We will be starting soon!

Thanks for joining us

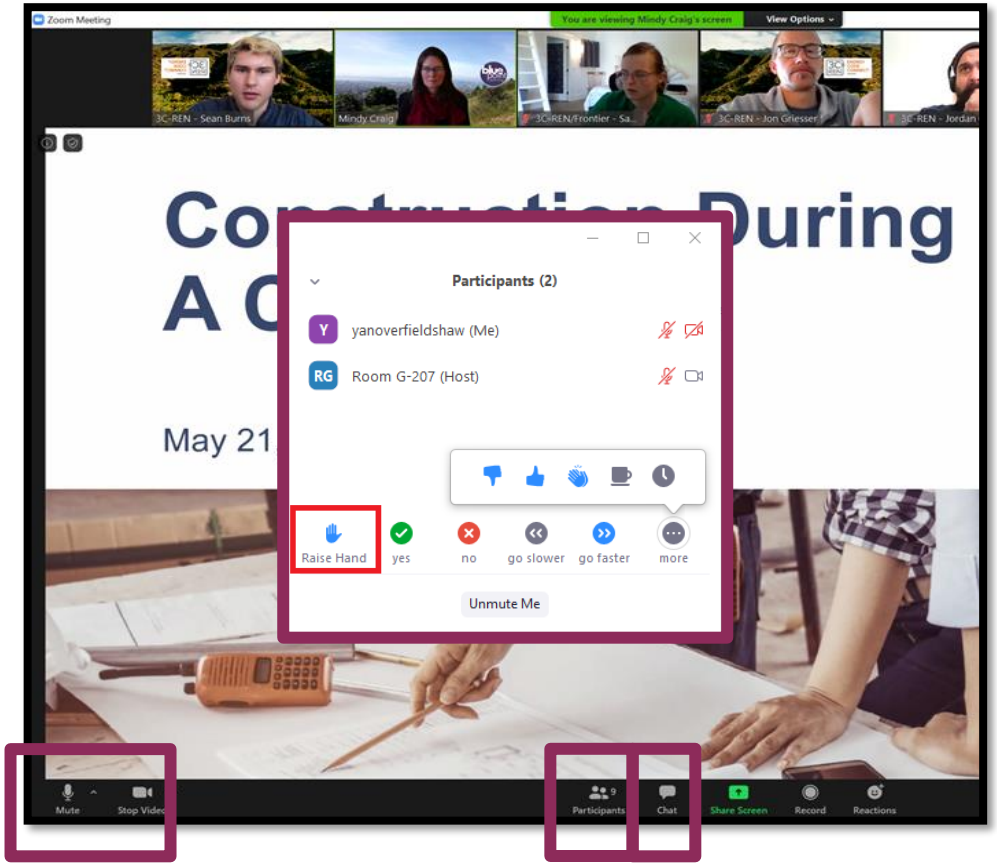
Why Energy Consultants Should Learn to do Residential HVAC Design

Russ King – Coded Energy Inc.

April 04, 2024

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
805.781.1201

Event Registration:
3c-ren.org/events

3C REN BUILDING PERFORMANCE TRAINING

- 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

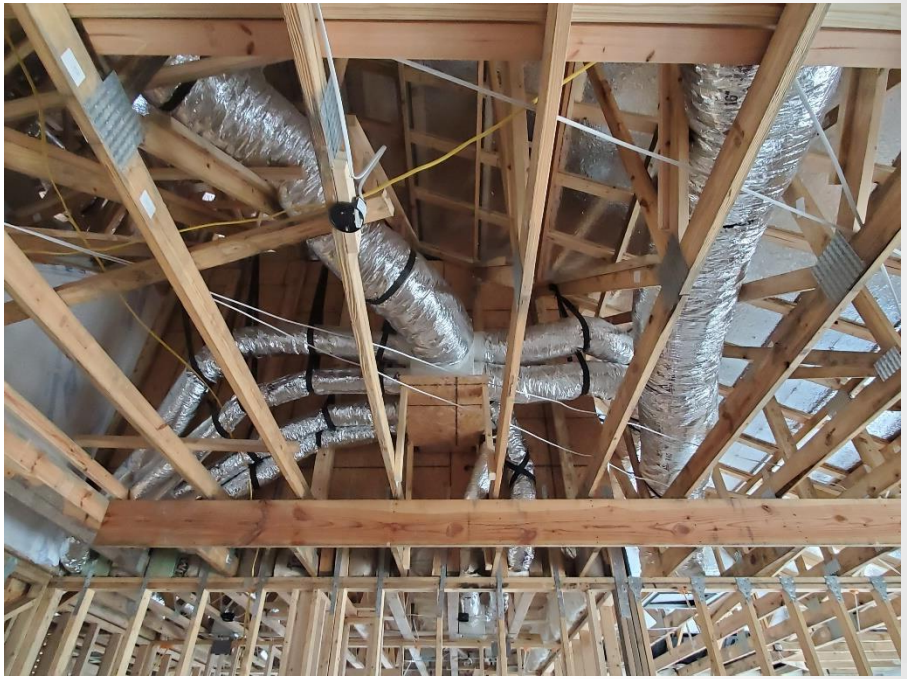
Single Family (up to 4 units)

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

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

KWIK MODEL3D

Why Energy Consultants Should Learn to do Residential HVAC Design



Instructor – Russell King, M.E.

- Licensed Mechanical Engineer
- CEO/Founder of Coded Energy, Inc., developers of Kwik Model 3D software.
- 35+ years experience with residential HVAC and energy efficiency
- May 30 @ 2pm, similar class with Nick Brown but demonstrating a new software that speaks both Title 24 and ACCA J/S/D.

Why Should Energy Consultants Do HVAC Load Calculations?

KWIK MODEL3D

1. Load calcs are easy! (equipment selection and duct design take much more experience – let the contractor do those)
2. It requires pretty much exactly the same inputs as an energy model.
3. An annual energy simulation is 8760 load calculations.
4. Most HVAC Contractors are not doing load calcs, even though they are required by code (not well enforced).
5. Energy consultants are good a getting this information from plans into the software.
6. New software will allow a house model to be used for both and energy model and a load calc.
7. The 2025 code will put a much bigger emphasis on proper sizing.

What Are Load Calculations?

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
- Widely recognized as the industry standard for HVAC design (though not the only recognized standard).

What Are Load Calculations?

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

- California Energy Code **requires** ACCA Manual J 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!

What Are Load Calculations?

- 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

What Are Load Calculations?

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.

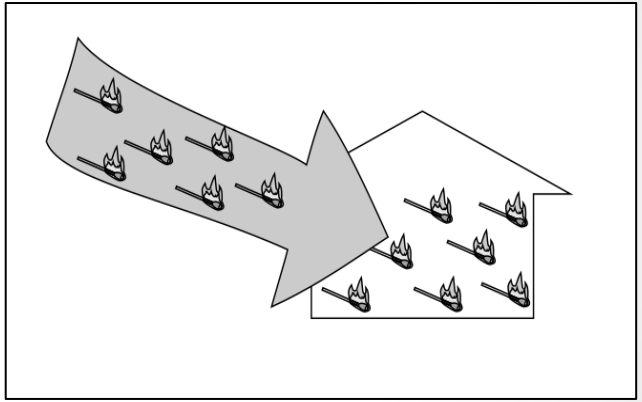
Heat moves at different ***rates***. We express this in BTUs per hour (Btuh)

What Are Load Calculations?

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*

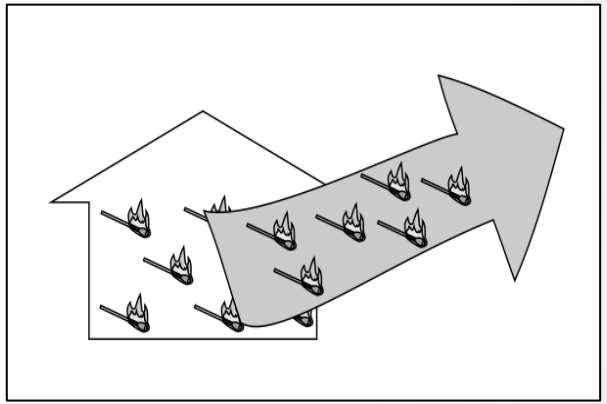
What Are Load Calculations?

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.



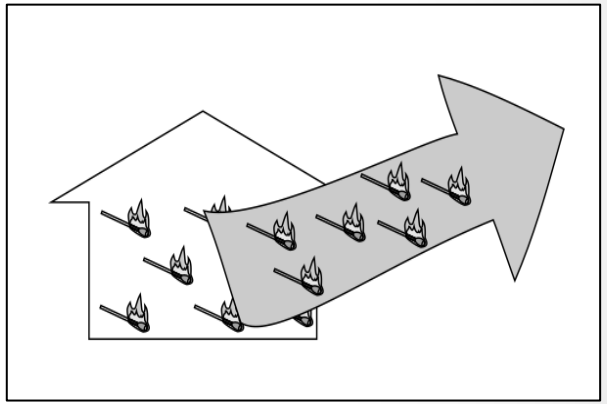
Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

What Are Load Calculations?

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*

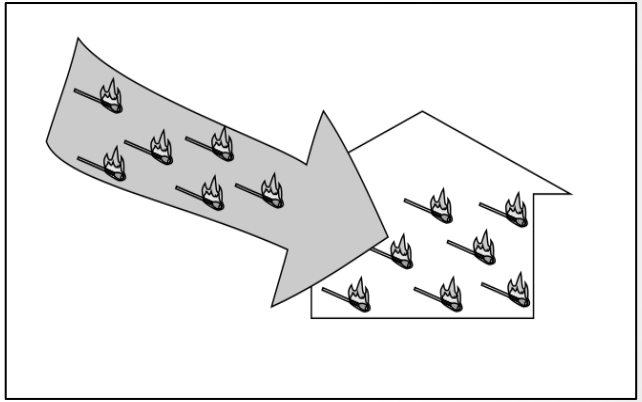
What Are Load Calculations?

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.

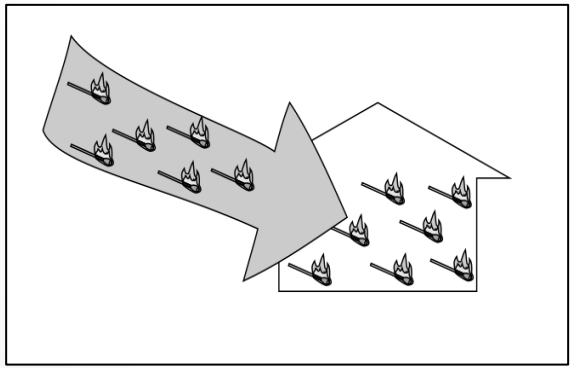


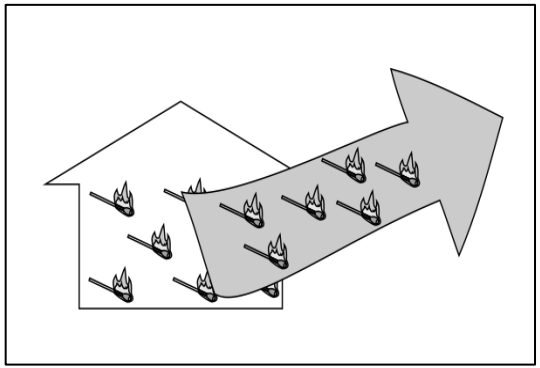
Images from *HVAC 1.0 – Introduction to Residential HVAC Systems*

What Are Load Calculations?

Definitions

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*

What Are Load Calculations?

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***.

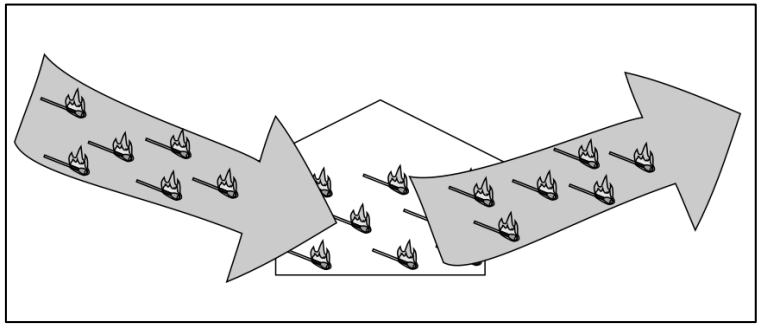
The **load** of the house is what the house *needs* in BTUs per hour to maintain a constant temperature at design conditions. Think of it as the ***demand***.

What Are Load Calculations?

KWIK MODEL3D

Definitions

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*

What Are Load Calculations?

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.

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

What Are Load Calculations?

Definitions

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

- 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.

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

What Are Load Calculations?

Definitions

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

- 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.

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

Why Are Load Calcs Important?

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

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

For **<u>Air Conditioners</u>**:

- ***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.

Why Are Load Calcs Important?

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

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

For **<u>Heaters (heat pumps or furnaces)</u>**:

- ***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.

Why Are Load Calcs Important?

KWIK MODEL3D

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

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

Why Are Load Calcs Important?

The Importance of Good Design: Equipment Sizing

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

Why Are Load Calcs Important?

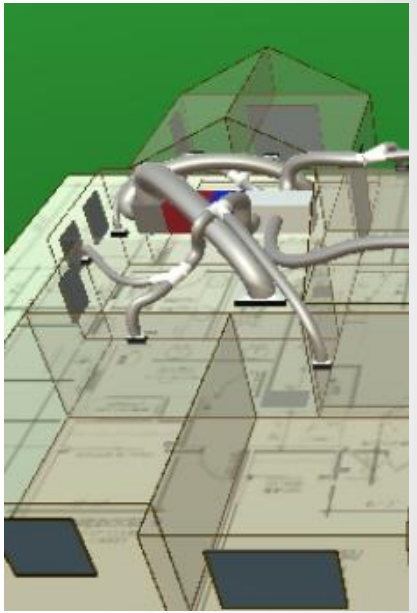
The Importance of Good Design: <u>Equipment Sizing</u>

- Historically, the most common method of equipment sizing was rules of thumb and trial and error.
- This almost always led to oversized equipment (and undersized ducts).

Why Are Load Calcs Important?

KWIK MODEL3D

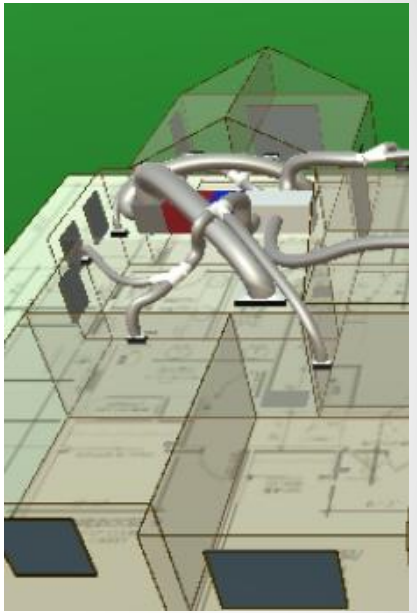
The Importance of Good Design: Duct Sizing



- 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).

Why Are Load Calcs Important?

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

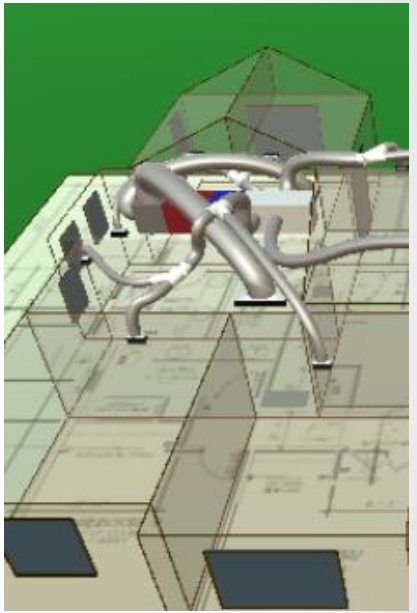


- Target room airflows need to be determined from **room-by-room loads** – you need to know what the load of a room is relative to other rooms.
- General undersizing of all ducts, especially return ducts, will reduce total system fan flow, which will reduce **<u>capacity and efficiency</u>** of system.

Why Are Load Calcs Important?

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

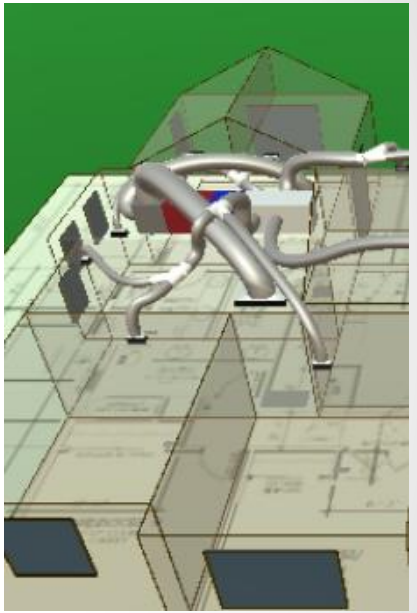
- Undersizing one or two ducts relative to the other ducts in the house will cause poor **air balance.**
- This will result in uneven temperature distribution in the house (some rooms warmer or cooler than others)
- This is made even worse by low overall airflow.



Why Are Load Calcs Important?

Remember:

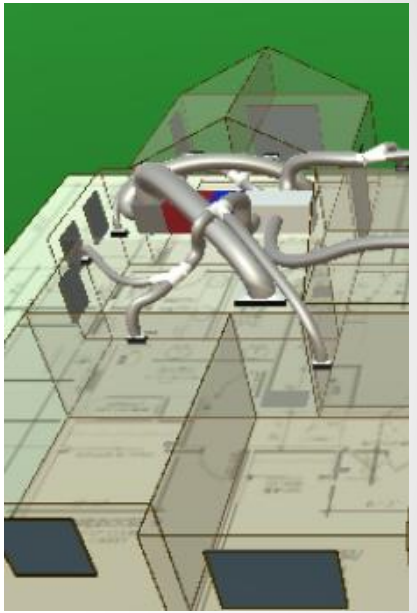
- Equipment cannot be properly sized unless you can accurately determine the capacity at design conditions. (Supply)
- Equipment cannot be properly sized unless you know the load of the house. (Demand)

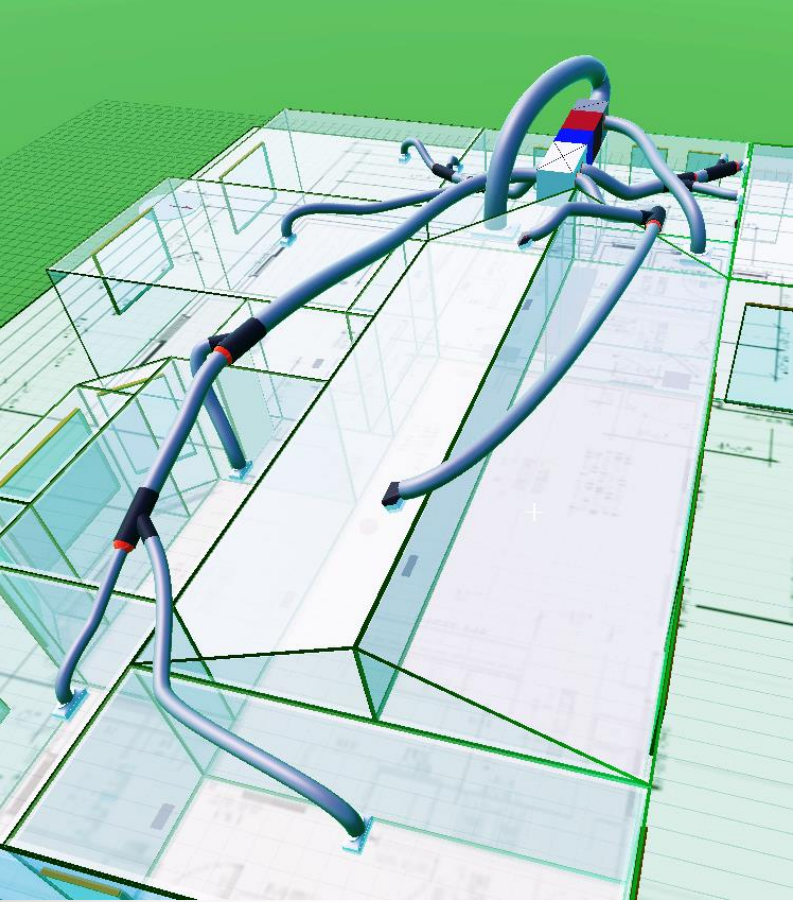


Why Are Load Calcs Important?

Remember:

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





KWIK MODEL3D

Overview of HVAC Design Process

Overview of HVAC Design Process

KWIK MODEL3D

The Process

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

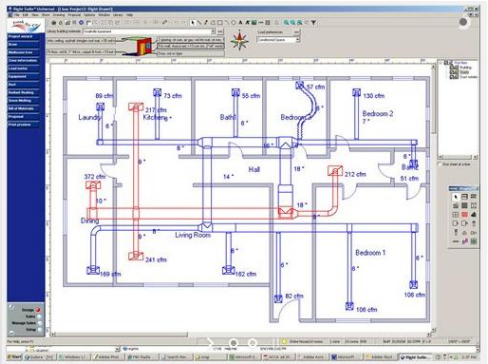
1. **Collect** information about the house
2. **Perform** *room-by-room* load calculations (Manual J)
3. **Select** equipment to meet the total loads (Manual S)
4. **Design** the distribution system (Manual D)

Overview of HVAC Design Process

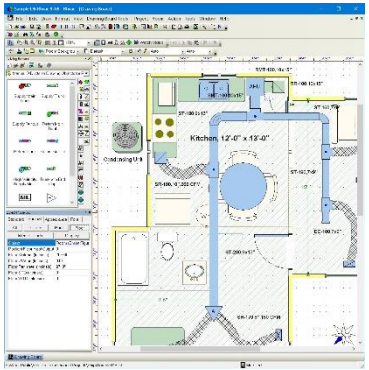
The Process

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

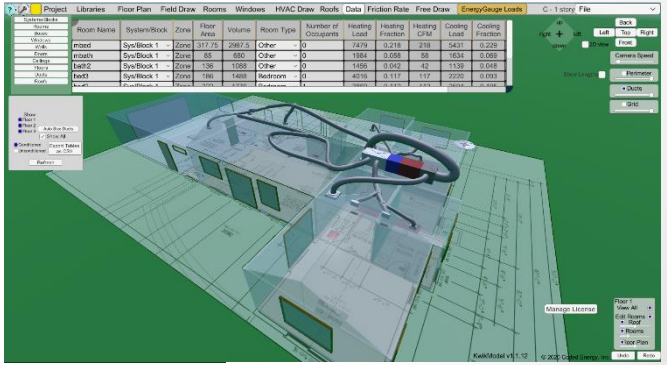
Right-Suite® by Wrightsoft



RHVAC by Elite Software



Kwik Model® with *EnergyGauge Loads*



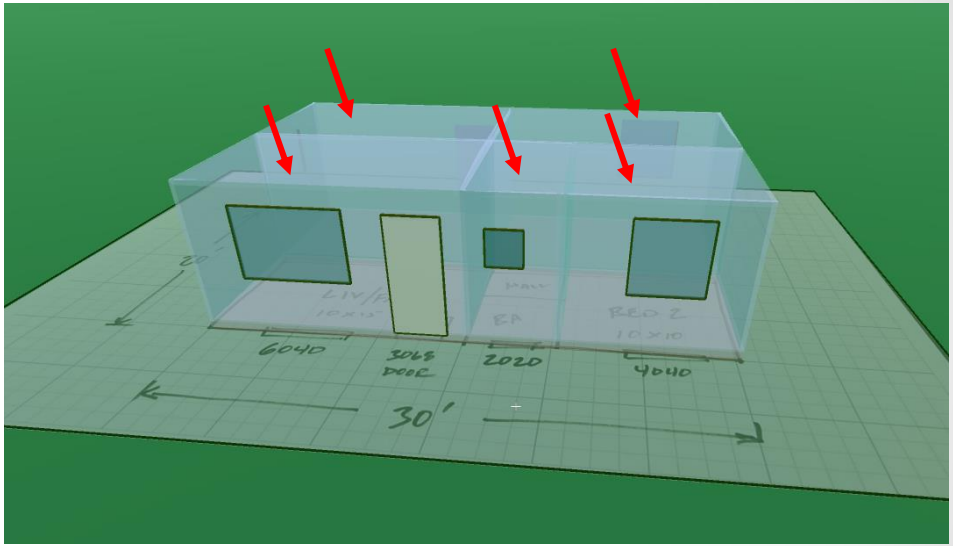
Overview of HVAC Design Process

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.



Overview of HVAC Design Process

Step 1. Collect Information About the House

- What you actually need areas for:
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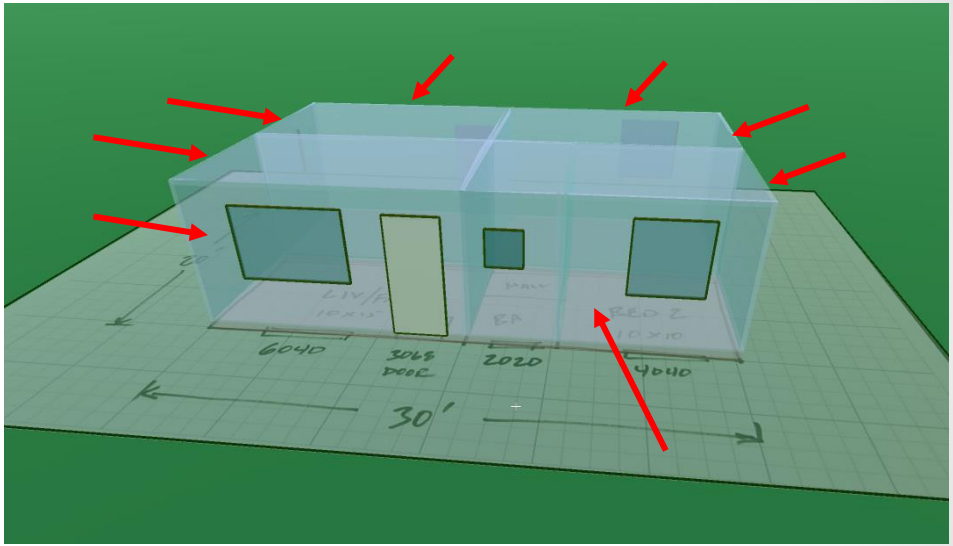

Overview of HVAC Design Process

Step 1. Collect Information About the House

- What you actually need areas for:
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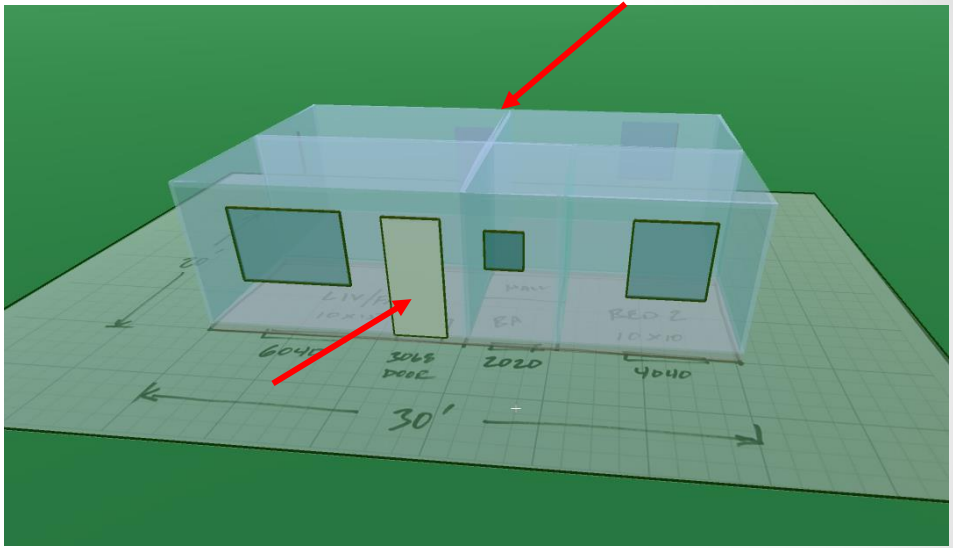

Overview of HVAC Design Process

Step 1. Collect Information About the House

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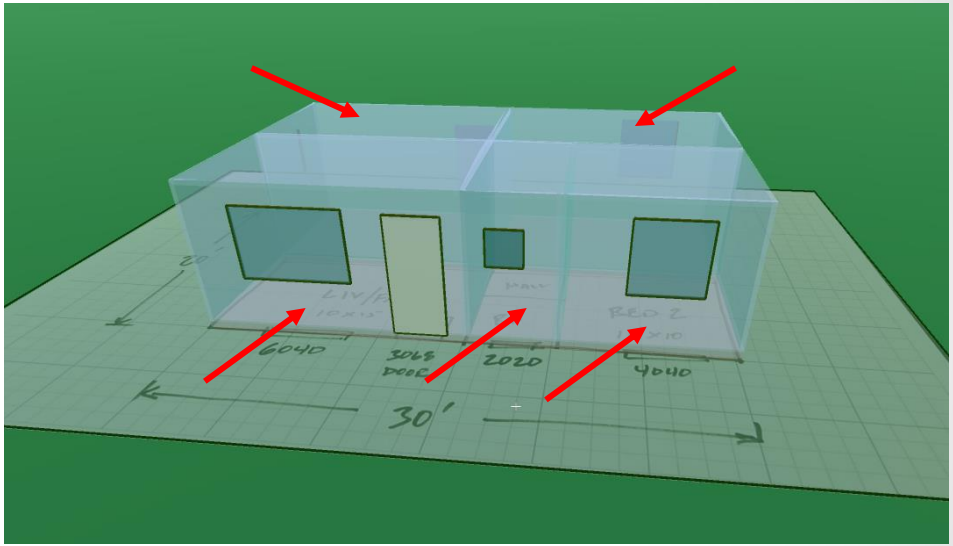

Overview of HVAC Design Process

Step 1. Collect Information About the House

- What you actually need areas for:
  - ceilings,
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  - and floors,
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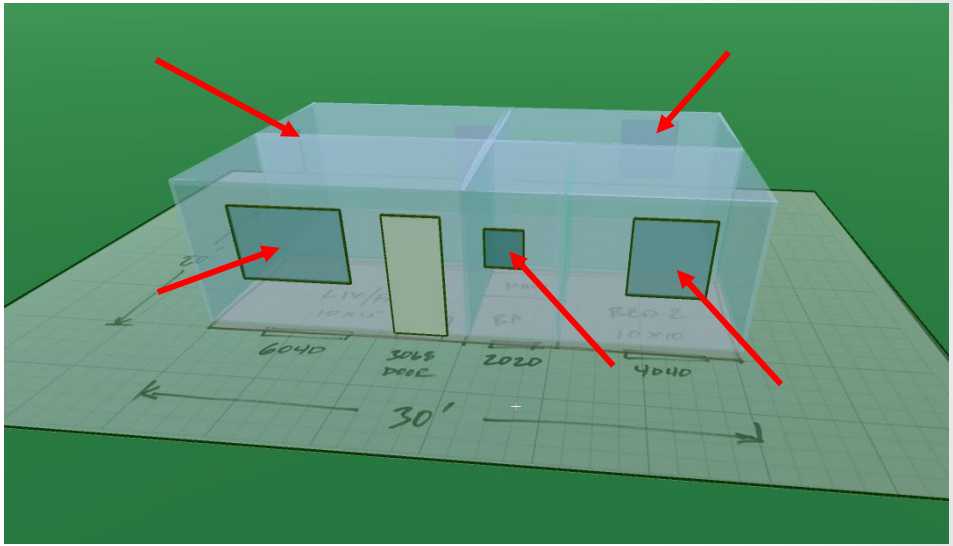
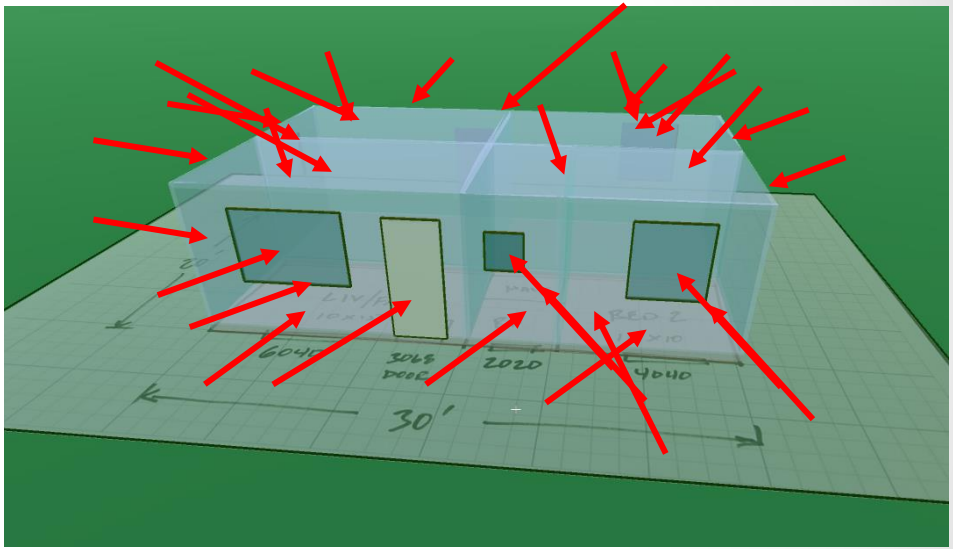
- These are the surfaces that will conduct heat into and out of the house.



Overview of HVAC Design Process

Step 1. Collect Information About the House

- What you actually need 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.**

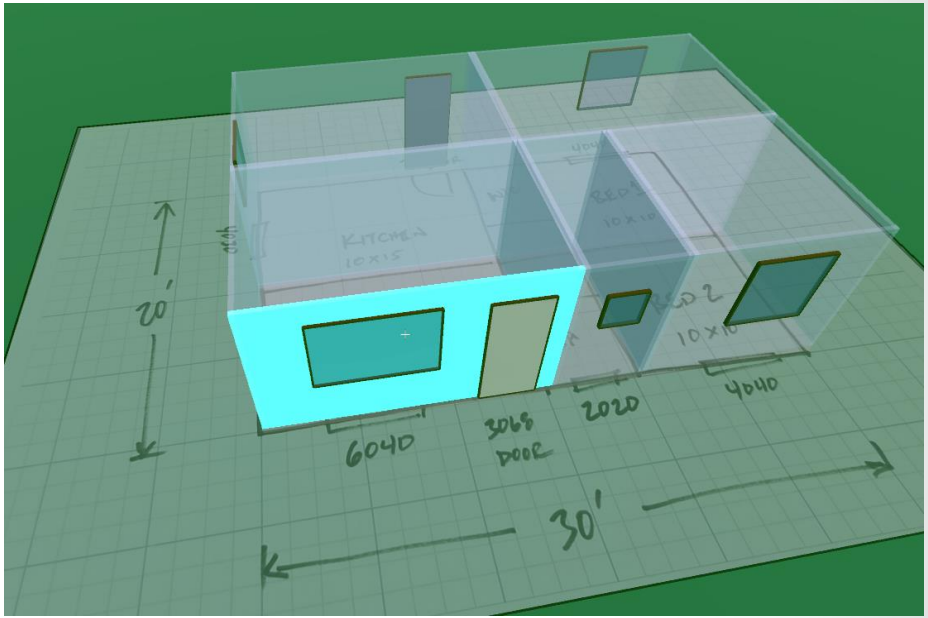


(This should all sound very familiar.)

Overview of HVAC Design Process

Step 1. Collect Information About the House

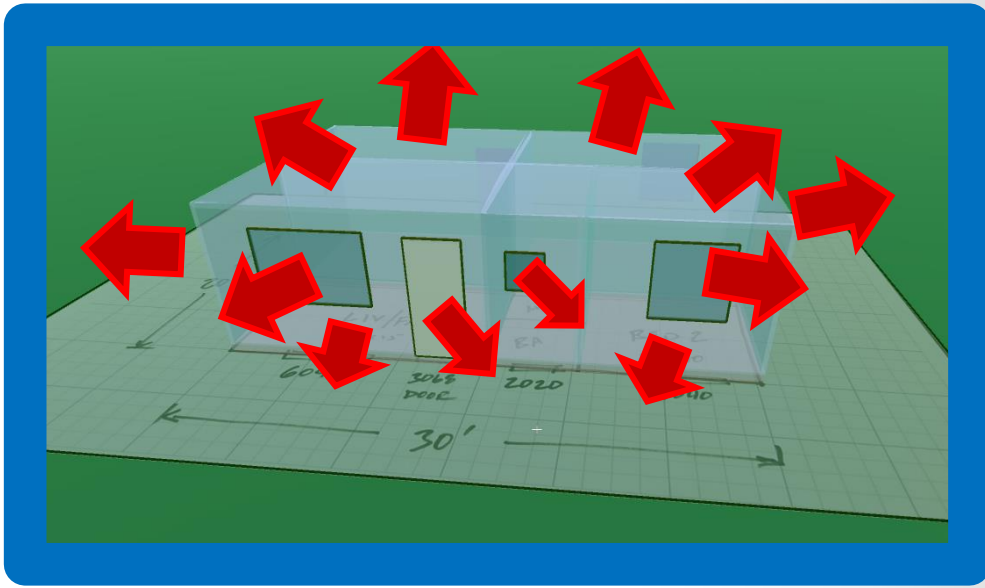
- You will need this on a room-by-room basis if you plan to also size the ducts.
- Keeping track of all these surfaces is challenging.
- This is where design software is most helpful.



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

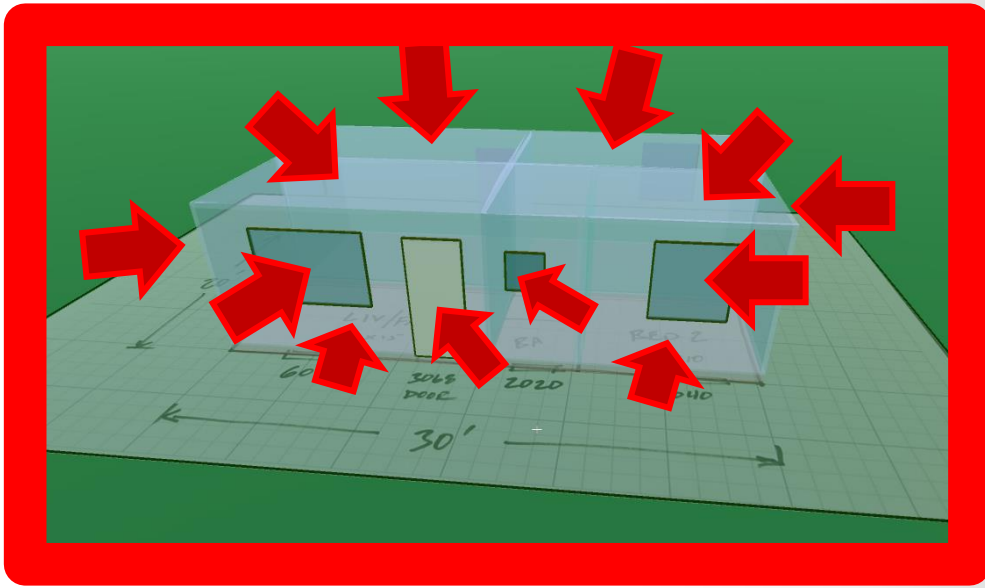


Winter

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.
- And for summer

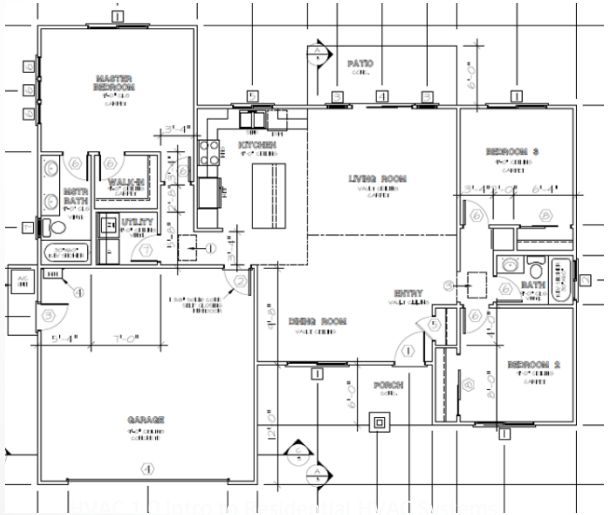


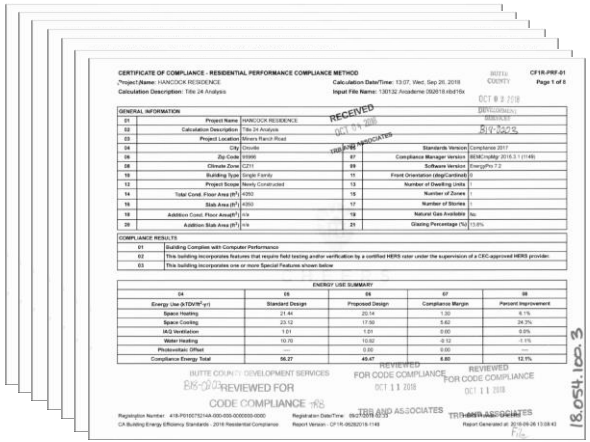
Summer

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**.

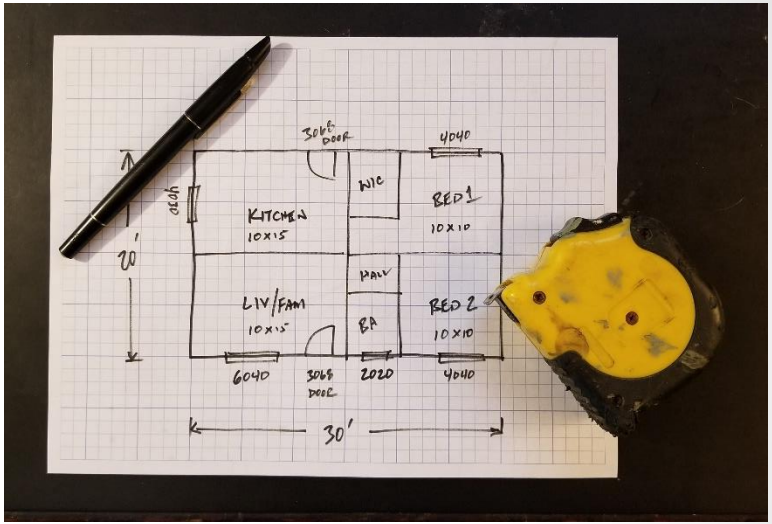




Overview of HVAC Design Process

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.

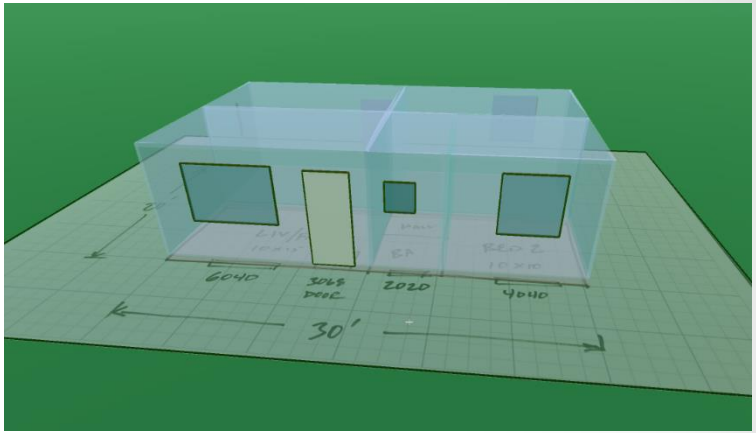


- Check out CubiCasa. It's a free phone app that creates a very good floor plan.

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.



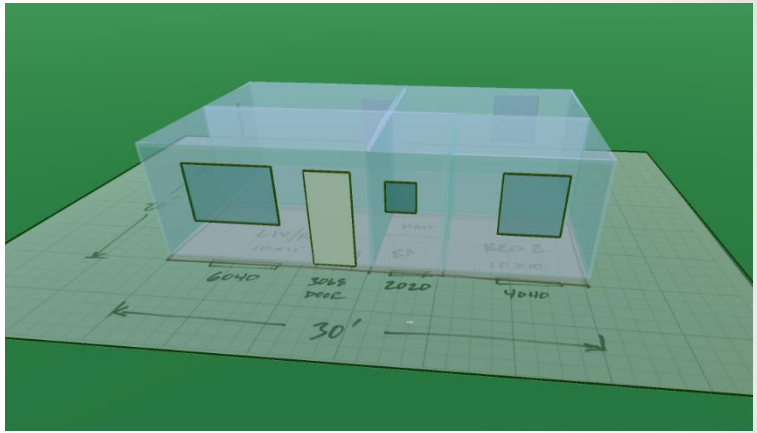
Overview of HVAC Design Process

KWIK MODEL3D

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.

For **existing** homes you will have determine these features



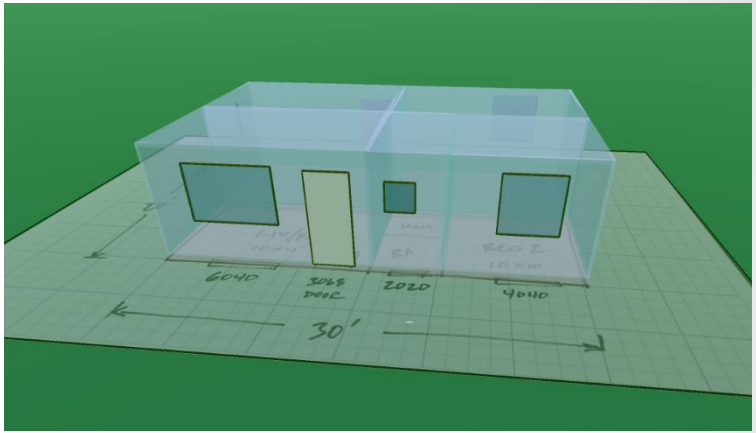
Overview of HVAC Design Process

KWIK MODEL3D

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.

For **new** homes, this information will be in the energy compliance calculations.

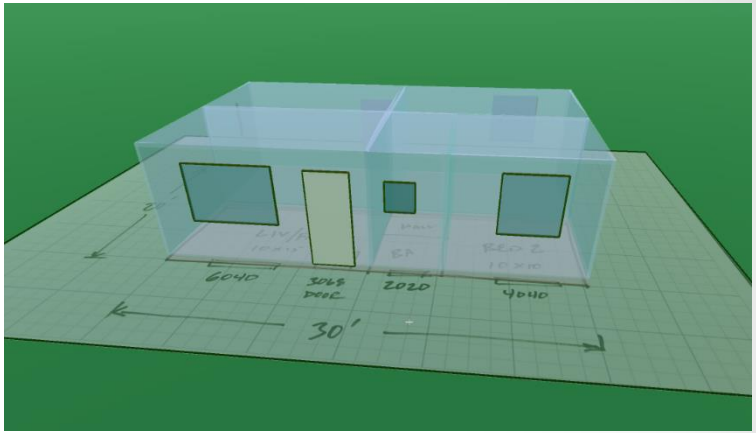


Overview of HVAC Design Process

KWIK MODEL3D

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.

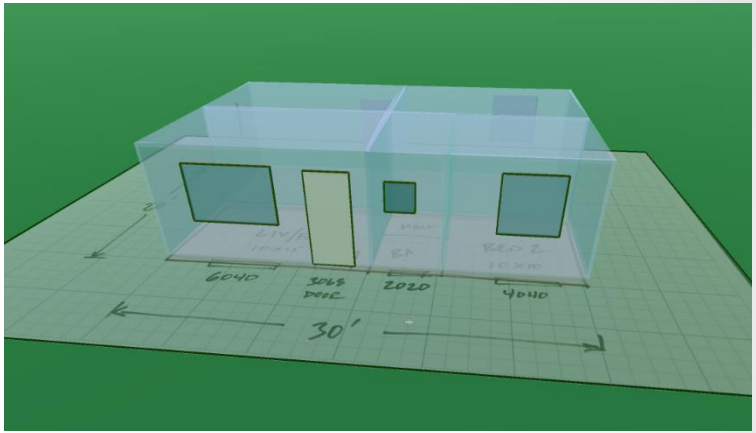


Overview of HVAC Design Process

KWIK MODEL3D

Step 1. Collect Information About the House

- **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%.

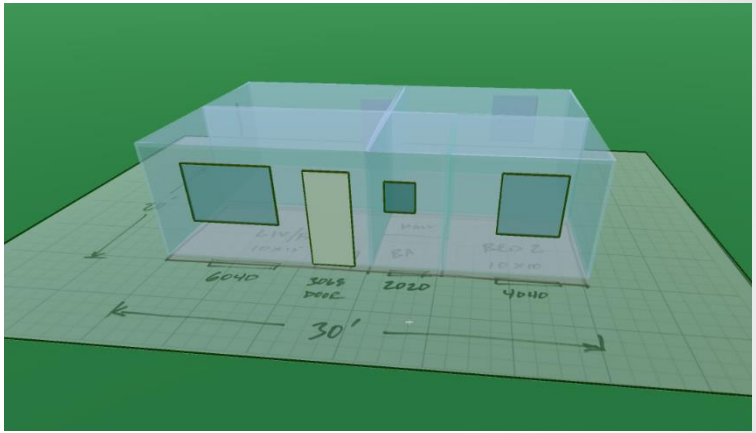


Overview of HVAC Design Process

KWIK MODEL3D

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.

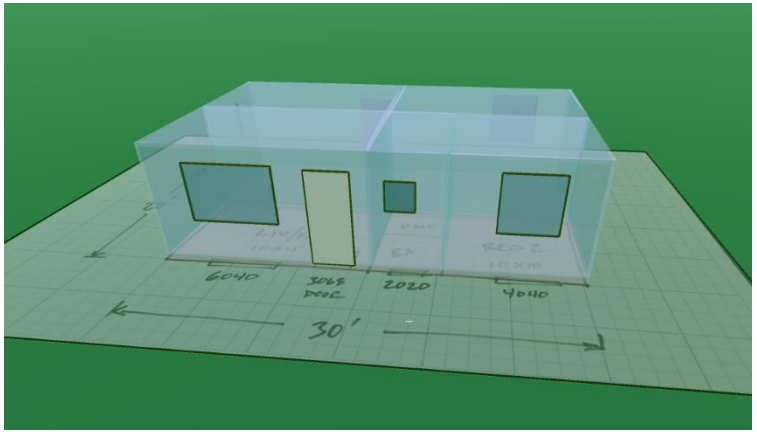


Overview of HVAC Design Process

Step 2. Perform Room-by-Room 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)

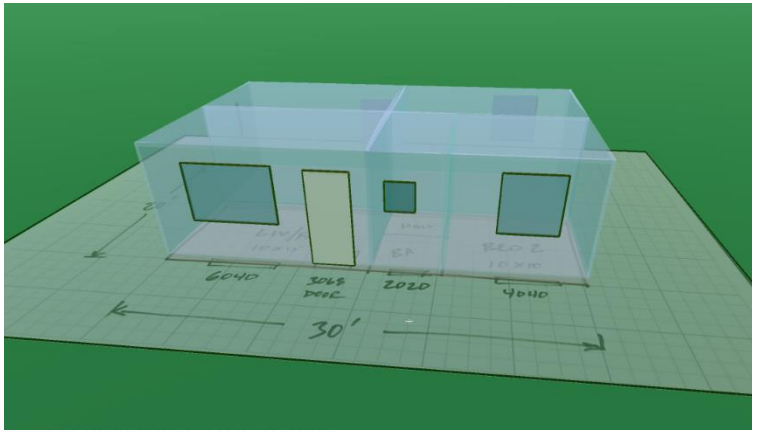


Overview of HVAC Design Process

Step 2. Perform Room-by-Room Load Calculations

There are two basic kinds of 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.

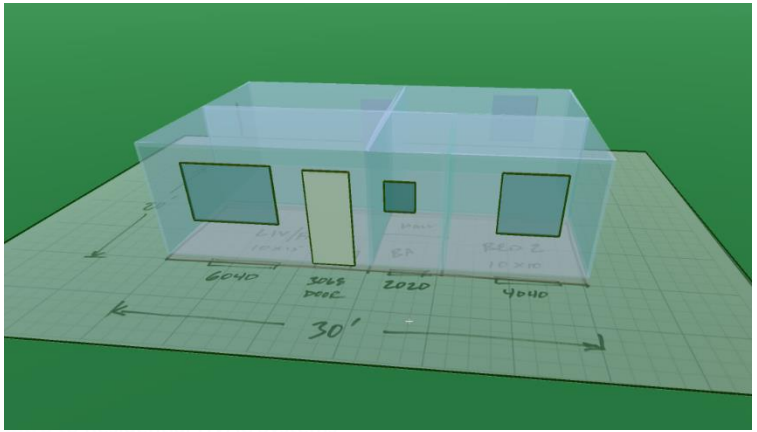


Overview of HVAC Design Process

Step 2. Perform Room-by-Room Load Calculations

There are two basic kinds of load calculations.

- Room-by-room load calculations are important for designing a distribution system.
- These help you ***distribute*** the heating and cooling correctly.



Overview of HVAC Design Process

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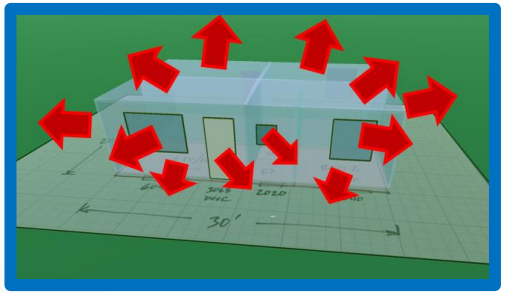
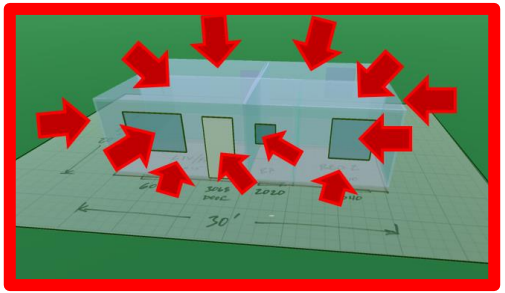
Step 2. Perform Room-by-Room Load Calculations

- 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 load calculations first.

Overview of HVAC Design Process

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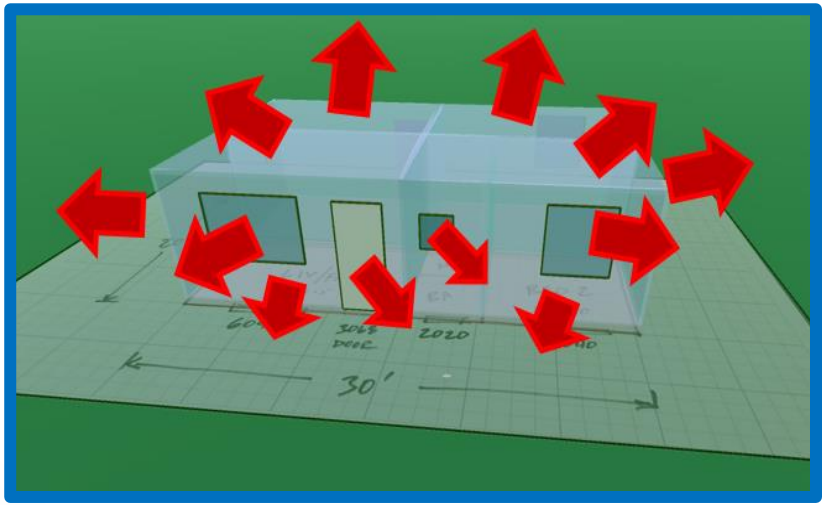
Step 2. Perform Room-by-Room Load Calculations

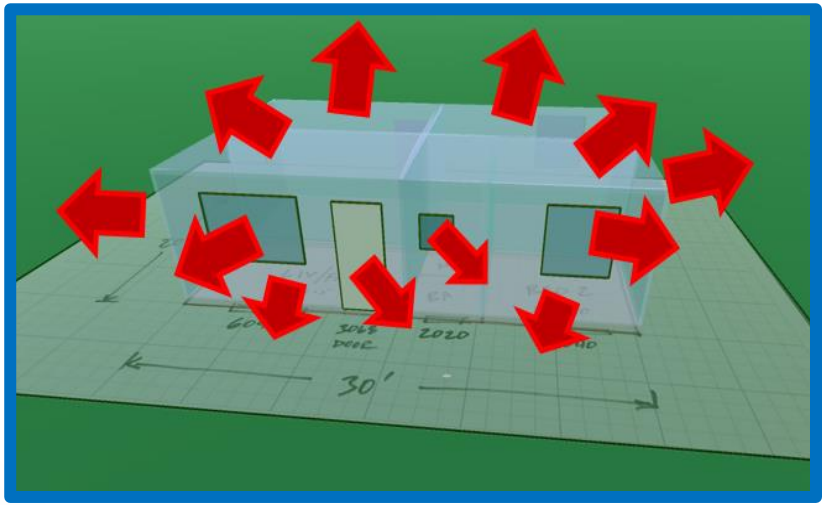
- A heating load calculation is a sum of all of the **BTU losses** (convection, conduction and radiation) that occur when it is a <u>certain delta T</u>.



Overview of HVAC Design Process

Step 2. Perform Room-by-Room Load Calculations

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

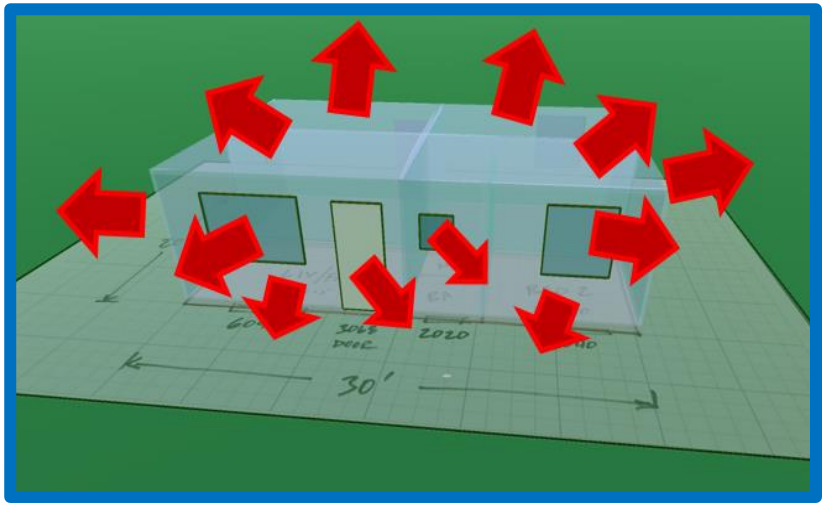


Overview of HVAC Design Process

KWIK MODEL3D

Step 2. Perform Room-by-Room Load Calculations

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



Overview of HVAC Design Process

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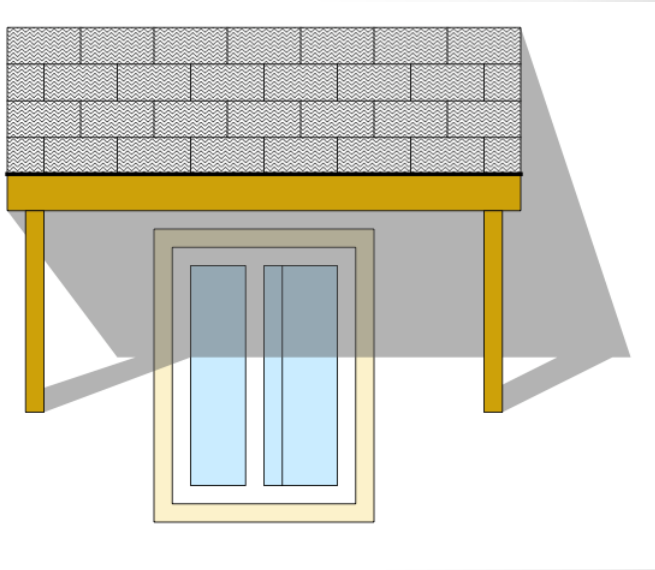
Step 2. Perform Room-by-Room Load Calculations

- 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.



Overview of HVAC Design Process

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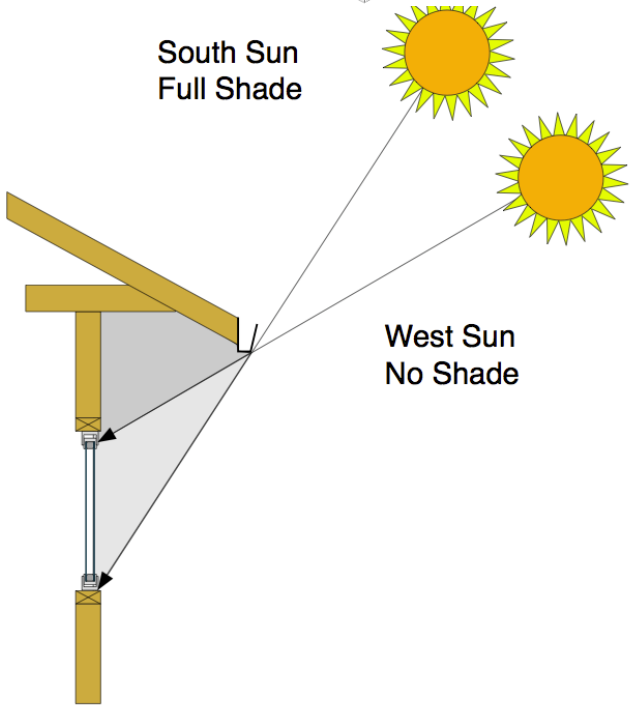
Step 2. Perform Room-by-Room Load Calculations

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



Overview of HVAC Design Process

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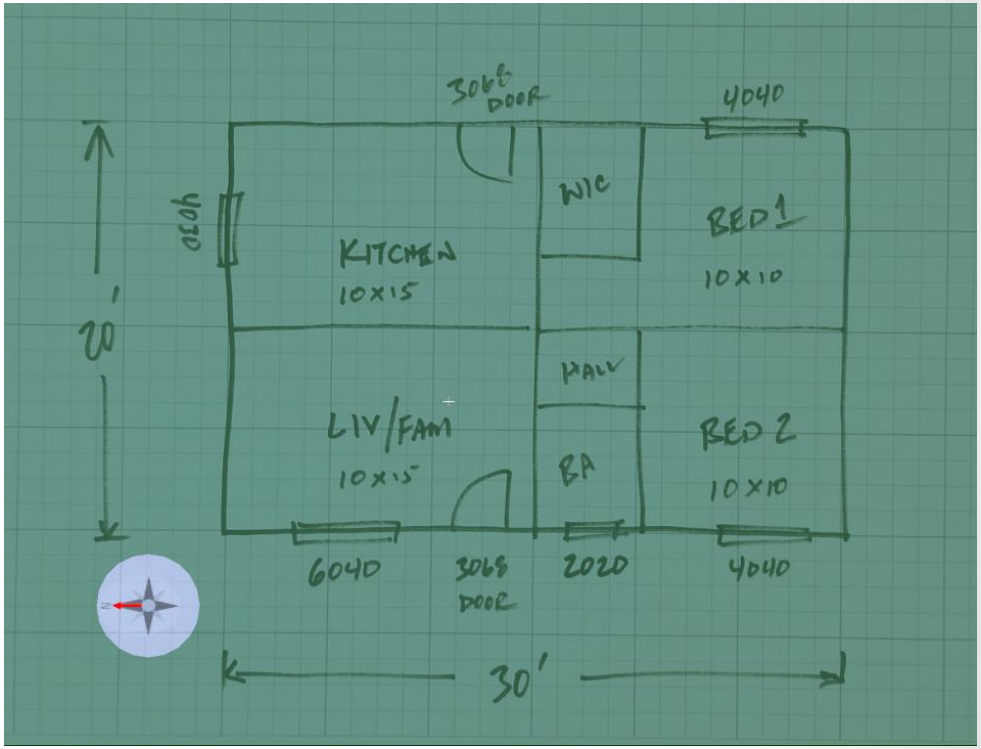
Step 2. Perform Room-by-Room Load Calculations

- Consider this simple example house, which is facing West.
- Notice that the kitchen and Liv/Fam room are the same size.



Overview of HVAC Design Process

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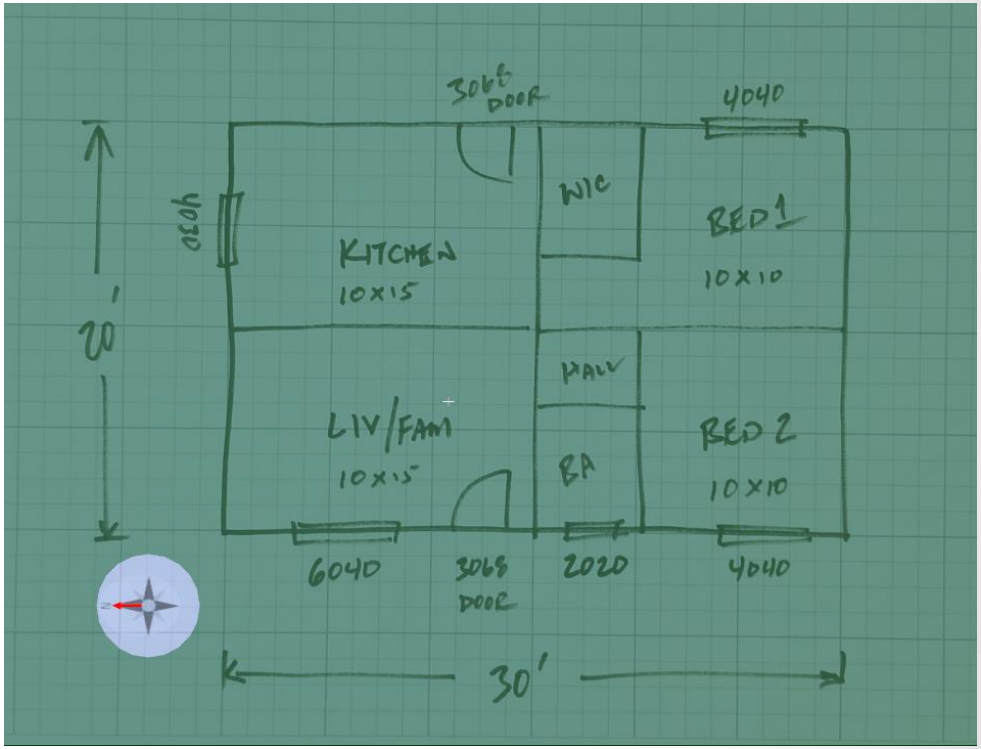
Step 2. Perform Room-by-Room Load Calculations

- The kitchen has a north facing window.
- The Liv/Fam room has a larger west facing window.
- We will see how this affects the cooling loads.



Overview of HVAC Design Process

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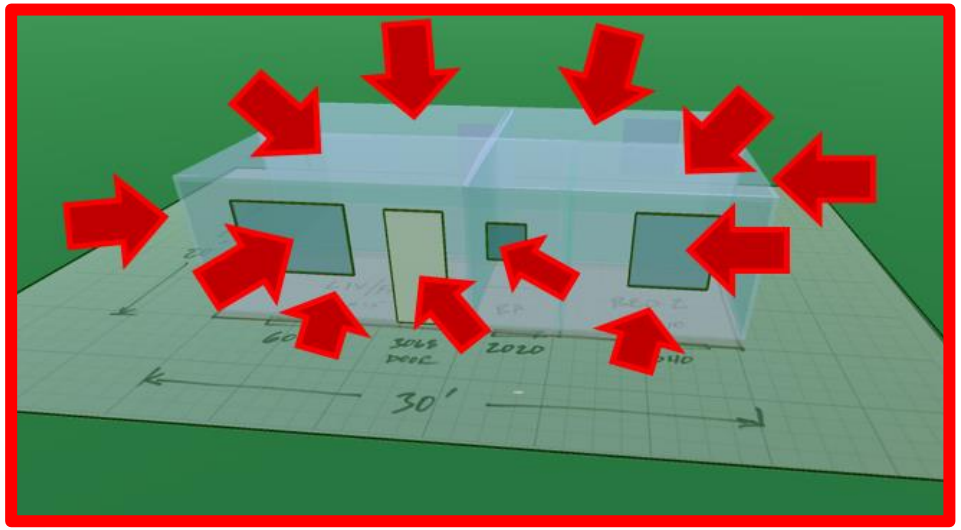
Step 2. Perform Room-by-Room Load Calculations

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



Overview of HVAC Design Process

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Step 2. Perform Room-by-Room Load Calculations

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

Overview of HVAC Design Process

- 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.

Overview of HVAC Design Process

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Step 2. Perform Room-by-Room Load Calculations

This is a table of the **windows** for our sample house.

Window Name	Room	Type Name	Direction	Azimuth	Tilt	Area	Touching	Overhang Height	Overhang Length
L1	Kitchen(1)	2P.metal.clear.1	Left	N	90	12	Outside	0	0
F1	Living(1)	2P.metal.clear.1	Front	W	90	24	Outside	0	0
B1	Bed 1(1)	2P.metal.clear.1	Back	E	90	16	Outside	0	0
F2	bath(1)	2P.metal.clear.1	Front	W	90	4	Outside	0	0
F3	Bed 2(1)	2P.metal.clear.1	Front	W	90	16	Outside	0	0
Total	---	---	---	---	---	72	---	---	---

Overview of HVAC Design Process

KWIK MODEL3D

Step 2. Perform Room-by-Room Load Calculations

This is a table of the **walls** for our sample house.

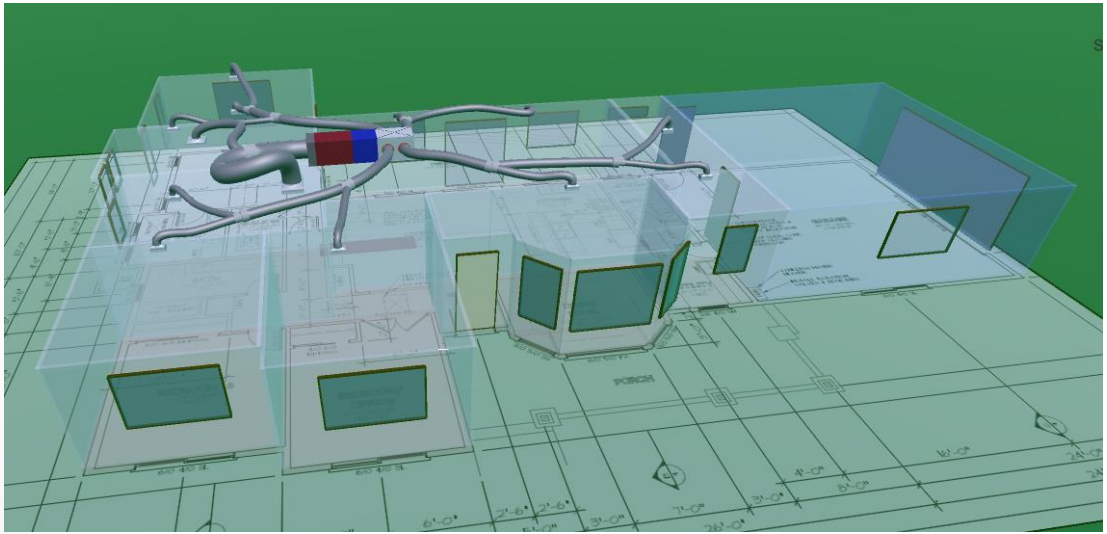
WallNum	Room	Type Name	Net Area	Direction	Azimuth	Tilt	Pitch	Touching
1	Kitchen(1)	2x4 R-13	100	Back	East	90	N/A	Outside
2	Kitchen(1)	2x4 R-13	68	Left	North	90	N/A	Outside
3	Living(1)	2x4 R-13	76	Front	West	90	N/A	Outside
4	Living(1)	2x4 R-13	80	Left	North	90	N/A	Outside
5	Bed 1(1)	2x4 R-13	104	Back	East	90	N/A	Outside
6	Bed 1(1)	2x4 R-13	80	Right	South	90	N/A	Outside
7	bath(1)	2x4 R-13	36	Front	West	90	N/A	Outside
8	Bed 2(1)	2x4 R-13	64	Front	West	90	N/A	Outside
9	Bed 2(1)	2x4 R-13	80	Right	South	90	N/A	Outside

Overview of HVAC Design Process

KWIK MODEL3D

Step 2. Perform Room-by-Room Load Calculations

You can imagine what these tables might look like for a more complicated house like this one.



Step 2. Perf

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WallNum	Room	Type Name	Net Area	Direction	Azimuth	Tilt	Pitch	Touching
1	mbed(1)	2x4 R-13	98	Back	North	90	N/A	Outside
2	mbed(1)	2x4 R-13	72	Right	East	90	N/A	Outside
3	mbed(1)	2x4 R-13	87	Left	West	90	N/A	Outside
4	mbath(1)	2x4 R-13	8	Back	North	90	N/A	Outside
5	mbath(1)	2x4 R-13	8	Front	South	90	N/A	Outside
6	mbath(1)	2x4 R-13	65	Left	West	90	N/A	Outside
7	bath2(1)	2x4 R-13	80.5	Left	West	90	N/A	Outside
8	liv/kit(1)	2x4 R-13	150.5	Back	North	90	N/A	Outside
9	bed3(1)	2x4 R-13	72	Front	South	90	N/A	Outside
10	bed3(1)	2x4 R-13	104	Left	West	90	N/A	Outside
11	bed2(2)	2x4 R-13	72	Front	South	90	N/A	Outside
12	bed2(2)	2x4 R-13	94.5	Right	East	90	N/A	Outside
13	bed2(2)	2x4 R-13	9.5	Left	West	90	N/A	Outside
14	dining(5)	2x4 R-13	20	Front	South	90	N/A	Outside
15	dining(4)	2x4 R-13	4.5	Right	East	90	N/A	Outside
16	dining(4)	2x4 R-13	4.5	Left	West	90	N/A	Outside
17	dining(1)	2x4 R-13	26	Front	South	90	N/A	Outside
18	dining(3)	2x4 R-13	18.941	Front Left	SouthWest	90	N/A	Outside
19	dining(2)	2x4 R-13	18.941	Front Right	SouthEast	90	N/A	Outside
20	lau(1)	2x4 R-13	54	Front	South	90	N/A	Outside
21	lau(1)	2x4 R-13	59.5	Right	East	90	N/A	Unconditioned Space
22	pdr(1)	2x4 R-13	40	Back	North	90	N/A	Outside
23	pdr(1)	2x4 R-13	124.5	Right	East	90	N/A	Unconditioned Space

KWIK MODEL3D

So, Why Should Energy Consultants Do HVAC Load Calculations?

KWIK MODEL3D

1. Load calcs are easy! (equipment selection and duct design take much more experience – let the contractor do those)
2. It requires pretty much exactly the same inputs as an energy model.
3. An annual energy simulation is 8760 load calculations.
4. Most HVAC Contractors are not doing load calcs, even though they are required by code (not well enforced).
5. Energy consultants are good a getting this information from plans into the software.
6. New software will allow a house model to be used for both and energy model and a load calc.
7. The 2025 code will put a much bigger emphasis on proper sizing.

The End

Thank You

russ@coded-energy.com

Questions about Title 24?

3C-REN offers a *free* Code Coach Service

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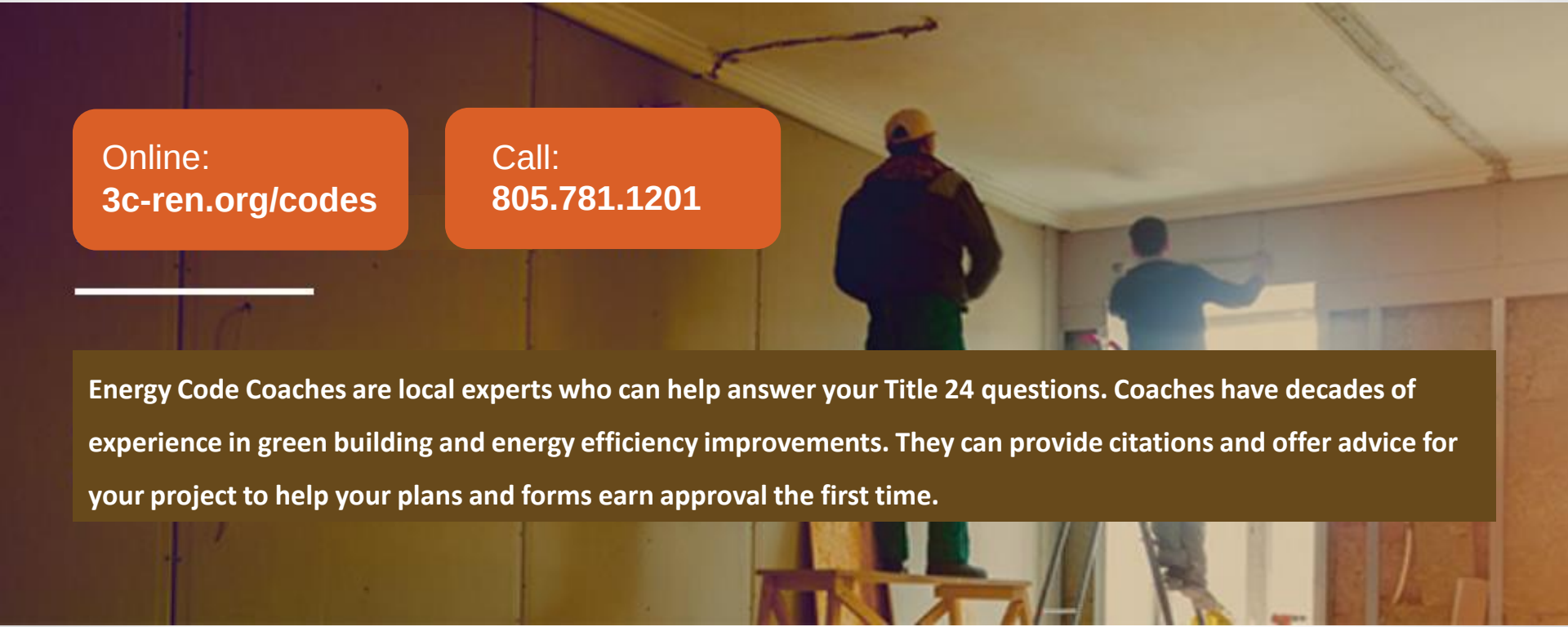
BALANCE™ Green Consulting



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