

# Comparative Evaluation Of Infrared Radiant and Forced-air Convection Heating Systems For Hog Barns

A. Alvarado, B.Sc.  
L. Moreno, M.Sc.  
B. Predicala, Ph.D.  
E. Navia, M.Sc.  
L. Dominguez, M.Sc.  
J. Price, M.Sc.



*Bernardo Predicala*

The overall goal of this study was to compare a gas-fired infrared radiant heating system with a conventional forced-air convection heater for supplying supplemental heat to pig production rooms. Forced-convection air heaters that are widely used in commercial barns typically heat the air near the ceiling, and in turn the heated air has to be physically moved, using fans and inlets, to the animal occupied zones. A radiant heater transmits heat to surfaces (i.e. floor, pen wall, animals, etc) through radiation heat transfer, thus facilitating the heating process at the pig's level and at the same time the heated surfaces serve as a thermal reservoir that help maintain the setpoint conditions

in the room. Because of this difference in mode of heat transfer, it is hypothesized that infra-red radiant heating could help reduce heating costs in pig production rooms.

## Experimental approach

The two heating systems (forced-convection vs. radiant heating) were compared for energy efficiency and impact on indoor air quality and hog performance. The comparative evaluation will be conducted over three trials, two of which are already completed. The study will cover the seasonal variation in ambient environmental conditions throughout the year.

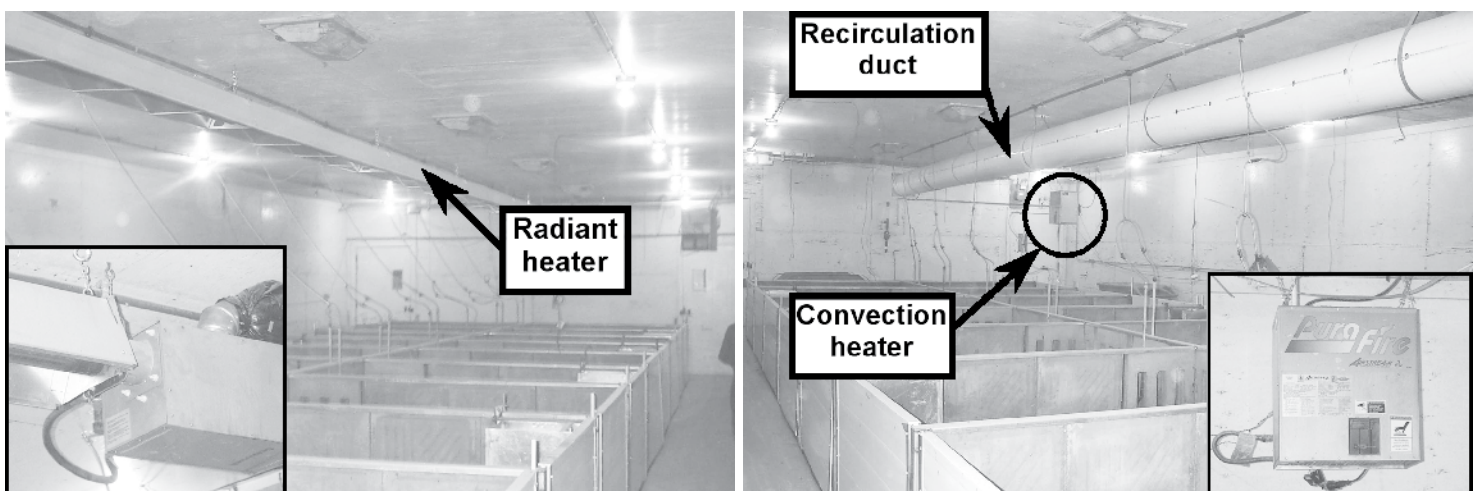
Two grow-finish rooms at PSCI research facility were used; one room had a 80,000 BTU/h forced-air heater (Control) while a 80,000 BTU/h gas-fired infrared radiant heater (Treatment) was installed in the other room (shown in Figure 1). Both heater units were brand new when installed. Each room has inside dimensions of 66 x 24 x 10 ft and has 20 pens that could accommodate 5 pigs per pen, each pig averaging between 25-30 kg starting weight. The rooms were identical in terms of building construction, pen configuration, animal capacity, and care and management.

Various monitoring instruments were set up in each room to assess the performance of the two heater types. A gas meter equipped with a pulser was installed in each room to monitor gas consumption. Energy loggers were also used to record electrical energy consumption of ventilation fans, lights, and heater blower motor. Sensors used to monitor air temperature and relative humidity, ventilation rate and gas concentrations were also deployed in the room. In addition, performance indicators for the pigs were recorded throughout each trial.

## Results from completed trials

### Gas and electrical energy consumption

The first trial was started in late spring in 2008, during which the ambient conditions became warm enough that the infrared radiant heater was needed only for the first 2 weeks while the forced-air heater ran intermittently only for the first 3 weeks. Gas consumption by the radiant heater was slightly higher in the first week but lower in the following 2 weeks than the forced-air heater. Trial 2 was started in early winter and the gas consumption of both heaters is shown in Figure 2. It can be observed that both heaters were barely



**Figure 1.** Photo of the experimental rooms. A: Treatment room with a 50-ft long infrared radiant heater (inset- heater part); B: Conventional production room with a forced-air convection heater (inset).

in operation after Week 7, which was expected since the setpoint room temperature at this stage of growth is lower and the pigs are large enough to generate adequate heat to meet the setpoint. However, for the weeks of the trial when both heaters were operating, the infrared radiant heater consumed 98 m<sup>3</sup> gas more than the forced-air heater.

The average amount of electrical energy consumed (Trial 1 and 2) in both the infrared radiant heater and forced-air heater rooms is shown in Figure 3. Throughout the 12-week test period, electrical consumption was relatively similar in both rooms. However, total electricity use was 205 kWh higher in the Control room than the Treatment room. This could be attributed to the additional electrical energy consumed by the recirculation fan in the Control room. It should be noted that the recirculation fan is part of the heating and ventilation system necessary to distribute heat more uniformly throughout the Control room; no recirculation fan was required for the Treatment room.

#### Indoor air quality

Air quality parameters monitored within each room include air temperature, relative humidity, ventilation rate and gas concentrations. Figure 4 shows the average temperature readings at the different locations within the Control and Treatment rooms during the first 3 weeks of each trial when both heaters were in operation. It can be observed that temperatures near the middle of the room were slightly higher than those at the peripheral locations of the room, especially near the exhaust fan. This slight temperature variation could be due to heat loss through the outside wall where the exhaust fans were installed. A comparison between the first and second trials (Comparative evaluation ... continued on page 11)

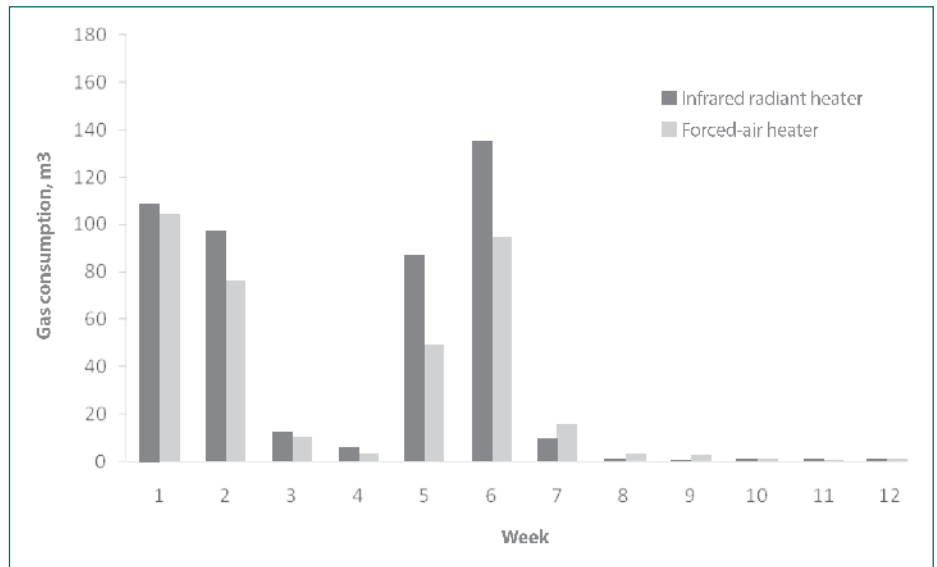


Figure 2. Gas consumption of infrared radiant heater and forced-air convection heater in Trial 2.

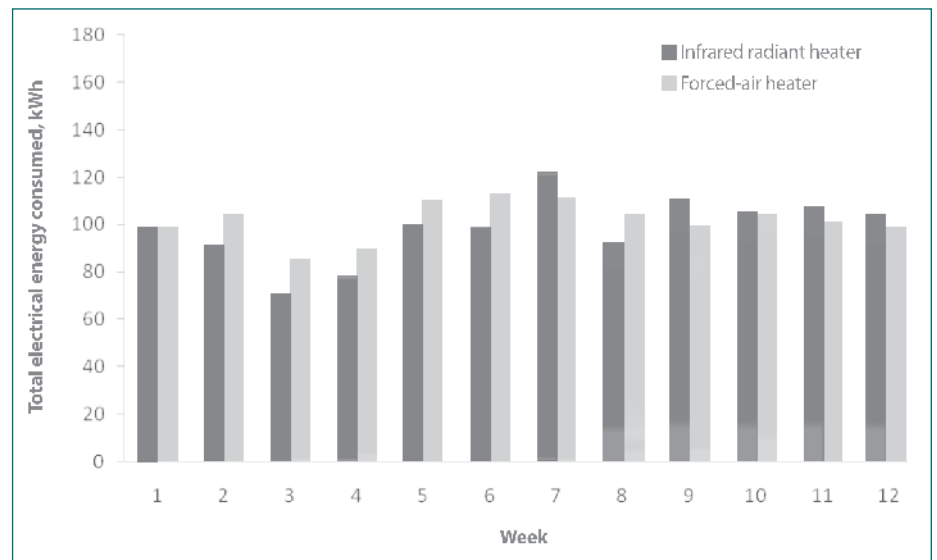


Figure 3. Total electrical energy consumption in the rooms with forced-air convection heater and with infrared radiant heater.

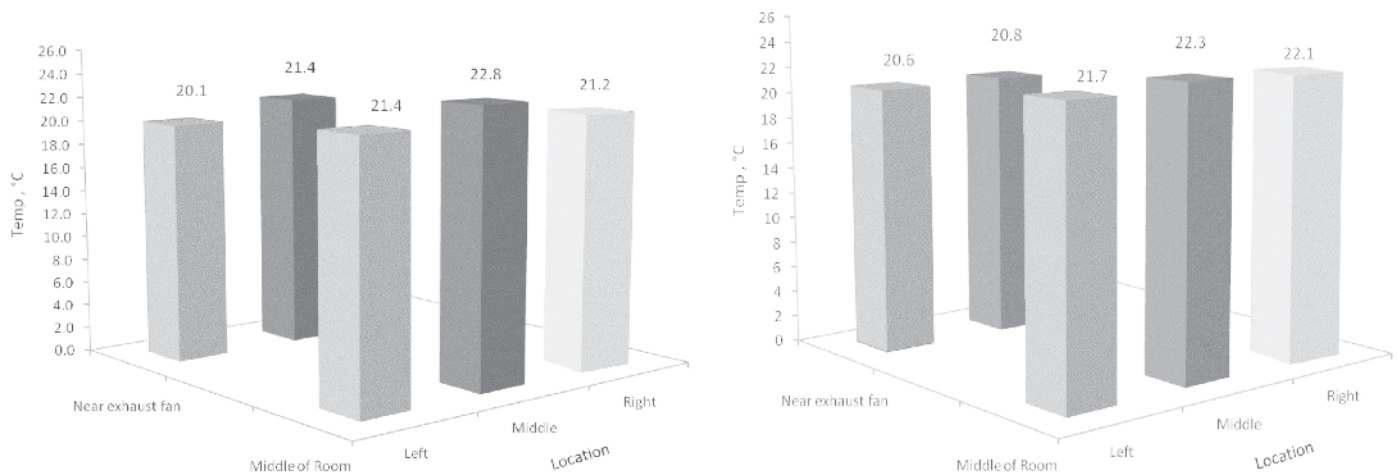


Figure 4. Average temperature distribution within the Treatment (A) and Control (B) rooms during the first 3 weeks of the test period.

“...compared to a grow-finish room with conventional forced-air convection heater, the room with infrared radiant heating system has consumed more gas but used less electrical energy ...”

showed that temperature variation was slightly higher in the second trial; this could be due to the colder ambient temperature since the average ambient temperature during the trial was 19.2 °C colder than during the first trial. Additionally, the setpoint temperatures for both rooms during the first 3 weeks of the test period was 23.7, 22 and 20 °C for the first, second and third week, respectively. The observed range of deviation above and below the setpoint temperature in all the locations in the Treatment room were 0.9 and 1.8 °C respectively, while the corresponding values in the Control room were 0.4 and 1.3 °C, respectively.

The average relative humidity readings recorded in the middle and near the exhaust fan in the forced-air heater room (59%) was slightly higher than those in the radiant heater room (57%). With regard to ventilation, average rates observed in the Control and Treatment rooms were 3269.7 and 3125.0 L/s, respectively during the first trial and 836.7 and 644.8 L/s, respectively in the second trial.

Over the course of the trials, hydrogen sulphide (H<sub>2</sub>S) and carbon monoxide (CO) concentrations in both rooms were usually at levels barely detectable by the sensors with average concentrations of less than 1 ppm for

either gas. However, during pit pulling events, concentrations of H<sub>2</sub>S were observed to spike to considerably high levels with peak concentration of 91 and 97 ppm in the Control and Treatment rooms, respectively. Ammonia and carbon dioxide levels were relatively similar in both rooms with average concentrations below 10 and 2000 ppm, respectively.

#### Pig performance

The average daily gain (ADG), average daily feed intake (ADFI), and mortality rate were monitored during the two trials to evaluate the effect on hog performance. Both ADG and ADFI were found to be relatively similar in both Control and Treatment rooms. Average ADG values from the two trials were 0.95 and 0.94 kg/pig-day, while ADFI values were 2.64 and 2.55 kg/pig-day for the Control and Treatment rooms, respectively. Feed intake of pigs in the Control room was slightly higher than in the Treatment room, hence resulting to a slightly faster growth rate. During the first trial, average mortality rates of 1.8% and 4.0% were recorded in the Control and Treatment rooms, respectively, and zero mortality was recorded in both rooms during the second trial. Based on observations during daily animal health checks, mortalities in both rooms were health related, such as incidence of lameness and infections, and were unlikely to be related to heater performance.

#### The Bottom Line

Observations from the two completed trials so far indicated that compared to a grow-finish room with conventional forced-air convection heater, the room with infrared radiant heating system has consumed more gas but used less electrical energy, had a more uniform temperature distribution within the room, and had no adverse impact on the growth performance of the pigs. These observations will need to be verified after all trials are completed and appropriate statistical tests are conducted.

#### Acknowledgement

Funding provided by Alberta Agriculture and Rural Development, Saskatchewan Agriculture Development Fund, and Advancing Canadian Agriculture and Agrifood Saskatchewan to this project as well as the equipment provided by the cooperating heater manufacturer is acknowledged. Strategic program funding provided by Sask Pork, Alberta Pork, the Manitoba Pork Council and the Saskatchewan Ministry of Agriculture to PSCI is also recognized.



when lying down. Marchant et al., (2001) reported that 89% of lying down events were carried out using either a sloping wall, or a wall fitted with a piglet protection rail.

With the transition towards group sow housing it is important that scientific research is used to design the optimum housing system which can facilitate social interactions and minimize aggression and competition. Future research resulting from this study will focus on methods for encouraging the sows to utilize the free space areas. This will include improving the comfort of the free space area with rubber mats, providing environmental enrichment, or possibly allowing sows access to the free area in different social groups (alternate groups) i.e. gilts and sows.

#### The Bottom Line

Group housing of sows is recognised as an alternative system for improving animal comfort and well-being however, we found that not all sows used the free space areas on a regular basis, or for extended periods of time. It is apparent that the older, heavier sows are utilising the space the most, therefore further research in this area will involve reducing social stress perceived by younger animals, and making the free space area more comfortable.

#### References

- Knowles, T. G. and Broom, D. M., 1990. Limb bone strength and movement in laying hens from different housing systems. *Veterinary Record* 126 354-356.
- Lanyon, L. E. 1984. Functional strain as a determinant for bone remodelling. *Calcified Tissue International* 36 S56-S61.
- Lanyon, L. E. 1987. Functional strain in bone tissue as an objective, and controlling stimulus for adaptive bone remodelling. *Journal of Biomechanics* 20 1083-1093.
- Marchant, J. N., Broom, D. M., Corning, S., 2001. The influence of sow behaviour on piglet mortality due to crushing in an open farrowing system. *Animal Science* 72 19-28.
- Whittemore, C. T., 1994. Causes and consequences of change in the mature size of the domestic pig. *Outlook Agriculture* 23 55-59.

#### Acknowledgements

Strategic program funding was provided by SaskPork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agricultural Development Fund. Specific project funding was provided by the Saskatchewan Department of Agriculture and Food.

In 2008 the new gestation barn was made possible through funding provided by Agriculture and Agri-Food Canada and the Saskatchewan Department of Agriculture and Food. Thank you to Egebjerg International for their equipment contributions. 