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Model Solar System No. 1

on the Leslie Prier Farm

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This guide has information on a demonstration solar system on a farm in Southwest Missouri. The system was designed to preheat ventilation air for livestock confinement buildings. The guide gives the goals for the solar system, the cost of building it, and an evaluation of its performance. The guide also shows the design, suggests modifications, and gives other tips for constructing and operating a solar system.

Leslie Prier, the farm owner, along with the University of Missouri Extension Division, the U.S. Department of Agriculture, and the U.S. Department of Energy, supported development and testing of this system.

The Farm

Leslie Prier's farm is about 2½ miles east of Newtonia, on state Highway EE. This is about 25 miles southeast of Joplin. Prier raises cattle and turkeys on his 290-acre farm.

The turkey facility is composed of three buildings: one brooder house, one intermediate grow-out house, and one finishing house. The brooder building, which has the solar unit, is a metal-clad, exposed-steel-truss, curtain-sidewalled structure, measuring 40 x 250 feet, oriented east and west. The roof and wall area, excluding the curtained area, is lined with ¾-inch urethane insulating board with an R value of 4.7. Thirty-four propane gas pancake-type brooders supply primary heat for brooding. Three 11,000 cubic-feet-per-minute (cfm) fans mounted in the north wall, along with side curtains, ventilate the building. The building and equipment are typical for the turkey industry in Southwest Missouri.

Ten thousand hen poults or 7,000 tom poults are brooded in seven-week cycles. As each new flock begins brooding, the older flock moves to the intermediate building and from the intermediate building to the finishing building. About 6½ flocks are brooded in a 12-month period.

Goals

The following objectives governed the design and construction of this system:

- Provide a preheat system for ventilation air using solar energy.
- Establish heat storage for use when the sun is not shining.
- Minimize cost and inconvenience to the operator during construction.
- Provide a solar system for use on existing poultry buildings.

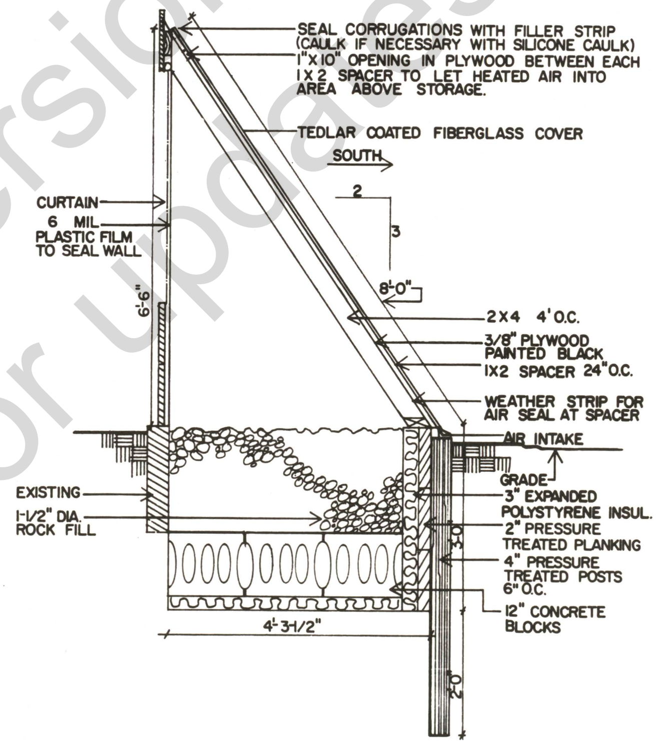

Figure 1. Cross section view of collector-storage system.

For heat, the 40- x 250-foot brooder building needs about 4,700 Btu per hour per degree temperature difference between inside and outside air. On an average December day with an inside temperature of 80°F, total energy demand would be 4.9 million Btu per day.

The space available for the design selected allowed construction of 2,000 square feet of collector. The collector was 250 feet long—same as the building. Average collection during December was estimated at 500 Btu per square foot per day for a total of one million Btu per day. On a completely clear day, collection should net nearly two million Btu.

The rock storage was designed to store maximum energy collection for one clear December day with a storage temperature range of about 30 degrees, assuming that 25 percent of the collected energy would be used directly and not stored.

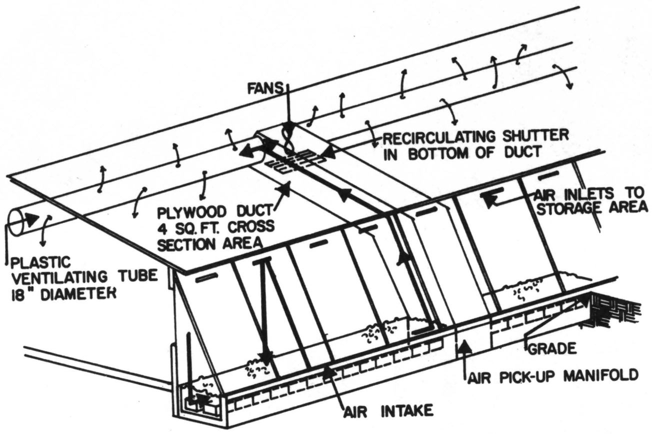

Figure 2. Diagram of air flow through the system.

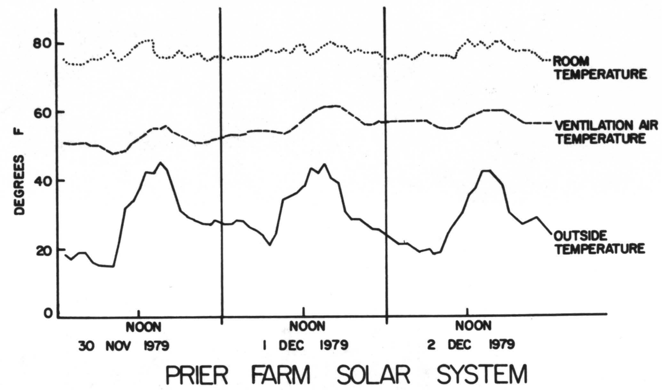

Figure 3. Typical performance data for the system.

The ventilation system was designed to provide 4,000 cfm of outside air or two cfm per square foot of collector surface. This volume is about the same as minimum winter needs for 10,000 birds brooded. Ducts were sized to keep air velocities below 1,000 feet per minute. A power louver was placed in the suction side of the fan system to recirculate some interior air from the brooding room. Preheated ventilation air is distributed throughout the room by means of perforated plastic tubes.

Figures 1 and 2 show construction details for the system.

Cost

Construction cost for this system was $8,661.42 for an average cost of $4.33 per square foot of collector.

Performance

The solar system began operation on Prier's farm on November 17, 1979. Air temperature, ventilation air flow, and solar radiation were monitored on 29 days between November 17, 1979 and January 1, 1980. During these 29 days, the system added 44 million Btu of heat energy to the ventilation air entering the building. This is equal to the heat energy obtained from 590 gallons of LP gas, or about 20 gallons per day was saved.

The rock bed performed extremely well in collecting heat during the day and releasing it into the ventilation air at night. In some instances, ventilation air entering the building was as much as 30°F above outside air temperatures.

Static pressures in the rock storage were somewhat higher than expected, resulting in a ventilation rate of 3,200 cfm through the collector instead of the 4,000 cfm expected. This volume reduction does not appear to affect the system's performance. When the recirculating shutter is open, air flow through the collector-storage system decreases to 1,900 cfm.

Figure 3 shows some typical performance data.

University agricultural engineers will collect additional performance data on this system through 1982. If you would like to review the data, contact the authors.

Construction and Operation Suggestions

- Completely seal solar systems against air leaks. These systems use relatively small amounts of air, and any air leaks will result in poor performance.
- Adequately brace duct work on the suction side of the fans to withstand the partial vacuum that exists.
- Provide positive drainage to prevent water from accumulating in the rock storage area. Make sure the drain outlet is sealed to prevent air leakage. (We suggest a water trap.)
- On extremely cold nights, you can save some energy by opening the recirculation shutter, thus reducing the amount of cold outside air brought into the system. *Caution:* Monitor room conditions when doing this to make sure enough fresh air is brought into the building. This is especially critical as birds increase in size.
- Make sure that solar system construction doesn't interfere with normal operation of the summer ventilation system for the building.
- Provide enough clearance from the base of the collector to grade to minimize the possibility of snow plugging the inlet. In areas that get much snow, air flow over the absorber plate can be reversed by placing the inlet at top. (The absorber plate in this system is plywood painted black.)

Suggested Modifications

As a result of our experiences with this system, we offer the following suggestions for constructing or modifying a collector-storage unit of this type.

- Provide a single fan for the system or install fans with a baffle to prevent interference with each other.
- Limit total collector length to 100 to 125 feet. This will allow use of smaller ducts and should improve system performance.
- Distribution tubes for heated air need to be of equal length to insure proper temperature distribution.
- If you adequately insulate (R=13) and seal the south wall of the building, you could eliminate the absorber plate from the system.
- You could place rock storage on top of the ground, but this would reduce collector area somewhat.

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