A COST ANALYSIS OF SWINE CONFINEMENT BUILDING SYSTEMS

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Robert R. Burr

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A COST ANALYSIS OF SWINE CONFINEMENT BUILDING SYSTEMS

By

Robert R. Burr

A THESIS

Submitted to the School for Advanced Graduate Studies
of Michigan State University of Agriculture
and Applied Science in partial fulfillment
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MASTER OF SCIENCE

Department of Agricultural Economics

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ABSTRACT

Specialization and rapid changes in technology concerning the construction of swine confinement buildings have caused much confusion among swine producers. This study is undertaken to alleviate part of this confusion by analysing twenty-six building alternatives and four swine confinement building systems. The building alternatives were selected on the basis of apparent popularity and use and according to recommendations by extension services of several midwestern universities.

The alternatives are analysed within a theoretical framework of dynamic production economics. Assuming the problem of the producer is to decide on the most desirable building alternative, the decision making process of : (1) defining the problem, (2) observing, (3) analysing, (4) deciding, (5) taking action and (6) assuming responsibility is used as the outline of the study.

The twenty-six alternatives include farrowing buildings, nursery buildings, combination farrow-nursery buildings, finishing buildings and a farrow-to-finish building.

A floor plan and cost estimate of each building alternative is presented to make possible an analysis from the viewpoint of agricultural engineering, swine husbandry and

agriculture economics. In addition, the use of each type of building was determined from two aspects: (1) physical limitation of the building and (2) physical possibilities of the pig.

Comparable building alternatives were selected from the twenty-six alternatives and placed into four swine building systems. The building cost of the system per pig produced at maximum efficiency was found to be:

Building System I	$66.06
Building System II	55.22
Building System III	55.65
Building System IV	57.11

In the author's opinion, Building System III is concluded to be the most profitable system for the swine producer.

The various levels of output of the building alternatives was determined to ascertain the efficiency of the building systems. It was found one set of buildings of Building System I could be used by two groups of pigs per year, Building System II could be used by four groups of pigs per year, Building System III could be used by ten groups of pigs per year and Building System IV could be used by twelve groups of pigs per year.

Throughout the study it was stressed that swine confinement production entails superior management practices. The swine producer must operate his swine enterprise as a business. In addition, it was emphasized that the swine producer must examine his values and goals and those of his family and associates before entering the business world of confinement swine production.

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CHAPTER I

INTRODUCTION

Reasons for the Study

The fact that the agriculture portion of the American economy is able to feed over 180 million people is evidence of the high productivity of present methods utilized by American farmers. The swine porducers in the economy produce 70-80 million head of swine annually.[1]

In spite of the high level of productivity, there are many problems of swine production. These problems pertain to such areas as: nutrition, breeding, disease, marketing and housing. The author has selected the housing phase of the swine problem area as the subject of this thesis. Since the problem area is too broad to enable the presentation of the entire housing problem, one phase will be discussed.

There are two systems of swine housing: (1) confinement and (2) pasture. The confinement housing method in the author's opinion is the most desirable in most cases because such resources as labor, capital, and land are

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[1] Livestock and Meat Situation, USDA, Nov 1961, LMS-120, p. 22.

used more efficiently than under pasture systems. Confinement methods have been attempted in the past but they have usually met with disaster because of disease or nutritional problems. Today it is possible to use confinement methods because much has been learned about disease and nutrition.

It is the feeling of the author that one of the biggest challenges facing swine producers is the selection of a swine confinement housing system. Some swine experts believe that one swine producer can provide the labor and management to raise over two thousand pigs a year in a confinement system. There is much disagreement among scientists, farmers and related persons as to the approach to these unique and dynamic swine producing systems. There seem to be as many ideas as there are producers. This thesis will be concerned with an examination of these building ideas as a potential area of profit and satisfaction.

Objective of the Study

The objective of this thesis is a cost analysis of swine confinement structures and the utilization of these structures in swine confinement systems. The utilization of agricultural engineering and animal husbandry concepts which will enable the swine producer to evaluate each structure and system will also be considered.

Methodology

The swine producer should use a logical theoretical framework to make decisions pertaining to the objective. The outline of the theoretical decision-making framework which will be used is: (1) define the problem, (2) observe, (3) analyse, (4) decide, (5) take action, (6) assume responsibility.

The definitions and assumptions of the objective are stated when the problem is defined. The definitions pertain to the various structures, their use and related terminology. Assumptions which are used as a basis for design of the structures and the systems are stated from the viewpoint of the agricultural engineer and the animal husbandry specialist.

Related problems pertaining to the successful design of a swine confinement system are observed. The problem areas to be discussed are: (1) the advantages and disadvantages of confinement and (2) multiple farrowing.

The swine producer must analyse each alternative building or system because rapid technological gains in the fields of agricultural engineering and animal husbandry have given the swine producer a tremendous package of new ideas and concepts of swine production. Modern technological advances are making possible a revolution in the hog lots that will probably equal if not excel the relative increase in corn production achieved from the introduction of hybrid corn.

The analysis of the building alternatives consists of a discussion pertaining to the following four areas (1) agriculture engineering, (2) animal husbandry, (3) agriculture economics, and (4) the human element. The use of such an analytic procedure will enable the swine producer to examine his enterprise from most of the relevant points.

The modern swine producer is faced with a host of decisions. There are decisions relating to engineering, husbandry, economic and human problems which must be made by the swine producer.

There are engineering problems relating to use of materials of construction, method of design, materials handling equipment, and the size of the building.

The control of stress factors is an animal husbandry problem. Such stress factors as temperature, drafts, feed and water may be controlled in a confinement system. Such stresses as overcrowding, sorting, boredom, and psychological disturbances must also be considered when selecting a swine confinement system.

Agriculture economics is concerned with the allocation of resources in the buildings and systems. More specifically, attention will be directed towards a cost comparison of all buildings and systems.

As the number of hogs increase with the herd, as costs continue to rise, and as net returns continue to level out or lower, it becomes imperative that the farmer give serious consideration to those costs which are contractual and which are non-contractual.[2]

The human element must be considered, before a swine system is selected. If swine production is as dynamic as has been indicated, if great technological advances have been made, if swine production is a business and not a way of life, if profit is not the only goal of the farmer; where then does the swine producer and his family fit into this mechanized, industrialized, economized and specialized picture? Therefore, the farmer must consider his goals and aspirations, those of his family and others.

These problem areas are part of the analytic procedure which may be used to ascertain the most desirable swine building and swine confinement system.

The theoretical framework will be a decision-making process which will enable the swine producer to: (1) define the problem, (2) observe, (3) analyze, (4) decide, (5) take action, (6) assume responsibility.

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[2]The term contractual cost is used in the same context as fixed cost. Contractual means that the cost has been set for a period of time. The term non-contractual cost is used in the same context as variable cost. Non-contractual cost are those which can vary after the planning period has started. The two terms are used to alleviate confusion about the terms fixed and variable cost.

CHAPTER II

THEORETICAL FRAMEWORK

Introduction

The farmer, whether he is aware of it or not, operates his farm utilizing economic theory. The economic theory should enable the swine producer to make right decisions. Therefore, the farmer must rely on some form of decision-making process to accomplish his goal.

The portion of economic theory which presents a logical consistent framework for decision-making and evaluation of swine confinement buildings and systems is agriculture production economics.

Agriculture production economics is defined as that theory "which facilitates choice in production patterns and resource use so that the ends of objectives of the farmers and consumers can be attained."[3]

Agriculture production economics is divided into two areas: (1) macro theory and (2) micro theory. Micro theory will be utilized in this thesis for two reasons:

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[3]Earl O. Heady, Economics of Agricultural Production and Resource Use. (Englewood Cliffs, New Jersey: Prentice-Hall, Inc, 1952) p. 3.

(1) The theory is sufficiently developed to use as an outline for evaluating swine buildings and systems.
(2) Micro theory pertains to the study of the individual firm. The swine enterprise is either a part of an individual firm or an entire individual firm, therefore micro-theory is used as a basis for decision making.

Micro theory pertains to the allocation of the swine producer's resources in such a manner as to enable the swine producer to choose the most "desirable" production combination of inputs and output.[4] The theory is divided into two areas: (1) micro static production economics and (2) micro dynamic production economics.

Micro static production economics through such assumptions as perfect knowledge, profit maximization, satisfaction maximization, fixity of production and consumption functions, and stable institutions, provides a foundation of economic concepts and direction of action in a given situation. Management and decision-making are skills in such a theory because the entrepreneur has perfect knowledge and control over all variables.[5] An outline which presupposes such confining assumptions is inoperative because the assump-

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[4]"Desirable" refers to level of profit or satisfaction, or some combination of the two.

[5]Lawrence A. Bradford and Glenn L. Johnson, Farm Management Analysis, (New York, New York: John Wiley and Sons, Inc., 1953) p.425.

tions fail to apply to the real world.

Micro dynamic production economics is a theory in which the rigorous assumptions of micro static production economics have been relaxed. The relaxation of the assumptions creates a theory in which there is uncertainty, unstable institutions, changes in technology and failure to maximize profit or satisfaction.[6] The theory is applicable to the objective because the theory applies to the real world in which the objective exists. Formulated micro-dynamic production economics consists of a decision-making process enabling the swine producer to arrive at the right action.[7] The decision-making process consists of six steps: which will enable the manager to: define the problem, observe, analyse, decide, take action, and assume responsibility. The first three of these six steps will be used as an outline to the remainder of this thesis.

Problem Definition

Swine building problems may be viewed by various swine

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[6]Agriculture Production Economics course outline, Spring Quarter 1961, Agricultural Economics 856, (Agricultural Economics Dept., Mich. State University, East Lansing, Mich) p. 2.

[7]"A right action or goal is an action or goal determined to be the best in view of the factual and normative beliefs involved, where 'best' means 'that which maximizes human interests and purposes as indicated by the value concepts involved.'" For more information see, G.L. Johnson and Lewis K. Zerby, Values in the Solution of Credit Problems, (Michigan State Univ.: East Lansing, Mich., 1960) p. 3.

producers in different ways. A swine producer will define the problems of his enterprise according to his own ideals, values and beliefs. Another swine producer in the same circumstances will define other problems. Or his definition of the same problems as the first producer may be according to a different set of ideals, values, and beliefs. Omitting intangibles, rationality is the only basis for evaluating each producer's definition of the problem.

The "definition of the problem" should clarify the underlying assumptions and the particular viewpoint from which the problem was formulated. The assumptions of the situation must be stated formally or informally to permit rational solution. For example, if a 114 day gestation period is used in determining a multiple farrowing schedule, the assumption should be recognized. If a 100 day gestation period is used by another producer his multiple farrowing schedule would be quite different. For this reason all of the assumptions of the particular farm situation must be stated to insure understanding of the problem. The assumptions furnish restrictions to technology and economics.

Observation

To observe is to --"perceive, notice, and watch a question or situation for a proposed solution."[8] Through observation the swine producer will observe possible alternative buildings, and information relating to efficient use of the buildings. Information places a manager in a knowledge situation where he may proceed to analyse and make a decision.

Information is classified to enable the swine producer to acquire relevant information in a logical and consistant manner. There are two methods of classifying information: (1) according to type and (2) by source.

The types of information that are important to the swine producer are classified as follows:[9]

(1) Existing production methods -- Information which affects farm practices, such as: specialization and reorganization of the farm.

(2) Prices -- Information on prices of inputs and outputs in organizing or operating a farm.

(3) Innovations -- Information on new technology which changes the production function.

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[8] Websters New Collegiate Dictionary, (G. & C. Merriam Co: Springfield, Mass), 1959, 580.

[9] Glenn L. Johnson and Cecil B. Haver, Agricultural Information as an Aspect of Decision Making, (Michigan State University Agriculture Experiment Station: East Lansing, Mich) Tech Bul 273, p. 21.

(4) Human -- Information about individuals that the producer must deal with or consider in making decisions about the farm.[10]

(5) Institutional -- Information on informal or formal groups, local, state, national, and international government which may affect decisions in the operation and organization of the farm.[11]

The sources of information for the swine producer may be considered as two kinds: (1) communicative and (2) non-communicative.

Communicative information is obtained from media, such as: radio and television, conversation with neighbors, college bulletins, machinery mnaufacturers (advertising and technical assistance), and farm magazines.

Non-communicative information is acquired through personal observation. Some of the sources commonly employed are: 4H projects, FFA work, previous employment.

If information is to be used in a logical and efficient manner, the manager must examine the sources of information and recognize their contribution and relationship to his enterprise. For example, several weeks spent

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[10] Ibid., p.30-32.

[11] Ibid., p.32.

visiting other swine enterprises, talking to university extension personnel, and visiting swine husbandry specialists, agricultural engineers, and economists may be more profitable than relying on a multi-product salesman to plan the swine enterprise. Specialization within agriculture has furthered the difficulty of obtaining sources of information which coincide with the problem. For example, if a farrowing house is constructed, the swine producer must visit many firms, some of which have no concept of the problem. This will involve discussions with persons familiar with only a particular part of the entire problem. It is left to the manager to discover and obtain the sources of information which coincide with a particular problem.

Analysis

One purpose of analysis is to determine the high-profit point of a production function. The analysis further tells the producer whether he can produce profitably and how much to produce. Average costs are considered in the analysis of profitability of a certain level of output. Marginal concepts are utilized in determining how much to produce. Since this thesis is concerned with ascertaining the cost of various building systems, consideration will be limited to examining the relative profitability of each building and system of buildings. Therefore the theory to be presented will pertain to average cost concepts.

Two reasoning processes which are used as a outline to analysis are: (1) induction and (2) deduction. Inductive and deductive reasoning are two different procedures of analysis to which the same rules of logic apply.

Deductive Systems as a Theory of Analysis

Deduction is defined as "reasoning from the general to the particular or from the universal to the individual."[12] Deduction requires the use of several disciplines in the solution of problems. In analysing a swine enterprise, those disciplines of particular, but not exclusive concern are:[13]

(1) Logic and Mathematics -- application of this discipline is necessary if rationality of decision is sought. Common sense should be included throughout this process of deduction.

(2) Physics is necessary for the solution of engineering problems. Engineering is necessary for the solution of problems concerning building construction, materials handling equipment, and heating systems. Since the agricultural engineer is familiar with the problems of the

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[12] Webster, op.cit., p. 215.

[13] Agric. Pro. Econ. course outline, op.cit., p.7.

swine producer and the solutions to those problems, he is directly concerned with the planning of a swine confinement building system.

(3) Chemistry, Zoology, and Botany are necessary for the solution of animal husbandry problems. Swine husbandry is concerned with the physiological and genological requirements of the pig.

(4) Sociology, Psychology, and Political Science are necessary for the solution of problems involving the behavior of people. The humanities must also be included as they affect the concepts of "what ought to be." Since human relationships are important, the entrepreneur of the swine enterprise must pay attention to the area of social science and philosophy. Just as a swine producer analyses his business in the area of science, he must also examine it in relation to himself and others. If the goals and aspirations of the swine producer center around his family, then his swine enterprise must be analysed with the human element as an important factor of operation. If the swine producer wants to achieve certain goals, he must not let the swine enterprise control him. An inadequately designed swine system contributes to the manager's anxiety and frustration.

(5) Another discipline of deductive reasoning is accounting. Simple accounting procedures enable a swine

producer to determine his returns, costs, and profits. Cost accounting is the determination of the costs of an enterprise or the cost per hundred weight of pork produced. Cost accounting has recently become of grave importance to the swine producer. Confinement has made the swine producer pay more attention to costs that were not considered a few years ago because, today, there are more recognized methods of producing pork. The present cost of production must be ascertained to provide a basis for economic interpretation and recommendation.

(C) Economics for the solution of problems concerning profit maximization is a deductive discipline. Agriculture economics is concerned with resource allocation into the most desirable combination. Making economic recommendations on swine building systems will involve comparing various building systems on the basis of: the cost structure presented by the accountant, the structural requirements by the engineer, control of stress factors as determined by the swine husbandry specialist and the human element as determined by the individual and his associates.

Induction as a Theory of Analysis

Induction may be defined as the "process - of reasoning from a part to a whole, from particulars to generals, or from the individual to the universe."[14]

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[14] Webster, op.cit., p.427.

There are two statistical procedures presented as informal inductive reasoning processes for analysis. Single sample analysis is used by swine producers to solve such problems as: proper feed mixture and environmental controls. Sequential Analysis is used in determining the number of alternatives of swine buildings.

Single Sample Analysis

The swine producer may analyse a problem by accepting or rejecting a hypothesis. The farmer is continually using informal statistical analysis in making many minor, but important, decisions. Problems such as weaning age or weight, breeding procedure, rations to be fed, and environmental control are tests that may be conducted by the farmer.

Sequential Analysis

Another alternative of choice is possible in the sequential analysis procedures. The statistican can: (1) accept the hypothesis, (2) reject the hypothesis, or (3) continue sampling. The major difference between single sampling and sequential sampling is that the size of the sample in single sampling is determined prior to collecting data.

Since the number of swine system alternatives is limitless, informal sequential analysis was used in determining which designs to use. It is necessary to continue designing contrasting systems until most of the major contrasts, characteristics and problems are presented. If the swine producer is aware of the informal though process that he is conducting, and if he is aware of the limitations of each procedure of analysis, he will be able to select the alternatives in a logical and rational manner.

DECISION

Decision is defined as - "To terminate by rendering judgement or settle, it implies the cutting of debate, doubt, analysis."[15] The swine producer having completed the other phases of the decision-making process must choose the alternative which is right. The problem of knowing when enough knowledge is accumulated to make the decision faces the producer.

The cost of defining the problem, observing, and analysing is the cost of the decision. "The value of an accurate decision is determined by responsibility for attaining and maintaining the ability to achieve more ultimate ends."[16] The swine producer has attained enough information for decision making when the marginal utility of accuracy equals the marginal cost of accuracy. To the swine producer this means that he shouldn't spend more time or money on gathering information for an accurate decision

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[15] Webster, op.cit., p. 214.

[16] Bradford and Johnson, op.cit., p. 35.

than the additional worth of the information.

There are three areas of concern which a swine producer should examine before making a decision pertaining to the selection of a swine confinement system: (1) degree of knowledge of the manager, (2) principles of strategy and (3) planning horizons.

Decisions may be classified according to the degree of knowledge of the swine producer. Knight, Hardy and Hart defined and classified the degrees of knowledge as: certainty, risk, and uncertainty. Since certainty and risk pertain to situations wherein management receives no return, uncertainity is the only classification pertaining to management decisions. Uncertainity may be defined as a degree of knowledge where in the probability of predicting an event is not known. If the manager predicts correctly there is a profit which is managerial return. It is possible through the acquisition of knowledge to move from a position of uncertainty to a position of risk or certainty. As this happens, the decision is no longer a management decision but an acquired skill.

There are four possible actions a manager can take within the classification of uncertainty: (1) continue learning, (2) forced decision, (3) inaction and (4) involuntary learning.[17]

Principles of Strategy

Many principles of strategy have been formulated by successful managers and business men which will enable the swine producer to make the right decision. These principles pertain to insuring, chance taking, flexibility, and miscellaneous strategies. Many of the principles are based on formalized theory. Others are simple statements of advice pertaining to what some individual has used in his decision making process. These principles are of importance to the swine producer because through their digestion he will more fully understand his alternatives of strategy in the uncertain situation in which he must act. Such principles have played an important role in deciding upon the design of the alternative buildings and the selection of the buildings.

Planning Horizons

Until the late 1950's swine building systems consisted of multi-purpose buildings, single "A" frame units and/or

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[17]Alan R. Bird and Curtis F. Sand, "Toward Effective Integration of Knowledge Situations in a Theory of Managerial Behavior," Journal of Farm Economics, XLIII (February, 1961), pp. 137-141.

portable units. Emphasis was placed on minimizing total building cost while solving some labor and convenience problems. The length of run was on a year to year basis, depending on the corn-hog ratio. Contractual cost (in the form of building & equipment cost) was minimized because the swine producer desired to "jump in and out" of the swine business.

Confinement systems and multiple farrowing schedules have caused farmers to reconsider the planning horizon of their swine program, because swine confinement systems are designed to last twenty to thirty years as opposed to a life time of five to ten years for most pasture system buildings. Many swine producers feel that although the buildings will last thirty years a planning period of ten-fifteen years might be more realistic in that further technological developments will make the highly specialized confinement building obselete in a relative short-period of time.

The acquisition and salvage value of the swine confinement system should be considered.[18] The high contractual investment of the swine confinement system presents many problems relating to future use of the buildings. A swine

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[18] For an explanation of acquisition and salvage value see Glenn L. Johnson, "Some Basic Problems for Economists and Statisticians Arising from U.S. Agricultural Policies", Rochester Statistical Society; (November 1959) pp.13-20.

producer must be careful to build a system which will produce swine at a low enough cost and of high enough quality to enable him to stay in production.

In addition the swine producer must consider the rate of use of the building, the variance in the situation and expected trends in cost of production and total revenue.

Action

Despite the importance of action in the management process there is a dearth of formalized theory. Those theories stated pertain to corporations and large business concerns. Two areas which pertain specifically to action, but are interrelated with other phases of the decision making process are: (1) the ability of a manager to follow-through once the decision is made and (2) consideration of the value system of the manager and others.

The ability of the manager to carry-out a decision, once it is made, is necessary if the goal of the manager is to be reached. Once the paper decisions have been made, they must be reorganized so that they may be carried out in a logical manner. It would be wasteful if a swine producer built his confinement buildings and then did not have pigs to fill them when the buildings were completed.

As in other areas of concern, the value system must be recognized by the manager. A right action as previously defined must be made in view of the normative concepts as well as the factual. The manager must have high regard for individual interests and purposes.

Responsibility

Responsibility will usually take two forms: (1) financial gain or lose and (2) praise or chastisement by one's peers.

The assumption of responsibility must be considered in view of that which is factual and normative. The manager not only has responsibility for decisions arrived at "scientifically" but he also has "moral obligation".

As more than one person becomes involved in the decision, the manager must consider responsibility of all who are involved. This can create a situation of complexity where in several systems of values must be considered.

CHAPTER III

DEFINING THE PROBLEM

Introduction

Definitions must be presented and assumptions formulated to enable the definition of the problem. The definitions will be directed towards the objective of determining the most desirable swine confinement system and the swine buildings in the system. This groundwork will insure the selection of alternatives which pertain to the objective. Assumptions will provide limitations which restrict the analysis to a discussion of relevant material.

Definitions

<u>Confinement</u> - restraint of the pig within one or more completely enclosed buildings from birth until market weight or age.

<u>Modified Confinement</u> - restraint of the pig within a closed area. The pig spends its entire life on concrete, part of which is in a uncontrolled environment.

<u>Nursery</u> - "Quarters for the care of pigs after removal from the farrowing house and before moving to the finishing house. Sows may or may not be with the pigs during part of this period depending on the weaning practices

adopted."[1]

Combination Farrow-Nursery Building - A building equipped to care for sows and baby pigs in a pen and stall arrangement for a period of three to eight weeks. The length of time depends on the weaning practices of the swine producer.

Farrowing House - A building equipped to care for sows and baby pigs in farrowing crates. The sows may be left in the crates up to four weeks if feed and water is provided. Pigs will remain in the building for a period of three to eight weeks depending on the farrowing schedule of the swine producer.

Finishing Building - A building to house pigs from the time they leave either the farrow-nursery building or the nursery building. The pigs should weigh forty to fifty pounds when they are placed in this building and are ready for market when they leave.

Farrow-to-Finish Building - A building equipped to care for sows during the farrowing period and for the pigs from birth to market. In theory, the pig would not leave the pen he is born in until ready for market.

One Building System - A farrow-to-finish building. One building is limited to one group of sows farrowing

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[1]D.G. Jedele, "Confinement Housing of Swine," *Agricultural Engineering*, Vol. 41, No. 9 (September, 1960), p.591.

twice a year.

Two Building System - A combination farrow-nursery building and a finishing building. This system can be used by as many as two groups of sows farrowing a total of four times per year.

Three Building System - A farrowing house, a nursery building and a finishing building. This system is limited to five groups of sows farrowing a total of ten times a year.

Four Building System - a farrowing house, two nursery units, and a finishing building. This system is limited to six groups of sows farrowing a total of twelve times a year.

Multiple Farrowing - The division of the sow herd into more than one group for the purpose of farrowing at different periods throughout the year. Each sow is assumed to have two litters per year. The number of groups of sows will vary from two-to-six. The number of litters farrowed will vary from four-to-twelve. The farrowing periods are spaced evenly throughout the year for the maximum use of building space.

Economic Efficiency - ratio of inputs to outputs measured in terms of physical units or dollars. The most efficient alternative will be one which utilizes resources most economically.

Assumptions

The following assumptions are presented to delineate specifications of the problem to be analysed. Since much of the discussion of the buildings is from the viewpoint of agricultural engineering and animal husbandry disciplines, the assumptions are classified within these two areas. The assumptions of agriculture production economics have been presented and implied throughout the theoretical framework of Chapter II.

Assumptions of Animal Husbandry

(1) The average length of the gestation period is 114 days, the period can vary in length from 112 to 115 days.

(2) Length of the heat period or estrus cycle is 21 days.

(3) A group of sows or gilts will be bred in seven days.

(4) The farrowing period is two weeks long per group.

(5) A sow can be fed and watered in the farrowing crate for up to four weeks without exercise outside of the crate.

(6) It is possible to wean pigs successfully at a minimum age of three weeks and at a maximum age of six weeks.

(7) Average litter size is eight pigs.

(8) The average pig will weigh forty pounds at eight weeks of age.

(9) Six months is allowed in all systems to raise a pig from birth to market. Six months includes the cleaning time and allowance for overflow in the finishing building.

(10) Each sow will give birth to at least two litters before she is marketed. Sows which are non-breeders or have small litters should be sold.

(11) The sows will come into heat five-seven days after her pigs are weaned from her. She will not be bred at this time.

(12) The sows will be bred approximately twenty-seven days after their pigs have been weaned.

(13) Fifty pigs per pen is the maximum number.

(14) Space requirements for swine in square feet per animal are indicated in Table III-1 and Table III-2.

(15) The number of pigs per watering cup is indicated in Table III-3.

(16) Feeder holes required by weight of pig are indicated in Table III-4.

Table III-1

Space Requirements for Various Weights of Swine in Square Feet per Animal[a]

Pig Weight	Enclosed Building	Open Shed	
		Concrete Lot	Shelter
40 to 80 lb	5	5	3
80 to 120 lb	6	6	4
120 to 160 lb	8	6	6
160 to 220 lb	10	6[b]	6

[a]Source: T.E. Hazen and D.W. Mangold, "Functional and Basic Requirements of Swine Housing," Agricultural Engineering Vol. 41, No. 9 (September, 1960), p. 590.

[b]From, Ed Miller, Charles Beer and Robert Madden, A Hog Production Program for Michigan Farmers, (Michigan State University, I.D. No.1, July, 1960), p. 28. (Published Mimeograph.)

Table III-2

Number of Pigs per Drinking Unit[a]

Pig Weight	Number of Pigs/Cup
40 to 75 lb	50
75 to 125 lb	40
125 to market	30

[a]Source: Ed Miller, Charles Beer and Robert Ladder, A Hog Production Program for Michigan Farmers I.D. No. 1, (July 1960), p. 26. (Published Mimeograph.)

Table III-3

Feeder Openings Required By Weight of Pig[a]

Pig Weight	Number of Pigs Self Fed/Hole
40 to 75 lb	6
75 to 125 lb	5
125 to market	4

[a]Source: Ed Miller, Charles Beer, and Robert Ladder, A Hog Production Program for Michigan Farmers, I.D. No. 1, (July 1960), p. 26. (Published Mimeograph.)

Assumptions of Agricultural Engineering

(1) The design winter temperature of -10° was used in all buildings.[2]

(2) 190° water is circulated through all hot water wall panels. The number of feet of panel determines the maximum BTU's per hour.

(3) BTU's radiated from the water pipe is not figured as added heat.

(4) Hot water in floor is regulated at a maximum of 130°.

(5) No bedding is figured to be on any floor having a heating system. If bedding is used on a floor having a heating system, the floor temperature would be slightly higher.

(6) There are two inches of fiber-glass insulation in the framewalls and ceiling of every insulated building.

(7) The concrete blocks are insulated with an expanded material in every building in which the environment is controlled.

(8) There is one inch of insulation under the concrete floors of the insulated buildings.

(9) There is eighteen inches of insulation around

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[2]"Winter Climatic Conditions-United States," Heating, Ventilating, Air Conditioning Guide 1960. 38th Edition (New York: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.), 163.

the exterior wall of insulated buildings.

(10) All enclosed buildings have a plastic moisture barrier under the concrete floor.

(11) Oil-fired boilers are used in all buildings having a heating system.

Table III-4

Temperature Levels of Heated Buildings

Type of Building	Minimum[a] & Maximum Temp	Temp Differences
Finishing House	-10° to 50°	60°
Nursery House	-10° to 70°	80°
Combination Bldg	-10° to 85°	95°
Farrowing House	-10° to 85°	95°
Farrow-to-Finish Bldg	-10° to 85°	95°[b]
	-10° to 70°	80°[c]
	-10° to 50°	60°[d]

[a] See assumption 1, page 30 of this theses. (outdoor temp.)

[b] Farrowing period only

[c] Nursery period only

[d] Finishing period only

Table III-5

Heat Production of Swine[a]

Size of Hog	BTU's Produced Per Hour
1 day old	33
10 lb	200
50 lb	375
100 lb	520
150 lb	675
200 lb	800

[a]H.H. Mitchell and M.A.R. Kelley, "Energy Requirements of Swine and Estimates of Heat Production and Gaseous Exchange for use in Planning Ventilation of Hog Houses," Journal of Agriculture Research, Vol. 56, 1938, pp.811-829.

Table III-6

Ventilation Rates Used in Determining
Environmental Controls

Pig Weight	Winter		Summer	
	CFM	CF/Hr	CFM	CF/Hr
Sow & One Day Old Litter	20	16,200	150	9,000
50 lb pig	7	420	22	1,320
150 lb pig	10[b]	600	200	12,000

[a]Source: Ed Miller, Charles Beer, and Robert Maddex, A Hog Production Program for Michigan Farmers, (Michigan State University, I.D. No. 1, July 1960) p. 23-26. (Published Mimeograph)

[b]10 CFM was used instead of the 20 CFM recommended in the above source through reconsideration of swine ventilation requirements.

Table III-7

Ventilation Requirements of Swine Buildings

Type of Building	Winter	Summer
Farrowing House	200 CFM	1,500 CFM
Nursery Building	760 CFM	1,760 CFM
Combination Farrow-Nursery	760 CFM	2,000 CFM
Finishing Building	3,200 CFM	64,000 CFM
Farrow-to-Finish Bldg	200-1,500 CFM	1,500-16,000 CFM

NOTE:

Ventilation rates in cubic feet per minute were determined by taking the ventilation rate per pig times the number of pigs in a building. Ventilation rate in farrow-to-finish building takes into account the extremes of all conditions of use.

CHAPTER IV

OBSERVATION

Introduction

Observation of the sources by type of information will enable the swine producer to determine the advantages and disadvantages of confinement swine production.

The communicative and non-communicative sources of information enable the swine producer to observe confinement and multiple farrowing. The types of information which are relevant are: information on existing production methods and information on innovations.

An informative discussion of multiple farrowing and its relationship to swine buildings will also be presented. This information is necessary to determine the most desirable swine system.

Advantages of Confinement Swine Production

Increase in Profits. -- In some enterprises it has been observed that an increase in capital may result in a very substantial decrease in labor and land requirements and at the same time increase output, thereby increasing profits.

Full Utilization of Available Resources. -- Land may be too valuable to be used as swine pasture.

Formulation of present day growing-finishing rations has made pasture unnecessary. More efficient use of labor and capital is possible. Profit may also be increased because of a reduction in feed cost per pig due to environmental control.

More control over stress factors. -- Therefore, the quality of edible pork is improved. Under present product pricing systems there is little incentive to increase the quality of the animal, so profits might not increase enough to justify spending capital for this purpose. By controlling temperature, humidity and draft it is possible to increase profits and reduce risk.

Less Labor. -- Many of the advantages center around an ability to design into the buildings conveniences which will ease labor requirements. The farm operator may desire to maintain the same output but work fewer hours or the basis for justification may be to increase output, while changing working conditions to controlled environmental conditions. i.e, eliminate such unpleasant tasks as hauling water, and removing ice from frozen waterers.

Disease control. -- The development of Specific Pathogen Disease Free Swine has made disease control possible in a confinement system. SPF swine may perform better in a confinement system than a pasture system because the swine producer could keep the pigs from coming into contact with diseased pigs, other livestock or rodents.

Subjective Advantages. -- A well designed confinement system may add to the beauty of the farmstead. Prestige attached with being the first in the neighborhood to have a new method of swine production.

Disadvantages of the Confinement Swine Production

High Investments. -- The high initial investment is one of the biggest deterents to the construction of a swine confinement system.

Disease Control. -- Even with SPF swine, disease is still a critical problem. Sanitation practices must be diligently carried out if herd health is to be maintained.

Excellent Management. -- The level of management ability is increased with a highly efficient swine confinement system. There are usually more pigs, more records, and more costs. Little problems cannot be over-looked for they may be the ones that add up to great financial loss. Swine confinement production is not a way of life; it is a business.

Multiple farrowing becomes necessary to justify building cost. A multiple farrowing program requires expert management and has the inherent disadvantage of year-around marketing whether the price is high or low.

Problem Stress Factors. -- There are certain stress factors such as tail-biting, bullying and psychological disturbances which become problems in swine confinement production.

Multiple Farrowing

Another major area of discussion that must be included in the observation process is multiple farrowing. The high cost of specialized structures in which to confine swine has forced many producers to keep their buildings full of swine through-out the year. The more swine that are produced in a given building system, the lower the cost of housing per pig. The desire to increase output without increasing peak labor requirements has also made farmers consider multiple farrowing.

Most swine producers desire to have their herd farrow in groups in which no farrowing period would last longer than two weeks, thereby making it possible for the manager to concentrate his labor on the swine enterprise for a short period of time and allow him control over his breeding herd. Since artificial insemination is not yet developed, concentrated boar power on sows which will have their heat period within a week seems to be the best procedure to use to breed a group of sows so that they will farrow within a two week period.

As mentioned the sows are maintained in groups, each group farrowing twice a year. The swine farm is an assembly line wherein each sow and each group has a number.

Chart IV-1

The Pig Cycle

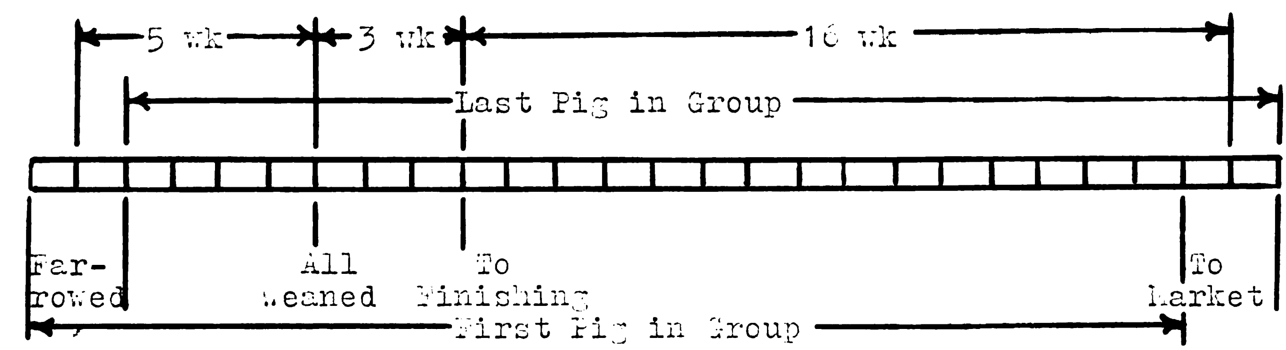

Chart IV-1 presents the assumptions regarding the growth of the pig from birth until marketed. The chart is based on assumptions made in Chapter 2. A five week mean weaning age is used in this example, with deviations of one week on either side.

Chart IV-2

The Sow Cycle

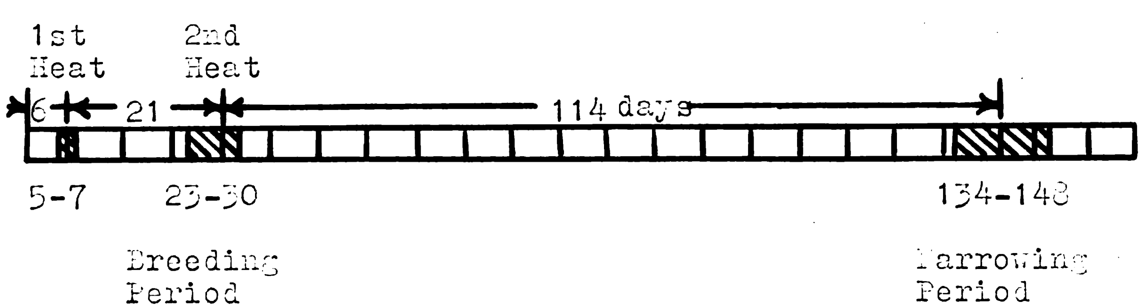

Chart IV-2 presents the physical limitations of the sow. The chart states that the group of sows is bred during their second heat period after weaning, some producers may desire to wait another twenty-one days before breeding. The sow will usually have more pigs if another twenty one days is allowed, but the cost of feeding the sows may offset the additional advantage.

The sow cycle is of grave importance in that it determines the efficiency of the swine system. If the sow cycles are maintained as indicated, the number of pigs in the building will be as planned.

The total number of days required from weaning of the first litter to the birth of the next litter is 141 days (Chart IV-2. 6 days plus 21 days plus 114 days equals 141 days).

Table IV-1

The Affect of Weaning Age on the Total Number of Days Between Litters[a]

Length of weaning period	Wean to Farrow in days	Number of days in weaning period	Total number of days
two weeks	141	14	155
three weeks	141	21	162
four weeks	141	28	169
five weeks	141	35	176
six weeks	141	42	183

[a]All pigs in the group are weaned on the same day to allow the cycle to start over with sows of same heat period.

Charts 2,3,4 and 5 in appendix A, present the physical possibilities of the sow if the pigs are weaned at three weeks, four weeks, five weeks and six weeks of age. The swine producer has only to choose the number of groups he feels he can manage and the weaning age he feels to be desirable.

Once the weaning age and the number of groups is selected, it is possible for the swine producer to determine a farrowing schedule.

The only problem of multiple farrowing remaining is to fit the multiple farrowing scheme to a building system.

If one week is necessary for a clean up period and flexibility, the possible use of the various buildings is as presented in Chart 1 of Appendix A.

Upon examination of the physical limitations of the buildings it can be seen that certain building designs present bottle-necks in the system. A combination farrow-nursery building can not handle more than four litters per year. A farrow-to-finish building can handle only two litters per year if the pigs are weaned at a age of six weeks. A farrowing house can be used up to twelve times a year if two nursery units are built. The nursery can be used up to ten times a year with one farrowing house before cleaning restrictions overload the building. The finishing building should be designed to handle the output of the farrowing house, combination farrow-nursery, or nursery building that is erected.

CHAPTER V

ANALYSIS

Introduction

The analysis is an examination of swine buildings and swine confinement systems according to the theoretical framework as presented in Chapter II. Thirteen plans composed of twenty-six cases have been analysed. The plans and cases were selected within the framework of inductive analysis as presented in Chapter II. The plans and cases are presented in the following groups: farrowing buildings; farrow-to-finish building; combination farrow-nursery buildings; nursery buildings; open finishing shed, uncovered feed floor; open finishing shed, covered feed floor and enclosed finishing buildings.

The buildings are analysed from three deductive areas of concern: (1) agriculture engineering, (2) animal husbandry, and (3) agriculture economics.

Agricultural engineering objectively analyses the buildings from the following problem areas:

(1) number of pigs in the building
(2) size of the building
(3) layout of floor plans
(4) employment of efficient equipment
(5) location of the building

The objective analysis within the framework of animal husbandry will pertain to the following stress factors:

(1) environmental controls
(2) sanitation
(3) disease
(4) water
(5) feed

The objective analysis by agriculture economics will be concerned with the following points:

(1) Construction cost
(2) Equipment cost
(3) Heating and ventilation system cost
(4) Cost comparison of the cases and plans of one type of building
(5) Cost of the controlled environment in view of improved swine growth rates and feed efficiency
(6) Flexibility of the building

The examination of swine systems as determined from the building alternatives is presented in Chapter VI.

There are four swine systems which are analysed from the following areas: (1) agricultural engineering, (2) animal husbandry, and (3) agriculture economics.

An analysis of the swine systems by agricultural engineering consists of the following points:

(1) Number of buildings and their function in the swine system
(2) Efficiency of the buildings as a system
(3) Use of common equipment between buildings
(4) Possibility of combining buildings

The objective analysis of swine systems by the animal husbandry field consist of a discussion of the stresses of the various systems upon the pigs.

Agricultural economics objectively analyses the systems according to the following points:

(1) Cost of the buildings in the swine system
(2) Cost of the buildings according to level of use

The conclusions of the chapter consist of a cost comparison of the various swine systems. Consideration of the human element will also be included in the conclusion.

The author believes that this approach will bring out the differences between the various buildings and systems. This will enable the swine producer and other interested persons to ascertain the most "desirable" swine system.

Basis for Comparison

It is necessary to design buildings which are comparable and realistic in a study of this nature. Much time has been spent in designing the buildings so that they would reflect differences due to design. For example, wooden pens and fencing were used in all buildings when it might be more desirable to use steel in some cases as a building material. The following features were incorporated into the 13 plans and twenty-six cases:

(1) The materials of construction are common to all structures.
(2) The equipment in all structures is made by the same company.[1]
(3) The heating and ventilation systems utilize the same types of boiler, fuel, ventilating fans, and etc.
(4) The materials of construction perform the same function.

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[1]Exception -- manure augers were estimated by one company, while manure shuttle stroke cleaners were estimated by another company.

The buildings are realistic in that they incorporate features and design practices which are recognized and used by farmers in the midwest.

The following list delineates the materials which were used in all structures:

(1) There is an eight inch concrete block wall four feet high on all enclosed walls of the buildings.

(2) Framewalls above the concrete wall are two by four construction with 25/32 inch impregnated wall board covered with corrugated steel.

(3) Ceilings are six and on-half feet above the floor.

(4) Trusses are used in all designs except the open shed. (plan 12).[2]

(5) Two inches of wall insulation is used in the framewall and ceiling of all heated buildings.

(6) Four inch reinforced concrete floors are used in all buildings.

(7) There is a moisture barrier under all floors which are heated by pigs or a heating system.

(8) Wooden partitions, farrowing stalls and farrowing crates are common to their appropriate design.

(9) All of the feeders are manufactured by the same company.

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[2]"Glue and Nail Truss Design" (plan no. 703-01-74), taken from Agricultural Engineering College, Michigan State University, East Lansing, Michigan.

(10) All of the feed handling equipment is manufactured by the same company.

(11) Two types of manure handling equipment is necessary. Where the manure is handled as a semi-solid or liquid a auger is used. When large quantities of strawbedding are used a shuttle stroke cleaner is used.[3]

(12) All of the heating systems are oil-fired boilers.[4]

Description of the Buildings, General

There are thirteen plans composed of twenty-six cases. The plans are identified by numbers 1-13 (see Appendix B). The plans point out variations in floor design of each type of building. The cases are identified by letters A-Z (see Appendix B). The cases present variations of equipment and heating systems within a plan. The plans and cases are composed of the following types of buildings:

(1) Farrow-to-finish building (Plan 1, Case A)
(2) Farrowing buildings (Plans 2 & 3, Cases B-E)
(3) Combination farrow-nursery buildings (Plans 4 & 5, Cases F-I)
(4) Nursery buildings (Plans 6 & 7, Cases J-M)
(5) Finishing buildings (Plans 8-13, Cases O-Z)

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[3]All estimates of equipment were made by representatives of the American Planter Company, Burr Oak, Michigan and of the James Manufacturing Company, Fort Atkinson, Wisconsin. The prices quoted are FOB and are subject to change without notice.

[4]All estimates of heating systems were made by Mr. Don Rummel of the Richle Heating & Plumbing Company, Saginaw Michigan. All prices are FOB Saginaw and are subject to change without notice.

The farrow-to-finish building is designed to care for pigs from birth to market. In theory, the pig will not leave the pen it is born in until it is ready to go to market. The building must incorporate features which are necessary to care for the pig from birth to market. The building has ten pens which hold ten sows and their litters.

The farrowing buildings provide an environment for the birth and care of young pigs. Ten farrowing crates are capable of holding ten sows and their litters. The building is usually used six to seven weeks per group farrowed. The period of use varies greatly according to the weaning practice, and efficiency with which the building is used.

The combination farrow-nursery is designed to care for pigs from the time they are farrowed until they are ready for the finishing shed (approx. 40 lbs.) The building presented has ten pens which will hold ten sows and their litters.

The nursery buildings are used with a farrowing house to provide a controlled environment for the pigs until they weigh enough to be placed in the finishing building. The buildings presented have five pens which will hold ten sows and their litters. The buildings are designed for attachment to a farrowing house, therefore a wash area for scrubbing sows is provided.

The finishing buildings are composed of three types of structures: (1) open shed, uncovered feed floor, (2) open shed, covered feed floor, and (3) enclosed buildings. The three buildings provide different environmental controls. There is much controversy between swine producers as to how much control is necessary. This thesis doesn't attempt to answer the problem; but it does determine the cost of controling the environment in the three types of buildings. The buildings are designed to handle the output of the farrowing house, nursery, and combination farrow-nursery.

Farrow-to-Finish Building

Engineering Aspects

This structure is designed to raise swine from birth to market without removing the pig from the pen until he reaches market weight. The building is designed much like the combination farrow-nursery buildings (Plan 4), except that the pens have been made larger to accomodate the pigs at market weight. If eight pigs are raised per litter then eighty square feet per pen is needed (Table III-1).

Since automation seems highly desirable for the finishing pigs (40 lbs - 220 lbs.) only one automated alternative of this building was estimated.

Husbandry Aspects

Since the building is designed to take care of pigs from birth to market, temperature, humidity and draft controls are built for every age and weight of swine. Therefore ventilation doors have been built into the framewall for summer cooling. In addition, a time-clock operated spray system cools the pigs during summer months. One circuit of hot water pipes are imbedded two inches below the surface of the creep area concrete. Another hot water circuit supplies heat through wall panels.

Each pen has a double sloped floor; this feature is essential for controling waste when feeding the sow in the crate. Two augers carry the manure out of the building. Water is provided automatically in all pens. Feed is automatically dispensed to each crate by a feed dispenser which regulates the feed to each sow in two pound increments.

The pigs, except the sows, in the building are the same age. Therefore, there is a minimum of bacteria buildup because the young pigs are the same age. The operator and the breeding herd are the principal sources of disease in this structure. If the breeding herd is clean, the manager can control disease by using sanitary practices.

Economic Aspects

This building costs $10,890.07. It will handle 160 pigs per year; therefore the building cost of production per pig is $68.06. This structure has the highest cost per pig produced of any considered in this study. The inefficient use of such equipment as farrowing crates, cooling systems, feed dispensers, heating system, ventilation equipment and augers causes the higher cost per pig produced.

The building is not used to capacity. From the time the pigs are weaned until a month before they go to market the excess number of square feet varys from 400 square feet to 100 square feet. This study did not examine the variable cost of production; therefore, there may be some advantages in feed consumption and rate of gain which will offset the increased fixed cost of production.

Farrowing Building

Engineering Aspects

Four combinations of building design and function were analysed. Plan 2 (see Appendix B) is the popular single aisle alternative. Two cases (B and C) are hot water heated. Case B has feed augers and manure augers to reduce labor. Case C has an outside platform for feeding and watering the sows. Plan 3 was designed to ascertain the cost of a double aisle building which uses equipment efficiently. The two cases analysed are an automatic alternative (case D) and a manual alternative (case E).

All the pens have a double sloped floor to control the flow of waste. The farrowing pens are designed to hold eight pigs and a sow. The pens are 5½ ft x 8 ft to allow for equipment. The pens should be 5½ ft x 7 ft in the unequipped alternatives. The "extra" two feet is added to the width of the aisle to make it easier to move the sows in and out of their crates. All alternatives have a hot water heating system consisting of two circuits. One circuit is copper tubing laid two inches below the surface of the concrete in the creep area of the pens. The other circuit consists of hot water panels on the wall.

Concrete block sidewalls 4' high were used to facilitate cleaning and to increase durability. The outside platform of the manual alternative consists of a fenced in concrete lot equipped with winterized waterers and a hand feeder.

Husbandry Aspects

Temperature is maintained at 85° during the first few days of life for the newborn pigs in the creep area. After the pigs are three days old the temperature will gradually be decreased to 70°. Humidity and odor are controlled by a ventilation system consisting of two fans with a time clock control to maintain humidity below 75% for building material protection. Drafts are controlled by using solid plywood paneling for pen walls. Sanitation is controlled by hand labor or mechanization similar to that in the nursery buildings (Plans 4 and 5). Disease must be controlled by management. The building design does incorporate some disease prevention features. (1) Each waterer is separately controlled unit. There is a float control in every waterer. This feature prevents transmission of of organisms from one sow to another. (2) The heating system was selected because of its ability to keep the floors dry and warm, thereby reducing organism breeding area. (3) In the automatic building, urine and wasted water is allowed to drain away.

Some poor features are the wooden pens (difficult to clean). They were used in the building design to facilitate estimation of building cost and comparison between buildings. Also, it may be desirable to remove feces from contact with the pigs more often than by the system of twice a day cleaning, therefore slatted floors have an advantage.

Economic Aspects

The cost of the alternative farrowing buildings considered is:

Single aisle, automated, hot water, plan 2 case B---$7,159.03
Single aisle, manual, hot water, plan 2 case C------$5,046.73
Double aisle, automated, hot water, plan 2 case D---$7,352.47
Double aisle, manual, hot water, plan 3 case E------$5,645.74

The single aisle building has 504 square feet as compared with 740 square feet in the double building. When the buildings are unequipped the single aisle costs $5,043.73 as compared with $5,645.74 for the double aisle farrowing house. The additional cost of construction offsets the advantage of using common augers for handling feed. If the buildings are equipped with feed augers and manure augers, the cost advantage is decreased because the additional cost of construction offsets part of efficiency of the equipment. Case D is $300 more than the equipped Case E.

The additional cost of equipment is $2,100.00. When used in a swine system, it is possible to reduce this relatively high equipment cost by combining buildings. The equipment would have to be justified on savings in labor and convience.

Nursery Building

Engineering Aspects

There are five nursery cases using two plans (see Appendix B). Plan 6 has three cases:

(1) Case J is an automatic design for weaned pigs only. It has a feed auger and two manure augers. Because of the desire for slatted floors, this alternative was selected for a comparison study. Steel mesh was used to cover the floor area of the pens. The concrete floor is "V" shaped to enable the manure to flow to an auger at the bottom of the "V'.

(2) Case K is an automatic design for weaned pigs only. It also has an feed auger and two manure augers. A conventional hot water system circulates water through the floor and panels on the wall. The circuits in the floor keep the pen area warm and dry, while the wall units add heat to air displaced by ventilation.

(3) Case L is a manual design for weaned pigs. This particular building is the lowest cost nursery of the alternatives presented. Feed must be brought into the building by hand and manure removed by hand.

Plan 7 has two cases:

(1) Case M is an automated design having a feed auger and two manure augers. Provisions are made for the care of sows; therefore there is a creep area for the pigs.

(2) Case N is an hand operated alternative. It has hot water heat as does Case M. All feed must be brought into the building manually and all manure removed manually.

Husbandry Aspects

The nursery building is necessary to facilitate maximum use of the farrowing houses. If there are more than four farrowings per year, at least one nursery building is necessary. Two buildings are necessary if farrowings number more than twelve times a year.

The decision regarding which building to erect depends on the weaning program of the manager. For those who wean pigs at three weeks of age or less, plan 6 would be the most realistic design because no provisions are necessary for the sow. If the weaning age is four weeks or older and there are at least three groups of sows some provision must be made for sows in the nursery building since another group of pigs coming into the farrowing house will force the movement of the sows and litters.

The nursery provides a tempered environment for the pigs until they are eight weeks of age or 40 lbs.

The pens are designed to hold two litters of pigs. In the slatted floor alternative it would be possible to build pens smaller than the ones designed as pigs on slatted floors require less square feet per animal than a concrete floor.

Temperature is controlled by two methods. In Plan 6, Case 3 a slatted floor design uses a hot air system. A duct carries the air down the center of the building providing even temperature throughout. A hot water system is used in the other building alternatives to provide the heat. The heating system is capable of maintaining the inside temperature at 70° when the outside temperature is -10°. The optimum temperature for little pigs is 70° and 60° for the sow; therefore the five week nursery building has a hot water circuit under the creep area.[5] Humidity

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[5]M.E. Ensminger, Swine Science (Danville, Ill.: The Interstate Publishers & Printers, 1961), p.366.

is regulated by a ventilation system adequate to maintain moisture levels below 75%. Drafts are controlled by using solid plywood partitions for all walls.

Manure is handled in three ways: by hand cleaning, augers, and a slatted floor. All three methods will control the manure problem, but varying amounts of labor are needed.

In the nursery care must be exercized to prevent disease from coming into contact with the pigs. If the pigs are "clean" when brought into the building they can be expected to remain that way if the manager exercises care in keeping suspected disease carriers out of the building and by using clean clothing and foot pans.

Economic Aspects

The two types of plans 6 and 7 differ significantly in cost. The building that is decided on must be governed by the age of weaning. When the cost of the heating system is considered the slatted floors cost the same as a hot water heated manure auger removal system. If the entrepreneur chooses some other method of heating such as electric pads or heat bulbs, the initial cost of the concrete floor building would be considerable less. Studies at the University of Illinois indicate that pigs gain 19.5% faster on a slatted floor than on a conventional concrete floor with bedding and supplemental heat in the form of 250 watt bulbs.[6] The hot water system of heating may balance some of the advantages of the slatted floor in that the floor is kept dry.

The slatted floor construction cost ($3,815.25) is considerably higher than a comparable concrete floor ($3,140.04) However, the hot air system of heating is much less expensive than the hot water. The total building cost of the slatted floor case is $5,924.59, while, the total building cost of the comparable concrete floor building is $6,297.89.

The slats must cover the entire area of the pen if they are going to save much labor in cleaning manure. Wooden slats show considerable wear after 16 months of use. Steel mesh (used in this study) has been used successfully. It is important that the right size openings be used to enable the pig to move around. The great advantage of slatted floors lie in two areas: (1) Reduced space per pig (2) lower initial cost of the heating system.

Combination Farrow-Nursery Building

Engineering Aspects

Two plans, composed of four cases are presented in

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[6] A.H. Jensen and D.E. Becker, Floor Design and Materials in Housing for Growing-Finishing Swine, A Report Prepared for the Illinois Swine Growers Day (Urbana, Ill: University of Illinois, 1961), pp. 1-4.

Appendix B. All four buildings have the same type of hot water heating system. Plan 4 is a single aisle building. It was selected because of its wide-spread use. Plan 5 is a double aisle building. Before estimating the cost of a double aisle building it was thought that the increased cost of building construction would be offset by the reduced cost of equipment. A sow lot is provided to exercise, feed, and water the sows in the unequipped cases G and I. The sow lot ($450.44) is regarded as an equipment expense in that it is not needed when the building is automated (assuming the sows do not need exercise beyond that they get in there pens).

The size of the building is determined by the number of sows in a group. If there are ten sows in a group, there must be ten pens. If the building is not automated then the pens could be a foot narrower. This space could be used to widen the aisle to five feet to enable easier sow handling.

Husbandry Aspects

Disease is an acute problem in this building. The building must be thoroughly cleaned between groups of pigs. Traffic in and out of the building must be controlled.

Water is provided automatically. Feed is fed through a controlled auger system that will deliver any ration to any one or a combination of feeders. The space requirements in the pens are adequate to hold eight pigs per litter and the sow. Temperature is controlled through a hot water system in all alternatives. The pipe is laid two inches below the surface of the concrete in the creep area. Supplemental heat is provided by hot water panel installed low on the outside wall. The installation of hot water pipe in the floor will provide adequate heat for the young pigs (85°) without over-heating the sows (65°).

Humidity will be kept below 75% by ventilating fans to prevent condensation of moisture in the building. Drafts are prevented by the solid plywood pen partitions.

Sanitation is controlled either by manual cleaning or mechanization. Manure augers are capable of handling some liquid waste. They have the disadvantage of being unable to handle straw adequately. If bedding is to be used, it should be sawdust or ground corn-cobs. Steel mesh covers the manure auger to prevent injury to sow or pigs during periods of operation. The pen has a double slope to prevent liquids from running from the front to the rear. Odor is controlled by an adequate ventilation system. Water is provided in each pen of the automated building. Feed is provided automatically to any combination of pens. In the manually cleaned building a single water faucet is provided in the clean-up area. The feed must be manually carried into the building for the piglets. The sows are fed and watered out of doors.

Economic Aspects

The decision remains with the entrepreur whether to chose automatic or manually cleaned building. The automatic equipment costs $2,200 to $2,700 under the assumptions made. There are no studies which point out if the equipment will pay for itself.

The cost of the alternatives of combination farrow-nursery buildings considered is:

Single aisle, automated, hot water, plan 4 case F--$9,340.76
Single aisle, manual, hot water, plan 4 case G-----$6,997.71
Double aisle, automated, hot water, plan 5 case H--$9,637.61
Double aisle, manual, hot water, plan 5 case I-----$7,427.36

The equipment expense is the difference in cost within the cases of one plan (case F vs. case G) The difference in cost between Case F and Case H and between Case G and Case I reflects difference due to design, and equipment. All four plans will produce the same number of pigs. It should be emphasized that management ability may reflect differences in performance of pigs within a building. If the manager refuses to clean properly, it may be more profitable for him to go to the expense of installing mechanized equipment to remove manure and urine.

Open Finishing Shed (Uncovered Feed Floor)

Engineering Aspects

The floor plan of the open finishing shed is presented in Plan 12, Appendix B. The shed on the concrete platform is large enough to provide sleeping area for 320 pigs. The rest of the platform is used for exercise and feed area. The alternatives of the plan are Case W and Case X. Case W differs from Case X in that Case W has an feed auger and a shuttle stroke manure cleaner, while Case X as a concrete apron from which to service the pens.

Once the farrowing schedule is ascertained, the size of the building may be determined. For example, if the farmer decides to have five groups of sows farrowing ten times a year, there would be four groups of pigs in the finishing building at one time (Appendix A Chart 5). Assuming that the farmer has ten sows in each group and the sows average eight pigs per litter than the finishing building would have to be designed to accomodate 320 pigs (80 times 4). The pigs in the buildings are four different ages and weights; however, some pigs will grow slower or faster than others, so there will be overlapping between some groups.

The following steps are presented to determine the size of the building necessary to house 320 pigs:

(1) Specify the total number of square feet needed by each group of pigs for sleeping and feeding. Table V-1 expresses the total number of square feet need to house 320 pigs of varying maturity in four groups.

Table V-1

Total Square Feet Necessary to House 320 Pigs In a Open Finishing Shed[a]

Pig Weight	Sq Ft Per Pen Open	Sq Ft Per Pen Sleeping	Pigs in Group	Space Required in Sq Ft	Total Space Required in Sq Ft
Wean to 75 lbs	5	3	80	240+400 =	640
75 lbs to 125 lbs	6	4	80	320+480 =	800
125 lbs to market	6[b]	6	80	480+480 =	960
			80	480+480 =	960
Total			320	1,560+1,840=	3,360

[a]Calculated from: T.E. Hazen and D.W. Mangold, "Functional and Basic Requirements of Swine Housing", *Agricultural Engineering*, Vol 41, No.9 (September, 1960), 590.

[b]Calculated from: Ed Miller, Charles Beer, and Robert Madden, "A Hog Production Program for Michigan Farmers", (Michigan State University, I.D. No.1, July 1960), p.28. (Published Mimeograph.

The table indicates that 3,360 total square feet, 1,840 square feet of open area, and 1,560 square feet of sleeping area are needed.

(2) Allow 300 to 500 square feet of additional area for flexibility and overflow caused by large litters.

(3) Determine the size of building that will meet the combined specifications of steps one and two. Although there are no set specifications for pen design, it is desirable to make the pens long and narrow, allow no more than 50 pigs per pen, and keep the pens of equal size for flexibility. Alleys and driveways will be added to the building specifications later. A concrete platform 32 feet by 120 feet equals 3,840 square feet. This platform will provide 480 square feet of extra space. It is divided into twelve pens 10 feet by 32 feet so that no pen will have over 50 pigs in it. A sleeping area 10 feet by 14 feet per pen will meet the total requirements of 1,560 square feet. The remainder of the area will be open for feed and exercise. A shed 14 feet by 120 feet will provide the area necessary for sleeping.

(4) The final step on paper, is to place the pigs in the pens to make sure that enough space has been provided. Chart 3 illustrates the pig arrangement used in the open finishing building of plans 12 and 13. There should be enough space in the sleeping area and the feed area of each pen to take care of the particular weight of pig that is in that pen.

Chart V-1

Placement of Pigs in Pens of the Open Finishing Shed

40	40	30	30	19+	23	23	23	23	23	23	23

When the pens are laid in a single row it is easier to install materials handling equipment. The shed also provides a wind break for the pens. Feeders are positioned in pen lines to permit two pens of pigs to use one feeder. There is 120 feet of ventilation doors on the shed for summer cooling. The unequipped alternative has an eight foot concrete driveway to facilitate manure cleaning and feeding.

Husbandry Aspects

This building does little to remove the pig from many of the stress conditions of the pasture system. Temperature, drafts, and disease controls are the same as pasture conditions. Bedding is provided in the sleeping area. There is a solid panel between every third pen to alleviate part of the draft problem. Water is automatically supplied through an underground piping system. Sanitation is handled either by a manure cleaner (Case A) or tractor and scraper (Case M). A slight breeze will take care of most odor problems. Summer cooling is provided by the ventilation doors and a time clock controlled water spray in each pen. Disease is of concern whenever hogs are confined. The hogs are close together - wetbedding, dampness, or carelessness can create conditions in which disease can spread rapidly.

Economic Aspects

The economics of constructing such a building are not clearly understood, because conclusive evidence concerning temperature, humidity and drafts has not been determined. The open shed does little more than bring the pig pasture to the barn lot or take the pigs from the drylot to a concrete floor. Therefore, many management problems of the pasture system plague the swine producer using this system. Wet bedding, wind, extreme cold, snow, rain and hot sun are some of the problems which remain in this modified confinement design. The water system and automatic feed system should prevent the pigs from experiencing the stress of running out of feed or water: however, it seems quite expensive to justify several thousand dollars for the convenience of handling feed and water automatically. This building is the lowest total cost finishing alternative considered: however, its effect on the cost of production per pig is to raise fixed cost and to lower variable cost to the extent of savings in labor. The automatic alternative, (case A), costs $10,620.01 as compared with $8,438.68

for the manual case (case A). This building is one of the most flexible of the alternatives considered because a swine producer can convert it easily to some other use if he desires to quit raising pigs. It should be further pointed out that the automatic alternative is $1,900.00 less than a completely enclosed, automated and unheated finishing building (Plan 9).

Open Finishing Shed (Covered Feed Floor)

Engineering Aspects

The floor plan of the finishing shed is presented as Plan 13 in Appendix B. The shed covers the entire concrete platform. It has three walls protecting the pigs from the weather. The fourth wall is left open so that special ventilation equipment is not needed to remove moisture and odors. The alternatives of the plan are Cases Y and Z. Case Y differs from Case Z in that Case Y has a concrete apron with which to service the pens. Case Z has either a feed auger for grind and mix rations (Case Z_1) or an high moisture auger and feed trough (Case Z_2). Both of the Case Z alternatives have a shuttle stroke manure cleaner.

Once the farrowing schedule is ascertained, the size of the covered feed floor can be determined. The floor plan of the covered feed floor is the same as the uncovered feed floor (Plan 12). Pen walls separate the sleeping area from the feed area to reduce the movement of air and to prevent the bedding from being pushed onto the feed floor. The purpose of covering the feed floor is to prevent the accumulation of snow in winter, to shade the area in summer and to prevent rain from diluting the manure.

Husbandry Aspects

From the view-point of the swine husbandry specialist this building does correct and control the stress factors of the pasture system. The pig is relieved from withstanding extreme cold, or heat and from walking through snow or rain to eat and drink. Drafts are controlled if the building is positioned correctly with the wind. There is usually sufficient natural ventilation to prevent odor from becoming a problem. Since the sun is not allowed to dry the floor or to kill organisms, the floor must be cleaned several times a week to keep the building sanitary. If management is lax, dampness, wet bedding, and manure can create disease breeding conditions. To encourage feed consumption on hot days there is a time clock controlled summer spray system.

Economic Aspects

This building, if erected as an automatic unit, costs $11,715.26 this is approximately $1,000.00 more than the open shed uncovered feed floor and approximately $[illegible]00.00

less than an enclosed automatic, unheated and ventilated building. If the manual unit is erected it will cost $[illegible],310.40. This is approximately $[illegible]00.00 more than the open shed uncovered feed floor and approximately $1,[illegible]00.00 less than the unequipped center driveway enclosed building. The biggest savings to the swine producer are in the form of reduced labor and increased feed efficiency. Bedding should not get wet as often as the open shed alternative as the feed floor is protected from the rain and snow. The covered feed floor should save many man-hours of removing wet bedding and snow from the concrete floor during the winter months. Furthermore feed efficiency and the rate of gain should improve because the feed area will be cooler in the summer.

Enclosed Finishing Building

Engineering Aspects

Four plans of enclosed finishing buildings are presented (8,9,10 and 11) in Appendix B. There are two cases with each plan. The objective was to determine the cost of structures with major equipment items arranged in different ways. Furthermore the cost of a heating system in the enclosed building was determined. Plans 8,9, and 10 are the same building with changes in equipment layout. Plan 11 is designed to admit a tractor or other farm vehicles.

This alternative was selected because of its apparent popularity and to ascertain the cost of such a design when automated.

When a building is completely enclosed, ventilation, odor, humidity and temperature become problems. There are three approaches to the solution of these problems.

(1) Placement of transparent fiberglass in the roof will admit heat to dry the floor, by opening ventilation. It is possible to control odor and to keep the humidity below 75%. The inside temperature of the building in the winter months will be the same as the outside temperature. The fiberglass in the ceiling has a disadvantage since it heats the building in summer months when the swine should be cool.

(2) Another approach is to insulate the building with the intention of letting the body heat of the pigs keep the building warm. If the building is kept full of pigs and the proper ventilation rate is used then the pigs can keep the inside temperature at 50° as long as the outside temperature doesn't fall below 7°.

(3) The third alternative is to insulate, ventilate, and add supplemental heat through a hot water heating system. Cases O.Q.S. and U present the cost of such systems. The buildings are designed to maintain inside temperature at 50° when the outside temperature is -10°. Hot

water pipes circulate through the floor to keep it dry and warm. Heat is provided by hot panel units mounted on the wall of the building.

A similar procedure of determining the total number of square feet required to house the pigs will be used as in the open finishing shed.

(1) Since there is no differentiation between the sleeping and feed area in an enclosed building, the space requirements are reduced. Table V-2 points out the total space needed for four groups of 80 pigs.

Table V-2

Total Square Feet Necessary to House 320 Pigs in a Enclosed Finishing Shed[a]

Pig Weight	Sq Ft Per Pig	Pigs in Group	Total Space Required in Sq Ft
40-80 lbs	5	80	400
80-120 lbs	6	80	480
120-160 lbs	8	80	640
160-220 lbs	10	80	800
Total		320	2,320

[a]Calculated from: T.E. Hazen and D.W. Mangold, "Functional and Basic Requirements of Swine Housing", *Agricultural Engineering*, Vol 41, No. 9 (September, 1960), p.590.

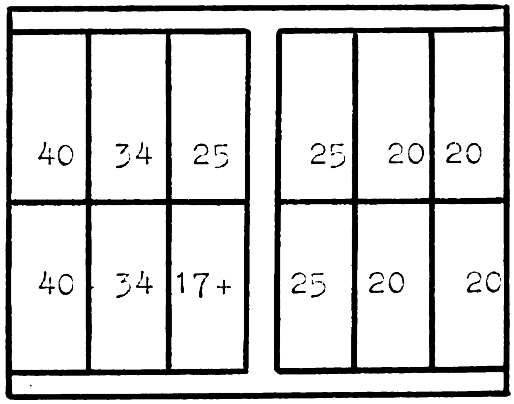
(2) An additional area of 200-400 square feet should be sufficient for flexibility and overflow caused by large litters.

(3) Determine the size of the building that will meet the specifications of steps one and two. Although there are no set specifications for pen design, it is desirable to make the pens long and narrow, allow no more than 50 pigs per pen, and keep the pens of equal size for flexibility. Alleys and driveways will be added to the building specifications later. A concrete platform 44 feet by 60 feet divided into twelve pens, each 22 feet by 10 feet will meet the requirements of 2,420 square feet to 2,720 square feet.

(4) The final step is to place the pigs in the pens (on paper) to make sure that enough space has been provided. Chart 4 illustrates the pig arrangement used in the enclosed finishing shed plans 8,9,10 and 11.

Chart V-2

Placement of Pigs in Pens of the Enclosed Finishing Shed



A rectangular building is usually more expensive to build than a square building; therefore, the pens are laid in a double row to make the building square. Double waterers are used to lower equipment cost. Feeders are also arranged so that two pens of pigs can utilize them.

Husbandry Aspects

Temperature, humidity and drafts are controlled on the basis that improved feed efficiency and rate of gain will offset the cost of the environment. Table V-3 presents the effect of temperature on the production efficiency

Table V-3

Effect of Temperature on Production Efficiency of Swine[a]

Feed required per cwt gain for a 100 lb pig	Temperature	Feed required per cwt gain for a 200 lb pig
750	100	
470	90	1,100
310	80	500
255	70	400
320	60	360
410	50	500
530	40	1,100

[a]T.E. Bond, *Hog Houses*, United States Department of Agriculture, Miscellaneous Publication No. 744, Jan 1958, 2.

of swine. The optimum temperature for a 200 lb pigs is 60° and the optimum temperature for a 100 lb pig is 70°. The average weight of the pigs in the building is approximately 130 lbs, therefore the temperature of the building should be between 60° and 70° for optimum efficiency. Humidity doesn't present a problem to the pig as tests have indicated that he will perform equally well under various levels of humidity. The effect of drafts on older pigs is not known, however chilled air in the winter time is thought to be detrimintal. Overcrowding is not a problem if the farrowing schedule is rigidly adherred to, if the groups of swine are maintained; and if the floor space requirements are followed. At no time should there be more than fifty pigs in a pen. Sanitation becomes a problem unless daily cleaning of the pens is used to control manure and odor. If the floor temperature of the building is high enough to keep the floor warm and dry no bedding is necessary. Disease control is the most critical problem of a enclosed building. When the building is being used in a system in which the pigs in the building vary in weight from 40 lbs to 220 lbs. The variance in weight and age, combined with a large number of pigs in a relatively small space, coupled with dampness, high humidity and the contagious nature of most damaging diseases creates many disease problems. However disease may be controlled if the farmer considers the following factors: (1) adequate ventilation, (2) supplemental heat, (3) use of disease free foundation stock, and (4) control of human carriers.

Ventilation must be adequate to prevent damp, disease breeding conditions.

Supplemental heat will prevent chilling of pigs due to sudden changes in temperature.

If the present foundation stock is diseased, the introduction of Specific Pathogen Disease Free Swine will aid the manager in controlling disease. An economic study has indicated that SPF swine can increase profits by $28.00 per litter.[7] These pigs should perform well in confinement systems, because problems of contamination are reduced by automatic equipment and well constructed pens.

The people that work with the hogs must be clean. They can not expect to visit their neighbors diseased hog lot and then come home to do their own chores and hope to control disease. Foot-pans and a special set of clothing should be worn in the finishing building only.

Economic Aspects

Plans 8,9, and 10 are the same structure with a rearrangement of equipment. Plan 8 has two manure augers and

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[7]Robert R. Burr, "The Economics of Specific Pathogen Free Swine for the Commercial Swine Producer", (unpublished term paper) 1961, p.30.

one feed auger. Through this arrangement the entrepreur has a smaller distance to move the manure to a gutter than any of the other floors designed. The feed auger is mechanized to the degree that any ration may be fed to any combination of feeders automatically. Plan 9 has the same feed auger as plan 8. The change in design is in the placement of the manure auger. (see plan 9). The advantage is the reduction in initial cost of equipment. The disadvantage is that the manure must be moved a longer distance. Plan 10 has one manure auger like plan 9. But it has two feed augers which are completely automatic. However the initial cost is higher with no apparent advantage.

Plan 11 is a building which can be entered with a tractor and wagon. Its design advantage lies in its initial cost. It can be erected without automatic equipment. It has the same environmental control when heated as plans 8,9,and10. It has the disadvantage in that when automation does take place two manure augers and one feed auger will be necessary to handle the feed and manure.

It should be emphazed that these buildings should not be erected unless a forced ventilation system is used, to keep moisture at under 75%. The ventilation doors are designed for summer use.

The cost of operation of the heating systems can be reduced by lowering the ceiling to the level of the truss;

however initial building cost would increase. If completely equipped heated buildings are compared, Plan 9 Case [illegible] is the lowest cost ($14,245.94). Plan 11 is the lowest cost ($11,105.31), if capital is limited to the extent that automation is not feasible (assuming that the manager has a tractor, scraper, loader, and feed wagon at his disposal)

CHAPTER VI

SWINE SYSTEMS

Introduction

The analysis of individual buildings is only one phase in the process of planning a swine confinement program. The choice of the building is partly controlled by the system in which the pigs will be produced. Before the system may be selected there must be agreement on the level of multiple farrowing and weaning age as they greatly affect the level of investment. The assumptions under which the system will operate should also be stated. The next step is the selection of a swine system. This study is limited to the buildings of the system that are used to grow pigs from birth to market, a more complete study would analyze the types of gestation housing, boar quarters, and isolation pens.

The first objective of this section is to analyse the different systems that may be used to raise swine given the alternatives that have been presented (see page 44). The second objective will be to emphasis the change in initial cost per pig as the buildings already presented are used to varying levels of efficiency. Engineering and animal husbandry problems will also be discussed as special problems of each system. The final selection of the swine system must be made subjectively by the swine producer.

Alternative Swine Systems

Table VI-1 presents four possible alternatives of constructing a swine system. The mechanized, heated, farrow-to-finish building (Plan 1, Case A) was the only alternative considered for System I. Other variations of equipment, heating systems, construction could have been presented, but they could not have been compared to other buildings examined in this study. System II is a two building system composed of a combination farrow-nursery building and a finishing building.

System III is a three building system which uses any alternative of the farrowing, nursery or finishing buildings that are presented. In System IV an additional nursery is needed to keep up with the output of the farrowing house and allow a clean-up and decontamination period of one week.

Table VI-1

Alternative Swine Systems

SYSTEM I - One Building			
Farrow-to-Finish Building			Maximum output = 160 pigs/year
SYSTEM II - Two Buildings			
Combination Farrow-Nursery			Maximum output = 320 pigs/year
SYSTEM III - Three Buildings			
Farrowing Building	Nursery Building	Finishing Building	Maximum output = 800 pigs/year
SYSTEM IV - Four Buildings			
Farrowing Building	Nursery Building Nursery Building	Finishing Building	Maximum output = 960 pigs/year

The choice of the system depends upon the following factors: (1) the number of pigs produced by the system, (2) the initial cost of the system, (3) average total cost per pig produced, (4) advantages & disadvantages of a particular system according to engineering and husbandry practices, and (5) the human element.

System I

Each system has a different maximum level of output, which greatly affects the initial cost of the system on a per pig basis. The charts on the effect of weaning age and level of multiple farrowing indicate that the farrow-to-finish building will be used for 6 months from the time the first sow is brought into farrow until the building is cleaned up and ready for the next litter. It can be readily seen that a farrow-to-finish building can produce only two litters of pigs per year under the assumptions made in Chapter 3. Even though the building has the lowest level of output when used as a swine confinement system, there are some advantages and disadvantages to such a building that may affect a decision regarding its desirability. It is argued that System I is the most desirable for the following reasons.[1]

"Reduced labor", the building needs to be completely cleaned and decontaminated only twice a year. If five farrow-to-finish buildings were constructed, to produce 800 pigs per year the number of thorough cleanings would number ten. In the conventional three building system at a level of output of 800 pigs the farrow and nursery would each have to be cleaned 10 times - a total of 20 times. In addition the pens used in the finishing shed would have to be thoroughly cleaned each time the pigs are moved

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[1]D.G. Jedele and Page L. Bellinger, "Farrow-to-Finish in One Building," Successful Farming, Vol 59. No. 10, October 1961, p. 41-58.

from one pen to another requiring as many as 40 pen cleanings (10 groups of pigs, each group using four pens).

"Reduced stress on pigs". In the farrow-to-finish system pigs are marketed from the same pen from which they are born. In theory this practice should eliminate the readjustment of the social order each time the pigs are moved. Changes in pen surroundings, water, and feeders are eliminated. However, in practice there would be some division of large litters of pigs from the pen they are born into smaller pens because of the limited space of eight pigs per pen. This division would not be very harmful since it would take place when the pigs were quite large.

"Disease outbreaks should occur less frequently and be more easily confined to buildings in which started." Because each group of pigs is separated according to sow group there is less chance for transmission of disease between groups. Also there is no introduction of new pigs into a relatively mature group of swine. Therefore, the new pigs are not subjected to the stress of adjusting to the organism build-up of the older pigs. If there is an outbreak of disease it should be possible to control it within the building there-by reducing the loss from the disease.

"Greater scheduling flexibility" is also regarded as an advantage since one group of sows is aligned with a particular farrow-to-finish building. Any miscalculation in scheduling does not affect the other groups because each building operates on its own time schedule. It should be pointed out that miscalculation in scheduling may cause excess labor requirements or idleness of building. This system is not a substitute for poor management of herd farrowing dates for any miscalculation is expensive in terms of feed , breeding time, labor, and investment.

The disadvantages of this building system are concerned with inefficiency of engineering and economics.

Because of large litters pigs will have to be moved It is necessary to keep the pigs in groups of about the same weight, thus in a farrow-to-finish building the weaker or lighter pig in the litter might be bullied and disturbed to the extent that he would not perform as well as if he had been placed in a different pen with pigs of his same condition.

Even though the sow and litter requires approximately the same floor space as a full grown litter there will be three to four months out of six in which there is excess floor space. The excess space may be as much as 40 square feet per pen for periods of one or two months.

Heating requirements are designed to take care of the new born pig, the system is only used to its capacity one month out of the year. Therefore there is wasted boiler capacity, copper tubing, and wall panels. The ventilation system must be capable of handling the large amounts

Table VI-2

The Level of Use of the System I Building Affects the Building Cost Per Pig Produced

Building	Total Bldg. Cost	160 Pigs	320 Pigs	480 Pigs	640 Pigs	800 Pigs	960 Pigs
1 - Farrow-to-Finish Bldg.	$10,890.07	$68.06					
2 - Farrow-to-Finish Bldgs.	21,780.14		$68.06				
3 - Farrow-to-Finish Bldgs.	32,670.21			$68.06			
4 - Farrow-to-Finish Bldgs.	43,560.28				$68.06		
5 - Farrow-to-Finish Bldgs.	54,450.35					$68.06	
6 - Farrow-to-Finish Bldgs.	65,340.42						$68.06

Since one building will produce 160 pigs at maximum efficiency, two buildings are necessary to increase output to 320 pigs. Additional buildings must be built if output is increased. If only 80 pigs are produced by a building the cost of the building would increase to $136.12 per pig.

of air for finishing pigs, when the pigs are under four months of age the system is not used to capacity.

It is impossible to fit the building into a breeding program of less than a six week weaning age without feeding the sow for an extra heat period.

The greatest disadvantage of the farrow-to-finish system is the investment cost. This system costs $68.06 per pig ($10,890.07 ÷ 160 = 68.06). The difference in cost reflects the wasted space, and inefficient use of equipment. Further disadvantages will be discussed in the advantages of the other systesm. Table VI-2 indicates that the building cost of production is constant.

Two Building System

This system is composed of a combination farrow-nursery building and a finishing house. If the assumptions of chapter 3 are used, two groups of sows farrowing twice a year is the maximum output of this system. The maximum output of the buildings designed in this study would be 320 pigs per year. The limitation is caused by three factors: (1) the physical limitation of the building (2) the gestation period of the sow and (3) the weaning age of the pigs.

Chart 1 in Appendix A shows that a combination farrow-nursery building can be used approximately five times a year. Charts 2,3,4, and 5 point out the possible alternatives considering the gestation period of the sow and the weaning age of the pig. If the pigs are weaned at an age of three weeks and the sows are rebred according to the chart, then four plus groups of pigs can go through the combination farrow-nursery building. Three groups of sows require the use of the building six plus times, which is more than the building can produce. If the pigs are weaned at six weeks of age and the sows are rebred according to the chart, then four groups of pigs can utilize the combination farrow nursery.

Therefore the combination farrow-nursery building can be used four times a year by 320 pigs. The total cost of the combination farrow-nursery is $9,349.76. The cost per pig produced is approximately $29.22. The finishing building designed for this study has a capacity of 320 pigs which is much too large for this system. Therefore, the cost of a building built to the specification of Table VI-3 has been estimated using the same basic data as used in the other buildings (see Appendix B) Space for 160 pigs will be sufficient according to the finishing building requirements for two groups of sows. (See Chart 6 Appendix B).

Table VI-3

System II Finishing Building Space Requirements

Pigs in Group	Square Feet/Pig	Total Space Required
80	5	400
80	10	800
Total		1200
Alleys		312
Flexibility (15% of total)		180
Size of Building		1,692 Square Feet

The cost per pig produced in the finishing system would be $26.04 (See Table V-8). The total building cost per pig produced is $29.18 + $26.04 = $55.22. The total cost of the enclosed finishing building is $8,335.20 (see Table VI-4).

Table VI-4

Building System II Enclosed Finishing Shed

Specifications:			
	Perimeter	171.3 ft.	Center Feed Auger
	Square Ft.	1,760	Center Manure Auger
	Size	51'4" x 34'4"	Hot Water Heat

CONSTRUCTION:		
Excavation	$59.[illegible]	
Footings	101.53	
Concrete Blks	342.15	
Farm Wall	1[illegible].76	
Gable Ends	1[illegible].00	
Roof	1,170.00	
Concrete Floor	651.20	
Gutter	49.05	
Doors (4)	200.00	
Pen Fencing	1[illegible].00	
Gates	132.00	
Ventilation Doors	56.00	
Wiring	150.00	
Solid Partition	64.00	
Water (Cooling)	99.73	
Water (Drinking)	79.50	
Perimeter Insulation	66.52	
Ceiling Insulation	314.1[illegible]	
Frame Wall & Gable Insul		175.[illegible]
Insulation in Concrete Blks		102.7[illegible]
Floor Insulation		[illegible]1.[illegible]
TOTAL CONSTRUCTION		[illegible]
EQUIPMENT:		
Feed Auger		$427.4[illegible]
Installation of Feed Auger		[illegible].40
Manure Auger		[illegible]
Installation of Manure Auger		[illegible]
Feeders		311.[illegible]1
Waters		[illegible]
Cover for Manure Auger		[illegible]
TOTAL EQUIPMENT		$1,[illegible].1[illegible]
HEATING SYSTEM:		
Heating		$1,171.[illegible]
Ventilation		202.[illegible]
TOTAL HEATING SYSTEM		$1,374.11
TOTAL BUILDING COST		$[illegible],333.[illegible]

Table VI-5

The Level of Use of the System II Buildings Affects the Building Cost Per Pig Produced[a]

Building	Total Bldg Cost[b]	160 Pigs	320 Pigs
Combination Farrow-Nursery			
Plan 4 Case F	$9,349.76	$58.44	$29.22
Plan 4 Case G	$6,997.71	$43.74	$21.87
Plan 5 Case H	$9,337.16	$58.36	$29.18
Plan 5 Case I	$7,427.86	$46.42	$23.21
Finishing Building[c]			
Plan 9 Case G1	$8,333.26	$52.08	$26.04

[a]The System can not produce more than 320 pigs per year or more generally more than four groups of pigs.

[b]See Table 14, Appendix B for explanation of numbers

[c] The finishing building design that is used is comparable to the condition of the farrow-to-finish building. Other plans may be used but they will be more expensive without improving conditions. If the other alternative has a lower cost it will not provide the same conditions as the farrow-to-finish building.

The advantage of the two building system is that the building cost per pig produced ($55.22) is much lower than the cost of production in system I. The disadvantages are in the form of labor and feed cost. The two building system requires more cleaning periods than the System I. Although there is no empirical evidence, it is thought the reduced movement and sorting of pigs in buildings System I as compared with System II will lower the feed cost per pig in System I. It has not been determined if the disadvantages will make System I more or less profitable than System II.

If a farmer built the two building system as described and only used it for the production of two litters per year his building cost would double. (see table VI-3, page 98).

Three Building System

The three building system is composed of a farrowing house, a nursery, and a finishing building. The size of the farrowing house and nursery are determined by the number of sows farrowing in one group. The size of the finishing building is determined by the number of pigs in the building at one time. According to Chart 1, Appendix A the finishing building will have to hold 320 pigs in four groups, if there are five groups of sows farrowing ten times a year.

The difference between System II and System III is that the function of the combination farrow-nursery has been divided into two phases: (1) farrowing and (2) nursery. If a building is erected for each phase then the initial building cost per pig can be reduced. (see Chart I Appendix 4). A separate nursery and farrowing house make it possible for up to ten farrowings per year to utilize the buildings.

The advantages of the three building systems are:

(1) Reduced initial cost of the building system per pig produced. If comparable structures are used for analytical purposes then the building cost of production would be as follows:

(1) Farrowing Building	8.94
(2) Nursery Building	8.79
(3) Finishing Building	17.91
Total Bldg Cost/Pig	35.64

(2) Pigs can be sorted into even groups to eliminate bullies, and tail-biters.

The disadvantages of the three building system are:

(1) Increase labor requirement because of the greater number of thorough cleanings.

(2) Excessive sorting may disturb pigs such that lower rates of gain and higher feed conversion ratios may result

(3) Disease buildup in the finishing shed because of various sizes of pigs in one building

It should be further noted that it is possible to place the nursery and farrowing buildings end-to-end. The cost of the structures combined would be reduced materially rather than be erected as separate units. The cost of the heating system would be reduced through the use of a common boiler. Manure augers could utilize the same motor drive unit. There would be further benefits in that the larger building could be built at a lower cost per square foot.

Table VI-6

The Level of Use of the System III Buildings Affects the Building Cost Per Pig Produced

Building	Total Bldg. Cost[a]	160 Pigs	320 Pigs	480 Pigs	640 Pigs	800 Pigs
Farrowing House						
Plan 2 Case B	$7,159.03	$44.74	$22.37	$14.91	$11.19	$8.94
Plan 2 Case C	5,048.73	31.55	15.77	10.52	7.89	6.31
Plan 3 Case D	7,352.47	45.96	22.98	15.32	11.49	9.19
Plan 3 Case E	5,645.74	35.28	17.64	11.76	8.82	7.06
Nursery House						
Plan 6 Case J	$5,924.59	$37.03	$18.52	$12.34	$9.26	$7.40
Plan 6 Case K	6,297.89	39.36	19.68	13.12	9.84	7.87
Plan 6 Case L	5,170.66	32.32	16.16	10.77	8.08	6.46
Plan 7 Case M	5,935.79	37.04	18.52	12.34	9.26	7.41
Plan 7 Case N	7,112.37	44.44	22.22	14.82	11.11	8.89
Finishing House						
Plan 8 Case O	$14,991.56	$93.72	$46.86	$31.24	$23.42	$18.74
Plan 8 Case P	13,254.20	82.86	41.43	27.62	20.71	16.57
Plan 9 Case Q	14,245.94	89.04	44.52	29.68	22.26	17.81
Plan 9 Case R	12,508.58	78.18	39.09	26.06	19.54	15.64
Plan 10 Case S	15,210.29	85.04	47.52	31.68	23.77	19.01
Plan 10 Case T	13,472.93	84.18	42.09	28.06	21.05	16.84
Plan 11 Case U	14,203.17	88.77	44.39	29.59	22.19	17.75
Plan 11 Case V	11,103.81	69.40	34.70	23.13	17.35	13.88
Plan 12 Case W	10,620.01	66.38	33.19	22.13	16.60	13.28
Plan 12 Case X	8,438.68	52.74	26.37	17.58	13.19	10.55
Plan 13 Case Y	9,310.46	58.20	29.10	19.40	14.55	11.64
Plan 13 Case Z_1	11,715.26	73.22	36.61	24.41	18.31	14.64
Plan 13 Case Z_2	11,660.38	72.88	36.44	24.29	18.22	14.58

[a] See Table 14, Appendix B.

If the building system is not used to capacity the cost per pig produced increases as the number of pigs produced is decreased. (See Table VI-6).

Four Building System

System IV is composed of a farrowing house, two nursery buildings and a finishing shed. Six groups of sows farrowing 12 times a year are necessary to keep the buildings full of pigs. The finishing shed is being used at peak capacity in that there are only four days of extra time between groups. When the finishing shed is used at peak capacity. Another nursery must be erected to absorb the output of the farrowing house and maintain finishing building at capacity (see Chart 1 Appendix E).

Increased building cost per pig produced is a disadvantage of System IV (See Table VI-7). The cost of the building system is as follows:

Farrowing House	$7.45
Nursery Bldg #1	7.41
Nursery Bldg #2	7.41
Finishing Bldg	14.84
Total Bldg. Cost/ pig	$37.11

The advantage of the four building system is to reduce the cost of the farrowing house and the finishing shed per pig produced.

There would be some advantage in building the structures so that common equipment could be used on all buildings; however, it is doubtful whether it would lower the cost so that it would compete with System III.

Other disadvantages of System IV are:

(1) Additional labor is required for many thorough cleanings.

(2) The pigs are sorted and moved to more new surroundings than any other system.

(3) Management ability must be superior if the groups are to be maintained for efficient production.

If only 800 pigs were produced by building system IV the building cost of production per pig would rise to $44.54. Table VI-3 presents how the use of the building will affect the cost of pigs that can be produced by the system.

Table VI-7

The Level of Use of the System IV Buildings Affects the Building Cost Per Pig Produced

Building	Total Bldg. Cost[a]	160 Pigs	320 Pigs	480 Pigs	640 Pigs	800 Pigs	960 Pigs
Farrowing House							
Plan 2 Case B	$ 7,159.03	$44.74	$22.37	$14.91	$11.19	$ 8.94	$ 7.45
Plan 2 Case C	5,048.73	31.55	15.77	10.52	7.89	6.31	5.26
Plan 3 Case D	7,352.47	45.96	22.98	15.32	11.49	9.19	7.66
Plan 3 Case E	5,645.74	35.28	17.64	11.76	8.82	7.06	5.88
Nursery House							
Plan 6 Case J	$ 5,924.59	$37.03	$18.52	$12.34	$ 9.26	$ 7.40	$ 6.17
Plan 6 Case K	6,297.89	39.36	19.68	13.12	9.84	7.87	6.56
Plan 6 Case L	5,170.66	32.32	16.16	10.77	8.08	6.46	5.39
Plan 7 Case M	5,935.79	37.04	18.52	12.34	9.26	7.41	6.18
Plan 7 Case N	7,112.37	44.44	22.22	14.82	11.11	8.89	7.41
Finishing House							
Plan 8 Case O	$14,991.56	$93.72	$46.86	$31.24	$23.42	$18.74	$15.62
Plan 8 Case P	13,254.20	82.86	41.43	27.62	20.71	16.57	13.81
Plan 9 Case Q	14,245.94	89.04	44.52	29.68	22.26	17.81	14.84
Plan 9 Case R	12,508.58	78.18	39.09	26.06	19.54	15.64	13.03
Plan 10 Case S	15,210.29	85.04	47.52	31.68	23.77	19.01	15.84
Plan 10 Case T	13,472.93	84.18	42.09	28.06	21.05	16.84	14.03
Plan 11 Case U	14,203.17	88.77	44.39	29.59	22.19	17.75	14.79
Plan 11 Case V	11,103.81	69.40	34.70	23.13	17.35	13.88	11.57
Plan 12 Case W	10,620.01	66.38	33.19	22.13	16.60	13.28	11.06
Plan 12 Case X	8,438.68	52.74	26.37	17.58	13.19	10.55	8.79
Plan 13 Case Y	9,310.46	58.20	29.10	19.40	14.55	11.64	9.70
Plan 13 Case Z_1	11,715.26	73.22	36.61	24.41	18.31	14.64	12.20
Plan 13 Case Z_2	11,660.38	72.88	36.44	24.29	18.22	14.58	12.15

a See Table 14, Appendix B.

Conclusions

There are four building systems. The systems are composed of several building alternatives. When comparing the building systems it is necessary to select those building alternatives which can be compared to the building alternatives of another system. For example, the farrow-to-finish building of System I is heated and automated. Therefore, the other systems must include automated and heated buildings if a fair comparison is to be made.

The farrowing building and finishing building of System II which are comparable to the farrow-to-finish building of System I are: Plan 5, Case H and Plan 9, Case Q_1. Both are the lowest cost of the alternatives considered which have a hot water heating system and automatic equipment comparable to the building in System I.

The farrowing building, nursery building and finishing building of System III which are comparable to the buildings of System I and II are: Plan 2, Case B; Plan 7, Case M and Plan 9, Case Q. The alternatives are the lowest cost which have the same facilities as the buildings of Systems I and II.

The farrowing building, two nursery buildings and the finishing building of System IV which are comparable to the buildings of System I, II and III are: Plan 2, Case B; two units of Plan 7, Case M and Plan 9, Case Q. The alternatives are the lowest cost which have the same heating

Table VI-8

The Efficient Use of the Building System Affects the Building Cost Per Pig Produced

Number of Pigs	Farrowing Building	Nursery Building	Nursery Building	Finishing Building	Total Cost of Building	Cost of System Per Pig Produced
Bldg. System I						
160 Pigs					$10,890.07	$68.06
320 Pigs					21,780.14	68.06
480 Pigs					32,670.21	68.06
640 Pigs					43,560.28	68.06
800 Pigs					54,450.35	68.06
960 Pigs					65,340.42	68.06
Bldg. System II						
160 Pigs	$9,337.16[a]			$8,298.26	$17,635.42	$110.22
320 Pigs	9,337.16			8,298.26	17,635.42	55.11
Bldg. System III						
160 Pigs	$7,159.03	$7,112.37		$14,245.94	$28,517.34	$178.23
320 Pigs	7,159.03	7,112.37		14,245.94	28,517.34	89.12
480 Pigs	7,159.03	7,112.37		14,245.94	28,517.34	59.41
640 Pigs	7,159.03	7,112.37		14,245.94	28,517.34	44.56
800 Pigs	7,159.03	7,112.37		14,245.94	28,517.34	35.65
Bldg. System IV						
160 Pigs	$7,159.03	$7,112.37	$7,112.37	$14,245.94	$35,629.71	$222.69
320 Pigs	7,159.03	7,112.37	7,112.37	14,245.94	35,629.71	111.34
480 Pigs	7,159.03	7,112.37	7,112.37	14,245.94	35,629.71	74.23
640 Pigs	7,159.03	7,112.37	7,112.37	14,245.94	35,629.71	55.67
800 Pigs	7,159.03	7,112.37	7,112.37	14,245.94	35,629.71	44.54
960 Pigs	7,159.03	7,112.37	7,112.37	14,245.94	35,629.71	37.11

[a] Combination - Farrow Nursery Building.

systems, automated equipment and etc. as the buildings of Systems I, II and III.

If the systems are used at maximum levels of efficiency, the building investment cost per pig will be:

Building System I	$60.06
Building System II	55.22
Building System III	35.65
Building System IV	37.11

If the advantages of disadvantages of the various systems are not considered, building System III has the lowest contractual cost per pig produced.[2]

Table VI-8 indicates the cost of the systems per pig at maximum efficiency and at various inefficient levels of use. If system III is not used at maximum efficiency its cost per pig will increase very rapidly ($39.12 if 320 pigs are produced).

The final decision on which building system to erect depends upon the advantages and disadvantages of the system, the cost of the system, and the human element. Since the first two have been discussed, the human element remains to be present for analysis.

Because the human element is subjective, a formalized methodology of analysis can not be presented. It is important the swine manager consider the human element because

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[2]If the buildings were capitalized over a ten year planning period the cost difference would be greater than has been indicated.

the profitability or satisfaction from the enterprise depends upon the manager as a human being. In general, the subjective analysis should pertain to an examination of the following points. More points could be added depending on the individual farm situation.

The swine producer must examine the swine enterprise as a business in view of his personal goals. For example, the labor and the investment in the swine enterprise must coincide with the time and the capital the swine producer desires to spend on the enterprise.

The swine producer must examine the goals of the swine enterprise in view of the goals of the farm family. The swine producer must decide for himself solutions to the following problems. The amount of capital spent on the swine enterprise should not stifle expenditures for the pleasure of the family unless the family is willing to make the necessary sacrifice. The farmer will have to be willing to spend several evenings a month aiding in the delivery of baby pigs to the exclusion of activity with the family.

The swine producer must analyze the means to the goals of the swine enterprise. The swine producer must ask himself if he has the ability to manage the system that he has selected. In addition, the farmer must have the physical resources of land, labor and capital to reach the goal.

Finally, the swine producer must be prepared to operate his enterprise as a business. Swine production can not be regarded as a way of life when the farmer chooses to enter the business world of mechanization and specialization.

The author, in view of the subjective nature of the decision and the human element which is envolved, can't make a general recommendation as to the most desirable swine building or system.

The author has the personal opinion that the evidence presented conclusively proves that System III has the lowest initial cost. It is conceded by the author that System III requires a high level of management, there are disease control problems, and that the labor for cleaning is increased. However the initial cost of System III ($35.04) is sufficiently lower than System I ($68.06) that the advantages of System I are not basis for justification of erecting farrow-to-finish buildings (System I).

The responsibility the manager must assume when managing an efficient swine system can't be ignored. If a manager feels he has the ability to operate a highly complex system (System III or IV) and erects that system; and later discovers he is unable to manage it; he must face the consequence of extremely high initial building cost per pig produced (see Table VI-C). Therefore System II may be a more desirable system even though the initial cost per pig produced is quite high ($55.22).

APPENDIX A

APPENDIX B

Table 1

Estimated Cost of the Farrow-to-Finish Building

Specifications:		
Perimeter	169.4 ft.	Hot water heat
Square Feet	1,305.5	Two feed augers
Dimensions	20'4" x 64'4"	Two manure augers

Item	Case A
CONSTRUCTION:	
Excavation	$ 59.29
Footings	179.58
Concrete Blocks	931.70
Framewall	296.45
Gable Ends	24.00
Roof	1,455.83
Concrete Floor	482.98
Gutter	159.59
Outside Doors (2)	100.00
Plywood Partitions	48.00
Panels for Farrowing Crate	240.00
Posts	120.00
Steel Endgates	71.00
Plywood End Panel	63.75
Fasteners for Endgate	20.00
Ventilation Doors	42.00
Water System (cooling)	152.20
Water System (drinking)	149.60
Electricity	167.00
Perimeter Insulation	67.70
Ceiling Insulation	134.11
Framewall & Gable End Insul.	107.00
Insulation in Concrete Blocks	101.64
Floor Insulation	234.95
TOTAL CONSTRUCTION	$5,388.39
EQUIPMENT:	
2 - Feed Augers	$1,201.20
2 - Manure Augers	846.72
Installation of Feed Auger	240.24
Installation of Manure Augers	84.67
Cover for Manure Augers	161.82
Feeders	299.00
Feed Dispensers	250.00
Waters	111.99
TOTAL EQUIPMENT	$3,195.84
VENTILATION & HEATING SYSTEM:	
Heating System	$1,850.94
Ventilation System	454.90
TOTAL HEAT & VENTILATION	$2,305.84
TOTAL BUILDING COST	$10,890.07

Table 2

Estimated Cost of the Farrowing House (Plan 2)

Specifications: Perimeter 98.3 ft. Square Feet 524.64 Dimensions 25'10" x 20'4" Single Aisle Hot Water Heat

Item	Case B	Case C
CONSTRUCTION:		
Excavation	$ 34.37	$ 34.37
Footings	104.09	104.09
Concrete Blocks	540.10	540.10
Framewall	171.85	171.85
Gable Ends	24.00	24.00
Roof	643.10	643.10
Concrete Floor	210.32	210.32
Gutter	82.37	
Outside Doors (2)	100.00	100.00
Plywood Dividers	16.00	16.00
Panels for Farrowing Crates	240.00	240.00
Posts	60.00	60.00
Steel Endgates	71.00	71.00
Plywood End Panel	22.50	22.50
Braces for Divider	8.00	8.00
Fastners for Endgate	20.00	20.00
Water System (drinking)	135.50	12.70
Wiring	153.00	109.00
Perimeter Insulation	39.28	39.28
Ceiling Insulation	104.88	104.88
Framewall & Gable End Insul.	65.10	65.10
Insulation in Concrete Blocks	58.92	50.92
Floor Insulation	105.24	105.24
TOTAL CONSTRUCTION	$3,035.60	$2,786.45
EQUIPMENT:		
2 - Feed Augers	$ 893.50	
2 - Manure Augers	509.38	
Installation of Feed Augers	178.66	
Installation of Manure Augers	55.94	
Cover for Manure Augers	72.00	
Feeders	149.50	
Waters	119.90	
Feed Dispensers	250.00	
Outside Platform		$ 450.55
TOTAL EQUIPMENT	$2,311.66	$ 450.55
VENTILATION & HEATING SYSTEM:		
Heating System	$1,566.25	$1,566.25
Ventilation System	245.50	245.50
TOTAL HEAT & VENTILATION	$1,811,75	$1,811.75
TOTAL BUILDING COST	$7,159.05	$5,048.75

Table 3

Estimated Cost of the Farrowing House (Plan 3)

Specifications: Perimeter 110.3 ft. Double Aisle
Square Feet 740.[illegible] Hot Water Heat
Dimensions 31'10" x 23'4"

Item	Case D	Case E
CONSTRUCTION:		
Excavation	$ 58.57	$ 58.57
Footings	116.81	116.81
Concrete Blocks	606.10	606.10
Framewall	192.85	192.85
Gable Ends	27.60	27.60
Roof	814.99	814.99
Concrete Floor	274.13	274.13
Gutter	90.94	
Outside Doors (4)	200.00	200.00
Plywood Dividers	12.00	12.00
Panels for Farrowing Crates	240.00	240.00
Posts	80.00	80.00
Steel Endgates	71.00	71.00
Plywood End Panel	46.50	46.50
Braces for Divider	6.00	6.00
Fastners for Endgates	20.00	20.00
Water System (drinking)	102.55	12.70
Wiring	160.00	109.00
Perimeter Insulation	44.08	44.08
Ceiling Insulation	132.88	132.88
Framewall & Gable End Insul.	75.50	73.50
Insulation in Concrete Blocks	66.12	66.12
Floor Insulation	153.36	153.36
TOTAL CONSTRUCTION	$3,549.98	$3,318.19
EQUIPMENT:		
1 - Feed Augers	$ 550.12	
2 - Manure Augers	612.94	
Installation of Feed Augers	110.24	
Installation of Manure Augers	61.29	
Cover for Manure Augers	79.50	
Feeders	149.50	
Waters	111.90	
Feed Dispensers	250.00	
Outside Platform		450.55
TOTAL EQUIPMENT	$1,925.49	$ 450.55
VENTILATION & HEATING SYSTEM:		
Heating System	$1,631.50	$1,631.50
Ventilation System	245.50	245.50
TOTAL HEAT & VENTILATION	$1,877.00	$1,877.00
TOTAL BUILDING COST	$7,352.47	$5,645.74

Table 4

Estimated Cost of the Combination Farrow-Nursery Bldg (Plan 4)

Specifications: Perimeter 145.3 ft. Single Aisle
Square Feet 1061.7 Hot Water Heat
Dimensions 52'4" x 20'4"

Item	Case F	Case G
CONSTRUCTION:		
Excavation	$ 50.82	$ 50.82
Footings	153.91	153.91
Concrete Blocks	798.60	798.60
Framewall	254.10	254.10
Gable Ends	24.00	24.00
Roof	1,167.87	1.167.87
Concrete Floor	392.83	392.83
Gutter	138.56	
Outside Doors (2)	100.00	100.00
Plywood Dividers	8.00	8.00
Panels for Farrowing Crates	240.00	240.00
Posts	100.00	100.00
Steel Endgates	71.00	71.00
Plywood End Panel	52.50	52.50
Braces for Divider	4.00	4.00
Fastners for Endgates	20.00	20.00
Concrete Block Wall	88.00	88.00
Water System (drinking)	146.30	146.30
Wiring	160.00	160.00
Perimeter Insulation	58.08	58.08
Ceiling Insulation	190.42	190.42
Framewall & Gable End Insul.	88.65	88.65
Insulation in Concrete Blocks	87.12	87.12
Floor Insulation	191.11	191.11
TOTAL CONSTRUCTION	$4,585.87	$4,450.31
EQUIPMENT:		
2 - Feed Augers	983.36	
2 - Manure Augers	769.42	
Installation of Feed Augers	196.67	
Installation of Manure Augers	76.94	
Cover for Manure Augers	121.25	
Feeders	222.10	$ 72.60
Waters	119.90	
Feed Dispensers	250.00	
Outside Platform		450.55
	$2,739.64	$ 523.15
VENTILATION & HEATING SYSTEM:		
Heating System	$1,778.75	$1,778.75
Ventilation System	245.50	245.50
	$2,024.25	$2,024.25
TOTAL BUILDING COST	$9,349.76	$6,997.71

Table 5

Estimated Cost of the Combination Farrow-Nursery Bldg (Plan 5)

<u>Specifications:</u>			
	Perimeter	151.3 ft.	Double Aisle
	Square Feet	1218.6	Hot Water Heat
	Dimensions	47'4" x 23'4"	

Item	Case H	Case I
CONSTRUCTION:		
Excavation	$ 52.92	$ 52.92
Footings	160.27	160.27
Concrete Blocks	831.60	831.60
Framewall	264.40	264.60
Gable Ends	27.60	27.60
Roof	1,340.35	1,340.35
Concrete Floor	450.85	450.85
Gutter	138.56	
Outside Doors (4)	200.00	200.00
Plywood Partition	45.00	45.00
Panels for Farrowing Crate	240.00	240.00
Posts	92.00	92.00
Steel Endgates	71.00	71.00
Plywood End Panel	76.50	76.50
Fasteners for Endgate	20.00	20.00
Plywood Divider	10.00	10.00
Concrete Block Wall	121.00	121.00
Water System (drinking)	105.55	105.55
Wiring	160.00	160.00
Perimeter Insulation	60.48	60.48
Ceiling Insulation	218.54	218.54
Framewall & Gable End Insul.	93.90	93.90
Insulation in Concrete Blocks	90.72	90.72
Floor Insulation	219.33	219.33
TOTAL CONSTRUCTION	$5,092.77	$4,893.21
EQUIPMENT		
1 - Feed Auger	$ 569.40	
2 - Manure Augers	769.42	
Installation of Feed Augers	113.88	
Installation of Manure Augers	76.94	
Cover for Manure Augers	121.25	
Feeders	222.10	$ 72.60
Outside Platform		450.55
Waters	119.90	
Feed Dispensers	250.00	
TOTAL EQUIPMENT	$2,232.89	$ 523.15
VENTILATION & HEATING SYSTEM:		
Heating System	$1,766.00	$1,766.00
Ventilation System	245.50	245.50
TOTAL HEATING & VENT	$2,011.50	$2,011.50
TOTAL BUILDING COST	$9,337.16	$7,427.86

Table 6

Estimated Cost of the Nursery Bldg (Plan 6)

Specifications:	Perimeter	109.3 ft	Double Aisle
	Square Feet	730.9	3 Week Weaning
	Dimensions	31'4" x 23'4"	Case K & L-Hot Water
			Case J-Hot Air Heat

Item	Case J	Case K	Case L
CONSTRUCTION:			
Excavation	$ 338.22	$ 38.22	$ 38.33
Footing	115.75	115.75	115.75
Concrete Blocks	600.60	600.60	600.60
Framewall	191.11	191.11	191.11
Gable Ends	27.60	27.60	27.60
Roof	803.99	803.99	803.99
Concrete Floor	528.13	270.43	270.43
Expanded Metal Floor	524.12		
Pen Walls	58.00	58.00	58.00
Posts	42.00	42.00	42.00
Gates	125.00	125.00	125.00
Doors (4)	200.00	200.00	200.00
Gutter	44.75	89.52	
Water System (drinking)	43.35	43.35	43.35
Wiring	122.00	139.00	88.00
Additional Excavation & Sand	85.90		
Perimeter Insulation	43.68	43.68	43.68
Ceiling Insulation	82.51	82.51	82.51
Framewall & Gable End Insul.	73.00	73.00	73.00
Insulation in Concrete Blocks	65.52	65.52	65.52
Floor Insulation		131.56	131.56
TOTAL CONSTRUCTION	$3,815.23	$3,140.84	$3,000.32
EQUIPMENT:			
1 - Feed Auger	$ 364.21	$ 364.21	
2 - Manure Augers	311.25	622.50	
Installation of Feed Augers	72.80	72.80	
Installation of Manure Augers	31.13	62.25	
Cover for Manure Augers		78.25	
Feeders	134.30	134.30	134.30
Waters	58.79	58.79	58.79
TOTAL EQUIPMENT	$ 972.48	$1,179.80	$ 193.09
VENTILATION & HEATING SYSTEM:			
Heating System	$ 891.38	$1,731.75	$1,731.75
Ventilation System	245.50	245.50	245.50
TOTAL HEATING & VENT	$1,136.88	$1,977.25	$1,977.25
TOTAL BUILDING COST	$5,924.59	$6,297.89	$5,170.66

Table 7

Estimated Cost of the Nursery Bldg (Plan 7)

Specifications:	Perimeter	117.3 ft	Double Aisle
	Square Feet	854.49	5 Week Weaning
	Dimensions	31'4" x 27'4"	Hot Water Heat

Item	Case M	Case N
CONSTRUCTION:		
Excavation	$ 41.02	$ 41.02
Footings	124.23	124.23
Concrete Blocks	644.60	644.60
Framewall	205.10	205.10
Gable Ends	40.50	40.50
Roof	939.94	939.94
Concrete Floor	316.16	316.16
Gutter		80.52
Outside Doors (4)	200.00	200.00
Plywood Partition	58.00	58.00
Posts	52.00	52.00
Gates	125.00	125.00
Creep Walls	60.00	60.00
Water System (drinking)	43.35	43.35
Wiring	88.00	139.00
Perimeter Insulation	46.80	46.80
Ceiling Insulation	153.25	153.25
Framewall & Gable End Insul.	85.00	85.00
Insulation in Concrete Blocks	70.20	70.20
Floor Insulation	153.80	153.80
TOTAL CONSTRUCTION	$3,446.95	$3,577.47
EQUIPMENT:		
1 - Feed Auger		456.52
2 - Manure Augers		655.04
Installation of Feed Augers		91.30
Installation of Manure Augers		65.50
Outside Platform	450.55	
Cover for Manure Augers		78.25
Feeders	209.05	359.05
Waters	58.74	58.74
TOTAL EQUIPMENT	$ 718.34	$1,764.40
VENTILATION & HEATING SYSTEM		
Heating System	$1,525.00	$1,525.00
Ventilation System	245.50	245.50
TOTAL HEAT & VENTILATION	$1,770.50	$1,770.50
TOTAL BUILDING COST	$5,935.79	$7,112.37

Table 8

Estimated Cost of the Enclosed Finishing Building (Plan 8)

Specifications:			
	Perimeter	231.3 ft	Double Aisle
	Square Feet	3,300	Center Feed Auger
	Dimensions	64'4" x 51'4"	Two Manure Augers

Item	Case O	Case P
CONSTRUCTION:		
Excavation	$ 80.92	$ 80.92
Footings	245.07	245.07
Concrete Blocks	1,271.60	1,271.60
Framewall	404.60	404.60
Gable Ends	135.00	135.00
Roof	3,300.00	3,300.00
Concrete Floor	1,221.00	1,221.00
Gutter	183.90	183.90
Outside Doors (4)	200.00	200.00
Plywood Partition	70.00	70.00
Pen walls	386.00	386.00
Gates	264.00	264.00
Ventilation Doors	70.00	70.00
Wiring	181.00	181.00
Water System (drinking)	136.10	203.50
Water System (cooling)	149.60	149.60
Perimater Insulation	114.40	114.40
Ceiling Insulation	591.86	591.86
Framewall & Gable End Insul.	205.60	205.60
Insulation in Concrete Blocks	138.72	138.72
Floor Insulation	594.00	594.00
TOTAL CONSTRUCTION	$9,943.37	$ 10,010.77
EQUIPMENT:		
1 - Feed Auger	$ 576.43	$ 576.43
2 - Manure Augers	1,030.30	1,030.30
Installation of Feed Augers	115.29	115.29
Installation of Manure Augers	103.03	103.03
Cover for Manure Augers	140.00	140.00
Feeders	623.62	623.62
Waters	141.56	207.56
TOTAL EQUIPMENT	$2,730.23	$2,846.23
VENTILATION & HEATING SYSTEM:		
Heating System	$1,920.76	
Ventilation System	397.20	397.20
TOTAL HEAT & VENTILATION	$2,317.96	$ 397.20
TOTAL BUILDING COST	$14,991.56	$13,254.20

Table 9

Estimated Cost of the Enclosed Finishing Building (Plan 9)

Specifications: Perimeter 231.3 ft | Square Feet 3,300 | Dimensions 64'4" x 51'4" | Double Aisle | Center Feed Auger | Center Manure Auger

Item	Case A	Case B
CONSTRUCTION:		
Excavation	$ 80.92	$ 80.92
Footings	245.07	245.07
Concrete Blocks	1,271.60	1,271.60
Framewall	404.60	404.60
Gable Ends	135.00	135.00
Roof	3,300.00	3,300.00
Concrete Floor	1,221.00	1,221.00
Gutter	91.95	91.95
Outside Doors (4)	200.00	200.00
Plywood Partition	70.00	70.00
Pen Walls	366.00	366.00
Gates	264.00	264.00
Ventilation Doors	70.00	70.00
Wiring	164.00	164.00
Water System (drinking)	136.10	203.50
Water System (cooling)	149.60	149.60
Perimeter Insulation	114.40	114.40
Ceiling Insulation	591.36	591.36
Framewall & Gable End Insul	205.60	205.60
Insulation in Concrete Blocks	138.72	138.72
Floor Insulation	594.00	594.00
TOTAL CONSTRUCTION	$9,834.42	$9,901.82
Equipment		
1 - Feed Auger	$ 576.43	$ 576.43
1 - Manure Auger	515.15	515.15
Installation of Feed Augers	115.29	115.29
Cover for Manure Augers	70.00	70.00
Installation of Manure Augers	51.51	51.51
Feeders	623.62	623.62
Waters	141.56	257.56
TOTAL EQUIPMENT	$2,093.56	$2,209.56
VENTILATION & HEATING SYSTEM:		
Heating System	$1,920.76	
Ventilation System	397.20	397.20
TOTAL HEAT & VENTILATION	$2,317.96	$397.20
TOTAL BUILDING COST	$14,245.94	$12,508.58

Table 10

Estimated Cost of the Enclosed Finishing Building (Plan 10)

Specifications: Perimeter 231.3 ft — Square Feet 3,300 — Dimensions 64'4" x 51'4" — Double Aisle — Two Feed Augers — Center Manure Auger

Item	Case S	Case T
CONSTRUCTION:		
Excavation	$ 80.92	$ 80.92
Footings	245.07	245.07
Concrete Blocks	1,271.60	1,271.60
Framewall	404.60	404.60
Gable Ends	135.00	135.00
Roof	3,300.00	3,300.00
Concrete Floor	1,221.00	1,221.00
Gutter	91.95	91.95
Outside Doors	200.00	200.00
Plywood Partition	61.00	61.00
Pen Walls	386.00	386.00
Gates	264.00	264.00
Ventilation Doors	70.00	70.00
Wiring	181.00	181.00
Water System (drinking)	136.10	203.50
Water System (cooling)	149.60	149.60
Perimeter Insulation	114.40	114.40
Ceiling Insulation	591.86	591.86
Framewall & Gable End Insul	205.60	205.60
Insulation in Concrete Blocks	138.72	128.72
Floor Insulation	594.00	594.00
TOTAL CONSTRUCTION	$9,842.42	$9,909.82
EQUIPMENT"		
2 - Feed Augers	$1,201.82	$1,201.82
1 - Manure Auger	515.15	515.15
Installation of Feed Augers	240.36	240.36
Installation of Manure Auger	51.51	51.51
Cover for Manure Augers	70.00	70.00
Feeders	829.51	829.51
Waters	141.56	257.56
TOTAL EQUIPMENT	$3,049.91	$3,169.91
VENTILATION & HEATING SYSTEM:		
Heating System	$1,920.76	
Ventilation System	397.20	397.20
TOTAL HEAT & VENTILATION	$2,317.96	397.20
TOTAL BUILDING COST	$15,210.29	$13,472.93

Table 11

Estimated Cost of the Enclosed Finishing Building (Plan 11)

<u>Specifications:</u>	Perimeter	229.3 ft	Center Driveway
	Square Feet	3,270	
	Dimensions	64'4" x 51'4'	

Item	Case U	Case V
CONSTRUCTION:		
Excavation	$ 80.22	$ 80.22
Footings	242.95	242.95
Concrete Blocks	1,260.60	1,260.60
Framewall	401.10	401.10
Gable Ends	140.40	140.40
Roof	3,270.00	3,270.00
Concrete Floor	1,209.90	1,209.90
Outside Doors(2)	250.00	250.00
Pen Walls	330.00	330.00
Gates	264.00	264.00
Ventilation Doors	70.00	70.00
Wiring	130.00	130.00
Water System (drinking)	119.50	184.30
Water System (dooling)	158.20	158.20
Perimeter Insulation	91.68	91.68
Ceiling Insulation	601.87	601.87
Framewall & Gavle End Insul	208.20	208.20
Insulation in Concrete Blocks	137.52	137.52
Floor Insulation	588.60	588.60
TOTAL CONSTRUCTION	$9,554.74	$9,619.54
EQUIPMENT:		
Feed Auger	$1,132.83	
Installation of Feed Auger	226.57	
Feeders	829.51	829.51
Waters	141.56	257.56
TOTAL EQUIPMENT	$2,330.47	1,087.07
VENTILATION & HEATING SYSTEM:		
Heating System	$1,920.76	
Ventilation System	397.20	397.20
TOTAL HEAT & VENTILATION	$2,317.96	$ 397.20
TOTAL BUILDING COST	$14,203.17	$11,103.81

Table 12

Estimated Cost of the Open Shed Finishing Building (Plan 12)

<u>Specifications:</u> Perimeter 272 ft
Square Feet - Inside 1,771 - Outside 2,183
Dimensions
Uncovered Feed Floor

Item	Case W	Case X
CONSTRUCTION:		
Excavation	$ 52.68	$ 76.98
Footings	288.74	288.74
Concrete Blocks	827.75	827.75
Framewall	263.38	263.38
Gable Ends	22.50	22.50
Roof	1,948.10	1,948.10
Concrete Floor	1,310.17	1,637.68
Front of Building	976.50	976.50
Doors on Front	84.00	84.00
Ventilation Doors	70.00	70.00
Cutter	173.46	
Pen Walls	519.00	519.00
Gates	264.00	264.00
Plywood Partition	66.00	66.00
Wiring	150.00	116.00
Water System (drinking)	187.60	187.60
Water System (cooling)	132.25	132.25
Perimeter Insulation	108.80	108.80
TOTAL CONSTRUCTION	$7,444.93	$7,589.28
EQUIPMENT:		
Feed Auger	$ 838.07	
Manure Cleaner	1,200.00	
Installation of Feed Auger	167.61	
Installation of Manure Cleaner	120.00	
Feeders	622.00	$ 622.00
Waters	227.40	227.40
TOTAL EQUIPMENT	$3,175.08	$ 849.40
TOTAL BUILDING COST	$10,620.01	$8,438.68

Table 13

Estimated Cost of the Open Shed Finishing Building (Plan 13)

<u>Specifications:</u> Perimeter 272 ft
Square Feet 3,954
Dimensions 121'4" x 32'8"
Covered Feed Floor.

Item	Case Y	Case Z_1	Case Z_2
CONSTRUCTION:			
Apron Excavation	$ 16.48		
Excavation	107.73	107.73	
Footings	326.27	326.27	
Concrete Blocks	1,025.75	1,025.75	
Framewall	326.38	326.38	
Gable Ends	48.00	48.00	
Roof	3,360.90	3,360.90	
Concrete Floor	1,637.68	1,463.12	
Support Posts	120.00	120.00	
Ventilation Doors	70.00	70.00	
Gutter		173.46	
Pen Walls	519.00	519.00	
Gates	264.00	264.00	
Plywood Partition	66.00	66.00	
Wiring	116.00	150.00	
Water System (drinking)	187.50	187.50	
Water System (cooling)	132.25	132.25	
Perimeter Insulation	123.12	123.12	
TOTAL CONSTRUCTION	$8,461.06	$8,540.18	$8,540.18
EQUIPMENT:			
Feed Auger		$ 838.07	$ 923.42
Manure Cleaner		1,200.00	1,200.00
Installation of Feed Auger		167.61	184.68
Install. of Manure Cleaner		120.00	120.00
Feeders	$ 622.00	622.00	464.70
Waters	227.40	227.40	227.40
TOTAL EQUIPMENT	$ 849.40	$3,175.08	$3,120.20
TOTAL BUILDING COST	$9,310.46	$11,715.26	$11,660.38

Table 14

Summary of Total Cost of the Building Alternatives

Building	Total Construction Cost	Total Equipment Cost	Total Cost Of Heat & Ventilation	Total Cost of Building	Total Square Feet	Cost / Square Foot
Farrow-to-Finish						
Plan 1 Case A	$5,388.39	$3,195.84	$2,305.84	$10,890.07	1,305.3	$8.34
Farrowing House						
Plan 2 Case B	$3,035.60	$2,311.68	$1,811.75	$7,159.03	584.6	$12.25
Plan 2 Case C	2,786.43	450.55	1,811.75	5,048.73	584.6	8.64
Plan 3 Case D	3,549.98	1,925.49	1,877.00	7,352.47	740.9	9.92
Plan 3 Case E	3,318.19	450.55	1,877.00	5,645.74	740.9	7.62
Combination Farrow-Nursery						
Plan 4 Case F	$4,585.87	$2,739.64	$2,024.25	$9,349.76	1,061.7	$8.81
Plan 4 Case G	4,450.31	523.15	2,024.25	6,997.71	1,061.7	6.59
Plan 5 Case H	5,092.77	2,232.89	2,011.50	9,337.16	1,218.6	7.66
Plan 5 Case I	4,893.21	523.15	2,011.50	7,427.86	1,218.6	6.10
Nursery House						
Plan 6 Case J	$3,815.23	$ 972.48	$1,136.88	$5,924.59	730.9	$8.11
Plan 6 Case K	3,140.84	1,393.10	1,977.25	6,297.89	730.9	8.62
Plan 6 Case L	3,000.32	193.09	1,977.25	5,170.66	730.9	7.07
Plan 7 Case M	3,446.95	718.34	1,770.50	5,935.79	854.5	6.95
Plan 7 Case N	3,577.47	1,764.40	1,770.50	7,112.37	854.5	8.32

Table 14--Continued

Building	Total Construction Cost	Total Equipment Cost	Total Cost of Heat & Ventilation	Total Cost of Building	Total Square Feet	Cost / Square Foot
Finishing Bldg.						
Plan 8 Case O	$ 9,943.37	$2,730.23	$2,317.96	$14,991.56	3,300	$4.54
Plan 8 Case P	10,010.77	2,846.23	397.20	13,254.20	3,300	4.02
Plan 9 Case Q	9,834.42	2,093.56	2,317.96	14,245.94	3,300	4.31
Plan 9 Case R	9,901.82	2,209.56	397.20	12,508.58	3,300	3.79
Plan 10 Case S	9,842.42	3,049.91	2,317.96	15,210.29	3,300	4.61
Plan 10 Case T	9,909.82	3,165.91	397.20	13,472.93	3,300	4.08
Plan 11 Case U	9,554.74	2,330.47	2.317.96	14,203.17	3,270	4.34
Plan 11 Case V	9,619.54	1,087.07	397.20	11,103.81	3,270	3.40
Plan 12 Case W	7,444.93	3,175.08		10,620.01	3,954	2.69
Plan 12 Case X	7,589.28	849.40		8,438.68	3,954	2.13
Plan 13 Case Y	8,461.06	849.40		9,310.46	3,954	2.35
Plan 13 Case Z_1	8,540.18	3,175.08		11,715.26	3,954	2.96
Plan 13 Case Z_2	8,540.18	3,120.20		11,660.38	3,954	2.95

Table 15

Construction Data[a]

Item		Labor & Material[b]
Excavation (36" deep by 8" wide)		$ .35/linear ft.
Footings		1.06/linear ft.
Concrete Blocks (16" by 8" by 48")		5.50/linear ft.
Roof (including truss)	55 ft span	1.00/square ft.
	40 ft span	.85/square ft.
	24 ft span	1.10/square ft.
Sidewalls (above blocks)		1.75/linear ft.
Concrete Floor	w/vapor barrior	.37/square ft.
	w/o vapor barrior	.30/square ft.
Perimeter Insulation		.40/linear ft.
2" Batt Insulation	ceiling	.17/square ft.
	gable ends & sidewall	.20/square ft.
Expanded Insulation in Concrete Blocks		.15/square ft.
Plywood for Pen Partitions		.25/square ft.
Pen Fencing		1.50/linear ft.
Hardware and Labor per Gate		7.00/gate
Treated Post Installed		2.00 each
30" Doors		50.00 each
Galvinized Water Pipe	1/2" dia.	.20/linear ft.
	3/4" dia.	.30/linear ft.
8" Vitrified Clay Tile		.40/linear ft.
Excavation (water pipe)		.20/linear ft.
"T" Valves		1.50 each
"T"'s and Elbows		.35 each
Filling Trench		.10/linear ft.
Nipples		.20 each
Wire & Installation for Water Heating Elements		4.00/unit
Labor for the Installation of Waterers		5.00 each
Labor for Cut and Fit on a Pipe		.50/cut & fit
Switch for Cooling System Timer		3.50/unit
Labor for the Assembly of a Spray Nozzle		1.00 each
Timer		14.00 each
60 Amp Electrical Service		60.00 each
Switch for Electric Motor		10.00 each
Cost per Electric Fixture Installed		3.50/fixture
Labor & wire for Electric Motor		7.00 each

[a]All estimates of building construction were made by Mr. Joe Miller Lansing, Michigan. All prices are FOB Williamston, Michigan and are subject to change without notice. The author used the construction data given to him by Mr. Miller to determine the construction cost of a building.

[b]Cost of Labor and material unless stated as the cost of labor or material.

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