Building America Case Study

Calculating Design Heating Loads for Superinsulated Buildings

Ithaca, New York

PROJECT INFORMATION

Project Name: Third Residential EcoVillage Experience (TREE)

Location: Ithaca, NY

Partners:

Builder: AquaZephyr, LLC

Consortium for Advanced Residential Buildings, *carb-swa.com*

Building Component: Heating, ventilating, and air conditioning

Application: New and/or retrofit; single-family and/or multifamily

Year tested: 2014

Climate zones: Cold (5–8)

PERFORMANCE DATA

Accuracy of Sizing Method:

PHPP method: 30%–37% higher than actual design loads

MJ8 method: 52%–61% higher than actual design loads

Superinsulated homes offer many benefits, including improved comfort, reduced exterior noise, lower energy costs, and the ability to withstand power and fuel outages under much more comfortable conditions than a typical home. The tighter building envelope reduces the heating and cooling loads, requiring much smaller heating, ventilating, and air-conditioning equipment than for a conventional home. Sizing the mechanical system to these much lower loads reduces first costs and the size of the distribution system.

Although these homes aren't necessarily constructed with extra mass in the form of concrete floors and walls, the increase in insulation of the building envelope results in high thermal inertia that makes the building less sensitive to drastic temperature swings and decreases the peak heating load demand. Alternative methods for calculating heating loads that take this inertia into account (along with solar and internal gains) result in smaller and more appropriate design loads than those calculated using Manual J version 8 (MJ8).

During the winter of 2013–2014, the U.S. Department of Energy's Building America team Consortium for Advanced Residential Buildings (CARB) monitored the energy use of three homes in the EcoVillage community in climate zone 6 to evaluate the accuracy of two different mechanical system sizing methods for low-load homes. The homes ranged from 1,300 ft^2 to 1,650 ft^2. Insulation levels were approximately double that required by the 2009 International Energy Conservation Code, and air leakage rates were lower than 0.6 ACH@50 pascals (Pa). Actual heating energy use was monitored and compared to predicted design heating loads from MJ8 and the Passive House Planning Package version 8.5 (PHPP), two calculation methods with very different sizing (see the table on the next page).

Based on these results, the team recommends that internal and solar gains be included and some credit for thermal inertia be used in sizing calculations for superinsulated homes. Implementing these procedures resulted in a much closer approximation of the building's design loads while still providing a slight safety factor for unusual weather.

Building America U.S. Department of Energy

Description

1. The homes in the TREE neighborhood at EcoVillage in Ithaca, NY, are superinsulated structures that have 12-in.-thick walls at R-43 (or 52 if Passive House), R-90 attics, R-35 under slab insulation, triple-pane windows with SHGC at 0.52, and air leakage rates under 0.6 ACH@50 pa.
2. The conditioned area of the test houses ranged from approximately 1,300 ft^2 to 1,660 ft^2.
3. Loads were so small in these homes they only required 9 linear ft of electric resistance baseboard.

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For more information see the Building America report *EcoVillage: A Net Zero Energy Ready Community* at *buildingamerica.gov*.

Image credit: All images were created by the CARB team.

Building Heating Loads	Heating Load Values (Btu/h)			
	Manual J8	Manual J8 with PH Parameters*	Passive House	
			Weather Condition 1	Weather Condition 2
Walls	2,196	1,663	2,122	2,100
Glazing	2,750	2,082	2,139	2,117
Doors	412	312	299	296
Floors	1,259	953	723	723
Ceiling	641	485	474	469
Infiltration	1,641	991	977	976
Ventilation	188	188	183	181
Subtotal	9,059	6,674	6,917	6,861

Comparison of predicted design heating loads from MJ8 and the PHPP
*From weather condition 2

Lessons Learned

Differences between MJ8 and the PHPP include:

- Two outdoor design temperatures are evaluated in the PHPP. These temperatures are daily averages and represent the maximum heating load days: (1) a cold but sunny winter day with a cloudless sky and (2) a moderately cold but overcast day with minimal solar radiation.
- The interior design temperatures used are 68°F for PHPP and 70°F for MJ8.
- Internal and solar gains are deducted from the total design loads in the PHPP, whereas MJ8 ignores both for calculating design heating loads.
- Based on data collected for three homes, the PHPP assumptions and methods for sizing equipment appear to be much more suited to these types of homes than those of MJ8.

Looking Ahead

This research evaluated only one method to calculate design loads that is intended for use with superinsulated structures. That method relies on the evaluation of two distinct design conditions under which the peak design load could occur. Which condition will result in the largest load depends on the orientation of the home, the number of windows, the solar heat gain coefficient (SHGC), and other factors. Thus, CARB recommends that the PHPP software be used to generate the heating design loads for superinsulated homes. However, research findings are currently limited to single-family homes that are smaller than 2,000 ft^2. Until further research on larger homes and in different climates is conducted, CARB does not recommend relying on this method for larger homes or for homes outside of climate zones 5–8.

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