PROJECT FOCUS #9

Small Farm Energy Project

The Pinkelman Solar Farrowing Barn

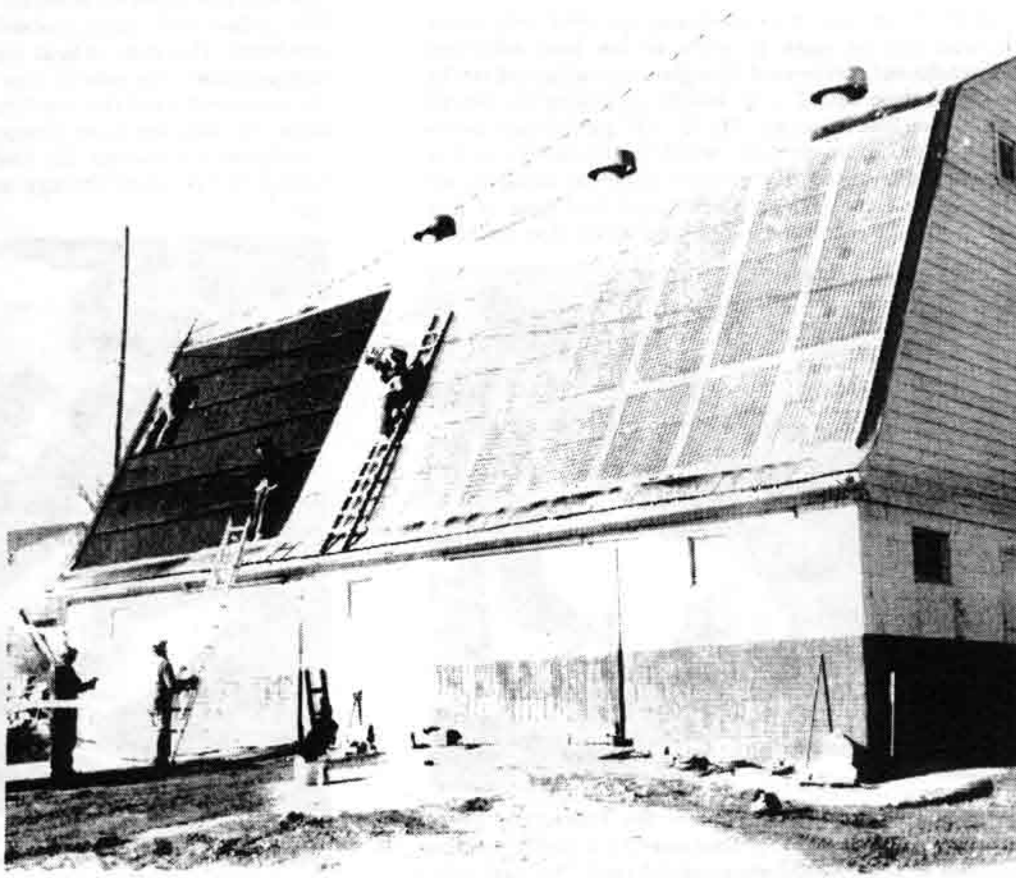
MARCH, 1980

—Rick Pinkelman.

When Rick and Mary Pinkelman took over the family farm, they decided to change the primary livestock of the farm from dairy to hogs. While planning the conversion of the dairy barn to a farrowing barn, the Pinkelmans joined the Small Farm Energy Project.

The Pinkelmans have found that solar energy can be used effectively in the hog farrowing enterprise. They constructed one of the first major solar innovations of the Energy Project onto an existing barn. They first insulated the structure well. Much was learned from the experience, including the importance of keeping a solar system air-tight. But the project demonstrated how a good innovation is developed when the farmer, and not just the engineer, is involved in the design. Other farmers will undoubtedly benefit from the Pinkelmans experience.

—Mary Pinkelman.



—Shown above is the 850 sq. ft. solar collector used for heating ventilation air in the farrowing barn of Rick and Mary Pinkelman. The 17 X 50 ft. solar collector was mounted onto the roof of an old dairy barn. The solar system was one of the first major solar devices used by Energy Project cooperators on an existing building.

First Solar Collector in the Area

Rick Pinkelman got interested in making use of solar energy after hearing about the simple window box collector at an Energy Project workshop early in 1977. Not one for delays, **Rick found an old storm window and enough spare lumber to build the first solar collector in the county.** After hooking up a small fan from an old slide projector, be became convinced that solar energy could work for him.

Renovating a Dairy Barn

Though solar energy seemed to be an idea with promise, it was hard for farmers to be optimistic that winter. The previous three years were dry as farmers in the plains experienced the worst drought in 20 years. Many farmers received FmHA disaster loans and the Pinkelmans decided to make their investment in livestock facilities.

With a disaster loan in hand and conversion of dairy barn to a 22-sow farrowing facility in sight, it wasn't long before Rick included elements of solar design in his renovation plans. **Bill Peterson, an extension engineer at South Dakota State University, provided imagination and timely technical assistance in the design of the Pinkelman's solar ventilation system.**

The 17' x 50' roof facing the south at a 70° angle from the horizontal was an ideal application for a flat plate solar air collector. So Rick and Mary were among the first cooperators to prepare for a solar installation by insulating the area to be heated.

Insulation Is the First Step

Weatherization and insulation measures are the first steps to be taken for solar heating projects. In the farrowing house this was accomplished by studding out concrete block walls, insulating with 3½" of fiberglass insulation, and covering it with chip board. The north wall is well protected from the elements as the barn, built into a hillside, was provided with a "berm" years ago. The ceiling of the farrowing unit was insulated economically by stacking bales of hay in the hay mow above. A bale of hay 1½' thick has an R' value of 14, according to experts.

The Solar Project Design

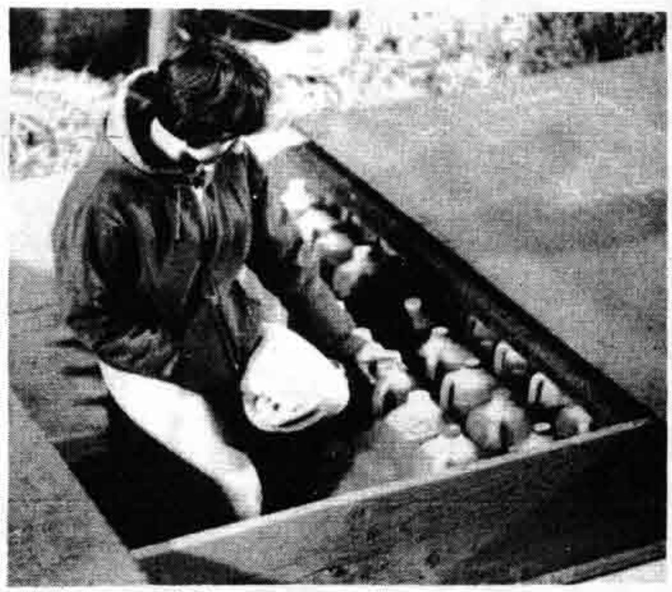
The basic ideas for the solar heating unit are fairly simple, but the actual application of the solar principles required careful design work and construction. William Peterson was most helpful in assisting Pinkelman with the solar design.

Designing and Building the System

The roof of the barn was previously covered with sheet **metal.** It was painted black to serve **as the heat collecting surface. Translucent corrugated fiberglass was attached to the roof/collectorsurface** with 2" x 2" boards extending the length of the roof at two foot intervals. The 2" x 2" purlins also serve as separations for the six air ducts which the air follows as it is drawn through the collector. In other collector designs, air often flows behind the collector plate and less heat is lost though the front of the collector. Redwood strips that matched the corrugations of the sheet metal and fiberglass were used with silicone caulk to minimize air leaks in the collector. Collectors have been known to lose heat through leaks before the warm air is delivered to the structuce.

Air from the barn is pulled through the collector by a 2000 cfm fan; the warm air is blown through a wide duct filled with 850 gallon milk jugs containing a mixture of water and methanol. This type of heat storage proved quite inexpensive and practical. The cubical jugs were donated by individuals in the community and the 1 to 8 ratio of methanol to water should keep the mixture from freezing to 0° F. A second fan pulls ventilation air through the heat storage duct where the air is heated before going through another duct into the farrowing unit.

—Construction work underway on the Pinkelman solar farrowing barn. Fiberglass was placed over 2 X 2 purlins, which were mounted to the original sheet metal roof. The roof was painted black. Holes at either end of the roof are used to move air between the barn and the collector. Heat storage is located in the loft of the barn, which has a capacity for farrowing 22 sows at a time.



—Mary Pinkelman assists in the construction of the solar system for the Pinkelman farm's farrowing barn by placing plastic milk jugs filled with water into the heat storage area. 850 one-gallon milk jugs were used for the storage system. Some difficulty has developed with leakage of the jugs.

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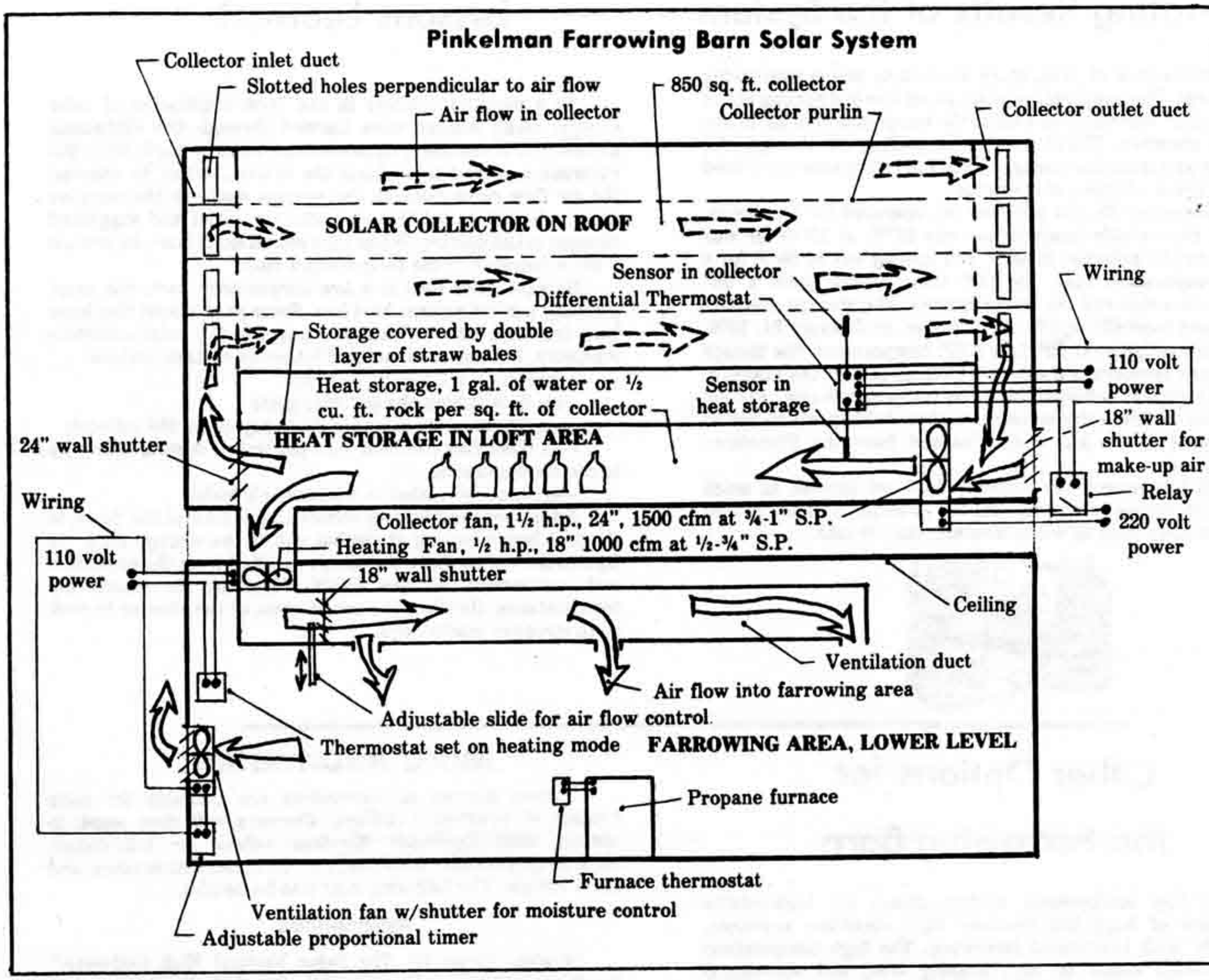

Integrating the System Controls

The four elements of the solar system: the collector, heat storage, air flow components, and propane back-up heater had to be integrated so they would work together. Bill Peterson's expertise was helpful in matching the size of the storage capacity with the collector size, figuring optimal flow rates, duct size and control instruments, as well as construction hints, which made the system more effective.

A differential thermostat controls the solar fan. A heating/cooling type thermostat regulates the second fan. A third fan also aids ventilation and is controlled by a timer.

Rick used his innovative talents to integrate the heating/cooling thermostat, which controls the storage fan, with the thermostat controlling the propane furnace. The furnace provides back-up heat for the solar system. **The combination of Rick's talents and Bill Peterson's expertise represents how a good system is developed when the farmer is a part of the design process.**

Rick built the collector himself with the help of neighbors when putting up the large fiberglass sections. **The cost of materials for insulating the barn and building the solar system was just over $1900.** Rick figures he built most of the system over a period of three weeks, while doing the rest of the usual farm operations.

Rick has found that the solar innovation and the added insulation have saved considerable amounts of propane, although the savings have varied from year to year, making it difficult to estimate actual return on the investment. The insulation of the barn is probably as effective or more effective in saving energy as the solar system.

Cooling Used in the Summer

The Pinkelmans have been using their system to **pre-heat ventilation air in the winter and to cool the facility in the summer.** The system is shifted from heating to cooling by reversing sensor connections on the differential thermostat. At **night, the water jugs in the storage compartment are cooled** so that the ventilation air can be tempered during the daytime. This saves the investment and expense of other air cooling devises.

The Cost of the Project

MATERIALS COST FOR BARN RENOVATION	
Insulation	550
Collector (850 sq. ft.)	600
Heat Storage & Ducts	500
Fans and Controls	310
Total Cost	**$1960**

Operating Results of the System

In November of 1978, Mary Pinkelman began **monitoring** the system. The temperature of air going into and coming out of the collector was noted as well as the temperature of air in the storage chamber. Clocks on the fan pulling air through the collector and from the storage to the farrowing area were used to keep track of hours of operation.

On November 30, the collector fan operated for 5½ hours. Though the outside temperature was 22°F, at 10:15 air was going into the collector at 46°F and coming out at 66°F for a **20°F temperature rise**. By 1:00 the collector gave **a 34° temperature rise** and the temperature in the storage chamber was raised from 52° to 58°. At 1:00 p.m. on January 24, 1979, air left the collector at 80°F for a 32° temperature rise though the outside temperature was 18°F. About 15% of the available solar energy was collected, based on temperature rise and air flow rates. Similar solar systems could probably perform better using some of the knowledge learned from the Pinkelman experiences.

Rick has noticed the collector does not provide as much heat when strong winds cool off the collector surface. It also provides more heat in warm weather than in cold.

Lessons Learned

As a pioneering effort in the farm application of solar energy, **many lessons were learned through the Pinkelman experience.** When the system was completed in April, 1978, Bill Peterson returned to evaluate the system. When he checked the air flow rates through the various ducts in the complex system, he concluded that air leaks may exist and suggested changes in the ducting. When Rick sealed leaks later, he noticed a 10° F increase in the temperature rise.

Because solar heat is a low-temperature heat, one must jealously protect against heat loss. **Some precautions that have been taken on later collectors** to improve the solar collection efficiency, but not used on the Pinkelman system, include:

—insulation behind the collector
—air flow behind the collector plate
—air filters in ducts where dust may cover the collector
—all fiberglass installed with protective coating facing up to reduce discoloring
—system well-sealed to minimize air leaks

After operating for two winters, Rick noticed the liquid in the jugs began leaking at the hot end of the storage duct. He figures the cracks along the seams resulted from the expansion and contraction of the liquid occurring in fluctuating temperatures. He plans to convert some of the storage to rock or to stronger plastic jugs.

Other Options for the Farrowing Barn

The hog confinement facility allows for high-volume production of hogs but involves high operating expenses, especially with year-round farrowing. **The high temperature requirements result in high heating bills,** and substantial ventilation is necessary to reduce moisture and minimize disease problems. **The heat lost in ventilation further contributes to the heating load.** By renovating an existing building, the Pinkelmans have reduced their initial investments, but alternative approaches do exist.

A heat exchanger is one alternative which reduces heat-loss in the ventilation system. It may be constructed in well-sealed buildings so that the **heat from exhaust air is transferred to cold ventilation air,** thereby saving considerable amounts of energy. In some cases the heat exchanger may be more cost effective than a solar system. Advantages of the exchanger are that it provides a more consistent humidity level than the solar system, and it operates daily without the sun.

A simple alternative to the confinement system is **portable huts** provided for each sow, located in alfalfa pasture or other areas, which may be moved to new locations for each farrowing. The **low investment and operating expenses** of such an approach may result in the most practical system.

Some cooperating farmers have adopted a European technique of building **hovers** in finishing sheds to conserve heat given off by feeder pigs. The simple concept involves straw bales suspended two feet above the floor. The same concept can be used for pigs in the farrowing pen. Some farmers have **built hovers of plywood located at the ends of the pens that are 1 ft. wide and 1 ft. above the floor**. The pigs congregate under the the hover where it is warm. The idea is to conserve the heat of the pigs for better health and also to conserve energy.

More Information

Various sources of information are available for solar heating of livestock buildings. **Farmers will first want to contact local Extension Services offices** for information regarding insulation, ventilation devices, ventilation rates, and other details. The following may also be helpful.

References

"Project Focus #3, The Solar Vertical Wall Collector," Small Farm Energy Project, P.O. Box 736, Hartington, NE 68739, 50 cents. A summary of various sizes of wall-type collectors used on homes for space heating. Many of the concepts could be applied to vertical walls for other buildings as well.

"Vertical Wall Solar Collector, Rules of Thumb", also available from the Energy Project for 75 cents. Includes suggestions for collector air gaps, painting procedures, fan sizes and other details.

"Catalog Sheet of Solar Heated Building Plans," Dept. of Agricultural Engineering, U. of Illinois, Urbana, IL 61801. The free, 2-page listing describes some 10 plans that are available from the U. of Illinois. Costs of the large blueprints are also included. Half of the plans apply to grain drying, but several provide information on solar heated farrowing barns.

"Heat Exchangers for Livestock Barns," Small Farm Energy Project Newsletter, March, 1979, page 10. A description of the heat exchangers developed by George Rauenhorst of Olivia, Minn. and used in various livestock barns to extract heat from exhaust ventilation air to pre-heat incoming cold air. For a copy, send 25 cents.