Passive Solar Heating
An Energy Factsheet

EEM-01258

Solar energy is often discounted as a viable energy alternative in northern latitudes such as Alaska. In reality, the energy of the sun can provide a significant portion of Alaska's heating needs. The most efficient and least expensive way to tap this resource is through design and construction of houses that collect and store solar energy without fans, pumps or other mechanical devices. Passive solar heating makes use of warmth moved by the natural processes of reflections, radiation, conduction and convection.

The Solar Energy Resource

Passive solar heating, especially when used in conjunction with conservation, can significantly reduce Alaskan dependence on costly fuels. For example, two identical houses, sitting side by side and facing south, will receive the same amount of solar energy. However, if one is more heavily insulated than the other and has less cracks where air can leak in and out, it will retain more heat, and require less fuel over the heating season. In fact, insulation may prove to be the most important element of passive solar design.

Insolation (incoming solar radiation) is usually measured in terms of the number of BTUs striking a square foot of surface during a specified time period. The amount of insolation received at a given point in the day is dependent upon the area and thickness of cloud cover as well as the sun angle and the number of hours of available sunlight. Because of the interplay of these factors, insolation statistics do not necessarily correspond with latitude e.g. Juneau doesn't receive more solar radiation than Fairbanks.

In Alaska, those regions with Continental (Interior) and Transitional (Southcentral, Southwest, and Northwest) climates are the areas where solar heating would most likely be practical. In March, the average insolation on a vertical south-facing surface in BTU/ft^2/day is 1687 for Matanuska, 1892 in Bethel and 1808 in Fairbanks. A vertical surface receives its maximum insolation in March and April; a horizontal surface receives its maximum insolation in May and June.

For efficient passive solar heating, a house must serve as a 1) solar collector, 2) heat storehouse and 3) heat trap.

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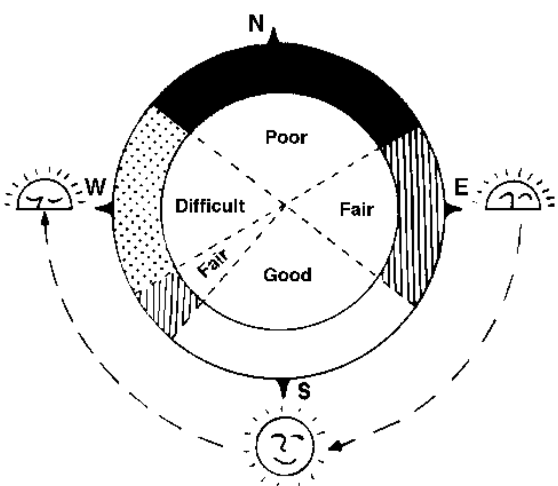
The House as a Solar Collector

Every surface of a building which is directly exposed to the sun's rays is collecting solar energy. Other surfaces, not directly exposed to the sun's rays, can be heated by convection, conduction and radiation. The passive solar house maximizes this collection by:

- Siting considerations. During the heating season, the sun's path makes an arc in the southern sky. When designing and constructing a passive solar house, the consumer should be aware of the placement of trees, other houses and mountains which might stand between the house and the sun's path in the sky. These objects may create shadows on a building and reduce the solar collection for that section of the house.



- House orientation and shape. South sides of houses receive the most solar radiation during the winter. East and west sides receive more solar radiation in summer than in winter. When designing a passive solar house, make the south side of the house longer than the east/west side. But don't build a long, one story California Ranch style house, because you have too much surface area of roof and walls where heat is lost.

- Window Placement. South-facing glass windows allow direct sunlight to heat the house interior. In an energy efficient house, south facing windows can provide up to 30% or more of the heating load. An overhanging eave or awning on south-facing windows will prevent overheating during the summertime. Also, too much glass on the west side of the house, where the low evening sun that hangs for hours, can easily overheat rooms that have already been warmed all day by the southern sun.

- Glass Design. Maximize the R-value of windows without inhibiting visibility. New low emissivity glass will decrease radiant heat loss and increase R-value, without markedly lowering visibility.

- House color. Dark colors absorb more sun energy that light colors do. Light interiors reflect more light and reduce lighting needs.

- Solar greenhouse. When attached to a south wall, a solar greenhouse provides additional collector area as well as space for house-plants and food production in winter months.

Storing Passively Gained Solar Heat—Not an Alaskan Strategy

The usual rule of thumb about passive solar design routinely includes an indexed amount of what is termed "Thermal Mass" in the home. This typically is accommodated by designing the solar gain space with a large amount of concrete masonry or other massive building material to store the solar heat during the day and release it (theoretically) back to the living space at night when the sun has set. But is this an economical strategy for Alaska? The answer is generally no! Why is this?

The rule of thumb for passive solar design which recommends one cubic foot of concrete for every square foot of solar aperture area was developed in the southern and southwestern U.S. where substantially more solar gain is to be had during the winter heating months than in Alaska. This thermal mass question needed to be tested with research, so in 1983-1984, Richard Seifert conducted a study of the effects of thermal storage mass for the heating of a test building in Fairbanks, at the University of Alaska. The conclusions from this testing indicate that it is not really feasible to size a mass system such that it can function well for any significant portion of the year. What happens is that for the major portion of the heating season (from mid November to mid February) the mass is of no practical use. Even during the best solar heating season of the year (March and April), the storage was useful on only 22 of 57 days (38%) . The fundamental conclusion is that sizing a storage system to moderate overheating and store useful heat for later release is, at subarctic latitudes, very limited. And there is the additional factor of high cost for inclusion of thermal storage in a building, so it is difficult to recommend this strategy for Alaskans. For the most effective utilization of Passive solar heating, we suggest south glazing, combined with a thermally efficient building envelope. Keep the mass to a minimum in the house, and ventilate when overheating occurs. This means solar gain is an economical source of opportunity, but not worth it to the average homeowner (at this time) to provide for its short term storage.

The House as a Heat Trap

Passive solar heating goes hand-in-hand with good building, insulation and conservation practices. High heat loss through walls, ceilings and windows increases both the area required for solar energy collection and the amount of additional energy source needed.

The recommended minimum insulation values for a passive solar house in Alaska are R-30 walls and R-50 ceilings. However, any increased insulation will increase the solar performance.

Well insulated walls and roofs, along with proper sizing and placement of windows can cut fuel bills by 50% and up. Single pane windows lose three times as much heat as triple pane and 40 times as much as an R-40 wall. Insulated shutters should be used to reduce nighttime heat loss. There are also a number of new glazings on the market, such as low emissivity, “heat mirror”®. These increase the insulating effect of glass and make the house more comfortable.

Economics

Depending on the type of system used, the builder’s familiarity with the concept and, more importantly, the small details of passive solar design and construction, passive solar features can add 0 to 15% to design and construction costs. However, this is a one time cost for energy saving features that last the lifetime of the building. Many features such as proper siting, house color, house orientation and shape, and window placement can be considered without additional costs. Use of computer-aided design, and new windows can minimize the extra cost of solar design.

Passive solar heating requires the occupant to become more aware of the surrounding environment.

Passive solar heating is gaining market acceptability. In Alaska, passive solar houses have been built in Anchorage, Homer, Juneau, Delta Junction, Copper Center, Ambler and Fairbanks, among others.

Passive solar heating provides space heat which is inherently simple, clean, safe, cheap and lasts the lifetime of the building.

Sources

An Analytical Study of Passive Solar Energy and Mass Storage: Observations from A Test Building in Fairbanks, Alaska, Research Report to Alaska Department of Transportation Public Facilities Research Section, 2301 Peger Road, Fairbanks, Alaska. Seifert, R.D., and Mueller, G.S. 42 pp. plus appendices.

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Additional Information

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A Solar Design Manual for Alaska. Seifert, R.D., 2002. Bulletin of the Institute of Water Resources: Second edition, CES publication number EEM-01255, $10.00. Available from:

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The following web sites are very deep sources of information about solar design:

www.ases.org is the web site of the American Solar energy Society.
www.ises.org is the web site of the International Solar Energy Society.

Visit the Cooperative Extension web site at www.uaf.edu/ces
See also www.alaskasun.org

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