



# The Basics of Manual J

RESNET Building Performance Conference, Atlanta GA  
February 24<sup>th</sup>, 2014

Learn more at [energystar.gov](http://energystar.gov)

# Agenda

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- Basic concepts behind load calculations.
- The value of accurate load calculations.
- Impact on load from right and wrong values for key inputs.
- Challenges to accurate load calculations.
- Question and answer session.



# Poll question #1

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- How familiar are you with the concept of calculating loads using Manual J?
  - A. Very familiar – I could do that with my eyes closed.
  - B. Somewhat familiar – Maybe I could do that if my life depended on it.
  - C. Unfamiliar – You're speaking Greek to me.



## Poll question #2

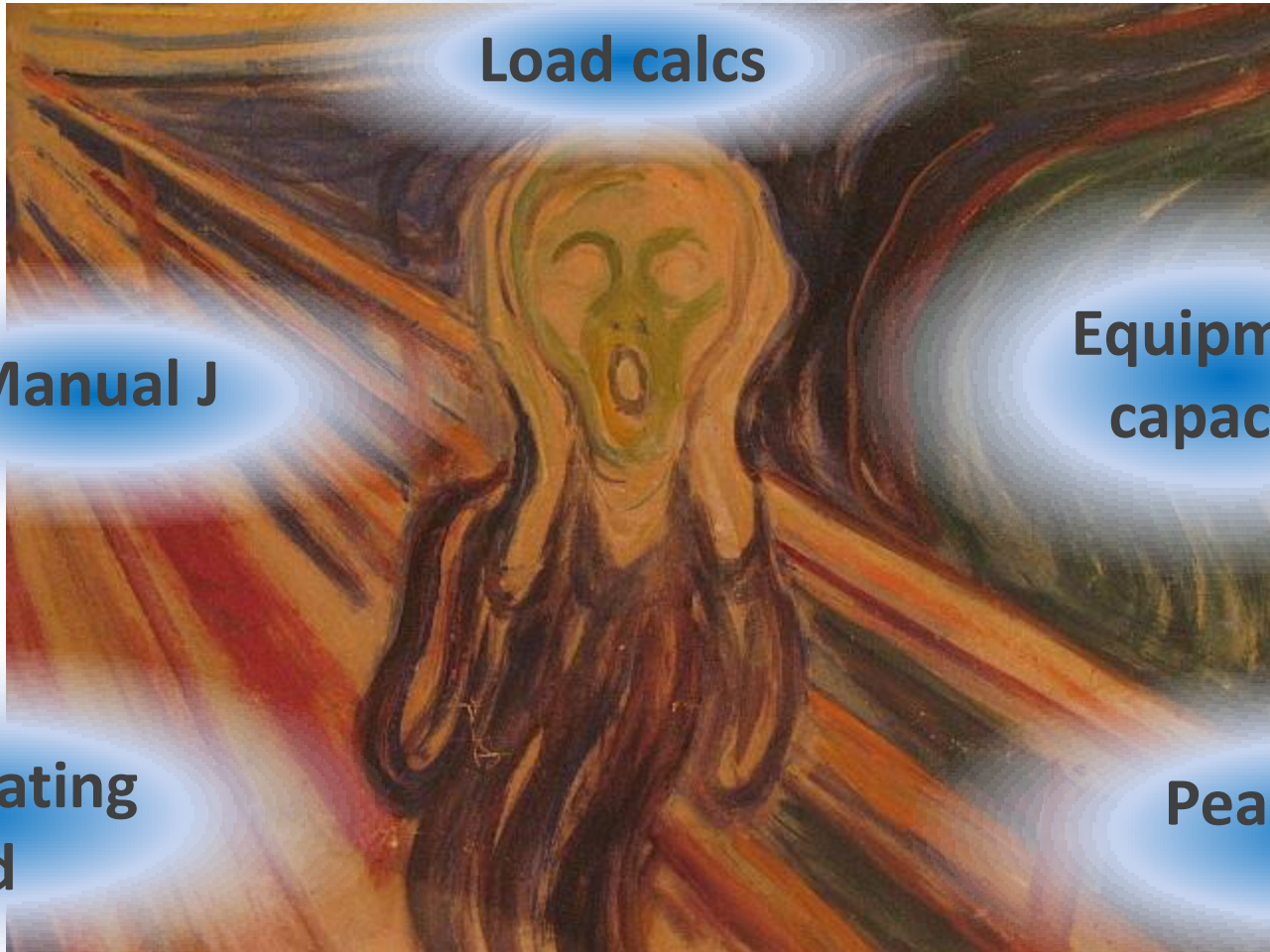
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- How would you rate the importance of doing accurate heating and cooling load calculations?
  - A. Very important.
  - B. Somewhat important.
  - C. Not important.
  - D. Not sure.

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# Basic concepts behind load calculations

# Basic concepts



Load calcs

Manual J

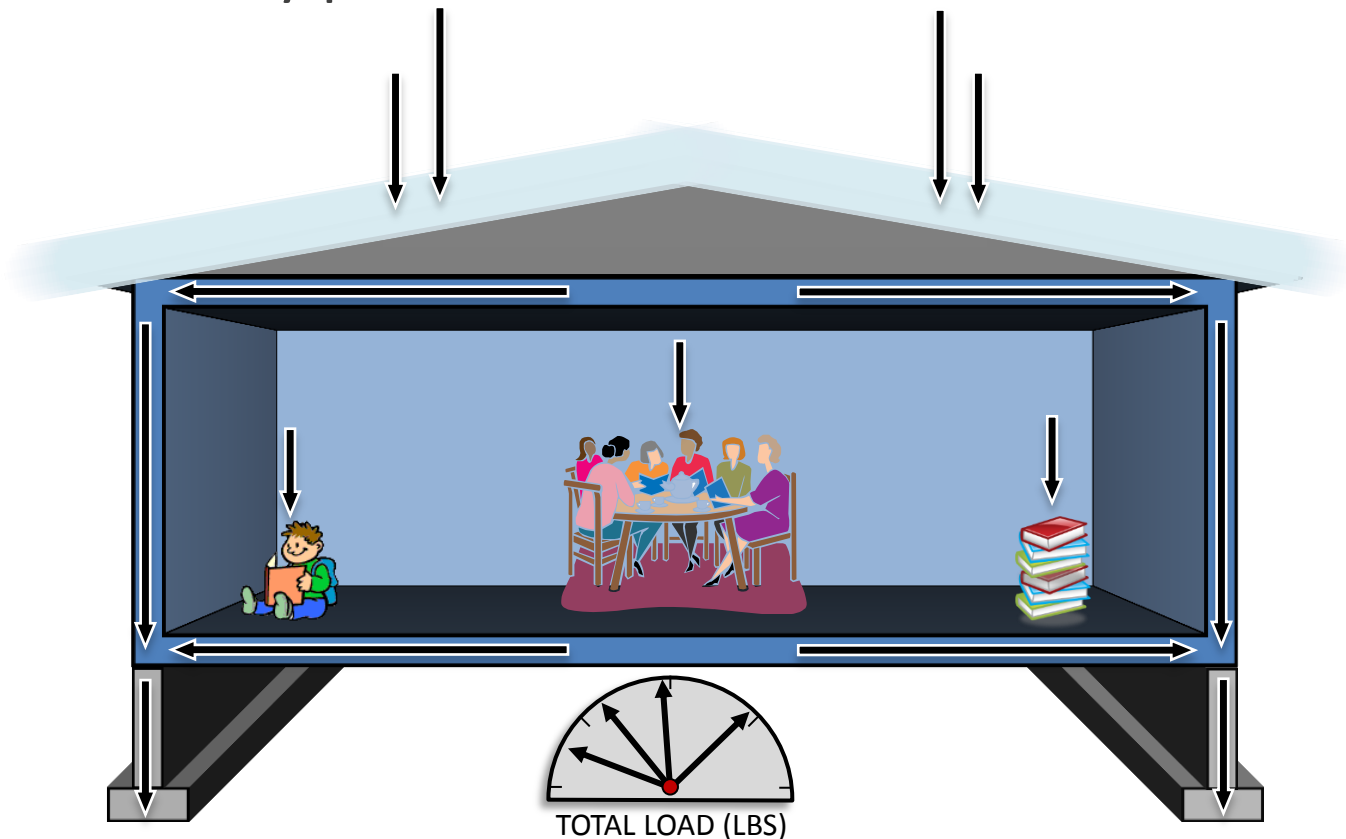
Equipment capacity

Peak heating load

Peak cooling load

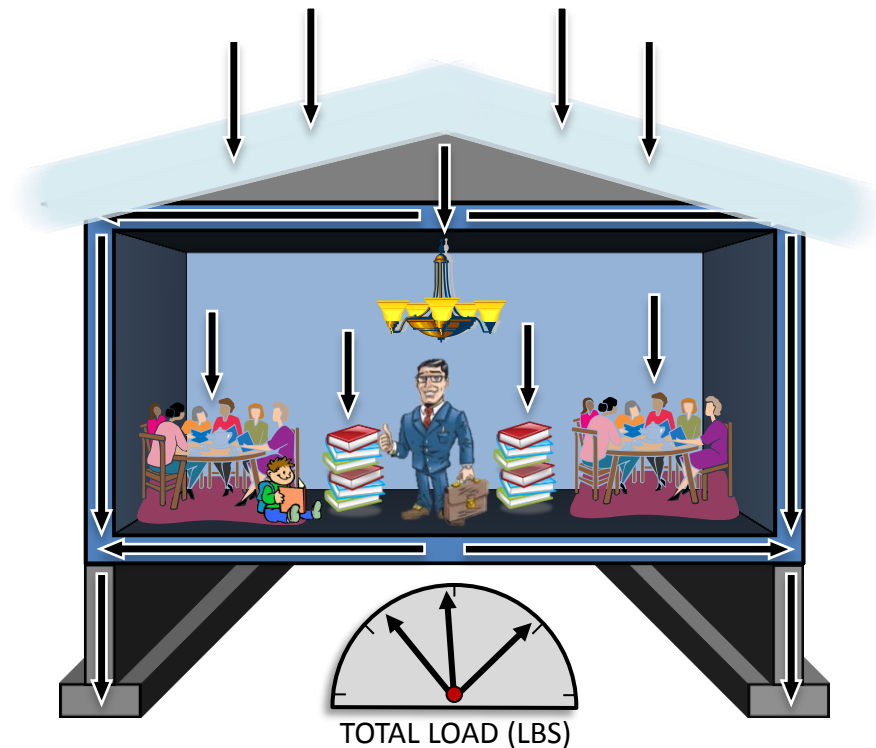
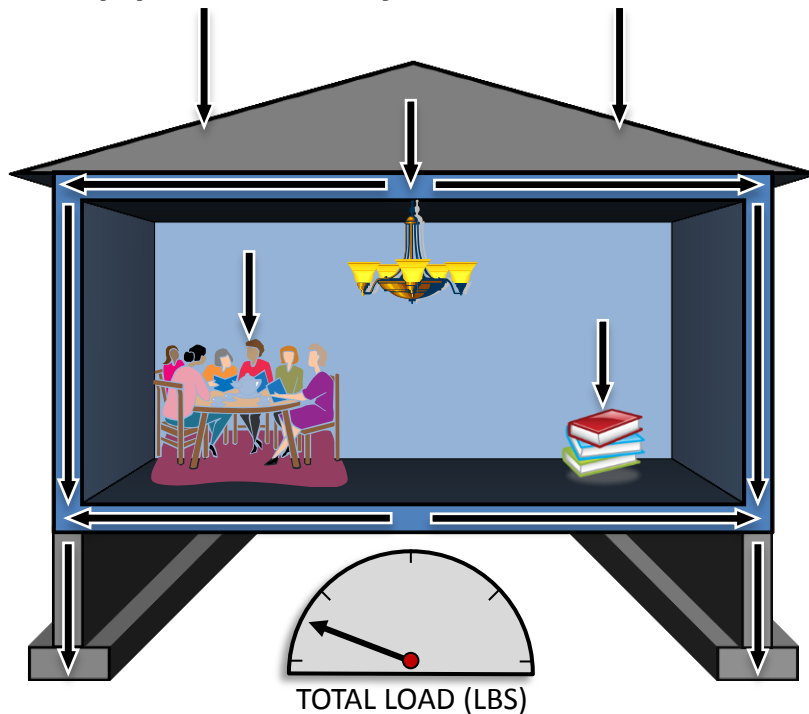
# Basic concepts

- Structural Load: The weight that must be supported by a foundation at any particular time.



# Basic concepts

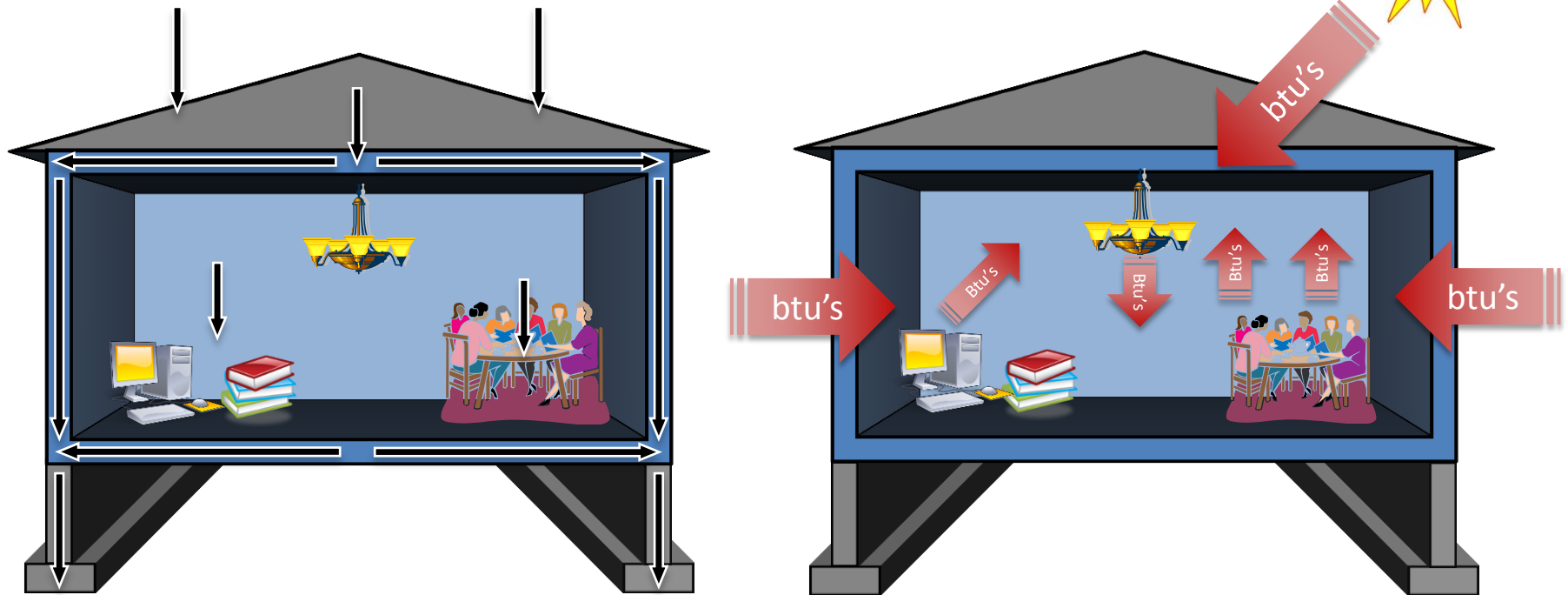
- Structural Load varies for each hour of the year.
- Structural Peak Load: The maximum weight that must be supported by a foundation.





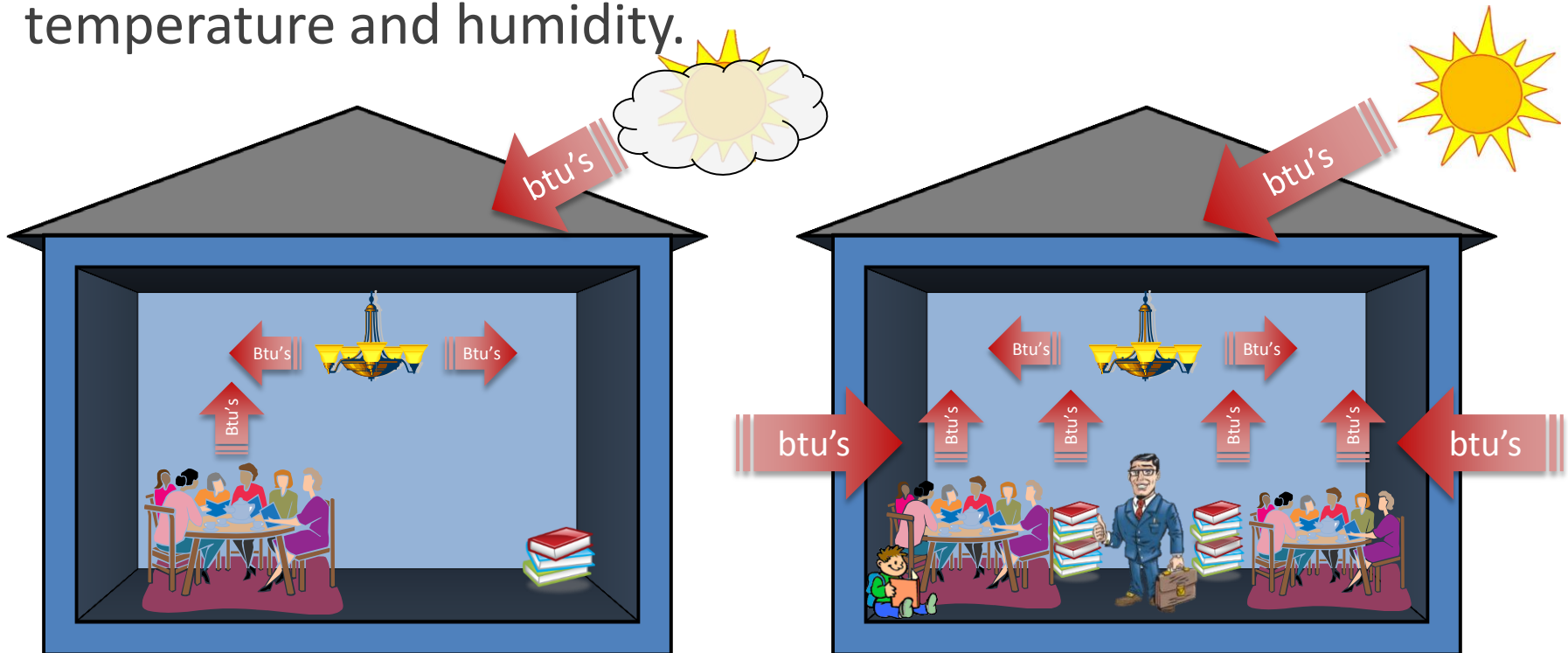
# Basic concepts

- Structural load measured in pounds of weight.  
..Cooling load measured in btu's of energy.
- 1 btu has about the same energy as 1 match.



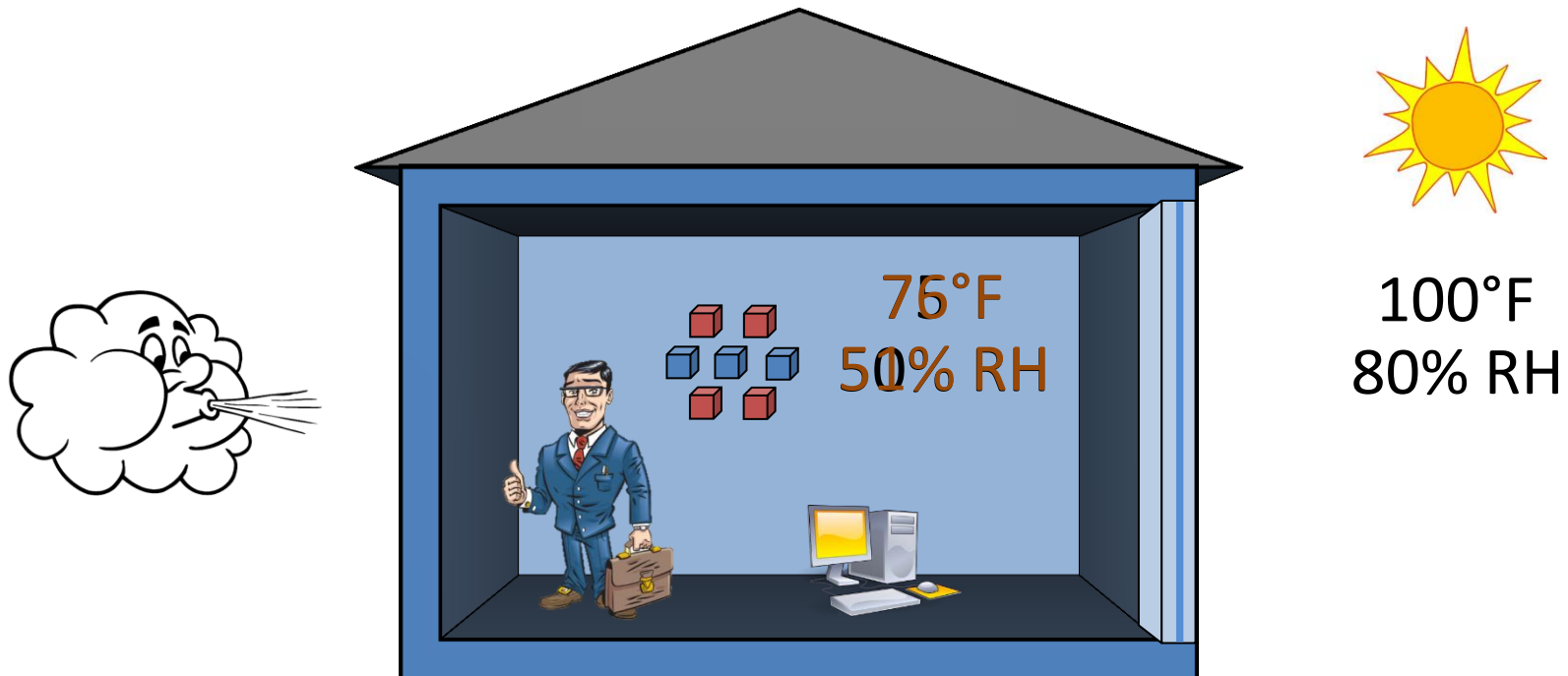
# Basic concepts

- Cooling Load varies for each hour of the year.
- Cooling Peak Load: The maximum energy that's added to the home in a single hour, and must be removed to maintain temperature and humidity.



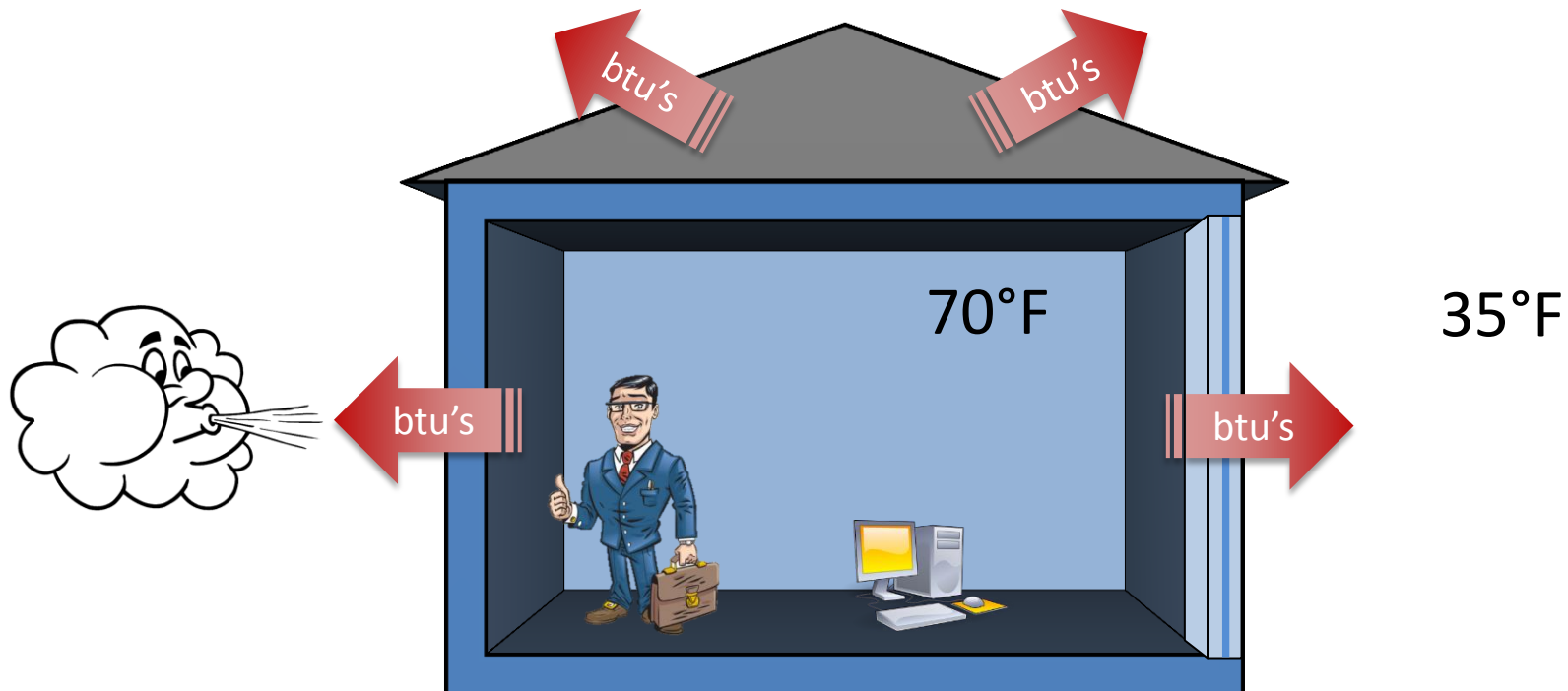
# Basic concepts

- Sensible Cooling Load: Btu's added to the home that increase temperature.
- Latent Cooling Load: Btu's added to the home that increase relative humidity.



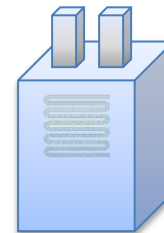
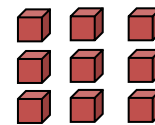
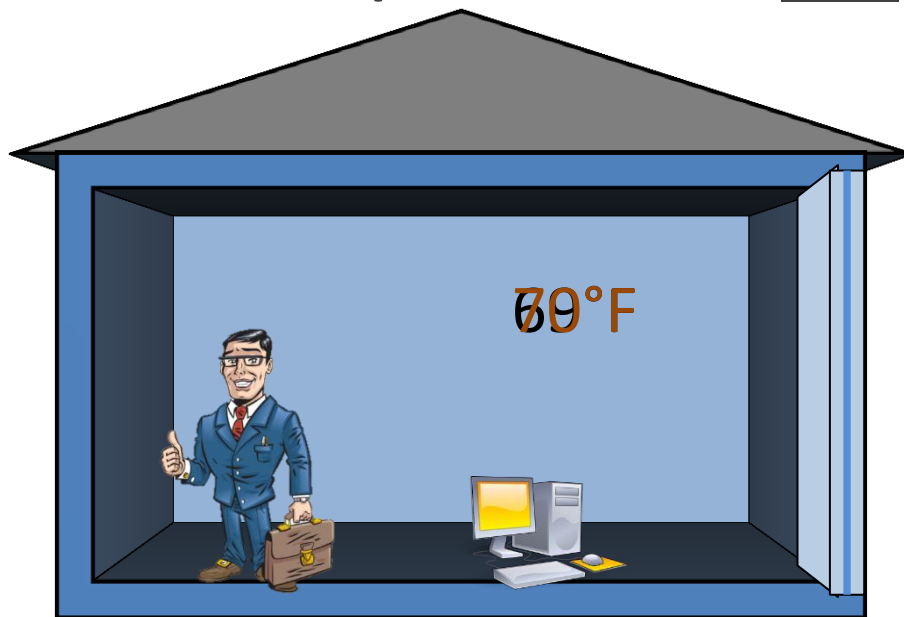
# Basic concepts

- Heating Load varies for each hour of the year.
- Heating Peak Load: The maximum energy that lost from the home in a single hour, which must be added back to maintain temperature.

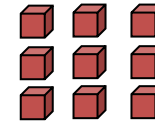


# Basic concepts

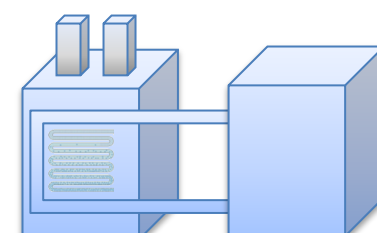
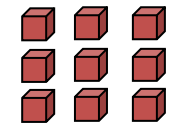
- Cooling & heating equipment are “btu machines” that add or remove btu’s to offset the load.
- The cooling and heating load tell you how many btu’s the equipment has to be capable of removing or adding.
- Load is independent of the type of equipment that will be used.



Furnace



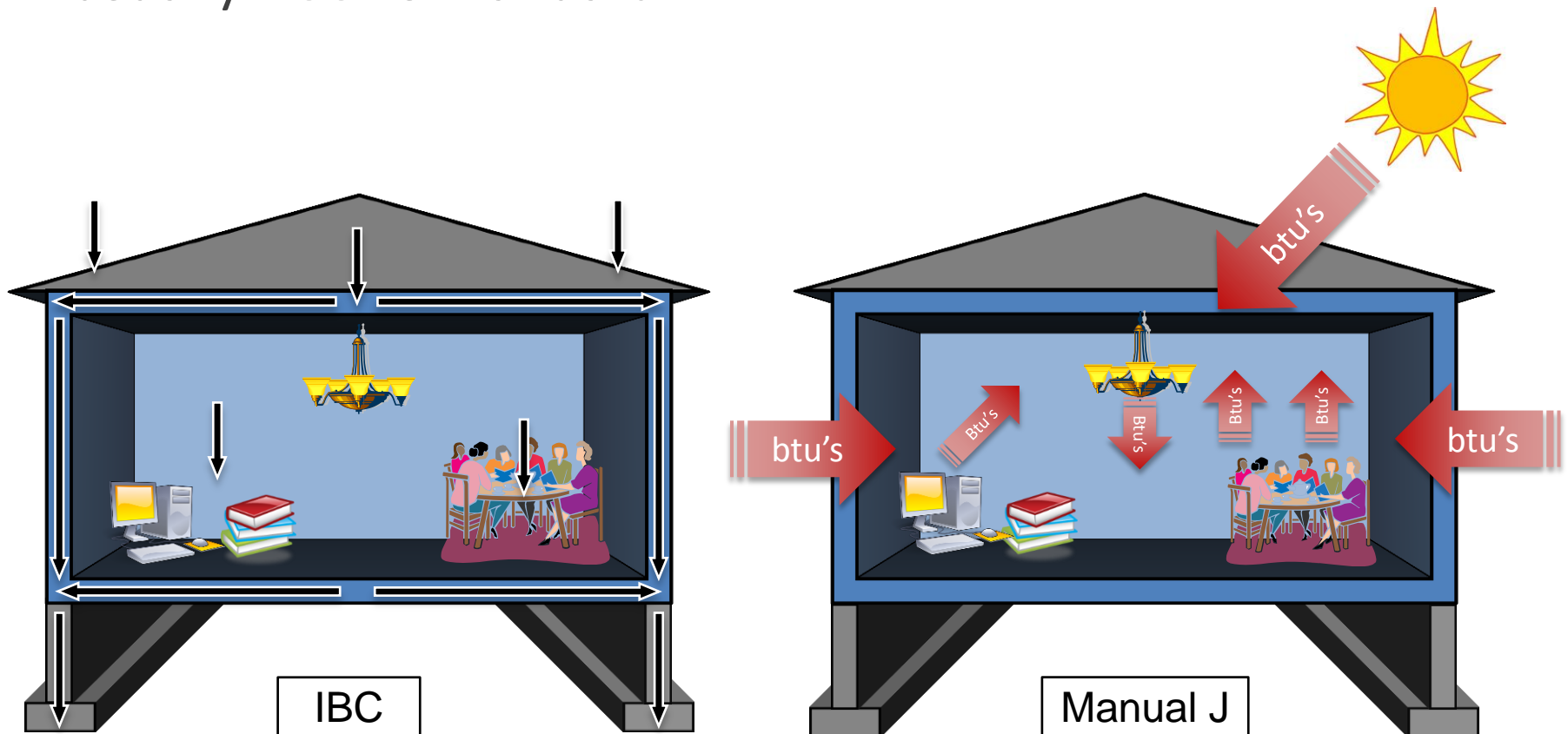
Boiler



HP

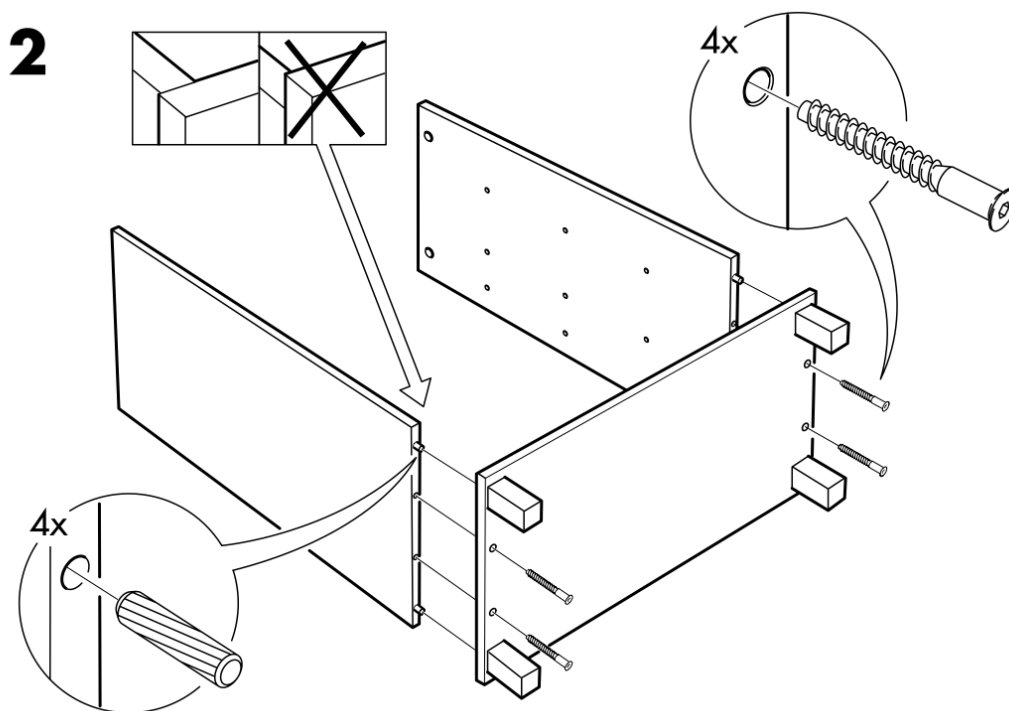
# Basic concepts

- Cooling & heating loads are calculated using a standard process – usually ACCA's Manual J.



# Basic concepts

- Process is able to be repeated by someone else.
- ACCA recognized Manual J programs:
  - [www.acca.org/industry/system-design/software](http://www.acca.org/industry/system-design/software)



## Poll question #3

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- What program do you most often use, or see HVAC designers use, to calculate loads?
  - A. Wrightsoft Right-J.
  - B. Elite Software RHVAC.
  - C. FSEC EnergyGauge.
  - D. Other



# Summary of basic concepts

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- Structural load = # pounds that foundation must support..  
.. Cooling load = # btu's that equipment must remove.
  
- Structural peak load = the max. weight..  
.. Cooling peak load = the max. btu's / hr equipment must remove.
  
- ACCA Manual J is the most commonly used standard for calculating cooling and heating loads.

# Value of accurate loads

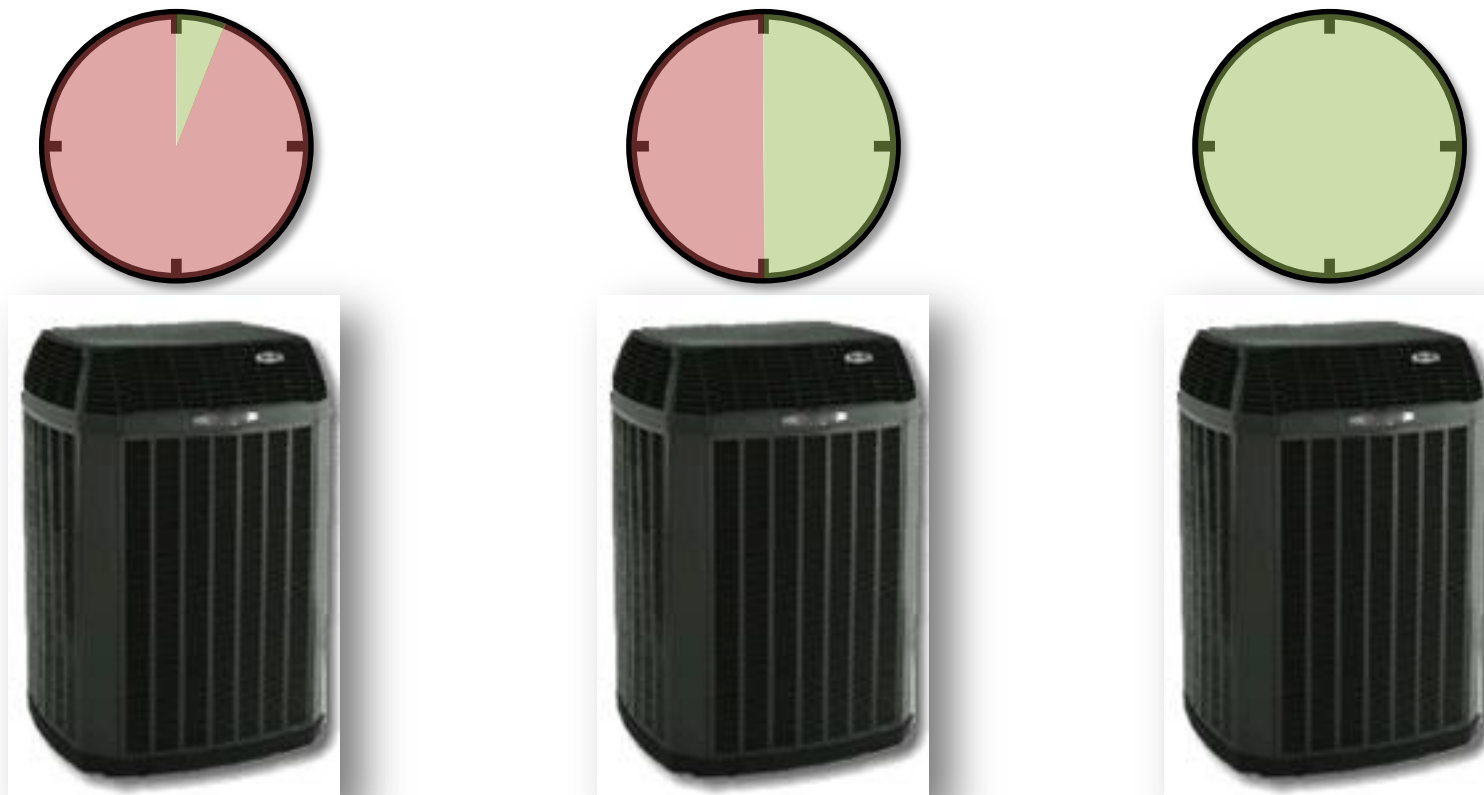
# Value of accurate loads



World's Most  
Uncomfortable Home

# Value of accurate loads

- Heating and cooling equipment generally has just two modes – on & off.



# Value of accurate loads

- Selecting a light for your living room:



A



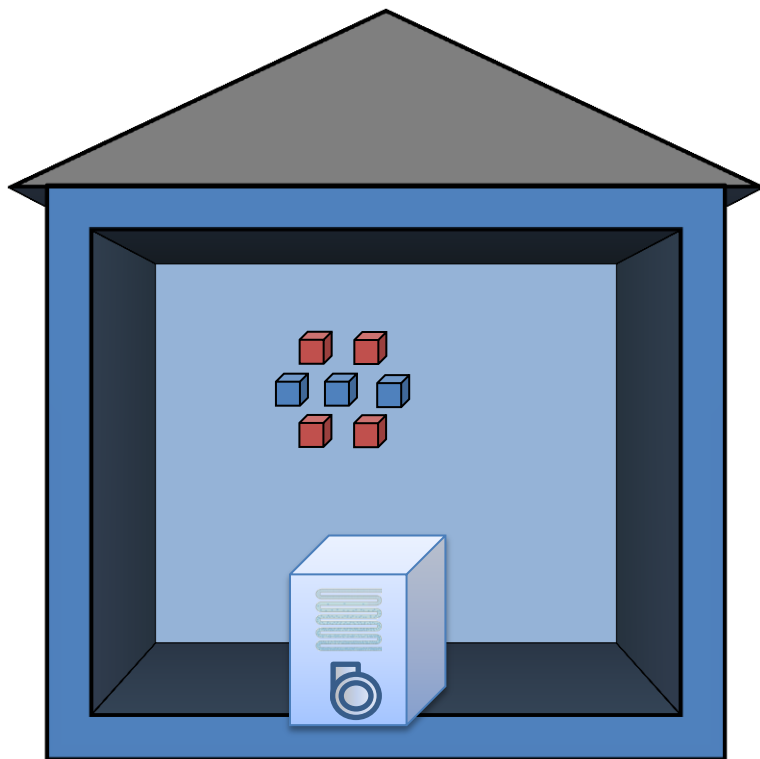
B



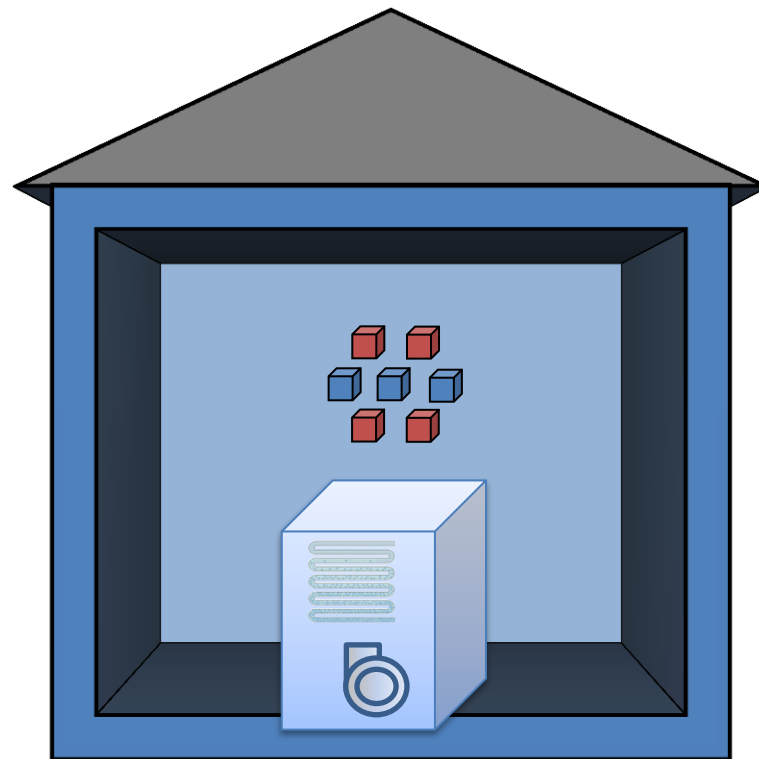
C

# Value of accurate loads

- Heating and cooling equipment generally has just two modes – on & off.



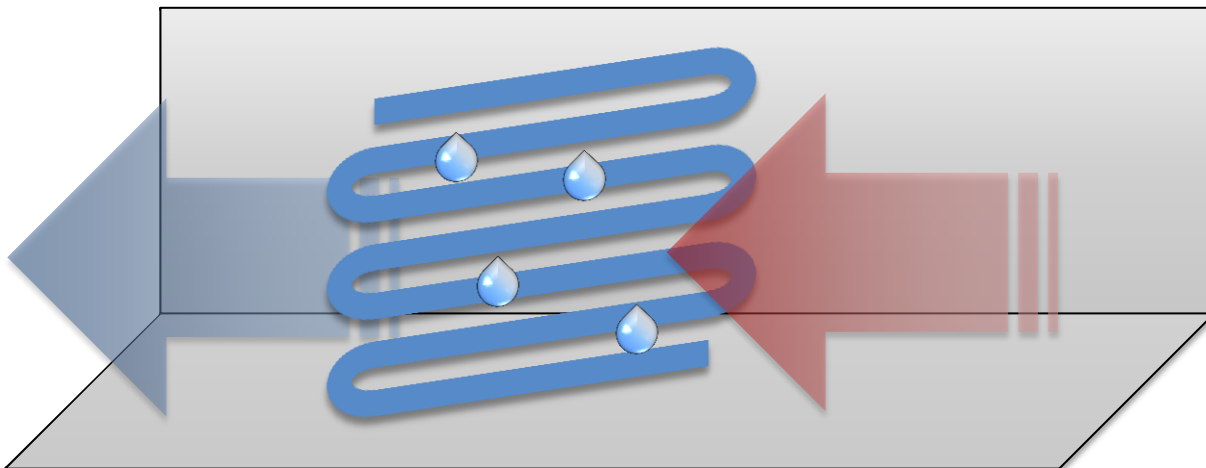
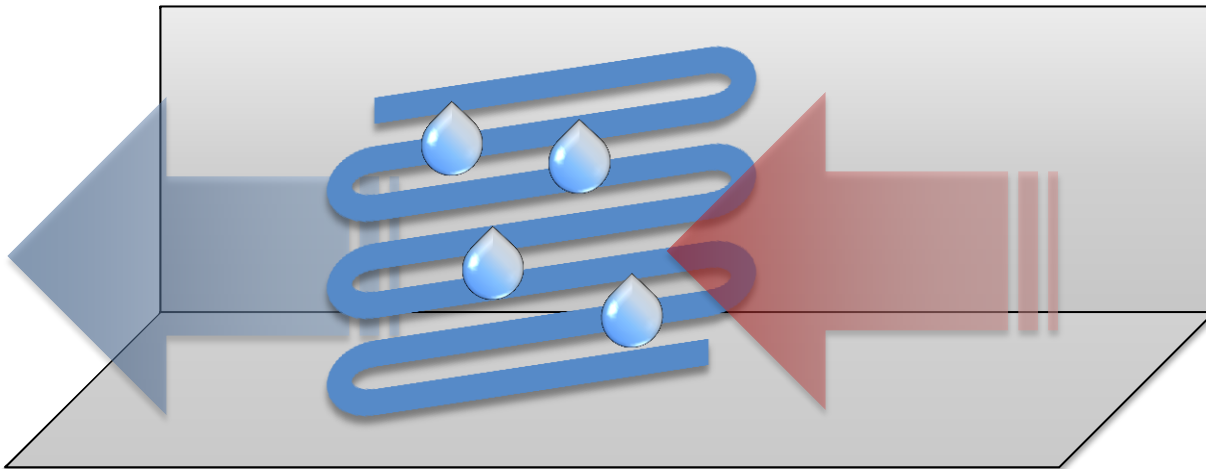
Calculated too low



Calculated too high

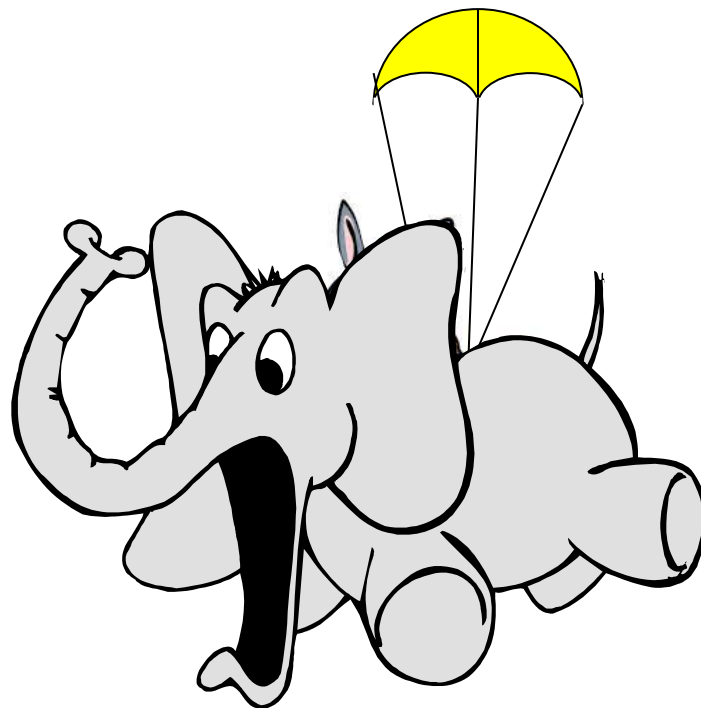
# Value of accurate loads

- How AC's control humidity.



# Value of accurate loads

- Calculating loads is Step 1 of the HVAC design process. This must be done right for the rest of the steps to work.
- Code requires load calculations to be done for every new home.







## Summary of value of accurate loads

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- Almost all HVAC equipment has just two modes – on and off.
- If you have the correct loads, you can select equipment that's the right size.
- Equipment that's based on an undersized load won't keep up.
- Equipment that's based on an oversized load will cycle on & off.
- Equipment that's based on an accurate load will best achieve comfort, efficiency, and durability.

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**Impact on load  
from right and wrong values  
for key inputs**

# Illustration of impact of key inputs

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- Two home configurations:
  - 2,400 square feet of conditioned floor area.
  - One-story above grade.
  - 15% window area to floor area ratio.
  - Built to the 2009 IECC.
  - One home, with slab, in Houston.
  - One home, with basement, in Pittsburgh.
- Loads calculated using Wrightsoft.

# Illustration of impact of key inputs

Houston					Cooling Load	
					%	
Input Type		Low Input	Correct Input	High Input	Low	High
Baseline		-	32.3 kBtu	-	-	-
1	Outdoor Design Temperature	89 F	94 F	99 F	-7%	7%



# Illustration of impact of key inputs

Houston					Cooling Load	
Input Type		Low Input	Correct Input	High Input	%	
Baseline		-	32.3 kBtu	-	-	-
					Low	High
1	Outdoor Design Temperature	89 F	94 F	99 F	-7%	7%
2	Home Orientation	N	E	W	-11%	2%
3	Number of Occupants	1	4	7	-4%	6%
4	Conditioned Floor Area (Sq. Ft.)	2,160	2,400	2,640	-2%	2%
5	Window Area (Sq. Ft.)	324	360	396	-3%	3%
6	Predominant Window SHGC	0.20	0.30	0.40	-7%	4%
<b>Combined Impact From First Six Parameters</b>		22.7 kBtu	32.3 kBtu	40.6 kBtu	<b>-30%</b>	<b>26%</b>



# Illustration of impact of key inputs

Pittsburgh

					Cooling Load	
					%	
Input Type		Low Input	Correct Input	High Input	Low	High
Baseline		-	22.6 kBtu	-	-	-
1	Outdoor Design Temperature	81 F	86 F	91 F	-7%	7%
2	Home Orientation	N	E	W	-17%	6%
3	Number of Occupants	1	4	7	-6%	7%
4	Conditioned Floor Area (Sq. Ft.)	2,160	2,400	2,640	-3%	3%
5	Window Area (Sq. Ft.)	324	360	396	-4%	4%
6	Predominant Window SHGC	0.30	0.40	0.50	-6%	11%
<b>Combined Impact From First Six Parameters</b>		14 kBtu	22.6 kBtu	31.7 kBtu	<b>-38%</b>	<b>40%</b>
7	Interior Window Shading	0.64 (light blinds)	0.74 (medium blinds)	0.85 (dark blinds)	-2%	2%
8	Infiltration Rate	Tight	Average	Loose	-1%	2%
9	Mechanical Vent. Rate (CFM)	50	75	100	0%	1%
10	Internal Loads (MJ Scenarios)	1	2	3	-5%	4%
11	Duct Location (% in Cond. Space)	100%	50%	0%	-3%	3%
12	Duct Leakage	Extreme	Notable	Average	-1%	1%
<b>Combined Impact From Last Six Parameters</b>		19.7 kBtu	22.6 kBtu	26.4 kBtu	<b>-13%</b>	<b>17%</b>
<b>Combined Impact From All Twelve Parameters</b>		11.4 kBtu	22.6 kBtu	35.0 kBtu	<b>-50%</b>	<b>55%</b>



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# **Key challenges to getting accurate load calculations**

# Key challenges to accurate load calculations

- HERS Raters do complete load calculations!
- HERS Raters collect all the data then verify the as-built home
- Compare that to the HVAC Designer

Rater	HVAC Designer
1. Collect detailed building Information from Builder.	1. Get home plans and maybe specs.
2. Use REMRate or Energy Gauge to simulate building performance.	2. Calculate detailed building loads using Manual J or other load calculation software.
3. Verify all Inputs in REMRate or Energy Gauge match as-built home.	3. Give reports to builder.

- Infiltration Rate
- Duct Leakage
- Window SHGC
- Window Area
- CFA
- Insulation Grade



# Key challenges to accurate load calculations

- HVAC Designers may get drawings and even some specs

House specs indicate R-15 walls...



What the designer thinks  
will be installed...



What is actually  
installed...

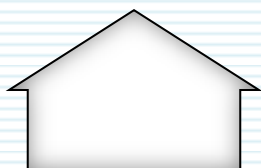
# Key challenges to accurate load calculations

- Can be difficult to get all of the correct inputs.
- Designers often use intuition: sometimes a little, sometimes a lot.

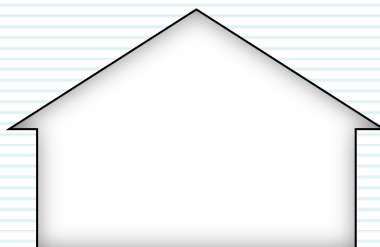
Directions:

Step 1) Stand across street from home and hold this card at arm's length.

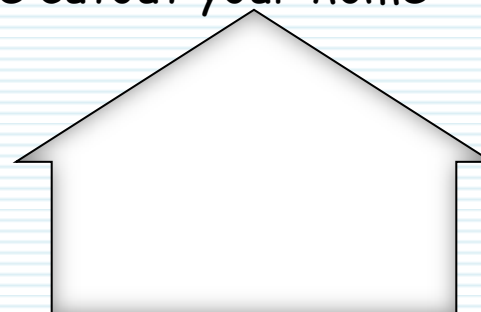
Step 2) Pick the AC capacity of the cutout your home fits in.



2 Tons



3 Tons



4 Tons



# Key challenges to accurate load calculations

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- ENERGY STAR helps overcome challenges by requiring:
  - Complete thermal enclosure system in every home.
  - Designers document several key inputs into load calculation.
  - Raters verify these inputs match actual home.

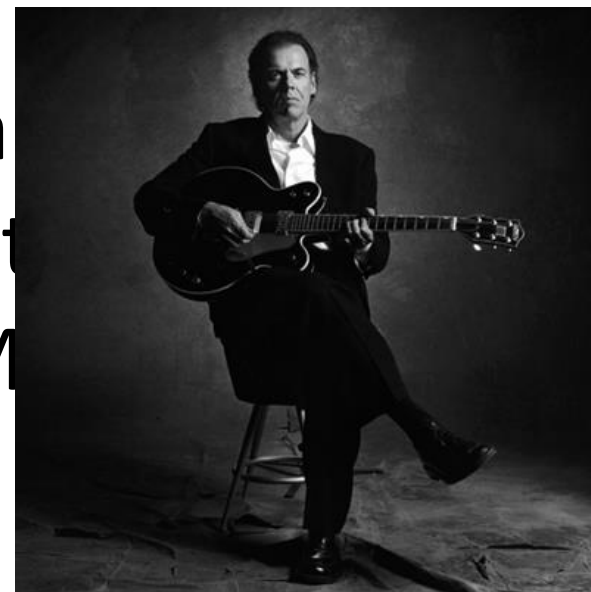
# Key challenges to accurate load calculations

- Some designers prefer to keep doing what they've always done.
- Some designers have yet to invest in load calc. software and training.
- Some designers have to have faith until they gain experience with Manual J.

“Have a little faith”  
[Manual J].”  
-John Hiatt (1987)



“I’ve gotta  
faith-a faith  
George M



# Key challenges to accurate load calculations

## NOAA Actual Houston Temperature Data 2000 through 2009

- 10 year average – 1.2% hours were hotter than the design temperature of 94°F.
- 8 of 10 – years that 1% of hours or less above 94°F

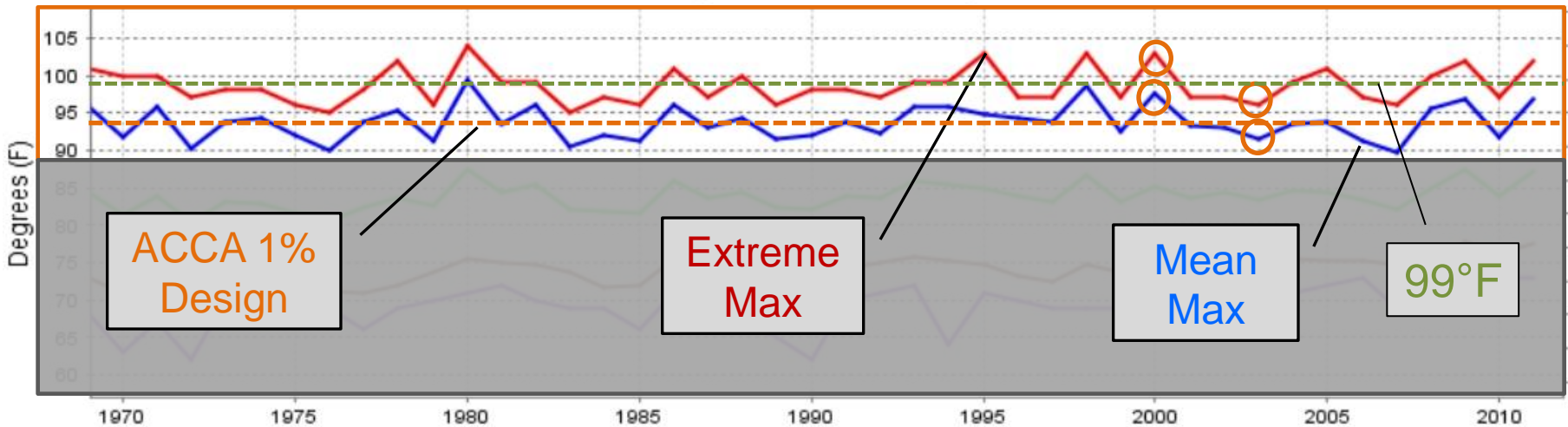
### What about the other two years?

2000	1.6%
2009	3.6%

# Key challenges to accurate load calculations



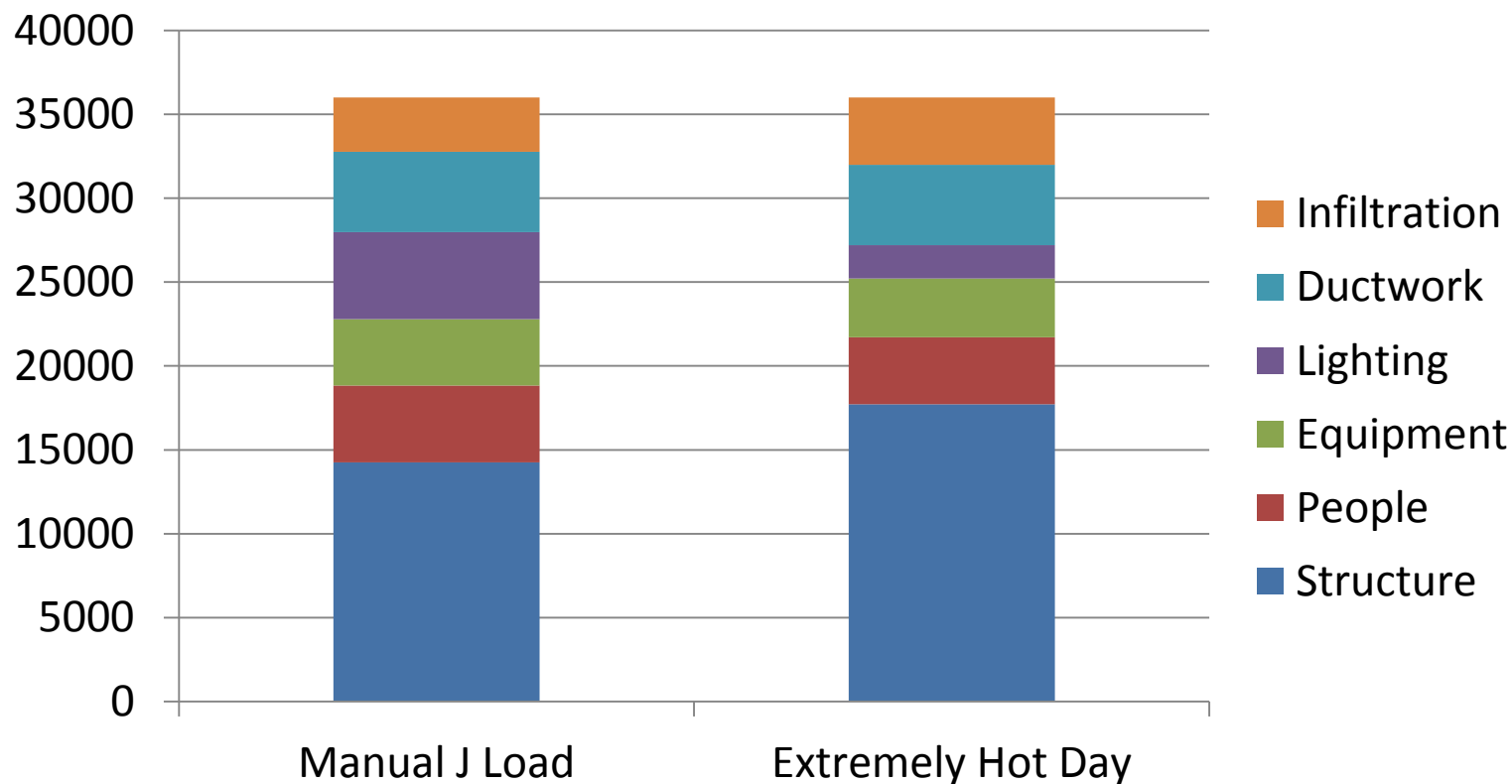
## Houston July Temperatures



- Manual J requires use of 1% summer cooling design temp.
- In a typical year, ~1% of hours are expected to be hotter.
- For the Houston Airport, the 1% design temperature is 94°F.

# Key challenges to accurate load calculations

- Just because the outdoor temp is above the design temp, this does not always mean the peak load increases.





# Key challenges to accurate load calculations

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- There's a safety factor built into Manual J
- Using absolute max temperature will compromise performance of AC system during all remaining hours.
- Shameless Plug

**ACCA Manual S Basics for  
ENERGY STAR Certified Homes  
NEXT Session- Right here in the Augusta Room**



# Key challenges to accurate load calculations

- ACCA Manual S allows 15% capacity above Manual J load.
- Sample one-story slab home in Houston with 2,400 square feet of CFA, 15% window area to floor area. Built to the 2009 IECC.

Cooling Load @ 94F

= 32.3 kBtu/h

Allowed Cooling Capacity

= 32.3 x 115%

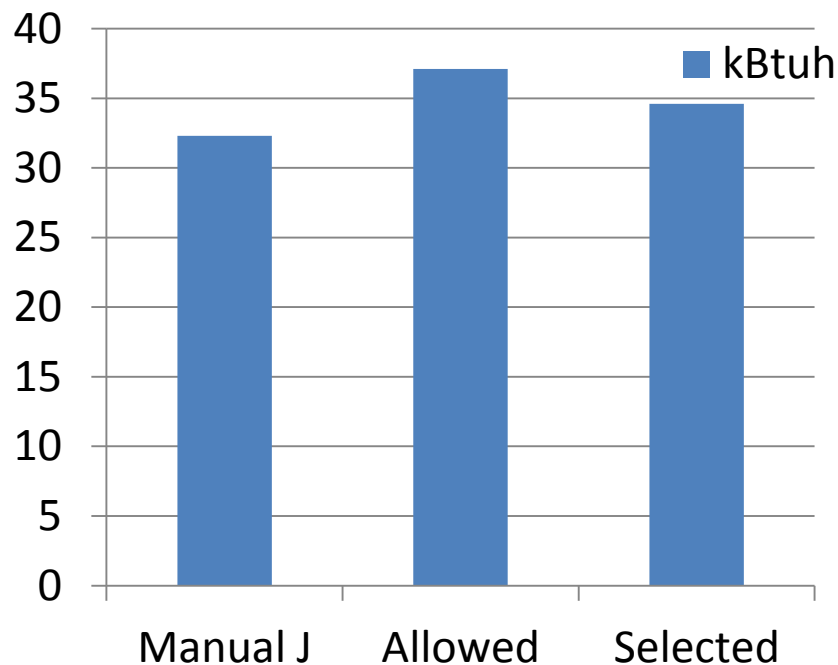
= 37.1 kBtu/h

Selected Cooling Capacity

= 32.3 x 107%

= 34.6 kBtu/h

Equipment Sizing



# Key challenges to accurate load calculations

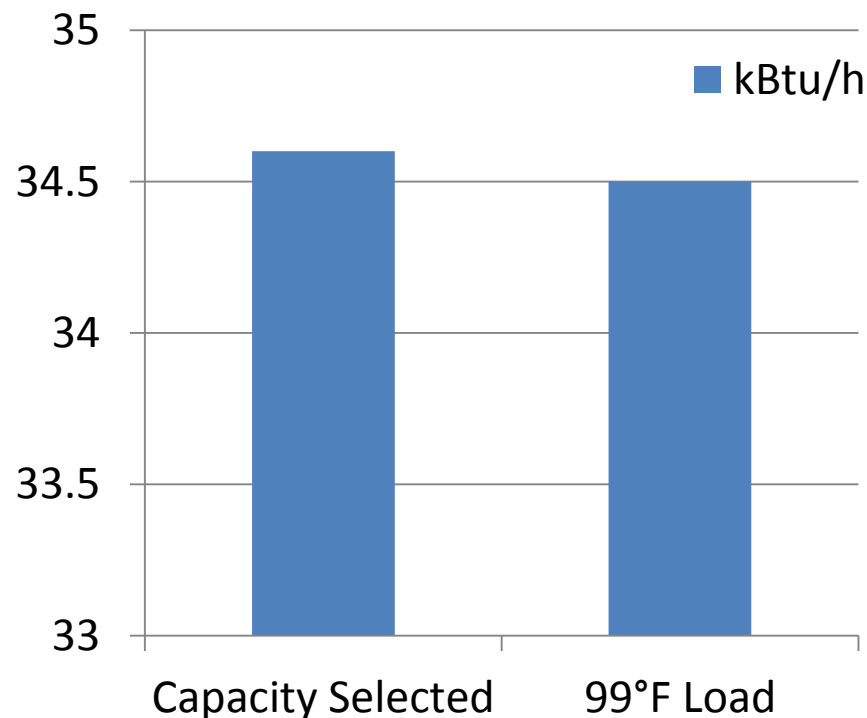
- What if its 99°F outside?

- How many btu's would you have to remove at 99F?

- Cooling Load @ 99F  
= 34.5 kBtu/h

34.6 kBtu/h > 34.5 kBtu/h

## Capacity versus 99°F Load



# Summary of key challenges to accurate load calculations

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- Not every designer does accurate load calculations today.
- Oftentimes, they rely on intuition because they don't have all the inputs.
- Also, some designers have to invest in software and training.
- ENERGY STAR helps ensure that accurate loads are calculated.
- Manual J has a safety margin built in. Designers faithfully using it have found that it produces accurate loads.

# Summary

- A structural load tells us the pounds a foundation must support;  
A cooling load tells us the btu's HVAC equipment must remove.  
A heating load tells us the btu's HVAC equipment must add.
- ACCA Manual J is most common method for calculating loads.
- Equipment that's based on an accurate load will best achieve comfort, efficiency, and durability.



# Summary

- Designers rely on intuition because:
  - Don't have correct inputs,
  - Not trained on the load calc. software, or
  - Haven't relied on Manual J for loads in the past.
- Using the correct inputs is critical to calculating the correct loads.
- ENERGY STAR can help
- Calculating proper loads is the first step in turning HVAC design from an art into a science.



## Recipe for Success:

**Step 1:** Use accurate Inputs to calculate accurate Heating and Cooling Loads

**Step 2:** Size the ...

# Solutions for working through Manual J

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1. Ensure Designer is designing correctly
  - How do Manual J inputs reach Designer?
  
2. Paper Management is a headache
  - How does the paperwork flow throughout the Rating process?

## **Solutions:**

- Hold a kick off meeting to discuss the work flow.
- Transition documents by having folder on the HVAC unit

# ENERGY STAR Certified Homes



## Web:

Main: [www.energystar.gov/newhomespartners](http://www.energystar.gov/newhomespartners)  
Technical: [www.energystar.gov/newhomesguidelines](http://www.energystar.gov/newhomesguidelines)  
Training: [www.energystar.gov/newhomestraining](http://www.energystar.gov/newhomestraining)  
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