# Evaluation of Heat Exchanger, Ground Source Heat Pump, and Conventional Heating Systems

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## SUMMARY
As part of the on-going effort to improve profitabiligy, this study aims to reduce the energy use in swine barns by evaluating the performance of various types of heating systems. A heat exchanger and a ground source heating system were installed in grow-finish rooms at Prairie Swine Centre compared with a conventional forced-air convection heater. Data from two heating seasons showed that the use of heat exchanger and ground source heat pump led to 54% and 45% reduction in energy consumption for heating and ventilation, respectively, compared to the conventional heater.


## INTRODUCTION
Energy cost is one component of production cost that can be further reduced by using energy more efficiently or reducing overall energy consumption. Results from 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 a heat recovery ventilator (HRV or heat exchanger), a ground source heat pump (GSHP), and a conventional heating system in grow-finish rooms in terms of energy consumption, in-barn environment, and animal productivity. To achieve a detailed comparison of the various heating systems, the study was conducted over several seasons.

## MATERIALS AND METHODS
To compare their performance, the three heating systems were installed separately in 120-head grow-finish rooms at PSC. 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.

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

*"After two heating seasons, the use of the heat exchanger and ground source heat pump systems resulted to 54% and 45% reduction in energy consumption"*

Figure 2 displays the components of the GSHP system, alternatively known as geothermal heat pump, geoexchange, earth-coupled or earth-energy system, used in the study. It is 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 barn. 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.

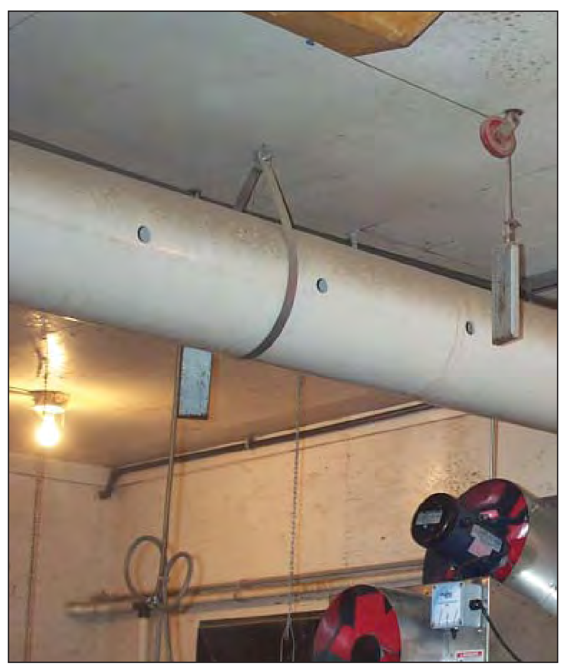

**Figure 1.** Heat exchanger installed in a grow-finish room.

**Figure 2.** Installation of pipes for the ground source heating system installed in a grow-finish room.

## RESULTS AND DISCUSSION

Three grow-finish cycles were completed to evaluate the impact of the various types of heating systems in swine rooms. The first grow finish cycle was conducted from October to December 2010 and the mild weather condition during the trial did not require the use of heating, thus no data for this cycle is presented. Data collection for the second and third cycles were conducted from January to March 2011 and from December 2011 to February 2012, respectively. For clarity, the January to March 2011 data collection is referred to as Trial 1 and the December 2011 to February 2012 data collection is Trial 2.

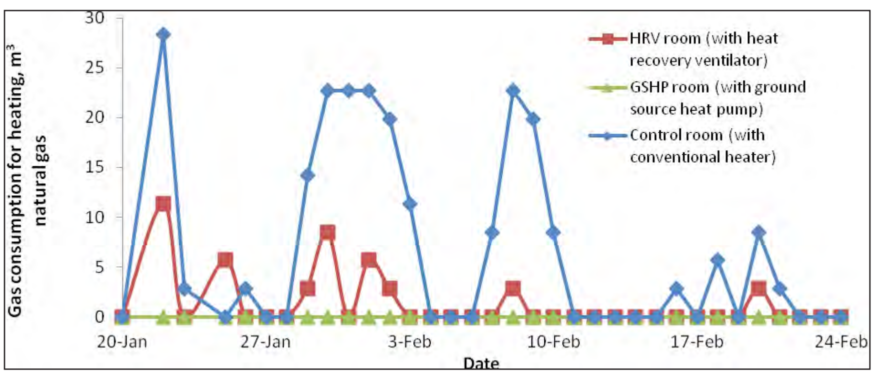


**Figure 3.** Daily natural gas consumption in the three rooms for Trial 1 (January to March 2011)

Daily gas consumption for heating each of the three rooms for the two trials are shown in Figures 3 and 4, respectively. For the duration of the Trial 1, the conventional forced convection heater (control) room consumed a total of 226.71 m3 of natural gas while the HRV room consumed 42.51 m3 of natural gas for heating. The GSHP room did not use any natural gas but it consumed a total of 1206 kWh of electricity (mainly to run the heat pump) to heat the room.

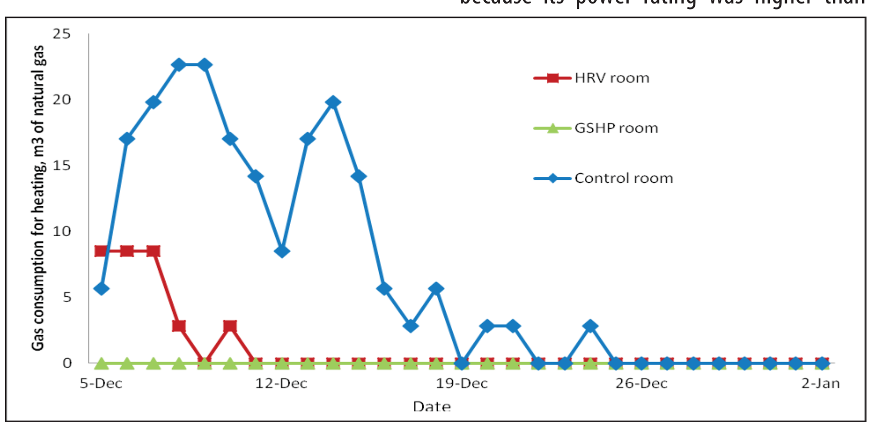


**Figure 4.** Daily natural gas consumption in the three rooms for Trial 2 (December 2011 to February 2012)

For Trial 2, the control room consumed a total of 224.0 m3 of natural gas while the HRV room consumed 31.2 m3 of natural gas for heating. The GSHP room consumed 714 kWh of electricity to heat the room.

To compare the systems better, all energy consumption data were converted to gigajoules (GJ). Energy consumption for heating and ventilation of each of the three rooms for Trials 1 and 2 are presented in Figures 5 and 6. 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.

Data for both trials showed that 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

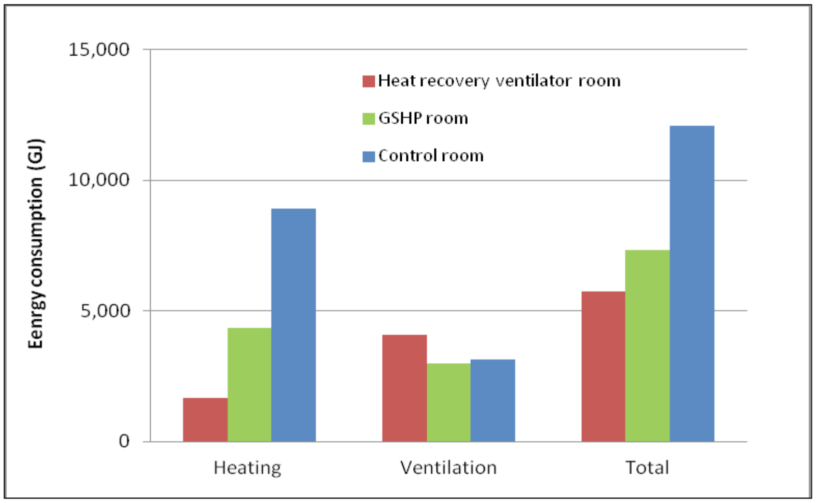


**Figure 5.** Energy consumption for the three rooms in the heating season of January to March 2011 (Trial 1)

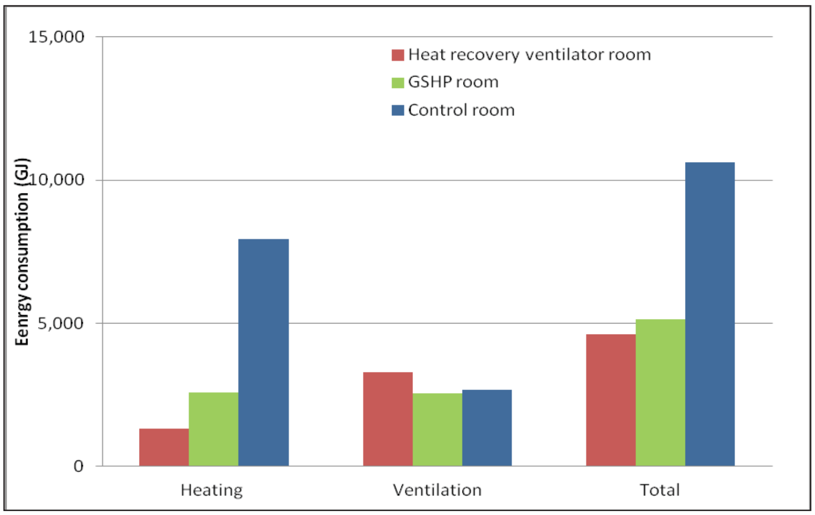


**Figure 6.** Energy consumption for the three rooms in the heating season of December 2011 to February 2012 (Trial 2)

that of a regular stage 1 fan, the energy requirement to ventilate the HRV room was higher compared to the conventional room. Nevertheless, the use of heat exchanger led to 52% less total energy used for heating and ventilation in Trial 1 and 57% less in Trial 2 compared to the conventional room with forced-convection heater.

The GSHP required less energy to extract heat from the ground and to 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 for Trial 1 and 52% reduction in Trial 2 compared to the control room.

When combined over the two heating trials, the HRV room and GSHP room used 54% and 45% less total energy for heating and ventilation, respectively, compared to the conventional room.

The performance of the pigs in terms of average daily gain, feed intake and feed efficiency were quite similar as shown in Table 1. However, the feed intake and feed efficiency values in the rooms with GSHP and heat exchanger are lower than that of the conventional heater room.

## CONCLUSIONS

After two heating seasons, the use of the heat exchanger and ground source heat pump systems resulted to 54% and 45% reduction, respectively, in energy consumption for heating and ventilation relative to the conventional forced-convection heater. Pigs in the three rooms performed similarly in terms of ADG. Pigs in the heat exchanger and ground source heat pump rooms, however, have slightly lower feed intake and more favorable feed efficiency than those in the forced-convection heater room. Additional trials during the summer months are being conducted to assess the cooling effect of the GSHP system and its impact on overall energy use and pig performance.

## ACKNOWLEDGEMENT

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**Table 1.** Average daily gain (kg/day), feed intake (kg/day-pig) and feed efficiency in the three rooms for the two heating trials.

| Room | | ADG (kg/day) | ADFI (kg/day-pig) | Feed Efficiency |
|---|---|---|---|---|
| Trial 1 | Control | 0.99 | 2.55 | 2.58 |
| | HRV | 0.97 | 2.37 | 2.44 |
| | GSHP | 0.99 | 2.48 | 2.51 |
| Trial 2 | Control | 0.98 | 2.52 | 2.57 |
| | HRV | 0.97 | 2.44 | 2.52 |
| | GSHP | 0.98 | 2.42 | 2.47 |