Research Report
IDWR Energy Division
Log Homes

Study Shows That Log Homes in Cold Climates Can Meet Energy Efficiency Standards

Utility representatives and code officials in the colder parts of the Pacific Northwest have long questioned whether log homes could comply with energy efficiency standards. Claims that log walls are self-insulating because of thermal mass heat storage have complicated analyses.

The RCDP Cycle III log home study sought answers to the following questions:

1. What U-factors do log walls achieve as installed, and how do they compare to U-factors calculated using standard procedures and assumptions?
2. Of what benefit is thermal mass of logs?
3. Can long- and short-term energy use of homes with log walls be accurately simulated?
4. How well do exterior log walls and typical log home details prevent air leakage, both initially and after settling and moisture stabilization?

Research Design

RCDP investigators recruited four homes in Idaho for long-term testing of heat usage and air leakage rates. Two of the homes underwent intensive short-term testing. The RCDP team also measured air leakage rates at two additional homes.

All of the homes were constructed from dry logs (standing dead or kiln-dried timber), and all were machine-scribed. The sample included one full round and five Swedish Cope systems. All were produced off-site as kits by commercial log builders.

Figure 1. Idaho log home that meets requirements of the Long Term Super Good Cents program. The home features R-50 ceilings, R-38 floors, and vinyl frame windows with low-e glass and argon gas fill. But its most impressive feature is tightness: It tested at 1.76 ACH at 50 Pascals. The home also takes advantage of passive solar heating — 79% of the glazing faces south. The home would qualify under the program without solar heating if it had a heat recovery ventilation system.

Long-term monitoring required the builder to install separate electric meters on the heating, refrigeration and water heater circuits. The Energy Division of the Idaho Department of Water Resources installed a temperature logger that recorded upper, main, crawl space or basement temperatures, and outside temperatures.

Based on the report *Residential Construction Demonstration Project Cycle III: The Thermal Performance and Air Leakage Characteristics of Six Log Homes in Idaho* by Carolyn Roos, Ken Eklund and David Baylon, Bonneville Power Administration, DOE/BP-2213, August 1993.

Long-term testing began in fall 1991. Researchers took at least a heating season's worth of weekly energy and temperature data on the four homes. They used a blower door to test air leakage at the beginning and end of the long-term tests.

Ecotope, Inc. of Seattle performed short-term testing in January 1993 with assistance from the Energy Division. Each short-term test lasted approximately 3 days. Data loggers recorded measurements taken every 8 minutes of interior and exterior air temperatures, solar data, and log wall surface temperatures and heat flux. Blower door and tracer gas decay tests measured air leakage.

Ecotope analyzed data from both the long-term and short-term thermal tests. The Energy Division reviewed and summarized air leakage control findings.

Although the study sample was small, researchers have confidence in their findings. First, results of long-term testing corroborate short-term results. In both tests measured energy consumption was virtually the same as that predicted by simulation using log wall U-factors developed with standard engineering assumptions. Second, observations on air leakage are direct and are confirmed by a major study by the Energy Division of the Minnesota Department of Public Service (reported in *Energy Related Performance Testing of Minnesota Log Homes*, June 1990).

Air Leakage, Log Wall Thermal Performance, and Air Sealing

Researchers report the following findings:

- Log wall performance is consistent with ASHRAE Handbook values for thermal conductivity of wood. (See table 1.)

- For walls of equal thickness, an insulated wall transfers heat less readily than a wall made of solid wood.

- Log homes can meet the requirements of the Long Term Super Good Cents program if they have high performance windows or other building components and/or advanced air leakage control plus heat recovery ventilation.

Table 1
U-Factors and R-Values of Log Walls

Avr. Log Diameter	U-Factor	R-Value
6"	0.148	6.8
8"	0.111	9.0
10"	0.089	11.2
12"	0.074	13.5
14"	0.063	15.9
16"	0.056	17.8

Note: Average wall thickness = 90% average log diameter.

- Air leakage in log homes depends on construction techniques. Homes will maintain their original level of tightness if logs are dry and stable when the home is sealed. Tightness must be determined with a blower door test. The study average was 5.6 ACH at 50 Pascals of pressure.

- Heat loss characteristics, not heat storage mass, are the main factors affecting log wall thermal performance in climates where thermostat setpoint temperature exceeds exterior temperature for extended time periods.

- The mass impact of log walls on heat transfer is relatively small because it depends on exterior heat to reduce the transfer rate from interior to exterior. In climates where thermostat setpoint temperature exceeds outside temperature for extended periods, the source of exterior heat is solar energy. The impact of this contribution is small and depends on solar exposure of the exterior walls. The effect on a building with complete solar exposure of the exterior walls is a 4% increase in R-value.

- Calculated thermal resistance values using standard engineering principles are good approximations of log wall thermal performance in cold climates. (See figure 2.) Using these values to model the building's short- and long-term energy use in a simulation program such as

Table 2
Effective Air Sealing Methods in Log Homes

Joint	Sealing Methods *Options for both chinked and chinkless systems.*
Linear joint between logs	Insert a triangular foam backer rod into the joint or space between logs on both the interior and exterior sides of the wall. Carefully choose the size of the backer rod to fit the space between logs. Apply a layer of acrylic latex chinking on top of the backer rods. —or— Apply an acrylic rubber caulk at the joint on both sides of the wall. —or— Lay a closed cell, 1/2" minimum foam gasket between precision milled Swedish Cope logs that have a tongue in the bottom of the log fitting into a groove in the top of the log underneath.
End joints between logs	Cut a notch or hole vertically into both ends of the logs. Caulk a tightly fitting board or spline and pound it in to hold the ends and seal the joint.
Corner joints	Seal inside and out with chinking or caulk.
Log ends	Seal by laying a gasket of 1/2" minimum compressible closed cell foam between logs at the end and spiking through it. Cover the edges of this gasket with the corner chinking. —or— Seal by caulking between the logs at the point where the corner is chinked such that the two seals intersect.
Checks	Fill with transparent caulk.
Door and window frames	Chink or caulk the joint between logs and dimensional lumber frames. Caulk the joint between dimensional lumber frame and door jamb or window.
Ceiling deck	Lay heavy plastic on top of the roof deck and seal it at all joints and edges. Deck planking should be fully dried and of high quality to avoid shrinking.
Gable wall ends	Chink or caulk the entire line where the ceiling meets the gable, taking care to fill each groove in the plank deck where it meets the gable end. —or— Nail the planks to the log at each side. Then, cut a slot between the nailings into the underlying log. Lay a generous quantity of caulk into the slot. Insert a continuous spline to form a seal.
Eave	Caulk or chink this joint on both the interior and exterior sides of the wall. —or— Apply caulk on top of the log where the ceiling deck contacts it.
Perlons	Chink around perlons on both the interior and exterior sides of the wall. —or— Bed perlons in caulk and closed cell foam. Drill a hole along the sides of the perlon and pound in a caulked spline. Caulk over the top.
Floor	Install the subfloor using a building adhesive at all panel edges. Chink or caulk the joint between the logs and floor.

General:
Caulks, chinking and gaskets should be of the highest quality. Caulks and chinking should be highly durable and flexible, such as acrylic rubber. Gaskets should be thick, durable, closed cell material.

Logs should be entirely dried and cured when placed and securely spiked every 3 feet or otherwise mechanically fastened at multiple points.

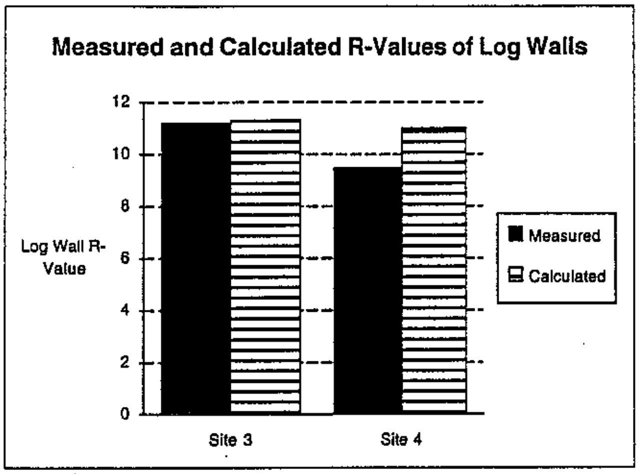

Figure 2. Calculated R-values using standard engineering assumptions are good approximations of log wall thermal performance in cold climates. The calculated R-value is higher than measured at Site 4 because of air leakage through unsealed log ends into spaces between logs.

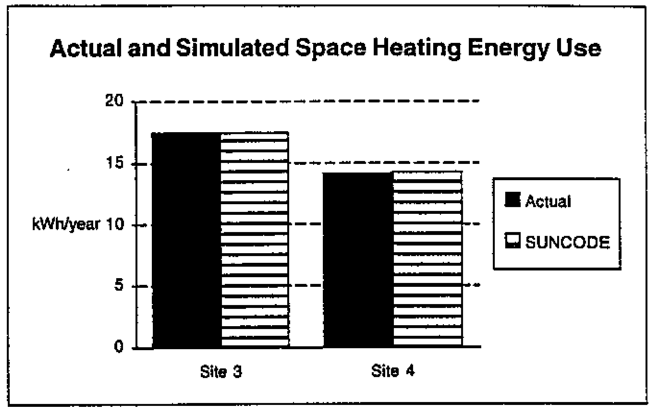

Figure 3. Accurate estimates of log home space heating energy requirements can be made with heat loss factors calculated using standard engineering assumptions and the SUNCODE simulation program.

SUNCODE produces highly accurate results. (See figure 3.)

- Major leakage areas are corners, log ends, ceiling/wall seams, floor/wall seams, and door and window frames — not linear cracks between logs.

- Failure to seal log ends allows air leakage into the space between logs and increases thermal transmission, even when the space is sealed from inside the home.

What Utilities and Code Officials Can Do to Improve Energy Efficiency of Log Homes

The study demonstrated how to improve compliance of log homes with energy efficiency standards:

- Qualify the home using WATTSUN and log wall values in table 1. If exterior walls have documented and legally protected access to a minimum of 80% direct solar exposure between 9 a.m. and 3 p.m. during the entire heating season, divide log wall U-factors by 1.04. The WATTSUN assumptions for mass are valid and pertain to storage of solar gains through windows — not the loss of heat through walls.

- Use any of these options to qualify the home: A conditioned basement reduces the heat loss impact of log walls. High performance glazing with U-factors as low as 0.25 may offset the lower R-values of log walls. Advanced air leakage control plus heat recovery ventilation, window area tradeoffs, and passive solar design are also options.

- Make sure the home is designed to control air leakage. All intersections of log walls with each other, with the floor and ceiling, and with window and door frames must be sealed with high quality, flexible sealant. Logs must be dry and the structure stable for an effective seal. Table 2 describes air sealing details.

- Check the air leakage control system with a blower door. A prescriptive air leakage package cannot be designed because of the wide variety of log building techniques.

If you have questions or comments about the information presented, please contact your local BPA Area or District Office Representative.

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DOE/BP-2152
October 1993
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