Evaluating Energy Usage and Various Energy Conservation Strategies for Swine Barns

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SUMMARY

Energy usage in swine barns and potential energy conservation measures were evaluated in this study. A survey of 28 swine facilities showed large variability in energy used per hog produced. Energy audits conducted in four selected barns identified the various areas, equipment, and practices in the barn that contributed significantly to the total overall energy consumption, thereby aiding in prioritizing areas for intervention. Using computer simulation, various potential strategies that can be applied in a barn in terms of lighting, creep and space heating, fans, feed motor, and heat recovery were examined. Simulation results for a typical 600-sow operation showed that potential annual savings up to 47,391 kWh electricity (79 kWh/sow) or 88,404 m3 natural gas (147 m3/sow) can be attained.

INTRODUCTION

Swine production in temperate regions like Canada requires substantial energy input. With the recent upward trends in energy prices, the cost of energy input to swine operations have been steadily rising such that for many operations, utilities now represent the third largest variable cost component of the total cost of production. The goal of this work is to assess the current energy usage and examine energy conservation measures that can improve the energy use efficiency in swine production operations, thereby reducing overall energy costs.

EXPERIMENTAL PROCEDURES

A survey questionnaire was developed and sent out to various swine producers to collect pertinent data from each operation over the past 3-year period to be able to calculate the average monthly utility cost per animal marketed ($/pig marketed) for each operation.

Based on the survey results, two barns which used the most energy per hog produced and two which used the least energy were selected for energy audits and monitoring of actual energy consumption during winter and summer seasons.

Following the barn monitoring, a mathematical model which simulated the energy use in a typical barn operation was developed based on fundamental principles of heat transfer, thermodynamics, and other engineering concepts. The model was applied to a typical 600-sow operation to simulate the theoretical energy consumption in the barn based on the building properties, climatic factors, barn management and practices, number and growth stage of animals, and equipment used in the barn. The baseline model was validated by comparing the predicted energy consumption in different operations within the barn with actual values obtained from barn monitoring. Finally, a number of potential energy conservation strategies were incorporated into the model and the projected energy savings resulting from each measure were calculated.

RESULTS AND DISCUSSION

Benchmarking results

Table 1 shows the range and average values of utility cost per animal marketed ($/head) based on the three-year information obtained from the survey. The average utility cost between types of barns were significantly different ($P<0.05$) for all comparisons except between grow-finish and farrow-wean barns ($P>0.05$). The survey results also showed almost 4x difference in energy consumption (per head) between the lowest and highest energy user barns. This indicated significant opportunities for improving energy use practices in some barns in order to reduce overall energy costs.

Monitoring of energy use in the four selected barns showed that the grow-finish rooms had the highest contribution to electrical energy consumption in the barn during summer months followed by farrowing, nursery, and gestation. The high energy consumption in the grow-finish area can be explained partly by the relatively larger footprint of this part of the barn compared to the other production stages in a typical farrow-to-finish operation and to the lower temperature set-point in grow-finish rooms (which meant all fan stages were operating almost continuously at full capacity during warm months). During winter, the highest natural/propane gas consumption was observed in nursery rooms followed by the grow-finish and farrowing rooms. This can be attributed to the high temperature set-point in nursery rooms relative to other production rooms. The gestation room had the lowest gas energy consumption because the heat generated by the sows was adequate to maintain the room at its set-point temperature.

Table 1. Results of benchmark survey of utility cost per animal marketed in different types of barns.

Type of barns	Size range	No. of barns, n	Utility cost per animal marketed			
			$/head pig sold		$/100-kg pig sold	
			Range (min – max)	Average (SD)	Range (min – max)	Average (SD)
Farrow-Finish	300 to 1,500 sow	9	3.0 -12.0	6.8 (3.41)	3.5-12.0	6.56 (3.05)
Farrow-Finish (excluding feedmill)	300 to 2,000 sow	7	3.8-13.0	6.5 (2.98)	6.0-11.5	6.75 (2.31)
Grow-Finish	10,000 to 40,000 feeders/weanlings	6	1.3-2.1	1.7 (0.58)	1.2-2.6	1.7 (0.74)
Nursery	130,000 to 140,000 feeders/weanlings	2	0.5-0.7	0.6 (0.12)	1.7-2.2	2.0 (0.41)
Farrow-wean	150 to 1,200 sow	4	0.8-4.3	1.9 (1.64)	8.2-17.8	12.2 (4.67)

Table 2. Average annual energy savings associated with different energy-saving strategies.

Areas	Average energy savings	
	kWh/yr	kWh/yr/sow
1. Lighting (from T12 to T5 fluorescent)	25, 957	43
2. Creep Heating (Heat lamps to Heat pads)	47, 391	79
3. Recirculation fan (High efficiency motor)	9,872	16.4
4. Exhaust fan (High efficiency motor)	42, 501	71
5. Feed motor (High efficiency motor)	1,846	3.1
6. Heat recovery (air-air heat exchanger)	88, 404 m3/yr	147 m3/yr/sow
7. Radiant heater (propane gas-fired)	52, 707 m3/yr	87.8 m3/yr/sow

Ventilation plays an important role in keeping the environment of the pigs at a level where production performance is optimized. The results of this study showed a medium to high negative correlation (i.e. -0.6 to -0.9) between the fan energy consumption and concentrations of NH_3, H_2S and CO_2 gases which are indicators of indoor air quality. This correlation indicated the need for careful consideration of conservation measures to reduce energy cost so as not to compromise the health of workers and animals the barn.

Simulation results

Simulation of the baseline case and the cases in which energy-conservation strategies were applied showed that significant energy savings can be attained in the areas of ventilation and heating as shown in Table 2. Using higher efficiency fans can reduce electrical energy consumption by 21% while the natural/propane gas consumption can be reduced by 70% using a heat recovery system (i.e. air-to-air heat exchanger). Furthermore, replacing conventional space heaters with gas-fired radiant heaters can reduce the gas consumption by 40%. Applying conservation strategies to other areas such as recirculation fans, feed motors, lighting, and creep heaters can reduce energy consumption by 12% and 20%, 26%, and 39%, respectively.

Piglets using heat pads

The Bottom Line

Benchmarking showed that the average utility cost (electricity and gas) per animal marketed is about $6.80/head, but can be as high as $12.0/head for some types of operations. Energy audits identified areas and operations in the barn such as ventilation and space heating in the grow-finish and nursery rooms as significant contributors to the overall energy consumption in the barn. Examination of a number of energy conservation strategies using computer simulation quantified the potential impact of the application of each measure on the overall energy use. Simulation results also identified the most promising measures that would merit further evaluation under actual swine barn conditions. Overall, the findings from this study would aid pork producers in focusing on specific areas and practices in the barn and in prioritizing conservation strategies to be considered for implementation, which would result in the most significant energy savings.

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at the farm. For example, the selection of feeder types, to the level of feed in the pan to maximize intake and reduce waste and the Net Energy value of that feed – all of these developments over the past decade and a half can be traced to a study, a report and countless producer and supplier meetings initiated by Prairie Swine Centre. There is no question the old formula worked to instil a competitive advantage for the Canadian pork producer. But times have changed and the current income crisis within the industry challenges us all first to survive and secondly to predict what the new industry that rises from this period will look like.

The 'future' makes a mockery of our attempt to predict its coming, but we are obliged to try. So this coming year we are on a path to reinvent our company, and its service to our stakeholders. Firstly, by broadening the definition of stakeholders to aggressively seek solutions for the many players within the pork value chain. This is a natural extension of the base of knowledge and expertise PSC personnel have within the barn and extend that up the value chain to include the transportation and packer components and down the chain in the opposite direction to the cereal breeder and genetics supplier for example. What about something more novel? How can we demonstrate a greater value to the broader Canadian population? The pig as a model for human or pet health and nutrition for example is an area where our in-depth knowledge of the pig would allow us to provide greater value to a greater portion of society.

At Prairie Swine Centre we believe in the Canadian pork producer's ability to be internationally competitive and we will do our part to ensure that you have the research expertise needed to sustain your competitive edge in the future.