Volume 2

MANAGING ENERGY COST IN THE BARN

PRAIRIE SWINE CENTRE

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Swine production is an energy-intensive industry. Over the past 10 years we have seen utility costs approximately double on a per hog basis. Energy/utility costs rank third in total cost of production, behind feed and labour. A large portion of the infrastructure in use today and constructed in the late 1990s and early 2000s may need renovations or replacement within a short time frame. The most common uses of energy are electricity for lighting, controllers, fans, and natural gas or propane for heating. By starting our focus on these areas, we can find opportunities to find efficiencies and reduce costs at the same time.

A previous survey (Predicala, 2008) of energy usage in 28 Saskatchewan swine barns showed a wide range of variability in energy use in different types of operations. A mathematical model applied to a 600-sow farm showed potential energy savings with different energy conservation strategies (Table 1). This survey and model shows the potential for numerous opportunities for improving energy use practices to reduce energy cost on-farm.

Table 1. Average annual energy savings determined by different energy-saving strategies applied to a typical 600 sow operation

Areas	Average energy savings		Energy cost savings
	kWh/yr	kWh/yr/sow	$/yr
1. Lighting (from T12 to T5 fluorescent	25,957	43	$3,893
2. Creep heating (heat lamps to heat pads)	47,391	79	$7,108
3. Recirculating fan (high efficiency motor)	9,872	16.4	$1,480
4. Exhaust fan (high efficiency motor)	42,501	71	$6375
5. Feed motor (high efficiency motor)	1,846	3.1	$276
6. Heat recovery (air-to-air heat exhcanger)	88,404 m^3/yr	147 m^3/yr/sow	$11,174

LIGHTS IN THE BARN

Arguably, one of the biggest changes we have seen in energy consumption is the type of light bulbs we use. In 2015, the Canadian government banned the import and sales of incandescent light bulbs, in favor of more energy efficiency compact fluorescent lights (CFLs). If your barn still has some incandescent lights kicking around, now is the time to swap them out. Even though it might seem wasteful to replace perfectly good existing bulbs, the savings in electrical costs for most bulbs will make up the difference in a matter of months. Besides CFLs, fluorescent tube systems have been a main source of light for barns where ceiling height is less than 12', and the more energy efficient high intensity discharge (HID) fixtures (including metal halide and high-pressure sodium) for barns with a ceiling height exceeding 12'. However, there is a new kid on the block, light emitting diode (LED) lights. Using LED lights reduces electrical consumption by 75-80% compared to incandescent bulbs and 50-60% over spiral CFLs. They are also more energy efficient than fluorescent tube and HID lights. While LED lights are more expensive to purchase compared to other light fixtures, in most situations the savings in electricity costs (with LED lights) provide a return on investment in one to two years.

LED lights are becoming very popular not only due to their high-energy efficiency, but also thanks to their long life and low maintenance cost. The expected life of LED bulbs is 50,000 to 100,000 hours, as opposed to 24,000 hours for fluorescent and HID lamps.

LED light dimmers

Energy efficient light bulbs. Left - compact fluorescent lights (CFLs); Right - light emitting diode (LED).

Another key benefit of LED lighting is the ability to dim the lights, allowing for the provision of dawn and dusk periods, much like natural sunrise and sunset. Providing a transition from light to dark periods can reduce stress caused by sudden changes in light, through reduction of feed competition when the lights are switched on in the morning. Lastly, LED lights can provide different colour spectra. Pigs have low sensitivity to red lights; in other words, they perceive red lighting as darkness, resulting in the possibility to provide a red 'service' light that allows workers to come into the facility after hours without disturbing or interrupting the sleep cycles of the pigs. Controllers can automatically control light intensity, colour spectrum and photoperiod length. You can even get fancy and connect the lighting system to Wi-Fi, so you can collect data and control lights from your phone or laptop.

LED lights come in a variety of shapes: tiles, tube units, fluorescent tube replacement LEDs (which fit the original fittings, often with the need to remove ballast devices or make other alterations), battens, flexible strips and globelike designs. Many LED lights come with an Edison fitting, so they can be screwed directly into existing light fixtures. All LED lighting systems operate using direct current (DC) with either a centralized AC-to-DC rectifier, or each lamp containing a rectifier within its body and electronics. Many LED lights designed for use in agriculture have heat sinks to remove heat from the semiconductors. In pig barns, it is important to ensure these sinks remain clear of contamination and you clean them between batches so that they operate efficiently - while taking care not to force water into light housings.

Make sure you provide a minimum lighting level of 50 lux, which is enough for a person to read a newspaper, for a minimum of eight hours a day to all pigs. Also provide at least six consecutive hours of darkness (<5 lux) per day. Table 2 displays the recommended light levels and photoperiods for different ages of pigs.

Other cost savings tips:

- To reduce energy use, consider using timers, programmed to turn lights on/off to meet daily swine needs.
- Another way to save some money on energy use is by installing motion sensors in personnel areas so lights are only on when people are around, like washrooms and storage areas.

LED LIGHTING

- Choose lights with a colour temperature between 2,700 (living room light) and 5,000 (bright outdoor light) Kelvin.
- Go with lights that have a color-rendering index (CRI) of 80-100.
- Go with bulbs that are sealed and easy to clean. Do not choose bulbs with a built-in fan because they plug up fast in a barn setting.
- Choose a bulb with an enclosure that has protection against dust and water -shown through an Ingress Protection (IP) rating on the bulb.
  - Go for a minimum IP65 or IP66 rating. The first number stands for dust protection, with 6 being the highest rating, and the second number stands for water protection, with 9 being the highest rating.
- Go with a brand that provides 5-to-10-year warranty. Make sure to keep the receipt and write down the date on the bulbs. This way, if there is a recall, or several bulbs burn out before the warranty period ends, you can get a new box of bulbs from the manufacturer.
- Light fixtures should be CSA and UL approved.
- Get a quality product with the ERNERGY STAR or DesignLights Consortium logo on it.

Table 2. Recommended light levels and photoperiods for pig barns.

Type of barn	Light levels	Photoperiod (h/d)	Comments
Breeding/gilts	>10 f.c. (>100 lux)	14-16	Necessary for estrus cycling
Gestation	>5 f.c. (>50 lux)	14-16	To assist missed cycles, bring estrus on again
Farrowing	5-10 f.c. (50-100 lux)	8	If no heat lamps, some light in room 24 h/d
Nursery	5 f.c. (50 lux)	8	Some light in room 24 h/d
Grower-Finisher	5 f.c. (50 lux)	8	

What's the cost?

Let's consider the cost of electricity for a 60-watt incandescent light bulb. Assuming the lights are on 8 hours per day for 30 days per month, the light bulb will use 14.4 kWh per month. At a price of $0.15/kWh, the electricity for this incandescent light bulb costs **$2.16** per month. If we replace the 60-watt incandescent bulb with an equivalent CFL bulb that uses 13 watts, the cost will go down to **$0.47** per month. To replace the bulb with an equivalent LED bulb that uses 9 watts, the cost would go down even further to **$0.32** per month.

Now let's consider replacing a 34-watt T-12 fluorescent tube light with a 16-watt T-8 equivalent LED tube light. Again, assuming the lights are on 8 hours per day and electricity costs $0.15/kWh, the T-12 fluorescent tube light would cost **$1.22** per month vs. **$0.58** per month for the LED tube light.

Before taking the plunge to switch to LED lights, do keep in mind that some electrical upgrades may be needed to accommodate the switch.

KNOW THE TEMPERATURE REQUIREMENTS OF YOUR PIGS

Just as we feel colder on a windy or humid day, pigs experience the temperature of their environment differently based on different factors. There is a difference between the room temperature and the effective environmental temperature for the pigs (the 'feels-like' temperature). For this reason, temperature requirements for pigs depend on many factors such as air temperature, air movement, humidity, flooring material, bedding/dryness (of the floor), age and size of the pigs, group size, feed type and intake level, and health status.

The aim of temperature control in the barn is to keep pigs in their thermoneutral zone. This is the temperature range in which an animal is comfortable, having neither to generate extra heat to keep warm nor expend metabolic energy on cooling mechanisms such as panting. The bottom temperature of the thermoneutral zone is the lower critical temperature, whereas the upper temperature of the thermoneutral zone is the upper critical temperature. Table 3 provides the optimum temperatures and desirable limits for pigs of all ages as measured at pig level. Producers should try to keep the temperature within these limits by using heat sources in the colder months, and by increasing ventilation in the warmer months.

Table 3. Recommended light levels and photoperiods for pig barns.

Category	Optimum Temperature* °C (°F)	Desirable Limits* °C (°F)
Creep area - newborn piglets	35 (95)	32-38 (89-100)
Creep area - older piglets *(2-5 kg [4-11 lbs])*	30 (85)	27-32 (81-89)
Young pigs *(4-5 days post-weaning)*	35 (95)	33-37 (91-99)
Young pigs *(5-20 kg [11-44 lbs]) in weaned pens*	27 (80)	24-30 (75-86)
Growing pigs *(20-55 kg [44-121 lbs])*	21 (70)	16-27 (61-81)
Finishing pigs *(55-110 kg [121-243 lbs])*	18 (65)	10-24 (50-75)
Gestating sows	18 (65)	10-27 (50-81)
Lactating sows	18 (65)	13-27 (55-81)
Boars	18 (65)	10-27 (50-81)

** Stated temperatures reflect the desired temperatures in the environment directly surrounding the pig, and not necessarily the overall temperature of the barn. Supplementary heat sources (e.g. heat mats) can be used to achieve desired temperatures.*

When temperature falls below the lower critical temperature, pig heat production increases 2-4% per °C. Cold pigs will huddle and lie with minimal body contact to the floor and piglets will shiver. Both shivering and heat production take energy that the pig cannot use towards growth; this results in reduced feed efficiency along with increased susceptibility to disease.

When temperature gets above the upper critical temperature, pigs need to use energy to cool down. Hot pigs will separate from one another and seek out wet parts of the pen - when pigs are warm, they eat less, and growth performance suffers. Keeping a room too hot also wastes energy, increasing energy costs and reducing performance, temperature control is therefore important. Table 4 shows the recommended setpoint temperatures during the heating season for various ages of pigs.

Pigs within their thermoneutral zone sleep side by side without huddling and without moving away from each other

Table 4. Recommended setpoint temperatures (°C) for various ages of pigs (heating season)

Room and body weight (kg)	Solid floor	Slatted floor	Solid floor with straw
Gestation	17	19	15
Lactation	16	18	14
Nursery			
7 kg	26	28	25
20 kg	23	24	22
Grower/Finisher (all in/all out)			
25-50 kg	21-15	23-15	20-14
55-90	14	15	13-10

Group-housed gestating sows can handle lower temperatures than the recommended temperature setpoint of 17°C.

Pigs prefer a diurnal pattern for environmental temperature with a preference for higher temperatures during the day when active, and lower temperatures at night taking advantage of huddling while sleeping. Research at the University of Minnesota showed that it is possible to drop the nighttime temperature after day five in the nursery room by 8.3°C without affecting growth performance. This resulted in a 30% and 20% savings in heating fuel and electricity use, respectively. Research at PSC showed that when given a choice, early-weaned piglets chose warmer temperatures during the day and lower temperatures at night. Another trial showed that grow-finish pigs could handle daily temperature fluctuations up to 13°C without affecting growth performance as long as this fluctuation is through a slow and steady change and mean daily temperature is within the optimal range. These trials show that there are opportunities to reduce energy use by reducing the temperature setpoints at night below the optimal or desirable temperatures for nursery and grow-finish pigs. It is very important to ensure there are no abrupt temperature fluctuations.

"There are opportunities to reduce energy use by reducing the temperature setpoints at night below the optimal or desirable temperatures for nursery and grow-finish pigs. "

Research at Prairie Swine Centre has also shown that group-housed gestating sows can handle lower temperatures than the recommended temperature setpoint of 17°C. When sows were given an option to control room temperature, group-housed gestating sows tended to maintain the room temperature at around 12.7°C when fed a standard diet and at around 11.9°C when fed a high fibre diet. This resulted in approximately a 75% and 11% reduction in natural gas and electrical consumption (during the heating season) respectively, when compared to rooms with pre-set temperature of 16.5°C, and translated to a reduction in facility costs of $2.80 per market hog.

This research suggests that it is safe to reduce the room temperature for group-housed gestating sows. It also shows diet type can have an impact on the preferred temperature of pigs, with high fibre diets reducing ideal room temperature. This is because dietary fibre has a high heat increment, meaning that it produces more heat inside the animal's body than other types of feed. As a result, the animal does not feel cold as quickly. Increasing dietary fibre in gestating sow diets only makes sense when the increase in the cost of these diets is lower than the savings in energy reduction through the slightly lower room temperature requirement.

Besides diet type, feeding level is also relevant, as full fed animals can withstand colder temperatures. Table 5 shows the tremendous drop in the lower critical temperature when growing pigs increased their feed intake. In other words, producers can decide to increase or decrease feed or fuel to maximize net returns.

Table 5. Relation between body weight, feed intake, and lower critical temperature in groups of growing pigs at normal levels of feeding (Source: Canadian Farm Buildings Handbook).

Body weight (kg)	Feed intake (kg/day) 0.5	1	1.5	2	2.5	3
	Lower critical tmeperature (°C)					
20	21	14				
40		20	14	8		
60			18	16	8	
80			16	11	7	
100			18	13	9	
120				15	11	8

What's the cost?

Let's consider a 200 head grow-finish room. The winter temperature recommendations are 21°C for 25-kg pigs reduced to 15°C for 75-kg pigs. Let's consider three temperature scenarios within this room and the impact that it has on energy costs.

- Scenario 1 — 21°C-15°C = represents the correct temperature recommendations.
- Scenario 2 — 21°C-18°C = temperature is maintained at 21°C until pigs are 50 kg and reduced to 18°C for 75-kg pigs and stays constant until animals reach their market weight.
- Scenario 3 — 21°C = maintains pigs at 21°C throughout the full production cycle.

Saskatoon and Winnipeg are the two locations chosen for this example. Calculations use monthly average temperatures over a 30-year period with a prairie energy cost of $0.031/kWh. Winnipeg had lower average temperatures than did Saskatoon. The following values look only at the heating costs to maintain the desired temperatures and do not consider the energy costs of ventilation. The carbon tax is not part of the calculation.

The results are as follows

Saskatoon
The cost to maintain the recommended temperature (21°C-15°C) would be $162.01/yr. Moving to the 21°C-18°C and 21°C temperature scenarios represents an additional **$90.40/yr** and **$226.43/yr** increase in heating costs, respectively.

Winnipeg
It would cost $179.10/yr in heating to maintain the recommended setpoint temperature of 21°C-15°C. Moving to the 21°C-18°C and 21°C temperature scenarios again would represent a large increase in the heating bill: an additional **$88.65/yr** for the 21°C-18°C scenario and **$222.23/yr** for the 21°C scenario.

HEATING

Heating costs is the largest component of total energy costs in pork production. On average, space heating contributes 95% of natural gas consumption in a hog operation. While natural gas is by far the most common fuel source used for space heating of hog operations, propane or biomass are also options. Heating systems must work in coordination with ventilation systems to provide a good environment for people and pigs. The most common systems for adding heat to the indoor environment are forced air heaters, infrared radiant tube heaters, hot water heating (consisting of a boiler, circulating pump, distribution piping and radiators in the space to be heated), and electrical devices such as heat lamps and heat pads. Table 6 outlines the heating requirements for each stage of development.

Forced air heater

Forced air heaters commonly use natural gas or propane in barns. Forced air heaters are units that heat the air in the whole room to the desired setpoint temperature. The warm air then warms the pigs. One drawback of using only forced air heaters is the possibility of heated air loss through windows or cracks within the facility, and the ventilation system. They also take longer to heat up the floor surface compared to other heating sources.

Older forced air heaters have an efficiency in the range of 78 to 82%, whereas the new generation high efficiency forced air heaters use condensing and have an efficiency up to 97%. They include a secondary heat exchanger to extract most of the heat remaining in the combustion by-products. Conventional forced air heaters always run at 100% kWh output, so they are either on full-blast or off. There are now new forced air heaters on the market that operate at firing rates as low as 25% of maximum kWh output. This results in more consistent room temperature and can save up to 35% in fuel costs.

It is important to install the proper sized heater. 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 $0.15/kWh, savings could be as much as $10.06/day.

Table 6. Heating requirements for pigs at different stages of development.

Age of pigs	Heating requirements (W/pig)
Gestation	300
Farrowing	700
Nursery	
7 kg	70
25 kg	50
Grower-Finisher (Continuous)	
25-60 kg	30
60-100 kg	35
Grower-Finisher (all-in-all-out)	
25 kg	60
40 kg	40
60 kg	30
80 kg	30
100 kg	30

"Natural gas is by far the most common fuel source used for space heating of hog operations, but propane or biomass are also options."

FORCED AIR HEATERS

- They require a lot of maintenance due to the recirculating dust and moisture. Some of the newer units draw fresh air from outside, thereby reducing this problem.
- They expel CO, CO2, and water 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%. Some of the newer models are vented, meaning these gases and byproducts are deposited outside the building instead of inside the room.
- They can alter the airflow patterns in a building, and uniform heat distribution may be a problem but rectified with a recirculation system.

Infrared radiant tube heaters use the heat of combustion from several flame units to heat a length of pipe, which then radiates the heat onto the pigs. The system only provides heat to the pigs and does not provide heat to warm the air, resulting in lower heating costs. The heaters are usually flueless, exhausting heat via the flue gases.

- A two-stage burner can increase efficiencies.
- Material used for the heat reflector affects the performance of radiant heaters.
- Ingrared radiant tube heaters are well suited to weaning and grow-finish facilities.

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. A PSC research trial showed that infrared radiant heaters consumed 60% less natural gas than a forced-air convection heater in a grow-finish room. The infrared radiant heating also provided more uniform heat distribution and had no adverse impact on the growth performance of the pigs.

Infrared radiant tube heater

"Infrared heaters reduce required heater output sizing by 15-20% compared to forced air systems."

Creep heat is a major consumer of energy. Creep heat can be delivered from the top down (through heat lamps) or from the bottom up (heat mats/pads). Heat rises, so having heat under the piglets tends to be more practical and economical. Heat mats have up to 35% lower power consumption, a larger heated area and distribute heat more evenly than heat lamps. Research at the University of Manitoba found using heat mats instead of lamps resulted in a daily saving of 2.8 kWh per crate. There are differences between heated creep mats - when buying new ones, look at the thermograph photos that should be provided and choose a mat that is evenly heated without any hot spots, such as mat C in Figure 1.

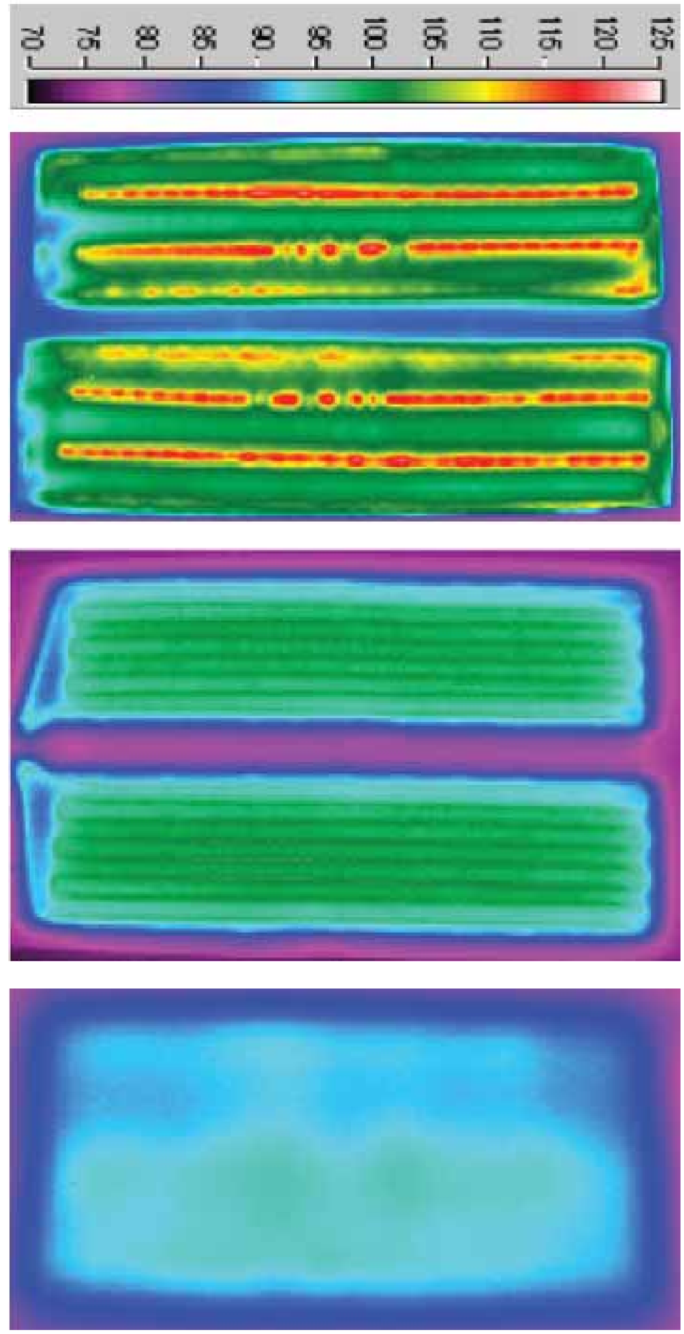


Figure 1. Thermograph photos of three different heat mats (Source: Zhang & Xin, 2000)

Both heat lamps and heat mats can be connected to a controller. This allows for adjustment based on the room temperature and the age of the piglets, with the controller turning off the lamps or mats when the temperature hits the desired setting. This can reduce electrical use by 20-30%. Studies have shown that piglets reduce their demand for supplemental heat at night; therefore, producers can take advantage of this by reducing nocturnal operation of heat lamps and heat pads and thus improve energy use efficiency.

Heat pad and heat lamp

HEAT LAMPS

- Utilize variable temperature heat lamps as they use 21% less electricity than constant temperature heat lamps.
- 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. Without dimmer switches, regulation of heat lamp temperature is through adjusting the hanging height of the lamp. The closer the lamp is to the floor, the higher the floor temperature but the smaller the heated area.
- Common problems with heat lamps are the bulbs breaking when they get wet and bulbs frequently burning out.

In the first week post-weaning, additional heat may be useful through heat mats, heat lamps, or radiant heat brooders. A brooder is similar to a heat lamp, but is bigger, and powered by natural gas or propane instead of electricity. Additional heat sources are especially important in wean-to-finish barns where we house pigs of all ages in the same room. When using brooders or heat lamps, place a rubber mat on the floor below it. Radiant heat provides heat directly to the animals. Colour impacts radiant heat transfer, so simply measuring the temperature of the black mat will not tell you what the temperature is like for pigs. Whereas the black mat absorbs most of the radiant heat, the tan-colored skin of pigs will reflect a certain amount of the radiant energy. As a result, the lying pattern of the pigs will need to be your guide whether the area under the brooder is providing the proper temperature.

Brooder

VENTILATION SYSTEMS

Exhaust fans with wind hoods

The goal of a well-managed ventilation system is to limit moisture and gas accumulation in the winter and heat in the summer. Too little ventilation results in low air quality - too much ventilation wastes energy. Ventilation systems use a lot of energy, especially the fans, with the finisher barn accounting for approximately 60% of all energy consumption. You can calculate electrical energy cost of a fan using the following equation:

Electrical energy cost of a fan ($) = (Reference kW) x (hr/day fan is running) x (#days/yr. fan is used) x (current cost of electricity $/kWh)

In winter, pigs lose heat by conduction through walls and floors so ventilation rate must be low. Table 7 shows general guidelines for the minimum ventilation rates for various ages of pigs. Several factors affect the minimum ventilation rate, such as barn design, number of animals in the room, fan specifications not being accurate, and fluctuating heating requirements. The implication is that minimum ventilation rates should be flexible for adjustment as conditions change.

Table 7. Minimum ventilation rates.

Room	Rate in cfm	Rate in L/sec/pig
Gestation	10	5
Farrowing	15	7 (per sow with litter)
Nursery	1.6	0.8
Grower-Finisher	3	1.5

A good relative humidity (RH) in the barn is around 60%. If RH is below 50%, ventilation rate is too high, wasting energy. For example, increasing the ventilation rate by 40% above the proper ventilation rate doubles your propane or natural gas use. Over-ventilating in the winter also expels heat, resulting in increased heating, thereby wasting more energy. A whopping 80 to 90% of heating energy is lost through the ventilation system, so it is important to use correct controller settings and ensure the correct fan size for each room and stage. Both can have a big influence on energy use. Do not try to winter ventilate a large room with several slowly operating variable speed fans. One properly sized fan running at its recommended speed is the most energy efficient.

Getting the ventilation system ready for winter

If you're in the market for new fans, be aware that performance data like air flow for fans are often reported for 0" static pressure, but barns generally have a static pressure of 0.1", and wind can cause the pressure across the fan to vary between 0.5" and 0.2". Generally, higher static pressure is associated with lower airflow. Use fans that are certified by BESS Lab (University of Illinois, http://www.bess.illinois.edu), so you get the airflow that you are paying for. BESS Lab provides the airflow and energy efficiency of fans tested at different static pressures (Table 8), as well as an 'airflow ratio', which is the ratio of a fan's airflow at 0.2" static pressure divided by its airflow at 0.05". An airflow ratio close to one is ideal, as this means the airflow does not go down much when static pressure increases. To reduce the effect of wind on the fan, it is helpful to add cones on large fans and wind hoods on small fans. Adding cones and wind hoods can improve energy efficiency by 15-20%.

Table 8. BESS lab test result for a 36" fan (Test: 00080bd) showing the efficiency at different static pressures

Static pressure (inches water)	Speed (rpm)	Airflow (cfm)	Efficiency (cfm/Watt)
0.00	860	12,210	26.1
0.05	853	11,300	22.5
0.10	846	10,450	19.5
0.15	838	9,420	16.3
0.20	830	8,050	13.0
0.25	817	6,300	9.6
0.30	784	4,060	5.4

When buying a fan, choose one that provides the proper amount of airflow at 0.1" static pressure. Keep in mind that you require backdraft devices on intermittently operating fans to prevent the fan from acting as an air intake. These backdraft devices close by gravity; so note that the fan must exert additional force to open the shutters.

Also, know that there is a difference in efficiency between fans. Energy efficiency of fans can be determined by looking at the cfm/W rating. The higher the cfm/W, the more energy efficient the fan is. In order to be considered efficient, small fans (≤ 24") should have a rating of at least 12 cfm/watt, whereas moderate sized fans (36"-48") should have a rating of at least 17 cfm/watt. Depending on the energy efficiency, every exhaust fan consumes between 1,000 and 10,000 kWh of electricity per year based on continuous operation. Over a 10-year period, savings for using efficient small sized fans (11.5-12.5") can be as high as $3,000 and $10,000 for medium sized fans (14.5-16.5").

Shutters on fans are used as backdraft devices to prevent the fan from acting as an air intake

Air inlets. 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. Ensure inlets close 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, which decreases output and energy efficiency. Often inlet adjustment and maintenance can accommodate changes or fluctuations in barn temperature. Instead of checking inlets, a common mistake is to increase ventilation rate to lower barn temperature and thus increase energy consumption.

These air inlets should be adjusted and calibrated to introduce air uniformly

What's the cost?

Assume that we will provide a minimum ventilation rate of 300 L/sec/pig for a 200-head grower-finisher room with dimensions 42' x 45' x 10'. This surface area works out to 9.45 ft2/pig including pens and alleyways. 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. Carbon tax is also not factored into the calculation.

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.

CONSIDER AIR-TO-AIR HEAT EXCHANGERS

Preheating incoming ventilation air offers the opportunity to reduce heating costs and can be accomplished by extracting heat from exhaust air through air-to-air heat exchangers, also called heat recovery ventilators (HRV). They transfer heat from exhaust air into incoming cold fresh air through exchanger plates. Heat removed from warm moist exhaust air by the exchanger is cooled and eventually reaches its dew point temperature, releasing heat and warming the incoming air. Production 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.

Heat exchangers will be most economical in nursery rooms and farrowing barns, due their higher temperatures, and drafts are a problem. While they can be expensive, energy savings should result in a 4 to 10 years payback in farrowing and nursery rooms. In Canada, heat exchangers may also be beneficial in grow-finish rooms and gestation rooms as some supplemental heat may be necessary in these facilities as well during the winter.

Heat exchangers replace minimum ventilation fans, as such should operate 24 hours a day, and should be manually controlled. It is essential that thermostatically controlled fans be on separate electrical circuits in the event of heat exchanger circuit failures. Heat exchangers require supplemental heat in certain situations, including cold weather and reduced barn capacity.

Producers should consider the advantages and disadvantages to this system and then decide whether it is right for their operation.

An air-to-air heat exchanger installed at Prairie Swine Centre

HEAT EXCHANGER ADVANTAGES

- Less need to run heaters thanks to incoming air being pre-heated.
- Heat exchangers reduce frosting problems which can impede fan performance.
- Incoming ventilation air is preheated thereby reducing draft potential.
- 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.

HEAT EXCHANGER DISADVANTAGES

- High initial purchase price.
- Not compatible with pit ventilation.
- Serviced or cleaned regularly to avoid clogging of exhaust air channels with moisture and dust, which restricts airflow.
- Since heat exchangers supply minimum ventilation, even a small reduction in air exchange affects the room's air quality.
- Clean heat exchangers on a daily, weekly, biweekly, or monthly schedule. Therefore, consider the ease and frequency of cleaning when selecting a heat exchanger.
- Due to the condensation happening inside the heat exchanger, there is a need to drain water from the unit and, during extreme cold temperatures, the need for a defrost cycle to remove frozen condensate.
- Older models have air discharged from a single point which limits room size unless more than one unit is used. If using a single heat exchanger, attach a distribution duct on the inlet side to provide adequate mixing of air within the ventilated room. This generally would be a rigid duct, either PVC or plywood, permanently attached to the heat exchanger with openings along the length for even distribution of air.

CONTROLLERS AND SENSORS

Integrated control systems exist to provide continuous monitoring of the thermal environment in the barn to achieve the optimum thermal conditions for pork production. This level of integration allows for control of the barn environment related to air temperature, but also for humidity and airflow levels to assess and control the effective environment of the pig. Electronic controllers have stages that work in unison where supplemental heat is interlocked to operate only when cooling is at a minimum. The newest trend is to have controllers integrated into a computer system that can adjust parameters based on a new self-learning (artificial intelligence) function.

Regardless of the type of system used, the control system is only as good as its sensors. Therefore, 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 and sensors:

Controller for an individual room

Centralized controller system for an entire barn

DO

- Avoid radiant heat sources, drafts, direct sunlight or stagnant air when mounting controller sensors.
- Place thermostatic controller sensors midway between the inlet and exhaust hanging from the ceiling. If on a plywood panel, hang the controller sensor parallel to the airflow.
- Place one minimum/maximum thermometer beside the controller sensor 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 overventilation 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 activate 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 controller sensors 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 sense the room air temperature and can result in either 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.

What's the cost?

Let's consider a theoretical example with a 200-head grower-finish room with dimensions 42' x 45' x 10'. This surface area works out to 9.45 ft2/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.

What is the outcome?

- if minimum ventilation rate increases by 10% an additional 2,526 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 5,052 W 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.

SEAL UP THOSE BARNS

Infiltration of air through unintentional air leaks or gaps in the structure reduces the amount of fresh air entering through air inlets, reducing the effectiveness of the ventilation system. Infiltration affects the desired operating static pressure at minimum ventilation, which negatively affects fresh-air distribution in the building. Infiltration originates from improperly sealed back-draft shutters and from building shell sources such as ceiling panel joints and the interface between walls and the ceiling. Wall-to-ceiling joints are best controlled with foam insulation in the attic, but this is an expensive option. On the other hand, significant improvement in minimum ventilation performance can be achieved by sealing unused fans, which can be achieved with interior plastic sheeting. Winter sealing of all unused fans is a cost-effective measure that can significantly reduce the negative impact from excessive infiltration.

Ensure there is a good vapour barrier in walls and ceilings, as moisture within the barn will lead to condensation accumulation and structural deterioration. An improperly placed vapour barrier can reduce the insulation value, leading to heating concerns. 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. Well insulated buildings are easier and cheaper to ventilate, is a good rule of thumb.

Insulation in the attic

BARN INSULATION

- 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 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 determine the R/RSI values using Table 9.
- 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 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.

Table 9. 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	2082	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

What's the cost?

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

- room filled with 60 kg pigs:
- outside temperature –19°C with a 60% RH
- inside temperature 18°C with a 70% RH
- 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**.

CUT BACK ON WATER WASTAGE AND MANURE VOLUME

Energy is used when slurry is pumped from the barn to the outdoor storage facility (left), when slurry is agitated in the storage facility (middle), and when slurry is loaded and transported for field application (right).

Manure pits in barns not only collect manure, but water wasted by pigs from drinkers and water used for cleaning. While we require some liquids to move the manure from the barn to an outdoor storage facility, slurry can include approximately 40% clean water wasted from drinkers. This is more water than required for easy flow, rather increasing wastage and manure produced.

Energy is used when slurry is pumped from the barn to the outdoor storage facility, when slurry is agitated in the storage facility, and when slurry is loaded and transported for field application. The more slurry there is, the more energy is needed for these processes, resulting in higher energy costs. When pigs waste a lot of water, it increases slurry volume. In other words, you're basically paying to get clean water moved out of your barn to the field. Reducing water wastage from drinkers is, therefore, a good way to reduce both the water bill and the energy bill.

Bowl drinkers can reduce the amount of water wasted by 10-15%

Pigs water consumption is roughly 2-3 times feed intake. Water consumption is dependent on many factors, including body weight, physiological status and feed intake of the pigs, location, type, angle and water flow/pressure of the drinkers, and climate in the barn. For example, a rise of 1°C above 20°C results in a sow drinking 0.2L more water per day. Pig feed intake is determined by the amount of water they drink, not the other way around, meaning that restricting water consumption will result in lower feed intake and weight gain, and may lead to urinary tract infections. The implication is that limiting water consumption cannot be used to reduce energy costs but decreasing water wastage can.

Grower-finisher pigs may waste up to 60% of the water from a nipple drinker. Cup or bowl drinkers can reduce the amount of water wasted by 10-15%. However, well-managed nipple drinkers can effectively reduce water wastage. Some general guidelines on how to manage nipple drinkers can be found in the factsheet "In-barn management to reduce feed costs", which is part of the "Managing feed costs" brochure. You can also visit the PSC website for a water checklist.

Wet/dry feeders address the water wastage concern by incorporating a nipple drinker in the feed bowl, reducing water use by 30% and slurry volume by 20-40%. However, it is recommended to also provide a separate drinker elsewhere in the pen to increase water consumption and feed intake. In other words, there is a balance between encouraging pigs to drink as much as they need to maximize feed intake and efforts to reduce water wastage to reduce manure volume.

"Reducing water wastage from drinkers is a good way to reduce your water and energy cost"

Another way to reduce the amount of slurry is by reducing the amount of manure produced by pigs. Pigs produce roughly 7.5L of manure per day. The best way to reduce this amount is by feeding diets that improve feed efficiency. A 7% improvement in feed utilization efficiency will translate into a 5% reduction in the weight or volume of manure excreted. One way of improving feed efficiency is by feeding pellets instead of mash, although this process uses energy and increases feed cost. For more information about feed processing, read our factsheet "Reducing feed costs through diet processing", which is part of the "Managing feed costs" brochure. Certain feed enzymes can also improve feed efficiency, and formulating diets based on the standardized ileal digestible amino acid content rather than total amino acid content ensures that diets better meet the nutritional needs of the pig. However, feed costs are higher than energy costs related to manure management and as such, diets should be formulated to minimize feed costs and maximize income over feed cost, which sometimes goes against efforts to reduce manure volume. For example, feeding alternative ingredients with a higher fibre content will often lead to better income over feed cost but will increase the amount of manure produced. More information on diet formulation is available in the factsheet "Diet formulation in a high feed cost environment", which is part of the "Managing feed costs" brochure. Due to these opposing priorities, the best way to reduce manure volume is by reducing water wastage by pigs from drinkers.

Well-managed nipple drinkers can effectively reduce water wastage

Wet/dry feeders effectively reduce water use by 30% and slurry volume by 20-40%

What's the cost?

As part of an on-farm demonstration project, we measured flow rate of nipple drinkers on 24 farms across Canada. A large percentage of nipple drinkers (40.7% in gestation, 45.9% in farrowing, 27.9% in nursery and 65.2% in grower-finisher) had flow rates considered high or very high, exceeding the target rate of 0.5-1.5 L/min for nursery and grower-finisher. This resulted in approximately a 60% increase in water wastage.

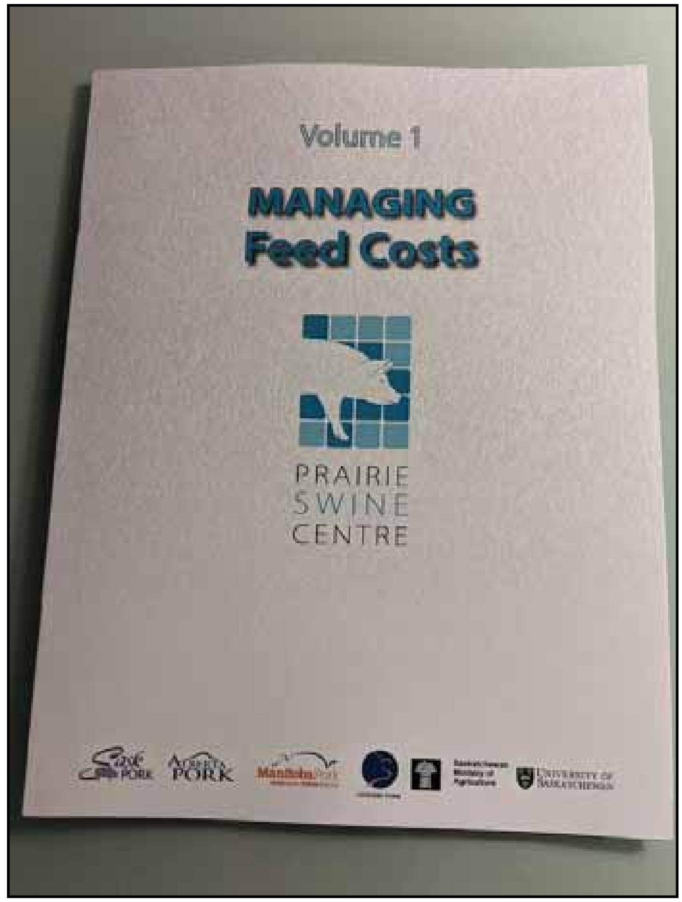
An average daily water disappearance on a 600-sow farrow-to-finish operation should be around 44,482 L/day based on the water requirements of pigs at different ages. Based on survey data, daily water disappearance would be 72,512 L, resulting in an additional 28,030 L of water wastage every day, or 2,250,539 L per year. If we assume a disposal cost of $0.068/L ($0.015/gallon) of manure, water wastage results in an additional cost of **$33,758/year** or **$2.25/hog** marketed for manure application. Additional costs associated with water pumping, manure transfer and water utilities should be included if applicable to your production.

Check out our other publications that can help your operation improve its operating position

The **MANAGING FEED COSTS** publications examines how you can effectively look at your feeding program. Topics include:

- In-barn management to reduce feed costs
- Reducing feed costs through diet processing
- Diet formulation when feed costs are high
- Measuring success when feed costs are high

Scan the QR code to access Managing Feed Costs on the Prairie Swine Centre website:



TAKE TIME TO DO MAINTENANCE

A well-designed maintenance program helps the building operate more efficiently and improve pig performance and comfort. A proactive maintenance program reduces the number of costly breakdowns that affect operational efficiency. Performing routine checks and maintenance of essential components throughout the barn can save a lot of headache and dollars in the end.

Attic, roof, and walls

Ensuring the structural integrity of the attic and roof is essential.

- Check trusses in the attic regularly, ensuring they are in good condition.
- Ensure there is no corrosion on brackets, truss plates, pins and rafters.
- Paint lightly rusted truss plates with a zinc-based spray paint and make sure they are tight.
- As the barn ages, an engineer should be brought in to evaluate the roof's integrity.
- Use light-colored rather than black steel on the roof and/or use a light-colored ceramic paint on the roof to reduce spikes in attic temperature on warm, sunny days.

Ensure there is no corrosion on brackets, truss plates, pins and rafters

Insulation

Pest management is important to maintain building integrity as birds and rodents can destroy the insulation within the walls and ceiling. Insulation is important in reducing winter heat losses and reducing radiant heat gains in hot weather. Good insulation also eliminates condensation, which improves the building life span. It is important to check the insulation and repair any holes in it as soon as possible. Make sure to seal all structural joints, holes from conduits and pipes, and the door trim and bottom sweep with a GE silicone or equivalent.

Feed system

The feed system is one of the most important components to regularly check and maintain. The main components are the bin boot, the auger / auger motor, switches, and feed line. Basic maintenance of the feed system includes regularly greasing boot bearings, checking oil level in the gearbox and changing it if necessary, and checking for overall wear and tear. Auger motors require monthly lubrication. One of the biggest mistakes with feed systems is overfilling it, causing system components to stretch, wear out and break down more often. Proper use of proxy and delay systems will avoid having the feed system always full.

The feed bin boot and auger with motor are important components of the feed system that need regular maintenance

Heating system

It is important to check components of the heating system after each room turn in addition to seasonally. For the heater furnace, open the main shut-off valve in Fall and close it in Spring - lighting the pilot light in Fall and turning it off in Spring. Inspect and clean heaters, checking wire connections between each room turn, including in the summer. When heaters are not in use, they can corrode and may not work when you need them in the Fall, this is one reason for running and checking heaters every three months, including in summertime.

Use a leaf blower to blow dust out of the heaters after each room turn. This avoids problems when starting the furnace in the fall.

Check controllers for the appropriate set-point temperatures, in addition to cleaning and calibrating thermometers and humidity sensors against a standard. Calibrate thermostats a minimum of two times a year. Controllers will not perform effectively if dust accumulates on the sensing elements, as the dust acts as an insulator and delays response. You can use compressed air or a cloth to clean thermostats or controllers. Large temperature fluctuations often point to dirty or worn-out controllers.

Gas leaks can be a major cause of increased energy costs. The most common point of leakage is where the line enters the barn, due to corrosion caused by the wide temperature differences. Make sure to do a high-pressure test of your gas lines once a year. Generally, your propane supplier can do this test at no charge.

You can use compressed air or a cloth to clean thermostats and controllers

Drinkers and pens

After cleaning pens, be sure to scrape up as much excess water as possible. Maintain leaking drinkers by cleaning or replacing valves, nozzles, jets, and hardware. A wet environment is detrimental to animal health and barn structure. Increasing ventilation rate will ensure a good moisture balance but increases the heating cost, resulting from the heat lost by increased ventilation. Energy to evaporate the water will be robbed from heat that otherwise would be used to keep the air space warm.

Ventilation system

A properly maintained ventilation system reduces energy loss, requiring maintenance and adjustment after each room turn and seasonally.

- For fans, check the direction of airflow or fan rotation, look for damage to the motor, housing or blades, and grease bearings.
- In addition, clean dust from blades through manual scrubbing or compressed air, otherwise dust on blades can lead to imbalance and vibration reducing the life of the motor. Clean shutters, louvers, and discharge cones with a wire brush or power washing. Dirty fans reduce airflow; causing higher stage fans to run earlier and use more electricity - in fact - dirty fans can reduce ventilation efficiency by up to 30%.
- Do not shut off minimum-stage fans between batches of pigs, even when there are no pigs in the room.
- In winter, install fan covers on fans not in use. Correct timing for the use of fan covers will depend on outside temperature. In the Spring and Fall, when large temperature swings occur, fan covers may need to be put on and taken off several times.
- Make sure inlets are adjusted and calibrated correctly. Check for seals to the ceiling or wall and inspect the system twice a year. Check to ensure attic inlets are functioning properly, not blocked with dirt or frozen shut. All inlets in use should open and close uniformly; check to see if actuators are functioning properly.
- Air leaks will reduce the efficiency of the ventilation system and can reduce inlet air intake. Check for and seal any air leaks through doors and external openings, fan housing and feeder or auger lines.
- Ensure dirt or ice is not plugging soffits and eaves, cleaning them if necessary. Adjust them according to the season, open in the summer and closed in the winter.
- For curtain-sided farms, put insulation into the curtains in the Fall and take it out in the Spring, exact timing is based on the weather forecast.

What's the cost?

Let’s consider a variable speed 12” (300mm) fan operating at minimum ventilation rate in a 200 head grow-finish room. The fan has an airflow rate of 402L/s and requires 0.105 kW input power. Assume a minimum ventilation rate over a three-month period of 1.5L/sec/pig and an electricity cost of $0.15/kWh. This fan runs 24 hours per day.

- The fan will cost $25.38 to operate for the three-month period.
- If the fan blade and shutters are dirty, airflow can be restricted 30% as stated above.
- The fan will now cost $36.32 to operate for the three-month period.
- This represents an approximate 43% increase in electricity costs over the three-month period.
- Remember that this example utilizes minimum ventilation rates. As ventilation requirements increase, the cost associated will also increase dramatically due to the effect of restrictions or drag on the exhaust fan.

ALTERNATIVE ENERGY AND HEATING SOURCES

Lighting, controllers, and fans are the largest draws for electricity in production facilities. Most barns get their electricity from the grid, which means they are dependent on the rates set by electricity providers; however, there are opportunities to use solar power, wind turbines, biomass, or methane digesters/biogas to provide power to the farm. These systems provide an opportunity to stabilize energy costs, minimize fossil fuel use, and reduce greenhouse gas emissions. These practices allow producers the potential to become carbon neutral, and even carbon negative, by providing renewable energy back to power grids.

Solar Power

Solar panels, also called solar photovoltaic (PV) systems, are the most common way to produce on-farm renewable energy, by converting light into electricity. Solar power is becoming increasingly accessible and affordable, with most solar installations lasting at least 25 years and a payback of 10 to 15 years.

The most common installations include roof or ground mounted. The orientation and angle of the panels is important to catch the greatest number of sunrays; ground-mounted panels are often more efficient than roof mounted ones due to a less efficient angle present on roof-mounted panels. The steeper angle of the ground-mounted panels is able to collect solar radiation more consistently throughout the year. Manually adjustable tilt racks for solar panels to catch the most sunrays in summer and winter are available for both roof and ground-mounted systems. However, ground-mounted solar panels are easier to access to adjust the angle. Another advantage of the easier access is that it makes snow removal and maintenance easier as well. Having said that, solar panels require very little maintenance. Despite being more efficient, ground-mounted systems cover a lot of potentially valuable land, so a roof-mounted system might be more economical.

Table 10. Advantages and disadvantages of roof and ground mounted solar panels.

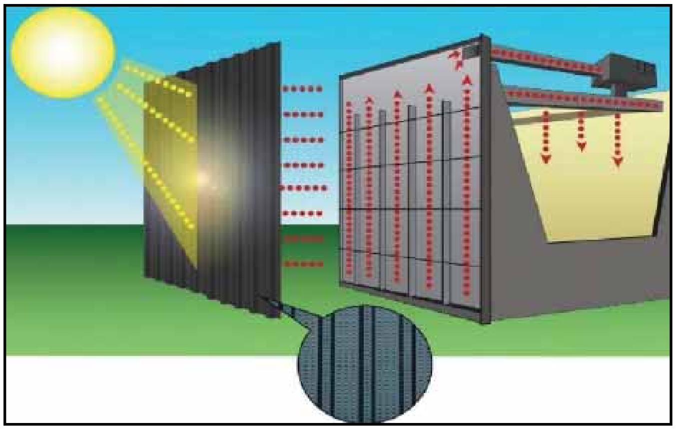
ADVANTAGES	DISADVANTAGES
Ground-Mounted Solar Panels	
• Can be installed to face any direction • Can be installed at multiple angles • Easy access for cleaning, removing snow, and maintenance • Stronger racking overall • System is not confined to the dimensions of the roof • Cooler panel temperatures mean higher energy output • No need to remove panels if roof is replaced	• Less expensive • Requires fewer materials to install (eliminates need to construct new solar foundation) • Installation cost is lower • Utilizes unused space • Easier to get permits • Panels can protect the roof from exposure to certain elements
Roof-Mounted Solar Panels	
• Installation is more labor-intensive • Installation is more expensive • Permitting process is more complex • Takes up space that could be used for other things • Requires upkeep of the land below the panels (such as mowing, weed control, etc.)	• Hard to access – especially if your roof is steep or slippery • Less accessible for cleaning, snow removal, and maintenance • Imperfect orientation and angle • Limited to the space on the roof • Need to install the panels again if the roof needs to be replaced within the panel's lifetime • Putting holes in your roof could lead to water damage • Higher panel temperatures mean lower panel output

Most solar installations tie into the utility grid, allowing the owner to sell excess electricity back during times of high production. In addition, at times of low or no solar electricity production, the utility grid provides access to backup power. Consult with your electric power supplier whether they have a net metering system in place, meaning the energy produced by your solar panels that you don't use is credited back to you. When you need to use electricity from the grid, it counts against the credits you've banked over time. As a solar customer, you will only be billed for your "net" energy usage. Some net metering systems use different prices for power produced and power consumed.

Benefits of an off-grid system include being self-sufficient; however, they require solar batteries to store electricity, which makes the system more expensive than one connected to the grid.

Example of a barn with a transpired solar collector, also called a solar wall

A simpler and much cheaper way to use the sun's power is by using a transpired solar collector, also called a solar wall. A solar wall converts the sun's energy into heat, through a typically dark-colored wall made entirely of metal sheeting with thousands of micro-perforations (tiny holes) in the surface. This wall is mounted to the building's structural wall, creating a 4-to-6-inch gap between the two, generally covering the south, west or east side of a barn. The solar wall sits over winter air intakes; air heated up on the surface of the dark wall is drawn through the micro-perforations by ventilation fans, increasing air temperature by as much as 22°C. The heated air flows to the top of the wall and is then distributed to the barn's interior through conventional ductwork. Solar walls can reduce heating cost up to 30% by using the sun's energy to heat incoming ventilation air, while improving indoor air quality and decreasing humidity. Systems have an estimated life span of 30 years, and a payback period of 3 to 12 years; payback is dependant on climate and type of fuel displaced.



Schematic showing how a solar wall uses the sun to warm up incoming ventilation air

SOLAR WALLS

- The solar wall has no moving parts and requires no maintenance.
- Converts as much as 80% of available solar radiation to heat.
- Ideal for use in sunny climates with long heating seasons.
- Less need to run heaters thanks to incoming air being pre-heated.
- Preheated ventilation air reduces draft potential.
- Warmed inlet air won't drop as rapidly as cold inlet air from a conventional system, thereby improving airflow in the room.
- Ventilation rates can be increased when solar walls are used to improve air quality without an increase in heating energy costs.

Close-up of a solar wall

Geothermal systems

A geothermal system utilizes the constant temperature of the ground to provide heating and cooling to buildings. The geothermal system, or alternatively known as ground source heating system is composed of a heat pump and a series of connected polyethylene pipes buried in trenches (vertical or horizontal) in the ground outside the barn, forming a closed loop. The buried pipes contain a solution that absorbs or deposits heat from the ground, depending on whether the outside air is colder or warmer than the soil. When air temperatures are colder than the ground, a geothermal heat pump removes heat from the collector's fluids, concentrates it, and transfers it to the building. When air temperatures are warmer than the ground, the heat pump removes heat from the building and deposits it underground. Conventional ductwork distributes heated or cooled air from the geothermal heat pump throughout the building. Heat pumps are usually electric powered, providing three to four units of heating energy for every one it uses for operation. This gives a geothermal system up to 400% efficiency rating on average. Geothermal systems have a high initial cost, but the underground loop systems last up to 50 years.

Geothermal heat pump installed in a grow-finish room at the Prairie Swine Centre

Work at Prairie Swine Centre

Prairie Swine Centre installed a geothermal system with a heat pump to examine the impact on cost and environment (heating/cooling) in one finishing room. The system consisted of 550 m of 1.9-centimetre diameter polyethylene pipes buried 2.6 - 3 m deep in trenches outside the barn, containing 20% methanol - 80% water solution. A 5-ton heat pump, using R-410a refrigerant, was installed in the geothermal room and its air-handling unit was connected to the room's air recirculation duct. A 22-kW forced convection heater served as a back-up heater in the room.

The project compared energy consumption (for heating and ventilation) in this room to a standard grow-finish room with a conventional gas-fired heater. Results showed the room with the geothermal system consumed about 45% less total energy for heating and ventilation during the cold season compared to the conventional room. The mean air temperature, relative humidity, and air quality within the two rooms were relatively similar during winter season. During the summer season, the use of the geothermal system to cool the room resulted in larger energy use compared to the control room, mainly for the operation of the heat pump. Levels of greenhouse gases (methane and carbon dioxide) were significantly lower in the geothermal room than in the room with the conventional gas-fired heater during both heating and cooling periods.

Building of a trench with a horizontal loop of polyethylene pipes as part of the Prairie Swine Centre geothermal system

Biomass

Another fuel source to consider is biomass. Biomass is organic material from plants or animals used as a fuel source to produce electricity or heat. Plant sources of biomass include wood and crop residues. Wood pellets have increased tremendously in popularity as a heating fuel during recent years, with many homeowners and commercial facilities choosing pellet stoves or boilers over traditional wood-fired equipment due to their relative ease of use. Wood pellets typically consist of sawdust, wood chips or shavings.

Wood pellets

An animal source of biomass that is abundantly available on hog farms is manure. Using a methane digester, methane from pig manure can be harnessed and used for power in the form of biogas. A methane digester is like a slurry lagoon, but it is fully covered, and it contains bacteria that digest the solids in the manure through anaerobic digestion to methane and carbon dioxide. This gas mixture is then captured and processed to convert it into pipeline quality gas. Unfortunately, methane digesters work better in warmer temperatures (35°C is ideal), meaning in Canada digesters would need to be heated in the winter to work properly, thereby using up a portion of the energy it produces. As such, methane digesters have limited applicability in Canada.

Funding opportunities

In 2022, Natural Resource Canada launched a $300 million funding opportunity that supports the deployment of clean energies in Indigenous, rural and remote communities. The funding will support communities launching clean heat and power projects, such as biomass, wind, solar, geothermal, and hydro. The funding also supports increased adoption of energy efficiency measures and is available until 2027. More information can be found by scanning the QR code:

The federal government also has other programs in place to fund sustainable farming practices. For an overview, go to https://agriculture.canada.ca/en/programs.

Each province has funding available through the Sustainable Canadian Agricultural Partnership (Sustainable CAP) program, a federal-provincial-territorial program to help producers implement projects that will support the sustainable growth of the agriculture and agri-food sector. To find more information, google 'Sustainable CAP' and the name of the province you are interested in to find province specific information.

Sustainable Canadian Agricultural Partnership

The Sustainable CAP program is a federal-provincial-territorial funding program

RECOMMENDED FLOW RATE & HEIGHT OF NIPPLE DRINKERS

Phase	Weight (kgs)	Intake (L/day)	Nipple Drinkers		
			Flow (L/min)	Height (45^0)	Height (90^0)
Gestation		Variable	0.5 to 1.0	90cm / 35in	75 cm / 30in
Lactation		12-20	1.0 to 2.0	90cm / 35in	75cm / 30in
Piglets		Variable	0.5 to 0.7	15cm / 6in	10cm / 4in
Nursery	5	1.0 - 2.0	0.5 to 1.0	30 cm / 12in	25cm / 10in
	7	1.5 - 2.5	0.5 to 1.0	35cm / 14in	30cm / 12in
	15	2.5 - 3.5	0.5 to 1.0	45cm / 18in	35cm / 14in
	20	3.0 - 4.0	0.5 to 1.0	50cm / 20in	40cm / 16in
Finishing	25	3.0 - 4.0	0.5 to 1.0	55cm / 22in	45cm / 18in
	50	5.0 - 7.0	0.5 to 1.0	65cm / 26in	55cm / 2in
	75	5.0 - 7.0	0.5 to 1.0	75cm / 30in	65cm / 26in
	>100	5.0 - 7.0	0.5 to 1.0	80 cm / 32in	70 cm / 28in

TIPS FOR SAVING WATER

- Nipple drinkers mounted at 90^0, nipples should be set at **SHOULDER HEIGHT** based on the height of the smallest pig in the pen.
- Nipple drinkers mounted downwards at 45^0, nipples should be set at 5cm or 2 inches **ABOVE** the back of the pig, based on the height of the smallest pig in the pen.
- Check flow rates. Flow rates determine the time spent at the nipple, water intake and water wastage.
- Repair or replace leaky drinkers and water lines.
- Individual water wastage increases with nipple flow rate.

HEATING AND VENTILATION SYSTEM MONITORING AND MAINTENANCE CHECKLIST

Name of person responsible: ______________________________

Name of barn: ______________________________

				Winter (before Nov 15)	Summer (before June 1)	Action required (if any)	Date required action completed	Completed by:
Heating	Heater furnace	Cleaned:		Yes / No	Yes / No			
		Main shut-off valve:	Opened	Yes / No				
			Shut off		Yes / No			
		Variable output valve: (if equipped)	Set to low	Yes / No				
			Set to high	Yes / No				
		Pilot light:	Lighted	Yes / No				
			Shut off		Yes / No			
	Controller	Checked:	Temperature set-points	Yes / No	Yes / No			
			Settings of fan stages	Yes / No	Yes / No			
			Varaible-speed fan bandwidth (not less tan 1°C)	Yes / No	Yes / No			
			Heater offset (1-1.5°C below room setpoint)	Yes / No				
	Sensors (temperature, humidity if equipped)	Cleaned:		Yes / No	Yes / No			
		Calibrated:	(against standard)	Yes / No	Yes / No			
Ventilation	Fans	Cleaned:	Blades	Yes / No	Yes / No			
			Shutters	Yes / No	Yes / No			
			Discharge cones	Yes / No	Yes / No			
		Checked:	Fan rotation (direction of air flow)	Yes / No	Yes / No			
			Belt tension	Yes / No	Yes / No			
			Motors, housing, blades (i.e. damages)	Yes / No	Yes / No			
			Electricial wires, plugs/sockets	Yes / No	Yes / No			
	Inlets	Cleaned:	Not blocked with dirt or frozen shut	Yes / No	Yes / No			
		Checked:	Uniform opening/closing of all inlets	Yes / No	Yes / No			
			Opening size range at least 4 inches	Yes / No	Yes / No			
			Actuators functioning properly	Yes / No	Yes / No			
	Air intake (soffits/eaves screen/sidewall)	Cleaned:	Not blocked with dirt of ice build-up	Yes / No	Yes / No			
		Checked:	Proper slot opening size	Yes / No	Yes / No			
	Air leaks	Checked and sealed (if any)	Door and external openings	Yes / No				
			Fan housing	Yes / No				
			Feeder/auger lines	Yes / No				
		Fan covers:	Installed	Yes / No				
			Removed		Yes / No			
	Insulation	Checked:	Attic	Yes / No	Yes / No			
			Hot water tank/pipes	Yes / No	Yes / No			
			Walls	Yes / No	Yes / No			
Emergency and alarm system		Checked:	Back-up power operation	Yes / No	Yes / No			
			Emergency thermostat settings	Yes / No	Yes / No			
			Alarm functions	Yes / No	Yes / No			

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