Energy Efficiency in Barns Part 2

Publication No. 01-00204 **Winter/Spring 2004**

Use Those Controllers and Sensors

Proper placement of controllers and sensors is essential to effective climate control within the barn. The following is a list of the 'do's and don'ts' of controllers:

Do

- avoid radiant heat sources, drafts, direct sunlight or stagnant air when mounting controllers
- place thermostatic controllers midway between the inlet and exhaust hanging from the ceiling. If on a plywood panel, hang the controller parallel to the airflow
- place one minimum/maximum thermometer beside the controller and check it often. This thermometer is essential to accurately calibrate and monitor thermostats
- step thermostatic controls to prevent simultaneous operation of heating and ventilation equipment. This is accomplished by setting moisture control ventilation controllers at least 3°C above minimum winter building temperature

- interlock heat and ventilation controllers to prevent over-ventilation while heating
- be aware of temperature and humidity readings levels. Tell the system what the humidity reading is within the barn by adjusting minimum fan speed or the minimum ventilation rate. Adjust the system to desired humidity levels in the room by adjusting the minimum fan speed or the minimum ventilation rate. For example, if it is too damp, input a higher minimum ventilation rate that is independent of temperature. This will be accompanied by the activation of the heater to add supplemental heat to the room. Readjust the minimum ventilation rate when conditions improve so as not to waste heat energy

Don't

- locate controllers on large pieces of plywood set perpendicular to building airflow or up on a beam out of the way. In these positions, the unit cannot accurately

(Continued on page 2)

Energy Saving Ideas:

Program Funding Provided by:

Sask Pork
Manitoba Pork Council
Alberta Pork
Saskatchewan Agriculture, Food and Rural Revitalization

What's the Cost?

Let's consider an theoretical example with a 200-head grower-finish room with dimensions 42' x 45' x 10'. This surface area works out to 9.45 ft^2/pig including pens and alleyways. Assume that this room within a barn is located in Saskatoon and the month is January. For the purpose of this exercise, the room will have 60 kg pigs, an inside temperature of 18°C (RH 70%) and an outdoor temperature of –19°C (RH 60%).

This outdoor temperature is an average January temperature for Saskatoon taken over a period of several years. The minimum ventilation rate to control the specific temperatures and relative humidity used in this example is 568 L/sec. Heating must also be provided at a rate of 4117 Watts (W) ($3.06/day or $94.95 for the month) to maintain these conditions. If the controller within this room is improperly set or calibrated, minimum ventilation rate will increase beyond optimum. The following values will be realized:

- if minimum ventilation rate increases by 10% an additional 2526 W of heat is required for the room. Based on a natural gas price of $0.031/kWh, heating costs for the room will increase to $4.94/day or $153.14 for the month, or an additional $1.88/day over the optimum ventilation setting
- if minimum ventilation rate increases by 20% an additional 5052W of heat will be required. Again cost to heat this room will increase to $6.82/day and to $211.42 for the month, or an additional $3.76/day over optimum ventilation settings

(Continued from page 1)

sense the room air temperature and can result either in over ventilation and or overheating, and wasted energy

- rely on commercial control systems with advanced technology. These systems often lack the ability to adequately monitor and manage energy efficiently (Example: CPU – automatic computer controlled ventilation system). A computerized system is no replacement for a manager with the proper training and know- how. He or she will be most accurate in terms of setting minimum fan and heating rates to optimize energy usage and animal comfort.

Other considerations for controllers and energy:

- a temperature/humidity control device offers the best thermal response and uses the least supplemental heat
- modern electronic controllers have stages that work in unison where supplemental heat is interlocked to operate only when cooling is at a minimum.

The Bottom Line

Very little electrical energy is required to monitor building temperature. Placement of controllers is crucial to obtain an accurate reading of the barn's environment. Be sure to properly set controllers to maintain effective minimum ventilation rates and supplemental heating.

Seal Up Those Barns

Up to 50% of the infiltration into older barns can be through unintentional air leaks or gaps in the structure. Leaks or drafts reduce the effectiveness of the ventilation system by allowing air to bypass the planned air inlets. The result is thermal and environmental problems within the barn. To reduce this problem the producer should:

- seal structural cracks and holes with caulking and/or weather stripping from the inside
- cover unused opening such as summer fans, inlets, access doors, etc.
- reduce inlet openings (adjust 4x a year)
- use hoods on the fans to prevent wind from entering
- seal leaks around fans to eliminate short circuiting of the air

Ensure a good vapour barrier exists in the walls and ceilings. This is important, as moisture within the barn will lead to condensation accumulation and struc-

tural deterioration. Insulation value can also be reduced with an improperly placed vapour barrier leading to heating concerns in the long term. Install a 6 mm polyethylene film vapour barrier on the warm side of the insulation.

Energy conservation is a good reason to consider high levels of insulation. Insulation will reduce fuel requirements in terms of heating in cold weather and minimize solar gain/temperature rise in warm weather. As a rule of thumb, well-insulated buildings are easier and cheaper to ventilate. The following tips should be considered regarding insulation in your barn:

- condensation or wetness on the interior side of walls in a barn indicates an insulation problem. Inspect walls and attics for insulation deterioration due to water and/or rodents. For more information check out Canada Plan Service bulletin M-9451
- for exterior walls of a feeder barn, insulate to a level of RSI 3.5 (R20) and for the ceiling: 5.25 (R30) to 7.0 (R40). Do you have sufficient insulation in your barn? Using a ruler, it is possible to remove a panel on the wall or in the attic and determined the R/RSI values using Table 1:
- when installing insulation, it can be feasible to exceed the recommended R-value by 25% depending on climate. Beyond these values however, extra insulation provides only marginal savings in heating costs due to

(Continued on page 3)

Table 1. RSI Value of Four Insulation Types

Depth of Material	Rockwool		Fiberglass Bats		Fiberglass Blown		Polyurethane	
	R Value	RSI	R Value	RSI	R Value	RSI	R Value	RSI
1"	2.5	0.44	3.5	0.62	2.7	0.47	5.9	1.04
2"	5.0	0.88	7.0	1.24	5.4	0.94	11.8	2.08
3"	7.5	1.32	10.5	1.86	8.1	1.41	17.7	3.12
4"	10	1.76	14.0	2.48	10.8	1.88	23.6	4.16
5"	15	2.64	21.0	3.72	16.2	2.82	35.4	6.24
6"	17.5	3.08	24.5	4.34	18.9	3.29	41.3	7.28
7"	20.0	3.52	28.0	4.96	21.6	3.76	47.2	8.32

the high proportion of heat lost through the ventilation system

- do not overlook the foundation, this can be a high percentage of total building heat losses. To decrease this loss, use a small strip of polystyrene providing an insulation value of RSI 1.2 or R7

The Bottom Line

Air leaks and drafts can adversely affect the efficiency of the ventilation system and therefore the barn environment. Apply a vapour barrier to prolong building and insulation life. Proper thickness of insulation is important for cooling the barn in the summer and heating it in the winter.

What's the Cost?

Consider again our 200-head grower-finish room. Let's use the same conditions outlined in the controller example:

1. room filled with 60 kg pigs:
2. outside temperature –19°C with a 60% RH
3. inside temperature 18°C with a 70% RH
4. minimum ventilation rate 568 L/sec

The room has an insulation value of RSI 3.35 mineral fibre in the walls and RSI 4.44 in the ceiling. Recall that under optimum conditions, the room costs $3.06/day or $94.95 for the month of January to heat. Over time a building will lose insulation value due to water and rodent damage. How does this affect heat loss from the room and more importantly does it impact heating costs?

- If 50% of the insulation value is lost, 1195 W of heat is lost. This room will now cost $3.95/day or $122.52/month to heat, based again on a $0.031/kWh natural gas price.
- If 30% of the insulation value is lost, 717 W of heat is lost. 17% more heat would have to be added for a total cost of $3.60/day or $111.49/month.

Energy Efficient Ventilation

Raising swine in a cold climate is energy intensive. In finisher barns, the ventilation fans account for most of the energy consumption. We ventilate to maintain thermal conditions, proper air quality and relative humidity while conserving energy and keeping costs low. Consider the following:

- cold weather ventilation is designed for moisture removal while warm weather ventilation is for heat removal
- ventilate to provide a RH of 60% within the barn. If RH is below 50%, ventilation rate is too high and energy is being wasted
- excessive ventilation in winter expels heat. Producers will often increase heating to compensate for this loss thereby wasting energy

Producers want the most effective and efficient ventilation for their barns. In winter, heat from animals is lost by conduction through walls, ceilings and floors so ventilation rate must be low. Outlined in following Table 2 are the minimum ventilation rates for various ages of swine.

Table 2. Minimum Ventilation Rates

Gestation Barn	10 cfm	5 L/sec/pig
Farrowing Barn	15 cfm	7 L/sec/ sow and litter
Weanling Barn	1.6 cfm	0.8 L/sec/pig
Grower-Finisher Barn	3 cfm	1.5 L/sec/pig

The values in Table 2 are meant as a general guideline. Several factors can cause uncertainty or discrepancy:

- barns differ with respect to gas/ moisture production
- fan specifications are not always accurate
- number of animals in the room can change from time to time
- heating requirements will fluctuate

The implication is that minimum ventilation rates should be flexible for adjustment as conditions change.

Fans use the most energy of any component of the ventilation system. A small exhaust fan operating continuously uses 2628 KWh/year of electricity at a cost of $208.93/yr, assuming $0.0795/ KWh. An electric fan forced air heater of 5 KW uses 120 KWh/day

in winter at a cost of $9.54/day. To reduce this cost producers must address the idea of fan size and fan efficiency.

- every exhaust fan consumes between 1000 and 10000 kWh of electricity per year based on continuous operation. Therefore, fan efficiency is of the utmost importance. Savings for using efficient small sized fans (11.5-12.5") over a 10 year period can be as high as $3,000 and for medium sized fans (14.5-16.5") $10,000
- Determine the electrical energy cost

(Continued on page 4)

(Continued from page 3)

of a fan by the following equation:

- (Reference kW) x (hr/day fan is running) x (#days/yr. fan is used) x (current cost of electricity $/kWh)
- do not use horsepower (HP) or amperage (Amps) to compare fan efficiencies. Fan energy use efficiency can be determined by looking at the cfm/W rating. The higher the cfm/W, the more energy efficient the fan.
- do not try to winter ventilate a large room with several slowly operating variable speed fans. Energy conservation is better achieved through one properly sized fan running at its recommended speed

Good inlets introduce air uniformly, direct winter air along the ceiling, are adjustable and require very little energy to operate. Self-adjusting air inlet baffles require no energy at all. Inlets should be closed tight enough to maintain negative static pressure across the fan. An air inlet velocity of 4 m/s to 5 m/s is desirable to prevent overloading of exhaust fans, decreasing output and decreasing energy efficiency.

Other considerations for ventilation:

- exhaust fan static pressure should be about 30 Pa or 1/8'' water gauge to maintain optimum fan efficiency
- Backdraft devices are needed on intermittently operating fans to prevent the fan from acting as an air intake. These backdraft devices close by gravity; so note that additional force must be exerted by the fan to open the shutters. For more detailed information on ventilation equipment and efficiency, see Canada Plan Service bulletins M-9750, M-9705 and Q-9706

What's the Cost?

Assume that we will provide a minimum ventilation rate of 300 L/sec/pig for the 200-head grower-finisher room. Two small ventilation fans will be compared with respect to energy usage and energy efficiency. This example only considers energy usage and fan efficiency and disregards heating, relative humidity and temperature dependent increases in ventilation.

To provide the 300 L/sec/pig one small ventilation fan can run continuously for the year. Prairie Agricultural Machinery Institute (PAMI) of Humboldt, SK. did a comprehensive evaluation of small sized fans evaluating flow rate versus energy efficiency. We will choose two of these fans and consider the results:

Fan 1 – Specifications: 12.5" (318 mm) propeller fan, variable speed, direct drive, 110 W, 220 V electric motor. To provide the 300 L/sec/pig, use a variable speed minimum setting at 0.105 kW input power. The fan will cost $39.97 to run for the year.

Fan 2 – Specifications: 12.38" (314 mm) propeller fan, variable speed, direct drive, 186 W, 115/230 V electric motor. To provide the 300 L/sec/pig, use a variable speed minimum setting at 0.165 kW input power. This fan will cost $63.00 to run for the year.

Fan 1 has a higher cfm/W rating than fan 2 and a higher total efficiency %. Therefore, Fan 1 is more energy efficient than Fan 2. This is confirmed in the calculation as Fan 2 costs $23.03 more per year to operate.

The Bottom Line

Ventilation is crucial for moisture and heat removal. Know the minimum ventilation rate for your animals and realize that as conditions change, so does the rate of ventilation. Motors and fans differ with respect to energy usage efficiency. Don't forget about inlets and air devices as they directly impact the system.

Heating in the Barn

Heating costs are a major component of the total energy costs in a swine operation. Most of the heat energy usage (up to 75%) occurs in farrowing. Energy savings associated with heating must be accompanied by sustained or improved pig performance. Supplemental heat required for each stage of development is outlined in the Table 3 below.

Producers should also be aware of the recommended ventilation rate and the temperature requirements for their animals (see Energy Efficiency in Barns – Part I). Extra heat (such as using a heating unit that is too large for the

desired temperature) will make the room too warm and waste energy. For example, with the proper ventilation rate, a 4.8 kW fan forced heater operating continuously uses 115 kWh/day whereas a 2kW fan forced heater operating continuously uses 48 kWh/day. If the smaller heating unit will suffice, based on an electrical energy cost of $0.0795/kWh, savings could be as much as $5.33/day.

Heat lamps. Much of the total energy in swine farrow to finish operations is through the use of heat lamps during the period from farrow to weanling. Heat lamps are attractive to producers for adding concentrated supplemental

(Continued on page 5)

(Continued from page 4)

Table 3. Heating Requirements

Age of Swine	Heating Required (W/pig)
Dry Sow	300
Farrowing	700
Weanling 7 kg 25 kg	 70 50
Grower/Finish (Continuous) 25-60 kg 60-100 kg	 30 35
All-in-all-out 25 kg 40 kg 60 kg 80 kg 100 kg	 60 40 30 30 30

heat to a relatively small area. Piglets exposed to excessive heat can be negatively affected. Studies have shown that piglets reduce their demand for supplemental heat at night. Producers can take advantage of this by reducing nocturnal operation of heat lamps and thus improve energy use efficiency.

Consider the following:

- utilize variable temperature heat lamps as they use 21% less electricity than constant temperature heat lamps
- put heat lamp circuits on thermostats set to turn off when the temperature hits the desired setting
- infrared heat lamps of 250 W are common but use excessive amounts of energy and often supply too much heat. Changing from the 250 W lamp to one with an aluminized parabolic reflector rated at 175 W will save 30% on energy usage
- heat lamp shrouds with diode dimmer switches allow radiant heat output to be halved as piglets grow and heat needs lessen

Fan Forced Unit Heaters. Fan forced unit heaters are used extensively for space heating because they are easy to buy, move and clean. They can provide adequate heat in a barn setting. Space heaters however, can alter the airflow patterns in a building with low minimum ventilation rates like a farrowing room. Gas fired unvented unit heaters expel CO, CO_2 and H_2O back into the room. As a result, minimum ventilation will have to increase to accommodate the increased gas levels as will heater sizing by as much as 25%.

Radiant Heat. Infrared radiant tube heaters are well suited to weaning and grower-finish facilities. Radiant heaters supply spot heating and save energy during warm weather farrowing or brooding. A given standard of comfort can be maintained at a lower air temperature with radiant heaters. Infrared heaters reduce required heater output sizing by 15-20% compared to forced air systems. Radiant tubes can also control humidity resulting in possible energy savings when considering minimum ventilation rates.

Other considerations for heating:

- barns that are well stocked require less supplementary heat than under-stocked barns
- microwave radiation is new, and energy efficient as it delivers heat directly to the animal and is not carried away by the airflow in the room
- catalytic radiant heaters are not thermostatically controlled so are therefore less efficient

The Bottom Line

Heating is a large part of energy costs in the barn. Know the heating requirements of your animals. Determine the size and type of heating unit that is best suited to your situation. Radiant heating systems are more efficient than forced air systems.

What's the Cost?

Gas space LB white heaters, radiant gas fired heaters and central boilers can all be used within a swine facility to provide supplemental heat. These systems vary greatly with respect to initial investment cost. For example, installation of a boiler for the purpose of hot water heating is much more expensive than a gas space LB white heater. These units also differ in heating efficiency:

Gas space heater (LB white):	98%
Radiant gas fired:	80-85%
Boiler (oil/gas)	80%
Boiler (wood/coal)	70%

Consider Air-to-Air Heat Exchangers

Energy required to heat incoming air can be extracted from exhaust air by heat exchangers. Heat from the exhaust air is transferred to incoming cold fresh air through exchanger plates.

When this heat is taken from the warm moist exhaust air by the exchanger, it is cooled and eventually reaches its dew point temperature. When this happens, heat is released and the incoming air is warmed. Swine facilities can benefit from the use of heat exchangers as 90% of the total heat loss occurs through the minimum ventilation air exchange.

Similarly, with the high cost of electrical energy, heat recovery might be a good alternative. The high purchase price will be exceeded in energy savings in an estimated 4 to 10 years. Producers should consider the advantages and disadvantages to this system and then decide whether it is right for their operation.

Advantages:

- heat exchangers reduce frosting problems which can impede fan performance
- incoming ventilation air is preheated thereby reducing draft potential

(Continued on page 6)

(Continued from page 5)

- warmed inlet air won't drop as rapidly as cold inlet air from a conventional system
- ventilation rates can be increased when heat exchangers are used to improve air quality without an increase in heating energy costs

Disadvantages:

- high initial purchase price
- not compatible with pit ventilation
- must be serviced or cleaned often
- older models have air discharged from a single point which limits room size unless more than one unit is used

The Bottom Line

Benefits of air-to-air heat exchangers are preheating of the inlet air and reducing cold drafts while lowering energy costs and supplemental heat requirements.

What's the Cost?

- Recall our 200-head grower-finisher room with 60kg pigs in the month of January. With an outdoor temperature of –19^{o}C, heating must be provided at a rate of 4117W. The cost to heat the room was calculated at $3.06/day or $94.95 for the month. What would be the cost savings for the month if heat exchanger technology were installed?
- If two (2) Del Air model V500 heat exchangers were installed in our 200-head room, supplemental heat could be eliminated. These two units are self-regulating and run continuously. The only cost realized by the producer would be the electricity cost to run the two units.

Acknowledgements

Special thanks to our writers and researchers:

Ron MacDonald of Agviro, Inc.

Ryan Fiddler, DGH Engineering

Bill Henley, Saskatchewan Agriculture, Food and Rural Revitalization

Darrell Lischynski, Prairie Agricultural Machinery Institute

Stéphane Lemay, Prairie Swine Centre

Lee Whittington, Prairie Swine Centre

Claude Laguë, University of Saskatchewan/Prairie Swine Centre.

Shala Christianson, Prairie Swine Centre

Energy Efficiency in Barns - Part I

Available on our website:

www.prairieswine.ca

Conversion Factors

1 kW = 1000 W = 1.34 hp
1 W = 3.412 Btu/hr
1 kPa = 1000 Pa = 4.02 in. of water
1 cubic meter = 1000 litres = 35.30 cubic foot
1 L/sec = 2 cfm

Prairie Swine Centre

Box 21057
2105 8th Street East
Saskatoon, Saskatchewan
S7H 5N9

Phone: 306-373-9922
Fax: 306-955-2510
Email: engelek@sask.usask.ca

We're on the Web!
prairieswine.ca

Prairie Swine Centre is an affiliate of