9-1978

Energy in Agriculture: Energy for Swine Facilities Part II: Alternative Sources of Energy

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AEES–2

ENERGY IN AGRICULTURE

ENERGY FOR SWINE FACILITIES

PART II: ALTERNATIVE SOURCES OF ENERGY

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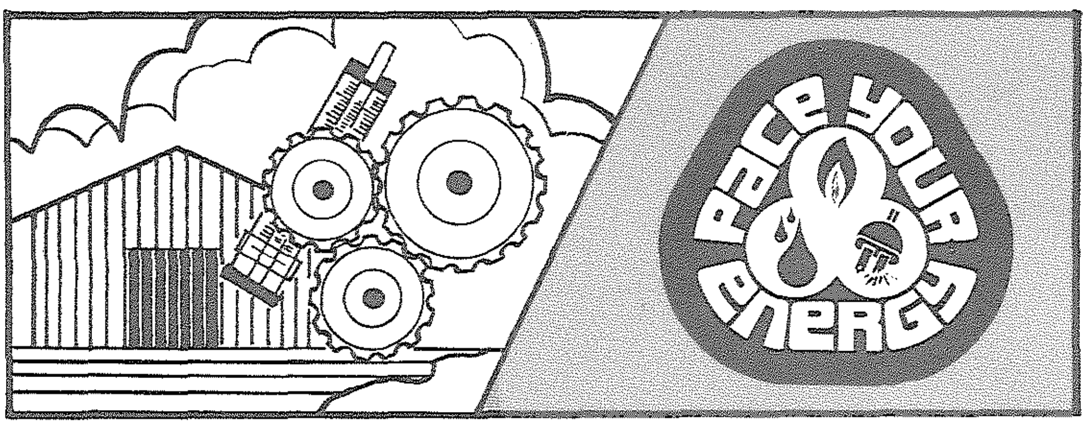

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INTRODUCTION

Recently, there has been some concern about energy utilization in agricultural production. Shortages of natural and LP gas have affected many livestock producers, especially swine producers utilizing LP gas as a supplemental heat source in farrowing facilities. These shortages, coupled with an ever-increasing price for fuel and electricity, have encouraged many producers to begin looking for alternative energy sources.

Fan energy and heat added to maintain the temperature in farrowing houses and nurseries, called "supplemental heat," are the two major energy costs in confinement swine facilities, excluding feed energy. Supplemental heat may take several forms, some of which may not be recognized as supplemental heat sources. One source is the creep heat used for small pigs. In a well-insulated building creep heat can provide a large amount of the heat required to maintain the temperature in a building. However, the creep heat added in the summer time requires higher ventilation rates to control temperatures, thereby increasing fan energy costs. Other uses of energy in swine housing include the lighting and feed handling.

When considering alternative energy sources one must understand that present systems now utilize common forms of energy, such as electricity and LPG, because by utilizing these forms of energy it is possible to eliminate or reduce the management input into the system. As shown in Figure 1, electrical and LPG high energy/low management systems can be replaced with a low electrical and LPG energy system, but, in general, this will increase the level of management required by the individual producer. Therefore, in reviewing different alternative fuel sources, remember that they may increase the level of management required for the system.

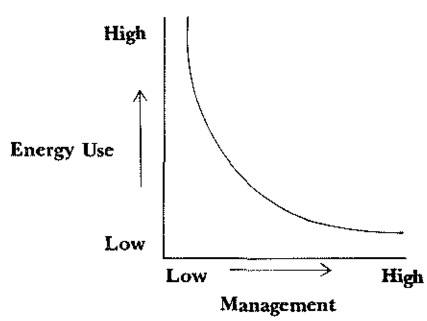

Figure 1.–The relationship between the level of energy use and management of swine facilities.

ALTERNATIVE ENERGY SOURCES

Solar Energy

One of the basic considerations in selecting an alternative energy source is economics and ease of use. Because the sun is free and provides a readily available and inexhaustible source of energy, it seems to be a very attractive alternative energy source for swine facilities. Present ventilation systems use solar energy, but in the form of air temperature. Some swine facilities already make use of some solar collection by allowing ventilation air in the winter to enter through the attic of the building. This can result in a temperature 2° to 20°F higher than the outside air.

Modifications can be made in an attic to increase its ability to collect solar energy–one method uses a black metal roof with the intake air drawn along underneath the metal to collect more solar energy. Another method uses clear fiberglass roofing and in some cases, painting the entire inside of the attic black. Both methods work and will increase solar energy collection. However, there may be a heat problem with such arrangements in the summer time, especially with the second method because the increased heat load in the attic increases the temperature inside the facility.

Solar energy collection systems have been utilized in swine facilities since the 1940's, in the form of single slope roofs with large windows on the south side. However, cheap fossil energy made their construction uneconomical. A complication connected with some of the early solar designs was that in the winter they occasionally caused sows to go into heat stress because of the bright sun shining on them.

Newer solar collection systems have been developed which utilize a sidewall collection system but keep the sun from directly hitting the sows, such as the one shown in Figure 2 (3). This system utilizes an 8″ block wall with no mortar and the outside edge of the block painted black. A plastic cover is installed over the block and the inlet is placed at the top to draw the air from the attic. The block wall is so constructed that all the air entering the facility passes through cracks between the blocks. The plastic cover allows solar energy to enter, striking the black painted surface, warming the air and warming the blocks at the same time. The advantage of this system is that at night the blocks which have been warmed by the sun give up their heat to the entering ventilation air. Therefore, it provides both a solar collection system and a method of some heat storage, which are important considerations.

This system may also be useful in the summer cooling of the building. This is accomplished by drawing ventilation air through the blocks at night, thereby cooling them with the lower nighttime air temperatures. Then, in the daytime, incoming air is cooled by drawing it through the blocks. The overhang of the building must be properly designed so that in the summer time the entire south side of the building is shaded. The system is presently being evaluated and more information will be available in the future.

Another solar collection system using sidewalls does not provide a direct method of storage. Instead, it utilizes storage system method the heated air is drawn through a very large volume of buried rock during the day, and intake air is drawn through the rocks at night. The rock storage systems do not necessarily need a solar collector to function. In Figure 3a it can be seen that as the outside air temperature varies, the air temperature, after it passes through the rock storage, experiences a temperature modification. The rocks cause this thermal lag and may reduce the high and low extremes of the outside air temperature. With proper operation and fan control (Figure 3b), it may be possible to utilize the rock bed, but only when the air temperature coming from the rock bed is greater than the outside temperature (which would increase the average temperature of the air entering the house). Storage systems may be useful for both summer and winter operation of swine facilities. Computer modeling research work is being conducted on these type of systems to determine their feasibility and design requirements for swine facilities.

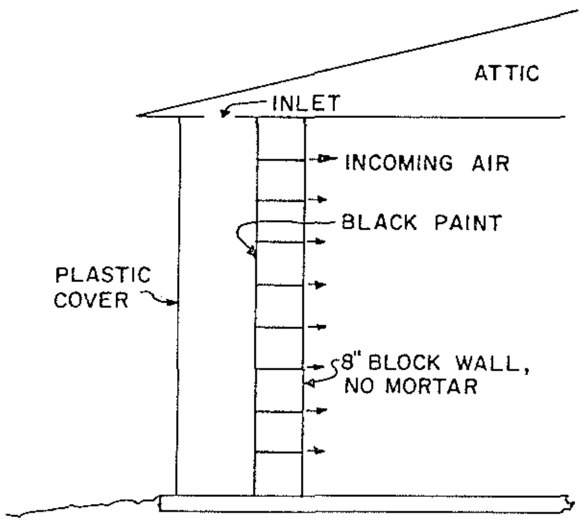

Figure 2.—A block wall solar collector and storage system.

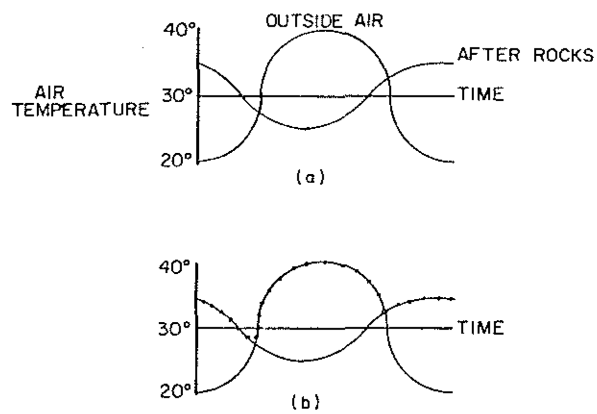

Figure 3.—The effect of a rock storage system on the intake air temperature.

black plastic behind the clear plastic cover with an air space between them, and an air space between the black plastic and the wall. Air is drawn through the air spaces to collect the solar energy. However, without a method of storage, a solar collection system may provide more energy than necessary during clear days, and provide no heat energy at night.

There are some commercial solar collectors available; however, commercial units tend to be relatively expensive, because they are designed for higher temperatures.

Since storage is an important consideration with any type of solar collection system there have been experiments with various methods of storing solar energy. In the rock

Heat Pumps

Another energy-saving device that has recently received attention is the heat pump. Generally used for homes, heat pumps can also be used for livestock ventilation systems. Basically, a heat pump is an air conditioner operating in reverse. In Kentucky, a heat pump will provide approximately twice as much heat per kwh as regular resistance electric heat. Figure 4a shows the standard installation of a heat pump in a swine facility ventilation system, with the heat collection coil on the outside and the heating coil on

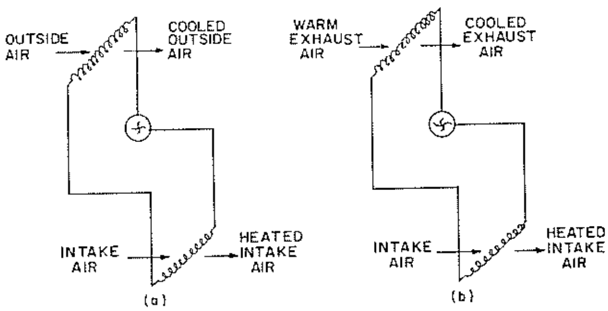

Figure 4.–Possible heat pump installations for swine facilities.

the intake air, thus raising the intake-air temperature.

Some research is being conducted on the feasibility of using warm exhaust air as the heat source instead of the cool outside air. Figure 4b shows the configuration of the heat pump operating in this manner. The advantage of this system is that the heat would be collected from warmer air rather than from relatively cooler outside air, thus improving the heat pump efficiency. The basic problem of this arrangement is that the exhaust air contains relatively large quantities of moisture and dirt, thereby increasing maintenance and corrosion with this installation. Maintenance may be such a major problem that this installation may never become feasible.

Alternative Fuels

Yet another current idea is alternative fuels. Some research is being initiated at the University of Kentucky to examine alternative fuel sources for the farm. When considering an alternative fuel, it is important to remember that any fuel must first be collected and processed, then stored and finally placed in the burner and the waste products removed. Currently, fuels such as natural gas, LP gas and oil need little management for collection, processing, storage, placement and waste product removal. However, using fuels like wood, coal, or crop residue requires increased levels of management. Present control systems for alternative fuel sources such as wood and crop residue are not well documented as to performance. Many of those are not completely automatic either, which further limits their application. Some commercial equipment is presently available; however, the equipment tends to be somewhat expensive and designed for operation with a fairly constant load. Because of the large daily temperature variations which exist in Kentucky, a supplemental heat system must start and stop and change speeds continuously through the day. This tends to be difficult with most alternative fuel systems.

Heat Exchangers

One energy-saving idea that has been considered is the heat exchanger. Heat exchangers are designed to move heat from the exhaust air to the intake air, similar to a heat pump. One type of heat exchanger that has been tested is a parallel plate unit in which exhaust air is passed between thin metal plates and the intake air drawn in next to it (Figure 5). One problem associated with this system is that a large plate area is required to exchange the heat between the exhaust air and the intake air. These units are capable of reclaiming from 30 to 40% of the heat normally lost in the exhaust air (2). However, they also have problems like the heat pump in that they become coated with dirt and moisture and are very difficult to clean, causing potential corrosion problems. Although most of the research on this type of exchanger was done in the 50's, there is presently renewed interest in this idea.

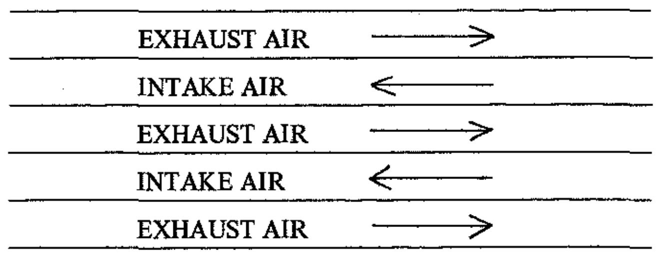

Figure 5.–Air flow pattern in a plate-type heat exchanger.

An alternative to the passing of air between plates is to use a heat sink which is similar to the rock storage concept, only it uses fewer rocks. Figure 6 shows a system in which two small beds of rock are utilized. One is warmed while the second is cooled, and then the fan direction is reversed. This causes the intake air to be warmed as it passes over the rock. One consideration with this system is finding fans and controls that will allow the fans to reverse properly. The storage area size, however, can be limited to 30 to 40 cubic feet, or can be very large depending on how frequently the fans are reversed. The biggest advantage of rock heat sink units is that the materials required for construction are relatively inexpensive and durable. Because of their low cost, it may be feasible to replace the rocks every year if moisture and dirt buildup is a problem. Another problem associated with this system during the winter is that as the rocks are cooled by the incoming air the moist exhaust air may condense and freeze on the rock surface when the fan is reversed. However, this situation was reported in a northern climate where the cold-weather temperature extremes exceed -30°F.

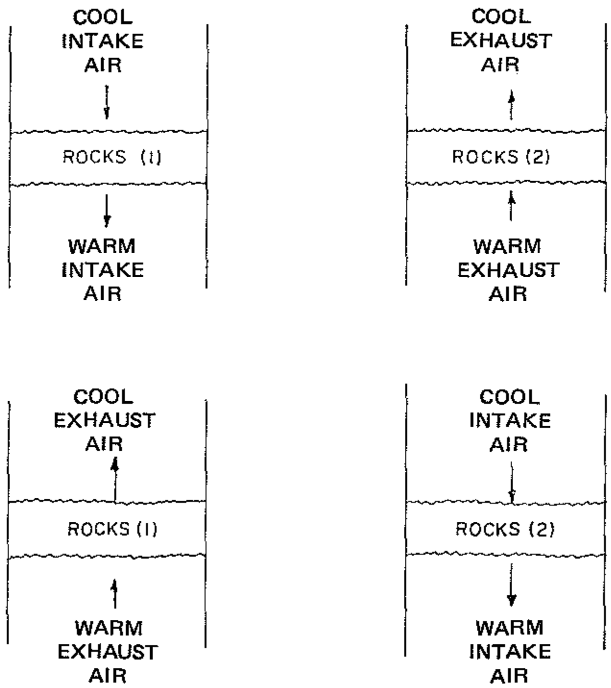

Figure 6.—Air flow pattern in a heat sink heat exchanger.

A new heat exchanger system currently under investigation is called a heat pipe. This device operates much like a heat pump but has no motor. A heat pipe is a long sealed tube which contains a fluid that evaporates and absorbs heat at exhaust air temperatures and then condenses, giving off heat to the intake air (Figure 7). The tube is then set at an angle so that the lowest end is the exhaust air. The liquid runs down to that end when it condenses and the gas created by evaporation circulates up to the top. This allows the system to move heat back and forth, with the fluid within the tube being the only moving part. Presently, these systems are somewhat expensive but interest is increasing in this type of unit because no moving parts are required.

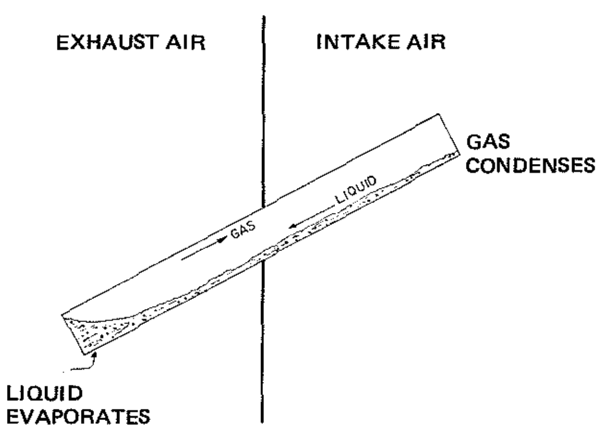

Figure 7.—A heat tube heat exchanger installation.

Methane Gas

The feasibility of on-the-farm methane gas production is limited at this point. Methane is the major component of natural gas. Presently, the method of methane gas production being promoted is the use of an anaerobic digester. Anaerobic digestion means the biological breakdown of material without any free oxygen being present in the system. This is a naturally occurring process, and methane is produced in anaerobic lagoons.

The system has much appeal and has worked in research trials for short time periods; however, long period trials have shown that the biological components in this system are very sensitive to unbalances and require a high level of management. Also, an excessive level of investment is needed to produce the quantity of methane gas required for a farm, making methane production not economically feasible at this time.

Another problem with methane is that gas production is temperature dependent; that is, the liquid used in an anaerobic digester must be heated to approximately 95°F in the winter time to maintain gas production, thus utilizing a large portion of the gas just to keep the digester warm. Excess gas is produced in the summer time when it is least needed for heating facilities or grain drying. Also, methane must be stored as a gas because storage as a liquid is impractical. Therefore, it is neither economically feasible nor practical to use methane gas at the present time.

Producer Gas

Producer gas is basically a low-heat value gas formed by burning any type of material in a limited supply of oxygen. The producer gas is composed of carbon monoxide and some hydrogen. Producer gas systems seem to be economically feasible and development is currently underway. This system allows crop residue and other biological material around the farmstead to be transformed into usable energy. Producer gas could be made whenever needed, thus eliminating the need for storage. A considerable amount of research and development work is necessary before this system can be utilized.

Windpower

Windpower generation of electricity has received a lot of public interest, and some large grants are underway to investigate its feasibility for large-scale electrical generation. However, for an individual utilizing his own equipment, windpower is not yet economically feasible, although it may provide a limited source of standby power in case of power outage. A disadvantage is the variability in wind velocity. The present wind generators require 8- to 15-mph wind velocity, but the average wind in Kentucky is less than

10 mph. Also, windmills do not generate the type of voltage and power needed in a full-scale swine production system without relatively expensive equipment. So, while windpower seems attractive and much research is presently being conducted, it may not be a feasible source of energy for many years to come.

SUMMARY

The overall future of using alternative energy sources for swine production facilities is somewhat limited. More research is being conducted on methods to save energy rather than in finding alternative energy sources. This is probably the most effective approach at this time because saving energy on the farm will assist in energy conservation nationwide while reducing operating costs.

Whenever an alternative energy source or energy saving device is presented one should consider what is being traded in terms of the level of management of the system for the amount of energy saved and the value of that energy. While energy costs may be high for some swine production systems, energy cost alone will not determine the economic feasibility of the swine production system.

REFERENCES

1. Albright, L. D. 1976. "Ventilation fans vary in operating efficiency." July/August Farm Building News, Milwaukee, Wisconsin.
2. Fehr, R. L. 1972. "Reclaiming heat in livestock ventilation." Master Thesis, NDSU, Fargo, North Dakota.
3. Murphy, J. P., C. K. Spillman and F. V. Robins. 1977. "Applications of solar energy for preheating ventilating air." ASAE Paper No. 77-3545, ASAE, St. Joseph, Michigan.
4. Person, H. L., L. D. Jacobson and K. A. Jordan. 1977. "Effect of dirt, louvers and other attachments on fan performance." ASAE Paper No. 77-4568, ASAE, St. Joseph, Michigan.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Charles E. Barnhart, Director of Cooperative Extension Service, University of Kentucky College of Agriculture, Lexington, and Kentucky State University, Frankfort.

Issued 9-78, 3M; 1.5M—11-81