ENERGY EFFICIENCIES - STRATEGIES FOR MINIMIZING UTILITY COSTS IN THE BARN

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ABSTRACT

This paper discusses the importance of maintaining both the desired environmental temperature for the pigs being housed as well as exchanging sufficient air to maintain good air quality for maximum pig performance. Equipment sizing and efficiencies are discussed as well as proper control of these devices. Additionally, various lighting options are discussed since this is another significant energy user in many swine enterprises. The paper concludes with comments regarding heat recovery, possible alternative fuels and renewable energy sources.

INTRODUCTION

Energy prices have escalated rapidly in the last few years. Natural gas has risen from as low as \$0.80/GJ to \$8.00/GJ, a ten-fold increase. No other segment of farm costs has risen as quickly. Energy may still be a small percentage of overall annual expenses, but it is an essential input. Wasting energy not only wastes money, it causes pollution in the form of greenhouse gas emissions, and it has also been shown that the quality of indoor air and overall swine barn environment can be lowered. As a result, it makes good sense to manage our energy resources wisely.

This paper focuses on the main consumers of energy in barns (Heating, Ventilation, Lighting) and energy efficient technologies.

COST OF ENERGY/ CONTRACTING

Energy costs have risen very rapidly in the last few years, Natural gas has gone from as low as \$0.11/m^3 to about \$0.42/m^3 (February 2006). Electricity prices have risen from \$0.08/kWh to \$0.11 and further increases are already scheduled.

Contracting natural gas can be arranged for one through five years. Typically the longer time periods have been the best bet for saving money. Short term has not been as valuable as simply staying with the market prices so far.

For small farms, staying with the price cap is recommended in the electricity world.

To evaluate various pricing and contracts, the best way is to check out www.energyshop.com, an independent company that will provide energy pricing from all companies selling gas and electricity. As well, the Ag Energy cooperative at www.agenergy.coop has new long and short term deals worth looking at.

HEAT BALANCE AND AIR QUALITY

The two main goals in every livestock room environment are to maintain the room temperature within the comfort zone of the animals being housed and to also exchange sufficient air to maintain good air quality for both the animals and the stockmen. During the three cooler seasons of the year, the amount of air exchange provided can affect the room temperature. If the animals are not able to provide sufficient heat energy to offset the building shell losses plus the heat loss with the ventilation air, then the room temperature will be lowered. Of course, the remedy is to add sufficient supplementary heat to make up the difference or balance the heat flow. Heat gains must equal the heat losses to maintain a consistent room temperature.

Let's look at a 500 pig capacity nursery room as an example of typical heat gains and losses. Typically these rooms start the pigs off at a relatively warm room temperature in the range of 29 or 30C depending on the weaning weight and then slowly allow the room temperature to drop over the next 6 to 8 weeks to approximately 21 or 22C. Even though this room will be reasonably well insulated, it will lose heat energy through all of the walls, ceiling, floor and foundation. These shell losses will reduce as the room temperature is lowered. The other main heat loss is that which exits through the ventilation fan. Interestingly, this heat loss continues to get larger as the pigs grow even though the room temperature is being lowered. This is due to the fact that more ventilation is required as the pigs grow to maintain good air quality. Since the small pigs do not provide a lot of heat energy to offset (or balance) these heat losses, supplemental heat must be added to maintain the desired room environment. But; how much heat? Table 1 summarizes the heat energy flows for this example nursery room.

Table 1. Heat balance table for 500 pig nursery room.

Room Parameter	4 Kg Pigs	7 Kg Pigs	10 Kg Pigs	18 Kg Pigs	27 Kg Pigs
Room Temp / RH	30C / 57%	29C / 60%	26C / 62%	23C / 64%	21C / 66%
Ventilation Rate CFM	550	750	900	1300	1600
Outside Design Temp	-12C	-12C	-12C	-12C	-12C
Room Shell Losses BTUH	31530	29570	24190	19800	16085
Ventilation Loss BTUH	51480	65390	71880	94500	115180
Total Heat Losses BTUH	83010	94960	96070	114300	131265
Heat Gain from Pigs	17690	30210	53100	92170	131265
Heat Balance BTUH	-65320	-64750	-42970	-22130	0

The interesting fact from this example is that the exhaust fan heat loss accounts for 62% of the losses with very small pigs and increases to 88% of the total heat losses for the largest pigs. Additionally, the total heat energy leaving the room increases by 58% as the pigs grow. Thus, the actual ventilation rate provided for the room really does impact the energy requirement for nursery pigs. Therefore, precise control of the air flow exchange rate is paramount to minimizing energy usage.

However, simply reducing the ventilation rate is not a good operating strategy, since air quality will deteriorate and resulting pig performance is often compromised. The key is to exchange enough air but do not over ventilate. This means sizing the stage 1 ventilation fan correctly and then controlling both it and the heater such that they work together and do not waste energy.

VENTILATION & HEATING EQUIPMENT SIZING

Generally properly sized equipment performs the best job and does it efficiently. With ventilation fans, this is a relatively easy task since we tend to provide at least 4 stages of ventilation from the winter minimum to the summer maximum rate. Even with the use of variable speed fans, most rooms will be equipped with at least 2 fans and more often than not, three or more exhaust fans. Having said that, it is still possible to over size the stage 1 (minimum fan) fan such that it is not able to run continuously and thus waste energy and promote earlier wear out. Starting an electrical motor generally takes at least 3 times the energy as it does to simply keep it running. However, an over sized fan is sometimes necessary. If the room is quite small or the animal population very low it may be difficult to purchase an exhaust fan with a low enough output to be able to run continuously. For this case, a timer function on the controller is workable until the pigs are larger or the weather warmer such that the fan can be operated continuously. Occasionally a large room may require several stage one fans to provide a reasonable spacing for exhaust points and yet need sufficient capacity with the larger pigs that when the pigs are young, the fans are too big and thus a timer cycle is also required for a short time frame.

Ideally, a complete ventilation and heating analysis should be undertaken as part of the design process for a new swine facility and as such the equipment would be specifically sized for that room or rooms. However, over the years a number of rate tables have been developed based on that type of analysis and of course good practical experience working in the ventilation design field. Table 2 provides some basic ventilation rates for different sizes of pigs that can be used as a guide to help select the proper size of fans.

Fan performance can vary considerably from one fan model to another depending on type of motor and blade design as well as housing and orifice arrangement. However, Table 3 provides a ballpark range of values for typical agricultural fans found in the market place. Always consult with the manufacturers' literature and ask if it has been tested for air flow by an independent laboratory. Also refer to the Equipment Efficiencies section of this paper.

Table 2. **Typical ventilation rates for pigs.**

Pig Size / Type Weight in Kilograms	Minimum Winter Ventilation	Maximum Summer Ventilation
5 Kg	1.5 CFM	18 CFM
25 Kg	3.0 CFM	35 CFM
50 Kg	4.0 CFM	50 CFM
75 Kg	5.0 CFM	65 CFM
100 Kg	6.0 CFM	75 CFM
120 Kg	7.0 CFM	80 CFM
Gestation / Breeding	10 CFM	200 CFM
Farrowing	15 CFM	300 CFM

Table 3. **Typical exhaust fan capacities.**

Fan Size (Blade Diameter)	Minimum Capacity (variable speed)	Maximum Capacity (full speed)
12”	300 CFM	1000 – 1300 CFM
14”	500 CFM	1500 – 1800 CFM
16”	700 CFM	2000 – 2500 CFM
18”	800 CFM	2800 – 3500 CFM
20”	1000 CFM	4000 – 4500 CFM
24”	1200 CFM	5000 – 6500 CFM
28”	1500 CFM	6000 – 7000 CFM
30”	2000 CFM	7000 – 8000 CFM
36”	2500 CFM	9000 – 10000 CFM
48”	NA	18000 – 20000 CFM

With heating equipment, sizing is always a problem since we tend not to have variable output heaters to choose from in the market place. Some heaters do offer a 2-stage burn feature while others have a variable output orifice that can be manually adjusted However, for the most part the heating equipment is sized for a cold winter day and that size is installed and used for all of the heating needs on an “on / off” basis. Thus we are forced to live with over-sized heating equipment for a good percentage of the year. There is some energy efficiency to be gained by installing a 2-stage burner or splitting the heating requirement into two separate heaters and then stage the heating with the room controller. However, the extra capital cost of either the 2-stage heater or 2 separate heaters makes the increased energy efficiency a no gain option.

Similar to exhaust fans, a detailed room analysis should be undertaken to determine the size of heater needed, but tables like the one provided here have been developed to get you in the ballpark for equipment sizing.

Table 4. Supplementary heat for pigs.

Type of Pig Room		Supplemental Heat BTUH / Pig		
		-20 C	-10 C	0 C
Weaned	4 Kg	220	170	120
Pigs	12 Kg	210	140	70
	20 Kg	200	100	25
Feeder	25 Kg	200	90	0
Pigs	40 Kg	100	40	0
Gestation / Breeding		500	250	0
Farrowing per Crate		1700	1100	450

EQUIPMENT EFFICIENCIES

Heating

Supplemental heat from various sources has been cheaper to buy than the added costs associated with extra feed, longer days to market and health problems, which can develop from the poorer quality environment caused with insufficient ventilation.

Heat is usually supplied in swine barns in two forms: 1) Convective and, 2) Radiant.

Convective heat directly heats the air. The heated air then moves throughout the space, either by a fan on the heater or as a result of the ventilation system causing air currents to move it. Convective heat systems require a warmer barn temperature than a radiant system and the use of re-circulation systems helps ensure uniform heat distribution in the barn.

Radiant heat is defined as the electromagnetic waves passing through space, which warm up an object (on contact) in the path of the waves. Radiant heat systems generally allow a cooler barn temperature because the heat energy output is used to heat the pigs, not the air. Even though the ambient temperature is lower, animal comfort is still maintained.

1) Convective Heating Systems

A) Direct-Fired Forced Air: These forced air unit heaters use propane or natural gas. The heater burns the fuel and barn air and then vents the heated air (actually the by-products of combustion) directly into the room. This is both an advantage and disadvantage for these units. The advantage is all of the heat energy available is being used in the room; none is vented up a chimney and wasted. The disadvantage is that the combusted air contains carbon dioxide (CO_2), carbon monoxide (CO) and moisture (H_20) and consumes oxygen (O_2), which is why the barn is being ventilated to start with.

B) Hot Water Heating Systems: Hot water systems can operate using just about any fuel source, including natural gas, propane, oil and wood. They usually consist of hot water pipes around the perimeter of the barn. Today’s modern "hydronic" heaters (fuelled by propane, oil or natural gas) are quite efficient, usually around 80% or so. This system provides good quality heat because it heats the outer perimeter of the barn. It is more expensive to install and the pipes can be a problem as they interfere with cleaning, shipping, etc.

2) Radiant Heating Systems

A) Gas Tube Heaters: The most popular system is the gas tube radiant heaters, using either natural gas or propane. These units usually use outside air for combustion, but vent the by-products (CO_2 and moisture) into the barn. This again requires a higher ventilation rate, but not as high as direct-fired since it burns outside air.

B) Catalytic or Open Flame Brooders: These heaters are designed for partial room brooding, using propane or natural gas. These units concentrate their heat energy in a specific area of the pen with the intent that the pigs will be attracted to this "more comfortable" heat zone. These units are direct fired and as a result higher ventilation rates are necessary. Maintenance is critical to proper operation; improper maintenance will result in incomplete combustion and poisonous carbon monoxide gas will result.

C) In-Floor Radiant: This consists of plastic piping buried in the concrete (or sand beneath) at approximately 12" on centre. A boiler and pump system provide hot water to heat the floor surface. One disadvantage is the thermal lead/lag; it takes a while to heat the concrete mass when temperatures change quickly and conversely, it takes a while to cool down when temperatures warm up. As a result, rapid outside temperature changes make it difficult to control the barn. Costs vary widely. However, it is safe to say that this will be the highest capital cost of the many heating systems available.

Ventilation Fans

Since ventilation fans are necessary on a 24/7 basis, it only makes sense that they should be as energy efficient as possible. Several comments are in order regarding fan efficiency.

1) Do not use amperage to compare fan efficiency. There are too many other factors affecting performance that makes amperage extremely unreliable.

2) Wherever possible, use 240 V motors, not 120 V to increase energy use efficiency. Higher voltage will decrease losses that occur in the wire itself.

3) Try to keep the length of wire from the panel as short as possible. Less than 100' is optimum. This may mean installing an electrical sub-panel in the building somewhere.

4) All wiring should be #12 gauge as a minimum, to reduce line losses.

Another motor rating is horsepower (H. P.). This refers to power at the shaft under steady state conditions. This number is also unreliable for comparing fan efficiencies.

There is only one method for comparing fan efficiencies and that is CFM/W (Cubic feet of air per minute ÷ watts). At the end of the day all we are concerned with is how much air did we move and how much did it cost to move it.

There are other issues that must be addressed when selecting a fan based on energy consumption.

1) The CFM/W ratings should be provided by an independent test laboratory such as University of Illinois BESS laboratory or Air Movement and Conditioning Association (AMCA). There may be other independent labs doing tests. Before relying on their data <u>consider the source</u>! Is it truly impartial and does it provide quality results?

2) CFM/W ratings should be provided at various 'static pressures', usually from 0 to 0.25" of water column in 0.05" increments. Compare all fans at the same static pressure, usually 0.10".

Fan efficiency ratings[3] that are considered acceptable (at 0.10" static pressure) are:

Direct drive fans (<12" diameter)	5-6 CFM/W
Direct drive fans (>12" diameter)	8-15 CFM/W
Direct drive and belt drive fans (30"+ diameter)	15-25 CFM/W

The higher the CFM/W, the more efficient.

3) Also, check to see if the CFM/W rating falls quickly as static pressure increases. This means the fan will perform poorly against wind pressure effects. For example, an energy efficient first stage fan (for example 15 CFM/W) producing 3000 CFM at 0.1" and only 1000 CFM at 0.25" would be very poor as a variable speed fan, and even worse in windy locations. A less efficient fan (for example, 9 CFM/W) may provide 3000 CFM at 0.1" and 2400 at 0.25", and would thus be far more stable. Far more losses and costs can be incurred from inappropriate winter stage 1 and 2 fans performing poorly (improper air quality, excessive fan cycling, etc.). Always use wind hoods on Stage 1 and 2 fans.

4) Fans should be sized first to match the various stages required. Subsequent stages beyond the stage 1 and 2 fans (typically single speed) can and should be more energy efficient as they are not as critical and usually not operated as variable speed.

5) Wind-breaks or hoods will be necessary to ensure optimum air flow. Consider wind hoods on Stage 3 and higher fans in windy areas.

6) Chimney fans can be more efficient than a wall fan. However, the added costs and control issues need to be carefully analyzed before chimney fans are chosen.

The best bet is to have a well-designed, integrated ventilation system, engineered for optimum energy use efficiency.

[3] ASAE EP X566 Guidelines for Selection of Energy Efficient Agricultural Ventilation Fans

Light Systems

With high light intensity and energy costs, and much longer photoperiods, the old Edison style incandescent lamp must be relegated to the museum shelves. They are less than 5% efficient at converting energy to light, wasting the remainder as heat energy and have a relatively short rated life (the time at which 50% of the lamps are expected to have failed).

Compact fluorescents (C.F.) have attracted much interest in recent years. They provide good energy efficiency and are easily retrofitted into incandescent fixtures. However, the shorter equipment life and higher cost of replacement C.F. lamps and ballasts compared to 4', T-8 fluorescent tube systems has resulted in higher operating costs and thus reduced cash-flows. So far, CF dimming below 50% of light output has been unreliable. When this is resolved, there will be more opportunity for them.

The new energy efficient standard is the T-8 fluorescent tubes with dimmable electronic ballast, mounted in weatherproof fibreglass or plastic housing with gasketed diffuser. These units are more than four times as efficient as regular life incandescents and the lamps last at least 24 times as long. Refer to Table 5 for relative system efficiencies and lamp life.

Where barn ceiling height exceeds 12', high intensity discharge (HID) fixtures may also be considered. They are easier to install, maintain and require fewer fixtures to provide the same level of light. Types to be considered include:

X metal halide (nice white light, good colour rendition, and good life)

X high-pressure sodium (excellent life, the lowest cost, and can be colour corrected for good colour rendition,)

Low-pressure sodium has been used for yard lighting in a few cases, but light quality is poor.

And finally the progress of diode lights has been dramatic. Within a few years, they should be competitively priced and be able to provide good quality, low cost light to smaller defined areas such as creep areas.

Table 5. Relative life and efficiencies of various light sources[1].

Lamp Type	Lamp Size (W)	CRI	Efficiency (Lumens/ W)	Typical Lamp Life (hr)
Incandescent	25 – 200	100	11 - 20	750 - 5,000
Halogen	50 - 150	100	18 - 25	2,000 - 3000
Fluorescent T8	32- 120	75	88	20,000
Fluorescent T5	28- 100	85	104	20,000
Fluorescent T5HO	54 +	85	93	20,000
Compact Fluor.	5 – 50	80 - 90	50 - 80	10,000
Metal Halide	70 – 400	60 - 80	60 - 94	7500 - 10,000
High Pressure Sodium	35 – 400	20 - 80	63 - 125	15,000 - 24,000
LED	1.4	70 - 90	47 - 53	100,000

[1] ASAE IET 433-4 Lighting EP, 2005

VENTILATION & HEATING CONTROLS

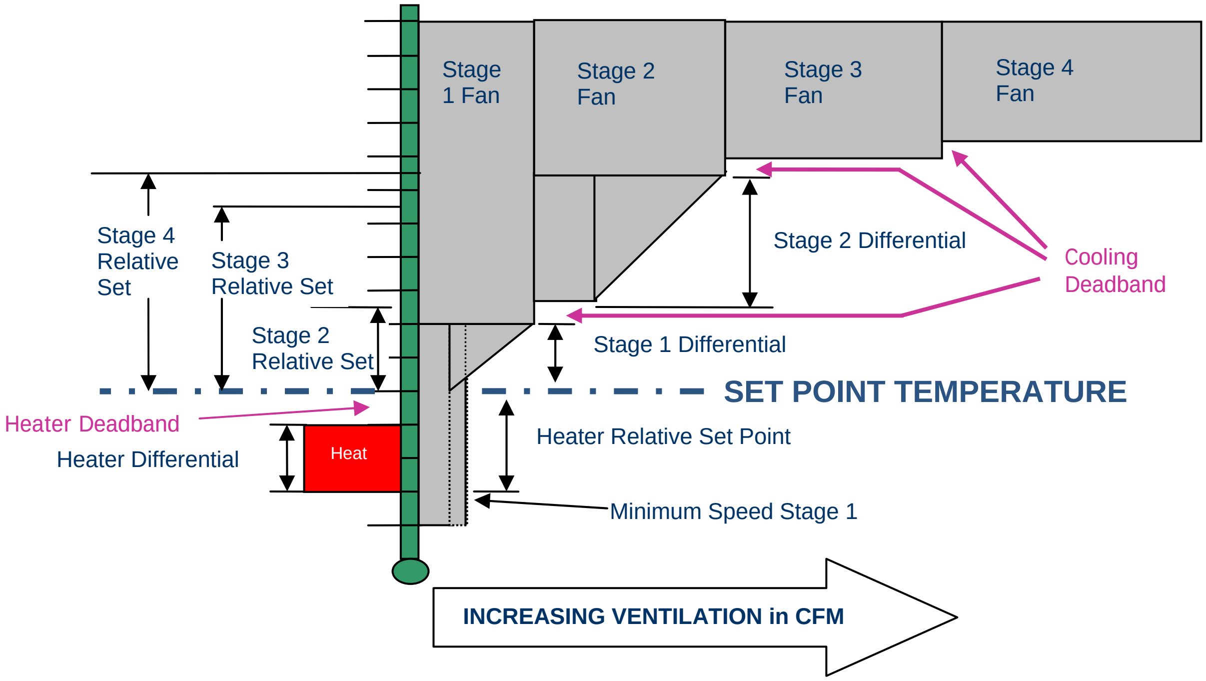
While today's electronic controls are very sophisticated and quite reliable, they are not totally automatic and need to be properly managed. Unfortunately many operators do not take the time to fully understand their controls and often can have settings that automatically waste energy.

The basic operating principle of these controllers is to establish a temperature set point and operate cooling fans at various room temperature values above that reference point and similarly operate a heating system at room temperature values below that same reference point. While the principle is straight forward, it is easy to program inappropriate start and stop temperature values which cause energy waste.

A classic example of heat waste is allowing the heating equipment to run sufficiently long to raise the actual room temperature up to the reference or set point temperature prior to shutting the heater off. While this sounds like a logical thing to do, the problem is that there is a considerable lag time in the temperature sensor responding to any change to which it is exposed. Complicating the matter is the fact that we must size the heating equipment for the coldest weather expected and as such is over sized for the majority of the heating season. Thus the heating equipment is putting a lot of heat energy into the room environment and the actual temperature will usually continue to climb at least 0.3C (0.5F) after the sensor calls for heat shut off. If this additional temperature rise (overshoot) brings the room above the set point temperature, the stage 1 fans simply speed up as programmed and extract the heat just purchased. Air quality may be better but heat is wasted. Additionally, the pigs are being subjected to an unwarranted temperature fluctuation. The simple correction is to ensure that the heating equipment is programmed to shut off at least 0.3C (0.5F) below the set point temperature.

A second energy waster is fan temperature settings that touch or even overlap. For example, the second variable speed fan starts at a temperature lower than the full speed temperature setting for the first stage variable speed fan. In this case, electrical energy is being used to operate two fans when generally only one was necessary. Another common setting that wastes energy is having the stage 2 or stage 3 fan start at the exact same temperature as the previous variable speed stage reaches full speed. In this case, the controller does not give the previous fan any time to run at full speed on its own to determine if it can maintain the desired room conditions without assistance. Typically the additional fan only runs for a brief period of time and after lowering the room temperature a half to one degree shuts back off. Not only is some extra energy used, we have exposed the pigs to another temperature fluctuation that often was unnecessary. The proper strategy is to build in a 0.3C (0.5F) cooling deadband between each fan stage to allow that level of fan power a chance to maintain the room conditions. If it is not adequate, the room temperature will slowly climb that part of a degree and then additional fan power will be activated.

Figure 1. Diagram showing typical ventilation control strategy.



Lastly, I often see the total ventilation bandwidth set too narrow, such that all of the ventilation fan power is operating far sooner than usually necessary. For most swine environments, the total temperature bandwidth between minimum and maximum ventilation should be in the range of 5C to 7C (9F – 11F). Tighter bandwidths not only waste energy, but again expose the pigs to a rapidly changing temperature and potential drafts that are often associated with extra ventilation.

HEAT RECOVERY

As we all know, a lot of heat energy is expelled continuously through the exhaust fans on every livestock facility. Fairly simple heat exchangers can recover 25% to 50% of this heat energy. However, there are two big problems with most heat exchangers. They plug up very quickly and require constant cleaning. Secondly, they only recover low grade heat. That is, they simply pre-warm the incoming fresh air so that it is warmer than outside but still considerably cooler than the room temperature. With an intake fan blowing this air into the room, it can still create drafty conditions for the pigs. Thus a secondary air distribution system is required or it needs to be ducted into the main air inlet system (if one exists). Again heat exchangers are often better suited to swine enterprises where the reclaimed heat can be directed to a central hallway that provides the winter fresh air supply to a number of rooms.

In the past most of the commercial heat exchangers were relatively small plate to plate units designed to provide some recapture of heat back into the same air space as it was exhausting from. While this concept still works for a design where the reclaimed heat is ducted to a common hallway, the multiple heat exchangers being employed increases capital cost and maintenance. Two locally based innovators are working on tube and shell type heat exchanger designs that may not be quite as efficient as the plate to plate style but are far easier to clean and maintain. Additionally they are sizing the units larger to be more practical for many of today's room populations and allow the use of variable speed fans.

Several innovators over the years have developed various forms of larger exchangers that take air from a number of rooms and deliver the incoming warmed air back to a common hallway. There can be significant capital savings in custom building a larger exchanger and utilizing a single intake fan to pull the fresh outside air through the exchanger tubes. In fact some designs even use a common fan to pull the minimum exhaust air from several rooms. The most common type of multiple room heat exchanger in the past was a side hallway design with all of the exhaust fans dumping the warm dirty air into this hallway and fresh outside air being pulled through either a full wall plate type exchanger or a number of air tubes suspended through the length of the hallway.

Air Works is a U.S. based company that offers a custom designed ventilation system that includes a very large tube and shell heat exchanger tied into pit ventilation for pigs. This company has several of these systems installed here in SW Ontario. There are definitely some increased energy efficiencies with these large scale systems that can make them attractive for energy conscious producers. A lot fewer exhaust fans are employed and those that are used tend to be larger and more energy efficient. However, these multiple room systems do increase the complexity of controlling the air quality in each individual room and thus require more management on a regular basis.

As the cost of energy continues to rise, I do believe that we will see an increased use of heat recovery and central hallway systems for winter air supply.

ALTERNATIVE FUELS

There has been a lot of interest in alternative fuels including biomass and even coal. There are a number of issues that need to be clearly identified and calculated into the equation prior to making an investment in an alternative fuel system:

- Is the cost of the new fuel going to be stable at least until the pay off of capital is complete? For example, a corn burner may look great with historically low corn prices, but if they rise to profitable levels in the next few months, how will the payback look then?
- Will the system integrate easily with my facility? For example, if the system uses hot water and your facility is completely forced hot air, then costly heat system delivery changes will also be required.
- Labour is also a major issue that many people overlook. Biomass systems will require much more effort to keep them going. If the fire goes out at 2:00 a.m., someone has to get out there and restart it. Clinkers, a hard substance left behind as part of the biomass combustion process, will need to be dealt with.

- Ash disposal; for large burners, ash removal and disposal can create serious problems due to the enormous volumes created.

RENEWABLE ENERGY: SOLAR & WIND ENERGY

If we recall the energy crisis of the early 80's, we saw the introduction of a number of alternate energy technologies. These included a whole range of heat exchangers, heat pumps and solar energy collectors. None of these technologies lasted longer than about 10 years for a couple of reasons. Generally speaking, the cost recovery for these systems was about neutral (i.e. the system wore out by the time the energy recovery had paid for the installation). Frequent cleaning and other maintenance issues plagued many of these units and they were quickly abandoned.

Now that energy costs are starting to take another forward leap, it may be time to revisit these technologies and see if we can utilize them more efficiently than was the case 20 years ago.

Last winter I took a trip into Quebec to look at a rather simple solar collector concept being employed on a number of livestock buildings in that province. This product, called SolAgra is simply perforated black painted metal siding that is used as a flat plate solar collector and tied into the fresh air intake system for the building. The perforations (created by surface indentations) are custom sized to allow between 1 and 20 CFM per square foot of fresh air to enter parallel to the back side of the metal surface such that the heat gain from the sun is transferred into the air stream.

In its simplest form, the SolAgra product is used to create the fresh air intake hood (installed with the metal ribs running either horizontally or vertically) for a typical continuous baffle board air inlet. With the addition of a winter closure board at the bottom of the intake hood, all of the cold weather fresh air enters through the perforated metal hood covering. Providing the sun is shining on the metal hood, a significant heat rise can be achieved for the incoming air. This temperature lift can be significant and makes the ventilation air drier and a more efficient moisture collector as soon as it enters the building. Secondly, less supplemental heat is required to complete the temperature lift to the desired room temperature.

However a large percentage of our swine enterprises utilize the entire attic space as the fresh air plenum. For this heat collection system to be effective it would be necessary to ensure the entire attic was well insulated to not lose this heat prior to it being introduced to the various rooms. This type of system is better suited for a ventilation system which utilizes a central hallway for its winter air supply to a number of rooms. This can work well with the entire end wall of the building being utilized as a solar collector.

Of course, the biggest downside with any solar energy source is that it only works when the sun shines on that particular portion of the building. If we have a bright sunny winter, there is a lot of heat energy to be gained during a portion of each day. However, this winter has not been particularly sunny and as such, limited energy was collected. Storing the sun's energy for later use is the other main downfall of many renewable; or so called, "green" energies.

Simple, economical energy storage has yet to be developed and until then will limit the wide spread use of this type of technology.

On the plus side, SolAgra metal siding is extremely simple with little or no maintenance and thus over the long run should be a net energy saver. Currently, due to patent rights, there is only one source for this product which makes it a seller's market. However, the good news is that Natural Resources Canada offers a grant of 25% for the purchase and installation of this type of system through their Renewable Energy Deployment Initiative.

Wind energy is highly unlikely to be a feasible alternative for most swine enterprises due to the extremely high capital costs involved with a wind turbine and generator. However, small systems are starting to appear in the market place and thus should not be entirely ruled out in the longer term.

CONCLUSIONS

Optimizing your facilities for energy efficiency will have a number of benefits; to your energy bills, pig performance, and overall indoor air quality. Developing an appropriate efficiency strategy will vary considerably from farm to farm and even barn to barn based on the existing situation and the cost analysis of any improvement or over-all system change.