RESEARCH HIGHLIGHT

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Energy Use in Straw Bale Houses

INTRODUCTION

Straw bale houses have walls that are the thickness of a straw bale, roughly 450 mm wide (or 18 inches). These thick walls provide far more insulation than standard house walls filled with fibreglass, cellulose, rock wool or other fibres. Although the insulation value of straw bale walls is under some dispute, there is good evidence that it attains a value of RSI 5 (or R28) or more vs. a typical wall value of about RSI 2.5 (or R14) for an insulated 2 x 6 wall. Note that a 2 x 6 wall with fibreglass insulation is usually listed as having an insulation value of about RSI 3.3 (or R19) but that is only for the sections of insulation. When you add in the losses due to the wood framing, the value drops to about RSI 2.5. Another potential energy advantage of straw bale walls is due to their high mass, relative to stud walls with fibreglass for instance. The mass of the straw and stucco/plaster coatings takes hours to warm up or cool down. This tempering effect of high mass walls can lead to additional energy savings when the outside temperatures are variable, such as in spring and fall. Light houses may have to heat through the night or in the morning, to “take the chill off” until the sun warms up the outside. A house, such as straw bale, with a high thermal mass will often maintain comfortable temperatures without requiring this sporadic heating.

While straw bale houses therefore have a theoretical advantage over conventional houses, there is little good data on how they actually perform. This survey attempted to provide a first cut at comparing the space heating energy consumption of straw bale homes and conventional homes. Many straw bale homes are wholly or partially heated with wood burning appliances. As wood consumption is difficult to measure accurately, the 11 houses in this survey used other fuel sources—gas, oil or electricity. Most surveys of this type compare the measured houses to “control” houses of the same size, construction quality, occupancy, etc. Control houses for this study were too hard to locate, given the diversity of straw bale house design and the use of slab-on-grade foundations. Only three of the eleven study homes had full or walk-out basements. Instead of actual control houses, the energy use of the conventional houses was modelled using HOT2000 software. The measured space heating consumption of the straw bale houses was compared to the modelled energy consumption of conventional 2001 British Columbia (B.C.) building code houses of the same dimensions as the straw houses.

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RESEARCH PROGRAM

The contractor located 11 straw bale houses that used measurable fuel types. He visited the houses, measured floor areas, windows and doors, and examined the energy bills. From the bills, he was able to extract the energy used only for house space heating, by subtracting the energy consumption of appliances, lighting, water heating, etc. Using the measurements of these houses, he created simulated houses built to current B.C. building codes and having 2 x 6 walls. All interior floor dimensions, floor insulation (if any), window dimensions, attic insulation, solar exposure, etc. were the same in the actual straw bale houses and the simulated conventional houses. The simulations used reinforced vinyl double-glazed windows with a 12.5 mm (half inch) air gap and insulated spacers, according to common B.C. construction practice, even if the windows of the straw bale houses were of a lesser quality. When the study home included windows with high-efficiency elements such as low-E tints and argon gas, the modelled home windows matched these details. The simulation program used, HOT2000, has had wide application in the Natural Resources Canada (NRCan) R2000 program and in the Energuide for Houses retrofit program. It has been extensively tested and is typically within 10 per cent of measured data on individual houses, perhaps with a small bias to overpredict energy usage. When a number of houses are averaged, the resulting mean should be close to the truth. In cases where the same hot water heater was used for space heating and domestic hot water use (dishes, showering, etc.), the modelling of these houses (and the energy usage in the table below) included simulated hot water usage as well.

One qualifier: B.C. building code requires some form of mechanical ventilation to be installed. The occupants of the straw bale houses may or may not have used the ventilation systems. In the simulated houses, an air change rate of 0.2 air changes per hour (ACPH) was used in the simulations to reflect both the natural infiltration rate and whatever use of mechanical ventilation. This is relatively low but still may be higher than the ventilation rates actually experienced in the straw bale homes. Similarly, the modelled house air leakage was set at 4.5 air changes per hour at 50 Pa, typical for new B.C. stock. There were no airtightness tests of the straw bale houses. The 40 mm (1 1/2 inches) thick stucco skins on the inside and outside of the straw generally provide good air barriers (and add to the thermal mass of the wall construction).

FINDINGS

House space heating consumptions listed in the table below. Electrical houses had their kWh readings changed to gigajoules (GJ), to provide an easier comparison to houses using other fuels. The energy use listed is usually for space heating only, with some exceptions as described above.

The straw bale houses used over 20 per cent less space heating energy when compared to the modelled conventional houses. Some of this may be due to underventilation of the straw bale houses and a small tendency for the model to overpredict energy consumption in the conventional houses. However, the size of the savings and the consistency (9 of 11 houses) indicate that the straw bale houses in this survey require significantly less space heating energy than comparable conventional houses.

House	Actual energie use (GJ)	Model energie use (GJ)	% SB vs. Model area	Total inside floor (m^2)	Year built	Bale wall type	Comments
1	115.6	100.9	12.7	133	1996	Post and beam	30% total wall area glazed; 78% single glazing
2	52.9	48.6	8.3	108	1998	Post and beam	20% total wall area glazed; 100% single glazing; hydronic heat
3	98.6	103.5	-4.7	156	1998	Post and beam	Hydronic heat: interior work unfinished
4	24.6	31.9	-22.8	48	1997	Load bearing	Cottage apartment and store room
5	96.7	129.7	-25.4	210	2000	Log post and beam	Two storey; hydronic heat; ventilation system not used
6	104.7	129.4	-19.1	189	2001	Modified post and beam	Hydronic heat
7	56.4	81.7	-31.0	218	1999	Modified post and beam	Water source heat pump
8	152.9	249.5	-38.7	267	1998	Timber frame	Two storey; basement apartment; B & B
9	142.1	186.3	-23.7	209	2000	Timber frame	Two storey; partial hydronic heat
10	105.7	137.4	-23.1	153	1999	Post and beam	HRV in use
11	73.4	95.7	-23.3	91	1998	Load bearing	Ventilation system not used
Mean	93.1	117.7	-21	162			

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Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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