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SOLAR ENERGY FOR HEATING FARM STRUCTURES IN KENTUCKY

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This report is intended to summarize the important decisions which must be made by farmers in Kentucky, who are considering the utilization of solar energy for heating farm buildings or drying grain.

Steps to take in deciding if solar energy can be used on your farm:

1. Evaluate your heat demands; in terms of temperature requirements and hours of heating during the year.
2. Bring insulation levels up to recommended levels in heated farm buildings.
3. Determine if the building is properly oriented and no shading will occur.
4. Consider preheating of ventilation air for animal buildings.
5. Consider more expensive and higher capacity solar collection system if multiple uses are available throughout the year for the collected heat.

Heat Demands:

Before considering the design of a solar energy system, the individual should evaluate the heating demand. Several articles have appeared in

popular magazines describing solar systems used to heat farm shops. Although this is a viable use for solar energy on some farms, one must consider the amount of time spent in the shop and the dollars spent on heating. Solar Heating applications,which require continuous heat throughout the year,are more likely to be economically feasible than short-term high demand uses for heat. Therefore, the heating of a swine nursery, which requires a warm dry environment with heating for as much as eight to ten months a year, is more likely to be economically feasible than grain drying.

Conservation Measures:

With the present cost of fuels, building materials, and insulation, the first investments should be to seal all cracks,which let air infiltrate the heated space, and bring insulation levels up to recommended levels. Table 1 represents the recommended insulation levels for agricultural buildings. By utilizing energy conservation techniques first, a smaller investment in solar heating equipment will be required because of a reduced heating load. Generally, insulation to conserve heat is less expensive than providing extra heat for any building which is heated all winter.

Orientation and Shading:

During the heating season in Kentucky (40° N latitude) the sun travels across the southern sky with its lowest angle of 30 degrees occurring on December 21st. For optimum exposure the building's solar absorbing surface should face due south, with a variation of up to 30 degrees from due south acceptable. The optimum tilt angle of a collector for winter space heating is the latitude + 15° (40 + 15 = 55° in Kentucky), but a tilt angle from 40° to 90° is acceptable. Fortunately, a poor southern exposure or tilt angle can be compensated for by increasing the absorption area.

Another consideration is shading by nearby trees, buildings, grain structures, etc. Shading can be avoided by checking the objects which might shade a collector which are located within 45° of due south. As a rough estimate in Kentucky, the distance from the solar absorbing surface to any object should be at least 1.75 times the height of the object to eliminate any possibilities of shading. Trees which loose their leaves during the winter need not be removed from the site. A bare tree presents little shading and will help to shade the collector during the summer to prevent overheating.

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Solar Collector Design:

Solar collectors which utilize air, rather than water, as the heat transfer medium, are recommended for most agricultural applications. This eliminates the need for heat exchangers and reduces the risk of damage due to leaks and freezing in the system. By identifying the uses for the collected solar heat and the heat load requirements in terms of minimum usable temperature and airflow rate, the optimum collector design can be found. (Refer to University of Kentucky extension publication "Air-Type Solar Collectors for Agricultural and Residential Use", AEES-3).

Solar Grain Drying in Kentucky:

There have been several articles in the popular press describing solar collection systems incorporated into the walls or roofs of agricultural structures used to heat air for drying grain. Most of these solar systems are located in states to the north or west of Kentucky, and are inherently low temperature designs (1 to 10°F temperature rise). These systems are designed to dry the grain slowly over a period of weeks using this warm air. In Kentucky and further south, the outside temperature and relative humidity during the harvest-drying season is typically higher than in these northern and western states. As a result of these conditions, grain must be dried to a safe moisture content in a shorter period of time to reduce the risk of grain spoilage, mold growth, and aflatoxin formation. (See University of Kentucky extension publication, "Low Temperature Drying - Use and Limitations", AEN 23).

The time constraints imposed by the weather conditions in Kentucky do put certain limitations on the operation and management of a solar grain drying system, but they do not completely eliminate its feasibility. By using the solar system to preheat the source air for grain drying before it enters the conventional heater-fan unit, a substantial amount of energy

can be saved. If the collector can be built as an integral part of a new building, and it can be used for other purposes, preheating of air for grain drying could be worthwhile.

The Major Considerations Are:

1. Solar assisted grain drying should be viewed as an alternate or off-season application for a proposed solar system. At present it is not cost effective to build a solar system to be used solely for grain drying in Kentucky.
2. Due to the variability of weather, solar heat should not be relied upon as the primary heat source for drying the grain.
3. When using the existing fan to pull air through a solar system and into the bin, make sure this added resistance does not overload fan capacity.

Portable Collectors:

One alternative which has been proposed is a portable solar collector, which can be moved to multiple applications on the farmstead throughout the year. In certain situations this may be a cost effective solution, but there are several considerations to this type of system.

1. To have a noticable affect, the collector must have at least 200 square feet of collection area. The wind resistance presented byby this area must be taken into consideration.
2. A portable framework must be built which adds to the cost of the system.
3. Additional insulation must be added to the back of the collector to reduce heat loss from this exposed area.
4. Ducts which bring heat from the collector to the building add to the cost and present more exposed area for heat loss.

The individual should realize that if the portable collector costs twice that of a built-in system it must have at least double the effective hours of use of a built-in system to show any advantage.

Preheating Ventilation Air:

During the heating season the heat lost in an animal structure through ventilation makes up a major portion of the heating load for the building.

By designing the appropriate solar energy collection system, makeup air could be preheated before it enters the building and significantly reduce the supplemental heat needed to maintain temperatures in the building. Because outside air is normally used for makeup air, any improvement in temperature over ambient conditions represents a heat savings for the building. This also enables the solar heating system to provide some heat during hazy and partly cloudy days when solar insulation levels are low. Because of these advantages, the solar preheating system is recommended as a first consideration for solar application.

In use of solar heat for agricultural buildings, one needs to consider the total quantity required, the temperature level at which the heat is required, and the distribution of the heat requirement throughout the year. Solar heating can most economically be accomplished for applications which need heat during much of the year or where the solar equipment can be utilized for more than one application. Low temperature heating, such as the preheating of ventilation air for animal housing is one of the easiest applications, since the low temperature collector can usually be constructed at little or no additional cost when building a new building or re-roofing an existing building. The construction of solar air heaters as a part of a building is more economical than constructing the same amount of area as a portable collector. Also, portable collectors are often too small to provide an appreciable quantity of heat. Grain drying requires a large quantity of heat in a short time in Kentucky so a solar heating system should serve only to preheat the air.

Table 1. Recommended Insulation R-Values for Various Livestock Buildings and Farm Shops

Facility	Desired temperature range (°F)	R-value for - Wall	Ceiling Or Roof
Swine			
Gestation/finishing (50 to 220 lbs.)			
Modified open-front	45 to 85°	13	20 13
Shed with lot	Outside ± 15°	*	-- 4
Nursery (20 to 50 lbs.)	65 to 90°	13	20 --
Farrowing (300 to 400 lbs.)			
Bedded solid floor	60 to 85°	13	20 --
Slotted floor	70 to 85°	13	20 --
Dairy			
Total covered free stall cold	25 to 85°	13	-- 13
Free-stall with lot	Outside ± 15°	*	-- 4
Stanchion	45 to 85°	13	20 --
Calf housing			
Hutch	Outside ± 15°	*	-- 4
Bedded stall	Outside ± 5°		-- 4
Raised stall	55 to 85°	13	20 --
Milking parlor	40 to 85°	4-13	20 --
Milk house	40 to 85°	4-13	20 --
Beef			
Open shed with lot	Outside ± 15°	*	-- 4
Slotted floor	Outside ± 15°	*	-- 4
Shops	45 to 60°	13	20 13

*Uninsulated.

Source: Jones and Friday, 1979.