Pork producers in the United States who are looking for lower cost structures for raising pigs have shown a great deal of interest in hoop barns or hooped shelters as facilities for housing gestating swine. Hoop barns can be used successfully for gestation and breeding as a workable alternative to gestation crates, but producers need to be aware of the advantages and disadvantages of this type of housing.

A number of manufacturers are offering these units for sale, and research-based information is available to help producers decide if a hoop barn is a good investment. To help producers and designers resolve some of the issues involved in using a hoop barn, this publication summarizes information about designing and using hoop barns. It discusses some of the management techniques that hoop barns require, and it presents economic factors that can be used to analyze design layouts and construction alternatives.
Overview

A hoop barn is a Quonset™-shaped structure with sidewalls 4 to 6 feet high made of treated wood posts and wood sides or concrete sidewalls. Tubular steel arches fastened to the tops or sides of the posts form a hooped roof, which is covered with a UV-resistant polyvinyl tarp. When used for swine housing, most hoop barns have concrete or earthen floors. Buildings with earthen floors have a concrete slab for a feeding and watering area. In a gestation housing application, the floor, except for the feeding and watering area, is deep bedded and cleaned one or more times per year.

Figure 1 shows a hoop barn used for gestating females, and Figure 2 shows the common components of a hoop barn.

Hoop barns are naturally ventilated and are sited to take advantage of prevailing winds. In the Midwest, most buildings are oriented in a north-south direction.

Basic Questions

Most of the previously available information about using hoop barns for swine housing came from farmer experiences and comparisons in magazines and news articles. Recent research performed in Canada and at Iowa State University has added to what is known about using hoop barns for gestation housing. Producers thinking about building any type of swine housing need to answer questions like the following to determine if building the structure is a good idea.

- Does the design of the building make possible and convenient the use of optimal or preferred management practices?
- Is the design conducive to providing for the animals’ needs during all seasons?
- Is the design structurally sound, and does it meet common tests of reliability and longevity?
- Is the design cost effective?
- How well does the structure fit in with the operation’s overall production goals?
- Is the site suitable for the structure?
- Is equipment to operate the structure available?
- Are environmental permits necessary?

When to Consider Hoop Barns

Hoop barns appear to be most beneficial for producers who satisfy one or more of the following criteria:

- Want facilities with versatility to match a rapidly changing swine industry.
- Need a short-term structure that could be removed after use or that is adaptable for other uses.
- Want to keep fixed costs low.
• Have limited capital.
• Are not interested in accepting the additional financial risk associated with a large capital investment.
• Want to improve the housing of the breeding herd that is currently on outside lots.
• Need an isolation area for new sows or gilts.
• Prefer to handle solid manure and have the capability to do so.
• Prefer a system of production that is less automated and requires different husbandry skills than those needed in confinement buildings.
• Believe pigs should be reared in an environment with bedding.
• Need a structure built quickly.
• May want to qualify for certain niche market requirements and premiums.

Table 1 shows a comparison of various sow gestation facilities. Hoop barns for gestating sows are a good alternative for people considering moving sows from outside lots or Cargill type floor units to a facility that has a more manageable thermal environment, that provides better runoff control, and that allows better feed usage and sow observation while allowing many of the sows’ natural behaviors.

If the producer is seeking a facility that has alternative uses, the case for investing in hoop barns becomes even stronger. Finally, if this producer’s goals in pork production include the use of a production system that requires a lower capital investment and if equipment for harvesting crop residue and for handling solid manure is already available, the logic of investing in a hoop barn is more compelling.

**Designing and Erecting Hoop Barns**

Producers who decide to build a hoop barn need to treat the construction project as they would any construction project involving a new structure. Aspects to consider include what type of structure to build; site selection; and proper access to the building for moving feed, bedding, and pigs. Producers thinking about building a hoop barn also should consider the building's usefulness within an existing operation, its proximity to neighbors, the availability of services and utilities, and the possibility of using the structure in conjunction with existing buildings.

**Using engineered or non-engineered hoop barns**

Although hoop barns do not have an extensive history in the United States, Canadian farms have been using hoops for several years. In both the U.S. and Canada, many models have proven to last 10 years or more if they are well maintained. Factors influencing the life include the use of strong, tear-resistant tarps, corrosion resistant structural members, and sidewalls that are well maintained and not abused.

One factor producers should consider is whether to purchase an engineered or a non-engineered structure. When a hoop barn is engineered, a qualified designer (typically a registered engineer) has analyzed how each component of the structure will interact with the other components of the structure. A qualified designer has analyzed how the loads applied to the roof (or tarp) will affect the design of the tubular frame and how the tubular frame will transfer forces vertically and horizontally to the sidewall frame.

In addition, the designer has considered how the animals themselves will exert against the sidewalls and has designed the sidewalls to withstand the outward push of the frame and pigs. In an engineered building, the foundation has been

<table>
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<th>Table 1. Comparison of gestation areas.</th>
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<tr>
<td>Gestation Area</td>
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<tr>
<td>Dirt Lots/pasture</td>
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<td>Cargill Floor Unit</td>
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<td>Hoop</td>
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<td>Confinement</td>
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specified to withstand the loads transferred from the wall. Structures that are engineered have been designed to meet snow and wind loads for the geographic area in which they are to be erected. An important point for producers to consider is that engineered structures are more easily insured because they are assured to meet weather design conditions. Insurance agents should be consulted about insurability issues before any building is purchased and constructed.

An engineered structure typically will include the frame, tarp, sidewall materials, and materials to anchor the building to the foundation. Warranties for engineered structures range from 10 to 15 years on materials and workmanship. Engineered structures often are more insurable than non-engineered structures, and engineered structures often cost less to insure.

Some hoop barns on the market have not been engineered. Hoop barn dealers often sell a roofing system instead of a complete structure. Included in most packages are the tubular frame, tarp, and material to attach the tarp to the sidewalls. The buyer must purchase the wood posts and tongue and groove boards to construct the sidewalls. Many times, non-engineered structures will have less than a three-year warranty on products and workmanship. Non-engineered structures may have little if any resale value after five years.

Producers must ask themselves questions like the following when considering the purchase of a hoop barn:

- How long do I want the structure to last?
- Do I want to have the opportunity to resell the structure in the future?
- Will the extra cost of buying an engineered structure outweigh the savings of buying a less expensive, non-engineered structure?
- How does having an engineered structure affect my ability to get insurance on the structure?

Design and construction details

Hoop barns are naturally ventilated and are sited to take advantage of the summer prevailing winds. For much of the Midwest, the building is oriented in a north-south direction to take advantage of the summer prevailing winds from the south. Prevailing summer winds should blow through the building.

Concrete slabs are used with some feeding systems. For slabs around waterers, slope the concrete away from the bedded area so that spilled water will not enter the bedded area. A slope of 1 to 2% (1/8 to 1/4 inch drop per foot) is sufficient.

The remaining deep-bedded area of the structure can have either an earthen or concrete floor, with many producers preferring concrete for ease of cleanout. A complete concrete floor will make cleaning much easier because it prevents the problem of sows digging into the underlying soil. A concrete floor also tends to reduce bedding usage in summer because pigs cannot dig to reach cooler soil. In some states, regulations require concrete floors to prevent nutrients from leaching into the underlying soil and groundwater.

If the bedding area is to be concreted, the soil should be compacted to prevent differential settling. A 5-inch slab with woven wire placed in the center (vertically) of the slab should be sufficient for most applications. The concrete floor should have a strength of 4,000 psi. Thicken the edges of the slab, particularly at the end where vehicles will drive into the bedding area for cleaning. Place the concrete flat.

When building multiple hoop barns, provide at least 10 feet of space between buildings. This will allow space for equipment to travel between buildings and allow for snow removal and moisture drainage. Grade soil to take rain away from the structure.

Both wood and concrete sidewalls are relatively common, with increasing interest in using concrete. For wood sidewalls, the steel frames are fastened to the tops or sides of the posts that support the outside wall. Commonly, pressure treated 6 x 6's are used as posts. Pressure treated tongue and groove 2 x 6's are used on the animal side of the posts to form the sidewalls of the animal space.

Either poured or precast concrete walls can be used for hoop barns. Either must be designed to support the design loads caused by the hoops. Properly engineered hoop frames connected to precast concrete walls, similar to those used in bunker silos, can be a good choice in that the structures can be moved if necessary. Concrete for the sidewalls is more durable than wood but may be more expensive, and may be colder for the animals to lie against. Pouring concrete sidewalls would make the hoop barn a more permanent structure. If concrete sidewalls are used, they must be designed to accommodate the fastening requirements of the selected brand of hoop barn.

Typically the sidewalls are 4 to 6 feet high. Six-foot sidewalls are recommended to prevent pigs from damaging the tarp when a great deal of bedding has accumulated. Figure 3 shows the inside details of a typical hoop barn.

Livestock panels or gates form the north and south endwalls at animal level. In the winter, these gates are covered with sheets of galvanized steel,
recycled plastic, or plywood to reduce drafts. In all instances, the north wall can be closed relatively tightly to reduce winter winds using commercially available tarps or plywood sheeting. Some producers also partially close the south end in cold weather using commercially available tarp kits, especially in northern climates of the United States. In the summer, both the north and south ends are totally open, with the steel, plastic, or plywood panels removed from the end gating to increase air flow in the pig zone.

Endwall construction should include posts that will be close enough to fasten the end gates adequately, but far enough apart to allow room for feeding and manure handling equipment. If the posts extend to the height of the hoops, do not fasten the posts to the end hoop. Hoops can deform during winds and will rub against the posts. Rubbing against the posts may damage the tarp material. Commercially available end tarps will reduce the potential for damage. Figures 4, 5, and 6 show typical endwall configurations for various weather conditions.

**Foundations**

The foundations of hoop frames must be able to transfer the loads applied to the frame to the earth. Wind applies horizontal and uplift loads to the sidewall frame, while snow, rain, and the weight of the frame apply vertical loads downward to the sidewalls. The foundation anchors the building to the earth and must resist corrosion from contact with manure, moisture, and the soil.

The most common method of anchoring the frame to the foundation is to build a post frame wall with the posts extended below the frost level and then
construct a 4- to 6-foot high wall along the sides of the frame. Some manufacturers also offer steel truss posts to which the arches are attached. In either case, the pipe frame is attached to the tops or sides of the posts. Posts must be set properly. If posts are set improperly, they can move out of plumb and affect the structural integrity of the building. Posts should be set below the frost line and on top of concrete footings. The soil around the posts must be tamped properly. Do not set posts in areas that have a high water table. Precast concrete sidewalls can be placed on a crushed rock layer or on concrete. The weight must be adequate for the hoop barn to resist wind uplift forces. Follow engineered designs from the hoop barn supplier.

Frames

Hoop frames are constructed primarily from 2- to 3-inch O.D. (Outside Diameter) round tubular steel to form a roof truss system. Steel purlins connect the trusses to each other to act as a unit, Figure 7. The thickness of the tubing used in frames ranges from 16 to 12 gauge. (The lower the gauge number, the thicker the tubing.) Frame sizes depend on building width and frame spacing. Some narrower hoops use tubing only, without forming a truss.

Frames are spaced at various widths from 6 to 16 feet, depending on the design. These frames support the roof and sidewall construction of the building. See Figure 8 for an illustration of how the tarp is fastened to the sidewall and frame. Galvanized steel tubing 1-3/8 inch O.D. is used for purlins and bracing to span and brace between the frames along the length of the building.

While frame widths for single span structures usually range from 18 to 36 feet, many hoop barns for gestation swine span 40 feet or more with engineered truss arches to allow more flexibility in layout. Some manufacturers span from 40 feet to well over 100 feet with engineered truss arches such as the one shown in Figure 7. Truss arches also are used when high snow or wind loads are a concern, or if a lower roof height is desired. Wider hoop barns should have an open ridge located in the middle of the arch to facilitate good moisture removal.

Because of the corrosive nature of an animal housing environment, high quality galvanizing is crucial. Some manufacturers use hot dipped galvanizing, which produces excellent results. Other types of galvanizing, however, may not be suitable for use in animal environments. Check the quality and amount of galvanizing in the frame tubing and determine what type of warranty is available from the supplier. Aluminum frames are an option with some suppliers. Aluminum frames used with the appropriate fasteners should experience less corrosion than steel in the conditions that exist in typical swine housing.

Covers

Tarp coverings for hoop barns come with various options, but evaluating what type of tarp to get should be an integral part of the overall design and decision-making process. Generally, tarps are made of woven polyethylene fabric that is produced from low-density polyethylene extruded over high-density woven polyethylene. Due to the woven nature of the tarps, punctures do not tend to run. When punctures occur, they may be patched with a kit the company provides. The better tarps are those that have been treated with ultra-violet (UV) stabilizers and a fire resistant substance to provide safety and longevity. Producers should consult their insurance company on which treatments are required for insurability.

Tarps generally come in different weights, which may include 10.0-, 12.5-, and 14.9-ounce fabric. Many colors are available, including clear and opaque fabric. Fabrics that have a white underside or are white and allow some light through tend to make a building brighter and make the animals easier to see. Clear fabrics are not a good choice because they allow a high degree of solar penetration, which may overheat animals. Pro-rated warranties for tarps are generally 10 to 15 years. Rub points, such as purlin connections and end wall connections, tend to wear first. It is best to minimize such rub points.
Snow and wind loading

In general, the structure must be able to meet snow and wind load requirements. Structures that do not meet snow and wind load requirements risk failure and may not be insurable.

The snow load design should be similar to what other agricultural building loads are for the area in which the building is being constructed. The effect of snow on the structure can vary. Snow may slide off the roof, or the snow may accumulate and put additional weight on the tarp and hoops. Generally, snow loads are not seen as a big concern because the curvature of the structure minimizes snow buildup.

Wind loads also should be calculated as they would be for other agricultural structures in the area. Additionally, uplift of the frame under wind loads needs to be considered in the design of the frame and the foundation anchoring. In some designs, diagonal bracing of the sidewalls from the endwalls and along the roof line should be incorporated. Outside guy wires can be important to keep the frame from racking or deforming out of plumb. Frames that have shifted off center are likely to be loaded unevenly and are subject to failure. Some reports of wind damage have indicated that hoops sometimes deform without failing.

Environment and Ventilation

Perhaps the top priorities for hoop barns used as swine housing are the issue of animal environment and the related issue of proper ventilation. Realistic expectations for these structures are that they reduce exposure to wind and snow in winter and sun and rain in summer. Hoop barns are cold barns and should be managed as such. Although the bedded-manure pack generates considerable heat and enhances animal comfort for pigs in the winter, hoops require special management for year-round operations.

The primary goal of hoop barns is to protect the animals from the weather. In the summer, the building should provide shade and allow cross ventilation by wind. In the winter, the housing should allow for moisture removal and draft control. In the winter, a cold barn with dry bedding allows the pigs to create a suitable, comfortable microenvironment in the bedding.

A natural tendency of producers using hoop barns is to restrict ventilation to keep warmed air inside the structure. However, when the hoop barn is being used to house animals, restricting ventilation traps the moisture the animals produce along with the warm air. This creates a situation that can be damaging to the pigs' health.

At night a hoop barn loses heat to the cold surroundings and the cold, clear, black sky. This cools the air in the structure, lowering its moisture-holding capacity substantially and causing relative humidity to rise. The result is cold, damp air and, most likely, excessive condensation on the underside of the tarp.

To reduce risks to animal health from poor air quality, hoop barns must be well ventilated, and the ventilation must be well managed. A hoop barn must be managed just as any cold, naturally ventilated structure. Do not close the structure too tightly. Do not attempt to manage the structure as a warm barn; it is primarily a shelter. Properly managed, air temperature in the hoop barn 4 to 6 feet above the bedding pack is often within 10°F of the outside air temperature.

Because wind is a major force in ventilating any naturally ventilated structure, orient hoop barns to intercept the prevailing summer wind through the end opening. Do not construct hoop barns where buildings, trees, or other large obstructions block the prevailing summer winds. For most structures, the minimum separation distance from obstructions to the end of the building is 75 feet.

Ventilation openings

Natural ventilation uses openings at different heights to achieve ventilation in the winter. Building a structure with an open ridge will allow the moist air that builds up to escape through the opening at the top of the structure. For sow housing, because of the relatively low stocking density, a ridge is unnecessary unless the structure gets excessively long. In these buildings, ventilation air enters through a continuous space along the sidewall where the tarp is attached and exits through the ends of the hoop, depending on wind direction. Figure 8 shows a 3- to 6-inch gap between the top of the wall and where the tarp overlays the wall; this gap serves as a continuous air opening for ventilation.

Because openings are not adjusted, the hoop acts mostly as a wind and snow shelter and does not maintain a set temperature. Problems with air quality occur most often when hoop barns are closed too tightly.

Endwall ventilation

Hoop barns without ridge vents are difficult to ventilate naturally if they are too long. Typically, a hoop barn longer than 100 feet, without ridge vents, and filled with animals will present ventilation problems. Longer hoop barns can be used in high wind areas. In all areas, hoop barns rely on endwall openings to aid airflow through the structure. The ends are open most of the year. Figure 9 shows an example of how
the gap between the top of the endwall and the frame and tarp acts to aid natural ventilation when the ends are closed.

Where such devices as hovers or wind baffles on gating are used to reduce drafts, the draft prevention devices must still allow ventilation and moisture removal to occur.

**Effects of temperature on breeding stock**

The production efficiency of breeding animals may be affected by the environment in which they are housed. Cold temperatures generally do not affect the reproduction efficiency of boars and sows unless boars suffer scrotal frostbite or the feeding levels of gestating sows are too low to maintain fetal pig development and meet body maintenance requirements. Sows and boars housed in colder conditions will require additional feed because they will use more energy to maintain homeothermic conditions. A common recommendation is 0.8 pounds of additional feed for every 10 degrees colder than 50 degrees, Table 2.

Hoop barns are designed to serve as cold housing. Heat is not added to the structure, and the indoor air temperature will generally remain 5 to 10 degrees above the outdoor temperature. During winter the north end of the structure will generally remain closed. Air comes in through slots on either side of the frame walls, rises to the top of the hoop, and moves out the ends. Sows remain comfortable in cold conditions because they can modify their environment with the use of bedding and huddling with other animals. A source of high quality dry bedding is essential to the success of this structure.

Hot weather is much more harmful for breeding efficiency. Boars that are exposed to an elevated effective temperature will experience poor semen quality for a 6- to 8-week period that begins 2 to 3 weeks after exposure. Sows are more heat tolerant except during the first 2 to 3 weeks of gestation and during the last 2 weeks before farrowing. Litter size and weight may be severely affected during these periods.

During summer months both ends of the hoop should be left open to allow air flow through the structure. Boars and sows should be maintained with effective temperatures below a daily average of 80 F and below 86 F as a maximum. To achieve this, less bedding is used, and interval sprayer systems may be necessary.

**Table 2. Additional feed requirements for gestation sows fed corn-soy diets in cold weather.**

 Additional feed usage of 0.8 pounds per 10 degrees for temperatures colder than 50 degrees. Results typical for midwest winters and feed intake.

<table>
<thead>
<tr>
<th>Month</th>
<th>Additional Feed Required</th>
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<tbody>
<tr>
<td>November</td>
<td>—</td>
</tr>
<tr>
<td>December</td>
<td>0.50 to 1.00</td>
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<tr>
<td></td>
<td>15 to 30</td>
</tr>
<tr>
<td>January</td>
<td>0.75 to 1.50</td>
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<tr>
<td></td>
<td>20 to 45</td>
</tr>
<tr>
<td>February</td>
<td>0.50 to 1.00</td>
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<td></td>
<td>15 to 30</td>
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<tr>
<td>March</td>
<td>0.00 to 0.50</td>
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<td></td>
<td>0 to 15</td>
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<tr>
<td>April</td>
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Additional Feed: 50 to 120 pounds per sow per year
Cooling

In confinement facilities with liquid manure systems, cooling can be accomplished using a thermostat and cycle timer with a sprinkler system to wet the pigs and then allow them to dry. Allowing the water to evaporate between cycles draws heat from the pigs' bodies as the water evaporates off their skin. This evaporation helps to cool the pigs. Any excess water ends up in the manure collection system.

With hoop barns, a similar system can work, but there are a few obstacles. Hoop barns are not always equipped with electricity so the use of a thermostat and cycle timer may not be practical. Excess water will go into the bedding rather than into a manure collection system thereby creating a wet place for the pigs to lie, even when temperatures cool off in the evening.

Work in Australia with bedded finishing systems has shown that it is best to wet most of the pigs at the same time. This spreads the water across a large area, including the bedded area, and helps to avoid excessive water on the bedding. Sprinklers can be attached to the roof trusses to cover a portion of the barn. This same system can be used for sows. With this type of arrangement, leave some areas of the hoop barn, including the feeding area, un-wetted to give animals a choice of environments. Pigs may have a tendency to lie on bare concrete to remain cool, but wetting the concrete feeding area will encourage the pigs to lie in the feeding area more, making it difficult for the animals to have access to feed. In operations using feeding stalls, the wetting device may be located over the stalls. Allow 10 to 12 square feet per pig when determining the area to be sprinkled.

Wetting of the pigs should be done using a cycle timer to allow evaporation of water from the pig's surface to provide the cooling effect. Sprinklers should put out large droplets instead of a mist. Large droplets are designed to cool the pigs; misters are designed to cool the air immediately above the pig. Also, misters depend in part on airflow and lose some effectiveness when the relative humidity in the pig zone where the misters are spraying is at or above 75%.

Timers should be set to operate anytime the temperature exceeds 80-84°F, and they should turn sprinklers on for 1 or 2 minutes out of a 10- to 20-minute period. Specific settings will vary with climate, pig size, humidity, temperature, wind, and water pressure, but the critical issue is wetting the pigs and then allowing them to dry and cool as the water evaporates. Producers will have to experiment with several settings to find the right one for a specific location. The goal is to wet all the sows in 1 to 2 minutes and then allow them to dry. Just as they become dry, the water should turn on again.

If electricity is not available, sprinklers will have to be managed manually, or there may be options using solar or battery-operated controllers. In either case, the producer must observe the pigs frequently, adjust the system accordingly, and avoid allowing puddles to form in the bedding. Careful management is necessary to prevent problems with wet bedding and inadequate drying time, but pigs digging holes in the bedding pack has not been a problem when wetting devices are managed properly.

Hoop Management

Equipment selection, material handling, and animal handling techniques are important factors that affect both the longevity of the structure and sow comfort. Hoop barns have four main management issues:

- Managing the physical structure.
- Managing group-housed gestating sows.
- Managing breeding of group-housed sows.
- Managing the feeding area.

Managing the physical structure

Structure management issues include:

- Managing the structure as a cold barn.
- Providing frost-free or no-freeze waterers.
- Handling rainfall runoff in an environmentally satisfactory way.
- Providing lights if heat checking is performed after dark.
- Providing one watering space for every 30 to 40 sows.
- Providing an extra nipple waterers in the summer if necessary.
- Developing a maintenance schedule that includes checking the entire structure every 12 months, and checking the tarp for tears and tautness every 6 months.
- Prevention of the floor/ground freezing in the hoop between groups.

Managing group-housed gestating sows

To minimize stress and maximize performance, group-housed sows need to be handled differently than sows housed individually. Bred sows should be housed separately from bred gilts. Bred sows or gilts should not be mixed into a group before 28 days of gestation, preferably not before 42 days of gestation. Studies have shown that litter size and farrowing rate are lower when sows are mixed...
during the first week after mating compared to 28 days after mating. When sows must be introduced to a large group, add at least 10% of the total group size to minimize fighting. Housing groups of sows with a mature boar during the first week can help minimize sow fighting as the boar is recognized as the dominant animal. The best method to manage sows is to maintain a group that does not increase or decrease in numbers. If sows or gilts need to be added to a group, a method of sorting and remixing gestating sows must be employed.

Sows in groups should be as uniform in size as possible. Uniformly sized sows are especially important when sows are group fed daily because there is less chance of a dominant sow getting too much feed. Sows must be fed in a way that minimizes competition for feed and manages individual sow feed intake. Interval feeding, trickle feeding, or providing locking feeding stalls can eliminate the possibility of the dominant sow getting too much feed. Interval feeding should be used with caution because it can lead to lower reproductive efficiency.

Introducing replacement gilts to a group is a challenge. First parity gilts are best kept separate through their first gestation, if possible. They can then be commingled after weaning of their first litter. This allows the pregnant gilts to be developed separately from older sows. Weaning is a good time to introduce new sows to the group. Keeping a static group as much as possible is the preferred management tactic. Static means managing the group as a batch. That is, the group is bred, farrowed, and weaned at the same time. Dynamic groups, groups of sows where sows are added and removed frequently, must continually reestablish their social order, leading to more fighting and possible injury.

Managing breeding of group-housed sows

Hoop barns can be used as breeding facilities. Boar pens, breeding areas, and weaned sow pens all can be included in the gestation hoop barn (Figure 19) or in a separate breeding hoop (Figure 20). Producers may want to build a small heated room to use as an AI lab, although such a room is not required. When designing the layout for breeding facilities, separate the boar pens from the weaned sow pens to prevent the sows from becoming refractory to the boars. If the sows are artificially inseminated in feeding stalls, it may be helpful to pen a boar in the alley immediately in front of the sows during insemination to improve estrus (heat) detection and to speed the insemination process. Design alleys and boar penning to facilitate boar movement for heat detection and rechecking of bred sows.

Although the hoop barn is not heated, the breeding area can be dry and draft free during the winter. Summer cooling is critical for boars and sows. Provide maximum airflow during hot periods, and sprinkle cool sows and boars. See page 8 for additional details. Boars are particularly subject to heat stress, and boar fertility and libido can be diminished if boars are not kept cool.

The example layout in Figure 20 uses three hoop barns. The two large barns are for sows, and the middle, smaller barn is for boars. Boars are moved to the sow barn for heat detection. Sows to be inseminated can be sorted out and walked to the boar barn for breeding in a breeding alley adjacent to the boar pens. Alternatively, the sows can be inseminated in the pens or alley in the sow barn. This alternative method reduces sow movement, which can be difficult during estrus when the sows lock up.

Managing the feeding area

The feeding area is the most expensive component of the hoop barn. Many times during planning the layout, producers decide how to make the best use of the feeding area. While it is important to make the feeding area economical, the most important issue of the feeding area is how to make this best fit the producer’s sow management goals.

Some of the questions a producer needs to ask when deciding on the layout of the feed system are

- How much do I want to control feed intake?
- How often do I want to feed sows?
- How often do I need to observe the sows?
- How much can I afford to spend on the feeding area and on a feeding system?
- How much labor do I want to use for feeding sows?

Deciding the feeding frequency is a good start to answering these questions. The two options in feeding frequency are to feed sows daily or at intervals.

Daily feeding

Daily feeding is the most common feeding plan and allows for the most flexibility when making choices about the feeding system. Daily feeding encourages daily sow observation. Feeding stalls, self-feeders, or floor feeding can be used for daily feeding. If self-feeders are used, provide one feeder space for every five to ten sows in a group. If feeding stalls are used, provide one stall per sow in a group. If floor feeding is used, provide enough space to allow all the sows in a group to eat at the same time.

Daily feeding requires more labor and planning if used with a shared feeding area. In a shared
feeding area arrangement, sows fed ad lib may not be able to consume all the feed they need before being moved back into their pen to allow the next sow group to be rotated into the feed area. Sow groups that have to wait while others are fed may become very loud and agitated.

**Interval feeding**

An interval feeding program allows sows to eat ad lib for a certain duration of time every two or three days. A fenced feeding pen with self-feeders is required. Because sows haven't eaten for at least a couple of days, at least one feeding space is needed for each sow fed, although extra spaces may be beneficial.

In interval feeding, sows are turned into a self feeding area where they eat until they are full, at which time they are removed. This method uses feeding equipment for several groups, thereby spreading the cost over more animals. Enough feed should be available so all sows eat their fill, with the dominant sows eating first and the others eating later.

The negatives of interval feeding are that the manager has little control over the individual sow's feed intake. Sow aggression may occur around the feeders. Avoid using interval feeding with bred gilts because they may not consume enough feed to provide the necessary energy needed to maintain pregnancy and their own growth between breeding and farrowing. Also avoid interval feeding during early stages of gestation because this is a time that sows need extra energy for maintenance, growth or recondition, and pregnancy. Sows or gilts will have lower reproductive efficiency if their energy levels are not maintained.

**Feeding Systems**

Selecting a feeding system is a major decision with group-housed sows. Three major choices are available:

- Feeding stalls.
- Self-feeders.
- Floor feeding.

Regardless of which systems us used, the feeding area in a hoop barn usually is a concrete pad elevated 12 to 18 inches above the bedded area to keep the bedding off the feeding platform, Figure 10. The pad should slope away from the bedded area. Many times the waterer is located on the concrete pad. The concrete pad should slope away from the waterer and drain away from the bedded area. The concrete pad should extend at least 10 feet around feeders and waterers. If the feeding area is located on only one side of the structure, it is preferable to locate the feeding area on the west side of the structure. Because of afternoon sun and wind patterns, the west side is often hotter than the east side. During summer, the cooler east side of the hoop is where the sows will spend most of their time.

**Feeding stalls**

Feeding stalls are an excellent choice when housing sows in hoops, Figure 11. Individual, lockable feeding stalls take up considerable space (about 12 square feet per stall). New stalls cost $50 to $100 each and can require more labor than other feeding systems. Sows should enter the stalls from the back.
Stalls also should have front gates that can allow the sow to exit the stall and be moved to the farrowing house or breeding pen. The key advantage of feeding stalls is that they allow individual management (feeding, vaccination, AI, etc.) of group-housed sows. Provide at least one feeding stall per sow in a group. Each stall should have a lockable rear gate. Vulva biting can be a problem when not enough stalls are available or locking exit gates are not provided.

Individual feeding uses feeding stalls in which animals may be confined during feeding. This allows each animal to get an individualized rate of feed to maintain uniform animal conditioning. The disadvantage is the cost and space used, and the increased labor to close and open the crates at the appropriate time. Automating feed delivery and gate opening can reduce labor costs but will add to facility costs. Because sows enter various feeding stalls at feeding time, an automated feed delivery system will give each sow the same amount of feed. Extra feed must be added by hand for thin or young sows.

One variation of the feeding stall is the electronic feeder. Electronic feeders are an automated way to feed and manage sows individually, Figure 12. A single electronic feeder can feed a single group of 50 to 60 sows. The electronic feeders use a relatively small amount of space. Typically, electronic feeders are located in a single pen and are not used in a shared feeding area. Electronic feeders allow increased management because they keep track of sows that do not eat. However, an electronic feeder requires a major capital investment and ongoing maintenance and management. Electrical power surges and lightning can cause problems with the computer that manages the feeding system.

**Self-feeders**

To feed group-housed sows, self-feeders are a lower cost option than feeding stalls. Because self-feeders are an ad lib feeding system, they work well with interval feeding management. Self-feeders can be easily incorporated into a shared feeding area. The main disadvantage of self-feeders is that they do not allow individual sow management.

Self-feeders take up less overall space than feeding stalls, but at least an additional 10 feet of space are needed around the feeder to allow sows to eat comfortably and to allow sow movement. The disadvantage of self-feeders is that feeding sows in groups can encourage aggression as well as create a disparity of feed intake.

**Floor feeding**

Floor feeding is accomplished by dropping feed on a concrete floor and allowing the sows to eat in a free-for-all manner. The disadvantage is that the dominant sows will tend to eat more than the timid sows. This can result in uneven conditioning. The advantage is that it is inexpensive because it requires minimal equipment.

Feeding on the concrete pad is low labor (especially with automated feed drops), can be relatively inexpensive, and uses a moderate amount of space. The manager has no control over individual sow feed intake. Sow fighting and aggression are encouraged because the larger, aggressive sows get more feed. Using feed drops can be expensive, while feeding with buckets is inexpensive but more labor intensive. Feeding is on a daily basis. Individual sow management is difficult, but feeding according to smaller groups of similarly sized sows can help make this system successful.

**Bedding**

Bedding is one of the keys to successful production in hoop barns, especially in the winter. The producer must determine how many bales of crop residue are required to provide bedding and then harvest in a timely manner to provide quality bedding. With earthen floors, enough bedding must be provided to keep the soil under the bedding pack relatively dry. Sows will establish certain dunging areas throughout the structure. Many times, winter groups will sleep in the far back and along wooden sidewalls and dung in the space between the bedding area and the concrete slab used for feeding and watering. Additional bedding will be required to prevent the dunging area from becoming sloppy.

Several materials have been used successfully for bedding although most experiences have been
with baled corn stalks. Table 3 lists other products that could be used, along with the approximate amount of bedding needed.

If a 1,200 pound bale of corn stalks costs $10 to $20 for baling, transportation, and storage, the cost of bedding per sow space with three gestation turns per year would be between $17 and $50. Besides corn stalks, some producers have used soybean stubble bales successfully. However, soybean bales tend to be dustier than corn stalks. Other producers use barley straw, wheat straw, oat straw, prairie hay, and wood shavings. Bedding used should be free of molds to prevent problems during sow gestation. Wood products should be used with caution. Shavings and sawdust need to go through a heat cycle to avoid the transmission of avian tuberculosis to the sows.

While the selection of bedding is based mostly on what is readily available, many other concerns should enter into the decision. These concerns vary from region to region and include the following:

**Soil conservation:** In regions where residue cover is required on highly erodible lands, the harvesting of corn or bean stalks may not be a good option. The producer must consider how much residue can be removed per acre while still complying with existing conservation plans.

**Custom baling:** Custom baling of stalks may cost between $10 and $15 per ton. Additional costs are incurred in transporting bales. On-farm baling, while requiring less out-of-pocket expense, is not a low-cost option. Additionally, stalk baling results in more wear on round balers than does normal hay baling.

**Bedding availability:** During years in which a wet fall or early snow prevents stalks from being baled in a timely manner, they may become less available and more costly. A situation of this type could require a shift in priorities from doing all of the grain harvesting first to a system of harvesting and baling stalks. A variety of bedding sources can minimize the risk on not having enough bedding due to inclement weather in the fall.

**Bedding storage:** Bedding baled in the fall and used before the spring generally does not deteriorate if stored outside. However, if stored into the spring and summer, bedding must be protected to prevent reduction in quality. Bales that will be used during spring and summer should be stored under cover on a well drained area. Bales stored outdoors will lose bedding quality, thereby increasing costs. Depending on bedding quality, most producers tend to use between 2,000 and 3,000 pounds of corn stalk bedding per sow space in the hoop barn. This means that for each 100 head of gestation capacity in hoops, approximately 200 bales of corn stalks would be required each year.

### Table 3. Estimated amount of bedding needed for gestation sows in a hoop barn.

<table>
<thead>
<tr>
<th>Material</th>
<th>Average Bedding Usage (lbs per sow turn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn stalks</td>
<td>670 to 1,000</td>
</tr>
<tr>
<td>Corn cobs</td>
<td>800 to 1,200</td>
</tr>
<tr>
<td>Barley straw (long)</td>
<td>800 to 1,200</td>
</tr>
<tr>
<td>Oat straw (long)</td>
<td>600 to 900</td>
</tr>
<tr>
<td>Wheat straw (long)</td>
<td>750 to 1,130</td>
</tr>
<tr>
<td>Sawdust (hardwood)</td>
<td>1,120 to 1,680</td>
</tr>
<tr>
<td>Sawdust (pine)</td>
<td>670 to 1,000</td>
</tr>
<tr>
<td>Wood shavings (hardwood)</td>
<td>1,120 to 1,680</td>
</tr>
<tr>
<td>Wood shavings (pine)</td>
<td>840 to 1,250</td>
</tr>
</tbody>
</table>

**Manure Handling**

Before considering a hoop barn, one must carefully plan on how to handle the bedded pack. The proper equipment to remove the manure resulting from the bedded pack must be available. If direct application to a field is not possible, then space to stockpile the manure must be available. Knowing the nutrient content of manure is essential for those who have a manure management plan. Because of the drier bedding from hoop barns, the manure will have a higher-carbon/low-nitrogen status than manure from facilities with semisolid or liquid manure systems. Manure with a high-carbon/low-nitrogen status may lead to nitrogen immobilization and crop stress if applied during or immediately prior to the growing season.

**Removing solid manure**

The manure/bedding mixture removed from the hoop barn is either directly spread on fields or stored for later use. Typically, there are few custom haulers available that will handle solid manure. If this is the case, a manure spreader, loader, and tractor must be available for on-farm usage. Corn stalks are often used in the Midwest for bedding. Corn stalk bedding is not easily handled due to the potential for wrapping on manure spreader beaters. An ordinary skid-steer loader will probably not be sufficient to tear apart the pack for loading.

Most producers agree on 7 to 9 hours of total labor to clean a moderate sized hoop barn and spread...
the material on nearby crop land. The best equipment to remove the bedding pack is a mechanical, front-wheel assist tractor with a grapple fork attachment on the front end loader. One producer reports using a chisel plow to disrupt the bedding pack before cleaning.

**Storing solid manure**

If manure is applied directly to the fields, storage requirements are minimal, but if solid manure is not applied directly to a field after cleaning then designing a space to safely stockpile the manure is necessary. Knowing the amount of manure to be stockpiled is necessary to properly design the storage area.

As it comes directly out of the hoop barn, the high degree of variability in the bedded pack makes it difficult to predict manure nutrient contributions to crop fertilization needs. Composting is likely to occur if the manure is stored for any length of time and will provide volume reduction of one-third to one-half and nutrient stabilization prior to field application. Such composting will occur with minimal management if the material is piled in windrows about 6 feet high and 12 feet wide.

Bedding from gestating sows in hoops tends to be much drier than that from finishing pigs, and moisture is likely to limit the extent of composting unless additional manure or water is added to the piles. Mixing the material to achieve a higher degree of uniformity would improve this situation, and mixing currently occurs to some degree if the bedded pack is piled for storage or composting prior to field application. Additional mixing, as would occur during turned windrow composting, may offer a benefit with this material. Contact your local Cooperative Extension service for recommendations on composting manure.

There is some concern about nitrogen leaching from storage, especially during high rainfall. In some states, the environmental control agencies are concerned about runoff and will inspect areas of stockpiled manure. Storing manure on a concrete pad can be an effective management tool that will provide a solid base to make manure removal easier and can be designed to safely control runoff from the area. Contact state environmental control agencies to determine proper procedures for stockpiling manure.

**Applying solid manure**

In some places in the Midwest, much of the agricultural land base is highly erodible. As part of their conservation plan, many producers have signed an agreement with the federal government to maintain 30% residue coverage after planting. Using large amounts of residue in hoop barns has raised the following concerns:

- The properties of the manure vary greatly throughout the structure. Some areas will have a high concentration of manure while others will be mostly bedding; therefore, the fertilizer value of the manure and residue mixture can not be estimated accurately and credited for nutrient content.
- If they are not chopped first, corn stalks spread on fields may interfere with minimum tillage operations.
- If the farming operation plans on using no-till, will the producer be able to land-apply the residue in a thin enough and uniform enough pattern with existing manure spreaders to minimize planting problems?
- Substantial organic matter will be returned to the cropland, but will a high carbon-to-nitrogen (C:N) ratio prevent the nitrogen from being fully available for crop use the first year following land application?

**Example Layouts**

Hoop layouts used for gestation and breeding generally are designed to provide at least 24 square feet of bedded area per sow. Pen layout usually depends on the feeding system and group size. The number of sows per pen or group is a factor of farrowing room/house capacity and conception rate. Pens should be at least 15 feet wide to minimize control by aggressive sows and allow timid sows to pass freely.

**Layout with feeding stalls**

The gestation layout in Figure 13 is designed for two groups of 44 sows. Feeding stalls are placed on a raised concrete pad at the south end of the hoop. The feeding area is designed so that only one group of sows is allowed to eat at a time. This design minimizes the equipment cost by allowing feeding stalls to be shared. Shared feeding stall usage on a daily feeding system may require some added labor.

Feeding stalls in Figures 14 and 15 are located on a concrete pad on which feed is dropped for feeding. Feeding stalls are located on the west side of the structure.

**Layout with self-feeders**

Figures 16, 17, and 18 show facilities designed for interval feeding with self-feeders. Figure 16 shows two groups that share an inside feeding area at the south end of the building. Figure 17 shows
four groups of 25 that share a feeding area in the center of the building. This design minimizes the area devoted to feeding, but animals will be exposed to different conditions depending on where in the facility they are housed. Added labor may be required since more than one group may need to be fed in a day. Feeding one group at a time will create a noisy environment due to the other groups being agitated as they wait.

The layout in Figure 18 was designed for two groups of 36 sows with an outside feeding area. This allows more of a uniform environment. Waterers are typically located on the walls, but one shared waterer can be located between the pens near the swing gates.
Figure 16. Interval feeding for two groups

Figure 17. Interval feeding for four groups.

Figure 18. Outside interval feeding.
Layout with floor feeding

This system is simple and probably one of the most inexpensive designs. However, individual conditioning of sows is sacrificed, and the groups of sows will be exposed to different environments. Feeding stalls are located along one wall with drop feeders, similar to Figure 14.

Cost Analysis

Table 4 shows a cost analysis comparing hoop barns with differing levels of use. Costs vary depending on location and availability of materials, so you are encouraged to fill in the Your Estimate column with values that reflect your operation. The table presents information for a hoop barn that is considered a basic unit without feeding stalls, and for another that has feeding stalls. They are also evaluated for two versus three groups per year. Initial investment cost is $11,500 for the basic unit per year and $19,500 for the unit with feeding stalls.

Fixed costs are as follows: Depreciation = 10%, interest = 5%, insurance and taxes = 1.5%, which leads to a fixed cost of 16.5%. The annual interest rate is 10% or 5% on average for the life of the investment. Depreciation at 10% is based on the premise that the hoop barn will last 10 years. Given that using hoops for animal housing is a relatively new practice, information on life expectancy is not complete. However, it appears that they will last at least 10 years.

Bedding requirements for 3 gestation turns per year using corn stalks is about 1 ton per sow space per year. For Table 4, the bedding is valued at $15 per 1,200 pound corn stalk bale. Assuming 670 pounds of corn stalks are used per sow turn, the cost per sow per turn is $8.38.

On average, buildings are cleaned after every 2 gestation turns. An operation using 3 gestation turns per year would clean the buildings an average of 1.5 times per year. Each cleaning will take about 7 to 9 hours or about one day. With a cleaning time of 8 hours and a labor cost of $8.00 per hour, the cleaning cost for 3 gestation turns would be $96 per year. The cleaning cost would be $32 per group or $0.53 per sow per gestation period.

Using 5 pounds of feed per day for 110 days, feed consumption would be 550 pounds per sow per gestation period. Using a feed cost of $0.06 per pound, total feed cost would be $33 per sow per gestation period. Feeding stalls can allow more precise feeding thereby reducing feed cost by about 4.5%. Feed cost per sow per gestation period would be $31.50 using feeding stalls.

Initial facility cost is higher for the system that has feeding stalls and an elevated platform. Note that cost per gestation (including those costs in Table 4) is affected by the level of use of the facility. A system with feeding stalls with three gestation groups per year costs less than the basic system used for two gestation groups per year. It is important to realize that the costs in Table 4 do not include all costs. For example, labor for sow feeding and care, veterinary medicine, utilities, and repairs, are not included. Systems with feeding stalls and other enhancements increase the ease of working with the sows, providing shots, using artificial insemination, and tracking sick sows. Information of this type

<table>
<thead>
<tr>
<th>Table 4. Swine gestation cost comparison. (Partial costs)</th>
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<tbody>
<tr>
<td><strong>Facility Investment</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Building Cost</td>
</tr>
<tr>
<td>Feeders-Waterers</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Capacity (sows)</td>
</tr>
<tr>
<td>Investment per Sow Capacity</td>
</tr>
<tr>
<td>Gestated Litters per Sow Space per Year</td>
</tr>
<tr>
<td>Investment per Gestated Litter</td>
</tr>
</tbody>
</table>

**Cost per Gestated Litter**

| | **Facility Cost (16.5%)** | **Bedding Cost** | **Feed ($0.06 per pound)** | **Cleaning** | **Total per Gestation *** |
| | | | | | |
| | $10.54 | $15.81 | $17.88 | $26.81 |  |
| | $8.38 | $8.38 | $8.38 | $8.38 |  |
| | $33.00 | $33.00 | $31.50 | $31.50 |  |
| | $0.53 | $0.53 | $0.53 | $0.53 |  |
| | **$52.45** | **$57.72** | **$58.29** | **$67.22** |  |

*Note: Does not include all costs.*
along with the amount of labor or differences in labor between the two systems is not known. These trade-offs cannot be easily evaluated at this time and will be related to management styles.

Research Analysis

Figure 19 illustrates the layout for the breeding and gestation hoop barn at the Iowa State University Armstrong Farm, Lewis, Iowa. This system, while it has worked well, is relatively expensive due to a large amount of concrete, low animal density, and high equipment cost. However, it fills a niche because it is designed for a small herd and includes boar and breeding pens. Constructing a crated gestation barn for this size herd would be economically impractical. The environment within the hoop is generally not consistent from end-to-end, so animals in different pens will experience different environments. In addition to the research done in this barn, Iowa State University also has conducted longer-term research with gestating sows in hoop barns in southwest Iowa. Conclusions in this document are drawn from both research activities.

The research at Iowa State comparing the performance of group-housed gestating sows in bedded hoop barns (similar to that shown in Figure 14 with groups of 35 sows) to that of gestating sows in individual gestation crates has led to the following conclusions:

- Well managed groups of gestating sows in bedded hoop barns with individual feeding stalls can achieve performance comparable to that of individually crated sows.

- Feeding stalls are an excellent way to manage sows individually within the group and to minimize fighting over feed. The stalls also provide a safe place for sows that are the target of aggression during non-feeding times or for sows that want to lie on concrete during hot conditions.

- Housing a boar adjacent to the sow pens has made detection of recycling sows easy in hoop barns.

- Soundness problems were fewer for sows housed in bedded hoop barns than for sows housed on concrete slats.

- The hoop barn requires cleanout about two times a year.

- The watering area needs to be constructed to drain to the outside of the hoop barn.

- Sprinklers over the concrete feeding area even with feeding stalls are very effective in cooling gestating sows in bedded hoop barns.

Summary

For diversified, moderate-sized swine producers, hoop barns offer some additional considerations. The structures are versatile and could be used for alternative purposes, for example, hay, machinery, or grain storage. The hoop barns can be constructed with on-farm labor. The versatility, production flexibility, and low capital costs may result in reduced financial risk. The quality of the work environment is generally good, with no liquid manure and a large volume of naturally-ventilated

![Figure 19. University research and demonstration layout for a small herd with space for boars, breeding, and bedding.](image-url)
air inside the building. Manure can be stockpiled for spreading at appropriate times.

However, the added bedding increases the volume of solid manure and requires a different type of manure management than liquid manure. Some bedding may need to be protected from adverse weather for use late in the year. Low cost, high quality bedding must be a high priority for the system. Also, it is unclear whether pathogens will build up in the soil floor over long periods of use.

Following is a summary of questions to be examined when considering hoop barns.

- How often does the tarp need to be replaced?
- What types of bedding can be used?
- Will storage be needed for bedding?
- Will there be disease and parasite buildup in soil under the deep bedded area?
- Will heat from the decomposing manure pack cause problems in hot humid weather?
- Will manure and residue harvesting equipment need to be purchased as an added expense?

The full impact of new swine housing alternatives such as hoop barns needs to be evaluated for short- and long-term effects. Producers considering a hoop barn need to evaluate initial costs and operating costs for each alternative. They also need to gather as much information as possible about animal performance in different types of housing.

Among the major issues that a producer must consider are the following:

- Hoop barns have lower fixed costs and higher operating costs (for example: bedding, labor, feed usage) than totally enclosed housing.
- Hoop barns are versatile and can be used for other applications, such as machinery storage, if not used to house pigs.
- If the tarp covering needs to be replaced before 10 years, tarp replacement costs must be added to cost calculations.
- Because hoop barns have a lower initial cost, producers can test their capability in swine production without a large investment.
- Producers who want to erect more than one hoop barn for a swine operation may find that...
the volume of crop residue for soil conservation will become a limiting factor.
• Producers wishing to improve their situation of earthen lots or Cargill style lots with shelters have a low investment opportunity.
• Feeding configuration has important implications on cost and sow conditioning.
• Group management can affect sow productivity.

The financial information presented in Table 4 of this publication suggests that for a particular application, a hoop barn can be a competitive alternative building for pork production. However, producers should analyze their costs and compare alternatives. Given similar costs, other factors may tip the building decision to a hoop barn or a totally enclosed building.

Personal preference and perceived benefits of one style over another may sway a producer to choose the housing type that is more appropriate for a specific situation. For example, a producer who wants to expand quickly may find a hoop barn to be the best alternative, while another producer might conclude that the longer history and known attributes of totally enclosed housing are more appealing.

References and Resources
Additional information about the topics discussed in this publication is available in the following sources:


Reviewers
Michael Brugger, Facilities Administration, The Ohio State University
Ted Funk, Assistant Professor and Extension Ag Engineer, University of Illinois
Jim Lindley, Associate Professor of Ag Engineering, North Dakota State University (retired)
James Murphy, Professor and Extension Ag Engineer, Kansas State University
Steve Pohl, Extension Ag Engineer, South Dakota State University
Randall Reeder, Associate Professor and Extension Ag Engineer, The Ohio State University
Tim Safranski, State Swine Breeding Specialist, University of Missouri
Thomas Scherer, Extension Ag Engineer, North Dakota State University
Thomas Socha, Livestock Swine Specialist, North Dakota State University
LaVerne Stetson, Agricultural Engineer USDA-ARS, University of Nebraska (retired)
Brian Strobel, Extension Associate Livestock Systems, The Ohio State University

...And justice for all.