Comparative Evaluation of the Use of Heat Exchanger, Ground Source Heat Pump and Conventional Heating Systems in Grow-Finish Rooms

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SUMMARY

A heat exchanger and a ground source heating system were fitted to grow-finish rooms in the PSCI Floral barn to evaluate their performance in comparison with a conventional forced-air convection heater. Data from one heating season showed that the use of heat exchanger and ground source heat pump led to 52% and 39% reduction in energy consumption for heating and ventilation, respectively, compared to the conventional heater.

INTRODUCTION

Any measure that can reduce production cost will help improve the profitability of swine production. Energy cost is one component of production cost that can be further reduced by using energy as efficiently as possible, particularly for many barns currently in use that have not been optimized due to minimal cost of energy in the past. Results from our previous work showed that space heating is an area where energy reduction can be achieved (PSC Annual Report 2008, pp. 19-20). This study aimed to evaluate the performance of heat exchanger, ground source heat pump (GSHP), and conventional heating systems in grow-finish rooms in terms of energy consumption, in-barn environment, and animal productivity.


Figure 1. Heat exchanger installed in a grow-finish room.

MATERIALS AND METHODS

Three heating systems: a heat exchanger with a forced-convection heater, a ground source heat pump, and a stand-alone forced-convection heater, were installed in 120-head grow-finish rooms at PSCI barn facility. The rooms had similar building construction, pen configuration and pig capacity. For each grow-finish cycle, a total of 360 pigs were distributed equally to the three rooms. Metering equipment were installed to monitor the electric consumption of the heat pump, heaters, lights, ventilation and recirculation fans, as well as the natural gas consumption of the forced-convection heaters in the heat exchanger and control rooms.

"Animal performance across these systems was similar as expected. However, energy savings of 39% - 52% were realized using non-traditional heating and ventilation systems"

The heat exchanger installed was a 1500-cfm aluminum core heat recovery ventilator (Figure 1), which recovers the heat energy from exhaust air stream by heat transfer to the incoming fresh air stream.

The ground source heating system, alternatively known as geothermal heat pump, geoexchange, earth-coupled or earth-energy system was composed of a heat pump and 1800 ft of 3/4" diameter polyethylene pipes buried in 8.5 to 10 ft deep trenches on the ground beside the PSCI barn (Figure 2). The buried pipes contained 20% methanol - 80% water solution for absorbing heat from the ground for heating and for using the ground as heat sink when cooling is needed.

RESULTS AND DISCUSSION

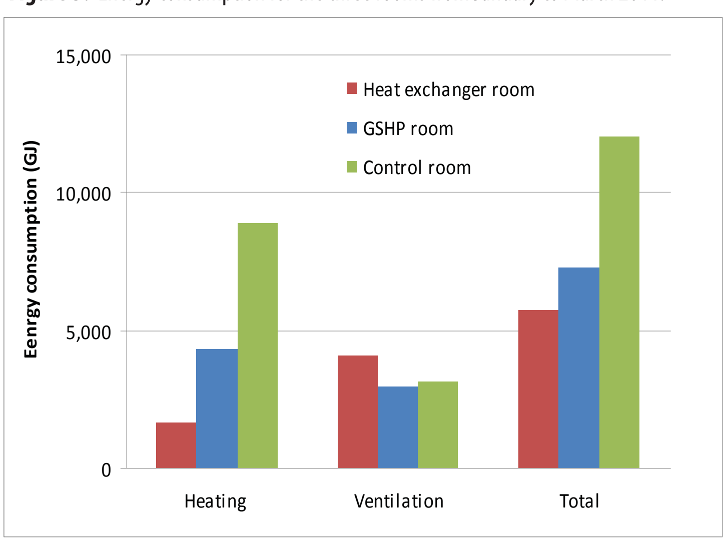
Data collection from two grow-finish cycles was conducted from October to December 2010 and January to March 2011, respectively. The mild weather condition during the first cycle did

Figure 2. (LEFT) Installation of pipes for the ground source heating system installed in a grow-finish room. (RIGHT) in-room heat pump connected to ground source heat system

not necessitate the use of heating. For the second cycle, energy consumption for heating and ventilation of each of the three rooms are presented in Figure 3. The energy consumption for heating included both the electrical and heating fuel consumption of the heat pump and heaters while that for ventilation included the electrical consumption for both ventilation and recirculation fans. The energy consumption data were all converted to gigajoules (GJ) to provide a better comparison of the systems.

Among the three heating systems, the heat exchanger required the least energy for heating but had the highest consumption for ventilation. The heating requirement was reduced as the heat exchanger pre-heated the incoming cold air with heat from the warm exhaust air. In terms of function, the heat exchanger basically replaced the stage 1 fan and because its power rating was higher than that of a regular stage 1 fan, the energy requirement for ventilation for the room was increased. Nevertheless, the use of heat exchanger led to 52% less total energy used for heating and ventilation compared to the conventional room with forced-convection heater.

Figure 3. Energy consumption for the three rooms from January to March 2011.



The GSHP required less energy to extract heat from the ground and heat the room air compared to the conventional heater. The use of the GSHP system led to 39% reduction in total energy needed for heating and ventilation compared to the control room.

Pig performance in all three rooms were relatively similar as shown in Table 1, although feed intake tended to be lower in the rooms with GSHP and heat exchanger compared to the conventional room.

Table 1. Average daily gain (kg/day) and feed intake (kg/day-pig) in the three rooms for the January to March 2011 cycle.

Room	ADG (kg/day)	ADFI (kg/day-pig)
Ground Source Heat Pump	0.99	2.48
Heat Exchanger	0.97	2.37
Control	0.99	2.55

CONCLUSIONS

After one heating season, the use of the heat exchanger and ground source heat pump system resulted in 52% and 39% reduction in energy consumption for heating and ventilation, respectively, relative to the conventional forced-convection heater. However, data collection from multiple heating and cooling seasons is still needed to be able to fully compare the performance and feasibility of these three systems.

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