energy management in agriculture

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ENERGY CONSERVATION IN SWINE BUILDINGS

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ENERGY CONSERVATION IN SWINE BUILDINGS

As a national average, it takes an energy equivalent of one gallon of propane gas to produce one market hog. The energy required for swine in confinement in Indiana is about three times greater. Even so, this higher energy utilization represents only 2-3 percent of total production costs in confinement systems.

While the energy requirement for confinement swine production is not large compared to other farming operations, increasing energy costs do mean increasing total costs. Therefore, when planning to construct or remodel swine buildings, the producer should place a high priority on energy conservation and the improvement of energy efficiency.

As important as conservation is, however, care must be taken as to *how* energy reductions are made. For example, substituting manual labor for low-maintenance equipment to cut energy costs is false economy. The continuous output of physical work by a farm laborer is about 1/10 horsepower or 1 horsepower-hour for a 10-hour day. This same amount of work could be performed with an electric motor at a cost of about 4 cents per kilowatt-hour. Figuring labor at \$4 per hour or \$40 for a 10-hour day, electrical energy is cheaper than human labor by a factor of 1000!

Table 1 shows typical energy usage for a modern confinement farrow-to-finish swine operation. Notice that nearly half the energy consumption is for farm-related travel (automobiles, trucks and tractors). Although here is where the greatest potential for saving energy lies, it's probably the most difficult area to affect, since the farm pick-up truck is usually considered so essential. However, a surprising amount of transportation fuel can be conserved merely by eliminating unnecessary errands, combining trips and turning off the tractor or truck engine when not moving.

In confinement swine buildings, *the greatest opportunity to save energy is by conserving existing animal heat* through both proper building construction and control of the environment. This publication focuses on those environmental management practices considered most important in the regulation of animal heat loss, thus the use of energy. Suggestions discussed include building insulation and modifications, heating and cooling system selection, ventilation system adjustments and proper building temperature.

BUILDING INSULATION AND MODIFICATIONS

One of the most obvious sources of heat in confinement buildings is the animals themselves. Based on 50 cents a gallon for propane (1980 price), a 20-sow farrowing house at capacity can produce over \$3 worth of heat per day!

Building Insulation

The surest way to conserve this animal heat—and one of the most effective for the cost—is to insulate. Adequate insulation not only cuts winter heating bills by reducing heat loss through walls, ceiling and floor, but also improves animal comfort by keeping building surfaces warm.

In cold weather, from 30-40 percent of animal heat is lost by radiation to cold wall or ceiling surfaces; and up to 15 percent more can be lost from conduction to a cold floor.

One way to combat cold floors is to use wood or plastic flooring materials, since they do not conduct heat away from the animal as rapidly as do metal and concrete. Two other ways are to provide perimeter in-

Table 1. Energy Usage in Swine Operations in the U. S.

Operation	Percentage
Light	0.91
Feed processing & distribution	11.09
Waste handling	7.77
Water supply	6.61
Swine handling	0.03
Space heat	16.19
Ventilation	8.67
Water heating	0.05
Farm-related travel	47.57
Other	1.11
Total	100.00

*From USDA's "A Guide to Energy Savings for Livestock Producers," June 1977 (Nonfarm-related travel not included).

sulation around the foundation and to use bedding. Both have the effect of raising floor temperature by about 10°F. Do not use bedding, however, if it could interfere with the liquid manure system.

Table 2 lists the recommended insulation 'R-values' for swine buildings. R-value is a measure of resistance to heat flow. The higher a material's R-value, the greater its resistance to heat flow and the better its insulation value. When remodeling, remember that adding 2 inches of insulation to an uninsulated ceiling will result in substantially more energy savings than adding the same amount to a ceiling which already has 6 inches of insulation.

The type of insulation you choose will probably depend on what it costs, where it's used and who installs it. Rigid foam insulation, for example, has a higher unit price but a lower installation cost than batt insulation.

(See Purdue Extension Publication AE-95 for information on selecting and installing insulation in livestock and other farm buildings.)

Table 2. Recommended Insulation R-Values for Swine Housing.

Type of structure	Walls	Ceiling	Perimeter insulation
Farrowing & nursery	R=13	R=20	Yes
Finishing & gestation			
Modified open front (with curtains or tilt doors)	R=13	R=13	Yes
Open front (with outside lot)	--	R= 5	No

Building Design, Modifications and Scheduling

How a confinement building is designed and scheduled can significantly improve the efficient utilization of animal-generated heat. By increasing the body heat produced in a given building volume, the additional heat needed decreases proportionately. This is one reason for the practice of double- and triple-decking nursery and growing pigs. Another effective way to keep supplemental heating costs down is to schedule so as to keep the building near capacity all winter long.

Animal heat can also be conserved by either of the following modifications in farrowing house design—(1) confinement of the gestation sows in farrowing and (2) room farrowing.

Confinement of gestation sows in the farrowing building is done mainly with a continuous farrowing schedule (Figure 1). The additional heat produced by these large animals permits use of a higher ventilation rate without increasing the supplemental heat requirements. This reduces the problem of poor air distribution, which often characterizes low winter ventilation rates.

Figure 1. Combination farrowing-gestation housing provides additional body heat during cold weather but makes cleanup more difficult.

A disadvantage is that the farrowing house is never completely empty, and cleanup must be limited to one farrowing crate area at a time. Presently, there are differing opinions as to whether the merits of obtaining additional heat and acclimating gestation sows to the farrowing environment outweigh the disadvantage of incomplete cleanup.

Use of room farrowing best fits the production system that calls for weekly farrowing, but will work in other systems as well (Figure 2). Each room should hold no more than 24 crates, preferably only 8-10.

Although requiring more walls and aisle space and separate environmental control systems, room farrowing has two major advantages in large farrowing houses. First, it allows any areas not in use to be closed off and heated only at the level needed to prevent pipes from freezing. And secondly, since a large house is seldom completely vacant for cleanup and fumigation, dividing it into rooms facilitates sanitation.

Figure 2. Dividing the farrowing house into several rooms permits lower temperatures for older pigs and allows the producer to close off any rooms not in use.

HEATING AND COOLING SYSTEM SELECTION

A number of heating systems for winter and cooling systems for summer are both workable and efficient in confinement swine operations. Following is a brief explanation of these different systems, their advantages and drawbacks. Which ones are best depend on the producer's preference, his existing or planned facilities and the type of production system he follows.

Heating Systems

Solar heat is now competitive with other energy sources in providing supplemental heat for swine in confinement if efficient collectors are used. Two types of solar systems are possible—passive and active. (1) In the passive system, translucent panels allow the sun to shine into the building to warm the animals and building surfaces. (2) An active system utilizes a transfer medium (air or water) to transport heat from a solar collector to storage and then to the animal environment. The passive system is relatively inexpensive, but has problems of high heat loss and moisture condensation on the poorly-insulated solar panels. Although the active system is more expensive to construct, it operates more efficiently.

Several types of solar collectors may be used. One that combines both collection and storage is the 'Kansas-type' collector, which involves a 16-inch-thick, south-facing concrete block wall painted black. Ventilation air is drawn through the sun-heated blocks, picking up the heat before it enters the livestock building (Figure 3). This storage method has been in use since 1978 at the Purdue Swine Nutrition Farm. At propane costs of 50 cents per gallon (1980 price) and 12 percent interest, the payback period for this unit is about 6 years.

(See Purdue Extension Publication AE-99 for more information on solar heat for livestock buildings.)

Space (or air) heating works best in heavily-insulated structures having warm wall surfaces. Space heaters heat the total environment, thus allowing animals freedom of movement in comfort.

Unit space heaters are located inside the animal environment and recirculate room air through the furnace unit. They are available in both indirect- and direct-fired models. Direct-fired furnaces are unvented and discharge the products of combustion (water and carbon dioxide as well as heat) into the room. Although more efficient than indirect-fired models (90% vs 60%), overall fuel efficiency is only about 75%, because direct-fired units require a higher ventilation rate to remove the moisture produced by the combustion process.

Make-up space heaters are located outside the building and heat incoming fresh air (as opposed to recirculated air). Usually unvented, they have proven dependable and are recommended by many insurance companies because of their low fire risk. Unless properly ducted to distribute incoming air, however, drafts

can be a problem with make-up heaters, especially at lower room temperatures.

Radiant heat should be used in poorly-insulated structures having cold inside wall surfaces. Radiant heating requires the animal to be directly beneath the heater, such as a heat lamp or catalytic heater.

Floor heat systems, a form of radiant heat, are more difficult to install and operate than space heaters, but are efficient since direct heat transfer occurs from floor to animal. At present, electric floor heat systems cost more to operate but less to install than hot water floor heat systems.

Cooling Systems

Cooling swine in confinement does not represent a major cost to the producer but can be very beneficial during part of the year.

Water spray and evaporative cooling both work well for finishing and gestating hogs. A spray cooling system is not complex or costly, even though periodic maintenance is required (such as replacement of in-line filters to keep sediment from plugging nozzles). Many producers favor misting systems over fogging systems, because the wind doesn't cause as much drifting of droplets, and more water reaches the animals.

Figure 3. Cross section view of a concrete block, vertical wall solar collector used to heat incoming ventilation air.

Zone cooling, takes air directly to the animal (Figure 4). Although it has a high initial investment, a zone system in a farrowing house is efficient to operate, since, at high surrounding temperatures, over 40 percent of a sow's body heat is given off by respiration. Snout cooling systems for sows confined to crates generally use evaporative coolers, which supply an 8-10°F temperature drop with relatively inexpensive equipment.

Air conditioning is usually limited to well-insulated breeding facilities with low animal densities where cool temperatures are essential. Air conditioners provide lower temperatures than evaporative coolers, but at a higher investment and potentially high maintenance cost. A particular disadvantage of air conditioners in confinement buildings is that they cannot tolerate the dust and corrosive gases in recirculated inside air, and therefore must continually draw in hot, humid outside air. This greatly increases operating cost.

(See Purdue Extension Publication AE-103 for more information on cooling systems for livestock.)

VENTILATION SYSTEM MANAGEMENT

Table 1 seems to indicate that ventilation systems account for less than 9 percent of the energy usage in swine buildings. But in reality, this is only a portion of the actual energy which probably should be attributed to ventilation.

For instance, in a typical environmentally-controlled swine building, up to 90 percent of energy used for space heat (16.19 percent of the total in Table 1) is exhausted through the ventilation system. *Roughly 50 BTUs per hour are lost for each cubic foot per minute (cfm) exhausted from a heated building in cold weather.* In other words, the heating and ventilation systems often work against each other.

Figure 4. Zone cooling systems cool only the area around the animals' heads through the use of fans and a duct system.

Ventilation System Adjustments

A few rather simple ventilation management practices can save up to 50 percent of the space heat requirements without affecting animal performance.

- Keep the ventilation system properly adjusted and calibrated.
- At least twice a year, check the accuracy of the fan and thermostat controls.
- Do not operate the furnaces except when the ventilation system is running at the cold weather ventilation rate given in Table 3.
- Keep the furnace shut-off temperature at least 3-4°F below the temperature at which the higher rate (mild weather or odor control, if used) ventilation fans come on.

Interlock control systems are now commercially available which prevent the furnace and ventilation exhaust fans from working against each other. (See Purdue Extension Publications AE-96 and AE-100 for more information on environmental control systems.)

Lowering Ventilation Rates

Swine buildings require a low ventilation rate in cold weather to control *humidity*. However, in order to control *odors* and provide a more uniform air distribution, many producers operate their ventilation systems at three or four times the rate actually needed. Here is a simple solution that can save hundreds of dollars per year in energy costs without sacrificing odor control:

The ventilation system can be designed to operate at two separate air flow rates during cold weather. Most of the time it would run at the lower (moisture-control) rate, except when persons are to be in the building. Shortly before such time, the ventilation system is switched to the higher (odor-control) rate for improved working conditions. (See Table 3 for the recommended rates.)

The odor control fan could be activated manually or by a simple time clock. So, if farrowing house chores are done between 8 a.m. and 10 a.m., the higher fan capacity can be set to come on around 7:30 a.m. and shut off at 10 a.m. The time clock or switch should be wired in parallel with a thermostat in the event that a rising inside temperature should signal for a higher ventilation rate.

Since uniform air distribution is difficult at the very low air flow rates, some producers use small fans within the building for better circulation. Two fans, each sized at about 1/2 cfm per square foot of floor area, should provide adequate air movement around the room (Figure 5).

Another way to conserve ventilation energy is to construct or remodel buildings with odor control in mind. Frequent waste removal (such as with flushing or scraping systems) and efficient underfloor ventilation reduce odor problems, thus permitting lower winter ventilation rates. If moisture is removed in the liquid form, the heat and air employed in evaporating the moisture for removal as a vapor are unnecessary.

(See Purdue Extension Publication AE-98 for information on manure pit ventilation.)

Table 3. Recommended Per-Head Ventilation System Rates for Swine in Confinement.

Type of animal	Cold weather rates				Mild weather rates	Hot weather rates
	Moisture control on —			Odor control		
	Fully slotted	Partly slotted	Solid floor *			
	cubic feet per minute					
Swine						
Sow and litter	10	17	20	35	80	325
Pre-nursery pig (12-30 lbs.)	1.0	1.6	2	3.5	10	25
Nursery pig (30-75 lbs.)	1.5	2.5	3	5	15	35
Growing pig (75-150 lbs.)	3.5	5.5	7	10	24	75
Finishing hog (150-220 lbs.)	5	8	10	18	35	120
Gestating sow (325 lbs.)	6	10	12	20	40	150
Boar (400 lbs.)	7	12	14	24	50	180

* Increase moisture control ventilation rate by about 20 percent of the solid floor value if unvented furnaces used.

Reuse of Ventilation Air— A Questionable Practice

In an effort to conserve heat in winter, some producers have designed ventilation systems that exhaust the air from one livestock building into an adjacent one. But if ventilation systems are designed properly, there will not be an advantage to reusing ventilation air; therefore, this method will have little effect on fuel costs.

In winter, ventilation air can remove only so much moisture. Thus, you will need a minimum specified amount of incoming air per animal and a specific amount of heat to warm this air, even if all the air is warmed in one building then exhausted into another. Veterinarians and animal scientists also discourage the practice of reusing ventilation air, because of increased possibility of disease spread, particularly for farrowing- and nursery-age pigs.

Still, the best approach is to manage well the existing ventilation system.

Natural Ventilation

Use of natural instead of mechanical ventilation in the finishing and gestation buildings can result in significant energy savings if done correctly. For example, assuming 35 percent of Indiana's hogs are finished in confinement, the difference in fixed and operating costs between mechanically- and naturally-ventilated finishing buildings would be more than \$500,000 annually. Extending this comparison to include gestation buildings increases the figure even further.

To date, performance data for hogs raised in both mechanically- and naturally-ventilated structures show no major differences. (See Purdue Extension Publication AE-97 for information on natural ventilation.)

Some producers use mechanical ventilation in winter and natural ventilation in summer. They obtain better control of ventilation air in winter when air distribution is critical and do not need large, energy-consuming fans during hot weather. While somewhat higher in initial cost than completely natural ventilation, most of these producers have found the dual system to be a good compromise.

Figure 5. Small circulation fans located as shown can be used to improve air distribution at low ventilation rates.

BUILDING TEMPERATURE AND DRAFT CONTROL

One of the greatest challenges in confinement farrow-to-finish swine production is keeping the environmental temperature for the lactating sow at 60°F, while providing a temperature of 95°F for her pigs. Many producers offset potential disease and, management problems associated with the temperature differences by operating their farrowing houses at 80°F. But this is an extravagant use of energy, particularly considering that the higher temperature is required in only a small percentage of the total building volume.

Safely maintaining low farrowing house temperatures represents a major saving in energy costs. For example, lowering farrowing room temperatures from 80°F to 60°F can save about \$2.50 per sow per month in winter, based on 1980 propane prices. Assuming that 50 percent of Indiana's 425,000 sows farrow in slotted floor confinement units, this is over \$1,000,000 per year in fuel savings for Hoosier farmers!

Use of Hovers and Partitions

When building temperatures are lowered, small animals in particular are more apt to be affected by stray air currents (drafts). The best way to prevent drafts is to use hovers (Figure 6). Hovers do not need to be insulated or of fancy construction. Tempered hardboard, sheet metal and exterior plywood will do. In fact, plexiglass or a heavy sheet of clear plastic mounted on a wood or metal frame makes an excellent hover and also allows the producer to observe the animals.

Provide enough hover space for all the animals in a pen at one time. Ordinarily, this will be about half of a farrowing creep area or a third of a nursery pen area. Hovers are most effective when placed next to solid pen partitions.

Figure 6. Hovers are one of the most effective methods of controlling drafts in livestock buildings.

Fire safety is essential with hovers that use any kind of suspended heating device, whether a light bulb, heat lamp or radiant heater. Make sure it is beyond the reach of the animals. Also, if it is attached to the hover, protect any combustible hover material with a fire resistant insulation. As an alternative, floor heat works quite well under a hover and involves little fire hazard.

Using solid partitions between pens, except over slats in a partly slotted floor, also helps break up drafts. Every other pen partition running across the width of the building should be solid for draft control (even on total slotted floors). The partitions along center aisles should be open (porous) to allow for the crossflow of ventilation air.

Lowering building temperatures without regard to animal needs could be false economy, because feed energy requirements are likely to increase. In the short run, substituting feed energy for fuel energy at today's fuel prices is only economical when grain prices are very low. In the long run, net energy savings will not be great because production of high concentrate swine rations requires substantial amounts of energy.

SUMMARY

The confinement swine producer has many options available to him for conserving energy. Major savings without substantial investment can be made by carefully analyzing present modes of operation and making needed management adjustments as outlined in this publication. In some cases, energy-saving measures may require modification of present building structures or may be incorporated into new facilities for long-term conservation.

Related Publications

Single copies of the following 'Energy Management in Agriculture' publications are available free to Indiana residents from their county Cooperative Extension Office or by writing to CES Mailing Room, AGAD Building, Purdue University, West Lafayette, IN 47907:

- "Cooling Systems for Livestock" (AE-103)
- "Environmental Control for Livestock Housing" (AE-96)
- "Insulation of Livestock and Other Farm Buildings" (AE-95)
- "Natural Ventilation for Livestock Housing" (AE-97)
- "Pit Ventilation Systems for Livestock Housing" (AE-98)
- "Solar Heating Systems for Livestock Buildings" (AE-99)
- "Swine Housing and Equipment Handbook" (MWPS-6)
- "Troubleshooting Mechanical Ventilation Systems" (AE-100)
- "Wind and Snow Control for the Farmstead" (AE-102)

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