME	36,000 24,000
ZERH	26,000 18,500

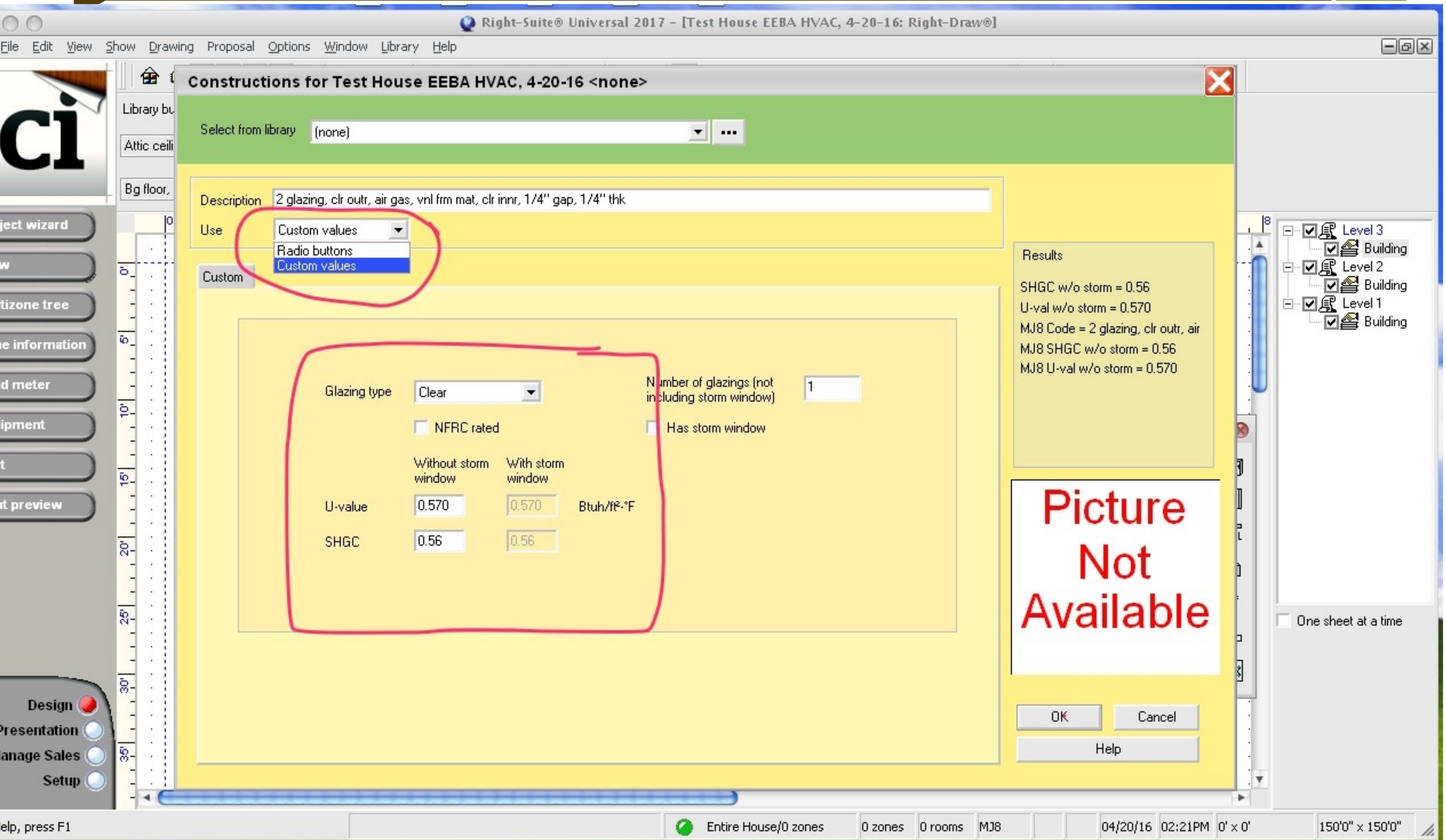
Provide your Contractor with Good Information

- Insulation levels
  - Wall and attic insulation levels
  - Foundation insulation
- Window data - use NFRC ratings
  - Solar heat gain coefficients
  - U values
- House Air leakage - (this is often the single biggest variable)
  - Provide blower door test values

Approved Software Guides Better Inputs



Approved Software Guides Better Inputs



You can check the numbers against the detailed Heat Loss / Gain Report

Check them against your HERs raters reports too

Component Constructions
Entire House
Authority Air Designs, LLC.

Job: V505
Date: Feb 09, 2015
By: Joe Colburn
Plan: Beazer Homes

6608 W. 95th Place, Westminster, CO 80021-6422 Phone: (720) 354-8105 Email: Joe@AuthorityAir.com Web: www.AuthorityAir.com

Project Information

For: Justin Wilson, Construction Instruction
3259 Spruce St., Denver, CO 80238
Phone: (719) 337-4749
Web: www.ConstructionInstruction.com Email: Justin@ConstructionInstruction.com

Design Conditions

Location:
Charleston Intl AP, SC, US
Elevation: 49 ft
Latitude: 33°N

Outdoor:	**Heating**	**Cooling**
Dry bulb (°F)	30	92
Daily range (°F)	-	16 (M)
Wet bulb (°F)	-	78
Wind speed (mph)	15.0	7.5

Indoor:	**Heating**	**Cooling**
Indoor temperature (°F)	70	75
Design TD (°F)	40	17
Relative humidity (%)	50	50
Moisture difference (gr/lb)	35.4	55.5

Infiltration:
Method: Simplified
Construction quality: Tight
Fireplaces: 1 (Tight)

Construction descriptions	Or	Area ft²	U-value Btuh/ft²-°F	Insul R ft²-°F/Btuh	Htg HTM Btuh/ft²	Loss Btuh	Clg HTM Btuh/ft²	Gain Btuh
Walls								
STD - Basement Wall - R-13 - Framed: 8" Below Grade Concrete Wall, 2"x4" Walls,R-13 Cavity Insulation,1/2" Gypsum Board Finish	n	123	0.057	13.0	0	0	0	0
	e	97	0.057	13.0	0	0	0	0
	s	143	0.057	13.0	0	0	0	0
	w	97	0.057	13.0	0	0	0	0
	all	460	0.057	13.0	0	0	0	0
STD - Frame - R-13S: Stucco Ext, 1/2" Wood Shth, 2"x 4" Frm Wall, R-13 Cavity Insulation, 1/2" Gypsum Board	n	402	0.092	13.0	3.68	1479	2.35	943
	ne	17	0.092	13.0	3.68	63	2.35	40
	e	861	0.092	13.0	3.68	3168	2.35	2020
	s	405	0.092	13.0	3.68	1491	2.35	951
	w	840	0.092	13.0	3.68	3092	2.35	1971
	nw	17	0.092	13.0	3.68	64	2.35	41
	all	2542	0.092	13.0	3.68	9358	2.35	5965
Partitions								
(none)								
Windows								
U-32 SHGC-32: U-32 SHGC-32 - Windows; NFRC rated (SHGC=0.32); 8 ft head ht	n	96	0.320	0	12.8	1260	12.0	1164
	ne	12	0.320	0	12.8	154	26.3	316
	e	110	0.320	0	12.8	1403	36.1	3957
	s	114	0.320	0	12.8	1455	15.7	1761
	w	71	0.320	0	12.8	914	36.1	2578
	nw	12	0.320	0	12.8	154	26.3	316
	all	417	0.320	0	12.8	5339	24.3	10133
U-32 SHGC-32 GD: U-32 SHGC-32 - Glass Door; NFRC rated (SHGC=0.32); 8 ft head ht	s	20	0.320	0	12.8	257	15.7	315
	w	18	0.320	0	12.8	229	36.1	645
	all	38	0.320	0	12.8	486	25.3	960
U-32 SHGC-32: U-32 SHGC-32 - Windows; NFRC rated (SHGC=0.32); 6 ft overhang (1 ft window ht, 0 ft sep.); 8 ft head ht	w	3	0.320	0	12.8	38	12.0	36
U-32 SHGC-32: U-32 SHGC-32 - Windows; NFRC rated (SHGC=0.32); 6 ft overhang (6 ft window ht, 0 ft sep.); 8 ft head ht	w	18	0.320	0	12.8	230	16.4	295

wrightsoft Right-Suite® Universal 2015 15.0.11 RSU18198
...uction\Beazer Homes\V505 Plan\Beazer - V505.rup Calc = MJ8 Front Door faces: W

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Page 1

Results can help you make better decisions

Building Analysis
Entire House
Authority Air Designs, LLC.

Job: V505
Date: Feb 09, 2015
By: Joe Colburn
Plan: Beazer Homes

6808 W. 95th Place, Westminster, CO 80021-6422 Phone: (720) 354-8105 Email: Joe@AuthorityAir.com Web: www.AuthorityAir.com

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	Heating	Cooling
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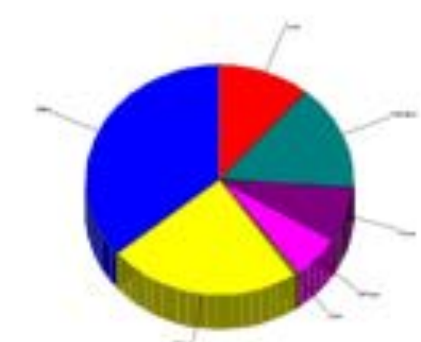
Indoor:

	Heating	Cooling
Indoor temperature (°F)	70	75
Design TD (°F)	40	17
Relative humidity (%)	50	50
Moisture difference (gr/lb)	35.4	55.5

Infiltration:
Method: Simplified
Construction quality: Tight
Fireplaces: 1 (Tight)

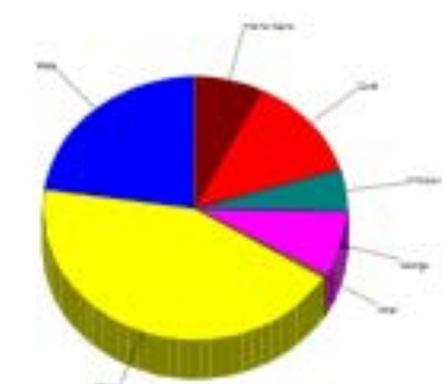
Heating

Component	Btuh/ft²	Btuh	% of load
Walls	3.1	9358	36.0
Glazing	12.8	6094	23.5
Doors	4.0	161	0.6
Ceilings	1.1	1572	6.1
Floors	1.3	2044	7.9
Infiltration	1.2	3851	14.8
Ducts		2899	11.2
Piping		0	0
Humidification		0	0
Ventilation		0	0
Adjustments		0	
Total		**25977**	**100.0**



Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	2.0	5965	22.7
Glazing	24.0	11424	43.4
Doors	3.0	123	0.5
Ceilings	1.4	2123	8.1
Floors	0	0	0
Infiltration	0.4	1355	5.2
Ducts		3398	12.9
Ventilation		0	0
Internal gains		1920	7.3
Blower		0	0
Adjustments		0	
Total		**26308**	**100.0**



Latent Cooling Load = 4042 Btuh
Overall U-value = 0.078 Btuh/ft²-°F

Data entries checked

2) Select the right equipment

ACCA Equipment Selection

Good System Selection

Heating and cooling systems come in specific sizes

(2, 2.5, 3 ton, or 45, 70, 90 Thousand BTUs for example)

- For heating it is acceptable to select a system that is within 110% -125% of the design load - slightly oversized
- For cooling choose a system that is between 90% - 110% of design load
- Other issues:
  - Equipment location (garage, attic, crawl…)
  - Blower type (ECM, PSC, HV…)
  - Filtration needs

Good System Selection

- Use manufacturer's technical manuals to match:
  - Required heat output
  - Required cooling output
    - Sensible & latent (moisture) loads
  - Fan / airflow delivery capacity and static pressure

*UH2C100A9V4V FURNACE COOLING AIRFLOW (CFM) AND POWER (WATTS) VS. EXTERNAL STATIC PRESSURE WITH FILTER											
OUTDOOR UNIT SIZE (TONS)	AIRFLOW SETTING	DIP SWITCH SETTING					EXTERNAL STATIC PRESSURE				
		SW 1	SW 2	SW 3	SW 4		0.1	0.3	0.5	0.7	0.9
2.5	LOW (350 CFM/TON)	ON	ON	OFF	ON	CFM WATTS	808 75	824 125	840 170	835 210	830 250
	NORMAL (400 CFM/TON)	ON	ON	OFF	OFF	CFM WATTS	938 100	963 160	959 205	964 255	975 310
	HIGH (450 CFM/TON)	ON	ON	ON	OFF	CFM WATTS	1058 150	1100 200	1121 265	1136 330	1142 395
3.0	LOW (350 CFM/TON)	OFF	ON	OFF	ON	CFM WATTS	1004 120	1010 175	1027 230	1044 285	1050 345
	NORMAL (400 CFM/TON)	OFF	ON	OFF	OFF	CFM WATTS	1141 170	1190 245	1214 310	1229 380	1234 450
	HIGH (450 CFM/TON)	OFF	ON	ON	OFF	CFM WATTS	1336 250	1375 330	1387 410	1388 480	1384 545
3.5	LOW (350 CFM/TON)	ON	OFF	OFF	ON	CFM WATTS	1153 180	1206 250	1230 320	1239 395	1244 460
	NORMAL (400 CFM/TON)	ON	OFF	OFF	OFF	CFM WATTS	1390 285	1418 465	1439 445	1441 515	1373 540
	HIGH (450 CFM/TON)	ON	OFF	ON	OFF	CFM WATTS	1575 400	1606 495	1632 590	1596 645	1445 590
4.0	LOW (350 CFM/TON)	OFF	OFF	OFF	ON	CFM WATTS	1388 290	1423 360	1444 440	1444 515	1390 540
	NORMAL (400 CFM/TON)	OFF	OFF	OFF	OFF	CFM WATTS	1610 415	1641 515	1666 635	1607 650	1449 595
	HIGH (450 CFM/TON)	OFF	OFF	ON	OFF	CFM WATTS	1847 630	1863 735	1816 780	1687 720	1532 665

NOTES: *First letter may be "A" or "T"

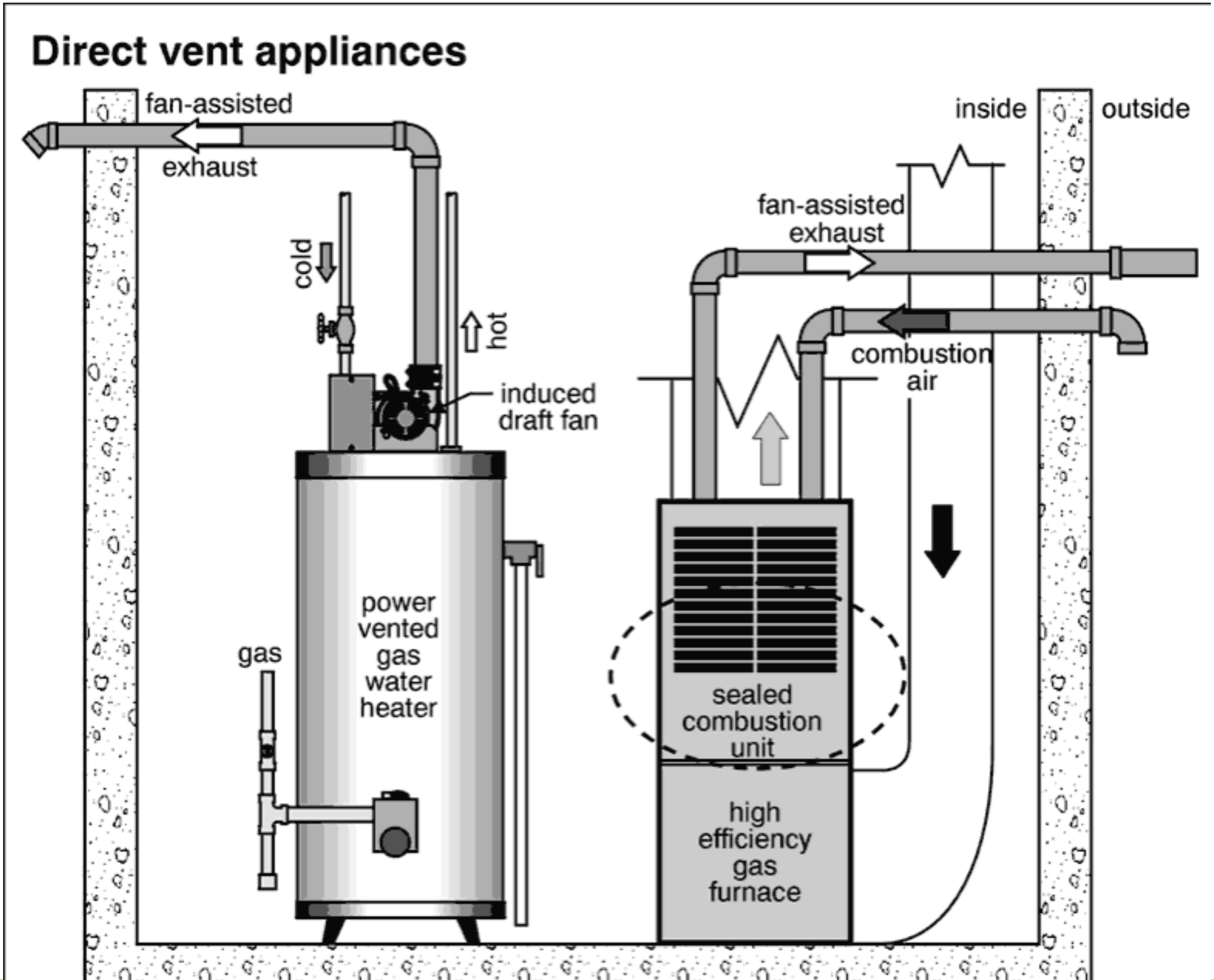
1. At Continuous fan setting: Heating or Cooling airflows are approximately 50% of selected cooling value.
2. LOW airflow (350 cfm/ton) is COMFORT & HUMID CLIMATE setting;
   NORMAL airflow (400 cfm/ton) is typical setting;
   HIGH airflow (450 cfm/ton) is DRY CLIMATE setting.

Use real fan specs.

Preferred furnace choices

- Sealed combustion chamber
- Venting system decoupled from house pressures
- Efficiencies of 90%+
- High efficiency blower motors - ECM
- Two/multi stage heating

Always Choose Direct Vent



LOW LOAD HOMES AND EQUIPMENT SELECTION

SINGLE STAGE

VS

2 STAGE

VS

FULL MODULATION

What's the difference???

Three-storey, town	Two-storey, detached	Single-storey, detached	Two-storey stacked back-to-back town
 Image used with builder's permission	 Image used with builder's permission	 Image used with builder's per	 ...e used with builder's permission
Description: • 1,600 sf on 3 floors plus basement • Front facing E (highest cooling) • Energy Star certified	**Description:** • 1,400 sf on 2 floors plus basement • Front facing W (highest cooling) • Energy Star certified	**Description:** • 1,300 sf bungalow plus basement • Front facing NW (highes... • Energy Star certified	...ription: ...00 sf on 2 floors ...nt facing SW (highest cooling); ...its A & B share an entrance ...ergy Star certified
Design Loads: (for mid unit)	**Design Loads:**	**Design Loads:**	...gn Loads: (for upper-mid unit)
Greater Toronto Area, ON DHL: 15,786 Btu/h DHG: 19,192 Btu/h	**Greater Toronto Area, ON** DHL: 16,547 Btu/h DHG: 18,556 Btu/h	**Greater Toronto A...** DHL: 20,335 Btu/h DHG: 19,354 Btu/h	**...onto Area, ON** ...6,901 Btu/h ...G: 13,850 Btu/h
Ottawa, ON DHL: 17,721 Btu/h	**Ottawa, ON** DHL: 18,573 Btu/h	**Ottawa, ON** DHL: 22,862 Btu/h	**...ttawa, ON** DHL: 7,984 Btu/h
Calgary, AB DHL: 19,817 Btu/h DHG: 18,118 Btu/h	**Calgary, AB** DHL: 20,738 Btu/h DHG: 17,375 Btu/h	**Calgary, AB** DHL: 25,601 DHG: 18,851 Btu/h	**Calgary, AB** DHL: 8,775 Btu/h DHG: 14,468 Btu/h
Saskatoon, SK DHL: 21,991 Btu/h DHG: 18,822 Btu/h	**Saskatoon, SK** DHL: 22,879 Btu/h DHG: 18,169 Btu/h	**Saskatoon, SK** DHL: 28,249 Btu/h DHG: 19,899 Btu/h	**Saskatoon, SK** DHL: 9,779 Btu/h DHG: 14,841 Btu/h

ZONE 6-7

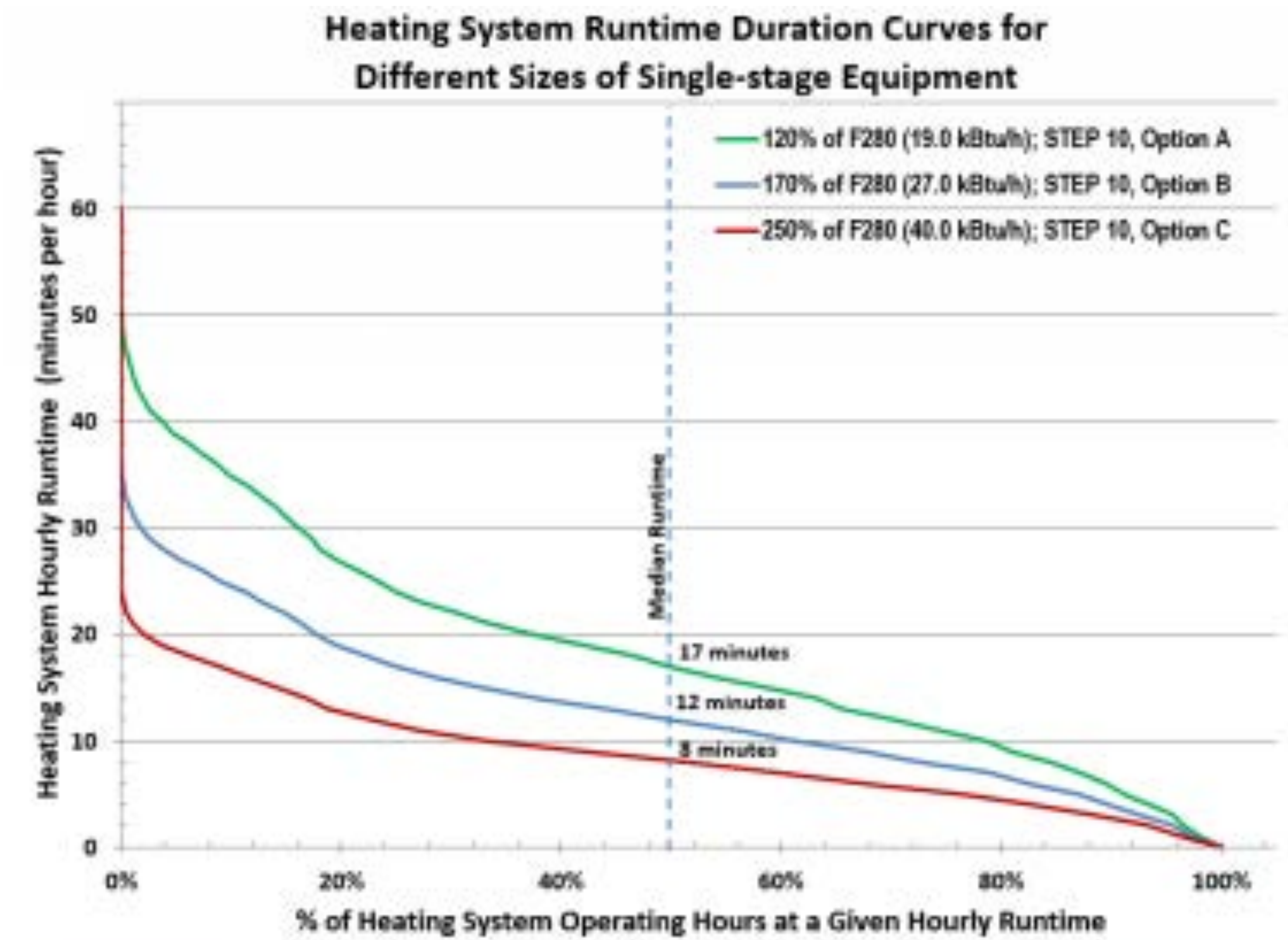


Figure 21: Runtime Duration Curves for Single-Stage Equipment

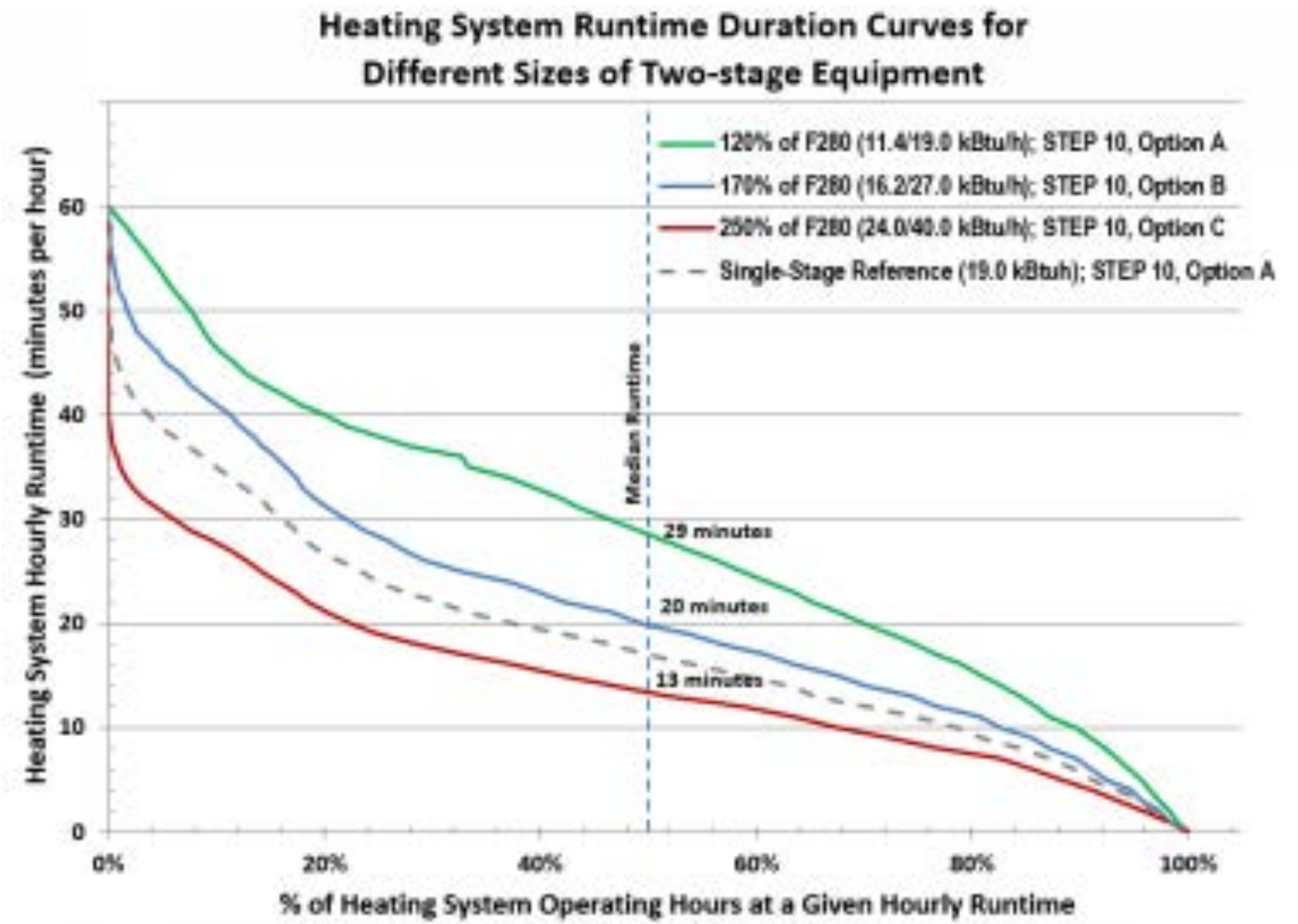


Figure 22: Runtime Duration Curves for Two-Stage Equipment

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

Preferred AC choices

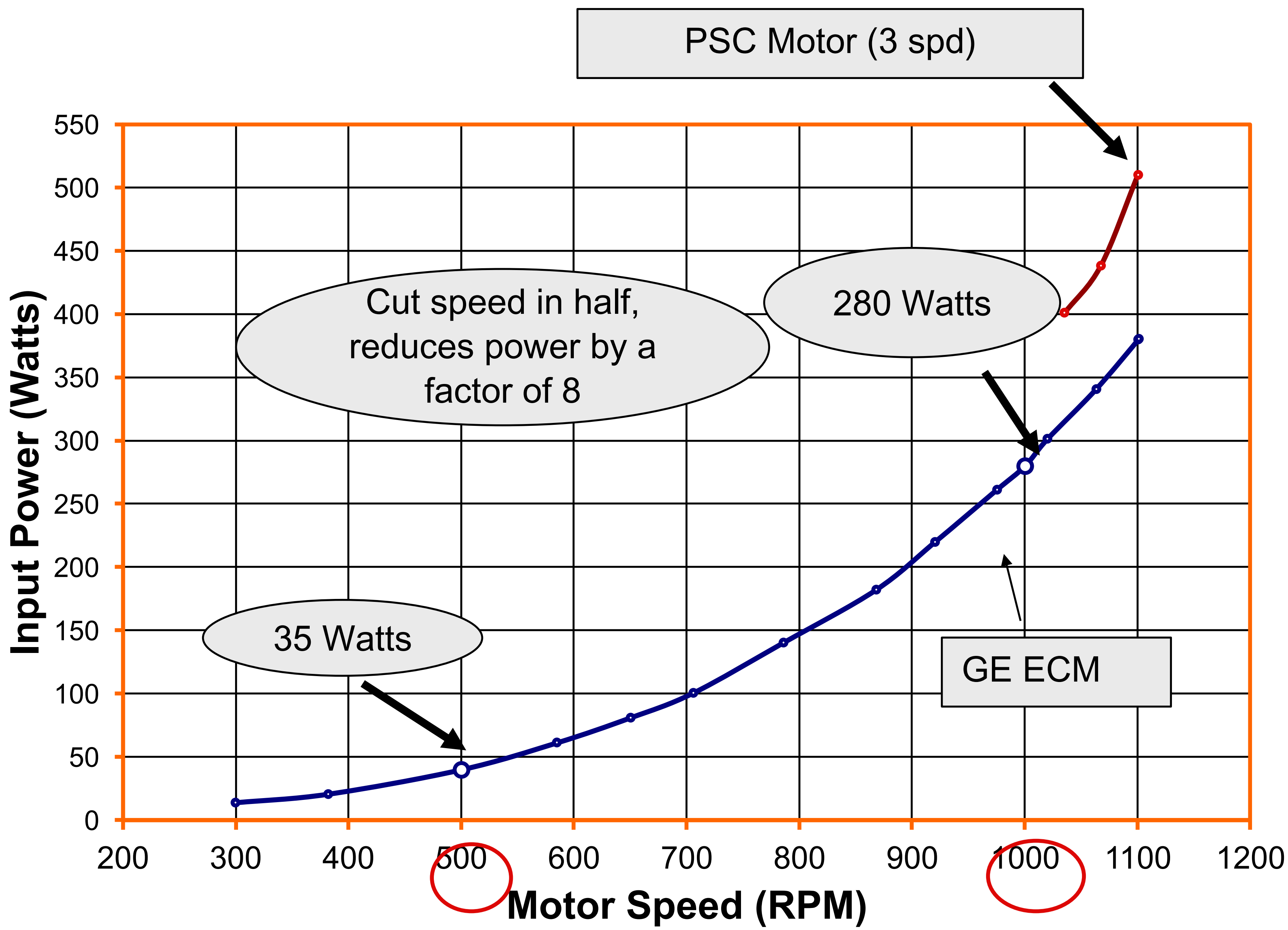
- Outdoor condenser matched to indoor coil
- SEER ratings of 14+
- High efficiency blower motors - ECM
- Two - stage cooling
- Dehumidification cycles
- Inverter for simple connection to solar

New Realities in HVAC Design & Performance

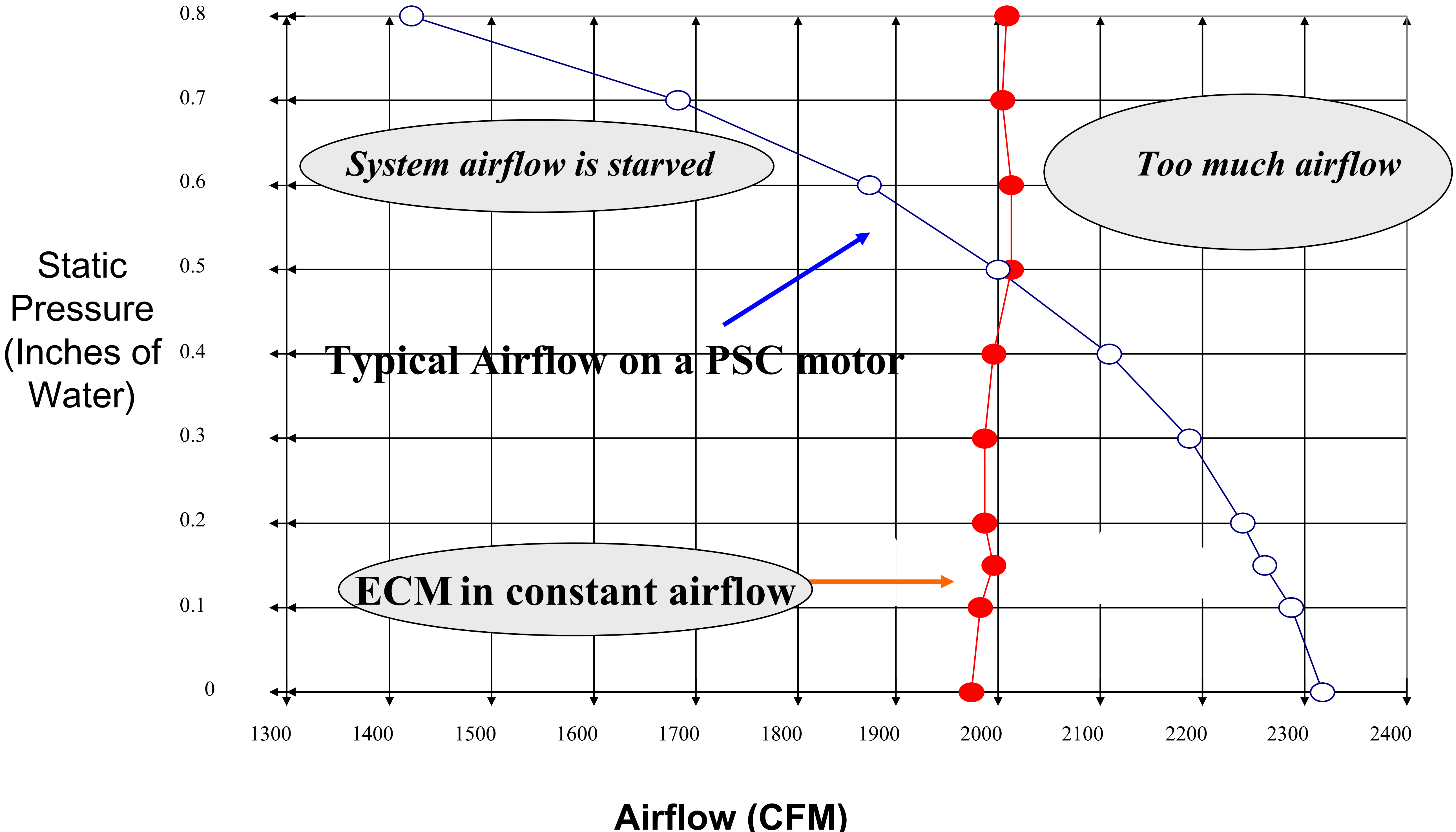
High Performance homes need more efficient motors!

- Capable of meeting small loads, part loads and full loads!
- Use 1/5 of original PSC motor types.
- Run efficiently at a variety of speeds (Modulation)
- Equipment lasts longer
- Enables balanced temperatures throughout home
- Enhances Ventilation "Effectiveness"

ECM Product Features: Efficiency

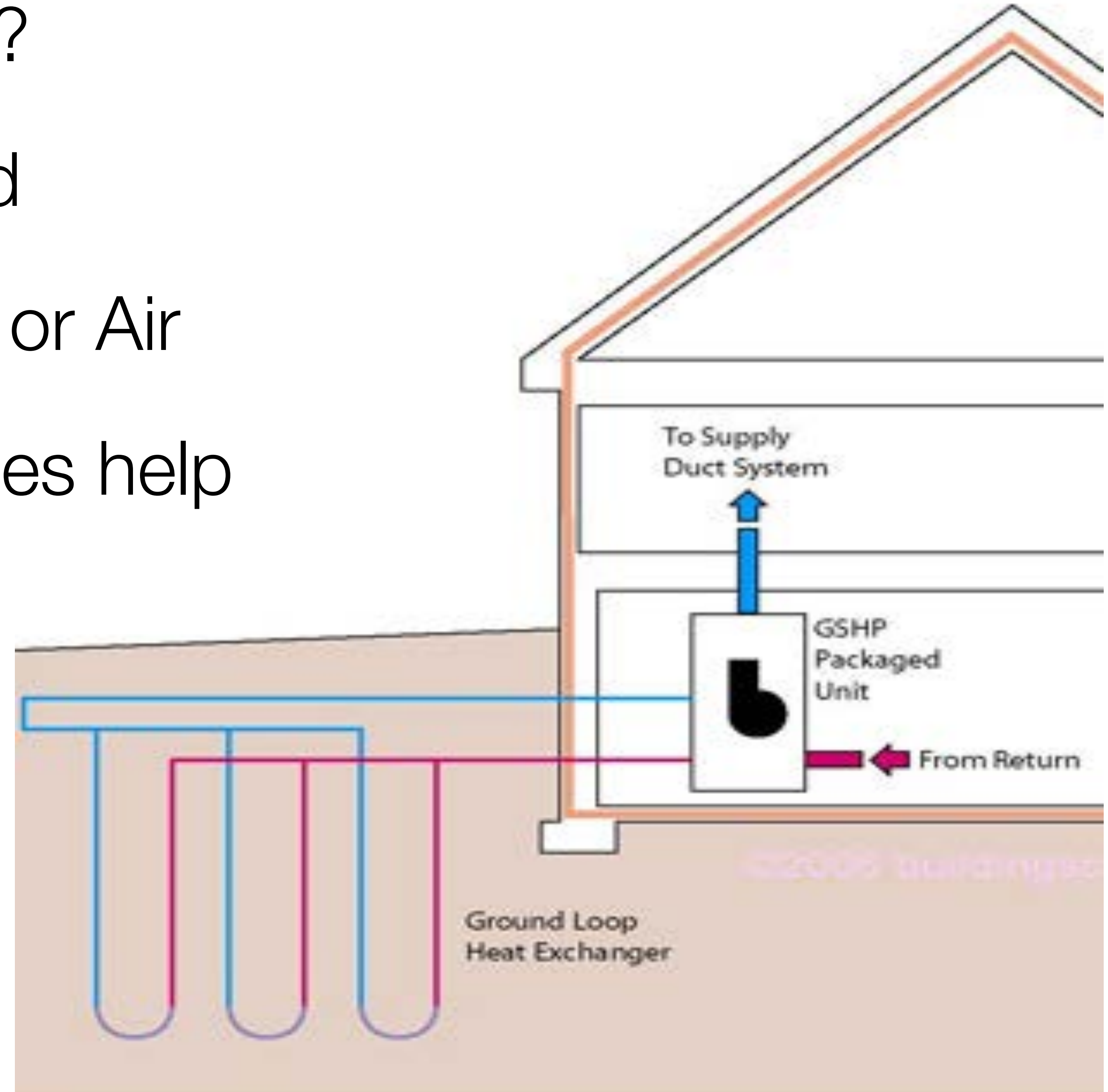


ECM Product Features: Constant Airflow



What about Heat Pumps?

- Is it the first thing to do?
- Reliance on electric grid
- Can do Ground, Water or Air
- High Performance homes help reduce capital cost



Energy Efficiency

- Heat pumps are hard to overlook
- Low ambient temperature units: COPs of 2 to 4
- Be mindful of HSPF rating points and operating conditions – cold weather:
- Zone 5+ + 8.6 HSPF+
- Dual Fuel /Auxillary back up as gas vs electric.

HVAC NET ZERO HOME LESSONS LEARNED: EQUIPMENT

- Enables "smart" use of Electrical or Gas
- Balance point can be either Operational OR Economic
- Provides resilience

HVAC NET ZERO LESSONS LEARNED:
Low loads change the game.
Low ambient heat pump study

	Manufacturer	EnerGuide	Test	Season
ASHP				
Seasonal Energy Efficiency Ratio (SEER)	16	>=14	18	Cooling
Coefficient of Performance (COP)	2.75	2.05	3.23	Heating
GSHP				
Seasonal Energy Efficiency Ratio (SEER)	12.9	>=14.1	19.7	Cooling
Coefficient of Performance (COP)	3.0	>=3.3	3.44	Heating

Select Heat Pumps for both Cooling & Heating Capacity

MUZ-HM24NA2

Outdoor unit model			MUZ-HM24NA2
Capacity Rated (Minimum~Maximum)	Cooling ※1	Btu/h	22,500 (5,800 ~ 22,500)
	Heating 47 ※1	Btu/h	26,000 (5,400 ~ 26,000)
Capacity Rated (Maximum)	Heating 17 ※2	Btu/h	18,500 (18,500)
Power consumption Rated (Minimum~Maximum)	Cooling ※1	W	2,575 (275 ~ 2,575)
	Heating 47 ※1	W	2,445 (265 ~ 2,445)
Power consumption Rated (Maximum)	Heating 17 ※2	W	2,245 (2,245)
EER ※1 [SEER] ※3	Cooling		8.6 [18.0]
HSPF IV ※4	Heating		8.5
COP	Heating ※1		3.05
Power factor	Cooling (208/230)	%	99/99
	Heating (208/230)	%	99/99

New Low Temperature Heat Pumps can be very effective - when properly sized and selected

Cooling Capacity Btu/h	EER	SEER	Heating Capacity Btu/h		COP	HSPF
95°F			47°F	17°F	47°F	
18,000	12.50	18.0	22,000	13,900	3.44	9.3
18,000	12.10	16.0	22,000	13,900	3.52	9.0
18,000	12.30	17.0	22,000	13,900	3.48	9.2
18,000	12.50	18.0	22,000	13,900	3.67	9.0
22,000	12.50	18.0	24,000	14,100	4.04	9.5
22,000	10.60	15.5	24,000	14,100	3.42	9.0
22,000	11.55	16.8	24,000	14,100	3.74	9.3
35,200	8.80	16.0	36,400	22,000	3.56	9.4
33,800	8.10	14.5	36,400	21,200	3.08	8.7
34,400	8.45	15.3	36,400	21,600	3.32	9.1

Select Heat Pump Capacity based on Outside Temperature

Outdoor Temp (°FWB)	Capacity (Btu/h)	Input (Watts)	COP
60	45,980	3,811	3.5
55	41,040	3,650	3.3
50	39,710	3,521	3.3
45	38,608	3,295	3.4
40	38,000	3,230	3.4
35	38,000	4,038	2.8
30	38,000	4,684	2.4
25	38,000	5,168	2.2
20	38,000	5,491	2.0
15	38,000	5,749	1.9
10	38,000	5,911	1.9
5	38,000	6,040	1.8
0	35,720	6,105	1.7
-5	33,820	6,072	1.6
-10	31,920	6,137	1.5
-15	29,640	6,202	1.4
-20	27,360	6,234	1.3
-25	25,080	6,266	1.2
-30	22,800	6,299	1.1
-35	20,520	6,331	0.9

* Above numbers are approximated

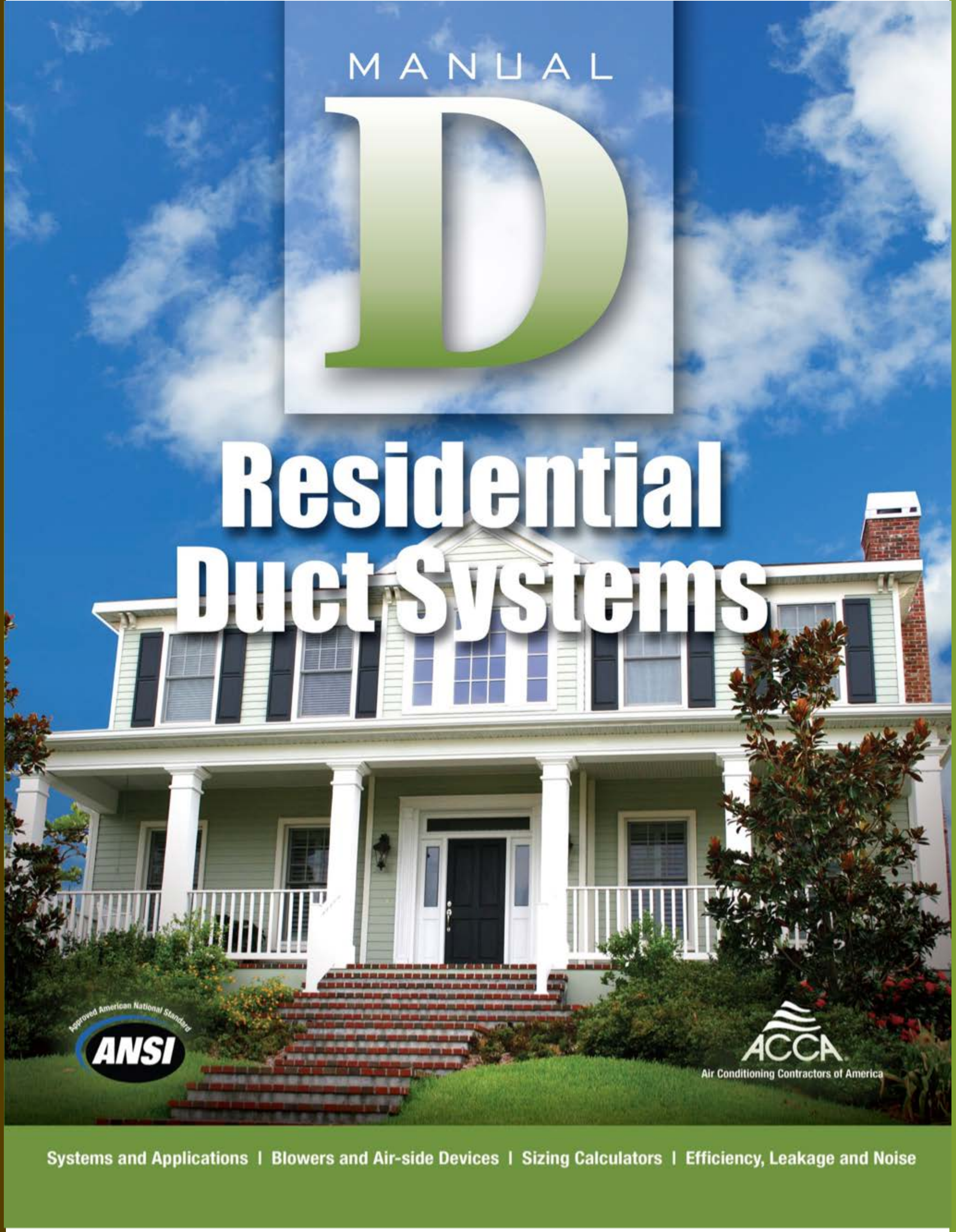
Example of a different strategy
- Ductless opportunities

- Provides zoning
- Can target specific high load areas

Mini-Split Systems - with Low Temp. capabilities

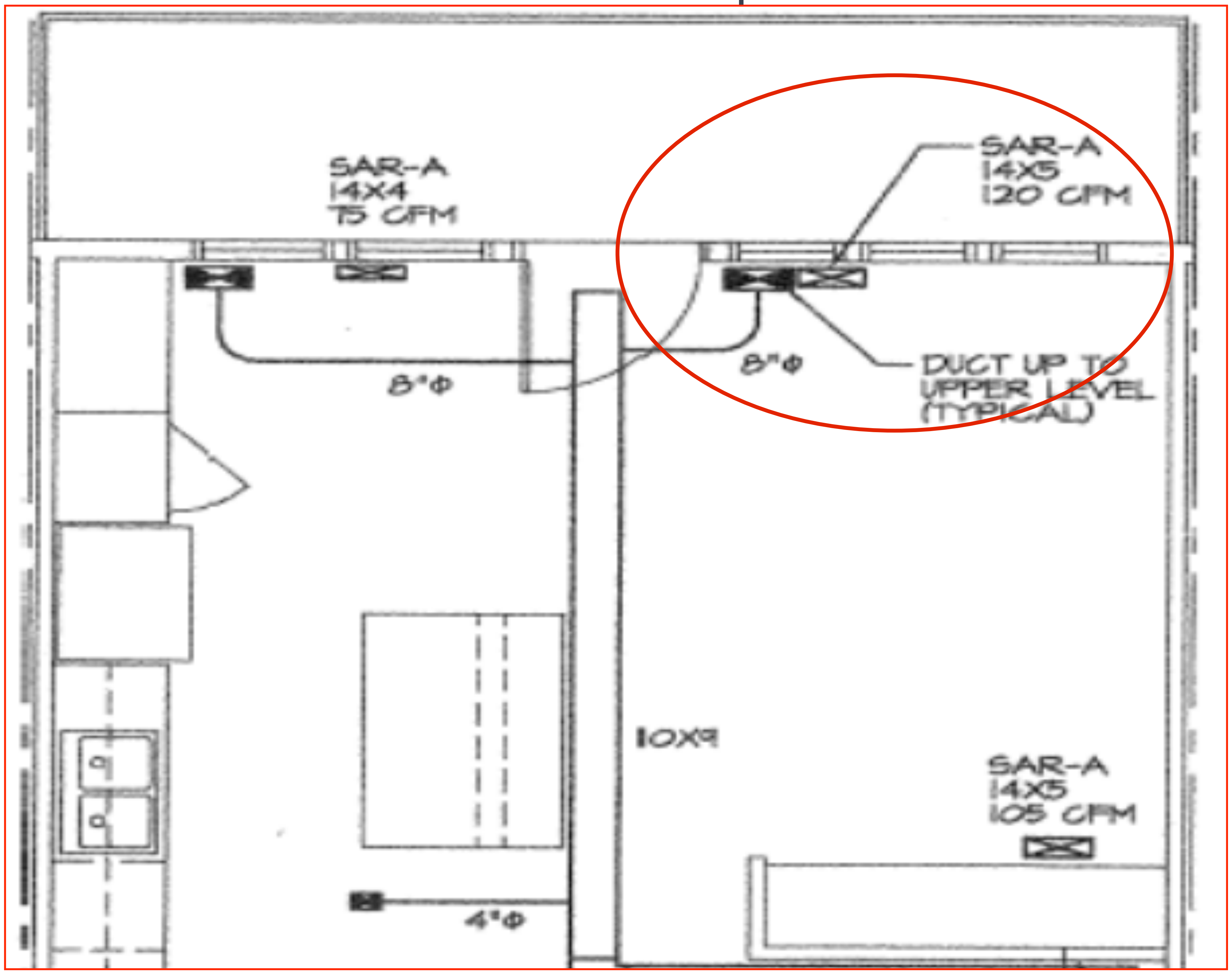
- In very high performance homes, it could provide all heating & cooling needs

3) Design the ducts correctly



ACCA Duct Design

Manual D provides a duct sizing schedule to deliver the air to the space intended



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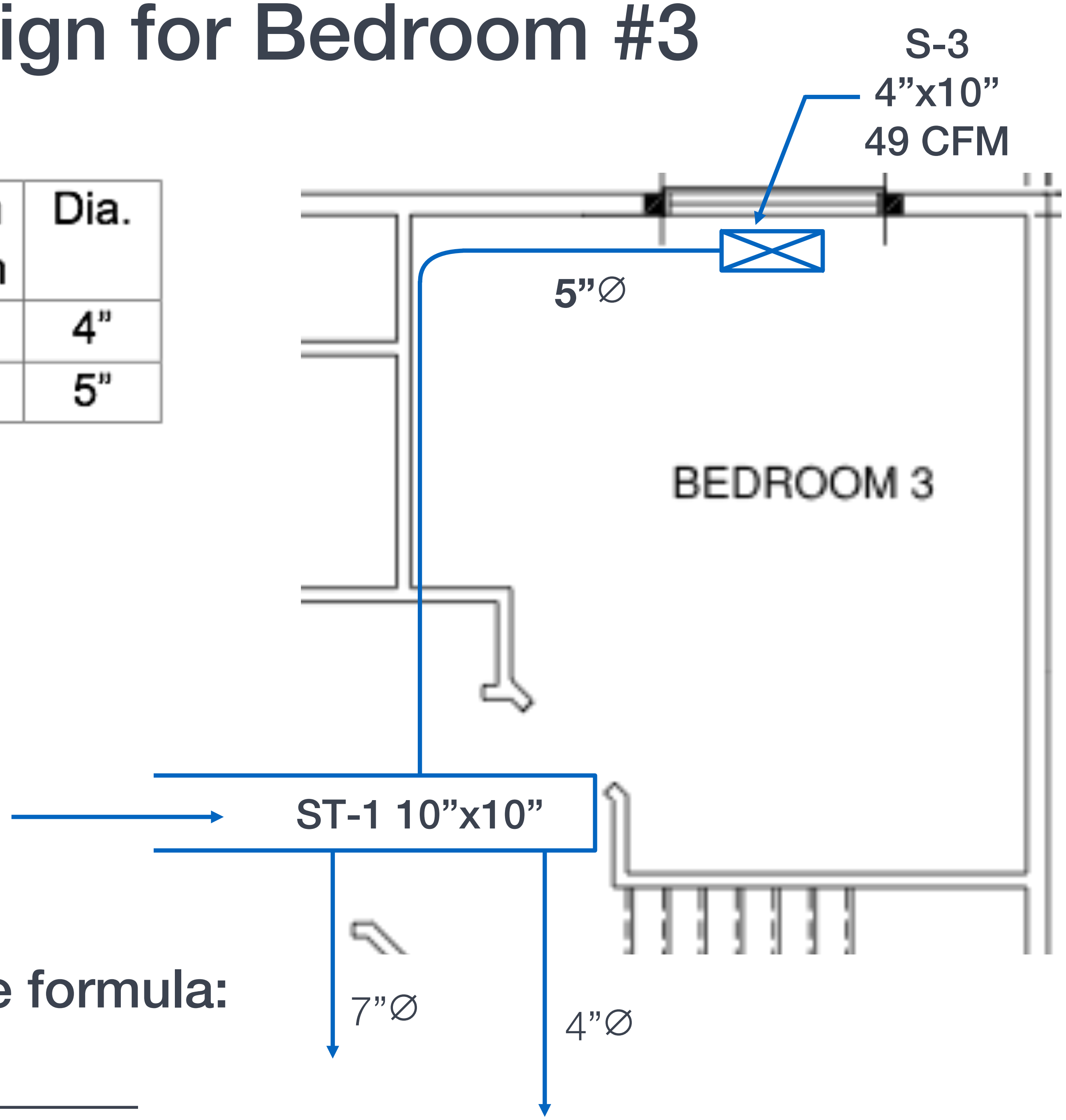
Name		Design (Btuh)	Htg (cfm)	Clg (cfm)	Design FR	Diam (in)	Rect Size (in)	Duct Matl	Actual Ln (ft)	Ftg.Eqv Ln (ft)	Trunk
Opt Bedroom	c	830	46	50	0.429	4	0x 0	ShMt	19.8	60.0	
Opt Bedroom-A	c	830	46	50	0.205	4	0x 0	ShMt	27.3	140.0	st1
Great Room	c	2395	121	144	0.242	6	0x 0	ShMt	21.8	120.0	st2
Master Bedroom-A	c	1679	72	101	0.092	6	0x 0	ShMt	60.6	310.0	st3
Master Bedroom	c	1679	72	101	0.123	6	0x 0	ShMt	29.5	250.0	st23
Master Bath	h	2000	61	50	0.134	5	0x 0	ShMt	35.4	220.0	st21
Bath	h	531	16	13	0.102	4	0x 0	ShMt	32.6	305.0	st18
Bedroom 2	c	1854	93	111	0.087	6	0x 0	ShMt	74.6	320.0	st16
Stairs/Hall Up	h	1323	41	35	0.085	4	0x 0	ShMt	40.9	360.0	st14
Bedroom 3	c	1977	88	119	0.094	6	0x 0	ShMt	50.3	315.0	st5
WIC	h	392	12	9	0.138	4	0x 0	ShMt	28.3	220.0	st20
Dining Room	c	891	45	54	0.130	4	0x 0	ShMt	17.9	245.0	st6
Living Room	h	3264	100	94	0.102	6	0x 0	ShMt	55.6	280.0	st10
Opt Bedroom 2	h	2271	70	63	0.098	5	0x 0	ShMt	55.8	295.0	st12
Powder	h	641	20	19	0.102	4	0x 0	ShMt	36.1	300.0	st7
Foyer/Stairs	c	890	53	53	0.084	5	0x 0	ShMt	42.8	365.0	st8
Opt Bath	h	330	10	1	0.129	4	0x 0	ShMt	30.3	235.0	st17
Opt Rec Room	h	1945	60	32	0.143	4	0x 0	ShMt	9.6	230.0	st19
Kitchen	h	2345	72	40	0.293	4	0x 0	ShMt	7.0	110.0	st2
Opt Rec Room-A	h	1945	60	32	0.128	5	0x 0	ShMt	23.7	245.0	st6
Laundry	h	1362	42	29	0.103	4	0x 0	ShMt	32.2	300.0	st7

Example- Duct Design for Bedroom #3

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



The air required is calculated by the formula:

$$CFM = \frac{BTU/hr}{1.1 \times \text{Temp. rise across furnace}}$$

Heat & **Air** Distribution

BTU/hr Carrying Capacity

Duct size	Airflow CFM	25 ^{0}F Cooling	45 ^{0}F Heating	55 ^{0}F Heating
4"	30-40	800 -1100	1485 -1980	1815 - 2420
5"	50-60	1300 -1650	**2375 - 3960**	3025 - 3630
6"	90-110	2475 -3025	4455 - 5445	5445 - 6710

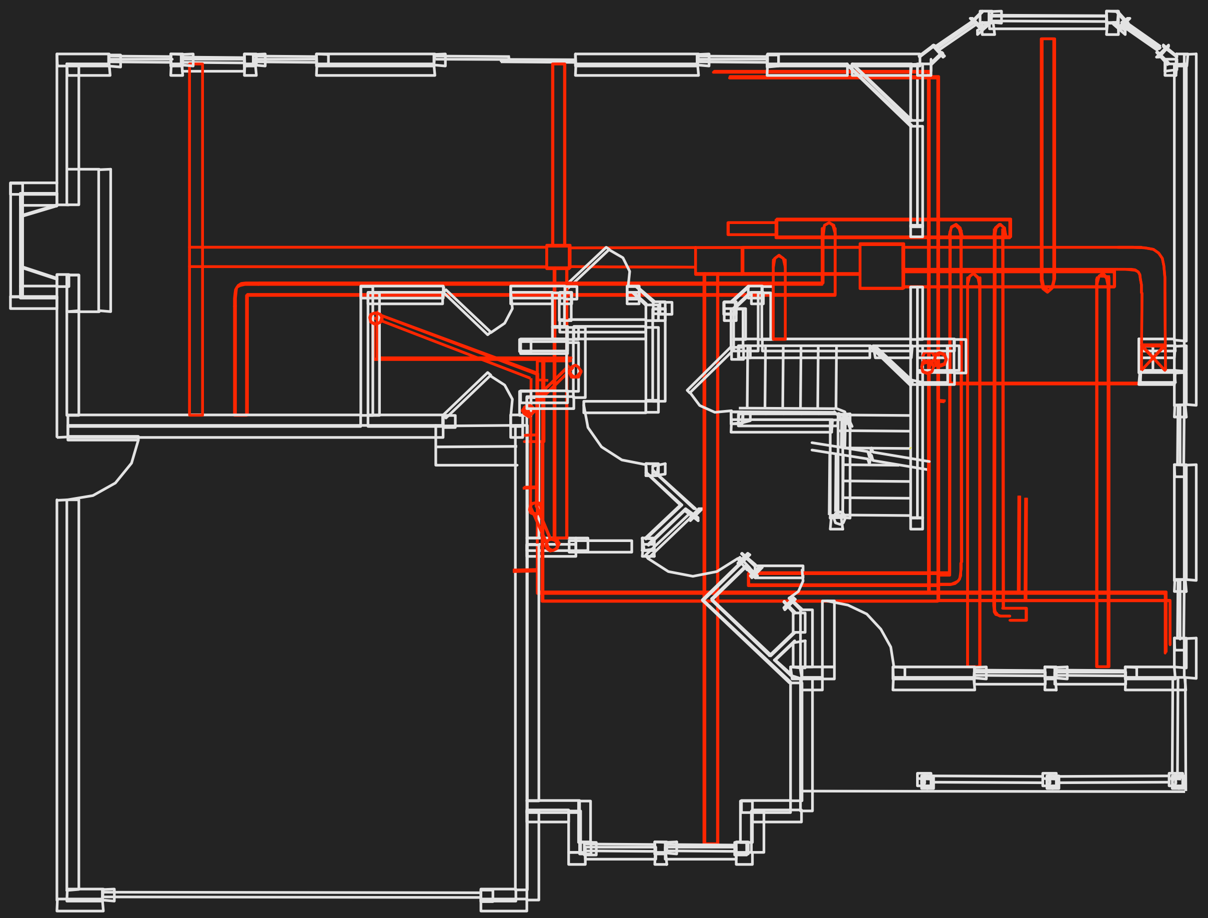
ZERH = LOW LOAD HOMES DISTRIBUTION SIZING AND SELECTION

	1990 Code	IECC 2012	ZERH
Load	70,000 BTUs 3.0 tons	36,000 BTUs 2.0 tons	26,000 BTUs 1.5 tons
Air Flow	1200 CFM	750 CFM	600 CFM
Duct sizes • **Mains** • **Branch**	 8"x28" 5" – 6"	 8" x 18" 5"	 8" x 12" 3"- 4"

Distribution Systems

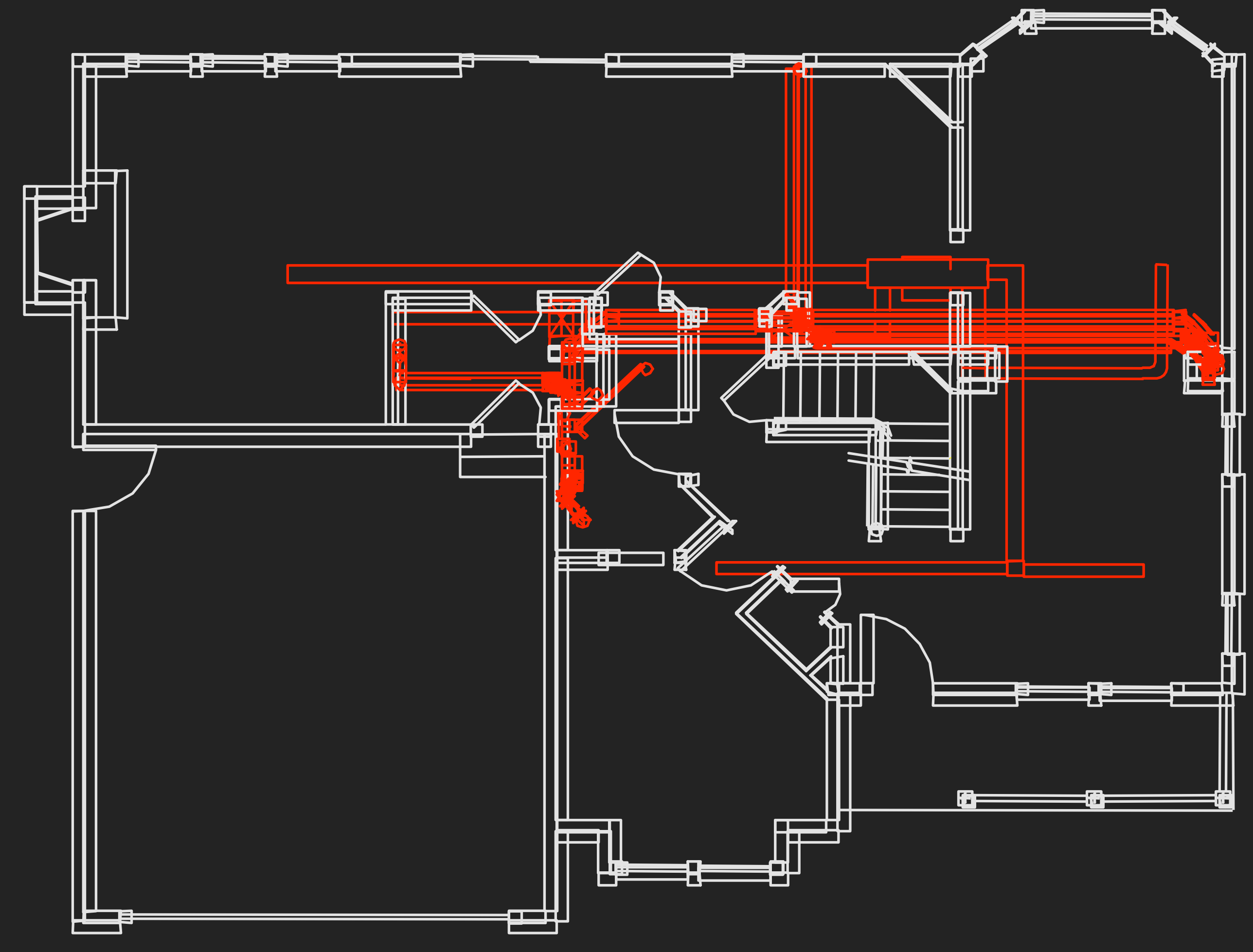
- HVAC contractor must use the heat loss/gain calculations to properly size duct work
  - It is critical to consider the entire system and process.
    - Layout & location of distribution system
    - Materials used - flexible duct or sheet metal, insulated or non-insulated
    - Impact on pressurization of rooms or spaces
    - Effective occupant comfort control

HVAC by Design



Traditional

- Properly size system
- Optimize duct layout



Advanced

Ducts & equipment in conditioned space

- A closet & dropped ceiling
- Use direct vent equipment

Ducts in conditioned space will be cooler in summer, warmer in winter

Conditioned attics are an option

Place the ducts in conditioned space

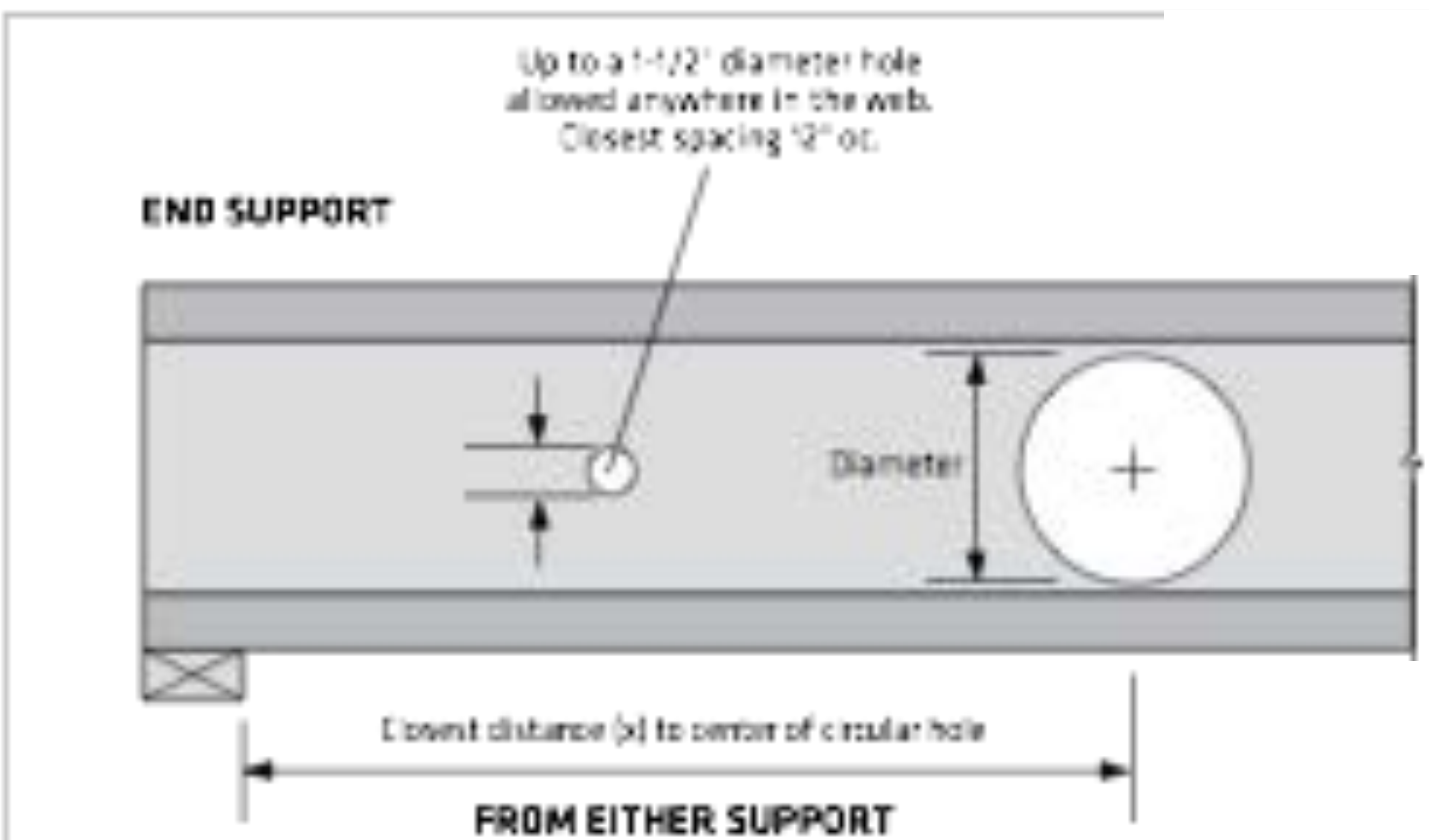
A dropped ceiling in the hallway can be effective

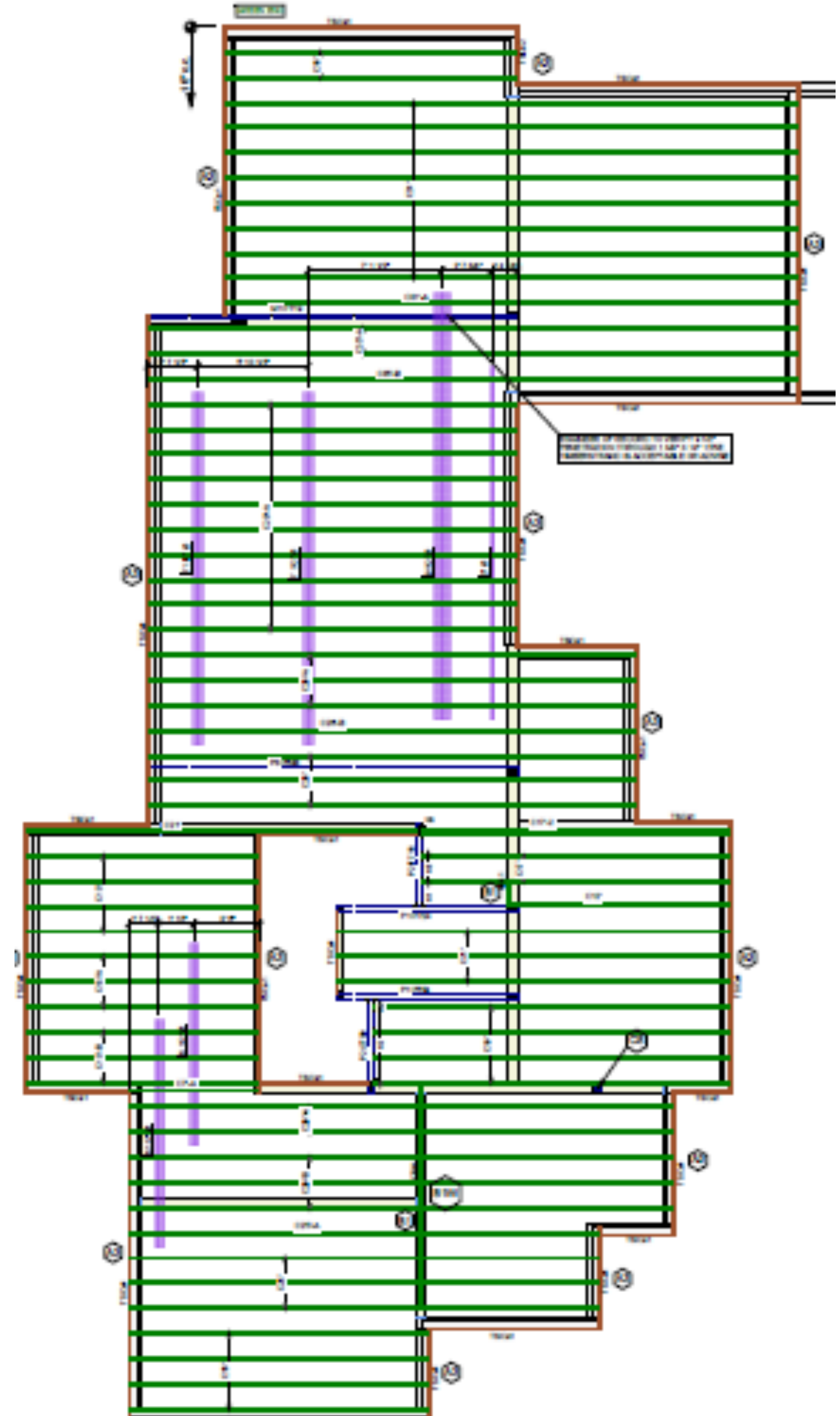

Ducts are now properly insulated and any duct leakage is to the interior

Properly sized and located grilles “throw” air to the perimeter windows and walls

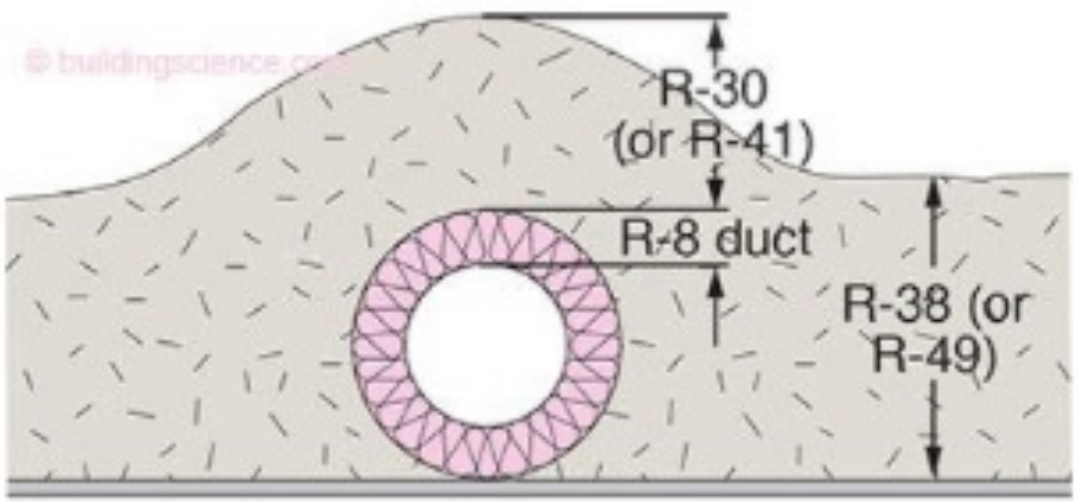
Open web floor joist systems

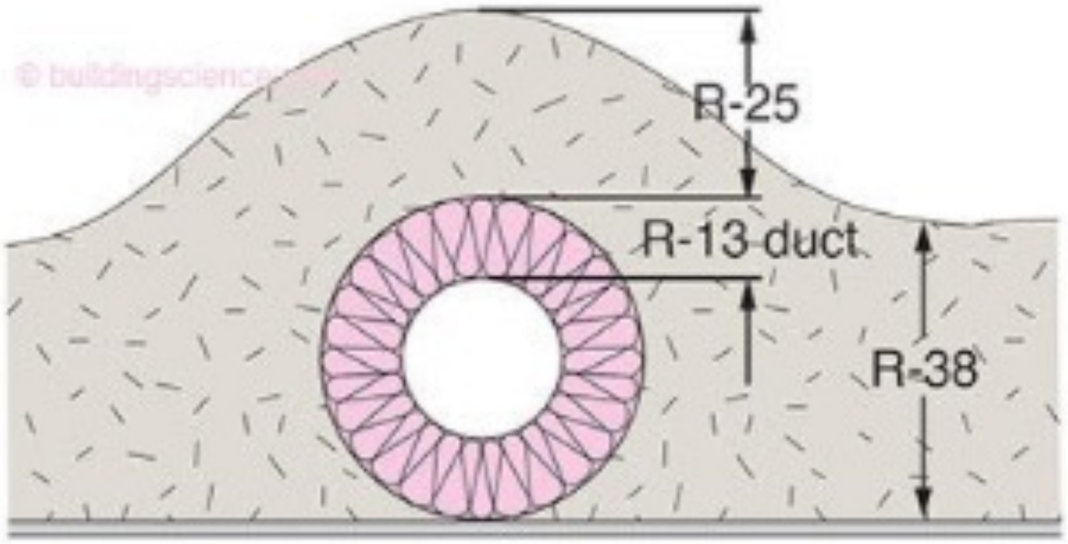
Layout your floors to accommodate duct





Buried Ducts are an Option



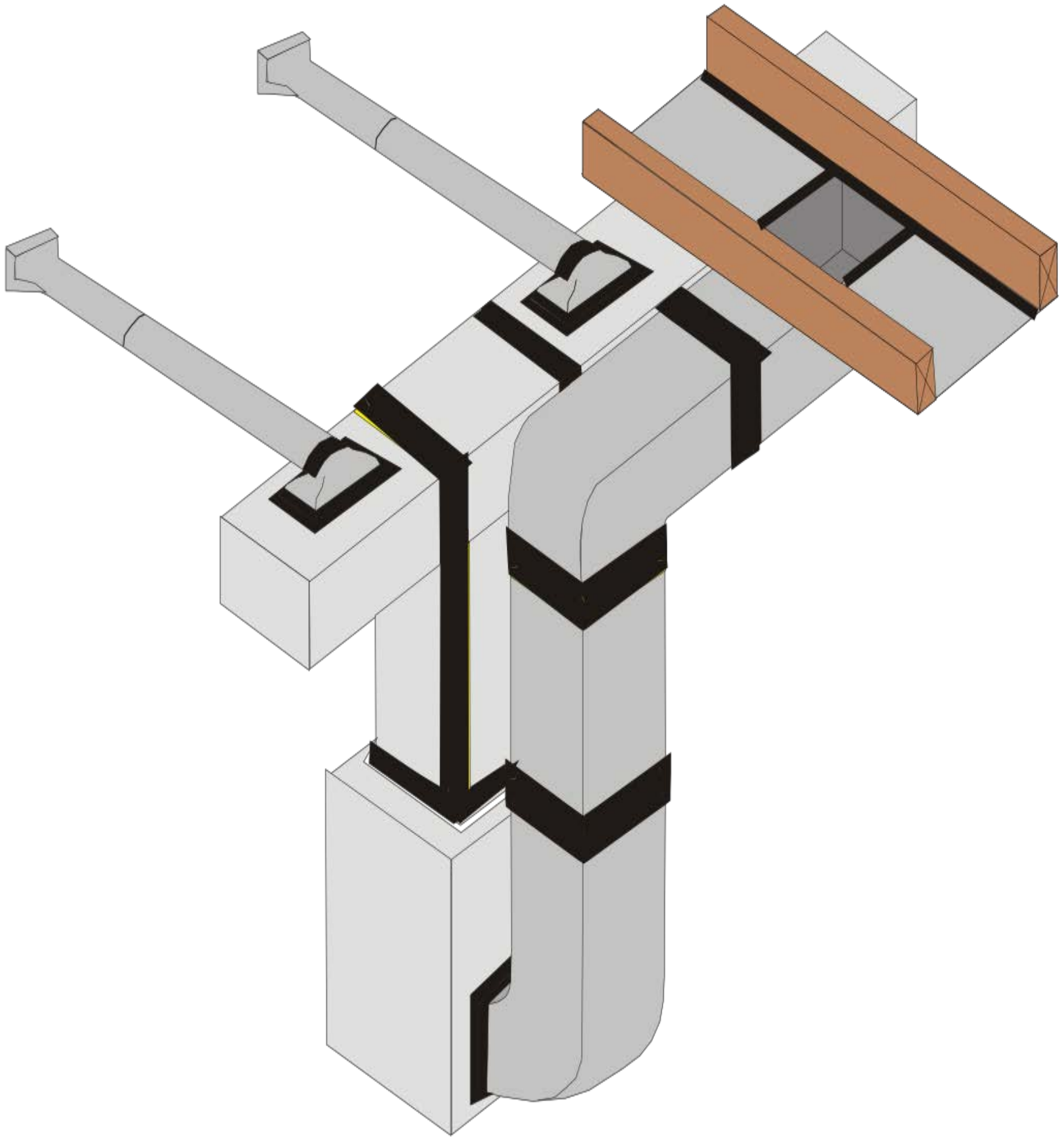


Seal Ducts

Mastic with a brush is quickest & best

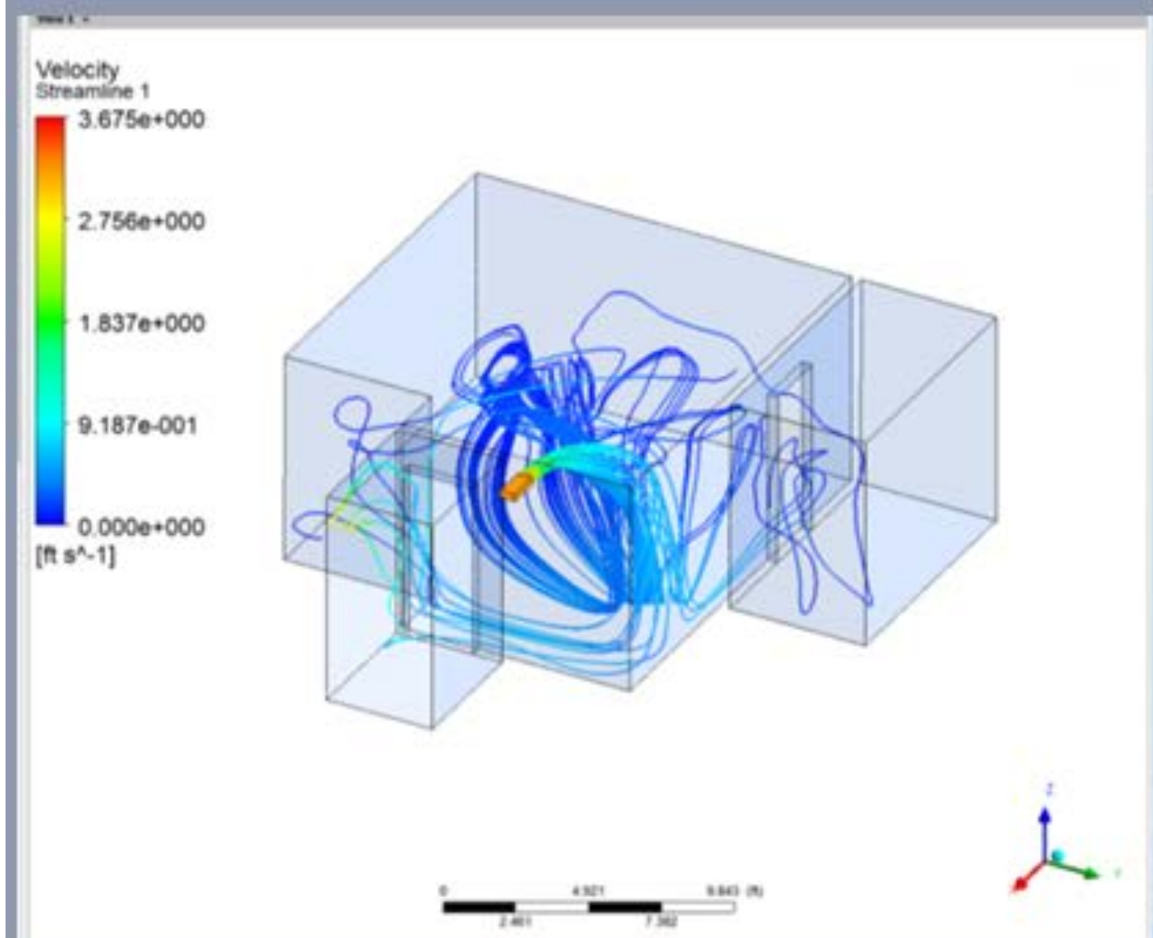
Sealing Ducts Matters!!!

- Getting air where you need it
- Allowing balancing & seasonal adjustment to work
- Empowers zoning to work

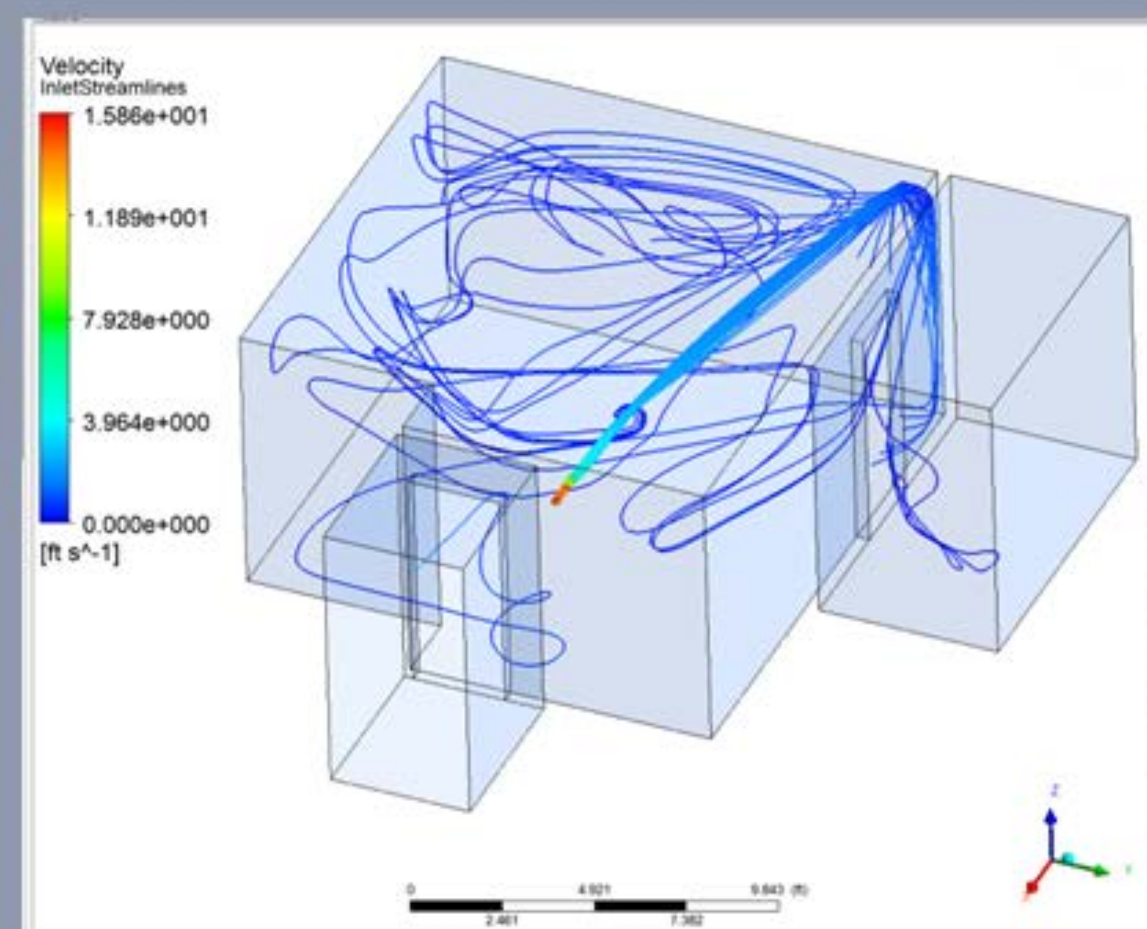


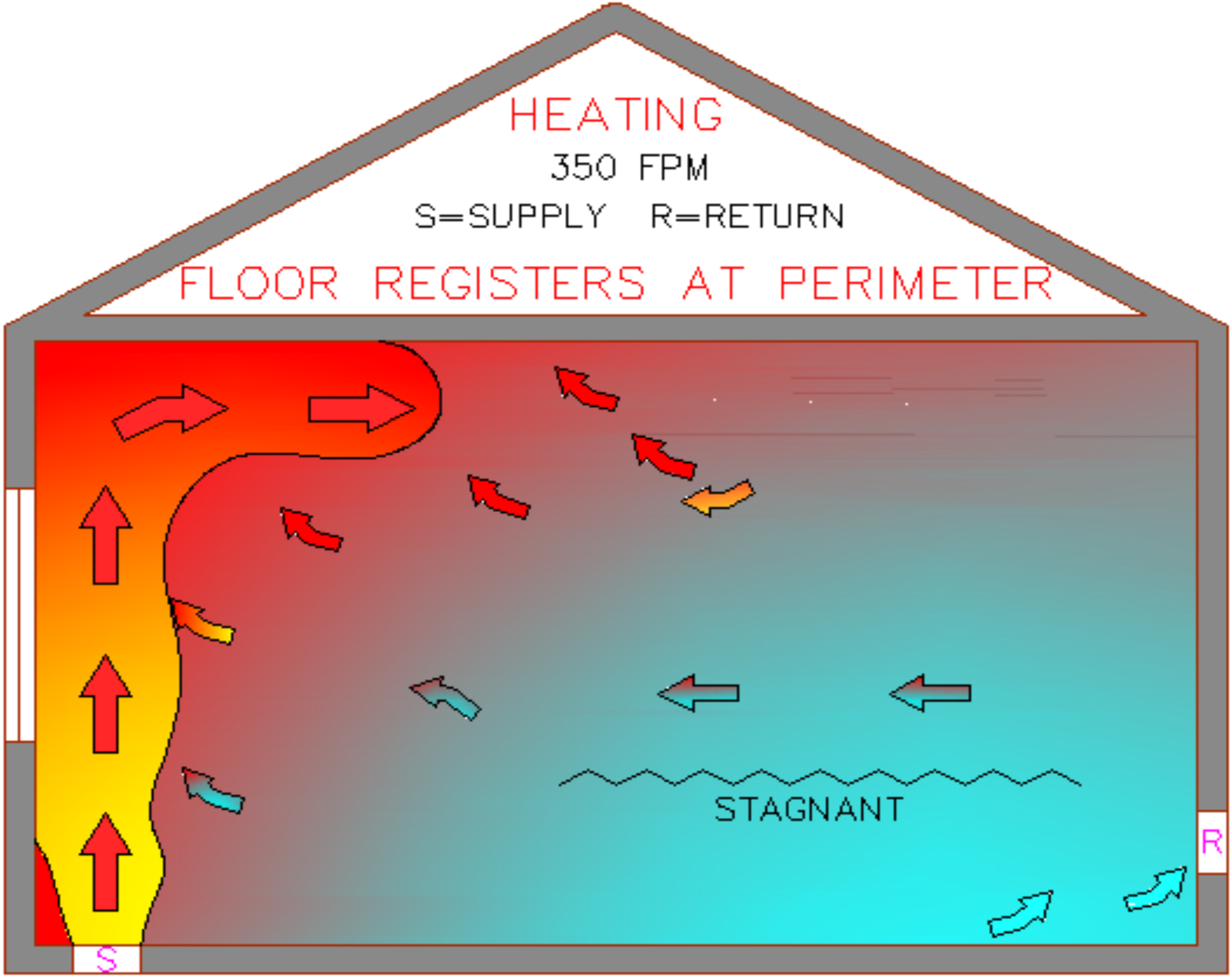
Low Load Homes suffer from lack of air flow-THROW and MIXING! (Not lack of Returns)

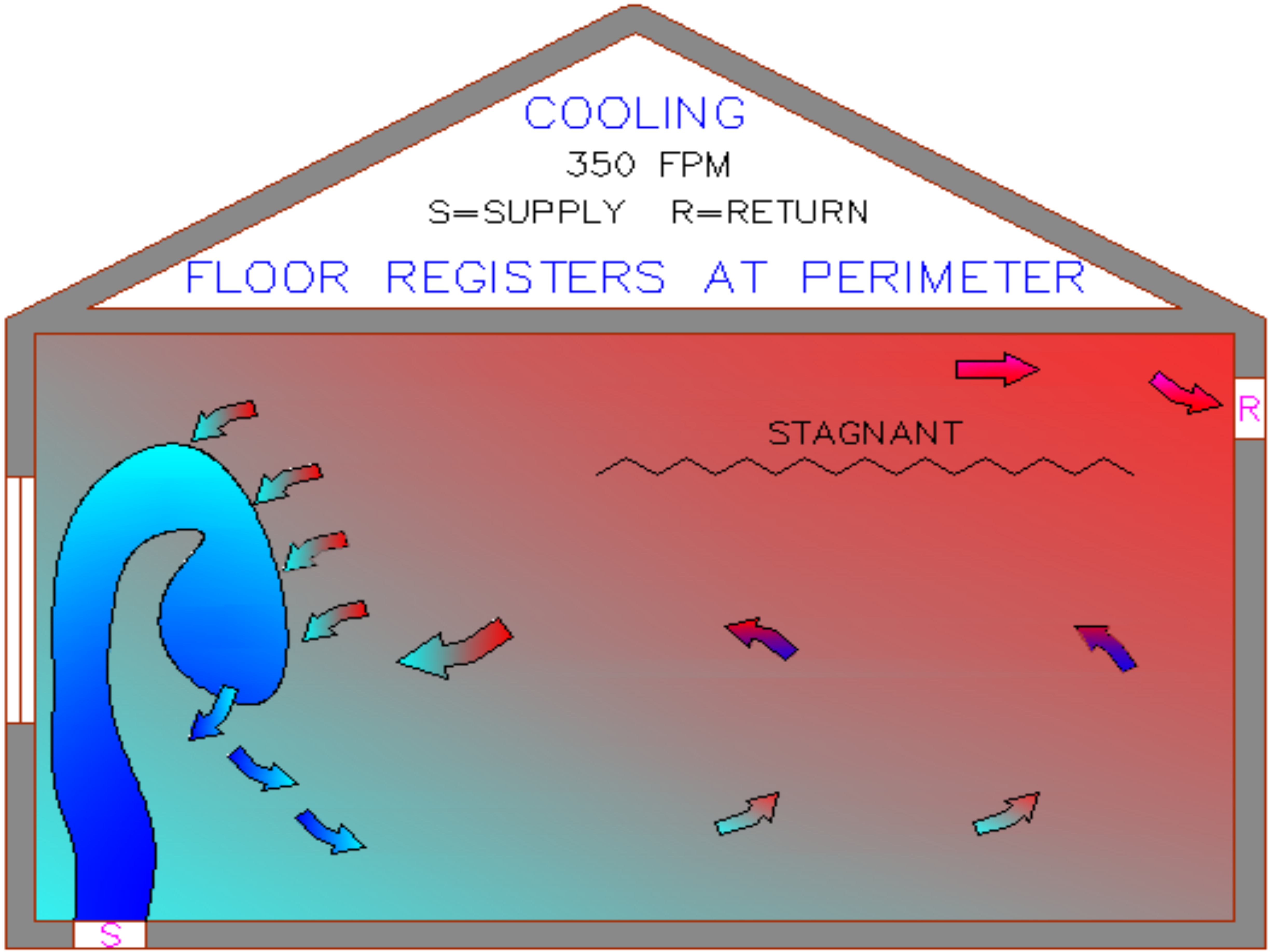
Standard register



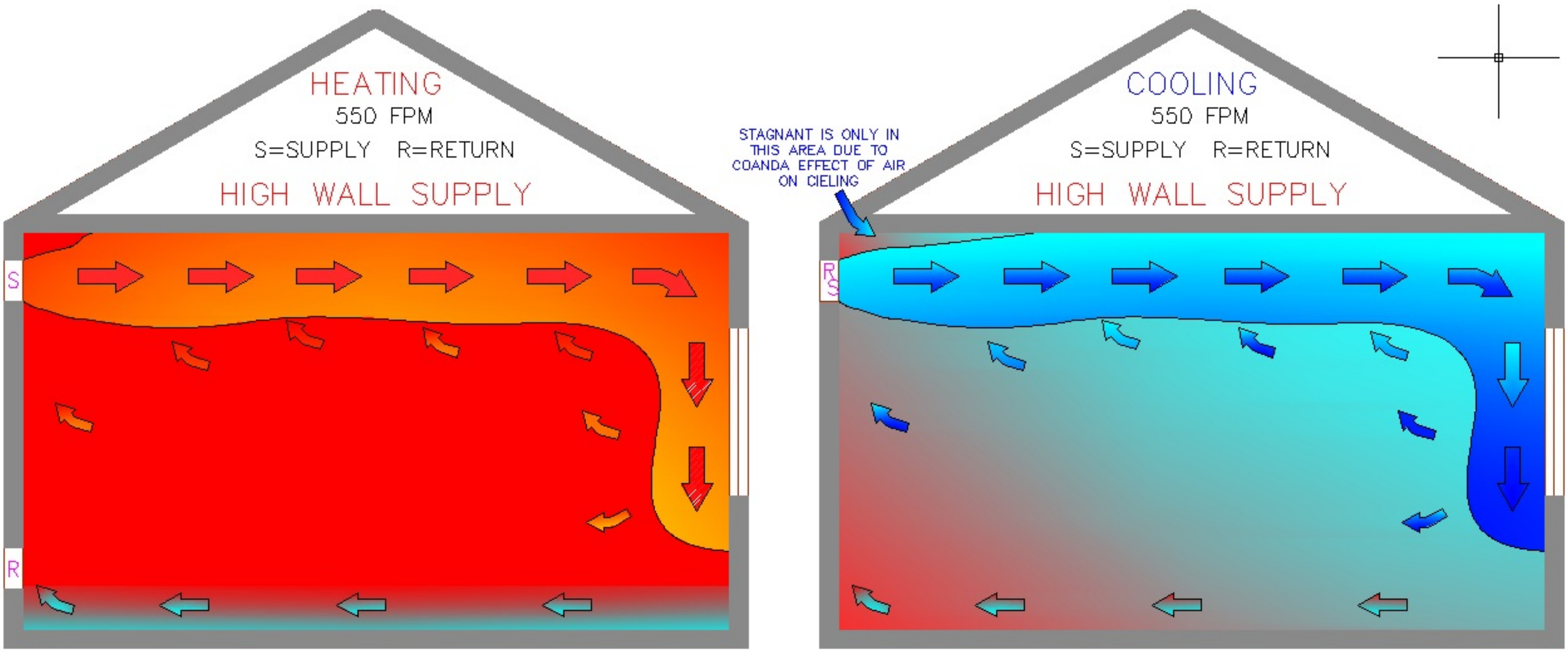
Small diffuser




HEATING
350 FPM
S=SUPPLY R=RETURN
FLOOR REGISTERS AT PERIMETER
STAGNANT
S
R


COOLING
350 FPM
S=SUPPLY R=RETURN
FLOOR REGISTERS AT PERIMETER
STAGNANT
R
S

Choose Proper Diffusers with Velocity and “Throw” in Mind



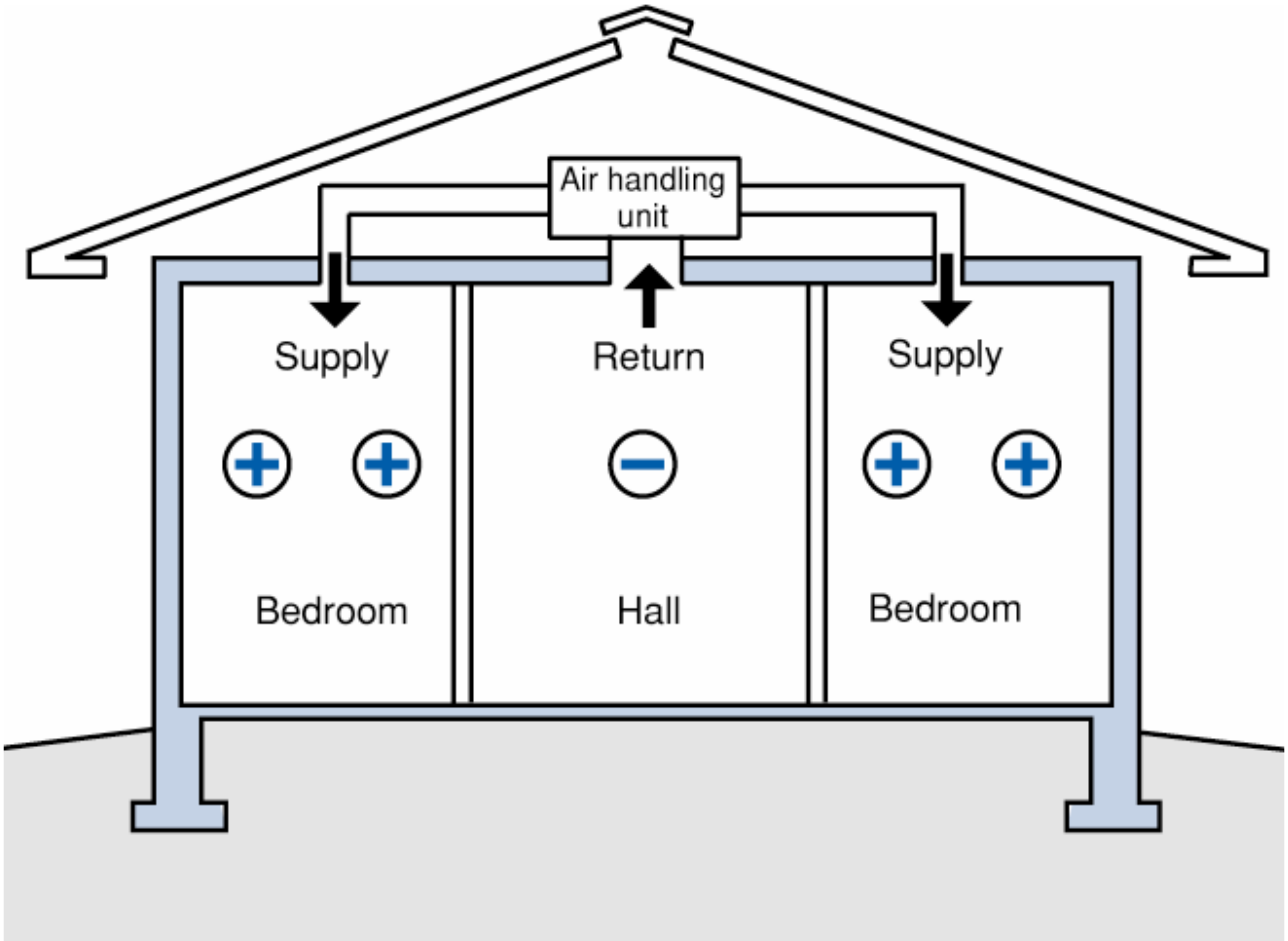
Zoning is becoming (almost) a requirement in some low load home designs

- Matching seasonal load adjustments
- Example – basements
- Accurate delivery of part loads in 3 story higher density townhome designs
- Making best use of equipment capacity
- Efficiency and cost savings? Cooling = 20% savings - +

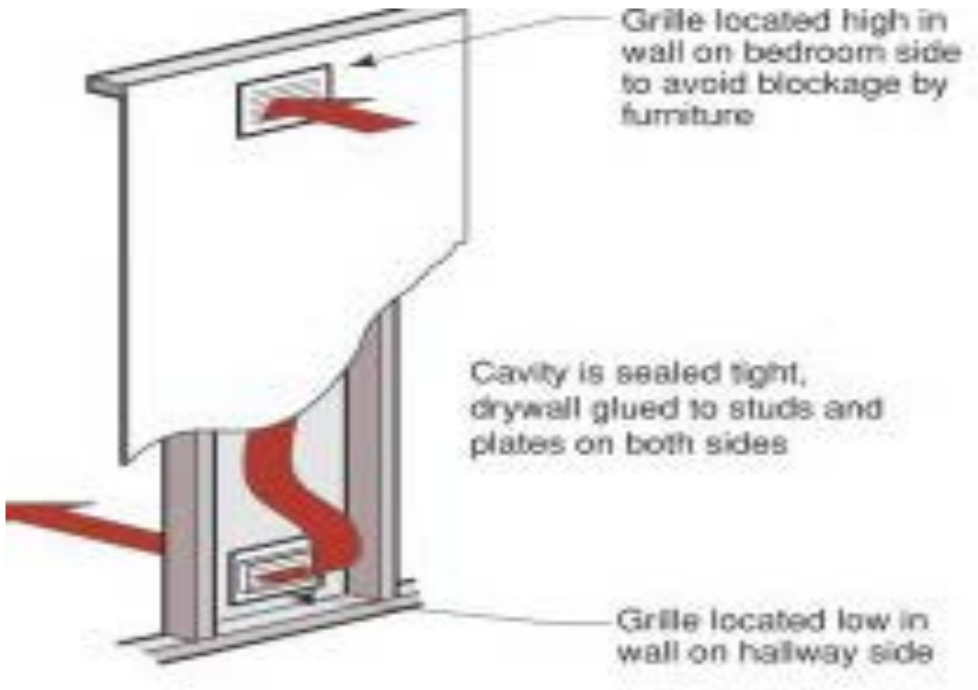
Ducted Returns will become expected

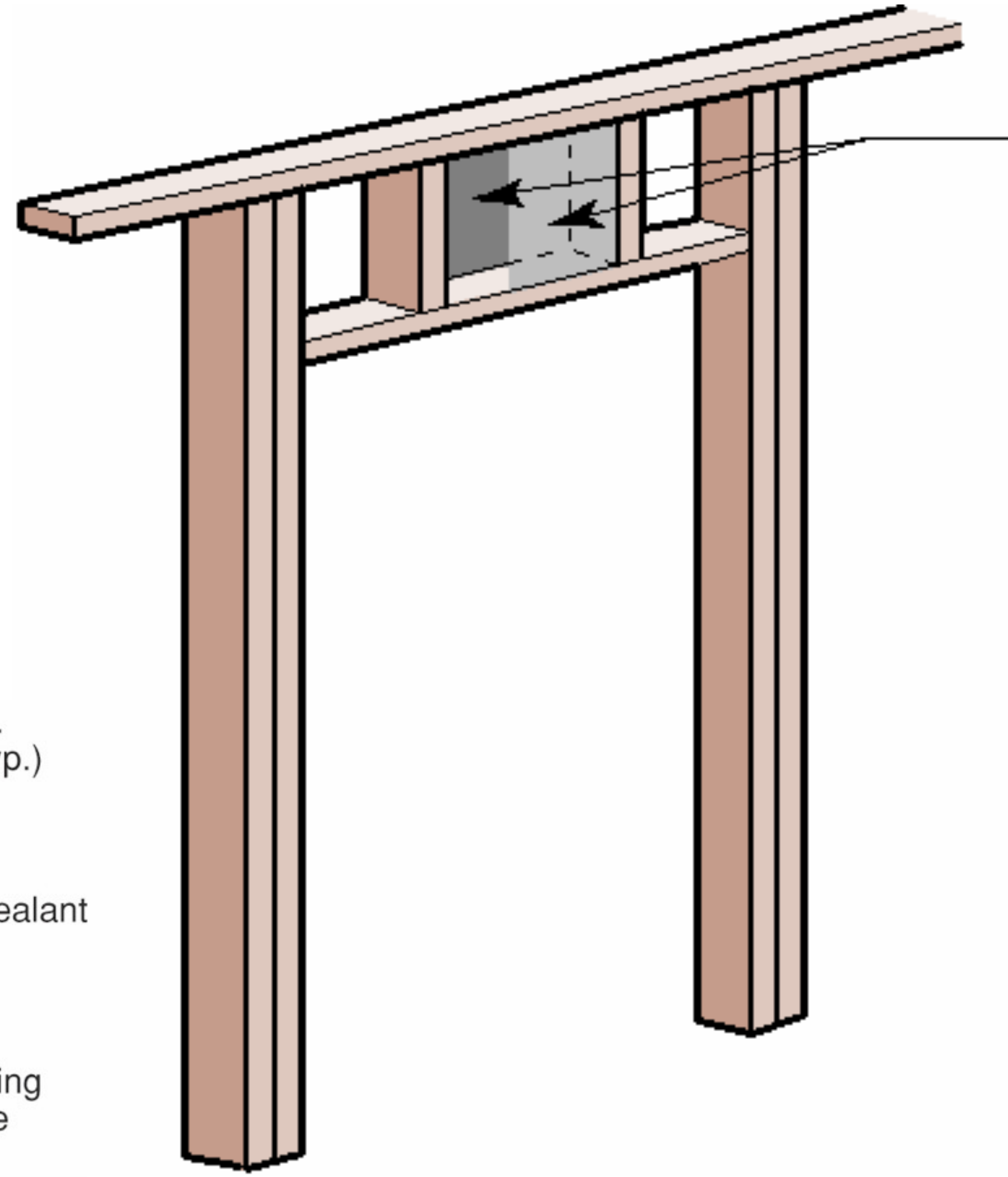
- A good choice is to hard duct returns...strategically to a centralized location

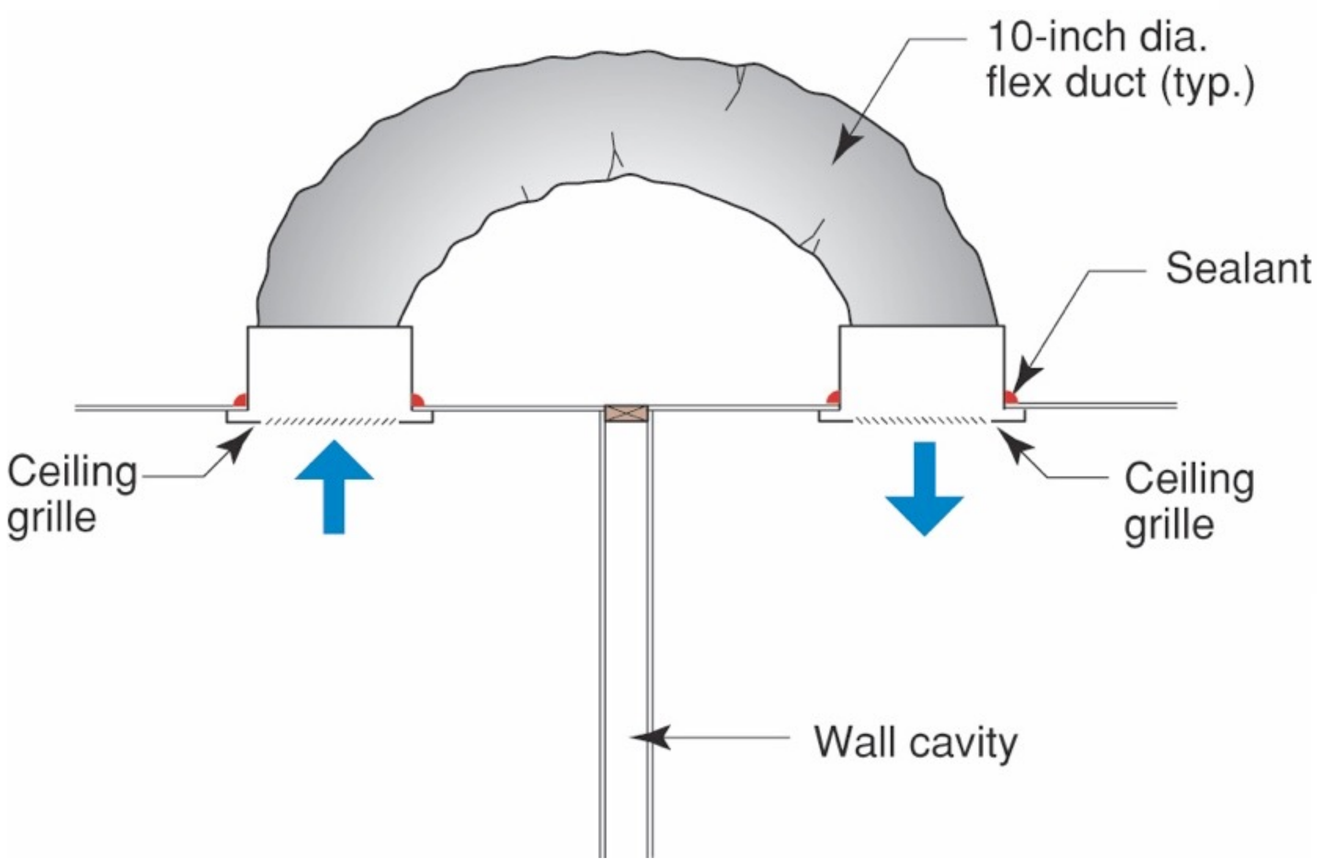
Return Air Paths



Graphics Courtesy of Building Science Corp.


Grille located high in wall on bedroom side to avoid blockage by furniture
Cavity is sealed tight, drywall glued to studs and plates on both sides
Grille located low in wall on hallway side




10-inch dia. flex duct (typ.)
Sealant
Ceiling grille
Ceiling grille
Wall cavity

A single return requires transfer grilles to provide a return path, and avoid pressurizing bedrooms

Note: not an IECC requirement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