ACCA Manual S Basics for ENERGY STAR Certified Homes

RESNET Building Performance Conference, Atlanta GA
February 24th, 2014

Agenda

- Basics of Manual S
  - The basic concepts behind equipment selection.
  - The value of accurate equipment selection.
  - The equipment selection process and common mistakes.
- Equipment selection exercise.
- Managing equipment selection process.
- Question and answer session.

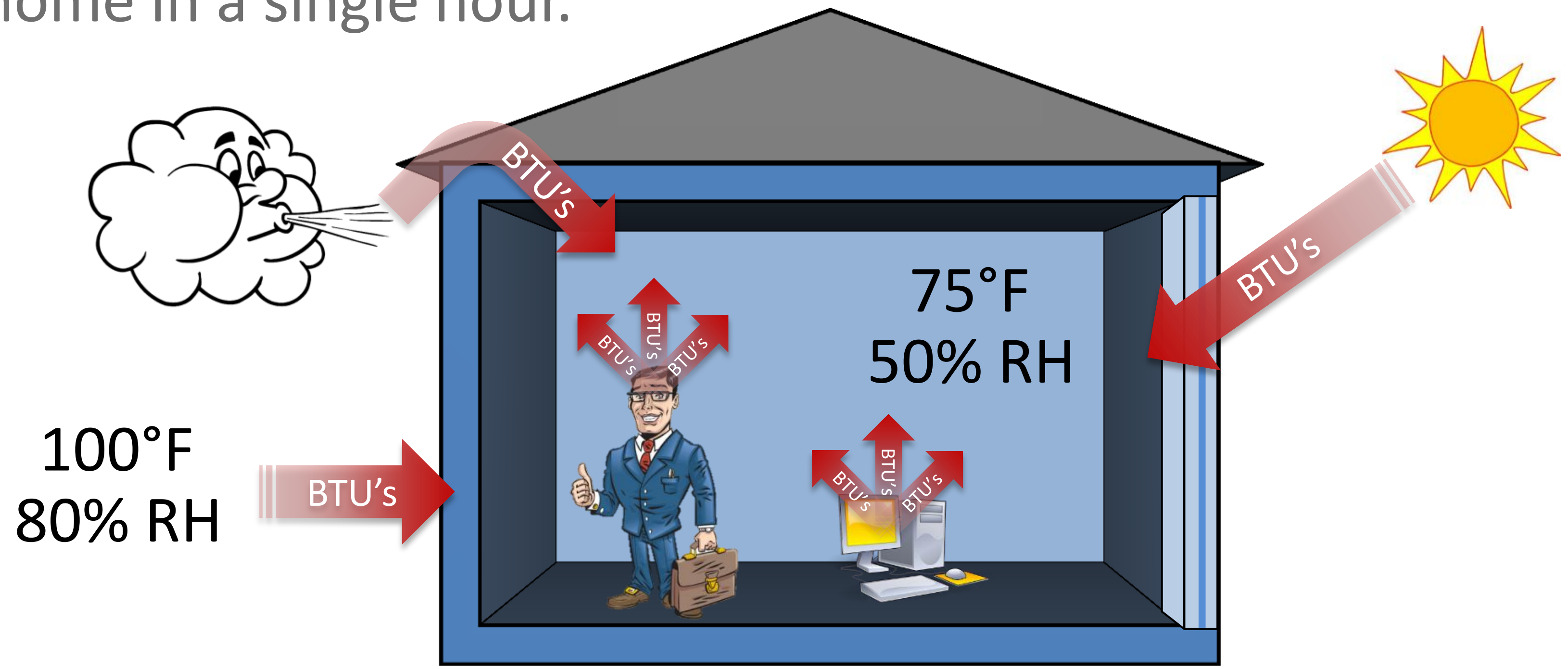
The Basic Concepts Behind Accurate Equipment Selection

The basic concepts

- Step 1: Calculate heating and cooling load.
- Step 2: Select heating and cooling equipment.
- Step 3: Design the duct system.

The basic concepts

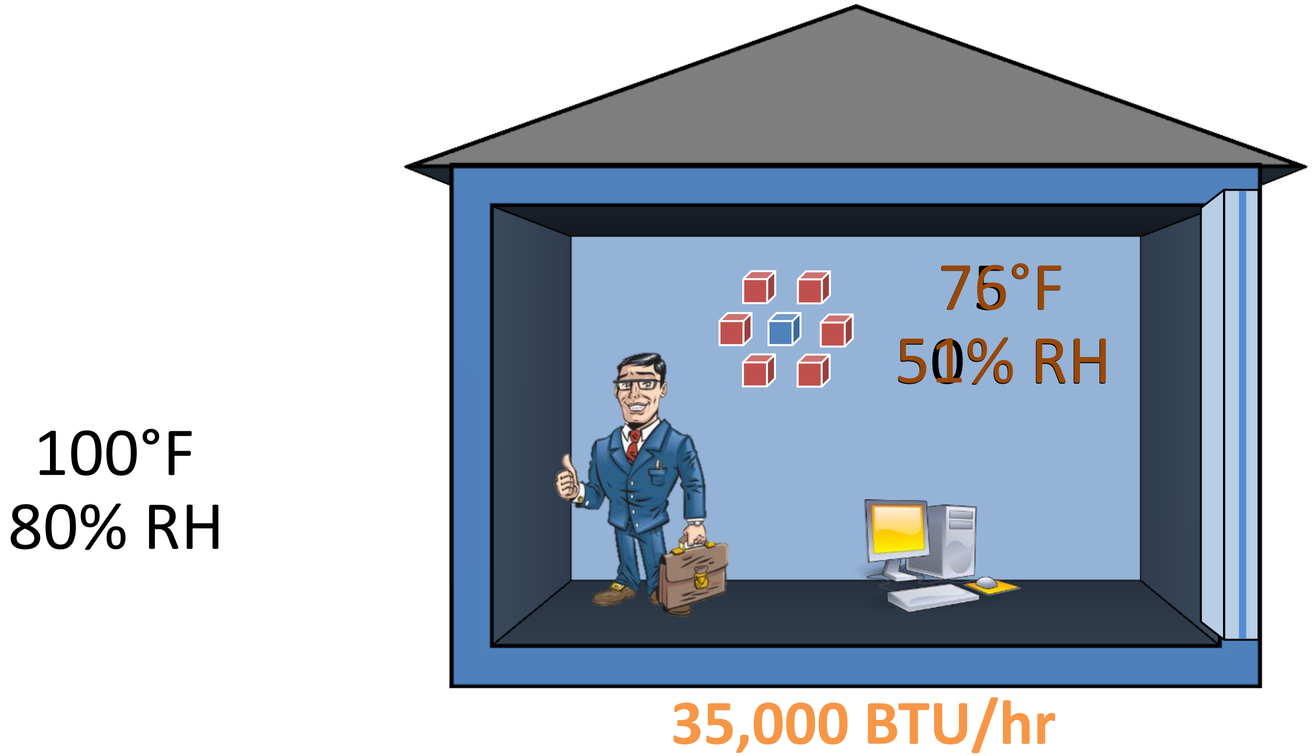
- Heat gain can be quantified in British Thermal Units (BTU's).
- 1 BTU has about the same energy as 1 match.
- <u>Cooling Peak Load</u>: The maximum energy that's added to the home in a single hour.



35,000 BTU/hr

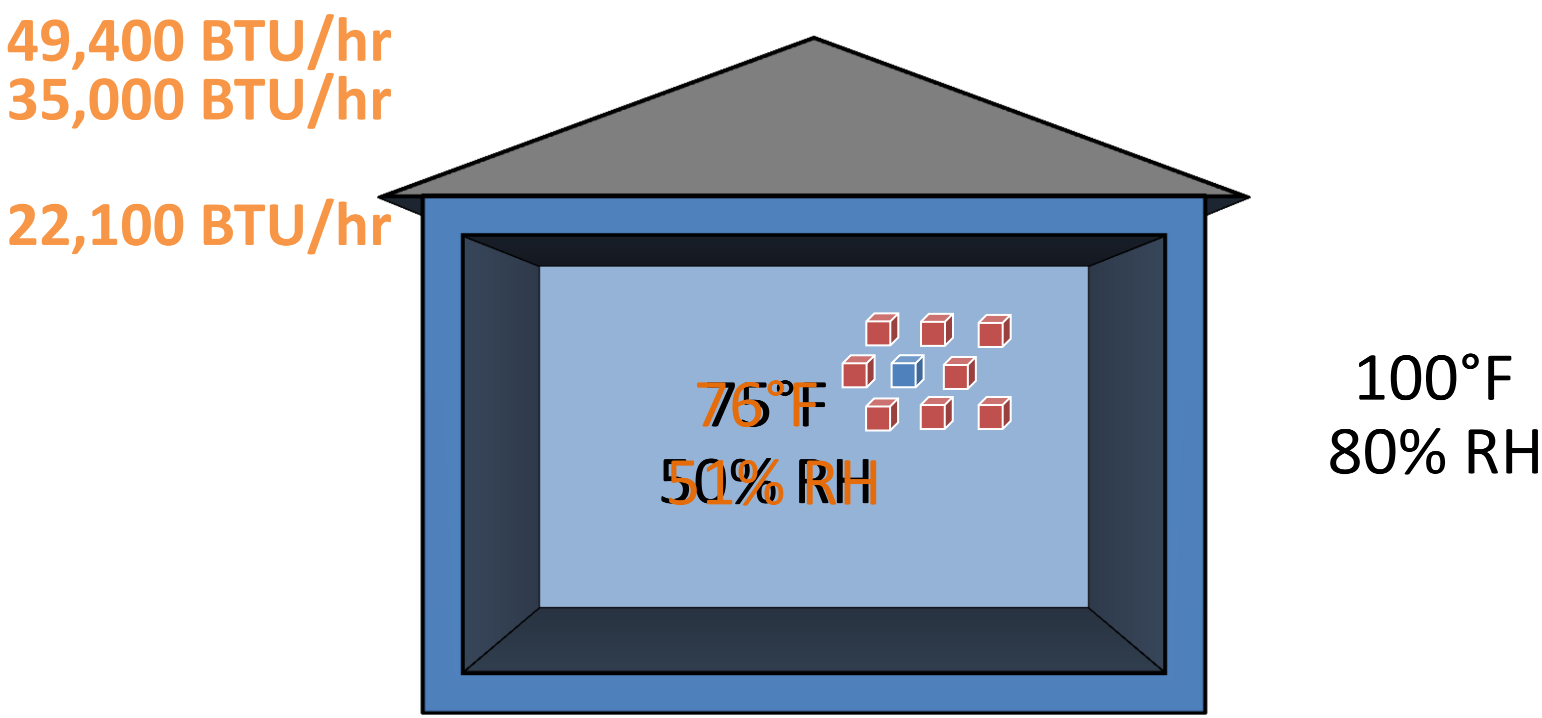
The basic concepts

- Sensible Cooling Load: BTU’s added to home that increase temp.
- Latent Cooling Load: BTU’s added to home that increase humidity.



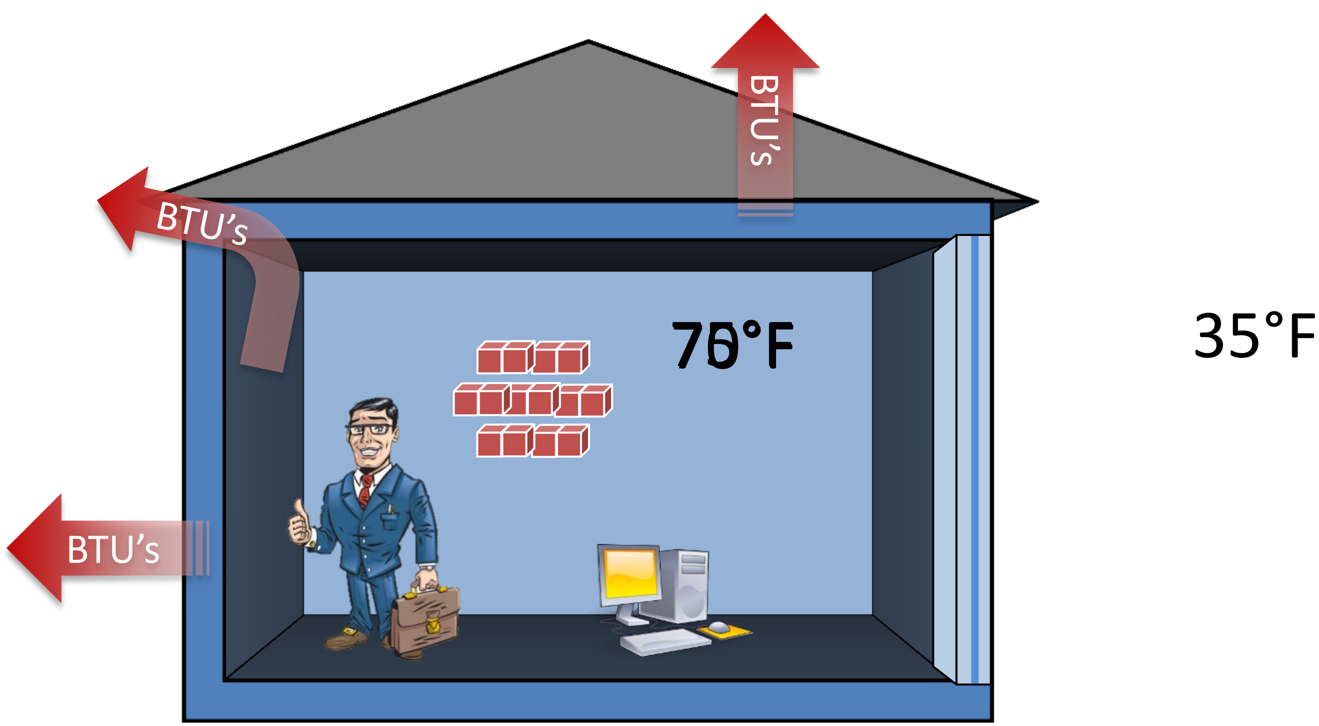
The basic concepts

- Cooling Capacity: BTU’s per hour that equipment can remove.



The basic concepts

- <u>Heating capacity</u>: BTU's per hour that equipment can add.



51,300 BTU/hr

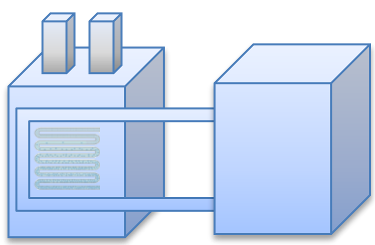
The basic concepts

Super-Simple Equipment Selection Goal

Capacity (in BTU's per hour)	=	Load (in BTU's per hour)

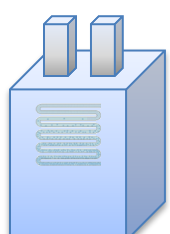
Sample ACCA Manual S Sizing Limits

AC



Total Capacity = 95-115% of Load

Furnace



Total Capacity = 100-140% of Load

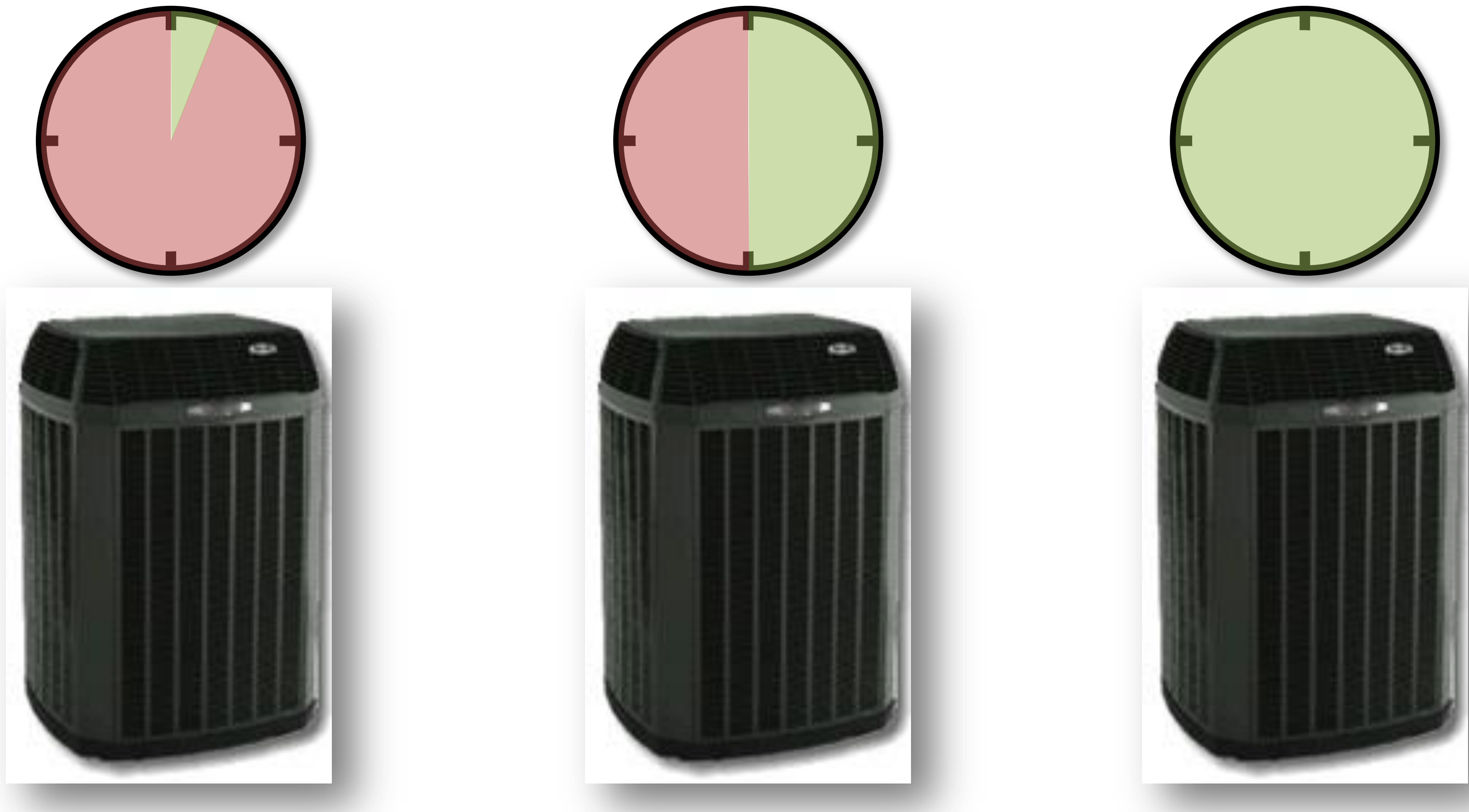
The basic concepts: Summary

- Heat gain and loss can be quantified in BTU's.
- Design Step 1: Calculate heating & cooling peak load.
- Design Step 2: Select equipment using those loads.
- Cooling Capacity: BTU's per hour that equipment can remove.
- Heating Capacity: BTU's per hour that equipment can add.
- ACCA Manual S helps standardize this process.

The Value of Accurate Equipment Selection

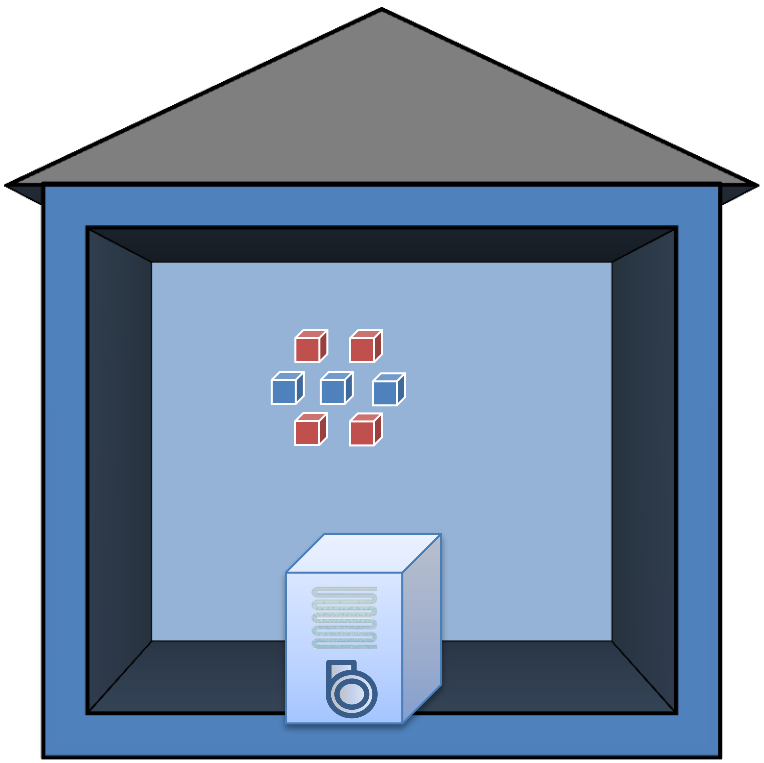
The value proposition

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

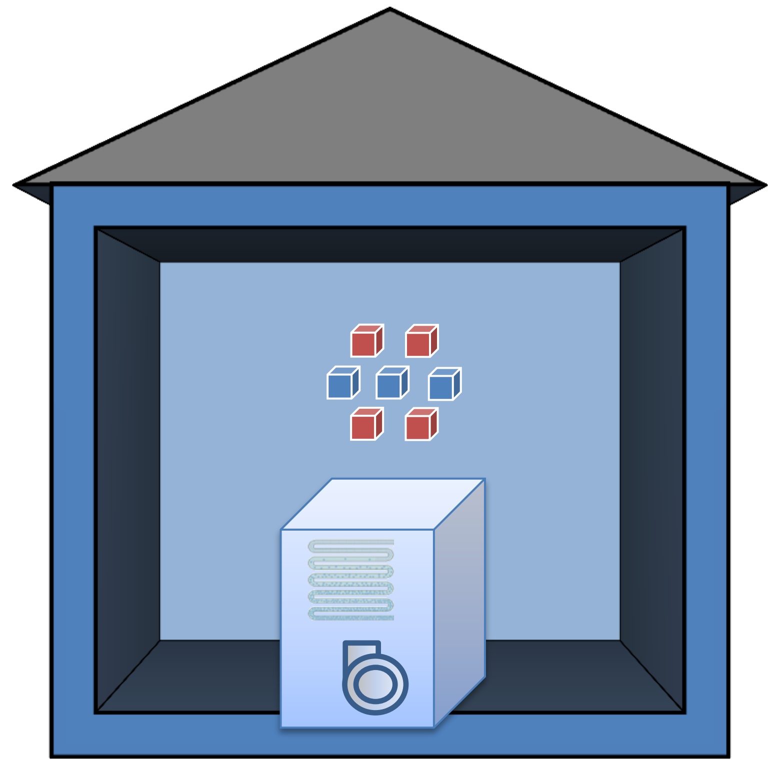


The value proposition

- Equipment that’s too big or too small causes problems.



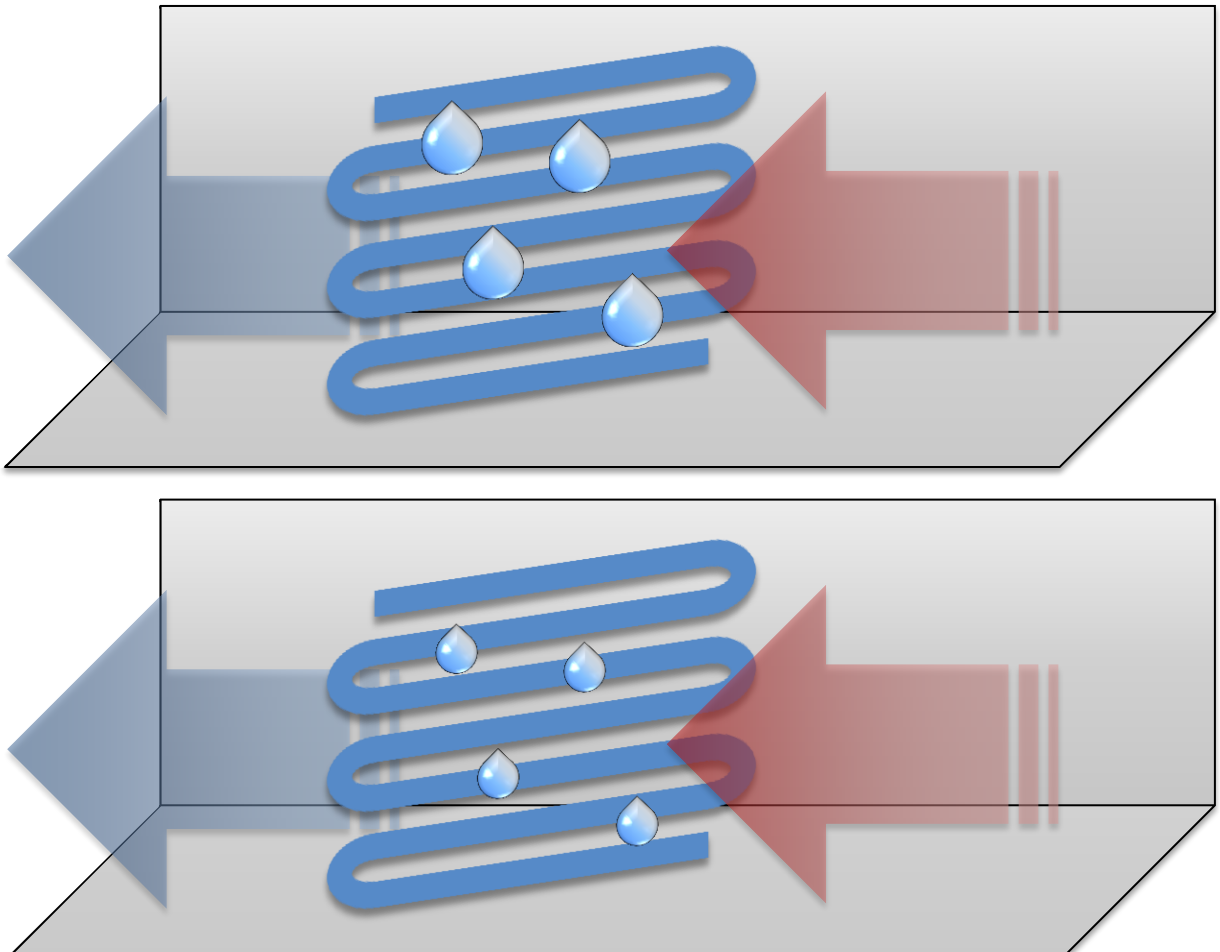
Equipment Capacity
< Load



Equipment Capacity
> Load

The value proposition

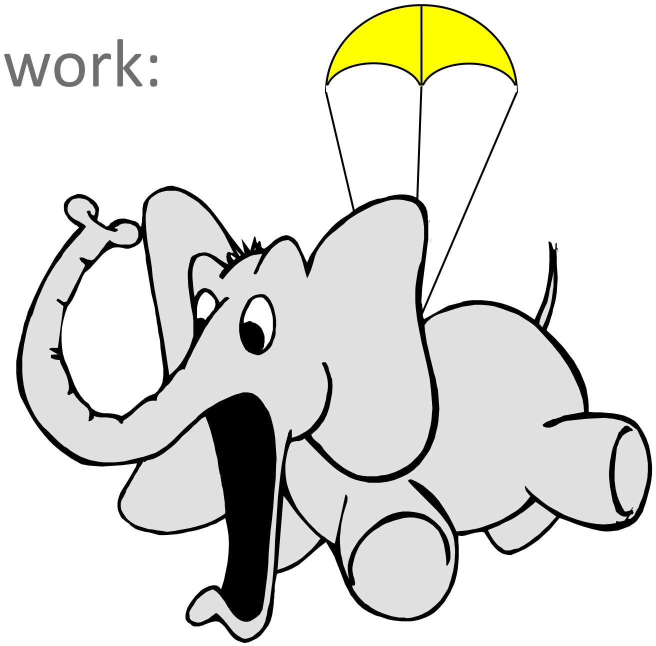
- How AC's control humidity.



The value proposition

- Load calculations and equipment selection go hand in hand.
- Both need to be right for the system to work:

Measured Weight		Parachute Rating		
1,000 lbs	+	1,000 lbs	=	
8,000 lbs	+	1,000 lbs	=	
8,000 lbs	+	8,000 lbs	=	



The value proposition

- Also, this is required by code!

2012 IECC

(2009 IECC has same language, different section)

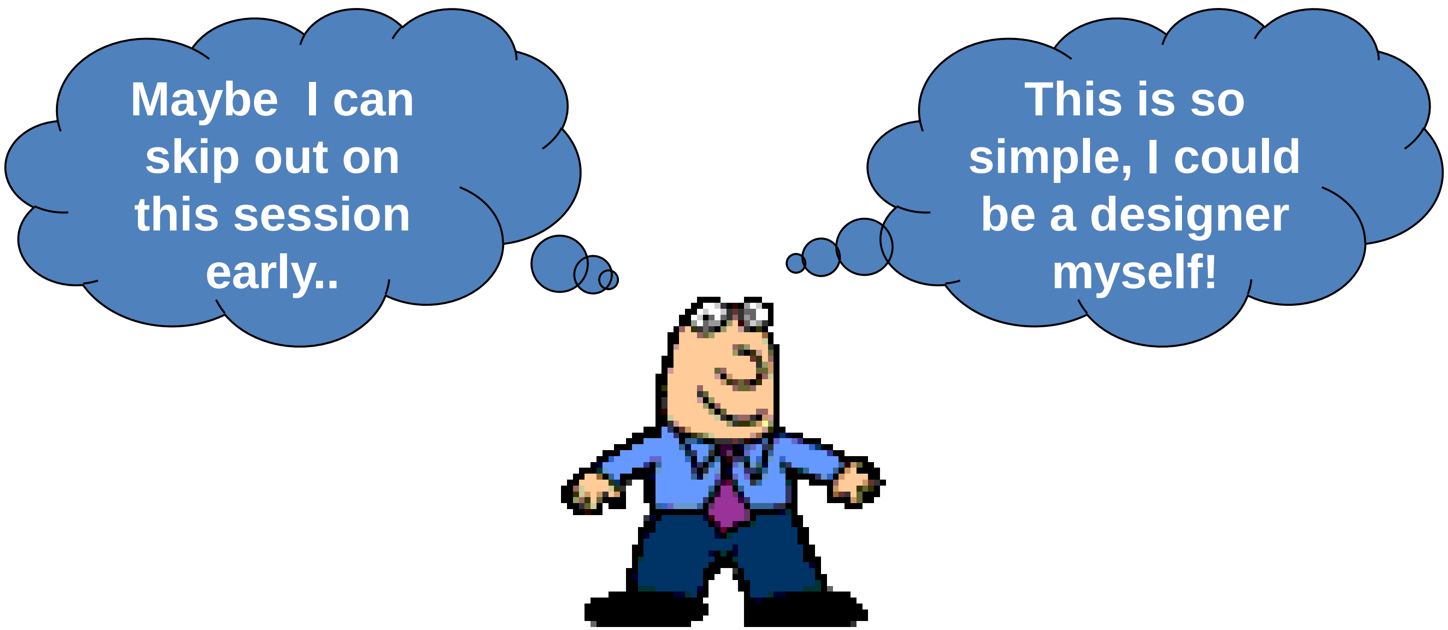
R403.6 Equipment Sizing (Mandatory).

Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J..

The value proposition: Summary

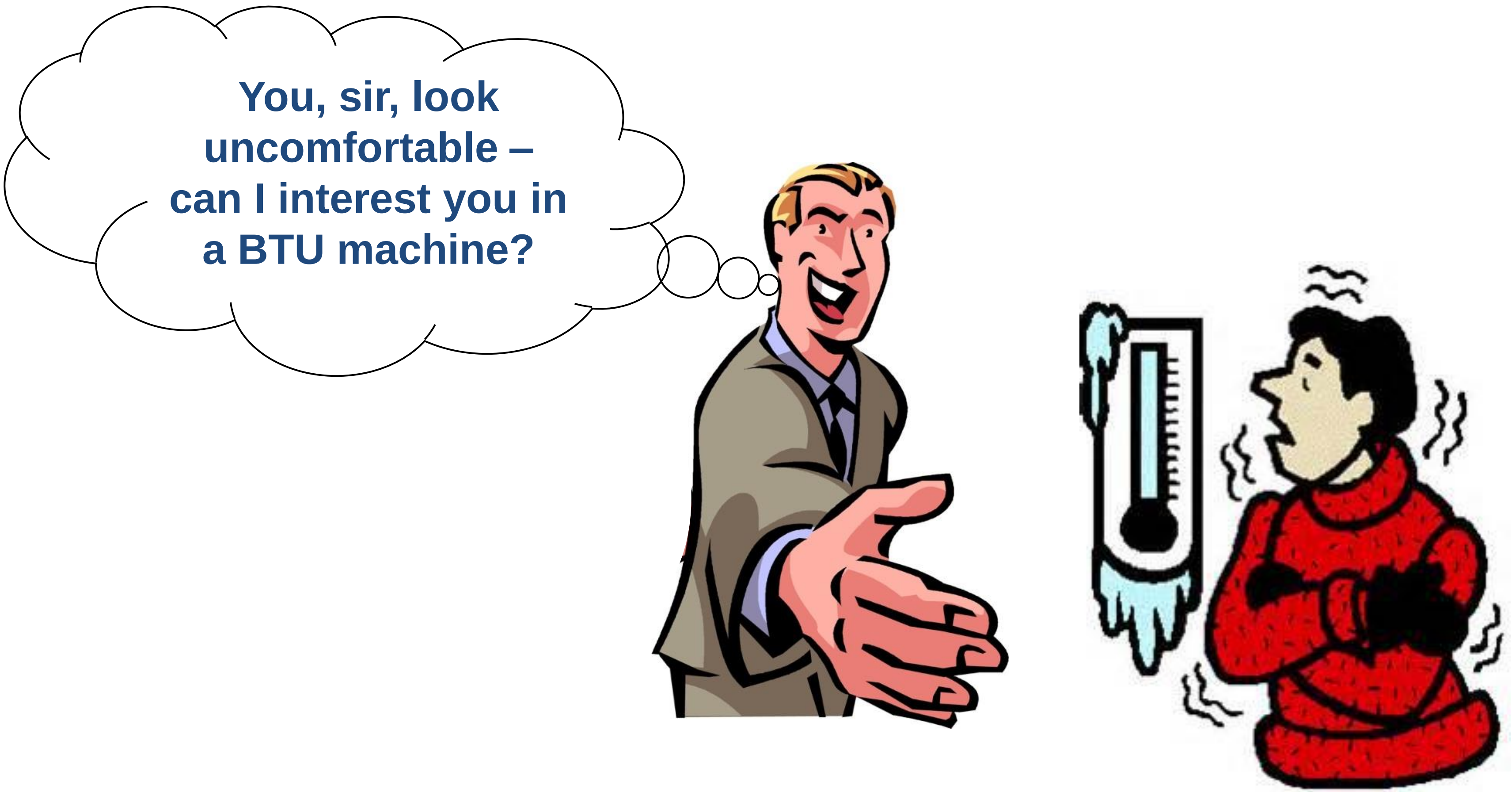
- Almost all HVAC equipment has just two modes – on and off.
- If you have the correct loads, you can select equipment that's the right size.
- Equipment that's based on an *undersized load* won't keep up.
- Equipment that's based on an *oversized load* will cycle on & off.
- Equipment that's based on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

The Equipment Selection Process and Common Mistakes



Equipment selection:
Process and common mistakes

- Think of heating & cooling equipment as just "BTU machines".



Equipment selection:
Process and common mistakes

ENERGY STAR

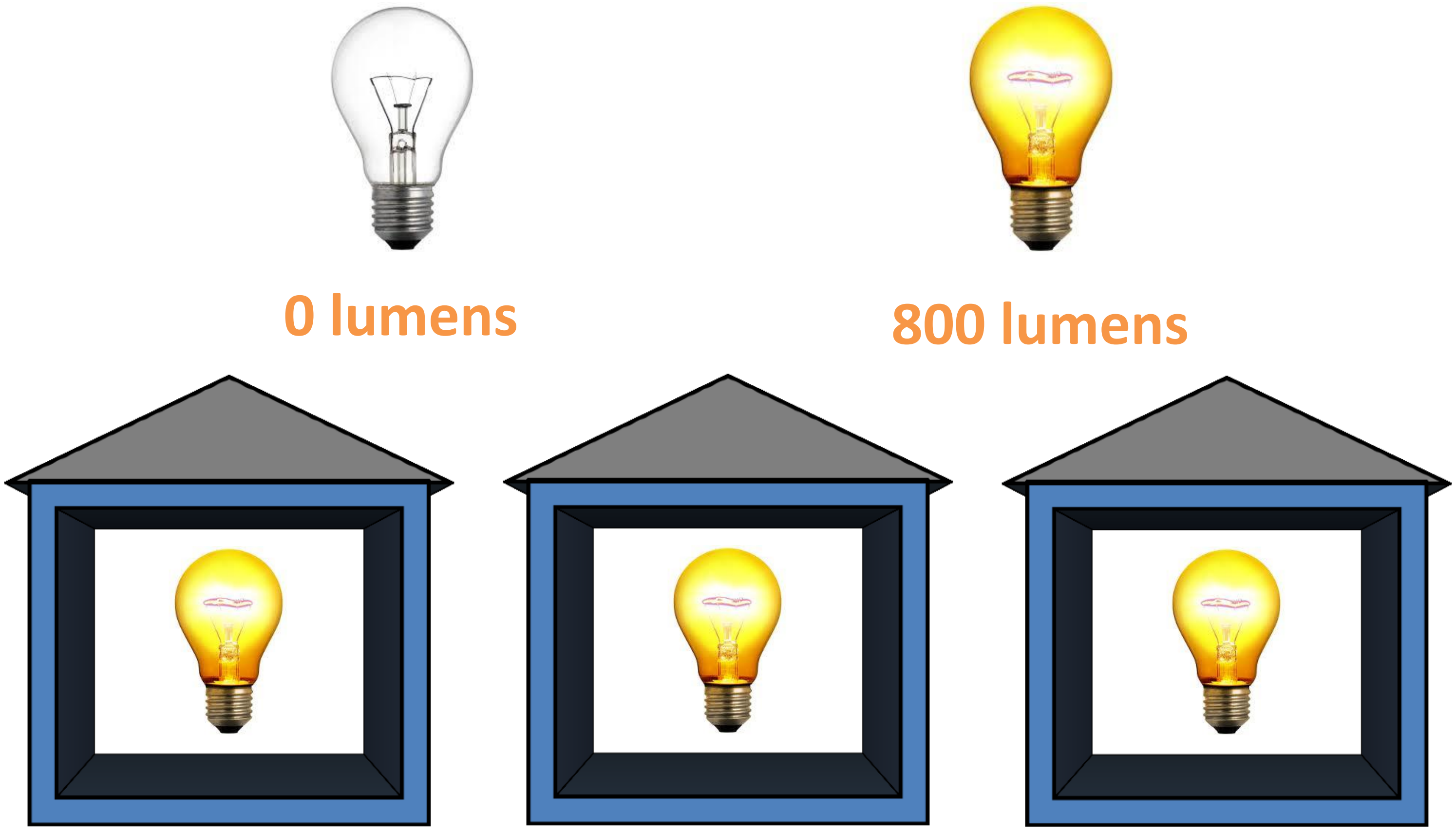
- 1 ton = 12,000 BTU’s per hour = 12k BTU’s per hour

1.5 tons
18 kBTU/hr

3 tons
36 kBTU/hr

5 tons
60 kBTU/hr

Equipment selection:
Process and common mistakes



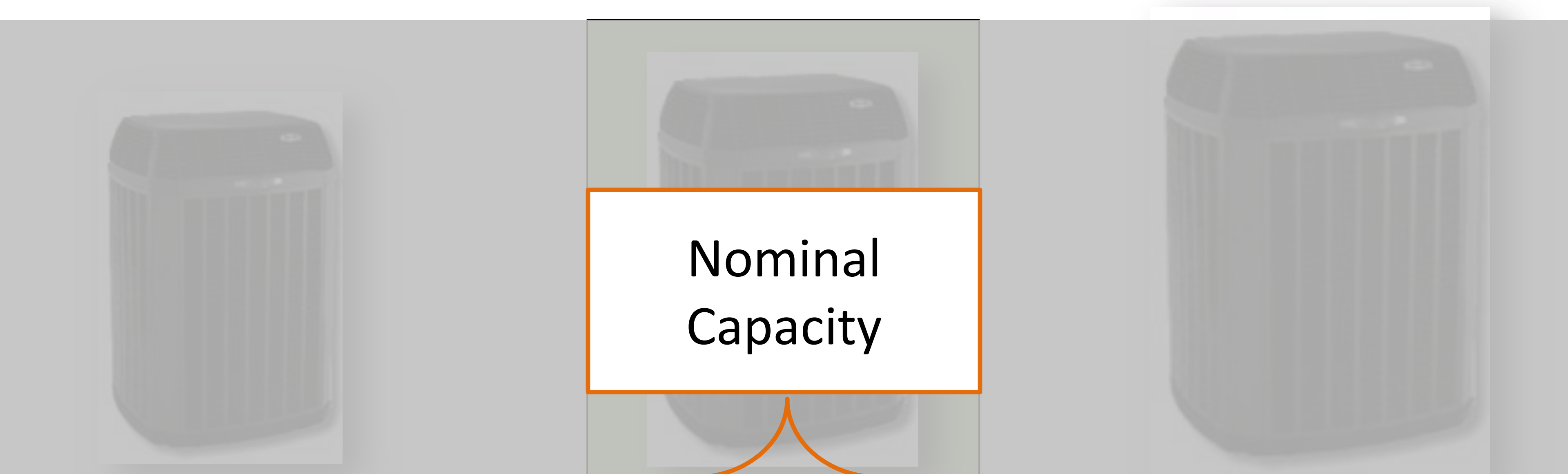
800 lumens / 750 lumens
Georgia

800 lumens / 900 lumens
Arizona

800 lumens / 1000 lumens
New York

Equipment selection:
Process and common mistakes

- "Nominal capacity" means "in name only".
- Nominal capacity is not relevant to the ENERGY STAR program or to code compliance.



1.5 tons
18 kBTU/hr

3 tons
36 kBTU/hr

5 tons
60 kBTU/hr

Mind blown.

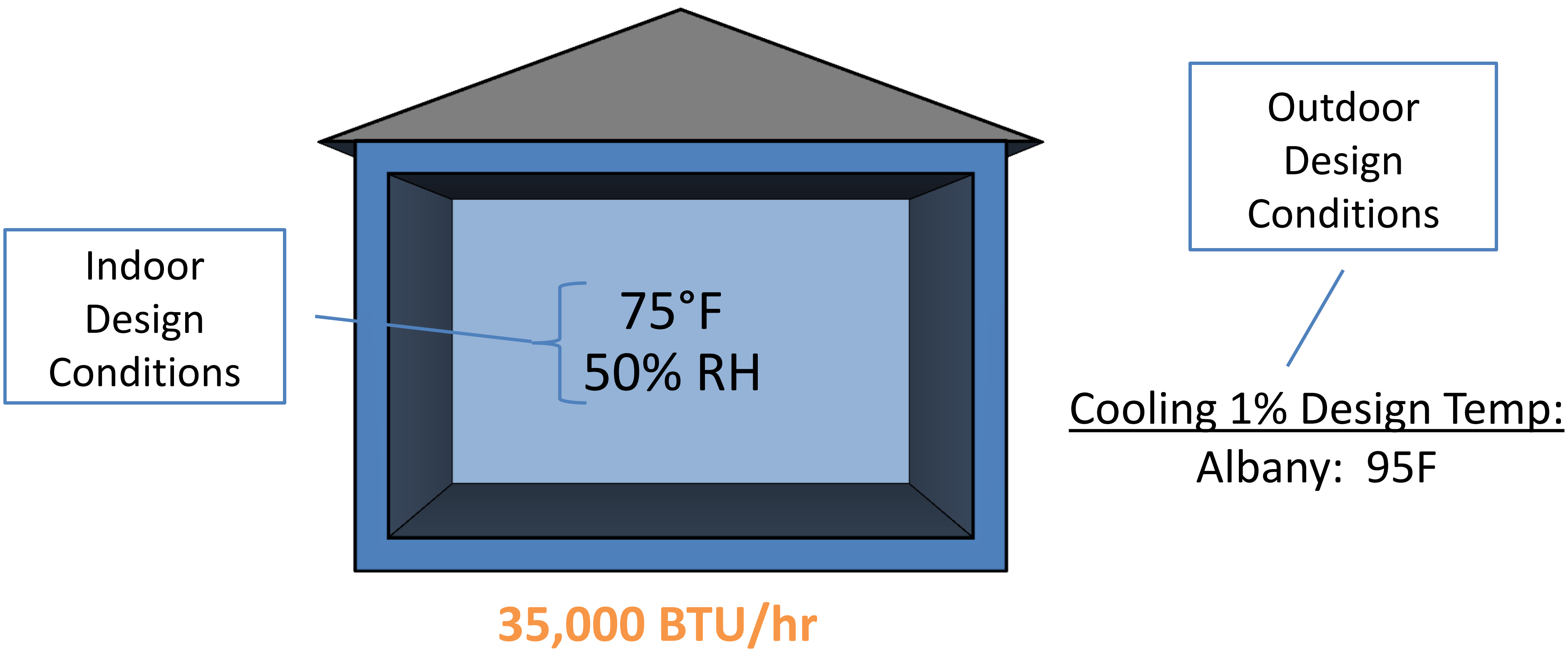
Equipment selection:
Process and common mistakes

- Actual capacity depends on design conditions.

		
36 kBTU/h / 33.2 kBTU/h	36 kBTU/h / 31.4 kBTU/h	36 kBTU/h / 34.8 kBTU/h
Georgia	**Arizona**	**New York**
95 F	**105 F**	**85 F**

Equipment selection:
Process and common mistakes

- Design capacity: Equipment capacity at same design conditions as those used to calculate peak load.



Equipment selection: Process and common mistakes

- Step 1: Gather design information.

- Peak cooling load from Manual J:
  - 27.0 kBTU/h sensible load
  - 2.0 kBTU/h latent load
- Indoor temperature: 75° F
- Indoor humidity: 50%
- Outdoor temperature: 95° F for Albany, GA

Equipment selection: Process and common mistakes

- <u>Step 2</u>: Shop for equipment using HVAC catalogs.

Equipment selection: Process and common mistakes

- Expanded Performance Data: Detailed technical information from manufacturer that gives designer the design capacity.

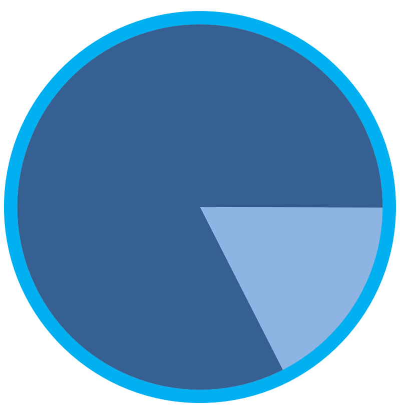
14ACX-036-230-13 - C33-36B/C-6F + EL296UH045V36B

Entering Wet Bulb Temper-ature	Total Air Volume	Outdoor Air Temperature Entering Outdoor Coil														
		85°F					95°F					105°F				
		Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb			Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb			Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb		
	cfm	kBtuh	kW	75°F	80°F	85°F	kBtuh	kW	75°F	80°F	85°F	kBtuh	kW	75°F	80°F	85°F
63°F	1020	33.6	1.95	0.77	0.92	1	32	2.21	0.79	0.94	1	30.2	2.51	0.81	0.97	1
	1210	34.8	1.95	0.81	0.97	1	33.2	2.22	0.83	0.99	1	31.4	2.52	0.86	1	1
	1370	35.6	1.96	0.85	1	1	34	2.23	0.87	1	1	32.6	2.53	0.9	1	1
67°F	1020	35.2	1.96	0.61	0.75	0.88	33.6	2.22	0.62	0.77	0.91	31.8	2.52	0.64	0.79	0.93
	1210	36.6	1.97	0.64	0.79	0.94	34.8	2.23	0.65	0.81	0.96	33	2.53	0.67	0.83	0.99
	1370	37.4	1.97	0.66	0.83	0.98	35.6	2.24	0.68	0.85	1	33.6	2.54	0.69	0.88	1
71°F	1020	36.8	1.97	0.47	0.6	0.73	35.2	2.24	0.47	0.61	0.74	33.4	2.53	0.48	0.62	0.76
	1210	38	1.98	0.48	0.63	0.77	36.4	2.24	0.49	0.64	0.79	34.6	2.55	0.49	0.65	0.81
	1370	39	1.98	0.49	0.65	0.8	37.4	2.25	0.5	0.67	0.83	35.4	2.55	0.51	0.68	0.85

Equipment selection:
Process and common mistakes

14ACX-036-230-13 - C33-36B/C-6F + EL296UH045V36B

Entering Wet Bulb Temperature	Total Air Volume	Outdoor Air Temperature Entering Outdoor Coil														
		85°F					95°F					105°F				
		Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb			Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb			Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb		
	cfm	kBtuh	kW	75°F	80°F	85°F	kBtuh	kW	75°F	80°F	85°F	kBtuh	kW	75°F	80°F	85°F
63°F	1020	33.6	1.95	0.77	0.92	1	32	2.21	0.79	0.94	1	30.2	2.51	0.81	0.97	1
	1210	34.8	1.95	0.81	0.97	1	33.2	2.22	0.83	0.99	1	31.4	2.52	0.86	1	1
	1370	35.6	1.96	0.85	1	1	34	2.23	0.87	1	1	32.6	2.53	0.9	1	1
67°F	1020	35.2	1.96	0.61	0.75	0.88	33.6	2.22	0.62	0.77	0.91	31.8	2.52	0.64	0.79	0.93
	1210	36.6	1.97	0.64	0.79	0.94	34.8	2.23	0.65	0.81	0.96	33	2.53	0.67	0.83	0.99
	1370	37.4	1.97	0.66	0.83	0.98	35.6	2.24	0.68	0.85	1	33.6	2.54	0.69	0.88	1
71°F	1020	36.8	1.97	0.47	0.6	0.73	35.2	2.24	0.47	0.61	0.74	33.4	2.53	0.48	0.62	0.76
	1210	38	1.98	0.48	0.63	0.77	36.4	2.24	0.49	0.64	0.79	34.6	2.55	0.49	0.65	0.81
	1370	39	1.98	0.49	0.65	0.8	37.4	2.25	0.5	0.67	0.83	35.4	2.55	0.51	0.68	0.85



Total Design Capacity (100%) = 33.2 kBTU/h

Sensible Design Capacity (83%) = 27.6 kBTU/h

Latent Design Capacity (17%) = 5.6 kBTU/h

Equipment selection:
Process and common mistakes

- Step 3: Verify that design capacity meets Manual S limits.

A. Latent Design Capacity ≥ Latent Design Load?

5.6 kBTU/h > 2.0 kBTU/h

B. Sensible Design Capacity ≥ 95% x Sensible Design Load..

27.6 kBTU/h ≥ 95% x 27.0 = 25.7 kBTU/h

.. AND Total Design Capacity ≤ 115% Total Design Load..

33.2 kBTU/h ≤ 115% x 29.0 = 33.4 kBTU/h

Equipment selection: Process and common mistakes

- In addition to sizing limits, ACCA Manual S addresses issues like:
  - How to adjust design capacity for high altitudes.
  - How to adjust design capacity for locations with low latent loads.
  - How to adjust the design capacity to account for high ventilation loads.

Equipment selection:
Process and common mistakes

- #1: Use of nominal capacity instead of design capacity.
  - May not know to report design capacity.
  - May not be aware of availability of expanded performance data.

Nominal Capacity

Design Capacity

14ACX-036-230-13 - C33-36B/C-6F + EL296UH045V36B

Outdoor Air Temperature Entering Outdoor Coil

Entering Wet Bulb Temperature	Total Air Volume (cfm)	85°F Total Cool Cap. (kBtuh)	85°F Comp Motor Input (kW)	85°F S/T Dry Bulb 75°F	85°F S/T Dry Bulb 80°F	85°F S/T Dry Bulb 85°F	95°F Total Cool Cap. (kBtuh)	95°F Comp Motor Input (kW)	95°F S/T Dry Bulb 75°F	95°F S/T Dry Bulb 80°F	95°F S/T Dry Bulb 85°F	105°F Total Cool Cap. (kBtuh)	105°F Comp Motor Input (kW)	105°F S/T Dry Bulb 75°F	105°F S/T Dry Bulb 80°F	105°F S/T Dry Bulb 85°F	115°F Total Cool Cap. (kBtuh)	115°F Comp Motor Input (kW)	115°F S/T Dry Bulb 75°F	115°F S/T Dry Bulb 80°F	115°F S/T Dry Bulb 85°F
63°F	1020	33.6	1.95	0.77	0.92	1	32	2.21	0.79	0.94	1	30.2	2.51	0.81	0.97	1	28.4	2.84	0.84	[illegible]	[illegible]
	1210	34.8	1.95	0.81	0.97	1	33.2	2.22	0.83	0.99	1	31.4	2.52	0.86	1	1	29.8	2.85	0.89	[illegible]	[illegible]
	1370	35.6	1.96	0.85	1	1	34	2.23	0.87	1	1	32.6	2.53	0.9	1	1	30.8	2.85	0.93	1	[illegible]
67°F	1020	35.2	1.96	0.61	0.75	0.88	33.6	2.22	0.62	0.77	0.91	31.8	2.52	0.64	0.79	0.93	30	2.85	0.65	0.81	[illegible]
	1210	36.6	1.97	0.64	0.79	0.94	34.8	2.23	0.65	0.81	0.96	33	2.53	0.67	0.83	0.99	31	2.85	0.68	0.86	1
	1370	37.4	1.97	0.66	0.83	0.98	35.6	2.24	0.68	0.85	1	33.6	2.54	0.69	0.88	1	31.6	2.87	0.71	0.91	1
71°F	1020	36.8	1.97	0.47	0.6	0.73	35.2	2.24	0.47	0.61	0.74	33.4	2.53	0.48	0.62	0.76	31.6	2.86	0.48	0.64	0.79
	1210	38	1.98	0.48	0.63	0.77	36.4	2.24	0.49	0.64	0.79	34.6	2.55	0.49	0.65	0.81	32.6	2.87	0.5	0.67	0.84
	1370	39	1.98	0.49	0.65	0.8	37.4	2.25	0.5	0.67	0.83	35.4	2.55	0.51	0.68	0.85	33.2	2.88	0.52	0.7	0.88

“3 tons” = 36 kBTU/hr

[illegible] 33.2 kBTU/hr

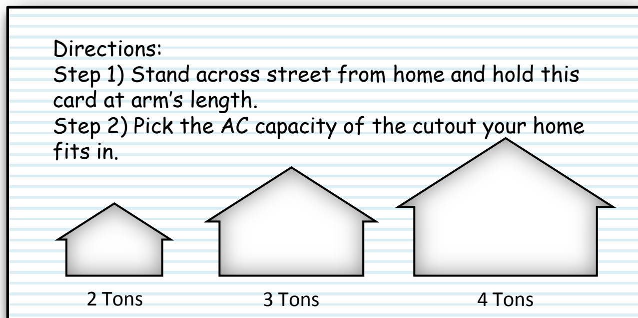
Reported Capacity

Selected Cooling Equipment			
3.8	Listed Sys. Latent Capacity at Design Cond.:		BTUh
3.9	Listed Sys. Sensible Capacity at Design Cond.:		BTUh
3.10	Listed Sys. Total Capacity at Design Cond.:	36,000 / 33,200	BTUh

Equipment selection: Process and common mistakes

- #1: Use of nominal capacity instead of design capacity.
  – May believe that nominal capacity + intuition is ‘good enough’.

Nominal Capacity



“3 tons” ≈ 36 kBTU/hr

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Design Capacity

14ACX-036-230-13 - C33-36B/C-6F + EL296UH045V36B

Outdoor Air Temperature Entering Outdoor Coil

Entering Wet Bulb Temperature	Total Air Volume	85°F					95°F					105°F					115°F				
		Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb			Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb			Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb			Total Cool Cap.	Comp Motor Input	Sensible to Total Ratio (S/T) Dry Bulb		
	cfm	kBtuh	kW	75°F	80°F	85°F	kBtuh	kW	75°F	80°F	85°F	kBtuh	kW	75°F	80°F	85°F	kBtuh	kW	75°F	80°F	85°F
63°F	1020	33.6	1.95	0.77	0.92	1	32	2.21	0.79	0.94	1	30.2	2.51	0.81	0.97	1	28.4	2.84	0.84	0.99	1
	1210	34.8	1.95	0.81	0.97	1	33.2	2.22	0.83	0.99	1	31.4	2.52	0.86	1	1	29.8	2.85	0.89	1	1
	1370	35.6	1.96	0.85	1	1	34	2.23	0.87	1	1	32.6	2.53	0.9	1	1	30.8	2.85	0.93	1	1
67°F	1020	35.2	1.96	0.61	0.75	0.88	33.6	2.22	0.62	0.77	0.91	31.8	2.52	0.64	0.79	0.93	30	2.85	0.65	0.81	0.96
	1210	36.6	1.97	0.64	0.79	0.94	34.8	2.23	0.65	0.81	0.96	33	2.53	0.67	0.83	0.99	31	2.85	0.68	0.86	1
	1370	37.4	1.97	0.66	0.83	0.98	35.6	2.24	0.68	0.85	1	33.6	2.54	0.69	0.88	1	31.6	2.87	0.71	0.91	1
71°F	1020	36.8	1.97	0.47	0.6	0.73	35.2	2.24	0.47	0.61	0.74	33.4	2.53	0.48	0.62	0.76	31.6	2.86	0.48	0.64	0.79
	1210	38	1.98	0.48	0.63	0.77	36.4	2.24	0.49	0.64	0.79	34.6	2.55	0.49	0.65	0.81	32.6	2.87	0.5	0.67	0.84
	1370	39	1.98	0.49	0.65	0.8	37.4	2.25	0.5	0.67	0.83	35.4	2.55	0.51	0.68	0.85	33.2	2.88	0.52	0.7	0.88

“3 tons” = 33.2 kBTU/hr

Equipment selection: Process and common mistakes

- #2: Inadvertent errors in the equipment selection process.
  - Equipment selection is often done by hand, which is just more error-prone.
  - Expanded performance data is formatted a bit differently by every manufacturer.

Online Shopping

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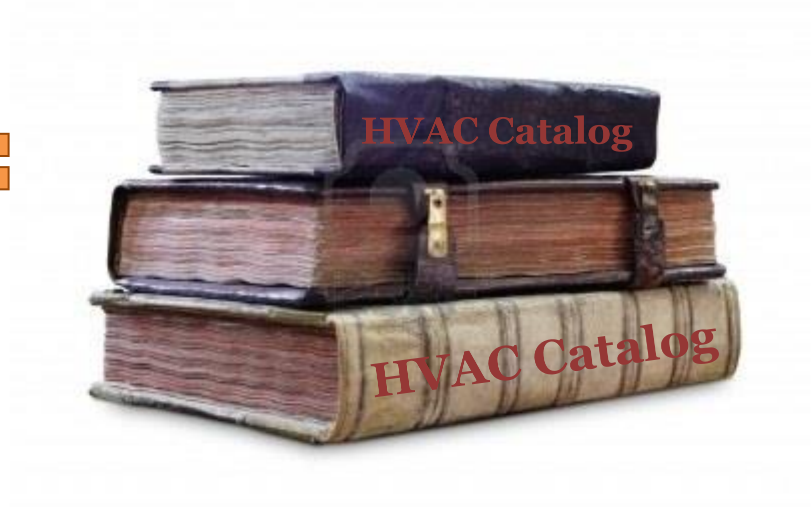
Catalog Shopping



Equipment selection: Process and common mistakes

- #3: Don’t yet believe in the ACCA design process.
  - May not believe that Manual J loads represents typical ‘worst-case’.
  - Therefore, may be uncomfortable with Manual S sizing limits.

Design Conditions ≟ **Field Conditions**

Equipment selection: Process and common mistakes

- #3: Don’t yet believe in the ACCA design process.
  - Other problems may be blamed on size of the equipment when, in fact they are unrelated.

Design Conditions

≠

Field Conditions

Equipment selection: Summary

- Designers need to select equipment using “design capacity”.
- Design capacity: Equipment capacity at same design conditions as those used to calculate peak load.
- Design capacity determined using expanded performance data.
- Top three reasons that things go wrong:
  - #1: Use of nominal capacity instead of design capacity.
  - #2: Inadvertent errors in the equipment selection process.
  - #3: Don’t yet believe in the ACCA design process.

Summary

Summary

- Goal of equipment selection is to match capacity to load.
- Properly sized equipment keeps home comfortable, while maintaining efficiency, and maximizing equipment durability.
- Designers use expanded performance data to select equipment according to its design capacity.
- Manual S helps standardize this process.

Equipment Selection Exercise

Equipment Selection Exercise

- Design Parameters:
  - Outdoor dry-bulb: 95°F
  - Indoor dry-bulb: 75°F
  - Indoor rel. humidity: 50%
  - Indoor wet-bulb: 63°F
- Design loads:
  - Latent: 6.7 kBTU/hr
  - Sensible: 27.2 kBTU/hr
  - Total: 33.9 kBTU/hr

Model A		Outdoor Air Temperature				
		95 °F				
Enter Wet-Bulb (°F)	Total Air Flow (CFM)	Total Cool Cap. (BTUH)	Comp. Motor Watts	Sensible-to-Total Ratio (S/T)		
				Dry Bulb °F		
				75	80	85
63 F	1,200	39,700	3,870	0.75	0.88	0.98
	1,325	40,700	3,910	0.78	0.91	1.00
	1,575	41,500	3,940	0.80	0.94	1.00

Equipment Selection Exercise

- Design Parameters:
  - Outdoor dry-bulb: 95°F
  - Indoor dry-bulb: 75°F
  - Indoor rel. humidity: 50%
  - Indoor wet-bulb: 63°F
- Design loads:
  - Latent: 6.7 kBTU/hr
  - Sensible: 27.2 kBTU/hr
  - Total: 33.9 kBTU/hr
- Selection Criteria:
  1. Latent cap. ≥ latent design load: ≥ 6.7 kBTU/hr
  2. Sensible cap. ≥ 95% sensible design load: ≥ 25.8 kBTU/hr
  3. Total cap. ≤ 115% total design load: ≤ 39.0 kBTU/hr

Equipment Selection Exercise

Summary of Equipment Selection Criteria				
Model	Meets All Criteria?	1. Latent Capacity	2. Sensible Capacity	3. Total Capacity
Model A	✗	✓	✓	✗
Model B	✓	✓	✓	✓
Model C	✗	✗	✗	✓

Managing The Equipment Selection Process

Introducing Greg Cobb

- President & CEO, iEngineer, LLC and Sonoran Air, Inc.
- Has been providing services for more than 10,000 ENERGY STAR certified homes since 2003.
- Provides services nationwide, but focused on Sunbelt states, including hot/dry and hot/humid climates.

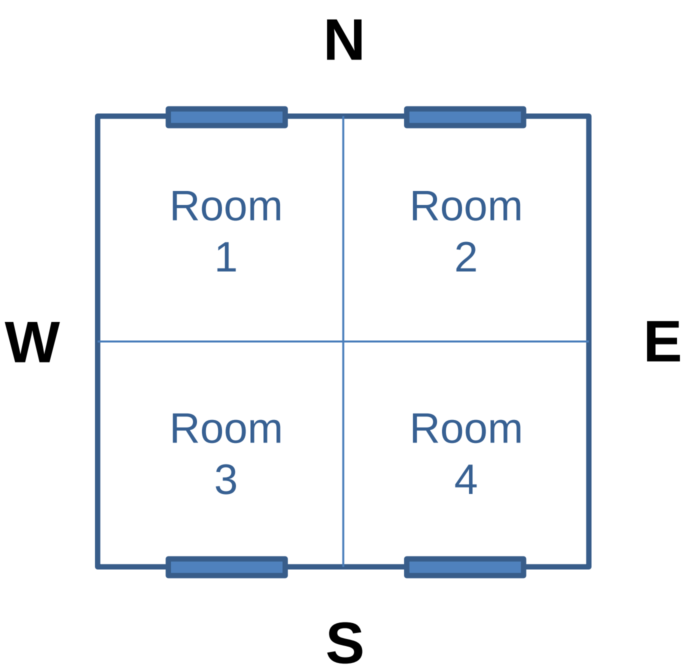
Session Objectives

- Multi-Configuration Complexity
- Three HVAC Design Methods
- Builder Recommendations
- Stakeholder Impact
- Triple Win
- Results/Experience

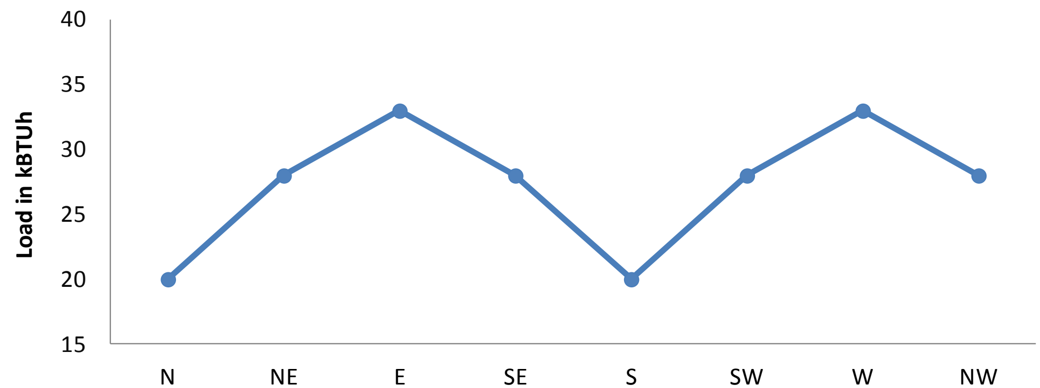
Multi-configuration complexity: Equipment selection & duct design

ENERGY STAR

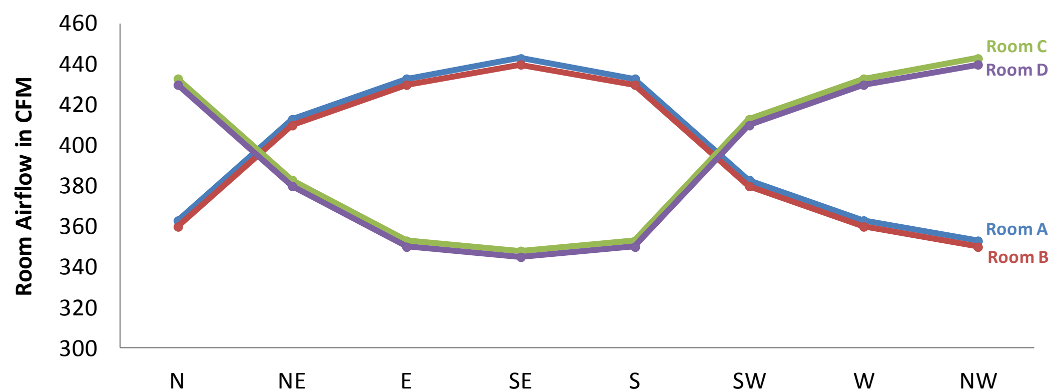
House A



**Whole-house load varies greatly with orientation..
..so multiple equipment selections are needed.**



**But some room airflows stay aligned with orientation..
..so duct designs can be more uniform.**

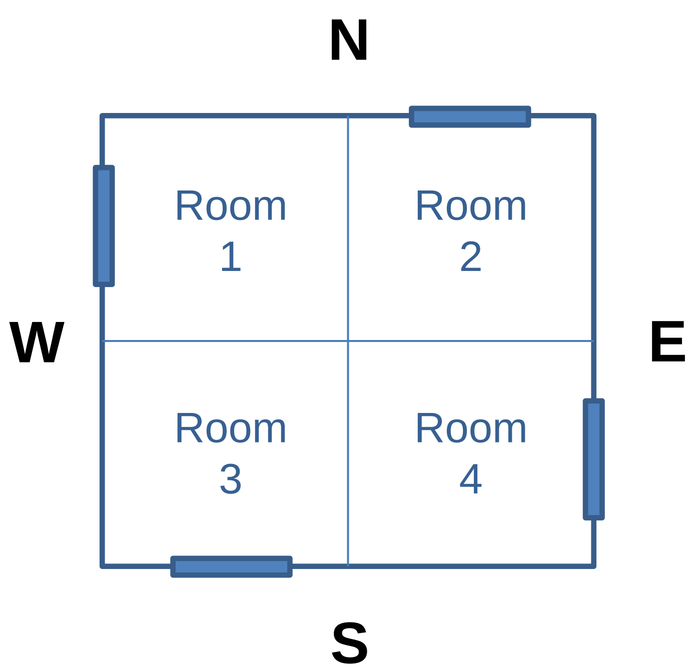


SONORAN

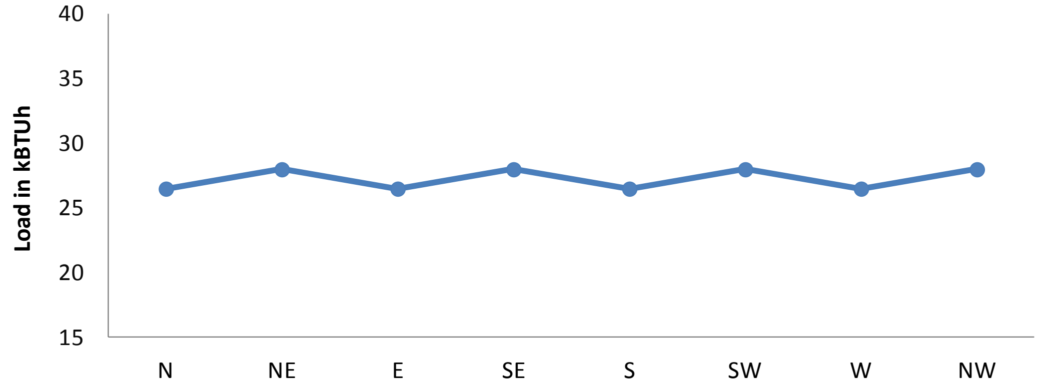
iEngineer

Multi-configuration complexity: Equipment selection & duct design

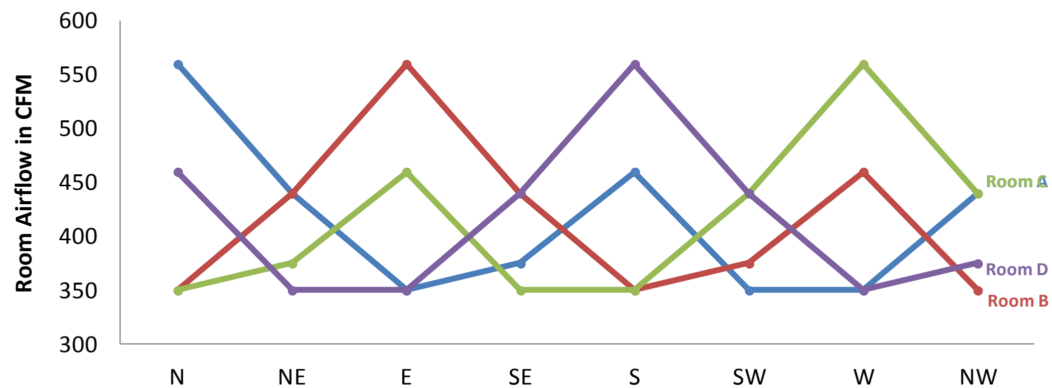
House B



Whole-house load varies little with orientation..
..so only a single equipment selection is needed.



But room airflows are not aligned with orientation..
..so multiple duct designs are needed.



SONORAN

iEngineer

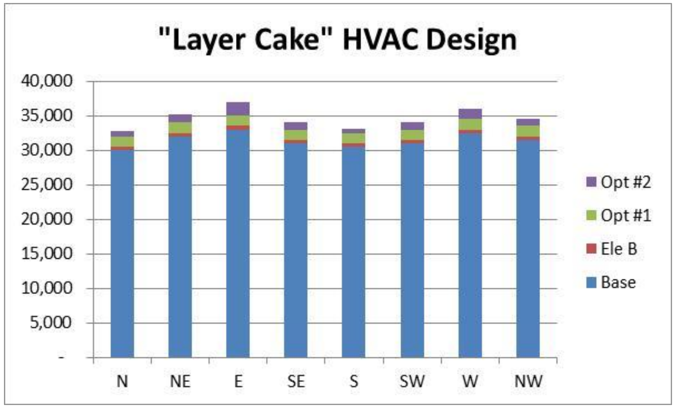
Multi-Configuration: Design Complexity

- Sample plan w/ 6 options impacting heat load:
  1. Elevation B
  2. Great Multi-Panel SGD
  3. Dining French Door
  4. Master Bay Window
  5. Bed 4 ILO Tandem Garage
  6. Extended Covered Patio

Plans	Options	Option Combinations	Load Configurations	Room-level Target Airflows
1	1	2	x 4 = 8	x 10 = 80
1	6	64	x 16 = 1,024	x 10 = 10,240
4	24	256	x 16 = 4,096	x 10 = 40,960
1	15	32,768	x 16 = 524,288	x 15 = 7,864,320
8	15	262,144	x 16 = 4,194,304	x 15 = 62,914,560

Complexity Solution – "Layer Cake"

- Create "Layer Cake" HVAC Design:
  - Layers:
    - Base Plan: First calculate base case with no options
    - Calculate heat load and duct layout changes:
      - Elevations
      - Floor Plan Options
      - Glazing Options
  - Slices:
    - Solar Orientation: Calculate each of the above for 8 solar orientations & Garage hand L/R



- Per Lot:
  - Select appropriate "layers" and "slice" for each lot, determine heat load, select equipment match-up and size duct system

HVAC Design Methods

- Methods
  1. Group
  2. Advanced
  3. Custom
- Phase
  - Initial Design – at plan submission
  - Per-Lot Design – at permit

HVAC Design Solutions

	Group Design	Advanced Design	Custom Design
Initial Design	By: Engineer	By: Engineer	By: Engineer
Load	"Layer Cake" Group Loads	"Layer Cake"	Worst Case
Equipment	Group	Range	Worst Case
Duct	One "Loose" Design per Group	One Design w/ Range of Sizes	Worst Case

HVAC Design Solutions

	Group Design	Advanced Design	Custom Design
Per-Lot Design	By: Contractor	By: Engineer	By: Engineer
Load	Determine Load & Select Group	Determine Load	Calc. Load
Equipment	Determine Match-up for Group	Determine Match-up for Load	Calc. & Select Match-up
Duct	Calc. Airflow Targets & Adjust Dampers	Calc. Airflow Targets & Select Sizes	Calc. Airflow Targets, Revise Design & Select Sizes

Where/When to Place the Complexity?

	Group Design	Advanced Design	Custom Design
Initial Design	Engineer	Engineer	Engineer
Per-Lot Design	Contractor	Engineer Contractor	Engineer Contractor

Recommendations

- Group Design
  - Least changes from traditional process to ensure minimum compliance
  - Comfortable relying heavily on HVAC contractor
- Advanced Design
  - Desire lowest per-lot costs, best homeowner comfort and best energy efficiency
  - Concerned about per-lot design turnaround time and/or HVAC contractor capabilities
  - Have communities with high # lots and fixed options
- Custom Design
  - Desire low upfront costs, best homeowner comfort and best energy efficiency
  - Less concerned about per-lot design cost or design turn around time
  - Have communities with low # lots or significant custom options

Stakeholder Impact

- HVAC Engineer/Designer
- HVAC Contractor
- Other Trades (Framing, Electrical & Plumbing)
- Builder
  - Purchasing
  - Field Ops
  - Sales & Service
- Municipal
  - Plan Review
  - Inspection
- Energy Rater

Triple Win: Advanced/Custom Design

- Improve Energy Efficiency:
  - Equipment sized for specific needs of each lot instead of worst case to eliminate over-sizing

- Enhance Homeowner Comfort:
  - Duct system balanced to provide room-level airflow for specific needs of each lot instead of worst case
  - Longer run times homogenize temperatures throughout home and remove moisture more effectively in summer

- Reduced Costs:
  - Lower equipment & materials costs
  - Lower customer service/warranty costs

Results/Experience: Costs

- Increase in engineering costs
- Decrease in equipment costs
- Change in materials costs
- Decrease in comfort calls / warranty costs
- Increase in homeowner misunderstanding calls

Results/Experience: Tips

- Right-sizing isn't as scary as many think
- Proper room-level airflow is critical
  - Designing balanced duct systems is possible
  - Designing & installing per-lot custom duct systems is also possible
- Controls are very important
  - T-stat placement
  - Remote temp sensors
  - Zoning

...Right-sizing w/ proper airflow & controls <u>WORKS</u>!!

Recap

- Multi-Orientation / Multi-Configuration Complexity
- Three HVAC Design Methods
- Builder Recommendations
- Stakeholder Impact
- Triple Win
- Results/Experience

Discussion

Web:

Main: www.energystar.gov/newhomespartners
Technical: www.energystar.gov/newhomesguidelines
Training: www.energystar.gov/newhomestraining
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