DOCUMENT RESUME

ED 242 478 RC 014 714

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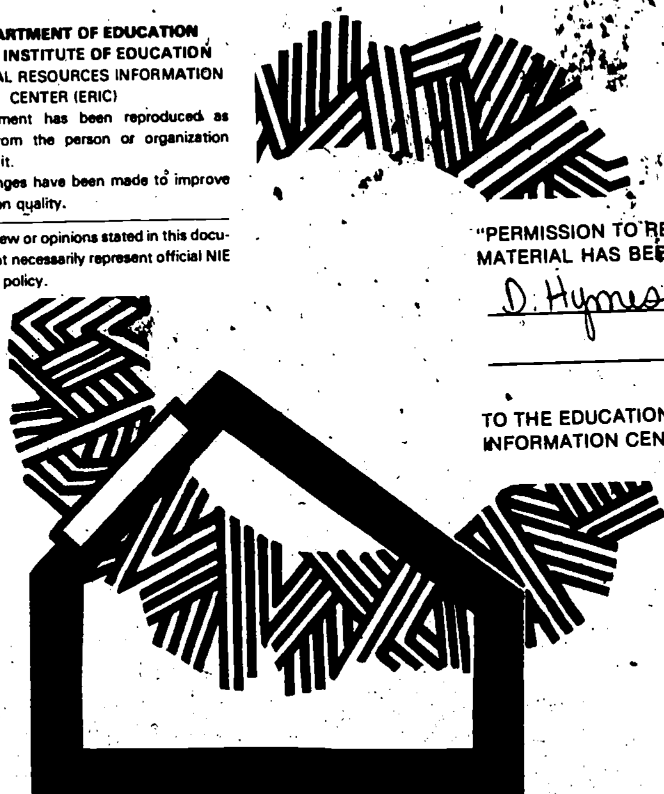
TITLE	Solar School House.
INSTITUTION	Montgomery County Public Schools, Rockville, Md.
PUB DATE	78
NOTE	17p.; A publication of the Lathrop E. Smith Environmental Education Center.
PUB TYPE	Guides - Non-Classroom Use (055)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Building Operation; Climate Control; *Diagrams; *Energy Conservation; Heating; Heat Recovery; *School Buildings; *School Construction; *Solar Energy; *Thermal Environment
IDENTIFIERS	*Lathrop E Smith Environmental Education Center MD

ABSTRACT

The Solar Schoolhouse at the Lathrop E. Smith Environmental Education Center (Rockville, Maryland) is described. Background and construction information is given. Drawings of the Schoolhouse's four sides are provided, as well as drawings illustrating the greenhouse effect, a solar collector, the Schoolhouse's summer cooling and winter heating systems, sun angle and tilt, and solar azimuth and radiation. Maps show mean daily solar radiation (annual) and zones of relative suitability for year-round solar energy collection. Solar collectors, the economy of the Schoolhouse's solar heating system, functioning of the winter heating and summer cooling system, other Schoolhouse features (windows, roof overhang, and insulation), orientation and tilt, and educational purpose are described. A 9-item glossary is provided. (MH)

SOLAR SCHOOL HOUSE



LATHROP E. SMITH
ENVIRONMENTAL EDUCATION
CENTER

1978

Pamphlet
by
David Harrison

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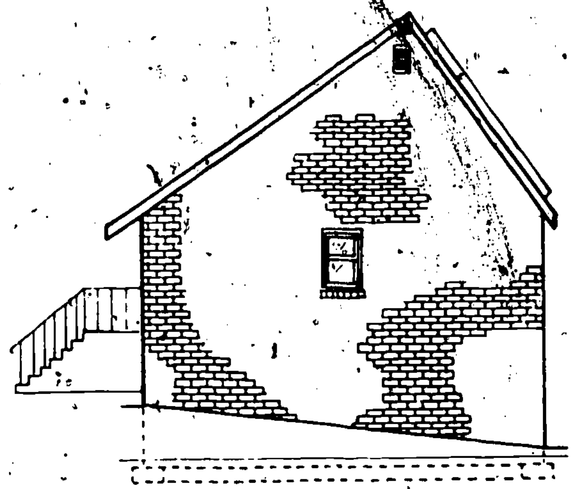
SOLAR SCHOOL HOUSE

Background

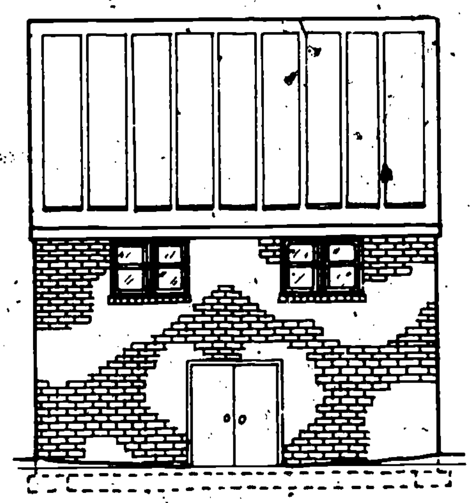
Solar Schoolhouse is a small part of the current movement to harness the energy of the sun for practical human needs. Sunlight is, by far, our most abundant source of energy. In fact, the amount of sunshine falling on the United States each year is 700 times our annual energy consumption. Viewed globally, the sun's energy output almost defies comprehension. For example, a two-week period of sunlight provides the earth with the energy equivalent of all its known reserves of coal, oil, and natural gas! Equally significant, during this time of ecological concern, is that this enormous energy source is 100 percent pollution free. Surprisingly, the technology to harness the sun's power for home heating has existed for over 30 years. Until recently, however, it was less expensive to use plentiful fossil fuels. Now, the increasing cost of rapidly depleting sources of oil and gas, along with environmental concerns, has made solar heating both practical and imperative.

Initial planning was begun on the Solar Schoolhouse in late summer of 1975 by the Division of Environmental Education of Montgomery County Public Schools. Ground was broken in April, 1976, and the structure was completed in the winter of 1978.

The Solar Schoolhouse is of wood frame and brick veneer construction and measures 28' x 28'. Except for the solar heating system and extra insulation requirements, the design and materials are the same as those of a conventional home. Much of the design and actual construction of the building was done by students in various drafting, masonry, carpentry, electrical, and plumbing classes of Montgomery County high schools under the supervision of the school system's Construction Trades Project.



WEST



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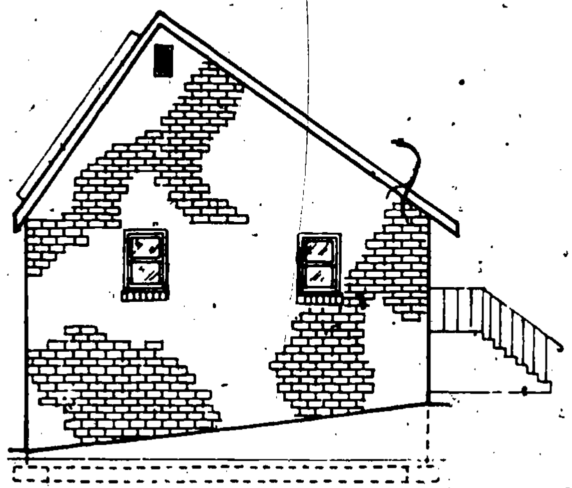

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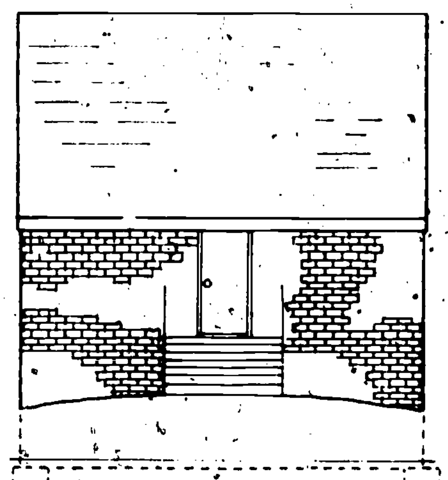
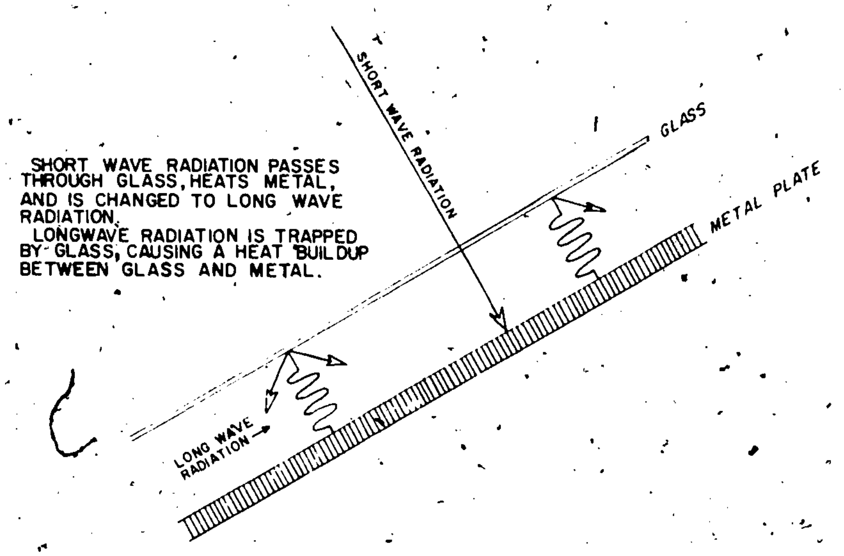
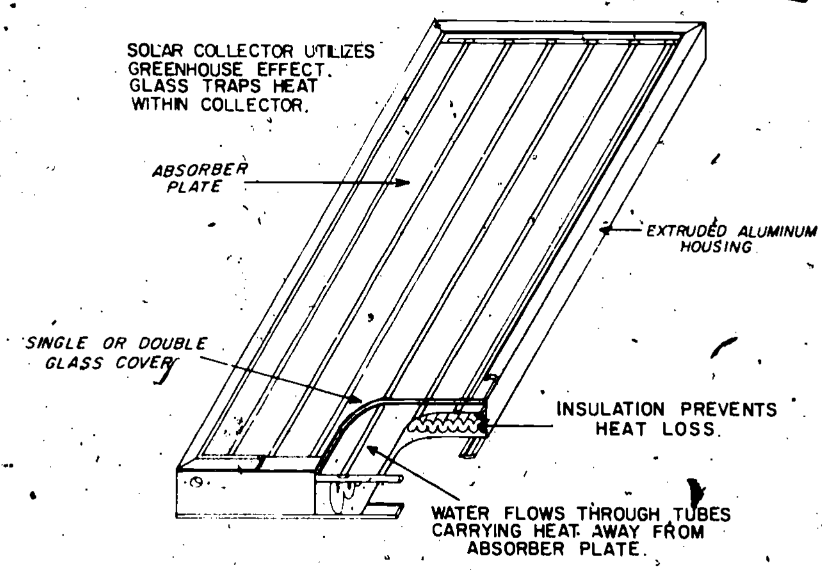


NORTH

GREENHOUSE EFFECT



SOLAR COLLECTOR



SOLAR COLLECTORS

The solar collector is the heart of the heating system because it absorbs the sun's radiant energy and transfers it to water which can provide heat to the house. Thanks to a well known, and long understood property of common glass known as the greenhouse effect, the principle behind it is simple. Invisible short wave solar radiation passes through the glass and strikes the collector plate which is black coated to maximize absorption of radiation. The short wave radiation is transformed into visible, long wave radiation. Much of these waves are prevented from escaping by the glass. The trapped heat is then carried away by water pumped through tubing in the collector plate.

The Solar Schoolhouse has a series of 9 solar collectors mounted on the south facing roof. They have copper collector plates, and each measures 92 7/8" x 34 7/8".

ECONOMY OF THE SYSTEM

A solar heated system supplemented by a heat pump and evaporative cooler has several advantages. The first is improved reliability. The heat pump operates most efficiently with water temperatures between 60°-90° F. (16°-32° C.). This means the solar system (collectors and storage tank) need only to raise and maintain water temperature above 60° F., well within the system's capacity, even during prolonged cloudy weather in the winter.

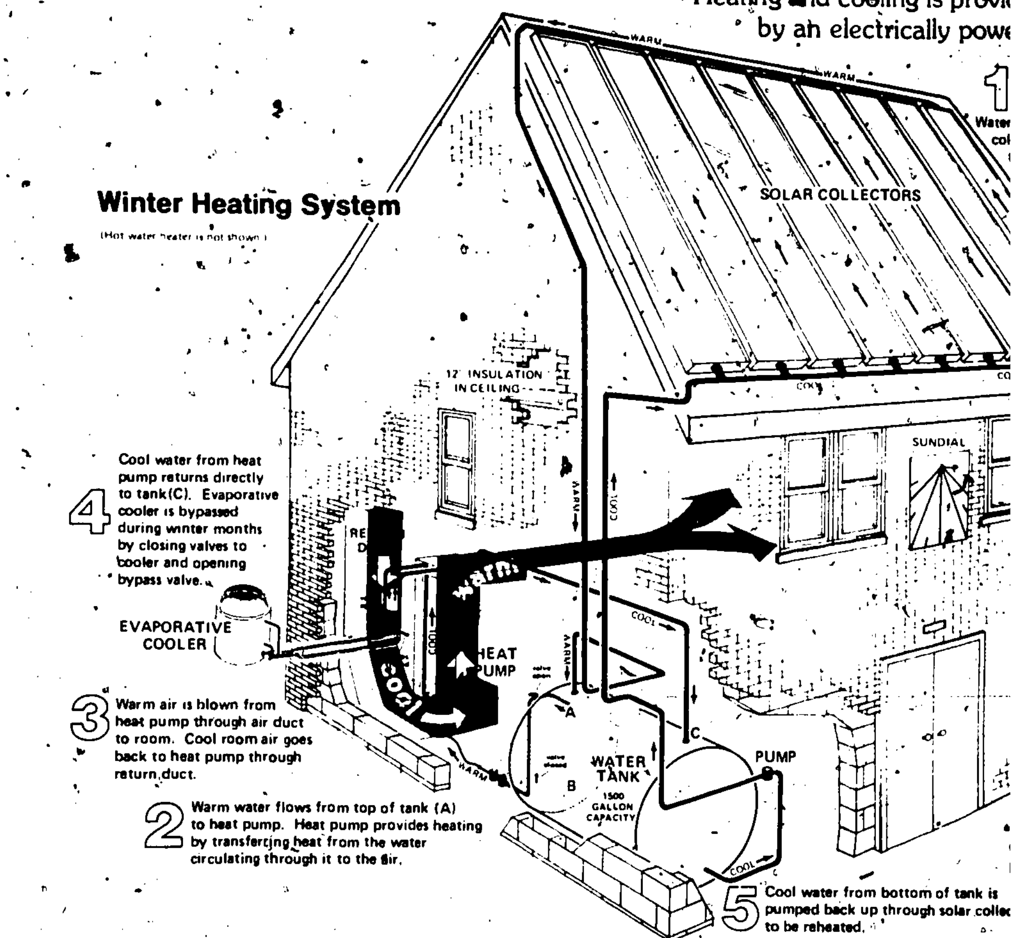
Secondly, the combination is economical. Solar powered systems at this latitude cannot supply 100 percent of heating needs. All of them require some type of conventional back-up heating system. The heat pump makes an ideal complement because it furnishes supplemental heat by extracting and concentrating the solar energy locked up in the water. Using a heat pump also holds down initial construction costs because fewer solar collectors are needed.

Finally, it is less expensive to cool with the heat pump-solar combination. Both the storage tank and evaporative cooler enhance the heat pump's cooling performance which is most efficient with water temperatures below 90° F. Water circulates between the storage tank and evaporative cooler lowering the temperature of the storage water. The evaporative cooler draws little electrical power (contrasted to a compressor air conditioner) because it is just required to prevent water temperature from exceeding the upper limit of 90° F.

It is anticipated that the sun's energy will supply about 70 percent of the total energy required to heat the classroom. The electrically powered heat pump will provide the balance along with summer cooling.

HOW THE HEATING AND COOLING SYSTEM WORKS

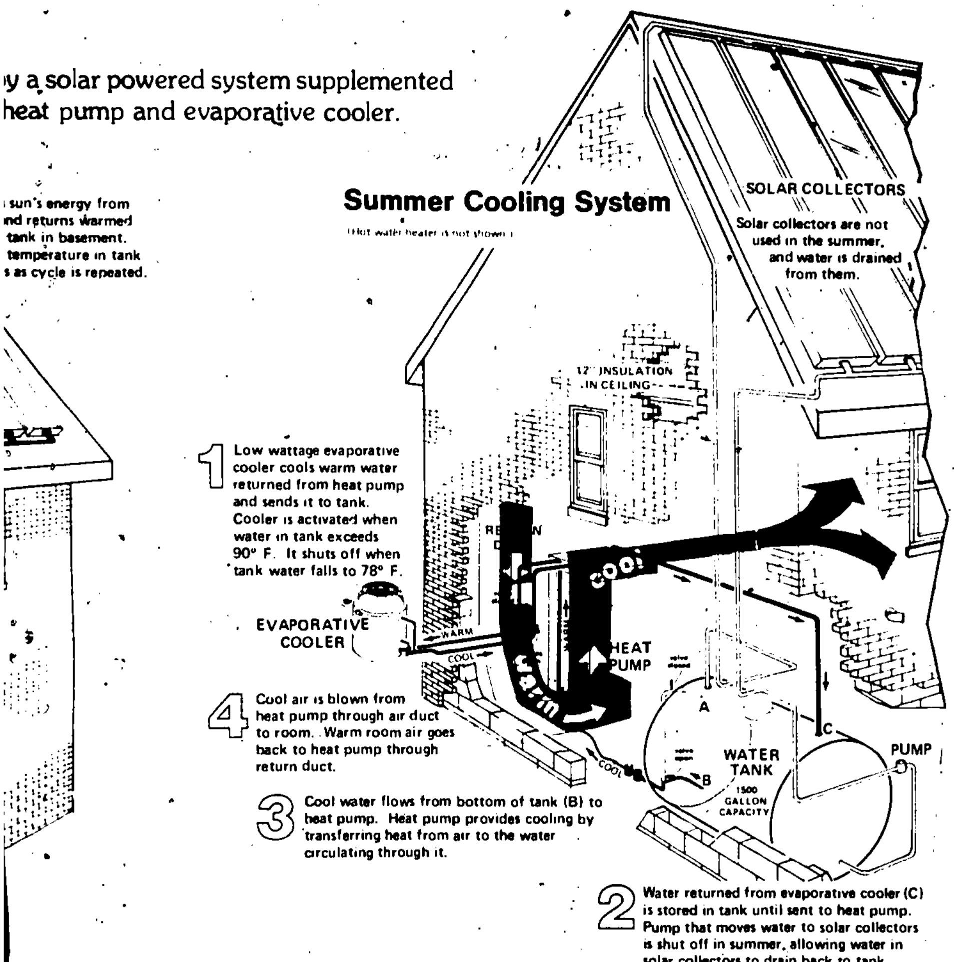
Heating and cooling is provi
by an electrically pow



Heating

- Water is pumped up through the solar collectors where it absorbs heat, then returns to a 1,500 gallon storage tank in the basement.
- The cycle continues until the temperature of the water in the tank is the same as the temperature in the collector. Whenever the water temperature decreases the cycle is repeated.
- Warmed water is pumped from the top of the storage tank to a heat pump next to the storage tank. The heat pump is a compression-type device which pumps (or transfers) the heat from the water to the air. An electric fan in the heat pump then blows the air through the ductwork into the schoolhouse. With its heat extracted, cooler water flows back to the storage tank where the cycle is repeated.

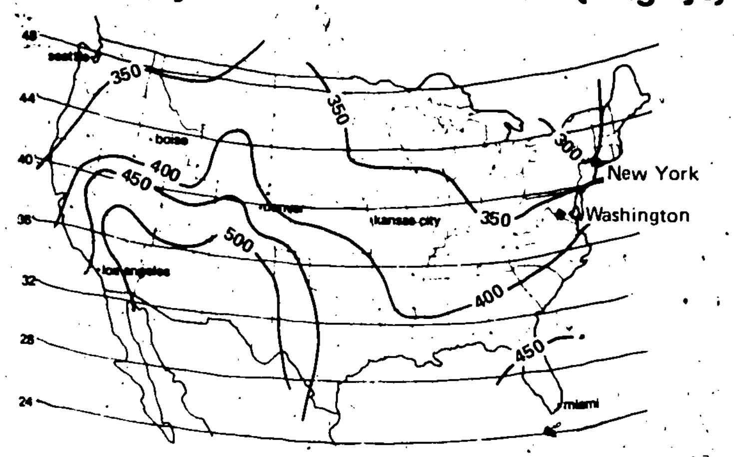
ly a solar powered system supplemented
heat pump and evaporative cooler.



Cooling

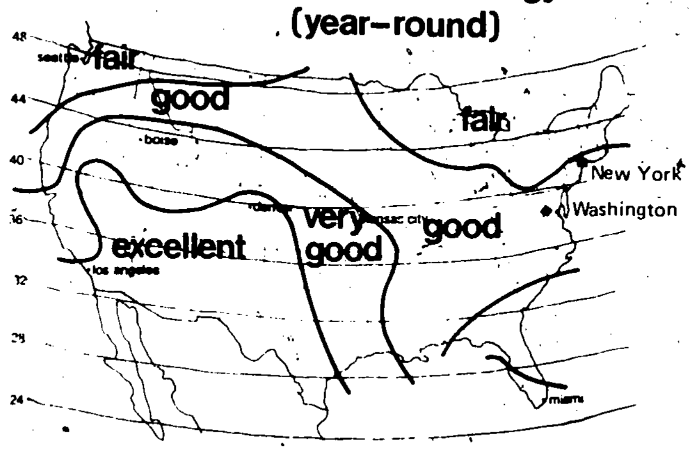
- For summer cooling, the heat pump reverses itself and pumps (removes) heat from the air and transfers it to water circulating between the heat pump and storage tank. The house is cooled by chilled air blown from the heat pump.
- The heat pump cannot cool efficiently when water temperature exeeds 90 F. When the water temperature in the tank reaches that temperature, a thermostat automatically activates the evaporative cooler which provides additional cooling. The evaporative cooler goes off when the water temperature falls to 78 F.
- To maintain the temperature setting, the two pumps that circulate water to the water tank, heat pump, and evaporative cooler are shut on and off by a thermostat on the main floor. During the summer, water is drained from the solar collectors.

Mean Daily Solar Radiation Annual (langleys)



Solar radiation is electromagnetic energy produced by the sun. The unit of measure is the langley, where 1 langley/day equals 1 calorie/sq. cm./day. As shown by the map above, the Solar Schoolhouse receives an annual mean daily radiation of about 350 langleys. This makes its suitability for solar energy collection "good" relative to the rest of the nation (below).

Relative Suitability for Solar Energy Collection (year-round)



Maps used with permission of Revere Copper and Brass, Inc.

OTHER FEATURES

A major problem with solar energy is that it is intermittent. The sun shines only by day and is often blocked by clouds. The 1,500 gallon steel water storage tank located in the southwest corner of the basement allows the storage of heat collected during sunny weather for use at night or during overcast skies. To prevent heat loss, the outside surface is coated with insulation. The tank has sufficient capacity to provide heat at a level above 62° F. (17° C.) for two consecutive sunless days where the outside temperature is as low as 15° F. (-9.4 C.).

Windows

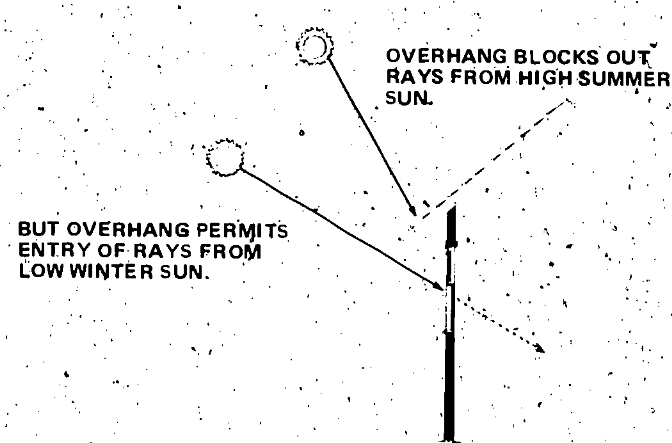
The windows of the Solar Schoolhouse are arranged to contribute to the efficiency of the heating system. There are 4 windows on the south side to take advantage of the sun to heat the main floor. On the cooler western exposure, where heat loss would be substantial, there is only one window, on the east side there are 2 windows, and on the coolest northern side, there are none. All windows are double glazed to minimize energy loss.

Roof Overhang

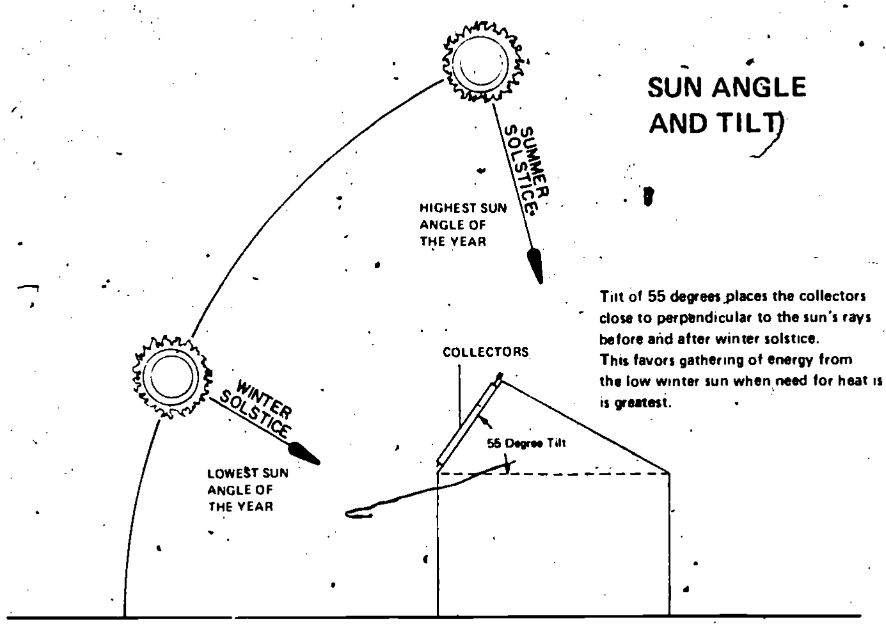
A standard feature, for many years, on any well designed home is proper roof overhang. As shown in the illustration, the overhang permits passage of sunlight in winter but blocks the hot summer sun. Use of awnings on the south side in the summer assists in keeping the building cool.

Insulation

The property of insulation to minimize the rate at which heat is lost or gained through exterior surfaces make it important to all houses, but critical to one solar heated. The insulation standards of the Solar Schoolhouse exceed those of a conventional home. Included are 3 inches of poured vermiculite between the brick veneer and cinder block walls of the basement, 3 1/2 inches of batting-type insulation under the main floor, and 12 inches of batting and poured insulation in the ceiling.

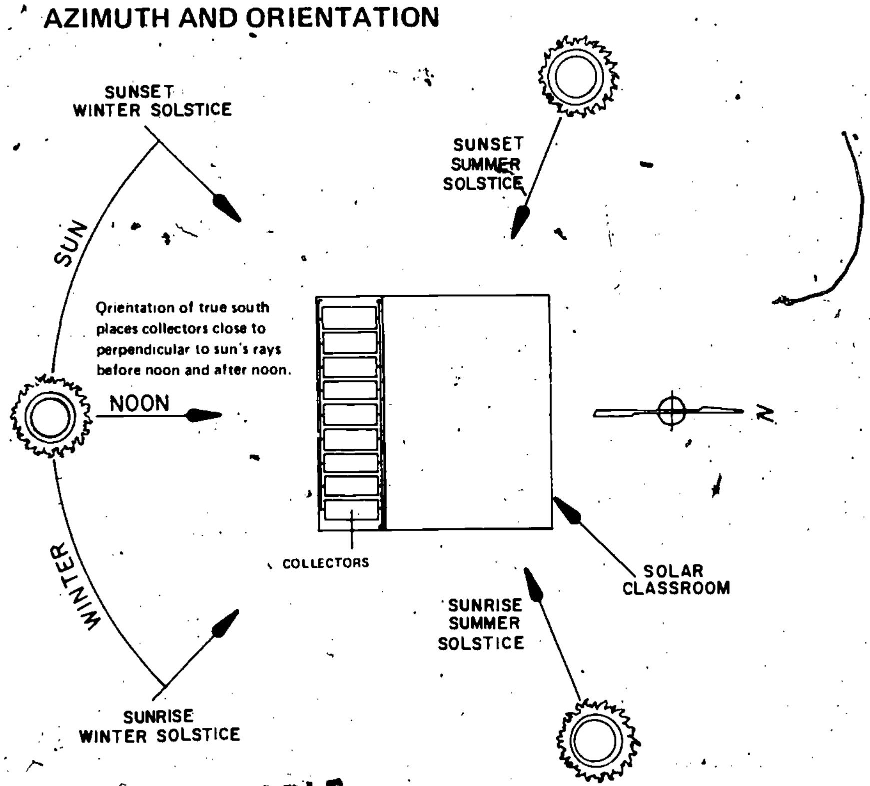


SUN ANGLE AND TILT



Tilt of 55 degrees places the collectors close to perpendicular to the sun's rays before and after winter solstice. This favors gathering of energy from the low winter sun when need for heat is is greatest.

AZIMUTH AND ORIENTATION



Orientation of true south places collectors close to perpendicular to sun's rays before noon and after noon.

ORIENTATION AND TILT

Orientation is a building's position in relation to the sun's azimuth arc, or the apparent path the sun travels every day. Since optimum radiation occurs when solar collectors are perpendicular to the sun's rays, the ideal collector would be one that moves and tracks the sun across the sky. However, for stationary collectors, such as those on the Solar Schoolhouse, the best orientation for gathering solar energy is true south. Such a position takes advantage of peak radiation of midday.

Another important design consideration is tilt. This is the angle of the solar collectors' surface on the south roof of the Solar Schoolhouse to horizontal. Due to the inclination of the earth's axis, the sun's angle with the earth's surface changes seasonally and varies according to latitude. For heating purposes, tilt angle should favor the gathering of energy from the low winter sun when heat need is greatest. The latitude of the Solar Schoolhouse is approximately 39° North. It has a tilt of 55° which places the collectors close to perpendicular to the sun's rays before and after the winter solstice. This also follows the rule of thumb that the tilt angle for heating should be latitude plus 10–20°.

EDUCATIONAL PURPOSE

The Solar Schoolhouse is unique in that it is the first substantial solar heated structure designed and constructed by public school vocational teachers and students. Providing high school students with the opportunity to work with an innovative technology has been one of the major goals of the project. Other objectives are: 1) to demonstrate to the school system and to the community the economic and environmental advantages of solar heating and cooling; 2) to provide a laboratory where students can learn the principles of solar heating and cooling and conduct investigations on its economy and practicality; 3) to provide a facility where various activities related to the outdoor education program can be conducted.

VISITORS

The Solar Schoolhouse is located on the grounds of the Lathrop E. Smith Environmental Education Center of Montgomery County Public Schools in Rock Creek Regional Park. Requests to visit the solar structure should be addressed to Director, Lathrop E. Smith Environmental Education Center, 5110 Meadowside Lane, Rockville, Maryland 20853.

GLOSSARY

1. **British Thermal Unit (BTU)** — The amount of heat required to raise the temperature of a pound of water one degree Fahrenheit.
2. **Collector Tilt** — The angle a solar collector makes with a horizontal plane.
3. **Heat Pump** — An economical compressor-type device which transfers (pumps) heat from a space to be cooled, or pumps heat into a space to be heated.
4. **Insolation** — Some of the sun's radiation does not reach the earth because it is reflected or scattered by clouds, dust, moisture in the air, etc. Insolation is the *direct* solar energy which strikes the earth.
5. **Orientation** — The position of a building in relation to the sun's azimuth arc or the apparent path the sun daily makes across the sky. Solarly heated buildings in the northern hemisphere are oriented with the collector roof facing south.
6. **Resistance Factor (R Factor)** — A term used to note insulation values of materials. The larger the R factor, the better the insulating quality.
7. **Solar Constant** — The intensity of radiation striking the outside of the earth's atmosphere. It equals 429.7 BTUs per square foot per hour.
8. **Solar Radiation** —Electromagnetic energy produced by the sun. Visible light is only part of solar radiation. Short wave radiation, although we cannot see it, is useful in solar heating.
9. **U-value** — The rate heat moves through building surfaces. It is expressed in terms of BTUs per hour, per square foot, per degree Fahrenheit. The U-value is the reciprocal of the R factor, i.e., 1/R.

Project Recognition
Montgomery County Public Schools

Project Coordination:

Staff, Lathrop E. Smith Environmental Education Center

Construction Supervision:

Staff, Construction Trades Project

Construction:

Teachers and students of Architectural Drawing and Carpentry Classes, Rockville High School

Teachers and students of Masonry Classes, Albert Einstein and Wheaton High Schools

Pamphlet Graphics:

Teachers and students of Architectural Drawing Classes, Springbrook High School

Graphic-Arts, Educational Services Center

SOLAR SCHOOL HOUSE

LATHROP E. SMITH
ENVIRONMENTAL EDUCATION
CENTER
5110 Meadowside Lane
Rockville, Maryland 20853

Owner: Montgomery County Public Schools
850 Hungerford Drive
Rockville, Maryland 20850

Area: 784 square feet (main floor)
784 square feet (basement — unheated)

Architectural Design:
One story with basement, 28′ x 28′
Wood frame with brick veneer

Capacity: 30 students

Estimated Fuel Savings:
Approximately 70 percent per year compared to conventional electrically heated building of similar size (based on 3¢ per kilowatt hour)

Solar Collector Manufacturer:
Revere Copper and Brass, Inc.
Solar Energy Department
P. O. Box 151
Rome, New York 13440

Consultants:
Solar Heating Services, Inc.
2728 Pittman Drive
Silver Spring, Maryland 20910

ITC Corporation
Box 346
Warrenton, Virginia 22186

OUTDOOR EDUCATION PROGRAM

Montgomery County Public Schools