Conducting Proper Load Calculations

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In the beginning!

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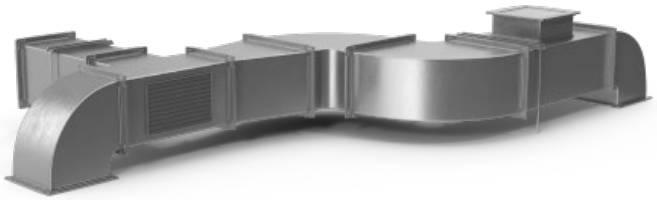
And then…



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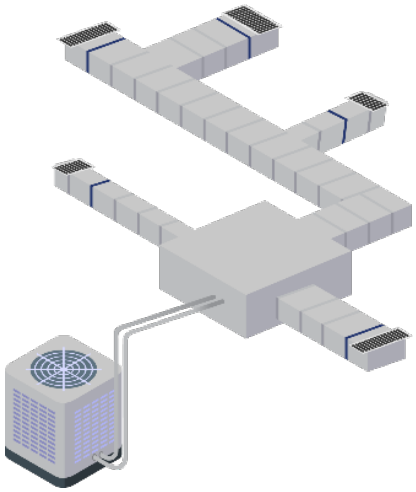
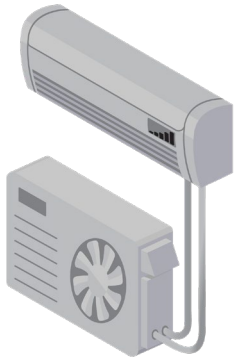
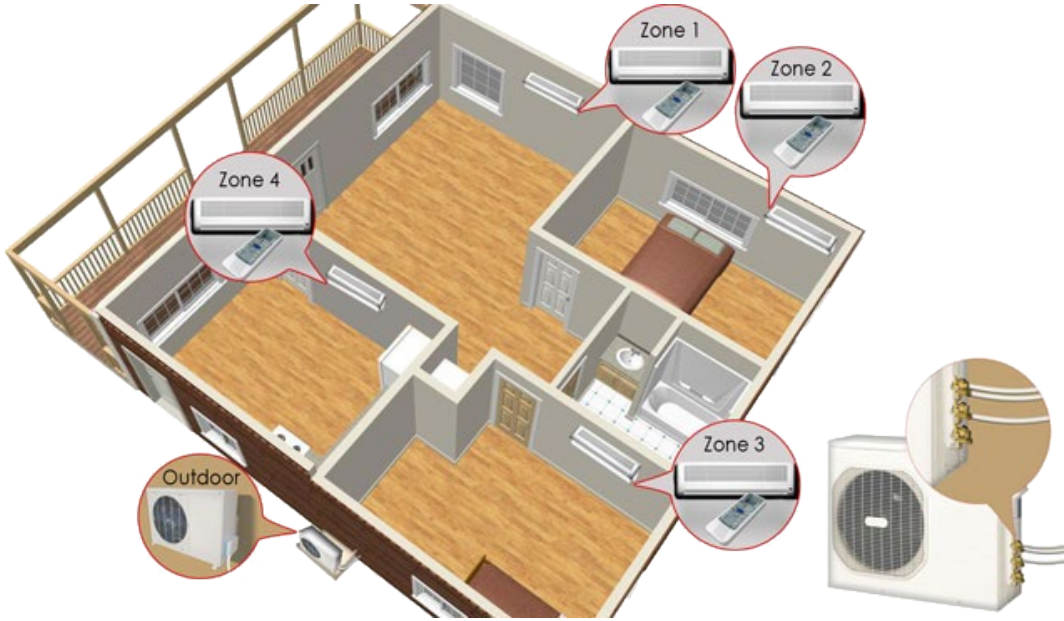
And now!?







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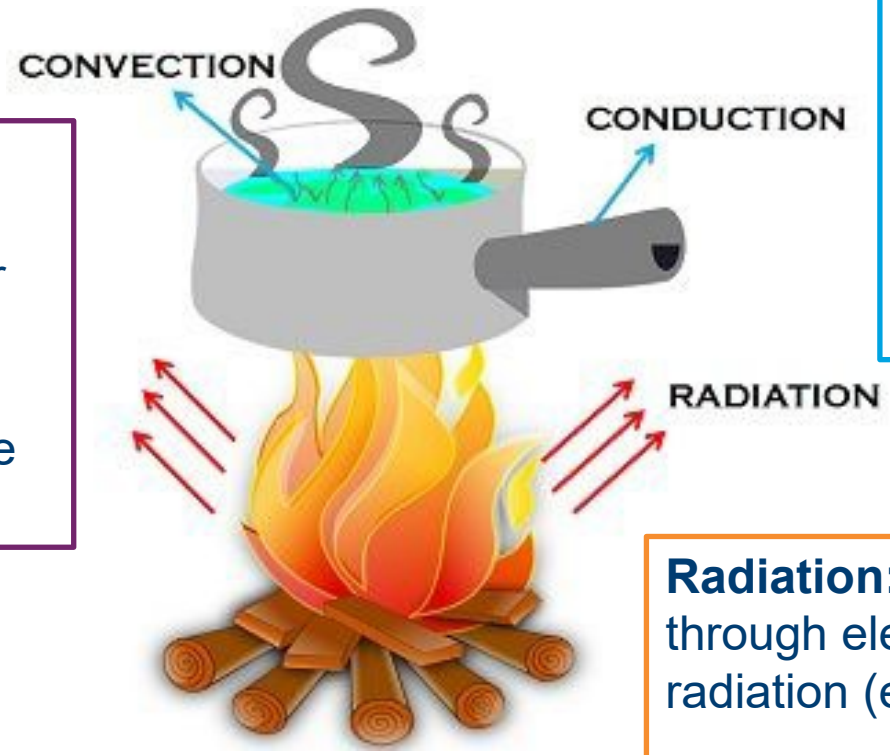
Let's refresh on thermodynamics

Convection: Heat movement through bulk particles (gas or liquid)

Ex: Air flow out of the house – stack effect



Conduction: Heat movement through a material (shaking molecules)

Ex: Heat moving through your wall; warm inside to cold outside

Radiation: Heat movement through electromagnetic radiation (energy particles)

Ex: Solar heat coming through your window glass. Heat coming off your fireplace.

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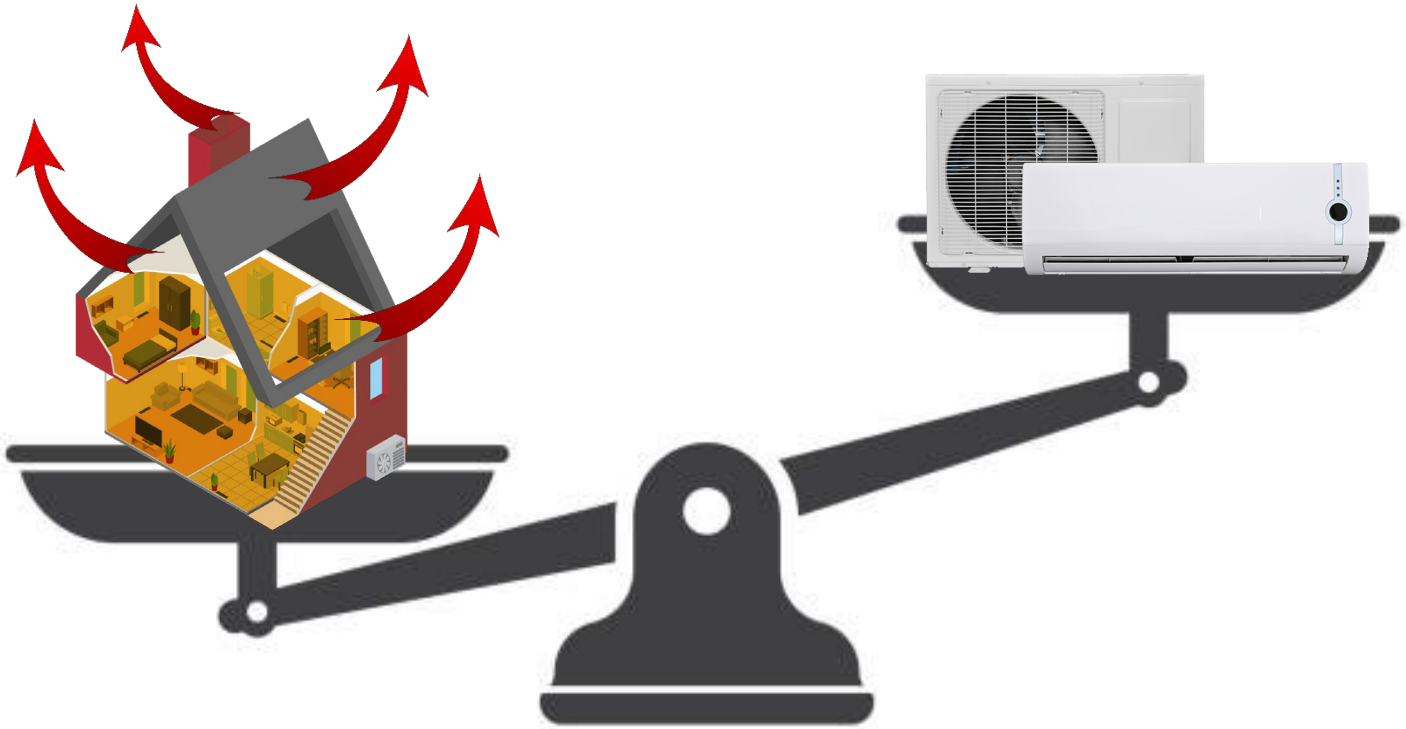
Heating Balance: Out = In



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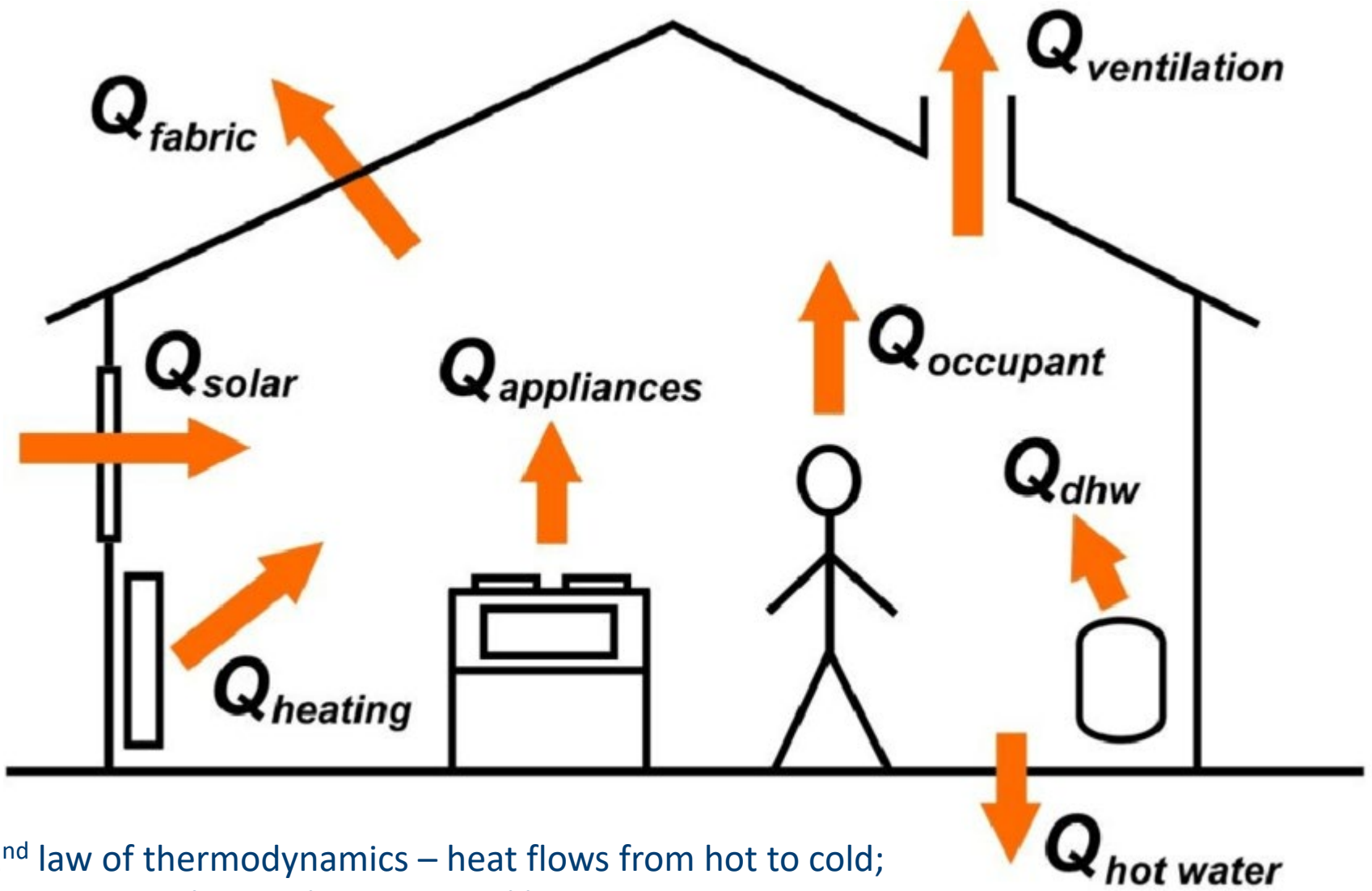
Home heat flows



2nd law of thermodynamics – heat flows from hot to cold; moving to a thermodynamic equilibrium

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What is a Building Load Calculation?

> A load calculation is a method of determining the heat gain and loss of a home or building so that HVAC equipment is properly sized.

> A building's heating or cooling design load is determined by how well insulated the building is and in what climate it is located.

> It represents the amount of heating or cooling capacity that is needed during peak* heating and cooling hours to keep the space comfortable.

** Technically 99th% coldest/hottest*

What is the ACCA Manual J Standard?

> ACCA = Air Conditioning Contractors of America

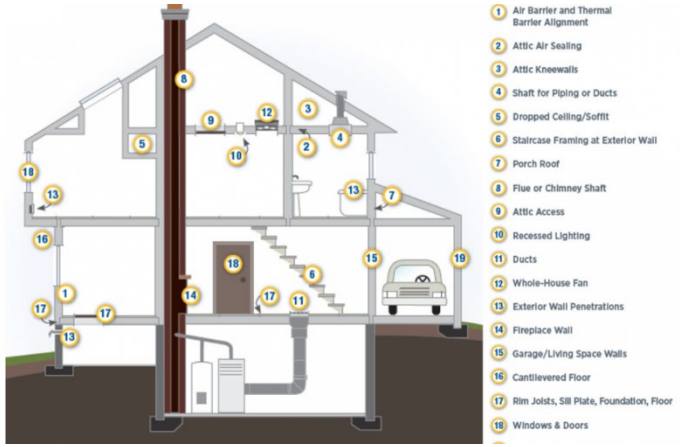
> ACCA is the national trade association furthering the interests of HVACR contracting businesses and the broader HVACR industry.

> Manual J is the national ANSI-recognized standard for producing HVAC equipment sizing loads for residential applications

> A proper load calculation, performed in accordance with the Manual J procedure, is required by national building codes and most state and local jurisdictions

> All contractors performing residential load calculations should be familiar with the ACCA Manual J Standard!

ACCA Manual J Load Calculation



New York heating design loads:

- Normal houses are from 10-30 Btuh per sq.ft.
- Old leaky farmhouse – as high as 35-50 Btuh/sq.ft.
- New construction to code – about 10-15 Btuh/sq.ft
- Passive house – 3.2 Btuh/sq.ft.

Right-J Worksheet

1					Room name			Entire House				
2					Exposed wall			240.0 ft				
3					Ceiling height			8.0				
4					Room dimensions							
5					Room area			1750.0 ft²				
	Ty	Construction number	U-value	Or	HTM (Btuh/ft²) Heat	HTM (Btuh/ft²) Cool		Area (ft²) or perimeter (ft Gross	Area (ft²) or perimeter (ft N/P/S	Load (Btuh) Heat	Load (Btuh) Cool	
6	W	15B-10sfc-2	0.083	n	0.305	1.129		560	492	189	397	
	G	1D-c2ow	0.570	n	2.850	19.32		40	0	114	773	
	D	11D0	0.390	n	1.950	11.19		28	28	55	313	
	W	15B-10sfc-2	0.083	e	0.305	1.129		400	368	142	303	
	G	1D-c2ow	0.570	e	2.850	61.39		32	0	91	1965	
	W	15B-10sfc-2	0.083	s	0.305	1.129		560	484	185	388	
	G	1D-c2ow	0.570	s	2.850	21.64		48	0	137	1039	
	D	11D0	0.390	s	1.950	11.19		28	28	55	313	
	W	15B-10sfc-2	0.083	w	0.305	1.129		400	384	148	321	
	G	1D-c2ow	0.570	w	2.850	61.39		16	0	46	982	
	C	16B-30ad	0.032	-	0.160	1.670		875	875	140	1462	
11	F	21B-28t	0.015	-	0.075	0.000		875	120	66	0	
		Total room load								2923	12031	
		Air required (cfm)								505	505	

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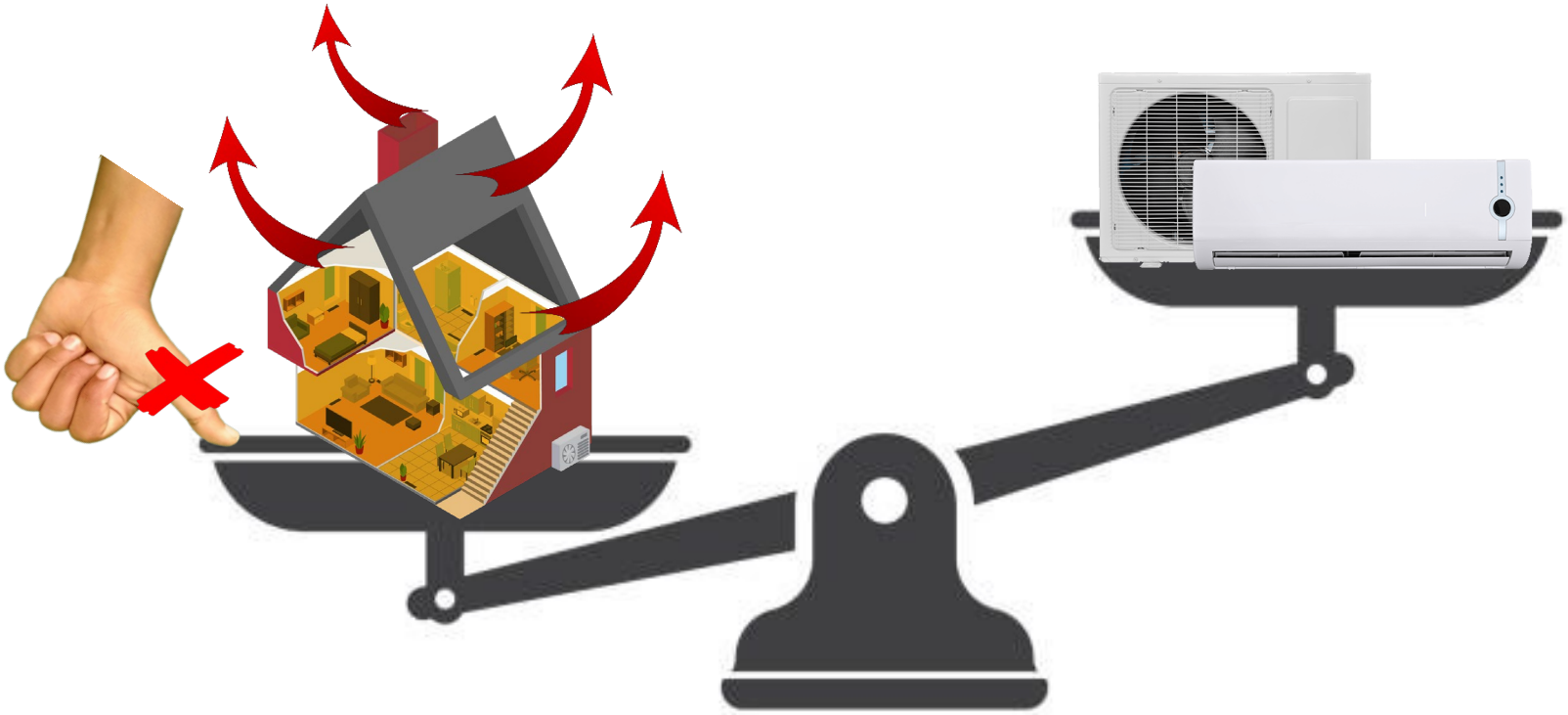
ACCA Manual J -



- Manual J is *already* conservative - experts estimate it at 20-40% overstated
- ACCA actively advises to use **aggressively accurate inputs**
- Accepting software defaults will ***often*** result in overstated loads
- Adding in "***safety factors***" will result in overstated loads

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A properly performed load calculation *will ensure the heating and cooling equipment is sized* ***based on a home's unique requirements****.*

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Why can't I use rules of thumb for load calculations?

> Rules of thumbs were commonly used with sizing fossil fuel fire equipment or traditional air conditioning systems…which was still wrong!

> Examples:
  – 30 to 60 Btu/hr. per square foot
  – 400 to 600 square feet per ton

> The rules of thumbs don't account for any of the building features that have an impact on heating and cooling loads
  – Heating – Indoor and outdoor temperatures, volume, airtightness, insulation levels, window u-values, etc.
  – Cooling – Indoor and outdoor temperatures, window type, building orientation, shading, airtightness, insulation levels, etc.

BIGGER is NOT always BETTER

Bigger HVAC equipment is not better, it is worse!

> Excess expense

> Reduced efficiency

> Unnecessary wear

> Decreased comfort

> Poor part-load performance

Load calculations are performed to meet historical, 99th percentile, worst case conditions! Thus, they are already oversized for mild weather!

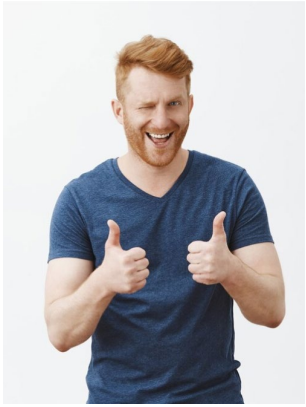
Why take the time to do an accurate load calculation?

Over-sizing

- Causes low-load cycling, purge cycling, and dehumidification issues
- Leads to discomfort, high energy use, high bills, shorter equipment life

Under-sizing

- Lack of enough heating capacity during freezing conditions
- Over reliance on backup heat
- Inadequate summer cooling



Right-sizing

- Positive public perception of heat pump technology and more business!
- Fewer call backs – reducing wasted contractor time, resources, and $$

When to do a Room by Room vs. Block Load Analysis?

- Room by room load analysis provides heating and cooling loads for individual rooms or zones.
- Block load analysis provides heating and cooling load for the entire building.
- Most whole home full load heat pump installations will be multi-zone systems.
- **Room by room is always better for multi-zone systems!**
- It's important to know individual zonal loads so no single zone is over or undersized.
- The totals may ***not*** always be the same for a room by room vs. block load.
  - Square footage totals may not 100% match.
  - Each room may have peak cooling load at a different time of day based on sun exposure and orientation.

Conducting Load Calculations

Order of Operations

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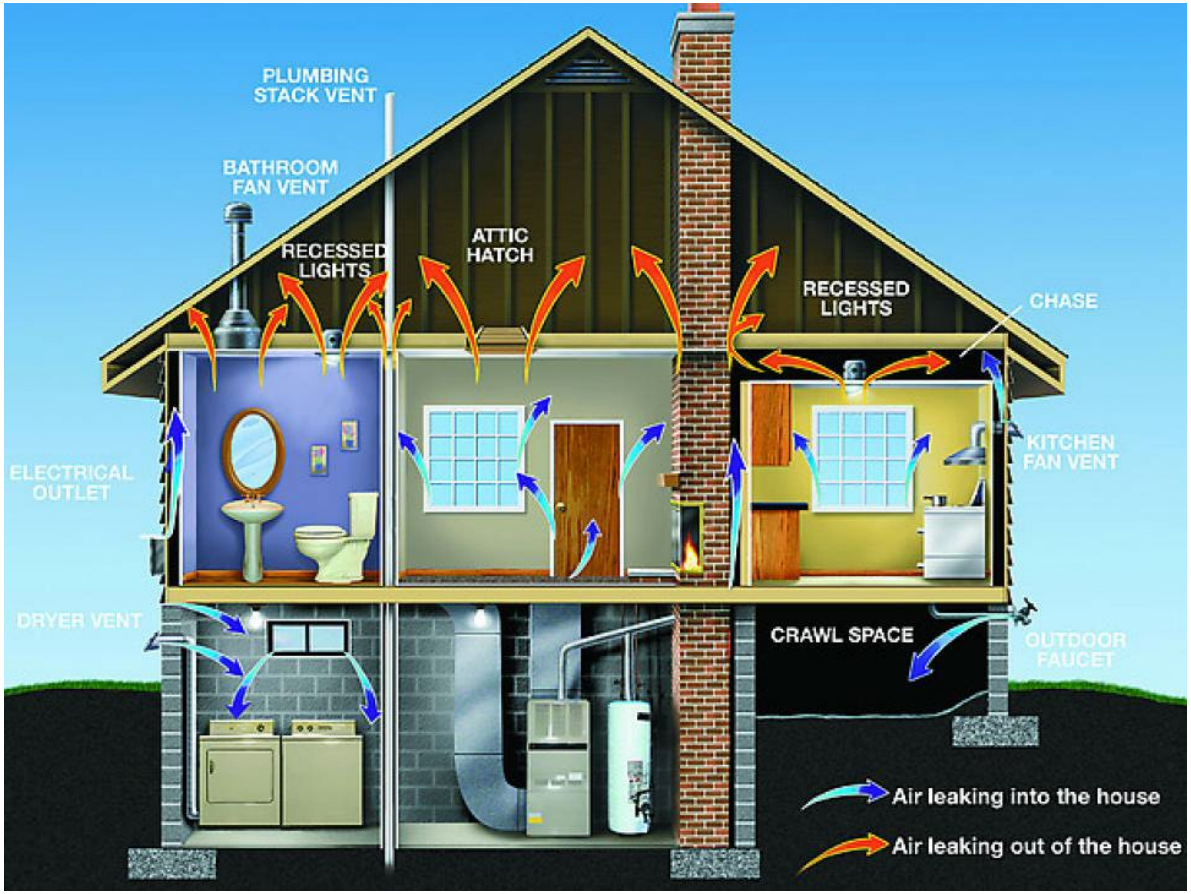
Bring down the load first



- Air-seal and insulate ***first*** – *then* calculate the load
  - Easier sizing, easier distribution planning, more balanced heating/cooling loads, lower cost, better comfort

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Order of Operations

☑ Proper Order

1. ***Assess - Data Captured for Load Calc***
2. ***Design - Building Load Calculation***
3. Customer Quote
4. Installation - Right-Sized System
5. Commissioning
6. Incentive Application

☒ Current Market Reality

1. Customer Quote
2. Installation - Like for Like System or Rule of Thumb Basis
3. Commissioning
4. ***Building Load Calculation***
5. Incentive Application

Load Calculations from the Contractor Perspective

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Contractor Thoughts

> TRC interviewed 3 air source heat pump contractors known to provide accurate load calculations as part of NYS Clean Heat project application submissions

> Contractors were interviewed to learn their approach to load calculations and tips to make the process more efficient

> Why do an accurate load calculation from the contractor's perspective?

- More accurate quotes
- Higher customer satisfaction

What are tips and tricks to make the process faster and more efficient?

Step #1: Visit the site initially to provide an initial quote, while still collecting all the data for the complete load calculation.

Step #2: Base the initial quote on a “first pass” that is less detailed than a complete load calculation.

Step #3: Quotes based on the “first pass” should be contingent on a complete load calculation and should expect to be revised.

What are tips and tricks to make the process faster and more efficient?

Step #4: Capture building details and take photos.

Step #5: Ask the homeowner about existing comfort issues.

Step #6: Pay close attention to spaces with hot/cold spots, humidity, distribution issues, and air quality issues.

Helpful Tools

> What tools do these contractors use to collect building information faster and perform load calculations more efficiently?

- Use a quick and easy load calculation website for a first pass to give a quote, which is later double-checked using ACCA approved software. Free Examples:
  - EZ Heatloss
  - HVAC Load Calculator - Manual J Calculation | ServiceTitan
  - Load-Calc (loadcalc.net)
- Use house scanning apps to produce floor plans and/or 3D models of the homes. Examples:
  - Amply (recently ACCA Manual J approval)
  - Conduit (recently ACCA Manual J approved)
  - CubiCasa
- Use data from real estate websites (zillow.com, redfin.com, realtor.com)

Helpful Tools

> What tools do these contractors use to make the load calculations more accurate?

- Blower Door – measures air infiltration and only takes approximately 30 minutes per house

*One contractor estimates that **40% of the time**, their **first pass air infiltration estimate** without a blower door is **off by more than 400 CFM**, especially with older homes.*

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Time Commitment

- First pass ranges from 15 minutes for simpler and smaller projects to 90 minutes for larger more complex projects
- The data input for the full load calculations often takes longer than the site visit
- The given range for data input is 20 minutes for a simple project up to three hours for the most complex projects

What team members typically do the load calculations?

- Contractor A - All new hires are trained internally to perform load calculations and the trainee goes out with an experienced coworker to shadow and see multiple example projects
- Contractor B – Sales team takes photos and collects data while a more experienced employee performs the load calculation
- Contractor C – Sales team take the photos, collects data, and inputs the data into software to perform the load calculation

Assess the Home

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Surveying a home *to gather information to perform the heat loss/gain calculations* ***can be time consuming****, but it is* ***time well spent*** *when it can save money, equipment life improve comfort and conserve energy.*

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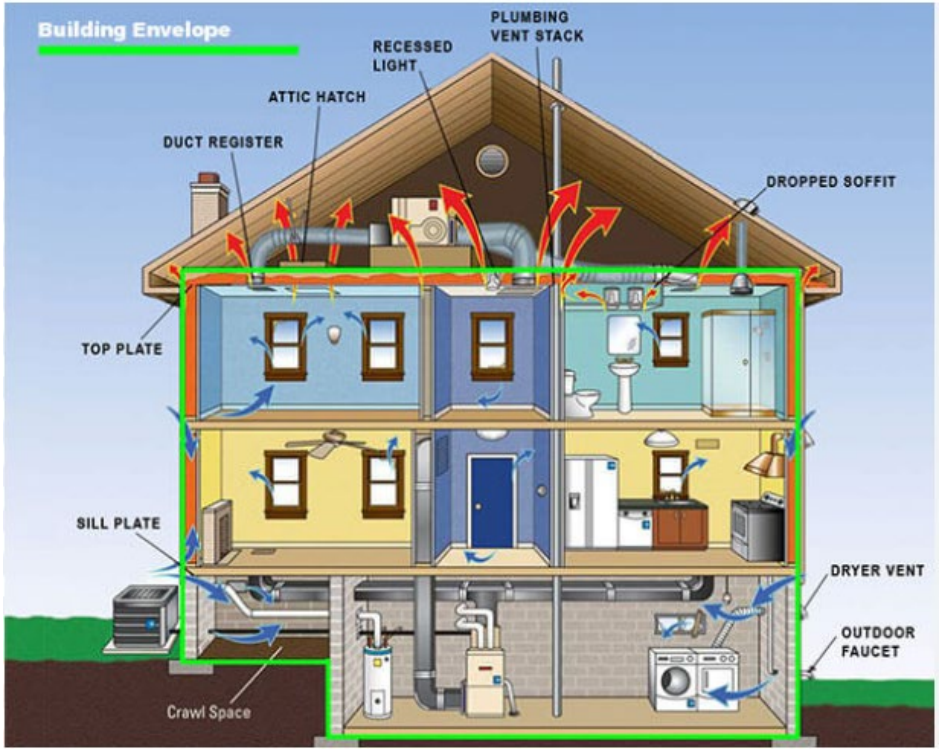
Building Envelope

- The barrier between the **conditioned** space and the **non conditioned** space.
- Made up of:
  - Foundation or Floor
  - Roof or Ceiling
  - Walls
  - Windows
  - Doors
  - Insulation



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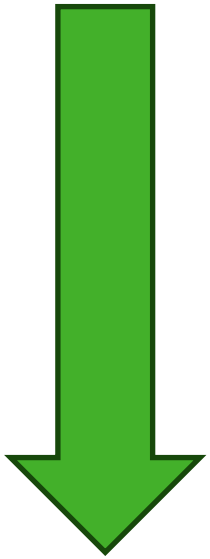
What matters most for a residential *heating load* calculation in *cold climates regions* like New York State?

HIGHEST IMPACT

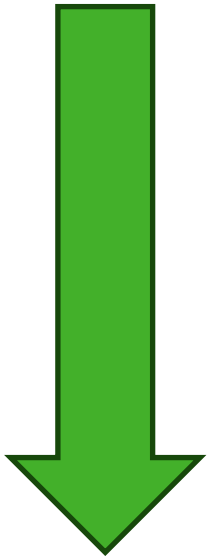


LOWEST IMPACT

1. Design temperatures
2. Infiltration (building air tightness)
3. Windows, glass doors, skylights (area, u-value)
4. Ductwork (location, leakage, and insulation r-value)
5. Ceilings (ceiling type, assembly r-value)
6. Ventilation & Heat Recovery
7. Floors (floor type, area, assembly r-value)
8. Above Grade Walls (area, assembly r-value)
9. Below Grade Walls (area, assembly r-value)
10. Doors

What matters most for a residential *cooling load* calculation in *cold climates regions* like New York State?

HIGHEST IMPACT



LOWEST IMPACT

1. Design temperatures
2. Windows, glass doors, skylights (area, exposure directions, u-value, SHGC, external/internal shading)
3. Internal Gains (occupants, appliances, electronics)
4. Ductwork (location, leakage, and insulation r-value)
5. Ceilings (ceiling type, assembly r-value)
6. Infiltration (building air tightness)
7. Ventilation & Heat Recovery
8. Floors (floor type, area, assembly r-value)
9. Walls (area, assembly r-value)
10. Doors

Building Assessment Tips & Tricks

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Better Tools = Better Load Calcs

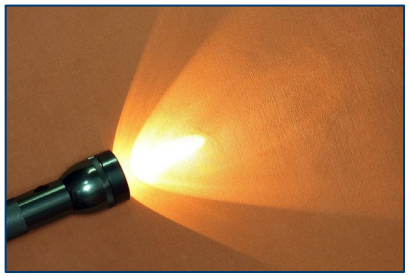
Blower Door

Duct Blaster

Lighter or Laser Pointer

IR Thermometer

Camera



Flashlight

Laser Distance Meter

Insulation Depth Gauge

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Find out what the homeowner knows.

- Send them a questionnaire ahead of assessing the home!
- Construction drawings
- Year built
  - Can also be found on real estate websites (Zillow, Redfin) or government building data websites (e.g., Saratoga County Assessment Database), but not all towns/counties may have this information conveniently available.
- Building upgrades and renovations completed since original construction as it relates to building envelope improvements or upgrades to the HVAC system
- Building square footage and if basement is included in that total
- Product submittals or cut sheets (windows or insulation)
- Insulation type, thickness, and/or r-value for walls, ceilings, and floors

Use the right design temperatures!

- Outdoor design conditions used are based on ACCA Manual J Table 1A, unless superseded by code
  - Heating: 99% Outdoor Dry Bulb Temperature
  - Cooling: 1% Outdoor Dry Bulb Temperature
- Indoor design conditions:
  - Heating 70°F
  - Cooling 75°F
  - 45%, 50%, or 55% RH

Table 1A
Outdoor Design Conditions for the United States

Location	Elevation Feet	Latitude Degrees North	Heating 99% Outdoor Dry Bulb	Cooling						$\frac{HDD_{65}}{CDD_{50}}$ Ratio
				Outdoor Air		Design Grains			Daily Range (DR)	
				1% Dry Bulb	Coincident Wet Bulb	55% RH Indoors	50% RH Indoors	45% RH Indoors		
New York										
Albany Co. AP	292	43	3	86	71	21	28	34	M	2.49
Albany CO	275	42	1	88	72	21	28	35	M	2.71
Ambrose Navigation Light (Raritan Bay)	69	40	18	81	68	11	18	24	L	1.62
Auburn	417	43	2	87	71	18	24	31	M	3.10
Bafavia	913	43	5	87	71	18	25	32	M	2.50
Binghamton, Edwin A-Link Field	1,637	42	4	83	68	12	19	26	M	3.13
Buffalo, Niagara IAP	705	43	7	84	70	17	24	31	M	2.51
Central Islip	98	40	15	85	72	26	33	39	M	1.74
Cortland	1,198	42	0	85	71	22	29	36	M	3.04
Dunkirk	646	42	11	80	72	36	43	49	L	2.44

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How to approach infiltration with a blower door?

Building tightness –

> Blower Door Testing

- Contractors are encouraged to conduct a blower door test for the most accurate infiltration inputs
- Manual J software tools will allow contractors to enter the air leakage rate of the home in air changes per hour (ACH)

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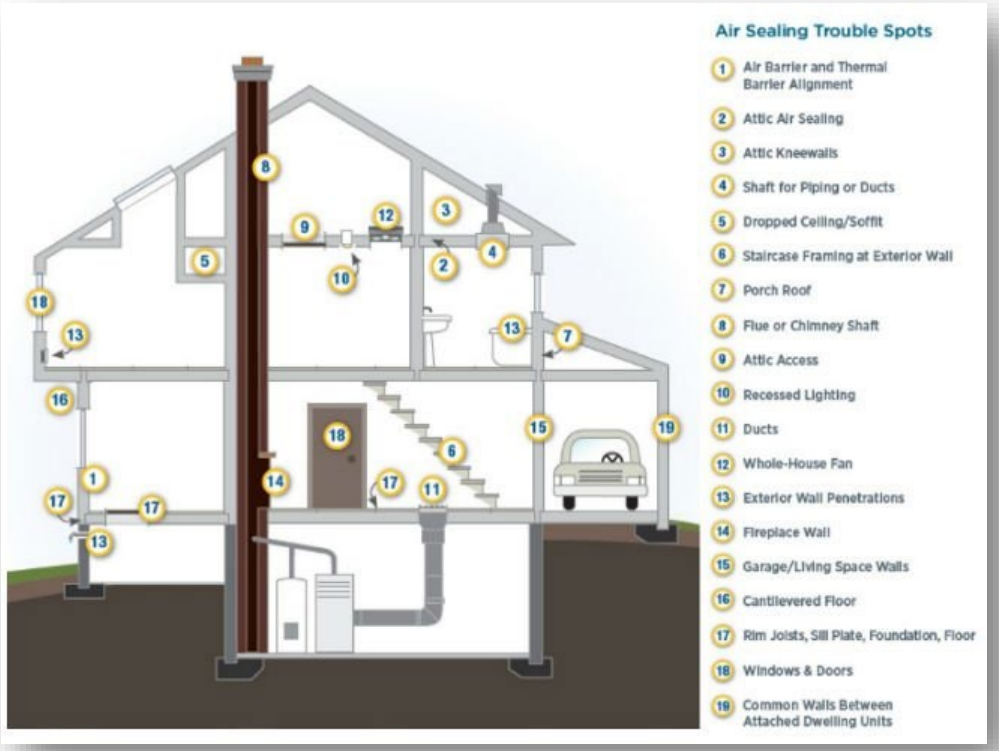
Offer Blower Door Testing and Air Sealing Services

If you are conducting a blower door test, you may as well bring down the load!

Simple Air Sealing Measures:

- Caulking cracks and openings
- Weatherstripping around doors and operable windows

Caulking and weatherstripping offer quick returns on investment, often one year or less.



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How to approach infiltration without a blower door?

- ACCA Manual J Table 5A – Default Values for Natural Air Changes Per Hour (ACHn).
- Default values depend on building construction, square footage, and number of stories.
- The year the building was built does not necessarily correlate to how leaky the building is.
- **For new construction – recommend maximum of 0.3 (design heating ACHn)**
- **For existing buildings – recommend maximum of 0.7 (design heating ACHn)**
- If a higher value is used, then you should always have sufficient evidence to justify this (photos, blower door testing, etc.)

Infiltration Level	Design Heating ACHn			
	Single Story	Two Story	Townhome /Condo	**AVERAGE**
Tight	0.1-0.21	0.13-0.27	0.12-0.24	**0.12-0.24**
Semi-Tight	0.19-0.41	0.25-0.53	0.22-0.47	**0.22-0.47**
Average	0.28-0.61	0.37-0.79	0.32-0.69	**0.32-0.69**
Semi-Loose	0.43-0.95	0.56-1.23	0.49-1.08	**0.49-1.08**
Loose	0.58-1.29	0.75-1.67	0.65-1.46	**0.65-1.46**

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Windows - Windows, Glass Doors, Skylights

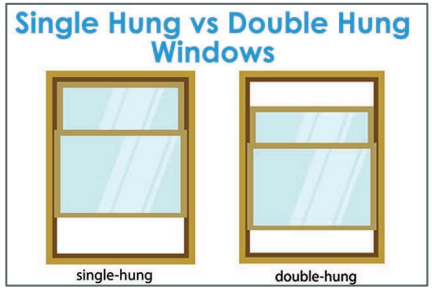
What matters most when it comes to windows?

- **Window Area**
- **U-factor -** heating and cooling
- **Solar Heat Gain Coefficient (SHGC) –** cooling only

The number of panes, framing materials, and glass coatings impact U-factor and SHGC.

Windows – Area

Understanding standard window sizes will help estimate window areas quicker! Most homes will have only 1- 4 different window sizes. When in doubt, take a quick measurement.



Single- & Double-Hung

- 2’ (w) x 3’ (h)
- 2’ (w)x 4’- 4” (h)
- 2’- 8” (w) x 4’ (h)
- 2’- 8” (w) x 5’-2” (h)

Picture

- 3’ (w) x 2’ (h)
- 5’ (w) x 3’ (h)
- 6’ (w) x 4’ (h)
- 4’ (w) x 5’ (h)

Casement

- 2’ – 4” (w) x 3’ – 6” (h)
- 2’ – 6” (w)x 4’ (h)
- 2’- 8” (w) x 5’ (h)
- 3’ (w) x 6’ (h)

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Windows – Area

The total glass area per wall is what really matters for window area inputs in a Manual J Load Calculation Software.

Glazing – U-factor & Solar Heat Gain Coefficient

U-factor ranges:

> Single Pane with clear glass – 0.49 to 1.27

> Double Pane with clear glass – 0.40 to 0.87

> Double Pane with low-e coating – 0.28 to 0.55

U-factors and SHGC range significantly and are impacted by more than just the number of panes.

> Framing material (metal, wood, fiberglass, vinyl)

> Operating type (dictates framing factor)

> Low-e coatings, coating quality, and coating surface(s)

> Warm-edge spacers

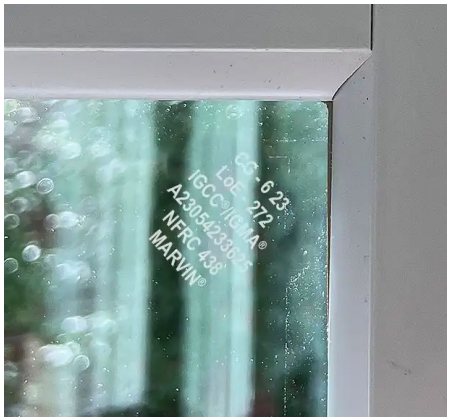
> Argon or other gas-fills

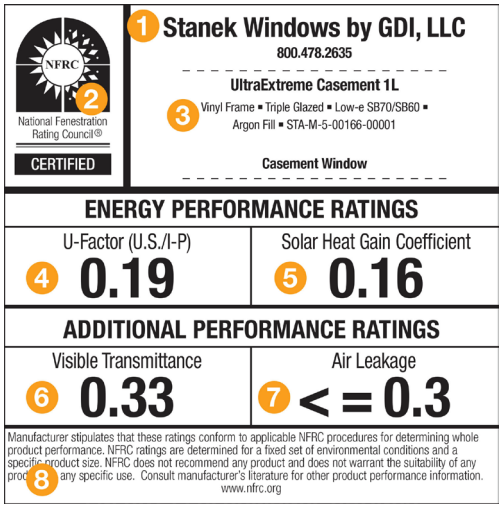
Glazing - U-factor & Solar Heat Gain Coefficient

Know how to assess the window

- First look for NFRC label
- All new windows are NFRC rated
- Manufacturer's website or NFRC directory may have window data (u-factor, SHGC)

- Many windows may have the model number or NFRC look up number either…
  - Etched in the glazing itself
  - Stamped on the spacer between panes





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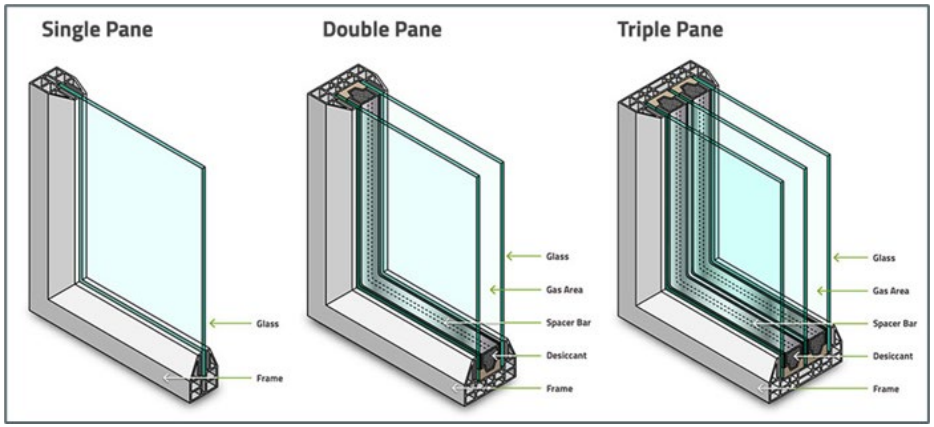
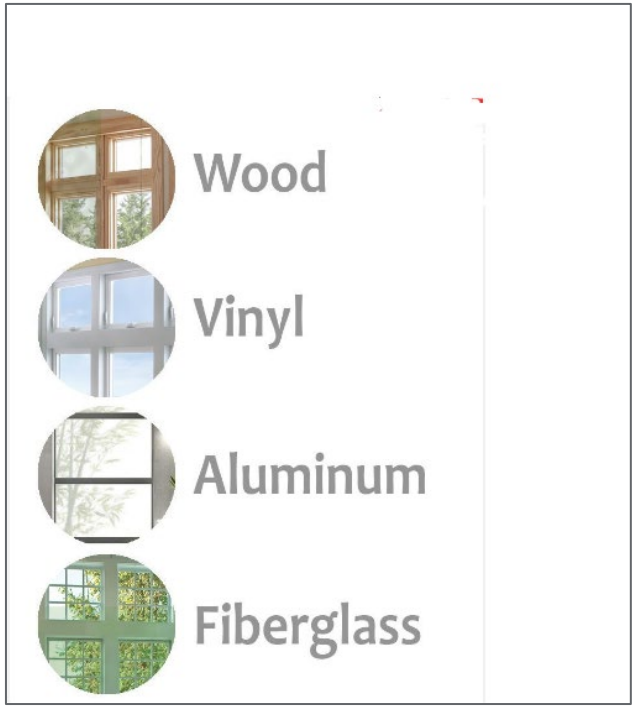
Glazing - U-factor & Solar Heat Gain Coefficient

Know how to assess the window

- Count the number of panes
- Note the framing material





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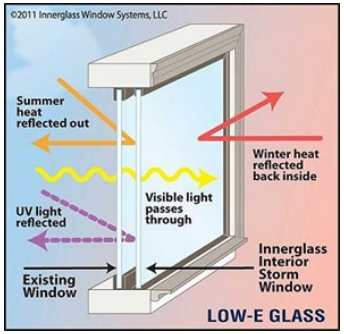
Glazing - Windows, Glass Doors, Skylights

Know your glass types

Clear Glass:
- No films or coatings
- Likely input for windows that haven't been replaced in 30 years

Low-e Coating:
- Look for NFRC label
- **Common in cold climates and newer buildings**
- Lighter trick – two reflections per pane? It has low-e coatings



Reflective:
- Film that creates mirror view from outside of window
- May be charcoal color from the inside

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Above Grade Walls

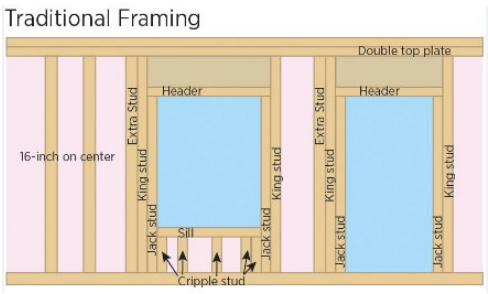
- What matters most when it comes to above grade walls?
  - **Wall Area**
  - **R-value of Insulation (cavity, exterior board, interior board, block)**
  - **Insulation thickness**
- For frame walls the stud spacing, and framing material (wood or metal) impact thermal performance.
- For masonry walls, structural wall material and thickness matter.
- What matters least when it comes to above grade walls?
  - Thickness of sheathing
  - Thickness or type of interior finish
  - Exterior finish type
- In residential and small commercial construction in the New York State, the most common above grade wall construction type will be wood framing with cavity insulation and vinyl siding.

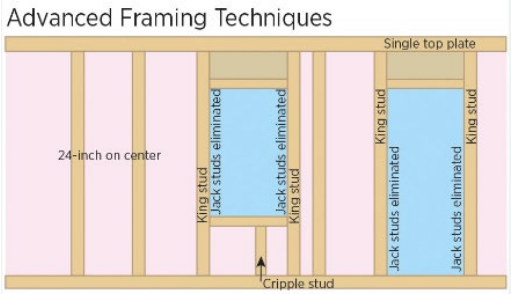
Wood Frame Construction

How to know if studs are 2 x 4 or 2 x 6?

- Measure a windowsill or door jamb (excluding any trim).
- Measure 4" - framing is likely 2x4.
- Measure 6" - framing is likely 2x6.
- **2x4 is more common in standard home construction.**

How to know if studs are 16” o.c. or 24” o.c.?





- 16” o.c. is most common.
- 2x4 framing is only allowed to be 16” o.c.
- 24” o.c. is rare and used in metal or deeper stud framing.
- **When in doubt, assume 16” o.c.**

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Wood Frame – Cavity Insulation

When in doubt, use R-13 for 2x4 or R-19 for 2x6 wood frame construction.

Cavity Insulation - Common Types

> Fiberglass Batt Insulation (R-2.9 to R-3.8 per inch)
  - 2 x 4 framing – R-11 to R-15
  - 2 x 6 framing – R-17 to R-23

> High Density Cellulose Insulation (R-3.2 per inch)
  - 2 x 4 framing – R-11 to R-13
  - 2 x 6 framing – R-17 to R-19

> Spray Polyurethane Foam (SPF) Insulation
  - Open-cell (R-3.7 per inch)
    - 2 x 4 framing – R-13
    - 2 x 6 framing – R-21
  - Closed-cell (R-6.0 per inch)
    - 2 x 4 framing – R-21
    - 2 x 6 framing – R-33

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Wood Frame – Continuous Insulation

Interior Board Insulation – uncommon in cold climate regions

Exterior Board Insulation

- **Exterior board insulation likely exists for homes with 2x4 wood frame construction and fiberglass batt cavity insulation built in…**
  - **2010 or later for Climate Zone 5 or 6**
  - **2015 or later for Climate Zone 4**
- NYS ECCC 2010 (2009 IECC) was the first time for climate zones 5 and 6 either R-20 cavity or R-13 cavity + R-5 continuous insulation was required.
- NYS ECCC 2015 was the first time for climate zone 4 either R-20 cavity or R-13 cavity + R-5 continuous insulation was required.
- Since R-20 cannot be achieved with batt insulation in a 2x4 stud frame, 1 to 2” exterior board insulation was required to meet energy code requirements
- **Hint: Recessed windows in wood frame construction is an indicator of exterior board insulation!**

Foundation Walls

> What matters most when it comes to below grade walls?
  - **Wall Area**
  - **R-value of insulation**
  - **Insulation depth**
  - **Below grade depth**
> For masonry walls, structural wall material and thickness matter.
> For finished basements with interior framed walls, the framing material and stud-width impacts thermal performance.
> What matters least when it comes to below grade walls?
  – Interior finish
  – Soil type

Foundation Walls – Insulation

- Is the basement finished or not?
- Basements also sometimes have open wall cavities where insulation is visible
- Common basement insulation types – fiberglass batt, rigid foam board, spray polyurethane foam

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Foundation Walls – Insulation

> Cavity + Continuous may also be used…

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Ceilings & Roof

What matters most when it comes to ceilings?

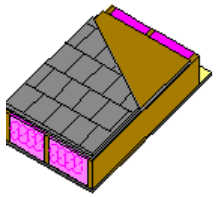
- **Ceiling Area**
- **Type of Insulation**
- **R-Value**
- **Installed Insulation Thickness**

Identifying the building envelope ceiling/roof styles, types of insulation, depth of insulation, and surface area are all integral to proper modeling.

Ceilings & Roof – Styles

There are several styles of ceilings/roofs that can make-up building envelopes. Identifying and modeling the correct style, its insulation type and thickness is very important.

- **Flat Ceiling**
- **Vaulted Ceiling with Airspace**
- **Vaulted Ceiling/Roof-Deck**



Many homes have more than one type of ceiling/roof that make up the envelope. It is important to identify each ceiling type for an accurate model.

Ceilings & Roof – Insulation Types

There are many types of attic insulation found in ceilings. Determining the type and depth of insulation is important in completing a correct load calculation. Below are a few common insulation types and there corresponding **average** R-values per **inch**.

Fiberglass Batt –
R-3.3 / inch

Cellulose Blown –
R-3.7 / inch

Closed Cell Polyurethane –
R- 6.0 / inch

Fiberglass Blown –
R-2.8 / inch

Open Cell Polyurethane –
R- 3.7 / inch

Ceilings & Roof – Insulation Levels

Different insulation types require different techniques to determine proper installed levels for modeling.

- **Batt Insulation –** Typically printed on the batt.

- **Loose Blown Insulation –** Paper measuring tapes are usually installed for reference.

- **Polyurethane Foam -** Probing the depth of the assembly.
  - Using a small diameter wire or insulation depth gauge.

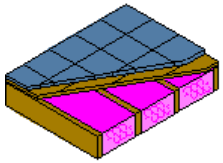
Floors

What matters most when it comes to floors?

- Floor area
- Type of floor – slab-on-grade, below grade, above basement/crawl, above unconditioned,
- Assembly R-value
- Perimeter and/or under-slab insulation

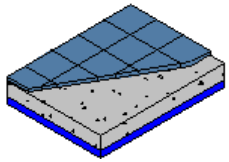
Framed Floor Considerations

- Framing material
- Framing size
- Stud spacing
- Insulation R-value
- Adjacent location



Concrete Floor Considerations

- Location regarding grade
- Perimeter insulation R-values
- Under floor insulation R-values



Floors - Framed

Framed Floors Over Garage, Basement, and Ambient

Determining the levels of insulation in framed floors can be challenging. Indicating the nature of the adjacent space to the framed floor is also just as important when completing an accurate load calculation.

Framed Floor Adjacent Space Modeling Variables

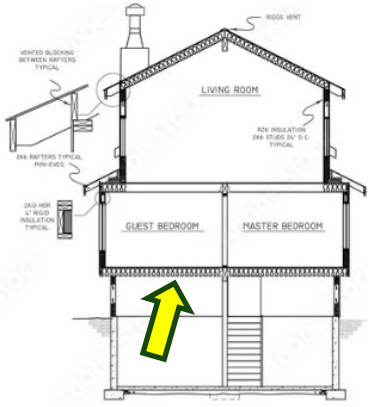
- Ambient/open crawl space
- Crawl space vented/leaky
- Crawl space sealed tight
- Unconditioned basement vented/leaky
- Unconditioned basement sealed tight
- Garage

Floors – Framed Insulation Levels

Fully finished framed insulated floors can pose a unique challenge when determining the correct insulation type and thickness, here are a few tricks that may help.

Remove a floor register to check for framing size and insulation type

Remove receptacle covers to access insulated space



Consult a building plan if available

Framed Floors – Insulation Types

There are several types of framed floor insulation used. Determining the type and depth of insulation is important in completing a correct load calculation. Below are a few common insulation types and there corresponding **average** R-values per **inch**.

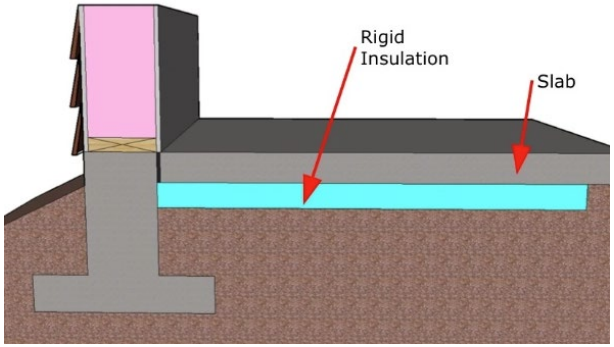
Fiberglass Batt – R-3.3 / inch

Cellulose Dense Pack – R-3.2 / inch

Closed Cell Polyurethane – R-6.0 / inch

Open Cell Polyurethane – R-3.7 / inch

Floors - Slab



Slab Floors At or Below Grade

Determining the levels of insulation, both around the perimeter and under a concrete slab floor, as well as the slab location in reference to grade are very important when completing an accurate load calculation.

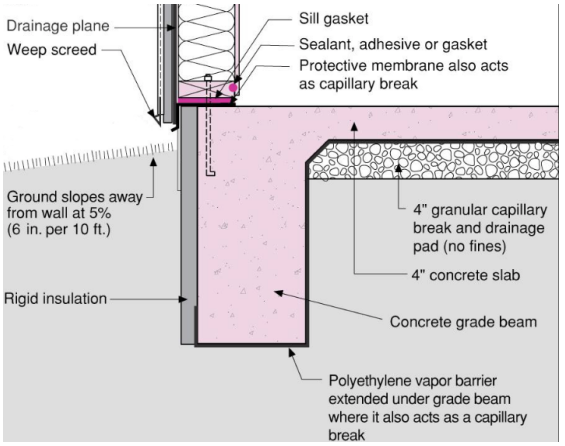
Slab Modeling Variables

- On grade/below grade
- Adjacent soil type (dry, damp, wet)
- Perimeter insulation level
- Perimeter insulation location interior/exterior
- Under slab insulation
- Floor finish

Floors – Slab Insulation Levels

Concrete slab floors can pose a unique challenge when determining the existence of insulation type and thickness.

There may be visible signs of perimeter insulation after the slab is poured



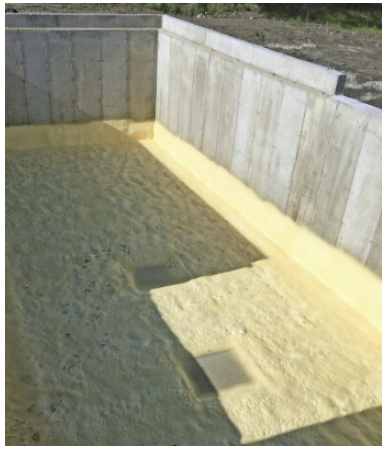
Consult a building plan if available. Have a conversation with the homeowner

Slab Floors – Insulation Types

There are several types of slab floor insulation used. Determining the type and thickness of insulation is important in completing a correct load calculation. Below are a few common insulation types and there corresponding **average** R-values per **inch**.

Extruded Polystyrene Board – R-5 / inch

Polyisocyanurate Board – R-7 / inch



Closed Cell Polyurethane – R-6 / inch

Doors

> What matters most when it comes to doors in load calculations?
  – **Area**
  – **Material**
> Since typical doors (wood panel or fiberglass) are such a small portion of the total wall area, doors are low priority in a building load calculation.
> In a load calculation software, doors only refer to exterior doors that contain less than 50% glass. Doors containing over 50% glass should be input as windows.

Mechanical Ventilation

Residential Ventilation Type	Load Calculation Software Input to Use
No ventilation	None
Exhaust only ventilation	Outside Air Damper
Balanced ventilation without recovery	Outside Air Damper
Balanced ventilation with recovery	Energy Recovery Ventilator (ERV) or Heat Recovery Ventilator (HRV)
Central fan integrated (uncommon)	Outside Air Damper
Ventilating Dehumidification (uncommon)	Ventilating Dehumidifier

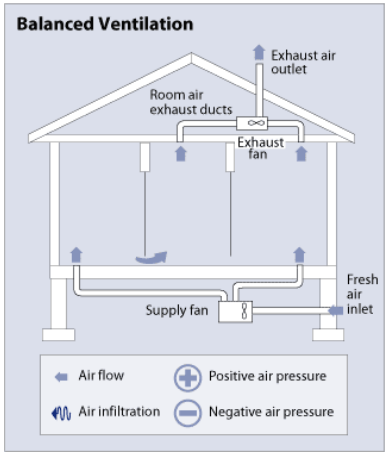
- How to Determine Ventilation CFM:
  - Look for the CFM on the nameplate of the fans, ERV, or HRV
  - Multiply the fans rated CFM by the scheduled intermittency
  - Fans may operate on a timer (30 minutes on or 30 minutes off)

Note a bathroom fan that you turn on after showering or a kitchen hood that you turn on after cooking is ***not*** mechanical ventilation. This is known as spot ventilation.

Mechanical Ventilation

- Exhaust Only Ventilation
  - Air is exhausted from a dedicated exhaust fan (attic, mechanical/laundry room, bathroom, basement, basement exhaust fan)
    - Spot ventilation (kitchen hoods, manually operated bathroom fans *do not count)*.
  - Fans may run on a timer

- Balanced Ventilation Without Recovery
  - Typically has its own separate set of ductwork from space conditioning ductwork
  - Fewer return and supply air grills than space-conditioning ducts



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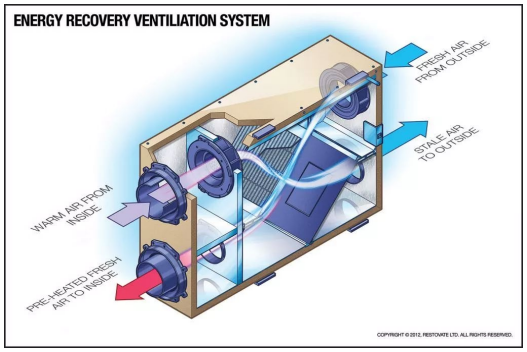
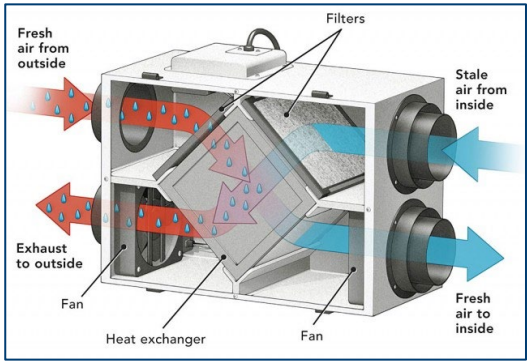
Energy/Heat Recovery (ERV/HRV)

- ERV transfers heat between incoming and outgoing air.
- HRV transfers heat between incoming and outgoing air, and transfers moisture.
- Determine the unit's recovery efficiency through nameplate data.
- Recovery Efficiency is typically 70-90%





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Ductwork

- ONLY APPLICABLE FOR DUCTED SYSTEMS
- Duct losses *should* ***not*** be included in the load calc for *ductless* heat pump installation, or when the ducts are entirely contained within the conditioned space.
- Duct losses *should* be included in the load calc for:
  - Existing ductwork reused as part of a retrofit
  - New duct installations
  - Ducts that are outside the conditioned space

Ductwork

What matters most when it comes to ductwork in load calculations?

- **Location – Conditioned or Unconditioned Space**
- **Sealing**
- **Insulation**
- **Function – Supply or Return**

You do not need to know duct run lengths for heating and cooling load calculations using typical software programs like Cool Calc or Wrightsoft.

Ductwork - Location

Typical Duct Location Software Inputs:

- Conditioned space

- Unvented attic
- Vented Attic
- Encapsulated attic
- Open crawl space
- Enclosed crawl space
- Unconditioned basement
- Garage
- Under Slab
- Exterior Wall

Unconditioned Space

Ductwork in unconditioned space is what impacts heating and cooling loads!

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Ductwork – Sealing

What to Inspect:

> Inspect the supply and return air plenum connections

> Inspect joints and connections

What sealant to look for:

> Duct Mastic

> UL-181 Tape

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Ductwork – Sealing

Method 1 (Best): Conduct a duct leakage test using a duct blaster

Method 2 (Acceptable): Select tightness category based on duct conditions

How to select tightness category?

Unsealed - no observable effort to seal the system

Partially Sealed – reasonable effort has been made to seal the duct runs and the air handler

Average/Default Sealed – all seams, joints, boots, grill flanges, and air handler panels sealed

Notably or Extremely Sealed - must be verified by a duct leakage test

Duct Table Leakage Options

SMANCA Leakage Rate – Cfm / 100 SqFt Surface Area			
Tightness	Supply	Return	Notes
Default Not Sealed	35	70	Could be worse
Partially Sealed	24	47	
Default Sealed	12	24	50% to 70% effective
Notably Sealed	9	15	Verify by test
Extremely Sealed	6	6	Verify by test

Figure 23-7

Unsealed or partially sealed ductwork should be upgraded as part of the scope of work!

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Internal Gains

Components of most common scenarios

- > **Internal gains** add heat to the space and **impact the cooling load**
- > ACCA Manual J Table 6A default appliance, equipment and lighting loads
- > ACCA Manual J Table 6B includes sensible and latent loads for individual appliances
- > Occupancy = Number of Bedrooms + 1

Appliance, Equipment and Lighting Loads			
Default Appliance Load	**Sensible Btuh**	**Latent Btuh**	**Notes**
Refrigerator and range with vented hood.	1,200	~	1,200 Btuh applied to the kitchen.
Scenario Options			
1) Refrigerator, range with vented hood, dish washer, clothes washer and vented clothes dryer, electronic equipment and lighting allowance.	2,400	~	1,000 Btuh for the kitchen, 500 Btuh for the utility room, 900 Btuh allowance for a TV or computer and a few lighting fixtures.
2) Two refrigerators or one refrigerator and one freezer, dish washer, range with vented hood, clothes washer and vented clothes dryer, electronic equipment and lighting allowance.	3,400	~	2,000 Btuh for the room or rooms equipped with a refrigerator, 500 Btuh for the utility room, 900 Btuh allowance for a TV or computer and a few lighting fixtures.
Adjustment Options			
A) Cooking range not equipped with a hood that is vented to outdoors, or an unvented dishwasher operating during the late afternoon in mid summer, or simultaneous use of unvented range and dishwasher.	+ 850	+ 600	Light duty cooking, 25 percent of the available range capacity used for 15 to 20 minutes. One dishwasher cycle load spread over a two hour recovery period.
B) Water bed heater (400 Watts, 33 percent duty cycle).	+ 450	~	Apply to each bedroom equipped with a water bed.
C) Ceiling fan (75 Watts).	+ 250	~	Apply to the room where the fan is located.
D) Large family using TV's, stereos, computers and laundry room during the late afternoon in mid summer.	+ 1,400	~	This is an additional 410 Watt allowance for A/V or computer equipment.
E) Allowance for above average lighting load.	+ 1,705	~	Five 100 watt lights.
F) Unvented clothes dryer.	Clothes dryers must be vented for air quality and efficiency.		

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Perform the Load Calc

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Manual J Don’ts

Impacts Heating and Cooling Loads

- Do not add safety factors – there are already safety factors built into the software (~20% oversizing built in)
- Do not design for record weather breaking conditions – design using ASHRAE or ACCA 99% dry bulb temperature for heating and 1% dry bulb temperature for cooling
- Do not reduce known ceiling, wall or floor R-values. What you see is real!
- Do not include walls, ceilings, or floors that separate conditioned spaces in the load calculation
- Do not assume ducts are not sealed or insulated – give fully sealed and insulated ducts full credit!
- Do not fail to give full credit for the builder’s effort to produce a tight envelope
- Do not use Manual J for commercial or large multifamily applications - use Manual N instead

Load Calc Quality Control

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Load Calculation Quality Control Checklist

Sanity Checks

- ❑ Homeowner name and address information are accurate
- ❑ Conditioned square footage is within +/- 10% of real estate websites (Zillow, Redfin) or government building data websites
- ❑ Confirm the number of stories.
- ❑ Outdoor design conditions used are based on ACCA Manual J Table 1A, unless superseded by code
  - ❑ Heating: 99% Outdoor Dry Bulb Temperature
  - ❑ Cooling: 1% Outdoor Dry Bulb Temperature
- ❑ Indoor design conditions shall be: Heating 70°F; Cooling 75°F; and 45%, 50%, or 55% RH
- ❑ Balance of heating load vs. cooling load. In cold climate regions, the building cooling load should generally be 1/2 to 1/3 the building heating load

Load Calculation Quality Control Checklist

Calculate the percent heating load for each component if not already done and compare to the following.

- ❑ Windows and glass doors – 15 to 30% of total load
- ❑ Above grade walls – 10 to 30% of total load
- ❑ Below grade walls – 20 to 40% (cold climate and no wall insulation)
- ❑ Ceilings – 10 to 30% of total load
- ❑ Infiltration – 5 to 30% of total load
- ❑ Doors – only a couple percent (0 to 5%) of total load
- ❑ Ventilation – 5 to 30% of total load

Note smaller and larger values are possible. Percentages depend on the climate and type of construction. If out of range, double check inputs are correct.

Load Calculation Quality Control Checklist

Sanity Checks

- ❑ No loads for adiabatic surfaces (e.g., floor, ceiling, or wall between two conditioned spaces)
- ❑ The glass area is 20% or less of the conditioned floor area
- ❑ The skylight area does not exceed 5% of the conditioned floor area
- ❑ Confirm wall surface areas are accurate. Multiply perimeter lengths by average ceiling heights (8 to 10 ft typ.).
- ❑ Check ceiling area total and floor area total are close to each other.
- ❑ No duct losses for a proposed ductless heat pump system

Software Programs

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Know Your Software and Study Manual J

> Software is a powerful and useful tool, but it is not magic.

> Load estimating software tools do not always do what Manual J stipulates

> All software products have built in defaults

> Defaults have a significant effect on the results

> If Manual J software is not used correctly, it will produce an inaccurate and misleading answer

> The person performing load calculations has a responsibility to…

- Study the ACCA Manual J
- Know the software they are using

Load Calculation Tools –

https://www.acca.org/standards/approved-software

Powered by ACCA Manual J

Full Residential Load Calculation

(Supports Block Load™, Room-by-Room Load™, Zone-by-Zone™ and Adequate Exposure Diversity™ or AED™ Calculations)

- Wrightsoft Right-J8
- Elite RHVAC
- Adtek Acculoads
- Florida Solar Energy Center's EnergyGauge
- Carmelsoft HVAC ResLoad-J
- Avenir MJ8 Editions of HeatCAD and LoopCAD
- Cool Calc Manual J
- Conduit Tech — LiDAR-capable devices
- Amply Energy — LiDAR-capable devices

Manual J Block Load Compliant

Limited to Block Load Only

- Wrightsoft Right-J Mobile
- CalcuNow MJ8-Calc

Other non-ACCA platforms:

- BetterBuiltNW HVAC Sizing Tool
- ServiceTitan HVAC Load Calculator
- Loadcalc.net - HVAC Load Calculator
- Kwik Model 3D - EnergyGauge Loads
- Quality First Heat Loss & Heat Gain Software
- Heat Load Pro

Even the same inputs into different software may lead to different results…

Software Inputs	Wrightsoft	Cool Calc
Winter Outdoor Air Temp.	9°F	9°F
Winter Indoor Air Temp.	70°F	70°F
Summer Outdoor Air Temp.	86°F	86°F
Summer Indoor Air Temp.	75°F	75°F
Square Footage	2,240	2,240
Door Total Area	40	48
Above Grade Wall Total Area	1,876	1,894
Above Grade Wall U-factor	0.068	0.068
Window Total Area	261	234
Window U-factor	0.47	0.47
Ceiling Total Area	1120	1120
Ceiling U-factor	0.032	0.032

Even the same inputs into different software may lead to different results…

Software Inputs	Wrightsoft	CoolCalc
Floor Total Area	1120	1120
Floor U-Factor	0.295	0.295
Leakage Category	Average	Average
Ducts Total Heating Load	6,600 Btuh	6,451 Btuh
Blower Motor	None	None
Winter Humidification	None	None
No. of Occupants	5	5
Appliance Load	2,000 Btuh	2,400 Btuh
Plants	0	0

Different Software = Different Results

Software	Wrightsoft	CoolCalc
Total Heating Load	32,896 Btuh	39,849 Btuh
Sensible Cooling Load	18,800 Btuh	16,224 Btuh
Latent Cooling Load	2,701 Btuh	2,901 Btuh
Total Cooling Load	21,501 Btuh	19,125 Btuh

Best Practices

- ✓ Conduct building takeoffs/ site-survey
- ✓ Get load calculations right
  - ✓ No extraneous *safety factors*
- ✓ Represent actual conditions
- ✓ Use the specified indoor and outdoor design conditions
- ✓ Use approved ACCA software
- ✓ Sanity check your results

Load Calculations

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Questions?

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Thank You

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