



# Residential Load Calculation Fundamentals and Insights (Manual J) and Equipment Selection (Manual S)

Presented by

Chris Morin, Founder, HVAC Pro Blog; Advisor,  
Conduit Tech; Area Sales Manager, Mitsubishi; Veteran,  
US Marines

Shelby Breger, Co-Founder, Conduit Tech;  
Breakthrough Energy Innovator Fellow

January 18, 2024



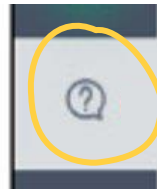
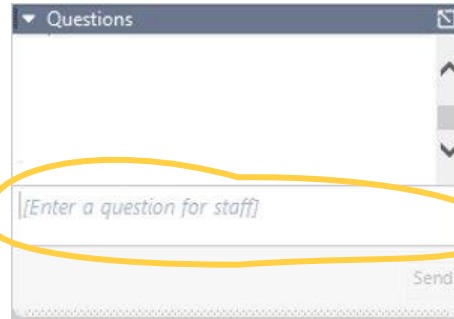
# Webinar Procedures

---

- All attendees are on mute
- Submit questions in **Questions** tab at any time
- The webinar is being recorded
- Please take the after-class survey!



Click this arrow if you don't see the GoTo toolbar. It might be on your other screen, if you have 2 monitors!



A couple different ways it might look to ask questions

# Upcoming Events

Course	Day	Time
Seattle's Brand-New Building Emissions Performance Standard: What You Need to Know Now	Thu Feb 1	10:00am-11:30am
SEM – Fundamentals of Strategic Energy Management and What It Can Do For You and Your Facility	Tue Feb 13	10:00am-11:30am
Improving Energy Performance and Achieving Decarb Goals With US DOE's 50001 Ready™ and Superior Energy Performance 50001™	Thu Feb 15	10:00am-11:30am
PAE CHPWH Retrofit in Seattle - Details to come	Thu Feb 29	TBD


Let us know what you think of this new programming and tell us what you want us to add at [lightingdesignlab@seattle.gov!](mailto:lightingdesignlab@seattle.gov)

Stay up-to-date at [LightingDesignLab.com](http://LightingDesignLab.com) and by [subscribing to our newsletter.](#)

# Related Rebates and Other Funding

---

- Heat pump contractor discounts through [participating distributors](#)
  - \$300-\$600 instant discount per home
- City of Seattle [Clean Heat Program](#)
  - \$2000 instant rebate
  - Oil-heated homes moving to electric heat
- [Federal tax credits](#) and upcoming funding
  - 2022: \$300; 2023-2032: 30% of cost (\$2000 cap per year)
  - IRA rebate possibilities from state



**Contact an Energy Advisor  
today** to find out more!  
Call **(206) 684-3800** or email  
**[SCLEnergyAdvisor@seattle.gov](mailto:SCLEnergyAdvisor@seattle.gov)**



# The Ultimate Introduction to HVAC Load Calculations

---



## About our host: Chris Morin





## What we'll cover today:

- **A brief overview of load calculations**
- **What today's environment and building codes mean are requiring**
- **Heat loss drivers**, and how to evaluate them
  - Temperature difference
  - Air exchange (infiltration)
- **Key factors impacting cooling gains**, and how to evaluate them
  - Solar heat gain
  - Internal gains and cooling
- **Tech & tools to streamline your process**
- **Q&A**



## Land Navigation







## Load Calculations: The Road Map to your Sales Process & Solution

Framework to evaluate the home

Build value on-site

Build the right solution

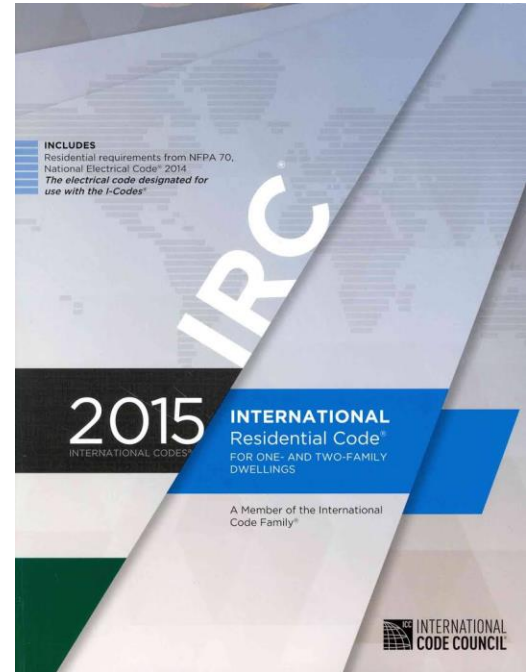


## Why do load calculations? Manual J load calculations are also required!

### **M1401.3 Equipment and Appliance Sizing.**

“Heating and cooling equipment shall be sized in accordance with ACCA Manual S or other approved methodologies based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies.”

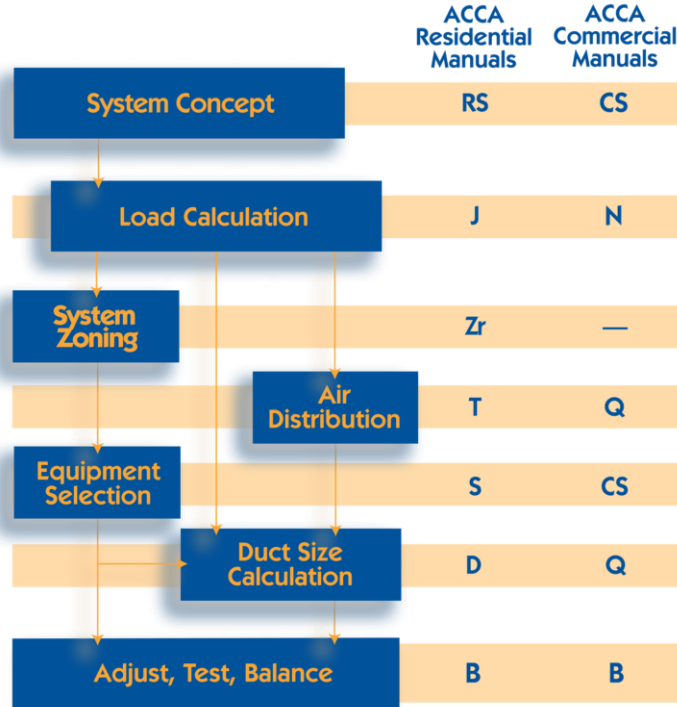
*2009, 2012, 2015 International Residential Code*





Why do load calculations? They're an input to critical system design!

## System Design Process



**Necessary input to System Sizing (Manual S) and evaluating ductwork (Manual D)**

## What do we need to understand to conduct a load calculation? 4 key elements:

- **Temperature Difference**
- **Air Exchange**
- **Solar Heat Gain**
- **Internal Gains**

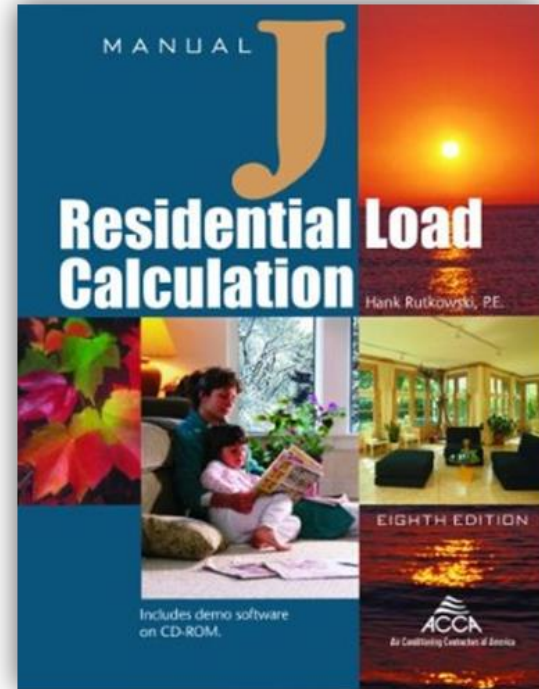




## What do the results of a Manual J load calculation yield?

1. Perform load calculation on whole structure to acquire BTU and CFM amount.
2. Break down room by room BTU and CFM amount.

*\*Manual J software is recommended, which will auto calculate room BTU's and CFM.*



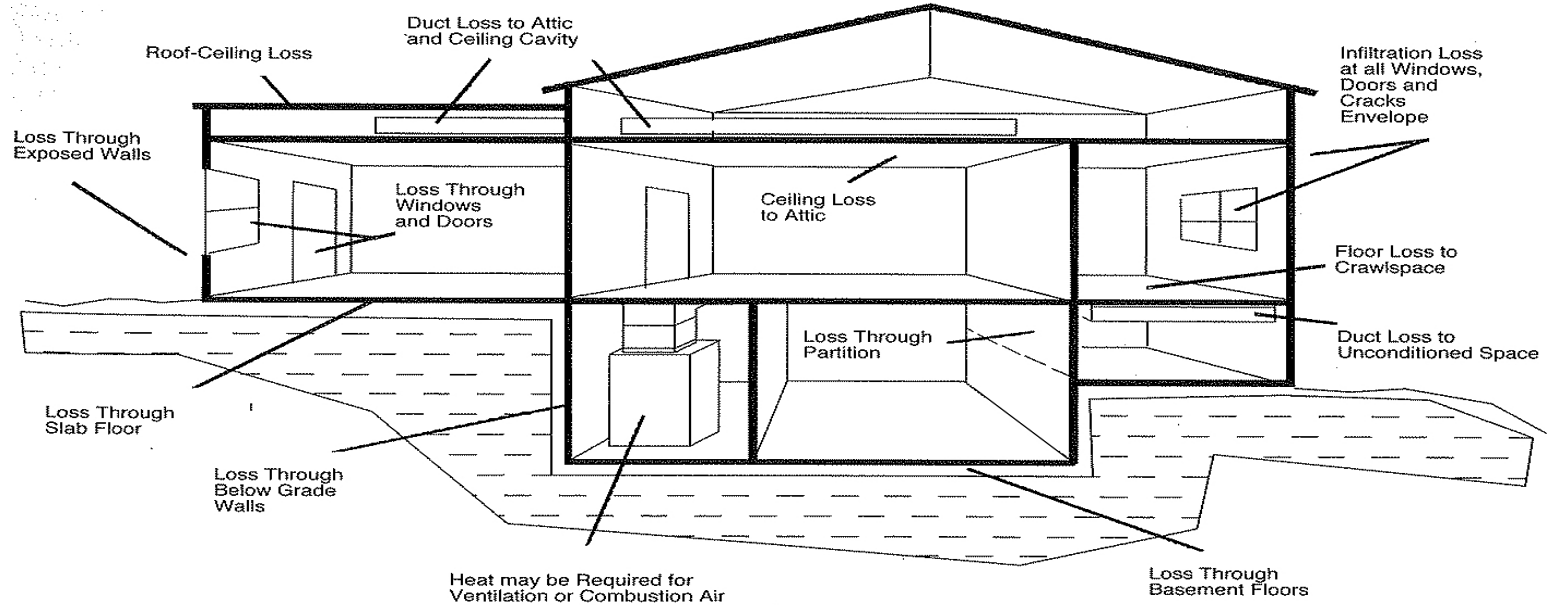


---

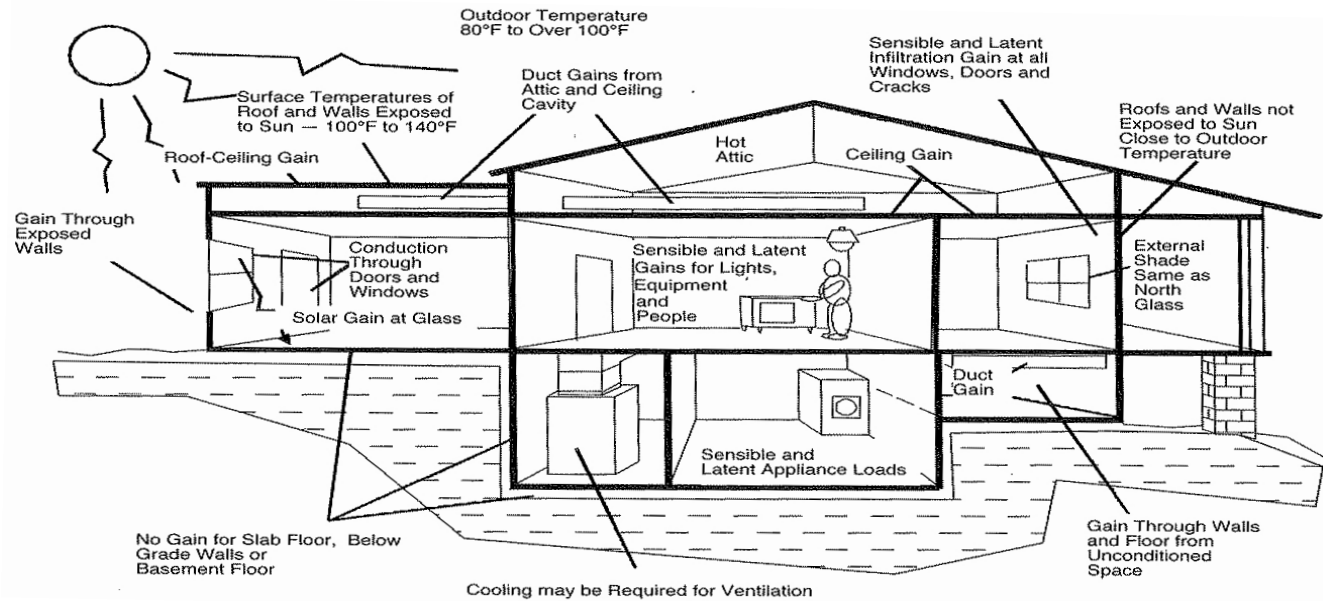
# Conducting a Site Survey to Capture What Matters



## We capture these details through a Manual J Site Survey: Heat Loss



## We capture these details through a Manual J Site Survey: Cooling Gains








## Manual J Site Survey

# Load Calculation Survey Sheet

- Location and Outdoor/Indoor Design Conditions
- Determine Framing and Wall Insulation
- Determine Attic and Ceiling Insulation
- Identify Roof Type and Unique Characteristics (Dormers?)
- Determine Floor Condition and Insulation
- Identify Internal Gains (People, Appliances, Plants, etc.)

 HVACProBlog.com - Site Survey Form ACCA Manual J 4th Edition Site Survey

**Contractor**

Name: \_\_\_\_\_  
Address: \_\_\_\_\_  
City: \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_  
Phone: (\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_  
E-mail: \_\_\_\_\_@\_\_\_\_\_.COM

**Customer**

Name: \_\_\_\_\_  
Address: \_\_\_\_\_  
City: \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_  
Phone: (\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_  
E-mail: \_\_\_\_\_@\_\_\_\_\_.COM

**Type Load Calc**

Block Load: Approved for system Replacements       Room x Room: Required for system design of new installations

**Construction Details**

Ceiling Height: Bsmnt \_\_\_\_\_ 1st Floor \_\_\_\_\_ 2nd Floor \_\_\_\_\_ Attic \_\_\_\_\_

Exterior Wall: Framing  Wood  Metal  Masonry  
 2" x 4"       2" x 6"

Insulation: Type \_\_\_\_\_ R-Value \_\_\_\_\_  
 R-5       R-11       R-19

Sheathing: Type \_\_\_\_\_ Ext. Board \_\_\_\_\_ R-Value \_\_\_\_\_

Exposed Floor:  Slab       Crawl       Open Crawl       Basement  
 Uncond.       Cond.

Ceiling:  Under Vented Attic       Unvented Attic       Roof/Ceiling Comb.       Encaps.  
R-Value \_\_\_\_\_       R-7       R-11       R-19       R-21       R-30

Roof:  Shed       Flat       Mansard/Gable       Pyramid       Frustum       Custom  
Height Above Wall: \_\_\_\_\_ Color:  Dark       Med       Light

Fireplaces: How Many? \_\_\_\_\_  
 Gas       Electric       Wood       Vented       Non-Vented

Construction Quality:  Tight       Semi-Tight       Average       Semi-Loose       Loose

**Internal Gains**

People: How Many? \_\_\_\_\_ = Number of Bedrooms + 1      Guests? \_\_\_\_\_

Appliances: Block Load:  Assume 1200 Btu/hr for Kitchen  
 Assume 2400 Btu/hr for Refrigerator, range with vented hood, dishwasher, clothes washer and vented dryer, electronic equip., lighting allowance.






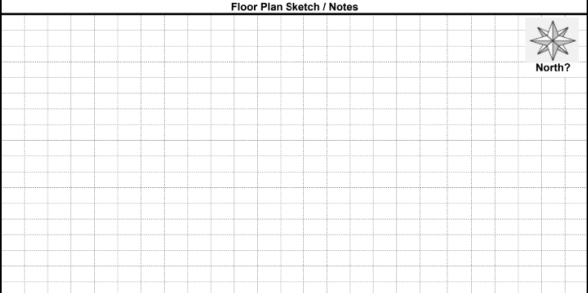
Other: \_\_\_\_\_



## Manual J Site Survey

# Load Calculation Survey Sheet

- Make rough drawing of floor plan – measure
- Evaluate Ductwork

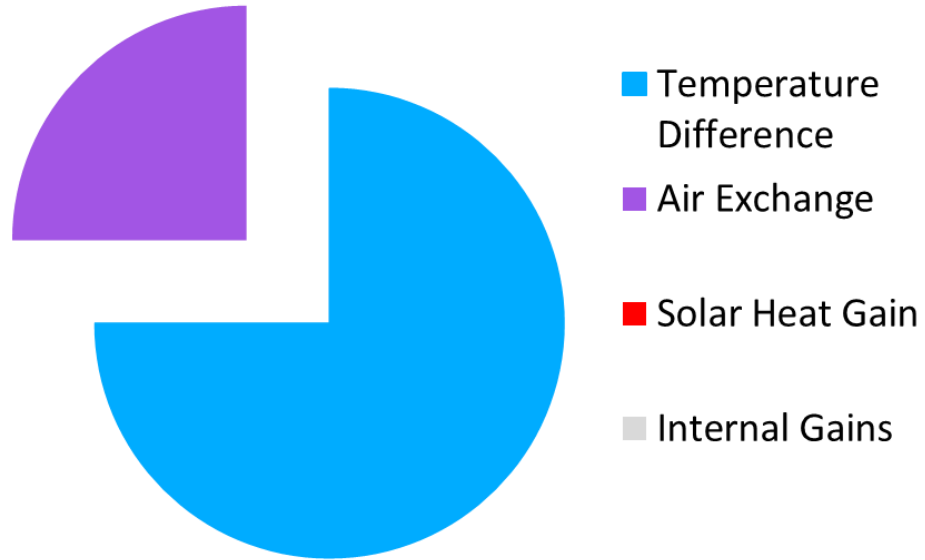
Ductwork	
<b>Location</b>	<input type="checkbox"/> Conditioned Space <input type="checkbox"/> Attic: <input type="checkbox"/> Vented <input type="checkbox"/> Unvented <input type="checkbox"/> Encap. <input type="checkbox"/> Open Crawl Space <input type="checkbox"/> Enclosed Crawl Space: <input type="checkbox"/> Vented/Leaky <input type="checkbox"/> Tight <input type="checkbox"/> Garage <input type="checkbox"/> Basement: <input type="checkbox"/> Cond. <input type="checkbox"/> Uncond. <input type="checkbox"/> Under Slab <input type="checkbox"/> Exterior Wall
<b>Config. Supply</b>	Sealing _____ R-Value _____ Heat Air Temp _____ °F <input type="checkbox"/> Radial <input type="checkbox"/> Perimeter <input type="checkbox"/> Center <input type="checkbox"/> Trunk & Branch <input type="checkbox"/> Perimeter <input type="checkbox"/> Center 100 - Heat Pump 120 - Gas 130 - Oil
<b>Config. Return</b>	Sealing _____ R-Value _____ <input type="checkbox"/> Radial <input type="checkbox"/> Perimeter <input type="checkbox"/> Close <input type="checkbox"/> Trunk & Branch <input type="checkbox"/> Perimeter <input type="checkbox"/> Close
Windows / Doors	
<b>Window Detail</b>	1  2  3  4  5 
<b>Frame</b>	_____
<b>Glass Type</b>	_____
<b>U-Value / SHGC</b>	_____
<b>Screen/Shading</b>	_____
<b>Door Detail</b>	# 1 _____ " x _____ "    # 2 _____ " x _____ "
	Dimensions    Construction Material    Dimensions    Construction Material
Floor Plan Sketch / Notes	
	



# How to Evaluate the factors that drive Heating



# Heating





## Temperature Difference:

Do NOT design for record breaking weather conditions

Do NOT add a “safety factor” to table 1A / 1b  
Do NOT design for abnormally low or high indoor temperature or humidity conditions



$$365 \text{ Days} \times 1\% = 3.65 \text{ Days}$$

## Air Exchange

### We want to evaluate how “leaky” the home is

- 1) A blower door, is best practice to tell you this
- 2) Alternatively, visual cues to evaluate infiltration:
  - a) Is there lots of dust accumulating?
  - b) Does the homeowner mention draftiness?
  - c) What was the year built / or year of major remodel?





## Air Leakage: Infiltration Rates & Construction Quality

Home Infiltration Rates are determined by ACH (Tightness) and Floor Area (sq. ft.)

Default Air Change Values for Single Story Construction						
Construction	Air Changes per Hour — Heating					Infiltration <sup>1</sup> Cfm for One Fireplace
	Floor Area of Heated Space (SqFt)					
	900 Or Less	901 to 1500	1501 to 2000	2001 to 3000	3001 or More	
Tight	0.21	0.16	0.14	0.11	0.10	0
Semi-Tight	0.41	0.31	0.26	0.22	0.19	13
Average	0.61	0.45	0.38	0.32	0.28	20
Semi-Loose	0.95	0.70	0.59	0.49	0.43	27
Loose	1.29	0.94	0.80	0.66	0.58	33

1) For one additional fireplace, add 7 CFM to the above fireplace values. For two or more additional fireplaces, add 10 CFM (total) to the above.



## Air Leakage: Infiltration Rates & Construction Quality

Assumptions almost always necessary based on age of home, unless a weatherization (air sealing/insulation) retrofit.

- Assume “Tight” for a Net Zero, Passive home, Spray Foam
- Assume “Semi-tight” for home Energy Star Home
- Assume “Average” for home built 1995+
- Assume “Semi-Loose” for home 1950 – 1994\*
- Assume “Loose” for home older than 1950\*

\*Assumptions based on average leakage rates provided by Lawrence Berkley Laboratory within study “Air-Tightness of U.S. Dwellings”, 1994 and Energy Star recommendations.





## Air Exchange - Ceilings

### Attic and Ceiling Insulation Key Questions:

- Is it under a Vented Attic?
- Unvented Attic?
- Roof/Ceiling Combination?
- Ceiling Insulation
- R-7, R-11, R-19, R-30?





## Air exchange: Evaluating the Insulation

What you see:		What it probably is	Depth (inches)	Total R-value
Loose fibers	light-weight yellow, pink, or white	fiberglass	_____	=2.5×depth
	dense gray or near-white, may have black specks	rock wool	_____	=2.8×depth
	small gray flat pieces or fibers (from newsprint)	cellulose	_____	=3.7×depth
Granules	light-weight	vermiculite or perlite	_____	=2.7×depth
Batts	light-weight yellow, pink, or white	fiberglass	_____	=3.2×depth



Closed Cell Spray Foam = 6.5 x depth



## Air Leakage - Ductwork

Ductwork may or may not be sealed, and it may not be tight. Evaluating the condition, location, materials and insulation of ductwork will impact your loads.





## Air Exchange: Fresh Air

Evaluate both what local code requires, and what actually serves the home today.



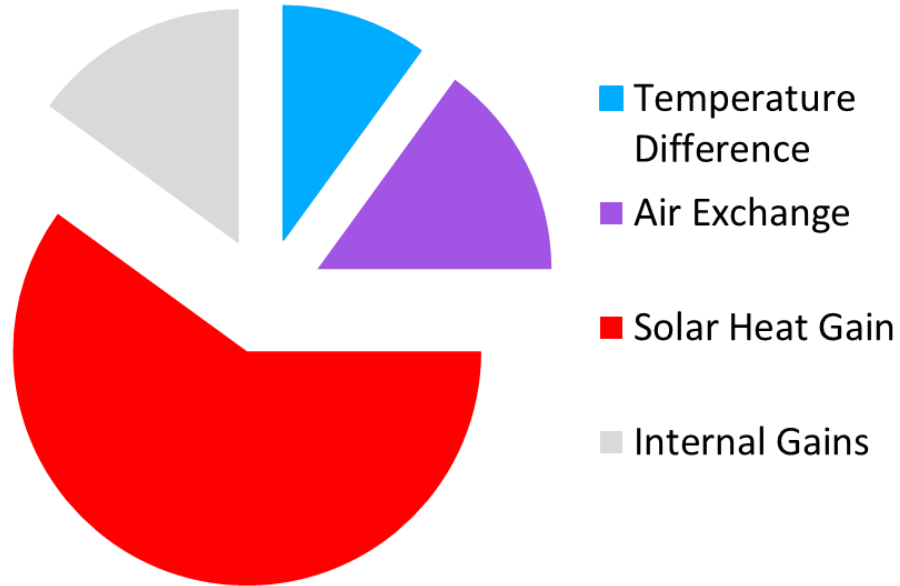


---

# How to Evaluate the factors that drive Cooling



## Cooling





## Solar Heat Gain: Windows & Skylights

### **Frame?**

Metal / Wood / Vinyl / Insulated Fiberglass

### **Glass Type?**

Clear, Heat Absorbing, Low-E, etc.

**U-Value?** NFRC Sticker...

**Exterior Bug Screen?**

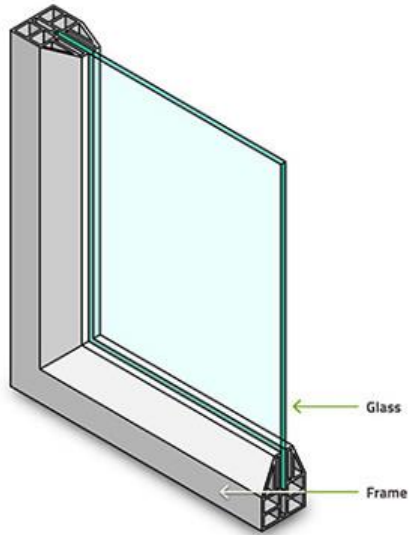
**Internal Shading?**

Assume Blinds at 45 degrees, unless otherwise noted.

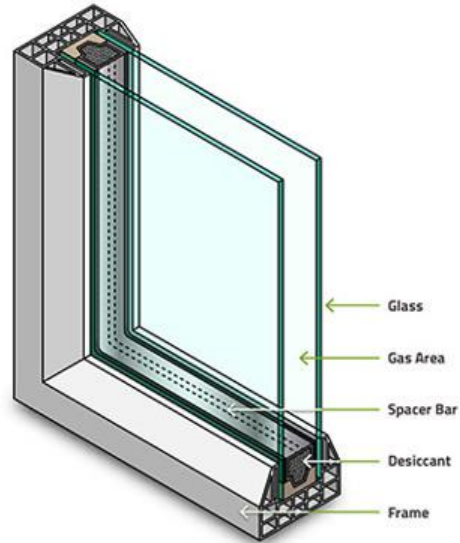


## Solar Heat Gain: Windows & Skylights

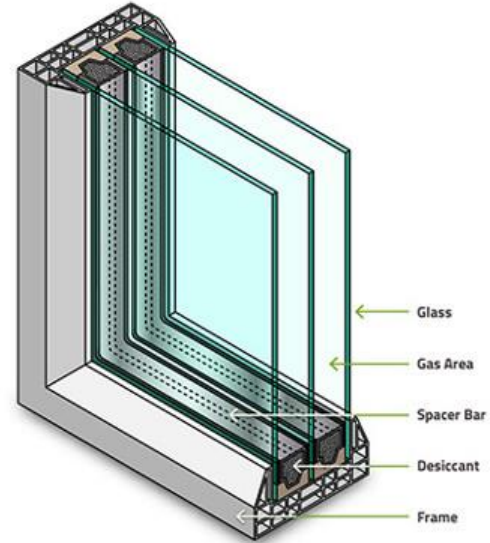
Single Pane



Double Pane



Triple Pane





## Solar Heat Gain: Windows & Skylights

**Overhang:** Can reduce SHGC

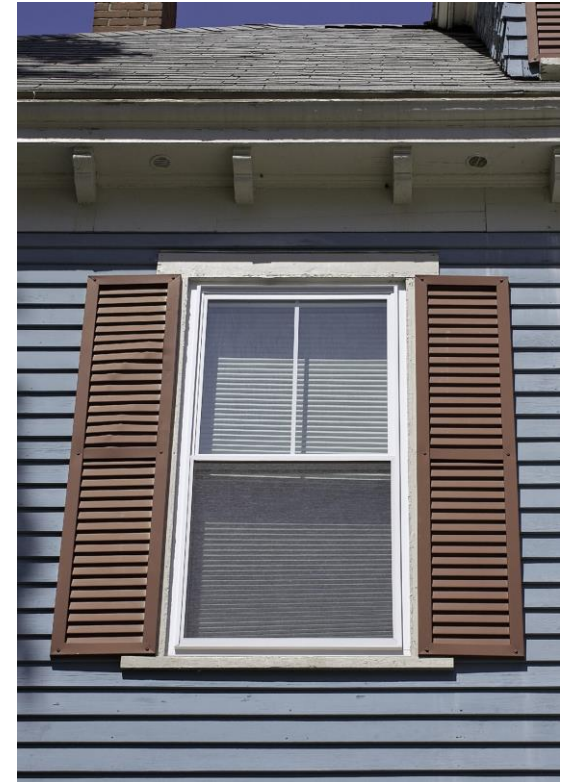
**Foreground:**

Grass

Asphalt

Concrete New/Old

Crushed Rock



## Solar Heat gain: Home Orientation

Take into account what windows / walls face North, east, South, West - they'll differentially impact the load





## Internal Loads

People = Number of Bedrooms + 1  
(Master Bedroom has 2)

**Full-time** Guests = Elderly Family, etc.

Appliances = Block load Amounts

1,200 Btu/hr - Kitchen

2,400 Btu/hr - Refrigerator

Other Major Appliances: Range with Vented Hood,  
Dishwasher, Washer/Vented Dryer, Electronic  
Equipment & Lighting





## Remember!

- No Manipulating Outdoor Design Temp (i.e. Max 14°F CLTD)
- Take full credit for efficient construction features!
- Research studies indicate that Manual J V8 procedure provides an adequate safety factor - don't add on!





## Using a load calculation to build value on site



**Evaluate efficiency gains**



**Comfort improvements**



**Cost efficacy & right-sizing**



## What Does This Mean For Me?



### Properly Sized vs. Oversized Equipment

- Equipment Costs less
- Uses smaller ductwork
- More Comfortable
- Less operating costs
- Reduce chance of cracked heat exchanger
- Reduces load on grid



# Manual S & Heat Pump Selection



## Manual S - Heat Pumps

ACCA Manual S Equipment Selection (2nd Ed): Air-Air Heat Pumps

Equipment Type	Climate	Capacity	Single-Speed	Multi-Stage	Variable Speed
Air-Air Cooling Only & Heat Pump	*Mild Winter or has Latent Cooling Load	Total	Min. 90% - Max. 115%	Min. 90% - Max. 120%	Min. 90% - Max. 130%
		Latent	Min. 100% - Pref. Max 150%		
		Sensible	Minimum 90%		
Air-Air Cooling Only & Heat Pump	**Cold Winter and No Latent Cooling Load	Total	Minimum 90% Max. Manual J Total Cooling Load + 15,000 Btu/hr		

\*Mild Winter: (Heating Degree Days Base 65F) / (Cooling Degree Days Base 50F) < 2.0

\*\* Cold Winter: (Heating Degree Days Base 65F) / (Cooling Degree Days Base 50F) > 2.0





# Manual S - ACCA Speedsheet

**Air Conditioning Conditions of America - Manual S 2nd Edition (2014) Residential Equipment Selection**

Project information		Design information	
Name		Building Name/Package or System	
Address		Design Code/ Termination Location	
City		Design Package Name	
State	IL	Customer Name or Title	
Country		Design Package Number	

Air Conditioning Package Data Comparison Worksheet			
Package	Manufacturer	Package #	BTU/h
	Model Name	Package #	BTU/h
	Manufacturer	Package #	BTU/h
	Manufacturer	Package #	BTU/h

Package	Flow	Flow	Flow	Flow	Flow
	1.00	1.00	1.00	1.00	1.00

Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

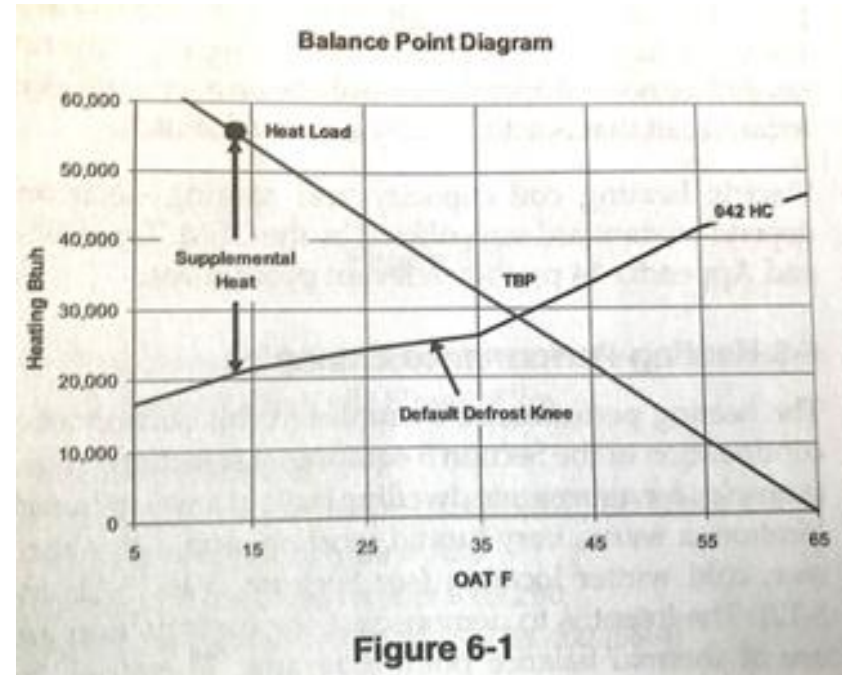
Cooling Capacity and Air Flow Data Comparison Worksheet						
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity
Capacity at 80°F DB	BTU/h	Capacity	BTU/h	Capacity	BTU/h	Capacity

## ACCA Manual S Speedsheet/Report

- Easily Interpolate (4 Different Tabs)
- Provides Report
- Complete Yellow Cells
- Still need Expanded Cooling Data
- Min/Max Check Built-in

## Manual S – Heat Pumps

- Heat Pumps are sized for *COOLING!*
- Balance Point Diagram needed for sizing supplemental



## Manual S – Heat Pumps

**MA Energy Prices (1/26/21)**

Electric	\$0.2438 per kWh	ERJ.org
Natural Gas	\$1.58 per Therms	ColumbiaGasMA.com
Oil	\$1.84 per gallon	Mass.Ann.Rpts
Propane	\$3.03 per gallon	Mass.gov/LEA

**UPDATED: Break Even COP's for MA**

How do you know if you should install a ductless mini-split, or upgrade your air-conditioner to a heat-pump and create a dual-source application during replacement this Winter? I have been asked this countless times over the past week! I personally always prefer the option of multiple fuel sources, particularly since energy prices have been all over the place during the last

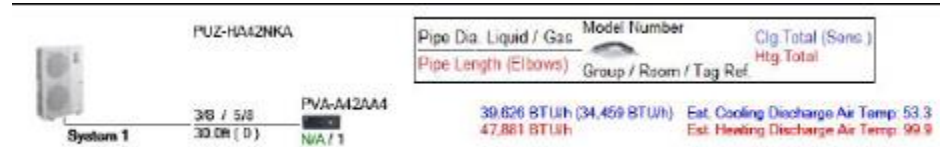
### When to switch over?

Comfort: Balance Point Diagram

Cost: Break-Even COP

## An example - the Diamond System Builder

Indoor Units:	1 / 1 to 1
Capacity:	42 / 42 to 42 (100.0%)
* Connectable capacity is not actual capacity.	
Total Pipe Length:	30.0 / 245.0 feet
<b>Correction Factors</b>	
Temperature:	0.96 1.00
Piping Lengths:	0.99 1.00
Defrosting:	- 1.00
Total Derate:	0.94 1.00
Additional Refrigerant:	0.0 lb
Total Refrigerant Amount:	29.2 lb
<b>Conditions (°F)</b>	
<b>Cooling</b>	
Indoor DB	75.0 Humidity 52.3% Indoor WB 63.0
Outdoor DB	91.0
<b>Heating</b>	
Indoor DB	70.0
Outdoor DB	6.0 Humidity 72.8% Outdoor WB 5.0



### Diamond System Builder

- Calculates Zones Capacities
- Built in Compatibility, Line Lengths
- Calculates Additional Ref. Charge
- Lists Available Accessories



# The Role of Technology

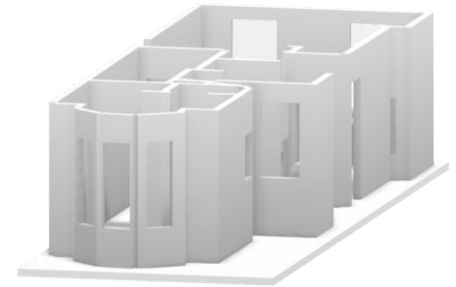
# Technology & Tools can dramatically change the speed of this process

Pen & Paper  
(example of streamlined  
site survey)

## Complex building modeling software

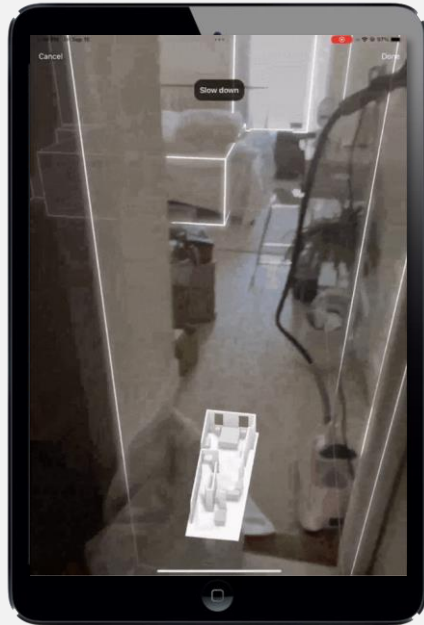
Right-J Worksheet				<< <		prev zone			
1	Room name		Entire Bouze						
2	Exposed wall		240.0 ft						
3	Ceiling height		8.0						
4	Room dimensions								
5	Room area		1750.0 ft²						
Ty	Construction number <small>(click any cell than click here)</small>	U-value	Or	HTM (Btu/ft²)	Area (ft²) or perimeter (ft)	Load (Btu/h)			
				Heat	Cool	Gross	N/P/S		
6	W-15B-10aFc-2	0.083	n	0.305	1.129	560	492	189	397
7	L-D-22ow	0.570	n	2.850	19.32	40	0	114	773
8	L-1150	0.390	n	1.950	11.19	28	28	55	313
9	W-15B-10aFc-2	0.083	e	0.305	1.129	400	368	142	303
10	L-D-22ow	0.570	e	2.850	41.39	32	0	91	1965
11	W-15B-10aFc-2	0.083	s	0.305	1.129	560	484	185	388
12	L-D-22ow	0.570	s	2.850	21.64	48	0	137	1039
13	L-1150	0.390	s	1.950	11.19	28	28	55	313
14	W-15B-10aFc-2	0.083	w	0.305	1.129	400	384	148	321
15	L-D-22ow	0.570	w	2.850	41.39	16	0	46	982
C	16B-30ad	0.032	-	0.160	1.670	875	875	140	1462
F	21B-28t	0.015	-	0.075	0.000	875	120	66	0
Total room load								2923	12031
Air required (cfm)								505	505

Automated 3D modeling,  
2D floorplans & 15  
minute load calculations





**Conduit creates accurate load calcs, 2D floorplans and 3D models in 15 minutes or less - all integrated into clear sales materials and documentation for the install team**



**DESIGN**



**SALES**



**INSTALLATION**