We will be starting soon!

Thanks for joining us

Intro to Residential HVAC Design (ACCA) Part 1

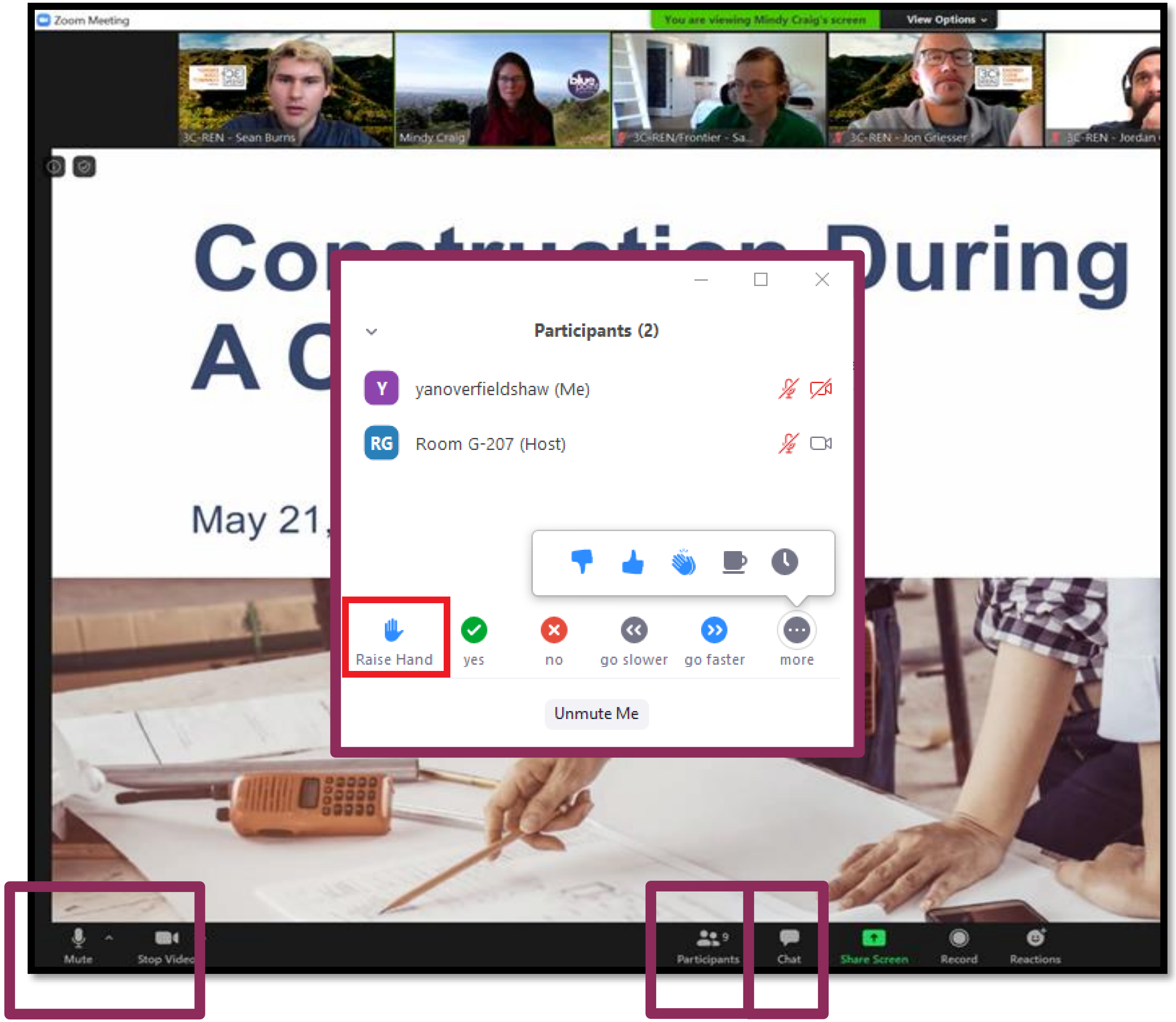
Russ King – Coded Energy

April 25, 2023

3C-REN

Zoom Orientation

- Please be sure your full name is displayed
- Please mute upon joining
- Use "Chat“ box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be recorded and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region

3C-REN ENERGY CODE CONNECT

3C-REN BUILDING PERFORMANCE TRAINING

3C-REN HOME ENERGY SAVINGS

3C-REN ENERGY CODE CONNECT

- Serves all building professionals
- Three services –
  - **Energy Code Coach**
  - **Training and Support**
  - **Regional Forums**
- Makes the Energy Code easy to follow

Energy Code Coach:
3c-ren.org/codes
805.220.9991

Event Registration:
3c-ren.org/events

- Serves current and prospective building professionals
- Expert instruction:
  - **Technical skills**
  - **Soft skills**
- Helps workers to thrive in an evolving industry

Event Registration:
3c-ren.org/events

3C-REN HOME ENERGY SAVINGS

Multifamily (5+ units)

- No cost technical assistance
- Rebates up to $750/apartment plus additional rebates for specialty measures like heat pumps

Single Family (up to 4 units)

- Sign up to participate!
- Get paid for the metered energy savings of your customers

Enrollment:
3C-REN.org/contractor-participation

RESIDENTIAL HVAC DESIGN SERIES

PART 1 OF 2

ACCA MANUAL J

LOAD CALCULATIONS

ACCA MANUAL S

EQUIPMENT SELECTION

DEVELOPED FOR:

SONOMA COUNTY ENERGY AND SUSTAINABILITY

PRESENT BY:

CODED ENERGY, INC.
RUSSELL KING, ME

CODED ENERGY

RESIDENTIAL HVAC DESIGN SERIES

- Part 1 - **ACCA Manual J Loads and Manual S Equipment Selection (Today)**
- Part 2 - **ACCA Manual D Duct Design (This Thursday)**

Agenda for Today

1. Introduction
2. Overview of the HVAC Design Process:
3. Manual J – Load Calculations
4. Manual S – Equipment Selection

Agenda for Part 2

1. Introduction (Some Review)
2. Overview of the HVAC Design Process (Review)
3. Manual D – Duct System Design

1. INTRODUCTION

1. INTRODUCTION

- Instructor – Russell King, M.E.
- Licensed Mechanical Engineer (3 states)
- CEO of Coded Energy, Inc. (Developers of Kwik Model 3D software)
- 30+ years experience with residential HVAC design and energy efficiency
- russ@coded-energy.com
- HVAC Blog: www.russellking.me
- Software Website: www.kwikmodel.com
- YouTube: Kwik Model (HVAC design and software demos)

1. INTRODUCTION

About ***ACCA Manuals J/S/D***

- ACCA is **Air Conditioning Contractors of America**, the largest HVAC trade association in the United States.
- They write and publish ANSI approved manuals on residential and nonresidential HVAC design
- Most widely recognized as the industry standard for HVAC design (though not the only recognized standard).

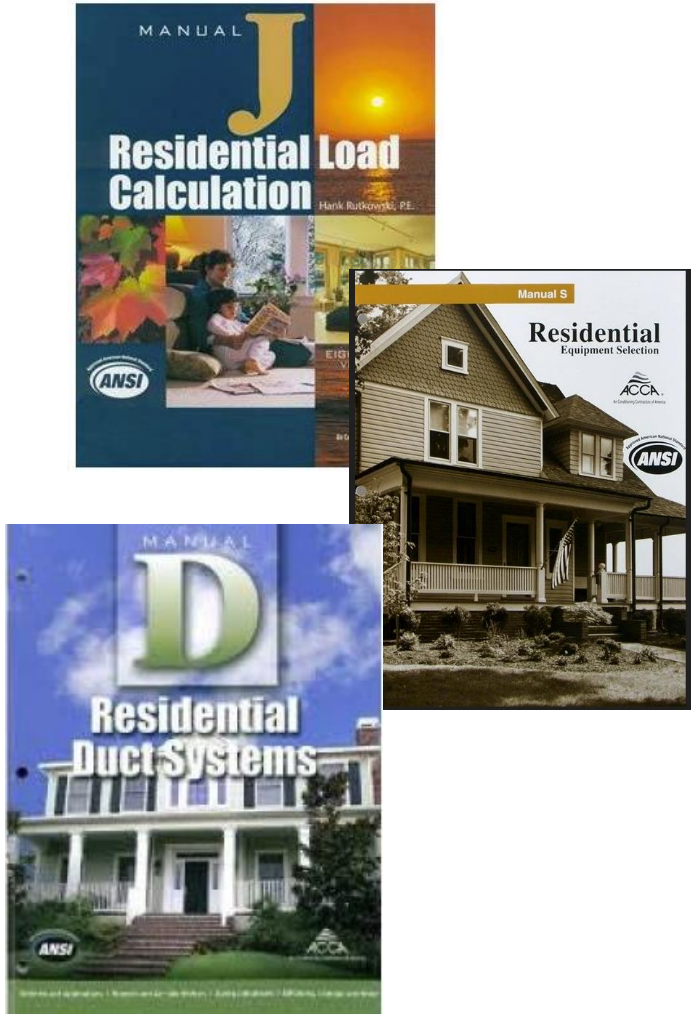
I. INTRODUCTION

About ***ACCA Manuals J/S/D***

- The California Energy Code and Mechanical Code **require** ACCA Manual J, S and D (or equal) for all ***new*** residential HVAC systems, whether in a new house or an existing house.
- More and more building departments are starting to enforce this requirement.
- HVAC contractors should be doing it anyway!

1. INTRODUCTION

- Basic Design Manuals
  - Manual J – Residential Load Calculations
  - Manual S – Equipment Selection
  - Manual D – Duct Design
- Other Related Manuals
  - Manual RS – Residential System Design (overview)
  - Manual T – Terminal Selection (registers)
  - Manual H – Heat Pumps
  - Manual LLH – Low Load Homes
- Other Standards and Checklists. (QI, QM, etc.)
- www.acca.org



1. INTRODUCTION

Definitions

British Thermal Unit (BTU)

This is a unit of heat energy that is approximately equal to the heat stored in a wooden kitchen match.

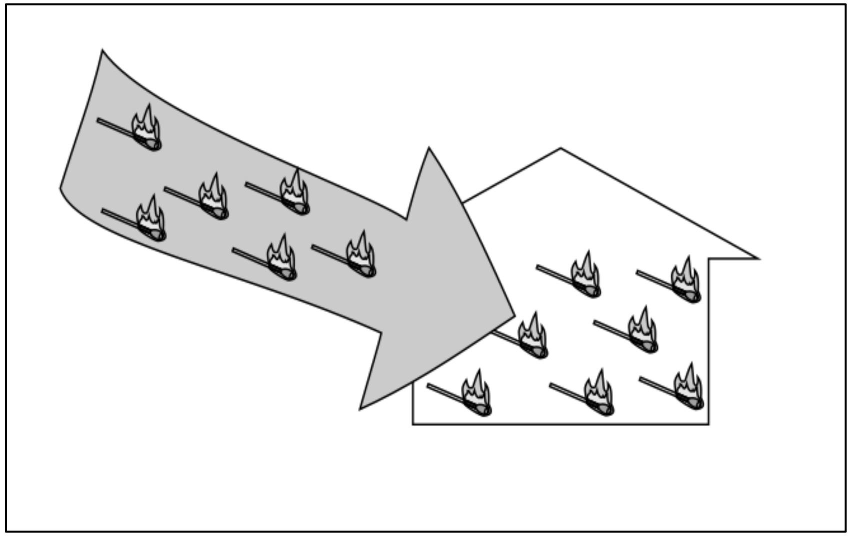
Heat moves at different ***rates***. We express this in BTUs per hour (Btuh)

I. INTRODUCTION

Definitions

Cooling Load

- In the *summer*, the BTUs are more concentrated outside the house than inside, so heat will naturally come into the house.
- The *cooling load* is the number of BTUs per hour that the air conditioner must *remove* at design conditions.



Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

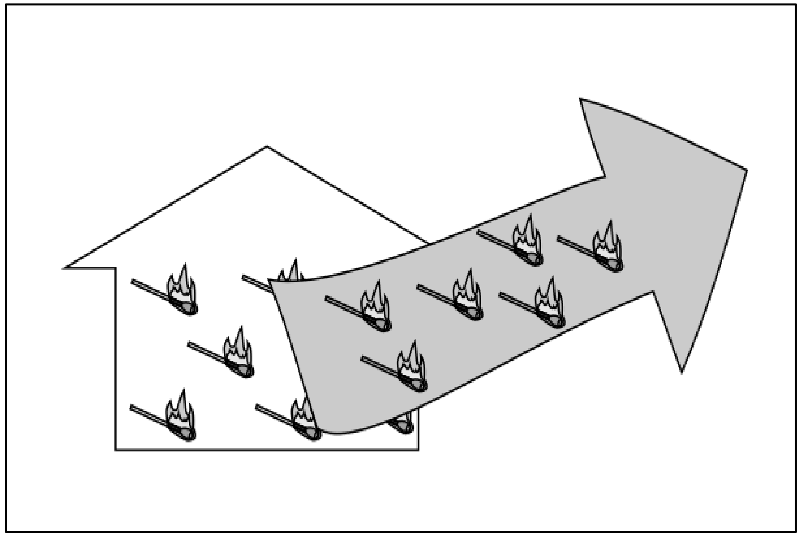
1. INTRODUCTION

Definitions

Cooling

Cooling is the process of removing heat from a house

- Consider an air conditioner that is tested to have a cooling capacity of 24,000 Btuh.
- This means that it can remove 24,000 kitchen matches worth of heat from the house in one hour.



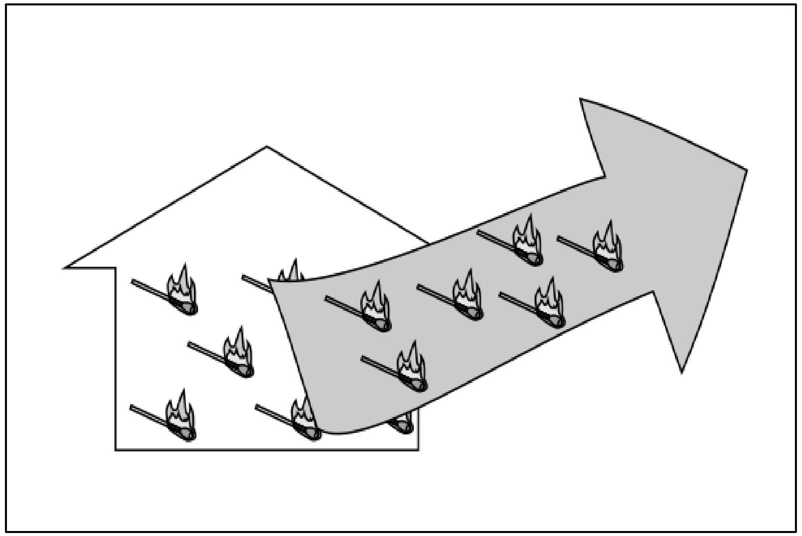
Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

1. INTRODUCTION

Definitions

Heating Load

- In the winter the BTUs are more concentrated inside the house than outside, so heat will naturally leave the house.
- *Heating load* is the number of BTUs that the heater (heat pump or furnace) must *add* each hour at design conditions.



Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

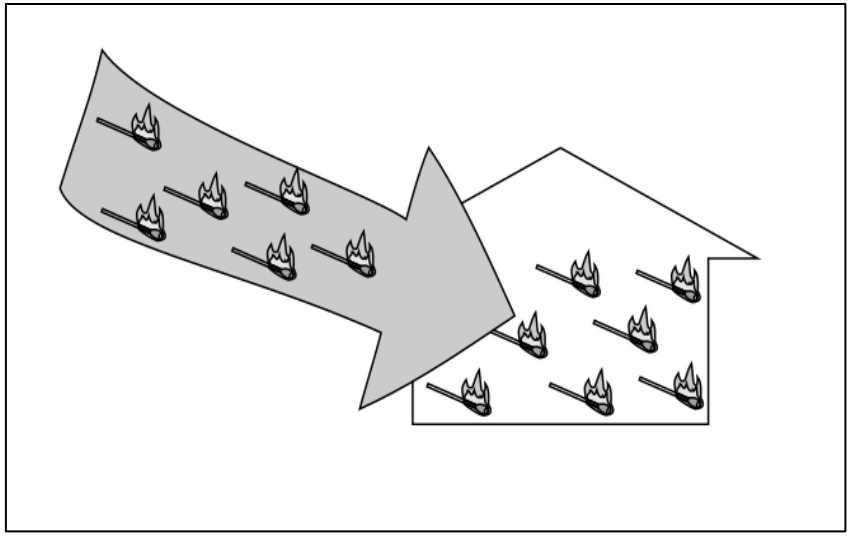
1. INTRODUCTION

Definitions

Heating

Heating is the process of adding BTUs to a house.

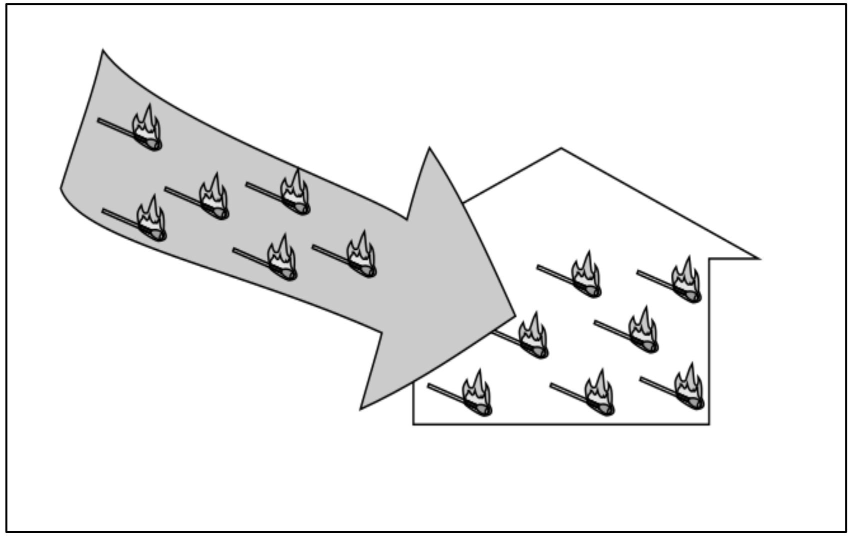
- Consider a heater that is tested to have a heating capacity of 30,000 btuh.
- This means that it can add 30,000 kitchen matches worth of heat to the house in one hour.

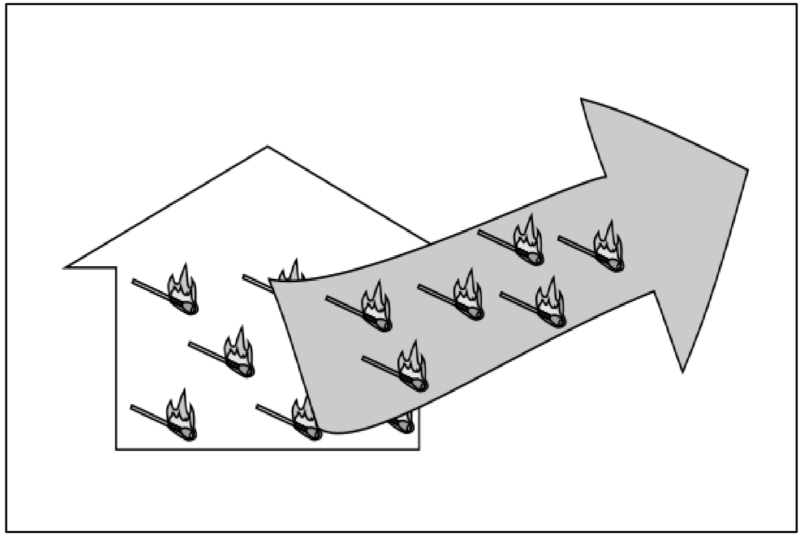


Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

1. INTRODUCTION

To maintain a **constant temperature** in a house the rate of heat coming in must **equal** the rate of heat going out.





Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

1. INTRODUCTION

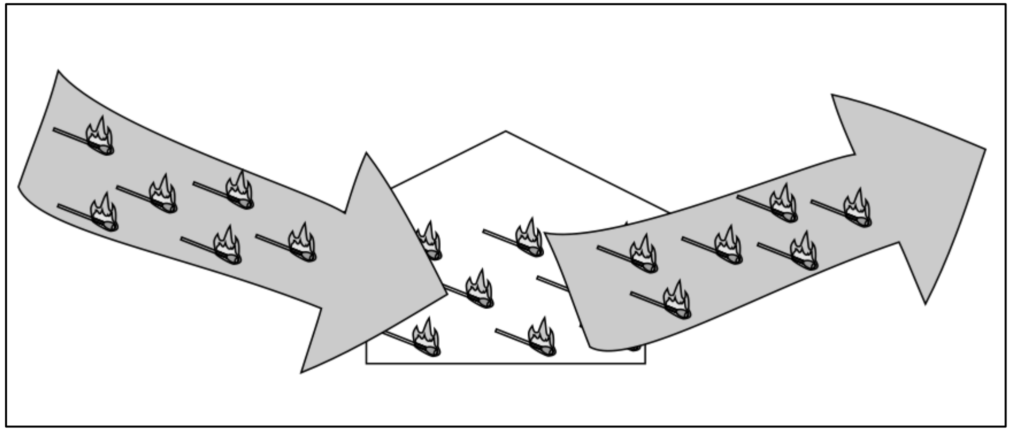
Definitions

The **capacity** of the heating or cooling equipment is the *output* of the equipment in BTUs per hour. Think of it as the ***supply***.

The **load** of the house is what the house *needs* in BTUs per hour to maintain a constant temperature at design conditions. Think of it as the ***demand***.

1. INTRODUCTION

Good equipment sizing is the ability to match the equipment's **supply** to the house's **demand**.

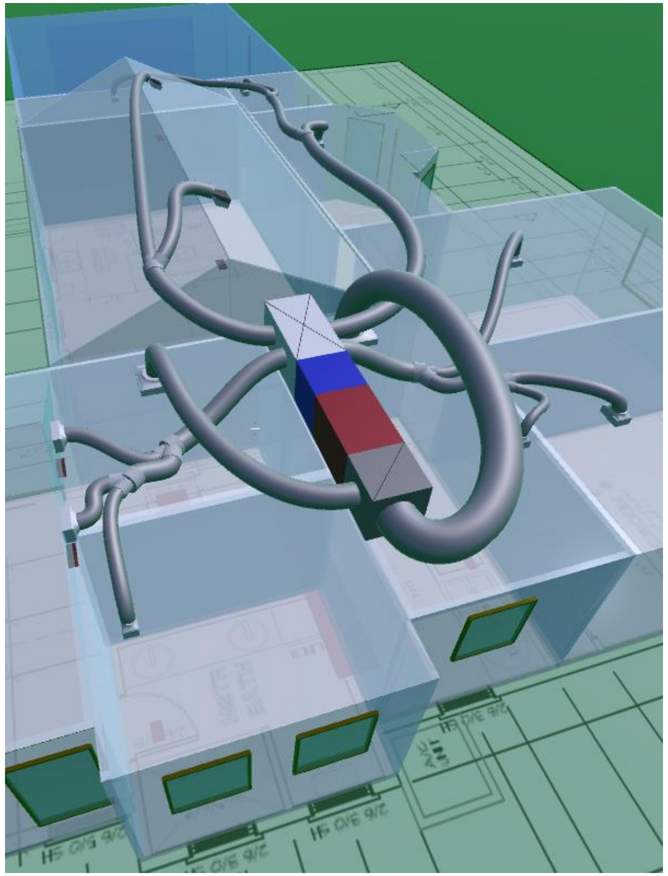


Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

1. INTRODUCTION

Definitions

Undersizing is defined as when the *capacity* of the equipment is less than the *load* of the house at design conditions.

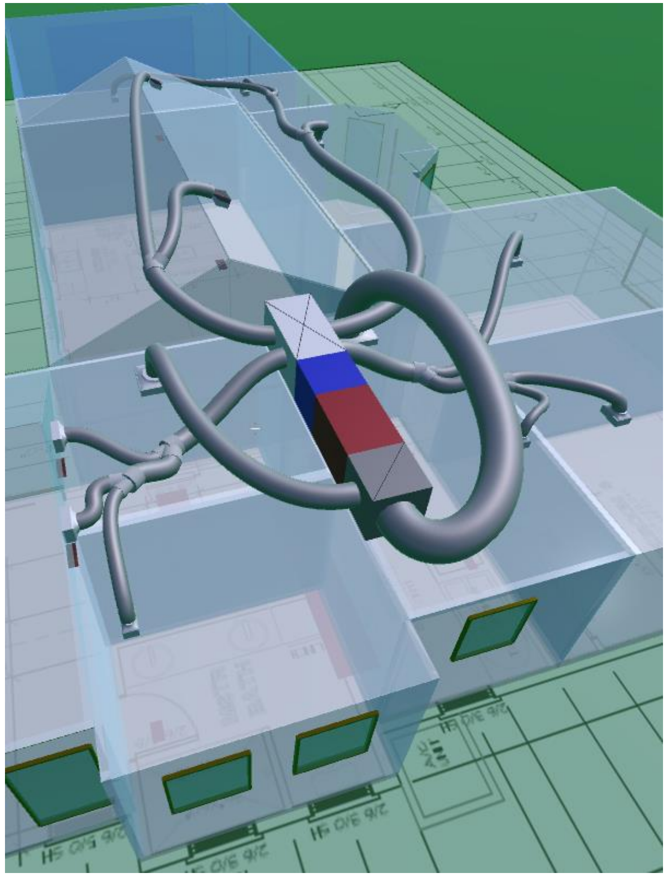


Screen snip from Kwik Model with EnergyGauge Loads

I. INTRODUCTION

Definitions

Oversizing is defined as when the *capacity* of the equipment is substantially higher than the *load* of the house at design conditions.



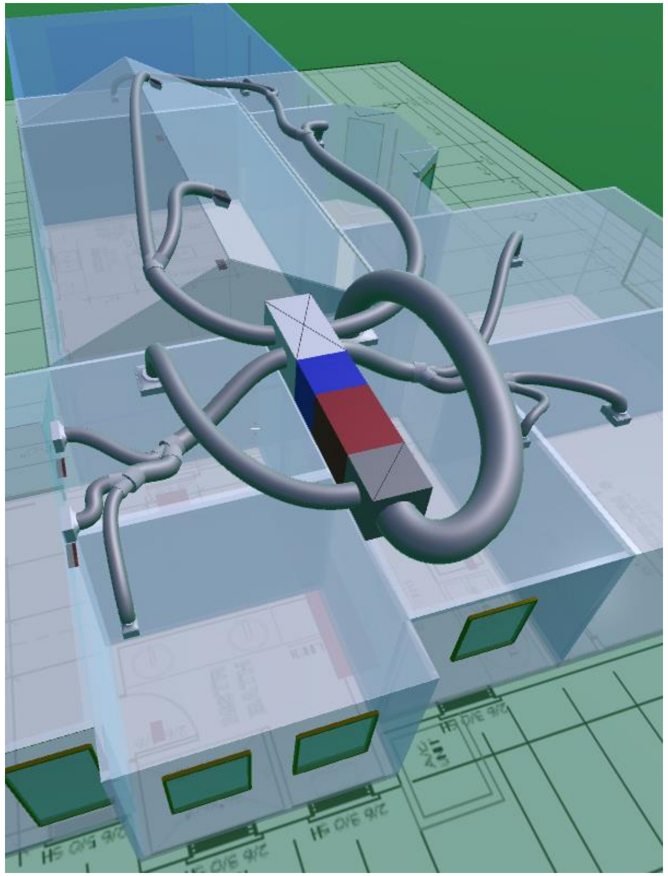
Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

Definitions

Design conditions are the specified indoor and outdoor temperatures at which the loads are calculated.

- These are not the *very worst* temperatures expected each summer or winter.
- It would not be wise to design to such temperatures because these rarely occur.

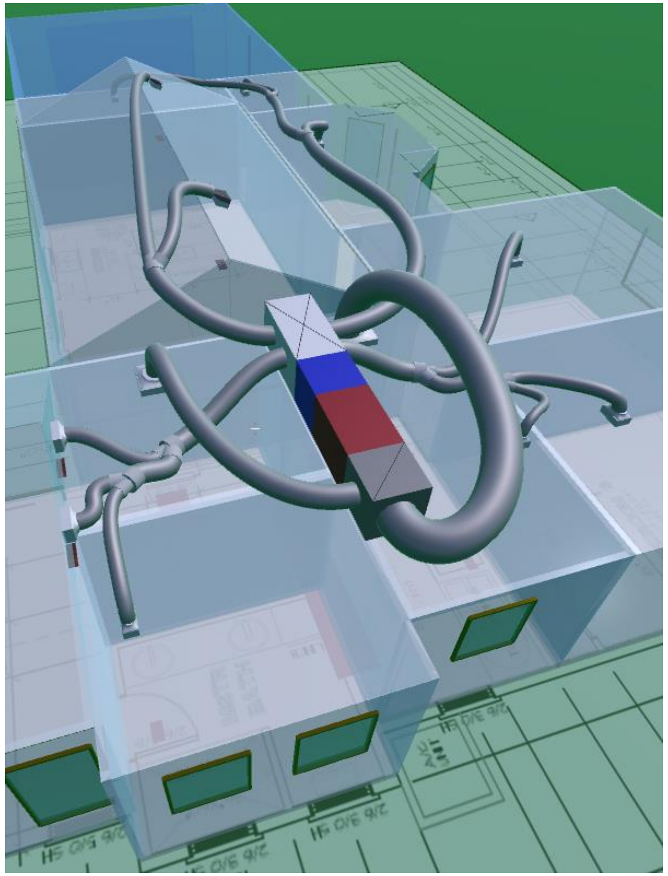


Screen snip from Kwik Model with EnergyGauge Loads

I. INTRODUCTION

Definitions - Design conditions

- The system needs to also work at milder conditions.
- If we design to really bad conditions, the equipment would be oversized for most of the season.

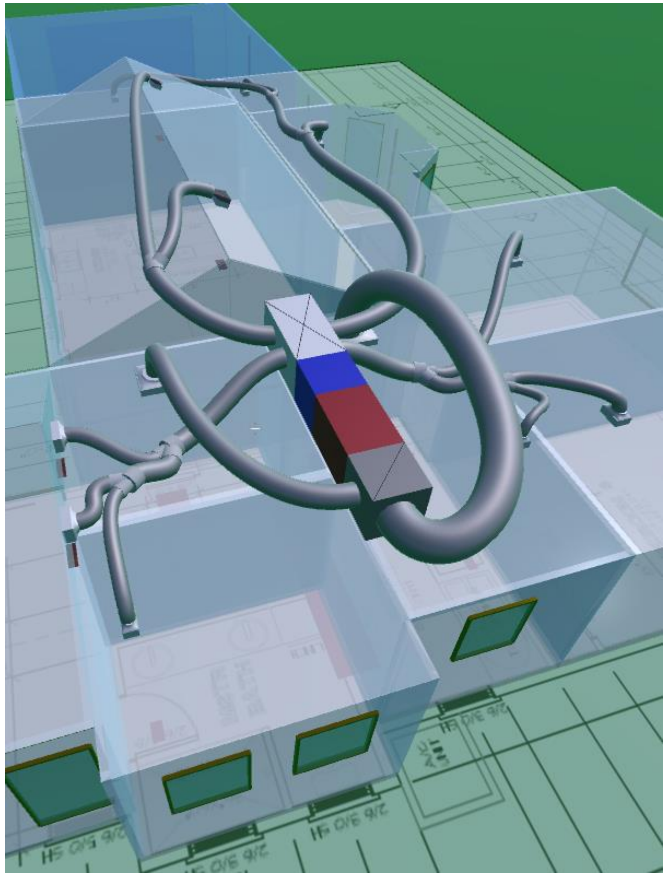


Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

Definitions - Design conditions

- The difference between the indoor design temperature and the outdoor design temperature is referred to as the "Delta T".
- There is a delta T for the summer and a delta T for the winter.



Screen snip from Kwik Model with EnergyGauge Loads

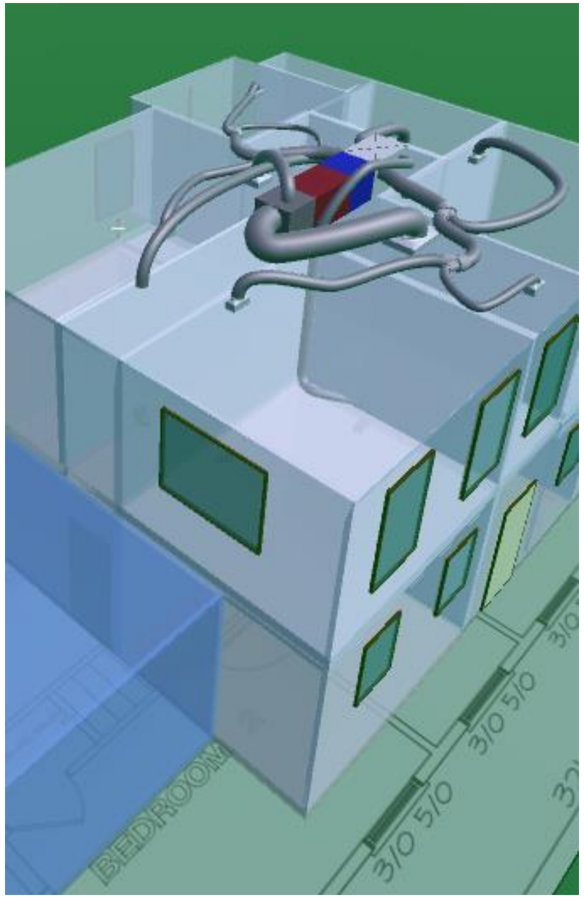
1. INTRODUCTION

The Importance of Good Design: Equipment Sizing

Load Calculations are critical to properly sized heating and cooling equipment.

For **Air Conditioners**:

- ***Undersizing*** may cause house not to cool well on very hot days.
- ***Oversizing*** can cause excess stratification, uneven temperature distribution. Plus, higher electric bills and shortened equipment life.



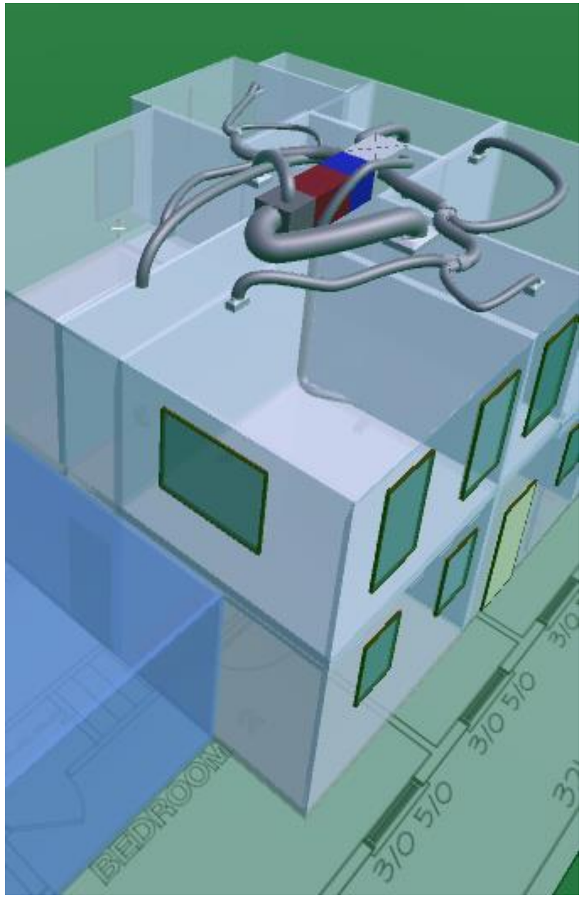
Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

The Importance of Good Design: Equipment Sizing

For **Heaters (heat pumps or furnaces)**:

- ***Undersizing*** may cause house not to heat well on very cold days.
- ***Oversizing*** can cause excess stratification, uneven temperature distribution. Plus, higher utility bills and shortened equipment life.

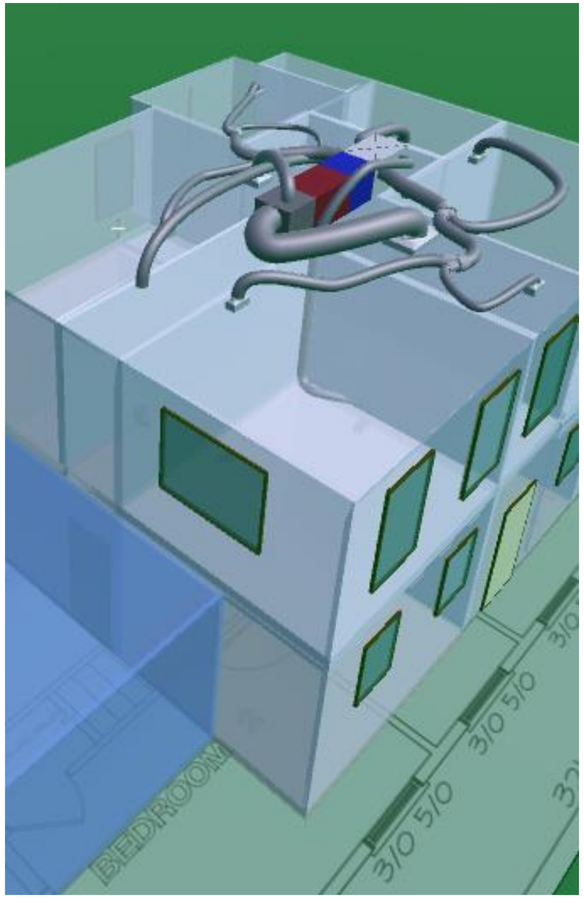


Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

The Importance of Good Design: <u>Equipment Sizing</u>

- ***Undersized Equipment*** will work ***fine*** on milder days (which is most of the time)
- ***Oversized Equipment*** will perform ***worse*** on milder days (which is most of the time)
- ***Oversized equipment*** will cause ***more*** comfort complaints than ***undersized equipment.***

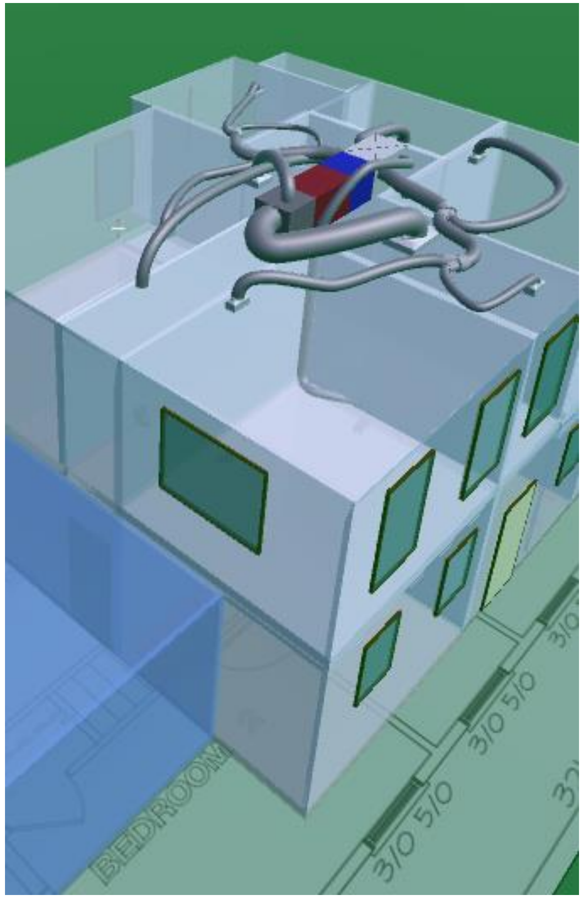


Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

The Importance of Good Design: Equipment Sizing

- The negative impacts of ***Oversized Equipment*** can be reduced by using dual speed or variable capacity units.
- The negative impacts of both ***Oversized and Undersized Equipment*** can be reduced with good duct design and good system airflow.

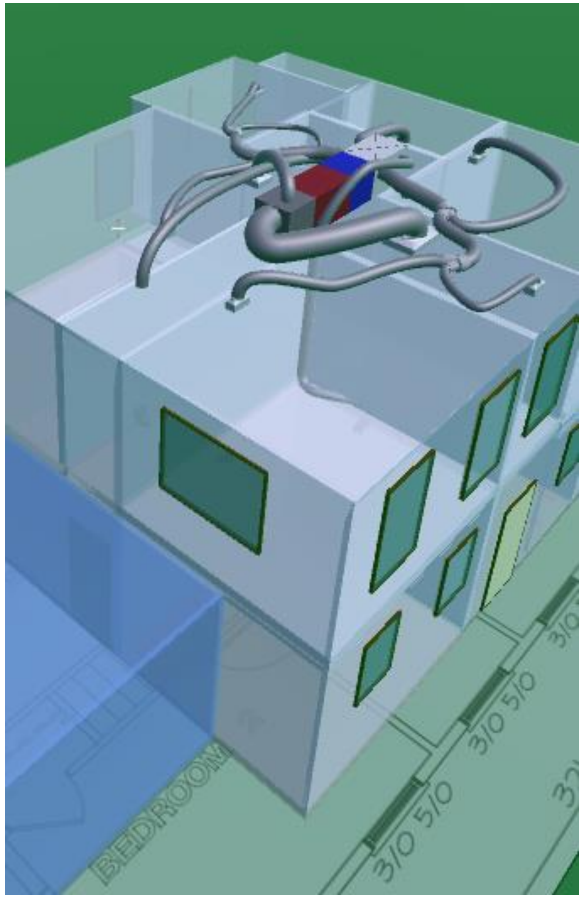


Screen snip from Kwik Model with EnergyGauge Loads

I. INTRODUCTION

The Importance of Good Design: <u>Equipment Sizing</u>

- The negative impacts of ***Undersized Equipment*** can be reduced by improving the house (reducing the load) and increasing the capacity of the existing equipment (improve airflow, proper charge, etc).
- This should **<u>always</u>** be considered first before increasing the **<u>size</u>** of the equipment

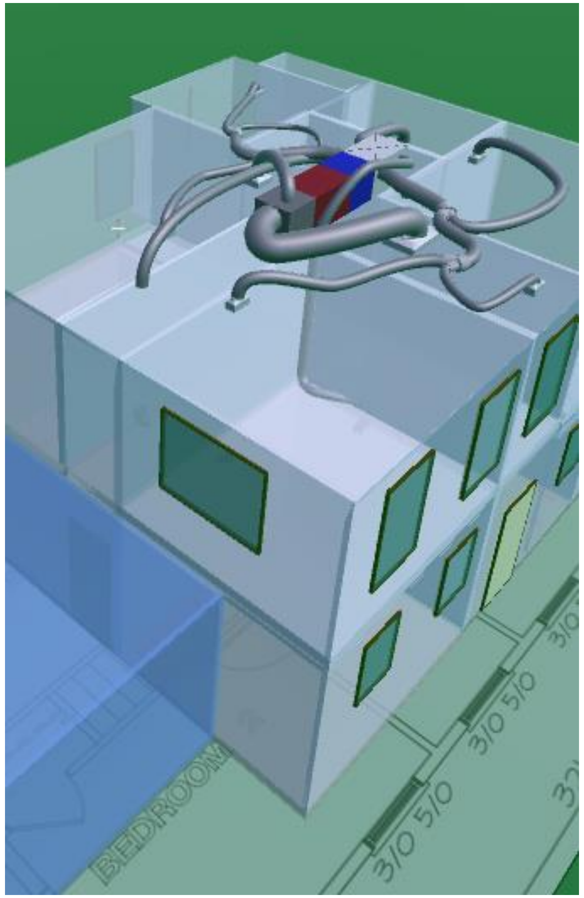


Screen snip from Kwik Model with EnergyGauge Loads

I. INTRODUCTION

The Importance of Good Design: Equipment Sizing

- Historically, the most common method of equipment sizing was **rules of thumb** and **trial and error**.
- This almost always leads to oversized equipment (and undersized ducts).
- Having a basis for your design (something to compare to) and field testing/monitoring is critical to becoming a good designer.

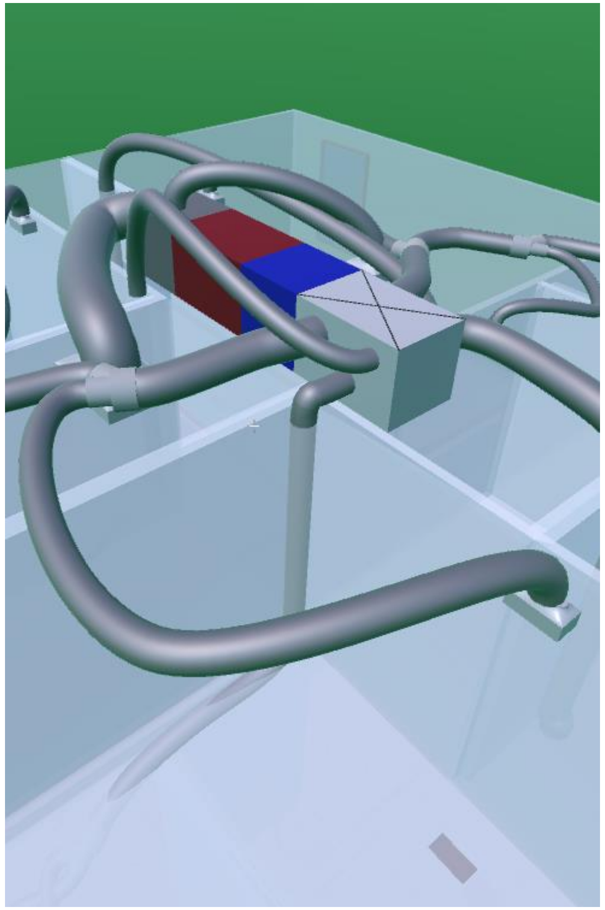


Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

The Importance of Good Design: Duct Sizing

- Since the temperature of the ***entire house*** (or zone) is determined by ***one location*** (at the thermostat) it is important for even temperature distribution that conditioned air be distributed evenly throughout the home.
- This is done by sizing the ducts to deliver the **proper airflow** to each room (register).

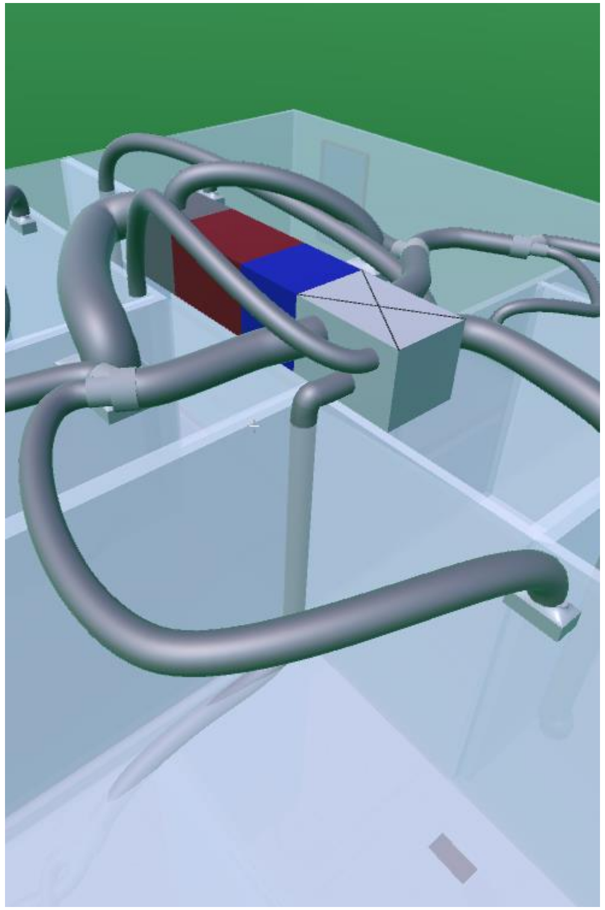


Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

The Importance of Good Design: Duct sizing

- Target room airflows need to be determined from **room-by-room loads** – you need to know what the load of a room is relative to other rooms.
- General undersizing of all ducts, especially return ducts, will reduce total system fan flow, which will reduce **capacity and efficiency** of system.

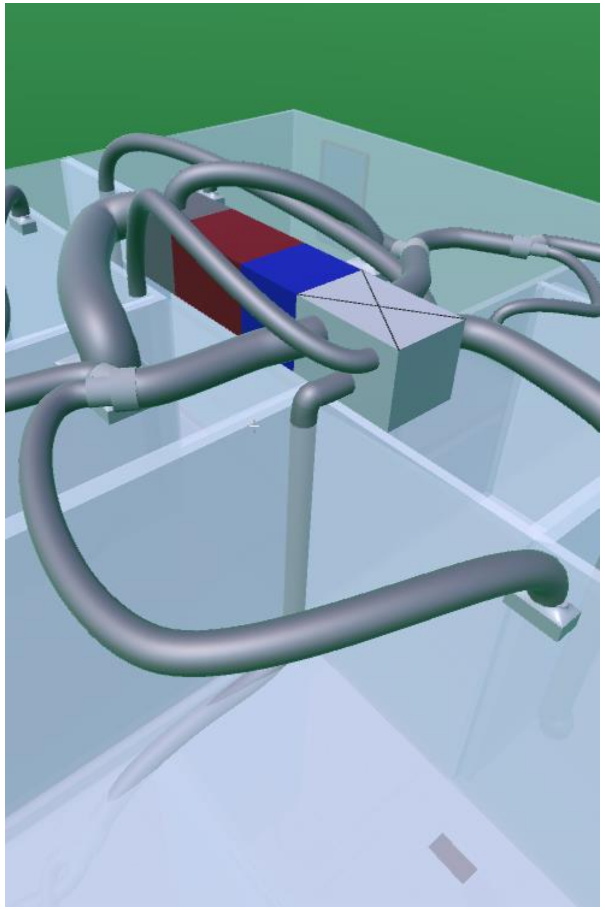


Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

The Importance of Good Design: <u>Duct sizing</u>

- Undersizing one or two ducts relative to the other ducts in the house will cause **poor air balance**.
- This will result in uneven temperature distribution in the house (some rooms warmer or cooler than others)
- These problems are made **more** noticeable by **low overall airflow**.
- Good overall airflow tends to hide these issues.



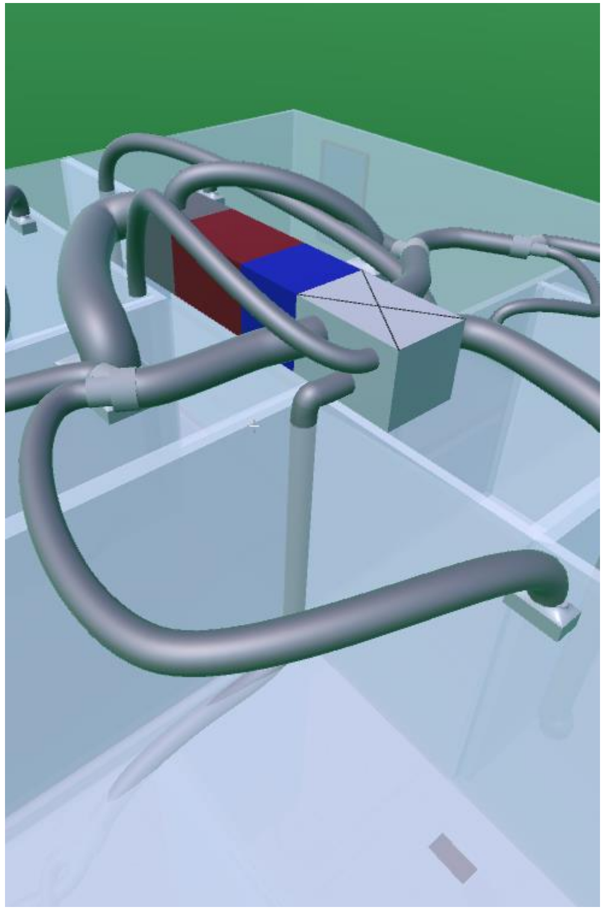
Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

Remember:

- Equipment cannot be properly sized unless you know the **load** of the house. (the Demand – what is needed)
- Equipment cannot be properly sized unless you can accurately determine the **capacity** at design conditions. (the Supply – what is being provided)

MANUAL J
MANUAL S



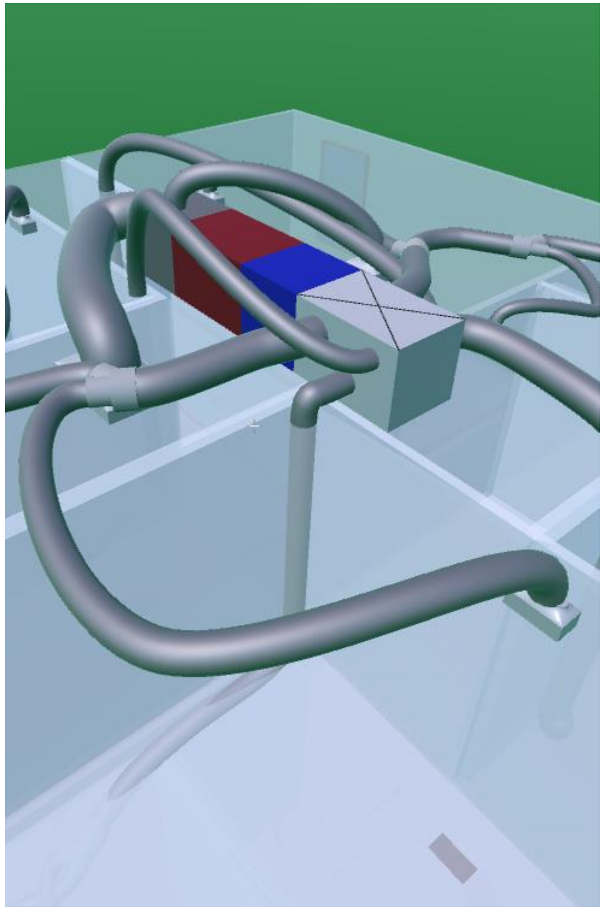
Screen snip from Kwik Model with EnergyGauge Loads

1. INTRODUCTION

Remember:

- Ducts cannot be properly sized unless you know how much air to distribute where to distribute it.
- To know how to distribute the air, you need **room by room** load calculations.

MANUAL D



Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

2. OVERVIEW OF HVAC DESIGN PROCESS

The Process

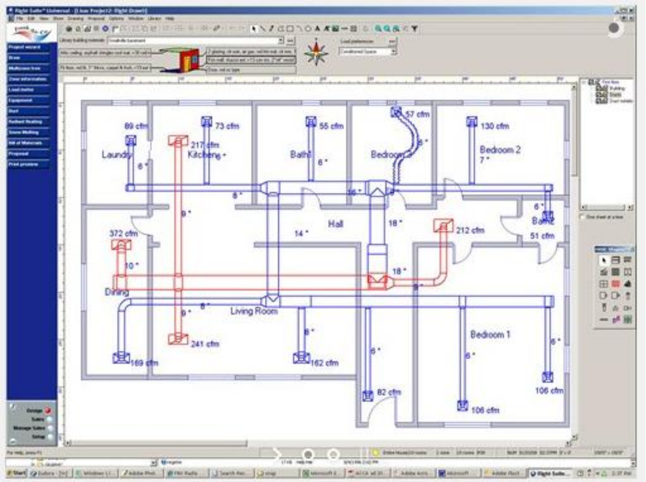
- The basic steps in designing a typical ducted central system for a home are:

1. **Collect** information about the house
2. **Perform** *room-by-room* load calculations (Manual J)
3. **Select** equipment to meet the total loads (Manual S)
4. **Design** the distribution system (Manual D)

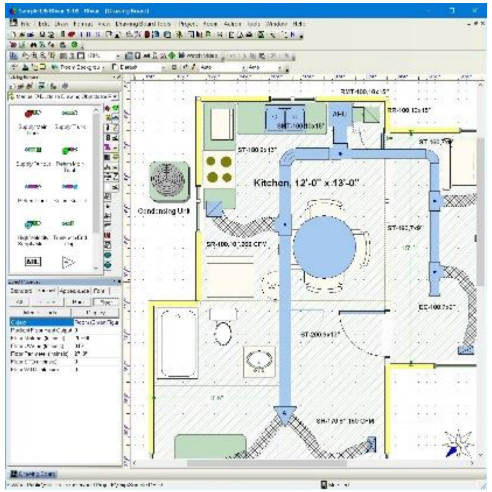
2. OVERVIEW OF HVAC DESIGN PROCESS

There are several ACCA approved ***software programs*** available to help you through this process. Examples:

Right-Suite® by Wrightsoft



RHVAC by Elite Software

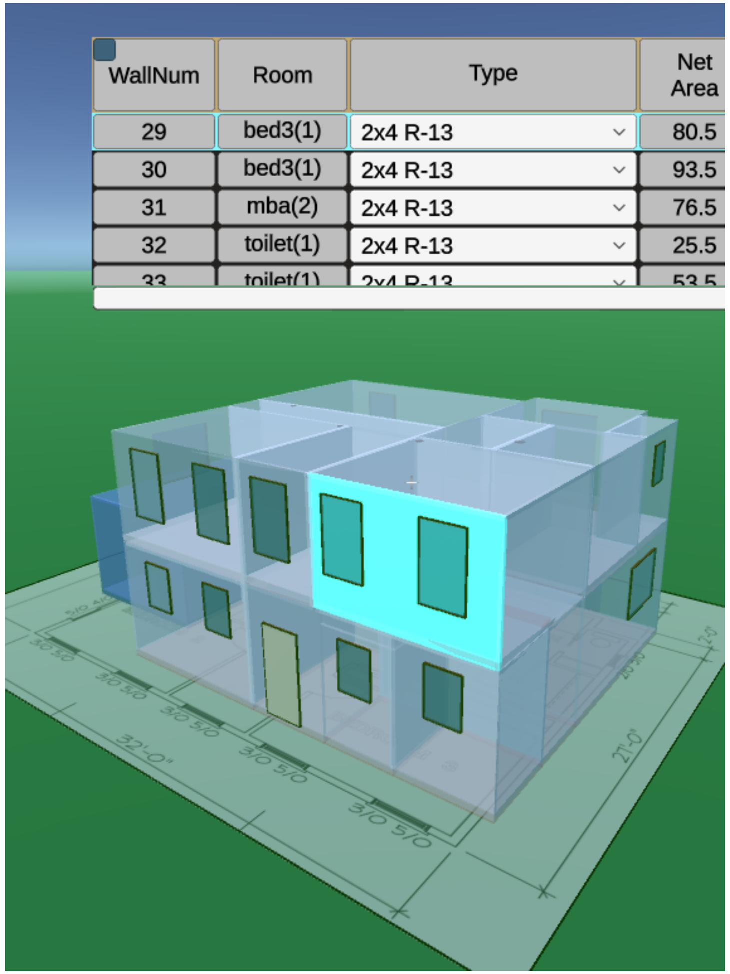


Kwik Model® with *EnergyGauge Loads*

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- What you really need are *areas* for:
  - ceilings,
  - walls,
  - doors,
  - and floors,
  - Plus, window areas and orientations (N, S, E, W)
- These are the surfaces that will conduct heat into and out of the house.

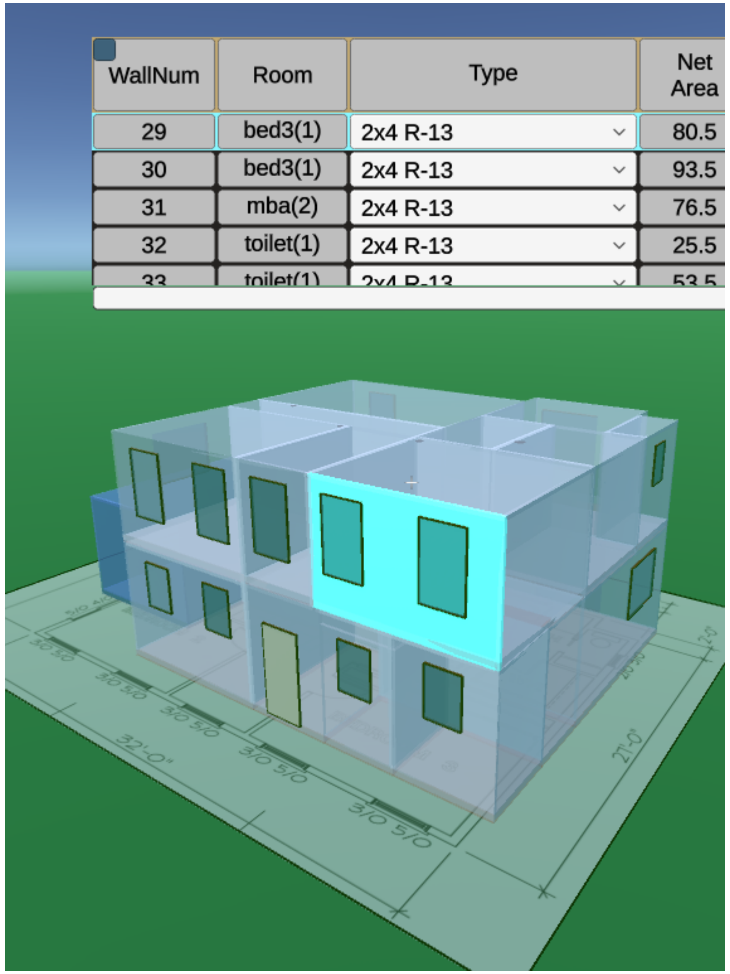


Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- You will need this on a room-by-room basis if you plan to also size the ducts.
- Keeping track of all these surfaces is challenging.
- This is where design software is most helpful.

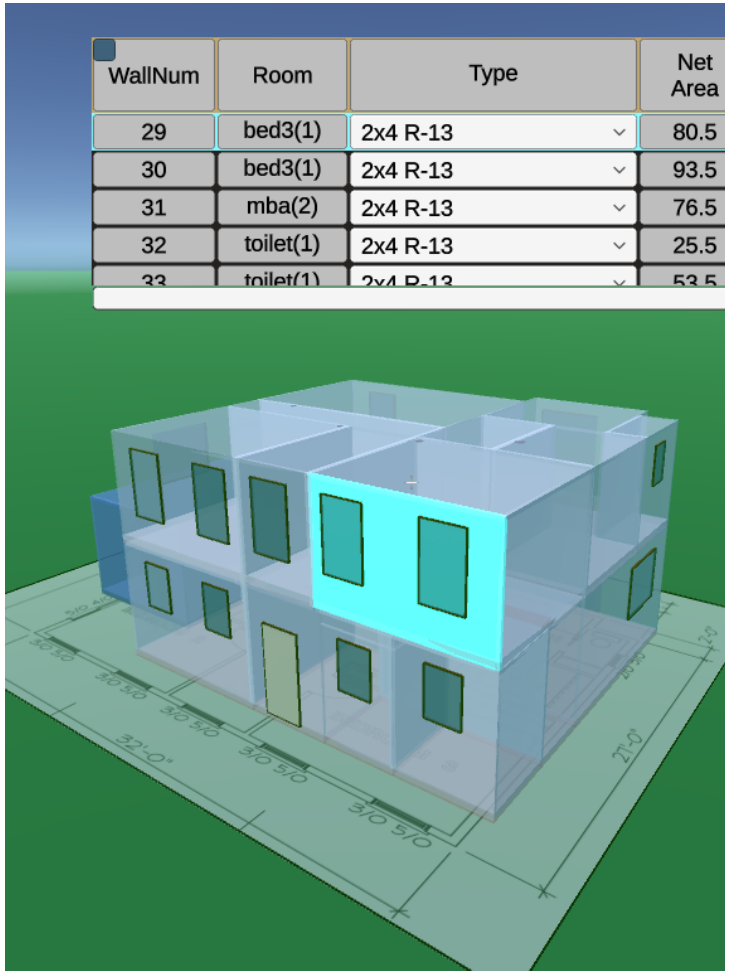


Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- The goal is to accurately estimate the **conduction, convection and radiation** heat transfer between the inside and outside of the house.
- You need to do it for **winter** and **summer**.

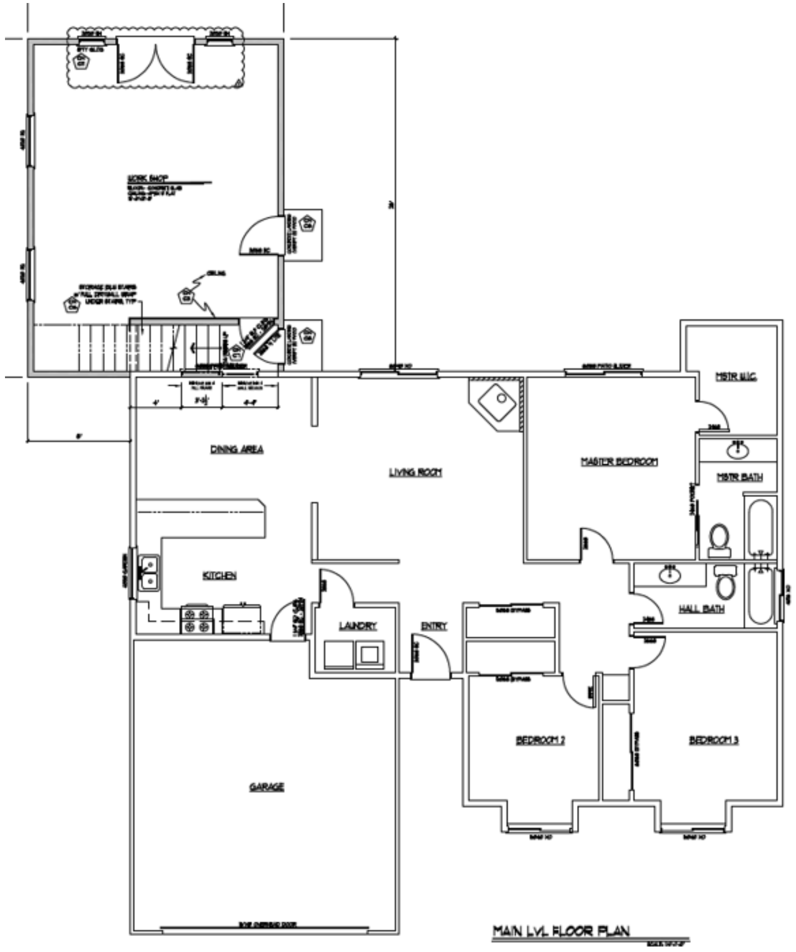


Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- If you are designing a system for a new house, most of the information you will need is on the **building plans and energy compliance docs**.

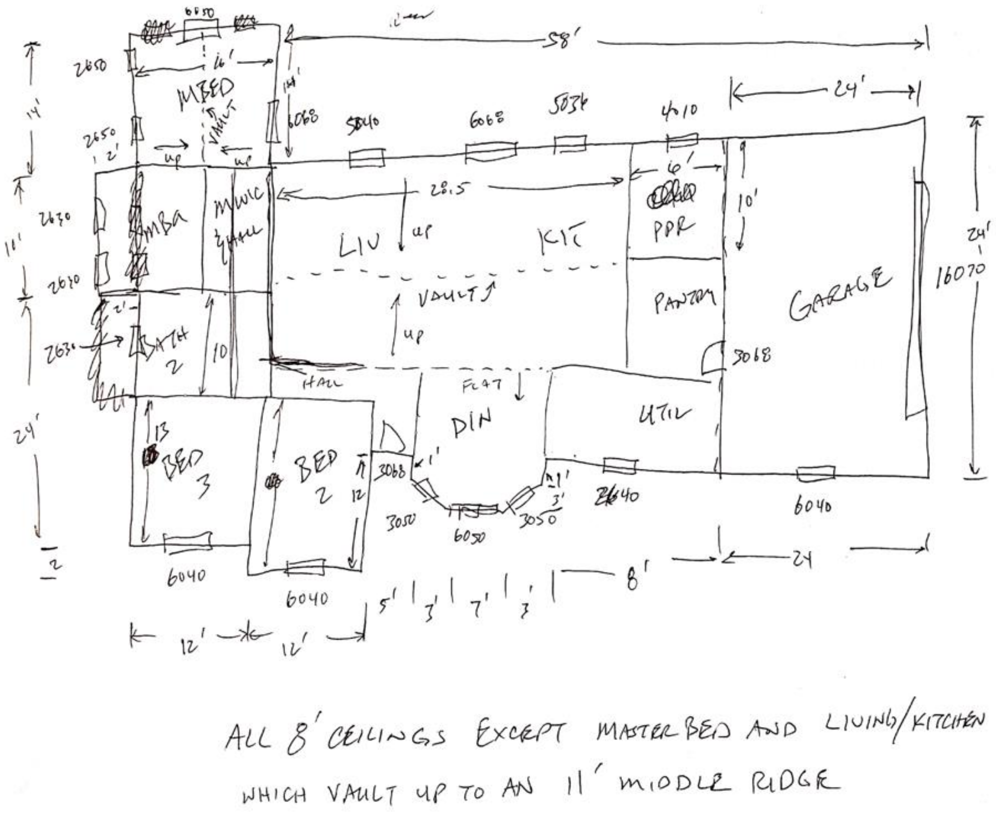


2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- If you are designing a system for an existing house, you may have to create your own plans by **sketching** a floor plan based on field measurements or use an app.

www.cubi.casa



2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- Then you will need information **about** these surfaces, such as
  - what *kind* of surface,
  - how *much* insulation,
  - what *kind* of windows, etc.

Ceiling Type Name	Ceiling Style
R-30 under attic	UnderAttic
R-39 under attic	UnderAttic
R-19 under attic	UnderAttic
R-19 cathedral	CathedralOrSingleAssembly

Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

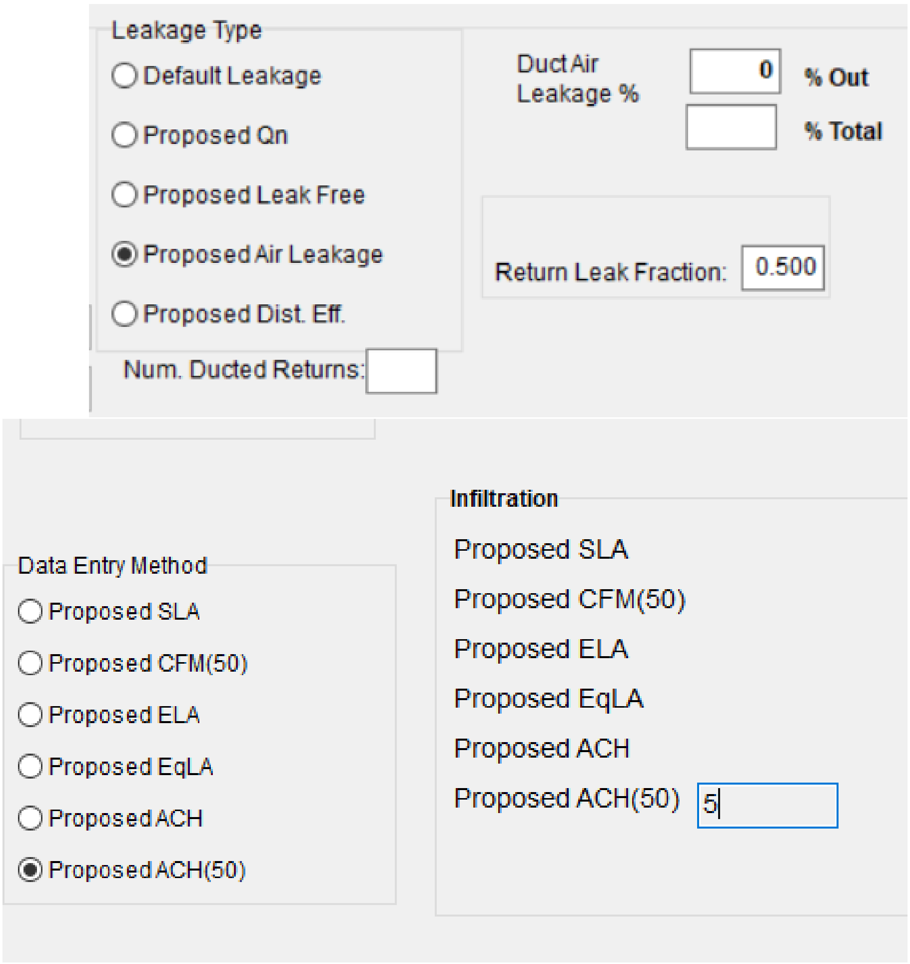
Step 1. Collect Information About the House

- For **existing** homes you will have to visit the house and determine these features
- For **new** homes, this information will be in the energy compliance calculations.

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- You will also need to make engineering estimates about things such as
  - duct leakage and
  - infiltration
- Whatever your assumptions are for these, they need to be ***verified*** in the field when possible.

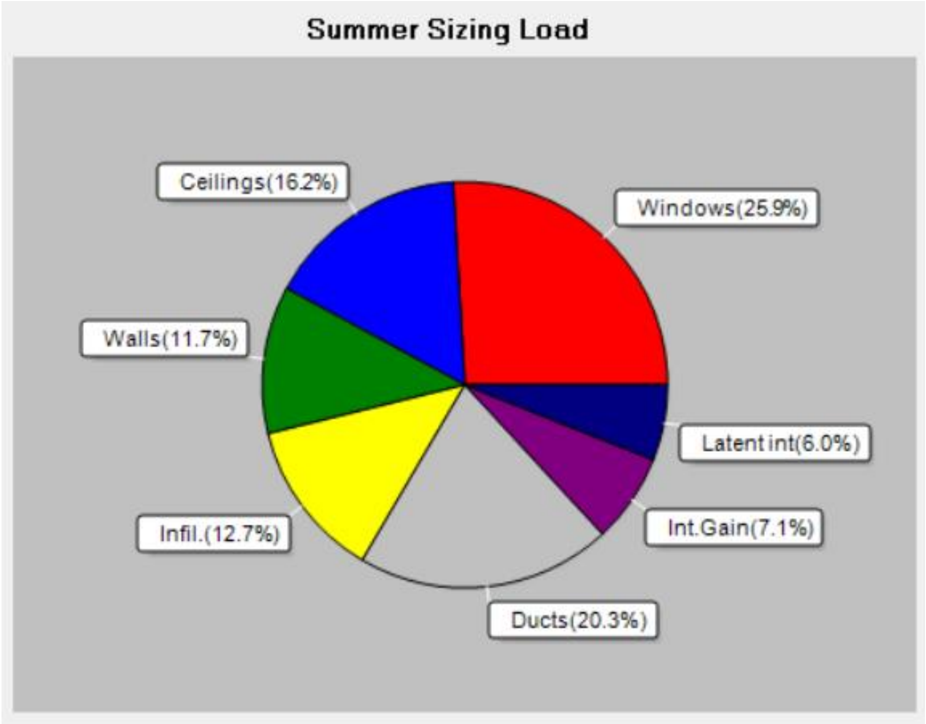


Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- In CA duct leakage is **required** to be improved as part of major work being done to an HVAC system.
- For substantially new systems (new equipment and 75% new ducts) the maximum allowed leakage is 5%.
- For altered systems the maximum allowed leakage is 10%.

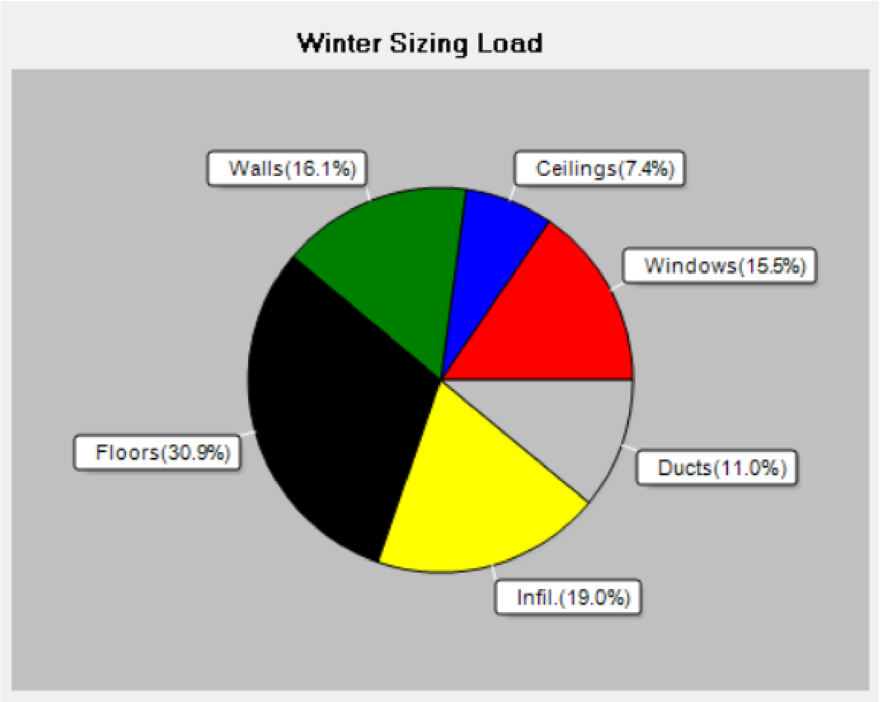


Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 1. Collect Information About the House

- **Infiltration** can have a dramatic effect on the load calcs.
- For existing houses, it is a good idea to measure it using a blower door prior to doing load calcs.
- If it is very bad (e.g., CFM50 > floor area of the house) it is *probably* cost effective to seal the house so that you can install smaller equipment and ***save energy***.



Screen snip from Kwik Model with EnergyGauge Loads

2. OVERVIEW OF HVAC DESIGN PROCESS

Step 2. Perform Room-by-Room Load Calculations

- Manual J – Coming up!

Step 3. Select Equipment to Meet Loads

- Manual S – Coming up!

Step 4. Design the Distribution System

- Manual D – Part 2 Class!

3. MANUAL J – LOAD CALCULATIONS

3. MANUAL J – LOAD CALCULATIONS

- There are **two** basic kinds of load calculations.
- One kind is a **whole house** load calculation that lumps the entire house (or zone) into one total value, which can be used to size the equipment. (aka "Block" loads)

Location for weather data: Sacramento (Met, CA - Defaults: Latitude(38.7) Altitude(23ft.) Temp Range(H)					
Humidity data: Interior RH (50%) Outdoor wet bulb (70F) Humidity difference(0gr.)					
Winter design temperature(CA Med.)	26	F	Summer design temperature(MJ8 99%)	98	F
Winter setpoint	68	F*	Summer setpoint	75	F
Winter temperature difference	42	F	Summer temperature difference	23	F
Total heating load calculation	**33450**	**Btuh**	**Total cooling load calculation**	**26131**	**Btuh**
Submitted heating capacity	% of calc	Btuh	Submitted cooling capacity	% of calc	Btuh
Total (Electric Heat Pump)	107.6	36000	Sensible (SHR = 0.76)	90.0	22011
Heat Pump + Auxiliary(0.0kW)	107.6	36000	Latent	415.4	6989
			Total (Electric Heat Pump)	111.0	29000

Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

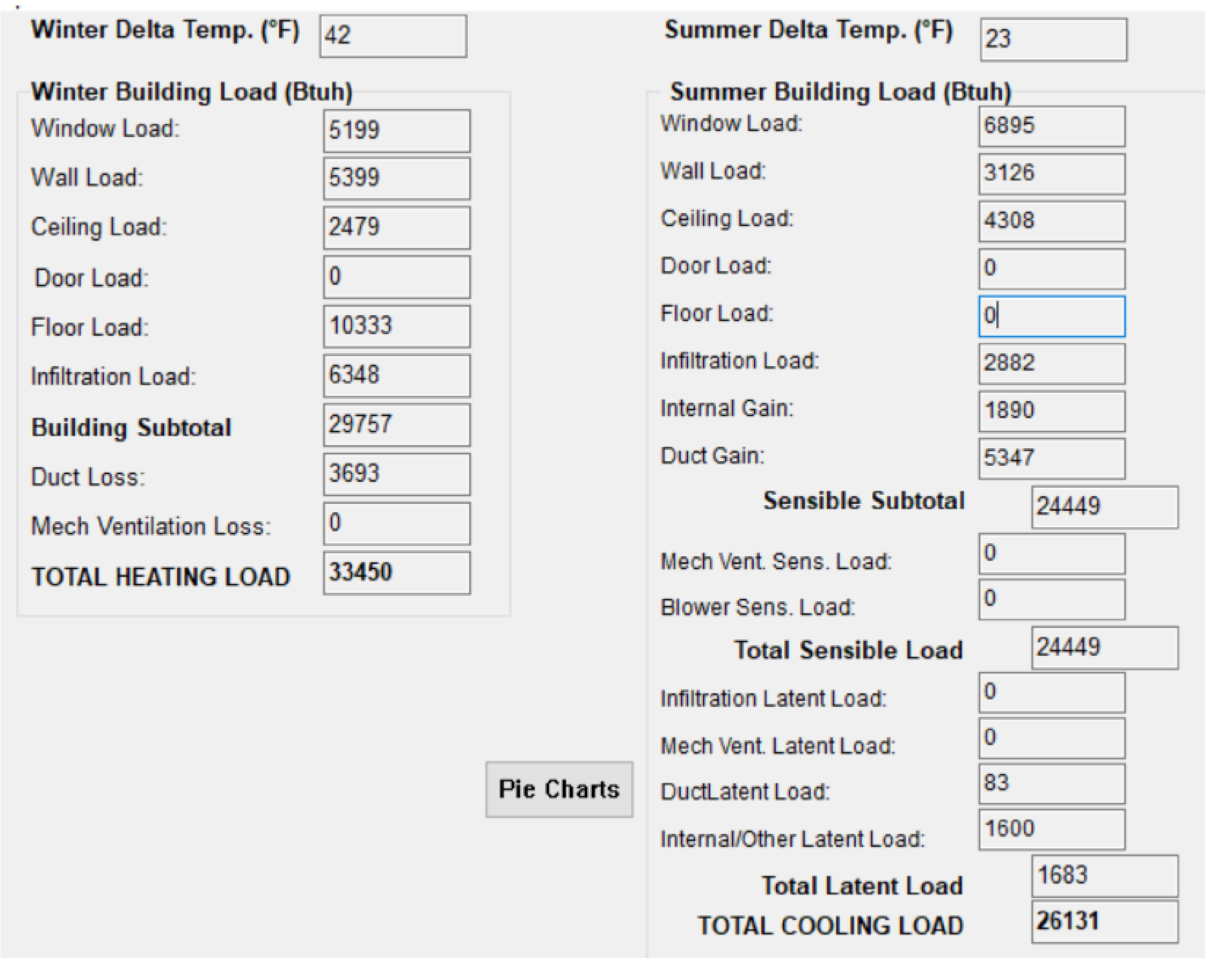
- The other kind is a **room-by-room** load calculation, which breaks the house into rooms and calculates a heating and cooling load for each individual room.
- These help you ***distribute*** the heating and cooling correctly.

Room Name	System/Block	Zone	Floor Area	Volume	Room Type	Number of Occupants	Heating Load	Heating Fraction	Heating CFM	Sens Cooling Load	Cooling Fraction	Cooling CFM	Duct Size CFM
mbed	Sys/Block 1	Zone	317.75	2987.5	Bedroom	0	8439	0.22	220	6047	0.217	261	261
mbath	Sys/Block 1	Zone	85	680	Other	0	2260	0.059	59	1763	0.063	76	76
bath2	Sys/Block 1	Zone	136	1088	Other	0	1594	0.042	42	1310	0.047	56	56
bed3	Sys/Block 1	Zone	186	1488	Bedroom	0	4596	0.12	120	2431	0.087	105	120
bed2	Sys/Block 1	Zone	222	1776	Bedroom	1	4370	0.114	114	2788	0.1	120	120
liv/kit	Sys/Block 1	Zone	493	4930	Kitchen	2	6751	0.176	176	6627	0.238	286	286
din	Sys/Block 1	Zone	184.25	1474	Other	0	4130	0.108	108	3474	0.125	150	150
pdr	Sys/Block 1	Zone	102	816	Other	0	3746	0.098	98	2273	0.082	98	98
util	Sys/Block 1	Zone	59.5	476	Other	0	2489	0.065	65	1113	0.04	48	65
Total	---	---	1785.5	15715.5	---	3	38375	1	1000	27825	1	1200	1232

Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

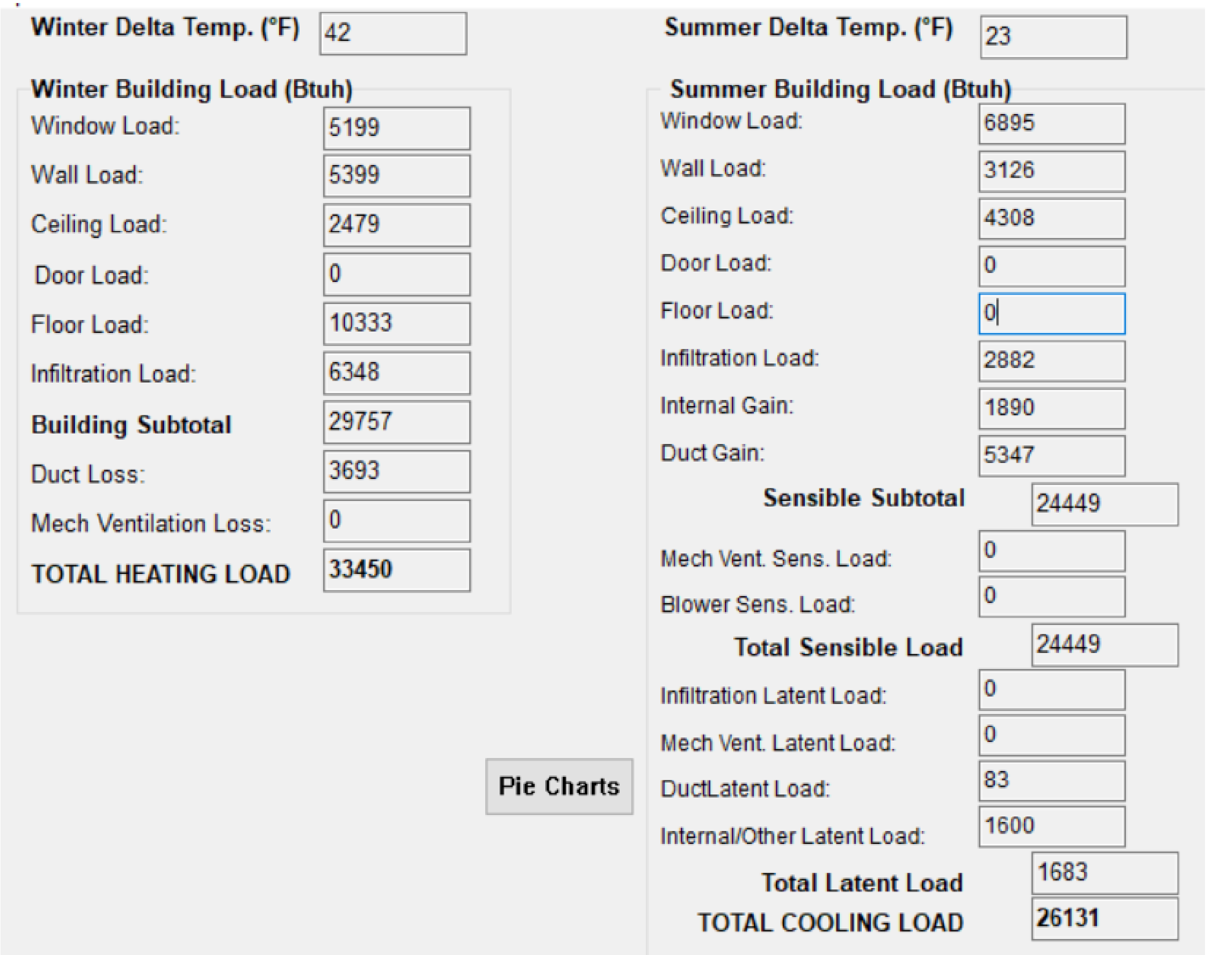
- There are load calculations for both heating (winter) and cooling (summer) loads.
  - Winter = Heat leaving the house
  - Summer = Heat coming into the house
- Let's look at heating loads calculations first.



Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

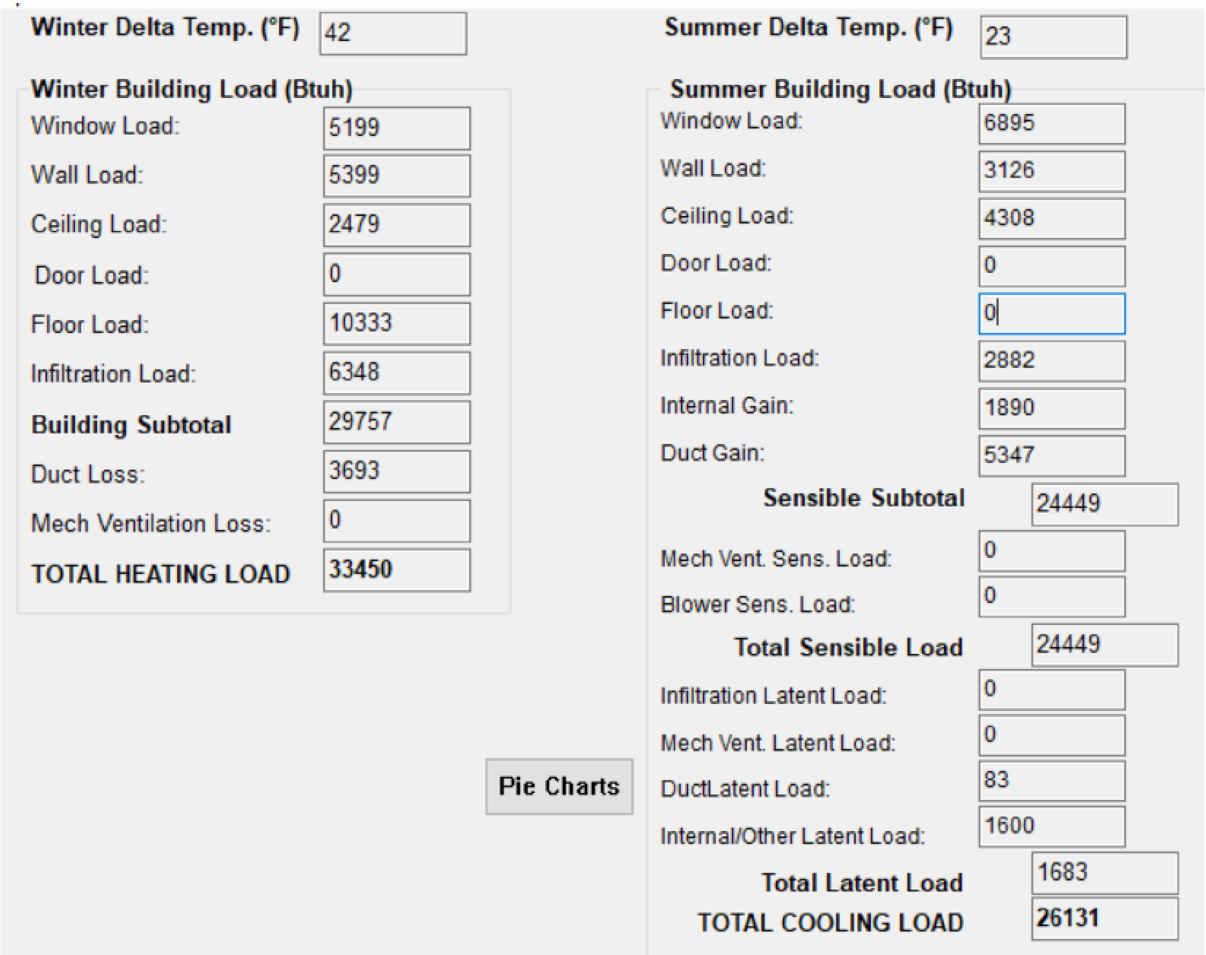
- A heating load calculation is a sum of all of the **BTU losses** (convection, conduction and radiation) that occur when it is a <u>certain delta T</u>.



Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

- The delta T is determined by two temperatures called the *winter* ***indoor*** *and* ***outdoor*** *design temperatures.*



Winter Delta Temp. (°F)	42
Winter Building Load (Btuh)	
Window Load:	5199
Wall Load:	5399
Ceiling Load:	2479
Door Load:	0
Floor Load:	10333
Infiltration Load:	6348
Building Subtotal	29757
Duct Loss:	3693
Mech Ventilation Loss:	0
TOTAL HEATING LOAD	**33450**

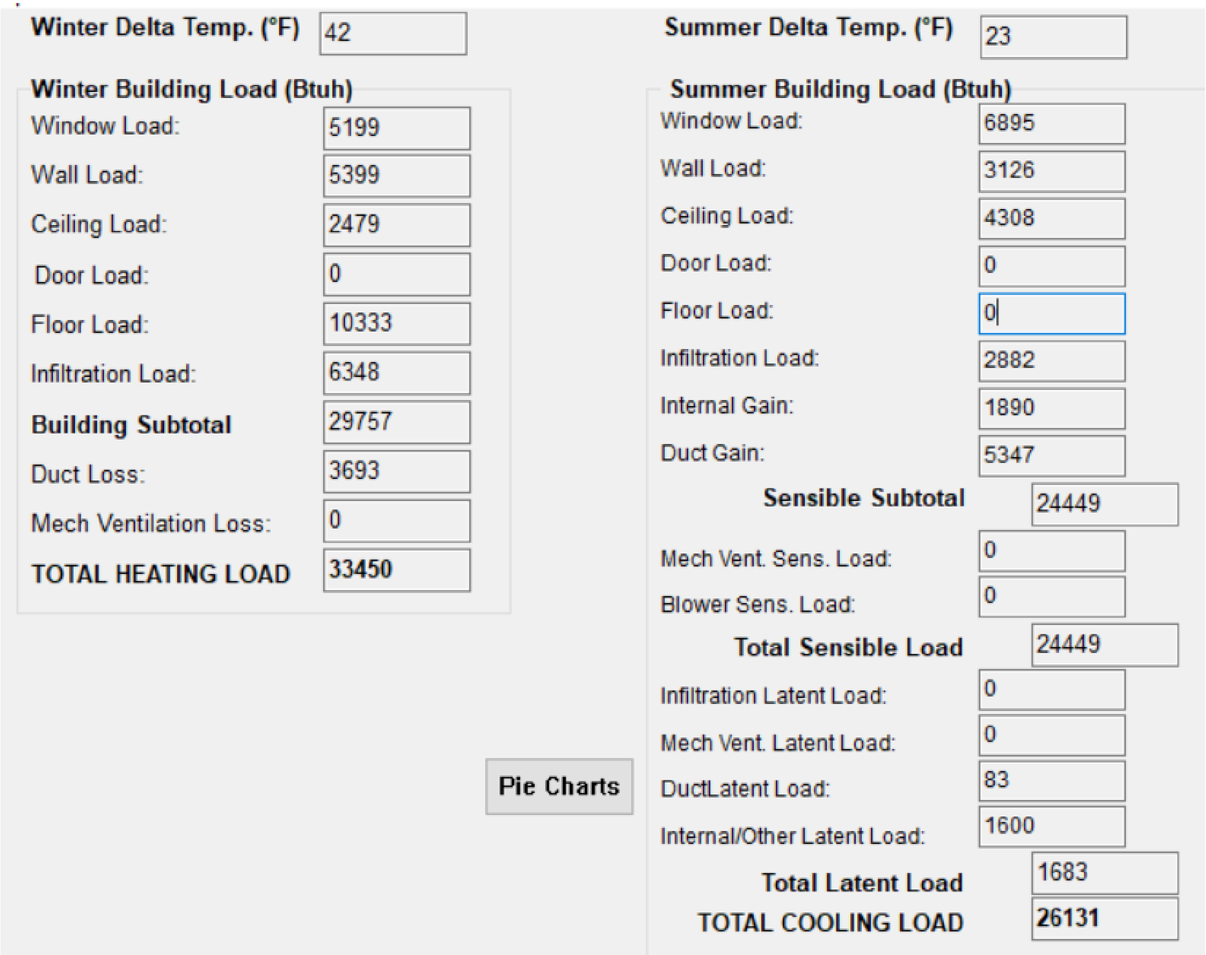
Summer Delta Temp. (°F)	23
Summer Building Load (Btuh)	
Window Load:	6895
Wall Load:	3126
Ceiling Load:	4308
Door Load:	0
Floor Load:	0
Infiltration Load:	2882
Internal Gain:	1890
Duct Gain:	5347
Sensible Subtotal	24449
Mech Vent. Sens. Load:	0
Blower Sens. Load:	0
Total Sensible Load	24449
Infiltration Latent Load:	0
Mech Vent. Latent Load:	0
DuctLatent Load:	83
Internal/Other Latent Load:	1600
Total Latent Load	1683
TOTAL COOLING LOAD	**26131**

Pie Charts

Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

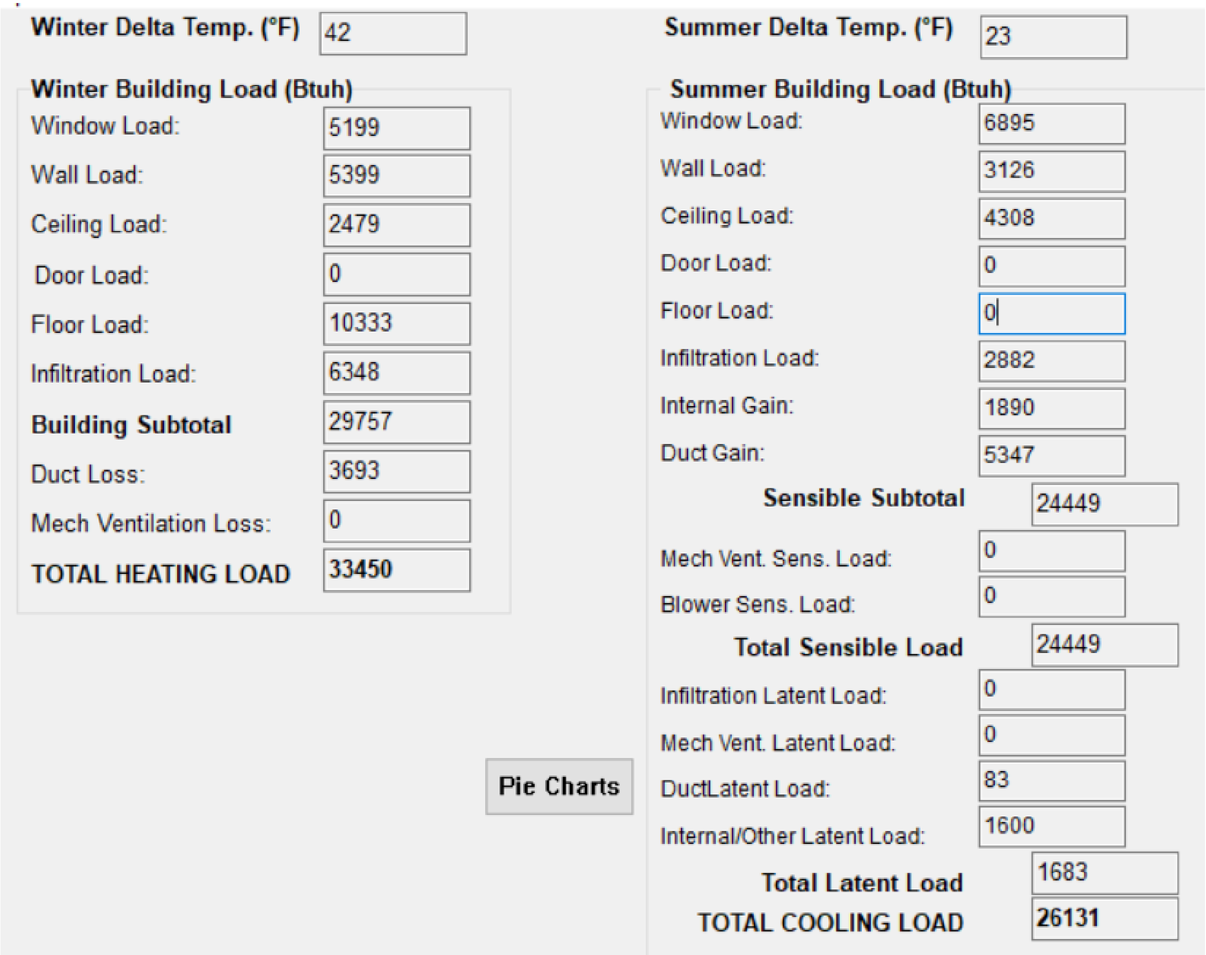
- For heating, assume that these occur at night when there are no solar gains to offset heating load



Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

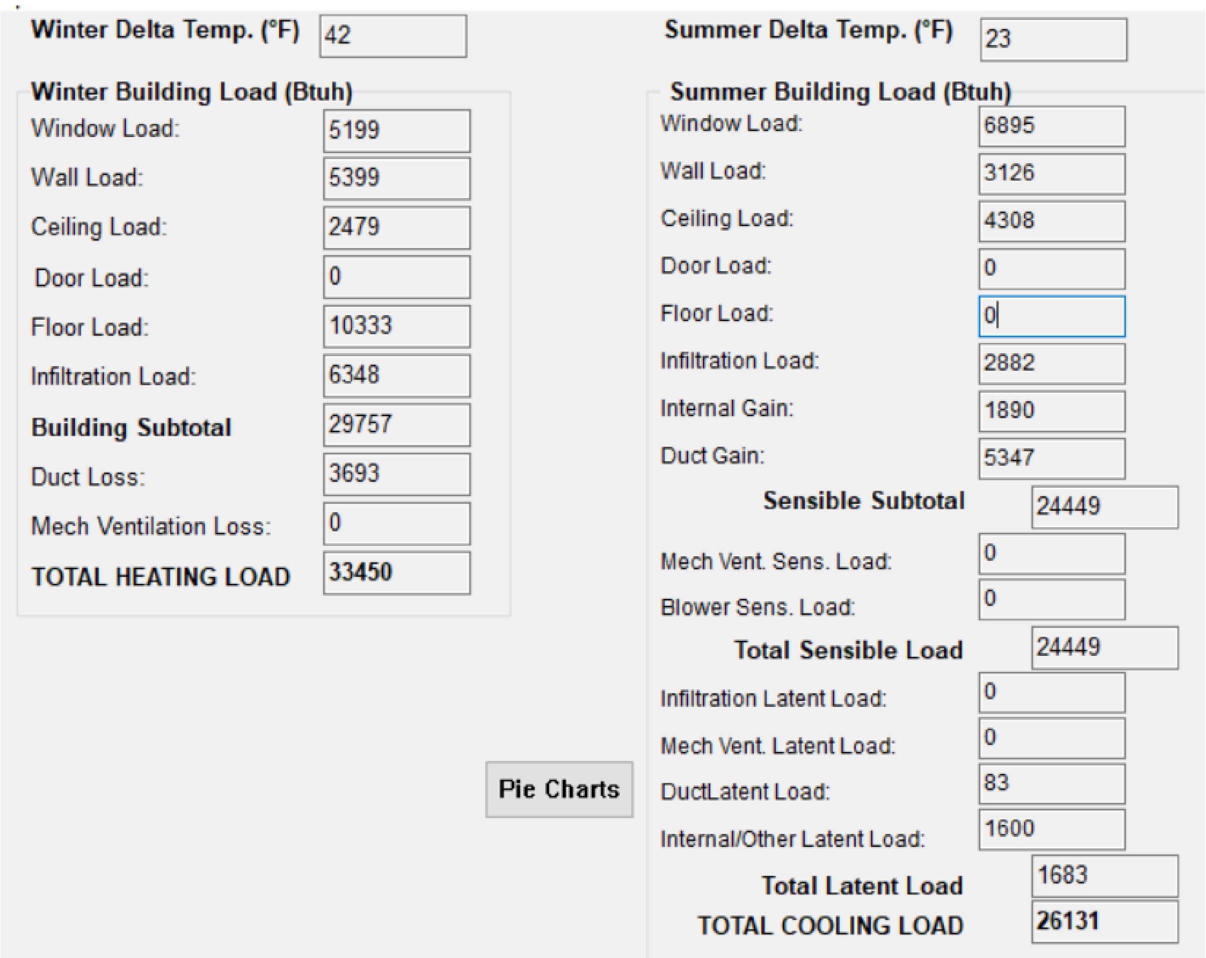
- Cooling loads are similar except that they are more complicated because solar gains are **not** ignored.
- Solar gains are a big part of the cooling loads.



Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

- What makes them so complicated is that solar gains are affected by **<u>orientation</u>** of windows and by shading from overhangs and interior shading devices such as drapes or blinds.



Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

- Cooling loads and the subsequent sizing of equipment is much more precise and involved than heating loads.

Winter Delta Temp. (°F)	42
Winter Building Load (Btuh)	
Window Load:	5199
Wall Load:	5399
Ceiling Load:	2479
Door Load:	0
Floor Load:	10333
Infiltration Load:	6348
Building Subtotal	29757
Duct Loss:	3693
Mech Ventilation Loss:	0
TOTAL HEATING LOAD	**33450**

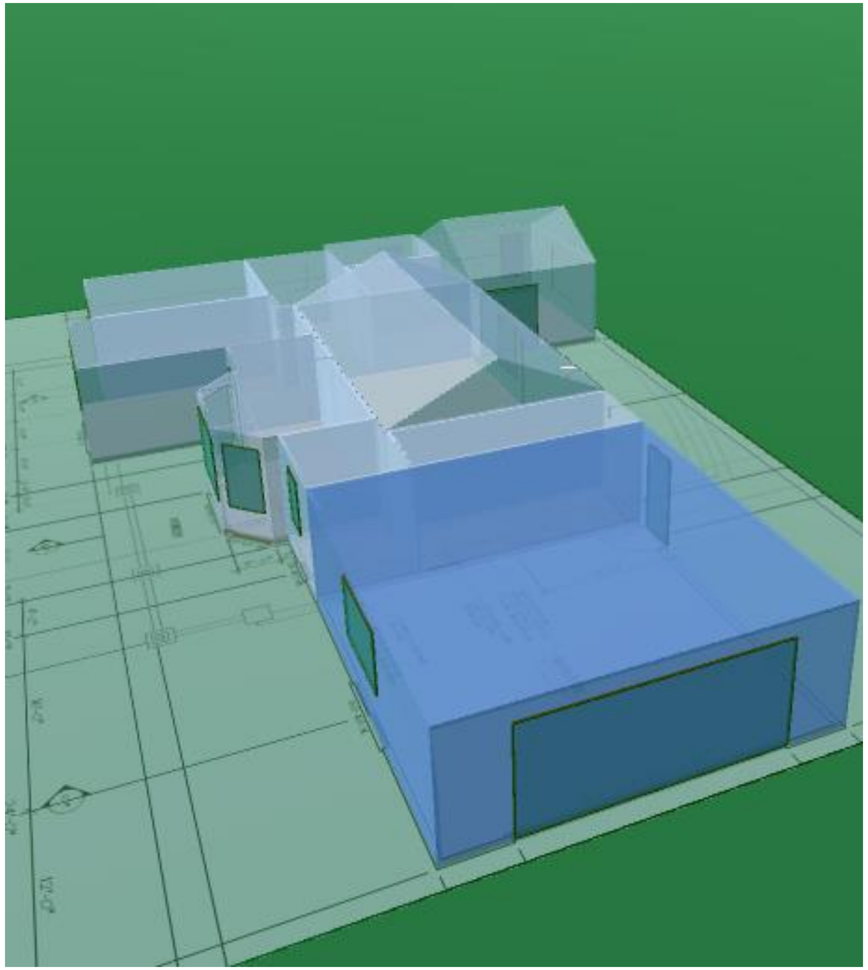
Summer Delta Temp. (°F)	23
Summer Building Load (Btuh)	
Window Load:	6895
Wall Load:	3126
Ceiling Load:	4308
Door Load:	0
Floor Load:	0
Infiltration Load:	2882
Internal Gain:	1890
Duct Gain:	5347
Sensible Subtotal	24449
Mech Vent. Sens. Load:	0
Blower Sens. Load:	0
Total Sensible Load	24449
Infiltration Latent Load:	0
Mech Vent. Latent Load:	0
DuctLatent Load:	83
Internal/Other Latent Load:	1600
Total Latent Load	1683
TOTAL COOLING LOAD	**26131**

Pie Charts

Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

- Depending on the software, you must input all the surface information (geometry), either:
  - By manually typing it in item by item,
  - by re-drawing the floor plan in 2D in the software, or
  - By creating a simple 3D model in the software



Screen snip from Kwik Model with EnergyGauge Loads

3. MANUAL J – LOAD CALCULATIONS

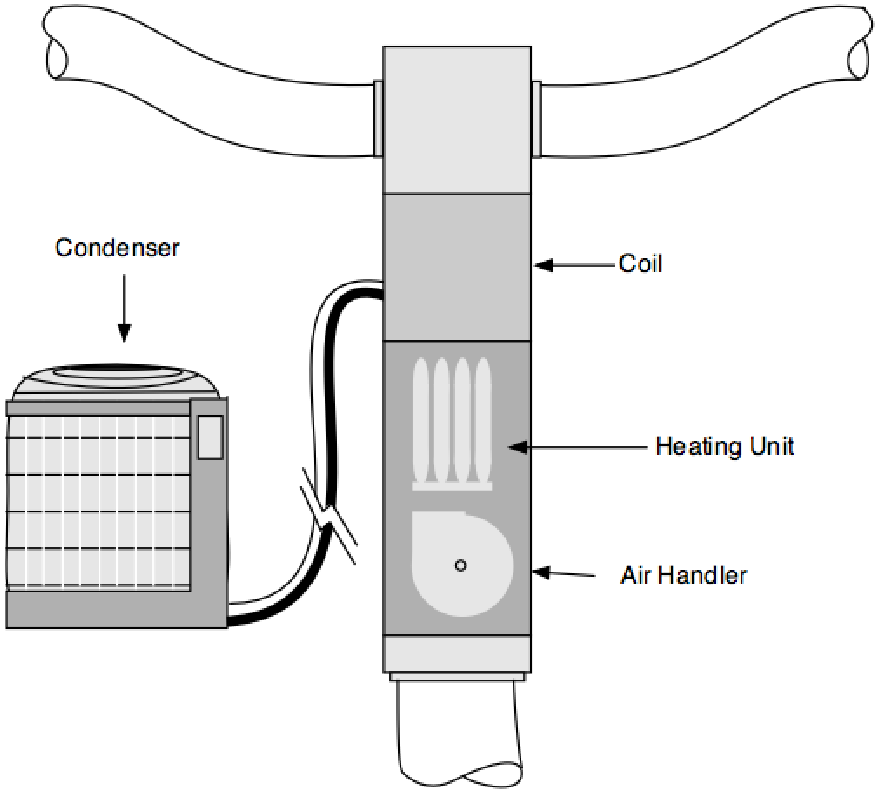
- The software will use that information to select the correct value from the Manual J tables to determine the heat transfer through each and every surface.
- As you can imagine, this is a lot of information to keep track of, especially for room-by-room loads.

WallNum	Room	Type	Net Area	Direction
1	mbed(3)	2x4 R-13	102	Back
2	mbed(3)	2x4 R-13	68	Right
3	mbed(3)	2x4 R-13	83	Left
4	mbath(1)	2x4 R-13	12	Back
5	mbath(1)	2x4 R-13	16	Front
6	mbath(1)	2x4 R-13	65	Left
7	bath2(1)	2x4 R-13	60.5	Left
8	bed3(1)	2x4 R-13	72	Front
9	bed3(1)	2x4 R-13	124	Left
10	bed2(2)	2x4 R-13	72	Front
11	bed2(2)	2x4 R-13	92	Right
12	bed2(2)	2x4 R-13	16	Left
13	liv/kit(3)	2x4 R-13	154.5	Back
14	din(1)	2x4 R-13	24	Front
15	din(2)	2x4 R-13	8	Right
16	din(2)	2x4 R-13	4	Left
17	din(4)	2x4 R-13	26	Front
18	din(5)	2x4 R-13	18.941	Front Left
19	din(3)	2x4 R-13	18.941	Front Right
20	pdr(1)	2x4 R-13	44	Back
21	pdr(1)	2x4 R-13	119.333	Right
22	util(1)	2x4 R-13	58	Front

Screen snip from Kwik Model with EnergyGauge Loads

4. MANUAL S – EQUIPMENT SELECTION

- Once the room-by-room loads are done, they can be added up to get the **total** heating and cooling loads.
- The next step is to select the equipment.



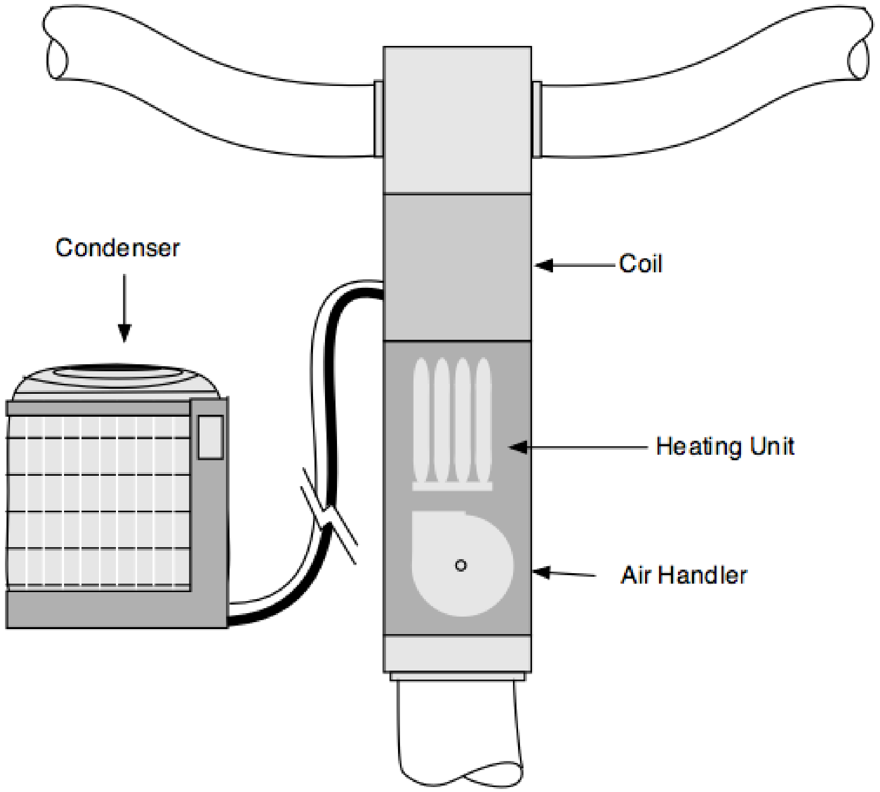
A Typical Split System

Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

4. MANUAL S – EQUIPMENT SELECTION

4. MANUAL S – EQUIPMENT SELECTION

- If it turns out that the total heating or cooling load is too large for a **single** piece of equipment, the house needs to be broken into smaller **zones** and a separate load calculation done on each one.

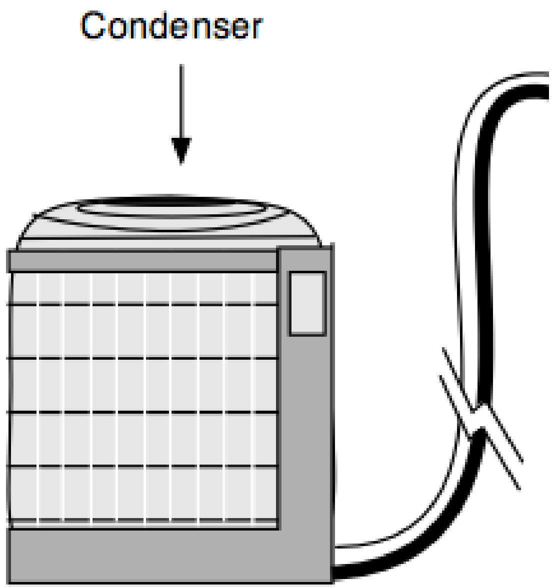


A Typical Split System

Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

4. MANUAL S – EQUIPMENT SELECTION

- Heat Pumps
- There are many good reasons for converting from gas to heat pump, not the least of which are rebates and other incentives.
- There are many myths about heat pumps that have given them bad reputations.



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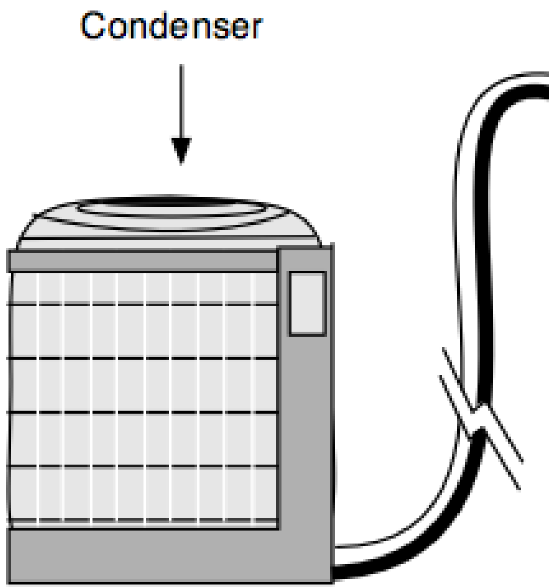
4. MANUAL S – EQUIPMENT SELECTION

- Heat Pumps
- The vast majority of these problems were due to **bad duct design**.
- Heat pumps have improved dramatically over the last few years.



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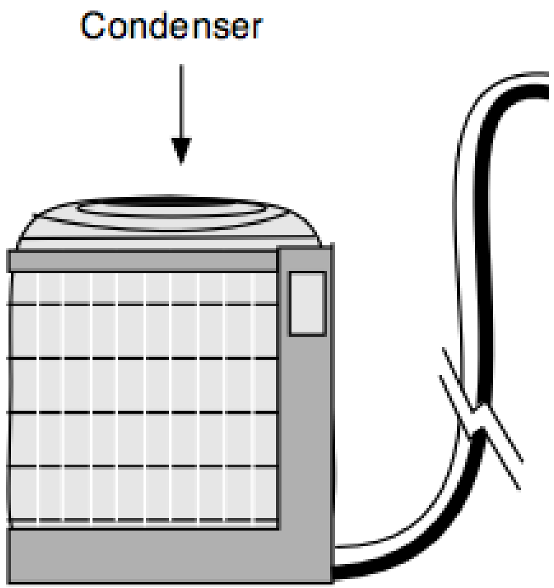
4. MANUAL S – EQUIPMENT SELECTION

- Heat Pumps
- They are super efficient because the MOVE heat that already exists rather than creating heat from scratch.
- Heat pumps will work at much lower outdoor temperatures than many people realize, without relying on back up resistance electric strips.



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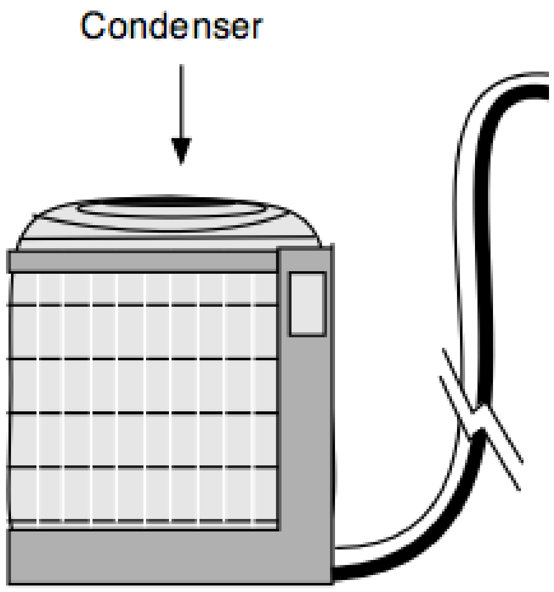
4. MANUAL S – EQUIPMENT SELECTION

- Heat Pumps
- Sizing Heat Pumps is certainly more complex than sizing furnaces, but not as difficult as many people think.
- Manual S covers heat pump sizing very well and Manual H goes into even more detail.



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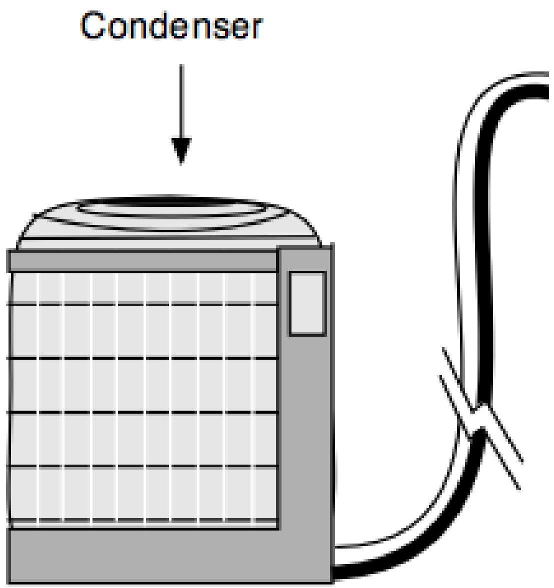
4. MANUAL S – EQUIPMENT SELECTION

- Heat Pumps
- Because the air conditioner and heat pump are the same condenser, you should size for air conditioning first, then check to confirm that it is not undersized for heating. If it is, you can go to a larger condenser.



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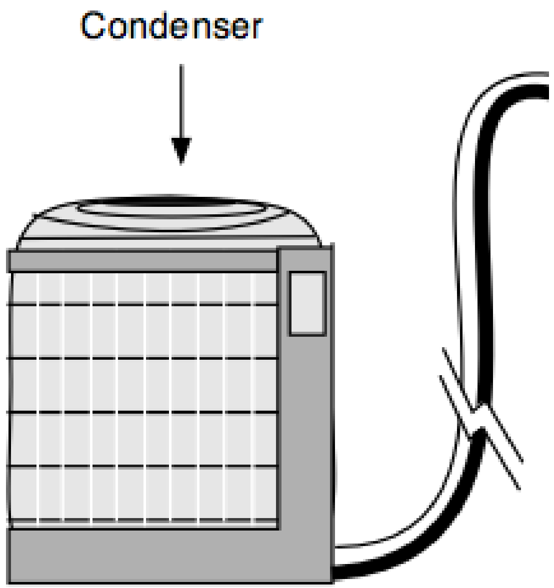
4. MANUAL S – EQUIPMENT SELECTION

- Heat Pumps
- Undersizing heat pumps may cause them to run excessively on the backup resistance electric strips.
- The oversizing issues on the cooling side can be mitigated by good duct design and good airflow.



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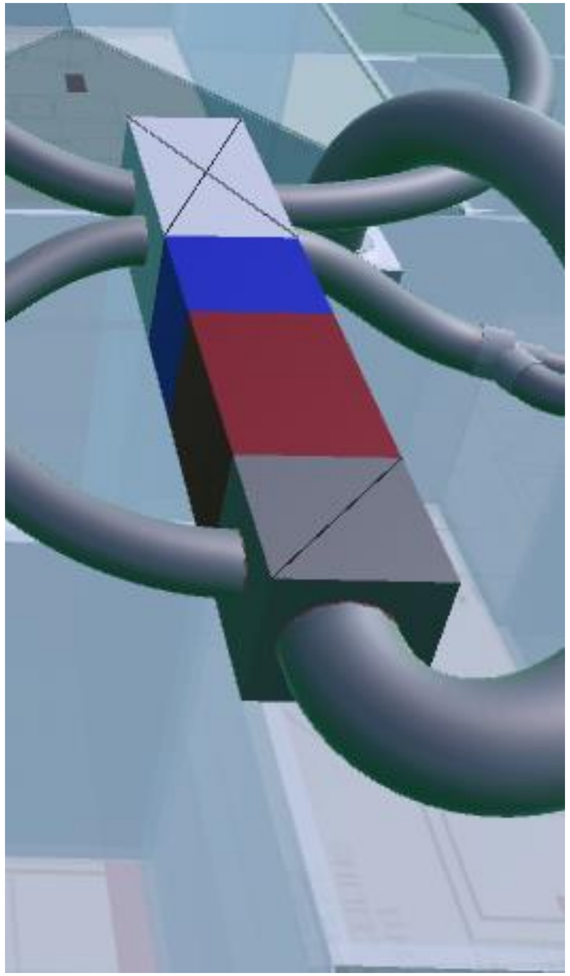
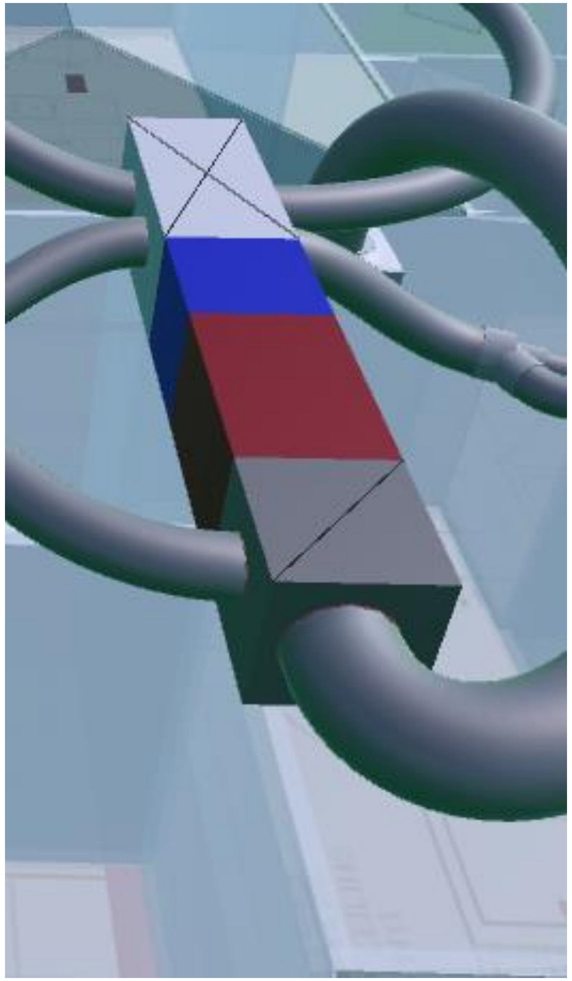
4. MANUAL S – EQUIPMENT SELECTION

- Selecting a gas furnace to meet the heating load is relatively simple.
- Whatever the load is, pick the furnace with a heating capacity (output) just a bit higher than the load.


Screen snip from Kwik Model with EnergyGauge Loads

4. MANUAL S – EQUIPMENT SELECTION

- But, don’t forget that the furnace is also the airhandler and you will need to make sure that it provides adequate airflow for cooling.
- If it does not, you will have to go to a bigger furnace which can potentially result in oversizing.



Screen snip from Kwik Model with EnergyGauge Loads

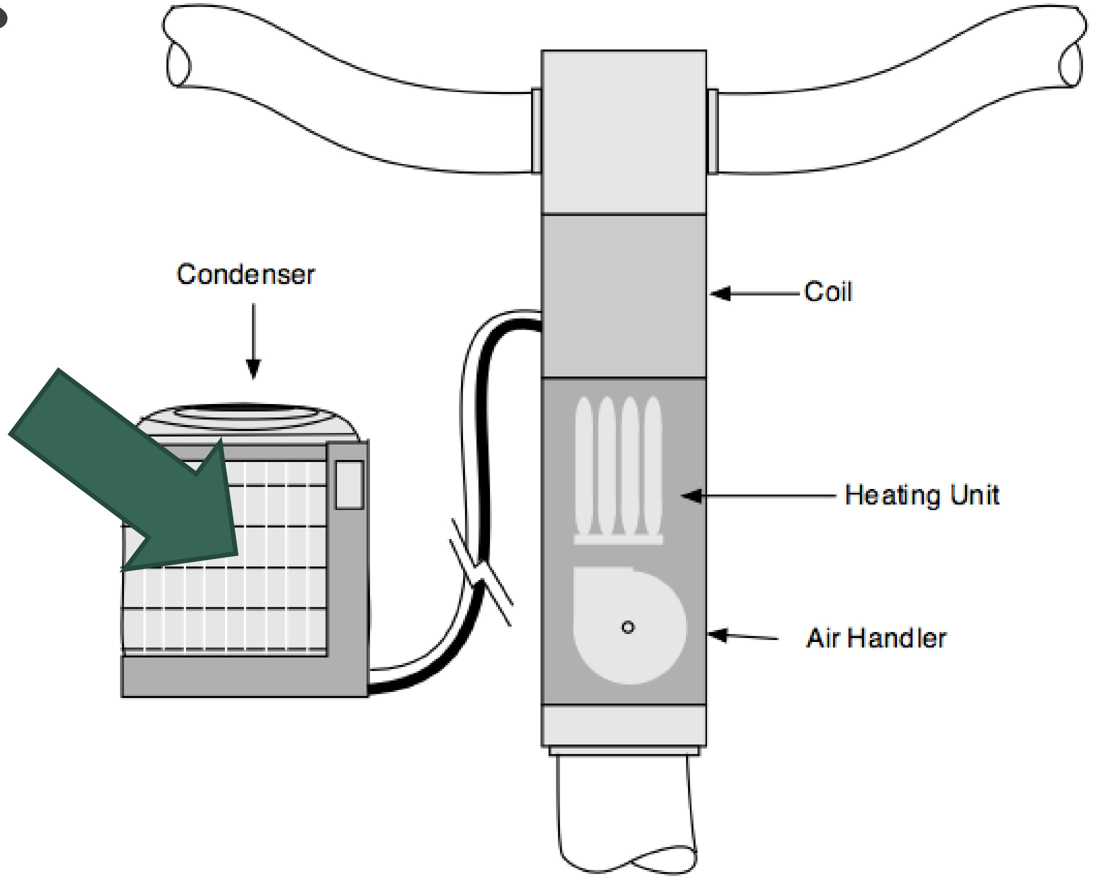
4. MANUAL S – EQUIPMENT SELECTION

- Selecting an air conditioner is much more complicated than selecting a gas furnace and is covered in detail by **ACCA Manual S**
- The reason it is more complicated is that many things affect its capacity.

			Outdoor Ambient Temperature																
			65ºF				75ºF				85ºF				95ºF				
			Entering Indoor Wet Bulb Temperature																
IDB	Airflow		59	63	67	71	59	63	67	71	59	63	67	71	59	63	67	71	59
70	525	MBh	17.9	18.1	18.7	-	17.7	18.0	18.5	-	17.3	17.5	18.0	-	16.4	16.7	17.2	-	15.5
		S/T	0.62	0.54	0.40	-	0.62	0.55	0.40	-	0.65	0.57	0.43	-	1.00	0.59	0.45	-	1.0
		ΔT	19	17	14	-	19	17	14	-	19	18	14	-	19	17	14	-	19
		kW	1.06	1.05	1.05	-	1.17	1.17	1.17	-	1.30	1.30	1.30	-	1.45	1.45	1.44	-	1.6
		Amps	4.0	4.0	4.0	-	4.5	4.5	4.5	-	5.1	5.1	5.1	-	5.8	5.8	5.8	-	6.5
		HI PR	244	245	247	-	283	284	286	-	323	325	326	-	367	368	370	-	414
		LO PR	125	126	129	-	132	134	137	-	139	141	144	-	145	146	149	-	150
	610	MBh	18.1	18.4	18.9	-	18.0	18.2	18.8	-	17.5	17.8	18.3	-	16.7	17.0	17.5	-	15.7
		S/T	0.69	0.61	0.47	-	0.69	0.62	0.48	-	0.72	0.64	0.50	-	1.00	0.66	0.52	-	1.0
		ΔT	18	16	13	-	18	16	13	-	18	16	13	-	18	16	13	-	18
		kW	1.06	1.06	1.06	-	1.18	1.18	1.18	-	1.31	1.31	1.31	-	1.45	1.45	1.45	-	1.6
		Amps	4.0	4.0	4.0	-	4.6	4.6	4.6	-	5.2	5.2	5.2	-	5.8	5.8	5.8	-	6.6
		HI PR	247	248	250	-	285	286	288	-	326	327	329	-	369	370	372	-	416
		LO PR	127	128	131	-	134	136	139	-	141	143	146	-	147	148	151	-	152
	675	MBh	18.4	18.6	19.2	-	18.2	18.5	19.0	-	17.8	18.0	18.5	-	16.9	17.2	17.7	-	16.0
		S/T	0.72	0.64	0.50	-	0.73	0.65	0.51	-	0.75	0.67	0.53	-	1.00	0.69	0.55	-	1.0
		ΔT	17	16	12	-	17	15	12	-	17	16	12	-	17	15	12	-	17
		kW	1.07	1.07	1.06	-	1.18	1.18	1.18	-	1.32	1.31	1.31	-	1.46	1.46	1.46	-	1.6
		Amps	4.1	4.1	4.0	-	4.6	4.6	4.6	-	5.2	5.2	5.2	-	5.8	5.8	5.8	-	6.6
		HI PR	248	250	251	-	287	288	290	-	328	329	330	-	371	372	374	-	418
		LO PR	128	130	133	-	136	138	141	-	143	144	147	-	148	150	153	-	154
75	525	MBh	17.9	18.1	18.7	19.5	17.7	18.0	18.5	19.3	17.3	17.5	18.1	18.9	16.5	**16.7**	17.2	18.1	15.5
		S/T	0.75	0.67	0.53	0.38	0.76	0.68	0.54	0.39	1.00	0.70	0.56	0.42	1.00	**0.72**	0.58	0.44	1.0
		ΔT	23	21	18	15	23	21	18	15	23	22	18	15	23	**21**	18	15	23
		kW	1.05	1.05	1.05	1.06	1.17	1.17	1.17	1.18	1.30	1.30	1.30	1.31	1.45	**1.45**	1.44	1.45	1.6
		Amps	4.0	4.0	4.0	4.0	4.5	4.5	4.5	4.6	5.1	5.1	5.1	5.2	5.8	**5.8**	5.8	5.8	6.5
		HI PR	245	246	247	252	283	284	286	290	324	325	326	331	367	**368**	370	374	414
		LO PR	125	126	129	135	132	134	137	142	139	141	144	149	145	**146**	149	155	150
	610	MBh	18.2	18.4	18.9	19.8	18.0	18.2	18.8	19.6	17.5	17.8	18.3	19.1	16.7	**17.0**	17.5	18.3	15.7
		S/T	0.82	0.74	0.60	0.46	1.00	0.75	0.61	0.46	1.00	0.78	0.64	0.49	1.00	**0.80**	0.66	0.51	1.0
		ΔT	22	20	17	13	22	20	17	13	22	20	17	14	22	**20**	17	13	22
		kW	1.06	1.06	1.06	1.07	1.18	1.18	1.18	1.19	1.31	1.31	1.31	1.32	1.45	**1.45**	1.45	1.46	1.6
		Amps	4.0	4.0	4.0	4.1	4.6	4.6	4.6	4.6	5.2	5.2	5.2	5.2	5.8	**5.8**	5.8	5.9	6.6
		HI PR	247	248	250	254	286	287	288	293	326	327	329	333	370	**371**	372	377	417
		LO PR	127	128	132	137	134	136	139	144	141	143	146	151	147	**148**	151	157	152
		MBh	18.4	18.6	19.2	20.0	18.2	18.5	19.0	19.8	17.8	18.0	18.5	19.4	17.0	**17.2**	17.7	18.6	16.0

4. MANUAL S – EQUIPMENT SELECTION

- An air conditioner's capacity (its ability to cool) is affected by:
  - **The outdoor temperature**
  - The amount of air blowing across the evaporator coil
  - The indoor temperature
  - The indoor humidity



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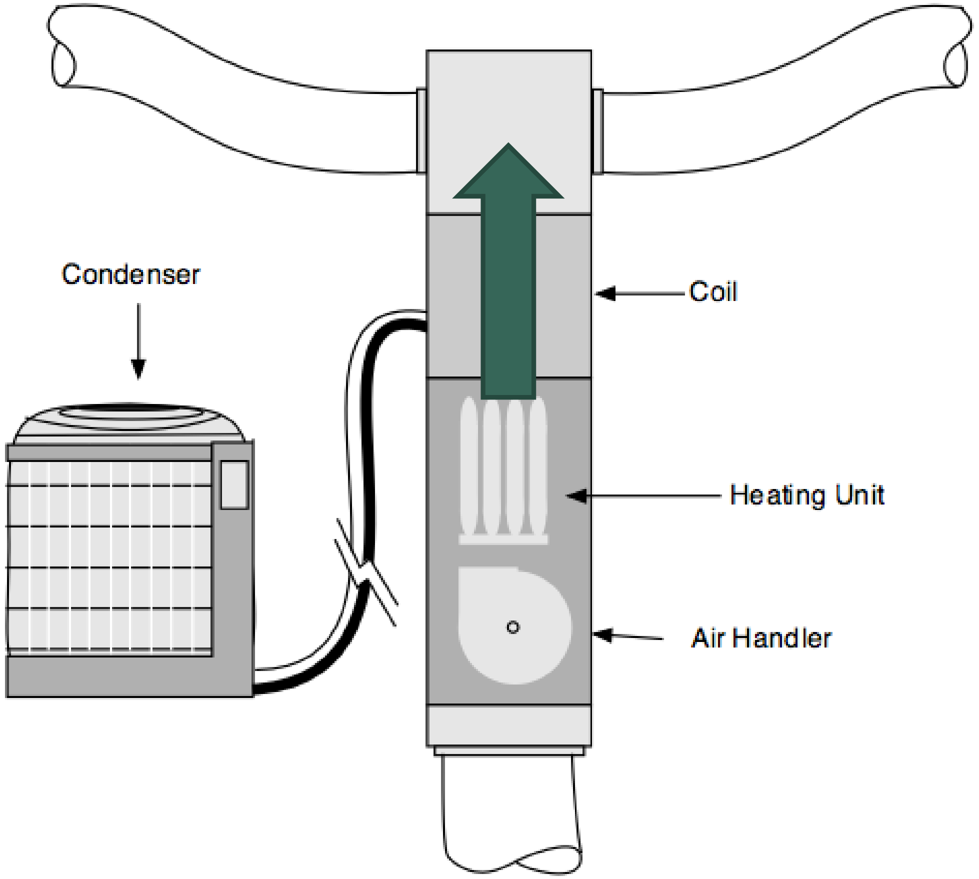

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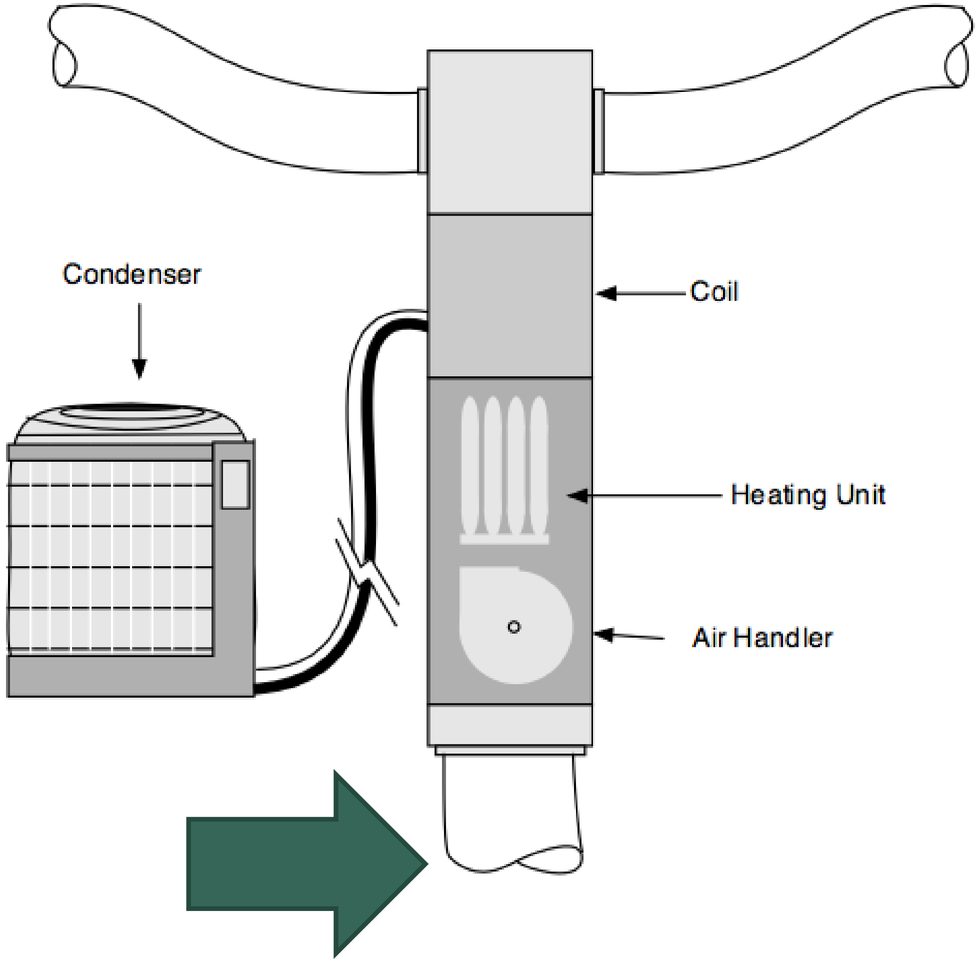
  - **The indoor temperature**
  - The indoor humidity



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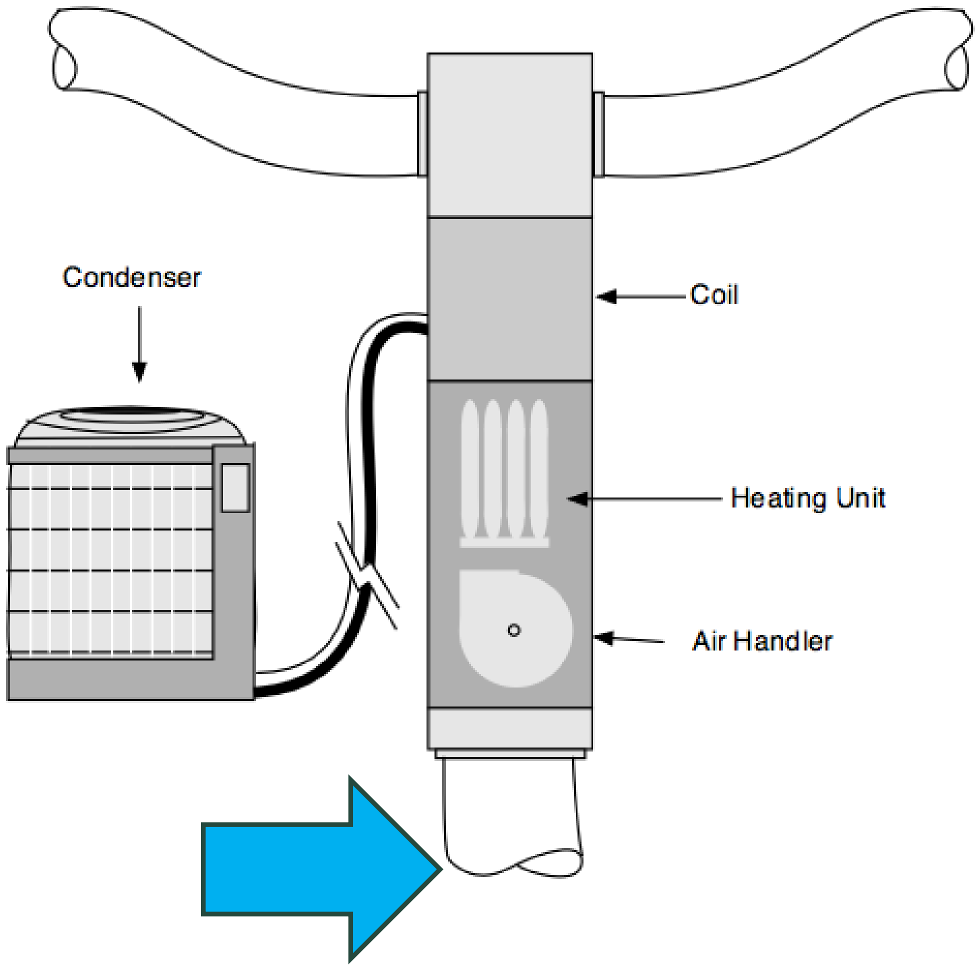
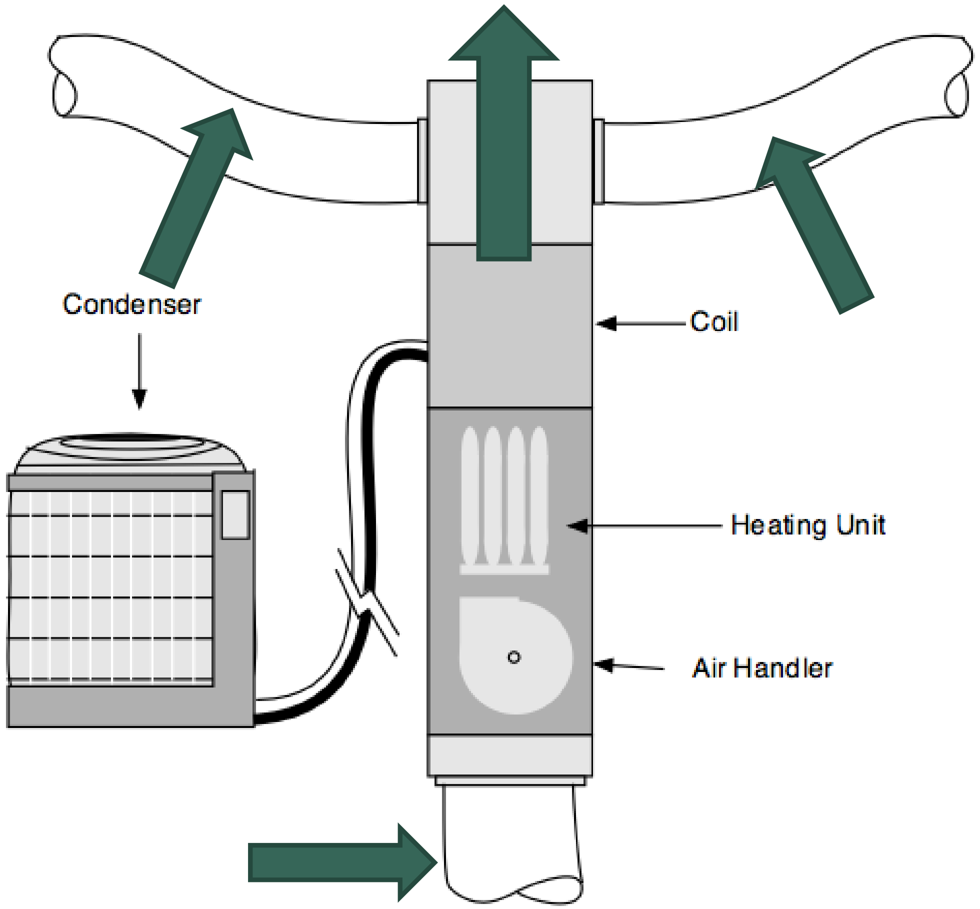
  - The indoor temperature
  - **The indoor humidity**



Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

4. MANUAL S – EQUIPMENT SELECTION

- **<u>Airflow is affected by duct sizes.</u>**
- This means that duct sizing can have a big impact on cooling capacity.
- **Oversizing** air conditioners and **undersizing** ducts is one of the most common causes of comfort complaints in homes.



Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

SUMMARY

1. Introduction
   - ACCA Manuals
   - Capacity vs. Load
   - Oversizing vs Undersizing
2. Overview of the HVAC Design Process.
   1. **Collect** information about the house
   2. **Perform** *room-by-room* load calculations (Manual J)
   3. **Select** equipment to meet the total loads (Manual S)
   4. **Design** the distribution system (Manual D)
3. Manual J – Load Calculations
4. Manual S – Equipment Selection

END OF PART 1

SEE YOU THURSDAY FOR PART 2!

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  - 2022 CALGreen Code for Residential and Non-Residential – (5/4)
  - Crafting High Performance Enclosures: Roofs, Walls, and Floors – (5/4)
  - 2022 Energy Code: Non-Residential – (5/17)

Thank you!

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