GRAIN-DUST PELLETING COSTS AND CAPITAL REQUIREMENTS FOR STATIONARY AND PORTABLE PLANTS

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U.S. Department of Agriculture
Economics, Statistics, and Cooperatives Service

ESCS-71

BIBLIOGRAPHIC DATA SHEET	1. Report No. ESCS-71	2.	3. Recipient's Accession No.

4. Title and Subtitle
GRAIN-DUST PELLETING COSTS AND CAPITAL REQUIREMENTS FOR STATIONARY AND PORTABLE PLANTS

5. Report Date
September 1979

6.

7. Author(s)
L. D. Schnake

8. Performing Organization Rept. No. ESCS-71

9. Performing Organization Name and Address
National Economics Division
Economics, Statistics, and Cooperatives Service
U.S. Department of Agriculture
Washington, D.C. 20250

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

Grain handlers can reduce the hazards associated with grain dust by pelleting the dust. Investment and operating costs are estimated for a portable plant and three sizes of independent stationary and add-on stationary plants (built adjacent to a grain-handling facility) at inland and port locations. Operating costs for the portable plant range from $15.17 to $55.57 per ton, depending on the level of production. Operating costs for the stationary plants range from $12 to $72 per ton, depending on the daily operating time, plant size, type (independent or add-on), and location (inland or port).

17. Key Words and Document Analysis. 17a. Descriptors

Byproducts
Dust explosions
Elevators (grain)
Flour mill
Grain
Hazards
Operating costs
Pelleting
Portable equipment
Production management

17b. Identifiers/Open-Ended Terms

Daily operating time
Port location
Processing grain dust
Stationary plant
Grain-dust pelleting
Grain-dust pelleting costs
Elevator dust

17c. COSATI Field/Group

18. Availability Statement
Available from
NATIONAL TECHNICAL INFORMATION SERVICE
5285 Port Royal Road, Springfield, Virginia 22161

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages

22. Price

ACKNOWLEDGMENTS

The author is especially grateful for the support and cooperation given to this research by the Science and Education Administration, Agricultural Research, U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

The author also thanks the following individuals for their contributions to this study: Pule Calderon, Sprout-Waldron, Koppers Company, Inc., St. Joseph, Mo.; Bill Catching and Richard White, Crescent Feed Commodities, Westwego, La.; Gerald Detweiler, FS Services, Inc., Bloomington, Ill.; Roy Robinson, California Pellet Mill Co., Crawfordsville, Ind.; Claire Tabor, Dodgen Industries, Inc., Humboldt, Iowa; E. V. Titheridge and Stan MacKay, United Grain Growers, Ltd., Winnipeg, Manitoba, and Thunderbay, Ontario, Canada, respectively; and Carl Vosloh, Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture.

CONTENTS

TABLES

SUMMARY

Capital investment and annual operating costs were estimated for three sizes (2.5, 5, and 10 tons per hour) of independent stationary and add-on stationary (built adjacent to a grain-handling facility) grain-dust pelleting plants at inland and port locations. Investment and operating costs were also estimated for a portable grain-dust pelleting plant.

Capital investment requirements for stationary plants varied from $460,170 to $880,500 depending on the type (independent or add-on), location, and size of operation. Equipment costs, including installation, ranged from about 60 to 75 percent of total investment. Investments for a portable pelleting plant and towing vehicle were estimated at $95,780.

Operating costs for independent and add-on stationary plants were estimated for four levels of daily operation--4, 6, 8, and 16 hours per day. Costs for plants operated 8 hours a day ranged from $12.31 to $35.63 per ton depending on type, size, and location of plant. Annual operating costs for port plants were $0.50 to $3 per ton more than for inland plants depending on size and type. Per unit operating costs declined by at least two-thirds when daily operating time increased from 8 to 16 hours, regardless of plant size or location. Per unit operating costs increased from 40 to 80 percent depending on type, size, and location of plant when daily operating time was decreased from 8 to 4 hours.

Operating costs for portable pelleting plants were estimated for 1,000, 2,500, and 5,000 tons annual production. The respective cost estimates were $55.57, $24.44, and $15.17 per ton.

Grain-Dust Pelleting Costs and Capital Requirements for Stationary and Portable Plants

L. D. Schnake 1/

INTRODUCTION

Explosions at two large Gulf Coast export elevators in December 1977 took 54 lives and did estimated damage exceeding $150 million. They spurred industry and Government officials to seek ways to reduce the level of dust in grain elevators. As a result, the quantity of grain dust collected by grain handlers has increased significantly. The quantity of grain dust collected will likely continue to increase with increased emphasis by governmental regulatory agencies to reduce grain dust hazards.

Conventional pelleting is a well-known, widely used, and proven technology employed in many industries to change the density of small particles associated with many commodities. For example, the formula feed industry pelleted over 73 million tons of primary feeds in 1975. 2/ Industry and Government have expressed much interest in pelleting as a readily applicable technology to reduce the hazards associated with elevator grain dust. However, cost data have not been available to evaluate the cost of adapting this technology to grain dust. Feed-pelleting costs developed for model formula feed mills have been published but are not applicable to grain-dust pelleting due to differences in the handling technology required for grain dust. 3/ In addition, the density and abrasive nature of grain dust severely reduces equipment life, particularly pellet mill dies, and consequently increases costs.

This study estimates only the costs of pelleting grain dust. The procurement, sales, and distribution functions which must also be considered by a grain-dust processor to determine total costs, revenues, and feasibility are not considered here. Each of these functions requires a separate study.

1/ The author is an agricultural economist with the Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture, stationed at the U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

2/ Carl J. Vosloh, Jr. Structure of the Feed Manufacturing Industry, 1975, A Statistical Summary, SB-596, Econ., Stat., and Coop. Service, U.S. Dept. Agr., Feb. 1978. Formula feeds are "two or more ingredients proportioned, mixed, and processed according to specifications" (in Harry B. Pfost and Diane Pickering, eds., Feed Manufacturing Technology, American Feed Manufacturers Association, 1976, p. 548).

3/ Carl J. Vosloh, Jr. Feed Manufacturing Cost and Capital Requirements, AER-335, Econ. Res. Serv., U.S. Dept. Agr., May 1976.

This cost analysis of grain-dust pelleting outlines the investment and operating costs for add-on stationary plants, independent stationary plants, and a portable plant. Data for economic analyses and guidelines for labor requirements and equipment costs are provided for these plants.

This information can be used immediately by management of grain-handling operations to determine their needs for and the costs of using either stationary or portable dust-pelleting facilities. Management of grain-handling operations that do not collect much grain dust can use this information to decide whether to ship grain dust for pelleting, to hire a portable pelleting plant, or to enter into joint ownership of a portable or independent stationary plant. Management of grain-handling operations that collect a considerable quantity of dust can use the information to compare the costs of building and operating an add-on plant to those of custom pelleting by portable or independent stationary plants.

METHODOLOGY

The economic-engineering approach was used to develop models of stationary and portable grain-dust pelleting plants. This method of analysis combines the sciences of economics and engineering for analyses of production processes to determine resource requirements. Per unit product costs were developed by applying costs to the resources used in the production process.

One advantage of the economic-engineering method is that estimates of costs can be provided in instances where historical operating records of actual operations are nonexistent, as in the case of grain-dust pelleting. In addition, this method of detailed analysis provides for easy updating of cost estimates when resource prices change. A disadvantage of the method is that it does not lend itself to standard tests of statistical reliability.

This cost analysis of grain-dust pelleting includes costs of equipment, facilities, and operation. Other costs not considered here involve optimum plant location, availability of grain dust, dust acquisition, and pellet marketing and distribution. A firm should address these costs in any feasibility study.

The models were designed to meet current environmental and safety regulations. Model specifications were based on recommendations of equipment manufacturers and practices of operators pelleting grain dust. The final models represent a workable combination of specifications from operators and equipment manufacturers and not the ideal of any one individual. Prices in effect as of March 1979 were used to determine all costs.

BASIC DUST-PELLETING OPERATIONS AND MODEL SPECIFICATIONS

Three types of facilities and operations for pelleting grain dust were analyzed: *independent stationary facilities,* which operate independently of other handling or processing facilities; *add-on stationary facilities,* which operate in conjunction with a grain-handling operation; and a *portable plant* which is transported to grain-handling facilities. Three sizes of independent stationary and add-on stationary models, and one size of portable model were evaluated. Independent and add-on stationary models are discussed throughout this report, usually without regard to inland or port locations. Port locations are discussed specifically only when major differences warrant. Those items in the remainder of the report that pertain only to stationary plants or only to portable plants are labeled for the reader's convenience.

Basic Product Flow

The product flow for grain-dust pelleting plants may be described briefly as three stages: dust receiving, dust processing, and, pellet storage and loadout. Figures 1, 2, and 3 represent product flows of independent, add-on, and portable plants, respectively.

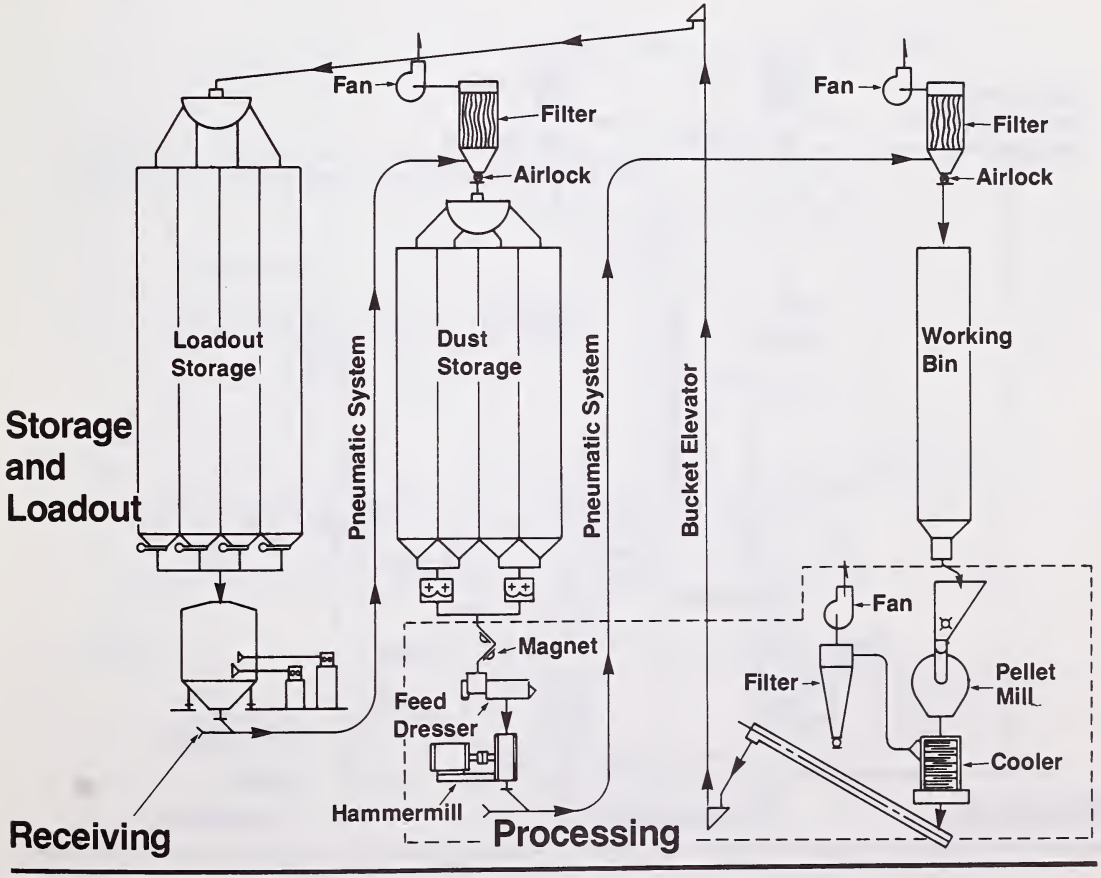
Dust Receiving

Stationary plants

Independent stationary plants receive dust by railcar or truck from grain-handling and storage operations and unload it pneumatically to dust storage bins. Power shovels are used in box cars and van trailer-trucks to deliver dust to the pneumatic system. The pneumatic system pulls dust directly from bottom openings of hopper cars and hopper trailers. Inbound trucks are weighed on platform scales included in the equipment of independent plants. Railroad weights were assumed to be correct for rail grain-dust receipts.

Figure 1

Flow Diagram of Independent Grain-Dust Pelleting Plant



Add-on stationary plants receive dust pneumatically from the dust holding bin of a nearby grain-handling and storage operation. Power shovels are not used in add-on plants. The pneumatic receiving systems of the add-on plants require more horsepower than those of the independent plants to compensate for the greater distance that the dust is conveyed.

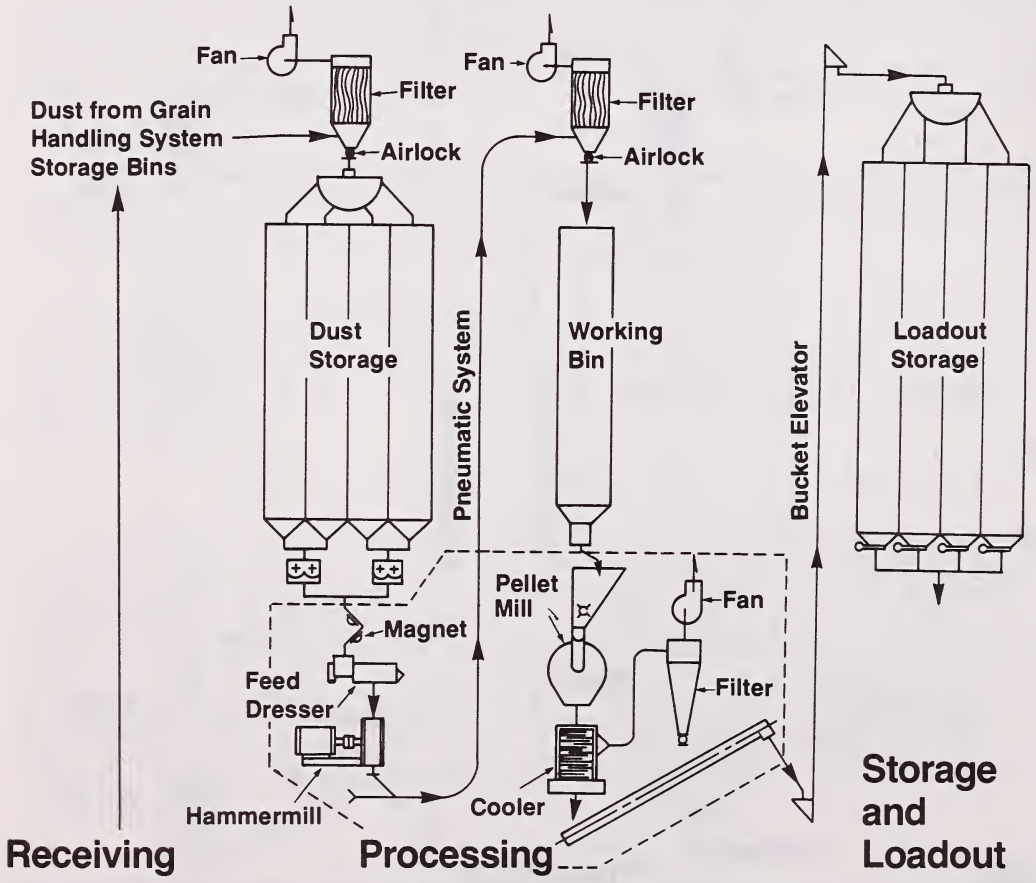
Add-on plants are the joint-product (grain and grain dust) processor of a grain-handling facility and receive dust directly through a pneumatic delivery system, so a weighing system for inbound dust was considered impractical and unnecessary. Thus, outbound weighing of dust pellets was assumed to accurately account for the dust throughput of these plants.

Portable plants

Commercially available, portable grain-dust pelleting plants are equipped with a working bin to receive dust by gravity from dust-holding bins of grain-handling and storage facilities.

Figure 2

Flow Diagram of Add-on Grain-Dust Pelleting Plant



Dust Processing

Stationary plants

Grain dust is conveyed from dust storage bins by twin-screw conveyors to a feed dresser ahead of a hammermill. The feed dresser removes nonmetallic objects that may be in the dust, thereby preventing possible damage to processing equipment. The hammermill reduces the particle size of any light material, such as chaff, to produce a uniform dust for pelleting. Grain-dust pelleting-plant operators report that such grinding by the hammermill increases the throughput of pellet mills by approximately 25 percent.

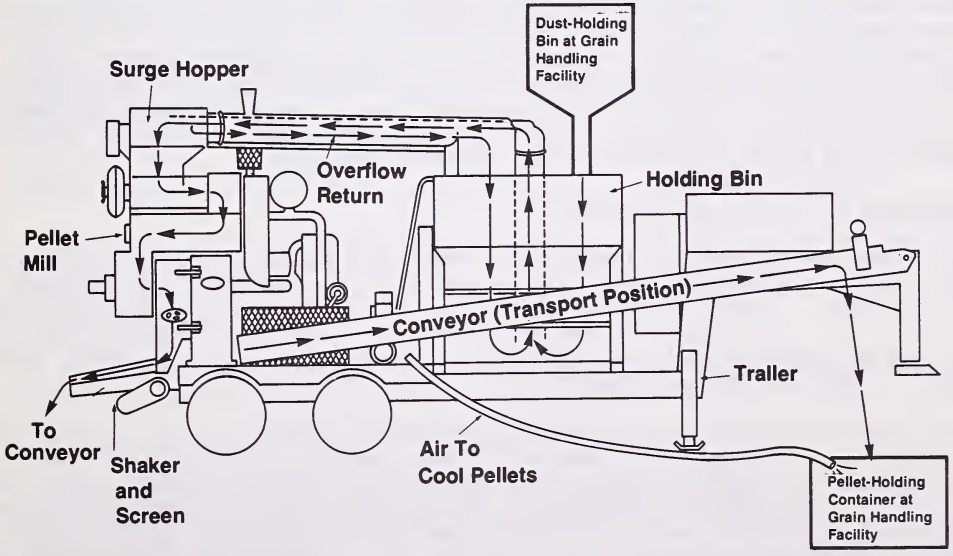
A pneumatic system conveys the ground dust from the hammermill to a working bin above the pellet mill. Dust flows by gravity to a feeder-conditioner where steam can be incorporated into the dust. Adding steam to dust reduces die horsepower by approximately 50 percent and extends die, roll, and bearing life.

Conditioned dust enters the pellet mill and is formed into pellets which drop by gravity to a pellet cooler. Sufficient air is provided on the cooler so that 5 to 6 minutes' retention time will cool the pellets to a safe handling and storage temperature.

Pellets leave the pellet cooler and are conveyed by a screw conveyor to a plastic-cupped bucket elevator which conveys the dust pellets to elevated storage bins for gravity loadout to railcars or trucks.

Figure 3

Diagram of a Portable Grain-Dust Pelleting Plant



Dust is conveyed from the working bin by a vertical screw conveyor to the pellet mill feeder. The available commercial portable plant includes a *Portable plants* molasses addition system, but molasses addition was not considered in this study. Experimental results indicate that addition of water is not always necessary in a portable plant to form pellets, but that pellet mill throughput is sometimes increased. Addition of water may be helpful, since steam conditioning is not possible on the portable pelleting plant considered in this study.

From the pellet mill, the pellets drop to an eccentric shaker and screen for removal of fines (small pieces of pellets), which are conveyed to repelleting by an auger. Finished pellets are delivered by conveyor to a receiving container supplied by the grain-handling facility. A high-speed blower with flexible tubing forces air around the pellets for cooling before binning.

Pellet Storage and Loadout

The storage bins that receive pellets are constructed of welded steel with a capacity to store 2 days' production at 16 hours per day. A batch *Stationary plants* scale is installed beneath the pellet storage bins for outbound weight records, particularly on railcars. A platform scale to weigh trucks is included in the independent models and was assumed to be available at add-on plants.

Storage is provided by the grain-handling facility using the portable plant. Thus, storage costs are not charged to the portable pelleting *Portable plants* plant in this study. The finished product was assumed to be weighed on approved scales of the hosting grain-handling facility.

Model Specifications

Model grain-dust pelleting plants incorporate currently available commercial equipment. The product flow technology, throughputs, and operating practices are those recommended by equipment manufacturers' engineers and grain-dust pelleting-plant operators in Canada and the United States. Add-on stationary plants are designed to be located a reasonable distance from grain-handling and storage facilities, as recommended by National Fire Protection Association (NFPA) committee members rewriting NFPA Code No. 61-B-1973, "Standard for the Prevention of Fire and Dust Explosions in Grain Elevators and Bulk Grain Handling Facilities."

Operating Capacities and Running Time

Add-on and independent stationary plant models are designed with hourly operating capacities of 2.5 tons (small), 5 tons (medium), and 10 tons *Stationary plants* (large) per hour. Manufacturers' recommendations of 6.75 running hours and 1.25 maintenance hours for each 8-hour shift were used to develop annual tonnages for the model plants operating 4, 6, 8, and 16 hours per day, 250 days per year (table 1).

Operating time of portable pelleting plants was difficult to model due to variability in the quantity of dust that may be available. Time in *Portable plants* transit to the site of dust is lost production time. Eight hours' production per day for 250 days, with all maintenance and travel performed on overtime, was considered maximum production time. At the manufacturers' suggested throughput of 2.5 tons per hour, 5,000 tons is the maximum annual tonnage attainable for 8 hours' operating time per day. The portable plant is also evaluated at 1,000 and 2,500 tons annually (table 5). Annual mileage traveled for the three production levels was 10,000 miles.

Equipment

Stationary plants

Basic equipment for independent and add-on stationary plants is listed in tables 2 and 3, respectively. The kind, type, size, and number of items required for each plant model were based on operating experience and equipment manufacturers' specifications.

Receiving equipment for independent and add-on plants is basically pneumatic with dust-control devices. The major difference between independent and add-on systems is the use of power shovels with the pneumatic intake system of the independent plants. Operators have found hand-held power shovels to be the most effective means to obtain initial dust movement from flat-bottomed containers.

Processing equipment includes feeder-conveyors, magnets, a feed dresser, a hammermill, a pneumatic delivery system from the hammermill, dust control equipment, a pellet mill and cooler, and conveying equipment between the dust storage bins and pellet storage bins.

Miscellaneous equipment includes the equipment control panel, an air compressor, equipment to test moisture and weigh samples, office equipment, and a boiler. Boiler size for each model was based on estimated steam requirements. The boilers burn fuel oil and are high-pressure systems equipped for pressure reduction at the pellet mill. Fuel tanks were sized large enough to hold transport-lot fuel purchases.

A platform scale was included to weigh inbound and outbound trucks at independent plants. Weighing of outbound trucks at add-on plants was assumed to be performed by the parent grain-handling firm. A batch hopper scale under the pellet loadout bins was included for rail shipments in both independent and add-on plants.

Portable plants

Equipment for a portable pelleting operation includes a heavy-duty 3/4-ton pickup truck equipped with a fifth wheel gooseneck package to pull a tandem-axle, trailer-mounted pelleting plant with diesel power source. The pelleting plant consists of a 180-cubic-foot holding bin with capacity indicators, an unloading auger, three leveling augers, a modified pellet mill with force-feed auger and magnets, a vane pump molasses system with 200-gallon holding tank with hot water preheater, an eccentric shaker and screen, a fines return auger, and a high-speed blower with flexible tubing to cool the pellets. The system is powered by an industrial diesel engine with a primary slipproof belt drive and secondary roller chain and V-belts.

The trailer is equipped with 12-volt lights for night operation and meets Interstate Commerce Commission safety regulations. An engine-driven air compressor and a 110-volt generator are available as optional equipment but were not considered in this analysis.

The stationary model plants do not include molasses equipment or a pellet screener as does the commercially available portable plant.

Facilities

Support facilities such as buildings, storage bins, and rail sidings are considered only for stationary plants, since portable pelleting plants provide processing services only.

Buildings. Cost of constructing a grain-dust pelleting plant depends on many factors, not all of which are considered in detail in this study. It was assumed that plants would be built on fairly level sites with access to railroads, high-

ways, and utilities. Normal concrete footings were assumed to be adequate to support buildings at inland locations. However, additional foundation is required at port locations due to soil conditions.

Buildings are of all-steel construction. The mill building, which houses equipment, is tall relative to its width and length to permit maximum use of gravity flow for moving dust and pellets. A separate boiler house is located away from the main mill building for safety and lower insurance rates. Independent stationary plants have a maintenance shop and office, which are not included for add-on stationary plants. Add-on plants use the maintenance shop and office in the parent grain-handling facility.

Storage bins. Dust holding bins and pellet storage bins with capacity for two 16-hour days' production are circular welded steel structures erected on steel frames. The dust holding bins are erected above the feed dresser and hammermill. Pellet storage bins are erected above the railroad track for railcar or truck loadout. Additional footings were assumed to be necessary for bins and buildings at port locations.

Rail siding. Stationary grain-dust pelleting plants are designed with rail shipping capability. Independent plants were assumed to receive and ship on a single siding. The linear footage of siding required for a plant was determined by estimating the maximum number of outbound cars required if the plant operated 24 hours per day, and multiplying 60 feet per car times a factor of 1.75 to allow for maneuvering. The siding estimates were 105, 210, and 315 feet for the small, medium, and large plants, respectively. One rail switch was included for each plant.

Land

An add-on stationary plant implies that adequate land is available adjacent to a grain-handling and storage facility for construction of a dust-pelleting plant. No additional space for truck movements was considered necessary. The acreage required for an independent stationary plant was determined by the area occupied by plant buildings, plus adequate space for truck movements. Site sizes for independent plants were estimated to be 2, 3, and 4 acres for small, medium, and large plants, respectively.

COSTS

Costs used in this study were based on prices prevailing in March 1979.

Capital Requirements

Table 4 presents estimated capital investment requirements for inland stationary dust-pelleting plants. Table 5 presents capital investment requirements for a portable dust-pelleting plant. It was difficult to develop a representative port area situation due to the wide range in soil conditions and land costs at U.S. port areas. Table 6 presents a low and high investment which account for the range in land prices and costs of additional foundation of port area plants. The following discussion pertains to inland situations, unless noted otherwise.

Equipment

Stationary plants

Equipment costs presented in table 4 for stationary plants include delivery and installation. Equipment investment for these plants ranged from about 70 to 63 percent of total investment as size increased for independent plants and from about 75 to 67 percent of total investment for add-on plants. Pelleting equipment alone accounted for over 29 per-

cent of total investment for independent plants and 35 percent for add-on plants.

Portable plants

The total investment for the portable operation was for equipment. The trailer-mounted mill accounted for 89 percent of the investment, the truck about 8 percent, and the remainder for tools and spare parts (table 5).

Facilities

The costs for support facilities, buildings, storage bins, and rail siding were estimated for stationary plants only, since portable plants provide processing services only.

Buildings. Mill buildings and boiler houses were estimated to cost $25.75 and $17.25 per square foot, respectively. Shop space for independent plants was estimated to cost $17.25 per square foot. The office space for administrative personnel and staff of independent plants was estimated to cost $20.50 per square foot.

Buildings costs, as a percentage of total investment for independent plants, ranged from 7 percent down to about 5 percent as plant size increased. Building costs for independent plants were greater than those for add-on plants, varying from 1.5 to 1 percent more as plant size increased.

Storage bins. Costs of storage bins sized for mill capacity do not increase linearly, due to economies in construction costs.

Storage capacity for a large plant, although four times as great as that for a small plant, costs only 2.5 times as much. Bin costs ranged from about 11 to 18 percent of total investment for independent plants and from 14 to 21 percent of total investment for add-on plants. Bin cost, as a percentage of pelleting equipment cost, ranged from approximately 39 percent for small plants to 56 percent for large plants.

Rail siding. Cost of a railroad siding was estimated at $55 per linear foot plus $12,600 for a switch. Extraordinary grading and ballast requirements were not considered since a level plant site was assumed.

Foundations at ports. Soil conditions vary extensively among and within U.S. port areas, requiring facilities there to have more foundation support than inland facilities. Some locations may require only a sand pad while others may require extensive deep piling. Costs of additional support for bins and buildings of plants ranged from $14,000 (low investment) to $90,000 (high investment), depending on the port area and its soil condition, as discussed earlier. Great Lakes and Pacific port areas have the lowest additional foundation costs while Gulf and Atlantic port areas have the highest foundation costs.

Land

No land cost was considered for add-on plants. Land costs for an independent grain-dust pelleting plant with highway and railroad access was estimated at $12,000 per acre, or $24,000, $36,000, and $48,000 for the small, medium, and large independent plants, respectively. These costs were about 5 to 7 percent of total investment.

Land costs for independent plants located in U.S. port areas with transportation and utility access similar to that of inland plants vary from about 50 cents to $1 per square foot, or $21,780 to $43,560 per acre. This represents a land investment ranging from 1.82 to 3.63 times that for inland locations.

Total Investment for Stationary Plants

Total investment increased about 44 percent as size increased from 2.5 to 10 tons per hour for independent plants at inland locations, and about 47 percent for add-on plants. Independent plants cost from $80,000 to $110,000 more than add-on plants, depending on plant size (table 4).

Total investment for independent plants in port locations (table 6) was 1.08 to 1.33 times that for similar inland facilities. Total investment for add-on plants in port locations, compared with that for inland add-on plants, was as follows: 1.04 to 1.24 times that for small plants; 1.03 to 1.19 times that for medium plants; and 1.02 to 1.16 times that for large plants.

Operating Costs

Operating costs were estimated for stationary and portable pelleting plants. Such costs include production costs incurred by producing grain-dust pellets in the plants specified earlier. Costs were categorized as either fixed or variable (tables 5, and 7 to 10). Operating costs for plants at port locations are shown in tables 11 and 12. Certain fixed costs differed significantly from those for the inland plant models.

Stationary Plants: Fixed Costs

Fixed costs include depreciation, interest on investment, insurance, taxes, and administrative expenses. Costs arising from investment (or ownership) constitute the major portion of fixed costs.

Total fixed costs. Total fixed costs for independent plants were less than 50 percent of total annual costs. Since port locations require greater investment, fixed costs for those facilities range approximately 1.5 to 5 percent higher than for similar inland facilities. Fixed costs as a percentage of total annual costs were greater for add-on plants than for independent plants, mainly due to reduced wages charged to add-on plants. Fixed costs for add-on port facilities ranged from 0.5 to 4 percent more than those for inland facilities. Total fixed costs exceeded 50 percent of total costs when the plants were operated less than 8 hours per day.

Depreciation. Depreciation is one of the two largest fixed costs for grain-dust pelleting plants. Depreciation costs were determined using Internal Revenue Service asset depreciation guideline periods for depreciable assets used in the manufacture of grain and grain mill products. A 17-year life was used for equipment; buildings were depreciated over 25 years using the straight-line method.

Interest on investment. Interest on investment was the largest annual fixed cost for stationary dust-pelleting plants. Interest on investment was calculated at 11 percent of half the initial investment in buildings and facilities and (for independent plants) 11 percent of total land investment (tables 7, 9, 11, and 12).

Insurance. Insurance on buildings and equipment installed was estimated at 46.2 mills per dollar of initial investment. This rate is based on average costs of 90 percent coinsurance on facilities and replacement costs for equipment under fire and extended coverage.

Taxes. Taxes were calculated using a tax rate of 1 percent of assessed value. The assessed value used was 35 percent of total investment in equipment, facilities, and land.

Administrative. Administrative expenses for independent dust-pelleting operations are for secretarial and bookkeeping services equivalent to salary and fringe benefits for a full-time secretary-bookkeeper.

Add-on plants were assumed to receive management services from the parent grain-handling operation for general management, dust purchasing, and transportation scheduling, in addition to secretarial and bookkeeping services. Industry executives indicated that the general superintendent of parent grain-handling facilities should handle these additional management responsibilities. Suggested management charges consistent with industry scales included in tables 9 and 12 were $6,588 for the small plant and $13,176 for medium and large plants. Charges for secretarial and bookkeeping services were estimated to be proportional to the plant size--$2,110, $4,220, and $8,440, respectively, for the small, medium, and large plants.

Stationary Plants: Variable Costs

Variable costs used for stationary plants include wages and salaries, utilities, maintenance and repairs, interest on working capital, and miscellaneous expense items. Variable costs for plants at port locations were assumed to be the same as those for inland locations. The annual costs of wages and salaries, utilities, and maintenance and repairs for independent and add-on plants are presented in tables 7 and 9, respectively, for four daily levels of operation.

Wages and salaries. The salary of a superintendent-manager, and wages of supervisors, mill operators, and mill laborers are included for independent plants. Management duties for add-on plants are included as administrative costs, as explained previously. The parent grain-handling facility of add-on plants was also assumed to have underutilized labor equivalent to one half-time employee who could operate the pellet mill or serve as mill laborer at no cost to the add-on plant. Estimated employee requirements of stationary plants are presented in table 13.

Superintendent salaries, including fringe benefits, for independent plants were computed at $30,000 annually. Supervisory labor was calculated at $6.60 per hour. Mill operator wages were calculated at $6.00 per hour, and mill laborer wages were calculated at $5.10 per hour. All wages include 20 percent fringe benefits. Wages paid for second shift operation include an additional 5 percent nighttime differential.

Utilities. Utility costs include electricity, water, and fuel oil. Electricity cost estimates were based on the average machine operating time required for pelleting and normal power used by equipment. A rate of 4.1 cents per kilowatt-hour was used.

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 60 cents per 1,000 gallons, which includes the monthly base charge and any other monthly water service charges.

Fuel requirements were based on steam requirements of the entire pelleting plant. Fuel cost was estimated at 45 cents a gallon for transport-lot purchases.

Maintenance and repairs. Annual costs for maintenance and repairs of equipment and facilities include costs of replacing equipment parts which have failed plus outside services hired to make repairs. Equipment maintenance costs were estimated from actual operating records. The costs of in-plant labor for preventive maintenance are included in wages and salaries. Annual maintenance costs of facilities including rail siding, bins, buildings, and fuel tank were estimated to be 2 percent of original investment cost.

Interest on working capital. Working capital needs for add-on plants were considered to be the sum of costs for 1 month's utilities, wages, and salaries; for independent plants, the cost for 1 month's dust supply was added to that sum. Grain dust cost was estimated at $18 per ton, the Kansas City 5-year average monthly grain-dust price. The interest rate used was 11 percent.

Other costs. Other costs include legal and audit fees, office supplies, communications, dues, subscriptions, donations, travel, advertising, promotion, uniforms, inspection tonnage fees, laboratory analysis fees, and miscellaneous supplies. These costs did not always vary by the annual tonnage of the plant.

Stationary Plants: Total Operating Costs

Annual variable costs for plants operating at least 6 hours per day exceeded annual fixed costs and increased as plant size increased. Independent plants had higher variable costs relative to fixed costs than add-on plants due basically to wages and salaries.

Annual unit operating costs of independent stationary plants in port areas at the low investment level were 2 to 3 percent higher than comparable inland plants. Operating costs for port facilities at the high investment level were 7 to 13 percent more than for inland facilities (tables 8 and 11). Costs for add-on plants in port areas were 1 percent higher at the low investment level and 3 to 11 percent higher at the high investment level than costs for comparable inland facilities (tables 9 and 12). The largest plants had the lowest percentage difference in cost since the fixed investment cost is spread over more units of production.

Average total cost curves for independent and add-on grain-dust pelleting plants are presented in figures 4 and 5 from data in tables 8, 10, 11, and 12.

Portable Plants: Fixed Costs

Annual fixed costs for portable plants include depreciation, interest on investment, taxes, insurance, licenses, and returns to management (table 5).

Depreciation. The useful life for the pellet mill and pickup truck were estimated at 17 and 10 years, respectively. Depreciation expense represented over 22 percent of annual fixed costs.

Interest on investment. Interest on investment and depreciation expenses were within $600 of being equal for portable dust-pelleting operations. Interest expense represented 20 percent of annual fixed costs.

Taxes. Property taxes were considered to be 1 percent of assessed value. Assessed value used was 35 percent of total investment. Annual property taxes were approximately 1 percent of total fixed costs.

Insurance. Insurance costs for the portable pelleting plant include collision, comprehensive, and liability coverages on the towing vehicle and the trailer-mounted pelleting equipment. These coverages were estimated at $925 for the pickup truck and $3,784 for the pelleting equipment including trailer. Table 5 lists the combined charges.

Licenses. License fees vary from State to State. Therefore, license costs were estimated at $500.

Figure 4a

Cost band for three inland independent dust-pelleting plants, 1979

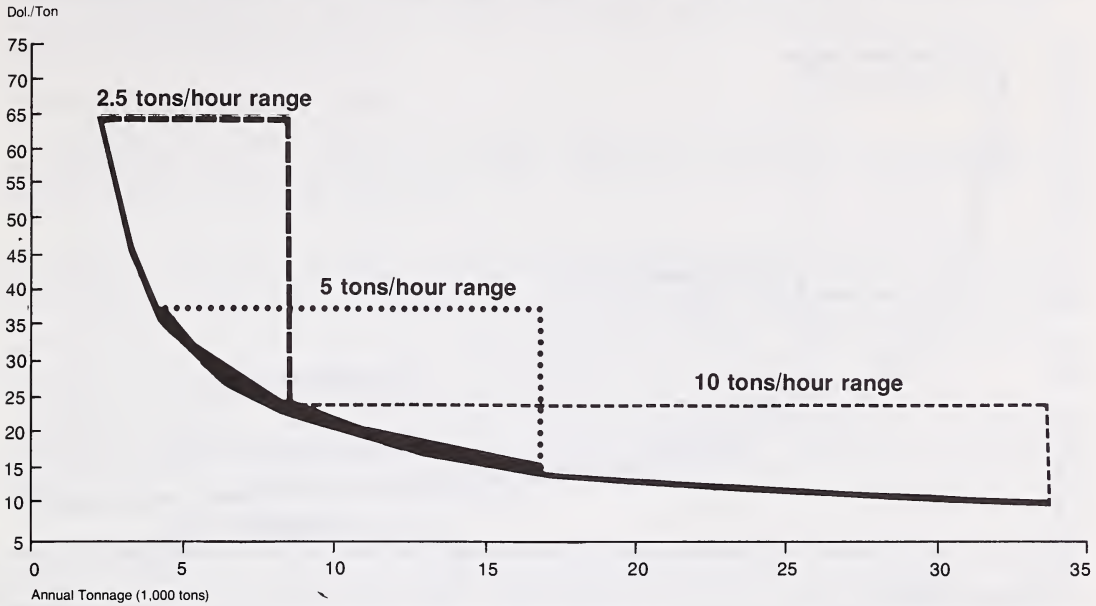


Figure 4b

Cost band for three inland add-on dust-pelleting plants, 1979

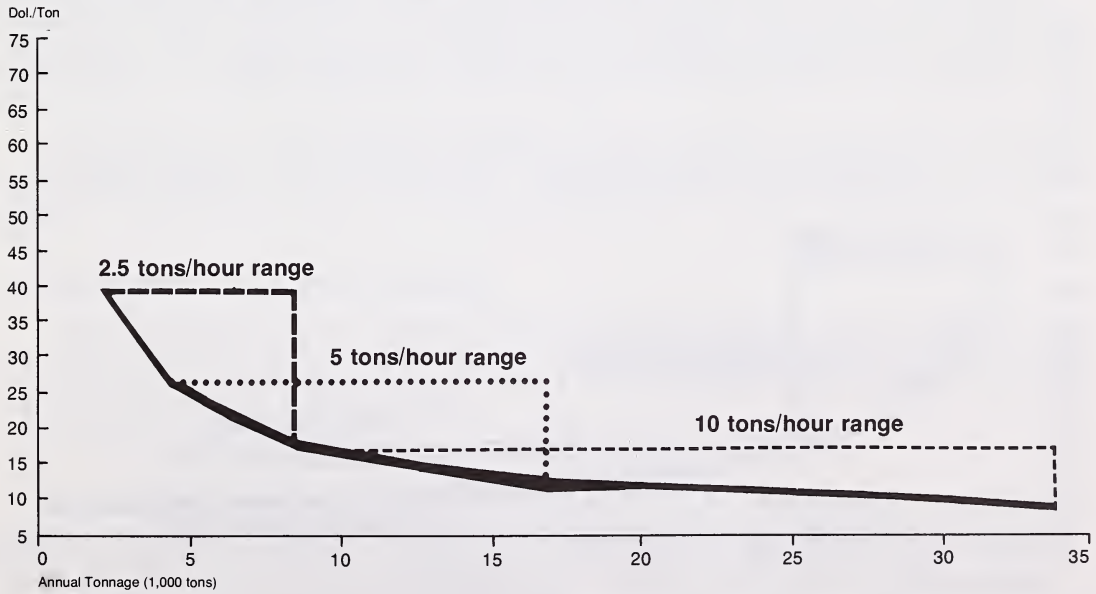


Figure 5a

Cost band for three independent dust-pelleting plants—port locations, 1979

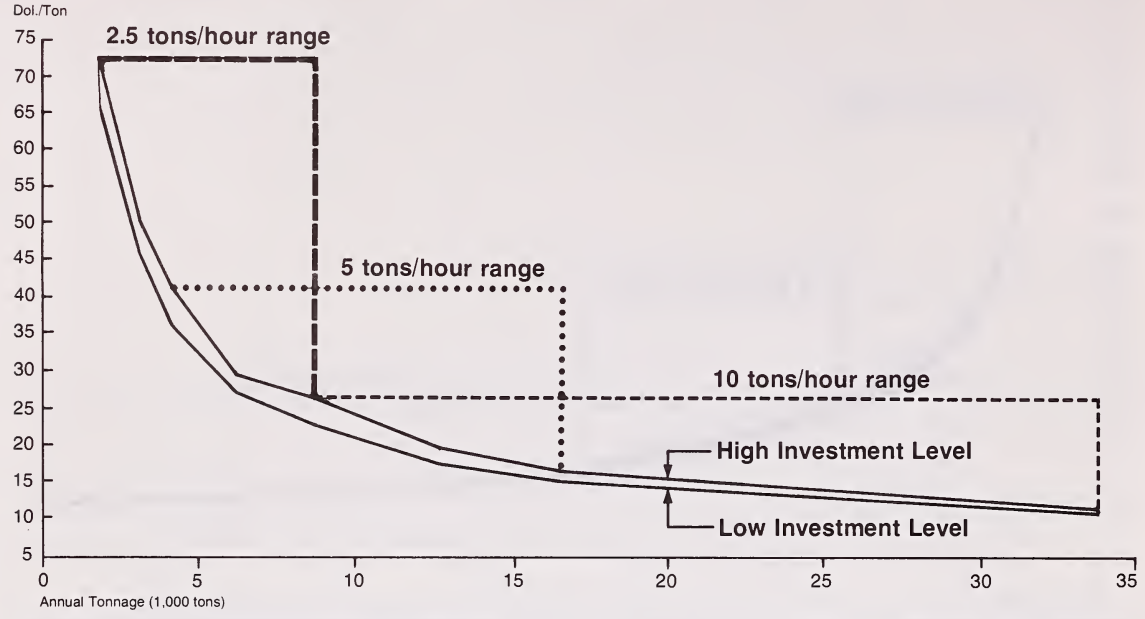
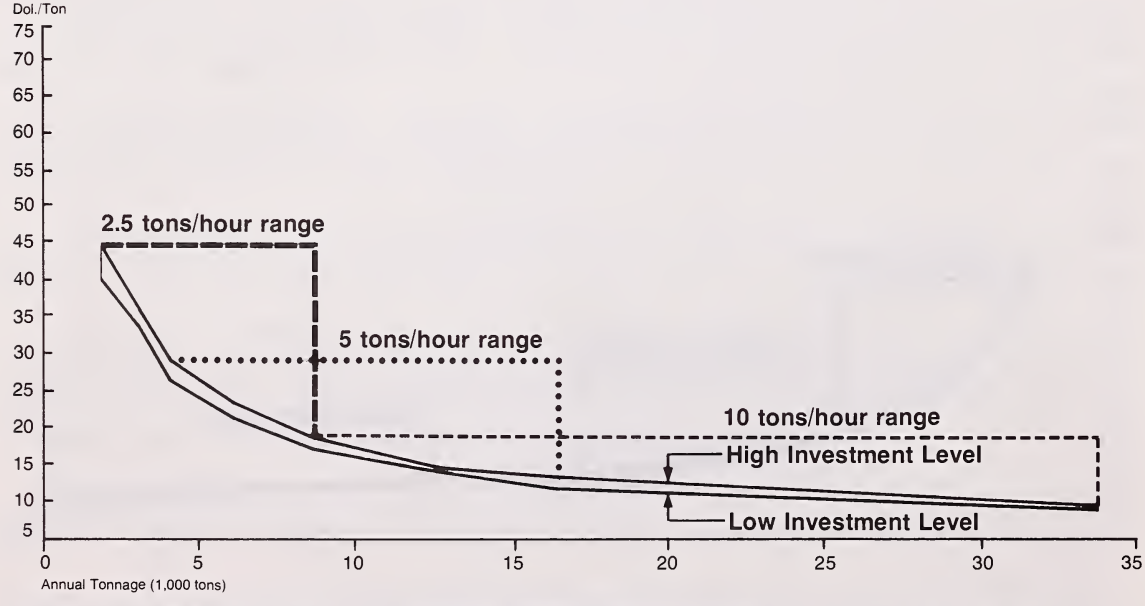


Figure 5b

Cost band for three add-on dust-pelleting plants—port locations, 1979



Returns to management. The portable pelleting plant was assumed to be operated by the owner, who has complete responsibility for its management and capital investment. For this ability and the risk involved, a return to management of 10 percent on this size of investment was included as a fixed cost. This amounted to over 36 percent of total fixed cost and over 12 percent of total annual costs at all levels of operation that were considered.

Portable Plants: Variable Costs

Variable costs for a portable pelleting operation include the hourly wages and travel expenses of the owner-operator, fuel, maintenance and repairs, and miscellaneous costs of pelleting grain dust.

Wages. Wages for the owner-operator were calculated at $7.20 per hour ($6 per hour plus $1.20 fringe benefits) for the first 40 hours per week worked; time and a half is paid for any hours worked above 40 hours per week. Overtime wages were determined necessary only to obtain 5,000 tons of annual production. Preventive maintenance and driving time of 450 hours were considered overtime. Total wages for portable pelleting plants at three annual output levels are presented in table 5.

Travel expense. Operation of portable pelleting plants was assumed to require the owner-operator to spend 4 nights per week away from home. Expenses to cover meals and lodging were estimated at $35 per day for 4 days and $16 for the day without lodging.

Fuel expense. Fuel costs for the diesel engine to operate the portable pelleting mill were calculated using 6 gallons per production hour at 2.5 tons per hour. A fuel price of 60 cents per gallon was used. The fuel cost for the towing vehicle was calculated on the basis of 10,000 miles annually for all levels of pellet production. Five gallons per mile was used to compute consumption. A fuel cost of 70 cents per gallon was used to arrive at the cost in table 5.

Maintenance and repairs. Maintenance and repair costs for the pelleting equipment were based on the manufacturer's recommendation of $2.25 per ton. Annual maintenance and repair costs for the towing vehicle, including tires and brake linings for the trailer, were estimated at 8.75 percent of the original purchase price of the towing vehicle. Annual maintenance costs for the gooseneck trailer were estimated at $75.

Miscellaneous. Miscellaneous expenses include telephone, bookkeeping, postage, advertising, office, and other expenses. Telephone expense was estimated to cost $600 annually regardless of output. The other miscellaneous expenses were estimated at $650.

Portable Plants: Total Operating Costs

Total variable costs for portable pelleting plants exceeded total fixed costs at all three levels of annual tonnage. Diesel fuel and mill maintenance and repairs were the main items that increased costs for the 2,500-ton level. Overtime wages increased costs further for the 5,000-ton level.

ECONOMIC RELATIONSHIPS

The foregoing data allow analyses of certain economic relationships. Economies of size and cost relationships among the four daily operating levels for stationary pelleting plants can be made. Economies of size cannot be evaluated for the one size of commercial portable plant manufactured, but the cost relationships of the three levels of operation were evaluated (table 5).

Economies are gained from increased mill size (tables 5 and 7 to 12). Estimated per unit costs declined approximately 37 and 34 percent for independent and add-on stationary plants, respectively, operating 8 hours daily as size increased from small to large. As size increased from medium to large, per unit costs declined approximately 35 and 28 percent for independent and add-on plants, respectively, operating 8 hours daily.

Varying Levels of Operation of Stationary Plants

Total fixed costs remained the same regardless of the number of hours a plant operates. Therefore, the lowest per unit fixed costs for the stationary plants of this study occurred at 16 hours of daily operation; at that level, the highest total output was attained (tables 8 and 10). Total labor costs remained static for daily operations of less than 8 hours, thus diseconomies occurred at those operating levels. The exception to this diseconomy occurred in add-on plants at the 4-hour operating level, since the parent grain-handling firm supplies enough otherwise underutilized labor at no cost to operate the dust-pelleting operation at this level.

As operating time increased from 8 to 16 hours, per unit costs decreased roughly 30 percent for stationary pelleting plants. As operating time declined to 4 hours, per unit costs increased approximately 80 percent for small independent plants and 62 percent for large independent plants. Per unit costs for add-on plants increased about 52 percent for small plants and 42 percent for large plants when production time declined to 4 hours; per unit costs for the medium add-on plant increased 54 percent.

Total Cost Curve for Portable Plants

Data from table 5 were used to develop figure 6. Spreading fixed costs over more units reduces per unit costs, provided that per unit variable costs do not increase. Annual production from portable dust-pelleting operations is highly dependent on the distance between grain-handling operations and the quantity of dust collected by these plants.

Annual production is affected by the time spent in transit and the quantity of dust available at a given stop. Attainment of 5,000 tons of annual production from the portable unit is a maximum for a mill producing 2.5 tons per hour, 250 days per year, 8 hours per day. All mileage driven and maintenance were assumed to be performed outside normal working hours. Thus, the cost curve in figure 6, developed from table 5, is likely representative of minimum and maximum costs that might be attained by portable grain-dust pelleting plants of a similar size.

Figure 6

Cost curve for a portable dust-pelleting plant, 1979

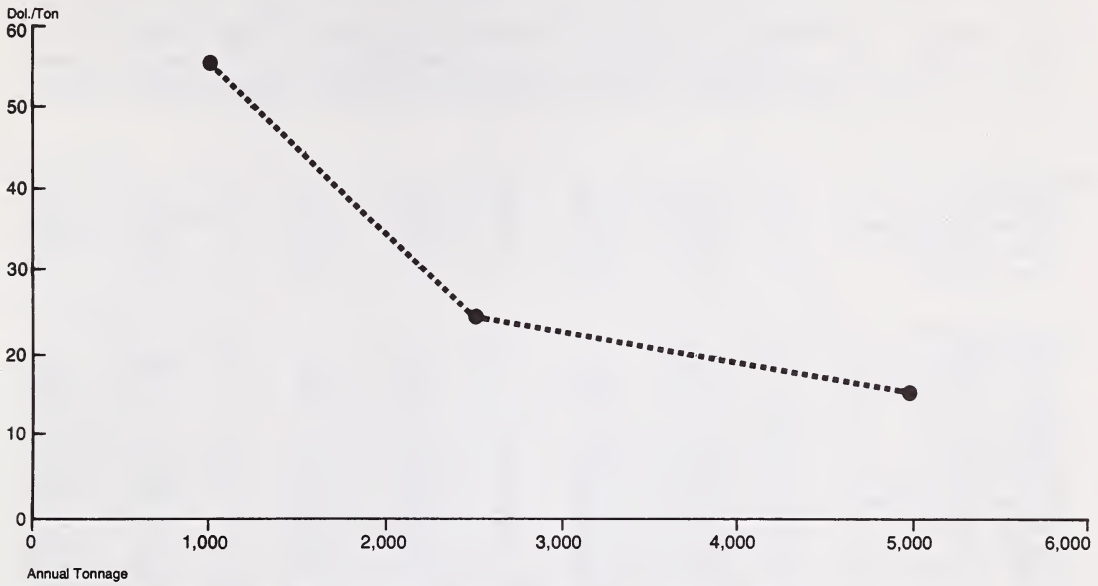


Table 1--Annual production of stationary grain-dust pelleting plants at four daily operating levels

Plant size	Daily operating hours			
	4	6	8	16
	Annual production 1/			
Small (2.5 tons per hour)	2,109	3,164	4,219	8,438
Medium (5 tons per hour)	4,219	6,328	8,438	16,875
Large (10 tons per hour)	8,438	12,656	16,875	33,750

1/ Annual production = 250 days per year x hourly production rate x daily operating time x the ratio of 6.75 running hours to 8 hours' operating time.

Table 2--Basic equipment, number of motors, and connected horsepower of motors in model independent grain-dust pelleting plants

Item	Small plant 1/			Medium plant 2/			Large plant 3/		
	Number of motors	Horse-power/ motor	Total horse-power	Number of motors	Horse-power/ motor	Total horse-power	Number of motors	Horse-power/ motor	Total horse-power
Receiving:									
Airlock	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Pneumatic system	1	30.00	30.00	1	60.00	60.00	1	60.00	60.00
Power shovels	2	5.50	11.00	2	5.50	11.00	2	5.50	11.00
Distributor	1	.25	.25	1	.25	.25	1	.25	.25
Processing and pelleting:									
Twin-screw feeders	2	3.00	6.00	2	3.00	6.00	2	3.00	6.00
Feed dresser	1	7.50	7.50	1	7.50	7.50	1	7.50	7.50
Magnet	--	--	--	--	--	--	--	--	--
Hammermill	1	30.00	30.00	1	50.00	50.00	1	75.00	75.00
Airlock	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Pneumatic system	1	20.00	20.00	1	30.00	30.00	1	40.00	40.00
Pellet mill	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
do.	1	3.00	3.00	1	7.50	7.50	1	10.00	10.00
do.	1	60.00	60.00	1	125.00	125.00	1	5.00	5.00
do.	--	--	--	--	--	--	1	300.00	300.00
Cooler	1	.50	.50	1	.50	.50	1	.50	.50
do.	1	.75	.75	1	.75	.75	1	.75	.75
do.	1	15.00	15.00	1	20.00	20.00	1	50.00	50.00
Screw conveyor	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Bucket elevator	1	3.00	3.00	1	3.00	3.00	1	3.00	3.00
Distributor	1	.25	.25	1	.25	.25	1	.25	.25
Gates	--	--	--	--	--	--	--	--	--
Miscellaneous equipment:									
Control panel	--	--	--	--	--	--	--	--	--
Boiler	1	.25	.25	1	.25	.25	1	.25	.25
do.	1	.33	.33	1	.33	.33	1	.33	.33
do.	1	.75	.75	1	.75	.75	1	.75	.75
do.	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Compressor	1	7.50	7.50	1	7.50	7.50	1	7.50	7.50
Fuel tank	--	--	--	--	--	--	--	--	--
Platform scales	--	--	--	--	--	--	--	--	--
Batch scales	--	--	--	--	--	--	--	--	--
Moisture tester	--	--	--	--	--	--	--	--	--
Trip balance	--	--	--	--	--	--	--	--	--
Total	25	--	201.08	25	--	335.58	26	--	583.58

-- = Not applicable.
1/ 2.5 tons per hour.
2/ 5 tons per hour.
3/ 10 tons per hour.

Table 3--Basic equipment, number of motors, and connected horsepower of motors in model add-on grain-dust pelleting plants

Item	Small plant 1/			Medium plant 2/			Large plant 3/		
	Number of motors	Horse-power/ motor	Total horse-power	Number of motors	Horse-power/ motor	Total horse-power	Number of motors	Horse-power/ motor	Total horse-power
Receiving:									
Airlock	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Pneumatic system	1	40.00	40.00	1	70.00	70.00	1	70.00	70.00
Distributor	1	.25	.25	1	.25	.25	1	.25	.25
Processing and pelleting:									
Twin-screw feeders	2	3.00	6.00	2	3.00	6.00	2	3.00	6.00
Feed dresser	1	7.50	7.50	1	7.50	7.50	1	7.50	7.50
Magnet	--	--	--	--	--	--	--	--	--
Hammermill	1	30.00	30.00	1	50.00	50.00	1	75.00	75.00
Airlock	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Pneumatic system	1	20.00	20.00	1	30.00	30.00	1	40.00	40.00
Pellet mill	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
do.	1	3.00	3.00	1	7.50	7.50	1	10.00	10.00
do.	1	60.00	60.00	1	125.00	125.00	1	5.00	5.00
do.	--	--	--	--	--	--	1	300.00	300.00
Cooler	1	.50	.50	1	.50	.50	1	.50	.50
do.	1	.75	.75	1	.75	.75	1	.75	.75
do.	1	15.00	15.00	1	20.00	20.00	1	50.00	50.00
Screw conveyor	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Bucket elevator	1	3.00	3.00	1	3.00	3.00	1	3.00	3.00
Distributor	1	.25	.25	1	.25	.25	1	.25	.25
Gates	--	--	--	--	--	--	--	--	--
Miscellaneous equipment:									
Control panel	--	--	--	--	--	--	--	--	--
Boiler	1	.25	.25	1	.25	.25	1	.25	.25
do.	1	.33	.33	1	.33	.33	1	.33	.33
do.	1	.75	.75	1	.75	.75	1	.75	.75
do.	1	1.00	1.00	1	1.00	1.00	1	1.00	1.00
Compressor	1	7.50	7.50	1	7.50	7.50	1	7.50	7.50
Fuel tank	--	--	--	--	--	--	--	--	--
Batch scales	--	--	--	--	--	--	--	--	--
Moisture tester	--	--	--	--	--	--	--	--	--
Trip balance	--	--	--	--	--	--	--	--	--
Total	23	--	200.08	23	--	334.58	24	--	582.58

-- = Not applicable.
1/ 2.5 tons per hour.
2/ 5 tons per hour.
3/ 10 tons per hour.

Table 4--Estimated capital investment requirements for inland independent and add-on grain-dust pelleting plants

Item	Independent plants			Add-on plants		
	Small 1/	Medium 2/	Large 3/	Small 1/	Medium 2/	Large 3/
	Dollars					
Equipment:						
Receiving system	84,820	97,440	97,440	84,820	97,440	97,440
Pelleting equipment	133,800	161,485	213,100	133,800	161,485	213,100
Tools and safety equipment	11,000	11,000	11,000	1,450	1,450	1,450
Control panel	11,100	11,100	11,100	11,100	11,100	11,100
Boiler	13,705	13,705	17,130	13,705	13,705	17,130
Compressor	3,000	3,000	3,000	3,000	3,000	3,000
Platform scales	32,930	32,930	32,930	--	--	--
Batch scales	10,100	10,100	10,100	10,100	10,100	10,100
Office equipment	2,865	2,865	2,865	2,265	2,265	2,265
Spare parts	16,750	17,000	19,800	16,750	17,000	19,800
Total 4/	320,070	360,625	418,465	276,990	317,545	375,385
Fuel tank	14,000	14,000	15,700	14,000	14,000	15,700
Bins	51,675	86,660	120,120	51,675	86,660	120,120
Rail siding	18,375	24,150	29,925	18,375	24,150	29,925
Buildings:						
Mill building	14,835	14,835	14,835	14,835	14,835	14,835
Boiler house	6,210	6,210	6,210	6,210	6,210	6,210
Office	6,865	6,865	6,865	--	--	--
Shop	4,140	4,140	4,140	--	--	--
Total	32,050	32,050	32,050	21,045	21,045	21,045
Land	24,000	36,000	48,000	--	--	--
Total	460,170	553,485	664,260	382,085	463,400	562,175

-- = Not applicable.
1/ 2.5 tons per hour.
2/ 5 tons per hour.
3/ 10 tons per hour.
4/ Equipment investment includes installation charges.

Table 5--Investment and estimated operating costs for a portable dust-pelleting mill at three levels of annual output

Cost item	1,000 tons		2,500 tons		5,000 tons	
	Total cost	Cost per ton	Total cost	Cost per ton	Total cost	Cost per ton
	Dollars					
Investment:						
Mill and trailer	85,280	85.28	85,280	34.11	85,280	17.06
Pickup truck	8,000	8.00	8,000	3.20	8,000	1.60
Spare parts	2,000	2.00	2,000	.80	2,000	.40
Tools	500	.50	500	.20	500	.10
Total investment	95,780	95.78	95,780	38.31	95,780	19.16
Annual fixed costs:						
Depreciation	5,867	5.87	5,867	2.35	5,867	1.17
Interest on investment	5,268	5.27	5,268	2.11	5,268	1.05
Taxes	336	.34	336	.13	336	.07
Insurance	4,709	4.71	4,709	1.88	4,709	.94
Licenses	500	.50	500	.20	500	.10
Returns to management	9,578	9.58	9,578	3.83	9,578	1.92
Total fixed costs 1/	26,258	26.26	26,258	10.50	26,258	5.25
Annual variable costs:						
Wages	14,400	14.40	14,400	5.76	19,935	3.99
Travel expense	7,800	7.80	7,800	3.12	7,800	1.56
Fuel: Mill	1,440	1.44	3,600	1.44	7,200	1.44
Vehicle	1,400	1.40	1,400	.56	1,400	.28
Maintenance and repairs:						
Mill	2,250	2.25	5,625	2.25	11,250	2.25
Vehicle and trailer	775	.78	775	.31	775	.16
Miscellaneous	1,250	1.25	1,250	.50	1,250	.25
Total variable costs	29,315	29.32	34,850	13.94	49,610	9.92
Total annual costs	55,573	55.57	61,108	24.44	75,868	15.17

1/ Summation of individual items may not equal total due to rounding.

Table 6--Estimated investment requirements for stationary grain-dust pelleting plants in port areas 1/

Size of plant and investment level	Total investment for comparable inland plant	Additional land cost	Additional foundation supports	Total investment
		Dollars		
Independent plants:				
Small 2/				
Low	460,170	19,560	14,000	493,730
High	460,170	63,120	90,000	613,290
Medium 3/				
Low	553,485	29,340	14,000	596,825
High	553,485	94,680	90,000	738,165
Large 4/				
Low	664,260	39,120	14,000	717,380
High	664,260	126,240	90,000	880,500
Add-on plants:				
Small 2/				
Low	382,085	--	14,000	396,085
High	382,085	--	90,000	472,085
Medium 3/				
Low	463,400	--	14,000	477,400
High	463,400	--	90,000	553,400
Large 4/				
Low	562,175	--	14,000	576,175
High	562,175	--	90,000	652,175

-- = Not applicable.

1/ The investment costs for port area plants were estimated using inland plant investment costs as a base (table 4) and increasing them for additional land costs and foundations required in port areas.

2/ 2.5 tons per hour.

3/ 5 tons per hour.

4/ 10 tons per hour.

Table 7--Estimated annual operating costs for inland independent grain-dust pelleting plants at four daily operating levels

Cost item	Small plant--2.5 tons per hour				Medium plant--5 tons per hour				Large plant--10 tons per hour			
	Daily operating hours				Daily operating hours				Daily operating hours			
	4	6	8	16	4	6	8	16	4	6	8	16
	Dollars											
Fixed costs:												
Depreciation--												
Equipment	17,842	17,842	17,842	17,842	20,213	20,213	20,213	20,213	23,451	23,451	23,451	23,451
Facilities	4,644	4,644	4,644	4,644	6,274	6,274	6,274	6,274	7,912	7,912	7,912	7,912
Interest on investment	27,551	27,551	27,551	27,551	33,357	33,357	33,357	33,357	40,264	40,264	40,264	40,264
Insurance	2,126	2,126	2,126	2,126	2,557	2,557	2,557	2,557	3,069	3,069	3,069	3,069
Taxes	1,611	1,611	1,611	1,611	1,938	1,938	1,938	1,938	2,325	2,325	2,325	2,325
Administrative	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440
Total fixed costs	62,214	62,214	62,214	62,214	72,779	72,779	72,779	72,779	85,461	85,461	85,461	85,461
Variable costs:												
Wages and salaries	42,000	42,000	42,000	64,560	42,000	42,000	52,200	76,680	52,200	52,200	62,400	87,420
Utilities	8,175	12,210	16,244	32,351	11,824	17,681	23,554	46,953	19,581	29,313	39,014	77,909
Maintenance and repairs	8,788	11,741	13,591	20,991	11,401	15,253	18,003	28,998	15,816	21,466	26,013	44,201
Interest on working capital	808	1,019	1,230	2,281	1,189	1,591	2,087	3,918	2,050	2,835	3,714	7,083
Other	13,676	14,362	15,047	17,789	17,622	18,993	20,364	25,849	25,179	27,921	30,664	41,362
Total variable costs	73,447	81,332	88,112	137,972	84,036	95,518	116,208	182,398	114,826	133,735	161,805	258,065
Total costs	135,661	143,546	150,326	200,186	156,815	168,297	188,987	255,177	200,287	219,196	247,266	343,526
Cost per ton	64.32	45.37	35.63	23.72	37.17	26.60	22.40	15.12	23.74	17.32	14.65	10.18

Table 8--Estimated per unit operating costs for inland independent grain-dust pelleting plants at four daily operating levels 1/

Cost item	Small plant--2.5 tons per hour				Medium plant--5 tons per hour				Large plant--10 tons per hour			
	Daily operating hours				Daily operating hours				Daily operating hours			
	4	6	8	16	4	6	8	16	4	6	8	16
	Dollars per ton											
Fixed costs:												
Depreciation--												
Equipment	8.46	5.64	4.23	2.11	4.79	3.19	2.40	1.20	2.78	1.85	1.39	0.69
Facilities	2.20	1.47	1.10	.55	1.49	.99	.74	.37	.94	.63	.47	.23
Interest on investment	13.06	8.71	6.53	3.27	7.91	5.27	3.95	1.98	4.77	3.18	2.39	1.19
Insurance	1.01	.67	.50	.25	.61	.40	.30	.15	.36	.24	.18	.09
Taxes	.76	.51	.38	.19	.46	.31	.23	.11	.28	.18	.14	.07
Administrative	4.00	2.67	2.00	1.00	2.00	1.33	1.00	.50	1.00	.67	.50	.25
Total fixed costs	29.50	19.66	14.74	7.37	17.25	11.50	8.63	4.31	10.13	6.75	5.06	2.53
Variable costs:												
Wages and salaries	19.91	13.27	9.96	7.65	9.96	6.64	6.19	4.54	6.19	4.12	3.70	2.58
Utilities	3.88	3.86	3.85	3.83	2.80	2.79	2.79	2.78	2.32	2.32	2.31	2.31
Maintenance and repairs	4.17	3.71	3.22	2.49	2.70	2.41	2.13	1.72	1.87	1.70	1.54	1.31
Interest on working capital	.38	.32	.29	.27	.28	.25	.25	.23	.24	.22	.22	.21
Other	6.48	4.54	3.57	2.11	4.18	3.00	2.41	1.53	2.98	2.21	1.82	1.23
Total variable costs	34.82	25.70	20.89	16.35	19.92	15.09	13.77	10.81	13.61	10.57	9.59	7.65
Total costs	64.32	45.37	35.63	23.72	37.17	26.60	22.40	15.12	23.74	17.32	14.65	10.18

1/ Summation of individual items may not equal totals due to rounding.

Table 9--Estimated annual operating costs for inland add-on grain-dust pelleting plants at four daily operating levels

Cost item	Small plant--2.5 tons per hour				Medium plant--5 tons per hour				Large plant--10 tons per hour			
	Daily operating hours				Daily operating hours				Daily operating hours			
	4	6	8	16	4	6	8	16	4	6	8	16
	Dollars											
Fixed costs:												
Depreciation--												
Equipment	15,308	15,308	15,308	15,308	17,679	17,679	17,679	17,679	20,917	20,917	20,917	20,917
Facilities	4,204	4,204	4,204	4,204	5,834	5,834	5,834	5,834	7,472	7,472	7,472	7,472
Interest on investment	21,936	21,936	21,936	21,936	26,422	26,422	26,422	26,422	32,009	32,009	32,009	32,009
Insurance	1,765	1,765	1,765	1,765	2,141	2,141	2,141	2,141	2,598	2,598	2,598	2,598
Taxes	1,338	1,338	1,338	1,338	1,622	1,622	1,622	1,622	1,968	1,968	1,968	1,968
Administrative	8,698	8,698	8,698	8,698	17,396	17,396	17,396	17,396	21,616	21,616	21,616	21,616
Total fixed costs	53,249	53,249	53,249	53,249	71,094	71,094	71,094	71,094	86,580	86,580	86,580	86,580
Variable costs:												
Wages and salaries	0	12,000	12,000	24,360	0	12,000	12,000	24,360	0	12,000	25,200	37,560
Utilities	8,157	12,182	16,207	32,278	11,805	17,654	23,518	46,790	19,545	29,258	38,968	77,763
Maintenance and repairs	8,568	11,521	13,371	20,771	11,181	15,033	17,783	28,778	15,596	21,246	25,793	43,981
Interest on working capital	75	222	259	519	108	272	326	652	179	378	588	1,057
Other	13,679	14,362	15,047	17,789	17,622	18,993	20,364	25,849	25,179	27,912	30,664	41,632
Total variable costs	30,479	50,287	56,884	95,717	40,716	63,952	73,991	126,429	60,500	90,794	121,213	201,933
Total costs	83,728	103,536	110,133	148,966	111,810	135,046	145,085	197,523	147,080	177,374	207,793	288,573
Cost per ton	39.69	32.72	26.10	17.66	26.50	21.34	17.19	11.71	17.43	14.02	12.31	8.55

Table 10--Estimated per unit operating costs for inland add-on grain-dust pelleting plants at four daily operating levels 1/

Cost item	Small plant--2.5 tons per hour				Medium plant--5 tons per hour				Large plant--10 tons per hour			
	Daily operating hours				Daily operating hours				Daily operating hours			
	4	6	8	16	4	6	8	16	4	6	8	16
	Dollars per ton											
Fixed costs:												
Depreciation--												
Equipment	7.26	4.84	3.63	1.81	4.19	2.79	2.10	1.05	2.48	1.65	1.24	0.62
Facilities	1.99	1.33	1.00	.50	1.38	.92	.69	.35	.89	.59	.44	.22
Interest on investment	10.40	6.93	5.20	2.60	6.26	4.18	3.13	1.57	3.79	2.53	1.90	.95
Insurance	.84	.56	.42	.21	.51	.34	.25	.13	.31	.21	.15	.08
Taxes	.63	.42	.32	.16	.38	.26	.19	.10	.23	.16	.12	.06
Administrative	4.12	2.75	2.06	1.03	4.12	2.75	2.06	1.03	2.56	1.71	1.28	.64
Total fixed costs	25.24	16.83	12.62	6.31	16.85	11.23	8.43	4.21	10.26	6.84	5.13	2.57
Variable costs:												
Wages and salaries	0	3.79	2.84	2.89	0	1.90	1.42	1.44	0	.95	1.49	1.11
Utilities	3.87	3.85	3.84	3.83	2.80	2.79	2.79	2.77	2.32	2.31	2.31	2.30
Maintenance and repairs	4.06	3.64	3.17	2.46	2.65	2.38	2.11	1.71	1.85	1.68	1.53	1.30
Interest on working capital	.04	.07	.06	.06	.03	.04	.04	.04	.02	.03	.03	.03
Other	6.48	4.54	3.57	2.11	4.18	3.00	2.41	1.53	2.98	2.21	1.82	1.23
Total variable costs	14.45	15.89	13.48	11.34	9.65	10.11	8.77	7.49	7.17	7.18	7.18	5.98
Total costs	39.69	32.72	26.10	17.66	26.50	21.34	17.19	11.71	17.43	14.02	12.31	8.55

1/ Summation of individual items may not equal totals due to rounding.

Table 11--Estimated annual operating costs for independent grain-dust pelleting plants in port areas, at four daily operating levels

Cost item 1/	Small plant--2.5 tons per hour				Medium plant--5 tons per hour				Large plant--10 tons per hour			
	Daily operating hours				Daily operating hours				Daily operating hours			
	4	6	8	16	4	6	8	16	4	6	8	16
	Dollars											
Fixed costs:												
Depreciation--												
Equipment	17,842	17,842	17,842	17,842	20,213	20,213	20,213	20,213	23,451	23,451	23,451	23,451
Facilities--												
Low investment	5,204	5,204	5,204	5,204	6,834	6,834	6,834	6,834	8,472	8,472	8,472	8,472
High investment	8,244	8,244	8,244	8,244	9,874	9,874	9,874	9,874	11,512	11,512	11,512	11,512
Total--low investment	23,046	23,046	23,046	23,046	27,074	27,074	27,074	27,074	31,923	31,923	31,923	31,923
Total--high investment	26,086	26,086	26,086	26,086	30,087	30,087	30,087	30,087	34,963	34,963	34,963	34,963
Interest on investment--												
Low investment	30,473	30,473	30,473	30,473	37,354	37,354	37,354	37,354	45,337	45,337	45,337	45,337
High investment	39,444	39,444	39,444	39,444	48,722	48,722	48,722	48,722	59,100	59,100	59,100	59,100
Insurance--												
Low investment	2,191	2,191	2,191	2,191	2,667	2,667	2,667	2,667	3,224	3,224	3,224	3,224
High investment	2,542	2,542	2,542	2,542	3,119	3,119	3,119	3,119	3,777	3,777	3,777	3,777
Taxes--												
Low investment	1,728	1,728	1,728	1,728	2,089	2,089	2,089	2,089	2,511	2,511	2,511	2,511
High investment	2,147	2,147	2,147	2,147	2,584	2,584	2,584	2,584	3,082	3,082	3,082	3,082
Administrative costs	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440	8,440
Total fixed costs:												
Low investment	65,878	65,878	65,878	65,878	77,597	77,597	77,597	77,597	91,435	91,435	91,435	91,435
High investment	78,659	78,659	78,659	78,659	92,952	92,952	92,952	92,952	109,362	109,362	109,362	109,362
Total variable costs:	73,447	81,332	88,112	137,972	84,036	95,518	116,208	182,398	114,826	133,735	161,805	258,065
Total costs:												
Low investment	139,325	147,210	153,990	203,850	161,633	173,115	193,805	259,995	206,261	225,170	253,240	349,500
High investment	152,106	159,991	166,771	216,631	176,988	188,470	209,160	275,350	224,188	243,097	271,167	367,427
Cost per ton:												
Low investment	66.06	46.53	36.50	24.16	38.31	27.36	22.97	15.41	24.44	17.79	15.01	10.36
High investment	72.12	50.57	39.53	25.67	41.95	29.78	24.79	16.32	26.57	19.21	16.07	10.89

1/ Low and high investment refer to the varying costs for foundations and land.

Table 12--Estimated annual operating costs for add-on grain-dust pelleting plants in port areas, at four daily operating levels

Cost item 1/	Small plant--2.5 tons per hour				Medium plant--5 tons per hour				Large plant--10 tons per hour			
	Daily operating hours				Daily operating hours				Daily operating hours			
	4	6	8	16	4	6	8	16	4	6	8	16
	Dollars											
Fixed costs:												
Depreciation--												
Equipment	15,308	15,308	15,308	15,308	17,679	17,679	17,679	17,679	20,917	20,917	20,917	20,917
Facilities--												
Low investment	4,764	4,764	4,764	4,764	6,394	6,394	6,394	6,394	8,032	8,032	8,032	8,032
High investment	7,804	7,804	7,804	7,804	9,434	9,434	9,434	9,434	11,072	11,072	11,072	11,072
Total--low investment	20,072	20,072	20,072	20,072	24,073	24,073	24,073	24,073	28,949	28,949	28,949	28,949
Total--high investment	23,112	23,112	23,112	23,112	27,113	27,113	27,113	27,113	31,989	31,989	31,989	31,989
Interest on investment--												
Low investment	22,706	22,706	22,706	22,706	27,192	27,192	27,192	27,192	32,779	32,779	32,779	32,779
High investment	26,886	26,886	26,886	26,886	31,372	31,372	31,372	31,372	36,959	36,959	36,959	36,959
Insurance--												
Low investment	1,830	1,830	1,830	1,830	2,206	2,206	2,206	2,206	2,663	2,663	2,663	2,663
High investment	2,181	2,181	2,181	2,181	2,557	2,557	2,557	2,557	3,014	3,014	3,014	3,014
Taxes--												
Low investment	1,387	1,387	1,387	1,387	1,671	1,671	1,671	1,671	2,017	2,017	2,017	2,017
High investment	1,653	1,653	1,653	1,653	1,937	1,937	1,937	1,937	2,283	2,283	2,283	2,283
Administrative costs	8,698	8,698	8,698	8,698	17,396	17,396	17,396	17,396	21,616	21,616	21,616	21,616
Total fixed costs:												
Low investment	54,693	54,693	54,693	54,693	72,538	72,538	72,538	72,538	88,024	88,024	88,024	88,024
High investment	62,530	62,530	62,530	62,530	80,375	80,375	80,375	80,375	95,861	95,861	95,861	95,861
Total variable costs:	30,479	50,287	56,884	95,717	40,716	63,952	73,991	126,429	60,500	90,794	121,213	201,933
Total costs:												
Low investment	85,172	104,980	111,577	150,410	113,254	136,490	146,529	198,967	148,524	178,818	209,237	289,957
High investment	93,009	112,817	119,414	158,247	121,091	144,327	154,366	206,804	156,361	186,655	217,074	297,855
Cost per ton:												
Low investment	40.39	33.18	26.45	17.83	26.84	21.57	17.37	11.79	17.60	14.13	12.40	8.59
High investment	44.10	35.66	28.30	18.75	28.70	22.81	18.29	12.26	18.53	14.75	12.86	8.83

1/ Low and high investment refer to the varying costs for foundations.

Table 13--Types of jobs and number of staff for grain-dust pelleting plants

Type of job	Small plant 1/				Medium plant 2/				Large plant 3/			
	Daily operating hours				Daily operating hours				Daily operating hours			
	4	6	8	16	4	6	8	16	4	6	8	16
	Number											
Independent plant:												
Superintendent-manager	1	1	1	1	1	1	1	1	1	1	1	1
Supervisor	0	0	0	0	0	0	0	0	0	0	0	1
Mill operator	1	1	1	2	1	1	1	1	1	1	1	1
Mill laborer	0	0	0	1	0	0	1	2	1	1	2	3
Total	2	2	2	4	2	2	3	5	3	3	4	6
Add-on plant:												
Superintendent-manager	--	--	--	--	--	--	--	--	--	--	--	--
Supervisor	0	0	0	0	0	0	0	0	0	0	1	1
Mill operator	0	1	1	2	0	1	1	2	0	1	1	2
Mill laborer	--	--	--	--	--	--	--	--	--	--	--	--
Total	0	1	1	2	0	1	1	2	0	1	2	3

-- = Not applicable.
1/ 2.5 tons per hour.
2/ 5 tons per hour.
3/ 10 tons per hour.

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