

Final Report – Dec 1, 2009

I. **Project Title: Reducing the Environmental Footprint of Swine Buildings.**

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II. **Abstract:**

An advisory group composed of agricultural engineers, animal scientists, economists, and ventilation specialists from several Midwestern universities and private industry met and took a comprehensive approach for developing a swine finishing facility for the Midwest that reduces production inputs, reduces environmental impacts, and increases animal production efficiency. The project's targeted goals were a 50% reduction in fossil fuel energy use and gas (hazardous gases hydrogen sulfide and ammonia plus greenhouse gas (GHG)) emissions from swine finishing barns while increasing animal production. This group met on July 30-31, 2008 in Minnesota and generated a list of critical environmental housing parameters to meet these targets. The list includes building components dealing with manure handling, ventilation/air quality, structural, energy recovery and generation, feed and watering systems, and maintenance and management. A conceptual building design was generated at a later meeting (2009) by a subset of the advisory team.

A pig production and building simulation model from Denmark (Staldvent) was purchased in 2008 to assist in evaluating the performance of the proposed building design(s). The model was adjusted and modified for use in the U.S. and the upper Midwest and was tested earlier this year (2009) using building and pig performance data (primarily from MN) with the assistance of its Danish developer. The comparison between model results and measured data shows that the StaldVent simulation can be successfully used to determine if our proposed finishing barn design will meet the target of 50% reduction in energy usage and gas emissions while improving pig performance.

III. **Introduction:**

This project provides pork producers and key stakeholders in Minnesota, the Upper-Midwest, and even in other pork producing areas in the US, with building design components and management practices that will reduce on-farm energy usage to provide more environmentally friendly production systems for both new and existing facilities. Fossil fuel energy costs, although still a relatively small portion of overall pork production (5 % or less) has increased over the past few years and even though that rate has temporarily slowed, the general consensus is that it will continue to rise. The rising global energy shortage and the international

concern over climate change will force all major US industries, including the pork industry, to increase energy efficiencies and also reduce the environmental impact of production processes. Competition nationally and internationally will pressure pork production systems in Minnesota and the Upper Midwest to utilize smarter and “greener” building designs and management practices that reduces energy (both fossil fuel and feed) use as well as air emissions including hazardous (ammonia and hydrogen sulfide) and greenhouse (carbon dioxide, methane, and nitrous oxide) gases plus odor and particulate matter. The use of greener building designs for producing pork in the upper Midwest will provide a competitive advantage over other sections of the U.S. and more importantly over pork production systems in emerging economies like China and Brazil. The short term benefits for implementing the design concepts and practices generated in this project will be the immediate energy cost savings but long term “greener” building designs may increase market share with retailers and consumer groups.

IV. Objectives:

This project has an overall goal of developing a new pig finishing barn design for Minnesota and the upper Midwest, which reduces energy and environmental impacts while increasing animal production efficiency. Most swine production facilities in the Midwest are built without proper integration of individual components (ventilation and heating/cooling, manure handling, flooring, insulation, feeding, watering, etc). A systematic design will integrate all these components with the goal of providing the optimum conditions for animal production and minimizing energy and air emissions. Many of the lessons learned in the development of such a facility may be transferred to existing facilities resulting in similar energy and emission reductions and production benefits.

The project goals can be condensed to the following two specific objectives:

- Generate a list of building design features or components that have the potential to lower the environmental footprint of swine finishing buildings in Minnesota and the upper Midwest.
- Develop a decision tool, consisting of a regional specific simulation computer model, for quantifying the environmental impact of various building design features generated for the project and potentially for other design components.

V. Procedures:

An advisory group composed of agricultural engineers, animal scientists, economists, and ventilation specialists from both the public sector and private industry met and took a comprehensive look at ways of obtaining the project’s targeted 50% reduction in fossil fuel energy use and gas (hazardous gases like H₂S and NH₃ plus greenhouse gas (GHG)) emissions from swine finishing barns.

The building design parameters developed in the brainstorming session by the advisory group will be evaluated for energy and environmental impact using information drawn from a literature review. A more robust ranking of the building designs and management practices will be developed to carry forward for evaluation by a pig and building simulation computer model (StaldVent).

VI. Results:

The advisory group met on July 30-31, 2008 in Minnesota and generated a list of critical environmental housing parameters to reduce energy usage and the ecological footprint of Minnesota or upper Midwestern pig finishing facilities. The list included building components dealing with manure handling, ventilation/air quality, structural, energy recovery and generation, feed and watering systems, and maintenance and management.

An abbreviated list of building and management ideas generated by advisory group is given below:

Manure Handling:

- Separate housing from manure storage
- Separate feces and urine in building before storage
- Partial vs. fully slatted floor
- Manure treatment options

Ventilation/Air Quality

- Micro climates inside buildings
- Use of smart controllers and sensors
- Customize animal based ventilation rates
- Use of reduced nocturnal ventilation rates
- Single vs. variable speed fans
- Effective heat and air distribution
- Clean and re-use ventilation air
- Passive vs. active cooling systems

Structural

- Pen size and layout
- Building infiltration control
- Ability to retrofit building
- Bldg material characteristics (thermal, recycled, & cleanability)
- Earth banked walls
- Lighting
- Roof color
- Building proportions (more square compared to rectangular)

Energy Recycle, Recovery, Generation

- Feed/Energy balance (food vs. feed energy)
- Other heating sources (geothermal, solar, biogas, etc)
- Seasonal or diurnal heat storage (peak demand management, etc)

Feeding and Watering Systems

- Nipple vs. cup waterers design and management
- Phase feeding-precision
- Larger on-site feed storage
- Pelletizing
- Liquid vs. dry

Management and Miscellaneous

- Nursery/Grow to finish vs. wean to finish production systems
- Between groups barn management
- Solid and open gate/fencing
- Manure depth in pit-relationship to pig flow
- Waterless cleaning? Fumigation
- Alternative co-systems (plant / fish growing adjacent to pig barn)

The following conceptual pig finishing building design (figure 1) was generated by a subset of the advisory team this past fall (2009).

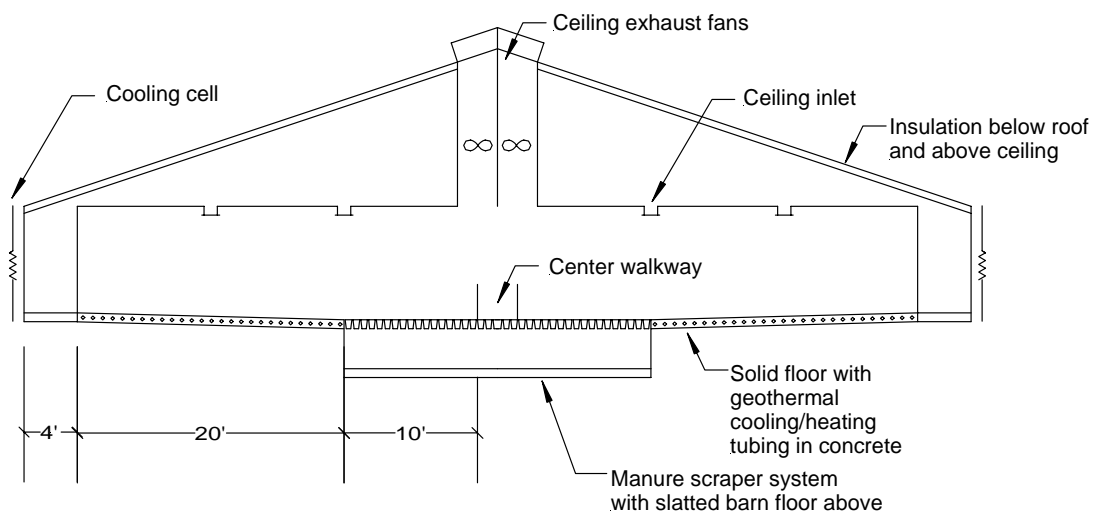


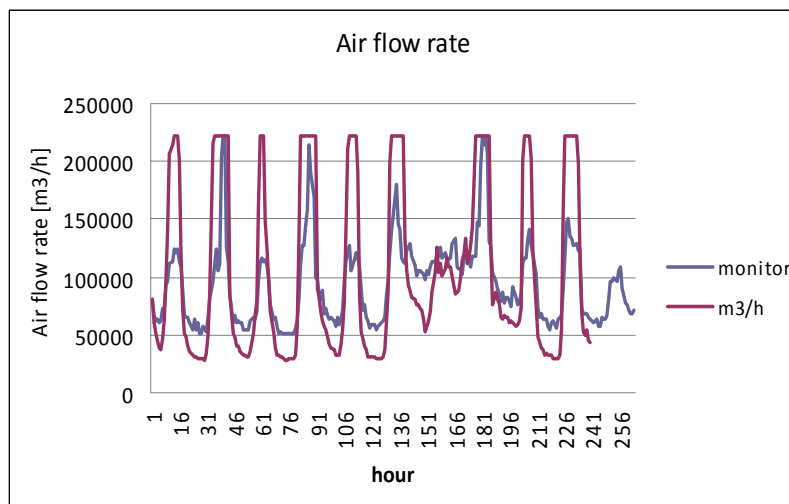
Figure1. Conceptual pig finishing design generated from subset of advisory team

This conceptual design features many of the above building and management ideas generated during the 2008 brainstorming meeting. For instance, this design

separates the animal space from the manure storage (manure is collected by a scraper to an outside manure storage) which will improve indoor air quality and reduce the risk of methane explosions and accidental pig deaths from hazardous gases. The design also includes perimeter hallways that can be cooled in the summer by evaporative cooling pads on both sides of the barn or a geothermal system and heated in the winter with the same geothermal system or a centralized hot water system. These same heating/cooling systems can be used to control the temperature of the solid floor sections in the partially slatted pens by the buried tubing under the concrete floor. The structure is well insulated (both under the roof and on the room's flat ceiling) to prevent condensation and reduce heat loss with several rows of ceiling inlets to provide good air distribution in the pig space. Finally air exchange will be controlled by ceiling mounted exhaust fans discharging air vertically through the roof that minimize wind effects.

Also, approximately 50 research and popular press articles on energy use and emissions from swine buildings have been collected and are under review. This literature includes baseline energy and emission data, key parameters impacting energy use and emissions, and management methods and technologies to reduce energy and emissions.

The pig production and building simulation model from Denmark (Staldvent) was purchased to assist in evaluating the performance of the proposed building design. The model was adjusted and modified for use in the U.S. and the upper Midwest and was tested using building and pig performance data (primarily from MN) with the assistance of its Danish developer and programmer. Results comparing model predictions and measurements (figure 2) from a MN pig finishing barns are shown below for airflow rates and ammonia concentrations



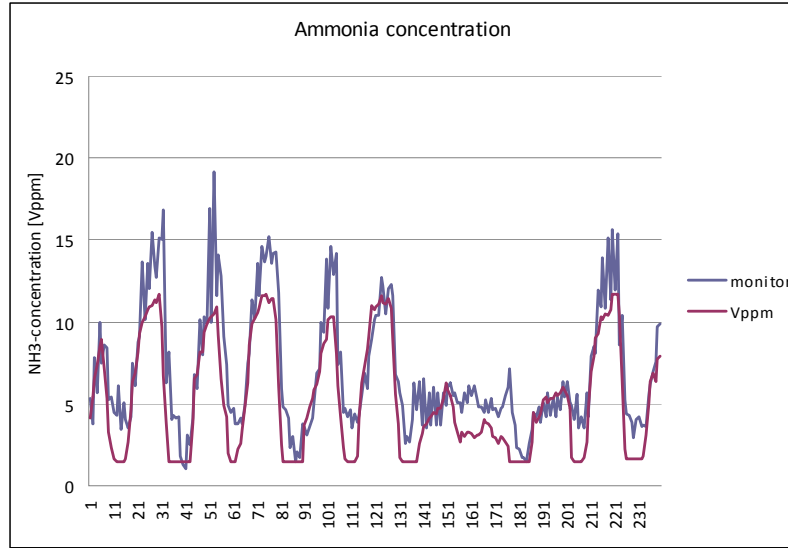


Figure 2. Comparison of StaldVent’s predictions with measurements for airflow rates and ammonia concentrations.

A demonstration of StaldVent’s capabilities is given below in Table 1, which simulates changing the ventilation rates, building insulation levels, and type of space heating. This simulation shows that fossil fuel (heat energy) usage can be reduced by more than 50% when minimum airflow rate is reduced. Also it reveals if supplemental heat is provided by hot water vs. the common direct fired gas heaters considerably less carbon dioxide (CO₂) is also produced.

Table 1. Initial energy modeling of existing finishing barn.

Design	Minimum Ventilation with small pigs. (% of max ventilation)	Minimum ventilation with large pigs. (% of max ventilation)	Heat Energy Annual MWh	Electric Energy Annual MWh	Maximum CO ₂ in room (ppm)
Current facility	8.6	8.6	334	27.6	4168
Option 1.	4.3	8.6	146	27.6	5395
Option 2.	4.3	8.6	146	27.6	3890

Option 1. Reduced minimum ventilation with direct gas combustion heater.

Option 2. Reduced minimum ventilation AND change to water based heating system.

Looking toward the second year of this project, the concept design(s) for a new pig finishing facility will be further developed and revised by the advisory group and will be evaluated by StaldVent. This will be the main objective of the next advisory group meeting (tentatively planned for winter of 2010), which will include two international experts in swine housing. The design(s) will integrate all system components discussed and have the general consensus of the advisory group and verified with StaldVent and the literature review.