13 Oct 1977

Solar Heated Animal Shelters

Joan M. Wood

SOLAR HEATED ANIMAL SHELTERS

Joan M. Wood
Georgia Institute of Technology
Atlanta, Georgia 30332

Abstract

Modern day agricultural methods have made todays farmers dependent upon fossil fuels to maintain their productivity. This paper addresses one aspect of the problem--the heating of animal shelters. In particular, the solar heating of a broiler grow-out house, where temperatures of up to 95°F must be maintained, is discussed.

A detailed analysis of a solar heated broiler grow-out house that has been operating for over a year will be presented. The solar system provided 47% of the heat required to grow 22,000 chickens. The system utilizes a 3,200 ft.^{2} integrated rock absorption and storage collector. An economic analysis of the solar system which cost $6,600 shows that it has a payback period of 5 years. Another circulating hot air collector has been designed and its design, construction and operation will be discussed.

1. INTRODUCTION

Modern day agricultural methods have made todays farmers dependent upon fossil fuels to maintain their productivity. According to ERDA studies agricultural heat processes currently use 0.44 quadrillion (0.44×10^{15}) BTU's per year. ERDA has predicted that it is possible for solar energy to provide about 0.1 quad per year by 1985, and 0.7 quad by the year 2000 for this purpose.

Two factors favor the growth of solar energy utilization for meeting the thermal requirements of agriculture. One is that farmers have traditionally been dependent upon propane for their heating fuel and since natural gas currently provides 70% of the domestic propane, the price and availability of propane is therefore dependent upon the price and availability of natural gas, which is in short supply. The second factor is that the low temperatures required in thermal agricultural applications are easily obtainable with relatively low cost solar collectors. Both of these factors tend to make the switch from fossil fuels to solar energy economically attractive for our nations farmers.

The challenge in utilizing solar energy for thermal agricultural applications is to construct a system which is economically feasible. The difficulty comes about because solar energy is a very diffuse form of energy. Solar radiating strikes the earth's surface at an average of 1500 BTU/ft^2/day. This means that to collect a significant amount of energy relatively large areas must be used. Thus, when designing a solar collector, it is imperative to keep the cost per square foot of collector area low.

A typical installed cost for the traditional copper tubed circulating water solar collector is about \$25/ft^2. A system costing about \$2.00/ft^2 would be economical for most agriculatural purposes.

Depending on the climatic conditions, swine, cattle, dairy cows, and poultry all require heated animal shelters at some time in their life span.

2. CHICKEN HOUSES

In the poultry industry a large percent of the energy consumed is used in the grow-out phase of production. Most of the energy used for heating chicken houses is derived from liquified petroleum gas. Estimates of the amount of LPG used in the United States for this purpose range from 120-170 million gallons per year. The temperatures range from 95°F for baby chicks to 70°F for fully-grown chickens. If lower temperatures are provided, the feed conversion ratio suffers because the chickens use more food energy to keep warm, and mortality levels may increase. The required temperatures are easily achieved by inexpensive nonfocusing solar collectors.

Because of the economic impact of rising feul costs on the poultry industry, the Georgia Poultry Federation and the Georgia Department of Agriculture have sponsored the following research for low cost solar collectors for broiler grow-out houses. These systems have been designed with three overriding considerations in mind.

1. The system should be low cost and have a payback period under 10 years.

2. The system should be designed so that it can be built of readily available materials.

3. The construction of the system should be simple enough for a farmer to build by himself.

2.1 PASSIVE SOLAR SYSTEM

The low-cost passive solar system illustrated in Figure 1 was specifically designed to meet the needs of a broiler grow-out house; however, the concept can easily be used for other animal shelters. This solar heating system was installed in May 1976 on a 14,600 ft^2 curtain-sided grow-out house in Cumming, Georgia. Split house brooding is used in this house. The total installed cost of the system was \$6,600, which included \$3,000 for materials, \$2,200 for labor, and \$1,400 for grading. In the first tests of the system, the solar system provided 47% of the energy required to grow 22,000 broilers. The system has an estimated payback period of five years.

The collector array is located on a south-facing hillside just below the grow-out house which has been graded to a 30° slope. The collector array is 208' x 16'; a layer of polyethylene lying on the hillside prevents groundwater from seeping into the collection medium; a 6" layer of black-painted rock acts as an absorber of the solar energy and also provides thermal storage. The rocks are granite grade B filter media gnice with an average diameter of 4 inches. The rocks are covered with two layers of 6-mil Monsanto 602 separated by a dead air space to insulate the rocks. Outside air enters through a slot at the bottom of the collector and rises as it is heated by the hot rocks. Natural convention carries it through 8" I.D. concrete pipes into the center brooding section of the chicken house. No fans or other moving parts are used by this system. The system is controlled simply by opening or closing the pipe outlets inside the chicken house. The air is not recirculated through the solar collector because of the oxygen requirements of the chickens. Standard exhaust fans are used to provide additional fresh air for the chickens. These exhaust fans create a negative pressure within the house which causes additional air to be brought in through the collector system.

The rocks in the collector have been observed at temperatures as high as 180°F. The normal winter operating range is 120°F-160°F. The system raises the temperature of the outside air an average of 18°C. Even when this temperature rise is not high enough to meet the requirements of the chickens, the solar system will provide a portion of the energy requirements and the backup gas heating system will provide the remainder. Figure 2 is a graph of the temperature difference between the outside air and the temperature of the air at the collector outlet on a typical sunny winter's day during which the outside temperature reached a low of 0°C.

2.2 EXTENDED ROOF HOT AIR COLLECTOR

A second system has been designed for houses which are not fortunate enough to have an available south facing hillside. This design called an extended roof hot air collector is shown in Figure 3. Fans are required to pull air down the black painted roof under a layer of polyethylene then through the rock storage bin and then either back through the collector to be reheated when heating is not required in the chicken house or into the chicken house.

It is also possible for this system to provide some cooling in the summer months. Cooling is desirable in the summer to prevent mortality in full grown birds. The solar collector can be closed off and at night cool outside air can be circulated through the rock storage bin. Then during the warmer part of the day ventilating air can be circulated over the cool rocks and into the broiler house.

It is expected that this system will cost about \$5,000 for 4000 ft^2 of collector, an area which should provide 70% of the heating requirements of the broiler house. This should give a payback period of about 3 years.

3. SWINE HOUSES

The University of Illinois at Urbana-Champaign has built several solar-heated swine buildings in western Illinois. Their work began in 1964 and has intensified in recent years as the price of energy has risen.

In their design, the ventilating air is preheated by being pulled under the entire roof area. The air flows through a 1-5/8 inch space to a central collection duct where it is blended and pulled into an inside distribution duct that runs the length of the building. This distribution duct contains the fans which blow the air into the building. These fans are controlled both by thermostats (0°-100°F) and 12 minute cycle time clocks.

The temperature rise between outside air and air entering the building ranged from 14°F to 44°F.

4. DAIRY PARLORS

Traditional circulating water flat plate collectors are being used to provide energy for dairy parlors in Colorado and Maryland.

The Colorado system utilizes 350 ft^2 of collector and a 200 gallon storage tank. The construction costs were $2,500. Dr. Norman Gibbs, the owner of the system, estimates that it provides an average of 40% of the energy needed to heat water to clean the milking equipment for a 200 cow herd.

The system located at the U.S. Department of Agriculture's research center in Beltsville, Maryland also provides energy to a 200 cow dairy operation. It consists of 1,000 ft^2 of solar collectors (4 different types of flat plate collectors are being tested) and a 10,000 gallon storage tank. By combining solar heating, conservation and waste heat recovery it is believed that the building's fossil fuel requirements will be reduced by as much as 75%.

5. REFERENCES

1. Wood, J. M., "Low-Cost Solar Heating Systems for Broiler Houses," Proceedings Georgia Broiler Workshop, Georgia Poultry Federation, Gainesville, Georgia, March 17, 1977.

2. Walton, J. D., "1977 Crucial Year for Solar Energy," Consulting Engineer, March 1977.

3. Hall, Marvin, "Sun Helps Heat Farrowing House," Crops and Soils Magazine, June/July 1974.

4. Wilkinson, Bruce M., "Solar Heat Scores 4%, New Dairy Energy Source," Dairy Herd Management, February 1976.

5. "Solar Energy Generates Power in the Parlor," Dairy Herd Management, August 1976.

6. BIOGRAPHY

Ms. Wood received her BS in Electrical Engineering from the Polytechnic Institute of New York in 1966. She has since worked for the General Electric Company, the University of Virginia and Western Connecticut State College. She is presently a Research Engineer at the Georgia Institute of Technology where her primary research field is low-temperature solar collectors.

FIGURE 1.
SOLAR HEATED BROILER GROWOUT HOUSE

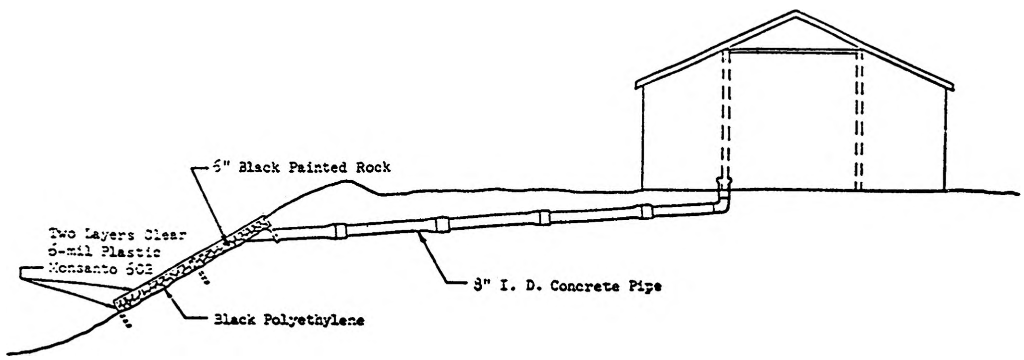

Figure 2

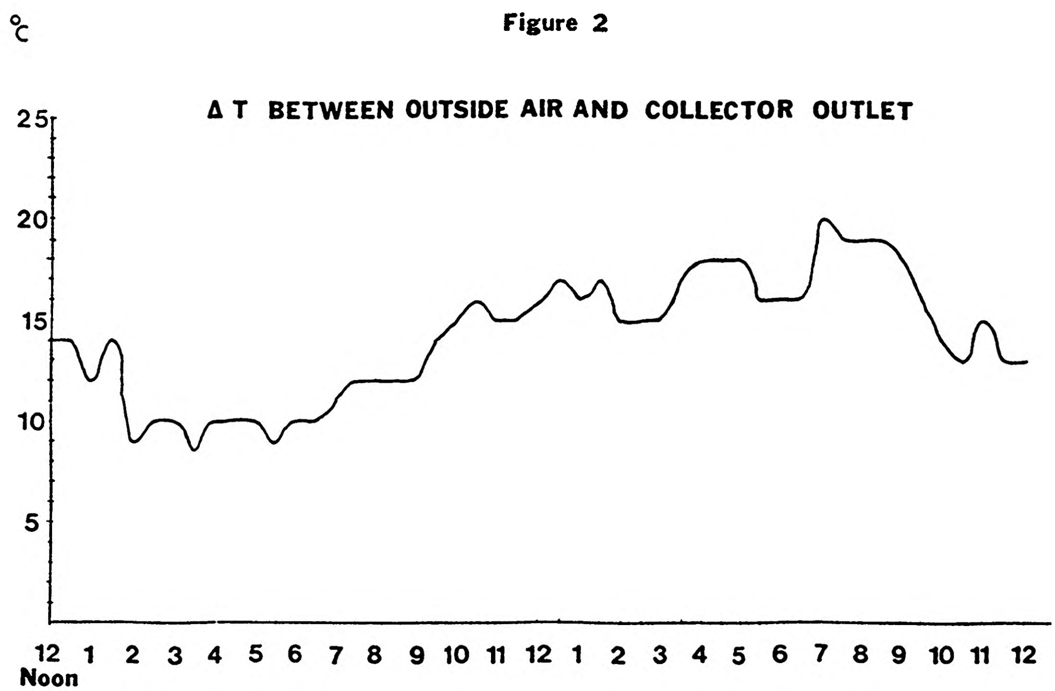

FIGURE 3.
EXTENDED ROOF HOT AIR SOLAR COLLECTOR