ASPI
Appalachia-Science in the Public Interest
50 Lair St., Mt. Vernon, KY 40456

ASPI TECHNICAL SERIES TP 40

THE ASPI SOLAR DEMONSTRATION HOUSE

Background

This solar home located just south of Livingston, KY in Rockcastle County, was built by Appalachia-Science in the Public Interest (ASPI) in 1979. The house demonstrates a variety of applications which people can use to minimize their monthly utility bills and their impacts on the environment. This technical paper gives an overview of many of these applications. For more specific information take a tour by contacting ASPI at (606) 256-0077.

The house is built on the southwestern side of a hill over a 30-in. seam of coal. ASPI promised the former owner that the property would never be mined. Being on a hillside known for its possibility of slippage, the house was built with a minimal amount of ground disturbance. Furthermore, the location of the house is removed from any springs or water lines. The goal in building this structure was to demonstrate a low cost (about $25,000), yet comfortable home which supplies its own energy, collects its own water, deals with its own waste, and can be built on unfavorable land which low-income people of Central Appalachia can afford.

Challenges

To build this home on a minimal budget, a number of difficulties had to be addressed. In many cases novel solutions were applied, some of which are still working exceptionally well today. In other cases, better solutions have been found, or research is being done to find better solutions. This is a working demonstration house where applications are often being modified and improved based on low-cost technology advancements. Originally, the solutions developed for the inexpensive solar house include:

- using volunteer labor to the degree possible for construction
- getting materials close at hand to limit transportation costs
- installing a composting toilet since the feasibility of a leach field was limited
- catching rain water off the roof and storing in a cistern for household use
- mounting photovoltaic (PV) panels to generate electricity from the sun
- designing the house to take advantage of solar heating for interior space and water

Passive Solar Design

The fundamental feature of this demonstration house is the passive solar heating of its interior space. Passive solar heating takes advantage of the greenhouse effect without fancy motors or gadgetry. Just as sunlight passing through the atmosphere warms the planet, so can it pass through south-facing windows to warm a house. When sunlight strikes a dark colored interior surface, it transforms into heat energy, which is much less able to pass back through the glass (*Figure 1*). Black surfaces change most of the light into heat, while light-colored surfaces reflect much of the light. Once the sunlight is converted into heat, the challenge is to keep as much of this heat in the house as possible. This is accomplished by installing significant amounts of insulation, sealing air leaks, and supplying the house with heat sinks. Heat sinks are heavy materials that store heat when the sun shines, and slowly release heat when the sun is not shining.

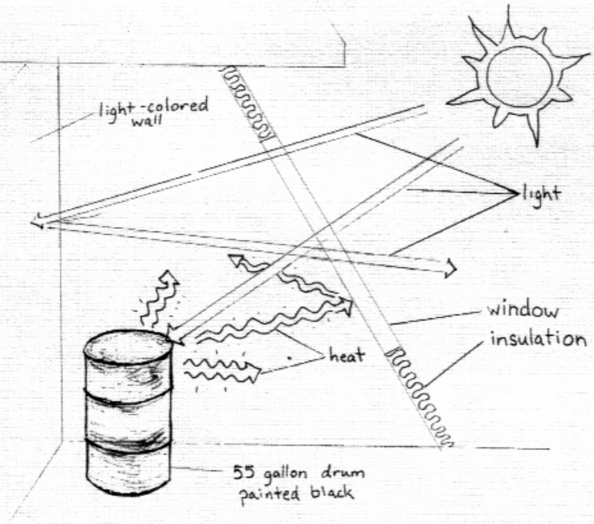


Figure 1 Greenhouse Effect

Solar House Design

The 1500 sq. ft. house was designed by Al Fritsch, Charlie Fritsch and builder Jerry Nichols. The house was insulated significantly with R-values of approximately 19 for the walls and 38 for the ceiling. It is rectangular in shape with one of the two longer sides facing within 25° of true south (*Figure 2*). The south facing wall is covered by glazing (430 sq. ft.) which permits a substantial amount of direct sunlight to enter the building especially in winter when the sun is observed lower in the horizon. Originally, twenty-five 55 gallon barrels, painted black and filled with water, were positioned in the house to act as heat sinks, absorbing heat from sunlight. The building has a cantilever design, in which the weight of the water barrels is counterbalanced by the weight of the building (*Figure 3*). Figure 2 includes a basic floor plan and Figure 3 gives a cross-sectional view of the two-story residence.

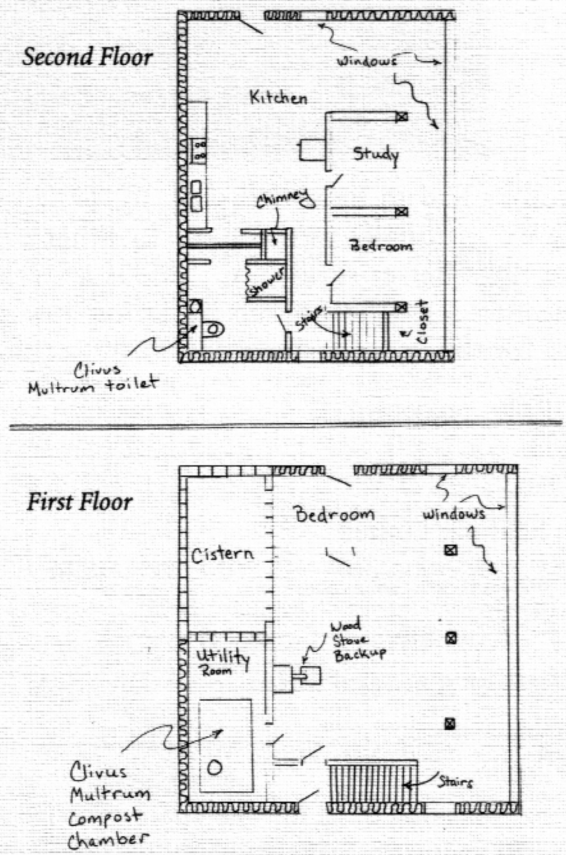


Figure 2 Basic Floor Plan

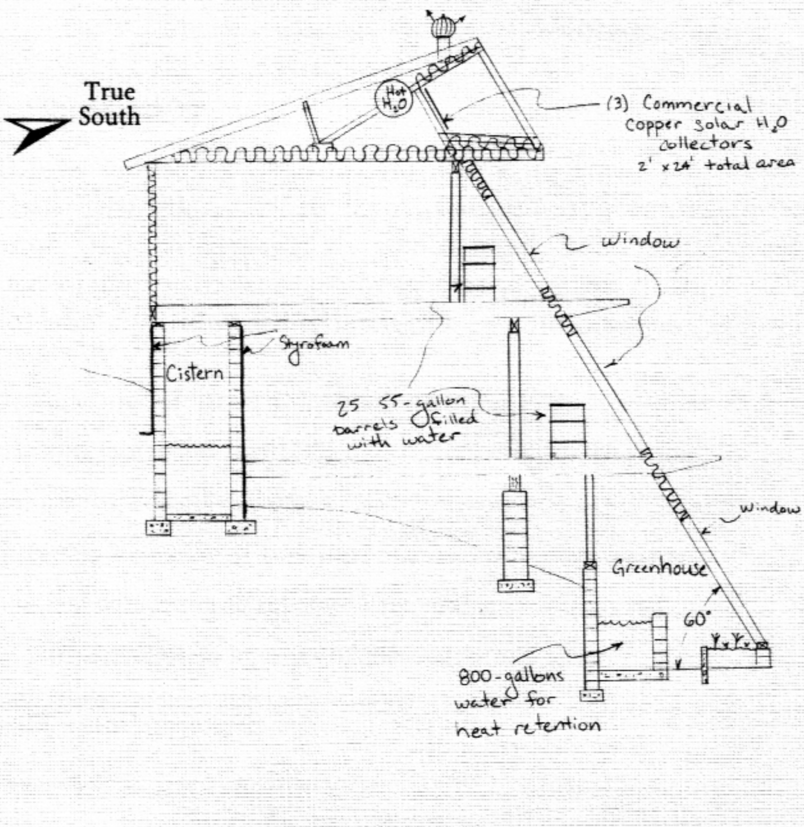


Figure 3 Side View

House Construction

Jerry Nichols along with 14 volunteers, working for various lengths of time, constructed the house within 6 months. Construction began with a minimal amount of bulldozing to provide a driveway and a flat area where the water cistern was to be placed. Local ready-mix concrete and inexpensive concrete blocks were used to build the cistern and footers. The house utilizes post and beam construction which permits a significant amount of interior space with a minimal amount of wood required for framing. The siding is made from local poplar that was partly dried at the construction site. The total basic cost was about $20,000 to which was added a 200 sq. ft. greenhouse in 1981 ($2000) and a 300 sq. ft. root cellar in 1983 ($1500). Both the greenhouse and the root cellar are positioned below the first floor of the house and are bermed into the earth.

Additional Features

The 55-gallon barrels used to store the solar heat were donated to ASPI. A virtually unused Clivus Multrum composting toilet that would have sold for $4000 at that time was obtained for $300 from a community land trust that was going out of business. The Clivus Multrum continues to function well. Two to three gallons of finished compost per user is removed from the composting chamber each year. If the unit ever fails, it will be replaced by an ASPI designed composting toilet that can be built for $250. To clean all the drain water from the sinks and the shower (graywater) before going into the environment, an artificial wetland was added in 1994 at a cost of about $2000, including labor. The original solar water heating system is not presently in use, as improvements are being made. A Chofu water heater is available to heat the water with wood.

Initially, the closest electric lines were 1½ miles away from the solar house. For this reason, it was cost effective to generate electricity at the site with photovoltaic (PV) solar modules and a backup generator used only intermittently during weeks of cloudy conditions in winter. Utility electric lines were brought into the valley in 1984. It was decided to extend the utility electric line to the Solar House in 1986. The solar electric system is still used to its full capacity, almost exclusively in summer months. However, now the house is not dependent on a noisy polluting generator for backup power in winter.

The Present Solar/Utility Electric System

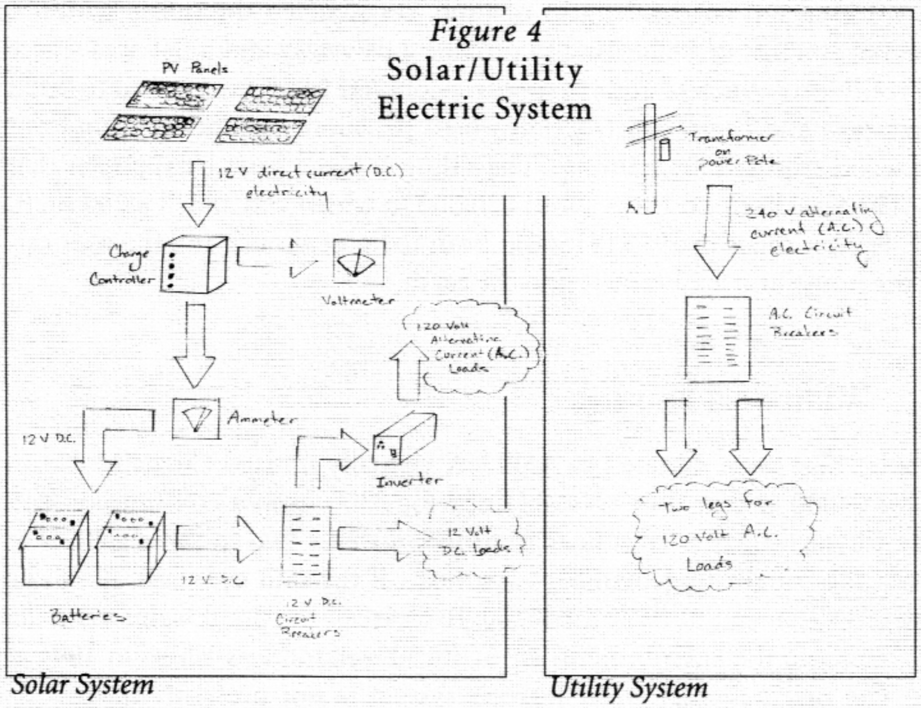
In order for solar electricity to be affordable, the electricity demanded has to be minimized. By using more efficient appliances, the same job can often be done with half the electricity required to run standard appliances. Unfortunately, there are many electrical appliances that waste electricity, and many use electricity even when they are not turned on (phantom loads)! Since PV modules are costly, the savings from purchasing standard appliances over efficient appliances rarely exceeds the cost of the added PV modules needed to run the less efficient appliances.

The solar demonstration house makes use of a number of efficient appliances, including compact fluorescent lights which use a third the electricity as standard incandescent varieties. Also, the cooking stove and water heater use propane gas, wood, or direct solar gain, rather than electricity.

The solar electric system and the utility electric system are completely separated. Each has its own circuit breaker box and distribution (*Figure 4*). Switches and outlets with white cover plates are powered by the solar system. These are used unless clouds have blocked the sun continuously for over a week. When this happens the demand on the solar electric system is reduced by using lights and appliances that are plugged into outlets with black cover plates, powered by the utility. This technical paper is being typed on a computer that is powered by the solar electric system.

The components of the solar system shown in Figure 4 are described as follows:

Figure 4
Solar/Utility
Electric System



1) **Photovoltaic (PV) panels** convert sunlight into low-voltage direct-current (DC) electricity suitable for charging batteries.

2) A **charge controller** keeps the batteries from overcharging by effectively disconnecting the PV panels from the batteries once the batteries reach a threshold voltage.

3) An **ammeter** provides at-a-glance knowledge of how much electricity is entering the batteries.

4) A **voltmeter** provides a general idea of how much electricity is stored in the batteries.

5) **Batteries** store the electricity for use at night and periods of incremental weather. These have to be true deep cycle batteries. Golf-cart varieties are best, marine batteries generally will not last as long.

6) An **inverter** turns low-voltage direct-current electricity from the batteries into high-voltage alternating-current (AC), used to run typical household appliances.

Features of the Solar House Today

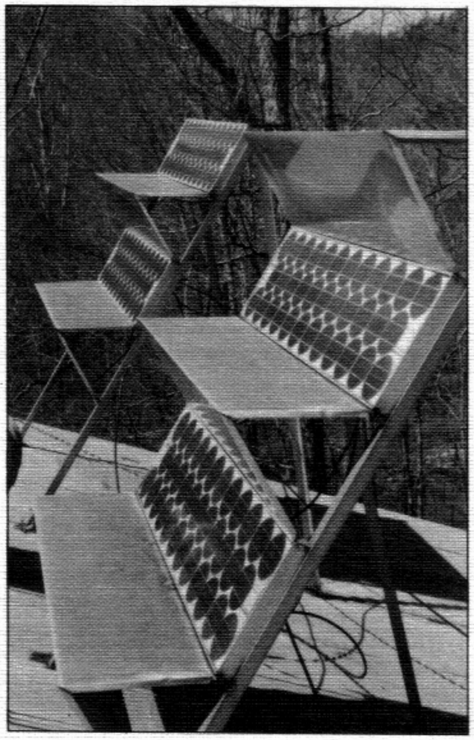
The solar house has undergone some modifications and additions since its conception in 1979. The applications in operation today include the following:

Greenhouse — Located on the bottom section of the house, but separated from the house by a crawlspace, the greenhouse provides fresh vegetables for the occupants year round. An 800-gallon cinder block rainwater cistern, which has grown bluegill fish for several years, is used as a heat sink. The greenhouse usually stays above freezing year round with only passive solar heating. A garden bed is located to the south of the greenhouse in which tall plants are grown in the summer months providing shade and moderating summertime greenhouse temperatures.

Root Cellar — This large room with a gravel floor is located to the north of the greenhouse, but below the living quarters. Dampness of the hillside has limited the effectiveness of this room for such a purpose. At the present it is being used as workshop space.

Cistern — Made from concrete block, it holds 5000-gallons of rainwater collected from off the roof. The rainwater first drips through a gravel/charcoal filter before entering the cistern. There is also a diverter on the gutter downspout to allow the initial 15 minutes of rain to wash the roof off before water is diverted into the cistern. This cistern was formerly twice the size as today, but broke in 1982 when overfilled. It was decreased in size and resealed with a masonry finish.

Photovoltaic Panels — Four used Arco 16-2000 solar modules charge batteries, producing a little over 30 watts of power each in full sun. Home-made concentrating aluminum reflectors increase their power output by about 20 percent. These panels were dismantled from a utility solar testing facility about 15 years ago and are still putting out the same amount of power. Today, there are very few of these panels left on the market. At $160 each, if one can be found, it's a bargain. New England Solar Electric Inc. (See Resources) may still have some left.



Compost Toilet —The Clivus Multrum, a large capacity toilet, is designed for use with a second floor bathroom (can be adapted to include a kitchen waste inlet as well). A chamber room is located on the first floor where materials are composted. Annually, this is emptied onto flowerbeds and fruit trees. A fan-forced ventilation system maintains a negative pressure inside the compost chamber for odor-free operation. Although much more costly than home-built composting toilets, these units are favored by inspectors since they are approved by the National Sanitation Foundation (NSF). These units are in use at many National and State Parks and thousands of residential homes.

Heat Retention System — Originally twenty-five 55-gallon barrels were used for heat sinks. These were painted black and filled with water, detergent, and a minute amount of waste oil to keep the water from oxygenating, which in turn could cause the barrels to rust and leak prematurely. Shutters were designed for manual operation to prohibit excessive heat from entering the south facing windows during hot summer days, or to prohibit excessive heat from escaping through the same windows during cold winter nights.

Life in a Solar House

Living in a completely solar home is not for everyone. Being your own electric company, heating service, water supplier, etc. does involve some time and energy for maintenance. However, many find it empowering and well worth it. It provides the opportunity to buy low-cost land beyond utility lines, and yet still live comfortably with modern conveniences if one chooses. One may also start small and add solar applications as time and budget permits.

It is a pleasure to see how low monthly bills can be in a solar house. While paying over 7¢ per KWH for utility electricity, our electric bill is consistently under $20 a month. Auxiliary heating generally consumes between one and two cords of wood during the winter season. Forget about water or sewage bills, they never arrive.

Solar House Advantages

- Low heating costs for water and space
- Savings on electric bill when part or all generated from solar PV panels
- Minimum noise from roads or neighbors since most won't build beyond utility lines
- Impact on environment minimized (lots of birds in the yard)
- Indoor plants thrive due to the large south facing windows
- Non-chlorinated household water; rainwater does wonders for hair
- Greenhouse allows much fresh food to be grown at home year round

Solar House Disadvantages

- Woodstove needed as backup heat during cold cloudy periods
- Maximum solar energy not utilized since built on a southwestern facing hill
- Original inexpensive 'Kalwall' used for the south facing windows had to be replaced with glass when they began to cloud with age
- Having two separate electric systems, utility and solar, has to be explained to guests

Future Solar House Plans

Future house plans are indefinite. The 55-gallon barrels are being replaced with 4-in. thick field stone floor covering. This will provide much more living space to the building. Also, the solar water heating system is being renovated, in hopes of heating more water with the sun.

Additions are being made to the exterior of the house including walkways, flowerbeds, a small orchard, as well as a trellis over the south facing windows to reduce their exposure to the sun in the summertime. The house has been here for almost 20 years and some trees are beginning to block the solar exposure, hence a few trees will need to be cut and used for firewood. More photovoltaic panels may be added when finances permit.

Make an appointment to visit the house for more details. An annual open house often takes place during the month of October, coinciding with the National Tour of Solar Homes sponsored by the American Solar Energy Society. Hope to see you soon.

REFERENCES

Home Power 6/yr $22.50, PO Box 520, Ashland, OR 97520 800-707-6585 *WWW:* www.homepower.com *E-Mail:* hp@homepower.org

"The Solar Home: How to Design and Build a House You Heat with the Sun", Mark Freeman, 1994 Stackpole Books, 5067 Ritter Rd, Mechanicsburg, PA 17055

"The Fuel Savers: A Kit of Solar Ideas for Your Home", Bruce N. Anderson , 1991 Morning Sun Press, PO Box 413, Lafayette, CA 94549 415-932-1383 *FAX:* 415-934-8277

"Alternative Energy Sourcebook, 9th Edition", Real Goods, 555 Leslie Street, Ukiah, CA 95482-5507 800-762-7325 *FAX:* 707-468-9486 *WWW:* www.realgoods.com

RESOURCES

Clivus Multrum 800-4-clivus FAX: 508-557-9658 *WWW:* www.clivusmultrum.com *E-Mail:* forinfo@clivus-mutrum.com

New England Solar Electric Inc. 226 Huntington Road PO Box 435, Worthington, MA 01098 800-914-4131 *FAX:* 413-238-0203 *E-Mail:* nesolar@tiac.net

American Energy Technologies, Inc. PO Box 1865, Green Cove Springs, FL 32043-1865 800-874-2190 *FAX:* 904-284-0006 (solar hot water equipment)

AAA Solar Service and Supply Inc. 2021 Zearing Ave. N.W., Albequerque, NM 87104 800-245-0311 *WWW:* www.rt66.com/aaasolar *E-Mail:* aaasolar@rt66.com (solar hot water equipment)

Sunelco PO Box 1499, Hamilton, Montana 59840-1499 800-338-6844 *WWW:* www.sunelco.com *E-Mail:* sunelco@montana.com (solar electric equipment)

Chofu Wood Water Heater Contact **EKAT**, 150 Gravel Lick Branch Rd, Dreyfus, KY 40385 606-986-6146

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