

IMPACT OF GESTATION HOUSING SYSTEM ON WEANED PIG PRODUCTION COST

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ABSTRACT. Construction and operating costs for two gestation housing systems were compared to assess their impact on cost per weaned pig produced. The systems compared were: 1) individual gestation stalls in a mechanically ventilated confinement building with slatted floor and 2) group pens with individual feed stalls in deep-bedded naturally ventilated hoop barns. Previous work has shown that reproductive performance of group-housed sows in hoop barns is equal to individually stalled sows, and for some measures, may be improved. Hoop barn gestation facilities can be constructed for 70% of the cost of typical confinement facilities with gestation stalls. Fuel and electricity use in mechanically ventilated gestation buildings is more than utility use in hoop barns, although bedding costs only occur in hoop barns. Assuming equal prolificacy, feed cost per pig weaned is 7% more for sows gestated in hoop barns, but total cost per pig weaned is 3% less for pigs produced by sows gestated as groups in hoop barns compared to pigs from individual stall gestation systems. When the reported increase (0.7 pigs/litter) in live pigs born for litters following hoop gestation was included in the cost analysis, the group housing in hoop barns for gestation resulted in a weaned pig cost that was 10% less than the cost of a weaned pig from the individual stall confinement system. In the upper Midwest United States, group housing of gestation sows in deep-bedded hoop barns may produce pigs at a lower cost than individual gestation stalls in confinement facilities if the bedded group housing system is managed optimally.

Keywords. Sow gestation, Bedded swine housing, Hoop barn, Alternative swine housing.

The sow is a robust animal and can perform well across a wide range of environmental conditions. Although the facility costs for farrowing are the greatest on most farms producing weaned pigs, the cost of gestation facilities is not inconsequential (Dhuyvetter and Tokach, 2005; Ellis et al., 2005). As part of the breeding herd, a sow will spend more than 85% of her time in gestation housing. Thus less capital intense systems that meet the needs of the animals may provide production cost advantages.

Historically most sows were housed in low-capital housing systems, usually in groups, and often with outdoor access. In 2001, 64% of the U.S. sow herd was gestated in individual gestation stalls inside of confinement buildings (USDA, 2001). Typical gestation stalls measure 2.2 × 0.6 m (Svendsen and Svendsen, 1997). Gestation stalls allow maximum stocking density within a capital-intensive building and sow-specific management of a large number of animals. Gestation stalls alter natural behavior patterns (Jensen and Wood-Gush, 1984; Stolba and Wood-Gush, 1989) and restrict movement (Barnett et al., 2001). Animal

welfare may decline in gestation stalls (Barnett et al., 1985; Broom et al., 1995), and public concern has led to both market and regulatory responses (Moynagh, 2000; Honeyman, 2005; Honeyman et al., 2006; Smith, 2007). European legislation, that takes effect in January 2013, prohibits keeping gestating sows as individuals for extended periods of time (Eur. Community, 2001).

Recent work has shown that reproductive performance of group-housed sows in hoop barns is equal to individual gestation stalls and for some measures may be improved (Lammers et al., 2007). The purpose of this study was to compare budgeted construction and operating costs for two gestation housing systems — individual gestation stalls in a mechanically ventilated confinement building with slatted floor, and group pens with individual feed stalls in deep-bedded naturally ventilated hoop barns. The costs associated with gestation facility type were included in an analysis of weaned pig production costs.

MATERIALS AND METHODS

The cost of producing a weaned pig can be divided into two parts: operating costs and fixed costs. Operating costs are the costs associated with actual production and include items such as feed, labor, and utilities. Fixed costs are costs that are incurred after a facility is built regardless of continued use of a particular building. Fixed costs include items such as depreciation, interest, insurance, taxes, and building repairs. Fixed costs are calculated based on the value of the facility. One method of valuing a facility is to consider the construction costs of a particular facility. In this analysis the projected costs of constructing a particular facility are used to calculate fixed costs. Operating and fixed costs are then

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compared for producing weaned pigs from different gestation housing systems.

OPERATING COSTS

Kansas State University Extension farrow-to-weaned pig cost-return budgets were adapted to compare operating costs for the two systems (Dhuyvetter and Tokach, 2005). Dhuyvetter and Tokach (2005) present detailed cost projections for a number of productivity scenarios using confinement facilities. The values for a productivity level of 21 weaned pigs sold per sow annually were utilized as the cost of production for a breed-to-wean operation using individual stalls in mechanically ventilated confinement facilities for gestation (Dhuyvetter and Tokach, 2005). Dhuyvetter and Tokach (2005) assumed 2.3 litters per sow annually.

Feed cost per litter was adjusted for the sows gestated in hoop barns to match relative amounts that were fed in an earlier study comparing reproductive performance of sows gestated in either deep-bedded hoop barns or individual gestation stalls (Lammers et al., 2007). Annual feed use by a sow is divided between two distinct production phases — gestation and lactation. Feed use during lactation was not different based on gestation housing system (Lammers et al., 2007). Our analysis assumes that lactation length will be 21 d/litter or 48 d/yr ($21 \text{ d/litter} \times 2.3 \text{ litters/yr}$). Thus for at least 13% of the year ($(48 \text{ d} / 365 \text{ d}) \times 100$) sows in the two systems will consume the same amount of feed. Temperature was not controlled in the hoop barns, and feed allotment to sows gestating in hoop barns was increased by a net 20% during five winter-months (November-March) to offset the colder environment. Sows housed in hoop barns received 20% more feed for 41% of the year if in gestation ($(151 \text{ d} \div 365 \text{ d/yr}) \times 100$). If a sow is nursing for 13% of the year, she is in gestation housing for 87% of the year or 317 d ($365 \text{ d/yr} \times 87\%$). Therefore a sow that is gestated in hoop barns will consume 20% more feed for 130 d/yr ($318 \text{ d in gestation} \times 41\%$) and the same amount of feed as a gestating sow housed in stalls for 187 d ($317 \text{ d gestation} - 130 \text{ d winter}$). In total, a sow housed in hoop barns will have the same feed cost as a sow housed in stalls for 235 d ($48 \text{ d lactation} + 187 \text{ d gestation outside of winter months}$) and will have a feed costs that is 20% more than the feed costs of an individually stalled sow for 130 d. Thus if we assume that the feed cost for sows housed in individual stalls is 1 unit/d or 365 units/yr, the feed allowance for sows in hoop barns becomes 391 units/yr ($(235 \text{ d} \times 1 \text{ unit/d}) + (130 \text{ d} \times 1.2 \text{ units/d})$). Therefore, the feed costs per litter from sows gestated in hoop barns is 7% more than the feed costs per litter from sows gestated in individual stalls ($391 \text{ feed units} \div 365 \text{ feed units}$).

Management and skill sets may be different for group housing systems than gestation facilities utilizing individual gestation stalls. However, group housing systems do not require more labor per animal than individual gestation stalls (Backus et al., 1997) and in some cases may require less (den Hartog et al., 1993; Bates et al., 2003). Labor use by different systems is difficult to quantify and varies depending on management skills, scale of operation, facility layout, and a variety of other factors. Our base system comparison was not designed to monitor labor by housing system (Lammers et al., 2007). The current analysis has gestation housing facility as the only difference between the two systems for producing weaned pigs. Labor during gestation is only a minor portion

of the total labor needed to produce a litter of weaned pigs. Therefore the authors decided to assume that equal labor is needed for the two systems on a per litter basis. Breeding and genetic charges, transportation and marketing costs, and professional fees are not dependent on gestation housing system and thus were kept equal for the two systems.

Bedding enhances the physical comfort of the floor, provides a stimulus and outlet for natural behaviors, and allows a sow greater control over her thermal environment (Barnett et al., 2001; Tuytens, 2005). Bedding does not uniformly impact sow health status (Tuytens, 2005). In a recent performance study, there was no influence on reproductive performance attributed to differences in sow health status (Lammers et al., 2007). In this analysis it is assumed that health status and thus veterinary, drugs, and related supplies are equal for the two systems on a per litter basis.

Bedding costs were calculated and added to the budget for sows gestated in hoop barns. Literature values for bedding use by gestating sows depends on the type of bedding used and range from 1.6 to 3.0 kg per day (Svendsen and Svendsen, 1997; Harmon et al., 2004). Corn stalks are commonly used as bedding in the Midwest United States and often cost \$0.02 to 0.04 per kg. This analysis assumes 2 kg of corn stalk bedding per day of gestation housing at a price of \$0.03 per kg (Harmon et al., 2004).

Utilities, repairs, depreciation, insurance, interest, and taxes were adjusted to reflect the differences between the two production systems. One-third of utility use on a breed-to-wean farm occurs in the farrowing facility (Carbon, 2005) ($\text{total utility costs} \times 33\% = \text{utility costs for farrowing from both systems}$). The major use of utilities by gestating sows in confinement facilities is operation of the ventilation system (Carbon, 2005). Hoop barns are naturally ventilated, and total utility use for feeding and watering systems found in hoop barns is very low. We estimate that utility use during gestation by sows housed in hoop barns is 10% of the utility use in individual gestation stalls. Thus total utility cost for a litter of pigs from sows gestated in hoop barns is 40% of the utility costs for a litter of pigs from sows gestated in individual stalls ($\text{total utility costs} \times 66\% = \text{utility costs for individual stall gestation}$; $\text{utility costs for individual stall gestation} \times 10\% = \text{utility costs for gestation in hoop barns}$; $33\% \text{ farrowing} + 7\% \text{ gestation} = 40\% \text{ utility costs for litters from sows gestated in hoop barns relative to litters from sows gestated in individual stalls}$).

CONSTRUCTION COSTS

General contractors familiar with agricultural construction in the Midwestern United States and suppliers of equipment and materials were surveyed during January 2006. The material list for the mechanically ventilated individual gestation stall facility is based on a 24- × 137-m facility with a totally slatted floor and a 2.4-m pit below the entire barn. This size of a facility would provide gestation housing for 1,700 sows. The material list for the deep-bedded hoop barns are based on two 9.1- × 27.4-m hoop barns constructed in January 2006 at the Iowa State University Swine Research Farm near Madrid, Iowa. The hoop barns were oriented north-south and provide gestation space for 52 sows each. Frost-free waterers and an automatic feeding system were included in the hoop building cost. A raised, concrete feeding platform was poured along the entire length

of the western walls of the hoop barns. Individual feed stalls with closing rear gates were installed on top of the platform. The platform extended 3.1 m from the western wall of the building and was 0.4 m higher than the finished floor of the lounging area. The entire lounging area had a 10.2-cm thick reinforced concrete floor. Example layouts of hoop-based systems are shown in MidWest Plan Service publications. The described layout is analogous to the one diagramed in figure 14, MidWest Plan Service AED 44 (Harmon et al., 2004).

The size of the sites required to build the two gestation systems is different and is accounted for in the analysis. In order to compare operations of similar size, it is assumed that the hoop barns needed to house 1,700 sows would be built on one site. It is assumed that the hoop barns will be built in one row with 6 m between adjacent buildings and a 6-m wide perimeter around the entire complex. The physical space occupied by the hoop barns would be 498.3 m × 39.4 or 2.0 ha. It is assumed that the confinement facility will have a 6-m wide perimeter around the entire structure thus the physical space required for the confinement facility is 36 × 149 m or 0.5 ha. For this analysis it is assumed that the value of land suitable for constructing gestation facilities is \$15,000/ha.

FIXED COSTS

Fixed costs—depreciation, interest, repairs, taxes, and insurance on buildings and equipment — are functions of construction cost and expected useful life (Dhuyvetter and Tokach, 2005). Hoop barn manufacturers offer a 15-year warranty on the tarp, although some hoop barns in operation are more than 20 years old and have not required replacement. Given production conditions and the rapidly evolving pig industry, a confinement facility with individual gestation stalls is likely to need major repair or retrofitting after a similar time period. Useful life of the building structure and equipment was assumed to be the same length for both types of gestation housing. It is assumed that the useful life of the building structure itself is 25 years and that the equipment will be replaced every 15 years (Dhuyvetter and Tokach, 2005).

Dhuyvetter and Tokach (2005) state that of the investment costs of a new farrow-to-wean facility, 47.6% of the costs are due to the farrowing facility and 52.4% of the costs are due to the gestation facility. In our comparison, both systems use a common farrowing facility and so the fixed costs allotted to the farrowing facility is the same for in both systems. Construction costs of hoop gestation are less than construction costs of individual gestation stall facilities. Thus the fixed costs for litters from sows gestated in hoop barns have been lowered using the following relationship: (total fixed costs × 52.4% × hoop facility construction budget:individual stall facility construction budget) + 47.6% = fixed costs for litters from sows gestated in hoops/fixed costs for litters from sows gestated in individual confinement stalls.

COST COMPARISONS

The cost of producing weaned pigs from the two systems were compared under two prolificacy scenarios. The first comparison assumed that productivity would be the same for both systems. The second comparison considered the

improved productivity of gestating sows kept in hoop barns that had been demonstrated in an earlier project (Lammers et al., 2007). Lammers et al. (2007) showed that sows gestated in deep-bedded hoop barns gave birth to 7.5% more live pigs per litter, (10.0 vs. 9.3 live pigs per litter) compared to sows gestated in confinement stalls. Pre-wean mortality was not affected by gestation housing. In the absence of cross-fostering between sows housed in different gestation systems, it is expected that sows gestated in deep-bedded hoop barns would wean more live pigs per sow based on more live pigs born per litter and equal pre-wean mortality.

RESULTS AND DISCUSSION

Prices used to generate budgets in this analysis were current for the year 2005. The given costs of individual budget items may become inaccurate due to inflation, deflation, or other factors. However this analysis is not a comparison of the actual cost of production per se, but rather a comparison of the relative difference in costs of producing weaned pigs using different gestation facilities.

General contractors' survey responses were used to generate component and total cost estimates per sow space. The survey responses are summarized in table 1. The construction cost per gestating sow space for group housing in hoop barns was 30.5% less than the construction cost per gestating sow space for individual confinement stalls (table 1).

Canadian work comparing gestation stalls to hoop barns equipped with individual feeding stalls shows that return to estrus following weaning was not affected by housing treatment (Connnor et al., 1997). Other researchers have also compared group housing systems to individual gestation stalls. Phillips (1997) found no difference in length of farrow-to-farrow interval between group housed sows and those kept in individual gestation stalls. Dutch research conducted over a 2-year period supports these findings and found number born alive, annual weaned pigs per sow, and wean-to-insemination interval were not different for group housed and individually stalled sows although there were trends favoring the group housed sows for those reproductive measures (Backus et al., 1997).

Table 1. Estimated construction costs^[a] per sow space for two gestation systems.

Item	Conf ^[b] (\$)	Hoop ^[b] (\$)	Hoop : Conf (%)
Land costs ^[c]	4.41	17.65	400.0
Building structure ^[d]	265.00	249.94	94.3
Ventilation system ^[d]	150.00	0	0
Flooring and manure storage ^[d]	135.61	78.13	57.6
Feed and water system ^[d]	71.20	58.77	82.5
Other expenses ^[d]	193.78	165.51	85.4
Total construction cost	\$820.00	\$570.00	69.5

^[a] Assumes facilities to house 1,700 sows.

^[b] Conf = individual gestation stalls in confinement facility;
Hoop = group pens in hoop barns with individual feed stalls.

^[c] Calculated: Conf = (0.5 ha × \$15,000/ha) ÷ 1,700 sow spaces;
Hoop = (2.0 ha × \$15,000/ha) ÷ 1,700 sow spaces.

^[d] Estimates based on survey of Midwest U.S. construction firms building gestation facilities.

Recently completed work in Iowa examined performance of gestating sows housed in deep-bedded hoop barns or individual gestation stalls in a confinement facility over a 2.5-year period (Lammers et al., 2007). All litters were farrowed in a mechanically ventilated building with raised farrowing crates. No bedding was used during farrowing or by the sows housed in individual stalls during gestation. For the last third of pregnancy and in winter months, feed allowance was increased for both gestation housing systems. During the months November-March, sows gestated in deep-bedded hoop barns received 20% more feed than sows kept in stalls to offset the colder temperatures. Lactating sows were fed *ad libitum*, and there was no difference in lactation feed intake between the two gestation housing systems (Lammers et al., 2007). During a one-year period, sows gestated in hoop barns received 107% of the feed that sows gestated in individual stalls were fed during gestation and lactation. Projected cost per weaned pig for the two systems with equal prolificacy are reported as table 2. This projection assumes that both systems have equal reproductive performance and ultimately produce 21 weaned pigs annually from 2.3 litters per sow.

The construction cost per sow space for group housing in hoop barns was 30.5% less than for individual confinement stalls. In this analysis sows housed in hoop barns in winter (November-March) consumed more feed during gestation than stalled sows resulting in 7% higher annual feed cost per weaned pig for the group housing system (table 1). The operating costs associated with weaned pigs from the hoop barn gestation system were 1% more than the operating costs for the individual stall system (table 2). Fixed costs were greater for confinement stalls than for hoop barns. Total fixed costs for hoop gestation were 84% of the total fixed costs for stall gestation (table 2). Assuming equal prolificacy, group housing in hoop barns during gestation resulted in a weaned pig total cost that was 3% less than the total cost of a weaned pig in the individual stall system (table 2).

Other workers have documented differences in sow prolificacy based on gestation housing (Morris et al., 1998; Bates et al., 2003). Iowa work demonstrated that sows housed in hoop barns for gestation farrowed 7.5% or 0.7 more live pigs per litter and had equal pre-wean mortality rates as sows housed in individual gestation stalls (Lammers et al., 2007). Projected costs per weaned pig that take into consideration the increase in litter size for group housed sows are reported as table 3.

Estimated costs of production per litter were divided by the number of pigs weaned from sows gestated in the two systems. When differences in prolificacy are included in the analysis, production cost per pig weaned is reduced for sows housed in deep-bedded hoop barns. Operating costs are 6% less to produce a weaned pig from a sow gestated in deep-bedded hoop barns (table 3). Total cost per pig weaned is 10% less for pigs from sows gestated in deep-bedded hoop barns compared to pigs from sows gestated in individual gestation stalls in confinement buildings (table 3).

CONCLUSIONS

Keeping sows in individual gestation stalls is coming under increased scrutiny. Reproductive performance can be maintained or enhanced in well-managed group housing systems such as deep-bedded hoop barns without increasing

Table 2. Budgeted costs per litter for two gestation systems with equal prolificacy.^[a]

Item	Conf ^{[b], [c]}	Hoop ^[b]	Hoop : Conf (%)
Pigs	9.1	9.1	100
Operating costs			
Feed	\$62.18	\$66.53 ^[d]	107
Labor	\$63.37	\$63.37 ^[e]	100
Breeding/genetics charge	\$46.84	\$46.84 ^[e]	100
Bedding	0.00	\$8.27 ^[f]	na
Utilities, fuel, and oil	\$16.34	\$6.54 ^[g]	40
Transportation, marketing	\$15.98	\$15.98 ^[e]	100
Veterinary, drugs, supplies	\$9.13	\$9.13 ^[e]	100
Professional fees	\$4.38	\$4.38 ^[e]	100
Operating costs subtotal	\$218.22	\$221.04	101
Interest on 1/2 operating costs ^[h]	\$7.64	\$7.74	101
Total operating costs	\$225.86	\$228.74	101
Fixed Costs			
Depreciation	\$29.95	\$25.16 ^[i]	84
Interest	\$28.30	\$23.77 ^[i]	84
Insurance and taxes	\$8.58	\$7.21 ^[i]	84
Repairs	\$16.53	\$13.89 ^[i]	84
Total fixed costs	\$83.36	\$70.03	84
Total costs per litter	\$309.22	\$298.83	96.6
Total costs per weaned pig	\$33.98	\$32.84	96.6

[a] From Dhuyvetter and Tokach (2005).

[b] Conf = system that uses individual gestation stalls; Hoop = system that uses groups pens in deep bedded hoop barn with individual feeding stalls for gestation.

[c] Conf values taken directly from Dhuyvetter and Tokach (2005). Hoop values adjusted as followings.

[d] Sows gestated in Hoop consumed 107% more feed annually than sows gestated in Conf. $\$62.10 \times 107\% = \66.53 .

[e] Identical under both systems.

[f] Bedding calculation: $(2 \text{ kg bedding/d of gestation} \times 317 \text{ d of gestation/yr} \times \$0.03/\text{kg bedding}) \div 2.3 \text{ litters/yr} = \$8.27/\text{litter}$.

[g] Litters from sows gestated in Hoop require 40% of utility use as litters from sows in Conf. $\$16.34 \times 40\% = \6.54 .

[h] Interest calculation of 1/2 of operating costs: Operating costs $\times 50\% \times 7\%$ interest.

[i] Farrowing facility cost is 47.6% of total fixed costs and is constant for both systems.

Gestation facility cost is 52.4% of total fixed costs.

Budgeted construction costs for deep-bedded hoop barn gestation is 69.5% of budgeted costs for individual stall gestation facility.

Hoop Fixed Costs = (Conf Fixed Costs $\times 47.6\%$) + (Conf Fixed Costs $\times 52.4\% \times 69.5\%$) = $84\% \times$ Conf Fixed Costs.

stockman labor during gestation (den Hartog et al., 1993; Backus et al., 1997; Bates et al., 2003). Construction and fixed costs are less for hoop barns equipped with individual feed stalls as compared to mechanically ventilated confinement systems. Operating costs are similar for both systems, but total costs per weaned pig are less for the system utilizing hoop gestation. When reported production differences were taken into account, the group housing of gestating sows in hoop barns resulted in a weaned pig cost that was 10% less than the cost of a weaned pig from the individual stall confinement system. In the Midwestern United States, group housing of gestating sows in deep-

Table 3. Budgeted costs per weaned pig for two gestation systems with different prolificacy.^[a]

Item	Conf ^{[b][c]}	Hoop ^{[b][d]}	Hoop:Conf (%)
Pigs	9.1	9.8	108
Operating Costs			
Feed	\$6.83	\$6.79	99
Labor	\$6.96	\$6.46	93
Breeding/genetics charge	\$5.15	\$4.78	93
Bedding	\$0.00	\$0.84	na
Utilities, fuel, and oil	\$1.80	\$0.67	37
Transportation, marketing	\$1.76	\$1.63	93
Veterinary, drugs, supplies	\$1.00	\$0.93	93
Professional fees	\$0.48	\$0.45	94
Operating costs subtotal	\$23.98	\$22.56	94
Interest on 1/2 operating costs	<u>\$0.84</u>	<u>\$0.79</u>	94
Total operating costs	\$24.82	\$23.35	94
Fixed Costs			
Depreciation	\$3.29	\$2.57	78
Interest	\$3.11	\$2.43	78
Insurance and taxes	\$0.94	\$0.74	78
Repairs	<u>\$1.82</u>	<u>\$1.42</u>	78
Total fixed costs	\$9.16	\$7.15	78
Total costs per litter	\$309.22	\$298.83	96.6
Total costs per weaned pig	\$33.98	\$30.49	89.7

[a] From Dhuyvetter and Tokach (2005).

[b] Conf = system that uses individual gestation stalls;
Hoop = system that uses groups pens in deep bedded hoop barn with individual feeding stalls for gestation.

[c] Costs from table 2 divided by 9.1 pigs.

[d] Costs from table 2 divided by 9.8 pigs.

bedded hoop barns may produce pigs at a lower cost than individual gestation stalls in confinement facilities.

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