Construction Resource Use of Different Types and Scales of Swine Production Facilities

A.S. Leaflet R R2471

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Summary and Implications

As global populations and affluence rise, there is increasing demand for energy, animal protein, and construction materials. In some cases, available resource pools are insufficient to meet growing market demands, resulting in increased prices and competition for limited resources. This study evaluates key construction resources needed to build different types and scales of swine production facilities. Two types of facilities—conventional confinement and hoop barn-based—within farrow-to-finish pig production systems scaled to produce either 5,200 or 15,600 market pigs annually are examined. Conventional confinement facilities are typical of pork industry practice in the United States and are characterized by individual gestation stalls and 1,200 head grow-finish buildings with slatted concrete floors and liquid manure systems. The hoop barn-based alternative uses bedded group pens in hoop barns for gestation and finishing. Five building materials: concrete, steel, lumber, thermoplastics, insulation, as well as crushed rock and diesel fuel used for building site preparation are considered. Land surface area required for buildings and pig production infrastructure are also compared. Fewer construction resources are needed to construct a hoop barn-based swine production system than conventional facilities. Using hoop barns for grow-finish and gestation also results in lower construction costs. Increasing the scale of pig production results in lower construction costs per pig space, however the construction costs per pig space for a 5,200 head hoop barn-based complex is less than the construction costs per pig space for a 15,600 head conventional confinement system. Hoop barns for swine are a viable alternative that are less dependent on the scale of production than conventional confinement facilities.

Introduction

Global population is projected to reach 9.2 billion people in 2050 and if realized will represent an increase of more than 360% over a 100 year time period. Population in China and the United States is also projected to increase dramatically. Those two countries lead the world in pork production and consumption, a trend that is likely to continue. Increased population and rising incomes have created increased market demand for energy, animal protein, and construction materials globally. Over time, increased market demand for available resources typically results in greater price competition for those resources. Examining the amount and types of construction resources needed to build different types of pig production systems will help pork producers and industry leaders prepare for the future.

Methods

This project considers input of construction resources for different types and scales of swine production facilities based upon physical material flows. Two types of facilities—conventional confinement and hoop barn-based are considered within identically scaled farrow-to-finish production systems. The conventional confinement system is typical of pork industry practice in the United States and is characterized by individual gestation stalls and 1,200 head grow-finish buildings with slatted concrete floors and liquid manure systems. The hoop barn-based alternative system uses group pens in bedded hoop barns for gestation and finishing. Both systems will use farrowing crates and climate controlled nursery facilities and are summarized in table 1. Resource use is related to volume of pig flow and so pig production systems sized to produce batches of either 400 or 1,200 pigs every 28 d, or 5,200 and 15,600 pigs annually are compared.

Five primary building materials are reported: concrete, steel, lumber, insulation, and thermoplastics. Each material is not a homogenous entity, but for this comparison material specifications have been standardized and material use is reported by mass. For this comparison, the volume of each material was calculated from a list of materials for each building and then multiplied by a density factor appropriate for the material. Material prices were established by interviewing multiple suppliers operating in Iowa and are summarized in table 2.

It was assumed that the building site had adequate wells, electrical service, and entrance driveway.

Building site preparation includes excavating manure storage pits, backfilling completed manure storage pits, grading the entire building site, and building access roads. Volume and type of earthwork was estimated based on discussions with contractors working in Iowa. Appropriately sized machines and fuel use for earthwork were then determined from equipment company literature.

Labor was estimated using RS Means Facilities Construction Cost Data, a resource commonly used by construction firms. Labor cost is a combination of time and the value of labor. Labor costs are highly dependent on specific activities, for example the labor cost of excavating a cubic meter of soil is nearly twice the labor costs of grading the same volume of soil. Task specific labor costs were calculated and then divided by a value of $20.00/hour to estimate total hours of generic construction labor for each pig production system.

Results and Discussion

Table 3 presents construction resource use for swine production facilities. Increasing the number of pigs sold annually resulted in increased use of construction resources. However, in most cases tripling pig production space increased construction resource use by less than 300%. There was little overall difference in the magnitude of resource use between the two scales of pig production within a facility type. More land area is necessary to site the hoop barn-based systems, but fuel use to perform earthwork operations is half of what conventional confinement facilities require. Generally, fewer building resources were required for the hoop barn-based systems.

The hoop barn-based system designed to produce 15,600 market pigs annually uses 15–16% less concrete and lumber as compared to the equivalent conventional system. Both systems use approximately the same amount of thermoplastics. Because hoop barns are not insulated, insulation use for the hoop barn-based system is less than 50% of the insulation use for the conventional system. In hoop barns, thermoplastic tarps cover metal trusses to create the roof of the building. Conventional facilities use steel sheeting for roofing material. In the grow-finish phase, 1 hoop barn is usually managed as a single pen, housing 180–200 pigs with minimal steel fencing. Steel fencing is extensively used in sorting and load-out areas that are shared among 6–8 hoop barns. In conventional 1,200-head grow-finish barns the barn is usually subdivided into multiple pens of 20–60 pigs using steel fencing material. Use of hoop barns for gestation and grow-finish production results in 71% less steel use for the entire hoop barn-based production system when compared to the conventional system.

Table 4 summarizes the estimated construction costs for swine facility complexes based on material mass. Based on material mass the cost per pig space for a hoop barn-based facility sized to produce 15,600 pigs is $92, while the hoop barn-based facility producing 5,200 pigs annually can be built for a cost of $107/pig space. Both are lower than the costs of building a 15,600 head conventional confinement facility which in turn is less than the construction cost of a 5,200 head conventional confinement facility. In the conventional confinement system, increasing size from 5,200 head to 15,600 head results in reducing construction costs by 25%. In the hoop barn-based system increasing the size of facilities from 5,200 head to 15,600 head results in a 14% reduction in construction costs.

Actual building costs are likely to be different than the estimates presented. However, it is expected that the magnitude of differences between conventional confinement facilities and hoop barn-based systems remain relatively constant. Systems that use bedded hoop barns for gestation and grow-finish cost less to construct than conventional confinement facilities for identically sized operations. Increasing the total volume of pigs produced results in reduced construction cost per pig space, however the hoop barn-based system producing 5,200 pigs annually costs less to construct per pig space than the conventional confinement facilities producing 15,600 pigs annually.

Based on construction costs per market pig sold, there is more incentive to increase the scale of pig production in conventional confinement systems than in hoop barn-based systems. If all firms have access to construction resources at the same price, construction cost per market pig sold for a hoop barn-based production facility sized to produce 5,200 market pigs annually is less than the construction costs per market pig sold for a conventional confinement facility producing 15,600 market pigs annually. Firms that are building facilities on a larger scale may be able to achieve some resource pricing advantages over smaller firms. However, it is unlikely that a conventional confinement swine facility sized to produce 15,600 pigs annually would have more negotiating clout than a hoop barn-based swine facility producing the same number of pigs.

Hoop barn-based swine facilities use less concrete, steel, lumber, thermoplastics, insulation, diesel fuel, and labor to construct than identically sized conventional confinement facilities. More crushed rock and land is needed for hoop barn-based swine facilities but these are relatively small contributors to the total construction costs of swine facilities. The relative impacts of resource price changes are similar for both types and scales of swine facilities examined. The construction costs of hoop barn-based swine facilities are more sensitive to land prices than conventional confinement facilities, but land price is a relatively minor factor in total construction costs. Increasing the scale of facilities

from 5,200 pigs to 15,600 pigs reduces construction costs per pig space regardless of system, but the magnitude of construction cost reduction is less for hoop barn-based facilities than conventional confinement facilities. Regardless of method for estimating construction cost, a swine production facility producing 5,200 market pigs annually and using hoop barns for gestation and grow-finish costs less to build per pig space than a conventional confinement swine facility producing either 5,200 or 15,600 market pigs annually. Hoop barns for swine are a lower cost alternative that is less scale dependent than conventional confinement facilities. As competition for construction resources increase, the cost advantages of building hoop barn-based swine facilities are expected to increase.

Acknowledgements

This project was supported by the Hatch Act, State of Iowa Funds, USDA North Central Regional SARE Graduate Student Grant Program, and the Leopold Center for Sustainable Agriculture.

Table 1. Pork production systems compared.

	System	
Production phase	Conventional	Hoop barn-based
Breeding and Gestation	individual stalls with deep pit	group pens in bedded hoop barns
Farrowing[1]	crates with pull plug system	crates with pull plug system
Nursery	pens with shallow pit	pens with shallow pit
Grow-finish	pens with deep pit	pens in bedded hoop barns
Bedding storage	not applicable	hoop barns

[1] Manure from farrowing building stored in gestation pit (conventional) or adjacent outside storage pit (hoop barn-based).

Table 2. Estimated market value of construction resources.

Resource	Value
Concrete	$0.04/kg
Steel	$1.14/kg
Lumber	$0.23/kg
Thermoplastics	$1.00/kg
Insulation	$0.59/kg
Crushed rock	$0.02/kg
Diesel fuel	$1.00/liter
Labor	$20.00/hour

Table 3. Construction resource use for swine production facilities.

		Conventional		Hoop barn-based	
Pigs sold annually		5,200	15,600	5,200	15,600
Construction Resource					
Concrete, kg		2,373,080	6,379,581	1,916,752	5,405,335
Steel, kg		114,670	317,162	90,086	221,901
Lumber, kg		56,029	151,074	44,985	129,856
Thermoplastics, kg	32,007	67,466	37,123	64,823	
Insulation, kg		19,361	51,017	9,210	24,325
Crushed rock, kg		132,000	264,000	303,600	475,200
Diesel fuel, l		1,562	3,910	753	1,700
Land, m^2		11,868	24,870	16,671	32,117
Labor, hr		23,000	45,900	14,300	39,300

Table 4. Estimated construction costs for swine facility complexes based on material mass[1].

	Conventional		Hoop barn-based	
Pigs sold annually	5,200	15,600	5,200	15,600
Concrete	$94,932	$255,183	$76,670	$216,213
Steel	$130,724	$361,565	$102,698	$252,967
Lumber	$12,887	$34,747	$10,346	$29,867
Thermoplastics	$32,007	$67,466	$37,123	$64,823
Insulation	$11,423	$30,100	$5,434	$14,352
Crushed Rock	$2,640	$5,280	$6,072	$9,504
Fuel	$1,562	$3,910	$753	$1,700
Land	$23,200	$48,800	$32,800	$63,200
Labor	$460,000	$918,000	$286,000	$786,000
Total	$769,375	$1,725,051	$557,896	$1,438,626
Construction cost per market pig sold	$148	$111	$107	$92

[1] Calculated by multiplying material use reported in table 3 by estimated market values of materials presented in table 2.