FEED MANUFACTURING COSTS AND CAPITAL REQUIREMENTS

ECONOMIC RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURAL ECONOMIC REPORT NO. 335

Feed Manufacturing Costs and Capital Requirements. By Carl J. Vosloh, Jr., Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No.

ABSTRACT

Costs were synthesized for 99 model feed plants producing between 6 and 50 tons per hour of size of operation and specialization on feed manufacturing costs. These costs were analyzed to show the effect on costs of such factors as: pelleting, packaging, warehousing and utilization of plants' capacity. Plant investment ranged from $368,440 for a 6-ton per hour plant to $1,839,380 for a 50-ton plant, with equipment counting for 35 to 55 percent of the total. Operating costs ranged from $15.16 to $4.80 per ton. Lowest costs were in plants which neither pelleted nor packaged feed. Fixed costs per ton were reduced between 12 and 20 percent for 16 hours of operation rather than 8 hours.

Keywords: Mixed feeds, Processing, Economic engineering, costs, formula feeds

Washington, D.C. 20250 May 1976

PREFACE

This study is part of the Department's program of economic research to expand market outlets and increase efficiency in marketing farm production. The farmer has a double interest in the feed industry's efficiency since he produces the feed ingredients and also purchases the finished products.

This is a revision of Marketing Research Report No. 815, Costs and Economics of Scale in Feed Manufacturing. It reflects improved technology as well as increased efficiencies realized by feed manufacturers since issuance of the earlier report in 1968. Information in this report is concerned with facility and equipment requirements, capital investment, labor requirements, and operating costs.

No report of this type is possible without the basic data supplied by individual companies in the formula feed industry. The author wishes to thank the individuals and their companies who cooperated in our research program. Acknowledgement also is due to the equipment manufacturers and their engineers who supplied equipment and facility cost information which was most vital to this study.

CONTENTS

SUMMARY

Numerous changes have occurred in the feed industry in recent years. It has largely decentralized into smaller mills, increased bulk deliveries, offered more products and services, and developed more interrelationships with livestock and poultry production. More local and regional mills have been built to meet these demands. Thus, owners and managers increasingly need information in making decisions about operating practices and efficiency.

Estimates of investment requirements and operating costs per ton of feed produced have been developed for 99 model plants. Four groupings form the nucleus for these model plants, with representative production of 6 to 10 tons per hour, 10 to 25 tons per hour, 25 to 35 tons per hour, and 35 to 50 tons per hour. From each of these groups, three production types of plants are developed so that effects of specialization, utilization of capacity, and variations in pelleting or packing may be measured.

Total investment requirements for equipment, facility, and land for the 6 to 10 tons per hour group range from $384,440 to $556,915. In the largest 35 to 50 tons group, investment is $1,395,850 to $1,871,380. On an annual ton capacity basis, costs for the 6 to 10 tons group are $30.80 and $26.77 per ton, respectively. In the 35 to 50 tons group, the costs are $19.17 and $17.99, respectively.

In each group, the lowest tonnage model plant manufactures all ruminant feeds, the highest tonnage plant produces a poultry-swine feed, and the plant in the mid-production range manufactures all types of feed. Larger volume plants tend to have a greater percentage of total investment in equipment. Investment costs are higher for model plants which provide for pelleting and both packaged and bulk shipments.

Total operating costs range considerably among groups and the numerous variations in operations. In general, the lowest costs per ton are realized in the specialized poultry-swine models at the highest production levels in each group. The 10-ton models in the 6 to 10 ton group have operating costs about 25 percent less per ton than those of 6 tons. Total costs for this group range from $15.16 to $7.20 a ton. The next group, 10 to 25 tons per hour, has a 42 percent reduction in costs from the low to the high. These per ton costs range from $14.52 down to $5.53. The other two groups, 25 to 35 and 35 to 50 tons per hour, have an average of 16 and 19 percent, respectively, decrease in cost from the lowest to the highest volume plants. Total costs per ton are $9.98 to $5.52 in the third group and $9.04 to $4.80 in the largest group.

Fixed costs for all groups account for 31 to 47 percent of total operating costs. Fixed costs make up a greater share of total costs in operations where labor is at a minimum. Variable costs increase primarily because of increased labor costs associated with bagging and warehousing.

Analyses in this study give definite indications of economies of size. Costs are synthesized for output ranging from 40 to 100 percent of capacity. As operations approach capacity, there is increased utilization of labor, yielding a lower labor cost per ton of output.

Manhour requirements for all models range from a low of .24 manhour per ton in the most efficient operation to 1.33 manhours in the least efficient. Pelleting and bagging finished feeds requires considerably more labor and more investment than other operations not doing it.

Operating costs are also estimated for a two-shift, 16-hour-a-day schedule. This reduces cost per ton of output by 12 to 20 percent. Total costs range from $3.93 per ton in the 50-ton plant to $13.18 per ton in the 6-ton model. Practically all savings by the two-shift operations are due to reduced fixed costs. Operations with pelleting or bagging operations tend to have smaller savings with the increased hours of operation.

FEED MANUFACTURING COSTS AND CAPITAL REQUIREMENTS

By

Carl J. Vosloh, Jr., Agricultural Economist
National Economic Analysis Division
Economic Research Service

INTRODUCTION

The mixed feeds industry has changed markedly in recent years in response to many economic and technical developments. It has largely decentralized into smaller mills with increased bulk deliveries, it has offered greater variety of products and services, and has developed more interrelationships with livestock and poultry production. More feed is now fed directly to livestock and poultry--either owned or custom fed--by feed companies, feedlot operations, and farmers. An increasing number of local and regional mills have been built to meet this varied demand.

Livestock and poultry production units have grown with improved, more efficient feeding patterns. Many have shifted from home produced to commercially prepared, nutritionally balanced feeds. Feeders have insisted on improved-quality mixed feeds made possible by research and advances in animal nutrition. Nutritional research has shown that livestock production can be greatly increased per unit of feed, particularly through the addition of ingredients such as vitamins, antibiotics, hormones, and drugs.

In recent years, strong economic pressures on agriculture have forced the producer to be increasingly aware of production costs. Since feed costs account for such a large part of livestock and poultry production costs, it is only good management to reduce them where possible.

Farmers are demanding numerous services from feed manufacturers and feed retailers. Frequently, these will include free delivery, extended credit, custom prepared feeds, quantity or volume discounts, guaranteed feed prices, and advice relating to various management problems.

Over the past 15 years, major relocations have taken place in livestock and poultry production, resulting in similar adjustments in the feed manufacturing industry. Specialized livestock and poultry production units have also contributed greatly to the decentralization of the mixed feeds industry. Large feed plants with extensive and relatively costly distribution systems have given way to the local, more efficient mills.

With better service and lower priced feeds in great demand, the feed industry has done several things to satisfy these demands. New technology and equipment, together with more efficient plant designs and material flows, have made possible tremendous improvements in plant operating efficiencies.

With the relocation of feed manufacturing facilities to production areas, the feed industry has realized potential cost reductions and savings by: (1) the operation of highly efficient, specialized feed mills, (2) direct distribution of larger volumes of mixed feed to production units, and (3) lower transportation costs.

Feed manufacturers attempting to meet competition are faced with many important questions. One of the most important is: "What size of manufacturing facility would minimize the production cost per ton of mixed feed?" Management must review numerous factors and analyze livestock and poultry production in its market area to determine the size and type of plant as well as the distribution system which would best serve customers' requirements.

METHODOLOGY

The economic-engineering approach is used to construct model feed plants. These models attempt to reflect current technology and operating practices of the feed industry. This study deals only with the plant facilities and the operating costs involved in manufacturing mixed feeds. Optimum plant location, marketing, and distribution are not analyzed.

Model mills are constructed to provide management with guidelines for labor standards, equipment costs, and other costs incurred in manufacturing livestock and poultry feeds. Investment and operating costs for these model plants represent average costs for the United States. A feed plant in a particular area or region may have higher or lower costs.

Revision of earlier developed models reflects the trends and practices of the feed manufacturing industry as indicated by equipment manufacturers, feed mill construction firms, and members of the mixed feeds industry. One important change in these models was associated with a major trend, the degree of specialization. About two-thirds of these models are specialized operations for either poultry and swine or ruminant feed. The other third of the models represent full-line feed plants mixing all types of livestock and poultry feeds.

In this study, four basic feed groups serve as the nucleus for the other models (table 1). A given set of equipment and facilities has the capability of manufacturing a wide range of tonnages, depending on the materials handled and the types of feeds produced. Basic types of operating equipment, including specification, used in designing the model mills, are listed in Appendix A.

Model mill capacities are based on the potential production of the mixing center in an 8-hour day. These models are assumed to operate one 8-hour shift

Table 1.--Basic feed plant groups: Kinds of feeds produced and tonnage 1/

Basic plant group and tonnage range		Kinds of feed produced and tonnage					
		Dairy		Mixed		Poultry-swine	
Group	Tons/hour	Per hour	Annual	Per hour	Annual	Per hour	Annual
I	6 to 10	6	12,480	8	16,640	10	20,800
II	10 to 25	10	20,800	18	37,440	25	52,000
III	25 to 35	25	52,000	30	62,400	35	72,800
IV	35 to 50	35	72,800	43	89,440	50	104,000

1/ Tonnages developed from average densities for various kinds of feeds (weight per cubic foot).

a day, 260 days a year. Production or output of these models is based on the average cubic foot weight of the feed ingredients and finished products. For example, dairy feed may weigh between 20 to 30 pounds per cubic foot while poultry feed may be between 38 and 42 pounds per cubic foot. This means on the average a cubic foot of manufactured poultry feed is considerably heavier than dairy feed. This variation makes it possible for a system to process a greater tonnage of the heavier, more dense feed than that of a lighter, less dense feed even though the total cubic feet of each material may be equal.

An average of 28 pounds per cubic foot of finished feed is used to estimate output of ruminant feed plant models in this study. The poultry and swine feed plant models uses 40 pounds per cubic foot. Therefore, it would be possible with a specialized poultry operation to increase output 40 percent above a plant manufacturing ruminant feeds.

Mill operations are further varied by: (1) quantity of total mill output that is pelleted, (2) quantities of output that are bagged and quantities that are in bulk (table 2). Each varied operation is designated by a letter A, B, C, etc. which are used throughout the report. 1/

1/ Four basic groups of mills encompassing variations in tonnage capacity and production forms are identified as I, II, III, and IV. For example, when discussing individual operations of a particular size and type mill, say, II-25-E, it would refer to a mill in group II, with a 25-ton per hour capacity and 100 percent pelleted product of which 50 percent is bagged.

Table 2.--Operational designation used for variations in models

Operation	Mash		Pellets	
	Bagged	Bulk	Bagged	Bulk
	Percent			
A	-	100	-	-
B	50	50	-	-
C	100	-	-	-
D	-	-	-	100
E	-	-	50	50
F	-	-	100	
G	-	50	-	50
H	25	25	25	25
I	50	-	50	--

BASIC MILL OPERATIONS

Using the cost center breakdown in an analysis of the plant operations permits examination of individual segments of the total manufacturing process and enables management to locate inefficient production areas. With cost centers as the basis for development of model mills and analysis, a general knowledge is required of the plant layout for processing feed ingredients and moving mixed feed through mills.

Receiving.--The model mills are equipped to receive both rail and truck delivery of grains and other ingredients. Ingredients such as meat, fish meal, limestone, fat, molasses, and premixes are usually delivered by truck, while grains and soybean meal are usually delivered by rail.

Dry ingredients may be received either in bulk or in bags. Bulk ingredients are delivered by rail in hoppers or boxcars. Hopper cars are discharged directly into a receiving conveyor or pit, a more efficient method of receiving than from boxcars. Boxcars require more time and additional labor to unload. Bagged ingredients are delivered by rail or truck, loaded on pallets, moved by forklift truck, and stored in the warehouse.

Heated liquid fat and molasses are delivered by tank car or truck and pumped directly into heated storage tanks within the mill.

Bulk grain and other ingredients are conveyed from the receiving pit by a drag conveyor to a bucket elevator, then elevated and gravity fed through a scalper cleaner and in larger plants through a scale for recording weights. Both nonmetallic foreign material and tramp metal are removed during the cleaning process. After cleaning and weighing, in the larger models the material is elevated a second time and sent through a distributor to holding bins or to horizontal conveyors which convey the ingredients into storage bins.

Shelled corn and other whole grains are stored in outside bins adjacent to the main building. Soybean meal, the largest volume soft ingredient, is also stored in outside bins. Other soft bulk ingredients are stored in workbins above the mill work area. The ingredient storage capacity of the workbins is assumed to about equal the volume required for 5 days of mill operation at designed capacity.

Processing.--Shelled corn and other whole grains are ground or processed before mixing with other feed ingredients. Whole grains to be ground are conveyed from the holding storage bin to the hammermill. Ground grains are elevated to workbins by a mechanical system. The ground grains will then be blended with other ingredients in the mixing center.

Mixing.--The mixing cost center consists of: (1) moving bagged ingredients to the mixing center, (2) weighing, (3) mixing, (4) conditioning, and (5) conveying the mixed feed to the next operation.

Bulk ingredients go from overhead storage bins to the batch scale by means of gravity and feeder conveyors. Feeder conveyors are typical in many mill installations since large quantities must be moved quickly to keep the feed mixers charged. Quantities of various ingredients fed into the scale hopper are controlled from central control panels operated manually or automatically.

Bagged ingredients are brought from the warehouse to the mixing area as needed where the bags are opened, ingredients weighed and dumped into the mixer. Heated stabilized animal fat is metered directly into the mixer and may be controlled automatically or manually.

Each batch of feed is timed-mixed to obtain an adequate blend. Mixing time depends on the feed formulation, characteristics of the mixer, and the ingredients mixed. Mixing time for horizontal type mixers (as used in the three larger groups) varies from 3 to 5 minutes and may be controlled manually or by an automatic timing device.

After mixing, the feed is dropped into a surge bin and conveyed to a bucket elevator. The surge bin reduces the total mixing time required. The mixed feed is elevated and passed through a cleaner and conditioner to remove any foreign material and to break up lumps. The finished feed then goes to a bulk feed bin or to a storage bin for pelleting or bagging.

Pelleting.--This process involves several operations depending on the desired finished form and formulation of the feed. Pelleting starts with the mash feed being fed into the pellet mill conditioner. At this point, steam is added to the mash which is then forced through the pellet die by the rollers.

The continuous flow of hot pellets from the machine moves by gravity into a vertical or horizontal cooler. Pellets flow directly to the scalper where unpelleted mash and fines are removed. Pellets are then conveyed to the storage bin from which they are either shipped in bulk or held for packaging.

Packing.--Finished feed, both pellets and mash, flows by gravity from the storage bin through an automatic trip scale set to deliver 50 to 100 pounds, depending on the desired package. The feed is packaged, sealed, and then moved to warehouse storage on pallets by forklift or loaded directly on a truck or into a rail car for shipment.

It is most important in the packing operation for the worker to check periodically to see that the feed does not contain any foreign materials or look off-colored. The operator must check weights to see that the customer is getting the quantity specified on the bag and that the margin or average weight per bag is within satisfactory limits.

Warehousing.--A limited inventory of bagged or bulk feed must be held to provide leeway in promptly filling a customer's orders. The warehouse model provides bagged storage for about 5 days' requirement of the finished feeds of largest volumes as determined by past inventory behavior and orders typically expected. Several batches of each type of formula feeds should be mixed consecutively and warehoused so there will be less time lost in making changeovers.

MODEL MILLS

Model mills are developed and analyzed in this study to determine the effects of specialization, varying size, and utilization of capacity. These models were developed with manufacturing systems based on current mill engineering designs. Each model is based on a different output level based on engineered capacity. Costs of operating each size model are estimated at working levels based on a capacity utilization of about 90 percent.

Specifications for Model Mills

Specifications used in constructing model mills were obtained from past survey data updated with current information from trade associations, equipment manufacturers, and feed manufacturers. When the economic engineering approach is used for cost comparisons, it is necessary to establish certain basic specifications for all models so that operational standards may be set and costs may be calculated.

Equipment.--The kind, type, size, and number of equipment items required for each model mill are developed from input-output relationships and manufacturers' equipment specifications. Each model mill of a given capacity has the manufacturing equipment and potential to produce most formulations in specific forms and quantities during an 8-hour day. Equipment is divided into seven categories or cost centers, Appendix A. The equipment cost represents an average delivered price of the equipment ready for installation. Installation costs of equipment items for each model are estimated separately.

Receiving equipment includes conveyors, bucket elevators, cleaning, weighing, and other equipment for handling the incoming ingredients from the receiving point to storage bins.

Grinding equipment includes conveyors needed to move the grain from storage to the hammermills and mechanical conveyors for moving the ground material to the workbins. Distribution turnheads and conveyors located on the bin floor direct and convey the materials into the proper workbins.

Mixing equipment consists of feeder conveyors, hoppers, mixers, weighing, and mixing control devices. There are considerable differences among equipment components for the smallest and the largest models. The basic ones, however, are in the types of mixers and the more extensive automation the larger sized mills.

Pelleting is the most expensive process in terms of equipment costs. This cost center requires pellet mills, pellet coolers, graders, conveyors, boiler, and other miscellaneous equipment.

Boiler size for each model was based on estimated steam requirements. Most of the steam used in a mill is required for the pelleting operation. Boiler sizes vary from 40 horsepower in the smaller 6-ton per hour unit up to 250 horsepower for the 50-ton per hour model. These boilers are high pressure systems but are equipped for pressure reduction at the pellet mill. This type of system enables the pellet mill operator to get the maximum amount of steam with the correct amount of moisture necessary for the best pelleting.

Miscellaneous equipment in the models includes items not assignable to any particular cost center such as pumping equipment, tanks for storage of liquids, air compressors, remote motor controls for the entire mill, and bin indicators.

Facilities.--A number of variables affect and determine construction costs, including: location with reference to transportation, topography, and soil conditions of the site, type and size of building constructed, building materials used, and local building costs. All model mills are assumed to be located on fairly level sites and to have rail and highway access. Soil conditions are assumed to be satisfactory to support buildings with normal concrete footings. Buildings are of a combination masonry and steel sheeting construction. All buildings are designed with provisions for future expansion.

The mill building which houses the workbins and the equipment area is tall in relation to its width and length. This type of design permits the maximum use of gravity flow for moving materials.

The first floor and basement area of the mill houses the major equipment. Space requirements vary and depend largely on the size and type of the mill, the technology used, and the physical plant layout. On the first floor of the mill are located the mixing panelboard, the scale hopper, the scale, and packing equipment.

The workbin area is above the first floor. Below each of the workbins is a feeder conveyor to carry material from the bin hopper to the hopper scale above the mixer.

Each model mill building has an adjoining warehouse for storing and handling bagged ingredients. The warehouse capacity for each model is limited by the type of operation performed; that is, the size increases as the percentage of output bagged is increased. Warehouse capacity is equivalent to about 5-days' supply of the bagged finished product. The warehouse building is of steel construction set on a concrete base. A construction cost rate of $8.70 per square foot was used to estimate the warehouse investment for each of the models.

An office is included for the administrative personnel and staff. Space required for each model is primarily a function of the number of personnel. A cost of $25 per square foot was used to determine investments for estimated space requirements.

Sizes of boiler houses and maintenance shops are determined by the relative sizes of the model mills. Substantial quantities of steam are required for the manufacturing pellets, and heating liquids as well as the heating necessary in certain sections of the mill. Each mill has a boiler to supply the steam needs. A cost of $14 per square foot was used to estimate the cost of the boiler room and the stack.

Outside grain storage is incorporated in all model mills. Each mill has outside capacity of at least 15-days' supply of whole grain and soybean meal. Outside storage bins are of bolted steel construction and are located next to the mill building and the rail siding.

Each mill requires a rail siding to spot the loaded cars of ingredients as well as the empty cars waiting to be picked up. The linear feet of siding was determined by estimating the maximum number of cars on the track daily. A rate of $25 per linear foot of track was used to estimate the cost of the siding.

For each model handling bulk feed, the finished products are stored in outside holding bins with capacities equivalent to at least 1-day's output of bulk formula feed. These welded steel bins are erected on a steel frame over a weighing unit and located next to the mill. In the larger models, a platform truck scale is used to weigh the feed; however, for the smaller mills, a traveling weigh-hopper is used under the bin hopper. The weighing of the bulk feed is handled by workers within the mill. A printed ticket for each weighing is provided as each order of formula feed is placed in the bulk truck.

Acreage requirements for the model mills are determined by the land occupied by the mill buildings plus adequate space for truck movements. Models were assumed to require a minimum of 2 acres for the smaller mills up to 4 acres for the larger mills. A cost of $8,000 per acre was assumed to be reasonable. Site costs, however, will vary considerably depending on availability of utilities and other services and the land market.

Labor.--Labor in the models was classed as production, maintenance, and supervisory. A wage rate of $4.70 was used for production workers. 2/ Super-

2/ Employment & Earnings, Statistics, U.S. Dept. of Labor, Monthly 1975.

visor hourly wage rate was assumed at $5.00 per hour and a maintenance labor rate of $4.90 per hour. This study also assumed that a worker's 8 hours would be spent in more than one cost center operation. Likewise, routine or preventive maintenance and supervisory duties would be performed during part of the 8 hours of work.

Labor standards used in estimating costs were derived by updating in-plant cost standards used in previous studies. Standards were revised using the most recent survey data and with the assistance of feed manufacturers and feed equipment manufacturers.

It should be kept in mind that for each model, these standards were developed in accordance with equipment and specified production conditions. If physical conditions, production requirements, or equipment of the mill were changed, these figures may also change. Generally however, these figures are fairly dependable standards in most mills manufacturing a full range of formula feeds. These standards were set at a normal level of effort for the working force in the mill. Therefore, in some mills, particularly the specialized ones, this level of efficiency might be exceeded. It is customary in planning and designing new plants to allow for some excess mill capacity. This is done for several reasons: (1) to better utilize plant labor, (2) to make up lost tonnage due to shutdowns and emergency maintenance, and (3) to allow for anticipated increased demand in feed tonnage.

Maintenance labor was estimated in terms of the time needed for daily equipment oiling and maintenance, as well as conducting a preventive maintenance program. Time required for normal repairs of operating equipment was also included.

Depreciation.--Depreciation is the cost of time, wear, and obsolescence. Rates for determining annual depreciation costs for the models are developed from information provided by mills, equipment manufacturers, and the Internal Revenue Service guide.

Obsolescence appears to be the primary consideration in the establishment of equipment and depreciation rates. A 17-year depreciation period for equipment is assumed to be average. Some in the industry take longer or shorter depreciation periods. Equipment for all model mills was depreciated by using the straight line method over a 17-year period. Depending on the type, equipment in the models may have a useful life of 10 to 25 years; however, this 17-year average appears realistic.

Numerous older mills and facilities have been depreciated over a longer period of time than is currently used for newer mills. Many other feed manufacturing facilities have been rendered obsolete by the numerous technological developments occurring in feed mill equipment. The industry is aware that obsolescence of a facility may become an even more important factor in the future.

For facility depreciation, the straight line method for a 25-year period was used. Internal Revenue Service provides a guide whereby facilities in the feed industry could be depreciated over periods of 25 to 50 years.

It is possible to make a good case for somewhat higher depreciation charges for plants operating more than one shift a day. However, annual hours of operation were not considered to be of major importance in making cost estimates for the models. Such depreciation is likely to be small in relation to time depreciation and obsolescence for equipment, particularly in a feed mill with an adequate preventive maintenance program.

Interest.--Annual interest cost was estimated by applying 4.5 percent (one-half the nominal interest rate of 9 percent) times the total capital investment in equipment and facilities. In addition, a rate of 9 percent was used on nondepreciable land investment.

The interest estimated is an imputed cost which did not take into account the source of investment capital. Although business firms show interest as an expense if paid to outside agencies, economic capital cost includes an interest allowance on the owner's equity.

Taxes.--Property taxes vary considerably by States and even by communities within a State. In some States, taxes may be levied on all property, while in other the equipment would be exempt. Also, communities in most States establish the percentage of total value to be assessed.

A tax rate of 1 percent of assessed value was used in this study. Assessed value was set equal to 35 percent of total investment in facilities and land.

Insurance.--Numerous factors affect the cost of insurance for a feed manufacturing facility. Those having to do with the plant include building materials used, type of electrical motors, fire prevention equipment in the mill, and location of the facility with regard to local fire protection. Mill location in relation to local fire fighting equipment and fire protection services is a very important factor in rate determination.

A rate of one-half of 1 percent of investment in buildings and 1 percent of equipment cost was used to estimate the annual cost of insurance.

Utilities.--Utility cost items include electricity, water, and fuel. Electricity cost estimates were based on the average machine operating time required in the feed manufacturing process and normal power used by equipment.

An average charge of 2.1 cents per kilowatt-hour was used. The straight line method was used since previous studies have shown total cost for electricity increases in direct proportion to increase in tonnage.

Water consumption was estimated by using a maximum of 100 gallons per day for each employee's personal use and 4.5 gallons for each boiler horsepower hour. Water cost was estimated using an average rate of 25 cents per 1,000 gallons. This average rate took into account the higher cost for the initial charge of minimum quantity used.

Fuel requirements were based on steam requirements in all parts of the mill. Steam is required for heating liquids, pelleting, and heating certain areas in the feed plant. An estimated average cost of 38 cents a gallon for

fuel oil was considered realistic. This may have overstated the fuel consumption costs in certain size mills and understated it in others; however, it was considered a realistic average for all sizes.

Other costs.--In addition to labor, ownership, administration, supervision, and utilities costs, there were other cost items to be considered.

Maintenance and repair annual costs for both equipment and facilities accounts for about 5-1/2 percent of the total original investment. Expenses for equipment repairs include the cost of replacing parts for equipment which has failed because of wear, as well as outlays for outside services hired by the mill to make such repairs. For example, it could involve the replacement of a burned-out hammermill motor. Equipment repairs tend to be a variable cost since they are a result of wear and use. Building maintenance was included since there is a cost involved in keeping the facilities in good repair. However, this is minor in relation to equipment maintenance.

Miscellaneous mill supplies include lubricants, housekeeping materials, feed registration and analysis fees, travel expenses for personnel, office supplies, telephone and other minor costs. Estimates of such costs per ton ranged from 60 cents for the smaller models down to 50 cents for the largest mill.

Plant Investment

Total plant investment for equipment and facilities in these models ranges from $368,440 in the I-6-A model, to $1,839,380 for the IV-50-H model (tables 3-6). Land costs would increase total costs for the smaller model to $384,440 and for the larger one to $1,871,380.

Investment of equipment and facilities per ton of annual capacity would range from $29.52 for the 6-ton-per-hour plant to $17.69 for the 50-ton model. Total cost including land would increase the smallest model's investment to $30.80 per ton and largest to $17.99. However, land is a minor portion of this investment even in the smallest models.

Feed mill investment (as shown in tables 3 to 6) represents the estimated cost of: (1) equipment, (2) facilities, and (3) installation of equipment. Equipment and facilities in model operations are synthesized from input-output relationships obtained from past surveys of feed manufacturers and recommendations of equipment manufacturers. A detailed breakdown of equipment and facility costs for all operations in the models is found in Appendix B.

Investment in equipment includes all equipment needed to have an efficient, well designed model. Installation costs were estimated separately. Total cost of equipment on the average is about one-third the total investment. Equipment and installation costs per unit of output tend to be slightly greater in both the smaller models and the ruminant feed models. Cost of the larger capacity equipment does not increase in direct proportion to increased capacity.

There are major differences in equipment and mill costs among the various models primarily because of variations in basic model requirements. For

Table 3.--Equipment and facility costs for model plants producing 6 to 10 tons per hour 1/

Size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
6-ton (ruminant feed)									
Equipment	159,870	187,260	170,640	2/	2/	2/	228,400	255,795	239,165
Facilities	208,570	217,670	214,570	2/	2/	2/	220,840	227,640	224,540
Total	368,440	404,930	385,210	2/	2/	2/	449,240	483,435	463,705
8-ton (mixed)									
Equipment	166,360	193,750	177,130	234,895	262,285	245,665	234,895	262,285	245,665
Facilities	240,690	252,060	246,800	247,780	256,660	251,400	253,810	262,660	257,400
Total	407,050	445,810	423,930	482,675	518,945	497,065	488,705	524,945	503,065
10-ton (poultry-swine)									
Equipment	150,970	178,370	160,750	158,670	186,060	169,440	219,595	246,885	230,275
Facilities	271,450	283,210	277,480	278,520	287,680	281,950	284,870	294,030	288,300
Total	422,420	461,580	438,230	437,190	473,740	451,390	504,465	540,915	518,575

1/ Detailed cost data are in Appendix B.
2/ No cost data developed for Models D, E, and F since this type of operation is not appropriate for an all-ruminant plant.

Table 4.--Equipment and facility costs for model plants producing 10 to 25 tons per hour 1/

Size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Percent								
10-ton (ruminant feed)									
Equipment	278,465	324,325	307,705	2/	2/	2/	382,730	428,590	411,970
Facilities	321,045	328,845	328,845	2/	2/	2/	333,735	344,030	338,310
Total	599,510	653,170	636,550	2/	2/	2/	716,465	772,620	750,280
18-ton (mixed)									
Equipment	287,700	333,560	333,715	391,965	437,825	437,980	391,965	437,825	437,980
Facilities	460,145	481,000	471,745	467,220	483,395	474,140	479,075	495,145	485,890
Total	747,845	814,560	805,460	859,185	921,220	912,120	871,040	932,920	923,870
25-ton (poultry-swine)									
Equipment	272,310	318,170	318,325	376,575	422,435	422,590	376,575	422,435	422,590
Facilities	527,740	551,295	537,620	534,395	553,375	539,700	545,420	581,405	550,830
Total	800,050	869,465	855,945	910,970	975,810	962,290	921,995	1,003,840	973,420

1/ Detailed cost data are in Appendix B.
2/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant plant.

Table 5.--Equipment and facility costs for model feed plants producing 25 to 35 tons per hour 1/

Size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
25-ton (ruminant feed)									
Equipment	471,725	518,195	536,590	2/	2/	2/	626,550	673,020	691,415
Facilities	596,335	623,115	609,440	2/	2/	2/	616,385	639,655	625,980
Total	1,068,060	1,141,310	1,146,030	2/	2/	2/	1,242,935	1,312,675	1,317,395
30-ton (mixed)									
Equipment	480,810	527,285	545,675	635,635	682,105	700,500	635,635	682,105	700,500
Facilities	684,320	715,000	699,400	693,995	718,225	702,555	710,220	734,450	718,850
Total	1,165,130	1,242,285	1,245,075	1,329,630	1,400,330	1,403,055	1,345,855	1,416,555	1,419,350
35-ton (poultry-swine)									
Equipment	460,490	506,965	525,360	615,315	661,790	680,185	615,315	661,790	680,185
Facilities	734,760	751,660	735,800	728,310	755,380	739,520	743,080	769,235	753,375
Total	1,195,250	1,258,625	1,261,160	1,343,625	1,417,170	1,419,705	1,358,395	1,431,025	1,433,560

1/ Detailed cost data are in Appendix B.
2/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant plant.

Table 6.--Equipment and facility costs for model feed plants producing 35 to 50 tons per hour 1/

Size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Percent								
35-ton (ruminant feed)									
Equipment	573,755	647,475	637,930	2/	2/	2/	692,125	765,840	756,295
Facilities	790,095	825,610	809,750	2/	2/	2/	818,280	846,830	830,970
Total	1,363,850	1,473,085	1,447,680	2/	2/	2/	1,510,405	1,613,670	1,587,265
43-ton (mixed)									
Equipment	582,835	656,550	664,400	755,205	828,920	836,770	755,205	829,920	837,085
Facilities	877,510	916,665	890,975	888,535	920,410	894,720	906,940	938,820	913,130
Total	1,460,345	1,573,215	1,555,375	1,643,740	1,749,330	1,731,490	1,662,145	1,767,740	1,750,215
50-ton (poultry-swine)									
Equipment	561,085	634,805	642,655	733,455	807,170	815,020	733,455	807,170	815,020
Facilities	968,145	1,010,370	983,330	979,065	1,014,010	986,970	997,265	1,032,210	1,005,170
Total	1,529,230	1,645,175	1,625,985	1,712,520	1,821,180	1,801,990	1,730,720	1,839,380	1,820,190

1/ Detailed cost data are in Appendix B.
2/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

example, more bulk bin and warehouse space is required for an increase in tonnage received, type of feed manufactured, and stored. Operations G, H, and I, with pellets representing 50 percent of the output, have more equipment than operations A, B, and C. Likewise, operations having both bulk and bagging operations must have an additional line of equipment for each function. These are the main differences for equipment and facility cost variations.

Building space is divided into categories based primarily on their function. They are: mill building and work bins, outside ingredient storage, bulk finished feed storage, warehouse, boiler room, and office. Representative construction costs are used for each type of building in the feed mill complex.

Total costs for all buildings range from $208,570 in operation A of the 6-ton model (table 3), to $1,032,210 for operation H in the 50-ton group (table 6). Operation A of all size models requires the least total space because it is the simplest type of operation, that is, all production is in mash form and sales are in bulk form. However, operation H is about the most complex with 50 percent of output bagged, bulk, mash, and pelleted. More equipment and more storage space are required to adequately handle the needs of this diverse operation.

Facility costs for the smaller models could be slightly less if all steel construction were used instead of concrete construction. However, this relationship between steel and concrete construction will vary with facility size, storage capacity, location, and competitive conditions of the two types of construction. Concrete construction costs become more favorable as the facility size increases in total capacity and height.

Facility costs account for 45 to 65 percent of total cost of equipment and facility (tables 3 to 6). For each size group, facility costs in relation to total cost for operation A in all models tend to be higher than in the other operations. Also, as the model size increases, facility cost makes up less of the total cost. A detailed breakdown is provided in Appendix B for a more thorough analyses.

Land cost was mentioned briefly in an earlier section. Cost of land varies depending on local conditions. Land cost for these models has been established at about $8,000 per acre. A maximum of $16,000 for land cost was used for the smaller models. A maximum of $32,000 was used for the larger models. Plant location was assumed to be satisfactory for construction and is accessible to rail and highway. Utilities were assumed to be adequate at the location or available at a nominal charge.

Components of Operating Costs

Operating costs for these models are the production costs incurred in manufacturing finished feed. These do not include costs of ingredients, transportation, cost of feed sacks, and other items which would be considered in a plant location analysis.

Operating costs for the models are categorized as either fixed or variable, and are discussed in that order (tables 7-18). Certain important cost items such as depreciation, labor, and utility costs are shown in greater detail in Appendix C.

Fixed Cost Items

A major portion of fixed costs arises from plant investment costs. The initial investment of the equipment and facility is spread over the useful or productive life of the durable input. Depreciation is a prime example. Other costs are taxes, insurance, and interest on investment. In the short run, the annual costs are fixed and do not vary with the output.

Depreciation.--One of the two largest cost factors in ownership costs is depreciation.

Depreciation for the models ranges between 65 cents per ton (table 18), to a high of $1.93 per ton (table 7). Operations H and I of all models tend to have the highest depreciation costs. The lowest depreciation is found with operation A. Total depreciation for operation H of each model is 20 to 35 percent more than in operation A. This condition does not hold true for equipment or facility depreciation separately.

Equipment depreciation accounts for the largest proportion of the total depreciation expense. Equipment depreciation is the most costly--it makes up between 45 and 62 percent of the total depreciation cost. Building depreciation increases from 5 to 10 percent between the lower and higher cost operations in each model mill.

Taxes.--Taxes were derived by taking 35 percent of initial investment as the assessed value and then applying a 1 percent annual rate to this assessment. Tax per ton ranged from a low of $.05 (table 18), to a high of $.14 (tables 7 and 10). Taxes per ton ranged considerably between model plants in each of the four basic groups.

Insurance.--Insurance cost is also derived from the initial investment. Insurance cost is calculated at 1 percent for equipment and one-half of 1 percent of building investment cost. Insurance cost ranges from a high of $.29 per ton in the I-6-H model (table 7), to $.11 per ton (table 18).

Interest.--Interest on investment is a major fixed cost in each model. This cost is the highest, $1.86 per ton, in the I-6-H ton per hour model (table 7) and lowest, $.68 per ton, in the IV-50-A model (table 18). Interest and total depreciation costs tend to be very close in most models. Interest accounts for 30 to 35 percent of the fixed cost expense of these models. A comparison of interest costs between operations of a given model shows that the high cost operation, usually H, has 30 to 35 percent greater cost per ton than operation A.

Table 7.--Operating cost per ton for 6-ton-per-hour model feed plant by operation (Ruminant feed)

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Fixed:						
Depreciation						
Equipment	.75	.88	.80	1.07	1.20	1.12
Building	.67	.70	.69	.71	.73	.72
Administrative	1.14	1.14	1.14	1.14	1.14	1.14
Taxes	.11	.12	.11	.13	.14	.13
Insurance	.22	.24	.23	.27	.29	.28
Interest	1.45	1.58	1.51	1.74	1.86	1.79
Total	4.34	4.66	4.48	5.06	5.36	5.18
Variable:						
Labor						
Production	1.47	2.84	4.41	1.76	3.13	4.70
Maintenance	.51	.61	.61	.82	.92	.92
Supervisory	.42	.52	.52	.63	.73	.73
Utilities	.56	.55	.55	.94	.94	.94
Maintenance and Repairs	1.62	1.78	1.69	1.98	2.13	1.04
Supplies and Miscellaneous	.65	.65	.65	.65	.65	.65
Total	5.23	6.95	8.43	6.78	8.50	9.98
Grand total	9.57	11.61	12.91	11.84	13.86	15.16

Table 8.--Operating cost per ton for 8-ton-per-hour model feed plant, by operation (Mixed feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.58	.68	.62	.82	.92	.86	.82	.92	.86
Building	.58	.60	.59	.59	.62	.60	.61	.63	.62
Administrative	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
Taxes	.09	.10	.09	.10	.11	.11	.11	.11	.11
Insurance	.18	.20	.19	.22	.23	.22	.22	.24	.23
Interest	1.19	1.29	1.23	1.39	1.49	1.43	1.41	1.51	1.45
Total	3.79	4.01	3.86	4.26	4.51	4.36	4.31	4.55	4.41
Variable:									
Labor									
Production	1.69	2.50	3.67	2.06	3.08	4.11	1.98	2.79	3.96
Maintenance	.38	.61	.61	.54	.61	.69	.54	.77	.77
Supervisory	.31	.47	.47	.39	.47	.55	.47	.62	.62
Utilities	.45	.45	.45	1.06	1.06	1.06	.81	.81	.81
Maintenance and Repairs	1.79	1.96	1.87	2.12	2.28	2.19	2.15	2.31	2.21
Supplies and Miscellaneous	.65	.65	.65	.65	.65	.65	.65	.65	.65
Total	5.27	6.64	7.72	6.82	8.15	9.25	6.60	7.95	9.02
Grand total	9.03	10.65	11.58	11.08	12.66	13.61	10.91	12.50	13.43

Table 9.--Operating cost per ton for 10-ton-per-hour model feed plant, by operation (Poultry-swine feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.42	.50	.45	.44	.52	.47	.61	.69	.64
Building	.52	.54	.53	.53	.55	.54	.54	.56	.55
Administrative	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Taxes	.07	.08	.08	.08	.08	.08	.09	.09	.09
Insurance	.15	.17	.16	.16	.17	.16	.18	.09	.19
Interest	.98	1.07	1.02	1.01	1.09	1.05	1.16	1.24	1.19
Total	3.19	3.41	3.29	3.27	3.46	3.35	3.63	3.82	3.71
Variable:									
Labor									
Production	1.35	2.47	3.29	1.70	2.82	3.64	1.70	2.82	3.64
Maintenance	.31	.49	.55	.37	.55	.61	.37	.55	.61
Supervisory	.25	.37	.44	.31	.44	.50	.31	.44	.50
Utilities	.35	.35	.35	.86	.86	.86	.66	.66	1.35
Maintenance and Repairs	1.10	1.20	1.14	1.14	1.23	1.17	1.31	1.41	.65
Supplies and Miscellaneous	.65	.65	.65	.65	.65	.65	.65	.65	7.41
Total	4.01	5.53	6.42	5.03	6.55	7.43	5.00	6.53	11.12
Grand total	7.20	8.94	9.71	8.30	10.01	10.78	8.63	10.35	14.83

Table 10.--Operating cost per ton for 10-ton-per-hour model feed plant, by operation (Ruminant feed)

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Fixed:						
Depreciation						
Equipment	.78	.91	.86	1.07	1.20	1.15
Building	.61	.62	.62	.63	.65	.64
Administrative	1.05	1.05	1.05	1.05	1.05	1.05
Taxes	.11	.12	.11	.12	.14	.13
Insurance	.22	.24	.23	.26	.28	.27
Interest	1.39	1.51	1.47	1.65	1.77	1.72
Total	4.16	4.45	4.34	4.78	5.09	4.96
Variable:						
Labor						
Production	1.58	2.70	4.40	2.00	3.17	4.70
Maintenance	.39	.67	.80	.49	.67	.92
Supervisory	.41	.44	.50	.37	.44	.56
Utilities	.46	.46	.46	.83	.83	.83
Maintenance and Repairs	1.56	1.70	1.66	1.86	2.01	1.95
Supplies and Miscellaneous	.60	.60	.60	.60	.60	.60
Total	5.00	6.57	8.42	6.15	7.72	9.56
Grand total	9.16	11.02	12.76	10.93	12.81	14.52

Table 11.--Operation cost per ton for 18-ton-per-hour model feed plants, by operation (mixed feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.43	.50	.50	.59	.66	.66	.59	.66	.66
Building	.46	.48	.47	.47	.48	.47	.48	.50	.49
Administrative	.92	.92	.92	.92	.92	.92	.92	.92	.92
Taxes	.07	.08	.07	.08	.08	.08	.08	.09	.08
Insurance	.14	.16	.16	.18	.18	.18	.17	.18	.18
Interest	.96	1.04	1.03	1.16	1.16	1.15	1.10	1.26	1.17
Total	2.98	3.18	3.15	3.48	3.48	3.46	3.34	3.61	3.50
Variable:									
Labor									
Production	.88	1.76	2.64	1.24	2.15	3.19	1.11	1.96	2.87
Maintenance	.44	.54	.65	.51	.61	.78	.44	.58	.82
Supervisory	.28	.35	.42	.38	.42	.52	.31	.38	.56
Utilities	.31	.30	.29	.82	.82	.82	.58	.58	.58
Maintenance and Repairs	1.12	1.22	1.21	1.29	1.38	1.37	1.31	1.40	1.38
Supplies and Miscellaneous	.60	.60	.60	.60	.60	.60	.60	.60	.60
Total	3.63	4.77	5.81	4.84	5.98	7.28	4.35	5.50	6.81
Grand total	6.61	7.95	8.96	8.16	9.46	10.74	7.69	9.11	10.31

Table 12.--Operating cost per ton for 25-ton-per-hour model feed plant, by operation (Poultry-swine feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.30	.35	.35	.41	.46	.46	.41	.46	.46
Building	.42	.44	.43	.43	.44	.43	.44	.46	.33
Administrative	.89	.89	.89	.89	.89	.89	.89	.89	.89
Taxes	.06	.06	.06	.06	.07	.07	.07	.07	.07
Insurance	.12	.13	.12	.13	.14	.14	.13	.15	.14
Interest	.73	.79	.78	.82	.88	.87	.83	.90	.88
Total	2.52	2.66	2.63	2.74	2.88	2.86	2.77	2.93	2.88
Variable:									
Labor									
Production	.70	1.29	2.09	1.08	1.64	2.47	.89	1.46	2.28
Maintenance	.39	.49	.59	.39	.51	.71	.39	.51	.71
Supervisory	.25	.32	.37	.25	.32	.45	.25	.32	.45
Utilities	.24	.24	.24	.67	.67	.67	.48	.48	.48
Maintenance and Repairs	.88	.96	.94	1.00	1.07	1.06	1.01	1.10	1.07
Supplies and Miscellaneous	.55	.55	.55	.55	.55	.55	.55	.55	.55
Total	3.01	3.85	4.78	3.94	4.76	5.91	3.57	4.42	5.54
Grand total	5.53	6.51	7.41	6.68	7.64	8.77	6.34	7.35	8.42

Table 13.--Operating cost per ton for 25-ton-per-hour model feed plant, by operation (Ruminant feed)

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Fixed:						
Depreciation						
Equipment	.52	.57	.57	.69	.74	.76
Building	.48	.50	.49	.49	.51	.50
Administrative	.89	.89	.89	.89	.89	.89
Taxes	.07	.08	.08	.09	.09	.09
Insurance	.16	.17	.16	.18	.19	.19
Interest	.96	1.02	1.01	1.11	1.17	1.16
Total	3.08	3.23	3.20	3.45	3.59	3.59
Variable:						
Labor						
Production	.70	1.43	2.40	.89	1.60	2.56
Maintenance	.39	.51	.64	.49	.54	.76
Supervisory	.25	.35	.40	.35	.35	.50
Utilities	.33	.33	.33	.59	.59	.59
Maintenance and Repairs	1.17	1.26	1.24	1.37	1.44	1.43
Supplies and Miscellaneous	.55	.55	.55	.55	.55	.55
Total	3.39	4.43	5.56	4.24	5.07	6.39
Grand total	6.47	7.66	8.76	7.69	8.66	9.98

Table 14.--Operating cost per ton for 30-ton-per-hour model feed plants, by operation (Mixed feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.43	.47	.49	.57	.61	.63	.57	.61	.63
Building	.44	.46	.45	.44	.46	.45	.46	.47	.46
Administrative	.87	.87	.87	.87	.87	.87	.87	.87	.87
Taxes	.07	.08	.08	.08	.08	.08	.08	.09	.09
Insurance	.14	.15	.15	.16	.17	.17	.16	.17	.17
Interest	.87	.92	.93	.99	1.04	1.04	1.00	1.05	1.05
Total	2.82	2.95	2.97	3.11	3.23	3.24	3.14	3.26	3.27
Variable:									
Labor									
Production	.65	1.39	2.06	1.02	1.76	2.43	.86	1.55	2.27
Maintenance	.39	.51	.59	.45	.57	.65	.45	.51	.65
Supervisory	.25	.33	.37	.29	.37	.43	.29	.33	.42
Utilities	.30	.30	.30	.74	.74	.74	.51	.51	.51
Maintenance and Repairs	1.05	1.12	1.12	1.20	1.26	1.26	1.21	1.27	1.28
Supplies and Miscellaneous	.55	.55	.55	.55	.55	.55	.55	.55	.55
Total	3.19	4.20	4.99	4.25	5.25	6.06	3.87	4.72	5.68
Grand total	6.01	7.15	7.96	7.36	8.48	9.30	7.01	7.98	8.95

Table 15.--Operation cost per ton for 35-ton-per-hour model feed plant, by operation (Poultry-swine feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.37	.40	.42	.49	.53	.54	.49	.53	.54
Building	.40	.41	.40	.40	.41	.41	.41	.42	.41
Administrative	.80	.80	.80	.80	.80	.80	.80	.80	.80
Taxes	.06	.06	.06	.07	.07	.07	.07	.07	.07
Insurance	.12	.13	.13	.14	.15	.15	.14	.15	.15
Interest	.77	.81	.81	.86	.91	.91	.87	.92	.92
Total	2.52	2.61	2.62	2.76	2.87	2.88	2.78	2.89	2.89
Variable:									
Labor									
Production	.66	1.28	1.95	.82	1.65	2.27	.86	1.48	2.13
Maintenance	.35	.47	.56	.42	.49	.61	.40	.51	.61
Supervisory	.23	.30	.36	.27	.32	.39	.25	.34	.39
Utilities	.25	.25	.25	.66	.66	.66	.44	.44	.44
Maintenance and Repairs	.96	1.01	1.01	1.07	1.13	1.14	1.09	1.14	1.15
Supplies and Miscellaneous	.55	.55	.55	.55	.55	.55	.55	.55	.55
Total	3.00	3.86	4.68	3.79	4.80	5.62	5.62	4.46	5.27
Grand total	5.52	6.47	7.30	6.55	7.67	8.50	8.50	7.35	8.16

Table 16.--Operating cost per ton for 35-ton-per-hour model feed plant, by operation (Ruminant feed) 1/

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Fixed:						
Depreciation						
Equipment	.46	.52	.51	.55	.61	.60
Building	.43	.45	.44	.45	.46	.46
Administrative	.80	.80	.80	.80	.80	.80
Taxes	.07	.08	.07	.08	.08	.08
Insurance	.14	.15	.15	.16	.17	.17
Interest	.87	.94	.93	1.00	1.06	1.05
Total	2.77	2.94	2.90	3.04	3.18	3.16
Variable:						
Labor						
Production	.77	1.36	2.30	.96	1.65	2.50
Maintenance	.37	.51	.59	.42	.49	.63
Supervisory	.23	.32	.38	.27	.32	.41
Utilities	.27	.27	.27	.49	.49	.48
Maintenance and Repairs	1.09	1.18	1.16	1.25	1.33	1.31
Supplies and Miscellaneous	.55	.55	.55	.55	.55	.55
Total	3.28	4.19	5.25	3.94	4.83	5.88
Grand total	6.05	7.13	8.15	6.98	8.01	9.04

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 17.--Operating cost per ton for 43-ton-per-hour model feed plant, by operation (Mixed feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.35	.39	.40	.45	.50	.50	.45	.50	.50
Building	.39	.41	.40	.40	.41	.40	.40	.42	.41
Administrative	.73	.73	.73	.73	.73	.73	.73	.73	.73
Taxes	.06	.06	.06	.07	.07	.07	.07	.07	.07
Insurance	.13	.14	.14	.14	.15	.15	.14	.15	.15
Interest	.75	.81	.80	.84	.89	.88	.85	.90	.90
Total	2.41	2.54	2.53	2.63	2.75	2.73	2.64	2.77	2.76
Variable:									
Labor									
Production	.65	1.45	2.07	1.01	1.84	2.41	.88	1.64	2.30
Maintenance	.35	.47	.57	.40	.50	.62	.41	.47	.62
Supervisory	.23	.30	.36	.26	.33	.41	.28	.30	.41
Utilities	.23	.23	.23	.65	.65	.65	.42	.42	.42
Maintenance and Repairs	.88	.94	.93	.99	1.05	1.04	1.00	1.06	1.05
Supplies and Miscellaneous	.55	.55	.55	.55	.55	.55	.55	.55	.55
Total	2.88	3.94	4.71	3.86	4.92	5.68	3.54	4.44	5.35
Grand total	5.29	6.48	7.24	6.49	7.67	8.41	6.18	7.21	8.11

Table 18.--Operating cost per ton for 50-ton-per-hour model feed plant, by operation (Poultry-swine feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Fixed:									
Depreciation									
Equipment	.28	.32	.32	.37	.40	.41	.36	.40	.41
Building	.37	.39	.38	.38	.39	.38	.38	.40	.39
Administrative	.65	.65	.65	.65	.65	.65	.65	.65	.65
Taxes	.05	.05	.05	.05	.06	.06	.05	.06	.06
Insurance	.11	.12	.12	.12	.13	.13	.12	.13	.13
Interest	.68	.73	.72	.76	.80	.79	.76	.81	.80
Total	2.14	2.27	2.24	2.33	2.43	2.42	2.32	2.45	2.44
Variable:									
Labor									
Production	.58	1.24	1.97	.98	1.61	2.30	.80	1.43	2.13
Maintenance	.34	.46	.54	.39	.46	.61	.39	.46	.61
Supervisory	.22	.30	.35	.25	.30	.40	.25	.30	.40
Utilities	.21	.21	.21	.59	.59	.59	.38	.38	.38
Maintenance and Repairs	.76	.82	.81	.86	.91	.90	.86	.92	.91
Supplies and Miscellaneous	.55	.55	.55	.55	.55	.55	.55	.55	.55
Total	2.66	3.58	4.43	3.62	4.42	5.35	3.23	4.04	4.98
Grand total	4.80	5.85	6.67	5.95	6.85	7.77	5.55	6.49	7.42

Administrative costs.--A number of administrative duties must be performed in the daily operation of a feed manufacturing plant. Some of these are general management, ingredient purchasing, nutrition formulation and quality control, typing, and bookkeeping of accounts. Estimates were derived from data received from the personal contacts with feed plant management. These costs will vary considerably between plants depending on the organizational structure and services received from a home office if the plant is controlled by a parent firm.

This study has assumed a fixed cost per ton for each particular size and type of model. Cost per ton is the same regardless of variations in method of operations. The Group I-6 and 8-ton-per-hour models have the highest cost, $1.14 per ton. The cost decreases as models increase in size to the Group IV model which has a cost of 65 cents per ton (tables 7 through 18).

Variable Cost Items

Variable costs as used in these models include such items asmmill labor, utilities, equipment maintenance and repairs, and supplies and miscellaneous expense items which are a function of plant output.

Labor inputs and costs.--The feed industry over recent years has attempted to increase efficiency through a reduction of production labor, thereby reducing labor cost per ton. Management has moved more and more whenever it is feasible to build a push-button automated mill. This is done not only to reduce production cost, but to eliminate opportunities for human error.

Manhours per ton, including both production, maintenance, and supervisory time for all models, range from a low of 0.24 in the IV-50-A hour model (table 22) to 1.333 in the I-6-I (table 19). The lowest manhours and labor costs per ton usually appear in operation A, the least complex of all models. On the other hand, manhours per ton requirements are the greatest in the operations F and I. Packing and warehousing in these models increase the cost per ton considerably over an all-bulk operation (tables 19 through 22).

In the I group, the 10-ton model requires a maximum of 10 full-time employees in the mill operation F and I. With the same basic operation in the IV group, the F operation requires 35 workers. Operation 6-A of Group I has the

Production labor cost in all models ranges from $.58 per ton in the IV-50-A (table 18) to a high of $4.70 per ton in the I-6-I and II-10-I models (table 7). Operations A and G in each group generally have the lowest production labor cost. The cost per ton is 58 cents in the I-50-A and is up to $1.69 in I-8-A (table 7). Operations F and I usually have the higher production labor cost operations in all model groups. Cost per ton in these operations ranges from $4.70 in I-6-I and II-10-I to $2.32 in the IV-50-F model (table 18).

Maintenance labor cost is considered separately because over the short run, this cost may be less than the estimates used in the models. However, most feed manufacturers realize that a good preventive maintenance program can be less costly in the long run.

Table 19.--Labor requirements for model feed plants producing 6 to 10 tons per hour

Plant size and labor	Method of operation								
	A	B	C	D	E	F	G	H	I
6-ton	Hours per day								
Production	15	29	45	1/	1/	1/	18	32	48
Maintenance	5	6	6	1/	1/	1/	8	9	9
Supervisor	4	5	5	1/	1/	1/	6	7	7
Total	24	40	56	1/	1/	1/	32	48	64
Manhours/ton	.500	.833	1.167	1/	1/	1/	.667	1.000	1.333
8-ton									
Production	23	34	50	28	42	56	27	38	54
Maintenance	5	8	8	7	8	9	7	10	10
Supervisor	4	6	6	5	6	7	6	8	8
Total	32	48	64	40	56	72	40	56	72
Manhours/ton	.500	.75	1.000	.625	.875	1.125	.625	.875	1.125
10-ton									
Production	23	42	56	29	48	62	29	48	62
Maintenance	5	8	9	6	9	10	6	9	10
Supervisor	4	6	7	5	7	8	5	7	8
Total	32	56	72	40	64	80	40	64	80
Manhours/ton	.400	.700	.900	.500	.800	1.000	.500	.800	1.000

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 20.--Labor requirements for model feed plants producing 10 to 25 tons per hour

Plant size and labor	A	B	C	D	E	F	G	H	I
					Hours per day				
10-ton									
Production	27	46	75	--	--	--	54	54	80
Maintenance	8	11	13	--	--	--	8	11	15
Supervisor	5	7	8	--1/	--1/	--1/	6	7	9
Total	40	64	96	--	--	--	48	72	104
Manhours/ton	.500	.800	1.200	--	--	--	.600	.900	1.300
18-ton									
Production	27	54	81	38	66	98	34	60	88
Maintenance	13	16	19	15	18	23	13	17	24
Supervisor	8	10	12	11	12	15	9	11	16
Total	48	80	112	64	96	136	56	88	128
Manhours/ton	.333	.556	.778	.444	.667	.944	.389	.611	.889
25-ton									
Production	30	55	89	46	70	105	38	62	97
Maintenance	16	20	24	16	21	29	16	21	29
Supervisor	10	13	15	10	13	18	10	13	18
Total	56	88	128	72	104	152	64	96	144
Manhours/ton	.280	.440	.640	.360	.520	.760	.320	.480	.720

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 21.--Labor requirements for model feed plants producing 25 to 35 tons per hour

Plant size and labor	A	B	C	D	E	F	G	H	I
25-ton	Hours per day								
Production	30	61	102	1/	1/	1/	38	68	109
Maintenance	16	21	26	1/	1/	1/	20	22	31
Supervisor	10	14	16	1/	1/	1/	14	14	20
Total	56	96	144	1/	1/	1/	72	104	160
Manhours/ton	.280	.480	.720	1/	1/	1/	.360	.520	.800
30-ton									
Production	33	71	105	52	90	124	44	79	116
Maintenance	19	25	29	22	28	32	22	25	32
Supervisor	12	16	18	14	18	20	14	16	20
Total	64	112	152	88	136	176	80	120	168
Manhours/ton	.267	.467	.633	.367	.567	.733	.333	.500	.700
35-ton									
Production	39	76	116	49	98	135	51	88	127
Maintenance	20	27	32	24	28	35	23	29	35
Supervisor	13	17	20	15	18	22	14	19	22
Total	72	120	168	88	144	192	88	136	184
Manhours/ton	.257	.428	.600	.314	.514	.686	.314	.486	.657

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 22.--Labor requirements for model feed plants producing 35 to 50 tons per hour

Plant size and labor	A	B	C	D	E	F	G	H	I
35-ton	Hours per day								
Production	46	81	137	1/	1/	1/	57	98	149
Maintenance	22	29	34	1/	1/	1/	24	28	36
Supervisor	13	18	21	1/	1/	1/	15	18	23
Total	80	128	192	1/	1/	1/	96	144	208
Manhours/ton	.286	.457	.686	1/	1/	1/	.343	.514	.743
43-ton									
Production	47	106	151	74	134	176	64	122	168
Maintenance	25	33	40	28	35	44	29	33	44
Supervisor	16	21	25	18	23	28	19	21	28
Total	88	160	216	120	192	248	112	176	240
Manhours/ton	.256	.465	.628	.349	.558	.721	.326	.506	.698
50-ton									
Production	50	106	168	84	138	118	68	122	182
Maintenance	28	38	44	32	38	50	32	38	50
Supervisor	18	24	28	20	24	32	20	24	32
Total	96	168	240	136	200	280	120	184	264
Manhours/ton	.240	.420	.600	.340	.500	.700	.300	.460	.660

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Maintenance labor requirements range from at least 5 hours per day in several operations of the I Group (table 19) to not more than 50 hours per day in two of the IV Group model operations (table 22).

In many operations, maintenance may require an uneven number of manhours. That is, in the I group, manhours required for maintenance range from 5 to 10 hours per 8-hour day. It is not unusual for a production worker or supervisor to perform certain jobs related to maintenance activities.

Maintenance labor cost will vary a great deal between models of different sizes and operations of the same tonnage model. Looking at it from another approach, maintenance labor will cost the feed manufacturer between $.31 and $.92 a ton (tables 7-18). Maintenance labor cost bears a definite relationship to the total cost of equipment in the models.

Supervisory labor for these model feed plants ranges between 4 hours per day in the I group to a maximum of 32 hours per day in the IV group. The same situation exists with use of supervisors as with maintenance personnel. It is not unusual to have a production worker performing certain supervisor's duties or a supervisor doing maintenance work.

Supervisory costs range from a low of $.22 a ton in the IV-50-A operation to $.73 a ton in two of the I-6 operations. It is possible to have a rather low cost per ton in some of the smaller plants since overall size is not the main factor in cost of supervision.

Total cost of mill labor is a significant item in the total cost picture. Mill labor cost ranges from a low of $1.14 per ton in IV-50-A to a high of $6.35 a ton in I-6-I. Production labor accounts for 50 to 78 percent of total labor cost. Operations F and I, where applicable, have the higher cost models and have a higher percentage production labor cost than does operation A. Maintenance and supervisory labor each account for 12 and 25 percent of the total.

Thus, the less complex operations, A and G. usually have the lower labor costs and the higher costs are found in operations F and I. Production labor cost in operation A in all size categories is between 28 and 32 percent of that in F and I. Pelleting and packing have tremendous effects on cost of production.

Utilities.--Utility costs include electricity, water, and fuel. Utility cost is a minor cost in most operations except the full pelleting operations, D, E, and F. In operations A, B, and C, total utility costs range from $.56 per ton in the I group to $.21 per ton in the IV group (tables 7-18). Electricity accounts for 62 to 80 percent of this cost. In operations D, E, and F, in which all feed is pelleted, total utility cost ranges from $1.06 per ton in the I group to $.59 per ton in the IV group. Electricity in these operations accounts for two-fifths to two-thirds of this total. In operations G, H, and I, costs range from $.38 per ton in the IV group to $.94 per ton for the I group. Electricity again is the largest item and makes up between 55

and 75 percent of the total cost. Utility costs for pelleting operations are about double the nonpelleting operations of all models. Pelleting places a greater demand for electricity on these models.

Maintenance and repairs.--Costs of maintenance and replacement parts for equipment as well as the services hired by the mill to make repairs are variable. They were assumed to be about 5-1/2 percent of the total investment cost over the long run.

Cost per ton decreases with increased plant size as do many expense items. The I group--8-ton-per-hour plant--has the highest cost of $2.31 per ton in operation H (table 7). Operation H in all groups usually has the highest investment of any operation in each model size and, therefore, its maintenance cost is high. The lowest cost for operation A occurs with IV-50-A, $.76 per ton (table 18), and the highest in I-8-A, $1.79 per ton (table 7).

Supplies and miscellaneous.--This cost includes a number of items which are generally used throughout the plant and pertain to the entire production operation. Cost estimates relating to this category were obtained from industry. These costs, like other cost items, may be tallied differently by each firm.

A fixed cost of $.65 per ton was used for the smaller group, 6 to 10 tons per hour. In the larger group, 35 to 50 tons per hour, a $.55 per ton estimate was used.

COMPARATIVE PLANT COST RELATIONSHIPS AND ECONOMIES

Total operating costs will vary widely with changes in mill operations as well as with the volume of mixed feed manufactured. There are definite economies of scale with increased size of plant. As group and model sizes increase between the 6 to 10-ton-per-hour group and the 35 to 50-ton-per-hour group, a noticeable reduction takes place in total costs per ton produced.

Many factors influence the total cost of operating feed mills. The major cost items are depreciation, interest on investment, and wages and salaries. Other factors of varying importance include volume of operation, variation in production, and percentage of capacity utilized. For the models constructed in this study, optimum output was assumed to be around 90 percent of plant rated capacity.

Interplant Optimal Operating Levels

For groups I, producing between 6 and 10 tons per hour, the fixed cost per ton ranges from a high of $5.36 per ton in 6-H to a low of $3.19 per ton in 10-A (table 23). Fixed costs per ton for all methods of operation decrease about 27 percent between the 6-ton and 10-ton-per-hour models. Variable costs range from $9.98 per ton in 6-I to a low of $4.01 per ton in 10-A. The larg-

Table 23.--Operating cost per ton for 6 to 10-ton-per-hour- model feed plants: Fixed, variable, and total costs by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
6-ton (Ruminant feed)									
Fixed	4.34	4.66	4.48	1/	1/	1/	5.06	5.36	5.18
Variable	5.23	6.95	8.43	1/	1/	1/	6.78	8.50	9.98
Total	9.57	11.61	12.91	1/	1/	1/	11.84	13.86	15.16
8-ton (Mixed feed)									
Fixed	3.76	4.01	3.86	4.26	4.51	4.36	4.31	4.55	4.41
Variable	5.27	6.64	7.72	6.82	8.15	9.25	6.60	7.95	9.02
Total	9.03	10.65	11.58	11.08	12.66	13.61	10.91	12.50	13.43
10-ton (Poultry-swine)									
Fixed	3.19	3.41	3.29	3.27	3.46	3.35	3.63	3.82	3.71
Variable	4.01	5.53	6.42	5.03	6.55	7.43	5.00	6.53	7.41
Total	7.20	8.94	9.71	8.30	10.01	10.78	8.63	10.35	11.12

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

est model producing 10 tons per hour has variable costs running 20 to 26 percent lower than the 6-ton model. The highest total cost is $15.16 per ton, 6-I. Model 10-A has the lowest cost per ton of $7.20.

In group II, fixed costs varies from $5.09 per ton in 10-H to $2.52 per ton in 25-A (table 24). Increased production of models reduces the fixed cost of operations between 40 and 42 percent. Model 10-I has the highest variable cost of $9.56 per ton and the lowest variable cost is in the 25-A model, $3.01 per ton. As the volume increases, the variable cost incurred is between 40 and 43 percent below the 10-ton model.

The highest total cost of $14.52 per ton occurs in 10-I, with the lowest total cost per ton in 25-A, $5.53. A greater reduction in total costs occurs within this group than in the other three. This volume appears to be the area of capacity where the greatest economies occur. There is about 28 to 30 percent reduction in total costs between the 10-ton and 18-ton models. Total costs decrease between 40 and 43 percent as output increases from 10 tons to 25 tons.

Model 25-H in group III has the highest fixed cost of $3.59 per ton (table 25). With the model producing 35 tons per hour, the fixed cost decreases to $2.52 per ton in model 35-A. The fixed cost between the 25-ton and 35-ton models decreases around 19 percent with the increase in output.

Model 25-I has the highest variable per ton cost of $6.39. Model 35-A has the lowest cost with $3.00. Variable costs in the largest models are between 12 and 18 percent less than in the smallest models. The 30-ton-per-hour models have variable costs between 7 and 11 percent below the 25-ton models. The largest models, producing 35 tons per hour, have variable costs between 12 and 18 percent less than smaller models.

The highest total cost model is 25-I, $9.98 per ton and the lowest is the 35-A model, at $5.52 per ton. Operating cost per ton is 7 to 10 percent as tonnage increases to 30 tons per hour. In comparing total costs between the 35-ton and 25-ton models, there is between 15 and 18 percent reduction with the increase of 10 tons per hour.

Model 35-H, group IV, has the highest fixed cost of $3.18 per ton (table 26). Model IV-50-A has the lowest per ton cost of $2.14. The 50-ton models' fixed cost decreases about 23 percent below the smaller models' cost. Variable cost in the IV-35-I is the highest, $5.88 per ton. Lowest per ton costs occur in model IV-50-A, $2.66 a ton. Variable costs drop from 15 to 19 percent between the smallest and largest models.

Model IV-35-I has the highest total operating cost, $9.04 per ton. Model IV-50-A has the lowest cost of $4.80 per ton. The 43-ton models have costs of 9 to 13 percent less per ton than the 35-ton models. Likewise, the 50-ton models have operating costs of 18 to 21 percent less than the smallest models.

Table 24.--Operating cost per ton for 10 to 25-ton-per-hour model feed plants: Fixed, variable, and total costs by operations

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
10-ton (Ruminant feed)									
Fixed	4.16	4.45	4.34	1/	1/	1/	4.78	5.09	4.96
Variable	5.00	6.57	8.42	1/	1/	1/	6.15	7.72	9.56
Total	9.16	11.02	12.76	1/	1/	1/	10.93	12.81	14.52
18-ton (Mixed feed)									
Fixed	2.98	3.18	3.15	3.32	3.48	3.46	3.34	3.61	3.50
Variable	3.63	4.77	5.81	4.84	5.98	7.28	4.35	5.50	6.81
Total	6.61	7.95	8.96	8.16	9.46	10.74	7.69	9.11	10.31
25-ton (Poultry-swine)									
Fixed	2.52	2.66	2.63	2.74	2.88	2.86	2.77	2.93	2.88
Variable	3.01	3.85	4.78	3.94	4.76	5.91	3.57	4.42	5.54
Total	5.53	6.51	7.41	6.68	7.64	8.77	6.34	7.35	8.42

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 25.--Operating cost per ton for 25 to 35-ton-per-hour model feed plants: Fixed, variable, and total cost by operations

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
25-ton (Ruminant feed)									
Fixed	3.08	3.23	3.20	1/	1/	1/	3.45	3.59	3.59
Variable	3.39	4.43	5.56	1/	1/	1/	4.24	5.07	6.39
Total	6.47	7.66	8.76	1/	1/	1/	7.69	8.66	9.98
30-ton (Mixed feed)									
Fixed	2.82	2.95	2.97	3.11	3.23	3.24	3.14	3.26	3.27
Variable	3.19	4.20	4.99	4.25	5.25	6.06	3.87	4.72	5.68
Total	6.01	7.15	7.96	7.36	8.48	9.30	7.01	7.98	8.95
35-ton (Poultry-swine)									
Fixed	2.52	2.61	2.62	2.76	2.87	2.88	2.78	2.89	2.89
Variable	3.00	3.86	4.68	3.79	4.80	5.62	3.59	4.46	5.27
Total	5.52	6.47	7.30	6.55	7.67	8.50	6.37	7.35	8.16

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 26.--Operating cost per ton for 35 to 50-ton-per-hour model feed plants: Fixed, variable, and total cost by operations

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
35-ton (Ruminant feed)									
Fixed	2.77	2.94	2.90	1/	1/	1/	3.04	3.18	3.16
Variable	3.28	4.19	5.25	1/	1/	1/	3.94	4.83	5.88
Total	6.05	7.13	8.15	1/	1/	1/	6.98	8.01	9.04
43-ton (Mixed feed)									
Fixed	2.41	2.54	2.53	2.63	2.75	2.73	2.64	2.77	2.76
Variable	2.88	3.94	4.71	3.86	4.92	5.68	3.54	4.44	5.35
Total	5.29	6.48	7.24	6.49	7.67	8.41	6.18	7.21	8.11
50-ton (Poultry-swine)									
Fixed	2.14	2.27	2.24	2.33	2.43	2.42	2.32	2.45	2.44
Variable	2.66	3.58	4.43	3.62	4.42	5.35	3.23	4.04	4.98
Total	4.80	5.85	6.67	5.95	6.85	7.77	5.55	6.49	7.42

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

In summary, fixed costs for all four groups range between 31 and 47 percent of the total cost. Fixed costs tend to decrease percentagewise as more feed is bagged. This is due to the fact that variable costs are increased by the larger labor costs incurred with bagging and warehousing functions.

Differences in production costs will vary greatly among firms in the industry, because sales demands affect production scheduling and reflect greatly on the production costs per ton.

Curves summarizing these interplant cost relationships at optimal operating levels for an 8-hour shift are depicted in the figure. These charts only indicate the relative economy of different sizes of plants and feed output combinations under a given set of economic conditions and technical possibilities for division and specialization of labor and for automation. With new developments in equipment design and technology and in production and operating methods, and with changes in prices and wage levels, new curves would need to be established.

In developing the models, particular emphasis was placed on the influence of both specialization of labor and larger automated equipment. In general, the larger the model, the larger the equipment and the more extensive the degree of automation and specialization of labor is incorporated into its specifications. As the size of plant and output are increased, the use of advances technological methods become more feasible and will usually result in considerable reductions in cost per ton. Frequently, it is possible to purchase much larger equipment for a small increase in price. Cost of equipment does not usually increase in direct proportion to its capacity.

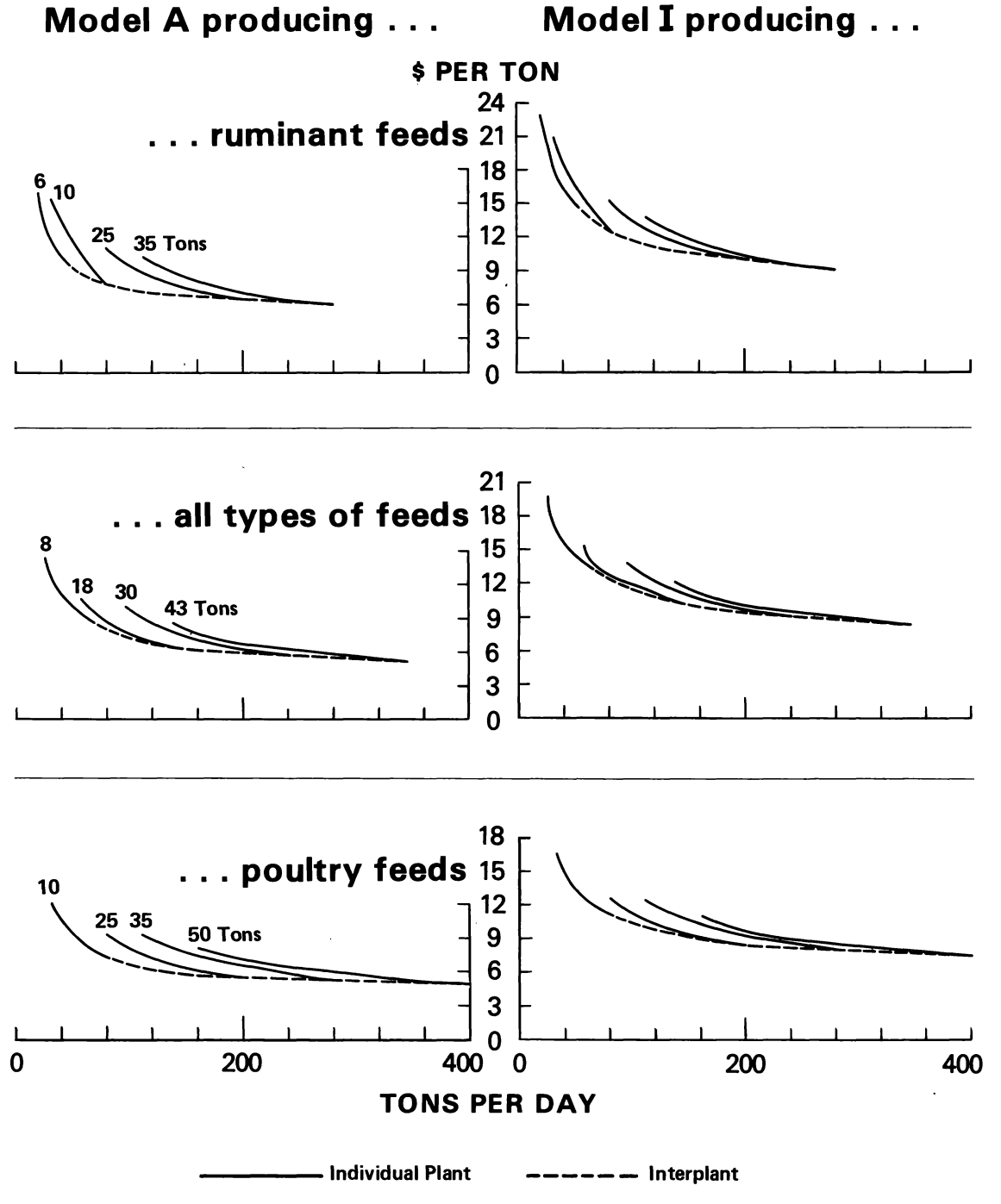
It may appear that further economies may be possible with equipment of greater processing capacity and through other improved technologies including automation. In practice, however, additional economies may well be offset by certain diseconomies, such as the requirement for additional formulas to satisfy new markets, or an increase in procurement or distribution costs. This result would be consistent with the industry trend toward decentralization and the fitting of plants to more localized markets.

Varying Operating Levels Within a Plant

Feed manufacturers are often faced with reduced demands for mixed feeds over short periods because of seasonal fluctuations in livestock and poultry production. Therefore, during these periods of reduced output, the mills are operating at something less than designed capacity. With lower output, production costs per ton will generally rise because fixed costs of mill ownership and management are spread over less output, and plant efficiency, particularly in terms of labor productivity, is impaired. The shortrun efficiency of alternative plants is therefore also an important consideration.

Curves showing cost behavior at different operating levels for model plants are also shown in the figure. As the size of the model mills' output increases nearer to capacity, the curves illustrate that the average cost per ton decreases. Economies as output approaches capacity are realized for most particular cost components within each model. However, some components con-

COST CURVES


Model A producing . . .
Model I producing . . .
$ PER TON
. . . ruminant feeds
6
10
25
35 Tons
24
21
18
15
12
9
6
3
0
. . . all types of feeds
8
18
30
43 Tons
21
18
15
12
9
6
3
0
. . . poultry feeds
10
25
35
50 Tons
18
15
12
9
6
3
0
0
200
400
0
200
400
TONS PER DAY
Individual Plant
Interplant

tribute more to lowering costs than others. The data in many models show that the variable cost components tend to decrease per ton at a slower rate than the fixed components.

The production at which the shortrun average cost is the lowest is the level of output that a given plant's operation is the most cost efficient but not necessarily the most profitable.

At this point on the curve, the value of resource inputs per unit of output is the lowest. This is true regardless of plant size; the output with minimum average cost is the most efficient rate of production. However, greatest profits most of the time will dictate levels of operation, and profits depend on revenue as well as costs.

As plant size increases, automation becomes a highly intregral part of the system. In most cases, automation will improve plant labor efficiency and will result in a considerable reduction in costs per ton. As mentioned previously, more automation is included as group model plants increase in size from 6 to 10 tons per hour up to 35 to 50 tons per hour. Frequently this enables a plant to operate at a lower level of capacity during the short run with lower costs. In the short run, a plant may continue operating by only covering variable costs. Over the longer term, however, it must be able to cover both variable and fixed costs.

Two-Shift Operations

Opinions vary in the feed manufacturing industry concerning the feasibility of operating a plant more than one 8-hour shift a day, as illustrated by practices in the industry. Mill managers are able to justify a second or third shift, depending on their own particular needs and circumstances.

Some managers are not willing to go to more than one shift for several reasons. Frequently, plant production does not require a full second shift. For example, pelleting may be the bottleneck in a particular mill. Therefore, only one or two men are required to handle production on the second shift. With this situation, management is confronted with deciding whether: (1) a night supervisor is needed, (2) a skeleton crew can remain flexible and perform several operations during their 8 hours of work, and (3) the production requirements will remain high enough throughout the year to warrant the additional shift.

Difficulty obtaining personnel for a night shift is another disadvantage. Even though a higher rate is paid to night workers, few really good men are available. Night shift personnel should be more highly trained than day workers since they may be called upon to make decisions not required of the others. Some plants have overcome some of their production problems by reducing the number of workers on the first shift and creating two shifts that have the same number of workers and responsibilities. But in general, many feed manufacturers find the cost per ton to be higher on a second shift and a tendency toward lower efficiency per manhour.

Why does management justify more than one shift? The most important reason cites economies of operation. A plant is designed and built by certain specifications to produce a set number of tons per hour of particular types of feeds.

Total fixed costs for multiple shifts do not change appreciably and at higher realized volumes are therefore lower per unit of output. Fixed facility and equipment costs per unit of output are at the minimum when these facilities are operated at capacity. For example, a feed manufacturer's fixed cost (depreciation, interest on investment, insurance and taxes) per ton of feed will be at a minimum when the plant is operated at full capacity, 24 hours a day, 365 days a year. This, however, is not feasible. Moreover, the total cost per ton of feed, including variable costs, may not be at the minimum when operating this way.

Fixed costs for administration and management can be reduced by spreading the total of such costs over a greater volume. But it is difficult to reduce this type of fixed cost per ton. Frequently, it is done in part by assigning routine, less complex jobs to lower paid employees.

Variable costs make up the other part of the total cost picture. Total variable costs increase (but not proportionately) as output increases. As mentioned before, variable costs include: (1) labor costs, (2) maintenance and repairs, (3) utility cost, (4) plant supplies, and (5) miscellaneous items which are incurred in feed manufacturing. Each of these contributes its share to the total operating cost per unit. Some of these cost items increase proportionately, or nearly so, with output. Some may even increase slightly more within certain levels of output. While some reductions in variable costs per unit of volume may be realized by increases in output, the greatest opportunities for reductions lie in reducing them in total.

The most important variable costs are for labor and utilities. Labor cost includes the wages of hourly employees, including rates for overtime and associated costs of fringe benefits. Probably the major opportunity for reducing these costs per unit of volume lies in increasing the productivity of the worker.

Total operating costs for the models working 16 hours a day are summarized in tables 27 and 30. A comparison with cost data (tables 23 to 26) will reveal the savings possible through operating a plant 16 hours a day instead of 8 hours. Total operating costs per ton for the 16-hour operation are between 80 and 90 percent of the 8-hour operation. For operations that pellet and/or bag finished feed, there appears to be less savings. Savings in these operations are closer to 12 percent per ton.

It is impossible to say whether all plants should or should not operate more than one shift. Each plant's situation and production problems are different. Therefore, this decision rests with management and must be made on the basis of factors at hand.

Table 27.--Operating cost per ton for 6 to 10-ton-per-hour model feed plant, 16 hours per day: Fixed, variable, and total costs, by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
6-ton (Ruminant feed)									
Fixed	2.17	2.33	2.24	1/	1/	1/	2.53	2.68	2.59
Variable	5.67	7.45	8.93	1/	1/	1/	7.33	9.36	10.59
Total	7.84	9.78	11.17	1/	1/	1/	9.86	12.04	13.18
8-ton (Mixed feed)									
Fixed	1.88	2.00	1.93	2.13	2.26	2.18	2.16	2.28	2.20
Variable	5.75	7.19	8.24	7.40	8.79	9.88	7.18	8.59	9.68
Total	7.63	9.19	10.17	9.53	11.05	12.06	9.34	10.87	11.88
10-ton (Poultry-swine)									
Fixed	1.59	1.70	1.64	1.64	1.73	1.68	1.82	1.91	1.86
Variable	4.31	5.88	6.77	5.35	6.92	7.80	5.36	6.94	7.83
Total	5.90	7.58	8.41	6.99	8.65	9.48	7.18	8.85	9.69

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 28.--Operating cost per ton for 10 to 25-ton-per-hour model feed plant, 16 hours per day: Fixed, variable, and total cost, by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
10-ton (Ruminant feed)									
Fixed	2.08	2.22	2.17	1/	1/	1/	2.39	2.54	2.48
Variable	5.42	7.05	8.92	1/	1/	1/	6.66	8.28	10.10
Total	7.50	9.27	11.09	1/	1/	1/	9.05	10.82	12.58
18-ton (Mixed feed)									
Fixed	1.49	1.59	1.58	1.66	1.74	1.73	1.67	1.80	1.75
Variable	3.94	5.11	6.17	5.20	11.18	7.68	4.71	5.89	7.22
Total	5.43	6.70	7.75	6.86	12.92	9.41	6.38	7.69	8.97
25-ton (Poultry-swine)									
Fixed	1.26	1.33	1.32	1.37	1.44	1.43	1.38	1.46	1.44
Variable	3.25	4.12	5.16	4.22	5.06	6.23	3.85	4.74	5.86
Total	4.51	5.45	6.48	5.59	6.50	7.66	5.23	6.20	7.30

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 29.--Operating cost per ton for 25 to 35-ton-per-hour model feed plants, 16 hours per day: Fixed, variable, and total cost by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
25-ton (Ruminant feed)									
Fixed	1.54	1.62	1.60	1/	1/	1/	1.72	1.79	1.79
Variable	3.70	4.78	5.92	1/	1/	1/	4.61	5.47	6.79
Total	5.24	6.40	7.52	1/	1/	1/	6.33	7.26	8.58
30-ton (Mixed feed)									
Fixed	1.41	1.48	1.49	1.56	1.62	1.62	1.57	1.63	1.64
Variable	3.47	4.52	5.32	4.58	5.61	6.43	4.20	5.07	6.05
Total	4.88	6.00	6.81	6.14	7.23	8.05	5.77	6.70	7.69
35-ton (Poultry-swine)									
Fixed	1.26	1.30	1.31	1.38	1.44	1.44	1.39	1.44	1.44
Variable	3.26	4.14	4.97	4.08	5.12	5.96	3.89	4.78	5.60
Total	4.52	5.44	6.28	5.46	6.56	7.40	5.78	6.22	7.04

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Table 30.--Operating cost per ton for 35 to 50-ton-per-hour model feed plants, 16 hours per day: Fixed, variable, and total costs, by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
35-ton (Ruminant feed)									
Fixed	1.38	1.47	1.45	1/	1/	1/	1.52	1.59	1.58
Variable	3.55	4.52	5.59	1/	1/	1/	4.28	5.20	6.26
Total	4.93	5.99	7.04	1/	1/	1/	5.80	6.79	7.84
43-ton (Mixed feed)									
Fixed	1.20	1.27	1.26	1.32	1.38	1.36	1.32	1.38	1.38
Variable	3.12	4.21	4.99	4.14	5.22	6.00	3.82	4.74	5.66
Total	4.32	5.48	6.25	5.46	6.60	7.36	5.14	6.12	7.04
50-ton (Poultry-swine)									
Fixed	1.07	1.14	1.12	1.16	1.22	1.21	1.16	1.22	1.22
Variable	2.86	3.82	4.67	3.86	4.68	5.63	3.47	4.30	5.26
Total	3.93	4.96	5.79	5.02	5.90	6.84	4.63	5.52	6.48

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

APPENDIX A: BASIC EQUIPMENT IN MODELS

Basic types of operating equipment for the four groups of models are itemized. There are 12 basic volume sizes with either size or 9 variations in each which in effect are different operations and may be considered as separate plants. Each of these has its own set of requirements in regard to equipment and facilities.

Equipment in receiving, processing, and mixing centers is essentially the same for each operation of a particular size model. Major differences arise in the arrangement of equipment to satisfy the varying requirements of each model. For example, pelleting equipment shown in the tables would be sufficient to handle the pelleting needs of operations D, E, and F. However, this equipment would have more than the needed capacity necessary for operating G, H, and I, which pellet only 50 percent of output. In operations A, B, and C, no pelleting equipment is needed. Packing and warehousing equipment would also change with the operation.

There are plants in the industry with much more equipment and capacity than is needed. However, all plants should have about 10 percent over-capacity for an overall efficient operation. If this condition is acceptable, it must carry throughout the design of the entire plant and not just in certain operations.

For one reason or another, older plants, particularly the larger, tend to have too much equipment or an over-capacity in one or more cost centers. This over-capacity may have been planned in anticipation of the need for a change in mill's activities. Or it may have resulted from a change in the mill's operations in response to unexpected shifts in market opportunities.

Mills are being constructed today with something different in mind. Feed manufacturers today try to build a facility that will do the job adequately at the least cost per ton over a relatively short time span.

Appendix table A-1.--Basic equipment in 6 to 10-ton model feed plants

Item	Number	Horsepower (each motor)	Size and capacity
Receiving--			
Truck hoist	1	10	8 ton
Power shovel	1	3	--
Conveyor, drag	1	5	9 in. x 48 ft.
Elevator, bucket	1	10	8 in. x 5 in. bucket, 109 ft.
Magnet, plate	1	--	8 in.
Scalper	1	1	25 ton/hr.
Distributor	1	1/4	10 positions
Storage tanks	2	--	5,000 gal.
Diverter valve	1	--	8 in.
Processing--			
Conveyor, screw	1	3	8 in.
Hammer mill	1	60	8-12 ton/hr.
Elevator, bucket	1	2	8 in. x 5 in. bucket
Diverter valve	1	--	8 in.
Mixing--			
Feeder conveyors	9	3-2 6-3	--
Feeder, loading board	1	--	--
Weigh hopper and scale	1	--	120 $ft.^3$
Vertical mixer w/surge bin	2	2-7 1/2	100 $ft.^3$ each
Conveyor, screw	1	3	12 in. x 20 ft.
Elevator, bucket	1	7 1/2	8 in. x 5 in. bucket
Continuous mixer	1	5	5 ton/hr.
Molasses pump, heating tank, and other equipment	1	7 5 1/2	10 gal./min.
Fat system	1	3	10 gal./min.
Diverter valve	1	--	8 in.

Appendix table A-1.--Basic equipment in 6 to 10-ton model feed plants--Continued

Item	Number	Horsepower (each motor)	Size and capacity
Pelleting--		75	
		5	
Pellet mill	1	1/2	7-10 ton/hr.
Cooler, fan, collector	1	20 1/2	7-10 ton/hr.
Crumbler	1	10	6 in.x 60 in.
Scalper	1	1	60 in.x 72 in.
		3	8 in.x 15 ft.
Elevator, bucket	2	1	8 in.x 30 ft.
Distributor	1	1/4	8 hole
Packing--			
Packing scale belt feeder	1	3/4	7-50 lb./min.
Bag conveyor	1	1	7-50 lb./min.
Sewing machine	1	1/3	7-50 lb./min.
Warehousing--			
Forklift	1	--	3,000 lbs.
Bulk loadout			
Conveyor, drag	1	5	12 in.x 30 ft.
Traveling weigh hopper	1	1	3 ton
Miscellaneous			
Boiler	1	1	150 hp
Air compressor	1	1	--
Control panel	1	1	--

Appendix table A-2.--Basic equipment in 10 to 25 ton model feed plants

Item	Number	Horsepower (each motor)	Size and capacity
Receiving--			
Truck hoist	1	10	8 ton
Front-end loader	1	15	1,000 lbs.
Conveyor, drag	1	3	12 in.x 40 ft.
Magnet, plate	1	--	--
Elevator, bucket	1	15	12 in.x 6 in.x 60 ft.
Scalper (grain, soft feed)	1	1	50 ton/hr.
Automatic scale w/surge bins.	1	--	5,000 lbs.
Elevator, bucket	1	10	10 in.x 5 in.bucket 100 ft
Conveyor, drag	1	2	12 in.x 15 ft.
Distributor	1	2 1/4	6 x 12 hole
Storage tanks	2	--	5,000 gal.
Processing--			
Conveyor screw	1	3	12 in.
Hammermill	1	100	38 in. 11-15 tons/hr.
Elevator, bucket	1	5	8 in.x 5 in.bucket 60 ft.
Distributor	1	1/4	6 hole
Mixing--			
Feeder conveyors	13	45	--
Feeder headbox	1	--	5,000 lbs.
Weigh hopper and scale	1	--	5,000 lbs.
Batch controls	1	--	Semi-automatic
Horizontal mixer w/surge bin.	1	20	2 ton (150 $ft.^3$)
Conveyor, drag	1	5	12 in.x 20 ft.
Elevator, bucket	1	7 1/2	10 in.x 5 in.bucket 110 ft.
Rotary feed dresser	1	7 1/2	14 in.x 24 in. 30 tons/hr.
Diverter valve two-way	1	--	10 in.
Distributor	1	1/4	8 hole

Appendix table A-2.--Basic equipment in 10 to 25 ton model feed plants--Continued

Item	Number	Horsepower (each motor)	Size and category
Mixing continued--			
Fat system	1	3	50 gal/min.
Continuous mixer	1	25	25 tons/hr.
Conveyors, drag	1	3	12 in.x 10 ft.
Molasses pump, heating tank, and other equipment	1	7 1/2 5	15 gal/min. 15 gal/min.
Pelleting--			
Pellet mill	1	250	25-30 tons/hr.
Cooler, fan and collector	1	40	14-20 tons/hr.
Crumbler	1	15	14-20 tons/hr.
Scalper enclosed	1	1	14-20 tons/hr.
Elevator, bucket	1	2	6 in.x 4 in.bucket 32 ft.
Elevator, bucket	1	5	8 in.x 5 ft.bucket 110 ft.
Distributor	1	1/4	7 hole
Packing--			
Packing scale	1	--	Double belt 10-100 lb./min.
Bag conveyor	1	1	10-100 lb./min.
Sewing machine	1	1/3	10-100 lb./min.
Warehousing--			
Forklift	1	--	4,000 lbs.
Bulk-loadout--			
Conveyor, drag	1	5	12 in.x 30 ft.
Traveling weigh hopper	1	--	3 ton
Miscellaneous			
Boiler	1	5 3/4 3	150 hp
Air compressor	1	15	--
Control panel	1	3	--

Appendix table A-3.--Basic equipment in 25 to 35 ton model feed plants

Item	Number	Horsepower (each motor)	Size and capacity
Receiving--			
Truck dump, platform scale...	1	2-25	10 in. x 50 ft.
Front-end loader.....	1	15	1,000 lbs.
Conveyor, drag.....	1	10	12 in. x 60 ft.
Elevator, bucket.....	1	15	12 in. x 6 in. bucket 60'
Magnet, drum.....	1	--	--
Scalper.....	1	1	80 tons/hr.
Automatic scale w/surge bin..	1	--	5,000 lbs.
Elevator, bucket.....	1	20	12 in. x 6 ft. bucket 120 ft.
Conveyor, drag.....	1	7 1/2	12 in. x 30 ft.
Distributor	1	1/2	20 hole 12 in. diameter
Capstan car puller.....	1	10	--
Storage tanks.....	2	--	5,000 gal.
Processing--			
Hammer mill.....	1	150	38 in. diameter 21-25 tons/hr.
Elevator, bucket.....	1	10	10 in. x 5 in. bucket 110 ft. 25 ton
Distributor.....	1	1/4	6 hole
Conveyor, screw.....	1	3	12 in.
Mixing--			
Feeder conveyors.....	18	60	--
Feeder headbox.....	1	--	--
Weigh hopper and scale.....	1	--	6,000 lbs.
Batch controls.....	1	--	Automatic
Horizontal mixer w/surge bin	1	25	3 tons (191 $ft.^3$)
Conveyor, drag.....	1	5	12 in. x 20 ft.
Elevator, bucket.....	1	15	10 in. x 5 in. x 100 ft.
Rotary feed dresser.....	1	15	18 in. x 36 in.

Appendix table A-3.--Basic equipment in 25 to 35 ton model feed plants--Continued

Item	Number	Horsepower (each motor)	Size and capacity
Mixing continued--			
Magnet, drum	1	--	--
Continuous mixer	1	30	30 in.x 12 ft. 30 ton/hr.
Conveyor, drag	1	3	12 in.x 10 ft.
Molasses pump, heating tank, and other equipment	1	5 7 1/2	50 gal/min.
Fat system	1	5	50 gal/min.
Pelleting--			
Pellet mill	2	2-150	28-40 tons/hr.
Cooler, fan and collector	2	2-40	Horizontal 2 pass
Crumbler	2	2-10	--
Scalper	2	2-5	4 1/2 ft.x 8 ft.
Elevator, bucket	1	5	10 in.x 5 in.bucket 90 ft.
Distributor	1	1/4	8 hole
Packing--			
Auto-packing scale belt feeder	1	2	Dual belt 14-1000 lb/min.
Bag conveyor	1	1	" "
Sewing machine	1	1/3	14-100 lb/min.
Impacker	1	3/4	--
Warehousing--			
Forklift	2	--	3,000 lbs.
Bulk-loadout--			
Conveyor, drag	1	7 1/2	16 in.x 30 ft.
•		--	10 ft.x 50 ft.
Scales, platform	1	--	50 tons
Miscellaneous--			
Boiler	1	3/4 3-5	200 hp
Air compressor	1	15	--
Control panel	1	--	--

Appendix table A-4.--Basic equipment in 35 to 50 ton model feed plants

Item	Number	Horsepower (each motor)	Size and capacity
Receiving--			
Truck dump, platform scale...	1	2-25	10 ft. x 50 ft.
Front-end loader.....	1	25	1,500 lbs.
Conveyor, drag.....	1	10	16 in. x 70 ft.
Elevator, bucket.....	1	15	14 in. x 5 in. bucket 65 ft.
Magnet, drum.....	1	--	--
Scalper.....	1	3	100 ton/hr.
Automatic scale w/surge bin .	1	--	5,000 lbs.
Elevator, bucket.....	1	40	14 in. x 5 in. bucket 145 ft.
Conveyor, drag.....	1	7 1/2	16 in. x 35 ft.
Distributor.....	1	1/2	14 in. diameter 20 hole
Capstan car puller.....	1	10	--
Storage tanks.....	2	--	8,000 gal.
Processing--			
Hammer mill.....	1	200	31 ton/hr. 38 in. x 12 in.
Elevator, bucket.....	1	7 1/2	10 in. x 5 in. bucket 110 ft.
Distributor.....	1	1/2	14 in. diameter 6 hole
Conveyor, screw.....	1	3	12 in.
Mixing--			
Feeder conveyors.....	25	70	--
Feeder headbox.....	1	--	1,000 lbs.
Weigh hopper & scale.....	1	--	1,000 lbs.
Batch controls.....	1	--	Automatic
Horizontal mixer w/surge bin	1	30	4 ton (254 $ft.^3$)
Conveyor, drag.....	1	3	16 in. x 20 ft.
Elevator, bucket.....	1	20	12 in. x 6 in. x 100 ft.
Rotary feed dresser.....	1	30	18 in. x 60 in. 90 ton

Appendix table A-4.--Basic equipment in 35 to 50 ton model feed plants--Continued

Item	Number	Horsepower (each motor)	Size and capacity
Mixing continued--			
Magnet, drum	1	--	--
Continuous mixer	1	40	40 tons/hr.
Conveyor, drag	1	5	12 in.x 50 ft.
Molasses pump, heating tank and other equipment	1	7 1/2 5 5	50 gal./min.
Fat system	1	3	50 gal./min.
Pelleting--			
Pellet mill	2	2-300	60 tons/hr.
Cooler, fan and collector	2	2-50	Horizontal 2 pass
Crumbler	2	2-15	9 in.x 60 in.
Scalper	2	2-5	5 ft.x 12 ft. 10 in.x 5 in.bucket
Elevator, bucket	1	7 1/2	90 ft.
Distributor	1	1/4	8 hole
Packing--			
Auto-packing scale belt feeder	1	2-1 1/2	Dual belt 14-18 100 lb./min.
Bag conveyor	1	1	" "
Sewing machine	1	1/3	14-18 100 lb./min.
Impacker	1	3/4	--
Warehousing--			
Forklift	2	--	4,000 lbs.
Bulk-loadout--			
Conveyor, drag	1	10	16 in.x 40 ft. 10 ft.x 50 ft.
Scales, platform	1	--	50 ton
Miscellaneous--		3/4 2-7 1/2	
Boiler	1	1-5	250 hp
Air compressor	1	25	--
Control panel	1	--	--

APPENDIX B: PLANT INVESTMENT COST

Certain basic assumptions were made in developing and estimating equipment and facility costs. Costs used in this study are representative for feed manufacturing plants with designated capacities. However, this does not mean that these models could not be built at a lower cost nor that the cost might not exceed these basic estimates.

In recent years, feed manufacturers have been increasingly concerned when planning new mills and remodeling current facilities to control contamination, meet EPA and OSHA requirements, and improve operational efficiency. During the next 10 years, there will undoubtedly be considerable progress made in meeting environmental, health, and safety standards. While feed mill operators in recent years have taken these factors into consideration, the necessity of meeting environmental and health standards currently is being given particular attention. Equipment manufacturers in recent years have tended toward use of so-called standard equipment which has helped to reduce some problems relating to environmental control and safety standards.

Automation is incorporated into feed plants wherever feasible. Not only does this reduce labor cost per ton, but facilitates the reduction of human error relating to safety and product quality. Interlocking controls and safety devices are used to great advantage in modern mill design. At the same time, basic systems and flows have been simplified. The simpler the flow of ingredients and feeds through the mill, the easier it is to maintain the plant and to schedule operations. More direct systems are used which incorporate gravity flow wherever possible.

Numerous variables affect the costs of construction, equipment, and other items. All feed manufacturers do not have the same basic requirements nor do they have the same amount of capital to invest. Usually the feed manufacturing facility is a compromise between what management believes is needed and what the available capital will allow.

Appendix tables B-1 through B-12 contain the equipment and facility costs for each of the models. Equipment cost is broken down by major cost center. Installation--mechanical, electrical, and plumbing-- not shown separately is a larger cost item than is usually recognized. Installation costs are taken as a percentage of equipment cost which equipment manufacturers and contractors considered to be reasonable. Actual installation cost may be higher or lower depending on local conditions.

The building cost index in appendix table B-13 illustrates the variations in construction costs since 1970. As the indices show, construction costs increased greatly in 1974 and early 1975. This table includes series for both steel and brick concrete concrete construction. A number of cities have been

included in this table to illustrate why it is possible to have such a wide variation in plant construction costs. Steel construction costs increased the least in Jacksonville between 1970 and 1974. Minneapolis had the smallest increase in brick concrete construction during this period.

During this period, steel construction costs tended to increase more than those for brick and concrete. Prior to 1970, many feed manufacturers used steel to build a new plant or add to an existing facility since it was least expensive for smaller facilities. Steel is also more flexible than slipform concrete construction, and does not usually require the extensive pilings needed for concrete construction.

Appendix table B-1.--Equipment and facility cost for model plants producing 6 tons per hour (Ruminant feed) 1/

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Equipment						
Receiving	28,590	28,590	28,590	28,590	28,590	28,590
Processing	11,010	11,010	11,010	11,010	11,010	11,010
Mixing	37,780	37,780	37,780	37,780	37,780	37,780
Pelleting	--	--	--	45,065	45,065	45,065
Packing	--	7,865	7,865	--	7,865	7,865
Warehousing	--	12,425	12,425	--	12,425	12,425
Bulk-loadout	12,310	12,310	--	12,310	12,310	--
Miscellaneous	28,730	28,730	28,730	34,430	34,430	34,430
Total	118,420	138,710	126,400	169,185	189,475	177,165
Installation	41,450	48,550	44,240	59,215	66,320	62,000
Total	159,870	187,260	170,640	228,400	255,795	239,165
Facilities						
Mill bldg	112,630	119,400	119,400	121,680	126,150	126,150
Outside storage	41,600	41,600	41,600	41,600	41,600	41,600
Bulk storage	16,120	12,100	--	16,120	12,100	--
Warehouse	2,750	9,100	18,100	2,750	9,100	18,100
Boiler house	6,350	6,350	6,350	9,570	9,570	9,570
Office	17,680	17,680	17,680	17,680	17,680	17,680
Rail siding	11,440	11,400	11,440	11,440	11,440	11,440
Total	208,570	217,670	214,570	220,840	227,640	224,540
Grand total	368,440	404,930	385,210	499,240	483,435	463,705

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table B-2.--Equipment and facility cost for model plants producing 8 tons per hour (Mixed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	28,590	28,590	28,590	28,590	28,590	28,590	28,590	28,590	28,590
Processing	11,010	11,010	11,010	11,010	11,010	11,010	11,010	11,010	11,010
Mixing	42,590	42,590	42,590	42,590	42,590	42,590	42,590	42,590	42,590
Pelleting	--	--	--	45,065	45,065	45,065	45,065	45,065	45,065
Packing	--	7,865	7,865	--	7,865	7,865	--	7,865	7,865
Warehousing	--	12,425	12,425	--	12,425	12,425	--	12,425	12,425
Bulk-loadout	12,310	12,310	--	12,310	12,310	--	12,310	12,310	--
Miscellaneous	28,730	28,730	28,730	34,430	34,430	34,430	34,430	34,430	34,430
Total	123,230	143,520	131,210	173,995	194,285	181,975	173,995	194,285	181,975
Installation	43,130	50,230	45,920	60,900	68,000	63,690	60,900	68,000	63,690
Total	166,360	193,750	177,130	234,895	262,285	245,665	234,895	262,285	245,665
Facilities									
Mill bldg	128,000	135,720	135,720	131,870	137,100	137,100	137,900	143,100	143,100
Outside storage	52,000	52,000	52,000	52,000	52,000	52,000	52,000	52,000	52,000
Bulk storage	21,580	16,180	--	21,580	16,180	--	21,580	16,180	--
Warehouse	3,640	12,690	23,610	3,640	12,690	23,610	3,640	12,690	23,610
Boiler house	6,350	6,350	6,350	9,570	9,570	9,570	9,570	9,570	9,570
Office	17,680	17,680	17,680	17,680	17,680	17,680	17,680	17,680	17,680
Rail siding	11,440	11,440	11,440	11,440	11,440	11,440	11,440	11,440	11,440
Total	240,690	252,060	246,800	247,780	256,660	251,400	253,810	262,660	257,400
Grand total	407,050	445,810	423,930	482,675	518,945	497,065	488,705	524,945	503,065

Appendix table B-3.--Equipment and facility cost for model plants producing 10 tons per hour (Poultry and swine)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	28,590	28,590	28,590	28,590	28,590	28,590	28,590	28,590	28,590
Processing	11,010	11,010	11,010	11,010	11,010	11,010	11,010	11,010	11,010
Mixing	31,190	31,190	31,190	31,190	31,190	31,190	31,190	31,190	31,190
Pelleting	--	--	--	45,065	45,065	45,065	45,065	45,065	45,065
Packing	--	7,865	7,865	--	7,865	7,865	--	7,865	7,865
Warehousing	--	12,425	12,425	--	12,425	12,425	--	12,425	12,425
Bulk-loadout	12,310	12,310	--	12,310	12,310	--	12,310	12,310	--
Miscellaneous	28,730	28,730	28,730	34,430	34,430	34,430	34,430	34,430	34,430
Total	111,830	132,120	119,810	117,530	137,820	125,510	162,595	182,885	170,575
Installation	39,140	46,250	41,940	41,140	48,240	43,930	56,900	64,000	59,700
Total	150,970	178,370	160,750	158,670	186,060	169,440	219,595	246,885	230,275
Facilities									
Mill bldg	127,500	135,200	135,200	131,350	136,450	136,450	137,700	142,800	142,800
Outside storage	76,860	76,860	76,860	76,869	76,860	76,860	76,860	76,860	76,860
Bulk storage	27,040	20,280	--	27,040	20,280	--	27,040	20,280	--
Warehouse	4,580	15,400	29,950	4,580	15,400	29,950	4,580	15,400	29,950
Boiler house	6,350	6,350	6,350	9,570	9,570	9,570	9,570	9,570	9,570
Office	17,680	17,680	17,680	17,680	17,680	17,680	17,680	17,680	17,680
Rail siding	11,440	11,440	11,440	11,440	11,440	11,440	11,440	11,440	11,440
Total	271,450	283,210	277,480	278,520	287,680	281,950	284,870	294,030	288,300
Grand total	442,420	461,580	483,230	437,190	473,740	451,390	504,465	540,915	518,575

Appendix table B-4.--Equipment and facility cost for model plants producing 10 tons per hour (Ruminant feed) 1/

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Equipment						
Receiving	62,940	62,940	62,940	62,940	62,940	62,940
Processing	15,050	15,050	15,050	15,050	15,050	15,050
Mixing	74,930	74,930	74,930	74,930	74,930	74,930
Pelleting	--	--	--	61,275	61,275	61,275
Packing	--	21,545	21,545	--	21,545	21,545
Warehousing	--	12,425	12,425	--	12,425	12,425
Bulk-loadout	12,310	12,310	--	12,310	12,310	--
Miscellaneous	41,040	41,040	41,040	57,000	57,000	57,000
Total	206,270	240,240	227,930	283,505	317,475	305,165
Installation	72,195	84,085	79,775	99,225	111,115	106,805
Total	278,465	324,325	307,705	382,730	428,590	411,970
Facilities						
Mill bldg	157,870	167,335	167,335	170,560	176,800	176,800
Outside storage	76,855	76,855	76,855	76,855	76,855	76,855
Bulk storage	27,040	--	--	27,040	20,280	--
Warehouse	4,575	29,950	29,950	4,575	15,390	29,950
Boiler house	9,570	9,570	9,570	9,570	9,570	9,570
Office	29,950	29,950	29,950	29,950	29,950	29,950
Rail siding	15,185	15,185	15,185	15,185	15,185	15,185
Total	321,045	328,845	328,845	333,735	344,030	338,310
Grand total	599,510	653,170	636,550	716,465	772,620	750,280

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table B-5.--Equipment and facility cost for model plants producing 18 tons per hour (Mixed feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	62,940	62,940	62,940	62,940	62,940	62,940	62,940	62,940	62,940
Processing	15,050	15,050	15,050	15,050	15,050	15,050	15,050	15,050	15,050
Mixing	81,770	81,770	81,770	81,770	81,770	81,770	81,770	81,770	81,770
Pelleting	--	--	--	61,275	61,275	61,275	61,275	61,275	61,275
Packing	--	21,545	21,545	--	21,545	21,545	--	21,545	21,545
Warehousing	--	12,425	24,850	--	12,425	24,850	--	12,425	24,850
Bulk-loadout	12,310	12,310	--	12,310	12,310	--	12,310	12,310	--
Miscellaneous	41,040	41,040	41,040	57,000	57,000	57,000	57,000	57,000	57,000
Total	213,110	247,080	247,195	290,345	324,315	324,430	290,345	324,315	324,430
Installation	74,590	86,480	86,520	101,620	113,510	113,550	101,620	113,510	113,550
Total	287,700	333,560	333,715	391,965	437,825	437,980	391,965	437,825	437,980
Facilities									
Mill bldg	235,870	250,015	250,015	242,945	252,410	252,410	254,800	264,160	264,160
Outside storage	109,825	109,825	109,825	109,825	109,825	109,825	109,825	109,825	109,825
Bulk storage	48,620	36,400	--	48,620	36,400	--	48,620	36,400	--
Warehouse	8,215	27,145	54,290	8,215	27,145	54,290	8,215	27,145	54,290
Boiler house	12,480	12,480	12,480	12,480	12,480	12,480	12,480	12,480	12,480
Office	29,950	29,950	29,950	29,950	29,950	29,950	29,950	29,950	29,950
Rail siding	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185
Total	460,145	481,000	471,745	467,220	483,395	474,140	479,075	495,145	485,890
Grand total	747,845	814,560	805,460	859,185	921,220	912,120	871,040	932,970	923,870

Appendix table B-6.--Equipment and facility cost for model plants producing 25 tons per hour (Poultry and swine)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	62,940	62,940	62,940	62,940	62,940	62,940	62,940	62,940	62,940
Processing	15,050	15,050	15,050	15,050	15,050	15,050	15,050	15,050	15,050
Mixing	70,370	70,370	70,370	70,370	70,370	70,370	70,370	70,370	70,370
Pelleting	--	--	--	61,275	61,275	61,275	61,275	61,275	61,275
Packing	--	21,545	21,545	--	21,545	21,545	--	21,545	21,545
Warehousing	--	12,425	24,850	--	12,425	24,850	--	12,425	24,850
Bulk-loadout	12,310	12,310	--	12,310	12,310	--	12,310	12,310	--
Miscellaneous	41,040	41,040	41,040	57,000	57,000	57,000	57,000	57,000	57,000
Total	201,710	235,680	235,795	278,945	312,915	313,030	278,945	312,915	313,030
Installation	70,600	82,490	82,530	97,630	109,520	109,560	97,630	109,520	109,560
Total	272,310	318,270	318,325	376,575	422,435	422,590	376,575	422,435	422,590
Facilities									
Mill bldg	220,690	234,000	234,000	227,345	236,080	236,080	238,370	247,210	247,210
Outside storage	170,975	170,975	170,975	170,975	170,975	170,975	170,975	170,975	170,975
Bulk storage	67,600	50,700	--	67,600	50,700	--	67,600	67,600	--
Warehouse	10,920	38,065	75,090	10,920	38,065	75,090	10,920	38,065	75,090
Boiler house	12,420	12,420	12,420	12,420	12,420	12,420	12,420	12,420	12,420
Office	29,950	29,950	29,950	29,950	29,950	29,950	29,950	29,950	29,950
Rail siding	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185
Total	527,740	551,295	537,620	534,395	553,375	539,700	545,420	581,405	550,830
Grand total	800,050	869,465	855,945	910,970	975,810	962,290	921,995	1,003,840	973,420

Appendix table B-7.--Equipment and facility cost for model feed plants producing 25 tons per hour (Ruminant feed) 1/

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Equipment						
Receiving	121,510	121,510	121,510	121,510	121,510	121,510
Processing	19,265	19,265	19,265	19,265	19,265	19,265
Mixing	117,395	117,395	117,395	117,395	117,395	117,395
Pelleting	--	--	--	94,165	94,165	94,165
Packing	--	21,545	28,840	--	21,545	28,840
Warehousing	--	12,880	38,645	--	12,880	38,645
Bulk-loadout	19,435	19,435	--	19,435	19,435	--
Miscellaneous	71,820	71,820	71,820	92,340	92,340	92,340
Total	349,425	383,850	397,475	464,110	498,535	512,160
Installation	122,300	134,345	139,115	162,550	174,485	179,255
Total	471,725	518,195	536,590	626,550	673,020	691,415
Facilities						
Mill bldg	274,975	291,510	291,510	297,025	308,050	308,050
Outside storage	170,975	170,975	170,975	170,975	170,975	170,975
Bulk storage	67,600	50,700	--	65,600	50,700	--
Warehouse	10,920	38,065	75,090	10,920	38,065	75,090
Boiler house	15,600	15,600	15,600	15,600	15,600	15,600
Office	41,080	41,080	41,080	41,080	41,080	41,080
Rail siding	15,185	15,185	15,185	15,185	15,185	15,185
Total	596,335	623,115	609,440	616,385	639,655	625,980
Grand total	1,068,060	1,141,310	1,146,030	1,242,935	1,312,675	1,317,395

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table B-8.--Equipment and facility cost for model plants producing 30 tons per hour (Mixed feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	121,510	121,510	121,510	121,510	121,510	121,510	121,510	121,510	121,510
Processing	19,265	19,265	19,265	19,265	19,265	19,265	19,265	19,265	19,265
Mixing	124,125	124,125	124,125	124,125	124,125	124,125	124,125	124,125	124,125
Pelleting	--	--	--	94,165	94,165	94,165	94,165	94,165	94,165
Packing	--	21,545	28,840	--	21,545	28,840	--	21,545	28,840
Warehousing	--	12,880	38,645	--	12,880	38,645	--	12,880	38,840
Bulk-loadout	19,435	19,435	--	19,435	19,435	--	19,435	19,435	--
Miscellaneous	71,820	71,820	71,820	92,340	92,340	92,340	92,342	92,340	92,340
Total	356,155	390,580	404,205	470,840	505,265	518,890	470,840	505,265	518,890
Installation	124,655	136,705	141,470	164,795	176,840	181,610	164,795	176,840	181,610
Total	480,810	527,285	545,675	635,635	682,105	700,500	635,635	682,105	700,500
Facilities									
Mill bldg	322,710	342,055	342,055	332,385	345,280	345,210	348,610	361,505	361,505
Outside storage	195,000	195,000	195,000	195,000	195,000	195,000	195,000	195,000	195,000
Bulk storage	81,120	60,840	--	81,120	60,840	--	81,120	60,840	--
Warehouse	13,625	45,240	90,480	13,625	45,240	90,480	12,625	45,240	90,480
Boiler house	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600
Office	41,080	41,080	41,080	41,080	41,080	41,080	41,080	41,080	41,080
Rail siding	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185
Total	684,320	715,000	699,400	693,995	718,225	702,555	710,220	734,450	718,850
Grand total	1,165,130	1,242,285	1,245,075	1,329,630	1,400,330	1,403,055	1,345,855	1,416,555	1,419,350

Appendix table B-9.--Equipment and facility cost for model plants producing 35 tons per hour (Poultry and swine)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	121,510	121,510	121,510	121,510	121,510	121,510	121,510	121,510	121,510
Processing	19,265	19,265	19,265	19,265	19,265	19,265	19,265	19,265	19,265
Mixing	109,075	109,075	109,075	109,075	109,075	109,075	109,075	109,075	109,075
Pelleting	--	--	--	94,165	94,165	94,165	94,165	94,165	94,165
Packing	--	21,545	28,840	--	21,545	28,840	--	21,545	28,840
Warehousing	--	12,880	38,645	--	12,880	38,645	--	12,880	38,645
Bulk-loadout	19,435	19,435	--	19,435	19,435	--	19,435	19,435	--
Miscellaneous	71,820	71,820	71,820	92,340	92,340	92,340	92,340	92,340	92,340
Total	341,105	375,530	389,155	455,790	490,215	503,840	455,790	490,215	503,840
Installation	119,385	131,435	136,205	159,525	171,575	176,345	159,525	171,575	176,345
Total	460,490	506,965	525,360	615,315	661,790	680,185	615,315	661,790	680,185
Facilities									
Mill bldg	293,905	311,585	311,585	302,640	315,305	315,305	317,410	329,160	329,160
Outside storage	243,775	243,775	243,775	243,775	243,775	243,775	243,775	243,775	243,775
Bulk storage	94,640	70,980	--	94,640	70,980	--	94,640	70,980	--
Warehouse	15,390	53,455	108,575	15,390	53,455	108,575	15,390	53,455	108,575
Boiler house	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600	15,600
Office	41,080	41,080	41,080	41,050	41,080	41,080	41,080	41,080	41,080
Rail siding	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185	15,185
Total	734,760	751,660	735,800	728,310	755,380	739,520	743,080	769,235	753,375
Grand total	1,195,250	1,258,625	1,261,160	1,343,625	1,417,170	1,419,705	1,358,395	1,431,025	1,433,560

Appendix table B-10--Equipment and facility cost for model feed plants producing 35 tons per hour (Ruminant feed) 1/

Cost item	Method of operation					
	A	B	C	G	H	I
	Dollars					
Equipment						
Receiving	138,750	138,750	138,750	138,750	138,750	138,750
Processing	19,150	19,150	19,150	19,150	19,150	19,150
Mixing	155,110	155,110	155,110	115,110	115,110	115,110
Pelleting	--	--	--	102,145	102,145	102,145
Packing	--	28,840	29,685	--	28,840	29,685
Warehousing	--	25,765	38,645	--	25,765	38,645
Bulk-loadout	20,795	20,795	--	20,795	20,795	--
Miscellaneous	91,200	91,200	91,200	116,735	116,735	116,735
Total	425,005	479,610	472,540	512,685	567,290	560,220
Installation	148,750	167,865	165,390	179,440	198,550	196,075
Total	573,755	647,475	637,930	692,125	765,840	756,295
Facilities						
Mill bldg	352,040	373,150	373,150	380,225	394,370	394,370
Outside storage	243,775	243,775	243,775	243,775	243,775	243,775
Bulk storage	94,640	70,980	--	94,640	70,980	--
Warehouse	15,390	53,455	108,575	15,390	53,455	108,575
Boiler house	18,420	18,420	18,420	18,420	18,420	18,420
Office	46,800	46,800	46,800	46,800	46,800	46,800
Rail siding	19,030	19,030	19,030	19,030	19,030	19,030
Total	790,095	825,610	809,750	818,280	846,830	830,970
Grand total	1,363,850	1,473,085	1,447,680	1,510,405	1,613,670	1,587,265

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table B-11.--Equipment and facility cost for model plants producing 43 tons per hour (Mixed feed)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	138,750	138,750	138,750	138,750	138,750	138,750	138,750	138,750	138,750
Processing	19,150	19,150	19,150	19,150	19,150	19,150	19,150	19,150	19,150
Mixing	161,835	161,835	161,835	161,835	161,835	161,835	161,835	161,835	161,835
Pelleting	--	--	--	102,145	102,145	102,145	102,145	102,145	102,145
Packing	--	28,840	29,685	--	28,840	29,685	--	28,840	29,685
Warehousing	--	25,765	51,530	--	25,765	51,530	--	25,765	51,765
Bulk-loadout	20,795	20,795	--	20,795	20,795	--	20,795	20,795	--
Miscellaneous	91,200	91,200	91,200	116,735	116,735	116,735	116,735	116,735	116,735
Total	431,730	486,335	492,150	559,410	614,015	619,830	559,410	614,015	620,065
Installation	151,105	170,215	172,250	195,795	214,905	216,940	195,795	214,905	217,020
Total	582,835	656,550	664,400	755,205	828,920	836,770	755,205	828,920	837,085
Facilities									
Mill bldg	367,850	389,895	389,895	378,895	393,640	393,640	397,280	412,050	412,050
Outside storage	290,160	290,160	290,160	290,160	290,160	290,160	290,160	290,160	290,160
Bulk storage	116,220	87,150	--	116,200	87,150	--	116,220	87,150	--
Warehouse	19,030	65,210	126,670	19,030	65,210	126,670	19,030	65,210	126,670
Boiler house	18,420	18,420	18,420	18,420	18,420	18,420	18,420	18,420	18,420
Office	46,800	46,800	46,800	46,800	46,800	46,800	46,800	46,800	46,800
Rail siding	19,030	19,030	19,030	19,030	19,030	19,030	19,030	19,030	19,030
Total	877,510	916,665	890,975	888,535	920,410	894,720	906,940	938,820	913,130
Grand total	1,460,345	1,573,215	1,555,375	1,643,740	1,749,330	1,731,490	1,662,145	1,767,740	1,750,215

Appendix table B-12.--Equipment and facility for model plants producing 50 tons per hour (Poultry and swine)

Cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
Equipment									
Receiving	138,750	138,750	138,750	138,750	138,750	138,750	138,750	138,750	138,750
Processing	19,150	19,150	19,150	19,150	19,150	19,150	19,150	19,150	19,150
Mixing	145,725	145,725	145,725	145,725	145,725	145,725	145,725	145,725	145,725
Pelleting	--	--	--	102,145	102,145	102,145	102,145	102,145	102,145
Packing	--	28,840	29,685	--	28,840	29,685	--	28,840	29,685
Warehousing	--	25,765	51,530	--	25,765	51,530	--	25,765	51,530
Bulk-loadout	20,795	20,795	--	20,795	20,795	--	20,795	20,795	--
Miscellaneous	91,200	91,200	91,200	116,735	116,735	116,735	116,735	116,735	116,735
Total	415,620	470,225	476,040	543,300	597,905	603,720	543,300	597,905	603,720
Installation	145,465	164,580	166,615	190,155	209,265	211,300	190,155	209,265	211,300
Total	561,085	634,805	642,655	733,455	807,170	815,020	733,455	807,170	815,020
Facilities									
Mill bldg.	364,210	386,050	386,050	375,130	389,690	389,690	393,330	407,890	407,890
Outside storage	362,750	362,750	362,750	362,750	362,750	362,750	362,750	362,750	362,750
Bulk storage	135,200	101,400	--	135,200	101,400	--	135,200	101,400	--
Warehouse	21,735	75,920	150,280	21,735	75,920	150,280	21,735	75,920	150,280
Boiler house	18,420	18,420	18,420	18,420	18,420	18,420	18,420	18,420	18,420
Office	46,800	46,800	46,800	46,800	46,800	46,800	46,800	46,800	46,800
Rail siding	19,030	19,030	19,030	19,030	19,030	19,030	19,030	19,030	19,030
Total	968,145	1,010,370	983,330	979,065	1,014,010	986,970	997,265	1,032,210	1,005,170
Grand total	1,529,230	1,645,175	1,625,985	1,712,520	1,821,180	1,801,990	1,730,720	1,839,380	1,820,190

Appendix table B-13.--Building cost index: Commercial and factory buildings, selected cities (1970 = 100)

City	1971		1972		1973		1974		1975	
	Steel	Brick Concrete	Steel	Brick Concrete	Steel	Brick Concrete	Steel	Brick Concrete	Steel	Brick Concrete
Albuquerque	101	102	116	107	121	113	136	129	153	140
Atlanta	106	105	120	115	126	124	140	138	144	139
Buffalo	106	106	130	113	136	119	148	130	155	157
Chicago	104	105	123	113	130	120	143	134	166	158
Cincinnati	106	106	131	117	135	120	148	133	153	154
Dallas	104	102	118	110	125	118	140	134	136	136
Denver	102	102	117	107	124	115	140	131	147	145
Des Moines	104	101	125	114	130	121	144	135	149	132
Indianapolis	105	105	124	116	130	124	144	136	148	148
Jacksonville	105	104	116	119	121	126	135	141	143	136
Kansas City	107	108	126	118	132	125	147	141	154	154
Los Angeles	108	103	130	113	140	123	153	135	158	154
Memphis	107	106	115	116	120	122	137	141	148	140
Minneapolis	106	104	126	110	130	116	143	128	137	148
New Orleans	104	102	117	109	124	118	138	134	144	141
Omaha	103	101	120	110	127	116	142	130	148	148
Portland, Oregon	103	102	123	115	129	118	142	131	149	149
Richmond	106	104	114	110	119	117	150	135	141	136
Seattle	103	101	120	107	127	116	141	129	157	163
Tuson	108	107	129	119	137	126	152	141	158	154
United States	110	109	118	117	124	125	136	141	151	155

Source: Developed from Boekh's Building Cost Index Numbers. The American Appraisal Company, Inc., Milwaukee, Wisc.

Appendix table C-1.--Depreciation costs for model feed plants producing 6 to 10 tons per hour, by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
6-ton									
Equipment cost..	159,870	187,260	170,640	1/	1/	1/	228,400	255,795	239,165
Deprec. per ton.	.75	.88	.80	1/	1/	1/	1.07	1.20	1.12
Facility cost...	208,570	217,670	214,570	1/	1/	1/	220,840	227,640	224,540
Deprec. per ton.	.67	.70	.69	1/	1/	1/	.71	.73	.72
Total.....	1.42	1.58	1.49	1/	1/	1/	1.78	1.93	1.84
8-ton									
Equipment cost..	166,360	193,750	177,130	234,895	262,285	245,665	234,895	262,285	245,665
Deprec. per ton.	.58	.68	.62	.82	.92	.86	.82	.92	.86
Facility cost...	240,690	252,060	246,800	247,780	256,660	251,400	253,810	262,660	257,400
Deprec. per ton.	.58	.60	.59	.59	.62	.60	.61	.63	.62
Total.....	1.16	1.28	1.21	1.41	1.54	1.46	1.43	1.55	1.48
10-ton									
Equipment cost..	150,970	178,370	160,750	158,670	186,060	169,440	219,595	246,885	230,275
Deprec. per ton.	.42	.50	.45	.44	.52	.47	.61	.69	.64
Facility cost...	271,450	283,210	277,480	278,520	287,680	281,950	284,870	294,030	288,300
Deprec. per ton.	.52	.54	.53	.53	.55	.54	.54	.56	.55
Total.....	.94	1.04	.98	.97	1.07	1.01	1.15	1.25	1.19

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-2.--Depreciation costs for model feed plants producing 10 to 25 tons per hour, by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
10-ton									
Equipment cost..	278,465	324,325	307,705	1/	1/	1/	382,730	428,590	411,970
Deprec. per ton.	.78	.91	.86	1/	1/	1/	1.07	1.20	1.15
Facility cost...	321,045	328,845	328,845	1/	1/	1/	333,735	344,030	338,310
Deprec. per ton.	.61	.62	.62	1/	1/	1/	.63	.65	.64
Total.....	1.39	1.53	1.48	1/	1/	1/	1.70	1.85	1.79
18-ton									
Equipment cost..	287,700	333,560	333,715	391,965	437,825	437,980	391,965	437,825	437,980
Deprec. per ton.	.43	.50	.50	.59	.66	.66	.59	.66	.66
Facility cost...	460,145	481,000	471,745	467,220	483,395	474,140	479,075	495,145	485,890
Deprec. per ton.	.46	.48	.47	.47	.48	.47	.48	.50	.49
Total.....	.89	.98	.97	1.06	1.14	1.13	1.07	1.16	1.15
25-ton									
Equipment cost..	272,310	318,170	318,325	376,575	422,435	422,590	376,575	422,435	422,590
Deprec. per ton.	.30	.35	.35	.41	.46	.46	.41	.46	.46
Facility cost...	527,740	551,295	537,620	534,395	553,375	539,700	545,420	581,405	550,830
Deprec. per ton.	.42	.44	.43	.43	.44	.43	.44	.46	.44
Total.....	.72	.79	.78	.84	.90	.89	.85	.92	.90

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-3.--Depreciation costs for model feed plants producing 25 to 35 tons per hour, by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
25-ton									
Equipment cost..	471,725	518,195	536,590	1/	1/	1/	626,550	673,020	691,415
Deprec. per ton.	.52	.57	.59	1/	1/	1/	.69	.74	.76
Facility cost...	596,335	623,115	609,440	1/	1/	1/	616,385	639,655	625,980
Deprec. per ton.	.48	.50	.49	1/	1/	1/	.49	.51	.50
Total.....	1.00	1.07	1.08	1/	1/	1/	1.18	1.25	1.26
30-ton									
Equipment cost..	480,810	527,285	545,675	635,635	682,105	700,500	635,635	682,105	700,500
Deprec. per ton.	.43	.47	.49	.57	.61	.63	.57	.61	.63
Facility cost...	684,320	715,000	699,400	693,995	718,225	702,555	710,220	734,450	718,850
Deprec. per ton.	.44	.46	.45	.44	.46	.45	.46	.47	.46
Total.....	.87	.93	.94	1.01	1.07	1.08	1.03	1.08	1.09
35-ton									
Equipment cost..	460,490	506,965	525,360	615,315	661,790	680,185	615,315	661,790	680,185
Deprec. per ton.	.37	.40	.42	.49	.53	.54	.49	.53	.54
Facility cost...	734,760	751,660	735,800	728,310	755,380	739,520	743,080	769,235	753,375
Deprec. per ton.	.40	.41	.40	.40	.41	.41	.41	.42	.41
Total.....	.77	.81	.82	.89	.94	.95	.90	.95	.95

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-4.--Depreciation costs for model feed plants producing 35 to 50 tons per hour, by operation

Model size and cost item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
35-ton									
Equipment cost..	573,755	187,260	170,640	1/	1/	1/	228,400	255,795	239,165
Deprec. per ton.	.75	.88	.80	1/	1/	1/	1.07	1.20	1.12
Facility cost...	208,570	217,670	214,570	1/	1/	1/	220,840	227,640	224,540
Deprec. per ton.	.67	.70	.69	1/	1/	1/	.71	.73	.72
Total.....	1.42	1.58	1.49	1/	1/	1/	1.78	1.93	1.84
43-ton									
Equipment cost..	166,360	193,750	177,130	234,895	262,285	245,665	234,895	262,285	245,665
Deprec. per ton.	.58	.68	.62	.82	.92	.86	.82	.92	.86
Facility cost...	240,690	252,060	246,800	247,780	256,660	251,400	253,810	262,660	257,400
Deprec. per ton.	.58	.60	.59	.59	.62	.60	.61	.63	.62
Total.....	1.16	1.28	1.21	1.41	1.54	1.46	1.43	1.55	1.48
50-ton									
Equipment cost..	150,970	178,370	160,750	158,670	186,060	169,440	219,595	246,885	230,275
Deprec. per ton.	.42	.50	.45	.44	.52	.47	.61	.69	.64
Facility cost...	271,450	283,210	277,480	278,520	287,680	281,950	284,870	294,030	288,300
Deprec. per ton.	.52	.54	.53	.53	.55	.54	.54	.56	.55
Total.....	.94	1.04	.98	.97	1.07	1.01	1.15	1.25	1.19

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-5.--Labor requirements for model mills producing 6 to 10 tons per hour: Production, maintenance, and supervision, hours per day and cost per ton

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
6-ton										
Production										
Hours per day	Manhours	15	29	45	1/	1/	1/	18	32	48
Cost per ton	Dollars	1.47	2.84	4.41	1/	1/	1/	1.76	3.13	4.70
Maintenance										
Hours per day	Manhours	5	6	6	1/	1/	1/	8	9	9
Cost per ton	Dollars	.51	.61	.61	1/	1/	1/	.82	.92	.92
Supervisor										
Hours per day	Manhours	4	5	5	1/	1/	1/	6	7	7
Cost per ton	Dollars	.42	.52	.52	1/	1/	1/	.63	.73	.73
8-ton										
Production										
Hours per day	Manhours	23	34	50	28	42	56	27	38	54
Cost per ton	Dollars	1.69	2.50	3.67	2.06	3.08	4.11	1.98	2.79	3.96
Maintenance										
Hours per day	Manhours	5	8	8	7	8	9	7	10	10
Cost per ton	Dollars	.38	.61	.61	.54	.61	.69	.54	.77	.77
Supervisor										
Hours per day	Manhours	4	6	6	5	6	7	6	8	8
Cost per ton	Dollars	.31	.47	.47	.39	.47	.55	.47	.62	.62
10-ton										
Production										
Hours per day	Manhours	23	42	56	29	48	62	29	48	62
Cost per ton	Dollars	1.35	2.47	3.29	1.70	2.82	3.64	1.70	2.82	3.64
Maintenance										
Hours per day	Manhours	5	8	9	6	9	10	6	9	10
Cost per ton	Dollars	.31	.49	.55	.37	.55	.61	.37	.55	.61
Supervisor										
Hours per day	Manhours	4	6	7	5	7	8	5	7	8
Cost per ton	Dollars	.25	.37	.44	.31	.44	.50	.31	.44	.50

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-6.--Labor requirements for model mills producing 10 to 25 tons per hour: Production, maintenance, and supervision, hours per day and cost per ton

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
10-ton						Dollars				
Production										
Hours per day	Manhours	27	46	75	1/	1/	1/	34	54	80
Cost per ton	Dollars	1.58	2.70	4.40	1/	1/	1/	2.00	3.17	4.70
Maintenance										
Hours per day	Manhours	8	11	13	1/	1/	1/	8	11	15
Cost per ton	Dollars	.49	.67	.80	1/	1/	1/	.49	.67	.92
Supervisor										
Hours per day	Manhours	5	7	8	1/	1/	1/	6	7	9
Cost per ton	Dollars	.31	.44	.50	1/	1/	1/	.37	.44	.56
18-ton										
Production										
Hours per day	Manhours	27	54	81	38	66	98	34	60	88
Cost per ton	Dollars	.88	1.76	2.64	1.24	2.15	3.19	1.11	1.96	2.87
Maintenance										
Hours per day	Manhours	13	16	19	15	18	23	13	17	24
Cost per ton	Dollars	.44	.54	.65	.51	.61	.78	.44	.58	.82
Supervisor										
Hours per day	Manhours	8	10	12	11	12	15	9	11	16
Cost per ton	Dollars	.28	.35	.42	.38	.42	.52	.31	.38	.56
25-ton										
Production										
Hours per day	Manhours	30	55	89	46	70	105	38	62	97
Cost per ton	Dollars	.70	1.29	2.09	1.08	1.64	2.47	.89	1.46	2.28
Maintenance										
Hours per day	Manhours	16	20	24	16	21	29	16	21	29
Cost per ton	Dollars	.39	.49	.59	.39	.51	.71	.39	.51	.71
Supervisor										
Hours per day	Manhours	10	13	15	10	13	18	10	13	18
Cost per ton	Dollars	.25	.32	.37	.25	.32	.45	.25	.32	.45

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-7.--Labor requirements for model mills producing 25 to 35 tons per hour: Production, maintenance, and supervision, hours per day and cost per ton

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
25-ton						Dollars				
Production										
Hours per day..	Manhours	30	61	102	1/	1/	1/	38	68	109
Cost per ton...	Dollars	.70	1.43	2.40	1/	1/	1/	.89	1.60	2.56
Maintenance										
Hours per day..	Manhours	16	21	26	1/	1/	1/	20	22	31
Cost per ton...	Dollars	.39	.51	.64	1/	1/	1/	.49	.54	.76
Supervisor										
Hours per day..	Manhours	10	14	16	1/	1/	1/	14	14	20
Cost per ton...	Dollars	.25	.35	.40	1/	1/	1/	.35	.35	.50
30-ton										
Production										
Hours per day..	Manhours	33	71	105	52	90	124	44	79	116
Cost per ton...	Dollars	.65	1.39	2.04	1.02	1.76	2.43	.86	1.55	2.27
Maintenance										
Hours per day..	Manhours	19	25	29	22	28	32	22	25	32
Cost per ton...	Dollars	.39	.51	.59	.45	.57	.65	.45	.51	.65
Supervisor										
Hours per day..	Manhours	12	16	18	14	18	20	14	16	20
Cost per ton...	Dollars	.25	.33	.37	.29	.37	.42	.29	.33	.42
35-ton										
Production										
Hours per day..	Manhours	39	76	116	49	98	135	51	88	127
Cost per ton...	Dollars	.66	1.28	1.95	.82	1.65	2.27	.86	1.48	2.13
Maintenance										
Hours per day..	Manhours	20	27	32	24	28	35	23	29	35
Cost per ton...	Dollars	.35	.47	.56	.42	.49	.61	.40	.51	.61
Supervisor										
Hours per day..	Manhours	13	17	20	15	18	22	14	19	22
Cost per ton...	Dollars	.23	.30	.36	.27	.32	.39	.25	.34	.39

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-8.--Labor requirements for model mills producing 35 to 50 tons per hour: Production, maintenance, and supervision, hours per day and cost per ton

Item	Unit	Method of operation								
		A	B	C	D	E	F	G	H	I
35-ton						Dollars				
Production										
Hours per day	Manhours	46	81	137	1/	1/	1/	57	98	149
Cost per ton	Dollars	.77	1.36	2.30	1/	1/	1/	.96	1.65	2.50
Maintenance										
Hours per day	Manhours	21	29	34	1/	1/	1/	24	28	36
Cost per ton	Dollars	.37	.51	.59	1/	1/	1/	.42	.49	.63
Supervisor										
Hours per day	Manhours	13	18	21	1/	1/	1/	15	18	23
Cost per ton	Dollars	.23	.32	.38	1/	1/	1/	.27	.32	.41
43-ton										
Production										
Hours per day	Manhours	47	106	151	74	134	176	64	122	168
Cost per ton	Dollars	.64	1.45	2.07	1.01	1.84	2.41	.88	1.64	2.30
Maintenance										
Hours per day	Manhours	25	33	40	28	35	44	29	33	44
Cost per ton	Dollars	.35	.47	.57	.40	.50	.62	.41	.47	.62
Supervisor										
Hours per day	Manhours	16	21	25	18	23	28	19	21	28
Cost per ton	Dollars	.23	.30	.36	.26	.33	.41	.28	.30	.41
50-ton										
Production										
Hours per day	Manhours	50	106	168	84	138	198	68	122	182
Cost per ton	Dollars	.58	1.24	1.97	.98	1.61	2.32	.80	1.43	2.13
Maintenance										
Hours per day	Manhours	28	38	44	32	38	50	32	38	50
Cost per ton	Dollars	.34	.46	.54	.39	.46	.61	.39	.46	.61
Supervisor										
Hours per day	Manhours	18	24	28	20	24	32	20	24	32
Cost per ton	Dollars	.22	.30	.35	.25	.30	.40	.25	.30	.40

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-9.--Utility cost per ton for model feed mills producing 6 to 10 tons per hour

Item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
6-ton									
Electric	.45	.44	.44	1/	1/	1/	.64	.64	.64
Fuel	.11	.11	.11	1/	1/	1/	.30	.30	.30
Total	.56	.55	.55	1/	1/	1/	.94	.94	.94
8-ton									
Electric	.34	.34	.34	.64	.64	.64	.51	.51	.51
Fuel	.11	.11	.11	.42	.42	.42	.30	.30	.30
Total	.45	.45	.45	1.06	1.06	1.06	.81	.81	.81
10-ton									
Electric	.26	.26	.26	.48	.48	.48	.38	.38	.38
Fuel	.09	.09	.09	.38	.38	.38	.28	.28	.28
Total	.35	.35	.35	.86	.86	.86	.66	.66	.66

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-10.--Utility cost per ton for model feed mills producing 10 to 25 tons per hour

Item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
10-ton									
Electric	.37	.37	.37	1/	1/	1/	.58	.58	.58
Fuel	.09	.09	.09	1/	1/	1/	.25	.25	.25
Total	.46	.46	.46	1/	1/	1/	.83	.83	.83
18-ton									
Electric	.22	.21	.20	.45	.45	.45	.33	.33	.33
Fuel	.09	.09	.09	.37	.37	.37	.25	.25	.25
Total	.31	.30	.29	.82	.82	.82	.58	.58	.58
25-ton									
Electric	.15	.15	.15	.30	.30	.30	.23	.23	.23
Fuel	.09	.09	.09	.37	.37	.37	.25	.25	.25
Total	.24	.24	.24	.67	.67	.67	.48	.48	.48

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-11.--Utility cost per ton for model feed mills producing 25 to 35 tons per hour

Item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
25-ton									
Electric	.24	.24	.24	1/	1/	1/	.37	.37	.37
Fuel	.09	.09	.09	1/	1/	1/	.22	.22	.22
Total	.33	.33	.33	1/	1/	1/	.59	.59	.59
30-ton									
Electric	.21	.21	.21	.41	.41	.41	.31	.31	.31
Fuel	.09	.09	.09	.33	.33	.33	.20	.20	.20
Total	.30	.30	.30	.74	.74	.74	.51	.51	.51
35-ton									
Electric	.17	.17	.17	.33	.33	.33	.25	.25	.25
Fuel	.08	.08	.08	.33	.33	.33	.19	.19	.19
Total	.25	.25	.25	.66	.66	.66	.44	.44	.44

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.

Appendix table C-12.--Utility cost per ton for model feed mills producing 35 to 50 tons per hour

Item	Method of operation								
	A	B	C	D	E	F	G	H	I
	Dollars								
35-ton									
Electric	.20	.20	.20	1/	1/	1/	.31	.31	.30
Fuel	.07	.07	.07	1/	1/	1/	.18	.18	.18
Total	.27	.27	.27	1/	1/	1/	.49	.49	.48
43-ton									
Electric	.16	.16	.16	.34	.34	.34	.25	.25	.25
Fuel	.07	.07	.07	.31	.31	.31	.17	.17	.17
Total	.23	.23	.23	.65	.65	.65	.42	.42	.42
50-ton									
Electric	.14	.14	.14	.28	.28	.28	.21	.21	.21
Fuel	.07	.07	.07	.31	.31	.31	.17	.17	.17
Total	.21	.21	.21	.59	.59	.59	.38	.38	.38

1/ No cost data developed for models D, E, and F since this type of operation is not appropriate for an all-ruminant feed plant.