Maisons
CanadaLog & Hybrid Timber
Homes Inc.

How energy efficient is a log home

Source: CMHC-SCHL Q&A, from cmhc-schl website

Question: How energy efficient is a log home and can you use any type of heating system?

Answer: Design and construction methods (size of logs, type of joining and methods of sealing joints), siting and maintenance all affect energy efficiency. Proper design is one key to energy efficiency in any home. Lots of windows, doors and skylights raise utility bills, unless you use proven solar design and excellent glazings. For instance, north-facing glass is usually a major loser of heat.

Airtightness is also important. Proper sealing of corners and roof intersections is critical, especially with cathedral ceilings. Log homes with many corners, joints, and roof angles can consume more energy than simpler designs. A high-quality roof package is important for energy efficiency and comfort. A well-built log home also has energy conservation benefits of thermal mass.Thermal mass effects are where materials absorb, store, and slowly release heat over time. Walls and floors with heavy construction, such as concrete or logs, do this well. Thermal mass effects occur best with logs in their natural, large, round state. Thick natural logs also are reasonably good insulation. There have been several studies on the effects of thermal mass and resulting energy savings. While it is clear that high mass buildings may operate more efficiently in moderate weather (spring and fall), there is no consensus yet on whether thermal mass will save you money in the winter months. Any type of heating system will work well in a log home.

Source: US Department of Energy

The R-Value of Wood

An R-value (Btu/ft2/hour/oF) is the rating of a material's resistance to heat flow. The R-value for wood ranges between 1.41 per inch (2.54 cm) for most softwoods to 0.71 for most hardwoods. Ignoring the benefits of the thermal mass, a six inch (15.24 cm) thick log wall would have a clearwall (a wall with no windows or doors) R-value of just over 8. Compared to a conventional wood stud wall [3½ inches (8.89 cm) insulation, sheathing, wallboard, a total of about R-14] the log wall is apparently a far inferior insulation system. Based only on this, log walls do not satisfy most building code energy standards. However, to what extent a log building interacts with it's surroundings depends greatly on the climate. Because of the log's heat storage capability it's large mass may cause the walls to behave considerably better in some climates than in others.

Logs act like "thermal batteries" and can, under the right circumstances, store heat during the day and gradually release it at night. This generally increases the apparent R-value of a log by 0.1 per inch of thickness in mild, sunny climates that have a substantial temperature swing from day to night. Such climates generally exist in the earth's temperate zones between the 15th and 40th parallels.

R E P R I N T E D I T I O NLogBuildingNews2

The National Research Council of Canada (NRC) conducted a study1on R-values of log walls for the National Energy Code in 1996. To facilitate the calculation of the R-value for log walls using a simple hand calculation, the NRC introduced an adjustment factor called "profile factor" to accommodate the profile of scribed log wall (thickness of the wall at the joints is less than the diameter of the logs). The profile factor for scribed fit log walls was found to be dependent on log diameter and the wall joint detail and to range between 0.7 and 0.84. The air close to the wall (Interior and exterior)contributes to the total R-value of the wall by approximately 0.88.The R-value of a round scribed wall canbe then calculated by using following equation: R-value = [(mean log diameter xwood resistivity) + resistivity of air films] xprofile factor.

It is important to understand that this very simple calculation is based on numerous simplifications and assumptions (e.g.disregards the contribution of the mineral insulation in the lateral groove). Therefore, the results should be used with caution. Here I want to share a story with you. Once I was approached to provide technical information to a builder who was" questioned" by the building official regarding the R-values of log walls. The builder sent me a slick computer-generated picture of a log house that I would put in the category of a "glass structure with a log infill." Beautiful home, but what kind of R-values are we talking about here? One half of the house was made of material(windows) that has thermal properties equivalent to 2" thick cedar blank. In that case, the importance of R-values of log homes was overestimated. According to research studies conducted in Canada and the US ,2, 3the heat loss through handcrafted log walls represents approximately 17 percent of total loss forth structure. On the other hand, the air infiltration/leakage can account for up to50 percent of all heating losses in a hand-crafted, chinkless log home. Although the reports are not conclusive, the pattern for a large population of homes is quite clear. The lateral joints were not identified as the main pathways for the air infiltration/leakage but, rather, each of the following items were shown to account for larger portions of the total heat loss :

• the ridge area of vaulted ceilings

• the joint between the plate log and the roof

• the protrusions of logs through the exterior walls (both frame and log)

• the connections between the floor and a sill log

• the connection of the log wall with the frame wall

• the window/door–to-wall log interfaces

• the log-corner interface.

It is very important to pay attention to these structural details during design and construction, as they make a large difference in overall energy efficiency of a log structure. It was shown that gasketed walls with tightened through-bolts perform better than those just using fiberglass, and that exterior/interior chinking reduces air infiltration even further.Last, is the issue of thermal mass; a difficult subject to address. While it is a relatively simple exercise to calculate the thermal mass (heat storing capacity) of a log wall, it is rather difficult to estimate how this affects the overall energy consumption of a particular building. Nevertheless, the effect of heat mass was confirmed by long-term testing in a study4conducted by the US Department of Commerce. In the 28 week-long test, the test house with nominal R-10 log walls "consumed" the same amount of energy as a light frame building of the same size and shape

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According to the National Research Council of Canada, one inch of Northern Pine White gives resistance of 2.21 (R = 2.21), hence:

6" log wall = R-13.26

8" log wall = R-17.68

10" log wall = R-22.10

Reference:

Technical guide for Milled-log Buildings, report 13142, published by the

Canadian Construction Materials Center

National Research Council of Canada

Ottawa (Ontario)

Canada K1A 0R6

NAHB Report

In 1991, the NAHB (National Association of Home Builders) Research Center conducted a study for the LHC (Log Homes Council). Excerpt from the study:

"the thermal mass of log walls significantly reduces energy use for heating in cold climates. The study compared the actual energy use by eight log homes and eight well insulated foam houses during one winter. The houses were evenly divided between upstate New-York and Montana. The study also compared the home's actual energy consumption. The results led to the conclusion that log homes are as energy efficient as frame houses, even though the average R-value of the log walls was 44 percent lower than the R-value of the frame walls.

Resource:

Research Report on Energy Efficiency of Log Buildings

Log Homes Council National Association of Home Builders

15th & M. Streets, N.W.

Washington, D.C. 20005

National Bureau of Standards Test

Confirmation of Energy Conserving "Thermal Mass Effect"

for Heavy (Log) Walls in Residential Construction

Summary of Test Findings

A study was conducted by the National Bureau of Standards (NBS) for the Department of Housing and Urban Development (HUD) and the Department of Energy (DOE) to determine the effects of thermal mass (the bulk of solid wood log walls, or brick and block walls) on a building's energy consumption. For the test, six 20'x20' test buildings were built on the grounds of the National Bureau of Standards, 20 miles north of Washington, DC, in the fall of 1980. Each structure was identical except for construction of its exterior walls. The buildings were maintained at the same temperature levels throughout the 28-week test period between 1981 and 1982. NBS technicians precisely recorded energy consumption of each structure during this entire period.

Test Results

During the three-week spring heating period, the log building used 46% less heating energy than the insulated wood frame building.

During the eleven-week summer cooling period, the log building used 24% less cooling energy than the insulated wood frame building.

During the fourteen-week winter heating period, the log building and the insulated wood frame building used virtually the same amounts of heating energy.

The National Bureau of Standards technicians conducting the test calculated the R-value of the log building, which was constructed with a 7" solid square log, at a nominal R-10. It rates the insulated wood frame building, with its 2'x4' wall and 3-1/2" of fiberglass insulation, at a nominal R-12, thus giving the wood frame structure a 17% higher R-value. Yet during the entire 28 week, three season test cycle, both buildings used virtually identical amounts of energy. This led the National Bureau of Standards to conclude that the thermal mass of log walls is an energy-conserving feature in residential construction.

NBS Tests Confirm Energy-Conserving "Thermal Mass Effect" of Log Walls Full Report

In the first extensive field testing of its kind, researchers at the Commerce Department's National Bureau of Standards (NBS) have confirmed that walls of heavyweight construction (such as those built with solid wood logs, concrete block or brick) exhibit an energy conserving "mass effect" in residential buildings during the summer and the intermediate heating season representative of fall or spring in a moderate climate. However, no mass effect was observed during the winter heating season.

According to NBS researchers, these extensive field tests should help resolve a controversy over whether residences having heavyweight walls consume less energy for space heating and cooling than buildings having lightweight walls of equivalent thermal resistance. The National Bureau of Standards research team found that the heavyweight walls (including building number 5, the log structure) "did exhibit a thermal mass effect and thus save significant amounts of energy both in the summer cooling season and the intermediate heating season representative of fall or spring in this (Washington, DC) area."

The Use of R-Values

Most state and local building codes require specific "R-Values," or thermal resistance values, for the walls, ceilings, and floors of houses. The R-Values in these codes vary with geographical location and climate considerations. The Building Systems Councils' technical staff and other industry professionals have often challenged the exclusive reliance on R-Values alone to rate the energy efficiency of a wall's building materials while ignoring the thermal mass effect inherent in heavyweight (log) walls. R-Values are recognized by most professionals to be a reliable indication of the thermal performance of a material--under conditions of constant interior and exterior temperatures. The Building Systems Councils' technical staff argues that these are not the conditions that exist in the "real world," where outdoor temperatures vary widely during a typical day-night cycle. To obtain a true rating of building's thermal efficiency in these conditions, building codes must also consider the "mass effect" of heavyweight (log) walls.

What Is "Mass Effect"?

According to NBS researchers, "the mass effect relates to the phenomenon in which heat transfer through the walls of a building is delayed by the high heat (retention) capacity of the wall mass. Consequently, the demand for heating or cooling energy to maintain indoor temperature may, under some circumstances, be pushed back until a time when wall heat transfer and equipment operating conditions are most favorable." This heat retention phenomenon is also referred to as "thermal capacitance" or time lag--the resistance of a material (such as solid wood walls) over time to allow a change in temperature to go from one side to the other.

How Mass Saves Energy

NBS researchers explained the energy saving effect of mass during the summer cooling season this way: "In an insulated wood frame building, which is considered to have low mass, the maximum wall heat gain rate during this season is operating most often and working the hardest. In a heavy walled building (such as the log building), however, the heat transfer lag means the maximum wall heat gain rate general during the cool night period when the cooling plant is operating least often or not at all. Consequently, the cooling energy requirement is reduced."

The NBS test showed that the log structure performed better than the insulated wood building in the intermediate heating season and the summer cooling season; however, there was no appreciable difference during the winter heating season. During the winter heating season, no effect of mass was noted since all insulated buildings and the log building required comparable amounts of heating energy each hour to maintain their predetermined indoor temperatures.

Test Limitations

As with all such test procedures, these tests have their own limitations, according to NBS, and therefore these factors should be considered in using the results. The structures had no partition walls or furniture; items which would tend to give the wood frame structures some of the mass effect. Also, the buildings were closed at all times, and the buildings were constructed to maximize the mass effect attributable to the walls. Also, the results are very climate dependent, and results relate to the moderate climate found in the Washington, DC, area.

Future Tests

Future tests to be carried out on the six buildings will address some of these limitations by installing partition walls and opening windows when appropriate. Moreover, a recently developed NBS computer model that predicts the energy consumption for multi-room structures will be validated and subsequently used to extend the NBS test results to other locations and climates around the country.

Conclusion

The Building Systems Councils is gratified that its long struggle to gain recognition for the importance of "thermal-mass" has been confirmed by these tests and that the energy efficiency of log homes has been proven. The Council is presently participating in a similar testing program being conducted by the Oak Ridge National Testing Laboratory in Albuquerque, New Mexico, and hopes to add the results of those tests to this material in an effort to gain acceptance of "thermal mass effect" in building codes throughout the country. We further await the results of future tests to be performed by the NBS at this test site and the results of the NBS computer-modeling program.

Technical Information

Description of Test Buildings

Six 20' wide and 20' long one room test buildings with a 7-1/2" high ceiling were constructed outdoors at the National Bureau of Standards facility located in Gaithersburg, Maryland (20 miles north of Washington, DC).

Construction Details of Walls

Building #1

An insulated wood frame home, nominal R-12 (without mass) with 5/8" exterior wood siding, 2x4" stud wall, 3-1/2" fiberglass insulation, plastic vapor barrier, and 1/2" gypsum drywall.

Building #2

An un-insulated wood frame home, nominal R-4 (without mass) with same detail as above, but without the fiberglass insulation.

Building #3

An insulated masonry home, nominal R-14 (with exterior mass) with 4" brick, 4" block, 2" polystyrene insulation, plastic vapor barrier, furring strips and 1/2" gypsum drywall.

Building #4

An un-insulated masonry home, nominal R-5 (with exterior mass) with 8" block, furring strips, vapor barrier, 1/2" gypsum drywall, and no polystyrene insulation.

Building #5

A log home, nominal R-10 (with inherent mass) with 7" solid square wood logs with tongue and groove mating system, no additional insulation, no vapor barrier, and no interior drywall.

Building #6

An insulated masonry home, nominal R-12 (with interior mass) with 4" brick, 3-1/2" loose fill perlite insulation, 8" block and 1/2" interior plaster walls.

Interior/Exterior Surfaces

Interior surfaces were painted off-white. Exterior surfaces of buildings 1,2 and 4 were painted approximately the same color as the exterior face brick of buildings 3 and 6.

Windows

Four double-hung, insulating glass (double pane) windows, with exterior storm windows, two in south facing wall, two in north facing wall. Total window area was 43.8 sq. ft. or 11% floor area.

Doors

One insulated metal door on east wall. Total door area was 19.5 sq. ft.

Ceiling & Roof System

Each test building contained a pitched roof with an attic space ventilated with soffit and gable vents. The ventilation opening was consistent with the HUD Minimum Property Standards. Eleven inches of fiberglass blanket insulation (R-34) was installed over the ceiling of each test building.

Floor System

The edges of the Concrete slab-on-grade floors were insulated with 1" thick polystyrene insulation at both the inner and outer surfaces of the footing.

Heating/Cooling Equipment

Each test building was equipped with a centrally located 4.1 kW electric forced air heating plant equipped with a 13,000 Btu/h split vapor-compression air conditioning system.

Technical Report Available

A complete technical presentation of this study was prepared by D.M. Burch, W.E. Remmert, D.F. Krintz, and C.S. Barnes of the National Bureau of Standards, Washington, DC, in June, 1982, and is entitled "A Field Study of the Effect on Wall Mass on the Heating and Cooling Loads of Residential Buildings." This study was presented before the "Thermal Mass Effects in Buildings" seminar held in Knoxville, Tennessee, on June 2-3, 1982, Oakridge National Laboratory, Oakridge, Tennessee.

Copies of this report and other studies are available by writing to: US Department of Commerce, National Bureau of Standards, Center for Building Technology, Building 226, Room B114, Gaithersburg, MD 20899.

BSC's Participation

The log building used by the National Bureau of Standards for this energy conservation study was donated and erected by members of the Log Home Council. Since the inception of the Log Homes Council in 1977, well over a quarter of a million dollars have been spent on research and testing projects related to the log home industry.

Members of the Council have voluntarily contributed tens of thousands of hours of their time to accomplish these tasks for the benefit of the industry and the builders and owners of log homes. On January 1, 1982, the Log Homes Council affiliated with the National Association of Home Builders as part of the Building Systems Councils. In July 1985, the Council membership expanded due to a merger with the North American Log Builders Association. All members of the Council are also individual members of the National Association of Home Builders and through their dues support the many worthwhile activities of the NAHB. The Log Homes Council is a non-profit, voluntary membership organization representing some sixty manufacturers of log homes.

A research report published by the Log Homes Council of the National Association of Home Builders, 1201 15th Street, NW, Washington, DC 20005 -- (800) 368-5242 ext. 576 Barbara K. Martin, Executive Director

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Research Report on Energy Efficiency of Log Home Buildings

Margaret Lowe, in her article entitled "Myths and Truths of Log Home Ownership" addresses the efficiency of Log Homes.

She wrote: "Myth #1: Log homes are not energy-efficient: FALSE, in capital letters. Early in this decade, the nation's model energy code finally recognized what the log home industry had claimed for 20 years -- that a log wall's thermal mass makes it as energy-efficient as a well-insulated wall. This claim wasn't acknowledged during all those years because thermal mass is difficult to quantify.   Log home owners had the heating bills to prove it was true. but the Department of Energy and national code officials needed more than empirical evidence. So for 13 years the Log Homes Council (a division of the National Association of Home Builders in Washington, DC) gathered scientific statistics from independent research projects to substantiate its claim.

"At the heart of the debate were R-Values, the measure of heat transfer through materials. When the energy crisis struck in the mid 1970's, state and federal governments had to quickly develop new energy-performance standards for residential construction and all the building materials used in that construction. Since the situation was a crisis, and the R-value methodology already existed, it became the standard, no questions asked.

"R-value measures a material's resistance of heat from one side to another. Log's have a relatively low resistance to heat transfer. In fact, they actually absorb and store heat in their cellular structure. This puts them at a serious disadvantage in the cold weather states. Producers had to overbuild their houses in order to meet total R-value requirements. This not only drove up construction costs, it also created a lot of confusion.

"The opposite of R-value, thermal mass, measures a material's capacity to absorb, store, and slowly release heat over time when temperatures drop.   Logs do this very well because of their cellular structure, bulk, and thickness.   The problem, was proving it.

"An early breakthrough came in studies conducted by the National Institute of Standards for HUD in 1981-82. The studies proved thermal mass does significantly reduce heating and cooling loads in moderate climates. however, energy experts continued to question the value of thermal mass during the winter months in northern climates where heat is a constant need (or during summer months in southern climates where cooling is in need) and thermostat settings are opposite outdoor temperatures.

"Two more recent studies, both conducted in cold climate states, proved the log home industry was right.

"In 1990, an independent testing agency, Advanced Certified Thermography, conducted a study for the Energy Division of the Minnesota Department of Public Service. Its focus was heat loss through air leakage, which was assumed to be a special problem with log homes because of their many joints. The study found the industry's improved joint construction and its use of expanded foam sealants and gaskets at joints and corner intersections had substantially reduced air-infiltration rates. The study concluded air leakage in a well-built, modern log home is not due to its log walls. In fact, in the 23 homes studied, it found air leakage occurs in the same places it occurs in conventional frame homes: at the top of cathedral ceilings, around window and door frames, and along the tops of walls where they join the roof.

"A second study, conducted in 1991 for the Log Homes Council by the National Association of Home Builders (NAHB) National Research Center, discovered the thermal mass of log walls does significantly reduce energy use for heating in cold climates. It based its conclusions on a comparison of actual energy use in eight log homes to the actual energy use of eight well-insulated frame houses during one winter.   The 16 homes were evenly divided between upstate New York and Montana. The study also compared the homes' actual energy use to their predicted energy consumption. The results led to the conclusion that log homes were as energy-efficient as well-insulated frame houses. What is especially significant about this study is that the average R-value of the log walls was 44 percent lower than the average R-value of the frame walls. Obviously, the thermal mass performance of log walls is an advantage to log home owners."

According to an article by **Peter M Hart** of New England Log Homes: "the oft-cited R-value (resistance) factor is meant to be a measure of heating efficiency but actually, that concept is both inaccurate and misleading. As an example, an illusion is created to convey to the homebuyer that if three inches of fiberglass is good, then six inches is twice as good and naturally, 12 inches is four times better.

"NOT SO! After a certain amount of insulation has reached optimum, the overage of insulation is waste and does not justify the additional cost.

" To arrive at the R-value of a particular type of insulation, heat is passed through the material by conduction, under fixed temperatures and only when the material is completely dry. No consideration is given to convection, radiation loss, solar input, heat and storage capabilities and the influence of moisture.

"For instance, a test of fiberglass sample rated R-13 when dry is reduced to R-8.3 when conditions reach a moisture content of 1.5% -- a loss of 40% insulation efficiency."

These R-value standards were determined under unrealistic conditions due to the fact that we all live in a humidity laden atmosphere. This humidity level is compounded in the home environment.

Table 1 Thermal Resistivity of Various Softwood Species Used in Log Construction

Wood Species	Specific Gravity	Thermal Resistivity (h·ft2·°F/Btu·in)	
		Oven dry	At 12% MC
Western Red Cedar	0.33	1.7	1.5
White Spruce	0.37	1.6	1.3
Eastern White Pine	0.37	1.6	1.3
Western White Pine	0.40	1.5	1.2
Lodgepole Pine	0.43	1.4	1.2
Eastern Red Cedar	0.48	1.3	1.1
Red Pine	0.46	1.3	1.1
Douglas Fir	0.51	1.2	1

(Source: Wood Handbook-Wood as an Engineering Material, USDA, 1999)