Alfalfa dehydration : operations and costs
by John George Zurenko

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Agricultural Economics
Montana State University

Abstract:
Alfalfa dehydration is a seasonal operation and requires a large capital outlay. Almost continuous operation during the season in order to generate the contribution is necessary to cover the fixed costs of production.

Drying drums are rated in terms of evaporative capacity per hour. Consequently dry tonnage (dehydrated alfalfa) production depends on the moisture content of the raw alfalfa, with production increasing as the moisture content of the raw alfalfa decreases.

Length of growing season is important. The product price at which similar plants can breakeven is inversely related to the length of the growing season. At a given price, the shorter the growing season the larger the plant size and the greater the acreage needed to reach breakeven volume. Acreage requirements decrease as length of operating season increases because more cuttings can be obtained from each field.

Cost data from the survey revealed that for plants of similar capacities, conversion costs decreased as average daily production and percentage of capacity at which the plants operated increased. There was no indication of economies of scale in this analysis. Larger sized plants did not, however, operate at as high a percentage capacity as smaller sized plants. The cost synthesis type of analysis, with all size plants projected to operate at similar capacities, indicated that economies of scale are possible in the industry.

The principal factor in plant location was availability of raw alfalfa with site at rail siding, natural gas supply, local market potential, and location with respect to community receiving consideration.

Contracts with alfalfa growers generally are oral. This seems to be a grower preference. A good reputation with growers seems to be more important than contractual commitments.

Ninety percent of the alfalfa supply of the survey plants came from within a 10-mile radius of the plant. Harvesting and trucking costs are affected by condition of roads, routes available and yields and condition of fields.

Marketing functions were generally performed by the plant managers. Most sales were to feed mills and livestock feeders and within a 100-mile radius of the plant. Most of the plants in the survey had inert gas storage and indicated that a plant should have inert gas storage for about one-half of its annual production.

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August, 1969

ACKNOWLEDGEMENTS

The author wishes to express gratitude to Dr. Charles Rust, committee chairman for advice and assistance in the undertaking of this study and patience and understanding shown throughout the writing period.

Thanks are extended to Dr. Richard McConnen, Dr. Layton S. Thompson, Dr. Clarence Jensen, Dr. Clive Harston, and Professor John Litschauer for their advice and assistance.

Appreciation is extended to Dr. J. Warren Mather and Mr. Charles Reed of the Farmers Cooperative Service for their cooperation.

Very deep thanks are expressed to the members of the alfalfa dehydration industry who gave so generously of their time and made this study possible.

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CHAPTER I

INTRODUCTION

Problem Situation

Farmers are constantly seeking ways to stabilize and increase farm returns. In many areas of the United States alfalfa is an important source of farm income. In recent years increased yields, and restrictions on other cash crops have contributed to the importance of alfalfa in the enterprise structure.

A field of alfalfa yields from one to seven cuttings per season, depending on the area in which it is produced. Sun-curing of alfalfa requires favorable weather conditions. The processing of alfalfa hay requires specialized machinery. The product is bulky and does not easily lend itself to automated handling, thus requiring a considerable amount of handling when harvested and fed. These characteristics of alfalfa hay processing (repeated cuttings, dependence on favorable weather conditions, specialized machinery and necessity of physical handling) encourage development of other means of processing that will be a more efficient means of utilizing alfalfa.

Alfalfa hay is a high bulk-low value product. Transportation costs for this type of product are relatively high. The result is a market with a small geographic area and few buyers and sellers. Many hay producers fear that demand for alfalfa hay will not keep up with the increases in supply. Many hay markets are subject to wide year-to-year and season-to-season price fluctuations. Consequently, farmer groups frequently request information concerning the economic feasibility of different means of processing alfalfa as a means of adding value to their product, expanding their market area, and thereby increasing demand and stabilizing the market. Other farmer-feeder groups may be interested in such processing as a means of obtaining a more economical or dependable source of feed ingredients. Business and community leaders sometimes are interested in the practicality of such an enterprise as a means of bringing a new industry and additional employment to an area. Several requests regarding the feasibility of establishing an alfalfa dehydration plant have been received by Montana State University and the United States Department of Agriculture within the last three years.

Dehydrated Alfalfa

Alfalfa dehydration is a process whereby moisture is removed from green alfalfa through exposure to high, artificially maintained temperatures. Dehydrated alfalfa is defined in the Trade Rules and Code of Ethics of the American Dehydrators Association as follows:

> The term 'Dehydrated Alfalfa Product' applies to any of the various forms and grades of products obtained from alfalfa provided that:
>
> (a) The alfalfa is reasonably free from other crop plants and weeds, and
>
> (b) The freshly cut alfalfa, having a moisture content of not less than sixty (60) percent, has been artificially dried at a temperature of not less than 212 degrees Farenheit and that the Drying process has covered a period of not more than forty (40) minutes. 1/

1/ Trade Rules and Code of Ethics, American Dehydrators Association, Kansas City, Missouri, p. 77.

Dehydrated alfalfa is used as an ingredient in poultry, swine, cattle, and sheep rations. It is a rich source of Vitamin A. It is included in many feeds because it contains certain, as yet unidentified, health, growth, and reproductive factors. It is used in poultry feeds because it contains the pigmenting agent xanthophyll. Dehydrated alfalfa contains a high quality protein. It also contains 11 other vitamins, 13 minerals, and 19 amino acids. It is sold on the basis of its protein and Vitamin A content.

The locations of dehydrating plants operating in the United States in a 1954 study are shown in Figure 1. 2/ Of the 321 plants shown in Figure 1, 157 are located in the states of Colorado, Kansas, and Nebraska.

Dehydrated alfalfa production through 1963 is shown in Table I. In 1962-1963, year beginning in May, total alfalfa production in the United States was estimated at 1,598,000 tons. Of this total, 861,000 tons or 57 percent of total production occurred in Colorado, Kansas, and Nebraska. California is the second largest producing area with 364,000 tons. The five-year average from 1957-1961 was 1,384,000 tons of which 731,000 tons, or 52 percent, were produced in Colorado, Kansas, and Nebraska.

Historical Development of Alfalfa Dehydration

Some of the earliest dehydrators in the United States were tunnel driers built by Fulmer. 3/ These dehydrators were located around the

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2/ Later accurate data of total population of numbers of plants is not available.

3/ Richard L. Kathe, "Silver Anniversary Banquet--Historical Review," Proceedings, American Dehydrators Association, (Kansas City, Mo., 1966), p. 1.

Figure 1. Number of Dehydrating Plants by States in 1954.

TABLE I. ALFALFA MEAL: PRODUCTION BY REGIONS AND STATES, YEAR BEGINNING MAY, AVERAGE 1957-61, ANNUAL 1957-62.*1/

Region and State	Average 1957-61	1957-58	1958-59	1959-60	1960-61	1961-62	1962-63 2/
	1,000 Tons						
North Atlantic 3/	33	24	34	36	35	35	33
East North Central							
Ohio	93	88	91	76	94	115	69
Michigan & Wisconsin	21	24	16	20	20	24	16
Illinois & Indiana	19	22	19	19	20	16	16
Total	133	134	126	115	134	155	101
West North Central							
Nebraska	473	436	451	493	492	490	522
Kansas	142	135	142	125	149	160	195
Missouri	46	50	46	46	46	43	39
Minnesota	24	21	19	22	22	34	39
Iowa	29	27	26	26	29	34	35
Total	716	685 4/	684	712	738	761	830
South Central							
Arkansas & Tennessee	22	20	14	21	30	26	23
Oklahoma	8	10	11	7	7	6	8
Texas	25	26	27	26	24	22	21
Total	55	56	52	54	61	54	52
Western							
California	233	187	218	240	257	266	364
Colorado	116	123	118	108	114	118	144
Washington & Utah	39	31 5/	42 6/	44	41	35	30
Total	392	359 7/	378	392	412	419	548 8/
Other States	55	30	54	76	67	49	34
Total U. S.	1,384	1,288	1,328	1,385	1,447	1,473	1,598

(table continued)

Footnotes for Table I

*Source: Jack S. Ross, Recent Trends and Seasonality in Alfalfa Meal Production, Use and Prices, Economic and Statistical Analysis Division, Economic Research Service, U. S. Department of Agriculture, FDS-200, August 1963, p. 37.

1/ Includes total of suncured and dehydrated.
2/ Preliminary.
3/ Pennsylvania only.
4/ Total includes 16,000 tons produced in North and South Dakota.
5/ Includes small quantity produced in Idaho.
6/ Includes small quantity produced in Arizona.
7/ Includes 18,000 tons produced in Arizona and New Mexico.
8/ Includes 10,000 tons produced in New Mexico and Nevada.

towns of Nazareth and Allentown, Pennsylvania, and consisted of a tunnel with a bed of hand-fired coals over which the green alfalfa was conveyed. 4/ The first rotary drum drier was built by Julius Heil in 1929 using a patent owned by Jerry Arnold. 5/ In this process green alfalfa is drawn by air flow through a rotating drum fired by natural gas or fuel oil. The Heil drum was installed and operated at the Arnold family farm north of Galesville, Wisconsin. In 1931, Heil installed another drum on a Mississippi plantation. The drum did not prove out and was brought by W. J. Small who moved it to Neodesha, Kansas, worked out the bugs and began producing a fair grade of alfalfa meal. 6/ The early 1930's also saw rotating drum machines pioneered in Nebraska and Ohio. 7/ The industry grew slowly at first. Dehydrated alfalfa was generally thought of in terms of dry hay. The only benefit was the avoidance of weather hazards in making hay. 8/ World War II saw rapid growth brought about by an increased demand for feed ingredients due to the rapid increase in the feed manufacturing business. Investigations showed dehydrated alfalfa was a rich source of carotene for Vitamin A, xanthophyll, and other factors which could not be identified. 9/

4/ Joseph Chrisman and Jerry W. Fielder, "Progress of an Industry," Seventh Technical Alfalfa Conference, (Albany, Cal., 1961), p. 3.

5/ Kathe, op. cit., p. 1.

6/ Ibid.

7/ Chrisman and Fielder, op. cit., p. 3.

8/ Ibid.

9/ Kathe, op. cit., p. 2.

The product until after World War II was dirty, dusty, varied greatly in physical and nutritional properties and could not be guaranteed for quality the year round. Feed mills found the product difficult to handle. Limited knowledge of its values combined with loss of some of the major nutrients through oxidation served to reduce its worth to the user. 10/

The first attempts to reduce the rate of oxidation took the form of cold storage and proved unsatisfactory. A milepost in the industry was the concurrent development of pelleting and inert gas storage. The pelleting of alfalfa meal reduced the bulkiness of the product, alleviated the dust problem and made it easily adaptable to automation and bulk handling. Methods were introduced for storing pelleted alfalfa meal under inert gas. The need to protect the product through this type of storage and reduced cost led to the general acceptance of pelleting. 11/ The introduction and acceptance of an anti-oxidant known as either santoquin or ethoxyquin further preserved those nutrients subject to oxidation.

Early field equipment consisted of mowers, windrowers, rakes, and pitchforks. The standing alfalfa was mowed, windrowed, and pitched by hand into a transport for hauling to the plant. The advent of the Redpath harvestor, a machine which cut and loaded alfalfa in one

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10/ Chrisman and Fielder, op. cit., p. 5.

11/ Ibid.

operation, eliminated the use of rakes and windrowers. At the dehydrating drum green hay still had to be pitched by hand into a silage chopper prior to entering the dryer. Field choppers, which cut, chopped, and blew the alfalfa into a towed unit eliminated the pitchfork in the field. An automatic feeder ended the use of the pitchfork at the plant. 12/

The Dehydration Process

Rotary Drum Dryers

There are two general types of rotary drum dryers--the single pass and the triple pass. The single pass dryer uses a single rotating drum. Flights running the length of the walls of the drum are arranged so that the alfalfa is picked up and showered evenly across the entire area of the drum as it is rotated. A single baffle, strategically located to increase air velocity during the time the alfalfa is subjected to the direct flame of the furnace at the front of the drum, rapidly moves it through this high temperature area. The leaves of the alfalfa plant, dried almost instantly by the initial exposure, are quickly drawn out of the drum by the exhaust fan. The stems retain more moisture and require a longer evaporation time. They are heavier than the leaves, and are tumbled at lower temperatures in the reduced velocity air stream toward the discharge end of the drum.

Figure 2 shows a cutaway view of the three-pass drum. It consists of three concentrically arranged cylinders. These cylinders are

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12/ *Ibid.*, p. 4.

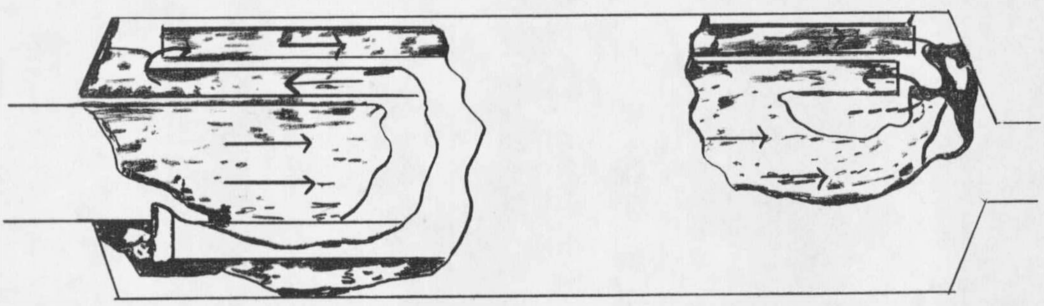

Figure 2. Cutaway View of Three-Pass Drum.

mechanically interlocked and all rotate at the same speed. The highest temperatures are in the inner cylinder with progressively lower temperatures in the intermediate and outer cylinder. The air stream created by the exhaust fan draws the material through the inner cylinder, back through the intermediate cylinder and forward again through the outer cylinder to the discharge end of the drum. The alfalfa is repeatedly carried to the top of each cylinder by built-in flights and showered through hot gases. As in the single pass drum, the leaves of the plant are dried almost instantly and carried away from the source of the heat. The stems retain moisture and take longer to dry. Their added weight slows their progress through the drum thereby increasing the exposure time.

The capacity of a drying drum in terms of dehydrated alfalfa produced will vary widely, depending primarily on the moisture content of the freshly cut alfalfa. The capacity of a drying drum is therefore rated in terms of water evaporated per hour. The number of pounds of water a drum will evaporate per hour is known as its evaporation capacity.

Product Flow

At the plant, the chopped alfalfa is deposited into a automatic feeder whose function is to maintain an even flow into the drying drum. Passage through the drum takes three to five minutes, and results in the evaporation of most of the moisture content of the alfalfa. Two systems of product flow from drying drum to pellet mill are illustrated.

In the process diagramed in Figure 3, the exhaust fan provides air for combustion and drying and generates the air stream for advancing the product. The product passes through the exhaust fan into the dryer collector where it is separated from the hot, moist gases. The dry product then passes through the cooling fan and is blown into the cooling collector for further aeration. From here the product flows to the hammermill to be ground into a fine meal. A plant employing this process is shown in Figure 4.

In the process diagramed in Figure 5, the exhaust fan provides air for combustion and draws the hot air currents carrying the product through the drum into the vacollector. The product does not pass through the exhaust fan. In the vacollector, all product settles out of the air flow while hot gases and moisture laden air are withdrawn by a negative air system and discharged in the atmosphere through the exhaust stack. The dried product flows directly from the vacollector into the hammermill where it is ground to desired particle size. From here the product flows to the pellet mill. A plant employing this process is shown in Figure 6.

The preceding flow diagrams are intended only to demonstrate the flow of alfalfa through the drying process. Although these diagrams illustrate the general form of the flow process, there are many other variations. This is also true of the product flow from hammermill to loadout or storage which is diagramed in Figure 7.

Figure 7 is largely self-explanatory with only a few items requiring comment. The alfalfa meal surge bin acts as a temporary storage facility

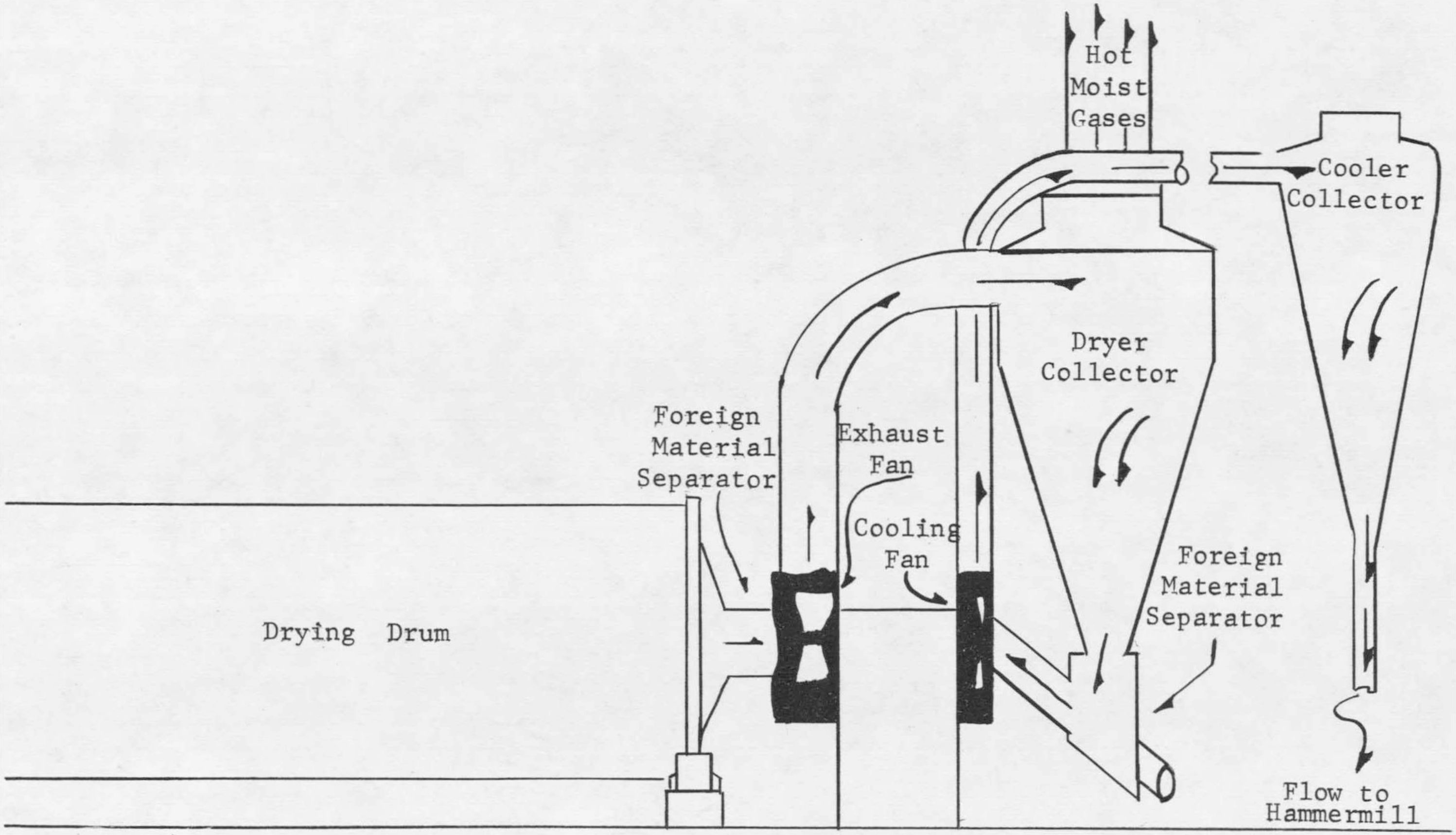

Figure 3. Product Flow from Drying Drum to Hammermill.

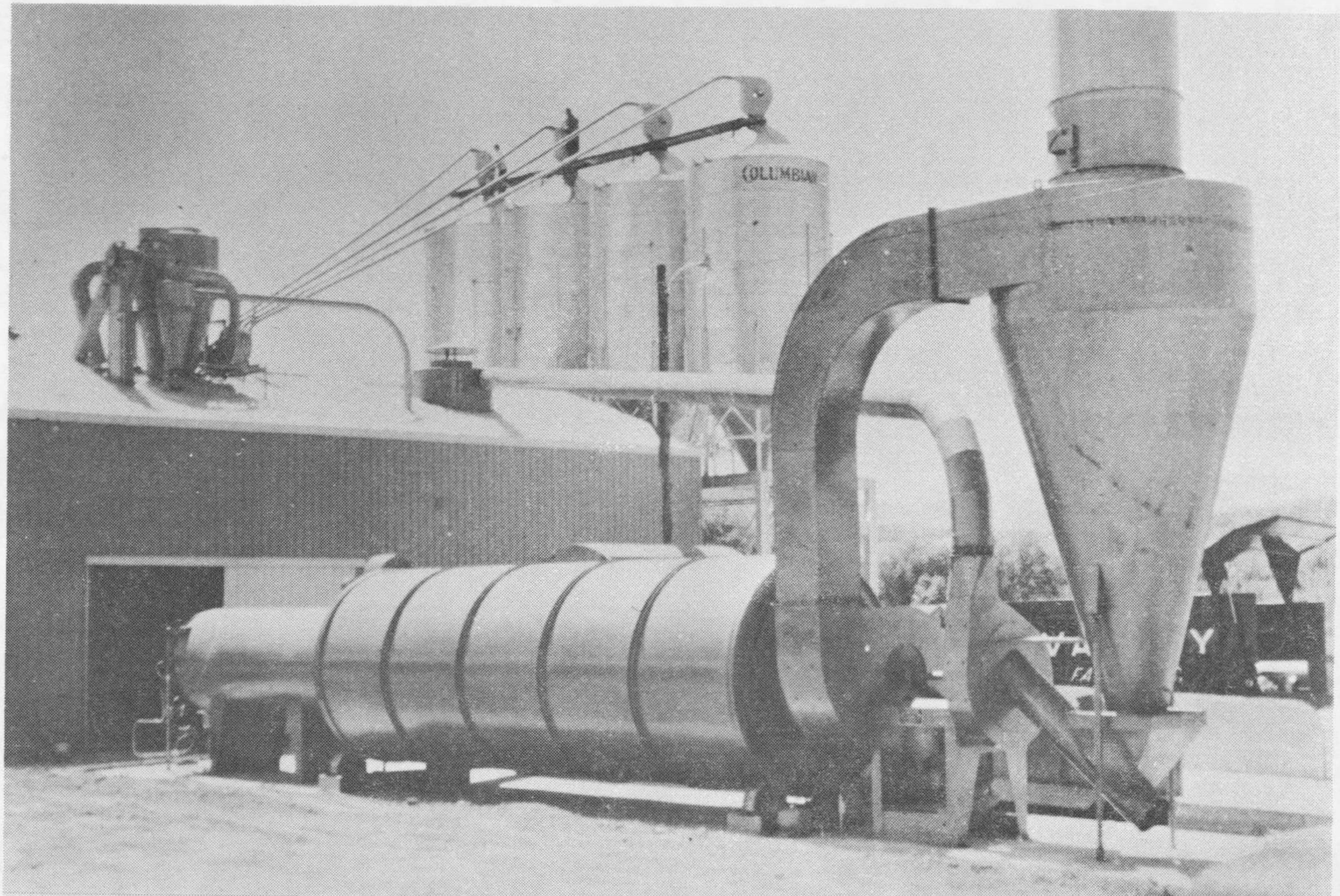

Figure 4. Plant Employing Process Diagrammed in Figure 3.

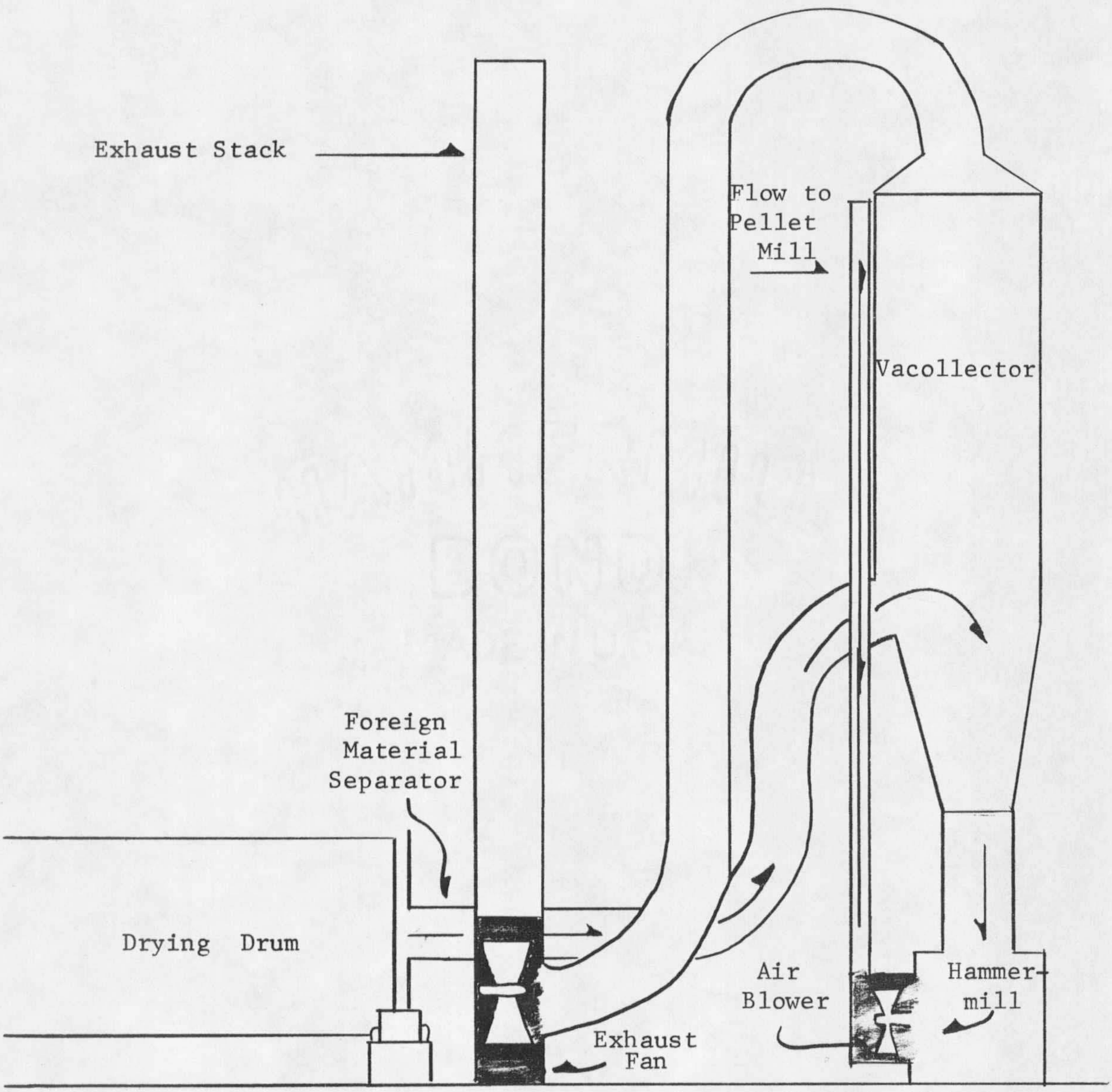

Figure 5. Product Flow from Drying Drum to Pellet Mill.

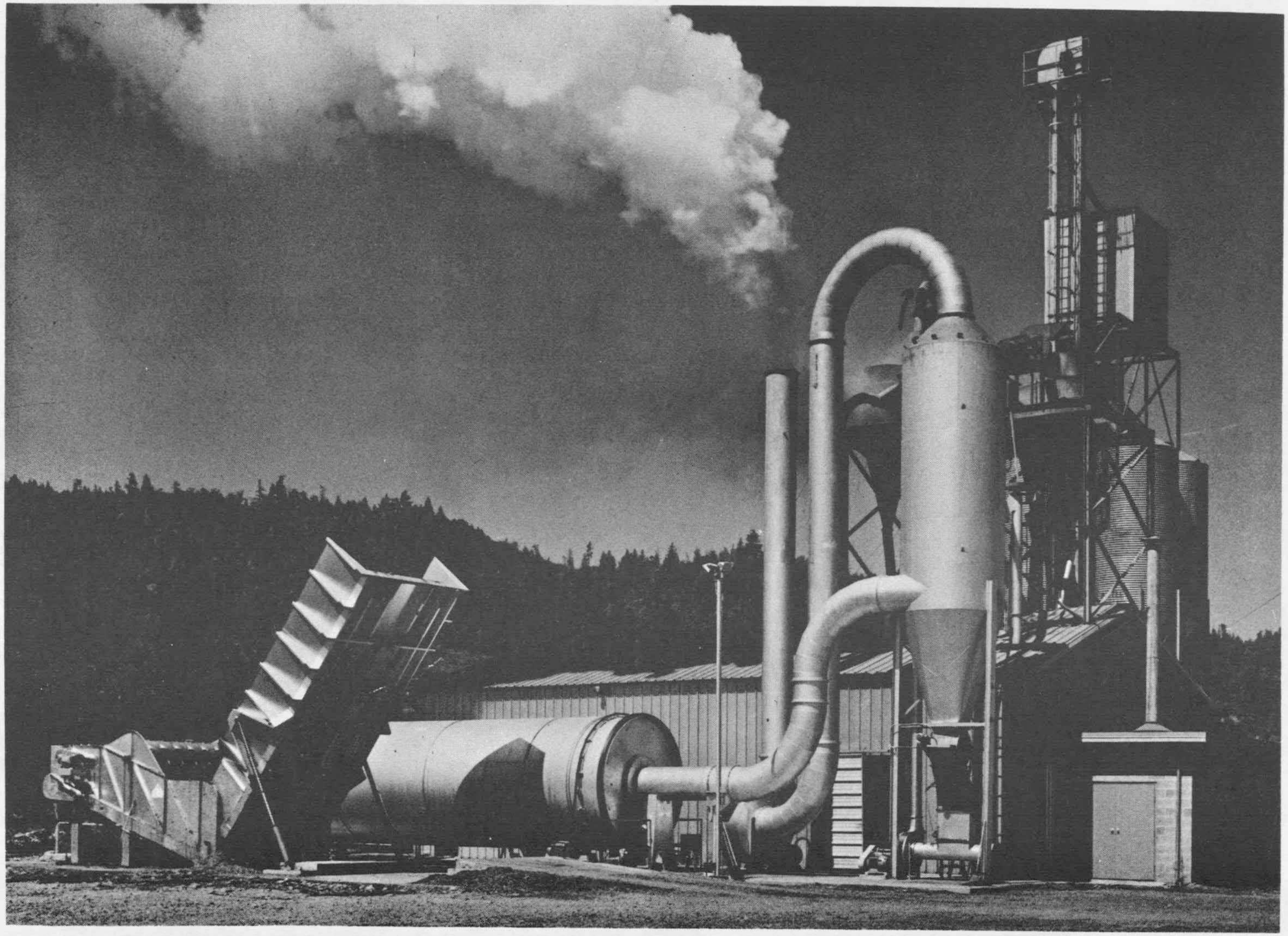

Figure 6. Plant Employing Process Diagrammed in Figure 5.

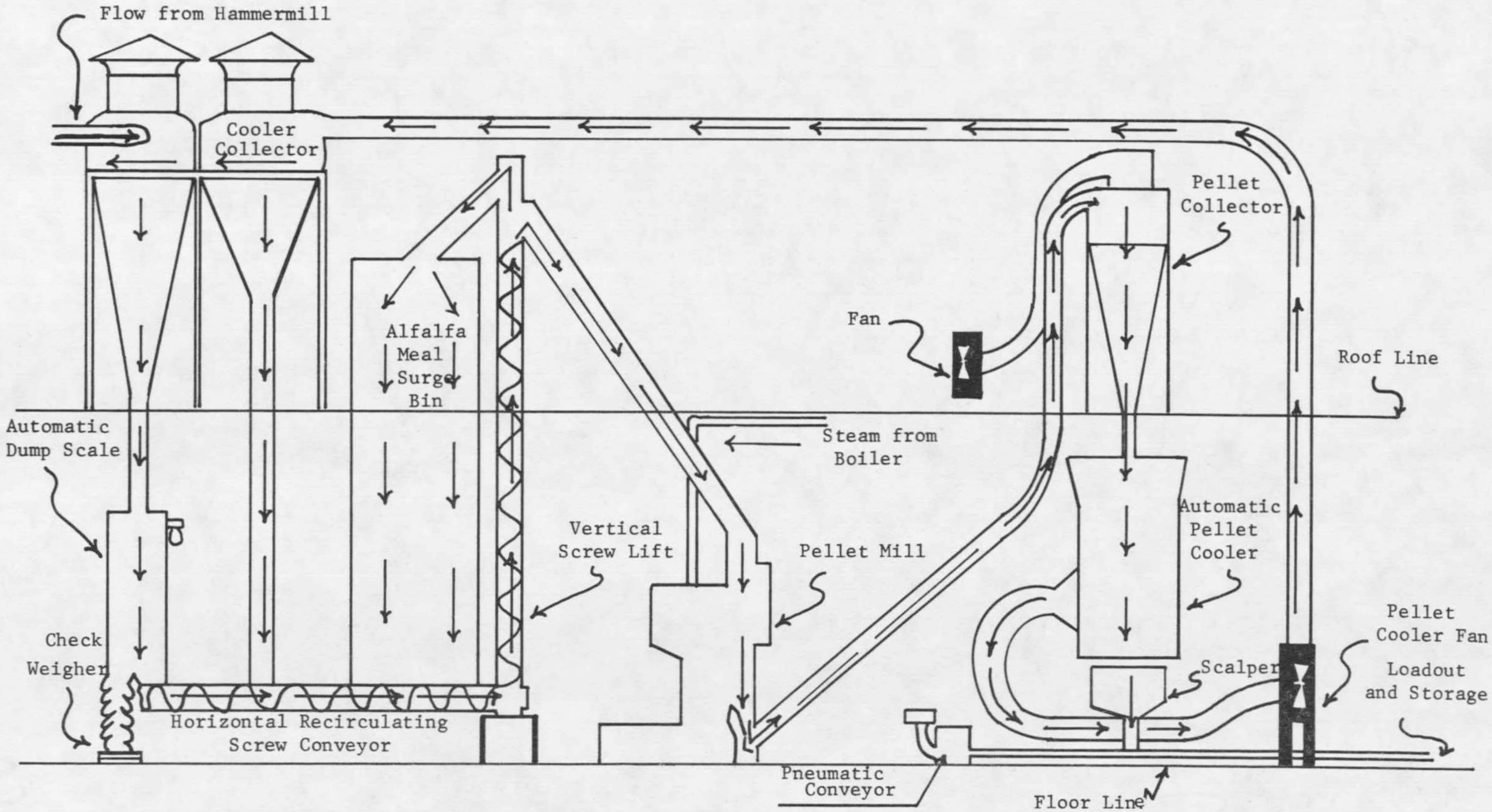

Figure 7. Product Flow from Hammermill to Loadout or Storage.

in the event the flow of alfalfa through the pellet mill is interrupted. This allows the flow through the dryer and hammermill to continue even though there is a temporary stoppage at the pellet mill. In another system, surge bins might be located to handle stoppages at both hammermill and pellet mill. Steam is added prior to pelleting to control moisture. The pressure used to pellet the dehydrated alfalfa produces considerable heat, thus the pellets go from the pellet mill to a cooler. The pellet cooling fan, in addition to providing the air flow for cooling pellets, draws fine material out of the flow and propels it to a cooler collector for recirculation. The pneumatic conveyor is used to convey the cooled pellets to storage or shipping points.

Harvesting and Trucking

Harvestors (either self-propelled or tractor drawn) mow the alfalfa, chop it into short lengths and blow it into a towed trailer or truck. If a trailer is towed, the alfalfa must be transferred to a truck for hauling to the plant site. If the towed vehicle is a truck, it is unhooked when loaded and replaced with an empty truck.

Research Problem

While some technical information on the physical operation of alfalfa dehydration and on the marketing of dehydrated alfalfa is available, the material needs to be updated. Previous studies have shown that plant costs are inversely related to annual production volume, but have not specifically related these cost differences to size of plant.

Thus, economies of scale should be examined in order to determine best plant size under given conditions and the competitive position of various sized plants assessed.

There is little information available on the organizational and managerial aspect of such operations or on market development, including potential and penetration. Information and guidelines in all these areas is therefore needed by farmers and others to assess the feasibility of alfalfa processing in their areas and to provide criteria for successful organization, management, and operation.

Hypothesis

Alfalfa growers interested in ways of adding value to their product, increasing demand and stabilizing the market, farmer-feeder groups interested in a more economical or dependable source of feed ingredients, and businesses and community leaders interested in new industry and additional employment have proposed the establishment of a dehydrating plant as a means of attaining these ends. In order that alfalfa dehydration be an effective means of attaining these ends, the establishment of a plant must be economically feasible. It is hypothesized that the following will prove to be principal factors in determining economic feasibility of alfalfa dehydration.

1. The available supply of alfalfa in conjunction with the length of harvest season.

2. Plant location with respect to competing in central markets and potential for establishment of local markets.

3. Legal organization, particularly with respect to the relationship of the policy-making body and management.

Objectives

The objectives of this study are as follows:

1. To determine the nature of the long-run cost function for alfalfa dehydration and thereby provide a basis for planning optimum plant size for a given volume and length of operating season.

2. To develop guidelines for establishing alfalfa dehydration plants under various physical and economic conditions.

3. To specify criteria for successful organization, management, and operation of alfalfa processing services.

CHAPTER II

THEORY AND METHODOLOGY

"The theoretical framework for studies of cost and efficiency is based on elaborations and modifications of the conventional economic theory of production. . . . Incorporation of modifications in the conventional theory . . . provides a more workable base for studies of cost and efficiency." 13/

Conventional Theory

Least-Cost Combination of Inputs

The problem is one of finding the least-cost input combination for the production of a specified level of output Y by a single product firm. Assuming a production function

$$Y = f(\nu_1, \ldots, \nu_k | \nu_{k+1}, \ldots, \nu_n)$$

where $\nu_1, \ldots, \nu_k$ are variable inputs and $\nu_{k+1}, \ldots, \nu_n$ are fixed inputs (the "plant" in the short run) the problem may be formulated as one of minimizing total costs as follows:

$$\begin{aligned} \text{TC (total cost)} &= \text{TVC (total variable cost)} \\ &\quad + \text{TFC (total fixed cost)} \end{aligned}$$

or

$$TC = \sum_{i=1}^{k} P_{\nu_i} \nu_i + \sum_{i=1}^{k+1} P_{\nu_i} \nu_i$$

13/ French, B. C., L. L. Sammett, and R. G. Bressler, "Economic Efficiency with Special Reference to the Marketing of California Pears," Hilgardia, Vol. 24, No. 19, University of California, Berkeley, July, 1956, p. 544.

subject to the output constraint

$$Y = f(\nu_1,\ldots,\nu_k | \nu_{k+1},\ldots,\nu_n)$$

In the case of imperfect competition between firms in the purchase of input factors, the price (P_{ν_i}) of any input is a function of the quantity of all inputs used, or:

$$P_{\nu_i} = q_i(\nu_1,\ldots,\nu_n)$$

Thus:

$$TVC = \sum_{i=1}^{k} P_{\nu_i}\nu_i = \sum_{i=1}^{k} [q_i(\nu_1,\ldots,\nu_n)]\ [\nu_i];$$

$$TFC = \sum_{i=k+1}^{n} P_{\nu_i}\nu_i = \sum_{i=k+1}^{n} [q_i(\nu_1,\ldots,\nu_n)]\ [\nu_i]; \quad \text{and}$$

$$TC = \sum_{i=1}^{k} [q_i(\nu_1,\ldots,\nu_n)]\ [\nu_i] + \sum_{i=k+1}^{n} [q_i(\nu_1,\ldots,\nu_n)]\ [\nu_i].$$

The Lagrangian multiplier method of solving a constrained extremum problem involves the forming of an augmented objective function which in this case is:

$$Z = TC + \lambda[y-f(\nu_1,\ldots,\nu_k | \nu_{k+1},\ldots,\nu_n)]$$

For critical values of Z regarded as a function of the variables $\nu_1,\ldots,\nu_n$ and λ the necessary conditions for cost minimization are

$$\frac{\partial \nu}{\partial \nu_1} = \frac{\partial TC}{\partial \nu_1} - \lambda\frac{\partial Y}{\partial \nu_1} = 0$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$\frac{\partial \nu}{\partial \nu_k} = \frac{\partial TC}{\partial \nu_k} - \lambda\frac{\partial Y}{\partial \nu_k} = 0$$

$$\frac{\partial \nu}{\partial \lambda} = y - f(\nu_1,\ldots,\nu_k|\nu_{k+1},\ldots,\nu_n) = 0$$

The first k equalities above may be restated as

$$\frac{\frac{\partial TC}{\partial \nu_1}}{\frac{\partial Y}{\partial \nu_1}} = \frac{\frac{\partial TC}{\partial \nu_2}}{\frac{\partial Y}{\partial \nu_2}} = \ldots = \frac{\frac{\partial TC}{\partial \nu_k}}{\frac{\partial Y}{\partial \nu_k}}$$

$\frac{\partial TC}{\partial \nu_i}$ is the marginal unit cost of the i^{th} input in the production of product Y (i.e., MUC_{ν_i}), and $\frac{\partial Y}{\partial \nu_i}$ is referred to as the marginal physical productivity of the i^{th} input in the production of Y (i.e., MPP_{ν_i}). Thus, when costs are minimized:

$$\frac{MUC_{\nu_1}}{MPP_{\nu_1}} = \frac{MUC_{\nu_2}}{MPP_{\nu_2}} = \ldots = \frac{MUC_{\nu_k}}{MPP_{\nu_k}} = \lambda$$

That is, at the point of optimal (least-cost) input combination, the marginal unit cost-marginal productivity ratio must be the same for each input. Since this ratio measures the amount of outlay per unit of marginal physical product of Y, the Lagrange multiplier, λ, can be interpreted as the marginal cost of production. The above condition then amounts to equating the marginal cost of each input subject to the output constraint.

For any given output, the least-cost combination of inputs and the output constraint equation can be used to determine the absolute amounts of each input to use. These values can then be "plugged" into the cost function to derive total cost of production for output Y given inputs fixed. In this manner, the total and also average (TC/Y) costs can be determined for a particular "plant". These cost curves may take several shapes. The conventional short-run cost functions are shown in Figures 8a and 8b below. Total costs for a time at a decreasing rate up to output OY_1 and then increase at an increasing rate. Average costs reach a minimum at output OY_2. Marginal cost reaches a minimum at the point of inflection and cuts average total cost at its minimum point.

The explanation of this behavior of the cost function lies in the law of diminishing returns. Because of increasing marginal productivities, equal additional increases in the amounts of variable resources will for a time result in successively larger units of total output produced. This means that total costs will increase at a decreasing rate. But when marginal productivities begin to decline as diminishing returns set in, additional amounts of variable resources will produce successively smaller units of output. Total costs will therefore increase at an increasing rate.

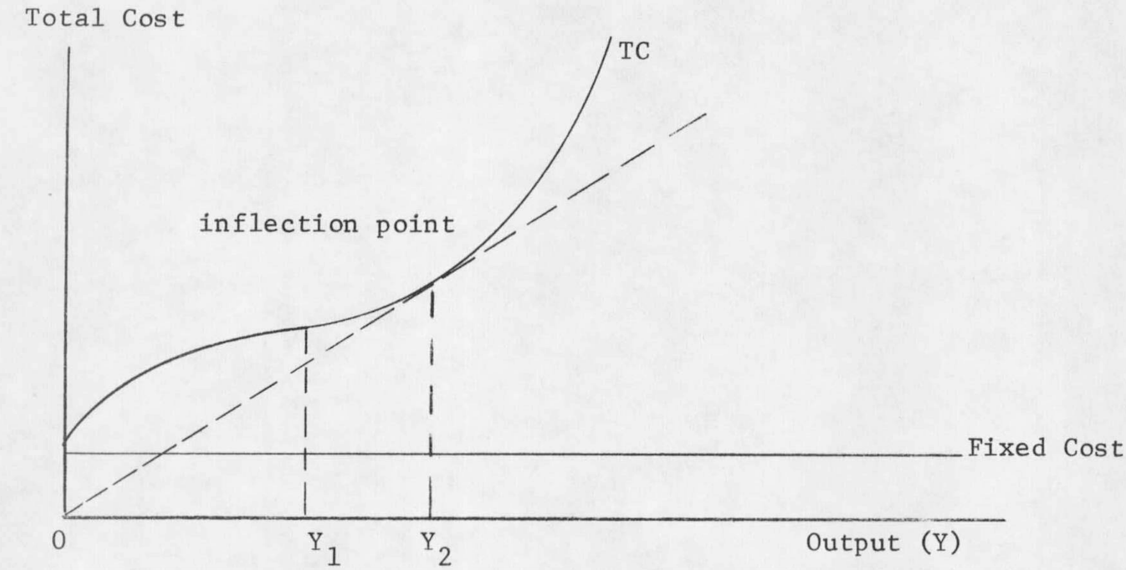

Figure 8a. Total Cost Curve.

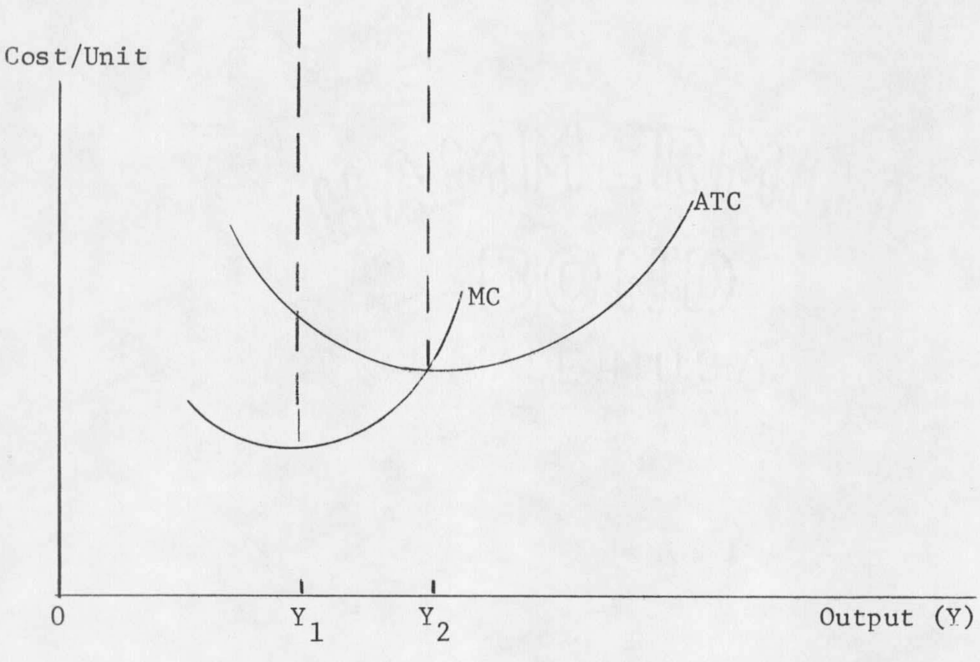

Figure 8b. Average Cost Curve.

Optimal Level of Output

The discussion of the preceding section sets forth the conditions necessary for minimizing the cost of a given level of output. Under conventional theory the optimal level of output is that which maximizes net revenue (π). Net revenue is equal to total revenue (TR) minus total cost (TC) and is maximized when

$$\frac{d\pi}{dY} = \frac{dTR}{dY} - \frac{dTC}{dY} = 0$$

or where marginal cost (MC) = marginal revenue (MR). Substituting for MC the equation for optimal level of output becomes

$$\frac{MUC_{\nu_1}}{MPP_{\nu_1}} = \frac{MUC_{\nu_2}}{MPP_{\nu_2}} = \ldots = \frac{MUC_{\nu_k}}{MPP_{\nu_k}} = MR$$

The above condition may also be rewritten as

$$\begin{aligned} MUC_{\nu_1} &= MVP_{\nu_1} \\ &\vdots \\ MUC_{\nu_k} &= MVP_{\nu_k} \end{aligned}$$

In verbal terms, this equation states that a necessary condition for the optimal level of output (i.e., profit maximization) is that the marginal unit cost of each factor be equal to its marginal value productivity.

Long-Run Cost Function

So far in the discussion, inputs $\nu_{k+1},\ldots,\nu_n$ have been held constant and considered to represent a fixed "plant". In contrast to the short-run where the plant is fixed, the long-run is defined as a period of time long enough to allow all factors of production to vary. If the heretofore constant inputs $\nu_{k+1},\ldots,\nu_n$ are allowed to vary over time an infinite number of fixed plants can theoretically exist. Correspondingly there will be an infinite number of cost curves. For convenience, only a few are shown in Figures 9a and 9b.

The long-run total cost curve (LRTC) shows the least cost at which any output can be produced after the firm has had time to make all appropriate adjustments in its plant size. The long-run cost curve does not intersect any of the short-run curves. It is tangential to those that allow minimum costs for each output. It is an envelope curve to the cost curves which are lowest for each particular output.

The total cost curves of Figure 9a are converted to the average cost curves of Figure 9b. The long-run average cost curve (LRAC) is derived in the same manner as the LRTC curve and is known as the economies of scale or planning curve. This curve is usually shown to have a U shape.

Economies of scale explain the downward sloping part of the LRAC curve. As size of plant increases, a number of considerations will for a time give rise to lower average costs of production. These are as follows:

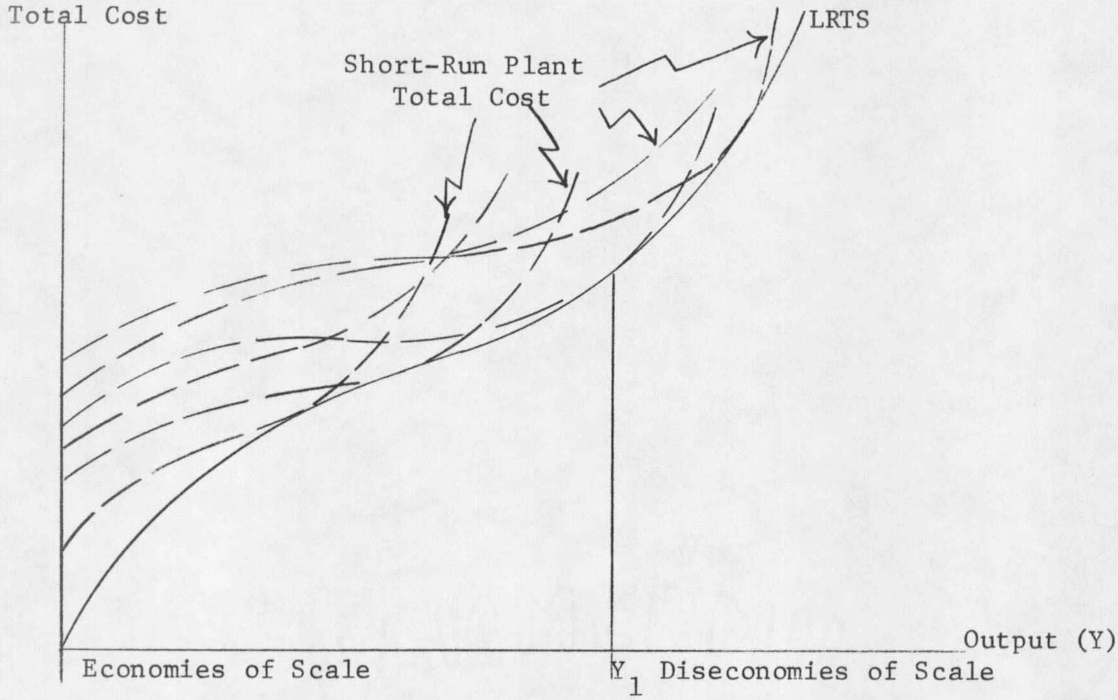

Figure 9a. Long-Run Total Cost Curve.

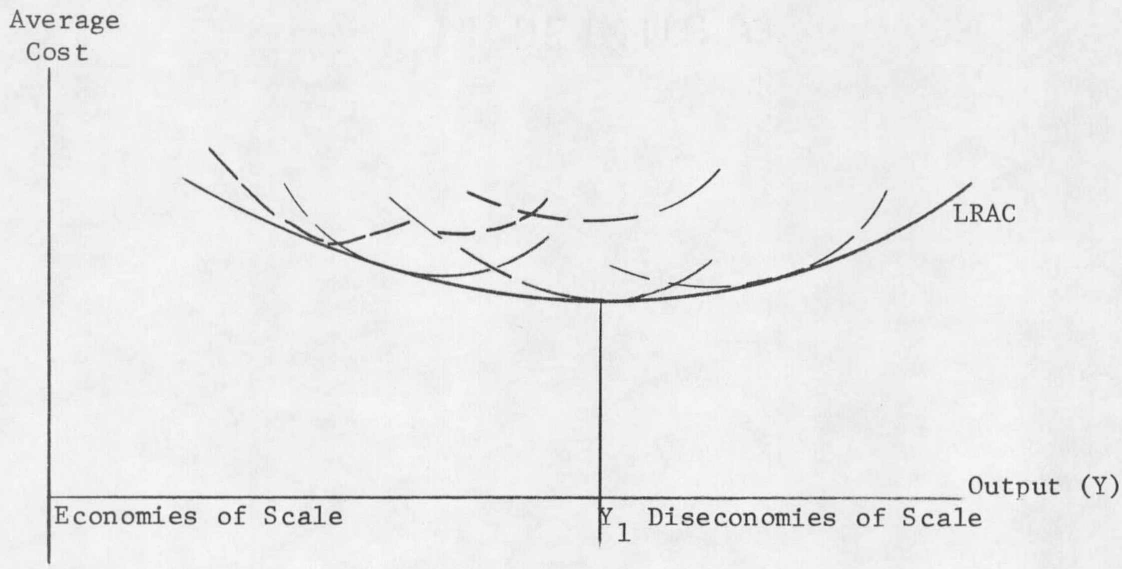

Figure 9b. Long-Run Average Cost Curve.

1. Increased specialization in the use of labor is feasible as plant size increases.

2. Large-scale production also permits better utilization of, and greater specialization in management.

3. Small firms are often not able to utilize the most efficient productive equipment. In many areas of production the most efficient machinery is available only in very large and extremely expensive units. Also, effective utilization of this equipment demands a high volume of production.

4. Larger plants through large-scale purchasing may experience certain "pecuniary" economies. That is, purchase inputs at relatively lower prices because of volume buying.

In time the expansion of the firm will give rise to diseconomies of scale usually "attributed to the increasing difficulties faced in coordinating and managing firm operations and increasing procurement and product selling costs (due to transportation, etc.) as plant size increases." 14/

Short-Comings of Conventional Theory

Linear Cost Curves Resulting from Variations in the Time Dimension

The conventional theory, by assuming a timeless production function, overlooks the fact that plant output may be varied either through a

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14/ Litschauer, J. G., "The Economies of Determining Plant Efficiency and Economies of Scale within the Poultry Feed Milling Industry," unpublished research essay in agricultural marketing, University of California, Berkeley, September 1965, pp. 7-9.

variation of rate or time of operation. If rates of plant output are held constant and total output varied by varying time of operation, marginal costs will be constant and the total cost function linear. This will hold true even though the cost function is curvilinear in the rate dimension. This situation is illustrated in Figure 10. Factor prices are assumed to be constant.

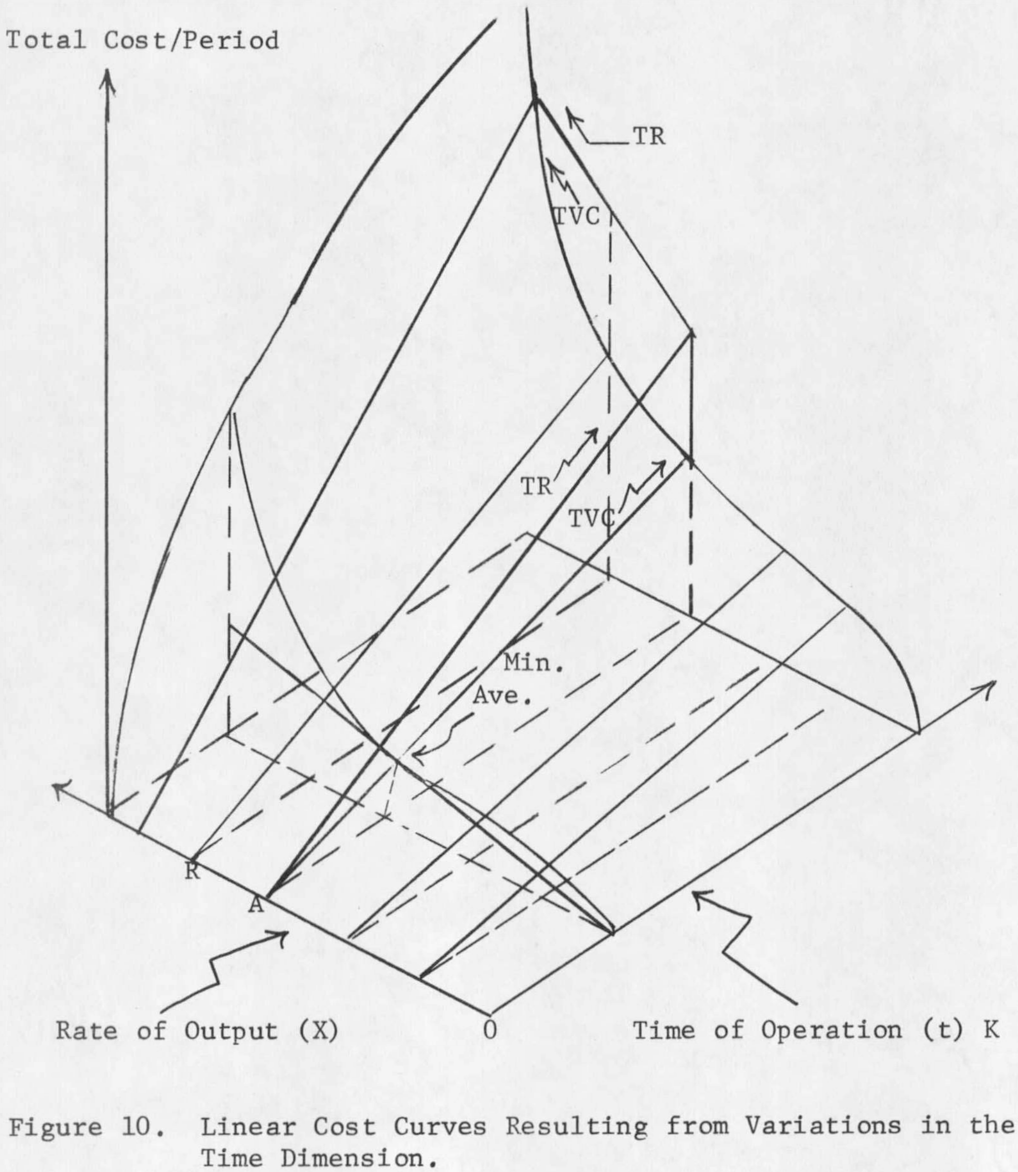

Figure 10. Linear Cost Curves Resulting from Variations in the Time Dimension.

The cost surface in the rate dimension has the conventional form and represents the least-cost combination of productive services. The surface is linear in the time dimension for any rate of output (x). K represents the total units of time available in the period. If product price (P) is greater than minimum AVC, the plant should operate at the minimum AVC rate of output (x), which is OA and expand output along the time dimension for the full amount of time, K, available. The relationship between TR and TVC is shown in Figure 10. When total time available, K, is reached, additional output can result only from increases in the rate of output (x). It would then pay the plant to increase the rate of output until MC = MR. In Figure 10, this is assumed to occur at rate of output OR. 15/

Linear Cost Curves Resulting from Segmentation

The explanation of the behavior of the conventional cost functions (the inverted S total cost function and U-shaped average cost functions), lies in the law of diminishing returns which requires that marginal productivities first increase and then decrease. Successive uses of identical machines and successive addition of workers to perform identical jobs with no real intensification on a fixed factor or changes in the proportions of inputs may, however, result in constant marginal productivities or a linearly homogeneous production function. The resulting total cost function will tend to be linear.

15/ For a more complete coverage of this concept, see French, B. C., L. L. Sammett, and R. G. Bressler, *op. cit.*, pp. 557-572.

Discontinuous Cost Functions

Conventional theory fails to mention the possibility of discontinuous cost curves. A cost function which is linear in the time dimension may also be discontinuous if input costs are not constant. Labor, for example, is usually paid a premium for overtime work. As a result the cost curve in the time dimension may appear as below in Figure 11. At time t_1 the firm is required to pay time and one-half and at time t_2 double time premiums.

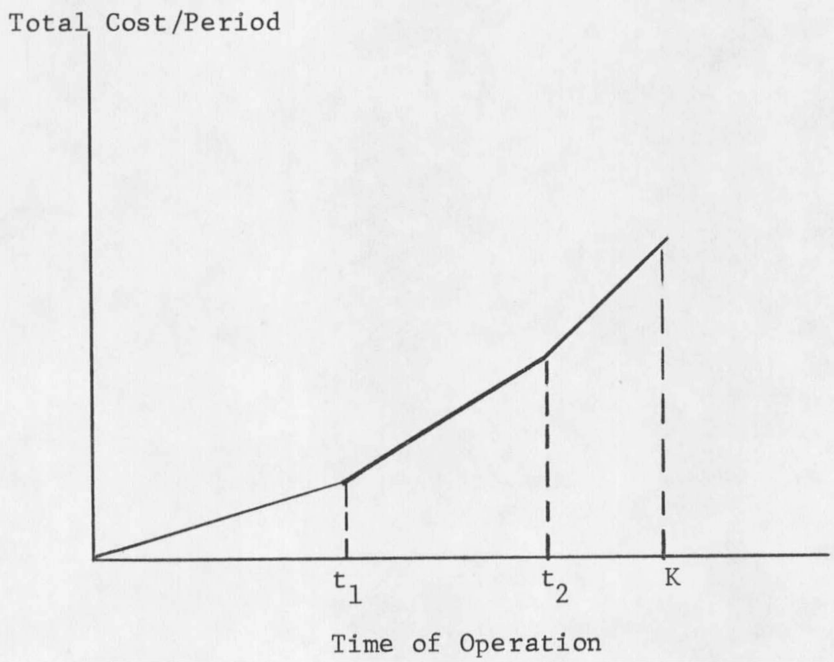

Figure 11. Effect of Overtime Premium on Total Cost Curve.

The firm may experience some discontinuities in its cost function in the rate dimension when employing additional, identical production lines. These discontinuities may result "if there is some 'fixity' in the 'variable cost components' that can in truth be avoided by not operating the additional lines." 16/ This cost may take the form of preparing certain equipment for operation. Cost functions of this type are shown in Figures 12a and 12b.

In Figures 12a and 12b, C_1 designates the output capacity at the limit of the time dimension for production line one, while C_2 designates the output capacity at the limit of the time dimension for production lines one and two. FVC is called a "fixed-variable cost" associated with bringing an additional line into production.

In many cases the variable inputs associated with a durable factor can only be varied in discrete units. The input-output relationships then may appear as a series of discontinuous steps. This is shown in Figure 13a. One discrete unit of the input could produce any output from zero up to Xa. The second discrete unit combined with the first could produce any output from zero to Xb. Three discrete units could produce any output from zero to Xc, etc. In this case, the shaded areas above the sloping line through the origin represent unutilized capacities for the particular discrete units. The average cost curves corresponding

16/ Litschauer, op. cit., p. 20.

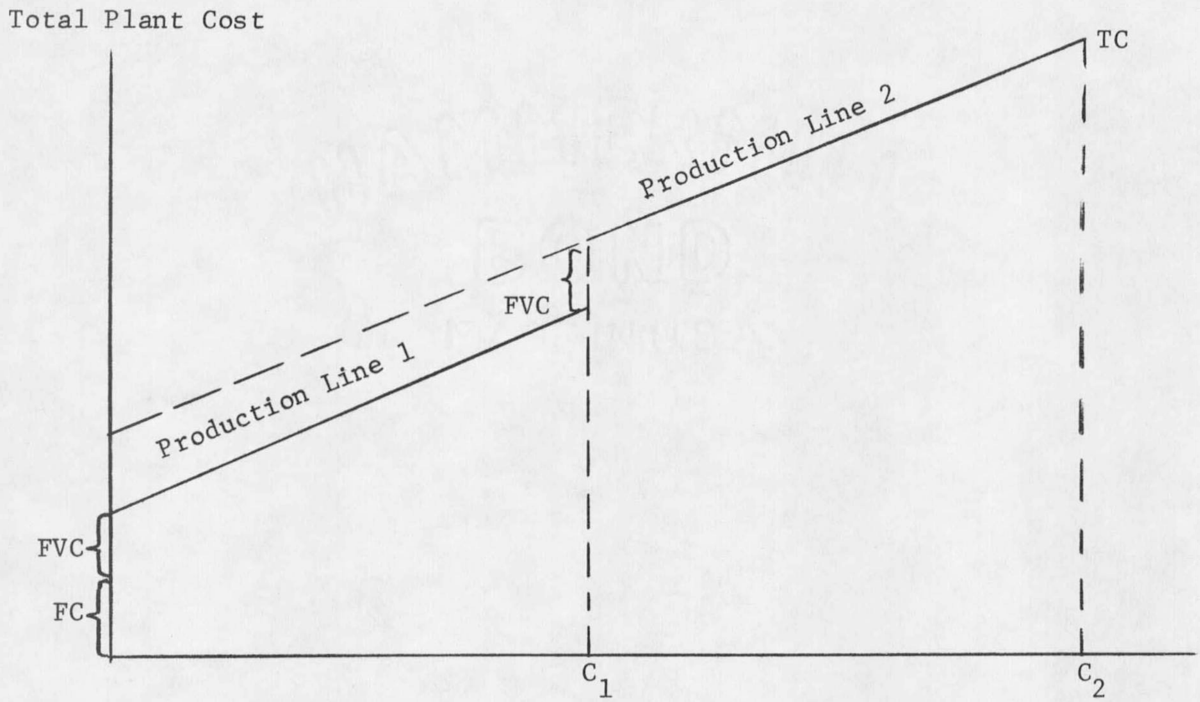

Figure 12a. Total Cost Function for a Plant Operating with Two Production Lines in the Time Dimension Only.

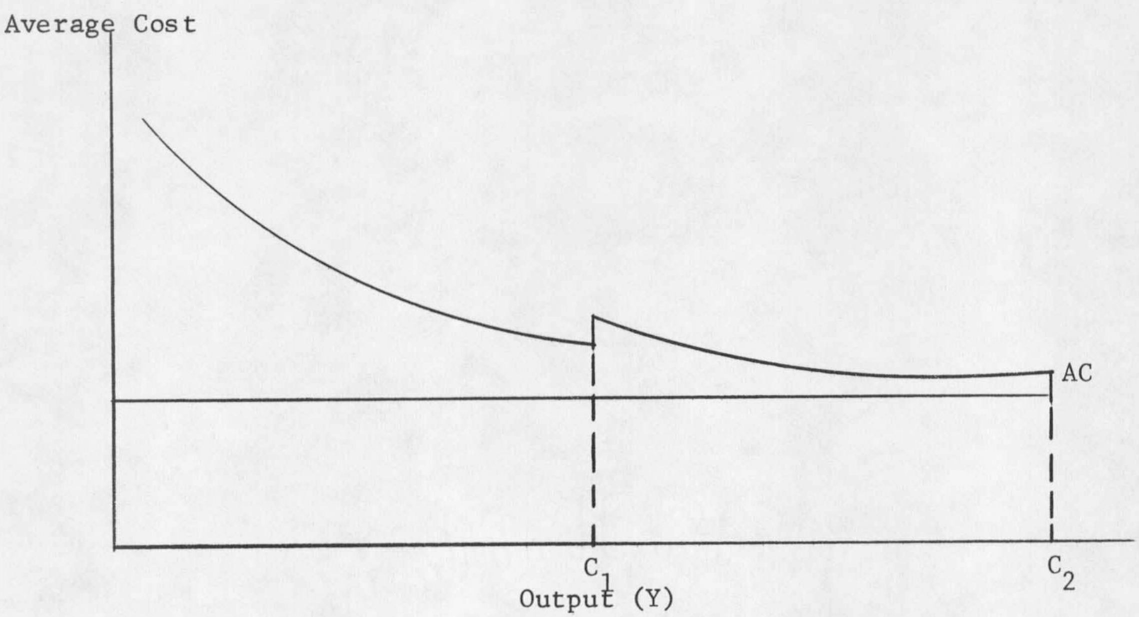

Figure 12b. Average Cost Function Corresponding to the Total Cost Function of Figure 12a.

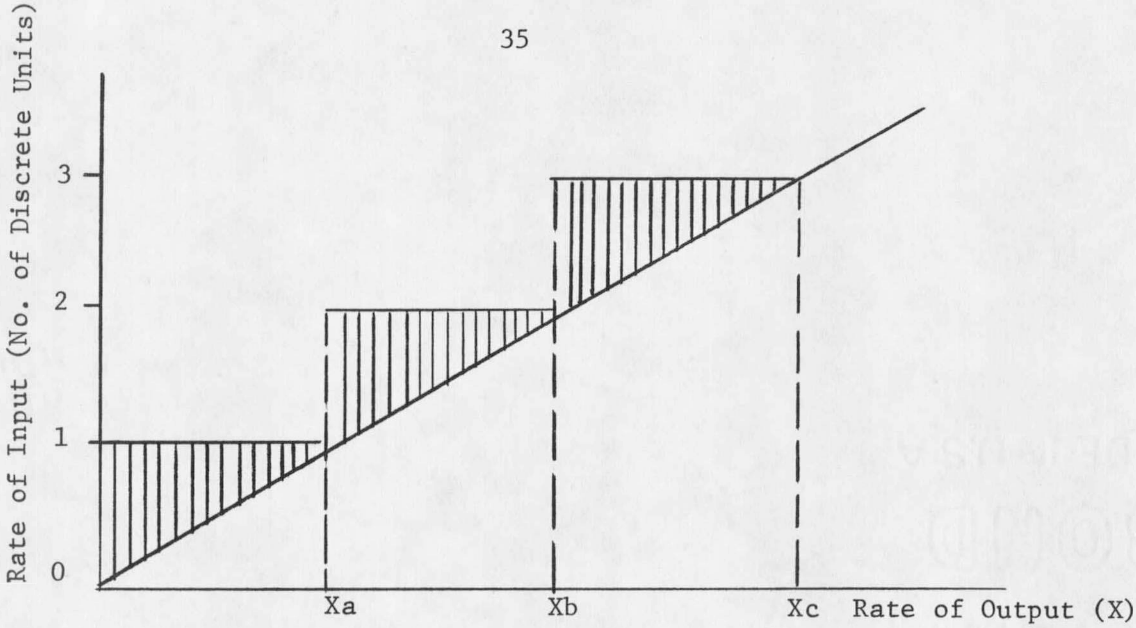

Figure 13a. Discontinuity in Total Input-Output Relationships.

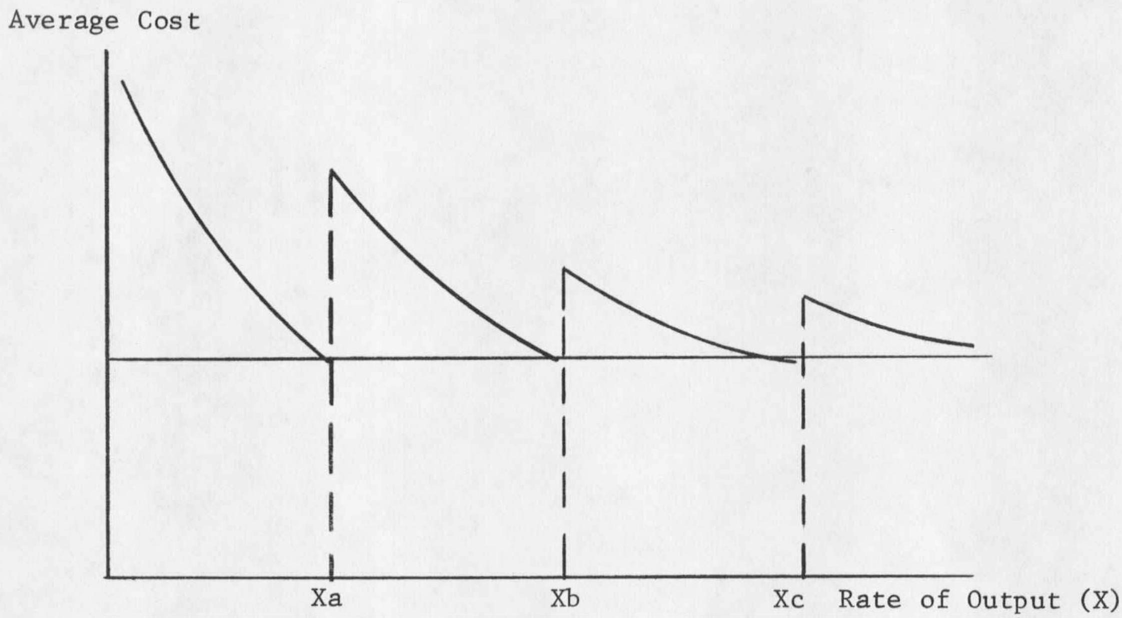

Figure 13b. Average Cost-Output Relationships Corresponding to Total Input-Output Relationships above.

to the total cost curves for this type of relationship are shown in Figure 13b. These average cost curves become discontinuous at capacity rates of output and reach a minimum at the same level when each discrete unit of input is utilized to capacity.

Long-Run Cost Functions from Linear Short-Run Cost Functions

It is theoretically possible to have economies and diseconomies of scale with straight-line total cost curves.

Figure 14 illustrates a long-run total cost curve drawn to short-run cost curves (linear) subject to capacity constraints. Points a, b, c, d, and e on the planning curve are determined by the effect of plant capacities Y_a, Y_b, Y_c, Y_d, and Y_e on the relevant short-run cost functions. The long-run total cost curve shown here is curvilinear but it is also possible for it to be linear.

The Problem of Durables

Conventional theory makes no assumptions concerning the nature of the factors "held fixed" in defining a plant. In a plant, these fixed factors are durable capital goods such as buildings and equipment. A durable factor contributes to production during several periods. The two major problems associated with a durable good are (1) measuring the amount of the durable good "used up" during any given production period and (2) establishing the "price" to be applied to such use. Bressler 17/

17/ Bressler, R. G., "Efficiency in the Production of Marketing Services," Soc. Sci. Res. Council. Project in Agr. Econ., Econ. Efficiency Paper No. 6, University Paper No. 6, University of Chicago, p. 14.

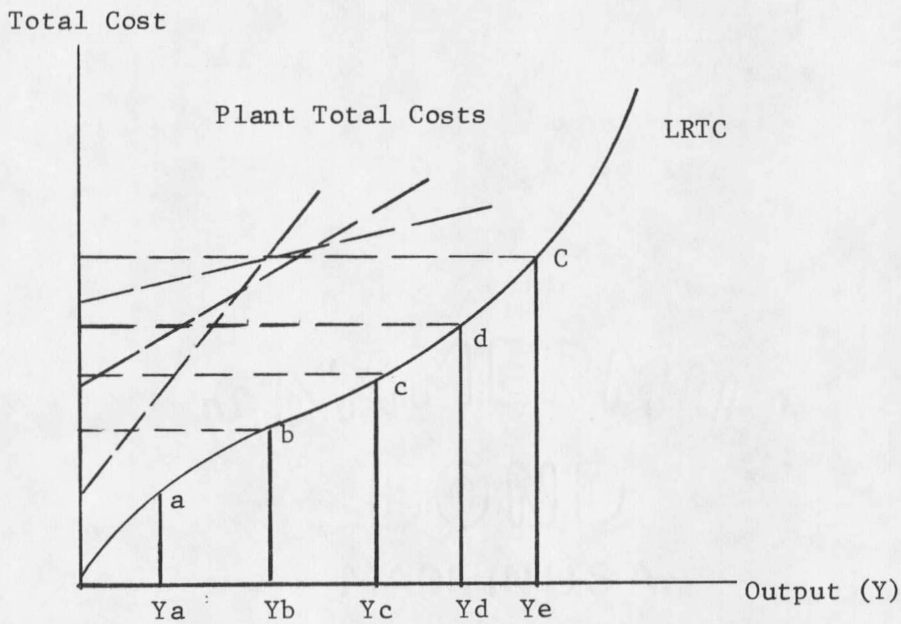

Figure 14. An Illustration of Long-Run Economies and Diseconomies of Scale Due to Capacity Constraints on the Individual Plant.

points out:

> It seems that over the useful life of the capital good these prices multiplied by the inputs or use must aggregate enough to repay the original investment, pay interest on capital including a return for risk, and keep the equipment in a useful state of repair. In addition, government services are financed in part by property taxes levied on the basis of some valuation of these investments, and these are costs that also must be covered. To summarize, the capital goods give rise to certain 'fixed' costs, including depreciation, interest, insurance (part of risk payment), repairs, and taxes.

The decision to invest in a capital good is determined by whether the present value of the expected net returns plus salvage value exceeds the purchase price of the machine. These expected net returns are referred to as the "quasi-rents" (ν_t) of the capital good for the periods under consideration. The present value (V) is given by the equation:

$$V = \frac{V_1}{(1+r)} + \frac{V_2}{(1+r)^2} + \ldots + \frac{\nu_n}{(1+r)^n} + \frac{S}{(1+r)^n}$$

where r is the rate of interest and S the salvage value.

There is considerable uncertainty involved in the calculation of the quasi-rents. Determination of the least-cost combination of inputs requires that a total cost function be projected for each period. Calculation of optimal output further requires that average revenue curves be projected for each period. For these and other reasons it is difficult to relate this approach to real-life problems. For practical purposes, it is considered adequate if the sum of the discounted quasi-rents and salvage value of the durable is sufficient to offset the sum of the "fixed" costs per period over the useful life of the durable. That is for any given period the fixed costs may exceed, be equal to or be less than the discounted quasi-rents for that period. However, the sum of the sum of the quasi-rents must exceed the sum of the fixed charges.

Most of the depreciation costs are a function of time. Therefore, they may be expressed as a constant for each time period. This is the reason for the use of "straight-line" depreciation over the expected useful life of the asset.

The Nature of Alfalfa Dehydration

Activity within plants usually consists of an integration and aggregation of many different operating stages. Bressler, Sammet, and French 18/ define a stage as consisting of all productive services--durable or nondurable--that cooperate in performing a single operation or a group of minor but closely related operations. The various stages are connected by transportation links. Transportation links are of two types--within stage and between stage. Within-stage transportation may be considered as part of the operations of the stage itself. In a sense, between-stage transportation is a stage itself in which the only operations performed are to move the product from one place to another.

Two types of storage occur within a plant. Temporary storage between the various stages plays an important role in coordinating and levelling out the flow of materials and products through the plant. Materials may

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18/ Bressler, R. G., L. L. Sammet, and R. G. French, op. cit., p. 545.

be received at irregular intervals and yet a fairly continuous flow through the plant maintained by feeding into and withdrawing from temporary storage. There is also the storage required to store production in excess of demand or production withheld from the market in anticipation of favorable price changes. A plant process flow diagram for alfalfa dehydration is shown in Figure 15. The mechanics of alfalfa dehydration is given in more detailed treatment in Chapter III.

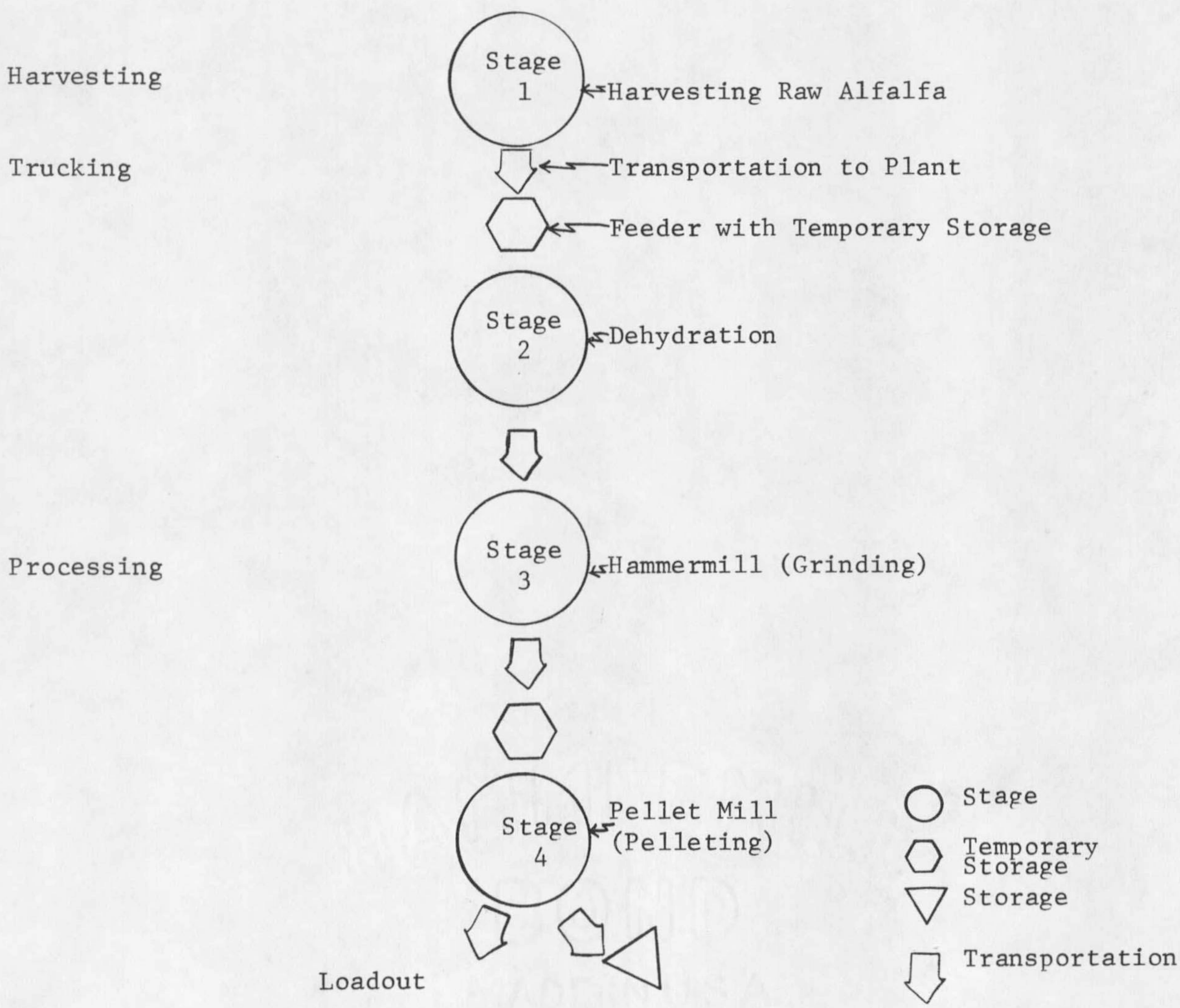

Figure 15. Plant Process Flow Diagram for Alfalfa Dehydration.

Hypothetical Cost Functions for Alfalfa Dehydration

Figure 14, page 37, illustrated a long-run total cost function drawn to short-run linear cost curves subject to capacity limitations. The long-run total curve was drawn as a continuous curve and, therefore, assumed a continuous range of plant capacities was available. In alfalfa dehydration plant capacities are generally varied in discrete units. This implies that the long-run total cost function may appear as a series of discontinuous steps as shown by the heavy lines in Figure 16a. The smallest size plant could be used to produce any output up to Y_a, the next larger plant any output Y_b, etc.

In alfalfa dehydration the labor inputs tend to be associated with durable factors in fixed proportions. That is, plants have "fixed station" jobs where tasks require a minimum of one worker regardless of output rate. Other inputs, such as fuel and power, tend to vary directly with output. These input characteristics would tend to give the short-run average cost curves the shapes shown in Figure 16b, i.e., downward sloping and reaching a minimum at capacity. Long-run average costs are indicated by the heavy lines. Figure 16b is for illustrative purposes and not meant to imply that economies of scale exist in alfalfa dehydration.

With an average cost-average revenue relationship such as that shown in Figure 16b it would obviously pay an alfalfa dehydration firm to build a maximum size plant and operate it at capacity for the maximum number of

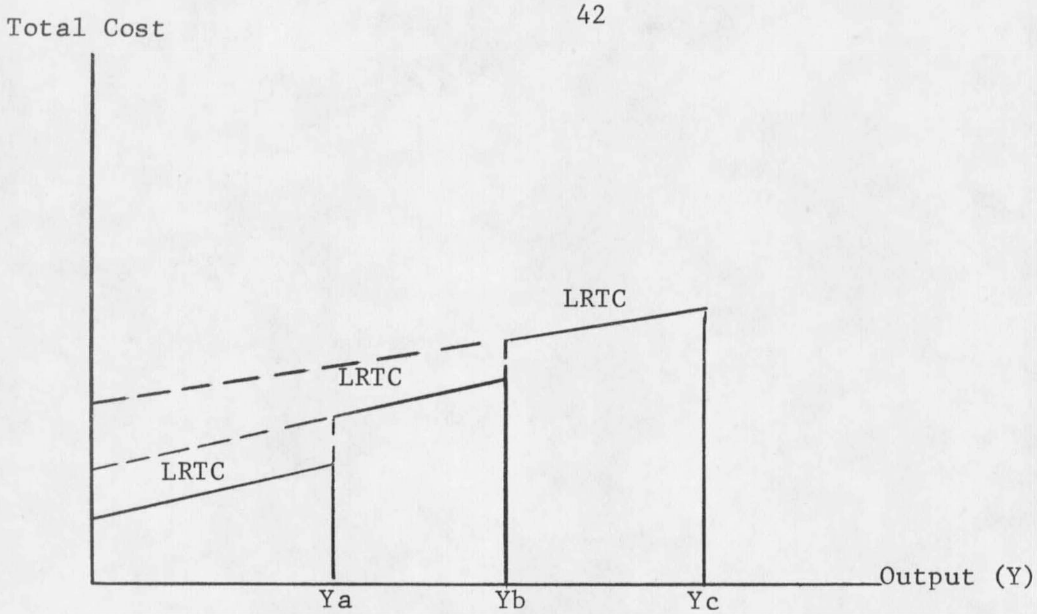

Figure 16a. Discontinuous Long-Run Total Cost Function Resulting from Discrete Variations in Plant Capacities.

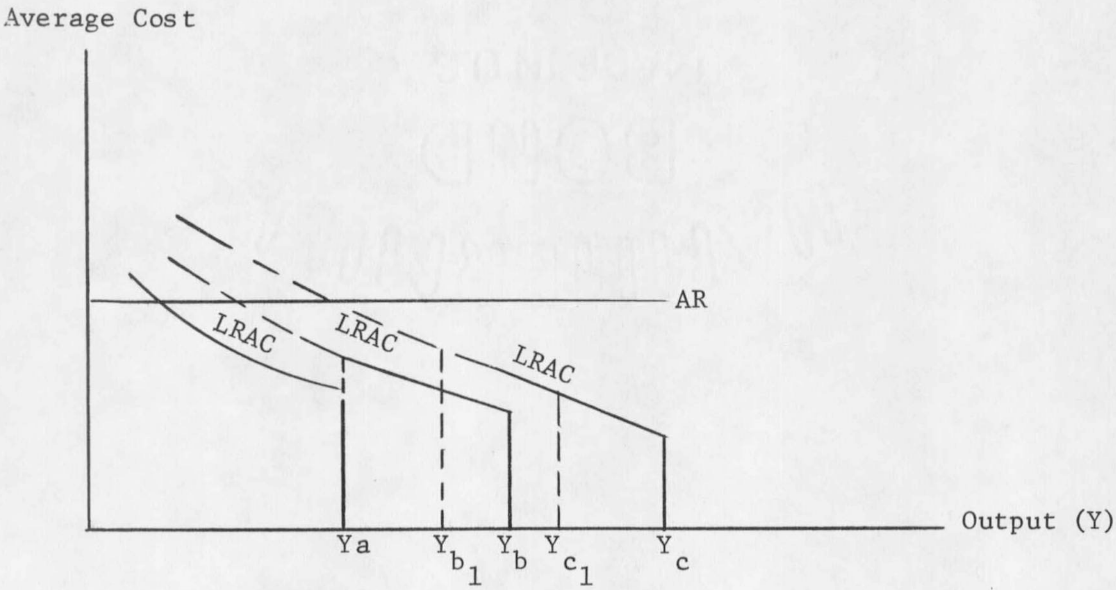

Figure 16b. Discontinuous Long-Run Average Cost Function Resulting from Discrete Variations in Plant Capacities.

hours possible. There are, however, institutional restrictions which prevent the firm from doing this. The available supply of alfalfa may be such that maximum output will be Yb_1 and plant b cannot be operated at capacity. In addition the length of harvest season imposes a restriction. The season may be so short as to not allow plant b to attain volume Yb_1. In this case, a plant of size c would need to be built.

Cost Analysis Using Cost Accounting and Output Data

Previous studies of alfalfa dehydration have used accounting cost and output data to show that differences in production costs among plants were inversely related to annual production volume. These studies failed to ascertain whether the variation in annual volume among plants was due to variation in hours of operation, variation in rate of output, or variation in plant size.

In this study accounting cost and output data are used in an attempt to determine whether differences in production costs among plants are due to variations in rate of output or variations in plant size. The approach is to hold constant variations in the time dimension by calculating hourly output and then examine to what extent production costs vary with differences in daily output (a variation in the rate dimension) for various plant sizes. This approach is used for each type of cost (i.e., labor, fuel, power, etc.) in order to observe individual cost behavior with respect to variations in output and plant size.

Advantages and Disadvantages of Using Accounting Cost and Output Data

Some of the advantages of using accounting cost and output data are (1) the general availability of data, (2) relatively low research cost, and (3) the reflection of real-world operating conditions.

Cross-sectional data are employed in this part of the study. Some of the problems encountered in using this type of data are as follows:

1. Accounting records between firms are not completely homogeneous. Thus, "book values" of plant and equipment differ because of different purchasing locations and/or different times of purchase. Depreciation is charged differently by different firms. Insurance rates, taxes and interest payments vary among localities. The quality of buildings and equipment may render "book values" useless. Finally accounting records are manipulated in different ways to ease the firm's tax burden.

2. Plants in a cross-sectional analysis usually operate in different environments. Hence the conditions under which they operate differ, techniques of production vary, input prices may vary among plants and different products may be produced.

3. Each observation gives only one output level and does not provide the position of each plant on its short-run cost curve. Thus, it would be possible to estimate the long-run average cost function accurately only if minimum cost plants are observed for each output. This is unlikely to occur.

Cost Synthesis Method of Analyzing Plant Costs

Plant cost synthesis begins with the determining of input-output relations for the various stages of production. Appropriate prices are applied to arrive at stage cost-output relationships that provide a fundamental basis for comparing the costs of alternative technologies. The synthesis (or development) of a long-run cost function from the various stage cost functions is a case of aggregating the individual stage cost-output relationships. If there are alternative technologies available at various stages that combination of technologies at each rate of output that gives a lower total cost than any other combination must be found. In this manner an "internally efficient" plant cost function is derived. This synthetically efficient plant can then be used for comparison purposes with actual plant costs in the industry and also to estimate an economies of scale curve for the industry. Also cost estimates obtained with this method may be adjusted for varying conditions in individual plants and for variations in prices of inputs.

The disadvantages of the cost synthesis method are (1) that in many cases it is time consuming and quite costly, (2) that the great deal of simplification involved in most cost synthesis studies (use of correct logic should hold error to a minimum), and (3) the extreme difficulty of obtaining statistical proof of results.

Cost Synthesis in Alfalfa Dehydration

The problem associated with the use of cost accounting data and output data prompted the inclusion of the cost synthesis method of production cost analysis as a supplement to the method discussed in the previous section. The cost synthesis method can be used to derive an economies-of-scale curve and the results compared with the implications derived from the results of the analysis of accounting cost and output data. It is also felt that this approach will enable the determination of optimal plant size and hours of operation given the supply of alfalfa in what is considered as economical hauling distance of the plant. The input-output relationships for the various stages of production in alfalfa dehydration are such that there is little additional research cost involved in employing cost synthesis as a method of analyzing production costs.

Methods of Estimating Costs in Alfalfa Dehydration

Labor

In alfalfa dehydration, all stages of production have "fixed station" jobs where the tasks to be performed require a minimum of one worker regardless of output rate. Some qualification is necessary here. Referring to Figure 15, page 40, the flow from feeder through to loadout or storage is automated and requires no human handling. There are then essentially three stages of production--harvesting, trucking, and processing. Labor requirements in each stage vary discretely according to capacity. For example, smaller size plants may require one operator at the processing stage, regardless of output, and larger plants two or three. It is, therefore, felt that plant payroll and output records along with the economic-engineering approach of detailed description of plant operations will suffice here as a method of determining labor input-output and labor cost-output relationships.

Materials

All materials used in alfalfa dehydration are contained in the final product. Alfalfa growers are paid on the basis of tons of dehydrated alfalfa produced from the raw alfalfa supplied. In order to determine raw material cost it is only necessary to obtain unit prices paid to growers. Additives also enter into the final product in some cases, but are in fixed proportion to output and, therefore, present no difficulty in determining their cost.

Fuel

Fuel used in alfalfa dehydration is natural gas used to fire the furnaces of the drying drum. There are three sources of fuel cost estimates. Plant accounting records are one source of fuel cost estimates. Manufacturers of equipment often provide estimates of fuel consumption which combined with fuel costs obtained from utilities companies provide an estimate of fuel costs involved in alfalfa dehydration. The third source is somewhat more complicated and involves a physics formula for determining the amount of natural gas required to evaporate a given amount of water. Knowing the evaporative capacity of a drying drum and the moisture content of the raw alfalfa enables determination of fuel consumption for a given amount of dehydrated alfalfa production.

Power

Either engineering estimates of power consumption for plant capacity or plant accounting records may be used to estimate power costs.

Gas and Oil

Gas and oil is used primarily by the field harvestors and the trucks. Estimating gas and oil costs presents a considerable problem. Plant accounting records are one source, but usually there is no breakdown of these costs between the harvesting and the trucking operation. Gas and oil costs also tend to vary not only with differences in prices between areas, but also with distance travelled from field to plant, types of roads and alfalfa yields.

Miscellaneous Supplies and General Expense

Data on these expenses are obtained primarily from plant accounting records. Miscellaneous supplies include such items as paper, pencils, staplers, etc. The quantities of these items used may be a function of plant size but have little relation to rate of output. General expenses include licenses, donations, dues, etc. These expenses are usually a very small part of the overall cost picture.

Administrative Costs

Administrative costs consist of the salaries of managers and executives. Accounting records are usually used to estimate these costs.

Separation of salaries from profit is sometimes difficult. There is a problem in allocating administrative costs to different plant functions. It is likely that this allocation will be highly arbitrary.

Durable Goods

There are three main sources of data used to estimate the cost of durable goods: (1) plant accounting records; (2) engineering-architecture estimates of buildings and equipment; and (3) data supplied by manufacturers of equipment and buildings. Two types of durables are considered in a cost synthesis study. Durable goods such as machines, which are used in a particular stage and whose costs are directly integrated into the stage costs. Durable goods such as buildings housing the plant which are not connected with any one stage and whose costs are aggregated to the total stage cost function to obtain the total cost function. Problems involved in estimating the cost of durables are determining correct depreciation rates and book values.

Sampling

The sample was selected to cover a range of plant sizes from which to develop basic cost standards. Plants were chosen on the basis of judicial selection. No attempt was made to design the sample in a manner that would be statistically representative of average conditions throughout the industry.

In order to develop an analysis of economies of scale the sample, it was felt, should be selected according to size. It should include (1) range of scale, (2) efficient plants, and (3) homogeneous output.

The major portion of the sample was drawn from the three-state area of Colorado, Kansas, and Nebraska. The alfalfa dehydrating industry is concentrated in these states and the area is compact enough to be compatible with the limited budget of the project. In order to include all forms of legal organization and recently established firms in the sample, firms in Idaho and Minnesota were interviewed. Interview schedules for three cooperative plants in Ohio were obtained by Mr. Charles Reed of the Farmers Cooperative Service.

There are 16 firms organized as either corporations or partnerships in the sample. Five of these were established after 1961. There are four cooperatives in the sample, one of which was established after 1961. Location, legal organization, and whether established after 1961 of each plant in the sample are shown in Figure 17.

Preliminary Research

Published literature and other information available from universities, manufacturers, marketing agencies, trade associations, and other sources on alfalfa dehydration was assembled and reviewed in order to gain familiarity with the subject, discover results already obtained and learn of the methods used to obtain them. Interviews were held with representatives of selected dehydrating equipment companies, feed

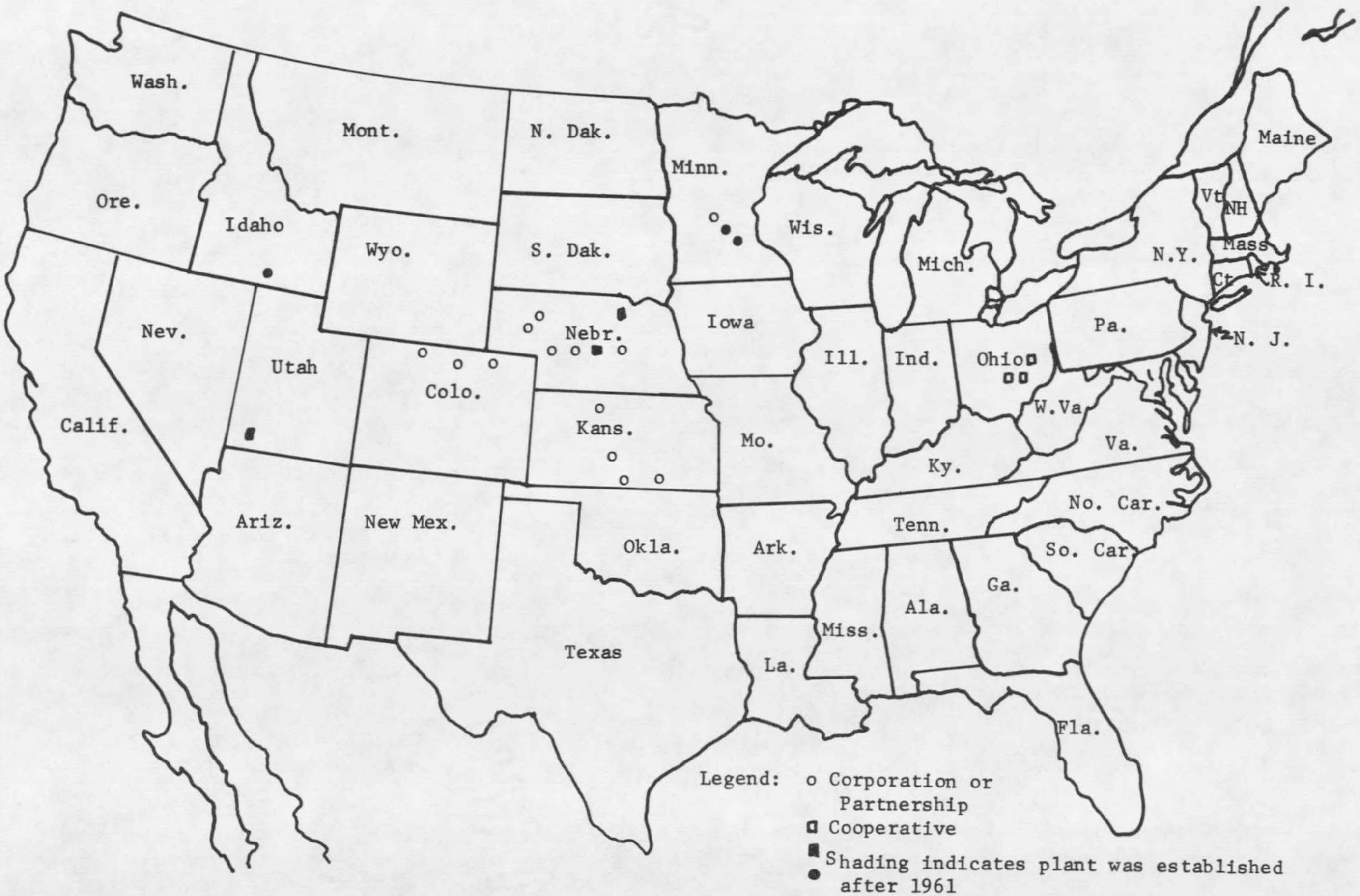

Figure 17. Location, Organizational Structure of Plants in the Sample and Whether Established After 1961.

manufacturers, brokers or commission agents, the American Dehydrating Association, and selected land grant universities.

Source of Data

The primary source of data was from questionnaires completed at selected alfalfa dehydrating plants. Data on equipment costs were obtained from manufacturers. Secondary data were obtained from previously published literature on alfalfa dehydration and publications of the United States Department of Agriculture.

CHAPTER III

FACTORS IN ALFALFA DEHYDRATION

Plant Location

The first requirement for an alfalfa dehydrating plant is that there be available throughout the operating season an adequate, consistent alfalfa supply. The source of supply must be within an economical hauling distance of the plant. Persons interviewed in this study were asked why they established an alfalfa dehydrating plant in the present location. In four cases, the present management had purchased the plant from previous management and could not answer the question. Of the remaining plants, 15 gave the availability of raw alfalfa as a reason for establishing their plants at the location chosen.

Two of the other three plants were established by farmer groups in dehydrated alfalfa producing areas who wanted their own processing facilities. The availability of raw alfalfa is implied. The third plant was established through the combined effort of a local Industrial Development Corporation and a person with considerable experience in the production of dehydrated alfalfa who wanted to locate in the area. This experienced dehy-man had assured himself that an adequate supply of alfalfa was available.

In addition to the availability of alfalfa, several other reasons for establishment were given. In two cases there had been a group interested in establishing a plant, but natural gas was not available. As soon as a gas line was laid in the area, a plant was established. One plant visited had originally been part of a chain of dehydrating plants established by a family with natural gas interest to provide a summer market for natural gas. Another plant was established because a plan by one farm operator to set up a small drum for his own use generated enough interest to allow expansion into a commercial venture.

Local market potential was a factor in the establishment of several plants. Location with respect to market is an important factor. Is there a local market for the product and if not, is the geographic location of the plant such that it can compete in the markets of the major producing areas?

If the supply of raw alfalfa within an economical hauling distance is considered adequate, the dehydrating plant should be located on a rail siding. Location on a rail siding allows automated delivery of the product to a railroad hopper car for transportation to market. Unless all sales are delivered locally by truck, a plant located away from a rail siding must absorb the additional costs of trucking to a rail siding. Raw alfalfa is three or four times as heavy and much bulkier than the dehydrated alfalfa pellets. Therefore, if there is no rail siding, favorably located with respect to the raw alfalfa supply available, the cost of transferring pellets to the rail siding may be less than the additional costs of hauling raw alfalfa which would have been incurred had the plant been located on a rail siding. In such situations, location toward the raw material source should take preference over location on a rail siding.

Of 20 plants interviewed, 5 were not located on a rail siding. One of these delivered all of its pellets by truck--either to local sales or to feed plants of the parent organization. Another sold 75 percent of its product to truckers as backhaul. The three others trucked most of their pellets to a rail siding and felt it was a disadvantage not to be located on a rail siding. In the case of four of these five plants a railroad siding favorably located with respect to the raw alfalfa supply was not available. Therefore, they felt it was to their advantage to strategically locate their plant sites in the area from which they would derive their raw alfalfa supply and, if necessary, truck the dehydrated alfalfa pellets to a rail siding.

The dust produced during the dehydration process possesses an odor that is unpleasant to many people. The settling of this powdery dust over a community adds to the difficulty in maintaining cleanliness. There is available a process that collects this dust so that it will not lend itself to air pollution problems for the community. However, it has not received popular acceptance. Consideration still should be given to a location downwind from the community, a location in the open country, or both. Other factors to be considered in choosing a plant site are fire protection, fire insurance rates, and taxes.

Raw Material

Requirements

Acreage requirements for a plant of given capacity can be estimated by the moisture content of the raw alfalfa and the yield per acre measured in tons of dehydrated alfalfa produced. Dehydrated alfalfa production for a drum of given capacity can be found by the formula 19/

$$Y = L(1-r) \div r-t$$

where Y = production per hour of dehydrated alfalfa

L = capacity of drying drum in pounds of moisture evaporated per hour

r = moisture content of raw alfalfa

t = moisture content of dehydrated alfalfa

For example, assume

Y = production of dehydrated alfalfa

L = a drying drum with evaporative capacity of 9,000 pounds per hour

r = raw alfalfa moisture content of 70 percent

t = dehydrated alfalfa moisture content of 10 percent

$$Y = 9{,}000\ (1-.70) \div (.70 - .10)$$

$$Y = 9{,}000\ (.30) \div (.60)$$

$$Y = 2{,}700 \div .60$$

Y = 4,500 pounds of dehydrated alfalfa produced per hour

If the plant operates on a 24-hour day, daily production is 178,000 pounds or 54 tons (24 x 4,500). If the plant operates 100 days, seasonal production is 5,400 tons (54 x 100). If yields average three tons per acre then the acreage requirements for this plant are estimated at 1,800 acres (5,400 ÷ 3).

19/ Derivation of formula used is shown in Appendix A.

The Supply Area

Alfalfa dehydration plants are closely tied to the fields from which they obtain their supply of raw alfalfa. Raw alfalfa is three to four times as heavy and many times as bulky as the dehydrated pellets. In this way it is a transportation sensitive item--high in weight and bulk and low in value. Cost of transporting it to the dehydrator restricts the area from which it may be obtained. As distance from the plant increases fuel, maintenance, and repair costs increase. As time required for transportation increases, more men and equipment are required to maintain the flow of raw alfalfa to the plant.

The time factor is also important in another respect. The primary reason for dehydrating alfalfa is nutrient preservation. Buyers associate the nutritional value of dehydrated alfalfa with its carotene or vitamin A content. Carotene loss is greatest just after the alfalfa is cut and this loss is a factor in keeping the elapsed time between cutting and drying to a minimum.

Reed, in 1958, found that over the United States as a whole, 60 percent of the acreage cut for dehydration was harvested within five miles of the plant and 90 percent within 10 miles of the plant. 20/ Schrenk, et. al.

20/ Reed, Charles E., et. al., Marketing Dehydrated Alfalfa, Agricultural Marketing Service, Market Research Division, USDA, Marketing Research Report No. 254, July 1953, p. 26.

in 1959 found plants to seldom drive more than 10 miles for their alfalfa. 21/ Rickey in 1956 found few plants obtained their alfalfa beyond a radius of 20 miles and usually obtain most of their alfalfa within 5 miles of the plant. 22/

Table II contains acreage distribution for acres harvested by plants in this survey. Fifty-four percent of all acreage was harvested by plants within 5 miles of the plant and 92 percent within 10 miles of the plant. Plants with large production volume travelled no farther for their alfalfa supply than small volume plants. It would therefore seem that one of the factors determining the amount of dehydrated alfalfa which can be produced profitably is the supply of raw alfalfa within approximately a 10-mile radius. However, it is possible to go further in locations such as California where alfalfa is produced the year-round allowing for greater utilization of equipment. Plants with such characteristics were not included in this survey.

Several factors are involved in the determination of how far a plant will reach out to obtain its supply of raw alfalfa. Time enroute between plant and field is extended when the route of travel is through towns or other congested areas. Roads maintained in good condition, paved roads,

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21/ Schrenk, W. G., et. al., Dehydrated Alfalfa, Bulletin 409, Kansas Agricultural Experiment Station, Manhattan, Kansas, April 1959.

22/ Rickey, Lacey F., Cooperative Alfalfa Dehydrators, Costs and Operations, FCS Circular 12, Farmers Cooperative Service, USDA, June 1956.

TABLE II. ALFALFA ACRES HARVESTED, DISTRIBUTION OF ACREAGE AND MEANS OF ACQUISITION BY PLANT, 1966 SURVEY.

	Number of Harvested Alfalfa Acres			Percent of Acreage Harvested Within	
Total Acres Harvested/Plant	On Which Alfalfa was Purchased	Leased	Owned	Five Miles of Plant	10 Miles of Plant
Acres	Acres	Acres	Acres	Percent	Percent
400		400		100	100
600	600			25	100
700	700			25	75
700	400	300		40	80
850	850			30	100
900	900			20	90
1,000	1,000			30	100
1,200	1,200			50	90
1,200	740	460		85	100
1,350	1,000	50	300	90	100
1,600	1,600			50	90
1,650	1,320	330		60	90
1,750	1,300	450		30	85
2,000	2,000			30	80
2,030	1,000	700	330	40	90
2,300	1,730	340	230	60	98
2,500	2,500			70	90
2,500	2,500			50	90
3,000	2,700	300		65	100
4,000	2,380	1,100	520	70	100

and long, straight stretches of road tend to shorten time enroute. A plant that has trucks of 8-10 tons green chop capacity can haul slightly longer distances than plants with trucks of 4-5 tons capacity. It is possible that alfalfa fields and plants with one or more of these characteristics of accessibility may be harvested as profitably as fields closer to the plant, but less accessible. This is especially true if they fit well into the harvesting cycle.

Harvesting is done most efficiently in fields requiring a minimum of turning and maneuvering. Fields that are rough tend to slow down the harvestor. Hard objects, such as rocks and iron, may damage the chopping knives resulting in a delay in opeations while repairs are made. Fields which drain well and dry quickly minimize the effect of weather on the harvesting cycle by permitting early re-entry. Fields with high yields are preferred to low-yield fields because the rate of harvesting is increased. The dehydrator operator is not in the business of selling dehydrated weeds and therefore prefers fields with a minimum of foreign growth. Therefore, in determining which fields to cut, consideration is given to size, shape, condition, yield and quality. Fields with a combination of these characteristics may be harvested in preference to poorer fields located nearer to the plant.

Procurement

Alfalfa is purchased from growers by the ton on the basis of dry weight after dehydration. Most firms bargain for alfalfa on a seasonal basis in order to assure their supply. After the heavier first cutting, additional acreage may be bargained for in order to compensate for the decreased yields per acre. The price paid for standing alfalfa may be established for all cuttings at the beginning of the operating season or negotiated prior to each cutting. Shown in Table III are conclusions drawn by Reed, et. al. 23/ in 1958 as compared to data from the 1966 survey of the factors dehydrator operators reported in considering when arriving at a price to pay growers for standing alfalfa.

Market price of dehydrated alfalfa is still the most important factor when arriving at the price to pay for standing alfalfa (Table III). Returns from other crops in the area are the second most important now whereas in 1958 they were not one of the major factors considered. This suggests that the prices paid by alfalfa dehydrating firms must reflect the market price of dehydrated alfalfa and be competitive with returns from other crops. These factors help determine a range over which prices paid to growers may vary. The relationship between prices paid growers and the market price of dehydrated alfalfa is at least partially explainable in terms of relations with growers.

When price of dehy is depressed a grower may go along with the dehydrating firm and accept a price for his alfalfa lower than that which he might receive for baled hay, anticipating the market price of dehydrated

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23/ Reed, et. al., op. cit., p. 25.

TABLE III. FACTORS CONSIDERED BY ALFALFA DEHYDRATING FIRMS IN ARRIVING AT A PRICE TO PAY GROWERS FOR STANDING ALFALFA 1958 AND 1966. 1/

Factors Considered	Number of Firms Mentioning and Percent of Total			
	1958 2/		1966 3/	
	Number	Percent	Number	Percent
Market price of dehydrated alfalfa	28	24.7	14	36.0
Returns from other crops in the area	6	5.3	9	23.6
Supply and demand for alfalfa	19	16.8	4	10.5
Prices paid by competing firms	21	18.5	5	13.1
Price of baled hay	19	16.8	4	10.5
Operating costs	3	2.6	2	5.2
Others	17	15.0	0	0.0

1/ Note: Data from 1958 included a sample of 35 plants and the 1966 data is from 20 plants.

2/ Data taken from Reed, Charles, et. al., Marketing Dehydrated Alfalfa, Agricultural Marketing Service, Market Research Division, USDA, Marketing Research Report No. 254, July 1953, p. 26.

3/ Source: Obtained in 1966 survey.

will come back and he will again receive from the dehydrating firm a competitive price for his alfalfa. Also, if the grower has been selling alfalfa to a dehydrating firm for some time he may have phased out his haying equipment. Therefore, he cannot readily change to baled hay if price for hay is temporarily favorable and he may feel the putting up of baled hay is an unpleasant task. A grower may be willing to accept a return lower than the alternative crop rather than make the adjustments necessary to take alfalfa out of the rotation. If the low prices continue over an extended time period then the producer will probably make alternative cropping adjustments.

In an area where there are several dehydrating firms, the smaller ones may follow the price set by a larger firm or firms. Other firms, such as one recently established, may follow the established pricing pattern. In the event there is an increase in the market price of dehydrated alfalfa, firms may raise prices paid to growers, particularly if a large number of growers are stockholders.

Only two firms reported considering their production costs when arriving at a price to pay growers. The principal reason, it appears, is that the price paid growers must reflect market price of dehy and be competitive with returns from alternative crops. Production costs of the firm vary inversely with the amount of dehydrated alfalfa produced. The amount of dehydrated alfalfa produced is directly related to the amount of standing alfalfa purchased which, in turn, may depend on the price paid to growers. This together with the unpredictability of yields and weather conditions make it difficult for the dehydrator operator to estimate accurately production costs for the coming operating season. Also, at the time the price paid to growers for standing alfalfa is negotiated the firm cannot easily change capacity or liquidate. In a situation such as this the decision of the firm on whether or not to operate will rest on whether or not product price will cover average variable costs. The dehydrator operator is aware that as long as product price exceeds average variable costs it is to his benefit to operate the plant and to generate as much volume as possible in order to cover fixed costs of production. He will attempt to obtain the supply of alfalfa necessary to maintain the plant at an acceptable level of processing activity at the lowest possible price.

Producer Agreements

Contracts with growers are both written and oral. Of 20 firms interviewed, 14 contracted for their alfalfa orally, 4 employed written contracts, one employed both, and one firm leased its entire acreage.

Plants using a written contract reasoned that it was more binding than an oral contract and therefore resulted in a firmer commitment to supply on the part of growers. The plant using both types of contracts indicated it would like to use all written contracts, but that some growers objected.

Of the 14 firms using oral contracts, 11 stressed either grower preference or maintenance of good relations with growers as a reason for employing this type of contract. The remaining three said the oral form of contract was an established custom in the area. Several closely related reasons were given as to why growers preferred an oral arrangement. In general, the oral contract is more flexible for both the plant and grower.

Both oral and written contracts are subject to misinterpretation on the part of the grower. The legal wording of a written contract sometimes leads to errors in interpretation. An agreement expressed orally may be clearer to the grower but is also subject to misinterpretation.

Plants in operation for a long period of time or operating in an established alfalfa dehydrating area used oral contracts almost exclusively. In these circumstances, it can be expected that the mutual responsibilities of growers and firms have been well-defined. From the standpoint of plant operations, some of the firms thought that a written contract, in reality, is no more enforceable than an oral contract. Involved is the cost of enforcement and the bad publicity the plant receives among growers.

In addition to the purchase of standing alfalfa from growers, some firms either own and/or lease all or part of their acreage. The amount of leased and owned acreage in the survey is shown in Table II. The primary advantage in leasing or owning acreage is the degree of control exercised by the firm. A plant which has leased or owned acreage is absolutely assured of that acreage for the season, and has complete control over harvesting.

Quality Control During Harvesting and Processing

Alfalfa harvested in the late bud or early bloom stage results in the best quality dehydrated alfalfa product. Dale Smith of the Department of Agronomy, University of Wisconsin, states:

> The highest yield of most of the important chemical constituents is obtained at near the 1/10 stage of growth. Although the yield of hay may continue to increase between 1/10 bloom and full bloom, it is due largely to an increase in the yield of fiber. The yield of protein and minerals may actually decrease after 1/10 bloom principally because of the loss of the lower, older leaves from diseases, lodging and other factors. While the amounts of leaves (which contain a larger proportion of the nutrients than the stems) are decreasing, the upper intermodes of the stems are continuing to elongate and the production of fiber continues to increase. Saving leaves has prime importance in hay making and this can be done best by cutting before many of the lower leaves are lost . . . 24/

Studies have shown most of the carotene loss in alfalfa occurs during the first few hours after cutting, necessitating keeping time between cutting and drying to a minimum.

Studies made at the Western Regional Research Laboratory, Albany, California, showed that underdrying or overdrying alfalfa in a commercial dehydrator did not increase carotene stability and content any more than material produced under more optimum drying conditions.

With respect to quality control during harvesting, dehydrator operators interviewed in the 1966 survey responded as follows. Nine mentioned cutting at an early stage of bloom as a method of controlling

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24/ Smith, Dale, "Alfalfa Cutting Practices for Quality and Longevity," Ninth Technical Alfalfa Conference Proceedings, Agricultural Research Service, USDA, 1965, p. 13.

quality during harvesting. Six mentioned cutting at the proper stage of maturity. Five operators mentioned cutting on a set cycle; cutting the same field every 25-35 days, depending on the area. Five operators mentioned the importance of getting the alfalfa to the dehydrator as soon as possible.

With respect to quality control during dehydration, responses were as follows. Eight operators mentioned proper heat control as a factor in quality control. Five operators mentioned proper drum operation stressing importance of having a skilled person operating the drying drum. Only five operators analyzed the product daily. Two of these stressed the importance of maintaining the moisture content of the dehydrated alfalfa at between 7 1/2 and 8 percent.

In general, quality control in the field is concerned with preservation of nutrients, especially carotene. At the plant it is concerned with this and the appearance of the dehydrated pellets. Uniform bright green pellets of the proper texture are easier to market than pellets not meeting these standards. Alfalfa that is burnt in the drying process does not make an attractive pellet. Neither does alfalfa that has not dried enough. Proper moisture control is an important factor in being able to turn out hard, uniform pellets which do not crumble easily.

Operations Procedure

Interruptions in processing activity are referred to as "downtime". These interruptions are usually caused by weather, mechanical breakdown, lack of coordination between plant and field operations, and lack of raw material. Unexpected short time interruptions with employees drawing pay increase labor costs per ton. If the interruptions are of a longer nature, fixed costs per ton are likely to be increased. Dehydrating plants, therefore, attempt to keep "downtime" to a minimum. They attempt to maintain a continuous and maximum operation. Maximum is used here in the sense that a plant will attempt to maintain, up to full capacity, the maximum level of processing activity permitted by the supply of alfalfa available within an economic hauling distance of the plant.

The Weather Factor

The dehydrating plant can do little about "downtime" due to inclement weather. Lack of precipitation results in low yields causing shutdowns due to a shortage of raw alfalfa. Rain during the operating season results in wet fields. Fields may not be cut if they are so wet that harvesting equipment cannot maneuver. Often dehydrator operators are hesitant to enter a wet field, even if equipment can maneuver, for fear of field damage and its effect on relations with the growers. Dehydrators compensate to some extent for this weather factor by using "high floatation" field equipment. This equipment has wide tires that roll over soggy fields leaving little or no damage. Because this equipment is more adaptable to operation on wet soil, it can continue to operate longer into a rainy period. After rain which has stopped harvesting has subsided, re-entry into the fields is hastened with high floatation equipment.

Many dehydrating firms owned or leased alfalfa acreage. There are times during rainy periods when the dehydrator operator will feel that alfalfa can be harvested without field damage while the grower fears field damage will result. In deference to the wishes of the grower, the operator will harvest on acreage owned by the plant rather than risk alienating the grower. Sometimes a dehydrating firm will gain possession of fields that drain exceptionally well. These fields can be entered very soon after the rain ceases.

Effect of Moisture Content on Raw Alfalfa on Dehydrated Alfalfa Production

The amount of raw alfalfa which can be dehydrated in a given period of time is determined by (1) its moisture content and (2) the evaporative capacity of the drying drum. For a drying drum of given capacity the amount of raw alfalfa processed, and consequently the amount of dehydrated alfalfa produced, is inversely related to its moisture content. This relationship is illustrated in Table IV. The moisture content of the dehydrated alfalfa usually runs from 8 to 10 percent. In this example it is assumed to be 10 percent. The drying drum is assumed to have an evaporative capacity of 9,000 pounds per hour. The raw alfalfa is assumed to have an initial moisture content of 80 percent. The formula used to arrive at the weights in Table IV and their derivation are in Appendix A.

Table IV shows that a decrease in the moisture content of raw alfalfa results in an increase in dehydrated alfalfa production. Each pound of

TABLE IV. EFFECT OF MOISTURE CONTENT OF RAW ALFALFA ON POTENTIAL PRODUCTION OF DEHYDRATED ALFALFA ASSUMING DEHYDRATED ALFALFA WITH A MOISTURE CONTENT OF 10 PERCENT AND A DRYING DRUM WITH AN EVAPORATIVE CAPACITY OF 9,000 POUNDS PER HOUR.

Moisture Content of Raw Alfalfa	Raw Alfalfa Processed/Hour	Change in Raw Alfalfa Processing Capacity from 80% Level	Dehydrated Alfalfa Produced Per Hour	Change in Dehydrated Alfalfa Production Capacity from 80% Level
Percent	Pounds	Pounds	Pounds	Pounds
80	11,571		2,571	
75	12,461	890	3,461	890
70	13,500	1,929	4,500	1,929
65	14,727	3,156	5,727	3,156

raw alfalfa yields more dry matter than previously and, in addition, more raw alfalfa can be processed per each hour of operation. Conversely, an increase in the moisture content of raw alfalfa results in decreased dehydrated alfalfa production. The increase in dehydrated alfalfa production in Table IV is equal to the increase in the amount of raw alfalfa processed. This is because the drying drum, no matter what the moisture content of the raw alfalfa, evaporates 9,000 pounds of water per hour at capacity. Therefore, any change in the amount of raw alfalfa processed is in the form of dry matter (dehydrated alfalfa). For example, when the raw alfalfa moisture content is 80 percent, 11,571 pounds of raw alfalfa can be processed per hour at maximum capacity. Dehydrated alfalfa production is 2,571 pounds. When the raw alfalfa moisture content is 75 percent, 12,461 pounds of raw alfalfa per hour can be processed at maximum capacity; an increase of 890 pounds. Dehydrate alfalfa production is 3,461 pounds; also an increase of 890 pounds.

Scheduling of Harvesting

In order to maintain a continuous and maximum operation an adequate supply of alfalfa must be available at the feeder at all times. The maintenance of an adequate supply of raw alfalfa at the feeder requires that manpower and equipment combinations be such that the functions of harvesting and trucking be timed to the raw alfalfa consumption of the drying drum.

The field rotation established during the first cutting sets the general pattern for succeeding cuttings. The dehydrator operator attempts to establish a pattern of movement from field to field such that the interruption of harvesting activity is not so long as to cause an interruption of product flow at the plant. Depending on the area harvesting is usually done on a 25 to 35-day cycle. Often "downtime" at the plant will cause a disruption in the cycle. In order to continue harvesting alfalfa at the proper stage of maturity, a plant will often bale hay on fields of advanced maturity and go on to fields farther down in the cycle and occasionally they will process alfalfa beyond one-tenth bloom if they have other high quality alfalfa to blend with it. If a plant has owned acreage it will usually bale hay on its own acreage and harvest alfalfa purchased from growers.

The first cutting is nearly always much heavier than later ones. Therefore, it is usually necessary to add fields to the harvesting pattern as the operating season progresses. In addition, it may be necessary to go out farther to obtain the alfalfa acreage to keep the plant operating at the desired level of processing activity. In some situations, the grower wants some of the later cuttings for his own use. In these cases, it may be necessary to find alternate sources of supply. Some plants may operate only one shift during the latter part of the operating season.

Because of the necessity of generating the volume necessary to cover the fixed costs of production, dehydrating plants like to start processing as soon as possible in the spring. Growers, on the other hand, because they are paid on the basis of dry ton, prefer to have their alfalfa harvested at later stages of maturity. Therefore, dehydrating plants like to own some acreage which they can harvest at an earlier stage of maturity than that preferred by growers.

Harvesting and Trucking Equipment

Field equipment is owned by the plant and moved from field to field. In order to maintain the continuity of the operation many plants keep in operating condition a reserve harvester. This is usually a harvester that has been replaced by a newer model. In case of breakdown the reserve chopper can be substituted for the regular chopper.

Most plants also have a pickup or trailer rigged with welding equipment and stocked with the tools and parts necessary to do most maintenance and repairing in the field.

Harvester and truck combinations used by the plants in this survey are shown in Table V. The number of harvesters required will obviously vary directly with plant capacity. Harvester requirements vary inversely with the capacities of the harvesters being used. Seven plants in Table V had daily capacities of 48 tons or less per hour; three indicate using two tractor-drawn harvesters with a 7 or 8-foot cut. Three other plants in this capacity range used one self-propelled harvester with a 10-foot cut.

The principal item affecting the number of trucks required is the size of the truck and the distance from field to plant. The greater the distance from field to plant, the greater the trucking distance,

TABLE V. ALFALFA DEHYDRATION HARVESTING AND TRUCKING EQUIPMENT BY PLANT SIZE, 1966 SURVEY.

Plant Code	24-Hour Plant Capacity	Self-Propelled Harvesters		Tractor-Drawn Harvesters		Trucks	
		No.	Width of Cut	No.	Width of Cut	No.	Tons of Raw Alfalfa Capacity Per Truck
	Tons		Feet		Feet		
3	30			2	7	4	6
1	30			2	8	5T a/	6
6	36	1	10			2	6
5	36			2	7	2	6
12	48	1	10			2	6
8	48	1	10			2	6
2	48	2	10			2	5
9	60			4	7	5	5
10	60			2	7 b/	4	5
15	60	1	10	1	7	3	6
11	78			3	7	5	5
4	84	2	10	1	8	4	5
16	72	2	10			5	6
19	90	2	10	1	7	7	6
13	96	2	10	1	7	6	6
7	96	2	10	1	7	5	6
18	102	2	10	1	7	5	6
14	78	4	10			5	7
20	120			4	10	9	6
17	140	3	10			5	6

a/ T indicates firm used trailers.
b/ Additional units rented when needed.

The equipment combinations in Table V include any reserve equipment the plant might have. This equipment is usually a harvester that has been replaced by a newer model and is not in full use throughout the operating season but is essential to a successful operation. The term "reserve" may be interpreted here in two ways. First, in the context of a substitute truck or harvester employed in case a regularly used truck or harvester breaks down. The second connotation of "reserve" is in terms of flexibility. During the heavier first cutting reserve equipment may be idle a great deal of the time and used only the case of breakdown of regularly used equipment. During later cuttings when yields are reduced reserve harvesters may be in use full time. If, during later cuttings, the plant is forced to travel greater distances to secure its alfalfa supply, reserve trucks may be in use full time. Reserve trucks and harvesters also add flexibility to the operation in that, during any cutting, some fields yield higher than others, are different in size and shape, and distances between fields and plants vary. Thus, at any given time, an extra harvester or truck may have to be employed to maintain a continuous flow of raw alfalfa to the plant.

Labor

Plant Labor

At the processing plant, handling of alfalfa, from the automatic feeder through to storage is essentially automatic. Small and moderate sized plants usually require only one operator. However, some small plants, because of poor plant design, require that two men be engaged in processing. "The function of the man or men responsible for plant operations consists primarily in adjusting rates of feeding, drying, and preventing clog-ups or other trouble from arising." 25/ Larger plants require more than one employee at the plant.

Labor requirements for the plants in this survey are shown in Table VI. Exclusive of sacking personnel, most plants with a 24-hour capacity of 60 tons or less required only one man to operate the plant. Exceptions are plants 8, 2, and 15. Plant 8 is an older plant which has not been modified for one man operation. The one-half man in Plant 2 is a general helper who divides his time between plant and field. This particular plant does a considerable amount of blending and must also haul its product by truck to a rail siding. The general helper adds flexibility to all of these operations. Most plants with a 24-hour capacity of 60 tons or more employed two operators or a combination of one operator and one helper to handle processing operations at the plant.

Field Labor

Field labor requirements will correspond to the number of harvesters and trucks in use. With the exception of Plants 2, 9, and 10, all plants with a 24-hour capacity of 60 tons or less used one harvester operator. Plant 2 splits an extra helper between plant and field. Plants 9 and 10 use a tractor-drawn harvester with a 7-foot cut while the remaining plant

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25/ Reed, Establishing Dehydrating Plants in Kansas, Extension Service, Kansas State University, Manhattan, Kansas, p. 9.

TABLE VI. LABOR REQUIREMENTS, 1966 SURVEY.

Plant Code	24-Hour Capacity of Plant	24-Hour Daily Production*	Plant				Field			Maintenance and Repair 2/	Total Laborers 3/
			Operators	Sackers	Helpers	Total 1/	Harvester Operators	Truck Drivers	Total		
	Tons	Tons	Men/Shift	Men/Shift	Men/Shift	Men/Shift	Men/Shift	Men/Shift	Men/Shift	Men/Shift	Men/Shift
3	30	25.60	1	3	--	1.0 (4)	1.0	1	2.0	--	3.0 (6)
1	30	19.98	1	--	--	1.0	1.0	1	2.0	0.5	3.5
6	36	33.48	1	--	--	1.0	1.0	1	2.0	0.5	3.5
5	36	33.33	1	--	--	1.0	1.0	1	2.0	0.5	3.5
8	48	39.94	2	--	--	2.0	1.0	1	2.0	0.5	4.5
12	48	48.21	1	--	--	1.0	1.0	2	3.0	0.5	4.5
2	48	24.39	1	--	0.5	1.5	1.5	1	2.5	1.0	5.0
9	60	40.00	1	3	--	1.0 (4)	3.0	3	6.0	0.5	7.5 (11)
10	60	43.92	1	--	--	1.0	2.0	2	4.0	1.0	6.0
15	60	53.38	1	--	1.0	2.0	1.0	1	2.0	1.0	5.0
16	72	56.20	2	--	--	2.0	2.0	2	4.0	2.0	8.0
14	78	52.45	1	2	1.0	2.0 (4)	3.0	3	6.0	--	8.0 (10)
11	78	45.02	1	--	--	1.0	1.0	3	4.0	1.0	6.0
4	84	27.50	2	--	--	2.0	2.0	2	4.0	0.5	6.5
19	90	75.64	1	--	1.0	2.0	2.0	2	4.0	2.0	8.0
7	96	39.20	2	1	--	2.0 (3)	2.0	2	4.0	1.5	7.5
13	96	50.00	2	1	--	2.0 (3)	2.0	2	4.0	1.5	7.5
18	102	75.48	2	--	--	2.0	2.0	2	4.0	1.0	7.5
20	120	100.00	2	--	--	2.0	3.0	3	6.0	1.0	9.0
17	140	69.57	2	1	--	2.0 (3)	2.0	2	4.0	1.5	7.5

1/ Totals in parentheses include sacking personnel.
2/ The 0.5 of a man indicates one maintenance man for two work shifts. The man works the main shift and is on call the other shift.
3/ Totals in parentheses include sacking personnel.
* Daily production during days when the plant is operating (does not include downtime).

with a 24-hour capacity of 60 tons (Plant 15) used a self-propelled harvester with a 10-foot cut. Beyond a 24-hour capacity of 60 tons, two or three harvester operators were required. Plants 9 and 20 used tractor-drawn harvesters with a 7-foot cut and required three machines in use and thus three operators.

The data in Table VI indicates that truck driver requirements vary directly with plant capacity. In most cases a plant will have more trucks in operation than there are drivers for them. This is because a driver will deliver a loaded truck to the plant, leave it and drive back to the field an already unloaded truck. At the field he will leave the unloaded truck and drive back to the plant a truck that is loaded and waiting for delivery.

<u>Other Labor</u>

With the exception of Plants 3 and 14, all plants hire maintenance and repair personnel. Plant 3 had access to the personnel of an affiliated feed mill. Plant 14, at the time the survey was taken, indicated that it was having difficulty in hiring a permanent maintenance and repair man. Some maintenance and repair work is done by the plant helper at this plant. In general, the number of maintenance and repair personnel required increased as plant capacity increased.

The importance of reliable maintenance and repair personnel cannot be overestimated. Loss of production due to mechanical breakdown cannot be recovered. If employees are drawing pay during breakdown, labor costs per ton are increased. Both short-time interruptions with employees drawing pay and longer-term interruptions increase fixed costs per ton.

In most plants the plant managers, non-manager owners, and many operators have a thorough knowledge of the mechanical aspects of plant and field equipment. A structure of skilled personnel such as this can keep downtime to a bare minimum.

The dehydrating industry has experienced difficulty in acquiring and keeping a reliable labor force. There are two major causes of this problem. One of these is wage rates; the other is seasonality of operation.

As indicated by Table VII, the wage rates in the alfalfa dehydrating industry are relatively low. However, an employee of the dehydrating industry, because of the long hours worked, makes a weekly wage somewhat higher than that indicated by the basic wage rates. For example, assume the employee is earning the minimum wage of $1.25 per hour and working 12 hours a day, 7 days per week. His earnings for one week with overtime will be $132.50. This has helped to establish a working force. The laborers work long hours during the operating season and in many cases draw unemployment compensation during the off season.

The seasonality of alfalfa dehydration is the second major cause of the employment problem. To reduce the turnover from season to season dehydrating plants attempt to keep a core of skilled personnel by employing them during the off-season. Some firms have supplemental enterprises such as feedlots and farms where these men, although probably underemployed, can work during the off-season. Many firms literally tear down and

TABLE VII. AVERAGE WAGES RATES AND RANGES, 1966 SURVEY.

Personnel	Average Wage Rate Per Hour Dollars	Range Per Hour Dollars
Plant operators	1.49	1.30 - 1.78
Harvester operators	1.40	1.25 - 1.50
Truck drivers	1.36	1.25 - 1.65
Maintenance and repair	1.60	1.25 - 2.00

rebuild plant and field equipment during the off-season and retain personnel to perform this task.

The low wage scale also results in a high employee turnover during the operating season. The seasonal help is primarily employed in the field operation and tends to be somewhat careless in the care and use of machinery. This results in machinery breakdown and necessitates outlays for either repair or replacement. Some dehydrating firms attempt to reduce the seasonal turnover by offering bonuses to employees completing an entire season. The worker accumulates a fixed amount for each hour worked. If he leaves before the operating season is completed, his accumulated bonus reverts to the firm.

Some dehydrating firms hire college or high school students during school vacation. The complicating factor here is that the dehydrating season begins before and ends after the school vacation period. There is, therefore, a void to be filled during these time periods. In one case the plant manager would hire students only if the father would fill in or guarantee someone to fill in during the periods the student could not work.

A dehydrating firm would probably find it difficult to keep a reliable labor force if there was competition for the labor force from a concentration of high paying industries. For instance, the dehydrating firms around Wichita, Kansas, have had serious labor problems since the expansion of the aircraft industry in Wichita.

CHAPTER IV

COSTS AND RETURNS

Average Production Costs

Previous Research

Two of the most recent and thorough investigations in the area of alfalfa dehydration have been conducted by Lacey F. Rickey, 26/ using 1953-54 data and a later study by Charles E. Reed using 1957 and 1959 data. The early study by Rickey had per ton processing costs of $33.33 for plants under 3,000 tons annual production and $22.50 per ton for plants over 3,000 tons production.

The later study conducted by Charles Reed, 27/ analyzed the production costs of 35 dehydrating plants located in the Midwest for the 1958 and 1959 plant years. Processing costs for plants under 3,000 tons annual production were $26.54 per ton; for 3,000-6,999 tons, costs were $22.64 per ton; and over 7,000 tons, processing costs were reduced to $18.05 per ton. Pelleting was common when this study was conducted. Consequently, the need for sacking was reduced because bulk handling was possible.

Fixed and Variable Costs

Some costs are subject to change as the rate of production changes and other costs will continue unchanged. If the time period is extremely

26/ Rickey, op. cit., p. 25.

27/ Reed, Charles E., Costs and Efficiency in Alfalfa Dehydration Plants, Tech. Bul. 124, Kansas Agr. Expt. Sta., Kansas State University, Manhattan, Kansas, August 1962.

short, all costs will remain unchanged or fixed. If the time period is very long such as 10 years, all costs will be subject to change. It will be useful here to use a time period which we call "the short run" in which it is possible to vary the rate of production, but short enough so that capacity or size of operation cannot be changed. In this period of one year or one operating season for an alfalfa dehydration plant, some costs will be variable as a result of change in the operations such as: amount of alfalfa purchased, labor, fuel, power, gas and oil, and maintenance and repair.

Other costs are fixed. They remain constant for the season regardless of the quantity of the output. These costs in the dehydrating plants interviewed are the managers and the salaries and other wages that are on a yearly basis: Depreciation of the plant equipment, insurance on the plant and equipment, taxes, interest, and some other miscellaneous fixed costs.

Classification of total costs into variable and fixed costs assists management in identifying specific problem areas in plant operation and allows for specific corrective action that will continue to keep the plant in an operational competitive position.

Variable Costs

Both studies by Rickey and Reed found that, in general, average variable costs varied inversely with annual production volume. This result implies that larger plants can produce dehydrated alfalfa at lower costs than smaller plants. Plant and field labor, fuel, power, gas and oil, and maintenance and repair costs, because they are directly involved in converting raw alfalfa into dehydrated alfalfa, are often referred to as conversion costs.

In this chapter, using the current survey data, an attempt will be made to determine if the above implication is correct. Each type of conversion cost will be examined separately. Average costs in this study are examined in terms of average daily production rather than annual production. This permits comparison of plant output on the basis of a common time period. The 24-hour day was chosen as the time period because all but two of the plants in the study operated around the clock. The two exceptions worked one 12-hour shift per day.

Plant 3 worked 125 twelve-hour days during the operating season. These were converted to 62.5 twenty-four-hour days. Plant 9 worked 120 twelve-hour days which were converted to 60 twenty-four-hour days. The method of analysis is the same for each type of cost and is outlined in the section on labor cost.

Labor

Labor costs per ton of output are shown in Table VIII. The data from this table are projected onto Figure 18. In Figure 18, the 24-hour plant capacities are divided into four ranges (30-40 tons, 41-70 tons, 71-90 tons, and over 90 tons). 28/ The 30-40 ton range has plants with

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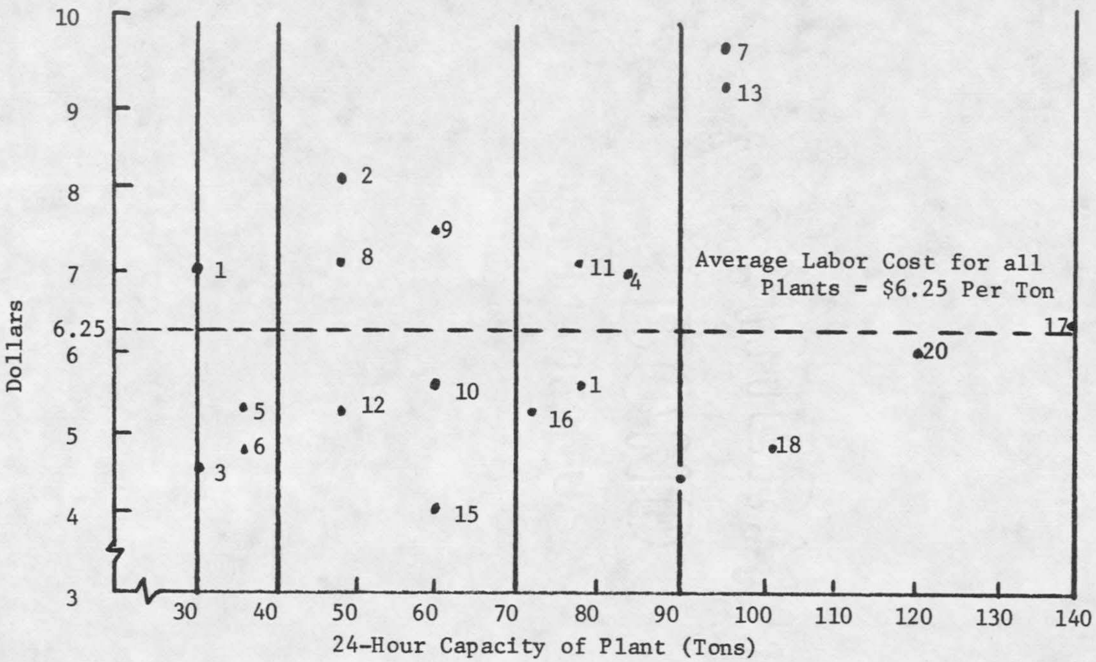
28/ These groupings were chosen in an attempt to group together plants most similar in size and yet have a representative number of plants in each size group.

TABLE VIII. PLANT AND FIELD LABOR COSTS PER TON, 1966 SURVEY.

Plant Code	24-Hour Capacity of Plant	Production Per 24-Hour Operating Day	Percent of Capacity at which Plant Operated 1/	Labor Cost Per Ton of Output: Including Sacking Personnel			Excluding Sacking Personnel 2/		
				Field	Plant	Total	Field	Plant	Total
	Tons	Tons	Percent	Dollars					
3	30	25.60	71	2.56	4.53	7.09	2.56	2.00	4.56 2/
1	30	19.98	56	--	--	7.08	--	--	7.08
5	36	33.33	93	2.34	2.97	5.31	2.34	2.97	5.31
6	36	33.48	93	2.12	2.63	4.75	2.12	2.63	4.75
2	48	24.39	47	1.38	5.75	8.13	2.38	5.75	8.13
8	48	39.94	83	2.65	4.46	7.11	2.65	4.46	7.11
12	48	48.21	100	--	--	3.26	--	--	5.26
9	60	40.00	67	--	--	8.68	--	--	7.50 2/
10	60	43.92	73	--	--	5.60	--	--	5.60
15	60	53.38	89	2.02	2.03	4.05	2.02	2.03	4.05
16	72	56.20	78	2.01	2.23	5.24	2.01	2.23	5.24
11	78	45.02	58	4.68	2.42	7.10	4.68	2.42	7.10
14	78	52.45	67	--	--	6.16	--	--	5.56 2/
4	84	27.50	33	3.00	4.00	7.00	3.00	4.00	7.00
19	90	75.64	84	2.85	1.61	4.46	2.85	1.61	4.46
7	96	39.20	41	3.82	6.61	10.43	3.82	5.98	9.80 2/
13	96	50.00	52	88	5.43	10.31	4.88	4.39	9.27 2/
18	102	75.48	74	38	2.42	4.80	2.38	2.42	4.80
20	120	100.00	83	--	--	6.02	--	--	6.02
17	140	69.57	50	37	3.91	7.68	3.37	3.01	6.38 2/

1/ Percent of capacity is the percent of capacity for an operating day. It does not include those days during the season that the entire plant is closed down.

2/ Indicates labor costs per ton of output have been adjusted not to include sacking personnel. For plants where sacking costs were not specified, plant labor costs per ton of output were multiplied by the ratio of weekly cost of sacking personnel to total weekly plant labor cost.



AVERAGE LABOR COST/TON				
Above Ave Plants	$ 7.08	$ 7.58	$ 7.05	$ 8.48
Below Ave Plants	4.87	4.97	5.40	5.41
Combined Average	5.42	6.27	6.23	6.78
AVERAGE DAILY PRODUCTION (TONS)				
Above Ave Plants	19.98	34.78	36.26	52.92
Below Ave Plants	30.80	48.50	61.43	87.74
Combined Average	28.09	42.97	53.70	66.84
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants	56%	66%	46%	48%
Below Ave Plants	85	87	76	78
Combined Average	78	76	64	60

Figure 18. Analysis of Per Ton Labor Costs. Four Plant Size Groups by 24-Hour Capacity.

24-hour capacities of 30 and 36 tons; the 41-70 ton range has plants with 24-hour capacities of 48 and 60 tons; the 71-90 range has plants with 24-hour capacities of 72, 78, 84, and 90 tons; the over 90 ton range has plants with 24-hour capacities of 96, 102, 120, and 140 tons.

The per ton labor cost of each plant is plotted in the size range corresponding to its 24-hour capacity. The dotted line represents the average per ton labor cost of all plants. Plants above the dotted line have above-average per ton labor costs; those below the dotted line have below-average per ton labor costs.

Within each capacity range in Figure 18, plants with above-average per ton labor costs have a lower average daily production than those plants with less than average labor costs. Within each size group the average per ton labor costs varied inversely with the average percent of capacity at which the plants operated (Figure 18).

The evidence indicates that per ton labor costs do not decrease as plant capacity or output increases but exhibit an inverse relationship with the percent of capacity at which the plant operates. This percentage of capacity is really a ratio of output to capacity, which is not a measure of efficiency because inputs are not specified. To determine whether plants with below-average per ton labor costs used labor more efficiently (had greater output per unit of labor) than plants with above-average per ton labor costs, it is necessary to determine whether they used essentially the same amount of labor input.

In Table IX the average number of employees employed at the plant, in the field and for maintenance and repair, are shown for each size group. The plants with above-average per ton labor costs did not employ appreciably greater amounts of labor than plants with below-average per ton labor costs.

Differences in per ton labor costs among plants, will, of course, exist if there are differences in wage rates. It is, therefore, necessary to determine whether plants with above average per ton labor costs paid a higher hourly wage rate than plants with below-average per ton labor costs.

In the 30-40 ton capacity range the above-average plants employ 0.17 more men per shift than the below-average plants but pay 13 cents less hourly. In the 41-70 ton capacity range the above-average plants employ 1.75 less men than the below-average plants and pay 2 cents per hour more. In the 91-140 ton range the above average plants employ 0.05 more men per shift than the below-average plants and pay 4 cents per hour more.

There is no clear indication that average adjusted hourly wage rates are appreciably higher for plants with above average per ton labor costs than for plants with below average per ton labor costs. Where differences do exist, they are apparently not large enough to change the findings depicted in Figure 18. It, therefore appears that within the established capacity ranges, per ton labor costs vary with the rate of output.

TABLE IX. NUMBER OF EMPLOYEES AND AVERAGE HOURLY WAGE RATES PER SHIFT: PLANTS WITH ABOVE-AVERAGE LABOR COSTS AS COMPARED TO PLANTS WITH BELOW-AVERAGE LABOR COSTS, BY SIZE GROUPS, 1966 SURVEY.

Plant Size Group By 24-Hour Capacity	Average Number of Employees Per Shift								Ave. Hourly Wage Rates a/	
	Plant		Field		Maintenance and Repair		Total Employees/Shift			
	Above Ave.	Below Ave.	Above Ave.	Below Ave.	Above Ave.	Below Ave.	Above Ave.	Below Ave.	Plants Above Ave.	Plants Below Ave.
Tons	Number of Men								Dollars	
30 - 40	1.0	1.0	2.0	2.0	0.5	0.33	3.5	3.33	1.68	1.81
41 - 70	1.5	1.33	3.5	3.0	0.67	0.67	5.67	5.0	1.71	1.62
71 - 90	1.5	2.0	4.0	4.67	0.75	1.33	6.25	9.0	1.68	1.66
91 & over	2.0	2.0	4.0	4.0	1.5	1.0	7.5	7.0	1.72	1.68

a/ In order that they reflect over-time premiums (over-time premiums are included in per ton labor costs) the hourly wage rate was adjusted in the following manner. The weekly wage per worker was determined by adding to the regular hours worked per week the over-time premium hours and multiplying this total by the hourly wage. The weekly wages of all workers were then summed and divided by total man-hours worked per week to get the adjusted hourly wage rate.

There was no indication that per ton labor costs decreased as plant size increased. This suggests that plants with small capacities are capable of keeping labor costs competitive with plants of larger capacities. There is, however, a qualification to this assertion. The qualification is that, in general, increases in plant size were accompanied by decreases in percentage of operating capacity.

Fuel

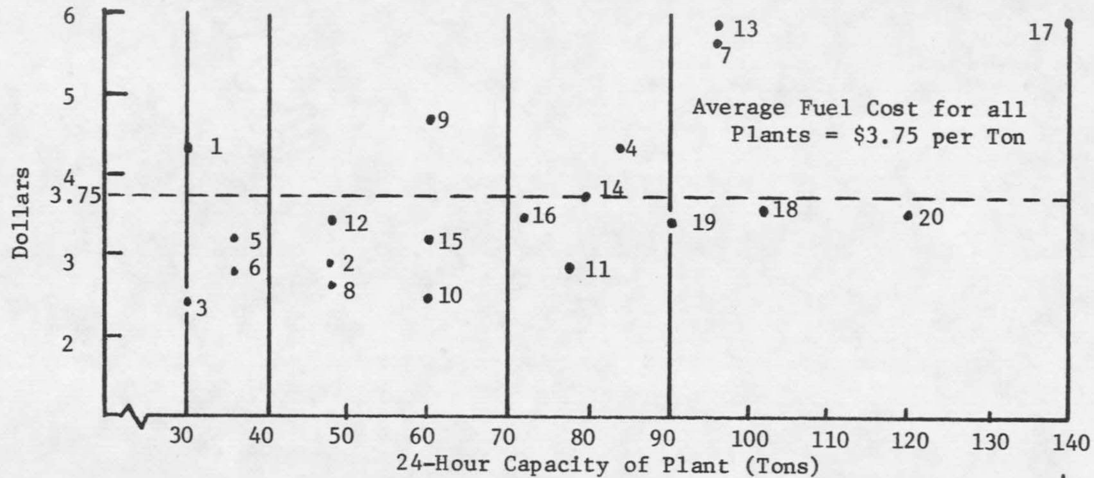
Fuel costs per ton of output are shown in Table X and are projected onto Figure 19. The average fuel cost is $3.75 per ton and the median is $3.48 per ton. A total of eight plants or 40 percent had fuel costs of between $3 and $4 per ton. There is a significant difference between plants with above-average costs and those with below-average costs per ton. The 70-90 ton size group has the least difference. In this group, the difference is 75 cents per ton while the others go from $1.55 to $2.25 per ton difference between below- and above-average plants. In each capacity range, plants with below average per ton fuel costs operated at a greater percentage of capacity than plants with above average per ton fuel costs.

In general, per ton fuel costs seem to increase as plant capacity increases. This seems to discount any argument that per ton fuel costs decrease as plant capacity increases. There also exists an inverse relationship between plant capacity and the percentage of capacity at which the plant operates. Relating back to costs, this means that

TABLE X. CONVERSION COSTS PER TON OF OUTPUT, 1966 SURVEY. 1/

Plant Code	24-Hour Capacity of Plant	Output Per 24-Hour Operating Day	Percent of Capacity at which Plant Operated	Fuel Cost Per Ton of Output	Power Cost Per Ton of Output	Gas and Oil Costs Per Ton of Output	Maintenance and Repair Costs/Ton of Output	Total Conversion Cost Per Ton of Output
	Tons	Tons	Percent	--Dollars--				
3	30	25.60	71	2.33	1.88	0.86	1.56	13.72
1	30	19.98	56	4.32	0.60	1.61	1.35	14.96
5	36	33.33	93	3.22	1.33	0.52	2.80	13.18
6	36	33.48	93	2.83	1.93	1.00	2.85	13.36
2	48	24.39	47	2.90	1.40	1.35	5.10	18.88
8	48	39.94	83	2.64	1.73	1.71	4.47	17.66
12	48	48.21	100	3.45	3.12	1.09	1.61	14.53
9	60	40.00	67	4.71	2.48	1.56	6.38	23.81
10	60	43.92	73	2.52	1.65	0.97	2.82	13.56
15	60	53.38	89	3.20	1.82	0.86	2.12	12.05
16	72	56.20	78	3.48	1.46	0.91	3.78	14.88
11	78	45.02	58	2.91	2.08	1.15	2.71	15.95
14	78	52.45	67	3.75	1.53	1.36	1.58	14.38
4	84	27.50	33	4.38	2.98	1.23	3.45	19.04
19	90	75.64	84	3.54	1.76	0.71	2.96	13.43
7	96	39.20	41	5.68	1.85	1.13	3.56	22.65
13	96	50.00	52	5.87	2.36	3.40	4.33	26.27
18	102	75.48	74	3.62	1.65	0.90	2.62	13.59
20	120	100.00	83	3.56	1.46	0.88	2.40	14.32
17	140	69.57	50	5.94	1.74	1.03	4.43	20.82

1/ Cost data is based on actual output of the plant and not capacity of the plant.



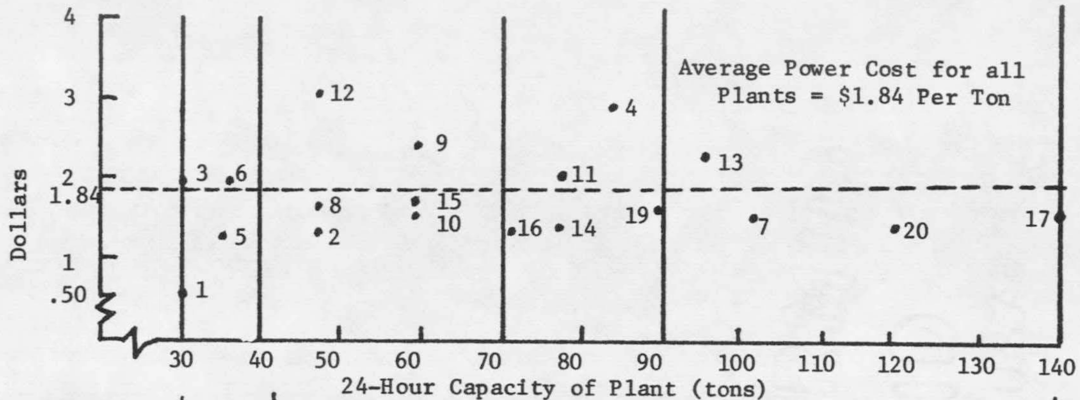
AVERAGE FUEL COST PER TON				
Above Ave Plants	$ 4.32	$ 4.71	$ 4.06	$ 5.83
Below Ave Plants	2.77	2.94	3.31	3.59
Combined Average	3.17	3.23	3.61	4.93
AVERAGE DAILY PRODUCTION (TONS)				
Above Ave Plants	19.98	40.00	39.98	52.92
Below Ave Plants	30.80	41.97	58.95	87.74
Combined Average	28.10	42.97	43.29	66.85
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants	56%	67%	50%	48%
Below Ave Plants	86	78	73	79
Combined Average	78	76	64	60

Figure 19. Analysis of Per Ton Fuel Costs. Four Plant Size Groups by 24-hour Capacity.

when viewed with respect to changes in capacity, per ton fuel costs increase as percentage of operating capacity decreases. It, therefore, appears that larger plants are not utilizing their capacity as fully as smaller plants and that this may be a reason for the higher per ton fuel costs experienced by them.

Power

Power costs per ton of output are shown in Table X and are projected onto Figure 20. The average power cost is $1.84 per ton and the median is $1.45 per ton. Power costs are lowest for the plants under 40-ton capacity. There is no consistent relationship to indicate that plants with below average power costs operated at a greater percentage of capacity than plants with above average per ton power costs. In the first two capacity ranges above-average plants operated at a greater percentage of capacity than below-average plants. In the last two capacity ranges the below-average plants operated at a greater percentage of capacity than the above-average plants. As plant size increases, per ton power costs seem to decrease despite decreases in the percentage of operating capacity (30-40 ton range excluded). With the first capacity range excluded the difference between the highest and lowest per ton power cost is 23 cents ($2.04-$1.81) indicating that it may be possible to curtail the use of electricity when there are short time interruptions in processing activity.



AVERAGE POWER COST/TON				
Above Ave Plants	$ 1.91	$ 2.80	$ 2.53	$ 2.11
Below Ave Plants	0.97	1.65	1.58	1.62
Combined Average	1.43	2.04	1.96	1.81
AVERAGE DAILY PRODUCTION (TONS				
Above Ave Plants	29.54	44.12	36.26	44.60
Below Ave Plants	26.67	40.40	61.43	81.68
Combined Average	28.11	41.65	51.36	66.85
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants	82%	84%	47%	47%
Below Ave Plants	75	73	76	69
Combined Average	78	77	64	60

Figure 20. Analysis of Per Ton Power Costs. Four Plant Size Groups by 24-Hour Capacity.

Gas and Oil

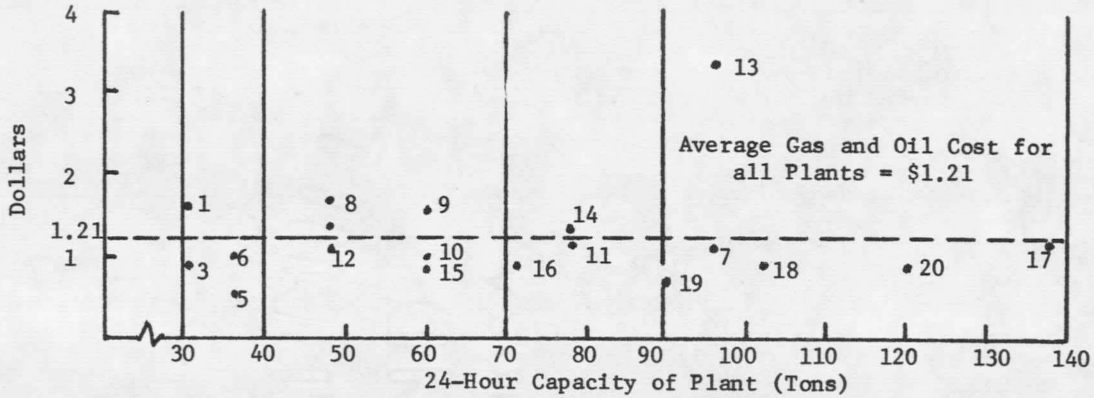
Gas and oil costs per ton of output are shown in Table X and are projected onto Figure 21. The gas and oil costs per ton of output hold rather consistently at all size groups for plants with below average costs. This cost is about \$1 as compared to the overall average of \$1.21 per ton. Eighty percent or 16 of the plants had gas and oil costs between \$0.50 and \$1.50 per ton. Those plants operating above average in the two smaller size groups run slightly over \$1.50 and the larger size group has one plant with an extremely high gas and oil cost of \$3.40 per ton which causes a much wider variation in that size group than in any other group.

Those plants that have the below-average costs are operating, in general, at a higher percentage of capacity than those plants that have the higher cost per ton of output, suggesting gas and oil costs per ton are less as percent of operating capacity increases.

There is no indication that per ton gas and oil costs decrease as plant size increases. This result might be expected in that distance from field to plant rather than level of plant utilization would seem to be the primary determinant of gas and oil costs.

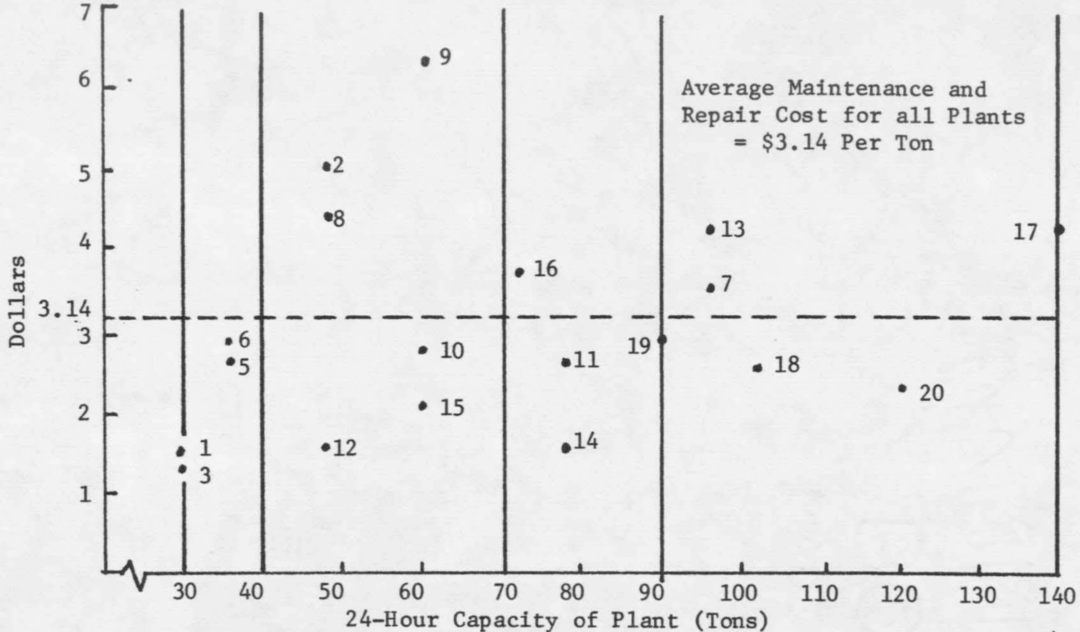
Maintenance and Repair

Maintenance and repair costs per ton of output are shown in Table X and projected onto Figure 22. Average maintenance and repair cost is



AVERAGE GAS AND OIL COST PER TON				
Above Ave Plants	$ 1.61	$ 1.54	$ 1.30	$ 3.40
Below Ave Plants	0.79	0.97	0.92	0.99
Combined Average	1.00	1.26	1.07	1.45
AVERAGE DAILY PRODUCTION (TONS)				
Above Ave Plants	19.88	34.77	40.00	50.00
Below Ave Plants	30.80	48.50	58.95	71.06
Combined Average	28.10	41.64	51.37	66.85
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants	56%	66%	50%	52%
Below Ave Plants	86	87	73	62
Combined Average	78	77	64	60

Figure 21. Analysis of Per Ton Gas and Oil Costs. Four Plant Size Groups by 24-hour Capacity.



AVERAGE MAINTENANCE AND REPAIR COST PER TON				
Above Ave Plants		$ 5.32	$ 3.62	$ 4.11
Below Ave Plants	$2.14	2.18	2.42	2.51
Combined Average	$2.14	3.75	2.90	3.47
AVERAGE DAILY PRODUCTION (TONS)				
Above Ave Plants				
Below Ave Plants	28.09	34.77	41.85	52.92
Combined Average	28.09	48.50	57.70	87.74
		42.97	1.36	66.85
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants		66%	56	48
Below Ave Plants	78%	87	70	79
Combined Average	78	76	64	60

Figure 22. Analysis of Per Ton Maintenance and Repair Costs. Four Plant Size Groups by 24-Hour Capacity.

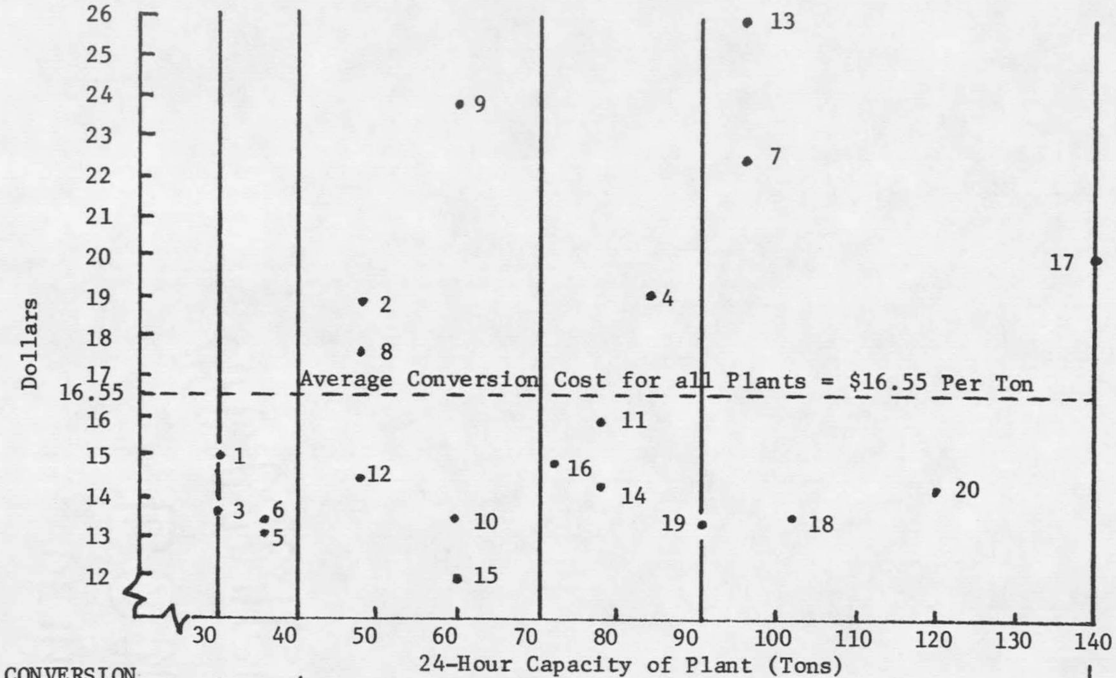
$3.14 per ton and the median is $2.82 per ton. The smaller plants, 30-40 ton range, had the lowest maintenance and repair cost per ton. Much of this is the result of the plant manager himself doing much of the maintenance and repair and the accounting system not allocating his time to maintenance and repair. This partially explains the wide range of these costs.

The plants with below-average maintenance and repair costs operated at a percentage of capacity greater than that of above-average plants. As plant size increased, there seemed to be no consistent relationship between maintenance and repair costs and plant size nor between maintenance and repair costs and percentage of operating capacity.

Total Conversion Costs

The average total conversion costs per ton of output are shown in Table X and projected onto Figure 23. The average per ton conversion cost was $16.55 and the median $14.70. Eleven plants (55 percent) had average conversion costs of between $13 and $15 per ton. With the exception of the 30-40 ton range where all plants were below average, plants with below-average conversion costs operated at a greater percentage of capacity than plants with above-average costs.

Average conversion costs are highest for plants in the 41-70 and over 90 ton ranges. The average conversion costs in the over 90 range are high because of plants 7, 13, and 17. These three plants operate in approximately the same geographical area. Therefore, it can be assumed



AVERAGE CONVERSION COST PER TON				
Above Ave Plants		$20.12	$19.04	$23.25
Below Ave Plants	$13.88	13.38	14.66	13.96
Combined Average	$13.88	16.75	15.54	19.53
AVERAGE DAILY PRODUCTION (TONS)				
Above Ave Plants		34.78	27.50	52.92
Below Ave Plants	28.10	48.50	57.33	87.74
Combined Average	28.10	41.64	51.36	66.85
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants		66%	33%	48%
Below Ave Plants	78%	87	72	79
Combined Average	78	76	64	60

Figure 23. Analysis of Per Ton Conversion Costs. Four Plant Size Groups by 24-hour Capacity.

that they operate under similar conditions. Following is an attempt to determine whether there were circumstances peculiar to plants 7, 13, and 17 which tended to result in relatively high conversion costs.

In the analysis of labor costs (Figure 18) it was found that plants 7, 13, and 17 had an average labor cost of $8.48 per ton as opposed to $5.41 for plants 18 and 20 (the other plants in the over 90 range). Plants 7 and 13 had the highest labor cost of all plants while plant 17 was near the average. Thus, there was variation among plants 7, 13, and 17. The hourly wage rate paid by plants 7, 13, and 17 was very close to that paid by plants 18 and 20 ($1.72 to $1.68) as was the amount of labor employed (7.5 to 7.0 employees). Plants 7, 13, and 17 operated at 48 percent of capacity while plants 18 and 20 operated at 78 percent of capacity. This difference in percentage of operating capacity plus the variation among plants 7, 13, and 17 makes it appear that low daily production rather than locational factors is the reason for the high labor costs experienced by plants 7, 13, and 17.

In the analysis of fuel costs (Figure 19) it was found that plants 7, 13, and 17 were the plants with the highest fuel costs. These operated at 48 percent of capacity as opposed to 78 percent for plants 18 and 20. However, the fact that plants 7, 13, and 17 all had fuel costs considerably higher than the other plants in the survey indicates other factors may be involved. It may be that the cost of fuel is relatively high in this area. It is also possible that the raw alfalfa moisture content may be higher in this area thus requiring greater fuel consumption per ton of dehydrated alfalfa produced.

Power cost analysis (Figure 20) revealed that plants 7, 13, and 17 compared favorably with the other plants in the survey. It will be recalled that no consistent relationship between power costs and percentage of operating capacity was discovered. Thus, plants 7, 13, and 17 compare favorably with the other plants in the survey in a cost category where percentage of operating capacity did not seem to be a significant factor.

In the analysis of gas and oil costs (Figure 21) plants 7 and 17 had below average costs while plant 13 was above average and, in addition, had the highest gas and oil cost of all plants. This dispersion indicates that the gas and oil costs experienced by plants 7, 13, and 17 because of their location did not place them at a disadvantage in cost comparisons with other plants in the survey. If there had been locational disadvantages, plants 7, 13, and 17 probably would all have had exceedingly high gas and oil costs.

To summarize, there is some reason to believe that locational factors (primarily regional differences in input prices and moisture content of raw alfalfa) may have resulted in relatively high fuel costs for plants 7, 13, and 17. In general, however, the relatively high cost position of these plants seems to result from operating at a low percentage of capacity.

Plant 9 falls in the above average group for all cost categories. It employed one man at the plant while the other plants in the 41-70 ton range employed 1, 1.5, or 2. In the field, however, plant 9 employed 6 men as opposed to between 2 and 4 for the other plants in the 41-70 range. The indication is that plant 9 may have had to operate under adverse field conditions. In fact, the area in which this plant is located experienced an exceptionally dry growing season in the year for which the cost data was obtained. Lower than usual alfalfa yields would also tend to increase fuel, power, and gas and oil costs. Plant 9 operated at 67 percent of capacity as opposed to 78 percent for the other plants in the 41-70 ton capacity range.

The average total conversion costs of the below average plants (13 or 65 percent of all plants in the survey) show little variation as plant size increases. The variation that does exist is inversely related to percentage of operating capacity--high average total conversion costs are associated with low percentages of operating capacity.

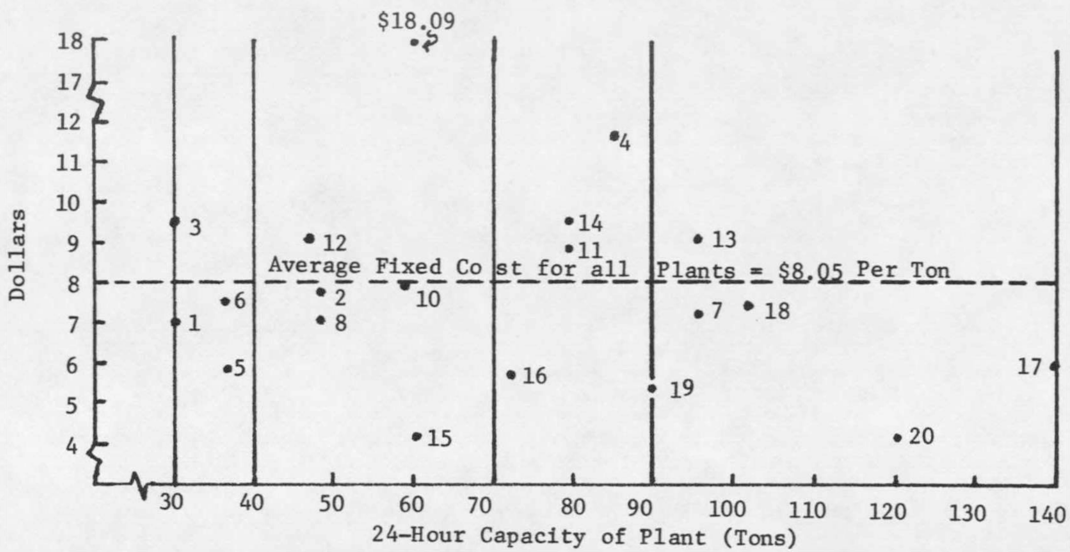
Fixed Costs

Fixed costs per ton of output are shown in Table XI and projected onto Figure 24. The major portion of the fixed costs for plants surveyed is the ownership cost. The initial investment in facilities is spread over their productive life and depreciation, therefore, is the prime ownership cost. Administrative personnel which was very high in terms of salaries in the survey plants is a significant fixed cost. Taxes, insurance, interest on investment and other miscellaneous fixed costs provide a total fixed cost ranging from a low of $4.04 per ton to a

TABLE XI. FIXED COSTS PER TON OF OUTPUT FOR 20 ALFALFA DEHYDRATION PLANTS, 1966 SURVEY.

Plant Code	Salaries and Wages	Depreciation	Insurance	Taxes	Interest	Other	Total Fixed Costs
	-----Dollars-----						
3	1/	1/	0.75	0.32		2.40	9.34
1	3.21	3.00	--	0.69		0.12	7.02
5	2.73	1.13	0.57	0.59		0.88	5.90
6	1.81	4.00	0.03	0.59		0.74	7.24
2	4.03	1.00	0.57	0.24	0.25	1.17	7.56
8	2.18	4.00	0.04	0.82		0.04	7.08
12	2.74	2.20	0.27	0.43	1.94	1.38	8.96
9	7.37	5.25	1.51	0.70		3.26	18.09
10	0.97	4.04	0.68	0.50	0.69	1.10	7.98
15	1.34	1.13	0.53	0.41		0.63	4.04
16	2.19	0.89	0.35	0.58		1.34	5.35
11	2.81	3.83	1.07	0.28	0.46	0.58	9.03
14	0.79	4.28	0.49	0.52	1.48	2.12	9.68
4	2.42	5.09	0.79	0.27	2.62	0.53	11.72
19	2.11	1.43	0.55	0.92		0.42	5.43
7	3.09	2.02	0.71	0.64	0.27	0.25	6.98
13	3.37	3.50	0.60	1.18	0.57	0.31	9.53
18	0.85	3.49	0.32	0.55	1.25	0.64	7.10
20	1.38	1.60	0.89	0.24		0.31	4.42
17	1.67	3.03	0.47	0.57	0.42	0.31	6.47

1/ Salaries and depreciation combined for a total of $5.87.



	30–40	40–70	70–90	90–140
AVERAGE FIXED COST/TON				
Above Ave Plants	$ 9.34	$13.53	$10.15	$ 9.53
Below Ave Plants	6.72	6.67	5.39	6.24
Combined Average	7.38	8.95	8.24	6.90
AVERAGE DAILY PRODUCTION (TONS)				
Above Ave Plants	25.60	44.11	41.66	50.00
Below Ave Plants	28.93	40.41	65.92	71.06
Combined Average	28.09	41.64	51.36	66.85
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants	71%	84%	53%	52%
Below Ave Plants	81	73	81	62
Combined Average	78	76	64	60

Figure 24. Analysis of Per Ton Fixed Costs. 1/ Four Plant Size Groups by 24-Hour Capacity.

1/ Fixed costs include salaries, depreciation, insurance, taxes, interest, and miscellaneous costs.

high of $18.09 per ton in the plants surveyed. The average fixed cost per ton was $8.05 for all plants and the median was $7.40 per ton. There were 13 of the 20 plants with below-average fixed costs and they tend to cluster between $7.40 and $8 per ton of output. In general, plants which had the lowest average fixed costs also operate at a higher percentage of capacity. The exception is in the 41-70 ton per hour capacity range. Plant 9 had an unusually high fixed cost that was largely attributable to the manager taking a higher return for salary and bookkeeping. This contributed to the high average fixed cost of the 41-70 ton capacity range. Plant 12, the other above-average plant in the 41-70 ton range was close to average. Depreciation for the plants ranged from a low of $0.89 to a high of $5.25 per ton. Salaries ranged from $0.79 to $7.37 per ton.

Total Costs

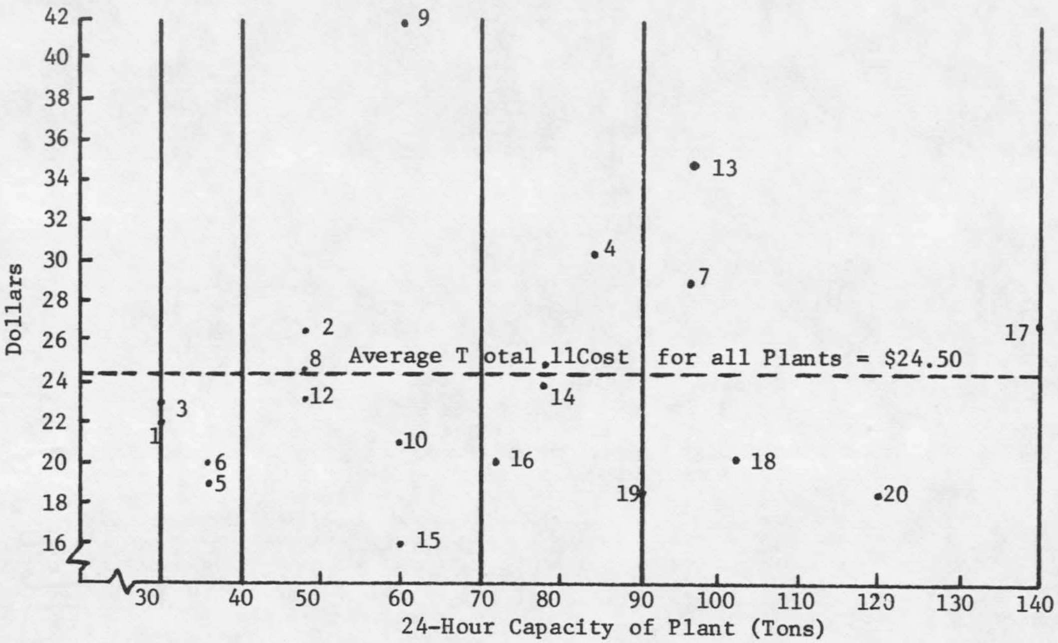
Total costs are shown in Table XII and are projected onto Figure 25. The combined average of all plants does not indicate that average total cost decreased as plant size increased. However, it should be remembered that for the combined average, percentage of operating capacity decreased as plant size increased.

With one exception, the relatively more efficient (below average) plants in each capacity range exhibit an inverse relationship between plant size and average total cost. The exception occurs in the 71-90 ton capacity range. In this range, the average total cost of the below-average plants is greater than that of the below-average plants in the

TABLE XII. TOTAL COSTS PER TON OF OUTPUT, 20 PLANTS, 1966 SURVEY.

Plant Code	24-Hour Capacity of Plant	Output Per 24-Hour Operating Day	Percent of Capacity at which Plant Operated	Total Conversion Costs Per Ton of Output	Total Variable Costs Per Ton of Output 1/	Total Fixed Costs Per Ton of Output	Total Cost Per Ton of Output
	Tons	Tons	Percent	Dollars			
3	30	25.60	71	13.72	14.03	9.34	23.06
1	30	19.98	56	14.96	14.96	7.02	21.98
5	36	33.33	93	13.18	13.18	5.90	19.08
6	36	33.48	93	13.36	13.56	7.24	20.60
2	48	24.39	47	18.83	20.40	7.56	26.44
8	48	39.94	83	17.66	17.91	7.08	24.74
12	48	48.21	100	14.53	14.58	8.96	23.49
9	60	40.00	67	23.81	24.79	18.09	41.90
10	60	43.92	73	13.56	15.18	7.98	21.54
15	60	53.38	89	12.05	12.05	4.04	16.09
16	72	56.20	78	14.88	15.13	5.35	20.23
11	78	45.02	58	15.95	16.55	9.03	24.98
14	78	52.45	67	14.38	18.26	9.69	24.07
4	84	27.50	33	19.04	20.19	11.72	30.76
19	90	75.64	84	13.43	13.43	5.43	18.86
7	96	39.20	41	22.65	22.65	6.98	29.63
13	96	50.00	52	26.27	26.27	9.53	35.80
18	102	75.48	74	13.59	16.58	7.10	20.69
20	120	100.00	83	14.32	14.32	4.42	18.74
17	140	69.50	50	20.82	20.82	6.47	27.29

1/ Includes storage, delivery, and miscellaneous costs.



AVERAGE TOTAL COST/TON				
Above Ave Plants		$31.03	$27.87	$30.91
Below Ave Plants	$21.18	20.37	21.05	19.72
Combined Average	21.18	25.70	23.78	26.43
AVERAGE DAILY PRODUCTION (TONS)				
Above Ave Plants		34.77	36.26	52.92
Below Ave Plants	28.09	48.50	61.43	83.71
Combined Average	28.09	41.64	51.36	66.85
AVERAGE PERCENT OF CAPACITY AT WHICH PLANT OPERATED				
Above Ave Plants		66%	46%	48%
Below Ave Plants	78%	87	68	79
Combined Average	78	76	64	60

Figure 25. Analysis of Per Ton Total Costs. Four Plant Size Groups by 24-Hour Capacity.

preceding (41-70 ton) range. However, the below-average plants in the 71-90 ton capacity range operated at 68 percent of capacity as opposed to 87 percent for the plants in the 41-70 ton capacity range and 79 percent for the plants in the 91-140 ton capacity range.

Breakeven Analysis

Breakeven analysis is commonly used as an analytical tool. The concept is covered in textbooks in the areas of quantitative management, quantitative analysis, managerial economics, etc. 29/ The breakeven point is the volume or level of operation at which total revenue is equal to total cost. Breakeven analysis may be approached either graphically or algebraicially. The approach here is algebraic.

The breakeven point occurs where total revenue (TR) is equal to total fixed costs (TFC) plus total variable costs (TVC). Since total revenue is equal to selling price times quantity sold (PQ) and total variable cost equals average variable cost times quantity (AVC x Q), the above statement may be expressed symbolically as:

29/ See, for example: Levin, Richard I. and C. I. Kirkpatrick, Quantitative Approaches to Management, (New York, 1968), pp. 16-46; Brabb, George J., Introduction to Quantitative Management, (New York, 1968), pp. 26-28; and Howell, James E. and Daniel Theichroew, Mathematical Analysis for Business Decisions, (Homewood, Illinois, 1963), pp. 80-94.

$$PQ = TFC + (AVC \times Q)$$

$$Q = \frac{TFC}{P-AVC}$$

where Q = the breakeven point in terms of volume.

The basic breakeven formula can be manipulated to expose raw material cost as a variable factor. The formula then becomes

$$PQ = TFC + (AVC \times Q) + (R \times Q)$$

where R = the per ton cost of raw alfalfa purchased.

Solving for Q, the formula becomes

$$Q = \frac{TFC}{P-AVC-R}$$

Positive Net Returns

At break-even volume all costs of production both fixed and variable have been covered. Fixed costs, by definition, do not vary with volume. After break-even volume is reached additional production results in positive net returns. These positive net returns are independent of fixed costs and can be determined by the formula

Positive net returns = TR' - TVC' - TAP'

where TR' = Total revenue after break-even

TVC' = Total variable costs after break-even

TAP' = Total alfalfa purchases after break-even

The formula may be rewritten as

$$\text{Positive net returns} = PQ' - AVC \times Q' - RQ' = Q' \, (P-AVC-R)$$

where Q' = Daily output times number of operating days after breakeven.

Application of Break-Even Analysis to Survey Data

The results of the break-even analysis for the plants in the survey are presented in Table XIII. Interest on investment was not included as a cost in determining breakeven volume. The approach used was to calculate positive net returns and capitalize them for an assumed discount rate.

Returns expected at some time in the future are discounted by the formula

$$V = \frac{R_1}{(1+i)} + \frac{R_2}{(1+i)^2} + \ldots + \frac{R_n}{(1+i)^n}$$

where V = present value of the expected returns

R_1 = return in period 1

R_2 = return in period 2

$\vdots$

R_n = return in period n

i = the rate at which the future returns are discounted.

TABLE XIII. BREAKEVEN ANALYSIS APPLIED TO SURVEY DATA.

Plant Code	24-Hour Capacity of Plant	Output Per 24-Hour Operating Day	Percent of Capacity at which Plant Operated	Average Price Received for Dehydrated Alfalfa (P)	Average Variable Costs (AVC)	Purchase Price of Raw Alfalfa (R)	Cost of Sacks Per Ton of Output	Cost of Additives Per Ton of Output
	Tons	Tons	Percent	----------	----------	Dollars	----------	----------
3	30	25.60	71	45.00	14.03	5.00	.70	
1	30	19.98	56	29.90	14.96	9.96		
5	36	33.33	93	33.45	13.18	9.46		.33
6	36	33.48	93	45.02	13.56	13.01		
2	48	24.39	47	40.26	20.40	10.50	.25	.30
8	48	39.94	83	46.02	17.91	14.61		.31
12	48	48.21	100	39.41	14.58	13.53	1.09	.30
9	60	40.00	67	43.50	24.79	9.00	.90	.50
10	60	43.92	73	35.80	15.18	10.00		
15	60	53.38	89	31.70	12.05	9.42		.34
16	72	56.20	78	34.73	15.13	9.34		.32
11	78	45.02	58	36.12	16.55	6.85		
14	78	52.45	67	39.44	18.26	10.00	.72	.51
4	84	27.50	33	45.00	20.19	10.27	.10	.16
19	90	75.64	84	31.90	13.43	9.52		.35
7	96	39.20	41	39.58	22.65	9.19	.06	.32
13	96	50.00	52	39.58	26.27	9.83	.48	.39
18	102	75.48	74	31.19	16.58	9.07		
20	120	100.00	83	32.50	14.32	9.71		.13
17	140	69.57	50	39.58	20.82	9.05	.90	.14

TABLE XIII. BREAKEVEN ANALYSIS APPLIED TO SURVEY DATA (cont'd).

P-AVC-R	Total Fixed Costs	Breakeven Volume $Q = \frac{TFC}{P-AVC-R}$	Actual Volume	Number of 24-Hour Operating Days Required to Breakeven Q/Daily Output	Actual Number of 24-Hour Working Days	Days from Beginning to end of Operating Season	Positive Net Returns	Positive Net Returns Capitalized at 8 Percent
Dollars	Dollars	Tons	Tons	Days	Days	Days	----Dollars----	
25.27	14,944	801	1,600	32	62.5	167	19,407	277,243
4.98	16,132	3,239	2,298*	162	115	128	**	
10.48	30,284	2,890	5,133	87	154	167	23,403	334,329
18.45	35,143	1,905	4,854	56	145	158	54,976	785,371
8.81	21,240	2,411	3,000	99	123	162	5,157	73,671
13.19	41,000	3,109	5,791	78	145	158	35,296	504,229
9.90	60,480	6,109	6,750	126	140	164	6,682	95,457
8.31	43,416	5,225	2,400*	130	60	136	**	
10.67	43,810	4,105	5,490	93	125	154	14,996	214,229
9.89	28,684	2,900	7,100	54	133	158	41,917	598,814
9.94	48,407	4,896	9,048	87	101	174	41,338	590,543
12.72	57,331	4,807	6,348	106	141	163	20,042	286,314
9.95	61,502	6,181	6,347	118	121	142	1,566	22,371
14.28	38,676	2,708	3,300	98	120	132	8,639	123,414
8.60	55,446	6,447	10,211	85	135	160	32,525	464,643
7.36	27,906	3,791	3,998	96	102	154	1,731	24,729
2.61	48,603	18,621	5,100*		102	154	**	
5.54	71,809	12,961	10,114*		134	160	**	
8.34	45,526	5,459	10,300	55	115	158	50,040	714,857
8.67	62,112	7,164	9,600	103	138	182	21,111	301,585

1/ Interest on investment is not included. *Indicates breakeven volume exceeded actual volume.
** Indicates there were no positive returns.

If the positive net returns from a dehydrating plant are discounted over its expected life, then V, the present value, is an indication of the value of the plant. V is often referred to as the capitalized value of the expected future returns. When the returns are expected to continue over an extended period of years the formula

$$V = \frac{R}{i}$$

gives a reasonably accurate estimate of the capitalized value. This formula was used to compute the values in the last column of Table X.

Four of the firms did not attain break-even volume. Firm 1 sold its product at the lowest price, had the highest average variable cost, and paid the second highest price for raw alfalfa in that capacity range. It needs 162 operating days to break-even in an operating season lasting 128 days. Low daily output and a product price that is lowest of all plants in the survey seem to be the critical factors. Plant 9 is the high cost plant in its capacity range. The plant, however, operated only the equivalent of sixty 24-hour days when 136 were possible. This would seem to indicate a shortage of alfalfa. Yields, in fact, were low in this area because of drought. Plant 13 is also the high cost plant in its capacity range. Plant 18 has relatively low average variable costs but received a relatively low price for its product. In addition, plant 18 had the highest fixed costs of all plants in the survey.

There are 8 plants in Table XIII where the capitalized values of the positive net returns probably exceed the investment (cost of plant plus interest) needed to install and erect the facility. These are plants 6, 8, 15, 16, 19, and 20. Possibly plants 3, 5, 11, and 17 could be built for the capitalized value of the positive net returns.

Limitations of Preceding Analysis

In addition to the shortcomings of cost accounting data mentioned in Chapter II, the preceding analysis has several other limitations. There was no indication of economies of scale. This may have been due to the fact that plants with larger capacities usually operated at lower percentages of capacity than smaller sized plants, while the long-run cost curve is derived from costs of most efficient plants. The previous analysis provides no information relating size of plant to length of operating season and raw alfalfa supply. There is also no information with respect to the relative positions of the average revenue and marginal cost curves.

The following is an attempt to construct cost information for several plant sizes commonly in use in order to supplement the analysis of the present chapter.

CHAPTER V

MODEL PLANT CONSTRUCTION

Estimation of Fixed Costs

Cost estimates are based on data received from equipment manufacturers. Equipment requirements and service life are based on information received during the personal interview survey.

The formula used to calculate annual cost of investment recovery and interest is:

$$\text{Annual cost of investment recovery and interest} = (I-S_n)\frac{i(1+i)^n}{(1+i)^n-1} + iS_n$$

where I = initial investment

i = percentage at which interest costs are to be taken

n = service life of equipment

S_n = salvage value of equipment at the end of n years of service 30/

In this study, the percentage at which interest costs are taken is 7 percent.

Harvesting

The harvester requirement for the 1.5 ton per hour plant is a self-propelled unit with a 10-foot cut. The alternative would be two tractor-drawn units which would exceed the cost of the self-propelled unit and also require an additional operator. The harvester for the 2-ton per

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30/ Morris, William T., The Capacity Decision System, (Homewood, Illinois, 1967), pp. 9-12.

hour plant is a self-propelled unit with a 12-foot cut. The requirement for the 3-ton per hour plant is two self-propelled units with 10-foot cutting heads. Cost estimates are presented in Table XIV.

Trucking

Each truck is assumed to have a capacity of six tons of chopped alfalfa. With few exceptions, this was the capacity of the trucks used by the survey plants. Cost estimates are shown in Table XV.

Processing

Plant costs have been estimated on the basis of a "packaged plant," or "turnkey" installation. The plant is installed by the firm selling the equipment and sold to the firm in a completed state. It should be noted, however, that many of the alfalfa dehydrating plants in the industry were engineered and installed by owners and/or employees with a thorough knowledge of the alfalfa dehydrating process. Many of these plants were built with some or all second-hand equipment. Engineering in the industry was, and still is, in many cases in the art stage. Methods of processing are far from being standardized. Some firms feel they have found improved methods of processing and diligently strive to keep them out of the hands of competitors. There are plants in the industry, considered to be models of efficiency, which were engineered and constructed by owners and/or employees.

Thus, it is not essential that a "package plant" be purchased. Nor is it absolutely necessary to install all new equipment. The alternatives,

TABLE XIV. HARVESTING--EQUIPMENT REQUIREMENTS AND COST.*

Equipment Description, Requirements and Cost	Plant Capacity in Tons Per Hour		
	1.5	2.0	3.0
Harvester			
Number required	1(10-ft.)	1(12-ft.)	2(10-ft.)
Replacement cost	$14,000	$16,000	$28,000
Annual cost of investment recovery & interest 1/	$ 1,776	$ 2,061	$ 3,552
Trailer			
Number required	1		2
Replacement cost	$ 3,500		$ 7,600
Annual cost of investment recovery & interest 2/	$ 330		$ 661
Maintenance and Repair Unit 3/			
Number required	1	1	1
Replacement cost	$ 2,000	$ 2,000	$ 2,000
Annual cost of investment recovery & interest 4/	$ 285	$ 285	$ 285

*Source: Cost estimates are based on data received from equipment manufacturers. Requirements are based on survey data.

1/ Based on straight-line depreciation over a period of 10 years with a salvage value of $3,000.

2/ Based on straight-line depreciation over a period of 20 years with no salvage value.

3/ Maintenance and repair unit is a second-hand pickup equipped with welding and cutting equipment and other tools necessary to make repairs in the field.

4/ Based on straight-line depreciation over a period of 10 years with no salvage value.

TABLE XV. TRUCKING--EQUIPMENT REQUIREMENTS AND COST.

Equipment Description, Requirements and Cost	Plant Capacity in Tons Per Hour 1.5	2.0	3.0
Number Required	2	3 1/	4
Replacement Cost	$16,000	$24,000	$32,000
Annual Cost of Investment Recovery and Interest 2/	$ 4,048	$ 6,072	$ 8,090

1/ Both the 1.5 and 2.0-ton per hour plants require one truck driver. The 2.0-ton per hour plant is assigned an additional truck as a flexibility factor. When hauling distance is particularly long, other plant personnel may serve as supplementary truck drivers. The 3.0-ton per hour plant is assigned two truck drivers.

2/ Based on straight-line depreciation over a period of four years with a salvage value of $1,500 per truck.

however, should be viewed with extreme caution. Many plants engineered and installed by amateurs have been models of inefficiency. On the other hand, some used equipment purchased has been either obsolete or unworkable. Plant equipment combinations have been incompatible. That is, the capacities of the various units such as feeder, drying drum, hammermill, pelletmill, etc., have not been properly coordinated. Improper installation has resulted in bottlenecks in the product flow and inefficient use of labor.

In effect, it is possible for a person or group of persons to engineer and install their own plant. They should do so however, only if they are thoroughly familiar with the processing of dehydrated alfalfa. As an alternative, they may wish to hire an individual to do the engineering and supervise the installation. However, that person's competency should be verified. There are individuals in the industry who have on more than one occasion been associated with unsuccessful enterprises. Second-hand equipment, if available, should be carefully scrutinized with respect to workability, obsolescence, and how the capacity of each individual item fits into the whole.

Manufacturers rate dehydrating drums in terms of evaporative capacity per hour. The 1.5-ton per hour plant has an evaporative capacity of 9,000 pounds per hour; the 2.0-ton per hour plant an evaporative capacity of 12,000 pounds per hour; and the 3.0-ton per hour plant an evaporative capacity of 18,000 pounds per hour. The initial moisture content of the raw alfalfa is assumed to be 70 percent. Cost estimates are presented in Table XVI. The plants were assigned one operator per shift. The 1.5 and 2.0-ton per hour plants were assigned one maintenance and repair man per day and the 3.0-ton per hour plant one maintenance and repair man per shift.

Variable Cost

Labor

Labor cost per ton are shown in Table XVII. Plants are assumed to work two 12-hour shifts per day with operating schedules of 4, 5, 6, and 7 days per week considered. Around the clock operation with a 12-hour shift was the standard mode of operation for most plants in the survey. The shortage of labor in the industry makes the 12-hour shift practical. The basic wage rate was taken from Table VII. Adjustments were then made for overtime pay on the basis of time and one-half for working hours in excess of 40 per week. The straight rates are $1.40 for harvester operators, $1.36 for truck drivers, $1.49 for plant operators, $1.25 for plant helpers, and $1.60 for maintenace and repair labor. The plant manager's salary is projected at $10,000 per year for the smallest plant with increments of $1,000 for the next two plant sizes. Payroll taxes are 3.85 percent of earnings up to $7,800 for FICA and 3.1 percent of earnings up to $3,000 for unemployment insurance.

Dehydrating Fuel

All plants are assumed to use natural gas. Consumption for the 1.5-ton per hour plant is 14,000 cubic feet per hour (CFH). For the 2.0-ton

TABLE XVI. PROCESSING: EQUIPMENT AND COST. 1/

Equipment Description	1.5 Ton Per Hour Plant: Replacement Cost	1.5 Ton Per Hour Plant: Annual Cost of Investment Recovery and Interest 2/	2.0 Ton Per Hour Plant: Replacement Cost	2.0 Ton Per Hour Plant: Annual Cost of Investment Recovery and Interest	3.0 Ton Per Hour Plant: Replacement Cost	3.0 Ton Per Hour Plant: Annual Cost of Investment Recovery and Interest
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Dehydrator	32,200	3,020	35,000	3,304	52,900	4,993
Feeder	10,500	991	10,500	991	10,500	991
Hammermill	6,120	1,493	8,000	1,951	9,200	2,244
Pellet transfer system	5,000	712	5,000	712	5,000	712
Pellet mill	17,000	1,866	20,000	2,196	20,000	2,196
Boiler & misc. equip.	7,000	661	8,000	755	10,000	944
Mill building	10,000	944	10,000	944	10,000	944
Loadout system	5,000	472	5,000	472	5,000	472
Scales	1,000	94	1,000	94	1,000	94
Electric service and lighting equipment	3,000	283	3,000	283	3,000	283
Office building	3,000	283	3,000	283	3,000	283
Storage tanks 3/	38,000	3,587	67,000	5,380	95,000	8,967
Inert gas generating & distribution system	14,000	1,321	14,000	1,321	14,000	1,321
Electric motor starters and controls	18,000	1,700	21,000	1,982	25,000	2,360
Installation & erection	9,000	850	10,000	944	12,000	1,133
Land	4,000	378	4,000	378	4,000	378
TOTALS	182,820	18,655	214,500	22,368	279,600	28,693

1/ Plant equipment requirements, where applicable, are one unit.

2/ The dehydration system, steam generation, and distribution equipment, loadout system, scales, electric service and lighting equipment, mill building, office building, storage tanks, inert gas generating and distribution system, and land have an investment recovery period of 20 years. The investment recovery period for the pellet mill is 15 years; for the hammermill, 5 years; and for the pellet transfer equipment, 10 years.

3/ Storage costs for tanks are estimated at $19 per ton of storage capacity. The 1.5-ton per hour plant has a storage capacity of 2,000 tons; the 2.0-ton per hour plant, 3,000 tons; and the 3.0-ton per hour plant, 5,000 tons.

TABLE XVII. LABOR COST PER HOUR. 1/

Days of Operation Per Week	Harvester Operators	Truck Drivers	Plant Operator	Maintenance and Repair
	---------------	--------------	Dollars --------	----------
4	1.52	1.47	1.61	1.73
5	1.63	1.59	1.74	1.87
6	1.71	1.66	1.82	1.96
7	1.77	1.72	1.88	2.02

1/ Wage rates are adjusted for overtime pay.

per hour plant it is 22,000 CFH, and for the 3.0-ton per hour plant it is 28,000 CFH. Cost estimates are based on a rate of 39 cents per 1,000 cubic feet for the first 6,000,000 cubic feet and 34 cents per 1,000 cubic feet for usage in excess of 6,000,000 cubic feet per year.

Power

Power requirements are 225 kilowatts for the 1.5-ton per hour plant, 250 kilowatts for the 2.0-ton per hour plant, and 300 kilowatts for the 3.0-ton per hour plant. Power costs for this analysis are assumed to be $.015 per kilowatt hour, based on information received from power companies.

Gas and Oil

Gas and oil costs are based on the survey data. Average gas and oil costs for plants in the 1.5-ton per hour range were $1.13 per ton. For plants in the 2.0-ton per hour range they were $1.38 and $1.69 for plants in the 3.0-ton per hour range.

Gas and oil costs are particularly subject to variation. They are affected by distance from plant to field, road patterns, type of road, raw alfalfa yields, and other physical factors in addition to cost differences between areas.

Maintenance and Repair

Maintenance and repair costs are estimated at 0.025 percent of replacement cost of each day of use. This estimate is esclusive of labor.

Other Costs

Cost of antioxidants is estimated at 50 cents per ton based on information received during the survey. Inert gas generation and distribution is estimated at $1 per ton based on information received from manufacturers. Insurance and tax cost estimates were based on survey data. Administrative costs consist primarily of part-time secretarial help.

Cost Integration

The cost estimates developed in the previous sections are combined in Tables XVIII, XIX, and XX to arrive at production costs for operating seasons of 12, 16, and 20 weeks. Operating season refers to the actual number of days the plant is in operation. In converting from a growing season to an operating season, allowance must be made for downtime. This information is then used to develop cost curves. These cost curves are shown in Figures 26, 27, and 28.

Figure 26 depicts the average cost curves for a 12-week operating season and work weeks of 4, 5, 6, and 7 days. Before the tabulated costs were plotted a raw alfalfa cost of $10 per ton was included. The minimum breakeven point is 1,728 tons and requires a product price of $48.52. The 1.5-ton per hour plant can continue to produce and break-even until product price drops to $38.02. At this point, the limits of production have been reached for this plant. It is operating 7 days per week and producing 3,024 tons annually. At a price just below $38.02

TABLE XVIII. PLANT COSTS FOR 1.5, 2.0, AND 3.0 TON PER HOUR PLANTS DURING A 12-WEEK OPERATING SEASON.

Type of Cost	1.5 Ton Per Hour Plant				2.0 Ton Per Hour Plant				3.0 Ton Per Hour Plant			
	4-Day Week	5-Day Week	6-Day Week	7-Day Week	4-Day Week	5-Day Week	6-Day Week	7-Day Week	4-Day Week	5-Day Week	6-Day Week	7-Day Week
	(1,728)	(2,160)	(2,592)	(3,024)	(2,304)	(2,880)	(3,456)	(4,032)	(3,456)	(4,320)	(5,184)	(6,048) 1/
Annual Cost of Investment Recovery & Interest												
Harvesting:												
Total	$2,391	$2,391	$2,391	$2,391	$2,676	$2,676	$2,676	$2,676	$4,498	$4,498	$4,498	$4,498
Per Ton	1.38	1.11	.92	.79	1.16	.93	.77	.66	1.30	1.04	.87	.74
Trucking:												
Total	4,048	4,048	4,048	4,048	6,072	6,072	6,072	6,072	8,090	8,090	8,090	8,090
Per Ton	2.34	1.87	1.56	1.34	2.64	2.11	1.76	1.51	2.34	1.87	1.56	1.34
Processing:												
Total	18,655	18,655	18,655	18,655	22,368	22,368	22,368	22,368	28,693	28,693	28,693	28,693
Per Ton	10.80	8.64	7.20	6.17	9.71	7.77	6.47	5.55	8.30	6.64	5.53	4.74
Insurance:												
Total	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000
Per Ton	1.45	1.16	.96	.83	1.30	1.04	.87	.74	1.16	.93	.77	.66
Taxes:												
Total	2,000	2,000	2,000	2,000	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000
Per Ton	1.16	.93	.77	.66	1.09	.87	.72	.62	.87	.69	.59	.50
Manager's Salary:												
Total	10,000	10,000	10,000	10,000	11,000	11,000	11,000	11,000	12,000	12,000	12,000	12,000
Per Ton	5.79	4.63	3.86	3.31	4.77	3.82	3.18	2.73	3.47	2.78	2.31	1.98
Administrative:												
Total	2,000	2,000	2,000	2,000	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000
Per Ton	1.16	.93	.77	.66	1.08	.87	.72	.62	.87	.69	.59	.50
Labor												
Harvesting:												
Total	1,751	2,347	2,956	3,568	1,751	2,347	2,956	3,568	3,502	4,694	5,912	7,136
Per Ton	1.01	1.09	1.14	1.18	.76	.82	.85	.89	1.01	1.09	1.14	1.18
Trucking:												
Total	1,693	2,290	2,868	3,467	1,693	2,290	2,868	3,467	3,387	4,579	5,737	6,935
Per Ton	.98	1.06	1.11	1.15	.74	.80	.83	.86	.98	1.06	1.11	1.15
Processing:												
Total	1,855	2,506	3,145	3,790	1,855	2,506	3,145	3,790	1,855	2,506	3,145	3,790
Per Ton	1.07	1.16	1.21	1.25	.80	.87	.91	.94	.54	.58	.61	.63
Maintenance & Repair 2/												
Total	3,556	3,906	4,253	4,596	3,556	3,906	4,253	4,596	5,513	6,213	6,907	7,592
Per Ton	2.06	1.81	1.64	1.52	1.54	1.36	1.23	1.14	1.60	1.44	1.33	1.26
Payroll Taxes												
Total	993	1,272	1,408	1,498	1,165	1,307	1,443	1,533	1,452	1,616	1,786	1,919
Per Ton	.57	.59	.54	.50	.51	.45	.42	.38	.42	.37	.34	.32
Fuel												
Total	5,783	7,154	8,525	9,896	8,917	11,071	13,225	15,380	11,267	14,009	16,751	19,503
Per Ton	3.35	3.31	3.29	3.27	3.87	3.84	3.83	3.81	3.26	3.24	3.23	3.22
Power												
Total	3,888	4,860	5,832	6,804	4,320	5,400	6,480	7,560	5,184	6,480	7,776	9,072
Per Ton	2.25	2.25	2.25	2.25	1.88	1.88	1.88	1.88	1.50	1.50	1.50	1.50
Gas and Oil												
Total	1,953	2,441	2,929	3,417	3,179	3,974	4,769	5,564	5,841	7,301	8,761	10,221
Per Ton	1.13	1.13	1.13	1.13	1.38	1.38	1.38	1.38	1.69	1.69	1.69	1.69
Maintenance & Repair												
Total	2,620	3,275	3,930	4,585	3,162	3,952	4,743	5,534	4,183	5,229	6,275	7,321
Per Ton	1.52	1.52	1.52	1.52	1.37	1.37	1.37	1.37	1.21	1.21	1.21	1.21
Antioxidant												
Total	864	1,080	1,296	1,512	1,152	1,440	1,728	2,016	1,728	2,160	2,592	3,024
Per Ton	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50
TOTAL	66,550	72,725	78,736	84,727	80,866	88,309	95,726	103,124	107,193	118,068	128,923	139,794
TOTAL PER TON	38.52	33.67	30.38	28.02	35.10	30.67	27.69	25.58	31.02	27.33	24.87	23.11

1/ Total annual production.

2/ Cost includes year-round maintenance and repair man for the 1.5 and 2.0-ton per hour plants and two year-round maintenance and repair men for the 3.0-ton per hour plant. A 40-hour work week was assumed for off-season employment.

TABLE XIX. PLANT COSTS FOR 1.5, 2.0, AND 3.0 TON PER HOUR PLANTS DURING A 16-WEEK OPERATING SEASON.

Type of Cost	1.5 Ton Per Hour Plant				2.0 Ton Per Hour Plant				3.0 Ton Per Hour Plant			
	4-Day Week	5-Day Week	6-Day Week	7-Day Week	4-Day Week	5-Day Week	6-Day Week	7-Day Week	4-Day Week	5-Day Week	6-Day Week	7-Day Week
	(2,304)	(2,880)	(3,456)	(4,032)	(3,072)	(3,840)	(4,608)	(5.376)	(4,608)	(5,760)	(6,912)	(8,064) 1/
Annual Cost of Investment Recovery & Interest												
Harvesting:												
Total	2,391	2,391	2,391	2,391	2,676	2,676	2,676	2,676	4,498	4,498	4,498	4,498
Per Ton	1.05	.83	.69	.59	.87	.70	.58	.51	.97	.78	.65	.56
Trucking:												
Total	4,048	4,048	4,048	4,048	6,072	6,072	6,072	6,072	8,090	8,090	8,090	8,090
Per Ton	1.76	1.40	1.17	1.00	1.98	1.58	1.32	1.13	1.76	1.40	1.17	1.00
Processing:												
Total	18,655	18,655	18,655	18,655	22,368	22,368	22,368	22,368	28,693	28,693	28,693	28,693
Per Ton	8.10	6.48	5.40	4.63	7.28	5.82	4.85	4.16	6.23	4.98	4.15	3.56
Insurance:												
Total	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000
Per Ton	1.08	.87	.72	.62	.98	.78	.65	.56	.87	.69	.58	.50
Taxes:												
Total	2,000	2,000	2,000	2,000	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000
Per Ton	.87	.69	.58	.50	.81	.65	.54	.46	.65	.52	.43	.37
Manager's Salary:												
Total	10,000	10,000	10,000	10,000	11,000	11,000	11,000	11,000	12,000	12,000	12,000	12,000
Per Ton	4.34	3.47	2.89	2.48	3.58	2.86	2.39	2.05	2.60	2.08	1.74	1.49
Administrative:												
Total	2,000	2,000	2,000	2,000	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000
Per Ton	.87	.69	.58	.50	.81	.65	.54	.46	.65	.52	.43	.37
Labor												
Harvesting:												
Total	2,367	3,139	3,940	4,758	2,367	3,139	3,940	4,758	4,654	6,278	7,880	9,516
Per Ton	1.01	1.09	1.14	1.18	.76	.82	.85	.89	1.01	1.09	1.14	1.18
Trucking:												
Total	2,258	3,053	3,836	4,602	2,258	3,053	3,836	4,602	4,516	6,106	7,672	9,274
Per Ton	.98	1.06	1.11	1.15	.74	.80	.83	.86	.98	1.06	1.11	1.15
Processing:												
Total	2,465	3,341	4,182	5,040	2,465	3,341	4,182	5,040	2,465	3,341	4,182	5,040
Per Ton	1.07	1.16	1.21	1.25	.80	.87	.91	.94	.54	.58	.61	.63
Maintenance & Repair 2/												
Total	3,632	4,099	4,562	5,019	3,632	4,099	4,562	5,019	7,265	8,198	9,124	10,037
Per Ton	1.58	1.42	1.32	1.24	1.18	1.07	.99	.93	1.58	1.42	1.32	1.24
Payroll Taxes:												
Total	1,258	1,429	1,540	1,652	1,293	1,464	1,575	1,687	1,685	1,895	2,085	2,278
Per Ton	.55	.50	.44	.41	.42	.38	.34	.31	.37	.33	.30	.28
Fuel:												
Total	7,611	9,439	11,267	13,095	11,789	14,662	17,134	20,406	14,923	18,578	22,234	26,018
Per Ton	3.30	3.28	3.26	3.25	3.84	3.82	3.80	3.80	3.24	3.23	3.22	3.22
Power:												
Total	5,184	6,480	7,776	9,072	5,775	7,219	8,663	10,107	6,912	8,640	10,368	12,096
Per Ton	2.25	2.25	2.25	2.25	1.88	1.88	1.88	1.88	1.50	1.50	1.50	1.50
Gas and Oil:												
Total	2,604	3,254	3,905	4,556	4,239	5,299	6,359	7,419	7,788	9,734	11,681	13,628
Per Ton	1.13	1.13	1.13	1.13	1.38	1.38	1.38	1.38	1.69	1.69	1.69	1.69
Maintenance & Repair:												
Total	3,493	4,366	5,240	6,113	4,216	5,270	6,324	7,378	5,578	6,972	8,366	9,761
Per Ton	1.52	1.52	1.52	1.52	1.37	1.37	1.37	1.37	1.21	1.21	1.21	1.21
Antioxidant:												
Total	1,152	1.440	1,728	2,016	1,536	1,920	2,304	2,688	2,304	2,880	3,456	4,032
Per Ton	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50
TOTAL	73,618	81,634	89,570	97,517	89,786	99,582	108,995	119,240	121,371	135,903	150,329	164,961
TOTAL PER TON	31.95	28.35	25.92	24.19	29.23	25.93	23.65	22.18	26.34	23.59	21.75	20.46

1/ Total annual production.

2/ Cost includes year-round maintenance and repair man for the 1.5- and 2.0-ton per hour plants and two year-round maintenance and repair men for the 3.0-ton per hour plant. A 40-hour work week was assumed for off-season employment.

TABLE XX. PLANT COSTS FOR 1.5, 2.0, AND 3.0 TON PER HOUR PLANTS DURING A 20-WEEK OPERATING SEASON.

Type of Cost	1.5 Ton Per Hour Plant				2.0 Ton Per Hour Plant				3.0 Ton Per Hour Plant			
	4-Day Week	5-Day Week	6-Day Week	7-Day Week	4-Day Week	5-Day Week	6-Day Week	7-Day Week	4-Day Week	5-Day Week	6-Day Week	7-Day Week
	(2,880)	(3,600)	(4,320)	(5,040)	(3,840)	(4,800)	(5,760)	(6,720)	(5,760)	(7,200)	(8,640)	(10,080) 1/
Annual Cost of Investment Recovery & Interest												
Harvesting:												
Total	2,391	2,391	2,391	2,391	2,676	2,676	2,676	2,676	4,498	4,498	4,498	4,498
Per Ton	.83	.66	.55	.47	.67	.56	.46	.40	.78	.62	.52	.45
Trucking:												
Total	4,048	4,048	4,048	4,048	6,072	6,072	6,072	6,072	8,090	8,090	8,090	8,090
Per Ton	1.41	1.12	.93	.80	1.58	1.26	1.05	.90	1.40	1.12	.94	.80
Processing:												
Total	18,655	18,655	18,655	18,655	22,368	22,368	22,368	22,368	28,693	28,693	28,693	28,693
Per Ton	6.48	5.18	4.32	3.70	5.82	4.66	3.88	3.33	4.98	3.98	3.32	2.85
Insurance:												
Total	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000	4,000	4,000	4,000	4,000
Per Ton	.87	.69	.58	.49	.78	.62	.52	.45	.69	.56	.46	.40
Taxes:												
Total	2,000	2,000	2,000	2,000	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000
Per Ton	.69	.56	.46	.40	.65	.52	.43	.37	.52	.41	.35	.30
Manager's Salary:												
Total	10,000	10,000	10,000	10,000	11,000	11,000	11,000	11,000	12,000	12,000	12,000	12,000
Per Ton	3.47	2.78	2.31	1.98	2.86	2.29	1.91	1.64	2.08	1.67	1.39	1.19
Administrative:												
Total	2,000	2,000	2,000	2,000	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,000
Per Ton	.69	.56	.46	.40	.65	.52	.43	.37	.52	.41	.35	.30
Labor												
Harvesting:												
Total	2,909	3,924	4,925	5,947	2,909	3,924	4,925	5,947	5,919	7,848	9,850	11,894
Per Ton	1.01	1.09	1.14	1.18	.76	.82	.85	.89	1.01	1.09	1.14	1.18
Trucking:												
Total	2,822	3,816	4,795	5,796	2,822	3,816	4,795	5,796	5,645	7,632	9,590	11,592
Per Ton	.98	1.06	1.11	1.15	.74	.80	.83	.86	.98	1.06	1.11	1.15
Processing:												
Total	3,082	4,176	5,227	6,300	3,082	4,176	5,227	6,300	3,082	4,176	5,227	6,300
Per Ton	1.07	1.16	1.21	1.25	.80	.87	.01	.94	.54	.58	.61	.63
Maintenance & Repair 2/												
Total	3,709	4,292	4,870	5,442	3,709	4,292	4,870	5,442	7,418	8,582	9,740	10,884
Per Ton	1.29	1.19	1.13	1.08	.97	.89	.85	.81	1.29	1.19	1.13	1.08
Payroll Taxes:												
Total	1,378	1,528	1,667	1,808	1,413	1,563	1,702	1,843	1,823	2,061	2,298	2,540
Per Ton	.48	.42	.39	.36	.37	.33	.30	.27	.32	.29	.27	.24
Fuel:												
Total	9,439	11,724	14,009	16,294	14,662	18,252	21,842	25,433	18,578	23,148	27,718	32,260
Per Ton	3.28	3.25	3.24	3.23	3.82	3.80	3.79	3.78	3.23	3.22	3.21	3.20
Power:												
Total	6,480	8,100	9,720	11,340	7,219	9,024	10,829	12,634	8,640	10,800	12,960	15,120
Per Ton	2.25	2.25	2.25	2.25	1.88	1.88	1.88	1.88	1.50	1.50	1.50	1.50
Gas and Oil:												
Total	3,254	4,068	4,882	5,695	5,299	6,624	7,949	9,274	9,734	12,168	14,602	17,035
Per Ton	1.13	1.13	1.13	1.13	1.38	1.38	1.38	1.38	1.69	1.69	1.69	1.69
Maintenance & Repair:												
Total	4,366	5,458	6,550	7,641	5,270	6,588	7,905	9,222	6,972	8,715	10,458	12,201
Per Ton	1.52	1.52	1.52	1.52	1.37	1.37	1.37	1.37	1.21	1.21	1.21	1.21
Antioxidant:												
Total	1,440	1,800	2,160	2,520	1,920	2,400	2,880	3,360	2,880	3,600	4,320	5,040
Per Ton	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	.50
TOTAL	80,473	90,480	100,399	110,377	98,441	110,799	123,026	135,360	133,972	152,011	170,044	188,147
TOTAL PER TON	27.94	25.13	23.24	21.90	25.64	23.08	21.36	20.14	23.26	21.11	19.68	18.67

1/ Total annual production.

2/ Cost includes year-round maintenance and repair man for the 1.5- and 2.0-ton per hour plants and two year-round maintenance and repair men for the 3.0-ton per hour plant. A 40-work week was assumed for off-season employment.

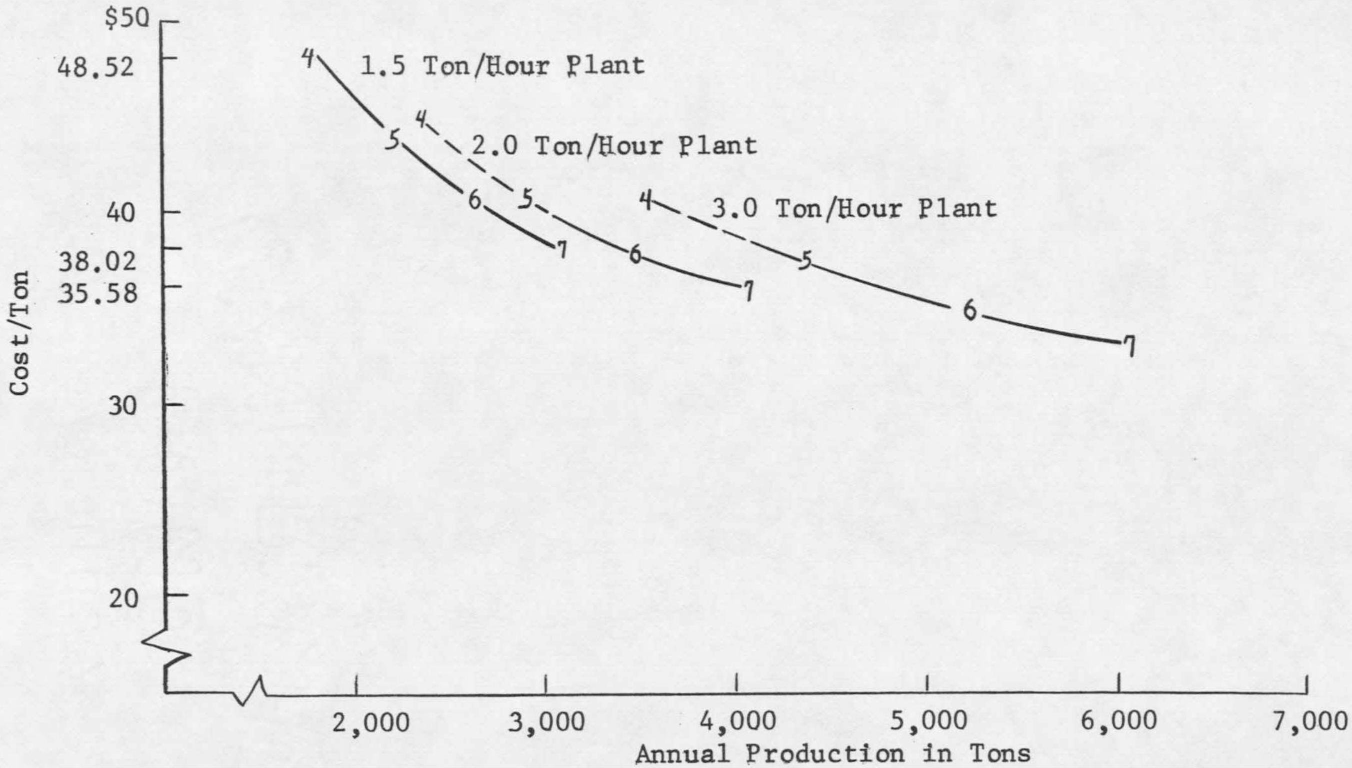

Figure 26. Average Costs for a 12-Week Operating Season with 4, 5, 6, and 7 Day Work Weeks for Plants with Capacities of 1.5, 2.0, and 3.0 Tons Per Hour. 1/

1/ Average costs include a $10 per ton raw alfalfa cost.

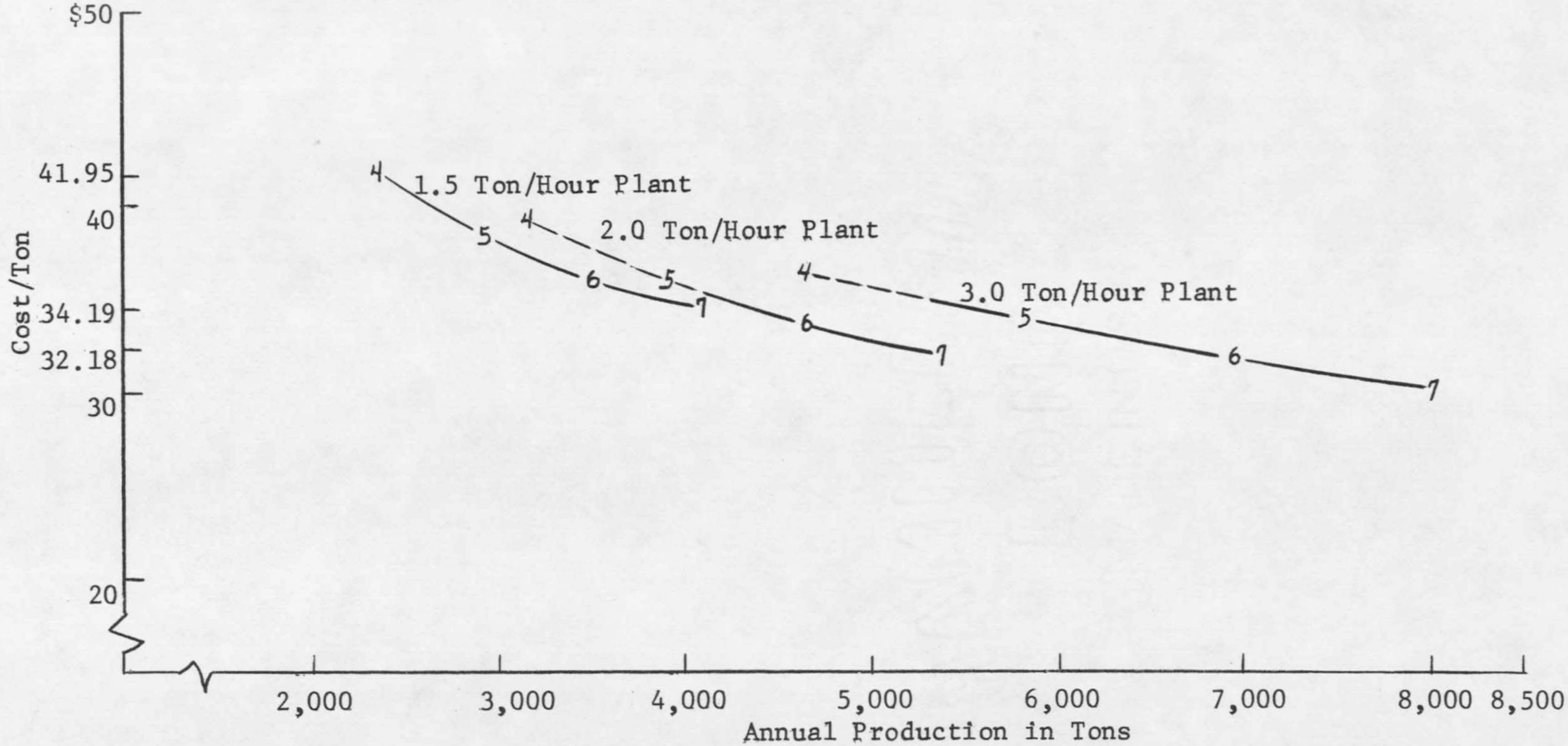

Figure 27. Average Costs for a 16-Week Operating Season with 4, 5, 6, and 7 Day Work Weeks for Plants with Capacities of 1.5, 2.0, and 3.0 Tons Per Hour. 1/

1/ Average costs include a $10 per ton raw alfalfa cost.

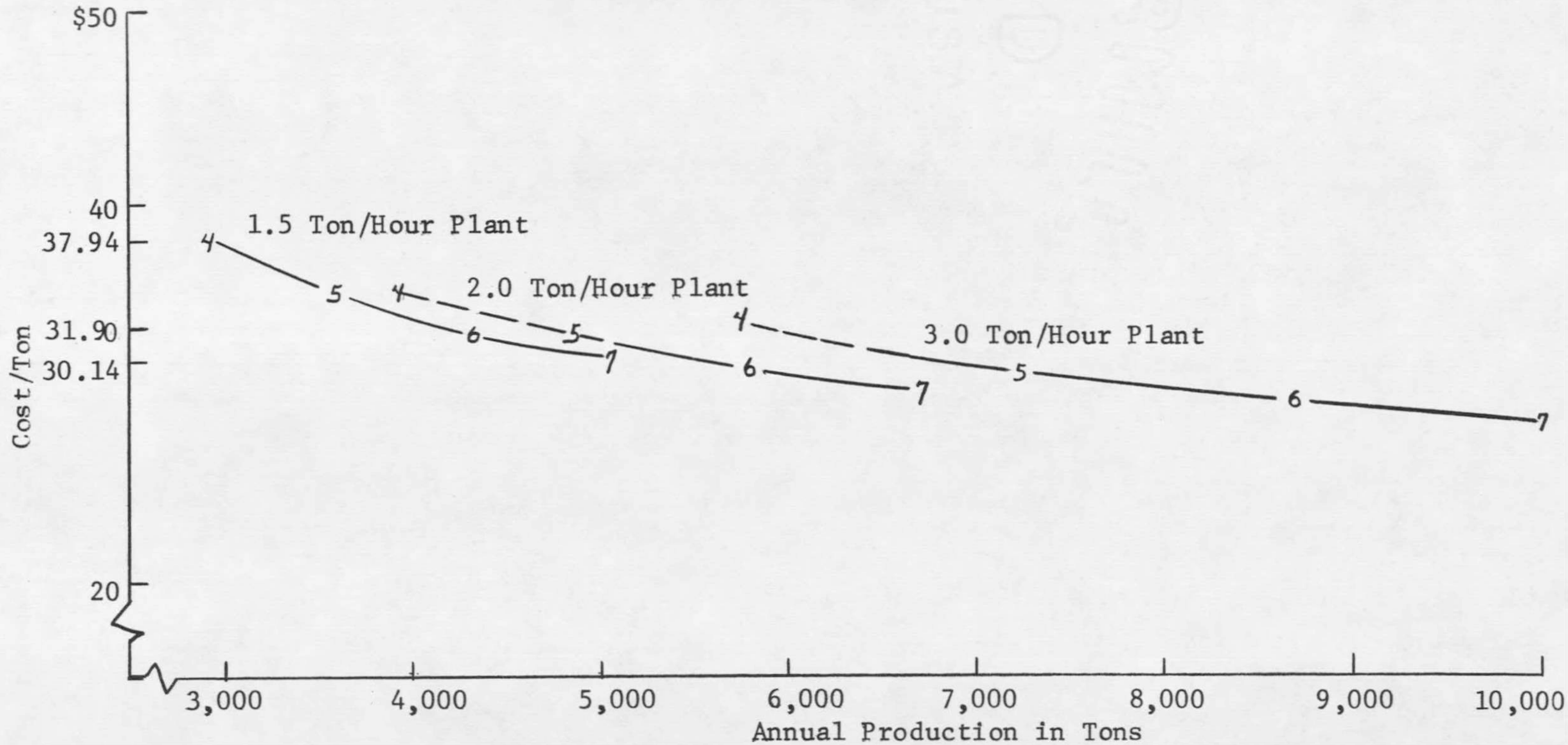

Figure 28. Average Costs for a 20-Week Operating Season with 4, 5, 6, and 7 Day Work Weeks for Plants with Capacities of 1.5, 2.0, and 3.0 Tons Per Hour.

1/ Average costs include a $10 per ton raw alfalfa cost.

the firm must go to the next larger plant. The breakeven point has increased to approximately 3,300 tons of annual production. The limits of production for the 2.0-ton per hour plant are reached when price falls just below $35.58. At a price of $35.58 the 2.0-ton per hour plant is working 7 days per week and producing 4,032 tons annually. When price falls just below $35.20 the firm must go to the 3.0-ton per hour plant with annual production requirements jumping to approximately 4,550 tons.

Figure 27 depicts the average cost curves for a 16-week operating season and work weeks of 4, 5, 6, and 7 days. The minimum breakeven point is 2,304 tons of annual production and requires a product price of $41.95. This is a decrease of $6.57 over the 12-week operating season. The 1.5-ton per hour plant reaches its production limit at an annual production of 4,032 tons and a product price of $34.19. At a product price just below $34.19 the firm must go to the 2.0-ton per hour plant. The tonnage requirement increases to approximately 4,250. At a price of $32.18 the 2.0-ton per hour plant reaches its production limit. The tonnage requirement increases from 5,376 to approximately 6,350 tons.

Figure 28 depicts the average cost curves for a 20-week operating season and work weeks of 4, 5, 6, and 7 days. The minimum breakeven point is 2,880 tons of annual production and requires a product price of $37.94. This is a decrease of $4.01 over the 16-week operating season and $10.58 over the 12-week operating season. The 1.5-ton per hour plant reaches its production limit at 5,040 tons of annual production. Minimum product price at this point is $31.90. At a price just below

$31.90 the firm must go to the 2.0-ton per hour plant. The production requirements for the 2.0-ton per hour plant at this point are approximately 5,600 tons. The production limit for the 2.0-ton per hour plant is reached at 6,720 tons of annual production. The firm can break even here at a product price of $30.14. At a price just below $30.14 the tonnage requirement is approximately 8,250 tons.

The firm will, of course, operate beyond breakeven volume. The limiting factor is the amount of raw alfalfa available. Since none of the cost curves turn up the marginal cost curves--long- and short-run--must lie below them. Therefore, as long as the average revenue curve is such that the firm can break even, it will pay the firm to expand production up to the raw alfalfa supply limitation. If the supply limit occurs before the 7 day work week is reached, the plant will not be operating at full capacity with reference to the time dimension.

It is recognized that the cost curves sketched in the preceding figures are extremely variable. It was assumed that the moisture content of the raw alfalfa was 70 percent. The same plants operating on alfalfa with a higher moisture content will have decreased hourly capacities and consequently higher average cost. Costs will also be affected by cost differences among areas for fuel, power, gas and oil, and labor. The location of the raw alfalfa supply with reference to the plant will affect production costs. The cost picture will also be determined by yields and per ton costs of raw alfalfa.

CHAPTER VI

MARKETING MANAGEMENT

Alfalfa dehydrating firms have historically counted primarily on direct sales to feed manufacturers and brokers as the principal market for dehydrated alfalfa. One of the major part-time functions of the plant manager has been the selling of the product to livestock feeders, feed mills, and other outlets. The dehydrated alfalfa industry has had comparatively few buyers and sellers and as a result individual parties have considerable influence on supply and price.

Pricing the product is the primary concern of marketing. Both what the plant is willing to pay farmers for raw alfalfa and what the plant will charge for processed alfalfa. How the plant managers determine what they will pay the producers for raw alfalfa has been discussed in Chapter II.

Establishment of price for the finished product is an important and integral part of the marketing management of the firm. Managers are concerned with the distribution channels by which they market their product and from which one they will realize the greatest return. Marketing must take into consideration any promotional activities or attempts to increase sales. When pricing his finished product, the manager must take into consideration the price of the raw alfalfa, the dehydrating costs, the distance to consumers of his product, the quality of the alfalfa dehy, the amount of time he has stored it, and the quoted central market price. Dehydrated alfalfa has few quoted central market prices. Alfalfa dehy prices has fluctuated seasonally (refer to Table XXI). Generally, prices are highest in the early winter months.

The above discussion centers primarily around the three basic utilities that are concerned with marketing, that is of time, place, and form. The survey attempted to determine what kind of a sales organization each firm had and how they sold their product. The discussion will proceed with sales organization, market demand, market outlets, sales information, and storage.

Sales Organization

Of the firms interviewed the bulk of them did not belong to any particular sales organization. The manager in most cases did the selling. A few of the firms did belong to a parent organization which sells the bulk of their output.

Half of the plant managers commented on whether or not they thought an overall cooperative sales agency sponsored by several firms would be helpful. Five of the plant managers didn't think it would be at all helpful for the following reasons: They would not like to commit their tonnage and they were afraid there might be some added costs in selling. In direct conflict another five managers thought it would reduce selling costs and also thought that there might be a better opportunity for financing sales.

Some of the major selling difficulties cited by managers are market fluctuations and the fact that there is no commodity market in

TABLE XXI. WHOLESALE PRICE PER TON, BULK, OF DEHYDRATED ALFALFA MEAL, 17 PERCENT PROTEIN, 100,000 UNITS VITAMIN A, AT KANSAS CITY.*

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Ave.
							Dollars						
1957-58	45.70	46.00	44.20	41.10	42.10	40.60	38.60	32.00	30.75	32.00	31.60	34.70	38.30
1958-59	43.00	46.00	49.00	57.00	61.00	61.00	61.00	54.25	41.60	41.50	43.00	43.40	50.15
1959-60	49.50	53.50	55.00	55.00	55.00	53.40	53.00	41.40	38.00	38.00	39.20	40.10	47.60
1960-61	45.35	47.90	47.10	46.50	46.50	48.10	47.50	46.20	40.75	40.25	43.00	43.00	45.15
1961-62	46.20	49.00	48.00	49.60	52.70	54.20	55.00	44.80	40.00	39.60	43.40	48.20	47.60
1962-63	52.20	53.50	52.00	53.00	54.80	52.22	46.00	41.50	41.20	42.40	46.50	46.50	48.40
1963-64	47.70	49.90	48.80	47.60	45.40	41.20	38.40	37.20	35.20	36.00	38.30	41.00	42.20
1964-65	42.60	43.50	43.50	43.50	41.60	38.80	37.20	36.00	35.60	38.50	41.00	42.00	40.30
1965-66	46.60	49.50	49.50	49.80	52.60	55.20	53.20	48.00	41.50	47.00	50.00	53.00	49.70
1966-67	53.70	56.30	59.60	61.30	61.90	59.50	53.30	46.40	45.90	48.00	47.80	47.00	53.40
1967-68	47.00	47.00	45.70	43.00	39.20	37.20	36.80	36.20	35.50	35.00	33.50	33.50	39.13
1968-69	37.30	41.20	44.40	46.50	47.00	46.50							

*Source: Feed market News, USDA, Washington, D. C., Vol. 45, No. 40, October 3, 1962, pp. 22-23; Vol. 48, No. 40, October 6, 1965, pp. 23-25; Feed Statistics, Stat. Bul. 410, September 1967, p. 87; Feed Situation, FDS-216 to 222, November 1966 to February 1968.

their immediate area seemed to bother some of the managers. About 50 percent of the plants said they had no major difficulties in selling their product in recent years. There was no relation between age of plant and their sales organization activities.

Market Demand

In only one instance did any one of the plant managers feel that lack of demand limited his plants production. The one instance where the individual figured that production was limited by demand thought it was basically a pricing problem.

Eleven of the plants indicated they considered cost of production as one of the factors considered when arriving at price for dehydrated alfalfa. All four plants three years of age and under considered cost of production and the competitive market price when establishing price. In total, nine plants considered market price and their competitors when establishing dehy prices. There were no other factors consistently mentioned as important when establishing prices for dehydrated alfalfa. Prices received at the plant varies considerably between plants and within plants, suggesting that there is no uniform pricing mechanism.

Marketing Outlets

The bulk of the plants indicated they sold most of their dehy within a 100-mile radius of their processing plant. One 20-year old plant sold 100 percent of its volume within a 25-mile radius of the plant, indicating they had a strong local demand. Some plants were part of a larger organization and shipped direct to the parent company which handled the sales.

Eleven plant managers felt that there was a definite opportunity to increase production of dehy in their areas and they listed increased cattle feeding as the primary reason for increased potential. Five of these plants were five years old or less but four plants had been operating 19 years or longer. In a few cases, dairies were listed as contributing to an increased demand.

Only one-half of the managers indicated that they had done any market development work in their area and these were with cattle feeders almost exclusively. Both new and old firms participated in market development activities. In two instances sales had increased with a feed manufacturing firm.

They indicated that their major problem in entering a new market is trying to convince the buyer that alfalfa dehy is not just hay, that it is definitely a feed and has excellent feed value. In some situations they indicated there was some competition from other feed products and the newer plants indicated they had some problems in establishing their reputation and the quality of their product with the potential buyers.

One of the basic strategies of marketing alfalfa is production differentiation. Alfalfa dehy is different from alfalfa hay but potential customers are reluctant to accept this as valid. Thus, part of expanding sales is an education effort. With emphasis on education; market development efforts cannot rely on sales promotion gimicks and advertising but must concentrate more on personal selling which is the process of assisting and persuading a prospect to buy alfalfa dehy in a face-to-face situation. Personal selling not only is needed but is the most practical. Potential buyers which have been identified as; feed mills, livestock feeders, dairymen, feed manufacturing companies, other livestock feeders in addition to brokers and commission men can be readily identified in a plant's market area. When calling on a potential customer the salesman needs to be equipped with considerable material related to the nutritional value of alfalfa dehy as well as the economics of it in the nation. The American Dehydration Association has suggested sales material that can be made available to a dehy firm.

Firms should try to hold expenditures for advertising and sales promotion gimmicks to a minimum and invest market development money in personal selling.

Before any major expenditure should be made on market development, the firm should make a critical appraisal of the market potential in its trade area. This can be done in several ways:

1) Determine number and volume of feed manufacturing plants within 150 miles of the firm;

2) Number and volume of alfalfa dehydrating within a 150-mile radius;

3) Number and size of livestock feeders within a 150-mile radius;

4) Number and size of dairy farmers within a 150-mile radius;

5) What has been the trend in livestock feeding, dairying, and feed manufacturing in the area (in it increasing, decreasing, or stable).

Much of the above information can be obtained from secondary sources. If unavailable the plant may have to take representative surveys in an attempt to determine how much dehydrated alfalfa could be used in the area. In general, most of this information should have been determined prior to establishment of the dehy plant. Greater detail on determining these factors is included in a later chapter. Once the above information has been determined, the plant management can allocate the appropriate effort to exploit the market potential in the area.

Sales Information

Over three-fourths of the plants indicated they made some sales with guaranteed protein content and 14 out of 20 indicated they guaranteed between 76 and 100 percent of their sales based on protein content (Table XXII). Only eight of the plants indicated that a high percentage of their sales were based on a guaranteed carotene content. The three newest plants made a 100 percent of their sales on a guaranteed protein content and 75 percent or more on guaranteed carotene content.

Price premiums were received in most instances above 17 percent protein. Premiums ranged from a dollar a point to two dollars a point about 17 percent. In some cases, this seemed to be a significant factor in terms of the prices they received and things that they considered in establishing a price.

TABLE XXII. NUMBER OF PLANTS WHO GUARANTEED PROTEIN AND CAROTENE IN THEIR PRODUCT, 1966.*

	% of Sales with Guaranteed Protein & Carotene Content			
	0-25%	26-50%	51-75%	76-100%
	Number of Plants			
Carotene	0	1	3	8
Protein	1	0	1	14

*Doesn't total because not all plants answered this question.

Very few sales were made on credit. However, over half of the plants made some sales based on future delivery. Five of the youngest plants sold 60 percent or more of their sales on future delivery. In each case where they made sales based on future delivery there was a fixed price with a down-payment. They did not indicate what the down-payment was as a percentage of total. Those plants who did make sales based on future delivery did between 50 and 60 percent of their business on this basis. One of the oldest plants made 95 percent of its sales based upon future delivery.

The plants interviewed sell through brokers, commission men, direct to feed mills, direct to livestock feeders and many of them sell through their own mixed feeds and some to a parent organization.

Of the 11 plants who sold through brokers the selling charge for eight of them was $1 per ton; for two of them, 75 cents per ton; and for one plant, the selling charge was only 50 cents per ton. The average price received varied all the way from $34 per ton to $43.50 (Table XXIII). The price through brokers generally was the same as through commission men. However, in some cases, was not as great as when the same plants sold direct to feed mills. The price spread when they sold directly to livestock feeders compared favorably with those sales directly to feed mills. Three of the plants sold a fair percentage of their volume through their own mixed feeds. Two others had all their sales handled through their parent company.

Storage

Storage is a very significant part of the marketing function. Nine of the firms interviewed indicated they had a definite storage policy (Table XXIV). Age of plant seemed to have very little influence on storage policy. The average age of both groups was over 10 years with a range from 2 to 25 years with those who have a definite policy and a range from 2 to 20 years for those who don't. Nine plants said they have about one-half of their production in storage so as to market at a more opportune time. Three plants indicated they store the lower grade dehy to sell locally and sell the higher quality product to more distant markets. A few plants store their early season production for a couple of months and then move it out as they do additional processing. Some regulate their storage volume according to the market. When the market is low they tend to hold more in storage longer than when the market is high.

TABLE XXIII. METHOD OF SELLING DEHYDRATED ALFALFA, 20 PLANTS, 1966.

	Sold Through Brokers			Sold Through Commission Men			Sold Direct to Feed Mills		Sold Direct to Livestock Dealers	
Firm	Percent Of Sales	Average Net Price/Ton	Selling Charges/Ton	Percent Of Sales	Average Net Price/Ton	Selling Charges/Ton	Percent Of Sales	Average Net Price/Ton	Percent Of Sales	Average Net Price/Ton
	Pct.	Dollars	Dollars	Pct.	Dollars	Dollars	Pct.	Dollars	Pct.	Dollars
1 1/	--	--	--	--	--	--	--	--	5	40.00
2	25	35.00	1.00	--	--	--	75	35.00	--	--
3 2/	20	44.50	0.50	--	--	--	70	45.00	--	--
4	30	40.00	1.00	10	38.00	1.00	50	45.00	10	50.00
5 3/	--	--	--	--	--	--	10	34.96	40	34.96
6	--	--	--	--	--	--	10	45.02	90	45.02
7 4/	--	--	--	--	--	--	--	--	--	--
8	--	--	--	--	--	--	10	45.02	90	45.02
9 5/	10	36.00	1.00	--	--	--	5	35.00	10	35.00
10	40	39.78	0.75	40	39.78	0.75	10	40.80	10	47.01
11	5	43.50	1.00	--	--	--	95	43.50	--	--
12 6/	5	--	1.00	--	--	--	90	44.00	--	--
13 4/	--	--	--	--	--	--	--	--	--	--
14	50	40.00	0.75	--	--	--	50	40.00	--	--
15 4/	--	--	--	--	--	--	--	--	--	--
16 3/	25	34.79	1.00	--	--	--	10	34.79	15	34.79
17 7/	10	--	1.00	10	--	--	20	--	--	--
18 3/	25	34.00	1.00	25	34.00	1.00	--	--	--	--
19 4/	--	--	--	--	--	--	--	--	--	--
20 4/	--	--	--	--	--	--	--	--	--	--

1/ Sold 95 percent through another company.
2/ Sold 10 percent through its own mixed feed.
3/ Sold 50 percent to another Dehy firm.
4/ Sold 100 percent through another company.
5/ Sold 75 percent to truckers at plant.
6/ Sold 5 percent to poultry feeders.
7/ Sold 20 percent for export and 40 percent direct at plant.

TABLE XXIV. STORAGE POLICY AND PROBLEMS, 17 ALFALFA DEHYDRATING PLANTS, 1966.

	Number of Plants	
	Yes	No
1 - Plant has a definite storage policy	9	8
2 - Present storage is adequate	11	5
3 - Limited storage has forced early selling	3	13

Eleven of the firms indicated that their present storage was adequate, and five said their storage was not adequate. Only three firms indicated that limited storage had forced them into selling before they really wanted to (refer to Table XXIV). Two of these were firms 20-years old and one was a new operator. Thirteen said they were not forced to sell because of lack of storage and four were noncommital suggesting that most firms in the survey have adequate storage facilities.

Plant managers were asked what the minimum and maximum storage requirements were for a plant of their size. In general, as the capacity of the plant increased production capacity increased and the minimum storage requirements increased (Table XXV). The maximum storage requirements are as high as 10,000 tons for plants that are producing in the neighborhood of 10,000 tons per year (Table XXV). Minimum

TABLE XXV. MINIMUM AND MAXIMUM STORAGE REQUIRED PER PLANT BY VOLUME OF OUTPUT, 1966.

Plant Code	Plant Age	Plant Production	Capacity of Plant	Percent of Capital Plant Operated	Storage Needed Minimum	Storage Needed Maximum
	Years	Tons	Tons		Tons	Tons
3	19	1,600	2,254	71	1,500	2,500
1	20	2,298	4,103	56	70 1/	70
9	13	2,400	3,482	67	3,000	5,000
2	20	3,000	6,383	47	NA 2/	NA
4	3	3,300	10,000	33	3,000 1/	3,000
7	26	3,998	9,751	41	NA	NA
6	4	4,854	5,219	93	1,500	1,500
13	8	5,100	9,807	52	NA	NA
5	19	5,133	5,519	93	1,800	1,800
10	2	5,490	7,520	73	2,300	2,300
8	NA 2/	5,791	6,977	83	1,500	1,500
14	2	6,347	9,473	67	5,000	8,000
11	20	6,348	21,889	29	4,000	6,000
12	2	6,750	6,750	100	3,500	3,500
15	9	7,100	7,977	89	NA	NA
16	25	9,048	11,453	79	7,000	10,000
17	12	9,600	19,200	50	3,600	3,600
18	5	10,114	13,667	74	3,500	10,000
19	21	10,211	12,155	84	NA	NA
20	20	11,500	13,855	83	NA	NA

1/ Plain storage (all other is inert gas).
2/ NA = not available.

storage requirements depend upon how strong the local market is and how much alfalfa dehy moves direct to farmers.

Only two firms had storage that was not gas storage. The plain or flat storage is of limited value. Inert gas storage is recommended in order to maintain the carotene content, which diminishes the presence of oxygen.

CHAPTER VII

SUMMARY

There are two principal criteria for determining the probability of success for an alfalfa dehydration operation. First of all, the growing season must be long enough to allow the plant to generate break-even volume. Secondly, there must be within an economical hauling distance of the plant, an adequate supply of alfalfa. Other factors playing an important role are plant location, variable inputs, plant and field equipment, available market, and organization structure.

Growing Season and Acreage Requirements

The plants in the survey had growing seasons carrying through four or more cuttings. It should be noted, however, that the time between cuttings is shorter when alfalfa is cut for dehydration than when it is cut for sun-curing. Therefore, alfalfa that is cut three times for sun-curing may be cut four or more times for dehydration. Break-even volume is determined by the relative values of selling price, purchase price, and fixed and variable costs. Once these costs are estimated it is important to be certain that there is enough alfalfa supply to enable the firm to generate the volume necessary to break even. Shorter growing seasons require plants with large capacities in order to generate break even volume. Therefore, acreage requirements are inversely related to length of growing season.

From the survey results it appears that an economical hauling distance is an area within a 10-mile radius or less of the plant.

It is not enough that the required acreage is produced in the defined area. That acreage must be available to the plant. How much alfalfa is available to the plant will usually depend on what the firm is willing to pay the grower.

Alfalfa must compete with the other crops for the use of land. A variety of crops are competitive with alfalfa, depending on the area in which the plant is considering locating. An evaluation of whether present alfalfa production will continue or the opportunity for expanded production can be made by budgeting the potential costs and returns for alfalfa and competitive crops.

Plant Location

The ideal location for an alfalfa dehydrating plant is on a rail siding in the center of the alfalfa supply. Most situations, however, are not ideal. In the less than ideal situation, which location does the plant chose?

From the formula

$$X = \frac{(1-t)Y}{1-r}$$

where t = 10 percent

r = 75 percent

it is seen that it takes 3.6 tons of raw alfalfa to produce one ton of dehydrated alfalfa. In addition, raw alfalfa is about three times as bulky as the dehydrated product. These factors strongly suggest that a strategic location with respect to the alfalfa supply may, in some cases, be preferable to location on a rail siding. Which location is chosen will depend on the locations of available rail sidings with respect to the alfalfa supply.

Variable Inputs

The survey data analyzed indicates that the per ton costs of labor, drying fuel (natural gas), power, gasoline and oil, and maintenance repair do not decrease as plant size increases. The principal factor affecting these costs seems to be the degree to which plant capacity is utilized. On this basis, it seems that small plants are competitive with larger size plants.

Needless to say, it should be determined that the available supply of these inputs is adequate. Particular attention should be given to the labor situation. Many of the firms interviewed indicated concern over the labor situation. Usually it is not too difficult to determine whether the supply of drying fuel (primarily natural gas), power, and gas and oil is adequate. There is, however, one caution. Some plants reported experiencing a shortage of natural gas toward the end of the operating season. This occurred because the cooler weather increased the general demand for natural gas for heating purposes. When shortages occurred, the natural gas supply of the dehydrating firms was curtailed.

Plant and Field Equipment

An alfalfa dehydration plant must start with good equipment and maintain it in good condition. Heavy duty trucks are recommended. Field equipment, because of the use it receives, should be of the industrial type. For plants operating on a 24-hour basis, losses in production cannot be made up. In addition, fields that are contracted to be cut, must be cut in order to maintain good grower relations. None of the firms interviewed mentioned mechanical breakdown as a major cause of time. Winter overhaul of equipment is probably a major factor in keeping equipment malfunctions to a minimum.

Available Market

Dehydrated alfalfa is sold direct to feed manufacturers, livestock feeders, farmers and to brokers and commission men. In an established dehydrating area, marketing will be less of a problem than in an outlying or isolated area. Potential customers often need to be convinced that it is a feed and not just another form of hay. Distant markets are difficult to serve and most plants sell the bulk of their product within a 100-mile radius of the plant.

Organizational Structure

Thirteen of the firms interviewed were organized as corporations. Four of these were family owned. Six had three or less stockholders, while another had seven. Of the remaining two corporations, one had 10 stockholders and the other 46. Three of the firms were organized as partnerships having two, three, and six partners. Three plants were owned by a central cooperative. One plant was a cooperative with 230 members. With the exception of the corporations with 10 and 46 stockholders, there appeared to be one person exerting control.

Table XXVI is used to present in tabulated form responses pertaining to the feasibility of alfalfa growers being stockholders in the firm. Judging from the responses, it appears that dehydrating firms are wary of growers being stockholders. The feeling appears to be that management must exert tight control and that interference with management would introduce inefficiencies into the operation.

Some problems arise in cooperative organizations. Growers may feel the plant is obligated to purchased their alfalfa. In the case of one firm, no longer operating, the by-laws stated that the firm was obligated to purchase a certain amount from each member. By the same token it is not unreasonable to expect that growers will feel no obligation to sell to the plant if they can get a better price elsewhere. The danger here is that the plant may be forced to harvest fields of poor quality, small and/or irregularly shaped fields, fields at considerable distance from the plant, etc. There may be cases where the number of members is so great that the firm cannot purchase alfalfa from all of them. In these cases, the patronage dividend method of distributing "savings" may be somewhat difficult to apply without alienating some part of the membership.

It would seem, therefore, that if the proposed organizational structure is such that a number of growers are stockholders, the obligation of plant and stockholders to each other should be carefully outlined. The plant should not be obligated to cut fields that do not meet certain

TABLE XXVI. ADVANTAGES AND DISADVANTAGES OF GROWERS BEING STOCKHOLDERS IN AN ALFALFA DEHYDRATING FIRM--RESPONSES FROM FIRMS INTERVIEWED.

Responses	Number of Firms Mentioning
Advantages to Plant:	
None	13
Would help to assume alfalfa supply	7
Disadvantages to Plant:	
Stockholders would expect preferential treatment, especially with regard to scheduling of harvesting	11
Interference with management (too many bosses)	9
Plant obligated to purchase from growers	2

specified standards of quality or are not within an economical hauling distance of the plant. Perhaps a bonus system should be established whereby exceptional fields are eligible for bonus payment. This approach is justified because the alfalfa off good fields may be processed at lower cost and the quality may be such that the product may have a greater market value.

The board of directors should define the responsibility of management and then allow it to operate within this defined area. The plant must operate as a competitive enterprise. Management should not be subject to the whims of individual members. It should not be coerced into cutting fields at the discretion of individual members.

Growers should expect from the plant no more than a competitive price for their alfalfa and the plant should not expect to purchase alfalfa from growers at a less than competitive price. Usually the function of the firm is to earn a profit for its stockholders. In the case where stockholders are growers it may be to provide them with an acceptable market for their alfalfa. If it is to continue performing the latter function, returns must cover all costs of production. If the firm does not perform either of these functions, there is no reason for its existence. In fact, it cannot exist.

As with any type of business, the importance of a skilled and conscientious labor force cannot be overemphasized. Established alfalfa dehydration plants make every effort to prevent the defection of key personnel. The manager in an industry such as dehy is of particular importance. The manager must be capable in at least four different areas. He supervises production. Usually he is skilled in maintenance and repair. He is responsible for the procurement of raw alfalfa which implies that he must possess a certain amount of diplomacy. Alienated growers tend to sell their alfalfa somewhere else. Finally, he is responsible for the marketing of the product. In essence, the most significant investment which will yield potential investors in a dehydration facility the greatest return, is probably the salary paid a competent manager. This certainly is not the place to start cutting costs.

All the above factors need to be carefully considered by anyone or group interested in establishing an alfalfa processing plant.

APPENDICES

APPENDIX A

Derivation of formulas for determining amount of dehydrated alfalfa of given moisture content produced and amount of raw alfalfa of given moisture processed for a drying drum of given capacities. 1/

Let: L = amount of moisture removed

r = moisture content of the raw alfalfa

t = moisture content of the dehydrated alfalfa

If Y is the amount of dehydrated alfalfa with r moisture content produced by removing L amount of moisture from X weight of raw alfalfa with r moisture content, the following equations may be formed:

$$X = Y + L$$

or the weight of raw alfalfa of r moisture content processed (X) is equal to the amount of dehydrated alfalfa of t moisture content produced plus the amount of moisture removed (L).

$$rX = tY + L$$

or the moisture content of the raw alfalfa processed (rX) is equal to the moisture content of the dehydrated alfalfa produced (tX) plus the amount of moisture removed (L).

When these equations are solved simultaneously the following equations can be derived.

1) $$Y = \frac{L\ (1-r)}{r-t}$$

1/ Concepts used in developing these formulas were introduced by Charles E. Reed, et. al. in Marketing Dehydrated Alfalfa, Agr. Marketing Service, U. S. D. A., Marketing Research Bul. No. 254, 1958, p. 20.

2) $$X = \frac{L\ (1-t)}{r-t}$$

3) $$Y = X - L$$

4) $$Y = \frac{(1-r)\ X}{i-t}$$

APPENDIX B

TABLE B-I. AVERAGE OPERATING COSTS PER TON FOR EIGHT COOPERATIVE ALFALFA DEHYDRATING PLANTS, 1953 AND 1954 PLANT YEARS.*

Type of Cost	Average of 7 Plant-Years--Under 3,000 Tons	Average of 9 Plant-Years--Over 3,000 Tons
	------------Dollars-----------	
Field labor	4.63	3.56
Plant labor	5.89	4.93
Power	2.05	1.77
Fuel		
Oil	7.45	5.54
Natural gas	4.38	3.93
Field maintenance and repair	2.09	.90
Plant maintenance and repair	1.85	1.32
Depreciation	4.43	1.65
Total Processing Costs	33.33	22.50

*Source: Rickey, Lacey F., Cooperative Alfalfa Dehydrators, Farmers Cooperative Service, USDA, Circular 12, June 1956, p. 25.

TABLE B-II. AVERAGE COSTS PER TON OF PRODUCING DEHYDRATED ALFALFA, THREE PLANT SIZES, 1957 AND 1959.*

	Annual Production		
	Less Than 3,000 Tons	3,000-6,999 Tons	7,000 Tons and Over
		Dollars	
Fixed Costs:			
Salaries	2.78	1.54	1.65
Depreciation	3.16	2.42	2.07
Insurance	.62	.72	.30
Taxes	.41	.58	.34
Interest	.66	.58	1.12
Total Fixed Costs	7.63	5.84	5.48
Variable Costs:			
Plant labor	2.25	2.44	2.09
Field labor	4.42	4.04	2.17
Fuel	2.60	3.12	3.19
Power	1.97	1.78	1.56
Maintenance and repair	3.58	1.90	1.78
Gasoline and oil	1.27	1.85	.95
Other variable costs	2.82	1.67	.83
Total Variable Costs	18.91	16.80	12.57
TOTAL PRODUCTION COSTS	26.54	22.64	18.05

*Source: Reed, Charles E., Costs and Efficiency in Alfalfa Dehydrating Plants, Tech. Bul. 134, Kansas Agr. Expt. Sta., Kansas State University, Manhattan, August 1962.

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