1984

The Economic Feasibility of Small Scale Cooperatively Organized Fuel Alcohol Production in Eastern South Dakota

Daryl Arthur Brehm

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THE ECONOMIC FEASIBILITY OF SMALL SCALE
COOPERATIVELY ORGANIZED FUEL ALCOHOL
PRODUCTION IN EASTERN SOUTH DAKOTA

BY

Daryl Arthur Brehm

A thesis submitted in
partial fulfillment of the
requirements for the Degree
Master of Science,
Major in Economics

South Dakota State University

1984
THE ECONOMIC FEASIBILITY OF SMALL SCALE
COOPERATIVELY ORGANIZED FUEL ALCOHOL
PRODUCTION IN EASTERN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Dr. Thomas L. Dobbs
Thesis Advisor

Dr. John Thompson
Head, Economics Department
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DAB
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CHAPTER I

INTRODUCTION

Over the past decade, fossil fuel prices have more than tripled, and it appears likely that a general upward trend will continue. In the face of these increasing costs, researchers are looking for alternative energy sources. One of these options is fuel alcohol produced from biomass. It has been estimated that alcohol fuels could replace 10% to 15% of this country's gasoline needs in future years.¹ A 10% replacement by 1990 could require the net use of 2.4 billion bushels of corn.²

Presently, the economic feasibility of fuel alcohol appears possible only with rather large production facilities (over 1 million gal./year, and possibly much larger). High per unit production costs seem to currently preclude farm operations of the 5,000 to 10,000 gallons per year size. However, small plants with capacities in the 100,000 to 200,000 gal./year range could conceivably have important economic benefits for farmers, as well as the communities in which they would operate. Because of the potential benefit to both farmers and communities, the question of how feasible a cooperatively organized fuel alcohol plant might be arises. It remains to be de-
terminated whether such ventures could produce sufficient financial returns to justify plant construction and operation.

Reasons for This Study

Research on the economic feasibility of a cooperatively organized small scale fuel alcohol plant is justified for several reasons. Policy makers could consult the results of this study as an aid in making decisions about public subsidies for fuel alcohol production. Investors concerned about the wisdom of allocating capital to this type of fuel alcohol production facility are also potential beneficiaries of this research.

Perhaps most importantly, this information would be valuable to farmers in eastern South Dakota. Alcohol plants organized on a cooperative basis could reduce the individual financial risk of farmers involved--by spreading commitments among all the cooperative's members. A cooperative fuel alcohol plant could ensure a reliable supply of farm fuel to its members. In addition, farmers producing corn in eastern South Dakota would have an alternative market for their crop if fuel alcohol plants were viable. Communities would benefit from such operations, as increased property taxes could be generated and local employment opportunities expanded.
Tax provisions directed toward the cooperative type of business may increase the prospects for economic feasibility of small scale fuel alcohol plants. Also, capital requirements, while considerable, would be decidedly less than for a large scale facility. Local ownership and management could help assure consideration of community interests in decision making procedures.

A very important aspect of fuel alcohol production is the feed byproduct which is generated by the fermentation and distillation process. This residue is suitable as a protein supplement for ruminant animals. The convenience of nearby utilization of this *distillers wet grain* (DWG) byproduct could be a strong advantage of a community scale alcohol plant.

The pragmatic merits of a small scale cooperative fuel alcohol production plant could be quite substantial. Grain producers, local workers, livestock feed users, and ultimately, the community economy could potentially benefit from such a facility.

The purpose of this study then, is to determine the economic feasibility of a small scale cooperative fuel alcohol operation. Since South Dakota State University operates a small scale pilot fuel alcohol plant, data from that operation will be used for this study.
Objectives of the Research

The overall objective of this research is to determine whether a hypothetical small scale cooperatively organized fuel ethanol production plant modeled after the South Dakota State University pilot plant could be economically feasible in eastern South Dakota.

The specific objectives of the research are three-fold:

1) to determine the economic and practical feasibility of utilizing and marketing the feed byproduct within a local area served by a cooperatively organized plant;

2) to determine a practical marketing territory and membership size for the fuel alcohol cooperative, given both fuel and feed byproduct utilization considerations; and

3) to determine financial and tax provisions applicable to this type of fuel alcohol cooperative and expected cash flows and levels of net returns from a plant producing approximately 175,000 gallons per year of 185 proof ethanol.

The Method of Study

The threefold specific objectives of this study
require that several research procedures be used. Since this study is a segment of an interdepartmental research effort, data from other individuals and disciplines constitute an important input to this research.

The economic feasibility of this type of fuel ethanol plant in eastern South Dakota will depend on several factors, including the following: the costs of ethanol production; acceptance and use of the feed byproduct by local farmers; plant location; types of long and short term financing obtainable; and, ultimately, after-tax net returns from the operation.

To determine the feasibility of utilizing the feed byproduct, a review of performance tests conducted by the SDSU Dairy Science Department will be made. Next, a replacement value for the feed byproduct used in the rations for the performance tests will be determined. In this way, a value for the feed byproduct will be found. The performance of the tested cattle and the ration costs will be important factors affecting the acceptance of the byproduct as a feed by farmers.

The effort to determine the practicality of using the feed byproduct must also include a determination of the probable storage life of the material. The SDSU Dairy Science Department has conducted studies investigating the storage and handling properties of the DWG, and these
will be reviewed to decide the most practical storage and transportation procedures in marketing the byproduct.

Assuming an ethanol plant capacity of approximately 175,000 gallons per year, a corresponding service area size must be determined which is both realistic and economically feasible. Transportation routes and schedules must be discerned for the marketing of the fuel product and the feed byproduct, for the purpose of calculating the capital and operating costs involved in product distribution. Clear Lake in Deuel County of South Dakota will be the assumed site of the fuel alcohol plant. A map displaying hypothetical farm locations will be used to locate probable transportation routes. Transportation costs (both capital and operating) will be estimated by the above procedures.

In pursing the third specific objective, literature pertaining to cooperative tax law and cooperative organizational structure will be reviewed. An organizational structure for this type of small cooperative will be formulated, with foremost considerations being efficient management and simple dividend distribution. A dividend scheme will be formulated, with consideration of Federal income tax laws and advantageous tax strategies.
Financial plans will be specified for the hypothetical plant. Appropriate interest rates and other financial terms will be specified after reviewing applicable government financing possibilities and after consulting with local banks, the Production Credit Association, and the Bank for Cooperatives.

Finally, to ascertain the possible after-tax net returns of the hypothetical cooperative fuel alcohol plant, a thorough financial analysis will be completed. Capital and operating cost estimates of the 175,000 gallon output per year plant will be obtained from other members of the SDSU Economics Department fuel alcohol research team. Possible returns from the ethanol product and byproduct will be estimated. A 10-year planning horizon will be set up for the plant, with a complete estimated cash flow.

The AGNET computer system BUSPAK program will be used to facilitate internal rate of return (IRR) calculations. This rate of return will give an indication of plant feasibility.

With the completion of each of these specific research objectives, conclusions can be drawn on the probable economic feasibility of this type of cooperative fuel alcohol plant.
Footnotes


CHAPTER II

LITERATURE REVIEW

Introduction

This chapter contains a review of literature pertinent to the subject of this thesis. Some of the information explored is of a background nature to enlighten the unfamiliar reader on the topic of fuel ethanol production. The literature review covers the properties of fuel alcohol, an alcohol processing overview, the feed byproduct, cooperatives, and, finally, a section on profitability and cash flow analysis procedures.

Ethanol has been used as a fuel for the internal combustion engine for quite some time. Henry Ford's first automobile models were designed to operate on ethanol. Under depressed economic conditions, many European countries required motor fuels to contain up to 25% ethanol prior to World War II. During this period, the United States investigated the properties of ethanol as a fuel. Wilke reported the excellent antiknock properties associated with its use and an octane rating of 95 (for 200 proof ethanol). The next section explores the properties of ethanol in more detail.
The Properties of Fuel Alcohol

Durland and Kelly compared the energy values of various engine fuels. Number two diesel fuel has 138,110 BTU's per gallon. Gasoline has approximately 116,455 BTU's per gallon, and ethanol contains 76,152 BTU's per gallon. The 185 proof ethanol the pilot plant covered in this thesis is expected to produce contains about 70,440 BTU's per gallon. Ethanol possesses about 35% less energy per unit volume than gasoline. Therefore, a larger quantity is needed to produce a given engine power output per unit time as compared to either gasoline or diesel fuel. Using the above values, it takes 1.65 and 1.96 gallons of 185 proof ethanol to replace one gallon of gasoline and one gallon of number two diesel fuel, respectively.

Durland and Kelly also discussed the engine alterations which may be required if ethanol is to be used. Carburetor and ignition adjustments should be made; also, an extra fuel tank should be added for gasoline starts in cold temperature conditions. The latter is required due to the lower volatility of ethanol.

Basset and Chisholm, working at South Dakota State University, modified a gasoline tractor to run on 180 proof ethanol and conducted performance comparisons with gasoline. Their findings indicated ethanol produced an
11% increase in thermal efficiency, but resulted in a
19% decrease in maximum power output. 4

The types of engine modifications required depend
on the method of ethanol intake into the engine and the
purity of the ethanol used. Currently, the most popular
method of using ethanol as an engine fuel is mixing
one part ethanol with nine parts gasoline to produce
"gasohol." This product requires the use of 200 proof
or "anhydrous" ethanol. (Less than 200 proof ethanol
contains water which can cause a separation of the two
fuels.) Anhydrous ethanol is not required for other
methods of utilization in the internal combustion engine,
however. Durland and Kelly reported the following methods
of burning ethanol, which are currently being researched: 5

1. straight ethanol in a spark ignition engine;
2. straight ethanol in a diesel engine;
3. ethanol-diesel mixture; and,
4. carbureting ethanol into a diesel engine.

Burning 180-190 proof ethanol in a spark ignition
engine would require certain engine modifications. Al-
terations would need to include an adjustable carburetor
or dual carburetors, an intake manifold heating system,
a special starting system, and easily adjustable timing.
With adjustments, the volumetric value of 190 proof etha-
nol relative to gasoline would be approximately 58%,
according to one report. This value would be somewhat improved by increasing the compression ratio and, therefore, taking advantage of the higher octane rating of ethanol.\(^6\)

Because of the relatively low cetane rating of ethanol, formidable difficulties arise in attempting to burn ethanol in a diesel engine. Likewise, an alcohol-diesel fuel mixture seems to bring on many difficulties. However, the U.S. Department of Agriculture reports special additives might help reduce these problems.\(^7\)

The approach of carbureting ethanol into diesel engines appears promising. Conversion kits have been available for that purpose, and costs appear moderate. A separate fuel tank is also required, adding to inconvenience, but risk of engine damage is reported to be low.\(^8\)

Other uses for ethanol produced in small scale plants should also be considered. Besides fuel for the internal combustion engine, ethanol could be used in grain dryers and as heating fuel for homes or livestock buildings.\(^9\)

**Processing Overview**

The traditional distillation process, familiar to many students of chemistry, is still used in the produc-
tion of ethanol. What is quite simple in the laboratory, however, can become quite complex in even a small scale fuel alcohol operation. The processing operation must be considered from input to product and byproduct stages. As expressed by Lush and Stampe, the alcohol plant is probably the most important aspect in the consideration of fuel alcohol production and use. A properly designed, efficient alcohol plant can add greatly to the prospects for economic feasibility.

The Solar Energy Research Institute has delineated a set of criteria which will affect the size and design of a plant. Among these are the amount of capital available; labor available for operating procedures; federal, state, and local laws concerning licensing, etc.; desired form of byproducts; and desired flexibility of feedstock input use.

The process of producing alcohol begins with the feedstock. Ideally, this is a crop high in sugar or starch content. Crops such as sugar beets, sugar cane, sweet sorghum, grains, potatoes, and Jerusalem artichokes are mentioned by the United States Department of Agriculture (U.S.D.A.). This thesis considers only corn, because of its high starch content and general availability in eastern South Dakota.

As Lush and Stampe explain, the corn must first
be shelled and ground, to expose the starchy area. A finer grind results in greater starch exposure and, consequently, a more technically efficient and quicker liquification process. The ground corn is added to approximately 20.5 gallons of water per bushel in a cooking vat. An enzyme, alpha amylase (Takatherm), is added to break the solid starch into smaller molecules. For this process, the grain is heated to 205°F. Constant mixing turns the mixture into a liquid. When the solid is completely broken down, the temperature is lowered to about 140°F. Another enzyme, glucoamylase (Diazyme), is then added to break the starch molecules into simple sugars.

At this stage, the mixture, called "mash", is pumped into the fermentation tanks (if cooking and fermentation are not done in the same tanks). The temperature is allowed to drop to about 85°F, and distiller's yeast is added. As the yeast begins fermentation, heat is produced, so cooling is required to maintain the proper temperature level. The fermentation process requires from 48 to 72 hours, depending on the temperature and the strain of the yeast utilized. The mash contains approximately 10% alcohol by volume at the end of this period.

The mash is now ready for the distillation proce-
dure, where the alcohol is separated from the non-alcoholic components, or byproducts. The differential boiling points of alcohol (173°F) and water (212°F) provide for the separation, which is achieved in two distillation columns. Theoretically, approximately 2.5 gallons of 95% ethanol could be expected per bushel of corn output, but the Solar Energy Research Institute states that this may vary with plant design and operational efficiency.¹⁵

Obtaining anhydrous, or 200 proof, ethanol requires another stage of processing, usually involving high amounts of energy inputs. It may not be feasible for many small scale plants to produce anhydrous ethanol economically, according to Dobbs.¹⁶ Therefore, alternative markets must be found for the hydrous ethanol produced in small scale plants. Ethanol in the range of 160-190 proof can be utilized in internal combustion engines; therefore, on-farm consumption has been suggested as a possibility.¹⁷

This discussion of ethanol production would be remiss without reference to the actual small scale production equipment. Apparatus of similar basic design is currently used for most small scale operations, though several different designs and technologies are available.
The following summary description is for a batch cooking and fermentation unit with two distillation columns, as outlined by Lush and Stampe, with specifications for the 175,000 gallon capacity facility described by Hoffman and Dobbs. 18

Four 5,500 gallon stainless steel tanks are used for the cooking and fermentation procedures, for a total capacity of 22,000 gallons. These tanks are lined with heating coils and agitators to enable heating and fermentation to be carried out in the same tank. With proper timing, these four tanks, each fermenting or cooking, can provide enough mash to keep the distillation columns in continuous operation. The distillation columns are 12 inches in diameter, to allow for a 20-25 gallon per hour capacity. A 10,000 gallon capacity fiberglass fuel tank is also required, for storage of the ethanol on the plant site.

An assortment of non-corrosive pipes is required with pumps, gauges, and heat exchangers. The pipes and pumps provide for the movement of mash, alcohol and water. The heat exchangers are energy saving devices, which absorb heat from cooling liquids and channel this heat to needed areas. Heat exchangers cut down on the boiler power required.
A 750,000 BTU per hour coal-fired boiler is needed for the ethanol plant. Additional equipment components such as temperature and pH gauges, valves, and electrical wiring are also needed.

The grain handling and byproduct handling equipment should also be mentioned. The grain handling equipment includes two 3,000-bushel steel grain bins, a 20-foot auger, and a small (5-horsepower) hammer-mill. The feed byproduct equipment includes a concrete storage bunker, measuring (in feet) 25 long x 10 wide x 5 high; a 16-foot long auger; a centrifuge for lowering the byproduct moisture level; and a skid-steer loader for loading the feed byproduct.

A 1,300-square foot building, complete with concrete floor and electrical wiring, houses the ethanol production equipment.

The Feed Byproduct

The feed byproduct produced along with the alcohol is also referred to in this thesis as distillers wet grain (DWG). Distillers grains, the main byproduct of commercial grain alcohol production, have been used by farmers as feed for many years. One source reports that a well established market for distillers dried grains existed in New England around 1900. Four types
of dried distillers grains are sold commercially and are defined by American Feed Control officials: Distillers Dried Solubles, Distillers Dried Grains, Distillers Dried Grains with Solubles, and Condensed Distillers Solubles.\textsuperscript{20}

The distillers wet grains produced from the ethanol plant as discussed in this thesis most closely resemble (nutritionally) the distillers dried grains with solubles. Of course, the moisture content is much higher (70\%), after only centrifuging and not totally drying.

The U.S.D.A. states that the high energy requirements for drying these byproducts cause preference for marketing of wet grains from small scale plants.\textsuperscript{21}

Approximately 16 to 17 pounds of dry residue equivalent are obtained per bushel of corn fermented, according to Kuhl, Schoper, and Voelker.\textsuperscript{22} They also point out the difficulties of drying the feed byproduct and recommend handling at 70\% moisture content after the centrifuging process.

The nutritional value of distillers grains have been extensively investigated. Such grains are often compared with soybean meal, since they normally substitute for the protein of soybean meal in a ration. Table 1 of Chapter III summarizes the nutrient composition of corn grain, corn distillers byproducts, and soybean
Several researchers have conducted experimental feeding trials utilizing distillers grains. DeHaan, _et al._ used wet distillers grains in performance tests on growing calves and lambs. This thesis will utilize data from an SDSU Dairy Science performance trial with growing heifer calves and lactating cows; hence, DeHaan, _et al._'s work will be reviewed here.

The test consisted of two trials—the first with 158 crossbred steers averaging 495 lbs, and the second with 29 steers averaging 489 lbs. The trials lasted 106 and 112 days, respectively. The rations in the first trial were composed of a 50-50 corn silage-corn cob mixture supplemented with one of the following: 100% urea (control group); 50% soybean meal--50% urea; 50% corn gluten meal--50% urea; 50% DWG--50% urea; or 50% wet distillers solubles--50% urea. The results showed that the highest daily gains were exhibited by the calves fed the mixture supplemented with the 50% DWG--50% urea. The lowest gains were made by the calves fed the ration supplemented with 100% urea. There were no statistically significant differences among the remaining rations.

In the second trial, rations were composed of 56% corn silage, 28% corn cobs, and 16% supplement comprised
of one of the following: 100% urea; 50% or 85% soybean meal (with urea comprising the remaining %) or 100% soybean meal; 30%, 40% or 50% DWG (with urea comprising the remaining %): or 30%, 40%, or 50% ensiled DWG (with urea comprising the remaining %). No differences in gain among the steers were observed in this trial. The researchers did note a higher protein conversion efficiency in both trials among calves fed the DWG supplemented ration.

Although limited data are available for performance tests on dairy cows fed distillers wet grains, trials have been performed to test the value of Distiller's Dried Grains (DDG) for producing dairy cows. One study reported in 1952 that cows performed slightly better on an oats and barley ration supplemented with DDG than on the same ration with soybean meal as a primary protein source.25

Recently, Murdock, Hodgson, and Riley conducted a performance test on 40 cows fed DWG.26 In this trial, milk production, fat percentage in the milk, and body weight were measured. No statistically significant difference was discovered between the ration supplemented with DWG and the identical ration supplemented with soybean meal.
Interestingly, Porter and Conrad reported very little difference in production between dairy cows fed rations containing dried distiller's grains and those fed distiller's wet grains. However, they did find that digestibility was higher with the wet grains than in the dried distiller's grains.

This preceding review of the literature pertaining to the nutritional quality of DWG as a protein supplement for dairy cows and calves supplies evidence indicating that DWG compares favorably with soybean meal and urea as a protein supplement.

An additional benefit may be derived from the byproducts in feeding the DWG to calves or lactating cows. Satter, Whitlow, and Beardsley indicated distiller's feeds seem to contain a high amount of "bypass protein." This protein resists degradation in the rumen, so it remains to be absorbed in the small intestine. In this way, additional amounts of limiting amino acids such as lysine or methionine are supplied to the animal.

It should also be noted that none of the researchers mentioned discovered any palatability problems with either the wet or dried distiller's grains.

Cooperative Overview

The cooperative approach to business organization
has been used successfully in a number of agricultural industries. The success of cooperatives in the past provides some basis of hope for this type of organization to operate a small scale fuel alcohol plant. Thus, background information on cooperative organization will now be reviewed.

Agricultural production and marketing cooperatives are by far the most important cooperatives in the United States. Abrahamsen reports cooperatives handle 25% of all farmers' products in this country.²⁹

Benning states that cooperatives are organized and operated much like other businesses.³⁰ They are incorporated under South Dakota laws. Cooperatives differ from other businesses in three aspects, however:

1. their primary purpose is not to gain a profit, but to serve members;
2. net returns are distributed to members in proportion to their use of the cooperative's services, not in proportion to individuals' investments; few dividends or none at all are distributed on invested capital; and
3. voting control is based on membership or patronage, not capital investment; usually, one member has one vote.
A cooperative is generally chartered as a state corporation, according to Kirkman. A cooperative may obtain all of its capital from members, or it may obtain investment capital by stock or bond sales or from loans. Because of the nature of cooperative operations, however, little incentive exists for outside investors looking for capital gains.

Kirkman says a fundamental feature of the cooperative business organization is the fact that most cooperatives do not retain net returns over expenses. Instead, net savings are returned to members as patronage refunds. Net returns distributed in this manner are not subject to corporate income taxes. Net returns derived from transactions with non-members are subject to corporate income taxes only if these earnings are not refunded to the non-member patrons.

These provisions are found in Section 521 of the Revenue Code of 1954. Cooperatively organized businesses are, however, subject to local property taxes on the same basis as other firms.

Cooperatives must meet the legal qualifications to exist. Usually, a set of articles of incorporation and by-laws must be formed. These documents state the purpose and method of operation of the business operation from the same basic blueprint, whether they are large
"federated" cooperatives or cooperative which are small, local, and for a specific purpose. Four distinct groups are involved in operations.

The foundation group is that of the member patrons. The need of these patrons is the reason each cooperative is originally formed. Often, the capital investments of members provide the original financing. Member patrons are intended to derive the greatest benefit from the services the business provides, and, in turn, must give their support. Members control the general purpose of their cooperative, though operation is controlled by the manager.

The next group, the Board of Directors, is elected from among the member patrons. The directors set the general policy the cooperative is to follow. They also make the basic financial decisions, hire the manager, and determine the amount of patronage dividends paid out each year.

The Manager and Staff (if needed) supervise the daily operation of the business and plan the operating budget. The manager must also try to maintain good working relationships with members, directors, and other employees. Benning emphasizes the importance of a good manager to the success of a cooperative.35

The final group considered by Kirkman consists of
the **Operating Employees**. Often these are not members, but are hired from the surrounding community.

Before a cooperative is formed, a thorough examination of its need and feasibility should be undertaken. In any case, this must be done prior to obtaining capital financing. Benning delineates a number of questions to be considered.

The beginning of a cooperative must start with the interest of potential members. Next, states Benning, a survey committee should be appointed to study all the conditions under which the cooperative would operate. The committee should consider the following aspects: 1) economic need for the cooperative; 2) potential membership and business volume; 3) management required; 4) facilities needed; 5) operating costs; 6) capitalization; and 7) scope of the corporate charter.

If, after the above aspects have been examined, a cooperative is determined to be feasible, an organizational committee should be formed. This committee is charged to sign up members, arrange for capital loans, draft legal organizational papers, file the articles of incorporation, and arrange for the first meeting of members. Assistance can be obtained from the Omaha Bank for Cooperatives, the South Dakota Association of Cooperatives, or the Farmers Home Administration.
As an example, it may be useful to review the set of criteria for cooperative formation discussed by Benning when considering the feasibility of a small egg processing facility in South Dakota. Such a facility is somewhat analogous to a small scale alcohol plant in that eggs are farm commodities subject to price fluctuations (as is corn), and somewhat similar marketing problems sometimes arise with the two commodities. Farm production is first considered. It should be determined if sufficient produce will be available for plant processing to operate on an efficient scale. Production costs should be considered; i.e., are costs low enough relative to costs in other geographic areas. Markets for the processed products must be evaluated. Location of markets, quality required, buyers' reputations, and required quantity must be considered. Transportation arrangements, costs, and distances must be considered. Finally, plant location, labor, and waste water facilities require evaluation. Most important, perhaps, financial arrangements (both for initial capital and operating expenses) require consideration.

**Profitability and Cash Flow Analysis**

Intrinsic to any investment or feasibility study is an analysis of the cash flow and profitability of the proposed firm. If a business enterprise cannot show net
returns over expenses in a given investment period, it is unlikely that any group or individual would be willing to provide capital for the venture. A potential investor will consider not only the existence of a net return, but its probability level and the degree of risk associated with the investment.

Barry, Hopkin, and Baker describe in detail the capital budgeting approach of investment analysis. They state five steps to be followed in the investment decision process: 1) the identification of investment alternatives; 2) the selection of appropriate choice criteria; 3) the collection of relevant data; 4) the analysis of data; and 5) the interpretation of the results in terms of the various choice criteria.

Since the ethanol plant investment alternative has already been identified for analysis in this thesis, the first step will not be reviewed here. The following discussion relates to the other steps and to the four capital budgeting criteria described by Barry, Hopkin, and Baker which pertain to this study.

The **simple rate of return** (SRR) expresses the average net profits generated each year as a percent of the original investment over the investment's expected life. This can be expressed as:
where:

\[ Y = \text{average annual profits (less depreciation)} \]

projected for the investment

\[ I = \text{value of the initial investment} \]

\[ \text{SRR} = \text{simple rate of return.} \]

It should be noted that this method does not consider the timing of the cash flows, so it can produce somewhat misleading results. For that reason, it will not be a criterion used in this thesis.

Another quantitative method of investment evaluation is the payback period. This method involves an estimate of the length of time required for an investment to pay for itself. The payback period is determined as follows:

\[ P = \frac{I}{E} \] (for uniform cash flows)

where:

\[ I = \text{the initial investment} \]

\[ E = \text{the projected cash flow per period for the investment} \]

\[ P = \text{the payback period, expressed in number of periods.} \]

In this type of analysis, a shorter payback period
is considered more desirable. The payback period could be an interesting criterion to use in this study, but the cash flow is not uniform for the ethanol plant.

The net present value criterion directly accounts for the timing and magnitude of the projected cash flows.

The model is expressed as follows:

$$\text{NPV} = \text{INV} + \frac{P_1}{1 + i} + \frac{P_2}{(1+i)^2} + \cdots + \frac{P_n}{(1+i)^n} + \frac{V_n}{(1+i)^n}$$

where:

- \(\text{INV}\) = the initial investment of capital
- \(P_n\) = the annual net cash flows attributed to the investment
- \(V_n\) = salvage value
- \(n\) = the length of the planning horizon in years
- \(i\) = the interest rate or required rate of return.

Each projected net cash flow is discounted to its net present value; they are then added together to yield a total net present value. The initial investment is negative since it represents a cash outlay; any projected operating losses are entered as negative values, also.
This criterion or method of investment analysis would identify the returns to ethanol production relatively well.

The final criterion or method, the internal rate of return, is the rate of interest which equates the net present value of the projected series of cash-flow payments to zero. The model is similar to the NPV above, except it sets NPV equal to zero and solves for the interest rate $i$. The equation appears as follows:

$$0 = -\text{INV} + \frac{P_1}{1+i} + \frac{P_2}{(1+i)^2} + \ldots + \frac{P_n}{(1+i)^n} + \frac{V_n}{(1+i)^n}$$

One then solves for $i$; $i$ = the IRR in this case. The larger the IRR, the more favorable the investment is considered to be. This method of investment analysis will be used in this study to evaluate the returns to the ethanol plant, because it specifically determines the interest rate earned by the investment.

None of the above methods will give a meaningful result if incorrect data are used in the models. An accurate estimate of the initial required investment is needed, and variations in estimates caused by different types of financing must be made.³⁹

Another important requirement of the analysis is the projected cash flow. The cash flow is an estimate
of the costs and returns of the business projected over a period of years or the economic lifetime of the business. The cash flow estimate can be either undiscounted or discounted back to the initial investment period. Undiscounted cash flows will be presented in this thesis both for the ease of understanding by the reader and for simplicity in later computer analyses. These cash flows are later discounted in the computer analysis in the process of determining IRR's. These authors stress the importance of the cash flow projection as an indication of the financial solvency of the business enterprise. Positive returns of large magnitude in later years may mean little to financial viability if substantial negative returns occur in the first several years of operation. A business could show a positive NPV or IRR, but because of the composition of the cash flow, be financially unfeasible.

Only relevant cash inflows and outflows should be included in the cash flow analysis. For instance, depreciation of the capital investment is not part of the cash flow analysis.  

**Taxes**

It is likely the cooperative will have a portion of its net returns subject to corporate income tax. The
The formula for determining the taxable income can be given as follows:

\[
\text{Taxable income} = \text{Gross returns} - \text{depreciation} - \text{interest payments} - \text{operating expense (other than interest)} - \text{dividends paid.}
\]

The **Investment Tax Credit** can be taken on depreciable property having a life of at least three years. Buildings do not qualify for the credit, though storage facilities do.\(^43\) The Investment Tax Credit is applicable at the rate of 10% of the investment the year the equipment is placed into service.\(^44\)

In addition to the conventional Investment Tax Credit, an Energy Tax Credit of an additional 10% is also available to the ethanol plant through the 1982 year.\(^45\) This brings the total tax credits available to the ethanol plant to 20%, assuming the plant equipment was placed into service during 1982.

**Depreciation** is allowable on all tangible and intangible property with a limited useful life of more than one year. It applies to property used in a business, or for the production of income.\(^46\) Land is not depreciated, though buildings and equipment are. Property placed into service after 1980 falls under the **Accelerated Cost**
Recovery System (ACRS) of depreciation. Table 2.1 delineates the percentage of depreciation allowable each year on items with useful lives of 3, 5, 10, and 15 years.

Interest Payments made on capital loans are also deductible in the year actually paid. It should be noted that principal repaid on capital and operating loans is not deductible.

As covered in the previous section, Dividend payments to cooperative members are eligible deductions on taxable income.

After the amount of the taxable income has been determined, the amount of corporate tax owed by the cooperative can be calculated. The corporate tax rate (current as of July 1983) is given in Table 2.2.

The cooperative would also be subject to property taxes levied by the local township.

This review of literature is intended to enable the reader to more fully understand the following chapters. To gain a more thorough understanding of specific material, the reader may wish to refer to the references in the footnotes at the end of the chapter.

The following chapters will contain analyses of the necessary information on the feed byproduct, the cooperative's territory, financing, and, finally, plant feasibility.
Table 2.1  Accelerated Cost Recovery System of Depreciation

<table>
<thead>
<tr>
<th>Recovery Year</th>
<th>Percent Depreciated/Year with Investment Life of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 Yrs.</td>
</tr>
<tr>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
</tr>
<tr>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

1 Table taken from: Internal Revenue Code Sec. 46 Reg. 146-3 (1983).

2 The amount of allowable depreciation remaining after 10 years will be approximately equal to the salvage value.
Table 2.2  Corporate Tax Rates\(^1\)

<table>
<thead>
<tr>
<th>Taxable Income ($)</th>
<th>Tax Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25,000</td>
<td>16</td>
</tr>
<tr>
<td>Over 25,000-50,000</td>
<td>19</td>
</tr>
<tr>
<td>Over 50,000-75,000</td>
<td>30</td>
</tr>
<tr>
<td>Over 75,000-100,000</td>
<td>40</td>
</tr>
<tr>
<td>Over 100,000</td>
<td>46</td>
</tr>
</tbody>
</table>

\(^1\)Taken from Internal Revenue Code Section 11, Reg. 1.11-1 (1983).
Footnotes

1Herman F. Wilke, *Food For Thought* (Indianapolis: Indiana Farm Bureau, Inc., 1942), pp. 7-9.

2Ibid., pp. 7-9.


5Bob Durland and Van Kelly, *Farm Use of Alcohol Fuels*, p. 3.


7Ibid., p. II-33.

8Ibid., p. II-34.

9Ibid., p. II-35.


13 Jerry Lush and Scott Stampe, Small-Scale Alcohol Plants, p. 1.

14 United States Department of Agriculture, Small-Scale Fuel Alcohol Production, p. IV-8.

15 Solar Energy Research Institute, Fuel From Farms, pp. 31 and 45.


18 Jerry Lush and Scott Stampe, How to Build An Alcohol Plant (Cooperative Extension Service, South Dakota State University, EMC 838, 1980); Randy Hoffman and Thomas L. Dobbs, A Small-Scale Plant: Costs of Making Fuel Alcohol (Agricultural Experiment Station, South Dakota State University, B-686, September 1982).


21 Ibid., p. VI-4.


23 Ibid., p. 5.


32 Martin A. Abrahamsen, Cooperative Business Enterprise, p. 228.

33 Ibid., p. 224.


36 Ibid., p. 3.
Leonard Benning, *Should We Have Egg Processing Facilities in Our County?* (South Dakota State University, Extension Economics, Feb. 1977).


Ibid.


Ibid., p. 23.

Ibid., p. 3.

Internal Revenue Code Sec. 46 Reg. 1.46-3 (1983).

Internal Revenue Code Sec. 50A Reg. 1.5 A-1 (1983).


Ibid.

CHAPTER III

THE UTILIZATION AND MARKETING
OF DISTILLERS WET GRAINS

Introduction

This chapter considers some of the utilization and marketing possibilities relevant to the distillers wet grain (DWG) byproduct produced from small scale ethanol production. If the nutritional composition of the DWG in rations for growing heifers and lactating dairy cows can be determined, then a per ton price for the DWG can be estimated. This estimation can be made by comparing the DWG to the protein source (soybean meal) it replaces in the ration. If this price is below the cost of the soybean meal (on a nutrient basis), perhaps local farmers would be willing to utilize the DWG as a substitute.

Another contributing factor to the utilization potential of the DWG is an effective storage and distribution scheme. Practical methods of storage and handling can aid in the promotion of byproduct utilization among farmers in the plant vicinity. The importance of efficacious use of the DWG to the feasibility of an alcohol plant is exemplified by the fact that
many alcohol analysts maintain that the difference between profit and loss in a facility depends on the by-products' use.¹

**Processing**

After the ethanol is removed, the untreated "stillage" contains approximately 90 percent water.² This high water content presents difficulties in handling and feeding. The stillage has the consistency of a slurry, and its feed use is limited by the amount of water an animal can intake. These problems can be mitigated by removing part or all of the moisture. Since dehydration costs may be prohibitively high in a small scale operation, South Dakota State University's pilot plant (and the hypothetical cooperative plant) employs a centrifuge to reduce the moisture content to the approximately 70 percent in the distillers wet grains.³ This process enables more efficient handling of the byproduct, as well as enhanced feeding characteristics.

**Nutritional Composition of Distillers Wet Grains**

The DWG contains about 30% dry matter after centrifugation. This dry matter has been analyzed for nutrient composition. It has nearly the same composition as corn grain, but with less starch and the
addition of yeast cells. Corn grain, distillers wet grains, and soybean meal nutrient compositions are summarized in Table 3.1.⁴

South Dakota State University researchers report that dairy cattle adapted quickly to the DWG, but that palatability can be reduced by spoilage.⁵

**Feeding Trials**

The Dairy Science Department of South Dakota State University conducted two separate feeding experiments utilizing distillers wet grains in a feed ration; one was with lactating dairy cows and the second was with growing dairy heifers. The experiment with the lactating dairy cows will be reviewed first.

Eight lactating dairy cows were grouped into two treatments in a switch back design experiment.⁶ The control group was fed a concentrate of corn, oats, and soybean meal. The experimental group was fed a concentrate of distillers wet grains, corn, and oats. The specific compositions of the concentrate mixtures are illustrated in Table 3.2.

Both groups were fed 7.1 lbs of alfalfa-hay and corn silage *ad libitum* daily for the three 4-week periods of the experiment. Dry Matter (DM) intake was very nearly the same for cows in both the control and
Table 3.1. Typical Nutrient Composition of Corn Grain, Corn Distillers Byproducts, and Soybean Meal.¹

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Distillers</th>
<th>Stillage³</th>
<th>Soybean Meal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corn Grain</td>
<td>Dried Grains</td>
<td>Wet Grains²</td>
</tr>
<tr>
<td>Moisture, %</td>
<td>13.0</td>
<td>8.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Crude Protein, %</td>
<td>8.7</td>
<td>27.3</td>
<td>8.9</td>
</tr>
<tr>
<td>Crude Fiber, %</td>
<td>2.2</td>
<td>12.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Nitrogen Free Extract, %</td>
<td>72.0</td>
<td>41.0</td>
<td>13.4</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.2</td>
<td>9.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Ash, %</td>
<td>1.4</td>
<td>2.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>


²Composition calculated from nutrient content of corn distillers dried grains adjusted to 70% moisture and corn distillers dried solubles adjusted to 97% moisture.

³Stillage becomes DWG after the centrifugation process.
Table 3.2. Ingredient Composition of Concentrate Mixtures Fed to Lactating Dairy Cows.  

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Test Group&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Control Group&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% as fed</td>
<td></td>
</tr>
<tr>
<td>Corn (ground, shelled)</td>
<td>47.9</td>
<td>39.0</td>
</tr>
<tr>
<td>Oats (rolled)</td>
<td>47.9</td>
<td>39.0</td>
</tr>
<tr>
<td>Soybean Meal (47% CP)</td>
<td>----</td>
<td>19.5</td>
</tr>
<tr>
<td>Dicalcium Phosphate</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Trace Mineral Salt</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>1</sup>This table taken from: A.K. Clarke, D.J. Schingoethe, and H.H. Voelker, Wet Corn Distillers Grains in Lactating Dairy Cow Rations (Agricultural Experiment Station, South Dakota State University, 1981), p. 10, Table 1.

<sup>2</sup>Plus 14,000 International Units added vitamin A per KG and 3,500 International Units added Vitamin D per Kg fed with test group concentrate mixture.

<sup>3</sup>Plus 8,800 International Units added vitamin A per Kg and 2,200 International Units added vitamin D per Kg fed with control group concentrate mixture.
the test groups (44.5 lbs/day and 46.1 lbs/day, respectively), which is illustrated in Table 3.3. The results indicated no significant difference in milk yield or composition between treatment groups. This finding is illustrated in Table 3.4.

The experiment showed that DWG can successfully be substituted for soybean meal in a dairy cow ration, while maintaining milk yield and composition. The researchers concluded: "This study indicated that wet distillers grain can be effectively used in lactating dairy cattle rations as a protein source." 8

The second experiment conducted by the South Dakota State University Dairy Science Department involved growing dairy heifers. This experiment is detailed below.

Eight Holstein heifers weighing from 572 to 770 lbs were divided into control and test groups. The two groups were fed a ration of corn, oats, oat straw, limestone, trace minerals, and either soybean meal (control) or distillers wet grains (test) as a protein source. Both rations were blended with .7% propionic acid (for preservation) and fed once daily ad libitum for the 85 days of the trial. Table 3.5 describes the amounts of each ingredient in detail. The results of the test indicated that the control group gained more (1.43 versus 1.23 lbs/day) and were more efficient (21.45 versus 23.30
Table 3.3 Feed Intake of Cows Fed Distiller Wet Grains (DWG) and Control Diets.¹

<table>
<thead>
<tr>
<th>Diet</th>
<th>Test Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item Group</td>
<td>(lbs. dry matter/day)</td>
<td></td>
</tr>
<tr>
<td>DWG</td>
<td>10.1</td>
<td>----</td>
</tr>
<tr>
<td>Concentrate mix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low protein²</td>
<td>13.9</td>
<td></td>
</tr>
<tr>
<td>High protein³</td>
<td></td>
<td>20.7</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>15.7</td>
<td>17.4</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>6.4</td>
<td>6.4</td>
</tr>
<tr>
<td>Total dry matter</td>
<td>46.1</td>
<td>44.5</td>
</tr>
<tr>
<td>consumer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Adapted from: A.K. Clarke, D.J. Schingoethe, and H.H. Voelker, Wet Corn Distillers Grains in Lactating Dairy Cow Rations (Agricultural Experiment Stations, South Dakota State University, 1981), Table 4, p. 13.

²Concentrate mix of "Test Group" in Table 3.2 10.9% Crude Protein.

³Concentrate mix of "Control Group" in Table 3.2 18.6% Crude Protein.
Table 3.4. Milk Yield and Composition From Cows Fed Distillers Wet Grains and Control Diets.

<table>
<thead>
<tr>
<th>Item</th>
<th>Diet</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DWG</td>
<td>Control</td>
</tr>
<tr>
<td>Milk, Kg/day</td>
<td>27.6</td>
<td>27.0</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.41</td>
<td>3.44</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.10</td>
<td>3.09</td>
</tr>
<tr>
<td>Total Solids, %</td>
<td>12.16</td>
<td>12.10</td>
</tr>
</tbody>
</table>

1Taken from: A.K. Clarke, D.J. Schingoethe, and H.H. Voelker, Wet Corn Distillers Grains in Lactating Dairy Cow Rations (Agricultural Experiment Station, South Dakota State University, 1981), Table 3, p. 12.
Table 3.5. Dairy Heifer Ration Composition.1,2

<table>
<thead>
<tr>
<th>Feed Type</th>
<th>Control Group (lbs)</th>
<th>Test Group (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn:Oats (2:1)</td>
<td>256</td>
<td>179</td>
</tr>
<tr>
<td>Soybean Meal</td>
<td>85</td>
<td>---</td>
</tr>
<tr>
<td>Distillers Wet Grain</td>
<td>---</td>
<td>427</td>
</tr>
<tr>
<td>Oat Straw</td>
<td>378</td>
<td>390</td>
</tr>
<tr>
<td>Limestone</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Water</td>
<td>275</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>1000</td>
</tr>
</tbody>
</table>

Both rations contain:

  a) 63.3% Dry Matter  
      36.7% H2O

  b) 0.7% Propionic Acid


2As fed basis, based on 1000 lb mixture.
lbs dry matter/lb of weight gain) than the DWG fed heifers. The control group of heifers consumed more dry matter (13.97 lbs versus 12.58 lbs per day) than those in the test group. These differences, however, were not found to be statistically significant. Therefore, distillers wet grains were considered in the following analysis to be an adequate nutritional substitute for soybean meal in the rations of growing heifers. What remains to be determined is if such a substitution might be economical for a farmer.

**Comparative Value of DWG to Soybean Meal**

Using the ration formulations composed by the SDSU Dairy Science Department for the previously discussed feeding trials, and considering the results of the trials, one should be able to derive a value for the DWG given the known values of the other ration components. Assuming the control rations (as formulated in the trials) can be considered relatively common on eastern South Dakota farms, an accurate and meaningful value estimate for the DWG can be made using the control ration as a baseline case. The value of the DWG used in the test ration will be equal to the value of the corn, soybean meal, and other ingredients it replaces in the control ration.
It should be noted here (as indicated above) that the results of the feeding trial conducted on growing heifers indicated slight differences in growth performance and dry matter consumption between the test and control treatments. As stated above, these differences were not found to be statistically significant. Therefore, they will be ignored in this valuation procedure.

The SDSU Dairy Science researchers measured the amounts of each ingredient in the rations differently for the heifer and cow trials. The quantities are measured on a "fed per day" basis in the cow trials and on a "per 1000-lb" basis in the heifer trials. For this reason, the budgeting calculations are slightly different in each case, though the method used to determine the value of the DWG is the same.

The total costs of the control rations and the total costs of the test rations (less the DWG ingredient) were calculated. The calculated cost of each test ration was then subtracted from that of the control ration to give a value for the amount of DWG used in the ration. The conversion was then made to a value per ton of DWG. Tables 3.6 and 3.7 give a detailed account of the ingredients and their costs in each ration.

A value of $46.15/ton of DWG was the result of this budgeting calculation for the dairy cow trials. From
### Table 3.5. Determination of the DWG Value in the Lactating Dairy Cow Trials.

<table>
<thead>
<tr>
<th>Group</th>
<th>Feed Type</th>
<th>Feed Intake/Day&lt;sup&gt;1&lt;/sup&gt; (As fed, lbs.)</th>
<th>Feed Price&lt;sup&gt;2&lt;/sup&gt; ($/lb)</th>
<th>Cost in Ration/Day ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn, rolled &amp; ground</td>
<td>9.4</td>
<td>2.59/bu</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>Oats, rolled</td>
<td>9.1</td>
<td>1.90/bu</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>Soybean Meal (47% CP)</td>
<td>4.5</td>
<td>240.00/ton</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Dicalcium Phosphate</td>
<td>0.3</td>
<td>19.00/cwt</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Trace Mineral Salt</td>
<td>0.2</td>
<td>7.00/cwt</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Corn Silage</td>
<td>41.5</td>
<td>17.50/ton</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Alfalfa Hay</td>
<td>7.0</td>
<td>80.00/ton</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Vitamin A, D</td>
<td>----</td>
<td>0.42/lb</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn, rolled &amp; ground</td>
<td>7.7</td>
<td>2.59/bu</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Oats, rolled</td>
<td>7.5</td>
<td>1.90/bu</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>Dicalcium Phosphate</td>
<td>0.3</td>
<td>19.00/cwt</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Trace Mineral Salt</td>
<td>0.2</td>
<td>7.00/cwt</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Corn Silage</td>
<td>37.3</td>
<td>17.50/ton</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Alfalfa Hay</td>
<td>7.0</td>
<td>80.00/ton</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Vitamin A, D</td>
<td>----</td>
<td>0.42/lb</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DWG (70% H&lt;sub&gt;2&lt;/sub&gt;O)</td>
<td>33.8</td>
<td>-----------</td>
<td>1.61</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup>Converted from Table 3.3 of this chapter.

<sup>2</sup>Feed price quotations from Brookings area elevators as of July 1981, delivered.
Table 3.7. Determination of the DWG Value in the Dairy Heifer Trials.

<table>
<thead>
<tr>
<th>Group</th>
<th>Feed Type</th>
<th>Quantity 1 (lbs/1000 lbs)</th>
<th>Feed Price 2 ($/lb)</th>
<th>Cost in Ration/ ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corn (ground)</td>
<td>171</td>
<td>2.59</td>
<td>7.91</td>
</tr>
<tr>
<td></td>
<td>Oats (ground)</td>
<td>85</td>
<td>1.90</td>
<td>5.05</td>
</tr>
<tr>
<td></td>
<td>Soybean Meal</td>
<td>85</td>
<td>240.00</td>
<td>10.20</td>
</tr>
<tr>
<td></td>
<td>Oats Straw</td>
<td>378</td>
<td>30.00</td>
<td>5.67</td>
</tr>
<tr>
<td></td>
<td>Limestone</td>
<td>6</td>
<td>4.50</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>275 (34 gal.)</td>
<td>1.60/1000</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>1000</td>
<td>$29.15</td>
</tr>
<tr>
<td>(2) Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corn (ground)</td>
<td>119</td>
<td>2.59</td>
<td>5.50</td>
</tr>
<tr>
<td></td>
<td>Oats (ground)</td>
<td>60</td>
<td>1.90</td>
<td>3.56</td>
</tr>
<tr>
<td></td>
<td>Oats Straw</td>
<td>390</td>
<td>30.00</td>
<td>5.85</td>
</tr>
<tr>
<td></td>
<td>Limestone</td>
<td>4</td>
<td>4.50</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>0</td>
<td>1.60/1000</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subtotal</td>
<td>573</td>
<td>$15.09</td>
</tr>
<tr>
<td></td>
<td>DWG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>1000</td>
<td>$29.15</td>
</tr>
</tbody>
</table>

1 From Table 3.5.

2 Feed price quotations from Brookings area elevators as of July 1981, delivered.
this value, the cost of the propionic acid preservative, $12.60/ton, was subtracted to give a net value of $33.55/ton of DWG.

The substitution value of the DWG in the dairy heifer trials was found to be $65.85/ton. The cost of the propionic acid preservative was deducted to give a net value of $53.25/ton of DWG.

The average of the two values for the heifer and dairy cow uses is $43.40/ton. Because of the handling and feeding inconvenience of the DWG (compared with corn and soybean meal), a 10% discount is subtracted from the determined price. This gives a net distiller wet grain value of approximately $39.00/ton.

This "discount" is not intended to also cover transportation costs, as in the Hutchinson and Dobbs study, but to compensate the cooperative members for their inconvenience incurred in substituting DWG into dairy or heifer rations. The cost of transportation, covered in the following chapter, is charged to the ethanol plant. Thus, the $39.00 per ton is on a delivered basis.

It should be noted here that this method of determining a value for the DWG was previously reported by Hoffman and Dobbs.
Handling of DWG

Because of the 70% moisture content of the distillers wet grain, even after centrifugation, special attention must be given to storage and handling procedures. Although the DWG at this moisture level contains little gravitational water drainage, it is of a "pasty" consistency which may present difficulties when attempts are made to handle it with mechanical equipment such as augers, silo loaders, and unloaders.

The DWG presents a storage problem because it presents an excellent medium for mold growth. Experience at South Dakota State University indicates spoilage can begin in open air within 24 hours in hot weather. Placing the DWG on a concrete slab may give a storage life of only two or three days in warm weather. Storing unpreserved DWG on this basis would only be practical for a farmer if byproduct deliveries were made to his farm frequently (maybe every two days) and if the farmer were to utilize the DWG in a short time period. The storage time could be extended in cooler months of the year.

A propionic acid based compound can be added to the DWG to substantially prolong its storage life. A product composed of 70% propionic acid and 30% acetic acid was used by the SDSU Dairy Science Department to
preserve the DWG used in the feeding trials mentioned. A weight to weight mixture of .7% preservation to 99.3% DWG is assumed to provide spoilage free storage for approximately two weeks. The treated DWG could be stored on a concrete slab, covered with black plastic, and handled with a power loader without great inconvenience, though freezing could be a problem in winter months.

Another storage scenario available involves mixing the DWG with dry grain and ensiling the mixture. SDSU Dairy Science researchers have tested various proportions of DWG mixed with dry ground corn in simulated oxygen limiting silos. Mold free storage for up to five weeks was achieved with a 50% to 70% dry corn to DWG mixture.

The best storage method may depend on the situation and management practices of each individual farmer involved in a distillers wet grain feeding program.

The value of the DWG has now been estimated, and the handling characteristics have been reviewed. The next chapter will seek to determine a distribution system for the DWG and to discover how large an area this system must serve.
Footnotes


4 Ibid., p. 5.

5 Ibid., p. 7.


7 Ibid., p. 1.

8 Ibid. p. 1.


10 Ibid.

11 Conversation of author with D.J. Schingoethe, South Dakota State University, Dairy Science Department, February 23, 1982.
12 Ron Hutchinson and Thomas Dobbs, Preliminary Cost Estimates - Producing Alcohol Fuel From a Small-Scale Plant (Agricultural Experiment Station, South Dakota State University, 1980), Annex E, p. 22.


14 G. Kuhl, R. Schoper, and H. Voelker, Use and Handling of Alcohol Plant By-Products, p. 7.


16 G. Kuhl, R. Schoper and H. Voelker, Use and Handling of Alcohol Plant By-Products, p. 8.

17 Ibid., p. 9.
CHAPTER IV

TERRITORY TO BE SERVED BY A SMALL-SCALE PLANT

Introduction

The purpose of this chapter is to determine an appropriate service area for a small scale plant with an approximate annual capacity of 175,000 gallons of denatured ethanol. The area required to provide the corn input and to utilize both the ethanol and byproduct output will be determined here. An effort will be made to provide a site that is as favorable to plant feasibility as is realistically possible.

Deuel County, in South Dakota, was selected as the hypothetical plant's location because of its large number of dairy farms and adequate corn production. Deuel County contains approximately 250 dairy farms, the most in any county of South Dakota.\(^1\) The basis for participation in the use of ethanol and its feed byproduct will be determined by a method using farm census statistics and the assumption that the farms are geographically located in a systematic pattern. This general method was outlined in a paper by Dobbs, Hoffman, and Lundeen\(^2\) and can be adapted for use in this thesis by using farm census statistics from Deuel County.
Plant Feedstock Requirements and Fuel Utilization

The specific feedstock supply requirements of the plant and the number of farms required to utilize the product and byproduct will determine the size of the area to be served by the ethanol plant. The following sections will address each of these three considerations.

Feedstock Requirements

The hypothetical plant producing approximately 175,000 gallons of denatured alcohol per year requires 63,976 bushels of corn per year.\(^3\) Corn was produced on 581 Deuel County farms with 50,275 total acres in 1978.\(^4\) An average of 86.5 acres per farm are in corn production in Deuel County, and the county had a 5-year average for corn yields of 72.4 bushels per acre.\(^5\) This indicates the following:

\[
\frac{63,976 \text{ bu. corn required}}{72.4 \text{ bu. corn per acre}} = 883.7 \text{ acres}
\]

Hence, 883.7 acres are required to produce an adequate feedstock supply for the plant. The results from the above equation are used as follows:

\[
\frac{883.7 \text{ acres of corn}}{86.5 \text{ acres per farm}} = 10.2 \text{ farms}
\]

Therefore, 10.2 farms could supply the plant's feedstock needs.

Fuel Utilization

An important cost to consider in operation of the alcohol fuel plant is that of transporting the product to
its buyer. Inherent in a distribution plan is an estimate of possible use by each farmer for the fuel. To estimate this use, one can start with the total fuel purchases of farmers in Deuel County. The Census of Agriculture gives these figures as 1,440,000 gallons of gasoline and 1,252,000 gallons of diesel fuel per year on 747 farms. Dividing by the number of farms in Deuel County gives an average per farm usage.

Gasoline: \[
\frac{1,440,000 \text{ gallons}}{747 \text{ farms}} = 1,927.7 \text{ gallons per farm}
\]

Diesel Fuel: \[
\frac{1,252,000 \text{ gallons}}{747 \text{ farms}} = 1,676.0 \text{ gallons per farm}
\]

At this point, several assumptions must be made concerning the substitution of ethanol for gasoline or diesel fuel by farmers. They are the following:

1) farmers who use ethanol will utilize it in tractors converted for such purposes;

2) each farmer substitutes 25% of his gasoline requirements with ethanol; or,

3) each farmer substitutes 50% of his gasoline and 50% of his diesel fuel requirements with ethanol; and,

4) 1.65 gallons of ethanol are required to replace the energy in one gallon of gasoline and 1.96 gallons of ethanol are required to replace each gallon of diesel fuel.
The basis for assumption 2 is contained in the Dobbs and Hoffman study. The second assumption will be considered the "baseline case" of ethanol consumption, and the third will be considered as the "alternative case."

The amount of ethanol used per farm may now be determined for the two consumption alternatives. First, considering the baseline case:

\[
(1,927.7 \text{ gallons gasoline} \times (25\%) = 481.9 \text{ gal/farm per farm})
\]

This indicates that 481.9 gallons of gasoline per farm are to be replaced by ethanol. Next, converting the energy to that of ethanol:

\[
(481.9 \text{ gal. gasoline} \times (1.65 \frac{\text{gals. ethanol}}{\text{gal. gasoline}}) = 795.1 \text{ gallons of ethanol required per farm in the baseline case}
\]

The alternative assumption of 50% gasoline and 50% diesel fuel replacement will be calculated next.

**Gasoline replacement:**

\[
(1,927.7 \text{ gals. per farm} \times (50\%) = 963.9 \text{ gallons of gasoline to be replaced by ethanol}
\]

\[
(963.9 \text{ gal. gasoline per farm} \times (1.65 \frac{\text{gals. ethanol}}{\text{gal. gasoline}}) = 1,590.3 \text{ gallons ethanol required per farm for 50% gasoline substitution}
\]
Diesel fuel replacement:

\[(1,676.0 \text{ gallons per farm}) \times 50\% = 838.0 \text{ gallons}\]
diesel fuel to be replaced by ethanol

\[(838.0 \text{ gals. diesel per farm}) \times \left(\frac{1.96 \text{ gals. ethanol}}{\text{gal. diesel}}\right) = 1,642.5 \text{ gallons of ethanol required per farm for 50\% diesel fuel substitution}\]

Now, the two amounts are summed:

\[1,590.3 \text{ gallons} + 1,642.5 \text{ gallons} = 3,233 \text{ gallons of ethanol per farm}\]

This indicates that 3,233 gallons of ethanol are required per farm per year in the alternative substitution case.

Next, the number of farms required to consume the 175,000 gallon ethanol output must be calculated in both cases. Considering the baseline case first:

\[\frac{175,000 \text{ gals. per year}}{795 \text{ gals. per farm}} = 220 \text{ farms needed to consume the ethanol output each year}\]

Considering the alternative case of 50\% gasoline and 50\% diesel substitution:

\[\frac{175,000 \text{ gals. per year}}{3,233 \text{ gals. ethanol per farm}} = 54 \text{ farms needed to consume the ethanol output each year}\]
Transportation and Distribution of Ethanol Fuel

The next step in this analysis is to determine the transportation routing and costs for the ethanol fuel product. First, the routing will be determined and the costs associated with the distribution will be estimated.

An assumption must be made concerning the location of farms receiving ethanol deliveries. Deuel County contains 747 farms on 639 square miles of land.\(^9\)

Dividing to find the farms per square mile:

\[
\frac{747 \text{ farms}}{639 \text{ square miles}} = 1.2 \text{ farms per square mile, or 6 farms per 5 square miles.}
\]

It will be assumed for convenience and consistency that 83% (or 5/6) of all farms are located in the northeast corner of a section, and every fifth section also contains a farm in the southwest corner. Additionally, it will be assumed that the alcohol fuel plant is located within the Clear Lake city limits on a section line road and that all section lines are bounded by a road. Figure 1 illustrates the assumed alcohol plant and service area.

Assuming the average farmer has a 500-gallon fuel tank for ethanol storage, two separate deliveries must be made to farms under the baseline case assumption. Seven separate deliveries must be made over the course of each year under the alternative case fuel substitution assumption.
Figure 1. The Estimated Service Area for the Fuel Alcohol Delivery in the Base Case (220 farms).
Using a least distance routing of deliveries with a 2,500 gallon capacity bulk gas truck, total mileage for a complete circuit of the ethanol delivery route under the baseline case assumption was calculated. It came to 663 miles, or 1,326 miles per year for two circuits of the 220 farm route.

Accounting for "miscellaneous" mileage, the figure can be rounded up to 1,400 miles per year. The calculation assumed that the farms closest to the alcohol plant are all ethanol users.

The alternative case of 50% substitution for gasoline and 50% substitution for diesel fuel requires the bulk gas truck to make seven deliveries of approximately 450 gallons of ethanol to each farm. The truck will cover about 800 miles per year in order to provide fuel for the 54 farms. This is adjusted to 850 miles to account for miscellaneous mileage. This case also assumed that the farms located nearest to the alcohol plant are all consumers of the fuel.

Now that the transportation distances have been calculated in each case, the actual costs involved will be determined.

Dobbs, Hoffman, and Lundeen have calculated fixed and operating costs associated with an alcohol delivery
truck for a plant similar to the one discussed here.\textsuperscript{10} Their gasoline and labor cost estimates require adjustment here. However, the fixed cost estimates from their study can remain unchanged.

First, the baseline case will be considered:

Gasoline: \[ \frac{1,400 \text{ miles/yr}}{5 \text{ miles/gallon}} = 280 \text{ gallons/yr} \]

\[(280 \text{ gallons}) \times ($1.30 \text{ gallon}) = $364 \text{ per year}\]

Labor: Assume deliveries can be made to 12 farms in an 8 hour day.

\[\frac{220 \text{ farms}}{12 \text{ farms/day}} = 18.33 \text{ days/route}\]

\[(18.33 \text{ days/route}) \times (2 \text{ routes/yr}) = 36.6 \text{ days, or about 37 days}\]

\[(37 \text{ days}) \times (8 \text{ hours/day}) = 296 \text{ hrs/yr}\]

\[(296 \text{ hrs/yr}) \times ($5.00/\text{hr}) = $1,480/\text{yr}\]

These costs are summarized in Table 4.1 The cost of alcohol delivery amounts to about $0.02 per gallon of ethanol in the base case.

Now, the alternative case will be considered, where 50\% of both gasoline and diesel fuel would be replaced by ethanol.

Gasoline: \[ \frac{850 \text{ miles/yr}}{5 \text{ miles/gallon}} = 170 \text{ gallons/yr} \]
Table 4.1. Fixed and Operating Costs Associated with the Alcohol Fuel Delivery Truck in the Baseline Fuel Substitution Case.¹

<table>
<thead>
<tr>
<th>Item</th>
<th>Full Capital Cost</th>
<th>Useful Life (years)</th>
<th>Full Amortized Cost (15% interest)</th>
<th>% Annual Amortized Cost²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Gas Truck</td>
<td>$25,000</td>
<td>10</td>
<td>$4,975.00</td>
<td>$1,244.00</td>
</tr>
</tbody>
</table>

Subtotal A              $1,244.00

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/unit ($)</th>
<th>Units/year</th>
<th>Annual Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>1.30/gal.</td>
<td>280 gals.</td>
<td>364.00</td>
</tr>
<tr>
<td>Oil, filter, grease</td>
<td>17.25/change</td>
<td>2 changes</td>
<td>34.50</td>
</tr>
<tr>
<td>Labor</td>
<td>5.00/hr</td>
<td>296 hours</td>
<td>1,480.00</td>
</tr>
<tr>
<td>Antifreeze</td>
<td>15.00/change</td>
<td>% change</td>
<td>3.75</td>
</tr>
<tr>
<td>Tune-up</td>
<td>200.00/job</td>
<td>% job</td>
<td>50.00</td>
</tr>
<tr>
<td>License, Insurance</td>
<td>2,300.00/yr</td>
<td>% year</td>
<td>575.00</td>
</tr>
<tr>
<td>Tires</td>
<td>220.00/yr</td>
<td>% year</td>
<td>55.00</td>
</tr>
</tbody>
</table>

Subtotal B              $2,562.25

Totals of A and B       $3,806.25

¹Adapted from Thomas Dobbs, Randy Hoffman, and Ardelle Lundeen, Framework for Examining the Economic Feasibility of Small Scale Alcohol Plants, (South Dakota State University, Economics Department, Staff Paper Series No. 81-3. August 1981), pp. 19-23.

²Since the bulk gas truck is utilized only about 3 months per year, it is assumed that the coop can rent the truck to another user for 3/4 of the year or that it is rented by the coop for % year. Therefore, only % of the fixed costs and relevant operating costs are assigned to the alcohol plant.
(170 gallons) x ($1.30 gallons) = $221/yr

Labor: Again, assume deliveries can be made to 12 farms in an 8 hour day.

\[
\frac{54 \text{ farms}}{12 \text{ farms/day}} = 4.5 \text{ days/route}
\]

(4.5 days/route) x (8 routes/yr) = 36 days

(36 days) x (8 hours/day) = 288 hrs/yr.

(288 hrs/yr) x ($5.00/hr) = $1,440/yr.

These costs are summarized in Table 4.2. The cost of alcohol delivery in the alternative substitution case amounts to about $0.021 per gallon of ethanol.

**Byproduct Utilization**

It has been estimated that the ethanol plant would produce approximately 42.4 lbs of 70% DWG per bushel of corn processed. This amounts to 1,356 tons of DWG per year.

The next step in the analysis is to determine the amount of DWG an average Deuel County farm would be likely to utilize in a year.

Calculating the amount of DWG utilization per farm requires estimates of the feeding requirements of an average producing dairy herd and of the growing heifers on such a farm in Deuel County. First, the DWG feeding requirements for the lactating cows will be addressed.
Table 4.2. Fixed and Operating Costs Associated With the Fuel Alcohol Delivery Truck in the Alternative (50% Gasoline and 50% Diesel) Fuel Substitution Case.  

<table>
<thead>
<tr>
<th>A. Fixed Costs</th>
<th>Item</th>
<th>Full Capital Cost</th>
<th>Useful Life (years)</th>
<th>Full Amortized Cost (15% interest)</th>
<th>% of Annual Amortized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bulk gas truck</td>
<td>$25,000</td>
<td>10</td>
<td>$4,975.00</td>
<td>$1,244.00</td>
</tr>
<tr>
<td>Subtotal A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1,244.00</td>
</tr>
<tr>
<td>B. Operating Costs</td>
<td>Item</td>
<td>Cost/Unit ($)</td>
<td>Units/year</td>
<td>Annual Cost ($)</td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>1.30/gal</td>
<td>170 gallons</td>
<td>221.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil, filter, grease</td>
<td>17.25/change</td>
<td>2 changes</td>
<td>34.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor</td>
<td>5.00/hr</td>
<td>288 hours</td>
<td>1,440.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antifreeze</td>
<td>15.00/change</td>
<td>2/ change</td>
<td>3.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tune-up</td>
<td>200.00/job</td>
<td>2/ job</td>
<td>50.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle license &amp; insurance</td>
<td>2,300.00/yr</td>
<td>2/ year</td>
<td>575.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tires</td>
<td>220.00/yr</td>
<td>2/ year</td>
<td>55.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal B</td>
<td></td>
<td></td>
<td></td>
<td>2,379.25</td>
<td></td>
</tr>
<tr>
<td>Totals of A and B</td>
<td></td>
<td></td>
<td></td>
<td>3,623.25</td>
<td></td>
</tr>
</tbody>
</table>

1Adapted from Thomas Dobbs, Randy Hoffman, and Ardelle Lundeen, Framework for Examining the Economic Feasibility of Small Scale Alcohol Plants (South Dakota State University, Economics Department, Staff Paper Series No. 81-3, August 1981), 19-23.

2Since the bulk gas truck is utilized only about 3 months per year, it is assumed that the coop can rent the truck to another user for 3/4 of the year or that it is rented by the coop for about 1/3 of the year. Therefore, only 1/3 of the fixed costs and relevant operating costs are assigned to the alcohol plant.
The SDSU feeding trials previously discussed are used as a basis for computing the amount of DWG required in the ration per cow.

Deuel County contains 251 dairy farms, with a mean of 31 cows per farm.\textsuperscript{13} An assumption is made that 85\% of the herd is in lactation in a given year, or 26 cows in an average herd in Deuel County.\textsuperscript{14} On the basis of this assumption, and drawing on the research results from the SDSU dairy cow trials cited in Chapter III, one can estimate the utilization of the DWG for dairy cows for a single farm as follows:

\[(26 \text{ cows lactating}) \times (365 \text{ days/year}) \times (33.8 \text{ lbs DWG per cow/day}) = 320,762 \text{ lbs of DWG required per farm per year for the dairy herd, or 160.4 tons.}\]

Dairy farmers generally raise herd replacement stock from the "calf crop." As shown by the SDSU trials, dairy heifers can also be fed a ration containing DWG. The amount of DWG fed in this manner must also be calculated. Again, several assumptions must be made as a basis for the quantity estimate of DWG utilized for the dairy heifers. The assumptions are as follows:

1) of the 31 cows in the herd, 30 successfully give birth per year; 50\% of the calves, or 15, are heifers;
2) only heifers in the ages between 3 and 24 months are fed a ration containing DWG;

3) dairy farmers of Deuel County replace 20% to 25% of their herd each year with 24 month old heifers, or seven head per year;

4) the heifers between 3 and 18 months of age will consume feed equivalent to 2% of their body weight per day, 21% of which is DWG (dry matter basis); and finally,

5) heifers between 18 and 24 months of age consume feed equivalent to 1.5% of their body weight per day, 21% of which is DWG (dry matter basis.)

Since herd replacement heifers will vary in age and weight and, therefore, in feeding requirements, it is necessary to assume an average composition of this replacement herd in order to obtain an estimate of the total feeding requirements. The depletion in numbers of this heifer herd occurs because of fatalities and culling by farmers. Table 4.3 details the assumed heifer herd composition and the feed requirements. With this composition of a replacement heifer herd, under the assumptions given above, 29.5 tons of DWG would be required per year.
Table 4.3. Composition of Heifer Herd for Replacement.\(^1\)

<table>
<thead>
<tr>
<th>Number of Heifers(^2)</th>
<th>Age (months)</th>
<th>Approximate Weight</th>
<th>Approximate Lbs. of DWG Consumed Per Head Per Day (70% moisture)</th>
<th>Days on Feed</th>
<th>Total DWG (lbs) (70% moisture)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0-3</td>
<td>---</td>
<td>0</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>3-6</td>
<td>330</td>
<td>4.62</td>
<td>90</td>
<td>5,821.2</td>
</tr>
<tr>
<td>13</td>
<td>6-9</td>
<td>495</td>
<td>6.93</td>
<td>90</td>
<td>8,108.1</td>
</tr>
<tr>
<td>12</td>
<td>9-12</td>
<td>660</td>
<td>9.24</td>
<td>90</td>
<td>9,979.2</td>
</tr>
<tr>
<td>8</td>
<td>12-15</td>
<td>825</td>
<td>11.55</td>
<td>95</td>
<td>8,778.0</td>
</tr>
<tr>
<td>8</td>
<td>15-18</td>
<td>990</td>
<td>13.86</td>
<td>90</td>
<td>9,979.2</td>
</tr>
<tr>
<td>7</td>
<td>18-21</td>
<td>1,155</td>
<td>12.13</td>
<td>90</td>
<td>7,641.9</td>
</tr>
<tr>
<td>7</td>
<td>21-24</td>
<td>1,320</td>
<td>13.86</td>
<td>90</td>
<td>8,731.3</td>
</tr>
</tbody>
</table>

\(^1\)Information in this table obtained from Dr. Andrew Clark, SDSU Dairy Science Department, in a conversation with the author on June 17, 1982.

\(^2\)Assume three fatalities between age 9-12 months. Decline in number of heifers over 12 months of age is due to culling by farmer.
The 29.5 tons of DWG required by the heifers added to the 160.4 tons per year needed by the dairy cows gives a per dairy farm requirement of 189.9 tons per year.

As previously stated, 1,356 tons of DWG are produced by the ethanol plant annually. The following calculation is now made:

\[
\frac{1,356 \text{ tons DWG}}{189.9 \text{ tons DWG per farm}} = 7.14 \text{ farms}
\]

Thus, the number of farms required to use the byproduct is 7.14.

The 7.14 farms is rounded down to 7.0 farms. The amount of DWG implied remaining by this rounding is assumed to be lost by waste and spoilage (about 2% of the DWG produced).

**Transportation and Distribution of DWG**

The transportation of the feed byproduct can be approached with methodology similar to that used with the fuel product, and developed by Dobbs, Hoffman, and Lun-deen.16

As calculated previously, seven farms are needed to utilize the 1,356 tons of DWG produced by the alcohol plant per year. Since the storage life of DWG treated with the propionic acid mixture is about 14 days, deliveries to consuming dairy farms must occur at
least every two weeks. It is assumed that participating farmers will have adequate storage facilities available.

As in the study by Dobbs, Hoffman, and Lundeen referred to earlier, a so-called "1-ton" truck would be used to deliver the DWG to consuming farms.\textsuperscript{17} This truck could carry about 2.8 tons per load.\textsuperscript{18} The following calculation can now be made:

\[
\frac{189.9 \text{ tons DWG required per year}}{2.8 \text{ tons per load}} = 68 \text{ loads}
\]

Hence, 68 loads are required per dairy farm per year. The following calculation is made to determine the length of time between deliveries:

\[
\frac{365 \text{ days per year}}{68 \text{ DWG deliveries}} = \text{1 delivery every fifth or sixth day}
\]

It is necessary to measure the amount of DWG delivered to each farm. Therefore, each load of DWG must be weighed. It would be necessary to weigh the truck only once per trip, since a normal empty weight of the truck can be consistently subtracted from the loaded weight to determine the amount of DWG on a load.

As previously noted, Deuel County contains 251 dairy farms on 639 square miles. We thus calculate as follows:

\[
\frac{251 \text{ dairy farms}}{639 \text{ square miles}} = .4 \text{ farms per square mile, or 1 dairy farm every 2.5 square miles.}
\]
As with the case of the alcohol fuel consuming farms, it is assumed here that each farm is located in the northeast corner of a section. Since farms are at a density of one every 2.5 square miles, they can be assumed to be located alternately in two of every five sections around the alcohol plant. It will be assumed however, that only every second dairy farmer will agree to be a DWG consumer, since it is unlikely all farmers could or would use the byproduct as a dairy feed. Figure 2 depicts this situation of two DWG consuming dairy farms per ten square miles around the plant.

A least mileage delivery route was calculated to be 59 miles to cover the seven farms. Since 68 such circuits must be traveled per year, the total mileage can be calculated as:

\[(59 \text{ miles per circuit}) \times (68 \text{ circuits per yr}) = 4,012 \text{ miles per year}\]

This result is rounded up to 4,200 miles to account for miscellaneous mileage.

The fixed and operating costs for a 1-ton delivery truck have been calculated by Dobbs, Hoffman and Lundeen. With the assumptions in this thesis, the fixed costs they have calculated will remain unchanged, but several of their operating cost estimates must be adjusted.
Figure 2. The Service Area of the Cooperative for DWG Deliveries.
* = Farms receiving DWG deliveries (7).
The cost of gasoline is estimated to be:

\[
\frac{4,200 \text{ miles per year}}{11 \text{ miles per gallon}} = 382 \text{ gallons}
\]

(382 gallons) x ($1.30 per gallon) = $496.60 per yr

The labor cost is estimated to be:

(1.5 hours per delivery) x ($5.00 per hr) x 
(7 farms) x (68 deliveries per farm) =

$3,570 per year

Additionally, a weighing cost must be included.
It is assumed that the truck could be weighed at a local elevator for $2 per weigh, one weigh per trip. The cost is computed as follows:

(476 trips per year) x ($2.00 per trip) = $952.00

per year weighing cost.

Table 4.4 summarizes the estimated fixed and operating costs incurred in DWG delivery. The total annual cost of $9,203.85 amounts to $0.05 per gallon of ethanol produced annually.

**Implications for Cooperative Service Area**

This chapter has provided several items to consider concerning the size and structure of the cooperative's service area.

The importance of a well organized system for distillers wet grain (DWG) delivery and storage was ob-
Table 4.4. Fixed and Operating Costs Associated With the DWG Delivery Truck.¹

<table>
<thead>
<tr>
<th>A. Fixed Costs</th>
<th>Full Capital Cost</th>
<th>Useful Life</th>
<th>Full Amortized Cost (15% interest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One ton truck</td>
<td>$14,000</td>
<td>10</td>
<td>$2,786.00</td>
</tr>
<tr>
<td>Subtotal A</td>
<td></td>
<td></td>
<td>$2,786.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Operating Costs</th>
<th>Cost/Unit ($)</th>
<th>Units/year</th>
<th>Annual Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>1.30/gal</td>
<td>382 gals.</td>
<td>496.60</td>
</tr>
<tr>
<td>Oil, Filter, Grease</td>
<td>14.75/change</td>
<td>3 changes</td>
<td>44.25</td>
</tr>
<tr>
<td>Labor</td>
<td>5.00/hr</td>
<td>714 hours</td>
<td>3,570.00</td>
</tr>
<tr>
<td>Antifreeze</td>
<td>15.00/change</td>
<td>1 change</td>
<td>15.00</td>
</tr>
<tr>
<td>Tune-up</td>
<td>200.00/job</td>
<td>1 job</td>
<td>200.00</td>
</tr>
<tr>
<td>License, Insurance</td>
<td>960.00/yr</td>
<td>1 year</td>
<td>960.00</td>
</tr>
<tr>
<td>Tires</td>
<td>180.00/yr</td>
<td>1 year</td>
<td>180.00</td>
</tr>
<tr>
<td>Weight Payments</td>
<td>2.00/weigh</td>
<td>476 weighs</td>
<td>952.00</td>
</tr>
<tr>
<td>Subtotal B</td>
<td></td>
<td></td>
<td>$6,417.85</td>
</tr>
<tr>
<td>Totals of A and B</td>
<td></td>
<td></td>
<td>$9,203.85²</td>
</tr>
</tbody>
</table>

¹Adapted from Thomas Dobbs, Randy Hoffman, and Ardelle Lundeen, Framework for Examining the Economic Feasibility of Small Scale Alcohol Plants (South Dakota State University, Economics Department, Staff Paper Series No. 81-3, August 1981), pp. 19-23.
served. The operating and fixed costs of the feed delivery truck were estimated to add about five cents per gallon to the cost of ethanol produced. Labor costs comprise more than one third of this total. The assumption concerning the close proximity of the DWG consuming farms to the ethanol plant was one major factor in keeping the DWG delivery costs that low. This indicates some benefit in locating the ethanol plant in a high density dairy region such as Deuel County.

In addition, fuel utilization and delivery were considered. An important point to note on this topic is the very slight difference in delivery cost between the "baseline" and the "alternative" ethanol utilization assumptions. Both the 25% gasoline substitution and the 50% gasoline and diesel fuel substitution assumptions involve a cost about two cents per gallon for ethanol delivery.20

In summary, it appears that it is more important to have the ethanol plant in close proximity to the DWG consuming farms than to the ethanol consumers, if close proximity to both is not possible. This is not only because the DWG is more costly than the ethanol to transport, but because the feed byproduct's utilization and perishability characteristics make its delivery timetable more critical.
It was found that, under the assumptions specified in this chapter, seven dairy farms in Deuel County could utilize all of the DWG produced by the ethanol plant. In the "baseline" case, 220 farms were required to utilize the ethanol produced; only 54 farms were required in the "alternative" fuel utilization case.
Footnotes


2 Thomas Dobbs, Randy Hoffman, and Ardelle Lundeen, Framework for Examining the Economic Feasibility of Small Scale Alcohol Plants (South Dakota State University, Economics Department, Staff Paper Series No. 81-3, August 1981), pp. 19-23.

3 Randy Hoffman and Thomas Dobbs, A Small-Scale Plant: Costs of Making Fuel Alcohol (Agricultural Experiment Station, South Dakota State University, B686, September 1982), p. 35.


7 See p. 10, Chapter II of this thesis.

8 Thomas L. Dobbs and Randy Hoffman, Small-Scale Fuel Alcohol Production from Corn: Economic Feasibility Prospects (Agricultural Experiment Station, South Dakota State University, B687, June 1983), p. 6.

9 U.S. Department of Agriculture, 1978 Census of Agriculture, Table 1, p. 118.


12. Ibid.


14. Conversation of the author with Prof. Andrew Clark, South Dakota State University, Dairy Science Department, June 17, 1982.

15. Ibid.


20. The calculations to determine the fuel delivery costs assumed no difference in certain fixed and operating costs, such as those associated with truck and tire life; in reality, that would not be entirely true.
CHAPTER V

FINANCIAL AND TAX CONSIDERATIONS FOR A
COOPERATIVELY ORGANIZED ALCOHOL PLANT

Introduction

The financing options and tax liabilities a cooperative fuel plant could expect to encounter are explored in this chapter. Cooperative organization may entitle the fuel plant to avenues of financing unavailable to other types of businesses. Proper organization of the cooperative could provide for exemption from taxation on possible net returns.

Additionally, as an alcohol fuel producer, the cooperative may qualify for financing under programs of the Department of Energy (DOE) or other federal agencies.

Capital Requirements

Both the fixed and operating capital requirements must be considered in the planning and organizing stages for an ethanol plant. The fixed costs will be considered first.

Fixed Costs

The fixed costs include all the equipment necessary for the production of ethanol, as well as the build-
ing to contain it. Fixed costs also include the equipment for storage and handling of the DWG byproduct. These fixed costs are itemized in Table 5.1 and total $206,750. The cost of a bulk gas delivery truck for the ethanol fuel is included. It is safe to assume that at least this total of $206,750 for fixed costs would be required for starting the alcohol plant considered in this study.

Operating Costs

The operating costs include all the variable inputs required in the production and distribution of the fuel product and DWG byproduct. The cost of insurance, various maintenance, and property taxes are also included here. The operating costs have been calculated on an annual basis and appear in Table 5.2. The costs are explained in detail in the Hoffman and Dobbs bulletin.¹

Cooperative Considerations

The fundamental aspects of cooperative organization and structure were covered in Chapter II. The task remains here to apply these aspects to the present situation.

It is assumed that all consumers of the plant product and byproduct are cooperative members. This
Table 5.1. Fixed Costs For Ethanol Plant Construction and Operation.¹

<table>
<thead>
<tr>
<th>Items Required Items</th>
<th>Capital Cost ($)</th>
<th>Useful Life (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-fired Boiler</td>
<td>26,450</td>
<td>10</td>
</tr>
<tr>
<td>Fermentation Tanks</td>
<td>23,300</td>
<td>10</td>
</tr>
<tr>
<td>Grain Handling System</td>
<td>12,800</td>
<td>10</td>
</tr>
<tr>
<td>Alcohol Storage</td>
<td>5,000</td>
<td>10</td>
</tr>
<tr>
<td>Auger</td>
<td>500</td>
<td>5</td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td>1,750</td>
<td>10</td>
</tr>
<tr>
<td>Byproduct Storage</td>
<td>1,200</td>
<td>20</td>
</tr>
<tr>
<td>Water Softeners (2)</td>
<td>1,000</td>
<td>5</td>
</tr>
<tr>
<td>Building</td>
<td>26,000</td>
<td>20</td>
</tr>
<tr>
<td>Distillation Columns</td>
<td>19,000</td>
<td>10</td>
</tr>
<tr>
<td>Temperature Meter</td>
<td>300</td>
<td>10</td>
</tr>
<tr>
<td>Pressure Gauges (2)</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Pumps and Motors</td>
<td>2,350</td>
<td>5</td>
</tr>
<tr>
<td>Pipes, Accessories</td>
<td>1,000</td>
<td>5</td>
</tr>
<tr>
<td>Centrifuge</td>
<td>32,000</td>
<td>10</td>
</tr>
<tr>
<td>Flow Meters</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>Differential Pressure Cell</td>
<td>250</td>
<td>10</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>3,900</td>
<td>10</td>
</tr>
<tr>
<td>Laboratory</td>
<td>3,000</td>
<td>10</td>
</tr>
<tr>
<td><strong>Subtotal A</strong></td>
<td><strong>160,000</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items Possibly Available Among Coop Members</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Auger</td>
<td>2,400</td>
<td>10</td>
</tr>
<tr>
<td>Skid Steer Loader</td>
<td>20,000</td>
<td>20</td>
</tr>
<tr>
<td>Steel Grain Bin</td>
<td>4,100</td>
<td>20</td>
</tr>
<tr>
<td><strong>Subtotal B</strong></td>
<td><strong>26,500</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Items Required for Distribution of Products</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>One Ton Truck for DWG</td>
<td>14,000</td>
<td>10</td>
</tr>
<tr>
<td>Bulk Gas Truck for Ethanol (½ of total cost)</td>
<td>6,250</td>
<td>10</td>
</tr>
<tr>
<td><strong>Subtotal C</strong></td>
<td><strong>20,250</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total (A+B+C)</strong></td>
<td><strong>206,750</strong></td>
<td></td>
</tr>
</tbody>
</table>

¹Data taken from Randy Hoffman and Thomas Dobbs, A Small-Scale Plant: Costs of Making Fuel Alcohol (Agricultural Experiment Station, South Dakota State University, B686, September 1982), p. 18; and Thomas Dobbs, Randy Hoffman, and Ardelle Lundeen, Framework for Examining the Economic Feasibility of Small-Scale Alcohol Plants (South Dakota State University, Economics Department, Staff Paper Series No. 81-3, August 1981), pp. 24 and 30.
### Table 5.2. Operating Costs for the Ethanol Plant

<table>
<thead>
<tr>
<th>Item</th>
<th>Annual Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Ethanol Plant</strong></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>160,166</td>
</tr>
<tr>
<td>Diazyme L-100</td>
<td>12,640</td>
</tr>
<tr>
<td>Taka-Therm</td>
<td>4,158</td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td>1,663</td>
</tr>
<tr>
<td>Ammonium Hydroxide</td>
<td>4,158</td>
</tr>
<tr>
<td>Yeast</td>
<td>3,990</td>
</tr>
<tr>
<td>Electricity</td>
<td>4,324</td>
</tr>
<tr>
<td>Coal</td>
<td>10,146</td>
</tr>
<tr>
<td>Water</td>
<td>1,830</td>
</tr>
<tr>
<td>Labor</td>
<td>78,840</td>
</tr>
<tr>
<td>Laboratory Tests</td>
<td>2,250</td>
</tr>
<tr>
<td>Denaturant (Gasoline)</td>
<td>11,476</td>
</tr>
<tr>
<td><strong>Subtotal A</strong></td>
<td>295,641</td>
</tr>
</tbody>
</table>

| **B. Product and Byproduct Distribution** |                 |
| DWG Delivery Truck                        | 6,418           |
| Alcohol Fuel Delivery Truck (base case)   | 2,562           |
| **Subtotal B**                            | 8,980           |

| **C. Other Annual Costs**                 |                 |
| Insurance for Plant                       | 9,500           |
| Maintenance for Plant                     | 7,450           |
| Property Taxes for Plant                  | 5,950           |
| **Subtotal C**                            | 22,900          |
| **Total (A+B+C)**                         | 327,521         |

---

situation then exempts the cooperative from paying federal income taxes on net returns received through sales to those members, providing these net returns are distributed back to those members in the form of dividends.\(^2\) The cooperative can purchase capital and operating supplies from any source with no effect on its legal status as a cooperative. Assuming all the fuel users are members, the cooperative could have from about 50 to over 220 members, depending on how much alcohol is consumed per farm. The "base case" cooperative would have about 220 members, based on the consumption scenario outlined as the base case in the previous chapter. It is also assumed that each member would be willing to supply some equity capital prior to the plant's construction. This will be addressed more explicitly in the following chapter.

As stated previously, effective management is required for a successful cooperative. In this case, as detailed in the Hoffman and Dobbs study, two managers would probably be required for the 175,000 gallon annual capacity plant.\(^3\) The overall plant manager would be expected to assume the duties of cooperative manager, while receiving some assistance from the plant technical manager. The overall manager is assumed to receive a salary of $21,600 per year, while the technical manager would get $19,440 per year.
Several other employees would be needed by the cooperative to provide assistance in the plant's operation. Hoffman and Dobbs estimate the need for the equivalent of three employees, each drawing salaries of about $12,600.4

Financial Structure

The original members who provide equity for the cooperative will actually be purchasing stock. These stockholders would be entitled to vote at cooperative meetings. The alcohol cooperative would be chartered as a corporation under South Dakota State law. In South Dakota, a cooperative is viewed as a type of corporation.5 Incorporated, the cooperative is a separate legal entity, and no individual cooperative member is liable for its activities.

As mentioned in Chapter II, dividends distributed by a cooperative are given as patronage refunds. Since the principle of a cooperative is to operate on a cost basis, net returns after costs should be returned to the member patrons.6 Of course, it is unlikely the cooperative would be able to distribute all of its net returns as patronage dividends each year, since a portion of these returns may be needed for operating capital in the following year. Net returns given back as patronage
Tax Considerations

The cooperative would be liable for property taxes assessed on the land and buildings comprising the alcohol plant at the same rate as other industries in the Clear Lake area. The cooperative is also liable for corporate taxes on net returns not distributed to member patrons, as well as net returns originating from sales to non-members. The latter case will not apply here, since it is assumed that all sales of products will be to the cooperative's members.

Another consideration is the tax credit available to ethanol fuel users under the Crude Oil Windfall Profits Tax Act of 1980 (Public Law 96-223). This tax credit amounted to 30 cents per gallon of ethanol (150 to 190 proof) to the user of ethanol fuels in 1981. As of June 1983, the credit was 37.5 cents per gallon. However, the figure of 30 cents per gallon will be used here to be consistent with related publications and production cost estimates. This tax credit would go to the individual cooperative member ethanol consumers. It will be assumed here that all member users qualify for the tax credit of 30 cents per gallon and are in a financial situation to be able to use this tax credit.
Possible Sources of Capital

The financing information in this section was compiled in the summer of 1982. Subsequent changes in the economy, laws, or government regulations could change some of the information (e.g., interest rates and loan programs).

The Bank for Cooperatives

The Bank for Cooperatives can provide term and seasonal loans to cooperative enterprises, including alcohol fuels cooperatives. The Bank for Cooperatives requires a cooperative to provide at least 50% equity capital for a venture. The exact amount of equity capital required depends on the projected financial condition of the business. The bank will provide term loans of 7-10 years for capital equipment and short term seasonal operating loans. The loan rates as of July 1982 were 13.75% for term loans and 13.25% for operating loans. These rates will be rounded to 14% and 13%, respectively, for the analysis in the subsequent chapter.

It is highly likely that an alcohol fuels cooperative could obtain financing from the Bank for Cooperatives, provided favorable cash flow and net returns projections were realistically favorable. The Bank for Cooperatives does not depend on the federal budget for funds, but instead generates funds through bond sales and repayment of previous loans.
Farmers Home Administration

The Farmers Home Administration (FmHA) has a number of loan programs "on the books" which could provide credit assistance to an alcohol fuel production cooperative. However, due to recent cuts in the federal budget affecting the FmHA, the agency was no longer able to provide direct loans to energy related industries as of June, 1982. 12

The Business and Industry Loan Program can be used to financially assist energy related industries. However, this assistance is in the form of loan guarantees. This is the only FmHA program under which a cooperative qualifies for financial assistance. Under this program, the FmHA contracts to reimburse the lender up to 90% of principal and interest in case of default. The application is responsible for obtaining a loan through a private lender. It can be expected that a private lender would look more favorably on a loan guaranteed by FmHA than a loan not guaranteed.

Small Business Administration

The Small Business Administration (SBA) has a program called the Small Business Energy Loans Program. This program contains authorization for direct loans of up to $350,000 to energy projects, as well as loan
guarantees of up to 90%. Direct loans are no longer available under this program (as of July 1982), due to lack of funding. However, loan guarantees were still available as of June 1982. A producer cooperative qualifies under SBA guidelines for a loan guarantee, provided that an adequate feasibility study gives justification to the project. The interest rate is determined by the local bank providing the loan.

Private Bank

The cooperative might logically look to private sources for financing, particularly to local banks. Such a bank would be likely to provide financing if the project appears economically feasible, especially if some of the cooperative members do business with the community bank on a regular basis.

A private bank could provide financing on a long term basis for capital equipment. Such a loan would probably be segmented to payback periods specific to the life of each item of capital equipment. For example, a loan on the building would have a payback period of 15 to 20 years, while that on the distillation columns would be 10 years.

The required equity for this type of financing would depend on the cash flow and net return projections
for the cooperative. Again, depending on the bank's working relationship with the members, the cooperative would probably be required to provide approximately 25% equity.

In general, a private bank would probably charge about 1% above the New York Prime Rate (about 16% as of July 1982), or more if the alcohol cooperative venture appeared quite risky.

Of course, if the cooperative obtained a loan guarantee by the FmHA or SBA, the interest rate may be slightly less. A private bank may be more likely to grant a loan if it is 90% guaranteed by one of these agencies. It should be noted here that the FmHA and SBA consider the rate of interest as well as the return projections before guaranteeing any loan.  

A private bank could also participate in a joint financing arrangement, such as with the Bank for Cooperatives. In this case, the private bank could help the cooperative raise the equity capital necessary by providing loans to the individual cooperative members. In effect, the private bank loan would constitute some of the "equity" required by the Bank for Cooperatives. The members would be individually responsible for negotiating the terms of these loans.
Other Sources

Both the Economic Development Administration (EDA) and the Department of Energy (DOE) have energy related financing programs under their authority. However, all EDA funding for energy projects had been stopped at the time this research was conducted (June 1982).\(^{15}\)

The Department of Energy has a grant program entitled the "Small Scale Appropriate Technology Program" under which a small scale alcohol producing cooperative would be eligible. This program allows a maximum grant of $50,000 toward capital expenditures on qualifying facilities. However, funding was not available for this program as of June 1982.\(^ {16}\)

The final financing method discussed here is that of 100% equity financing by cooperative members. The members would each be required to purchase an amount of stock (depending on the size of the membership) which, in total, would provide equity for the cooperative. For example, if the cooperative were formed with 220 members, each would purchase about $1,000 in stock to cover the costs of plant construction. It is assumed under this financing scenario that operating capital would be borrowed.
Most Likely Options

The financing option which appears most likely to be pursued by a small scale alcohol fuels cooperative is a loan from the Bank for Cooperatives, with 50% equity provided by cooperative members. If 50% of the capital could be obtained from the Bank for Cooperatives at a 13.75% rate (rounded to 14%), with a segmented payback period equal to the useful life of each item of equipment, the terms would be more favorable than the terms for other financing options discussed. Operating capital could also be obtained (at approximately 13% as of June 1982) from this source. This financing scenario will be used for the "base case" analysis in the following chapter.

The following chapter draws on this financing information in attempting to determine if the ethanol cooperative enterprise, as specified, could be economically feasible.
Footnotes


4 Ibid.


6 Ibid., Section 47-16-45.


8 Ibid.


Telephone interview of the author with Mr. Thomas Hauser, Loan Officer, Omaha Bank for Cooperatives, Omaha, Neb., August 18, 1982.

Telephone interview of the author with Mr. Boyd Jones, Loan Administrator, Farmers Home Administration, Huron, S.D., June 10, 1982.

Telephone interview of the author with Mr. Lyle Benson, Loan Administration, Small Business Administration, Sioux Falls, S.D., June 10, 1982.

See references 12 and 13.

Telephone interview of the author with Mr. Thomas Mann, Department of Energy, Washington, D.C., June 11, 1982; and telephone interview of the author with Mr. Scott Rutherford, Economic Development Administration, Washington, D.C., June 11, 1982.

Ibid.
CHAPTER VI

FEASIBILITY ANALYSIS

Introduction

The value of the distillers wet grains and ethanol and the amount used per farm were estimated in Chapters III and IV; financing options and cooperative aspects of the plant were explored in Chapter V; now, the separate parts of the study will be melded together to determine the feasibility of a cooperative fuel alcohol facility. The primary purpose of this research project will then be achieved.

In this chapter, we will lead through the cost and return assumptions of the plant, several financing scenarios, the cash flow for the "baseline case" situation, and sensitivity analyses to determine the effects of alterations in the base case assumptions.

Principal Cost Assumptions

The plant equipment and operating costs are summarized first. These costs are necessary for the construction and operation of the alcohol facility; they have been detailed in previous chapters. These costs are summarized for the base case in Table 6.1.
<table>
<thead>
<tr>
<th>Capital Equipment</th>
<th>(Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Cost of Plant Equipment</td>
<td>160,000</td>
</tr>
<tr>
<td>2) Cost of Loading and Storage</td>
<td>26,500</td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>3) Distribution Equipment Costs</td>
<td></td>
</tr>
<tr>
<td>a) One Ton Truck for DWG</td>
<td>14,000</td>
</tr>
<tr>
<td>b) Bulk Gas Truck for Ethanol Fuel</td>
<td>6,250</td>
</tr>
<tr>
<td>Subtotal (3)</td>
<td>20,250</td>
</tr>
<tr>
<td>Total (A)</td>
<td>206,750</td>
</tr>
</tbody>
</table>

| Operating Costs                        |           |
| 1) Ethanol Plant                       | 295,641   |
| 2) Plant Maintenance, Insurance,       | 22,900    |
| and Property Taxes                     |           |
| 3) Distribution Equipment             |           |
| a) For One Ton DWG Truck              | 6,418     |
| b) For "Bulk Gas" Ethanol Truck       | 2,562     |
| Subtotal (3)                          | 8,980     |
| Total (B)                             | 327,521   |
In addition to the operating cost assumptions for the base case, an alternative estimate will be made which assumes the price of corn to be $2.00 per bushel, rather than the $2.50 per bushel of the base case. This assumption is illustrated in Table 6.2. Note that the fixed costs remain unaffected.

Another case, illustrated in Table 6.3, assumes that the cooperative member buyers are willing to provide DWG transportation. This could be possible where several very large dairy farmers are located in very close proximity to the plant. Therefore, the DWG transportation costs (both capital and operating) are assumed unnecessary in this case.

These assumptions in Tables 6.1 through 6.3 will be used for analyses in a subsequent section of this chapter.

Financial Scenarios

Three financing scenarios will be presented here, as options the cooperative may choose or face. The previous chapter presented a number of financing possibilities available to a cooperative; now, three of these are used as assumptions in the cash flows illustrated later in this chapter. Presumably, the cooperative will pursue the alternative most financially favor-
Table 6.2. Operating Costs Summary Assuming Corn is $2.00/bushel.¹

<table>
<thead>
<tr>
<th>Operating Costs</th>
<th>(Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Ethanol Plant</td>
<td>263,608</td>
</tr>
<tr>
<td>2) Plant Maintenance, Insurance, and Property Taxes</td>
<td>22,900</td>
</tr>
<tr>
<td>3) Distribution Equipment</td>
<td></td>
</tr>
<tr>
<td>a) For One Ton DWG Truck</td>
<td>6,418</td>
</tr>
<tr>
<td>b) For &quot;Bulk Gas&quot; Ethanol Truck</td>
<td>2,562</td>
</tr>
<tr>
<td>Subtotal (3)</td>
<td>8,980</td>
</tr>
<tr>
<td>Total</td>
<td>295,488</td>
</tr>
</tbody>
</table>

¹Note: Capital equipment costs are the same as those of the base case in Table 6.1.
<table>
<thead>
<tr>
<th>A. <strong>Capital Equipment</strong></th>
<th>(Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Cost of Plant Equipment</td>
<td>160,000</td>
</tr>
<tr>
<td>2) Cost of Loading and Storage Equipment</td>
<td>26,500</td>
</tr>
<tr>
<td>3) Ethanol Distribution Truck</td>
<td>6,250</td>
</tr>
<tr>
<td><strong>Total (A)</strong></td>
<td>192,750</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. <strong>Operating Costs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Ethanol Plant</td>
</tr>
<tr>
<td>2) Plant Maintenance, Insurance, and Property Taxes</td>
</tr>
<tr>
<td>3) Ethanol Distribution Truck</td>
</tr>
<tr>
<td><strong>Total (B)</strong></td>
</tr>
</tbody>
</table>
able and available to it. The alternatives used in the feasibility analyses are detailed below.

**Base Case Scenario: Bank for Cooperatives Loan**

It is assumed that the cooperative can raise half of the required capital cost among its members, $103,375.1. The cooperative would then borrow the remaining half from the Bank for Cooperatives. The terms of the loan would be 14% interest, with a payback period of 10 years after plant operation begins. Operating loans would also be obtained from the Bank for Cooperatives. The operating loan is assumed to be at 13% interest and it is assumed that, on average, the annual operating cost of $327,521 would need to be available for 3 months per year. This is equivalent to saying that one fourth of the annual operating capital would need to be available at any given time. The baseline case financial scenario will be presented in cash flow form in Table 6.4.

**Alternative A: Availability of a Department of Energy $50,000 Grant**

As stated in Chapter V, the Department of Energy (DOE) has the authority to grant up to $50,000 toward small scale alcohol projects. Though money for this is not presently available, the situation could change in the future. The grant would be used for capital
items with a life of ten years or longer, leaving the remainder of the required capital to be obtained from other sources. This financing assumption will be used with the capital and operating assumptions of Table 6.3 (which does not include DWG transportation costs) and the corn cost assumptions of Table 6.2 ($2.00/bu).

Therefore, the capital cost remaining after the grant is applied is $142,750. Half of this ($71,375) will be financed by a Bank for Cooperatives loan at 14% interest with a payback period of ten years after the start of plant operations. The remainder will be financed by member equity. The operating costs are also assumed to be covered for three months each year with a Bank for Cooperatives loan at 13% interest. The cash flow for this financing scenario will be shown in Table 6.5.

Alternative B: 100% Equity Financing

It is possible that the cooperative would be unable to obtain any outside financing for this relatively high risk project. In that case, the members would raise all the necessary capital themselves. This would be possible if, for example, the 220 members in the base case scenario would each invest about $1,000.

The cooperative is assumed to be able to obtain financing from the Bank for Cooperatives at 13% interest
for the equivalent of three months each year for all of its operating costs. The 100% equity financing alternative will be presented in Table 6.8.

**Principal Return Assumptions**

Various estimations can be made about the level of returns to the plant from the sale of ethanol and distillers wet grains. Chapter III contained an estimate of the byproduct's value, based on prices of dairy cow and heifer feeds. The value of the ethanol product will be shown in the following section. If the price of gasoline and these feeds rise, the value of ethanol and DWG should rise correspondingly. Assumptions about variations in the ethanol value will be treated first.

**Ethanol Value Assumptions**

The ethanol value assumptions made in this section are based on information contained in Bulletin 687 by Dobbs and Hoffman.  

To determine the value of the ethanol produced, one can compare the energy value of a gallon of the 185 proof ethanol with that of one gallon of gasoline. Since the ethanol produced in the plant contains about 61% (1 ÷ 1.65) of the energy of gasoline, the value of a gallon of ethanol should be about 61% that of gasoline. This logic forms the basis for the first assumption about the value of
ethanol.

**Assumption I (Base Case):** The price of gasoline is $1.30 per gallon.

This assumption allows the following simple calculation:

($1.30 \text{ per gallon gasoline}) \times (61\% \text{ energy of gasoline}) = \$0.79 \text{ per gallon value of ethanol.}

Adding the $0.30 \text{ per gallon tax credit} = \$1.09 \text{ per gallon}. This tax credit goes directly to the farmer; therefore, it increases the value of the ethanol by $0.30 \text{ per gallon.}

The next assumption involves a change in the price of ethanol. The base case assumes gasoline sells for $1.30 \text{ per gallon. Now a case will be considered where the price of gasoline has risen by 100\% over the base case. This results in the following:}

($1.30 \text{ per gallon gasoline}) \times (200\%) = \$2.60 \text{ per gallon of gasoline}

**Assumption II:** The price of gasoline is $2.60 per gallon.

($2.60 \text{ per gallon gasoline}) \times (61\% \text{ energy of gasoline}) = \$1.59 \text{ per gallon of ethanol.}

Adding the $0.30 \text{ per gallon tax credit} gives an ethanol value of $1.89 \text{ per gallon.}
Both of these assumptions will be used in the cash flow analyses. Assumption I will be used in the base case (Table 6.4) and in Table 6.5, while Assumption II will be used in Tables 6.6, 6.7, and 6.8.

Variations in the value estimates for the DWG will be considered next.

**DWG Value Assumptions**

The first assumption about the value of the distillers wet grains to be used in this analysis is that of the base case discussed in Chapter III. This value was $39.00 per ton, including a discount for handling inconvenience.

**Assumption I (Base Case):** The value of the DWG is $39.00 per ton. This assumption is used in Tables 6.4 and 6.5.

Subsequently, the value of the DWG is assumed to be 25% higher than in the base case. This assumption is plausible, since a rise in the price of dairy and heifer feeds would tend to increase the value of the DWG correspondingly. We can calculate as follows:

\[
\text{Assumption II: } (\$39.00/\text{ton}) \times (125\%) = \$48.75/\text{ton}
\]

**Assumption II:** The value of the DWG is $48.75 per ton. This assumption is used in Tables 6.6, 6.7 and 6.8.
The Base Case Cash Flow

The base case cash flow analysis consists of the base case cost, financing, and return assumptions derived and explained in earlier chapters, and presented previously in this chapter of the thesis.

The cash flows are projected over the ten operational years of the plant. "Year 0" is the point at which financing is obtained. Year 1 is allowed for construction of the plant. Operating expenses are assumed to be incurred, and all returns are collected within each of the operating years 2 through 11. An "average" borrowing time of three months is assumed to be required for an operating loan which equals the operating costs (Column 13 in Tables 6.4 through 6.7) in each operating year. Only interest is paid on the plant and equipment loan in year 1 (Tables 6.4, 6.5, 6.6).

The base case cash flow projection is presented in Table 6.4. An outline of the base case assumptions is given below.

Base Case Assumptions of Table 6.4

Returns: Ethanol value is $1.09 per gallon.

DWG value is $39.00 per ton.

Costs: Corn price is $2.50 per bushel.

The cooperative is responsible for ethanol and
Table 6.4. Base Case Cash Flow Projection.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
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<td>103,375</td>
<td>206,750</td>
<td>14,473</td>
<td>206,750</td>
<td>-103,375</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>11</td>
<td>190,750</td>
<td>52,896</td>
<td>243,646</td>
<td>20,301</td>
<td>295,641</td>
<td>8,980</td>
<td>22,900</td>
<td>327,521</td>
<td>10,644</td>
<td>338,165</td>
<td>358,466</td>
<td>-114,820</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See Continuation Sheet for footnotes to this table.
Continuation Sheet: Footnotes to Table 6.4

Column

1. Assumes plant construction begins at the start of year 0 and continues through year 1. Production begins at the start of year 2.

2. $0.79 per gallon of ethanol x 175,000 gallons/year = $138,250.
   Tax credit $0.30 x 175,000 = $52,500
   Total = $190,750.

3. $39.00/ton x 1,356.3 tons/year = $52,896.

4. $103,375 loan is one half of the estimated start-up cost. From Bank for Cooperatives at 14%.

6. Salvage value is calculated by Accelerated Cost Recovery System for depreciation of capital equipment. Equipment of 10 years or shorter life has no salvage value. For equipment having an estimated life of 20 yrs, salvage value is the value remaining after 10 yrs of depreciation on a 15 yr schedule, or 30 percent (see Table 2.1).

<table>
<thead>
<tr>
<th>Item</th>
<th>Original Cost ($)</th>
<th>Value After 10 Years ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed byproduct storage</td>
<td>1,200 x .30 = 360</td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>26,000 x .30 = 7,800</td>
<td></td>
</tr>
<tr>
<td>Skid Steel Loader</td>
<td>20,000 x .30 = 6,000</td>
<td></td>
</tr>
<tr>
<td>Steel Grain bin</td>
<td>4,100 x .30 = 1,230</td>
<td></td>
</tr>
<tr>
<td>Total Salvage value</td>
<td></td>
<td>15,390</td>
</tr>
</tbody>
</table>

9. (Yr 1) -- Interest only = 103,375 x 14% = $14,473.
   (Yrs 2-11) -- Four items required for the plant have an estimated life of only five years (see Table 5.1, Chapter V). The total cost of these items is $4,850. A reinvestment of
Continuation Sheet: Footnotes to Table 6.4 (continued)

$4,850 is, therefore, required after five years. The payback period on these items is also five years.

\[
\begin{align*}
\text{Total} & = \$4,850 \times 0.19171354 = \$98,525 \\
& + \$4,850 \times 0.29128354 = 1,413 \\
& \text{Total} \quad \text{\$20,301.}
\end{align*}
\]

14 Interest from 3 months operating loan = 13% x 327,521 x \( \frac{1}{4} \) = \$10,644.
Financing: Bank for Cooperatives loan of $103,375 at 14% for 10 operational years.
Members provide equity of $103,375.
Operating loan also from the Bank for Cooperatives, at 13% interest.

Alternative Cash Flows for Sensitivity Analysis

Sensitivity analyses are carried out to discover the effects of selective changes in costs and returns on the overall feasibility of the project. Each result of a specific change is examined through the use of a 10-year cash flow projection. It was seen in the earlier cash flow projection of the base case that the net returns were negative each year. The sensitivity analyses will concentrate on substitutions of more favorable assumptions than those in the base case. In this manner, one can discover situations required to produce positive net returns.

The return on the investment by the cooperative members will be measured using the internal rate of return (IRR) in those cases with a positive undiscounted total net return. The IRR will not be considered in the negative total net return cases, since there would be no reason for investors to carry out such a project under those
circumstances.

A number of changes were tried concerning costs associated with the plant. Not all of the sensitivity analyses will be presented as examples; only those of illustrative significance will be discussed here. Changes examined include corn price, distribution costs, and financing costs.

Adjustments have also been made in the returns estimates, involving both the fuel alcohol and the DWG values.

For the purpose of brevity, several changes in the assumptions from those in the base case will be presented simultaneously in various cash flow analyses.

The reader should note that several of the sensitivity analyses involve highly optimistic assumptions.

Change in Corn Price

The first change to be made in the base case is that of the price of corn. Recall that in the base case assumption the price was $2.50 per bushel. This scenario will assume the price of corn is a more optimistic (from the standpoint of alcohol producers) $2.00 per bushel.

Recall that Table 6.2 illustrates the effect of this change in corn price on operating costs for the ethanol plant. The reduction in cost compared to the base case
assumption is computed as follows:

\[ 295,641 - 263,608 = 32,033 \]

Additionally, a reduction in borrowed operating capital would be possible, thus lowering interest costs.

The magnitude of this reduction in operating costs over the 10-year investment period can be seen to be substantial. However, this reduction in corn price alone is not nearly enough to make the plant profitable. This is illustrated in Table 6.5.

The assumptions contained in Table 6.5 are given below.

The Assumptions Used in Sensitivity Analysis I

Returns: Ethanol value is $1.09 per gallon.

\[ \text{DWG value is $39.00 per ton.} \]

Costs: Corn price is $2.00 per bushel.

The cooperative is responsible for ethanol distribution only.

Financing: Bank for Cooperatives loan of $71,375, at 14% interest

Members provide equity of $71,375.

Department of Energy provides grant of $50,000 toward capital costs in time 0.

Operating loan also from the Bank for Cooperatives, at 13% interest.
Table 6.5. Sensitivity Analysis I Cash Flow Projection

<table>
<thead>
<tr>
<th>Year</th>
<th>Alcohol</th>
<th>DWC</th>
<th>Loans</th>
<th>Other</th>
<th>Salvage</th>
<th>Total Inflows</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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See Continuation Sheet for footnotes to this table.
Continuation Sheet: Footnotes to Table 6.5

Column

2+3  Identical to base case.

4  Bank for Cooperatives loan of $71,375 at 14%.
Plant cost of $192,750 - 50,000 DOE Grant = $142,750. Half of this figure is $71,375. The remainder is equity financed by coop members.

5  Grant by DOE of $50,000.

6  Salvage value is calculated by Accelerated Cost Recovery System of depreciation of items with a 20yr life. The value of these items after 10 yrs is $15,390. See footnote 6 of Table 6.4.

8  Total estimated cost of capital items, less DWG transportation truck.

9  (Year 1) Interest only
$71,375 x 14% = $9,993.

(Years 2-11) Total cost of capital items is $192,750. Less DOE Grant, cost is $142,750. Half of this remaining capital cost is loan financed, or $71,375. Of this $71,375:
a) the value of items with a 5 year life is 4,850, and;
b) the value of items with a 10 year life is 66,525.

$4,850 x .29128354 = $1,413
$66,525 x .19171354 = $12,754
Total $14,167

11  Distribution cost for ethanol only, since it is assumed here that no DWG delivery is required.

14  Interest from 3 months operating loan = 13% x $289,070 x \( \frac{1}{2} \) = $9,395.
Note that Table 6.5 contains deviations from the base case assumptions in addition to that of the price of corn (no distribution costs for the DWG, as well as a change in the financing scenario). However, columns 10, 14, and 17 help to illustrate that a reduction in the price of corn is not sufficient to produce a positive total in the 10-year undiscounted cash flow projection.

Change in Transportation Costs

The next operating cost item that can be changed is that covering transportation. The discussion in Chapter IV included sections concerning the transportation of the distillers wet grains. It may be possible that in some instances several large farms located very close to the ethanol plant could utilize all of the DWG. A situation such as this might essentially eliminate transportation costs for the DWG. Referring back to Table 6.3, and comparing it to Table 6.1, one can note a saving of $14,000 in capital and $6,418 in annual operating costs; also a small amount is saved in operating loan interest. This is not a very substantial reduction in expenses, which can be seen by comparing the relevant columns of Tables 6.4 and 6.5.
It is highly doubtful that the ethanol fuel could be marketed without involving some transportation cost, so no change is made in the fuel distribution cost.

Because the total of the undiscounted cash flow in Table 6.5 still remains negative, other scenarios will be examined.

Change in Estimated Returns

Another approach to providing for a more optimistic investment scenario is to increase the level of estimated returns. It is possible that liquid fuel prices could increase substantially in the future, thus making a scenario of more optimistic returns plausible. Likewise, an increase in feed prices could justify an increase in the return estimates for the distillers wet grains. The case of higher ethanol prices will be treated first.

Several ethanol price levels differing from the base case were examined, only one of which will be illustrated with a cash flow table. As discussed earlier, the ethanol value is essentially dependent on the price of gasoline (or diesel fuel). With the price of gasoline double that of the base case, the value of ethanol becomes $1.89 per gallon (see earlier discussion). This ethanol value, with all other base case assumptions
ceteris paribus, gives a positive total for the 10-year operational undiscounted cash flow. This is the lowest of the ethanol price levels examined, with the rest of the base case assumptions ceteris paribus, which results in a positive total. This ethanol price level is reflected in the 10-year undiscounted cash flow in Table 6.6 (column 2). Note that the DWG price level has also been increased in this table (from 39.00 to 48.75 per ton). The various assumptions upon which Table 6.6 is based are given in outline form below.

Assumptions Used In Sensitivity Analysis II

Returns: Ethanol value is $1.89 per gallon.
          DWG value is $48.75 per ton.

Costs: Corn is $2.50 per bushel.
          The cooperative is responsible for both DWG
          and ethanol distribution.

Financing: Same as the base case. Bank for Cooperatives
          loan of $103,375 at 14% interest.
          Members provide $103,375 in equity.
          Operating loan is also from the Bank for
          Cooperatives, at 13% interest.

It is possible to obtain a positive outcome for the undiscounted cash flow with a lower ethanol price ($1.49
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<th>Fixed Costs</th>
<th>Plant &amp; Equip.</th>
<th>Loan Payments</th>
<th>For Distribution</th>
<th>For Plant</th>
<th>Sub. Int. 10+</th>
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<th>Cost or Return</th>
<th>Total Outflows 8+9+15</th>
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See Continuation Sheet for footnotes to this table.
Continuation Sheet: Footnotes to Table 6.6

Column

2 Alcohol = $1.59/gallon
Tax Credit = $0.30/gallon
Total price = $1.89/gallon

175,000 x $1.89/gallon = $330,750

3 DWG = $48.75/ton
1,356.3 tons/yr x 48.75/ton = $66,120.

4 Same as Base Case. See footnote 4 of Table 6.4.

6 Same as Base Case. See footnote 6 of Table 6.4.

9 Same as Base Case. See footnote 9 of Table 6.4.

14 Same as Base Case. See footnote 14 of Table 6.4.
per gallon, for example) only if lower operating costs or alternative financing costs are assumed.

The second method by which revenue estimates may be increased is by altering the DWG value. A moderate increase of 25% is considered in Table 6.6 (column 3). It should be noted that under this assumption of higher DWG returns, it would not be logical to simultaneously use a lower ($2.00) corn cost assumption.

The DWG price increase has a moderate effect on the overall undiscounted cash flow, increasing returns by a little over $13,000 per year. This amount alone is not enough to offset the negative net returns of the base case scenario. The change in returns can be noted by comparing column 3 in Tables 6.4 and 6.6.

An internal rate of return was calculated for the investment represented in Table 6.6. Recall that both ethanol and DWG returns were increased in this case (relative to the base case) -- to $1.89 per gallon and $48.75 per ton, respectively. The IRR was discovered to be 24%. Again, the reader should note that these assumed return levels are currently quite optimistic.

Change in Method of Financing

The final sensitivity analyses to be carried out deals with the method of financing the plant and equip-
ment. A number of financing methods differing from the base case were analyzed. These ranged from the method of 100% equity financing for the capital expenses to the method of private bank financing, all explained in Chapter V.

Tables 6.5 and 6.7 serve to illustrate a method of financing notably different from the base case. In Table 6.7, for instance, it is assumed the cooperative is able to obtain a $50,000 DOE Grant—a program explained in Chapter V. The grant is used towards plant and equipment costs in time.

A Bank for Cooperatives loan and member equity each provide $71,375 of the remaining $142,750.

To produce an even more optimistic scenario, it is also assumed in Table 6.7 that the cooperative is not required to provide for DWG delivery—thus saving the initial equipment cost of the delivery truck and its operating cost, compared to the base case.

The assumptions upon which Table 6.7 is based are given in outline form below. Note that the increased returns over the base case assumed in Table 6.6 remain in Table 6.7 to produce an extremely optimistic scenario.

The Assumptions Used in Sensitivity Analysis III

Returns: Ethanol value is $1.89 per gallon.

DWG value is $48.75 per ton.
Table 6.7. Sensitivity Analysis III  Cash Flow Projection

| Year | Alcohol | Plant & Equip. | Loan Payments | Total Inflows | 1) 14 · 15a 16 | 2) 12 13 3 | 4) 11 10 9 | 5) 8 7| 6) 5 4 3 | 7) 1 2 | Net Cost or Return |
|------|---------|----------------|---------------|---------------|-----------------|-----------------|-----------------|------------------|----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|      |         |                |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 0    |         |                |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 1    |         |                |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 2    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 3    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 4    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 5    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 6    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 7    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 8    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 9    | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 10   | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |
| 11   | 330,750 | 66,120         |               |               |                 |                 |                 |                  |                 |                  |                  |                  |                  |                  |                  |                  |                  |                  |

See Continuation Sheet for footnotes to this table.
Continuation Sheet: Footnotes to Table 6.11.

Column

2 Gross returns from column 7, Table 6.7. Note that salvage value is not included in gross returns in year 11, since it is assumed salvage items will not be sold at a price above salvage value as calculated by depreciation methods.

3 Depreciation from Table 6.10.

4 Allowable interest payment deductions include interest paid on both capital and operating loans. The interest paid on the operating loan in years 2 through 11 is given in column 14 of Table 6.7. Interest paid on the capital loan of $71,375 was calculated on the "Loan Equity" program of the AGNET computer program. Interest payments on both loans were then summed for each year to give the values in column 4.

5 Operating expenses taken from column 13, Table 6.7.
Continuation Sheet: Footnotes to Table 6.7

Column

2+3  Same as Table 6.6. See footnotes 2 and 3 to Table 6.6.

4  See footnote 4 of Table 6.5.

5  See footnote 5 of Table 6.5.

6  Same as Base Case. See footnote 6 of Table 6.4.

8  See footnote 8 of Table 6.5.

9  See footnote 9 of Table 6.5.

11  Distribution operating cost for ethanol only, as it is assumed no delivery of the DWG is required.

14  3 month operating loan =

$321,103 \times 13\% \times \frac{1}{4} \text{ year} = $10,436.
Costs: Corn is $2.50 per bushel.

The cooperative is responsible for ethanol distribution only.

Financing: Bank for Cooperatives loan of $71,375 at 14% interest.

Members provide equity of $71,375.

Department of Energy provides grant of $50,000 toward capital costs in time 0.

Operating loan is also from the Bank for Cooperatives, at 13% interest.

The internal rate of return was found to be 44% on the scenario illustrated in Table 6.7. The IRR is of a relatively high magnitude since the cooperative's investment is a relatively low $71,375, while the total undiscounted net returns are $448,082.

This testing of various financing scenarios is important because a cooperative is likely to face several such options. If no institution is willing to provide a loan, or if the interest cost of the capital is very high, the cooperative may wish to draw on the equity of members to raise the necessary funds. The drawback of this scenario is the higher member investment required. Members may or may not be willing to invest a thousand dollars or more each in such a venture. On the other hand, the resulting savings to the cooperatives' ethanol plant is substantial.
The savings in interest and principal payments would be $14,473 in year 1 and $20,301 per year thereafter, compared to the base case. The ten year operational undiscounted cash flow illustrates this scenario in Table 6.8. Note that in Table 6.8 returns to ethanol and DWG have also been increased relative to the base case, to produce a more optimistic outcome.

The assumptions upon which Table 6.8 is based are outlined below.

The Assumptions Used in Sensitivity Analysis IV

Returns: Ethanol value is $1.89 per gallon.

     DWG value is $48.75 per ton.

Costs: Corn price is $2.50 per bushel.

The cooperative is responsible for both the ethanol and DWG distribution.

Financing: Members provide the entire capital cost of $206,750.

     Operating loan is from the Bank for Cooperatives, at 13% interest.

An internal rate of return was calculated for this investment scenario, since the total undiscounted cash flow was positive ($395,690). The result of 20% (shown in Table 6.9) is lower than the other calculated internal rates of
| Year | Alcohol | DMC | Loans | Other | Salvage | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17  |
|------|---------|-----|-------|-------|---------|---|---|---|----|----|----|----|----|----|----|----|----|
| 0    |         |     |       |       |         |   |   |   |    |    |    |    |    |    |    |    |
| 1    |         |     |       |       |         |   |   |   |    |    |    |    |    |    |    |    |
| 2    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 3    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 4    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 5    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 6    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 7    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 8    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 9    | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |
| 10   | 330,750 | 66,120 |       |       |         | 396,870 | 295,641 | 8,980 | 22,900 | 327,521 | 10,644 | 338,165 | 338,165 | + 58,705 |

See Continuation Sheet for footnotes to this table.
Continuation Sheet: Footnotes to Table 6.8

Column

2+3  Same return assumptions as Table 6.6. See footnotes 2 and 3 of Table 6.6.

6  Same as Base Case. See footnote 6 of Table 6.4.

9  No capital loan, so there are no payments in this case.

14  Same as Base Case. See footnote 14 of Table 6.4.
return, but it is still substantially positive. The risk to each member under the 100% equity financing assumption, however, is higher than under the other financing assumptions.

Another financing scenario considered (but not included in this thesis) was that of private bank financing of the capital expenses. The assumption made was that the interest rate would be 16% (see Chapter V). This is a more costly method than that of the base case, but one which a cooperative may face.

_Summary of Sensitivity Analyses_

The feasibility analyses carried out in this chapter have shown that under the base case assumptions, the 10-year undiscounted cash flow analysis results in negative total net returns for the ethanol plant. The base case assumptions were then changed to provide a more favorable investment situation for the plant. Changes were made in the cost assumptions, return assumptions, and finally in the financing assumptions. The sensitivity analyses produced three 10-year undiscounted cash flows with positive total net returns and one with negative total net returns. An internal rate of return was calculated for these positive outcomes, and they are summarized in Table 6.9 along with the base case and the sensitivity analysis with a negative total net return.
Table 6.9. Summary of Sensitivity Analyses and Internal Rates of Return

<table>
<thead>
<tr>
<th>Cash Flow Table</th>
<th>Members Investment ($)</th>
<th>Total Undiscounted Net Returns ($)</th>
<th>Internal Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 6.4</td>
<td>103,375</td>
<td>-1,250,658</td>
<td>---</td>
</tr>
<tr>
<td>Table 6.5</td>
<td>71,375</td>
<td>-755,838</td>
<td>---</td>
</tr>
<tr>
<td>Table 6.6</td>
<td>103,375</td>
<td>+281,582</td>
<td>24%</td>
</tr>
<tr>
<td>Table 6.7</td>
<td>71,375</td>
<td>+445,662</td>
<td>44%</td>
</tr>
<tr>
<td>Table 6.8</td>
<td>206,750</td>
<td>+395,690</td>
<td>20%</td>
</tr>
</tbody>
</table>
Taxes and Dividends

Three cases were presented (Tables 6.6, 6.7, and 6.8) in which total net returns were found to be positive over the 10-year investment period. Any portion of these net returns not distributed as dividends to cooperative members would be subject to corporate income taxes. It is now possible to estimate the amount of the corporate tax liability and suggest tax strategies for particular cases.

The investment case shown in Table 6.7 will be used to demonstrate the methods required to calculate investment tax credits, depreciation, and the corporate tax liability for years 2 through 11 of the cash flow projection period. Since negative net returns occur in years 0 and 1 in the case presented in Table 6.7 and the equipment is assumed not to go into service until year 2, depreciation, investment tax credits, and corporate income taxes do not apply in years 0 and 1.

The reader should now recall the formula for "Taxable Income" given in Chapter II. That is:

\[
\text{Taxable Income} = \text{Gross returns} - \text{depreciation} - \text{interest payments} - \text{operating expenses (other than interest)} - \text{dividends paid.}
\]

The gross returns are given in Table 6.7. The allowable
depreciation, interest payments, dividends paid, and operating expenses (other than interest) remain to be calculated.

The final section of Chapter II describes how the depreciation and interest payment allowances are deductible and how investment tax credits are handled. Table 6.10 gives the allowable depreciation and investment tax credits (which will be discussed later) for years 2 through 11 for the investment represented by Sensitivity Analysis III (Table 6.7). New equipment goes into operation in years 2 and 7; therefore, it is here assumed that investment tax credits can be taken in those two years (as presented in Table 6.10).

Note that under the Accelerated Cost Recovery System, the allowable depreciation may vary annually over the useful life of the item. Items with a useful life of 20 years are depreciated on a 15 year schedule—with the remaining depreciable value after 11 years being the salvage value. As can be seen in Table 6.11, the salvage value of $15,390 is not included as income in year 11 for tax purposes (because it is assumed that the salvageable items are not actually sold, or, if sold, are sold at the salvage value, as calculated by ACRS depreciation methods).

The allowable depreciation, interest payments (on capital and operating loans), and operating expenses are presen-
Table 6.10. Accelerated Cost Recovery System of Depreciation and Investment Tax Credit Deductions for Years 2-11 of the Fuel Ethanol Plant (In Dollars).

<table>
<thead>
<tr>
<th>Item</th>
<th>Capital Cost</th>
<th>Useful Life</th>
<th>Yr 2</th>
<th>Yr 3</th>
<th>Yr 4</th>
<th>Yr 5</th>
<th>Yr 6</th>
<th>Yr 7</th>
<th>Yr 8</th>
<th>Yr 9</th>
<th>Yr 10</th>
<th>Yr 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-fired Boiler</td>
<td>26,450</td>
<td>10</td>
<td>2,116</td>
<td>5,200</td>
<td>3,703</td>
<td>3,174</td>
<td>2,645</td>
<td>2,645</td>
<td>2,381</td>
<td>2,381</td>
<td>2,381</td>
<td>2,381</td>
</tr>
<tr>
<td>Fermentation Tank</td>
<td>23,300</td>
<td>10</td>
<td>1,864</td>
<td>4,660</td>
<td>3,263</td>
<td>2,796</td>
<td>2,330</td>
<td>2,330</td>
<td>2,097</td>
<td>2,097</td>
<td>2,097</td>
<td>2,097</td>
</tr>
<tr>
<td>Grain Handling System</td>
<td>12,800</td>
<td>10</td>
<td>1,024</td>
<td>2,560</td>
<td>1,792</td>
<td>1,536</td>
<td>1,280</td>
<td>1,280</td>
<td>1,152</td>
<td>1,152</td>
<td>1,152</td>
<td>1,152</td>
</tr>
<tr>
<td>Alcohol Storage</td>
<td>5,030</td>
<td>10</td>
<td>400</td>
<td>1,000</td>
<td>700</td>
<td>600</td>
<td>500</td>
<td>500</td>
<td>450</td>
<td>450</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Auger</td>
<td>500</td>
<td>5</td>
<td>75</td>
<td>100</td>
<td>110</td>
<td>105</td>
<td>105</td>
<td>105</td>
<td>110</td>
<td>105</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td>1,750</td>
<td>10</td>
<td>140</td>
<td>150</td>
<td>295</td>
<td>210</td>
<td>175</td>
<td>175</td>
<td>158</td>
<td>158</td>
<td>158</td>
<td>158</td>
</tr>
<tr>
<td>Byproduct Storage</td>
<td>1,200</td>
<td>20</td>
<td>60</td>
<td>240</td>
<td>120</td>
<td>108</td>
<td>96</td>
<td>84</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>Water Softeners</td>
<td>1,000</td>
<td>5</td>
<td>150</td>
<td>200</td>
<td>220</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>220</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>Building</td>
<td>26,000</td>
<td>20</td>
<td>1,300</td>
<td></td>
<td></td>
<td>2,600</td>
<td>2,340</td>
<td>2,080</td>
<td>1,820</td>
<td>1,820</td>
<td>1,560</td>
<td>1,560</td>
</tr>
<tr>
<td>Distillation Columns</td>
<td>19,000</td>
<td>10</td>
<td>1,520</td>
<td>3,800</td>
<td>2,660</td>
<td>2,280</td>
<td>1,900</td>
<td>1,900</td>
<td>1,710</td>
<td>1,710</td>
<td>1,710</td>
<td>1,710</td>
</tr>
<tr>
<td>Temperature Meter</td>
<td>300</td>
<td>10</td>
<td>24</td>
<td>60</td>
<td>42</td>
<td>36</td>
<td>30</td>
<td>30</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Pressure Gauges</td>
<td>50</td>
<td>10</td>
<td>4</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pumps and Motors</td>
<td>2,350</td>
<td>5</td>
<td>353</td>
<td>470</td>
<td>517</td>
<td>493</td>
<td>493</td>
<td>493</td>
<td>517</td>
<td>493</td>
<td>493</td>
<td>493</td>
</tr>
<tr>
<td>Pipes, Accessories</td>
<td>1,000</td>
<td>5</td>
<td>150</td>
<td>200</td>
<td>220</td>
<td>210</td>
<td>210</td>
<td>210</td>
<td>220</td>
<td>210</td>
<td>210</td>
<td>210</td>
</tr>
<tr>
<td>Centrifuge</td>
<td>32,000</td>
<td>10</td>
<td>2,560</td>
<td>6,400</td>
<td>4,480</td>
<td>3,840</td>
<td>3,200</td>
<td>3,200</td>
<td>2,880</td>
<td>2,880</td>
<td>2,880</td>
<td>2,880</td>
</tr>
<tr>
<td>Flow Meters</td>
<td>150</td>
<td>10</td>
<td>12</td>
<td>30</td>
<td>21</td>
<td>18</td>
<td>15</td>
<td>15</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Differential Pressure Cell</td>
<td>250</td>
<td>10</td>
<td>20</td>
<td>50</td>
<td>35</td>
<td>30</td>
<td>25</td>
<td>25</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>3,950</td>
<td>10</td>
<td>316</td>
<td>790</td>
<td>553</td>
<td>474</td>
<td>395</td>
<td>395</td>
<td>356</td>
<td>356</td>
<td>356</td>
<td>356</td>
</tr>
<tr>
<td>Laboratory</td>
<td>3,000</td>
<td>10</td>
<td>240</td>
<td>600</td>
<td>420</td>
<td>360</td>
<td>300</td>
<td>300</td>
<td>270</td>
<td>270</td>
<td>270</td>
<td>270</td>
</tr>
<tr>
<td>Vertical Auger</td>
<td>2,400</td>
<td>10</td>
<td>192</td>
<td>480</td>
<td>336</td>
<td>288</td>
<td>260</td>
<td>260</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>Skid Steer Loader</td>
<td>20,000</td>
<td>20</td>
<td>1,000</td>
<td>4,000</td>
<td>2,000</td>
<td>1,800</td>
<td>1,600</td>
<td>1,400</td>
<td>1,200</td>
<td>1,200</td>
<td>1,200</td>
<td>1,200</td>
</tr>
<tr>
<td>Steel Grain Bin</td>
<td>4,100</td>
<td>20</td>
<td>205</td>
<td>820</td>
<td>410</td>
<td>369</td>
<td>328</td>
<td>287</td>
<td>246</td>
<td>246</td>
<td>246</td>
<td>246</td>
</tr>
<tr>
<td>Bulk Gas Truck for Ethanol</td>
<td>6,250</td>
<td>10</td>
<td>500</td>
<td>1,250</td>
<td>875</td>
<td>750</td>
<td>625</td>
<td>625</td>
<td>562</td>
<td>562</td>
<td>562</td>
<td>562</td>
</tr>
<tr>
<td>Total</td>
<td>192,750</td>
<td></td>
<td>14,225</td>
<td>33,350</td>
<td>25,329</td>
<td>22,033</td>
<td>18,787</td>
<td>18,274</td>
<td>17,984</td>
<td>16,444</td>
<td>16,395</td>
<td>16,395</td>
</tr>
</tbody>
</table>

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ted in Table 6.11. The taxable income for the cash flow scenario illustrated in Table 6.7 is then calculated and shown in Column 7 of Table 6.11.

Having calculated the corporate taxable income for the cooperative (in this case), two extreme cases will be presented showing how this taxable income could be handled. The first case assumes that the cooperative wishes to distribute a large portion of its annual net returns as dividends. The second case assumes that a large portion of net returns are held as retained earnings by the cooperative.

The first case, presented in Table 6.12, illustrates how the cooperative could distribute a large share of the net returns as patron dividends. If this strategy is followed, the tax liability for the cooperative (in this case) becomes zero. The cooperative is able to retain some earnings for a cash reserve (Column 6 of Table 6.12), to cope with cashflow uncertainties and for possible reinvestment at the end of the 11-year period. Under these assumptions, members obtain average dividends of $1,844 over years 2 through 11 on an average investment in year 0 of $324.4

The second case, presented in Table 6.13, illustrates how the cooperative could handle the tax liability (in this case) if no dividends are distributed to members. The tax liability is found by applying the corporate tax rate (see Table 2.2) to the taxable income given in column 3.
The rate of 19% applies to the "tax bracket" of the cooperative. The investment tax credit allowed in year 2 is "carried forward" through year 6 to reduce the tax liability of the cooperative. The cooperative is therefore liable for taxes only in years 6 through 11 (see column 6 of Table 6.13).

The above two cases are presented as possible tax strategies the cooperative could follow. The author is aware that many other possible strategies could be followed.

The reader should again note that this section has been a descriptive exercise to illustrate how positive net returns could be handled if the alcohol cooperative had the financial scenario described by Sensitivity Analysis III (Table 6.7). Please note that the analysis underlying Table 6.7 contains several rather optimistic assumptions, and that the author believes the Base Case Scenario of Table 6.4 is more realistic.

The following chapter contains a discussion of the results of the feasibility analysis and the conclusions that can be drawn from the analysis.
Table 6.11. Projected Taxable Income for Cooperative with the Financial Scenario Described by Sensitivity Analysis III (Table 6.7). All Amounts in Dollars.

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Returns</th>
<th>Depreciation</th>
<th>Interest Payments</th>
<th>Operating Expenses</th>
<th>Total Deductions (3+4+5)</th>
<th>Taxable Income (2-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>396,870</td>
<td>14,225</td>
<td>9,993</td>
<td>321,103</td>
<td>355,757</td>
<td>41,113</td>
</tr>
<tr>
<td>2</td>
<td>396,870</td>
<td>14,225</td>
<td>20,429</td>
<td>321,103</td>
<td>366,276</td>
<td>30,594</td>
</tr>
<tr>
<td>3</td>
<td>396,870</td>
<td>22,033</td>
<td>19,178</td>
<td>321,103</td>
<td>362,314</td>
<td>34,556</td>
</tr>
<tr>
<td>4</td>
<td>396,870</td>
<td>18,787</td>
<td>18,419</td>
<td>321,103</td>
<td>358,309</td>
<td>38,561</td>
</tr>
<tr>
<td>5</td>
<td>396,870</td>
<td>18,274</td>
<td>17,553</td>
<td>321,103</td>
<td>356,930</td>
<td>39,940</td>
</tr>
<tr>
<td>6</td>
<td>396,870</td>
<td>17,984</td>
<td>17,245</td>
<td>321,103</td>
<td>356,332</td>
<td>40,538</td>
</tr>
<tr>
<td>7</td>
<td>396,870</td>
<td>16,444</td>
<td>16,215</td>
<td>321,103</td>
<td>353,762</td>
<td>43,108</td>
</tr>
<tr>
<td>8</td>
<td>396,870</td>
<td>16,395</td>
<td>15,041</td>
<td>321,103</td>
<td>352,539</td>
<td>44,331</td>
</tr>
<tr>
<td>9</td>
<td>396,870</td>
<td>16,395</td>
<td>13,702</td>
<td>321,103</td>
<td>351,200</td>
<td>45,670</td>
</tr>
<tr>
<td>10</td>
<td>396,870</td>
<td>16,395</td>
<td>12,176</td>
<td>321,103</td>
<td>349,674</td>
<td>47,196</td>
</tr>
</tbody>
</table>

See Continuation Sheet for footnotes to this table.
Table 6.12. Projected Dividends and Retained Earnings for Cooperative with a Financial Scenario Described by Sensitivity Analysis III (Table 6.7). All Amounts in Dollars.

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Returns</th>
<th>Taxable Income</th>
<th>Total Dividends</th>
<th>Average Dividend Per member</th>
<th>Retained Earnings (2-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-71,375</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-9,993</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>51,164</td>
<td>41,113</td>
<td>41,113</td>
<td>187.14</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>51,164</td>
<td>30,594</td>
<td>30,594</td>
<td>139.06</td>
<td>20,570</td>
</tr>
<tr>
<td>4</td>
<td>51,164</td>
<td>34,556</td>
<td>34,556</td>
<td>157.07</td>
<td>16,608</td>
</tr>
<tr>
<td>5</td>
<td>51,164</td>
<td>38,561</td>
<td>38,561</td>
<td>175.28</td>
<td>12,603</td>
</tr>
<tr>
<td>6</td>
<td>51,164</td>
<td>39,940</td>
<td>39,940</td>
<td>181.55</td>
<td>11,224</td>
</tr>
<tr>
<td>7</td>
<td>51,164</td>
<td>40,538</td>
<td>40,538</td>
<td>184.26</td>
<td>10,626</td>
</tr>
<tr>
<td>8</td>
<td>51,164</td>
<td>43,108</td>
<td>43,108</td>
<td>195.95</td>
<td>8,056</td>
</tr>
<tr>
<td>9</td>
<td>51,164</td>
<td>44,331</td>
<td>44,331</td>
<td>201.50</td>
<td>6,833</td>
</tr>
<tr>
<td>10</td>
<td>51,164</td>
<td>45,670</td>
<td>45,670</td>
<td>207.59</td>
<td>5,494</td>
</tr>
<tr>
<td>11</td>
<td>51,164</td>
<td>47,196</td>
<td>47,196</td>
<td>214.53</td>
<td>3,968</td>
</tr>
</tbody>
</table>

Totals = 430,272 | 405,607 | 1,843.73 | 96,040

See Continuation Sheet for footnotes to this table.
Contuation Sheet: Footnotes to Table 6.12

Column

2  Net returns taken from column 17, Table 6.7 (except salvage value for year 11 is not included).

3  Taxable income taken from column 7, Table 6.11.

4  This case assumes all "taxable income" would be distributed as dividends, effectively decreasing the tax liability to zero.

5  Assuming the base case cooperative of 220 members.

6  Retained earnings is the difference between column 2 (Net Returns) and column 4 (Taxable Income). Note, however, that in year 2 the overdue interest for year 1 ($9,993) on the capital loan has also been subtracted from the net returns (e.g., $51,164 - $41,113 = $10,051; $10,051 - $9,993 = $58).
Table 6.13. Projected Retained Earnings for Cooperative with a Financial Scenario Described by Sensitivity Analysis III (Table 6.7), Assuming no Dividend Distribution. All Amounts in Dollars.

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Returns</th>
<th>Taxable Income</th>
<th>Tax Liability</th>
<th>Investment Tax Credit</th>
<th>Corporate Tax due (4-5)</th>
<th>Retained Earnings (2-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-71,375</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9,993</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>51,164</td>
<td>41,113</td>
<td>7,811</td>
<td>7,811</td>
<td>0</td>
<td>41,171</td>
</tr>
<tr>
<td>3</td>
<td>51,164</td>
<td>30,594</td>
<td>5,813</td>
<td>5,813</td>
<td>0</td>
<td>51,164</td>
</tr>
<tr>
<td>4</td>
<td>51,164</td>
<td>34,556</td>
<td>6,566</td>
<td>6,566</td>
<td>0</td>
<td>51,164</td>
</tr>
<tr>
<td>5</td>
<td>51,164</td>
<td>38,561</td>
<td>7,327</td>
<td>7,327</td>
<td>0</td>
<td>51,164</td>
</tr>
<tr>
<td>6</td>
<td>51,164</td>
<td>39,940</td>
<td>7,589</td>
<td>5,833</td>
<td>1,756</td>
<td>49,408</td>
</tr>
<tr>
<td>7</td>
<td>51,164</td>
<td>40,538</td>
<td>7,702</td>
<td>970</td>
<td>6,732</td>
<td>44,432</td>
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<tr>
<td>8</td>
<td>51,164</td>
<td>43,108</td>
<td>8,191</td>
<td></td>
<td>8,191</td>
<td>42,973</td>
</tr>
<tr>
<td>9</td>
<td>51,164</td>
<td>44,331</td>
<td>8,423</td>
<td></td>
<td>8,423</td>
<td>42,741</td>
</tr>
<tr>
<td>10</td>
<td>51,164</td>
<td>45,670</td>
<td>8,677</td>
<td></td>
<td>8,677</td>
<td>42,487</td>
</tr>
<tr>
<td>11</td>
<td>51,164</td>
<td>47,196</td>
<td>8,967</td>
<td></td>
<td>8,967</td>
<td>42,197</td>
</tr>
<tr>
<td></td>
<td><strong>Totals</strong>=430,272</td>
<td></td>
<td><strong>77,066</strong></td>
<td><strong>34,320</strong></td>
<td><strong>42,746</strong></td>
<td><strong>458,901</strong></td>
</tr>
</tbody>
</table>

See Continuation Sheet for footnotes to this table.
Continuation Sheet: Footnotes to Table 6.13

Column

2 Net returns from column 17, Table 6.7 (except salvage value for year 11 is not included).

3 Taxable income taken from column 7, Table 6.11.

4 Tax liability is calculated by multiplying annual taxable income by 19%. See tax rates given in Table 2.2.

5 Investment tax credit is given in Table 6.10 for years 2 and 7. The amount of $33,350 in year 2 is "carried forward" in years 2 through 6, until it is depleted. The amount of $970 is used in year 7 only.

7 Retained earnings are found by subtracting column 6 from column 2. Note however, that in year 2 the capital interest payment of $9,993 from year 1 is subtracted from the net return of $51,164 to give $41,171. Note that the summed totals of column 6 and column 7 are greater than column 2 (Net Returns) by $71,375, the member's initial investment. This case assumes all net returns are retained as earnings, and member-investors are not repaid during the 11-year investment period.
Footnotes

1 The Bank for Cooperatives requires the borrowing cooperative to provide 50% of the equity. See Chapter V.

2 The total cost of the plant and equipment less the DWG 1-ton truck is $192,750. $192,750 - $50,000 = $142,750.

3 Thomas L. Dobbs and Randy Hoffman, Small-Scale Fuel Alcohol Production from Corn: Economic Feasibility Prospects (Agricultural Experiment Station, South Dakota State University, B687, June 1983) pp. 11-12.

4 The total member investment (given in column 2 of Table 6.12) is:

$71,375 ÷ 220 members = $324.43 average investment per member.

5 Internal Revenue Code Sec 46(6)(l); Reg 1.46-2 (b),(c),(d) (1982).
CHAPTER VII

CONCLUSIONS

Introduction

This thesis has covered a review of relevant cooperative and alcohol fuel production literature, a determination of the value of the distillers wet grain, an evaluation of the market area for an alcohol cooperative, and financial considerations in funding a cooperative alcohol plant. Finally, the economic feasibility of the proposed cooperative alcohol plant was considered.

It is now possible to combine the results of each part of the research, particularly the sensitivity analyses, to form some conclusions on the feasibility of a small scale cooperatively organized alcohol plant.

This final chapter contains a discussion of the results of the sensitivity analyses, conclusions on the project's feasibility, and the implications of this study for farmer investors, public policy makers, and researchers.

Results of the Sensitivity Analyses

The following sections contain conclusions on the results of the various sensitivity analyses carried out
in this study. Corn and transportation costs, values of the ethanol product and DWG byproduct, and financing arrangements were all treated in the sensitivity analyses and, thus, will be discussed below.

Corn and Transportation Costs

The cost of corn was varied in the sensitivity analyses from $2.50 per bushel (in the base case) to $2.00 per bushel. Decreasing the corn cost by $.50 per bushel resulted in a savings of $32,033 in costs per operational year, amounting to over $.18 per gallon of ethanol produced. Clearly, the cost of corn is a very important factor in the overall feasibility of the plant. The $.18 savings relative to the base case cost of corn represents nearly 17% of the value ($1.09) of a gallon of the 185 proof ethanol. Although this lower corn cost did not by itself bring about a positive overall net return, it can be considered a very important factor in plant feasibility. This has an implication for farmers which will be discussed in a later section.

The transportation costs to the plant were also adjusted to reflect a situation in which the cooperative would not be responsible for the distribution of the DWG. The cooperative was found to save $14,000 in fixed costs and about $6,600 annually in operating costs (including
interest charges). This savings amounts to about $.05 per gallon of ethanol, not a very significant amount relative to other costs and not a significant contribution to alleviating the base case negative net return situation. The transportation costs for DWG, both fixed and operating, cannot be considered a major factor in the negative net return projections.

Value of the Distillers Wet Grains

The value of the distillers wet grains (DWG) was increased from the $39.00 of the base case by 25%, to $48.75. Alternatively, this can be viewed as an increase in returns from approximately $.30 to $.38 per gallon of ethanol produced, or about $13,000 annually. This addition to revenue caused by the DWG price increase was not by itself found to be significant. The overall importance of the DWG as a source of returns for the plant is very significant, however, as it's sale value comprises up to 25% of the plant's potential income (depending on the value estimates of the ethanol and DWG used).

Value of the Ethanol

The value of the ethanol product was varied from the base case $1.09 per gallon (including tax credit) to a high of $1.89 per gallon (also including the tax
credit). The latter case was based on a gasoline price of $2.60 per gallon, 100% over that of the base case. With the price of ethanol at $1.89 per gallon, the 10-year operational cash flow yielded positive total net returns in Sensitivity Analyses II, III and IV (Tables 6.6, 6.7 and 6.8). Other variations from the base case also existed in these three analyses.

Since the returns to ethanol constitute the major income source for the plant, feasibility strongly hinges on the ethanol value, especially given the results of the other sensitivity analyses. Raising the price of ethanol was the factor which contributed in a major way toward a positive total net return in the cash flow tables.

Barring technological breakthroughs which might decrease the cost of ethanol production, the sensitivity analyses suggest that one of the factors most likely to improve the feasibility outlook for the ethanol plant analyzed is higher gasoline prices and, thus, higher ethanol product values.

Financial Arrangement

The financing arrangements were varied from the base case in two ways. The base case scenario assumed partial Bank for Cooperatives financing. In the sensi-
tivity analyses, it was assumed in two cases that a Department of Energy grant was obtained, with the remainder financed by the Bank for Cooperatives and member equity (Tables 6.5 and 6.8 of Chapter VI). The DOE grant of $50,000 reduced the required capital loan by $50,000 and, thus, by an additional $9,500 (approximately) per year in principal and interest payments. This grant would, of course, be an aid to the cooperative, but it would not produce a positive total net return by itself. It is doubtful that feasibility for a plant this size would depend on the availability of a grant no larger than $50,000.

The other alternative financing case tried in the sensitivity analysis consisted of 100% plant and equipment financing by members' equity. This method of financing produces a slightly more favorable 10-year undiscounted cash flow projection total (other factors being equal) than does the method utilizing the $50,000 DOE grant. Each of the base case 220 members would be required to "put up" an average of about $1,000 initially for this method of financing to succeed. An ethanol production cooperative may face a situation such as this, if no outside financing is available.
Cooperative Organization

Although no sensitivity analysis was carried out on the benefits to economic feasibility brought about by the cooperative organization as compared with other forms of legal organization, several points were made in the thesis. The Bank for Cooperatives was seen to typically lend at lower interest rates than private banks. It is also likely that an ethanol production cooperative could obtain a loan from that institution, given a favorable outlook for an alcohol plant investment.

Second, if the ethanol production facility is unable to obtain outside financing, a cooperatively organized plant seems more likely to be able to obtain equity from its members than would other types of corporations. This is due primarily to the member oriented philosophy of the cooperatives.

Third, if positive net returns are obtained by the cooperative, the tax and dividend structure gives the organization a definite financial advantage over other forms of corporations. Yearly dividends to member patrons would encourage continued cooperative support. The federal corporate income tax structure allows cooperative members to obtain a greater share of net returns than stockholders in corporate businesses would be able to.
Fourth, comparing Tables 6.12 and 6.13 of the previous chapter, it is seen that a savings of $43,746 in corporate taxes is attained over the investment period by distributing a portion of net returns as dividends. This is an option that a non-cooperatively organized corporation does not have.

Finally, it is more likely (because of the points discussed above) that the ethanol organization explained in this thesis would form if it were cooperatively organized, rather than if it were incorporated privately.

Conclusions

This study has shown that under current economic conditions the small scale, cooperatively organized ethanol plant analyzed is not economically feasible.

It was discovered that the distillers wet grains by-product has a current value of $39.00 per ton, in the base case situation. The DWG was found by SDSU researchers to be a satisfactory feed source for lactating dairy cows and growing dairy heifers.

In addition to the above conclusions, the sensitivity analyses provided several insights into the most important economic factors to consider in a small scale, cooperatively organized ethanol plant. They are as follows:
1) the value of ethanol per gallon;
2) the price of corn or other feedstock used;
3) the type of capital financing;
4) the value of the distillers wet grain by-product; and,
5) transportation costs for the ethanol product and DWG byproduct

**Implications of the Research**

**For Investors**

The implications of this research for farmers in eastern South Dakota (the probable investors) are several. First, it is not currently advisable for farmers to invest in the type of small scale operation described in this thesis. Second, the sensitivity analyses included the possibility of corn being priced at $2.00 per bushel. Corn at this price was shown to enhance the potential economic feasibility of the ethanol plant, but it is unlikely it is favorable to the economic condition of the eastern South Dakota farmer. It may, therefore, be recommended that farmers look to alternative feedstocks for ethanol production, barring substantial rises in ethanol values. Finally, it was shown in Chapter IV that a relatively small corn acreage could supply the feedstock needs for this type of plant. This point illustrates the
need for farmers to be cautious of claims that ethanol production could create a large new demand for corn. This would result only from very large scale or widespread ethanol production efforts.

For Public Policy

The results of this research give a few points for public policy makers to consider. The fact that this thesis indicated a negative overall economic feasibility for a small scale alcohol production plant should raise questions about direct public subsidies to such projects.

The Department of Energy grant was used as a subsidy example in the sensitivity analyses; the analyses showed that the grant was not nearly large enough to make the plant economically feasible. This research pointed out that the initial plant cost is not the major cause of the negative returns situation; the high feedstock and operating costs are a greater contributing cause.

If the public wishes to subsidize ethanol production, it seems more beneficial to provide the type of subsidy which goes to the ethanol consumer, such as is provided for in the Windfall Profits Tax Act, discussed in Chapter V. A tax credit such as this provides cooperative producer-consumers with assistance in offsetting operating
costs. As was seen in the base case undiscounted cash flow projection (and Table 6.5), the consecutive negative annual net returns result in the unfavorable financial outlook of the plant. The causes of these negative net returns can be viewed as either the high feedstock and operating costs, or alternatively, the inadequate revenues obtained from the ethanol and DWG products. It was seen that the downward adjustments in feedstock and transportation costs made in the various sensitivity analyses were not adequate to close the margin between positive and negative net returns. Likewise, over the range of financing options tried in the sensitivity analysis, none was found to be adequate to substantially reduce the margin between positive and negative returns. The most effective method of eliminating this margin was found to be a substantial increase in revenues from the ethanol product. This finding indicates that the most likely factor that will cause the economic feasibility of this plant to become favorable is a substantial rise in the price of gasoline (and ethanol).

The subsidy created by the windfall Profits Tax Act gives a 37.5 cent rebate to the consumer -- thereby increasing the net returns to the plant. The sensitivity analyses indicated this subsidy is directed at the proper problems, but was not nearly large enough in this case.
Finally, this research indicates the need for further study on ethanol production processes. Perhaps this area is where public funding is needed most. High energy requirements, high costs of feedstocks, and difficulties in anhydrous ethanol production are problems which might be alleviated with more research.

For Researchers

As stated above, there are a number of areas in the field of small scale ethanol production which could benefit from further research. In addition to the three items mentioned above, further research could potentially benefit hydrous and anhydrous ethanol utilization in diesel and gasoline engines for various vehicles and farm equipment.

Many refinements could aid the basic ethanol production process itself. As shown by the cash flow analyses, operating expenses for the ethanol plant are very high. Perhaps an alternative feedstock would be less costly.

Labor costs were relatively high for the size of plant analyzed. A different design could possibly reduce the labor requirements.

The utilization of the DWG byproduct is another area which should be researched more thoroughly. Improved
technology may make it economically feasible to dry it in small scale plants. Other uses may be found for it in addition to that as a cattle feed.

The cost of corn (at $2.50 per bushel) amounts to fully 54% of the operating costs of the ethanol plant. This again underscores the possible benefits of research directed toward discovering a lower cost (yet practical) feedstock than corn. If the economic feasibility of the cooperative fuel ethanol plant in this thesis is to become favorable, the cost of the feedstock will likely be an important contributing factor. Therefore, the discovery of a feedstock that is more economical than corn should be a prominent goal of future fuel ethanol production researchers.
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