

WUFI, Manual J, and RTS: HVAC Design for Passive Building

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By Way of Introduction

- Passive Builder
- Cascade Comfort Systems
- Build With Balance
- CPHC®



Temperature Check

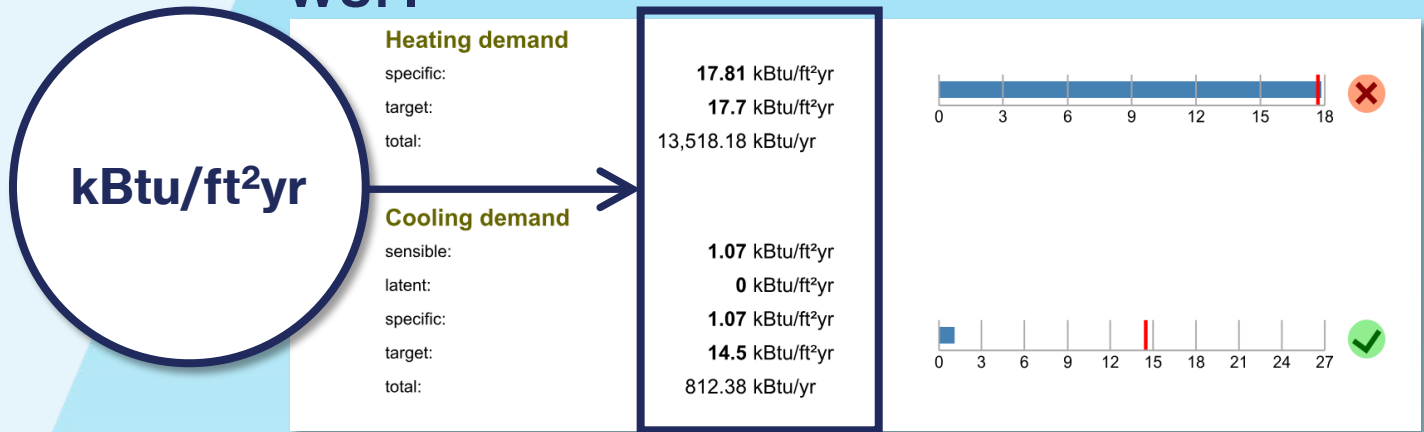
- Who does their own HVAC design using the guidelines that the CPHC course lays out?
- Who uses HVAC design consultants?
- Who checks that what gets installed is appropriate to the passive design load?



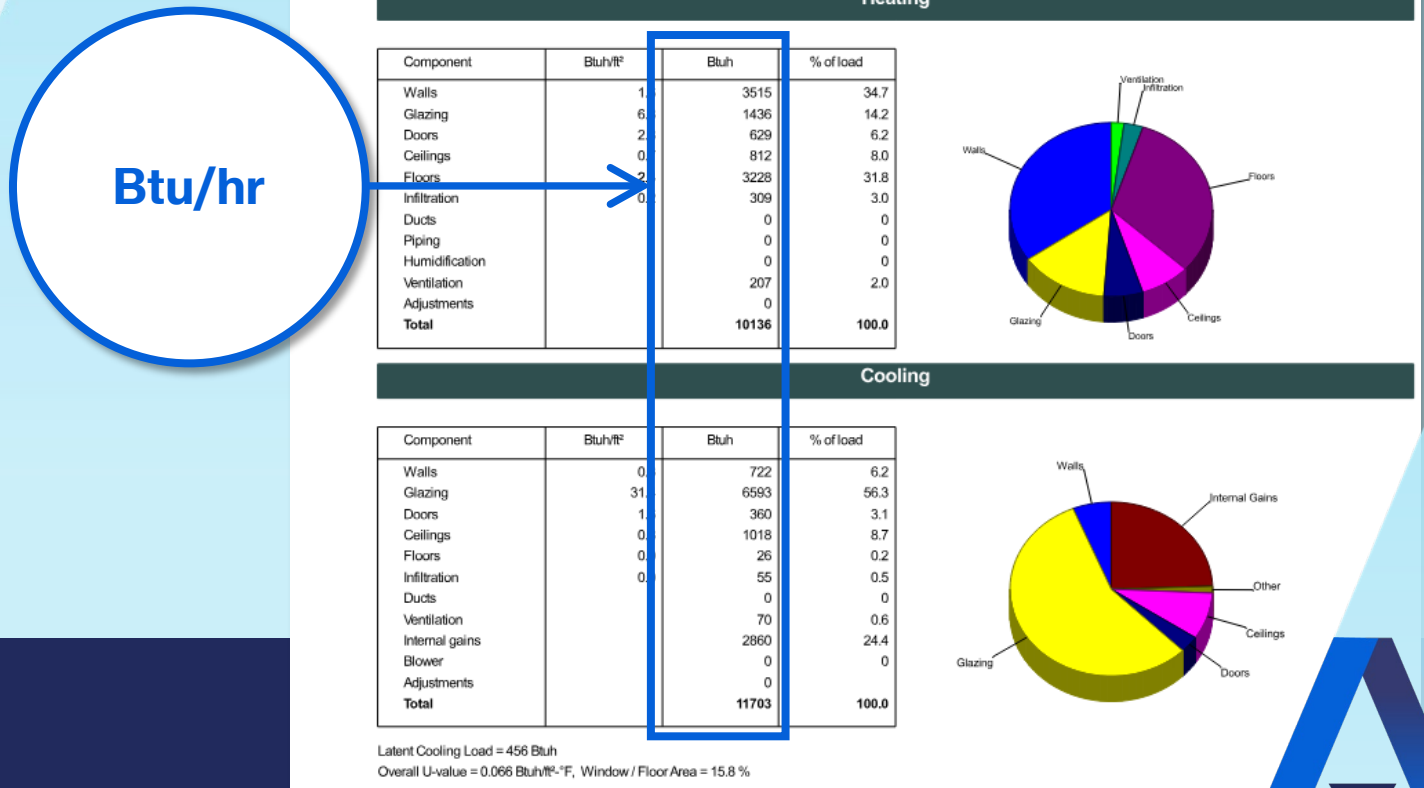
WUFI and MJ8: Distant Cousins?

- Both energy modeling protocols
- WUFI is a scalpel
- MJ8 is a machete

WUFI



MJ8



Very Different Results

WUFI

ROOM NAME	Area (ft²)	Htg load (Btu/h)	Clg load (Btu/h)	Htg AVF (cfm)	Clg AVF (cfm)
Main Level FCU	1715	7574	23253	900	900
(Unconditioned)	166	0	0	0	0
Lower Level FCU	1220	8034	12756	448	448
Primary Suite FCU	675	4060	3323	353	353
Bedrooms FCU	785	4381	10050	600	600
Garage FCU	716	3790	0	43	0

Entire House	5276	27839	48740	2344	2301
Other equip loads		1076	110		
Equip. @ 1.00 RSM			48850		
Latent cooling			724		
TOTALS	5276	28916	49574	2344	2301

Heating
Load

Cooling
Load

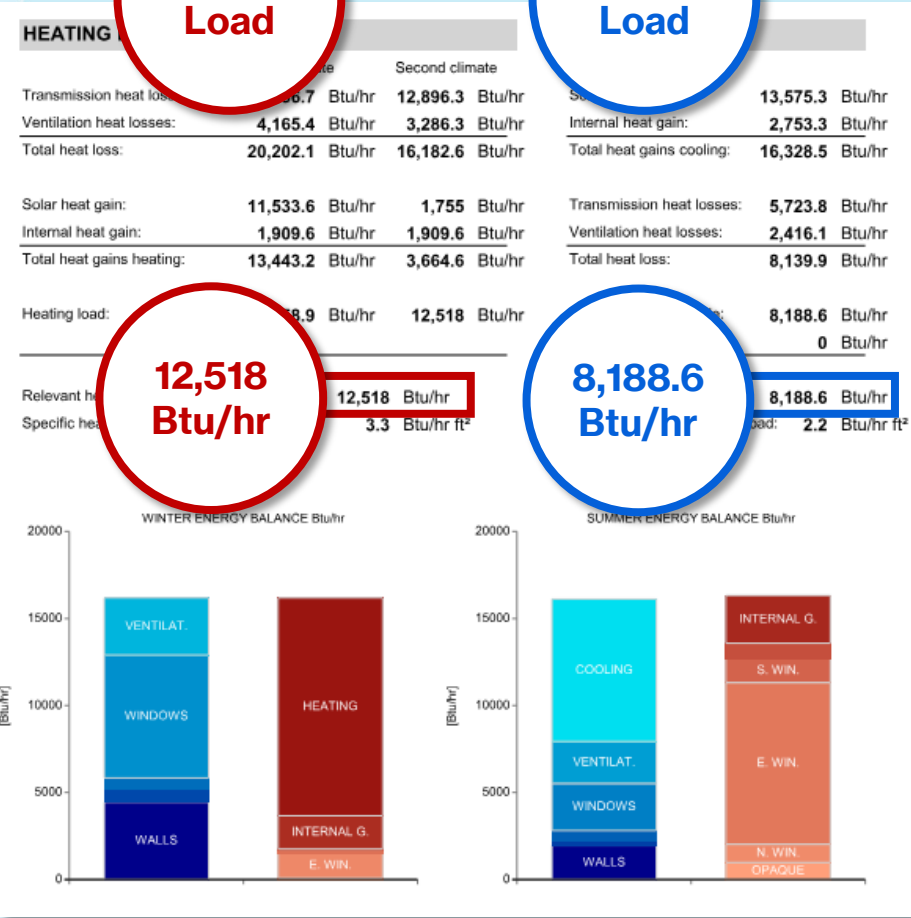
28,916
Btu/hr

49,574
Btu/hr

MJ8

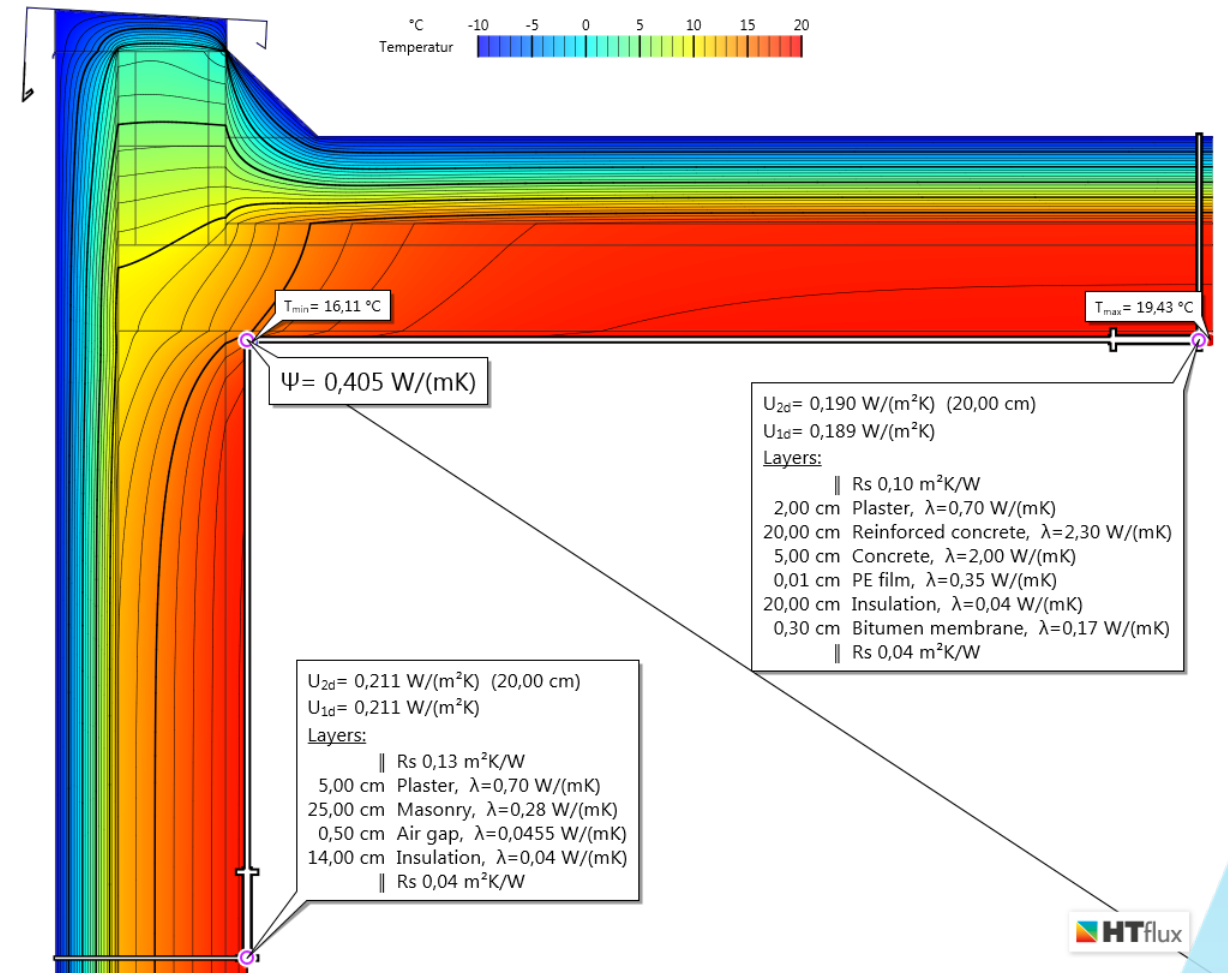
Heating
Load

Cooling
Load



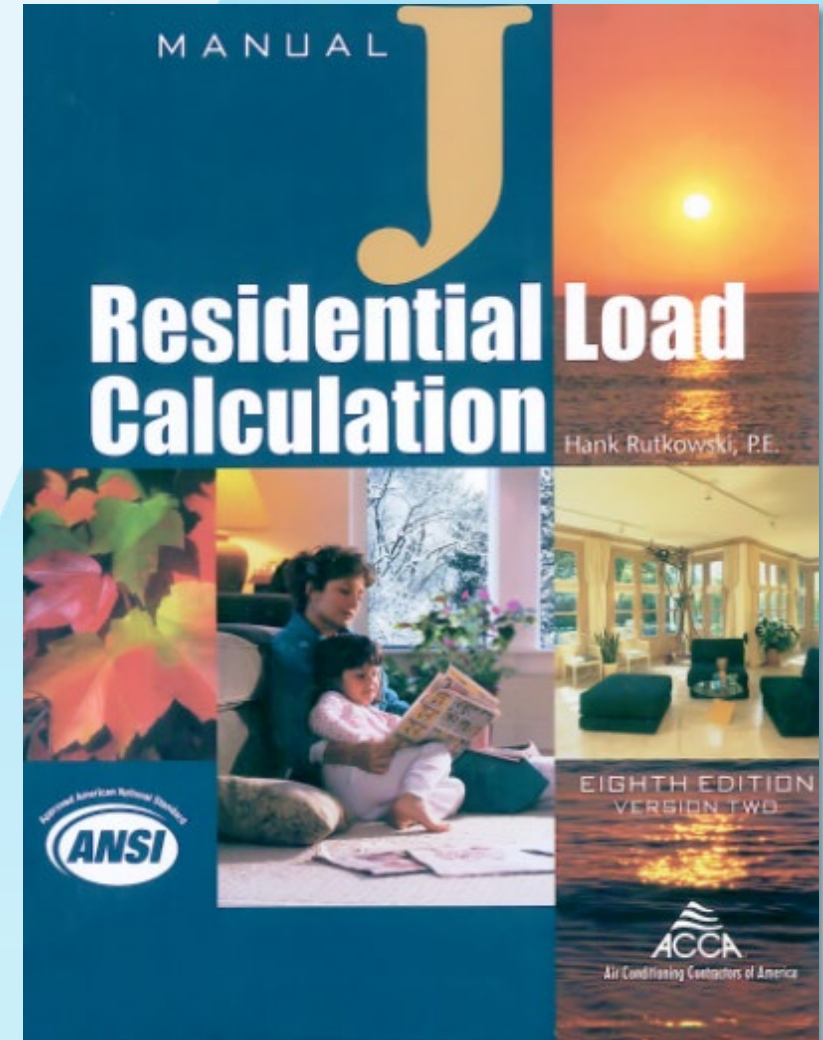
What is WUFI?

- Total energy modeling tool
- Goes to great lengths to be accurate and realistic
- Interested in high level outcomes on annual basis



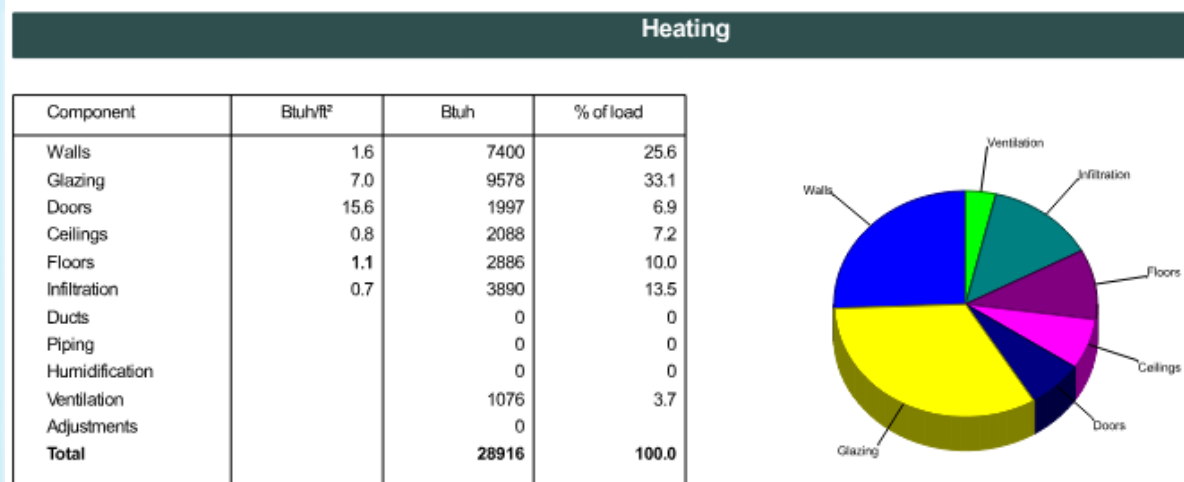
What Is Manual J (& RTS)?

- Thermal Energy Modeling
- Created by the Air Conditioning Contractors of America in 1972
- Focus on comfort in extreme conditions
- Interested in peak loads at the single hour level
- Minimal interest in being realistic



Minimal Interest in Being Realistic!?

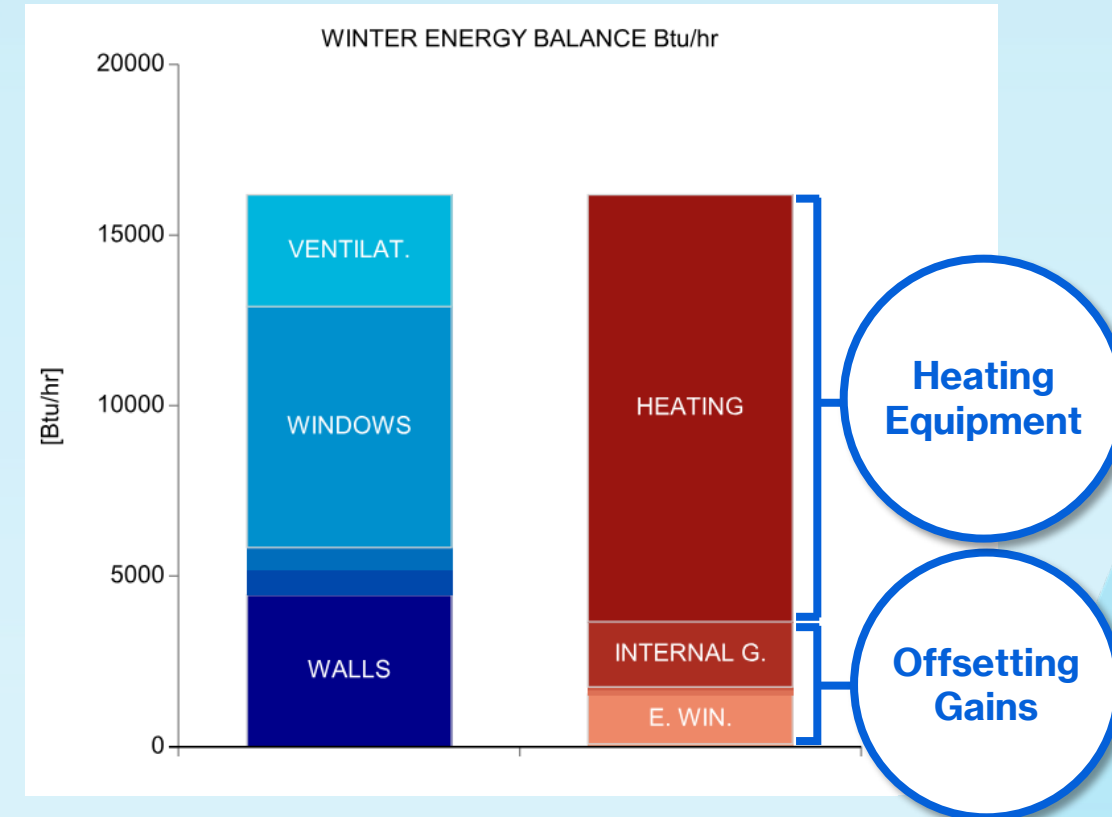
MJ8 - Conservative



ASHRAE Standard 183

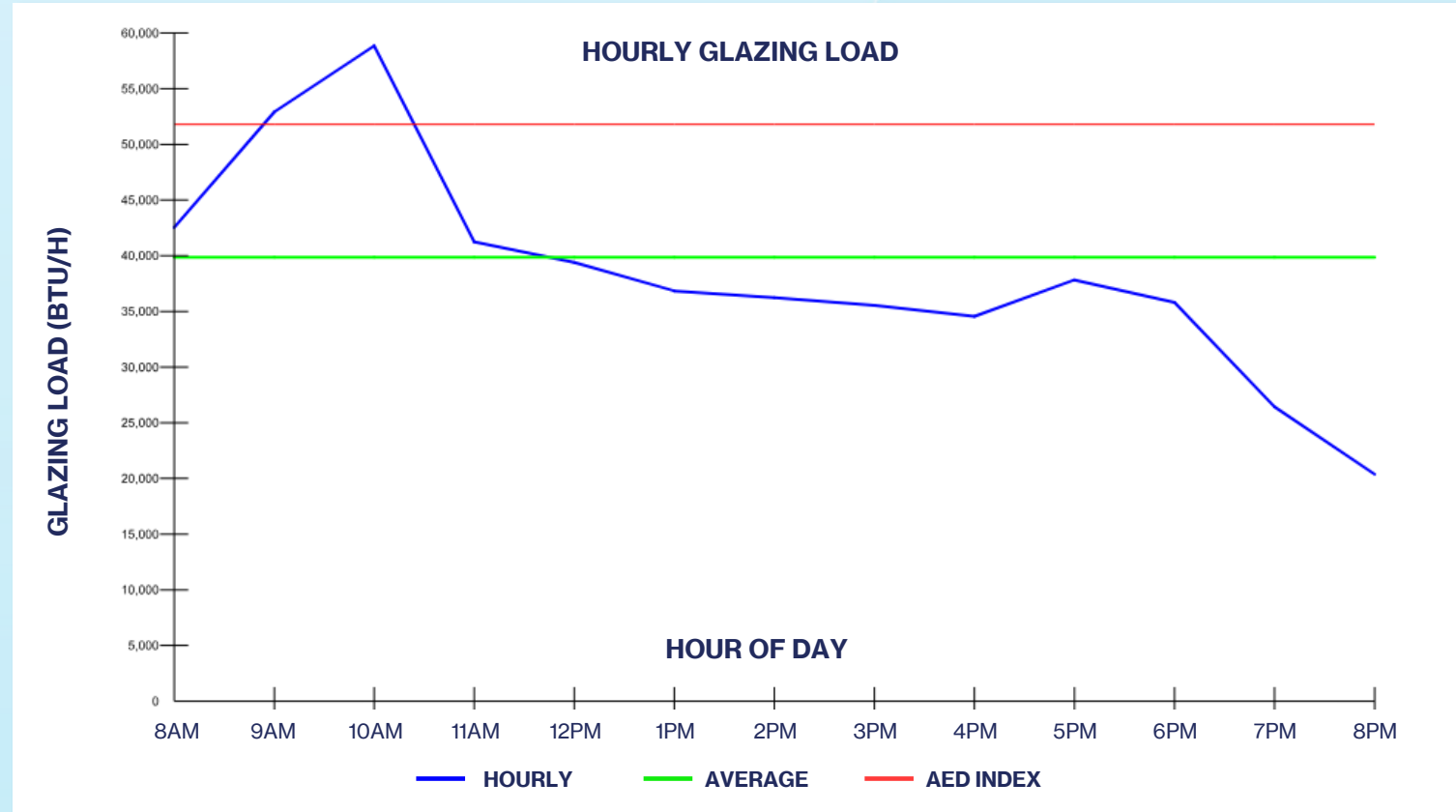
9.2 Credit for solar heat gains and for internal heat gains shall not be included as part of the calculation of the peak heating load.

WUFI – More Realistic



A Single Hour?

AED Analysis: Adequate Exposure Diversity



So Why Use MJ8 at all?

Primary Suite FCU

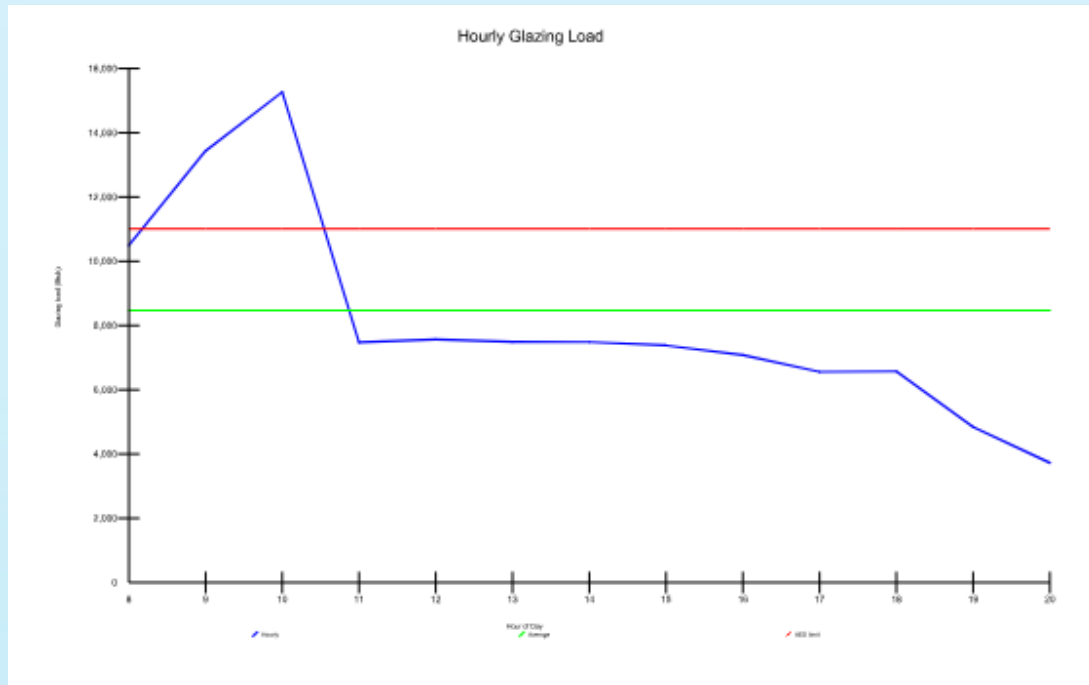
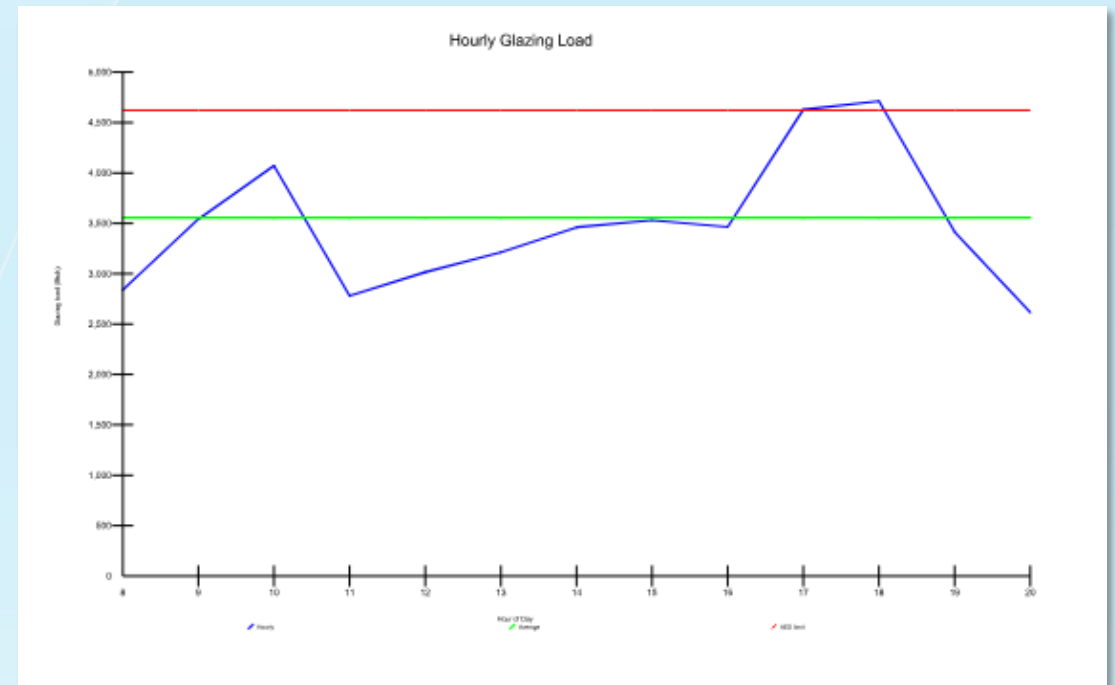
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(Unconditioned)	166	0	0	0	0
Lower Level FCU	1220	8034	12756	448	448
Primary Suite FCU	675	4,060 Btuh	3,323 Btuh	353	353
Bedrooms FCU	785	4381	10050	600	600
Garage FCU	716	3790	0	43	0

Main Bedroom

ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Primary Bath	157	922	797	80	85
Main Bedroom	287	1,755 Btuh	1,506 Btuh	153 cfm	160 cfm
Main WIC	130	804	459	70	49
L3 Elevator	42	0	0	0	0
Laundry Room	58	579	562	50	60
Primary Suite FCU	675	4,060 Btuh	3,323 Btuh	353	353
Other equip loads		160	16		
Equip. @ 1.00 RSM			3339		
Latent cooling			133		
TOTALS	675	4220	3472	353	353



AED Zoning Analysis



How Can We Apply MJ8 to Passive Building?

- Bring in offsetting loads from WUFI?
- Intentionally Undersize Equipment?
 - Manual S calls for 90-130% sizing
 - Allison Bailes case study
 - 2015 NREL Study



Dr. Allison Bailes Case Study

Since the total capacity of the system is dictated by the outdoor unit, here's what the totals look like:

Zone	Floor Area (ft ²)	Heating (BTU/hr)		Cooling (BTU/hr)		Total
				Sensible	Latent	
Both	2,103	Load: 31,452 BTU/hr		31,452	2,003	21,341
		Capacity: 20,509 BTU/hr		20,509	1,808	18,862

The capacities shown in both tables above are from Mitsubishi's software called Diamond System Builder. As you can see, the numbers don't look too bad for total cooling, with a total capacity deficit of about 2,500 BTU/hr. But the heating capacity is 11,000 BTU/hr lower than the load. Can that possibly work?

Yeah, the winter wasn't terribly cold, but we did get tested a bit. We had about 2,200 heating degree days December through April, which is below the Atlanta average of about 3,000 HDD. We did have a three-day stretch of cold weather when it got down close to our outdoor design temperature each night. The night-time lows were 25° F, 24° F, and 25° F, with daytime highs of 37° F, 40° F, and 49° F. The house stayed warm the whole time. We woke up to an indoor temperature a bit below the thermostat setting, but it caught up when the day warmed up. If we'd had colder weather with daytime highs in the low 20s, I think we would have needed supplemental heat.

NREL Study

For the two occupied homes, MJ8 calculations result in loads that are on average 56% higher than actual measured design loads; Passive House Planning Package calculations resulted in loads that were 34% higher on average. Based on these results, CARB recommends that designers use a method other than MJ8 for calculating design heating loads for superinsulated buildings and that thermal inertial and internal gains be included in sizing calculations. Doing so results in a closer approximation of the building's design load and still provides a slight buffer zone.



Conclusion

- WUFI and Manual J are methods with very different approaches.
- As a result, they give very different answers to the same questions
- We, as thoughtful practitioners, must synthesize that into high quality designs

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