A Scale Model House for Demonstrating Energy Efficient Alternatives

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Increasing energy shortages and the higher costs associated with these shortages will likely continue. About 20 percent of the energy consumed in the United States is used in the home, and thus waste in home energy usage could be a significant part of the overall waste of energy (Freeman, 1974). This paper describes a scale model house that is used to present energy conserving possibilities in housing. The model is the result of the combined efforts of housing and home management specialists and physical and biological scientists, and represents a house which is designed to be energy conservative, convenient, and environmentally sound.

An interdisciplinary research project was funded by a New Mexico state grant to design and build a scale model of an energy self-sufficient house to be used for educational demonstrations.

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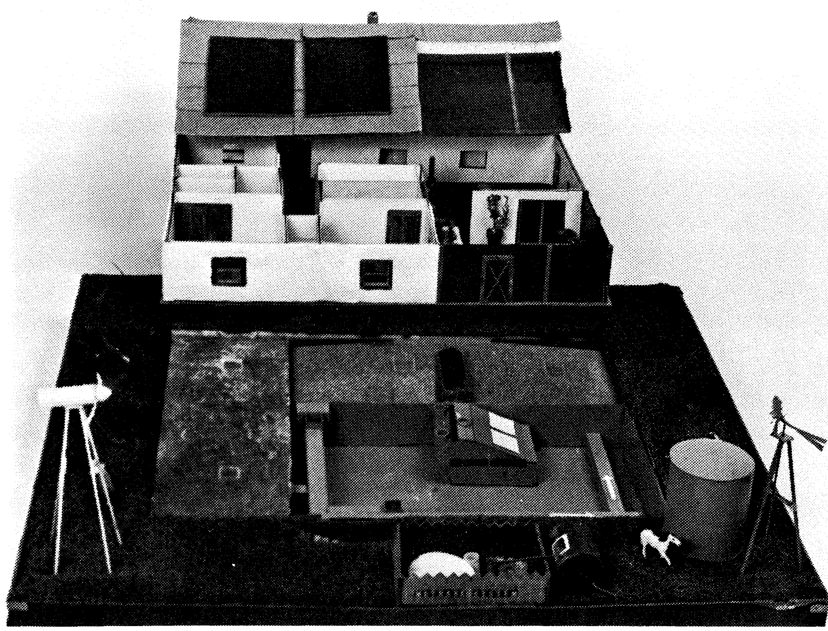
Self-sufficiency was defined as being minimally dependant on community energy sources while environmentally acceptable. Some of the waste disposal aspects of the model were based upon the works of architect-philosopher-designer Bengt Warne and environmental expert Carl Lindstrom. The first part of the project involved researching, designing, and building the scale model. The second part of the project was to determine people's reaction to the model. This article focuses on the first part of the project.

The primary function of the model was to serve as a portable instructional device to stimulate thinking in regards to energy conservation in housing. The model was built so that all three



levels could be separated and examined. It was built on a scale of ¼" = 1' to represent a house of 1500 square feet which could accommodate four persons. It contained three bedrooms, two baths, closet space, a combination kitchen-living-dining room (a great room), and utility space. The open living space encouraged efficient circulation both of heat and human activity. Bathrooms and kitchens were placed together to consolidate plumbing and to minimize hall space. Emphasis was placed on the support systems rather than on the interior design to demonstrate that a conventional single family dwelling could utilize the systems. In subsequent models more emphasis will be placed on interior design.

The model incorporated the following resource conservation/energy production features: a) a greenhouse, b) solar panels for for partial heating of the house, c) solar water heater, d) methane generation for partial fulfillment of the cooking and other heating needs, e) wind generation for light electrical loads, f) Clivus-Multrum system for biological waste disposal, g) gray water reuse, h) wind-powered water pumping, and i) wood/coal stove heating.

Heat Storage

Heat from the solar collectors is stored in a large concrete bin filled with rocks approximately 2 inches in diameter, with a fan system underneath and above for both heating and cooling. Solar heat is delivered to the bottom, heats up the rocks, is withdrawn through the top and distributed throughout the house for heating. For cooling, air in the collectors is cooled by radiation at night. This cool air is introduced to the bottom of the rocks by a fan and forced through the house for cooling at night. During the day, either the outside air or air from the house is forced through the cool rock bed and distributed throughout the house.

Water Heating

Domestic hot water demand is met from a 55-

gallon barrel, placed within the rock bed. Since this method would consume only "available" energy, a backup heating system, using methane gas, is planned.

Methane Generation

The methane generation system was designed to supply energy for cooking and as an alternative for heating water. The system includes a digester unit, in which organic wastes are placed for digestion. Water is added to the fermenting material in the insulated digestion barrel to bring the mixture to about 9 percent solids. Any organic solids such as manure, grass clippings, leaves, or papers (other than newspaper) can be used. The gas from the digested material is filtered to remove the hydrogen sulfide, pumped by a compressor into a pressurized storage tank, and used as needed. Some of the gas produced will have to be used to maintain the generation system of the proper temperature. The methane generation system is outside the house to minimize odor and safety problems. The system is dependent upon farm animals to provide manure; therefore this part of the model is most feasible in rural areas where manure is readily and inexpensively available.

Clivus-Multrum Organic Waste Disposal System

The Clivus-Multrum system of organic waste disposal has been used in various countries in Europe and to a limited extent in the United States. This system is installed under the kitchen and baths.

The system includes a toilet requiring no flushing and a kitchen garbage chute. The wastes are decomposed biochemically in the container below there fixtures. It uses an introduced supply of air to eliminate odors and the moisture naturally present in the waste. Approximately two years are required to establish decomposition equilibrium. A small amount of organic residue should be removed annually. This material can be used to fertilize plants other than root crops. This system is a Swedish invention, but there are licensed dealers for the units in the United States.

Water Purification

Gray water is water collected after dishes are done, baths are taken, and laundry is done. It can be purified by a simple collector-condensate system where the water is pumped up to the collector plates and allowed to trickle down the plates. During the trickling period vaporization occurs and a condensate forms on the underside of the glazed plate. At this time, debris, minerals, and foreign material are removed from the water which drips down into a collection vat (Figure 3). This water is suitable only for watering greenhouse plants and limited household uses. It is not recommended for drinking. The residue collection plate requires periodic manual cleaning.

Wind-Mill, Water Storage, and Wind Turbine

A conventional wind-mill and water storage system are used to provide drinking and household water. In many places, it is difficult to rely solely on a wind turbine as the source of electricity. The threshold wind speed needed to operate most wind turbines is approximately 15 mph. Against the time when the winds are not strong enough, the excess electricity produced at peak wind periods must be stored. Leadacid batteries are satisfactory for energy storage during non-windy periods.

Systems larger than 10 kw are needed for a range or electric heat. Smaller systems can provide the electricity for household lighting and a few small appliances. The choice of system to use with this house depends upon the availability of a power line to the site of the house. A small system could consist of a 1 kw unit, batteries, and an AC-DC inverter.

Codes

This house includes construction practices usually considered to be adequate for a house utilizing solar energy for heating. Each functional area of this house has been researched for its compliance with the Uniform Building Code, National Plumbing Code, and the National Electrical

Code. Before construction, however, the plans for any structure should be discussed with personnel in an area office of the State Environmental Improvement Agency as well as with personnel of the appropriate planning and building inspection office.

Operation

Successful operation of the self-sufficient house requires the coordination of the different systems and the cooperation of the inhabitants. The house could be operated by electronic/mechanical controls but this would partially defeat the energy saving purpose.

Discussion

The model was researched, designed, and built to help communicate the self-sufficient housing concept. Instructors who have used the model in Cooperative Extension demonstrations and college classrooms report more avid interest and understanding by their audiences than was previously elicited by 2 dimensional drawings and posters. Audiences appear to respond most positively to the solar, greenhouse, and wind generation features and least positively to the Clivus-Multrum system.

The model affords a practical and portable instructional device. Its development however, was not seen as an end in itself but rather a means to stimulate creative thinking in regard to imaginative yet practical housing. In the long run it would be desirable to go beyond the model stage and incorporate these concepts into full scale houses. All the systems discussed have been individually used in homes around the country, but a single home including all the systems discussed in this article has not yet been constructed. When universities, government agencies, and utility companies decide to build experimental houses they should consider incorporating a number of systems, rather than just focusing on one, in order to maximize the instruction and research that could take place.

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Notes

1. The technical aspects of the house are treated in more detail in Freeburg and Goldsmith (1979). For more design information the reader is referred to the following: heat storage (Yellott, 1976); water heating (Vale and Vale, 1975); organic waste disposal (Stoner, 1977; Wiley and Westerberg, 1969); water purification (Vale and Vale, 1975); wind machines (N.M. Energy Institute, 1977, 1978); solar systems (Neubauer and Cramer, 1966; Yellott, 1976); methane production (Schellanbach, et. at., 1977; Williams, et.al., 1976); greenhouses (Stepler, 1978); wood stoves (Schneider, 1977); and codes (Duff, 1977; Uniform Bldg. Code, 1978).