ENERGY AND VENTILATION MANAGEMENT ISSUES
IN U.S. PIG BUILDINGS

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ABSTRACT

A recently completed Minnesota / National Pork Board (MPB/NPB) funded project entitled: Reducing the Environmental Footprint of Swine Buildings (Jacobson, et al., 2011), had the requirement to provide retrofit or remodeling guidelines to reduce energy use and the amount of air emissions for pig finishing buildings presently being used in the Midwestern U.S. Barn retrofit concepts reported in this document focus on structural upgrades such as insulation and mechanical items like improved environmental control, fan and heater maintenance and management, along with manure pit management. Also included are more extensive suggestions to improve pig performance through more effective cooling systems since most production losses due to poor housing systems occur during warm ambient conditions.

INTRODUCTION

A large majority (≥ 85%) of the pig finishing buildings presently being used in the Midwestern U.S. to grow pigs are either the curtain sided (CS) or the tunnel ventilated (TV) barn. The CS barn (Figure 1), as the name implies, typically has vinyl curtains on both long sidewalls which are adjusted with a temperature controller to provide ventilation or air exchange in the barn during warm and some cool weather conditions. During cold weather, the sidewall curtains are closed up completely and the barn is mechanically ventilated by pit and possibly one or two end wall fans plus designed ceiling inlets. The typical mechanical ventilation fan capacity for a CS barn is from 20 to 25 cubic feet of air per minute per pig (cfm/pig).

Figure 1
Typical Curtain Sided (CS)
Pig finishing barn.
The TV barn (Figure 2) is mechanically ventilated year around with total fan capacities generally at 120 cfm/pig that is divided between pit fans (~20 cfm/pig) and tunnel or wall fans (~100 cfm/pig). These barns have solid insulated sidewalls and one end that contain the large diameter “tunnel” exhaust fans while the other end has an adjustable vinyl curtain. During the winter the curtain end wall is completely closed and all the air is brought in through designed ceiling inlets that draw air from the barn’s attic (similar to the CS barn). In the summer, the end wall curtain opens as needed by the number of operating tunnel fans at the opposite end of the barn. During warm temperatures most of inlet air comes through the end wall curtain with some entering through the ceiling inlets.

**DISCUSSION**

**Options for Reducing Energy**

Several publications and reports address energy use in swine production. These publications can be found on-line and in many trade journals. The following are the most common practices and considerations found supplemented with additional information developed by our project. Note that most of the ideas presented below relate to the heating and ventilation systems as these systems represent an estimated 70% of energy use in a finishing building (Brodeur, 2008).

**Fan Maintenance**

As has been the focus of many extension publications and producer workshops, proper fan maintenance can have an impact on energy use. Cleaning fans and especially shutters on a routine basis will allow the fans to operate at maximum efficiency. Belt driven fans should be closely monitored for belt slippage.

**Fan Efficiencies**

In general, small fans are less energy efficient (cfm/watt) compared to larger capacity fans (Figure 3). Because of this,
ventilation control systems should limit operation of minimum ventilation fans (smaller fans) during periods of higher ventilation requirements. Also, variable speed fans should be operated at full speed whenever possible as fan efficiencies are highest at full power (when operated at 100%). Frequency drive motors for fans are gaining popularity as they are much more efficient when run at less than 100% capacity.

**Minimum Ventilation**
Make sure minimum ventilation fans are sized to provide the minimum or continuous air exchange rate. Over ventilation during cold weather will increase furnace run-times and fossil fuel use. However, remember that maintaining minimum ventilation is essential for providing a healthy environment for pigs and workers. Small nursery pigs (15 lbs) require a minimum ventilation or air exchange rate of 2 cubic feet of air per minute (cfm/pig) while large finishing pigs (200+ lbs) require approximately 10 cfm/pig.

**Controller Set points**
Temperature setpoints or targets on controllers that regulate barn heaters and ventilation fans can have a dramatic affect on energy use. Optimum temperatures for pigs from 12-30 lbs are between 85-75°F while pigs between 30-75 lbs require temperatures between 75 and 70°F and temperatures between 70 and 55°F for pigs between 75-265 lbs. Often this setpoint temperature control is based on one or two sensory locations in the barn. A check should be made to determine if the environmental control system is indeed providing proper temperatures throughout the barn. A degree or two different temperature setpoints can significantly impact heater run-time and fuel use. Figure 4 shows estimates of fuel use and electrical use with changes in temperature setpoints. Note that decreases in temperature setpoints result in decreased fuel consumption (winter) and increased electrical consumption (summer). Additionally, the controller’s setpoints for heaters, inlets, and ventilation fans should be synchronized properly to produce acceptable static pressure ranges in the barn and prevent “heater overshooting” that causes unnecessary cycling of the heater and excessive fossil fuel use.

![Graph showing fuel use with setpoints](image1)

**Figure 4.** Model predictions for fuel use based on changes in setpoint for a typical 2800 hd, mechanically ventilated swine finishing barn in West Central MN.

**Heaters**
Heaters are often over sized to insure adequate heating capacity to maintain room temperatures during cold weather. However, this over-sizing often results in the overshooting of temperature setpoints and more frequency cycling of the second stage ventilation fans. The temperature when the heater comes on should be at least 2°F below the ventilation setpoint. Radiant heaters
offer an advantage over direct-fired combustion furnaces because they heat surfaces rather than the air. In general, radiant heaters will reduce total barn energy use by as much as 50% since it heats strategic “zones” such as the solid floor for weaned pigs rather than the whole barn.

**Insulation and draft reduction**

Reductions in winter heating can also be achieved by reducing any drafts (undersized air inlets) in the barn from leaky curtains or fan openings. Insulating curtains and summer fan openings with bubble wrap, although requiring some initial investment and seasonal labor will tighten up the barn substantially and result in heat and fossil fuel savings. Barns with poorly insulated sidewalls such as un-insulated concrete and curtains may only have an average R-value of 1. Increasing the R-value to 2, 5 and 10 (as estimated by the Danish StaldVent pig housing/growth model (Morsing, et al., 1997) for central Minnesota) results in fuel savings of 30% and 50%, and 65% respectively. Smaller saving would occur in warmer climates.

**Prevent wind pressure on the fans**

Wind pressures against the exhaust fans result in reduced fan efficiency and over or under ventilation of the building. With a typical barn operating static pressure of 0.1 inches of water, wind speeds of 15 mph would reduce fan output to nearly 0 cfm. These wind pressures result in under-ventilation and more fans running to meet the temperature setpoint requirements. Wind pressures can be reduced with the use of fan baffles (Figure 5) and cones or by having fans exhaust vertically through the ceiling and roof. Also, for tunnel ventilated barns, an east/west vs. north/south layout is more desirable since the east/west orientation has the large tunnel fans facing east rather than south which is the common summer wind direction in the Midwest. Operating at a higher static pressure will also reduce this effect but decreases energy efficiency.

**Guidelines for energy saving plus ventilation management in either CS or TV barns**

The use of “bubble wrap” insulation, as shown in Figure 6, can be helpful to insulate and also seal curtain side or end walls during cold weather operation. This will save conductive heat loss and L.P. Gas usage, plus it will prevent frosting and excessive condensation on the inside curtain surface and tighten up the barn so inlet air will enter the barn through the design inlets rather than undersigned openings around the curtains.

Insulate any concrete knee side or end walls that are not presently insulated. This is best done on the outside with at least 2 inches of rigid board insulation. This will prevent conductive heat loss and thus L.P. Gas usage plus prevent frosting and most condensation on the inside kneewall surface.
Insulate the warm weather exhaust fans with an insulated cover placed over the inside louvers. This will reduce conductive heat loss plus more importantly prevent backdrafting of cold air through the warm weather fan louvers. Also, place a fan “sock” on the outside of any non-continuous running fans that will operate during cold weather to prevent backdrafting of air when these fans are not operating.

Relocate pit exhaust fans to side or end walls to eliminate pit exhaust fans (Figure 7). This will reduce gas and odor emissions while still maintaining indoor air quality as long as similar air exchange or ventilation rates are maintained.

Pump manure from the deep pit twice a year instead of once. This management practice will prevent the manure level in the deep pit from becoming too high (goal is to keep three feet of freeboard below slats) which will reduce air emissions especially if pit fans are used.
Change L.P. Gas heater setting on controller to prevent heater overshoot (temperature in room continues to rise in barn after heater shuts off and triggers first stage ventilation fans to come on). The shut off temperatures for heater should be at least 2°F under the controller “setpoint” temperature. Also, make sure the controller’s temperature sensors are placed well away from heated furnace jet airstream and are sensing a true room temperature. Preventing heater overshoot will save large amounts of L.P. Gas.

Change L.P. Gas heaters setting to low (most direct fired heaters will have a low and high setting) which will also save L.P. Gas usage since very often heaters are oversized in pig finishing barns. Ventilation performance will be improved (less temperature variations) since heaters will run longer but use less L.P. Gas and allow building to respond and prevent “heater overshoot”. Typically heaters only need to be switched to the high setting when there are only young pigs in barn (wean to finish) or after power washing.

When selecting fans for the minimum or continuous ventilation rates in the winter, select the fewest number of exhaust fans possible and if possible only use single speed fans that can be manually operating (hot-wired or not part of controller). However, if variable speed fans are used for providing this rate, they should never run under 50% rpm, since they do not provide a reliable airflow rate and are energy inefficient at or below that speed. Energy and ventilation efficiencies will be improved when single speed fans are used to provide the minimum ventilation rate rather than using variable fans.

**Guidelines for energy saving plus ventilation management in only CS barns**

If the mechanical ventilation capacity for a CS barn is only 20 or 25 cfm/pig consider increasing it to 40 or 45 cfm/pig. This will require the installation of an additional exhaust wall fan or two plus corresponding additional ceiling and attic inlets. Such an increase in the ventilation rate, will allow the mechanical ventilation season for the barn to be extended to later in the fall and spring so the sidewall curtains will not need to operate when there are cold (≤ 30°F) ambient temperatures. Although there will be increased use of electrical energy for the additional fans, there will be less L.P. Gas usage due to the over ventilation of barn that almost always occurs when curtains are operating during cold outside temperatures.

The sidewall curtains in a CS barn should have over-lap of at least 3 inches to prevent leakage of air during winter conditions. An annual check of the curtain cables is required for CS barns to account for possible cable stretching.

**Guidelines for additional cooling in either CS or TV barns**

Nearly all CS and TV finishing barns in the Midwest have sprinklers installed with timers (common to run them 1 or 2 minutes out of 10) and ceiling mounted circulation fans above pens to increase evaporation from the pigs, whenever inside room temperatures reach a threshold. To maximize pig cooling and prevent feed intake reduction and growth, the room temperature when these direct “on the pig” evaporative cooling is initiated should begin at roughly 80 F when pigs are small (50 lbs) and decreased proportionally to approximately 70 F when pigs are > 230 lbs.
Although common in sow gestation and farrowing buildings, consider adding evaporative cooling pads in TV pig finishing barns. The tunnel exhaust fans selected for an evaporative cooling pad TV barn must include the added pressure drop that the cooling pad will add to the ventilation system.

Another room cooling practice that can be used in either CS or TV barns is directly evaporative “misting” of the air as it enters either of these buildings through the sidewall or endwall curtains respectively. Direct misting is being done with high pressure lines and nozzles that create a mist or fog that evaporates in and cools down the incoming ventilation air. This might be best used in the TV barns but could also have application in CS barns, especially on the prevailing summer wind direction side (typically south in the Midwest). The activation time for these misting systems would be similar to those given above in pen sprinkler systems, namely 80 F when pigs are small (50 lbs) and decreased proportionally to approximately 70 F when pigs are > 230 lbs.

CONCLUSIONS

Barn retrofit concepts reported in this paper focus on structural upgrades such as insulation and mechanical items like improved environmental control, fan and heater maintenance and management, along with manure pit management.

Moving the swine industry forward in more sustainable pig production was the primary focus of this project. Results from the project indicate that current facilities can be modified or managed to reduce energy inputs. Results also indicate that there are alternatives to the current pig finishing facilities that could result in reduced energy and emissions per pound of meat produced while still being economically viable.

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REFERENCES

