PROJECT FOCUS #4

Small Farm Energy Project

The Fish Solar Greenhouse

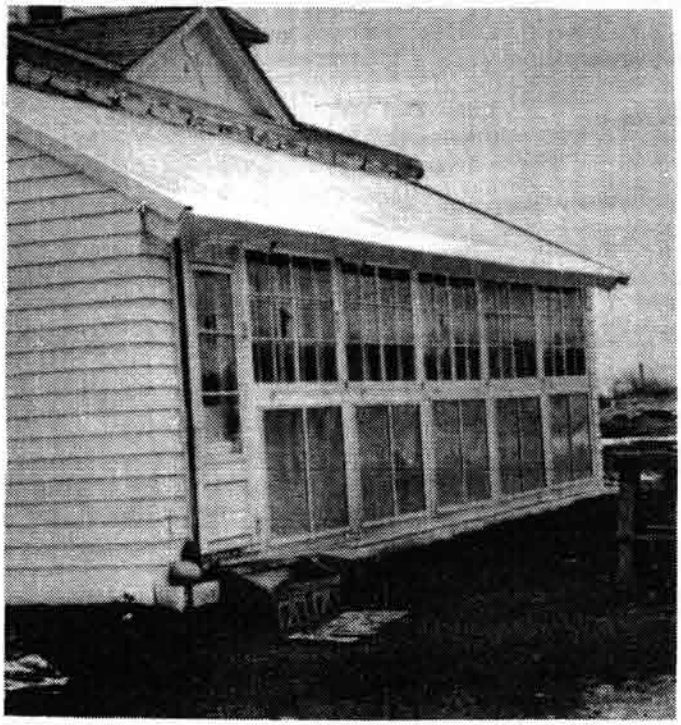
MAY, 1979

"Project Focus" is part of a primer on energy alternatives that would help lower the high costs of energy inputs on small farms. The examples are drawn from innovations built by northeast Nebraska farmers who are participants in the Small Farm Energy Project, a special 3-year research effort sponsored by the Center for Rural Affairs of Walthill, Nebraska and based in Hartington, Nebraska. The aim of Project Focus is help small farmers discover and develop viable alternatives for their own farms.

Many visitors to the Earl and Dolores Fish farm of Belden, Nebr., during early 1979 have been attracted to the family's solar greenhouse filled with beautiful green plants. The greenhouse provided a refreshing break from the past winter of record breaking cold temperature. The solar and wood heated greenhouse is attached to the south side of the Fish home providing extra heat and humidity to the home. A major savings in propane heating costs has also been realized. In addition, solar greenhouses can provide fresh vegetables for the family. A well constructed and energy conserving greenhouse, as the Fish family realizes, can provide many benefits.

Fish Family Expands on Use of Solar

The Earl and Dolores Fish family of rural Belden have enjoyed the first winter with their attached **12 ft. x 28 ft. solar greenhouse.** Filled with green plants, the added solar room provides **a comfortable addition to the home.** Earl and Dolores became interested in developing the greenhouse concept after attending a workshop sponsored by the Energy Project on the topic. In addition, the porch which was replaced by the greenhouse needed considerable repair, and the solar room provided an extra bonus to the rehabilitation. Dolores, whose mother operates a commercial greenhouse in Wayne, Nebr., was well acquainted with the care of a greenhouse.



—The southwest view of the solar greenhouse used by the Earl and Dolores Fish family of Belden, Nebr. The 12 x 28 ft. greenhouse provides a home for a variety of plants and vegetables. Extra solar heat is provided to the living area of the home during sunny days. A wood stove is also used in the greenhouse.

Solar Energy was not new to the Fish family, either. Prior to the greenhouse venture a solar grain dryer was added to a 6000 bu. bin on the farm. The system, installed in the summer of 1977, has provided excellent results in drying corn for two harvest seasons. The Fish farm is a diversified hog/dairy/beef operation on 380 acres. Two of four children, Bonnie and Bryan, are still at home taking in the solar experiences.

—Dolores Fish enjoys the pleasant surroundings of her greenhouse while a visitor inspects the green plants. The greenhouse has provided extra heat and humidity to the home the past winter. An exhaust fan for summer ventilation is shown in the upper center of the photo.

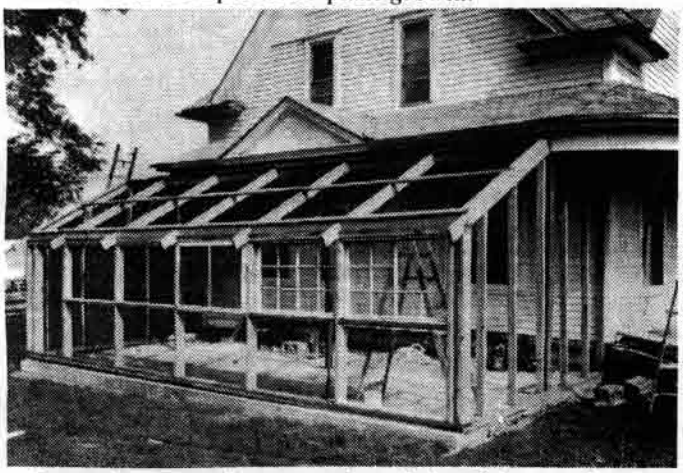
The Greenhouse Design

The Attached Greenhouse

Solar greenhouses are usually categorized into two different types. The "free standing" structure is a building separate from other structures. It lends itself well to commercial greenhousing. The "attached greenhouse" is suitable as an addition to the south side of a house.

There are numerous advantages to the **attached greenhouse.** Because the greenhouse is attached to the home, **lower construction costs can be realized,** and there is the opportunity of **heat exchange between the greenhouse and the home.** The attached unit also serves as an enclosed porch to enhance a family's lifestyle.

As an addition to the home, the attached greenhouse makes use of the south home wall as part of the structure, reducing material cost. There is also reduced heat loss by the greenhouse with the home on the north. The home can also realize a lower heat loss by the protection of the greenhouse on the south. With the home heating system nearby, back-up heating equipment can often be less costly than in the free standing unit, since the home's heating system is shared between the two structures. Plants and humans have a symbiotic relationship; with the attached greenhouse plants give off oxygen for human use, while humans give off carbon dioxide which is required for plant growth.



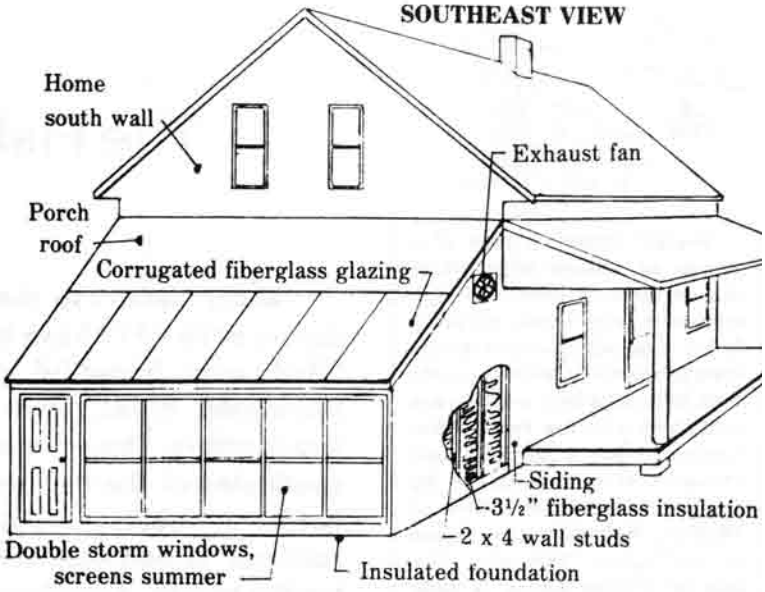
—An early stage of construction of the Fish greenhouse is shown above. The greenhouse is attached to the home as an extension of the existing porch, which required repair.

Energy Conserving Construction

The solar greenhouse requires special care during construction. A well insulated and air tight structure will minimize heating fuel requirements and maintain constant temperature. It therefore will make best use of solar gain. Only the south wall and a portion of the roof are translucent to receive solar energy for the solar reliant greenhouse. East and west walls are insulated.

In the Fish greenhouse, the east and west walls of the greenhouse are fully insulated with 3½" of fiberglass batt insulation. A black "fiberboard" sheeting ½" thick, was placed under the exterior siding. The inside of the insulation was covered by a vapor barrier and additional sheeting. Cedar shingles cover the interior of the side walls as well as the north wall. This choice of shingles gives a warm, attractive look to the interior of the Fish greenhouse, while also lowering the amount of glare from sunlight during the day. For optimum plant growth, however, white walls are preferable to darker ones, in order to reflect more light onto plants, especially for a greenhouse well stocked. Plants in the shade of other plants can receive sunlight indirectly by the reflection of the white walls.

THE FISH SOLAR GREENHOUSE
SOUTHEAST VIEW



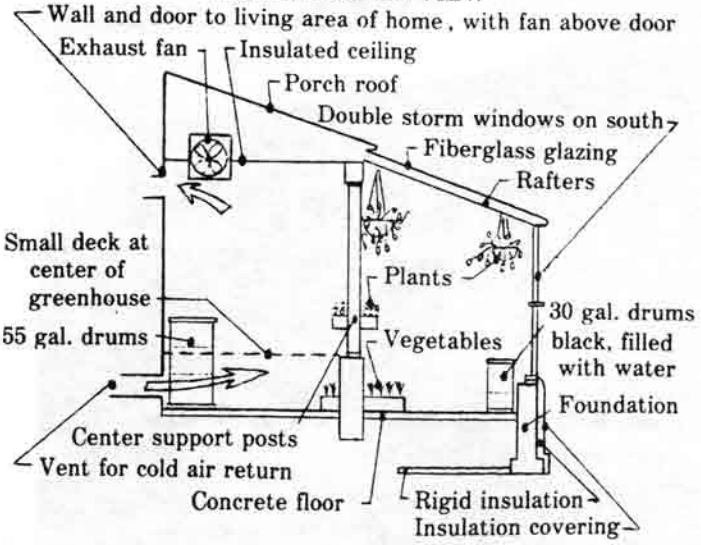
Insulation around the foundation is important to lowering the flow of heat to the cold soil during the winter. (see fig. 1) Earl Fish was only able to install part of the insulation. Proper rigid board insulation was not available at the time of placement of the concrete, which was also hampered by a cement shortage. Water-resistant rigid insulation should be used.

The south wall of the greenhouse has double windows. The south half of the roof is glazed with corrugated greenhouse fiberglass. An additional glazing material would also help to conserve energy. **Insulated shutters** had been considered earlier for the roof glazing, but Earl found it difficult to develop a convenient method of installing, removing and storing the shutters, which were to be made of rigid insulation board. Such insulated shutters should have a fire retardent quality.

The ceiling of the greenhouse, which was also the ceiling of the previous porch, is also insulated. The opaque ceiling contributes to shading in the summer to keep it cooler.

Considerable **caulking and weatherstripping** were also used to limit air infiltration into the greenhouse.

FIGURE 1 **THE FISH SOLAR GREENHOUSE**
CROSS-SECTION VIEW



—Earl Fish points out the used storm windows used for the south glazing of the greenhouse. The lower windows were made from screen frames and flat fiberglass.

Materials and Cost

Since the attached greenhouse requires only the insulated east and west walls, and the glazed portion on the south and part of the roof, it has a lower construction cost than the free standing greenhouse.

To save further dollars in construction, Earl Fish made use of a number of **recycled materials.** Old storm windows, no longer used, were installed in the south wall of the greenhouse. Earl did not have enough windows for a double layer over the entire wall, so he made some additional windows by installing flat fiberglass in old window screen frames. Old lumber from around the farm also provided material for the structure.

Corrugated greenhouse fiberglass is used in the south roof of the structure. "Tedlar" coated fiberglass is recommended for long life.

A concrete floor was poured for the greenhouse; this required a slight slope and outlet to the west for drainage of water. Lower cost, recycled brick, gravel, or wood chips have also been used in other types of greenhouses for the floor. Two fans, and a thermostat control air flow and temperatures of the solar room.

The cost of the Fish greenhouse and materials is listed in Table 1. **The cost of the greenhouse will vary with its size and also with individual preferences for finishing materials.** Greenhouses can be larger or smaller than the Fish unit. The Federation of Southern Cooperatives in Alabama, for example, has promoted small greenhouses costing $300 or about $3 per sq. ft. of floor area.

TABLE 1

Material and Cost List

Exhaust Fan With Shutter, 1625 cfm, Dayton #2C708	$ 70
Squirrel Cage Fan, 525 cfm, Dayton #2C906	40
Thermostat, Dayton #2E206	20
Filon Corrugated Fiberglass	205
Cedar Shingles (optional)	260
Insulation	165
Concrete	220
Lumber, paint & misc. hardware	1420
TOTAL COST	**$2400**

Heat Gain

There are two forms of solar heat available to the interior of the Fish greenhouse. First, **solar energy** combined with "thermal mass" of barrels of water provides heat during the day, and also at night. Secondly a **wood stove** keeps house plants thriving the coldest winter nights.

The sun's energy enters the greenhouse through the glass windows of the south wall and half of the roof glazed with fiberglass. The heat is trapped within the structure. "Mass" within the greenhouse, including the concrete floor and black barrels of water stored along the south and north wall, provide **storage for some of the day's excess heat.** The heat then is released at night.

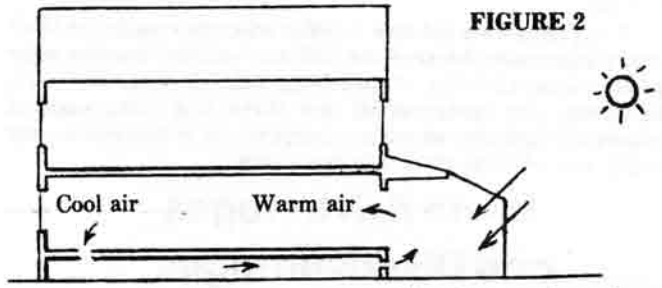
A pot-bellied stove serves as a back-up heat source for the greenhouse. Earl Fish reports using two dead trees the past winter to fire the stove. Both solar and wood heat provide heat to the living area of the home.

Air Circulation

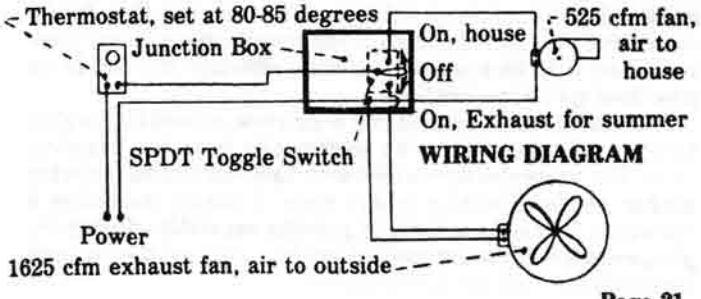
There are two purposes of air circulation for the Fish greenhouse. During the winter, warm air is provided to the home; during the summer, warm air is removed from the greenhouse to the outside to cool the structure.

In the Fish system, a squirrel cage **fan is used to move warm air from the greenhouse to the home during winter,** when the solar room reaches 85 degrees. It is regulated by a thermostat and is located over the door between the greenhouse and the home. At its height, warmest air is circulated by the fan. The cold air return to the greenhouse is through the crawl space from the kitchen area on the north side of the house. (see fig. 2) As a result the crawl space also tends to act as heat storage during periods of excess heat. It has also been noted that just opening the door to the home offers venting of the greenhouse heat to the living area without the fan. This makes use of convection currents. The Fish family has been pleased with the extra heat provided to the home. Says Earl, **"Even on the coldest days the heat from the greenhouse circulating in the other rooms kept the furnace from kicking on all day ."**

FIGURE 2



For the summer months, "passive" roof **vents that release warm air** by convection can be used. Wind turbines have also been used. However, in the Fish greenhouse, a ventilation fan is provided and is regulated by the thermostat, although screens will be installed in place of the windows on the south during the warmest season of the year. The ventilation fan will be particularly helpful during the fall and spring when the south windows are required for frost protection but when additional heat may not be needed in the home.



Greenhouse Living

Since Earl completed the greenhouse, the family has received considerable **pleasure from the addition to the house.** The Fish's daughter, Bonnie, does all her studies there and her mother often goes to the greenhouse just to sit during the day. Dolores says its a real treat to see all the greenery in the middle of winter. It must be like a bit of the tropics moved up to an ice box.

Dolores received many houseplants from her mother, who operates a commercial greenhouse, and they all thrived during one of the harshest winters to date. This fall, the Fish family hopes to grow more vegetables in the greenhouse. Fresh tomatoes are to be Earl's Christmas presents for neighbors and friends.

Like other farmhouses with attached greenhouses (see SFEP News, 9/78) the wood stove is an important source of heat. This is especially true because of Earl's reluctance to insulate the windows at night and on cloudy days. On clear, cold January days, the greenhouse becomes warm enough that the fan blows warm (90°F) air into the house, reducing furnace operation. During the evening and on cloudy days Earl stokes the stove, keeping the greenhouse warm and contributing to house heat. Because the higher humidity levels in the greenhouse (30% to 40% this winter) contributed to house humidity, comfort in both areas was improved. The exhaust fan should vent excess humidity in the summer.

Energy Savings

Because both solar and wood energy contribute to heating the greenhouse, it was not possible to analyze the effectiveness of the structure as a passive design, although the **Fish family realized considerable fuel savings.** For those who are interested, a simple test of greenhouse design is to place a thermometer which records maximum and minimum temperatures in the greenhouse and another outside. By comparing the temperature swings for the greenhouse with the outdoors, one can get an idea of how effectively the greenhouse operates.

The Fish's were not able to claim solar tax credits for their energy innovation because the IRS has excluded passive solar systems from their list of qualifying solar devices. However, the ruling was controversial and there was Congressional support for inclusion of passive systems, so greenhouses may qualify for solar tax credits in the future.

Some Advantages and Disadvantages of Solar Greenhouses

Some cooperators of the Energy Project turned thumbs down to the idea of a greenhouse for the winter months. After working all summer in the garden, they were tired of working with plants. That's a respected personal preference. Special care is required in the greenhouse for such difficulties as pest control and for proper lighting, watering and temperatures.

Trees to the south can be a difficulty to cope with when considering a greenhouse addition. However, the Fish family has a large tree directly south of the greenhouse and they have not found it to be a serious problem, although the deciduous tree does give some shading.

The simplicity of the retrofit solar room as used by the Fish family is an advantage to its construction over free standing units. The home also is provided with **heat and humidity during winter months,** lowering energy costs. A family can realize a savings in food costs as well, by **growing vegetables during** the winter months. Growing small plants for resale can also be used for supplementing the family income.

Options for the Greenhouse

The solar greenhouse may have a secondary use of food drying during hot summer months when garden crops are predominant. In Alabama, there has been an interest in converting the greenhouse to a wood kiln to dry wood during the summer. Solar distillation of "hard" water may be another possibility.

Greenhouses may have other options for the farm. For commercial greenhouses, some researchers have suggested that locating greenhouses near livestock buildings can take full advantage of carbon dioxide, moisture and heat exhausted from the livestock housing by ventilation fans. Greenhouses may also be combined with alcohol and methane production systems in the future.

More Information

References

"Solar Reliant Greenhouse Plans," Solstice Publications, 12520 W. Cedar Dr., Lakewood CO 80215, $7.50 plus $1.00 shipping and handling. Detailed plans are included in several pages of blueprints for construction of free-standing and attached greenhouses.

The Food and Heat Producing Solar Greenhouse by R. Fisher and Bill Yanda from John Muir Publications, P.O. Box 613, Santa Fe, NM 87501 for $6.50. A do-it-yourself book, the 160 pages discuss design, construction and performance of various types of greenhouses, including that of 30 innovators. Well illustrated.

The Solar Greenhouse Book edited by James C. McCullagh from Rodale Press, 33 E. Minor St., Emmaus, PA 18049; $8.95 paperback and $10.95 hardcover, 134 pages. Describes design, construction and crop production in low-cost, low-energy units and includes technical and design information for freestanding, attached, and pit greenhouses. Many photographs and illustrations are included.

"Solar Greenhouse Annotated Bibliography and Plans List", National Solar Information Center, Box 1607, Rockville, MD 20850, 1977, free. A comprehensive list, including addresses for 11 useful plans.

"Noti Solar Greenhouse: Performance & Analysis", by Hoff, Jenkins & VanDuyn, Center for Environmental Research, School of Architecture, U. of Oregon, Eugene, OR 97403, 1977, 32 pages. A presentation of the design of a greenhouse using the sun as the only heat source for one winter. Uses earthen berm and rock thermal storage. Well illustrated.

Greenhouse Plans, David Kruschke, Route 2, Box 34-A, Wild Rose, WI 54984, $5. Plans for a "live-in" greenhouse or an add-on solar greenhouse. Includes reports on the use of the greenhouse in cold Wisconsin winters.

The Survival Greenhouse by J.B. DeKorne, The Walden Foundation, P.O. Box 5, El Rito, NM 87530, $7.50. Construction and operation details of a pit greenhouse used in southern climates.

The Federation of Southern Cooperatives, P.O. Box 95, Epes, AL 35460, phone 205-652-6976. Two 1979 publications on attached greenhouses are available, each for $3. **Greenhouse Operations Manual** is a 60-page horticultural guide on how to make the solar greenhouse function well. **Pop-Out Front Solar Greenhouse** is a 35-page, detailed construction manual, including material sources and costs. Developed in Alabama, the manuals are oriented for the warmer, southeastern part of the country.