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An Economic Examination of Potential Ethanol Production in Texas

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An Economic Examination of Potential Ethanol Production in Texas

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Executive Summary

The resurgence of interest in ethanol production has prompted various stakeholders in Texas to call for an unbiased analysis of the economic potential for ethanol production in Texas. There are a number of reasons for the increased interest in ethanol production, including:

- Depressed commodity prices for producers of potential feedstocks;
- Potential for increased gasoline prices due to international events and interest in renewable sources of energy;
- Finding that methyl tertiary butyl ether (MTBE), which is a competing oxygenate with ethanol, contaminates groundwater; and
- Local, State and Federal officials see ethanol production as a source of business activity and tax base.

Much of the research on ethanol production and economics, particularly from the early 1980's, are quite dated and not relevant to today's industry. Government regulations are stricter on clean air non-attainment cities leading to increased ethanol demand. Technological innovations in ethanol production have led to substantially lower production costs than 20 years ago.

Ethanol is an additive used primarily to produce cleaner burning fuels. The majority of ethanol is produced with a fermentation process using a high starch content feedstock such as corn or grain sorghum. Ethanol can also be produced through the chemical breakdown of biomass material such as grasses, hay, or even saw dust. However, these processes have not been developed to the point of commercial production. As a final consumer product, ethanol is used in the following forms:

- As an additive to gasoline – typically using 10% ethanol,
- As a component of reformulated gasoline both directly and/or in the form of ethyl tertiary butyl ether (ETBE),
- Blended with 15 percent (or sometimes more) gasoline known as E85, and
- In its pure form to be used in diesel engines specifically configured for that purpose.

The impact of a major business activity on the local, regional, and state economy can be significant. In fact, the primary interest in bringing ethanol production to Texas lies in the extended economic benefits to rural communities and regional economies. While the focus of stakeholders calling for this analysis is not the profit potential of ethanol equity investors, the profit potential is a primary focus of this study. The reason for this focus is that regardless of plant size, economic activity, or number of jobs created, the potential economic benefits will not be realized if the equity investor, seeing no profit potential, does not support development of the industry in Texas.

This project is designed to assess the feasibility of ethanol production in Texas. While not intended to determine the feasibility of an individual site or region of the state, the feasibility of constructing a plant in several regions of the State is assessed. An attempt is made to focus on both the positives and negatives for various regions of the state in terms of the economics of locating an ethanol plant in the area and on the feasibility of the plant. Obviously, there will be additional site specific factors not covered in this report that can enhance or reduce the economic viability and therefore, the success of a plant.

The following assumptions were adopted:

- Existing information from industry and other sources on ethanol production costs were used;
- Feedstock prices (corn and grain sorghum) reflect local Texas market conditions.
- A state incentive program of $0.20 per gallon for a maximum of $3 million. This is similar to legislation in other states and past proposals in Texas.

Risk is incorporated into the analysis through the use of stochastic simulation modeling techniques. This method of economic and financial analysis recognizes that prices are variable, both higher and lower. Corn, grain sorghum, natural gas, ethanol, and

DDGS prices are modeled with the variability seen historically. This is the preferred method of analysis compared to deterministic, static models because it not only provides an average financial outcome, but also, a range of possible risky outcomes. The results then incorporate the variability in prices as seen historically.

Construction costs for 20, 40, 60, and 80 million gallon per year plants (MMGY) are $30, $55, $78, and $100 million, respectively. Variable costs, not including feedstocks, range from $0.55 per gallon for the 20 MMGY plant to $0.44 per gallon for the 80 MMGY plant. There are economies of size in ethanol production, as highlighted by these production costs.

A plant feasibility analysis was conducted for the Panhandle, Central, and Southeast regions of the state, for each of the four plant sizes. In brief, the results for corn based plants indicate that net present values (NPV) range from -$11.9 to -$33.1 million. The probability of the NPV being greater than zero, meaning that the plant generates greater than an 8 percent return, is 10.6 percent for the 80 MMGY corn based Panhandle plant. The results are much more positive for grain sorghum fueled plants. An 80 MMGY Panhandle grain sorghum plant is estimated to have an $11 million average NPV and a 75 percent probability of a positive NPV.

While the results for some of the plant sizes and regions are not positive, sensitivity analyses indicate that only small changes in factors, such as ethanol or feedstock prices, are needed to generate positive results. An ethanol price increase of less than 2 cents per gallon would generate positive results for the 20 MMGY Panhandle grain sorghum plant. A $0.10 per gallon increase in ethanol price would generate positive results for the 20 MMGY panhandle corn based plant. Price changes (both higher and lower) of this magnitude are well within the historical range of prices. In addition, proposed changes in federal energy policy, when enacted, could easily result in higher ethanol prices.

Economic impact analysis estimate an increase in annual sales tax revenue ranging from $353,000 for the 20 MMGY to $1.29 million for the 80 MMGY plant (pp. 102-103). The impact on economic output from the same size plant is estimated to be $232 million annually. Economic output increases can vary depending on the extent to which inputs to the ethanol plant are sourced within the state.

Chapter 1.

Introduction and Study Approach

The recent resurgence of interest in ethanol production has prompted various stakeholders in the State to call for an unbiased analysis of the potential in Texas. There are a number of reasons for the increased interest in ethanol production, including:

- Depressed commodity prices for producers of potential feedstocks;
- Potential for increased gasoline prices due to international events and interest in renewable sources of energy;
- Finding that methyl tertiary butyl ether (MTBE) which is a competing oxygenate with ethanol contaminates groundwater; and
- Local, State and Federal officials see ethanol production as a source of business activity and tax base.

Over the past 30 years there have been a large number of ethanol feasibility analyses undertaken. In fact, Texas A&M University conducted one in 1981 that found ethanol production infeasible in Texas (Avant et al., 1981b). Since that time, two major changes have occurred. First, EPA regulations on non-attainment cities have increased the demand for ethanol. And second, technological innovations in the production of ethanol have resulted in lower costs of production.

Many state governments, as well as, the Federal government have provided various financial incentives intended to assist in the development of production facilities leading to an increase in ethanol production.

Much like the push in the 1970s and 1980s to revitalize rural areas by attracting industry, locating an ethanol plant in a rural area is seen as a major boost to rural communities and their tax base. The ethanol industry is responsible for adding more than $6 billion to the U.S. economy each year and 40,000 direct and indirect jobs (Bernard).

Industry Size and Growth Potential

U.S. ethanol production has steadily increased since the late 1970's to exceed 2.7 billion gallons per year in 2002. Between 1980 and 1998 ethanol production has grown an average of 12 percent per year (DiPardo). Ethanol production is dominated by large firms such as Archer Daniels Midland (ADM) and Cargill; with 35.4 percent and 4.1 percent (as of October 8, 2002) of the total ethanol production capacity, respectively. The top five ethanol producers have a combined share of 51.7 percent of the production capacity. However, most production plants and producing firms are small, less than 20 million gallons per year (MMGPY). In fact, 48.2 percent of the ethanol firms produce less than 20 MMGPY (**Table 1.1**). Only 5.4 percent of the total firms exceed 101 MMGPY (company-wide capacity).

Table 1.1. Distribution of Ethanol Plant Size Capacities.

Plant Capacity Range (MMGY)	Percentage of Total Firms
0 to 10	23.2%
11 to 15	14.3%
16 to 20	10.7%
21 to 50	33.9%
51 to 100	12.5%
101 to 950	5.4%

Source: Summary of information contained in Bryan and Bryan International, 2001b.

Individual plant size varies as much as total firm capacity. According to Bryan and Bryan International (BBI, November 2002), the smallest ethanol plant, as of January 25, 2002, produced only 0.7 MMGY, while ADM's average plant capacity, taken from their four listed plants, is 238 MMGY.

Figure 1.1 shows the location of the current ethanol plants in operation throughout the United States as of October 2002. Very few are located outside the Corn Belt. Most of the ethanol plants located outside the Corn Belt are small and use beverage waste or other waste material as the feedstock. There is one plant in Eastern New Mexico producing 15 MMGY and it is planning an expansion. This plant uses grain sorghum as its primary feedstock and sells the DDGS as a wet product to dairies and feedlots.

Figure 1.2 shows the location of the plans currently under construction. They are also located solely in the Corn Belt. Of the nine plants under construction, 5 are 40 MMGY capacities or more with 3 being 20 MMGY and 1 at 15 MMGY. State and federal incentives and the limited ability of farmers to raise equity capital have tended to keep plant sizes smaller.

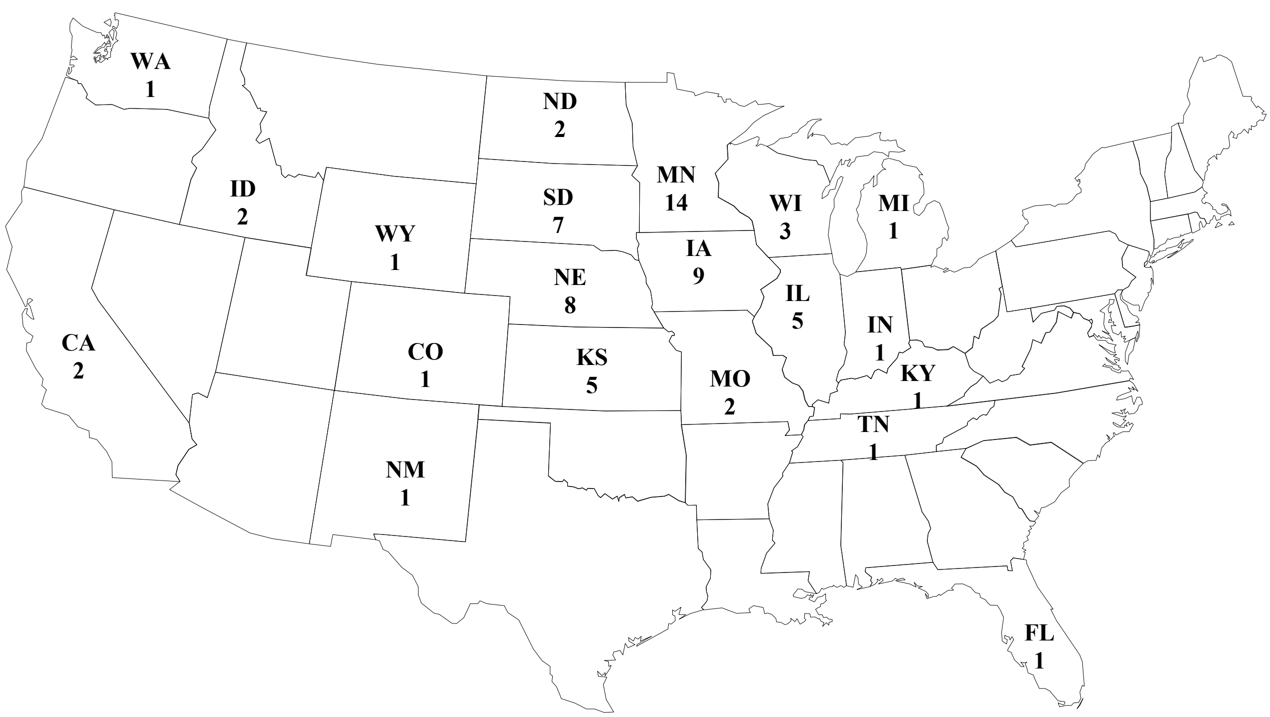

Figure 1.1. Number of Ethanol Plants in Operation by State, as of October 28, 2002.
Source: BBI 2002

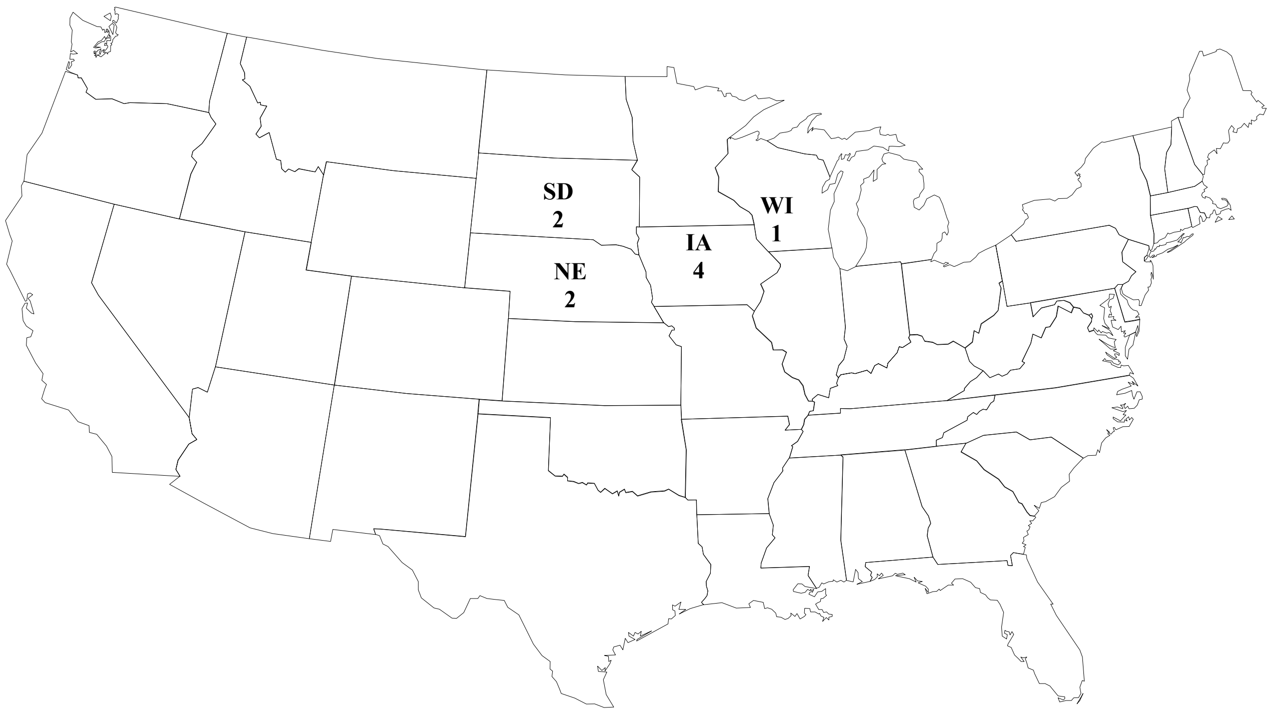

Figure 1.2. Ethanol Plants Under Construction by State, as of October 28, 2002.
Source: BBI 2002

As indicated on the two previous graphs, the ethanol industry in the United States tends to be located in the Midwest. This is primarily due to the abundant supply of relatively low priced corn used as the primary feedstock. **Figure 1.3** indicates the 10 year average corn price received by farmers by state. This is not intended to imply that ethanol plants do not locate outside the Midwest. It does mean, however, that in order to compete with plants located near cheap feedstocks, a plant located in another area will need to have some other advantage.

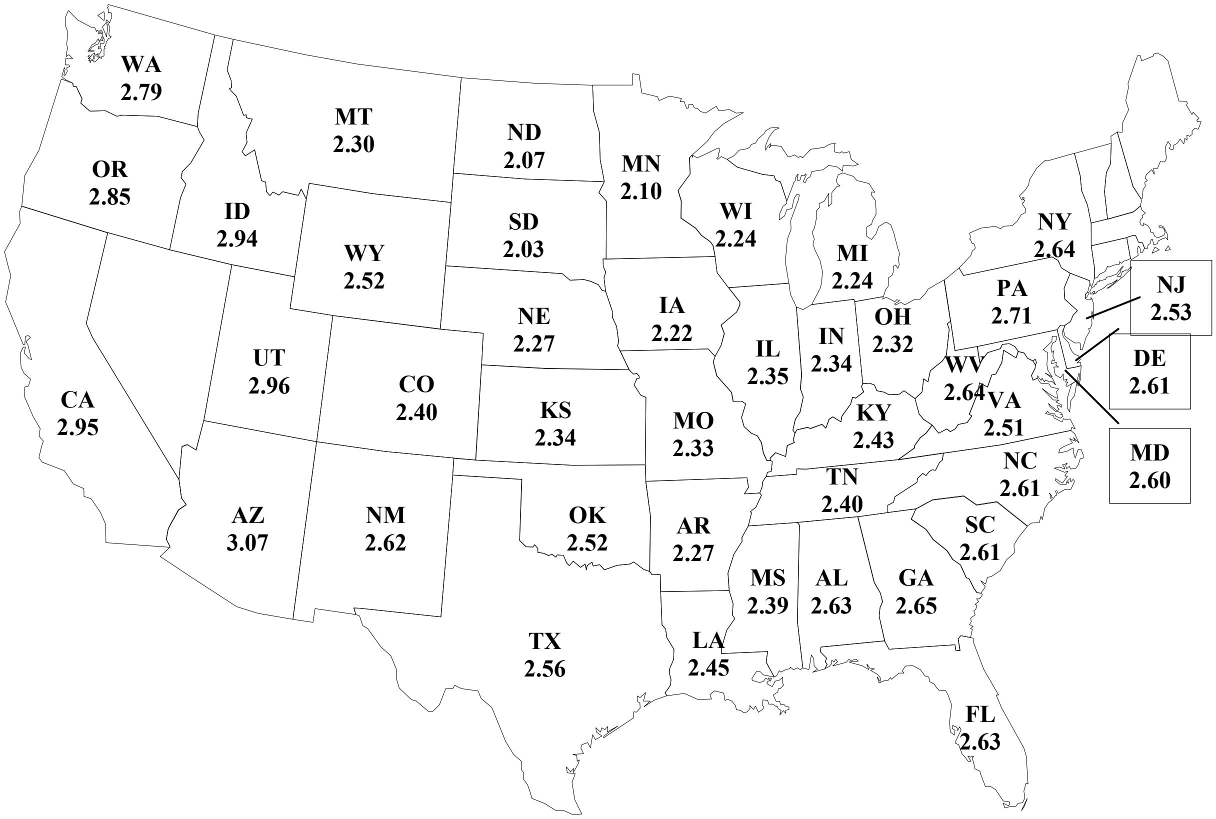

Figure 1.3. Average Corn Price per Bushel, 1992 to 2001.
Source: USDA-NASS

Evaluation of Ethanol Production in Texas

This analysis is designed to assess the feasibility of ethanol production and its economic impact in Texas. While not intended to determine the feasibility of an individual site or region of the state, the feasibility of constructing a plant in several regions of the State will be assessed. An attempt is made to focus on both the positives and negatives for various regions of the state in terms of the economics of locating an ethanol plant in the area and on the feasibility of the plant. In some cases, there will be additional site specific factors not covered in this report that can enhance the economic viability and success of a plant.

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The intent of this study is to utilize existing information on plant costs (both construction and operating) obtained from industry estimates and actual costs from other states and other studies. Appendix A contains a list of articles reviewed in the process of completing this analysis. The primary source of plant costs estimates comes from the Ethanol Plant Development Handbook (Bryan and Bryan International, 2001b). Additional information came from a feasibility study conducted for the Dumas Economic Development Foundation by Bryan and Bryan International (August 2001a). Their costs were compared to those found in other feasibility analyses as well as a recent USDA publication comparing costs between wet and dry mill plants (Shapouri, et al., January 2002). The authors have also cross-checked cost estimates with experts in the ethanol industry.

One major contribution of this study is the use of risk analysis which has not been performed in any of the previous ethanol feasibility studies. Risk analysis incorporates variability in input prices(e.g., corn, grain sorghum, natural gas) and output prices (ethanol and DDGS). For example, annual average corn prices have been as high as

$3.80/bushel and as low as $1.80/bushel over the last decade. Understanding this variability and incorporating it into the analysis is critical in understanding the economic feasibility of ethanol production in Texas.

The portrayal of financial results for an ethanol plant with probabilities of success gives decision makers much more information than presenting only the expected annual outcomes. This report contains annual averages and probabilities of reaching a required return. That makes this type of risk analysis more powerful than previous feasibility studies.

Chapter 2.

Status of Ethanol Legislation and Texas Resource Base

Currently, the ethanol industry in the United States is growing at a tremendous rate. Every month during 2002 the U.S. ethanol industry set a new monthly production record. This is primarily due to increased plant capacity being brought online. Whether the industry continues to experience growth or not depends primarily on pending legislation.

Review of Federal and State Legislation

The development and growth of the ethanol industry has been aided by federal and state policies. At the federal level, the National Energy Act, passed in 1978 exempted ethanol blended gasoline from the U.S. federal excise tax. Since 1978, the tax exemption has been revised and extended five times. Currently the tax exemption is $0.053 of the $0.183 total excise tax and is scheduled to expire in 2007 unless new legislation is passed (**Table 2.1**). The exemption benefits gasoline blenders/marketers by reducing their taxes, indirectly benefiting ethanol producers.

Table 2.1. Federal Excise Tax Exemption Schedule

Years	$/Gallon of Blended Product
2001-2002	$0.053
2003-2004	$0.052
2005-2007	$0.051

Source: BBI, 2001

The Clean Air Act Amendments of 1990 (CAAA90) was aimed at reducing air pollution in targeted problem areas across the United States. The two principle components of the CAAA90 are the oxygenated fuels program and the reformulated fuel program. The oxygenated fuels program mandates the sale of oxygenated fuels during at least four winter months in metropolitan statistical areas (MSAs) for carbon monoxide non-attainment. In Texas, El Paso has successfully been using ethanol to cut pollution since 1992. Since entering the oxygenated fuels program, the number of days El Paso has exceeded the EPA standard for carbon monoxide levels has decreased significantly to either one or none per year.

The reformulated fuel program addresses pollution concerns in the worst (in terms of pollution) MSAs in the country for ozone non-attainment. These areas include, but are not limited to: the Los Angeles Basin, Baltimore, Chicago Area, Houston Area, Milwaukee Area, New York-New Jersey, Hartford Region, Philadelphia Area and San Diego (Gill). Together, these two programs have spurred most of the demand for ethanol in the United States.

There is also a federal program that provides small ethanol producers a tax credit on qualified ethanol fuel production. To date, this program has not been widely used because the tax credit cannot be passed on to the farmer owners of cooperatives which tend to be of the size that would benefit from the program.

State Legislation

Almost every state that has ethanol production has some type of ethanol producer support ranging from tax credits to producer incentives. The Department of Energy, Alternative Fuels Fleet Buyer's Guide has a complete list of individual state producer incentives (DOE, 2002). There are currently 20 states that have State Excise/Sales Tax Exemption or State Producer Incentives for Ethanol.

Seven of these states have excise or sales tax exemptions. Most of these have a price per gallon exemption and range from $0.01 per gallon in states such as Connecticut and Iowa to $0.12 tax exemption on E85 in South Dakota.

Twelve states have producer incentives in place. Most of these incentives range from $0.20 to $0.40 per gallon in producer credit. Many of these states place conditions on these incentives. For example, in Missouri, $0.20 per gallon applies to the first 12.5 million gallons produced and is then reduced to $0.05 per gallon for the next 12.5 million gallons. Missouri also limits the time length of the incentive to the first 5 years of plant production. Other states such as Montana and Kansas place a cap on the amount of compensation and set sunset dates for the incentive programs. Montana places a $3 million cap on the program with a sunset date of July 1, 2005, and Kansas places a $3.5 million cap on the program with a sunset date of July 1, 2011. Ohio's incentive plan is an investor incentive rather than a producer incentive, whereby they grant investors a $5,000 state income tax credit for every $10,000 invested in farmer owned ethanol plants over a three-year period.

There is also movement in California to ban MTBE and replace it with ethanol to meet federal clean air requirements. California Governor Davis issued an order banning MTBE from state gasoline supplies effective at the end of 2002. However, in early 2002, Gray postponed the ban for one year fearing California gasoline suppliers would not have access to adequate ethanol supplies this year. The California market is estimated to be between 700 and 800 million gallons of ethanol per year (McGinnis).

New Federal Legislation

The 107th Congress adjourned without passing an energy bill that would have been a major positive incentive for ethanol production. The House and Senate versions of the bill differed enough that compromise could not be achieved by the conference committee. The bill reportedly contained a mandate to use 5 billion gallons of ethanol annually, up from the 2 billion used today. But more importantly it banned MTBE, the main oxygenate competitor of ethanol.

The recently passed Farm Security and Rural Investment Act of 2002 (also referred to as the 2002 Farm Bill) included an energy title that commits $405 million to the development of resources used in the production of ethanol and biodiesel. Specifically, the farm bill:

- Continues the bioenergy program which makes payments to bioenergy producers who purchase agricultural commodities for the purpose of expanding production of biodiesel and fuel grade ethanol;
- Establishes a new program for the purchase of biobased products by Federal agencies;
- Creates a grant program to educate government and private fuel consumers about the benefits of biodiesel use;
- Establishes a loan, loan guarantee and grant program to assist farmers in purchasing renewable energy systems and making energy improvements; and
- Reauthorizes and funds the Biomass Research and Development Act (House Agriculture Committee).

Status of State Incentive Legislation in Texas

HB 788 which was introduced in the 77th legislature by State Representative Swinford would have provided a $0.20 payment to be capped at 15 million gallons per plant. No plant would receive more than $3 million per year, no matter their productive capacity. Cost to the state would depend on how many plants were producing at a given time. For example, if three plants came on line and payment was capped at the first 15 million gallons produced, the payment would total $9 million for that year. If one plant came on line, with the cap, the payment would be $3 million no matter the plant's production level. Producer payments are not paid until ethanol is produced. The bill in this form did pass the House committee, but not a House floor vote.

Texas Agricultural Base in Relation to Ethanol Production

To have an ethanol industry that provides the benefits other states appear to have gained, the production base of corn and grain sorghum needs to be large enough to support a plant. The choice between corn and grain sorghum does not necessarily have to be mutually exclusive. This means that given the same conversions, a plant could effectively use both corn and grain sorghum throughout the production year. Texas county level data were organized into two production regions for corn (**Figure 2.1)** and three production regions for grain sorghum (**Figure 2.2**).

Dr. Mark Waller, Texas Cooperative Extension grain marketing specialist developed these regions based on production regions and the normal movement of production to alternative markets. Generally, corn in the Panhandle region flows to the feedlots around Amarillo while Southeast Texas corn would flow to various uses in the region and to ports on the coast.

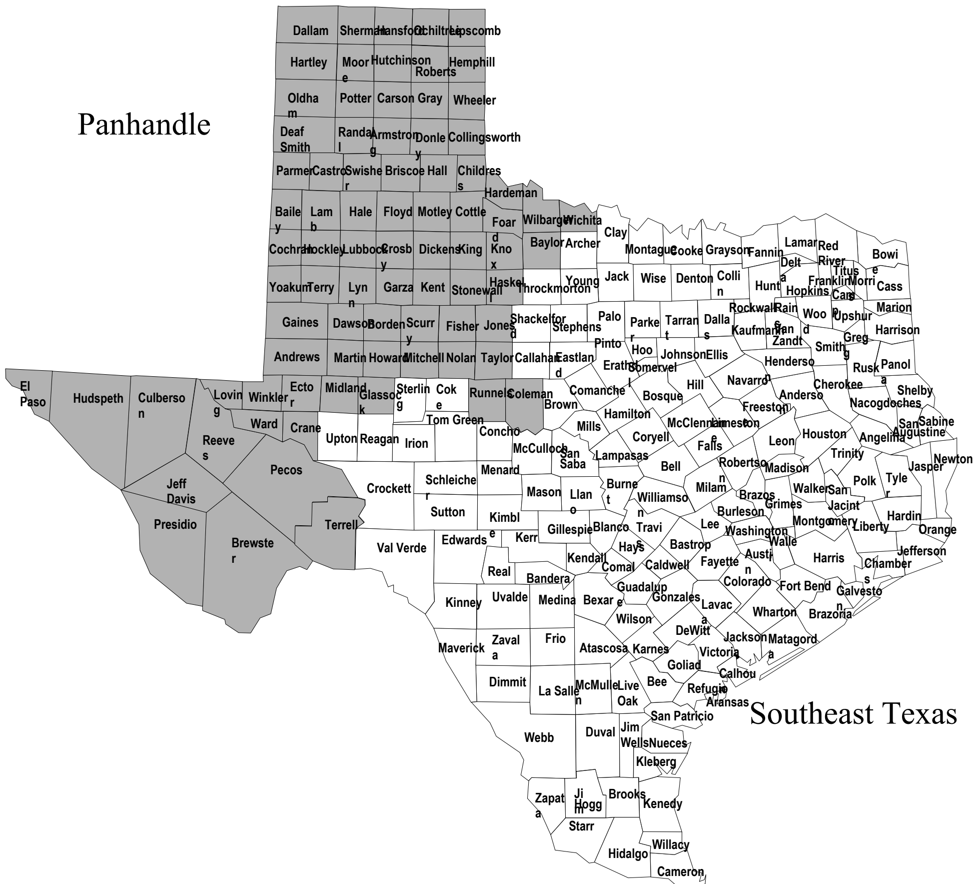

Figure 2.1. Corn Production Regions.

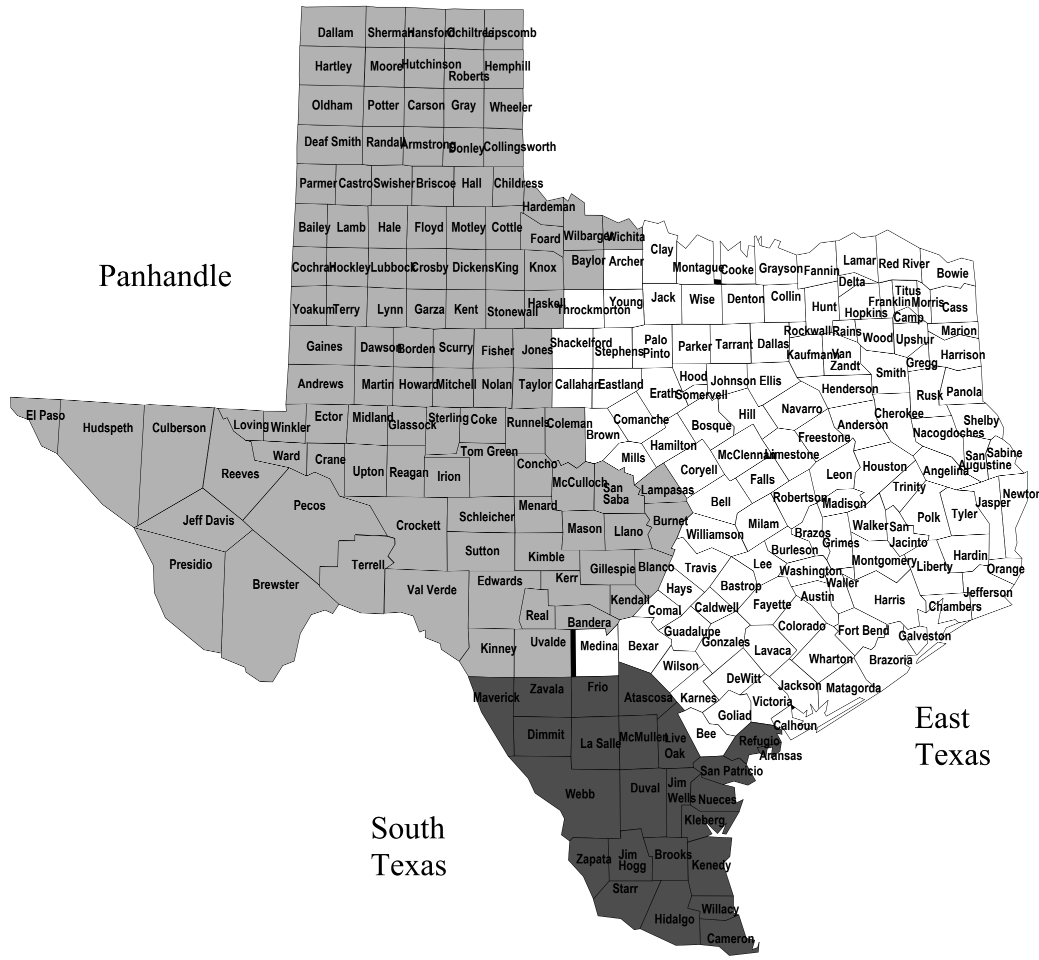

Figure 2.2. Grain Sorghum Production Regions.

Grain sorghum produced in the Panhandle tends to be consumed in the Panhandle area. East Texas produced grain sorghum generally moves to the port, while South Texas grain sorghum typically is exported to Mexico.

In general, production of corn in Texas has been increasing over the past two decades (**Figures 2.3 and 2.4**). Production in both the Panhandle and Southeast regions has trended upward over the period. However, there has tended to be a large amount of annual variability in production. Especially in the Southeast region which is generally not irrigated production.

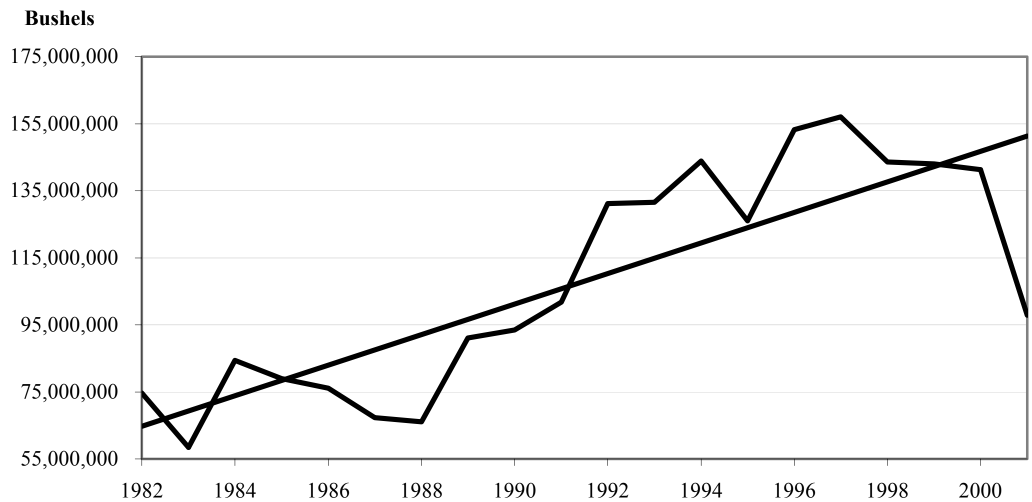

Figure 2.3. Historical Annual Texas Panhandle Corn Production and Trend Line, 1982-2001.

Source: USDA-NASS: http://www.nass.usda.gov:81/ipedb/

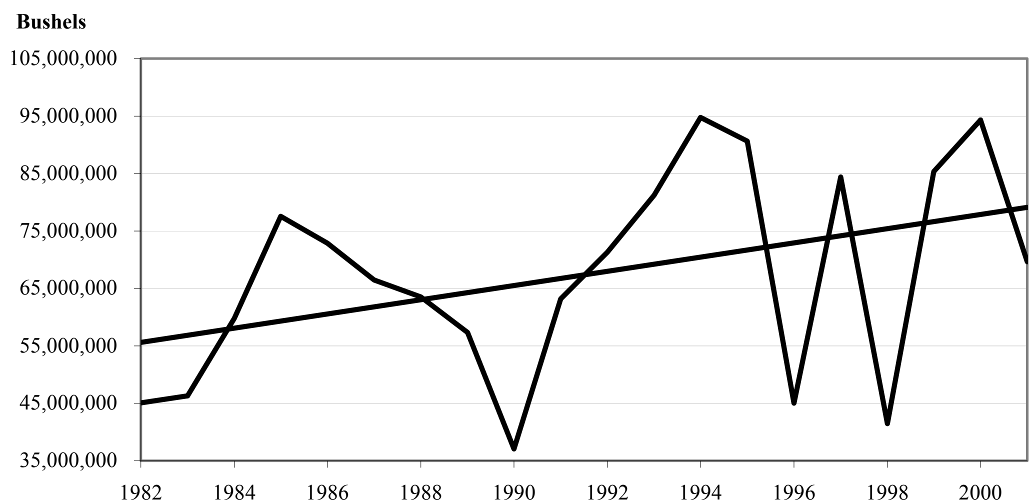

Figure 2.4. Historical Annual Southeast Texas Corn Production and Trend Line, 1982-2001.

Source: USDA-NASS: http://www.nass.usda.gov:81/ipedb/

Texas grain sorghum production has trended downward over the past twenty years (**Figures 2.5 – 2.7**). This would be particularly troublesome if a plant were to depend solely on grain sorghum. South Texas production has declined but not as much as in the other areas.

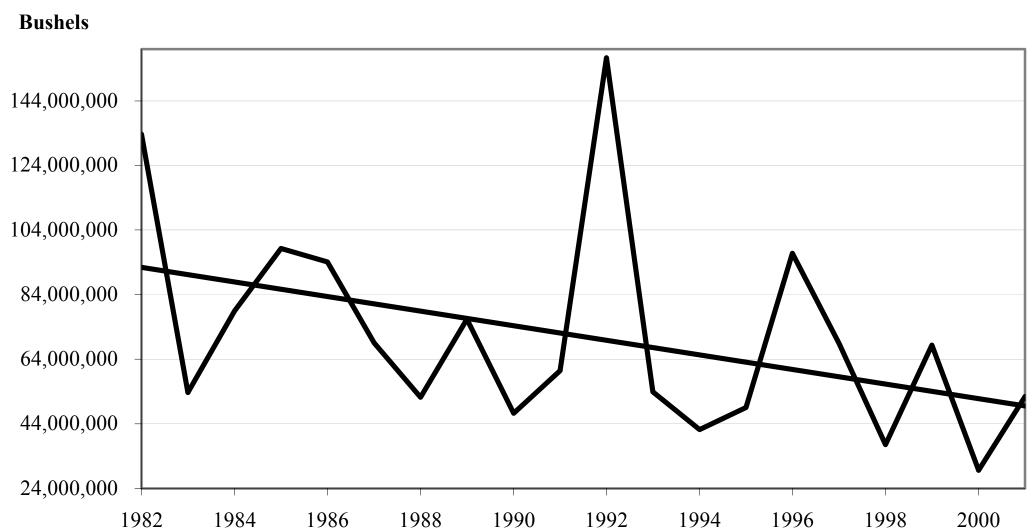

Figure 2.5. Historical Annual Panhandle Grain Sorghum Production and Trend Line, 1982-2001.

Source: USDA-NASS: http://www.nass.usda.gov:81/ipedb/

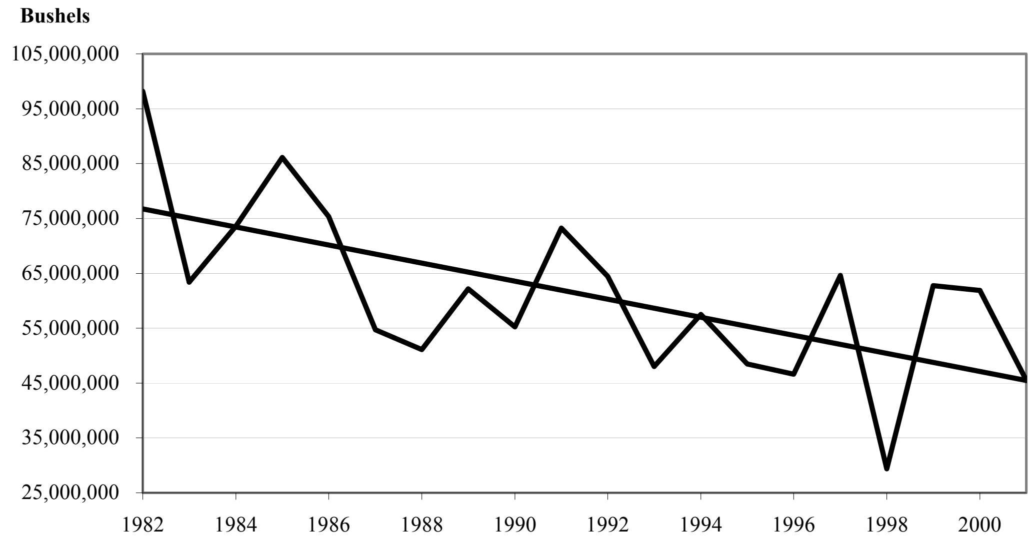

Figure 2.6. Historical Annual East Texas Grain Sorghum Production and Trend Line, 1982-2001.

Source: USDA-NASS: http://www.nass.usda.gov:81/ipedb/

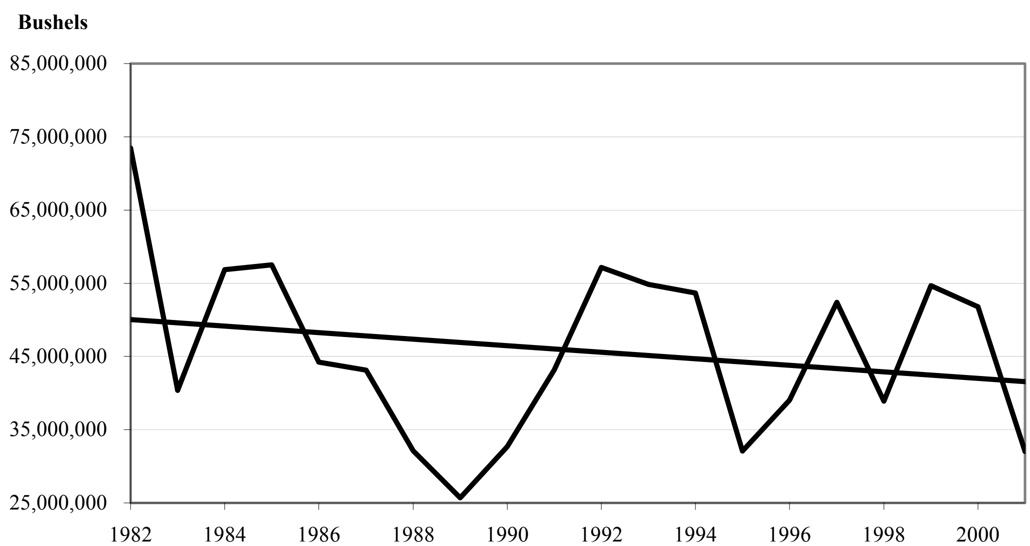

Figure 2.7. Historical Annual South Texas Grain Sorghum Production and Trend Line, 1982-2001.

Source: USDA-NASS: http://www.nass.usda.gov:81/ipedb/

Texas Regional Issues in Ethanol Production

For the purposes of this study, Texas is divided into four regions: Panhandle/Plains, Central, Southeast and Coastal Bend. The Panhandle/Plains Region includes all of the Texas Panhandle and extends south past Lubbock. It encompasses the primary cattle feeding area and the largest corn and cotton producing area of the state. The Central Texas Region includes an area from Cameron through Waco and north through the major dairy producing area of Stephenville. Southeast Texas includes the Houston area east to Beaumont. It includes the west and east sides of Houston and contains the major rice producing area of the state. The Coastal Bend Region includes the area around Corpus Christi.

Site-specific factors are key in choosing a location for an ethanol plant. However, beyond a particular site's advantages there may be regional advantages and disadvantages. **Table 2.2** contains a matrix of advantages and disadvantages for ethanol production in these four Texas regions. Advantages are denoted by "+" and disadvantages by "—" signs.

Table 2.2. Matrix of Regional Advantages and Disadvantages for Ethanol Production.

Region	Feedstock	Livestock Feeding	Feedstock Surplus	Petro-chemical Infra-structure	Year Round Supply	Market & Transport-ation	Aflatoxin	Corn Basis*
Panhandle	Corn/GS	+			+		+	+
Central	Corn/GS		+			+		-
Southeast	GS/Rice/Corn			+		+		-
Coastal Bend	Corn/GS			+				-

* In this case + and – refer to positive or negative cents

Livestock Feeding

The abundant cattle feeding industry in the Panhandle/Plains is a major advantage for the region in producing ethanol. The ability to develop an expanding market for either wet or dry distillers grains is key to profitable ethanol production. The "by-product" profit from ethanol must be a "co-product" profit center for profitable production.

While there are opportunities for nearby feeding in the other regions, notably to dairies in the Central Region and some feedlots to the south, opportunities are more limited outside the Panhandle. The absence of any critical mass of feeding infrastructure in southeast Texas is seen as a major drawback for the area.

Feedstock Surplus

The Central Texas Region is seen as being in a relative feedstock surplus position. Most of the production is shipped out to other areas for use. A negative corn basis and frequent large negative price spreads may make grain sorghum and corn potential ethanol feedstocks.

The Panhandle Plains area is a feed deficit region. Currently, unit trains of corn enter the region from the Eastern Corn Belt to provide the necessary feed for the cattle feeding industry. The area's positive basis to futures and approximately $0.35 per bushel positive price spread to the annual national average corn price indicates the area's disadvantage. The deficit feed nature of the area means the ethanol feedstocks, the largest cost sector of any plant, will be more expensive than for competitors in the U.S. Corn Belt and even for other regions of Texas.

While the Panhandle/Plains Region is a feed deficit area, the already developed infrastructure for unit trains of corn does provide easy access for year round supply. As an ethanol plant requires constant feedstock delivery or large amounts of storage this is an important factor. A potential problem for the rest of the state is the lack of year round supply. A related issue is a lack of storage infrastructure currently in place.

Storage has always been a difficult proposition in Central and South Texas. The warm winters make a good habitat for pests and other factors that reduce grain quality. In addition, the bulk of the South Texas grain sorghum is exported to Mexico soon after harvest leaving little production for other uses without bidding to keep it in place.

Petrochemical Infrastructure

The vast petrochemical infrastructure in southeast Texas and the Coastal Bend is an advantage in those areas. The advantage to the Panhandle/Plains and Central Texas areas are not as clear. There are refineries in those areas and co-location could be a large advantage. It is not as clear an advantage simply because there may not be as many of them.

Year Round Supply

The current ready access of the Panhandle/Plains Region to unit trains of corn from the Eastern Corn Belt is seen as an advantage to the area. While not local production, this ability to supply feedstock, as needed, through the existing, operating infrastructure is a positive.

Other regions face some difficulties in this area. The first difficulty is storage. These regions do not have large storage capacities in place. A good reason for that is weather. The warm winters do not provide the best climate for grain storage. While feedstocks can be shipped in or storage built, the lack of existing infrastructure adds to the cost of developing the industry.

In the Coastal Bend and south, much of the grain sorghum produced is exported within a couple of months of harvest to Mexico. This already developed market would compete strongly with any new ethanol venture.

<u>Market and Transportation</u>

The potential for air quality non-attainment in the major metropolitan areas of Texas including Dallas, Fort Worth, Houston, San Antonio, and Austin has some implications for potential ethanol demand. The close proximity of the Central and Southeast Texas areas to these cities is viewed as a positive. Those areas would be closer to their intended market

Transportation is closely related to market as a regional issue. The Central and Southeast areas are closer to Texas metropolitan areas that could be an intended market. However, all of the regions have interstate highways and rail access. The Southeast and Coastal Bend could potentially benefit from port access. The advantage of reduced transportation costs will depend on the location of the market. These Texas locations may have an advantage over Midwestern plants in shipping to the West coast.

<u>Aflatoxin</u>

Aflatoxin is a toxin that builds up, particularly in corn and cottonseed, in hot, dry years. Corn that contains aflatoxin is highly constrained in its use based on the tolerance by different livestock classes. Milk cows are the least able to use corn containing aflatoxin because it goes into the milk. Feedlot cattle can use corn with higher concentrations. Corn with more than 300 parts per million can't be used in any animal feed.

Due to its nature, aflatoxin occurs more frequently in the dry land production areas of Central Texas and the Coastal Bend. Aflatoxin survives the distilling process and becomes concentrated in the Dry Distillers Grains with Solubles (DDGS) co-product, thus limiting the potential sales of DDGS. This is an important concern because DDGS sales are critical to ethanol plant viability.

<u>Corn Basis</u>

Basis, in this case, refers to the price relationship of corn to the corn futures market in each area of the state. A positive basis means that cash corn prices in the area are typically higher than the nearby futures price. The Panhandle/Plains Region typically runs about $0.11 per bushel positive basis to the futures market. A positive basis is considered a disadvantage given that it means higher production costs relative to other areas with a negative basis.

The other three regions of the state generally have a negative basis. At times that may not be the case in the Coastal Bend area as the crop is marketed and exported to Mexico.

Feedstock Requirements

It takes one bushel of corn or grain sorghum to produce about 2.7 gallons of ethanol (**Table 2.3**). At that conversion rate a 20 MMGY plant would need 7,407,407 bushels of corn or grain sorghum to operate. An 80 MMGY plant would need 29.6 million bushels of corn or grain sorghum.

Table 2.3. Bushels of Corn or Grain Sorghum Required by Plant Size.

Plant Size	Bushels
20 MMGY	7,407,407
40 MMGY	14,814,815
60 MMGY	22,222,222
80 MMGY	29,629,630

When compared to corn and grain sorghum production in the state, an ethanol plant or industry could be expected to require a significant amount of the state's annual production. **Table 2.4** contains the percent of corn and grain sorghum production required by four sizes of ethanol plants. One 80 MMGY plant would use the equivalent of 14% of the entire state's corn production. Regionally, the same size plant would use 22% of the Panhandle's normal production and 39% of southeast Texas' production. An 80-MMGY plant would take more than half of the grain sorghum production of the Panhandle, East Texas and South Texas.

Table 2.4. Percent of State/Region Feedstock Production Required by Plant Size.

	Corn				Grain Sorghum			
	20 MMGY	40 MMGY	60 MMGY	80 MMGY	20 MMGY	40 MMGY	60 MMGY	80 MMGY
All Texas	4%	7%	11%	14%	5%	10%	15%	20%
Panhandle	5%	11%	16%	22%	14%	29%	43%	58%
East					14%	28%	42%	56%
South					16%	32%	48%	64%
Southeast	10%	20%	30%	39%				

Co-Products of Ethanol Production

Ethanol production from corn and grain sorghum has two co-products or by-products, carbon dioxide and dry distillers grains with solubles (DDGS). One bushel of corn or grain sorghum yields approximately 2.7 gallons of ethanol, 17 pounds of carbon dioxide and 17 pounds of distillers grains. In this project we are not assuming provision is made to capture CO_2 for use in other industries, since only one-third of CO_2 resulting from ethanol production is currently captured. A number of plants have not found a sufficient market for CO_2 necessary to make CO_2 capture profitable. For example, a 40 MMGY plant would generate $650,000 in additional annual revenue and the cost of facilities would add an additional $7 million to the construction cost of the plant. That does not include any variable costs associated with CO_2 capture and transportation. Therefore, in this report, no discussion of CO_2 capture and sale will be made. However, the potential for the sale of CO_2 can be a significant advantage when it is possible. The remainder of this section deals with DDGS.

Fermentation by yeast converts the corn and grain sorghum to ethanol. The remaining DDGS is processed into animal feed. The DDGS contains all the nutrients of the original corn except the starch. Recycled stillage increases the amino acids and nutrients of the DDGS. The additional vitamins, particularly the B-complex vitamins contributed by the yeast, contribute additional value to the DDGS as feed.

Typically, DDGS contains 27 percent protein, 11 percent fat and 9 percent fiber. It is a source of by-pass protein and can be sold wet or dry. Nutrient research indicates that DDGS can be fed successfully to all major livestock species (cattle, hogs, poultry). The widespread use of DDGS in the livestock industry confirms its productive use. This report is not meant to convey the technical findings of nutrition research in the area of DDGS feeding. For a starting point in that area of research see the proceedings of the National Corn Growers Association Southwest Distillers Grain Conference (NCGA, 2002).

Dairies use about 60 percent of all DDGS used as animal feed. Beef producers use about 36 percent and poultry and swine consume the remaining 4 percent. About 90 percent of the turkeys in Minnesota, the largest turkey producing state, are fed rations containing DDGS.

A number of advantages and points to consider are cited when feeding DDGS to cattle. Using wet or dry DDGS is a consideration. For cattle feeding operations the ability to run the DDGS through the feed mill is critical to its use. Feeding the wet product requires different management to feed the amount on hand before spoilage sets in. Delivery timing will also be important. The consistency of supply, both in its availability and composition will be important.

Research on the use of "ag bags" and other treatment for the storage of wet distillers grains has demonstrated long-term storage capability. This type of storage is similar to that commonly used for silage on dairies.

For finishing cattle DDGS, is a source of protein and energy and it has a metabolizable energy value greater than or equal to corn. The use of DDGS in the ration allows for the reduction of corn, supplemental nitrogen and phosphorus.

In swine, field observations on the use of DDGS include decreased mortality, improved growth performance and improved "gut health". This last attribute is under current research. It is speculated that the increased fiber from DDGS contributes to better herd health.

In addition, for all livestock species research shows that DDGS provides more useable phosphorus. This feature may allow reduced phosphorus levels in waste aiding in complying with environmental regulations (NCGA, 2002).

Research shows that feeding wet distillers grains is advantageous from the higher feed value versus dry distillers grains. Its important to note that the ability of an ethanol plant to develop a market for wet products affects the bottom line in two ways. One, a ready market for the co-product is developed. Two, a significant portion of the energy required to run an ethanol plant is tied up in the drying process. Elimination of this step can result in significant savings and reduced ethanol production costs.

Potential Use

A 60 MMGY ethanol plant would produce about 189,000 tons of DDGS per year. The potential for use depends highly on location. Texas is the largest cattle feeding state in the nation. Texas is also a top-ten dairy state with production concentrated in the Erath County area of Central Texas, the areas around Sulphur Springs in East Texas and increasing in the Panhandle. Hog production continues to expand in the Panhandle and other parts of the state have large concentrations of broilers.

For example, a dairy milking 2,000 cows per day feeding 6 pounds of DDGS per head per day would feed 2,190 tons per year. A feedlot selling 70,000 head per year, feeding about 2 pounds per head per day would feed about 9,800 tons in a year. It’s relatively simple to calculate the possibility that there is sufficient animal numbers to consume the level of DDGS produced by a plant in the Panhandle.

International Outlook

In a report on the world ethanol production 2001, by Dr. Christoph Berg, it was found that 65.5 percent of the world ethanol production came from the Americas, mainly Brazil (37.9%) and the United States (24.1%), followed by Asia/Pacific region with 19.6 percent, and Europe was third with 13.2 percent. The largest producer in the world is Brazil at 3.1 billion gallons produced in 2001. However, due to increased sugar exports, ethanol production has slowed down. The primary feedstock used in Brazil is sugarcane and the price for exports has been high enough to pull sugarcane use from ethanol to sugar for export.

With the upcoming ban on MTBE in California, the demand for ethanol in the United States has significant growth potential. However, the lack of storage facilities and train unloading facilities at this time in California could cause problems. California currently produces 4 million gallons of ethanol a year or 0.5 percent of potential demand. Canada is currently producing 62 million gallons with expected increases to 90 million gallons over the next few years. From 2001 to 2006 Brazil is expected to increase production by 11 percent, the United States 75 percent and other countries 860 percent. The Americas are expected to increase production from 5.1 billion gallons in 2001 to 8.1 billion gallons by 2006.

In Europe, production levels are not expected to grow over the next few years with the exception of the Ukraine. In the Ukraine, they are trying to increase production with a new fuel alcohol program. Spain is trying to build a biomass plant that would be the largest biomass ethanol plant in the world at 52 million gallons. Africa produces only 1.7 percent of the world ethanol and most of that is not fuel grade ethanol. Asia produces

1.5 billion gallons of ethanol per year and is an expanding market. China is the major player in the Pacific Rim with over 750 million gallons of ethanol produced annually and India is second with over 450 million gallons of production.

A small amount of ethanol is currently being imported into the United States. Most of the imports are going into California. The law allows for 100 million gallons to be imported from the Caribbean Basin without having to pay a 3 percent Ad Valorum tax. Imported ethanol does not get the tax break when blended like domestic ethanol or the 100 million gallons from the Caribbean.

Scott Birtle of Atlas Maritime Association Limited provided information on the shipping costs of ethanol. Currently ethanol is being shipped from Brazil to California for $0.15 per gallon. This is based on a minimum of 5,000 metric ton orders, with 333.5 gallons per metric ton.

Summary

While Texas has the resource base in corn and grain sorghum acres to produce ethanol, it is a feed deficit state. This means that we import feed to go to the animal industries. The implication for ethanol production is that a plant will face higher feedstock costs than competing plants in feed surplus states. That is not an insurmountable problem but other local advantages may have to be found to offset higher feedstock costs.

Much uncertainty remains in the policy arena. The federal energy bill that would encourage ethanol use has not been passed. Most states with ethanol production have some sort of incentive. Tariffs do apply on imported ethanol to prevent foreign ethanol from being eligible for the federal income tax exemption.

Chapter 3.

Methodology and Assumptions

This report utilizes a stochastic simulation model of an ethanol production facility using standard capital budgeting procedures. Stochastic simulation is defined as a "tool for addressing 'what if . . .' questions about a real economic system in a non-destructive manner" (Richardson 2002). Pouliquen wrote that (stochastic simulation) is the preferred method for dealing with uncertainty in project evaluation.

Simulation can be done both deterministically and stochastically. Deterministic simulation does not address the risk around estimated parameters or risky variables. Rather, it uses a point estimate for each parameter and variable. Most business decisions have a degree of risk surrounding their parameters. Unfortunately, many feasibility studies often assume perfect knowledge and ignore risk. The assumption of perfect knowledge is referred to as deterministic simulation.

Richardson and Mapp, Pouliquen, and Reutlinger all describe benefits of Monte Carlo or stochastic simulation for analyzing risk in business. If risk is incorporated into the model, as described by Richardson and Mapp, Pouliquen, and Reutlinger, probability distributions may be developed for key output variables, showing the risks of success and failure.

Richardson and Mapp outline the methodology for conducting a production based investment feasibility study. First, probability distributions for all risky variables need to be defined. Secondly, the probability distributions for the stochastic variables need to be linked to known or deterministic variables that affect the investment analysis. The last step is to specify the accounting relationships related to the project being analyzed.

Accounting equations need to be linked to the stochastic variables and the deterministic variables. The use of random sampling for a large number of iterations generates cumulative distributions for returns and other key output variables to evaluate the project.

Pouliquen indicated that the advantages of risk analysis in dealing with the problem of uncertainty is the ability to eliminate the need for an individual to restrict their judgment to a "single optimistic, pessimistic, or best evaluation (p. 2)." Richardson and Mapp suggest that by drawing random values for identified probability distributions, using the random values in financial statement analysis, and then repeating this process numerous times (iterations) gives the investor (decision maker) an empirical estimate of the cumulative probability distribution(s) for the identified key output variables.

Simulation Software

This analysis utilized the SIMETAR© simulation package developed by Richardson, Schumann, and Feldman in the Department of Agricultural Economics at Texas A&M University. SIMETAR is an Add-In to Microsoft Excel© that was developed in Visual Basic for Applications. It consists of both Menu Driven and User Defined Functions in Microsoft Excel. The power of this software is that capital budgets can be developed for each size plant in one Excel file. Risk can then be added to selected stochastic variables within the capital budget framework.

Framework for Ethanol Plant Model

This chapter describes the framework of a stochastic simulation model for the evaluation of ethanol plants under alternative feedstocks and locations. The model simulates the economic activity of a 20 MMGY plant located in the Panhandle with corn as its feedstock. The assumptions can be changed to evaluate grain sorghum in the central and southeast regions of Texas and three other plant sizes, 40, 60, and 80 MMGY.

The feasibility of ethanol production in Texas is evaluated using capital budgeting and simulation analysis. Capital budgets were developed for construction and operating costs for each of the four alternative size (20, 40, 60 and 80 MMGY) dry milling plants. Alternative feedstock and dry distillers grain with solubles (DDGS) price assumptions were used to analyze four different regions of Texas. These plant sizes provide a good range of the size plants that are currently in production across the country. Dry milling was chosen over wet milling because the standard in new plant construction over the past few years has been dry milling (Shapouri, et al., January 2002).

The following sections of the chapter describe the development of stochastic variables used in the model, capital requirements and interest rate assumptions, production assumptions, and key output variables.

Stochastic Variables

The stochastic variables used in the ethanol model are annual prices for the feedstock (corn or grain sorghum), ethanol, DDGS, electricity, and natural gas. Differentials between national and local prices for corn and grain sorghum, referred to as price wedges, are also stochastic. These stochastic variables capture the risk in both production cost and plant revenue. Ethanol and DDGS prices affect the receipts while the other variables affect cost of production. A description of the method used to develop parameters for simulating the stochastic variables is provided in this section.

Ethanol prices are neither collected nor reported by government agencies. Therefore, only a limited amount of monthly historical ethanol prices were found for use in this study. The average prices used in this analysis are based on the calendar year, January through December, instead of commodity marketing years. Monthly ethanol prices were collected from Independent Commodities Information Service – London Oil Report (ICIS-LOR), from February 1994 to May 2002. The data collected for ICSI-LOR is a simple average of high and low ethanol prices for each month.

The source for historical monthly corn, grain sorghum, DDGS, and soybean meal prices for the period of January 1994 to December 2000 is the Feed Grains Data Delivery Service within the Economic Resource Service of the United States Department of Agriculture (USDA). Historical monthly commercial electricity and natural gas prices were taken from the United States Department of Energy and the Texas Comptroller web page, respectively, for the period January 1994 to December 2000. Dr. Mark Waller, who maintains a database of local cash grain markets in Texas, provided local market grain prices. Annual historical prices wedges were calculated as the difference between the national average commodity price and the local cash price. Localized wedges were calculated for corn in the Panhandle and Central Texas regions and for grain sorghum in the Panhandle, Central and Southeast regions.

Once historical monthly corn, grain sorghum, ethanol, DDGS, electricity and natural gas prices were collected, the data was sorted and matched by date, February 1994 to December 2000. An annual model is used in this study so the monthly prices were averaged to generate annual average prices for corn, grain sorghum, localized wedges, ethanol, DDGS, electricity and natural gas. A correlation matrix of annual prices for corn, ethanol, electricity, natural gas and soybean meal was estimated in preparation for simulating these variables. Due to the strong historic correlation, grain sorghum was assumed to be perfectly correlated to corn. The wedges were also correlated to the prices for corn and grain sorghum based on their respective observed correlation to history.

There was significant correlation between corn prices and DDGS prices, resulting in a correlation coefficient of 0.94, with a t-statistic of 6.08, and significant correlation between natural gas prices and electricity prices, resulting in a correlation coefficient of 0.90, with a t-statistic of 4.69; using 7 observations of annual data between 1994 and 2000.

Simple ordinary least squares regressions were run for corn prices, grain sorghum prices, ethanol prices, natural gas prices, electricity prices, and soybean meal prices as a function of time to calculate their respective residuals from trend (**Table 3.1**). The alpha and beta coefficients as well as their respective t-statistics are summarized in **Table 3.1**. Each trend regression resulted in insignificance parameter estimates. Because of the lack of trend in the data, the actual historical distribution of each price was used to develop the projected risk in prices. Relative deviations from mean were used to quantify the variation of each variable to develop stochastic deviates for an empirical probability distribution. The relative variability for the projected price distribution is a result of the historical coefficient of variation (C.V.). The C.V. is found by dividing the standard deviation by the series mean, and it represents the relative variability in price. The C.V. of each price series will hold for all projected distributions.

Because there was a significant correlation between DDGS and corn prices, and DDGS and soybean meal prices, a multiple regression was run with DDGS being a function of corn and soybean meal prices. The respective alpha and beta coefficients as well as their respective t-statistics, R^2 and F-test values are included in Table 3.1. The relationship established for DDGS was held throughout the projection. Therefore, the risk projected for DDGS price is a result of stochastic corn and soybean meal prices as well as the relative variability present in the regression residuals.

Table 3.1. Regression Results and Statistics

	Mean (std. dev.)	Intercept (t-stat)	Coefficient (t-stat)	Coefficient (t-stat)	F-test	R2
			trend			
Trend Regression on Corn	2.29	306.490	-0.152		2.440	0.328
	(0.4328)	(1.575)	(-1.562)			
Trend Regression on Sorghum	2.10	34.416	-0.016		6.942	0.581
	(0.4225)	(2.806)	(-2.635)			
Trend Regression on Ethanol	1.17	24.081	-0.011		0.140	0.027
	(0.1391)	(0.393)	(-0.374)			
Trend Regression on Electricity Price	0.0411	-0.242	0.000		0.138	0.027
	(0.0017)	(-0.318)	(0.372)			
Trend Regression on Nat Gas Price	2.22	-437.366	0.220		5.593	0.528
	(0.6059)	(-2.353)	(2.365)			
Trend Regression on SBM	178.00	10584.027	-5.208		0.336	0.063
	(39.0278)	(0.590)	(-0.580)			
			soybean meal	corn		
Multivariate Regression of DDGS* Prices		-5.621	0.215	31.897	189.879	0.826
on Corn and Soybean Meal Prices		(-0.897)	(5.230)	(10.641)		

* Denotes dry distillers grains (DDGS)

The residuals from the respective means contributed the risk component for the stochastic variables in the model. More precisely, the residuals were used to develop the parameters for simulating the stochastic variables in a multivariate empirical (MVE) distribution. The key parameters for a MVE distribution are the correlation matrix for the residuals and the sorted residuals. The MVE probability distribution was simulated with

SIMETAR generating stochastic deviates that were then applied to the projected means for 2003 to 2022.

Forecasted means for 2003-2011 corn and soybean meal prices (SBM) were taken from the Food and Agriculture Policy Research Institute (FAPRI) July 2002 Baseline Projections. After 2011, the FAPRI forecast was flat lined and used as the forecasted corn and SBM prices for 2011 to 2018 (**Table 3.2**). DDGS forecasted mean prices were calculated from the multivariate regression of DDGS as a function of FAPRI's projected corn and soybean meal prices. Mean prices for ethanol, electricity and natural gas were held constant for 2003 to 2018 at a historical average price for the last 3 years. Forecasted mean prices of corn, grain sorghum, ethanol, DDGS, electricity, localized wedges for the three regions and natural gas prices for 2003 to 2018 were combined with annual stochastic deviates from the MVE distribution to simulate stochastic prices for each year of the planning horizon.

Table 3.2. Average Prices Used for the Analysis.

		2003	2004	2005	2006	2007	2008	2009	2010
Corn	$/bu	2.25	2.10	2.15	2.19	2.23	2.27	2.32	2.37
Sorghum	$/bu	2.15	1.97	2.03	2.06	2.09	2.13	2.18	2.21
Natural Gas	$/MCF	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
Electricity	$/kWh	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Ethanol	$/gal	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
DDGS	$/ton	99.09	95.36	97.85	100.01	102.20	104.52	106.91	108.94
SBM	$/ton	153.09	158.29	162.84	166.81	171.40	175.64	179.01	181.92
Corn Wedges									
Panhandle		0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Triangle		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Sorghum Wedges									
Panhandle		0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Triangle		0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Southeast		0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62

		2011	2012	2013	2014	2015	2016	2017	2018
Corn	$/bu	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Sorghum	$/bu	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26
Natural Gas	$/MCF	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
Electricity	$/kWh	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Ethanol	$/gal	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
DDGS	$/ton	110.90	110.90	110.90	110.90	110.90	110.90	110.90	110.90
SBM	$/ton	184.86	184.86	184.86	184.86	184.86	184.86	184.86	184.86
Corn Wedges									
Panhandle		0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Triangle		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Sorghum Wedges									
Panhandle		0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Triangle		0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Southeast		0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62

*Denotes dry distillers grains with solubles (DDGS)

The MVE simulation procedure insured that the future prices are correlated the same way they were correlated in the past and the relative risk of simulated prices equal their historical relative risks. The stochastic annual prices were linked into the financial statements to calculate the effects on costs and receipts; thus making net returns as stochastic as they have been in the past.

Capital Requirements and Interest Rate Assumptions

Interest rates for the 10-year loan on the proposed ethanol facilities are 8 percent. Revolving or operating loans would not be needed because the plant would carry the needed working capital to cover short-term cash requirements. Yearly cash flow short falls would be refinanced at 8 percent interest for 1 year.

The initial capital loan requirements for the four different size plants were taken from current industry standards (Bryan and Bryan International, August 2001a). Total capital loan amounts are: $30 million, $55 million, $78 million and $100 million, respectively, for the 20, 40, 60 and 80 MMGPY facilities. This study assumes that the value of the property (land only) does not appreciate as normal property would, as upon the termination of the facility's use, the property should have significant clean-up costs that should offset the appreciated value of the property. Lastly, initial capital loan requirements include startup costs of working capital, start-up inventory, spare parts, organizational costs and independent engineering costs.

It was assumed that 50 percent of the capital requirements are borrowed funds. The remaining half of the total capital requirements is contributed capital from prospective investors. This ratio of borrowed to owned equity is an industry standard. According to Jeff Kistner of CoBank, most lenders require 50 percent of the total required capital to be made up by equity and the loan is broken up between 3 or 4 different banks to spread out the risk.

Instead of assuming a certain type of business structure (e.g., corporation, cooperative, limited liability company, partnership, etc) this analysis assumes a generic entity. This means that profits are taxed at 30 percent, which is consistent with shareholders and/or partners paying taxes on their earnings. Dividends equal to 30 percent of after-tax net income are paid any time net income is greater than zero. If the plant experiences losses, the analysis assumes that there is unlimited financing available.

While this is not realistic, it is important for evaluation purposes that the plant is allowed to operate without having to shut down because of a cash shortage.

Production Assumptions

Ethanol yields, DDGS yields, variable costs including denaturant, enzymes, chemicals, natural gas, maintenance materials, labor, administrative and miscellaneous costs were taken from the feasibility study developed for the city of Dumas, Texas (Bryan and Bryan International, August 2001a). They were then modified to a 20 MMGY basis from a 15 MMGY. These assumptions are summarized in **Table 3.3** on a cost per gallon basis.

Table 3.3. Assumed Plant Costs by Size.

Plant Size	20 MMGY	40 MMGY	60 MMGY	80 MMGY
Capacity (gal)	20,000,000	40,000,000	60,000,000	80,000,000
Capital Requirements $/gallon	1.5	1.38	1.30	1.25
Total Construction and Start-up Cost	$30,000,000	$55,000,000	$78,000,000	$100,000,000
Variable Cost	$/gallon			
Denaturant	.04	.04	.04	.04
Enzymes	.06	.06	.06	.06
Chemicals	.03	.03	.03	.03
Main. Materials	.04	.03	.02	.02
Labor	.10	.07	.05	.04
Admin. Costs	.05	.03	.0233	.02
Misc. Costs	.03	.03	.03	.03
Natural Gas	.16	.16	.16	.16
Electricity	.04	.04	.04	.04

The corn and grain sorghum to ethanol conversion was assumed at 2.7 gallons/bushel. The DDGS yield is assumed to be 6.41 lbs/gallon of ethanol produced or 17.3 lbs/bushel of feedstock. These conversions tend to be on the upper end of the range contained in the literature. However, these levels are justified based on the efficiency gains the industry has obtained over the past 15 years.

Variable costs in **Table 3.3** are inflated at 1 percent per year to adjust for inflation over the 15-year analysis period. Variable electrical and natural gas costs per gallon were stochastically simulated and incorporated into the variable costs in the income statement. The mean electricity and natural gas prices from 2003 to 2018 were held constant. The respective costs and assumptions for each of the four size facilities being analyzed are incorporated into the individual models for the analysis.

There are economies of size as evidenced by cost saving for large plants (**Table 3.3**). The primary differences in costs across plant size are due to labor, administration and maintenance costs.

Assuming there is a start-up and learning curve for all ethanol facilities, this report assumes that each of the four size facilities would be operated at 50 percent capacity in 2004, and at 100 percent of capacity for the rest of the period of analysis.

State Subsidy

This study assumed the passage of a state subsidy of $0.20 per gallon. The subsidy was provided to the plant regardless of size on production up to 15 million gallons of ethanol production or $3 million per facility.

Indicator Variables

The analysis of this report is based on five indicator variables, which are reported for each of the four size facilities. The five variables are as follows:

1. Net Income - Net income is defined as revenues minus operating expenses minus depreciation expense.

2. Ending Cash Before Borrowing - Ending cash before borrowing is the ending cash flow (total cash inflows less outflows). This value does not reflect short term borrowing to cover cash flow deficits.
3. Dividends Paid - Dividends are paid at the rate of 30 percent of positive net income.
4. Real Net Worth - Real net worth is the nominal net worth discounted at 8 percent per year to reflect net worth in 2003 dollars. This eliminates the effects of inflation over time.
5. Net Present Value - Net present value was calculated through 15 years of operation. The discount rate used in the net present value calculation was 8 percent.

Net present value is:

$$NPV = -InitialEquityInvestment + \sum_{t=1}^{16}\left(\frac{Dividends}{(1+i)\hat{\ }t}\right) + \left(\frac{EndingNetWorth}{(1+i)\hat{\ }16}\right)$$

and is the average return at the end of the period above what was invested.

The discount rate, i, is the 8 percent rate at which returns are discounted to present value dollars. The discounting of future returns allows for the comparison of the initial capital investment to returns that occur in different time periods. Included in the discount rate of 8 percent are the combined assumptions of future inflation and the investors required real rate of return. In this simple NPV framework, an NPV of zero would suggest that the investment exactly meets the required 8 percent rate of return. A positive NPV would indicate returns over and above eight percent.

Economic Impact Analysis

The projected plant costs and revenues are used to develop estimates of the overall economic impact of locating a plant in an area. In essence, how many times does the money turn over in the economy? For an ethanol plant, there two sets of impacts. First, the one-time impacts that occur during construction. And second, the annual impacts resulting from plant operations. Multipliers obtained from the Bureau of Economic Analysis, U.S. Department of Commerce are used to develop economic impact estimates.

Review of Literature

It would be logical to assume that ethanol production facilities would benefit local communities. Most of the literature supports this proposition. However, the results of a 1999 report from the Office of the State Auditor for Minnesota found that Minnesota may have experienced a net loss of jobs (Long and Creason). In 1999, Minnesota had possible employment impacts ranging from a negative 492 to positive 583 jobs. Personal income impacts range similarly from negative 3 to positive 25 million dollars per year. The loss in jobs could possibly be contributed to differences in labor patterns between the sectors where jobs are gained or lost. However, it is obvious that there would be a one-time employment and personal income benefit generated by plant construction.

Van Dyne indicated that the construction of both the Northeast Missouri Grain, LLC and Golden Triangle Energy, LLC plants, generated 546 direct, 190 indirect and 118 induced (time delayed) jobs totaling 854 jobs for the construction phase for a labor income figure of $18.72 million. Upon entering the operational stage, both plants created a total of 40 direct jobs, 1,474 indirect, and 301 induced jobs for a total of 1,815 translating into $31.27 million of annual labor income. Van Dyne's results indicate the effects of building one 40 MMGPY facility in Missouri generates 480 direct, 292 indirect and 351 induced (time delayed) jobs totaling 1,123 jobs for the construction phase for generating total labor income of $36.487 million. Upon entering the operational stage, the 40 MMGPY facility would employ 39 direct jobs, and generate 1,445 indirect, and 295 induced jobs totaling 1,779 jobs generating annual labor income of $30.65 million. Studies by Petrulis, et al., Littlepage, Evans, Urbanchuk and Otto et al., each found comparable impact numbers based on alternative size plants.

Chapter 4.

Results

The simulation results for each of four plant sizes (20, 40, 60, and 80 MMGY), two feedstocks (corn and grain sorghum), and three regions (Panhandle, Central, and Southeast) are contained in this chapter.

Panhandle Results

Corn

The results for an ethanol plant based in the Panhandle of Texas using corn as its major feedstock are included for all four plant sizes. The results also include a $0.20 per gallon state incentive up to $3 million per year. The percent of production covered by the incentive declines from 71.4 percent for the 20 MMGY plant to 17.9 percent for the 80 MMGY plant (**Table 4.1**).

Table 4.1. Percent of Ethanol Production Covered by a $0.20/Gallon Incentive Limited to $3 million and the Effective Incentive per Gallon Produced, by Plant Size.

Plant Size	Gallons Produced Including Denaturant	Percent of Production Covered by Incentive	Effective Incentive
20 MMGY	21 MMGY	71.4	$0.1429
40 MMGY	42 MMGY	35.7	$0.0714
60 MMGY	63 MMGY	23.8	$0.0476
80 MMGY	84 MMGY	17.9	$0.0357

Net Income

The graph of annual net income indicates that all four plant sizes follow the same pattern -- just on a different scale (**Figure 4.1**). This is primarily due to there being only a few differences in the cost of production for the different plant sizes. The only per gallon input costs that differ by plant size are labor, administration, and maintenance cost.

Also, as the size of plant increases, initial capital requirements per gallon are lower. Therefore, long term-debt and interest total expenses are lower per gallon. One advantage of the smaller plant size is that the incentive will cover a larger percentage of total plant production.

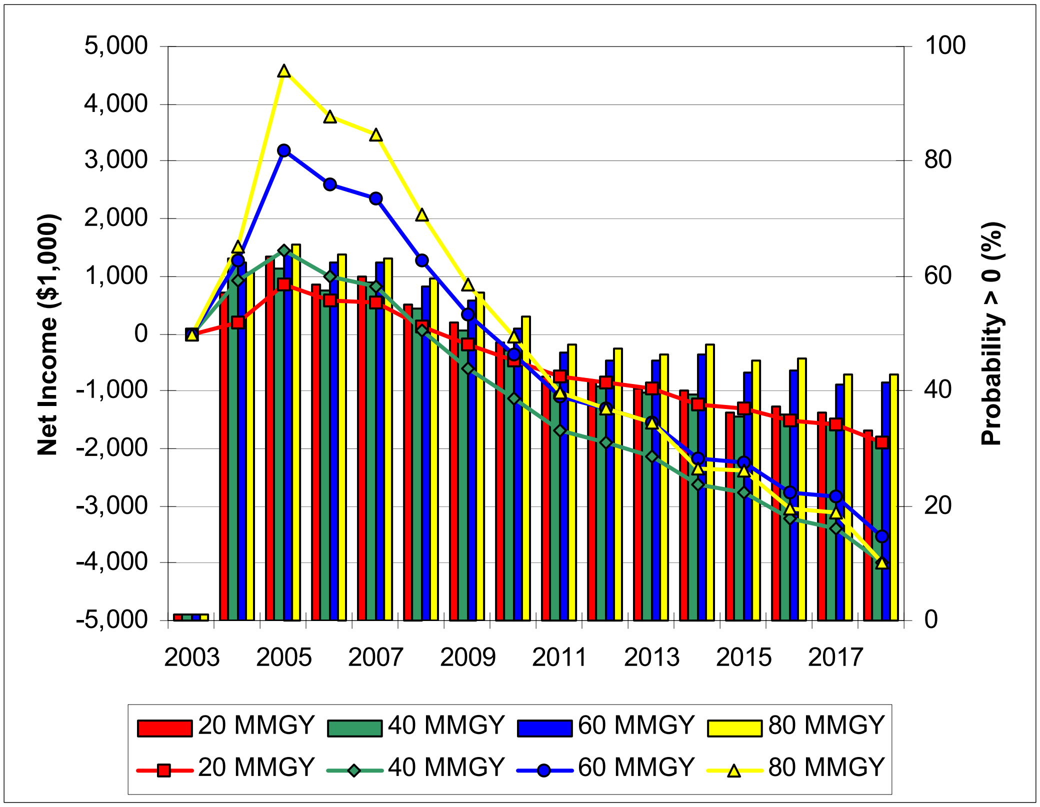

Figure 4.1. Projected Average Annual Net Income and Probability of Net Income > 0 for an Ethanol Plant using Corn in the Texas Panhandle Region.

The 20, 40, 60, and 80 MMGY plants have a net income on average of $800,000, $1.4 million, $3.2 million and $4.6 million respectively, in 2005 (indicated in the figure as lines). The average net income is projected to decrease each year through 2018 (-$1.9 million), (-$4.0 million), (-$3.5 million), and (-$4.0 million) for the 20, 40, 60 and 80 MMGY plants. In the event of losses, debt for larger plants grows more quickly than smaller plants because of the compounding interest on the larger volume losses. The incentive, which is capped at $3 million, helps to stem the losses for the smallest plant relatively more than for the larger plants.

The probabilities of positive net income also decrease over time for each plant size (indicated in the figure as bars). The probability of a positive net income for the 20 MMGY plant declines from 63 percent to 33 percent from 2005 to 2018. The probabilities for the 40, 60, and 80 MMGY plants drop 29, 23, and 23 percentage points from 61, 65, and 66 percent over the 2005 to 2018 period. The 60 and 80 MMGY plants maintain more than a 40 percent probability of positive net incomes even in 2018.

Figure 4.2 indicates the range and risk in projected annual net income for each plant size. The upper and lower lines contain 90 percent of the projected values. The two inside lines contain 50 percent of the projected values. The solid black line indicates the projected annual average. One observation that can be made by scanning the graphs is the increased range in net income as plant size increases. While most plant sizes generate negative net income on average, particularly in the later years, the graphs show that the range containing 50 percent of the projected values contains a significant positive area for most plant sizes. These results emphasize the need to consider more than annual averages when making the decision to build a plant.

In 2005, 90 percent of the projected net income results for the 20 MMGY plant range from -$5.5 million to $6.5 million. Fifty percent of the time net income ranges between -$1.4 and $3.2 million, with an average of $800,000. In 2018, 90 percent of the projected net income would range from -$9.7 million to $4.0 million, with 50 percent between -$4.2 million and $800,000, with an average of -$1.9 million. This indicates a gradual deterioration in the projected net income values. This deterioration is due to constant average ethanol prices while corn prices are projected to increase long term. Negative outcomes result in debt carryover that "snowball" in the out years leading to higher interest expenses and higher risks of negative net incomes.

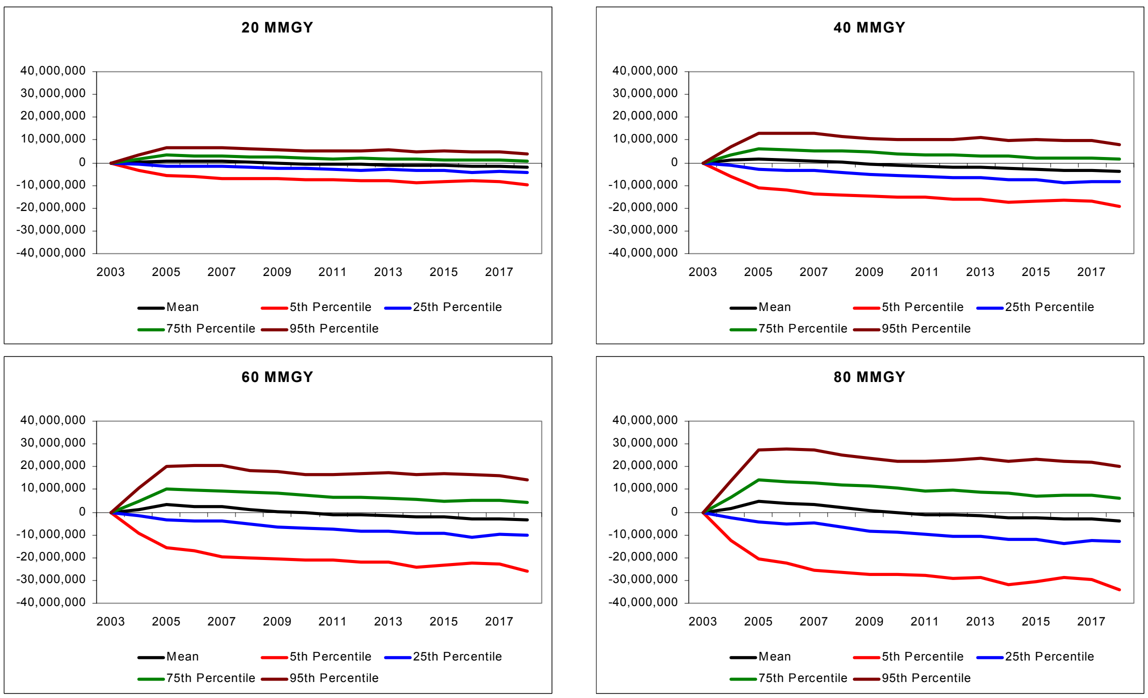

Figure 4.2. Projected Annual Net Income Risk for an Ethanol Plant using Corn in the Texas Panhandle Region by Plant Size.

For the 40 MMGY plant, 2005 net income ranges from -$11.2 million to $12.8 million 90 percent of the time and between -$3.0 million and $6.2 million 50 percent of the time averaging $1.4 million. The net income in 2018 for the 40 MMGY plant ranges from -$19.2 million to $7.8 million 90 percent of the time and between -$8.5 million and $1.5 million 50 percent of the time averaging -$3.9 million.

In 2005, 90 percent of the projected net income values for the 60 MMGY plant range from -$15.7 million to $20.1 million. Fifty percent of the time net income ranges between -$3.5 million and $10.3 million, with an average of $3.2 million. In 2018, 90 percent of the projected net income outcomes would range between -$26.2 million and $14.3 million, There is a 50 percent probability net income would be between -$10.2 million and $4.3 million, with an average of -$3.5 million. Again the larger volume plant facing a cost price squeeze and increasing debt loads has increased chances of large losses in any one year.

The projected net incomes in 2005 for the 80 MMGY plant range from -$20.6 million to $27.2 million 90 percent of the time and -$4.3 and $14.1 million 50 percent of the time, with an average net income of $4.6 million. By 2018, the ranges widen to -$34.3 million to $19.9 million and -$12.8 million and $6.3 million, with an average of -$4.0 million.

Ending Cash Before Borrowing

With a net income that is projected to become negative, ending cash before borrowing is going to decline into what most would call a debt spiral and will not recover. As the negative net income grows, ending cash declines at an increasing rate. The 20, 40, 60, and 80 MMGY plants would have an average ending cash value of $1.1 million, $2.4 million, $4.2 million, and $5.6 million, respectively, in 2005 (**Figure 4.3**). Average ending cash is projected to decrease each year to -$23.8 million, -$48.7 million, -$54 million, and -$66 million, respectively, by 2018. Debt grows faster for the larger plants because of the increased exposure from the larger amounts of money needed to operate.

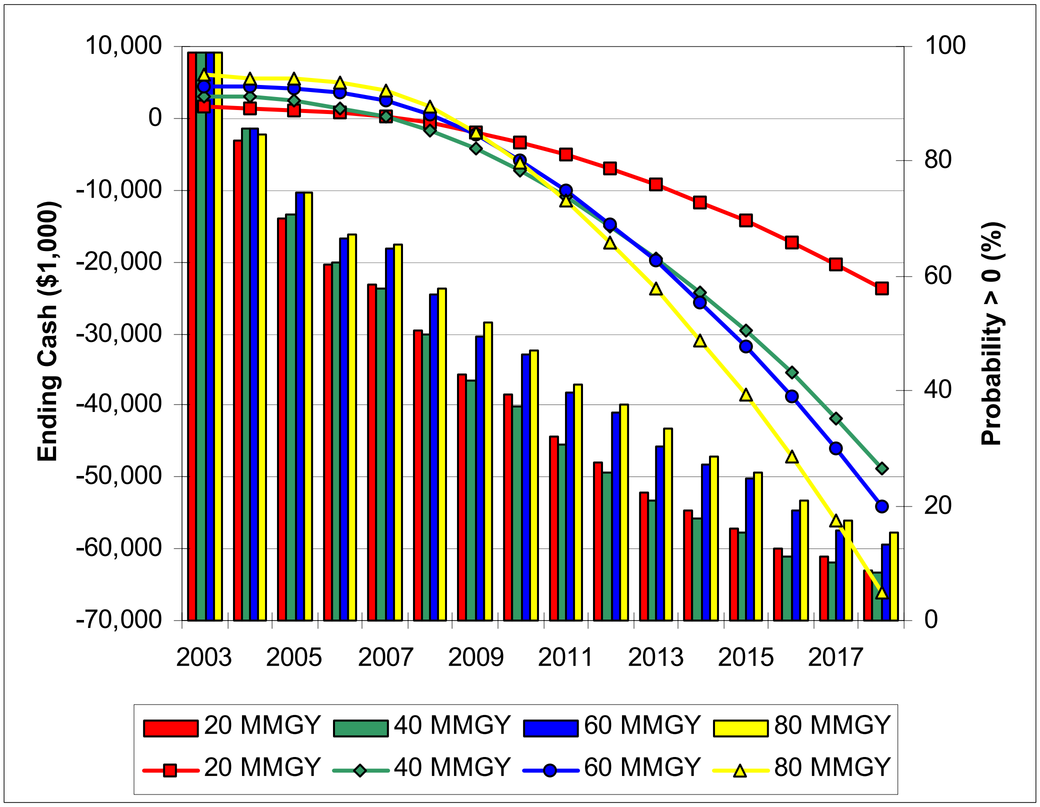

Figure 4.3. Projected Average Annual Ending Cash and the Probability of Ending Cash > 0 for an Ethanol Plant using Corn in the Texas Panhandle Region.

The probability of having a positive ending cash balance also decreases over time for each plant size. The 20 MMGY plant goes from 70 percent in 2005 to 9 percent by 2018. The 40 MMGY plant goes from 71 percent to 8 percent from 2005 to 2018. The 60 MMGY declines from 74 percent to 13 percent from 2005 to 2018 and the 80 MMGY plant goes from a 74 percent chance of positive ending cash in 2005 to only a 15 percent chance in 2018. While the largest plant has the lowest average ending cash in 2018, it also has the highest chances of positive ending cash of the four plants because of the wider range in risk it faces.

Figure 4.4 indicates the risk in projected ending cash balances for each plant size. Notice as plant size increases the chances of debt spiraling out of control is greater.

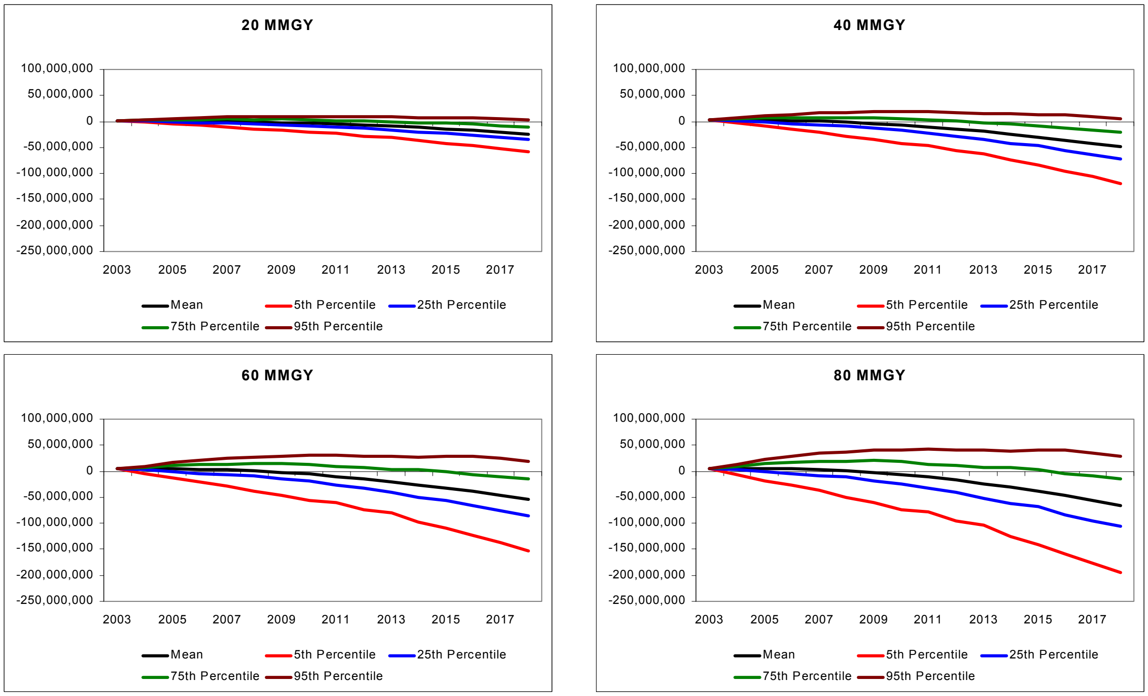

Figure 4.4. Projected Annual Ending Cash for an Ethanol Plant using Corn in the Texas Panhandle Region by Plant Size.

This is indicated by the widening in the range of projected outcomes throughout the period. None of the plant sizes are projected to have an average ending cash balance greater than zero beyond the first few years of the analysis.

Dividends Paid

In this analysis, dividends to stockholders will be paid at 30 percent of the positive net income after taxes. The probability of paying a dividend reflects the same percent of the time that the net income is positive. The 20, 40, 60, and 80 MMGY plants would average \$500,000, \$950,000, \$1.6 million, and \$2.1 million in dividends paid, respectively, in 2005 (**Figure 4.5**). The average dividend is projected to decrease each year with dividends at \$200,000, \$400,000, \$850,000, and \$1.2 million for the four plant sizes by 2018. The probabilities of paying a dividend also decrease over time.

Figure 4.5 also indicates the probability of paying dividends for each plant size. In 2005, 63, 61, 65, and 66 percent are the probabilities that the 20, 40, 60, and 80 MMGY plants would pay a dividend. By 2018, the probabilities decline to 33, 32, 42, and 43 for each of the four plant sizes.

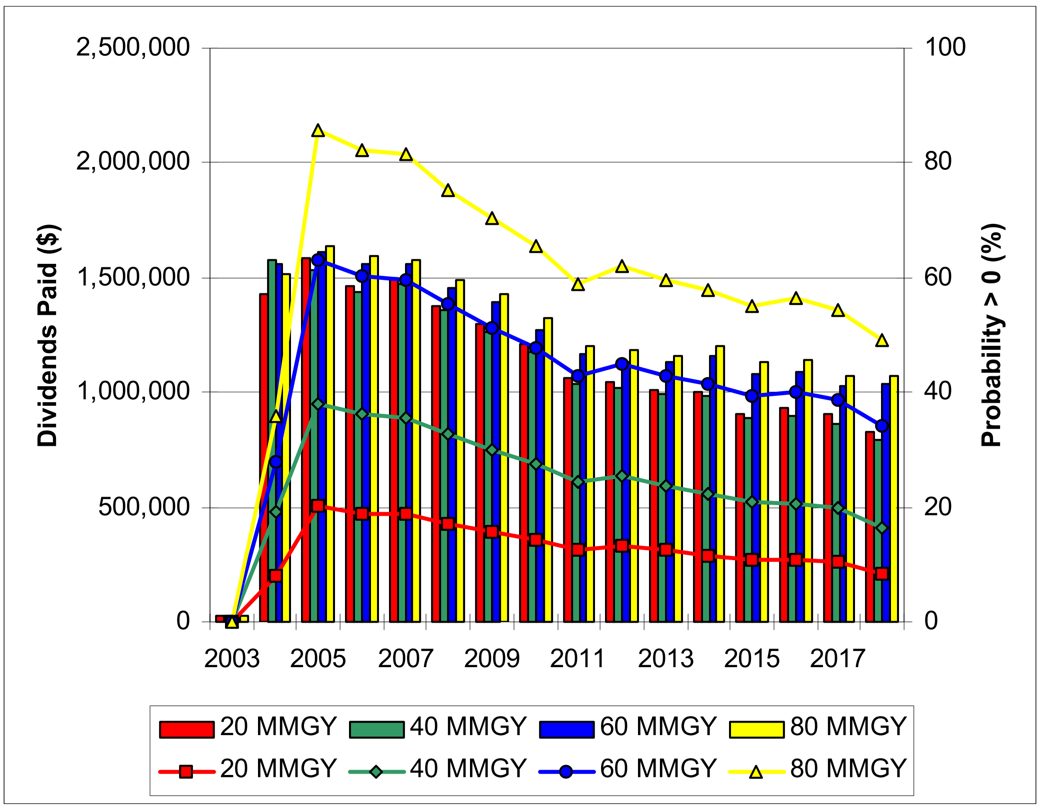

Figure 4.5. Projected Average Annual Dividends Paid and Probability of Dividends Paid > 0 for an Ethanol Plant using Corn in the Texas Panhandle Region.

Figure 4.6 indicates the risk for projected dividends paid by plant size. The dividends projected to be paid by the 20 MMGY plant range from 0 to $1.2 million early in the period and 0 to $1.2 million by 2018. This same pattern holds for all plant sizes with projected dividends paid increasing for each plant size.

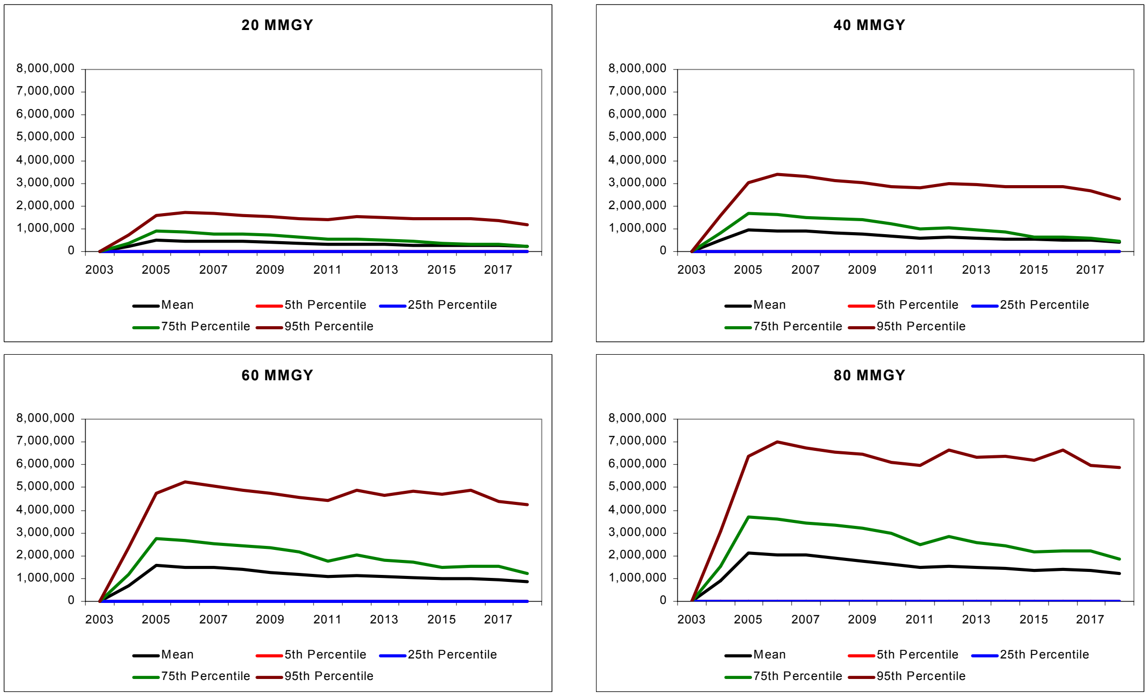

Figure 4.6. Projected Annual Dividends Paid for an Ethanol Plant using Corn in the Texas Panhandle Region by Plant Size.

Real Net Worth

With the projected declines in cash position and net income coupled with declining asset values, nominal net worth (not adjusted for inflation) is going to decline. Nominal net worth is adjusted to take into account inflation over time on the real value of the plant's net worth. This is referred to as real net worth.

Figure 4.7 contains the projected real net worth results and the probability that net worth will be greater than zero. The 20, 40, 60, and 80 MMGY plants have an average real net worth of $12.8 million, $23.6 million, $34.1 million, and $43.7 million, respectively, in 2005. The average real net worth is projected to decrease each year of the analysis. By 2018, average real net worth for the 20, 40, 60 and 80 MMGY plants is expected to be $50,000, -$1.3 million, $3 million, and $5 million, respectively.

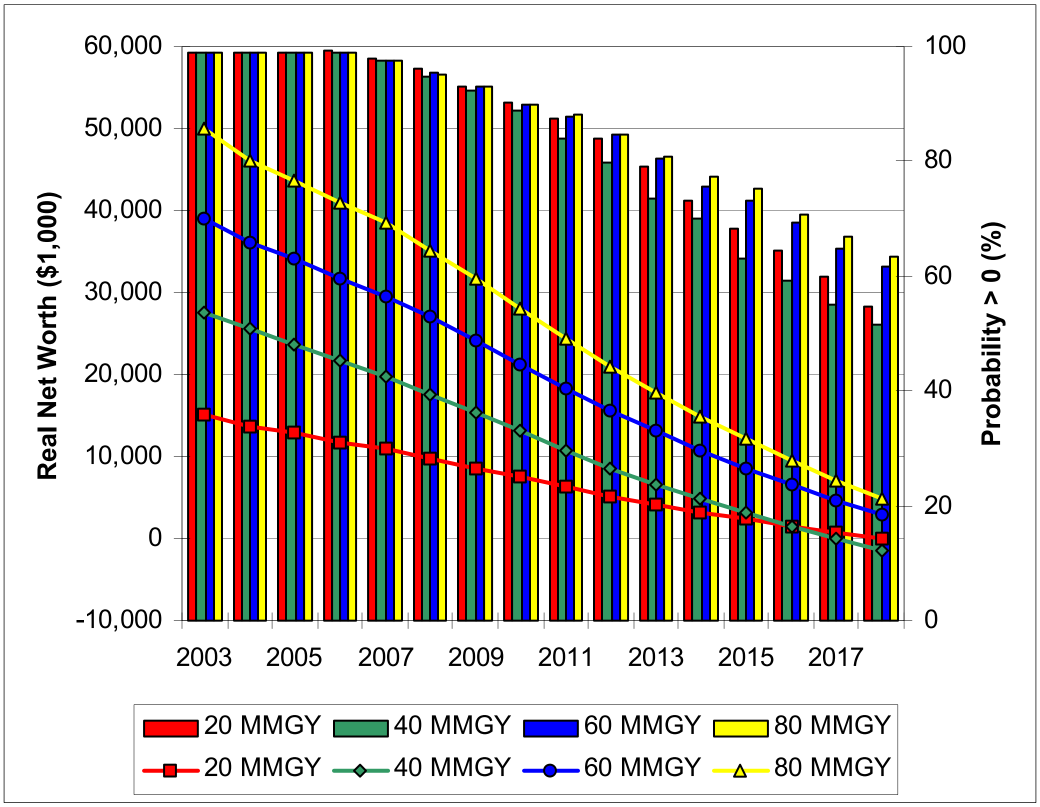

Figure 4.7. Projected Average Annual Real Net Worth and Probability of Real Net Worth > 0 for an Ethanol Plant using Corn in the Texas Panhandle Region.

The probabilities of positive real net worth also decrease over time for each plant size. Each plant size has a 99 percent chance of a positive real net worth in 2005, but all decline annually ending at 55, 52, 62, and 63 percent, respectively by 2018.

Figure 4.8 indicates the risk for projected annual real net worth for each plant size. Real net worth for all four plant sizes is projected to decline over the period with the 20 and 40 MMGY plants having a negative average real net worth by 2018 and the 60 and 80 MMGY plants remaining positive, on average.

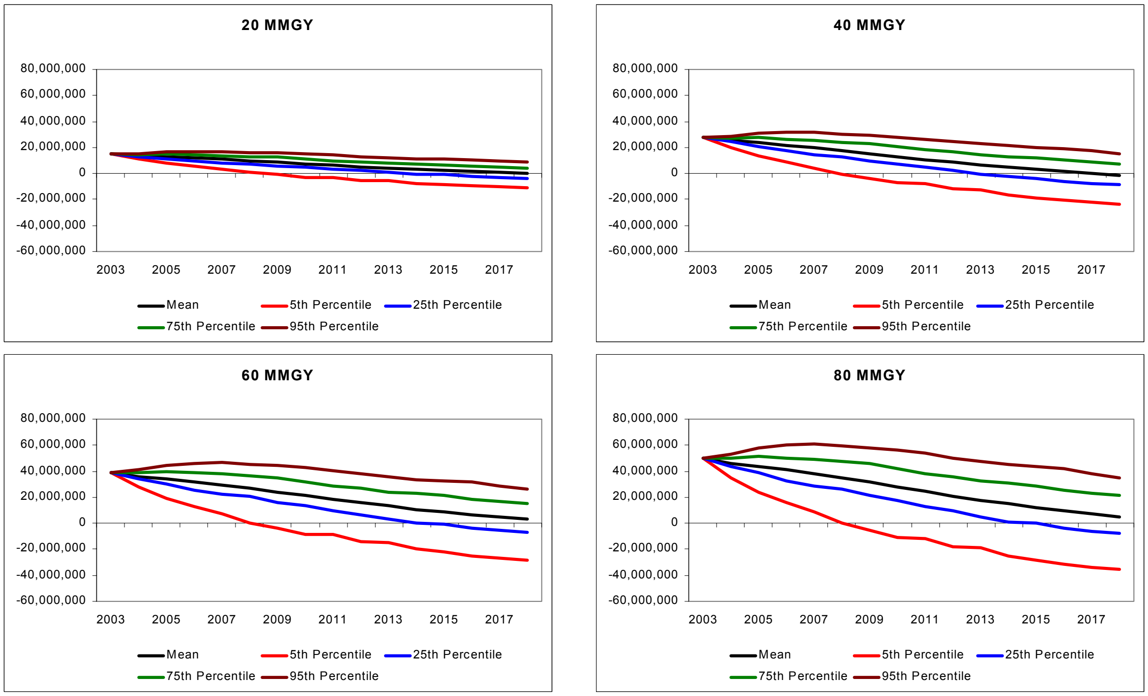

Figure 4.8. Projected Annual Real Net Worth for an Ethanol Plant using Corn in the Texas Panhandle Region by Plant Size.

Net Present Value

Net present value (NPV) provides in one number, a summary of much of the information presented earlier. A positive NPV indicates that the discounted stream of net returns is more than sufficient to achieve the desired rate of return as given by the discount rate, in this case eight percent.

Figure 4.9 provides a cumulative density function of NPV for the four plant sizes. Average NPV for the 20, 40, 60, and 80 MMGY plants are -$12 million, -$23 million, -$26 million, and -$31 million respectively. The cumulative density function illustrates the risk of potential NPV outcomes. For example, the 40 MMGY plant could realize an NPV ranging from -$75 million to around $10 million. Each point of a single CDF represents the intersection of an NPV (horizontal axis) and a probability (vertical axis).

Each point can be interpreted as the probability that NPV would fall below a particular number.

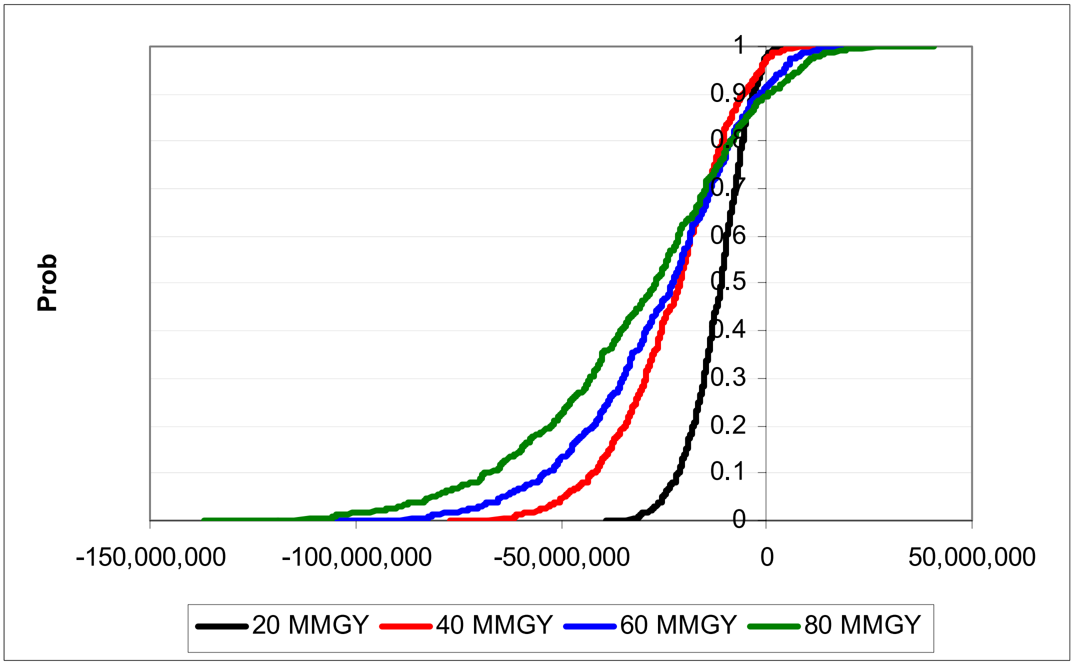

Figure 4.9. Cumulative Density Function (CDFs) of Net Present Value for an Ethanol Plant using Corn in the Texas Panhandle Region by Plant Size.

The analysis indicates that there is a very small chance (roughly 10 percent) that any of the alternative plant sizes would return a zero or positive NPV (this is measured by the portion of the line at and to the right of the vertical axis ($0)). Which means that there is a 90 percent or greater chance that none of the four plant sizes will provide a return greater than the discount rate.

<u>Grain Sorghum</u>

The results for an ethanol plant based in the panhandle of Texas using grain sorghum as its major feedstock are included for four plant sizes, 20, 40, 60, and 80 MMGY.

Net Income

As with corn, net incomes for each plant size follow the same pattern (**Figure 4.10**). This is primarily due to there being only a few differences in the cost of production for the different plant sizes.

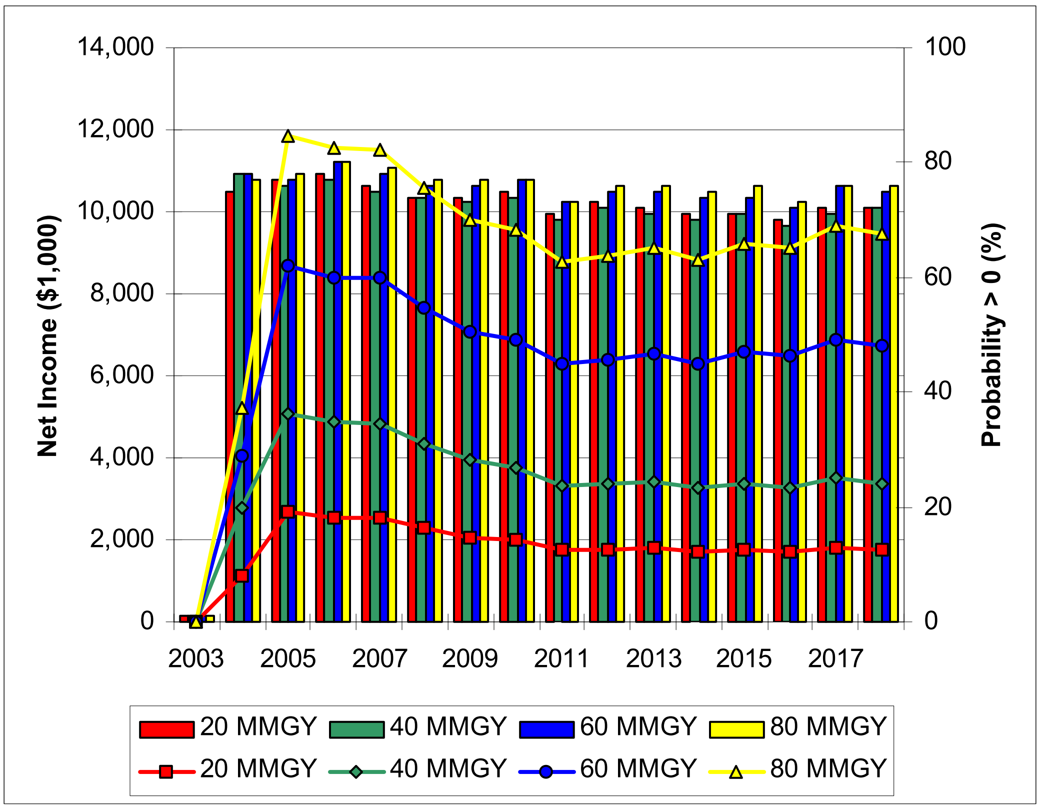

Figure 4.10. Projected Average Annual Net Income and Probability of Net Income > 0 for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region.

The 20, 40, 60, and 80 MMGY plants have an average net income of $2.6 million, $5.0 million, $8.7 million, and $11.8 million respectively, in 2005. The average net income is projected to decrease each year to $1.8 million, $3.4 million, $6.7 million and $9.5 million for the 20, 40, 60, and 80 MMGY plants by 2018. In contrast to the corn plants, net income remains positive for each size plant throughout the study period.

The probabilities of positive net income also decrease slightly over time for each plant size. The probability of a positive net income for the 20 MMGY plant declines from 77 percent in 2005 to 72 percent in 2018. The probabilities for the 40, 60, and 80 MMGY plants decline 4, 2, and 2 percentage points from 76, 77, and 78 percent over the 2005 to 2018 period.

Figure 4.11 indicates the risk for projected annual net income for each plant size. In 2005, 90 percent of the projected net income results for the 20 MMGY plant range from -$4.9 million to $8.8 million. Fifty percent of the time net income ranges between $300,000 and $5.6 million, with an average of $2.7 million. In 2018, 90 percent of the projected net income would range from -$6.9 million to $7.7 million, with 50 percent between -$500,000 and $4.4 million, with an average of $1.8 million. This indicates a gradual deterioration in the projected net income values.

For the 40 MMGY plant, 2005 net income ranges from -$10.1 million to $17.4 million 90 percent of the time and between $300,000 and $10.9 million 50 percent of the time averaging $5.1 million. In 2018, net income for the 40 MMGY plant ranges from -$1.2 million to $8.7 million 50 percent of the time with an average of $3.4 million. Again, this is in contrast to the average annual losses for the corn plant.

In 2005, the projected net income values for the 60 MMGY plant averaged $8.7 million. Fifty percent of the time net income is between $1.6 and $17.3 million. By 2018, there is a 50 percent chance that net income will be between -$150,000 and $14.7 million, with an average of $6.7 million. There is also the chance of significant losses with a 90 percent chance that net income would range between -$17.1 and $24.5 million.

Net income in 2005 for the 80 MMGY plant averages $11.9 million and declines to $9.4 million by 2018. By 2018, the ranges of net incomes widen from -$22.3 million to $33.1 million.

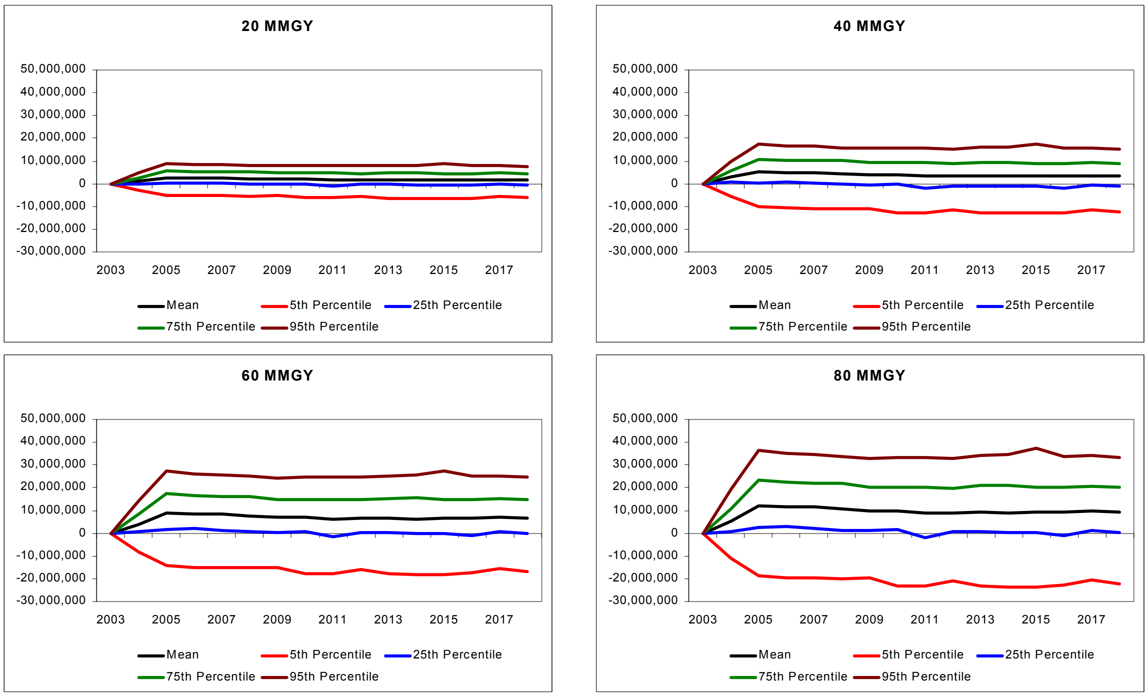

Figure 4.11. Projected Annual Net Income Risk for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region by Plant Size.

Ending Cash Before Borrowing

With a net income that is projected to remain positive, ending cash before borrowing is going to reach a peak and then slightly decline but remain positive. As the positive net income begins to decline, the ending cash number will grow at a decreasing rate and then decline as it services debt. The 20, 40, 60, and 80 MMGY plants would have an average ending cash value of $2.8 million, $5.8 million, $9.2 million, and $12.4 million, respectively, in 2005 (**Figure 4.12**). Average ending cash is projected to increase at each plant size with peaks from 2010 to 2017 depending on the plant size, then decrease each year to $3.6 million, $6.5 million, $21.9 million, and $32.9 million, respectively, by 2018. The larger plants ending cash peaks later than the smaller plants because of the economies of size. These plants are caught in a cost price squeeze as feedstock prices are projected to increase slowly while ethanol prices remain flat.

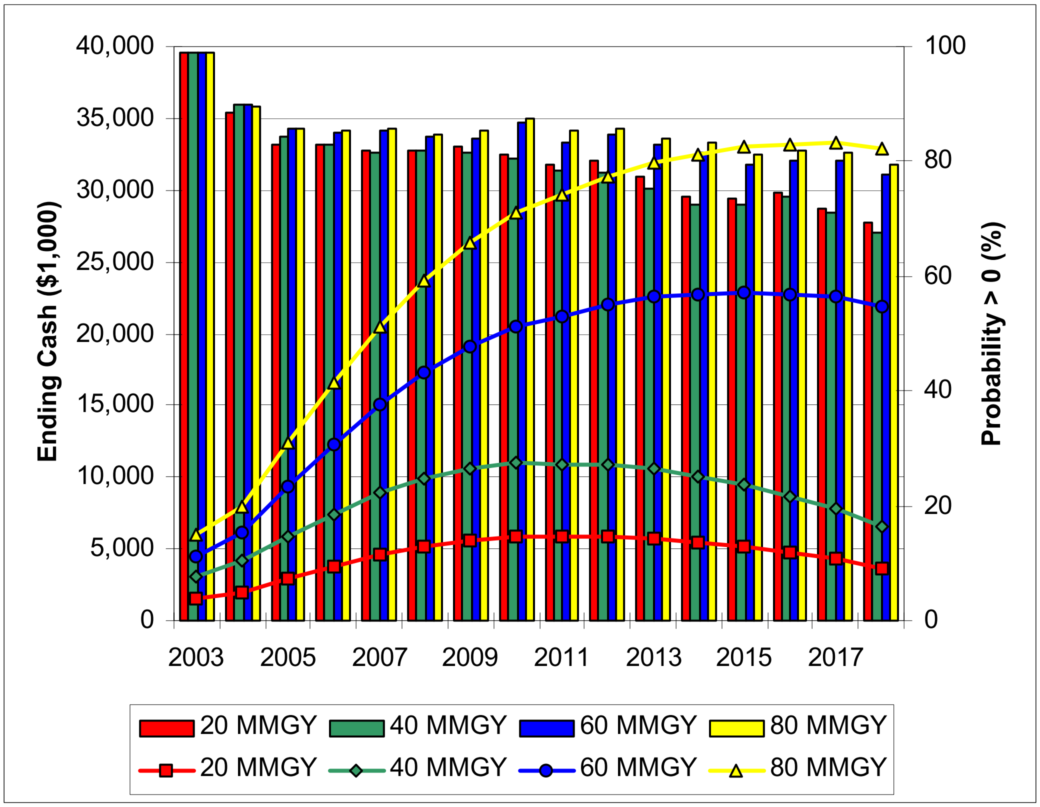

Figure 4.12. Projected Average Annual Ending Cash and the Probability of Ending Cash > 0 for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region.

The probability of having a positive ending cash balance decreases over time for each plant size. The 20 MMGY plant goes from 83 percent in 2005 to 69 percent by 2018. The 40 MMGY plant goes from 84 percent to 68 percent from 2005 to 2018. The 60 MMGY declines from 86 percent to 78 percent from 2005 to 2018 and the 80 MMGY plant goes from a 86 percent chance of positive ending cash in 2005 to 80 percent chance in 2018. While declining, these probabilities are positive and relatively high.

Figure 4.13 indicates the risk in projected ending cash balances for each plant size. Notice as plant size increases the chances of ending cash growing and remaining positive over time increases. This is indicated by the widening in the range of projected outcomes throughout the period. All of the plant sizes are projected to have an average ending cash balance greater than zero throughout the analysis. There is greater than a 25 percent chance of negative ending cash reserves after 2005 for the 20 and 40 MMGY plants, and less than 25 percent for the two larger plants.

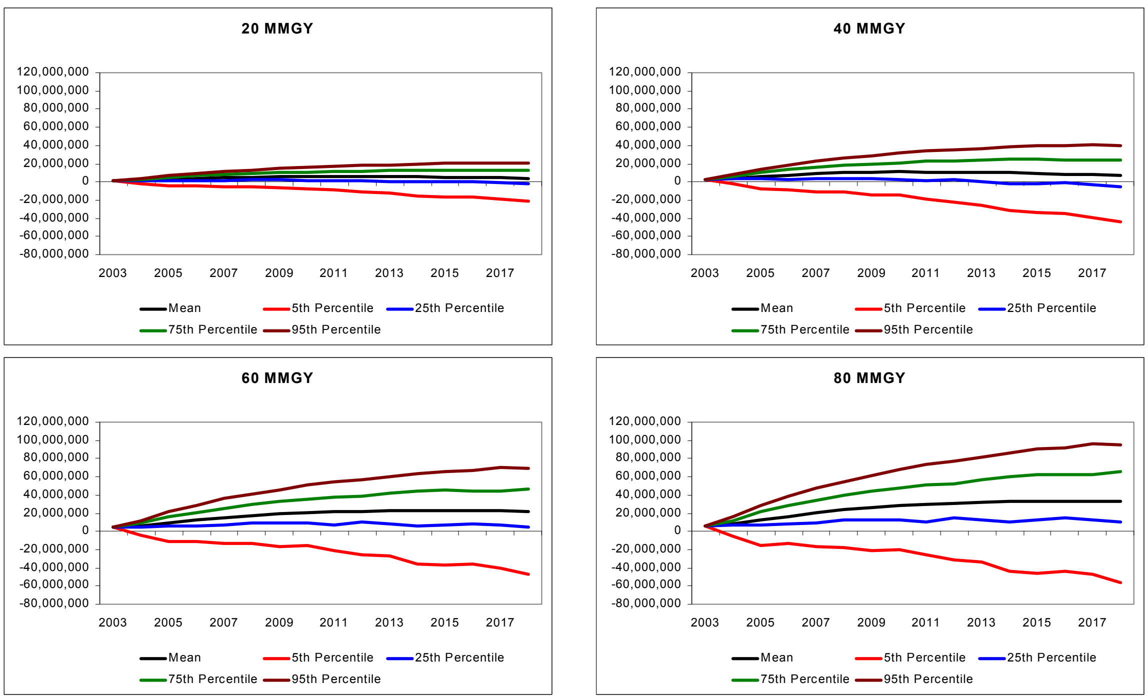

Figure 4.13. Projected Annual Ending Cash for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region by Plant Size.

Dividends Paid

In this analysis, dividends to stockholders will be paid at 30 percent of positive net income after taxes. The probability of paying out a dividend reflects the same percent of the time that the net income is positive. The 20, 40, 60, and 80 MMGY plants would pay an average of $850,000, $1.6 million, $2.6 million, and $3.4 million in dividends, respectively, in 2005 (**Figure 4.14**). The average dividend is projected to decrease slightly each year with dividends of $700,000, $1.4 million, $2.4 million, and $3.2 million for the four plant sizes by 2018. The probabilities of paying a dividend also decrease over time reflecting slightly lower net income.

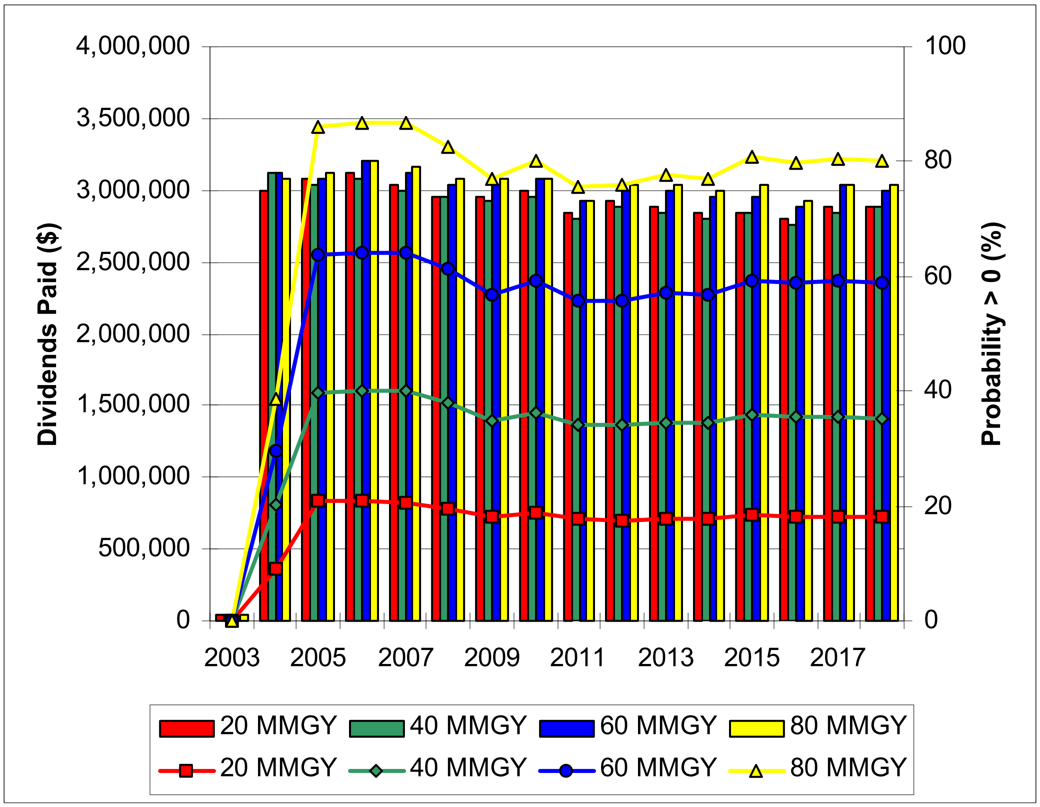

Figure 4.14. Projected Average Annual Dividends Paid and Probability of Dividends Paid > 0 for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region.

Figure 4.14 also indicates the probability of paying dividends for each plant size. In 2005, each plant pays a dividend more than 75 percent of the time. By 2018, the probabilities are roughly the same at 72, 72, 75, and 76 for each of the four plant sizes.

Figure 4.15 indicates the risk in projected dividends paid by plant size. The projected dividends paid by the 20 MMGY plant range from $0 to $2.1 million early in the period to $2.0 million to no dividends by 2018. This same pattern holds for all plant sizes with projected dividends paid increasing for each plant size.

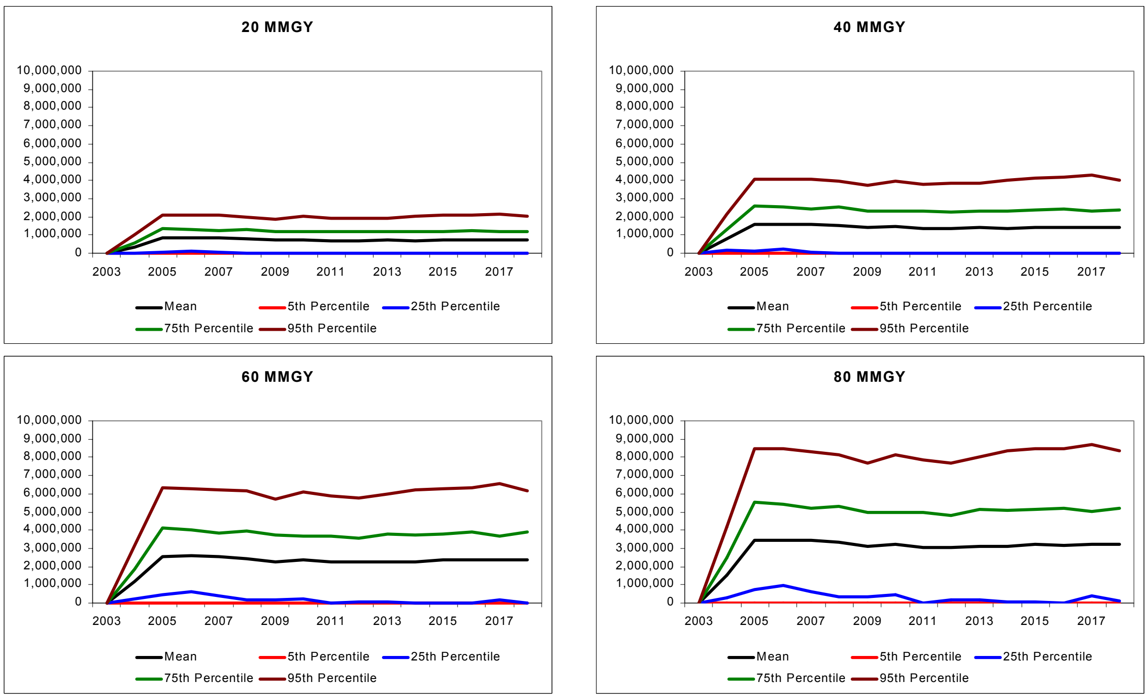

Figure 4.15. Projected Annual Dividends Paid for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region by Plant Size.

Real Net Worth

Figure 4.16 contains the projected real net worth results and the probability that real net worth will be greater than zero. The 20, 40, 60, and 80 MMGY plants would have an average real net worth of $14.3 million, $26.6 million, $38.4 million, and $49.6 million, respectively, in 2005. The average real net worth is projected to decrease over the analysis period. By 2018, average real net worth for the 20, 40, 60, and 80 MMGY plants is expected to be $8.7 million, $16.1 million, $27 million, and $36 million, respectively.

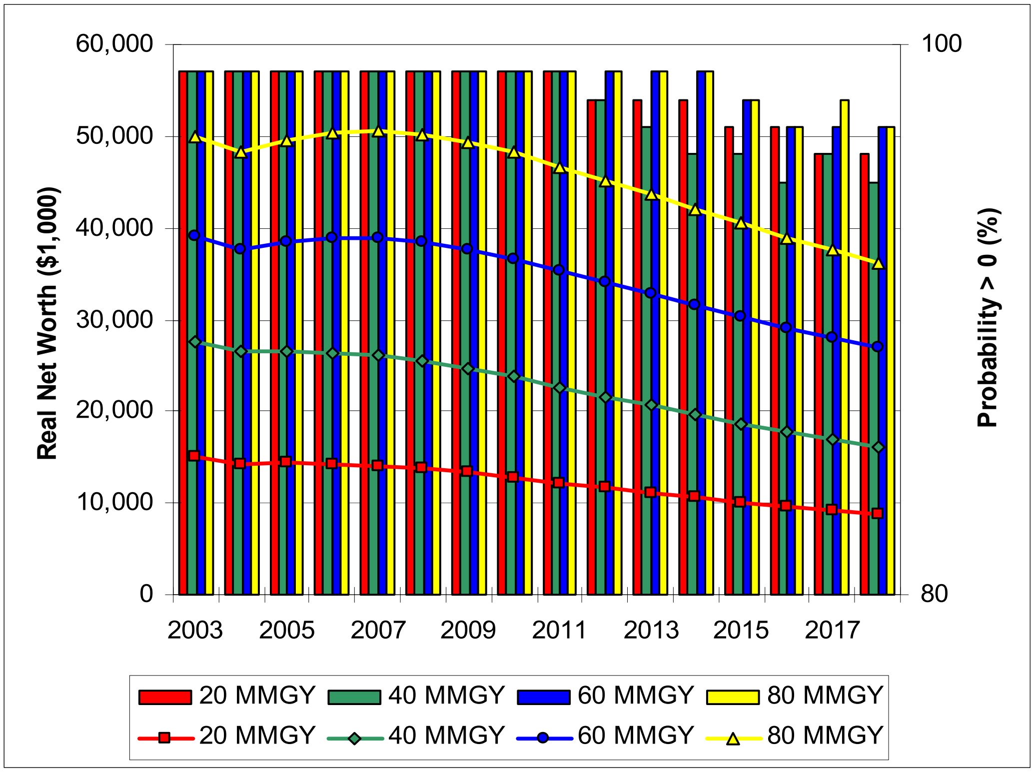

Figure 4.16. Projected Average Annual Real Net Worth and Probability of Real Net Worth > 0 for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region.

The probabilities of positive real net worth also decrease over time for each plant size. Each plant size has a 99 percent chance of a positive real net worth in 2005 but all decline slightly ending at 96, 95, 97 and 97 percent, respectively by 2018.

Figure 4.17 indicates the range in projected annual real net worth for each plant size. All are projected to decline over the period with the all plant sizes staying positive with less than a 5 percent chance of falling below zero.

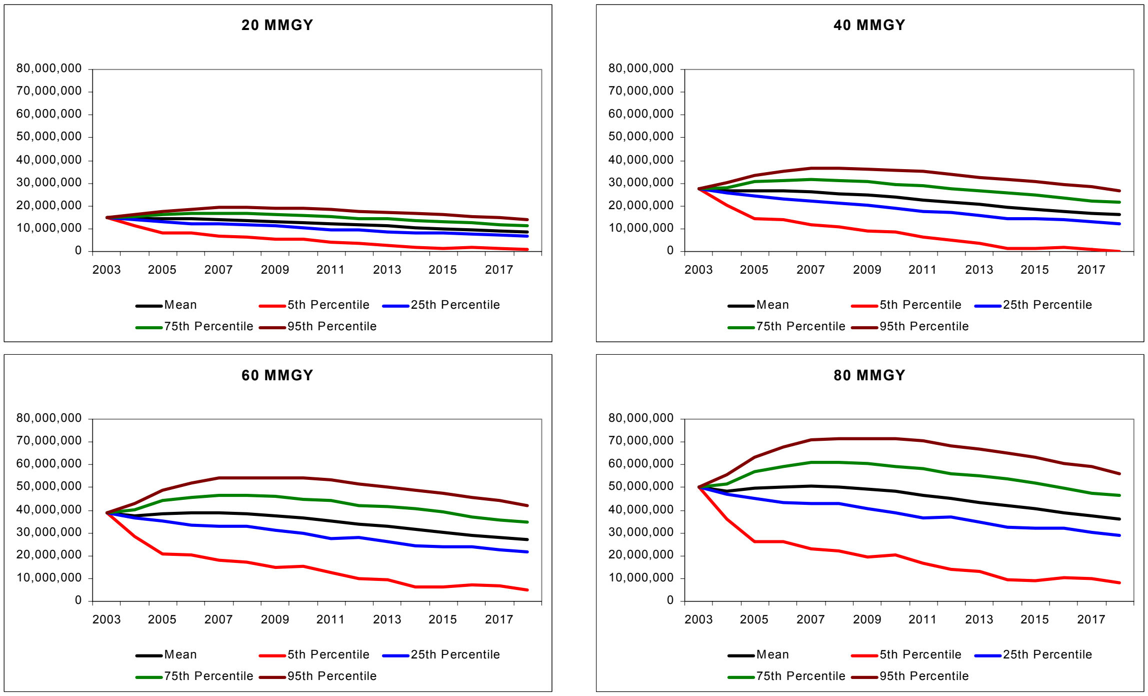

Figure 4.17. Projected Annual Real Net Worth for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region by Plant Size.

Net Present Value

Figure 4.18 provides a cumulative density function of NPV for the four plant sizes. The analysis indicates that there is an above average chance (roughly 75 percent) that the 80 MMGY plant would return a zero or positive NPV (as measured by the portion of the line at and to the right of the vertical axis ($0)) and a 50 percent chance that the 20 MMGY plant would return a zero or positive NPV.

The economic results for an ethanol plant using grain sorghum as its primary feedstock appear to be substantially better than that of corn. The most important reason is the price relationship between grain sorghum and corn. Grain sorghum's, at times, sharp price discount to corn allows the plant to source their most important input, feedstocks, at relatively inexpensive levels. The result is a substantially more promising

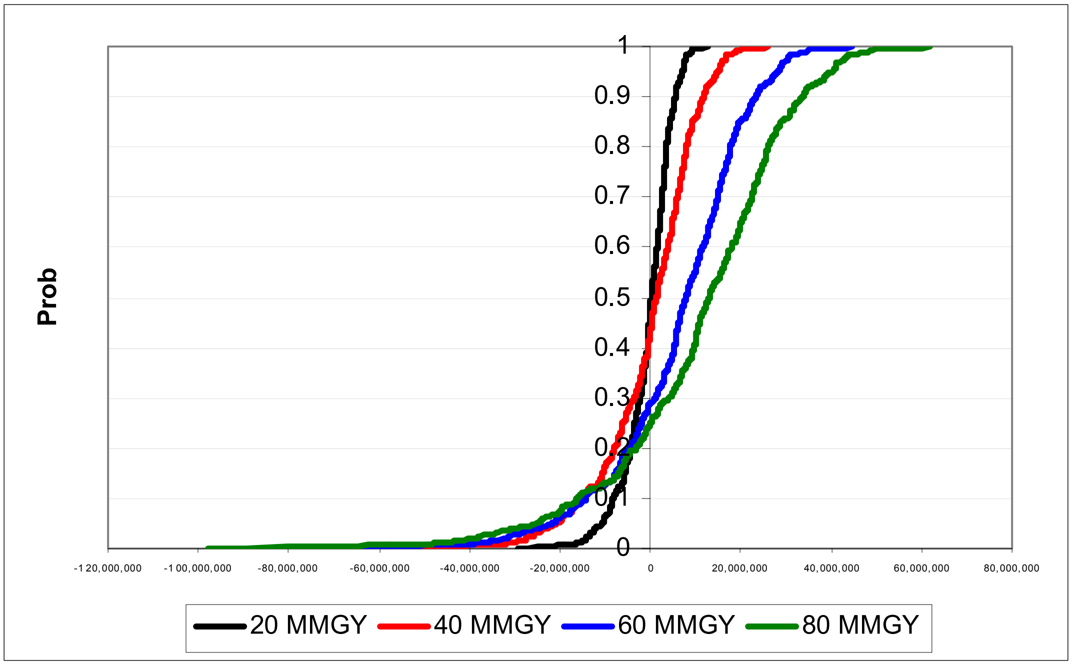

Figure 4.18. Cummulative Density Function (CDFs) of Net Present Value for an Ethanol Plant using Grain Sorghum in the Texas Panhandle Region by Plant Size.

outcome if grain sorghum is used as the feedstock of choice. It is important to note that these results are influenced by the assumption that the presence of an ethanol plant would not substantially change the prices of corn or grain sorghum.

Central Texas Results

<u>Corn</u>

The results for an ethanol plant based in the central part of Texas using corn as its major feedstock are included for four plant sizes producing 20, 40, 60, and 80 MMGY.

Net Income

Net incomes for all four ethanol plant sizes follow the same pattern (**Figure 4.19**).

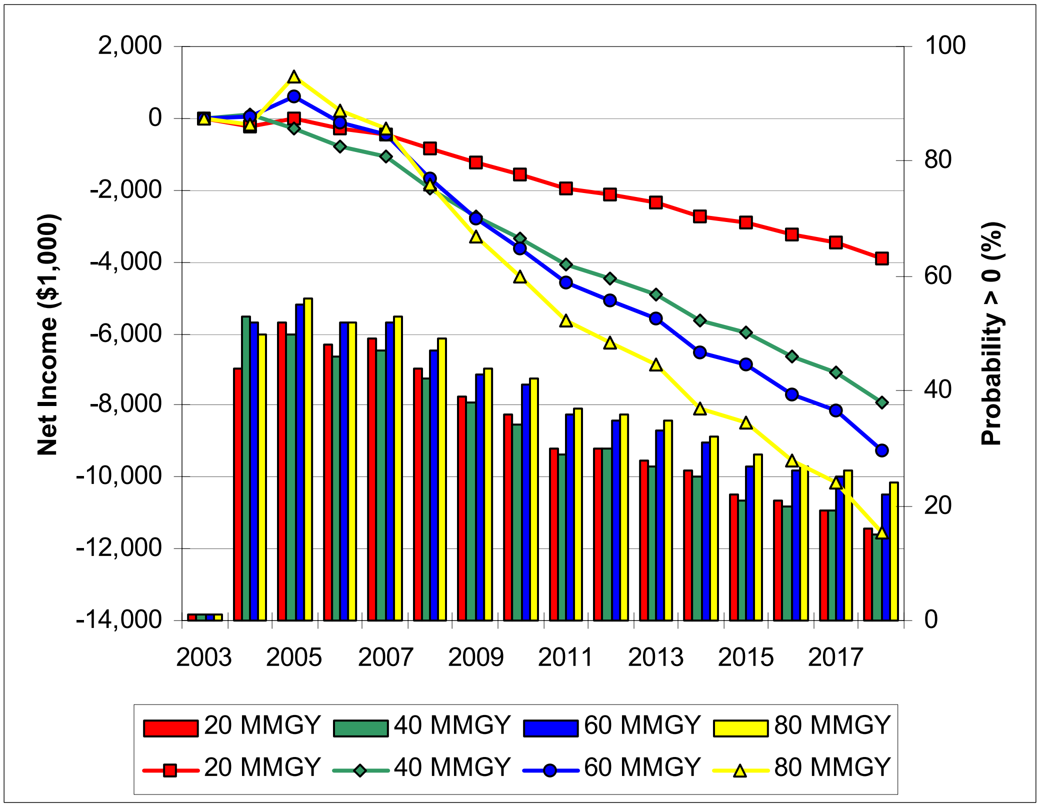

Figure 4.19. Projected Average Annual Net Income and Probability of Net Income > 0 for an Ethanol Plant using Corn in the Central Texas Region.

The 20, 40, 60, and 80 MMGY plants have an average net income of -$25,000, -$250,000, $600,000, and $1.1 million respectively, in 2005. The average net income is projected to decrease each year to -$3.9 million, -$7.9 million, -$9.2 million, and -$11.5 million for the 20, 40, 60, and 80 MMGY plants by 2018.

The probabilities of positive net income also decrease over time for each plant size. The probability of a positive net income for the 20 MMGY plant declines from 52 percent in 2005 to 16 percent in 2018. The probabilities for the 40, 60, and 80 MMGY plants drop 35, 33, and 32 percentage points from 50, 55, and 56 percent over the 2005 to 2018 period.

Figure 4.20 indicates the risk in projected annual net income for each plant size. In 2005, 90 percent of the projected net income results for the 20 MMGY plant range from -$6.7 million to $5.7 million with an average of -$25,000. By 2018, 90 percent of the projected net income ranges from -$12.0 million to $2.1 million, with an average of -$3.9 million. This indicates a sharp deterioration in the projected net income values.

For the 40 MMGY plant, 2005 net income ranges from -$13.6 million to $11.1 million 90 percent of the time, averaging -$250,000. The net income in 2018 for the 40 MMGY plant ranges from -$24.3 million to $4.0 million 90 percent of the time averaging -$7.9 million.

The projected net income values for the 60 MMGY plant range from -$19.4 million to $17.7 million 90 percent of the time in 2005. By 2018, 90 percent of the projected net income ranges between -$33.6 million and $8.6 million, with an average of -$9.2 million. Average net income declines by almost $10 million between 2004 and 2008. The results for the 80 MMGY plant indicate the same trend.

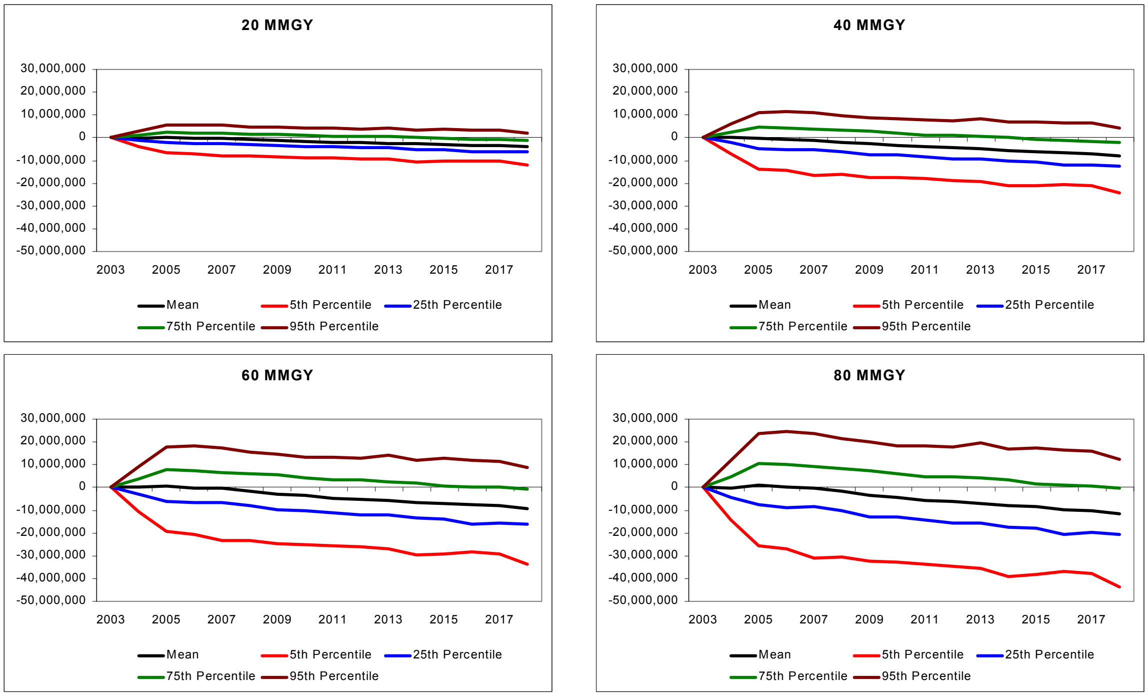

Figure 4.20. Projected Annual Net Income Risk for an Ethanol Plant using Corn in the Central Texas Region by Plant Size.

Ending Cash Before Borrowing

With a negative net income, ending cash before borrowing declines into an unrecoverable debt spiral. As the negative net income grows, the ending cash number declines at an increasing rate. The 20, 40, 60, and 80 MMGY plants have average ending cash values of $125,000, $425,000, $1.3 million, and $1.8 million, respectively, in 2005 (**Figure 4.21**). By 2018, average ending cash is projected to be -$40.2 million, -$81 million, -$100 million, and -$127 million, respectively. Debt grows faster for the larger plants because of the increased exposure from the larger amounts of money needed to operate.

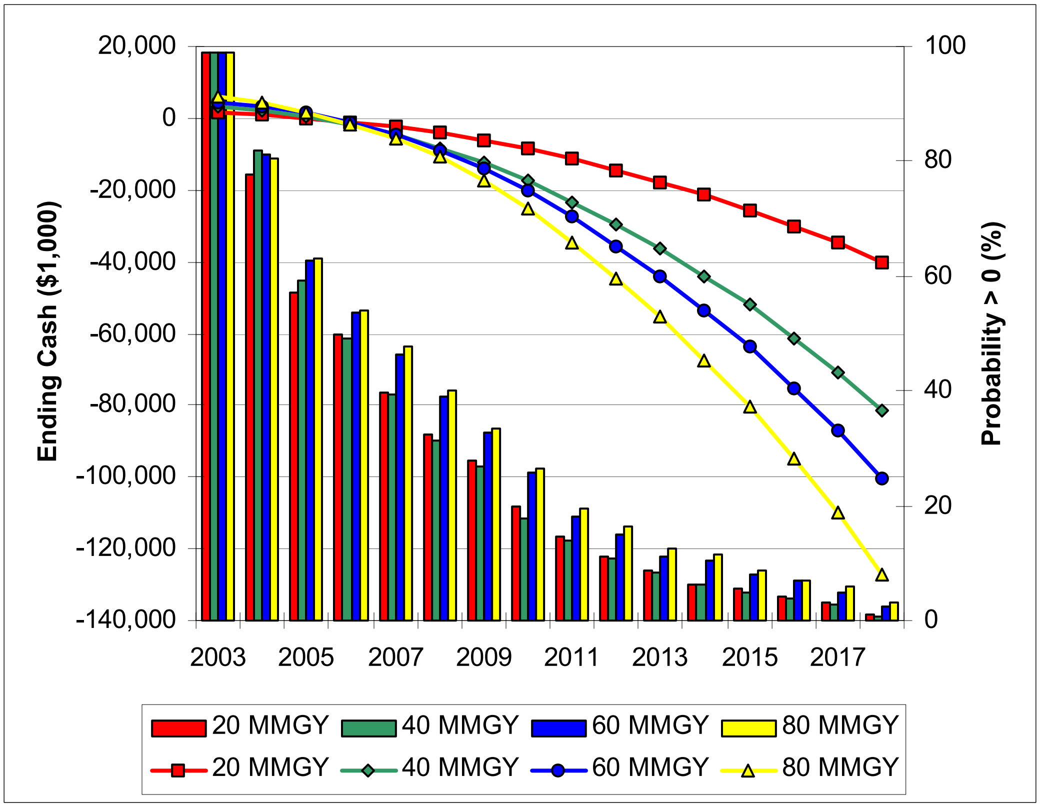

Figure 4.21. Projected Average Annual Ending Cash and the Probability of Ending Cash > 0 for an Ethanol Plant using Corn in the Central Texas Region.

The probability of having a positive ending cash balance also decreases over time for each plant size. By 2018, no plant has more than a three percent chance of a positive ending cash balance.

Figure 4.22 indicates the range in projected ending cash balances for each plant size. As plant size increases, the probability that debt spirals out of control is greater. This is indicated by the widening in the range of projected outcomes throughout the period. None of the plant sizes are projected to have an average ending cash balance greater than zero beyond the first few years of the analysis.

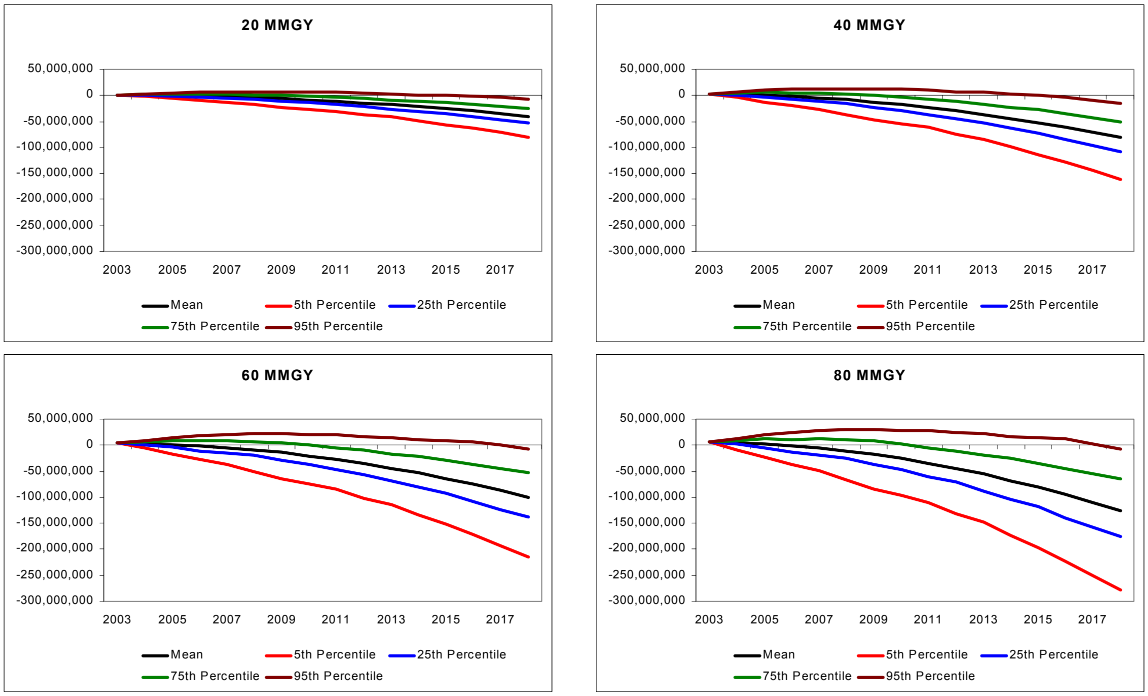

Figure 4.22. Projected Annual Ending Cash for an Ethanol Plant using Corn in the Central Texas Region by Plant Size.

Dividends Paid

The probability of paying out a dividend reflects the same percent of the time that the net income is positive. On average, the 20, 40, 60, and 80 MMGY plants would pay $375,000, $735,000, $1.2 million, and $1.7 million in dividends, respectively, in 2005 (**Figure 4.23**). The average dividend is projected to decrease each year with dividends at $75,000, $150,000, $350,000, and $525,000 for the four plant sizes by 2018.

Figure 4.23 indicates the probability of paying dividends for each plant size. In 2005, 52, 50, 55, and 56 percent are the probabilities that the 20, 40, 60, and 80 MMGY plants would pay a dividend. By 2018, the probabilities decline to 16, 15, 22, and 24 for each of the four plant sizes.

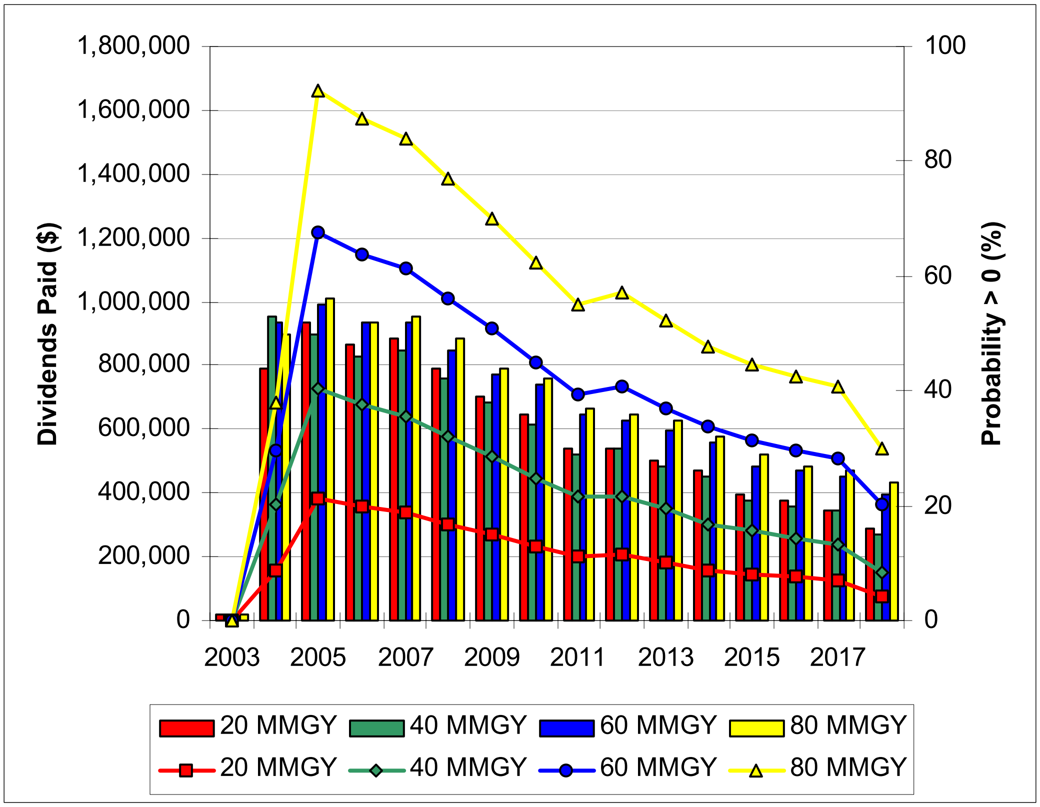

Figure 4.23. Projected Average Annual Dividends Paid and Probability of Dividends Paid > 0 for an Ethanol Plant using Corn in the Central Texas Region.

The dividends projected to be paid by the 20 MMGY plant range from 0 to $1.4 million early in the period to 0 to $625,000 by 2018 (**Figure 4.24**). This same pattern holds for all plant sizes with projected dividends paid increasing for each plant size.

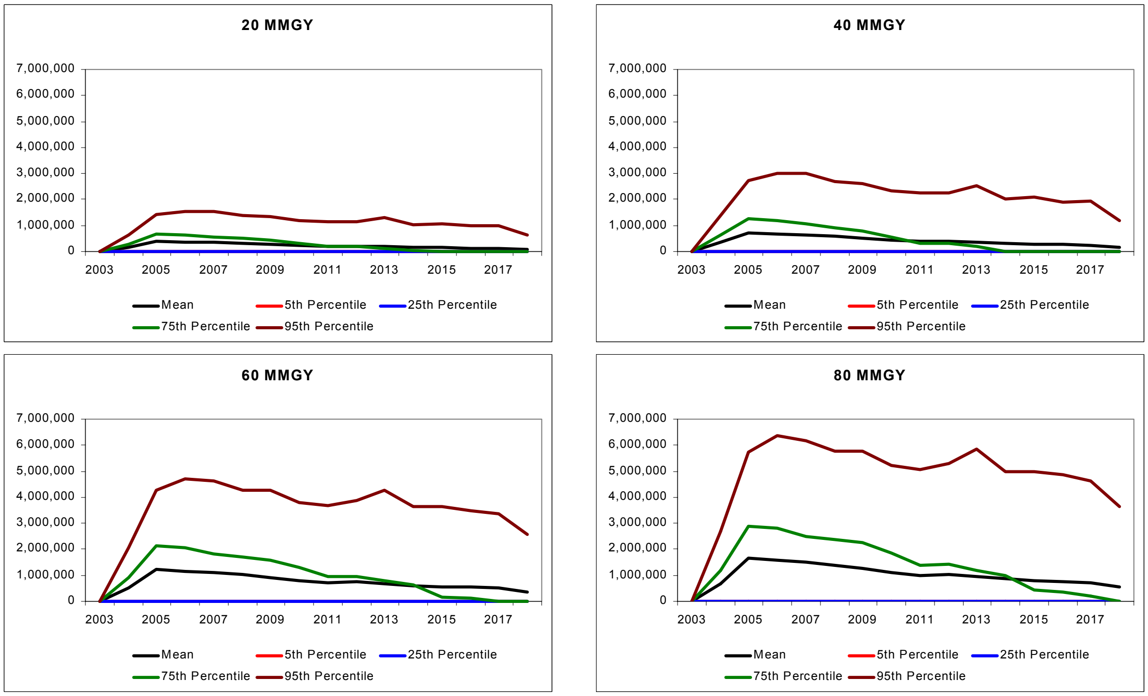

Figure 4.24. Projected Annual Dividends Paid for an Ethanol Plant using Corn in the Central Texas Region by Plant Size.

Real Net Worth

The 20, 40, 60, and 80 MMGY plants would have an average real net worth of $12.0 million, $22.0 million, $31.6 million, and $40.5 million, respectively, in 2005 (**Figure 4.25**). The average real net worth is projected to decrease each year of the analysis. By 2018, average real net worth for the 20, 40, 60, and 80 MMGY plants is expected to be -$5.1 million, -$11.7 million, -$11.6 million, and -$14.2 million, respectively.

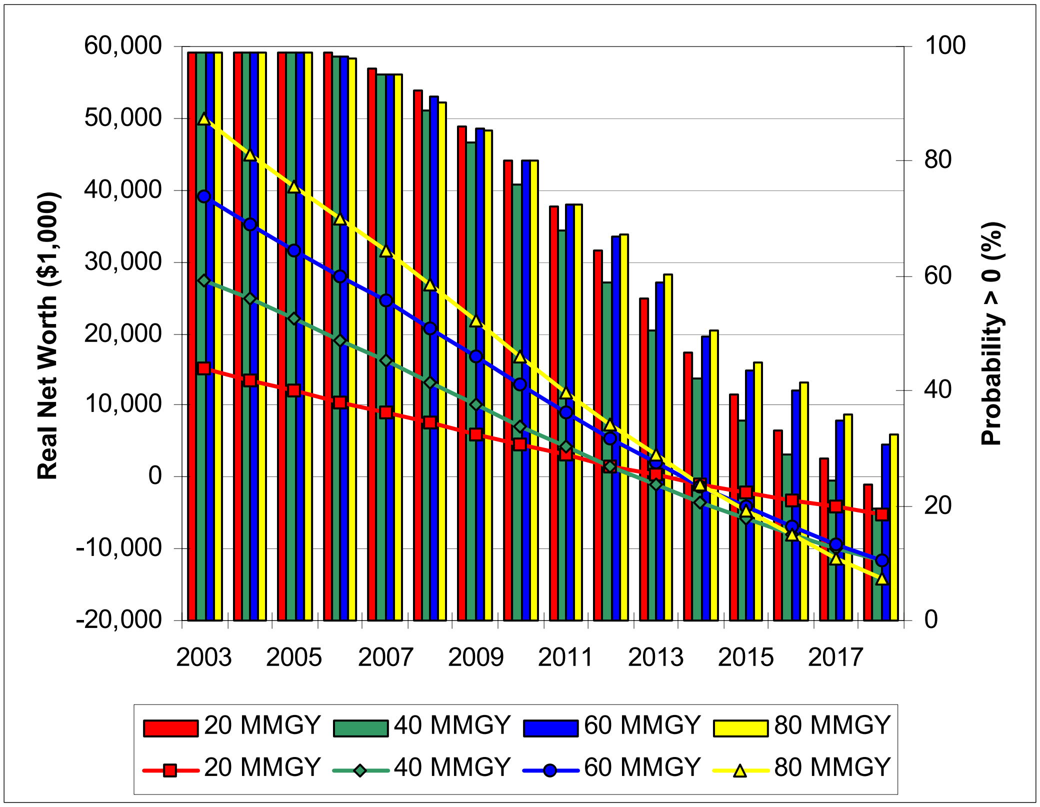

Figure 4.25. Projected Average Annual Real Net Worth and Probability of Real Net Worth > 0 for an Ethanol Plant using Corn in the Central Texas Region.

The probabilities of positive real net worth also decrease over time for each plant size. Each plant size has a 99 percent chance of a positive real net worth in 2005, but all decline annually ending at 24, 20, 31, and 32 percent, respectively by 2018.

Figure 4.26 indicates the range in projected annual real net worth for each plant size. All are projected to decline over the period with all four plant sizes, on average, becoming negative by 2014.

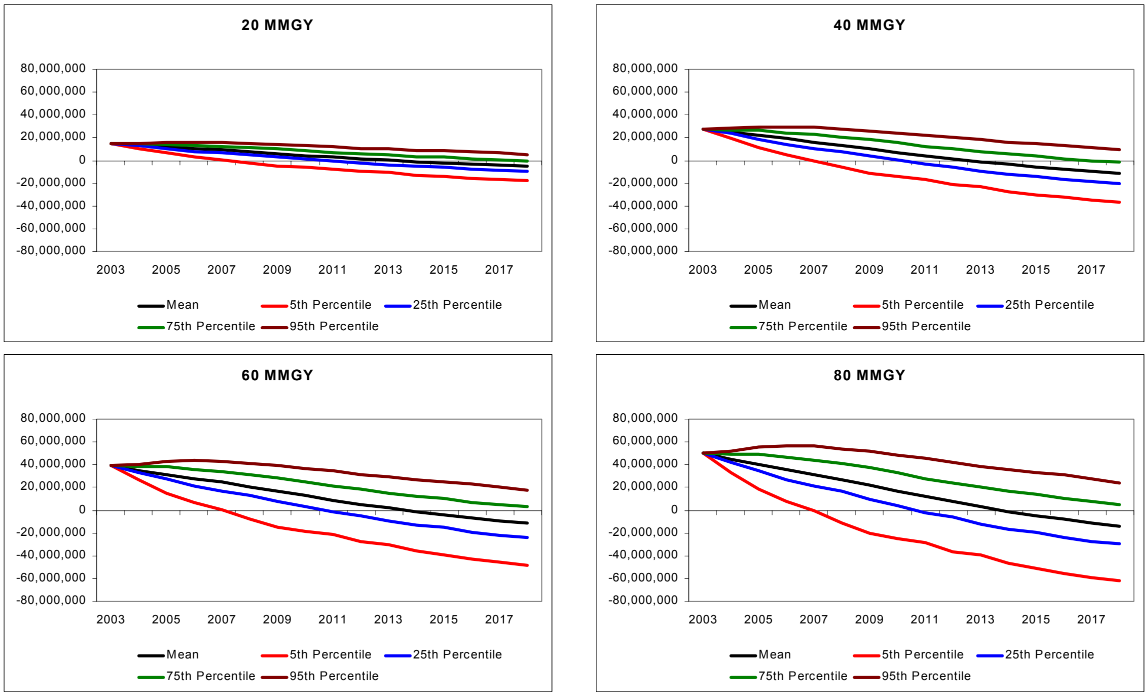

Figure 4.26. Projected Annual Real Net Worth Paid for an Ethanol Plant using Corn in the Central Texas Region by Plant Size.

Net Present Value

Figure 4.27 provides a cumulative density function of NPV for each plant size. The analysis indicates that there is a very small chance (roughly 2 percent) that any of the alternative plant sizes would return a zero or positive NPV (this is measured by the portion of the line at and to the right of the vertical axis ($0)). Which means that there is a 98 percent chance that none of the four plant sizes will provide a return greater than the discount rate, in this case a return greater than eight percent.

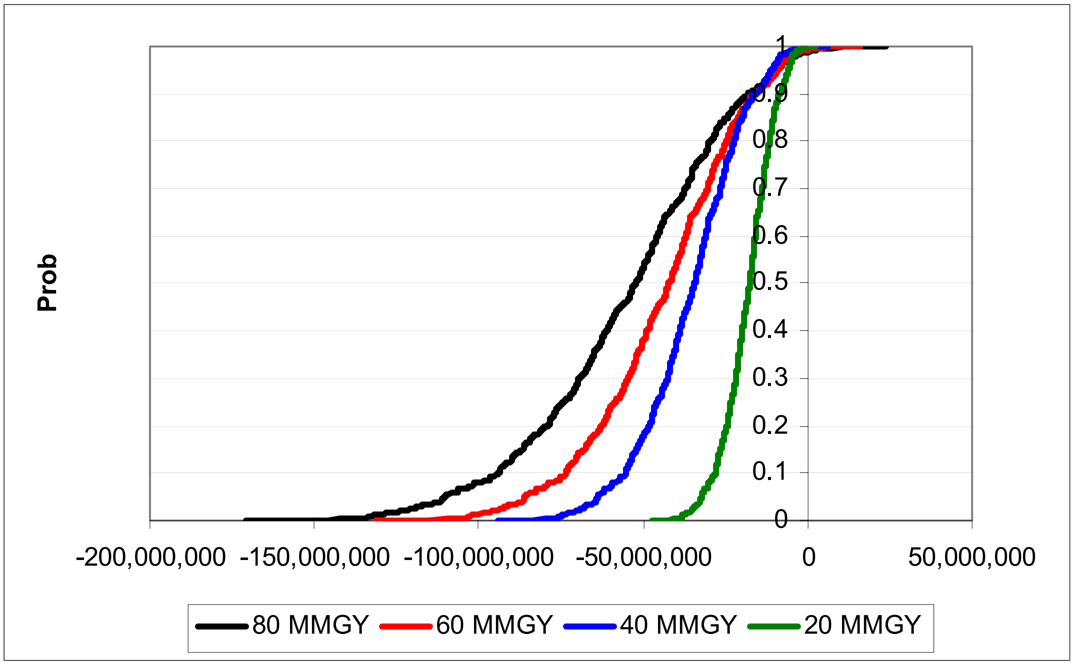

Figure 4.27. Cummulative Density Function (CDFs) of Net Present Value for an Ethanol Plant using Corn in the Central Texas Region by Plant Size.

<u>Grain Sorghum</u>

The results for an ethanol plant based in the central part of Texas using grain sorghum as its major feedstock are included for all four plant sizes, 20, 40, 60, and 80 MMGY.

As in the grain sorghum feedstock alternative in the Panhandle, the often steep price discount for grain sorghum relative to corn is a real advantage for the ethanol plant. The price spread allows the plant to source its most important input, the feedstocks, at a relatively inexpensive level. As a result the economic implications for a Central Texas grain sorghum ethanol plant appear much more attractive than corn.

Net Income

The 20, 40, 60, and 80 MMGY plants have an average net income of $1.9 million, $3.7 million, $6.5 million, and $9.0 million respectively, in 2005. The average net income is projected to decrease each year to $600,000, $1.1 million, $3.5 million, and $5.2 million, respectively, by 2018 (**Figure 4.28**).

The probabilities of positive net income also decrease slightly over time for each plant size. While some decline does occur, each plant maintains at least a 60 percent probability of a positive net income in 2018.

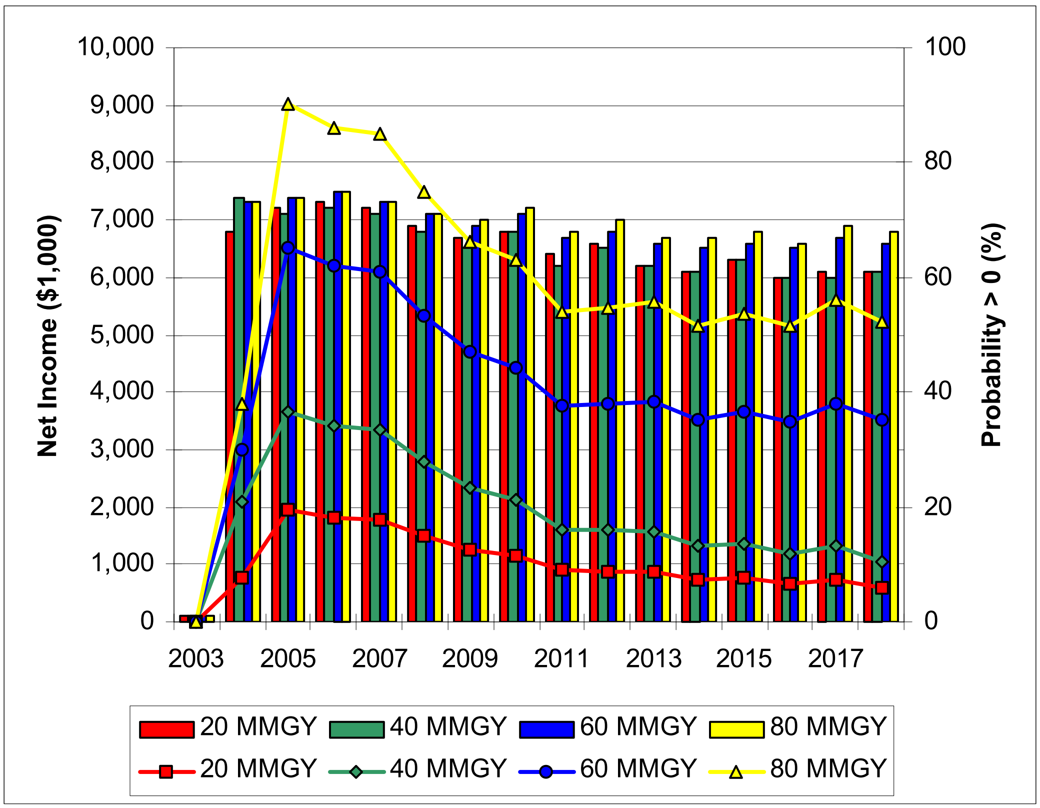

Figure 4.28. Projected Average Annual Net Income and Probability of Net Income > 0 for an Ethanol Plant using Grain Sorghum in the Central Texas Region.

Figure 4.29 indicates the risk in projected annual net income for each plant size. In 2005, 90 percent of the projected net income results for the 20 MMGY plant range from -$5.7 million to $8.0 million. Fifty percent of the time net income ranges between -$475,000 and $4.8 million, with an average of $1.9 million. In 2018, 90 percent of the projected net income would range from -$7.5 million to $6.7 million, with 50 percent between -$1.8 million and $3.4 million, with an average of $600,000. This indicates a gradual deterioration in the projected net income values for this small plant.

For the 40 MMGY plant, 2005 net income ranges from -$11.5 million to $15.7 million 90 percent of the time averaging $3.7 million. By 2018, net income ranges from -$15.2 million to $13.3 million 90 percent of the time and between -$3.7 million and $6.6 million 50 percent of the time averaging $1.1 million.

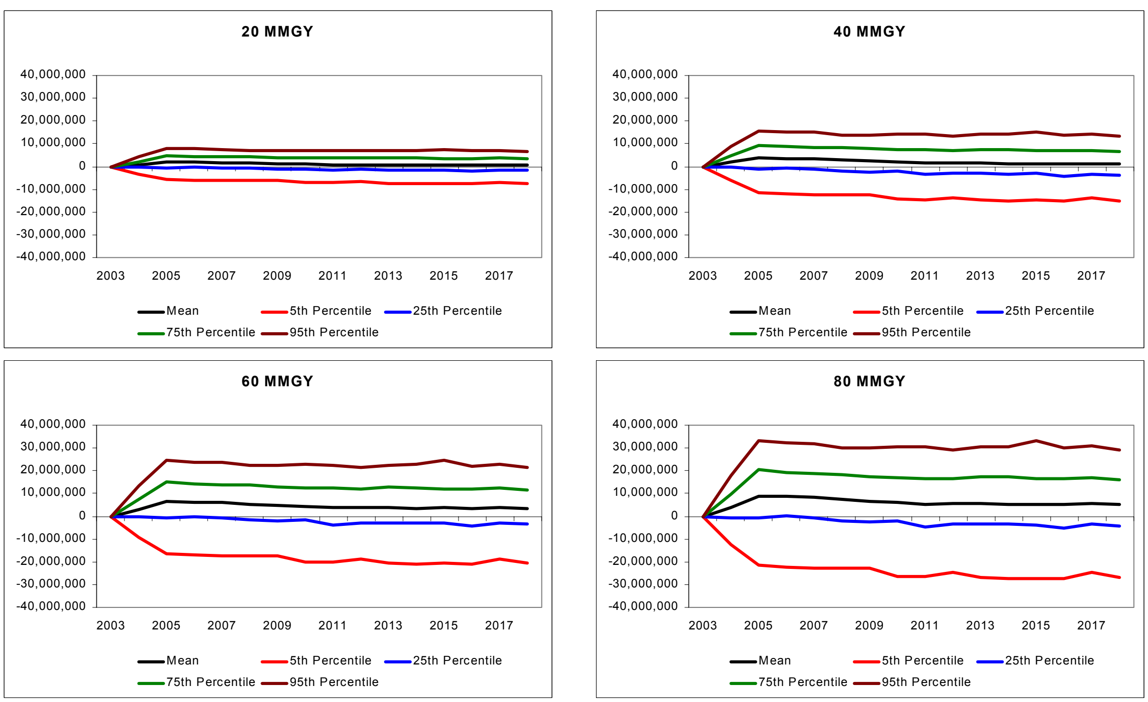

Figure 4.29. Projected Annual Net Income Risk for an Ethanol Plant using Grain Sorghum in the Central Texas Region by Plant Size.

Ending Cash Before Borrowing

The 20, 40, 60, and 80 MMGY plants would have an average ending cash value of $2.2 million, $4.5 million, $7.2 million, and $9.7 million, respectively, in 2005 (**Figure 4.30**). Average ending cash is projected to increase and peak for each plant size by 2010, then decrease to -$5.1 million, -$11.1 million, -$2.5 million, and $1.0 million, respectively, by 2018. The larger plants ending cash peaks later than the smaller plants due to economies of size.

The probability of having a positive ending cash balance also decreases over time for each plant size. The 20 MMGY plant goes from 79 percent in 2005 to 43 percent by

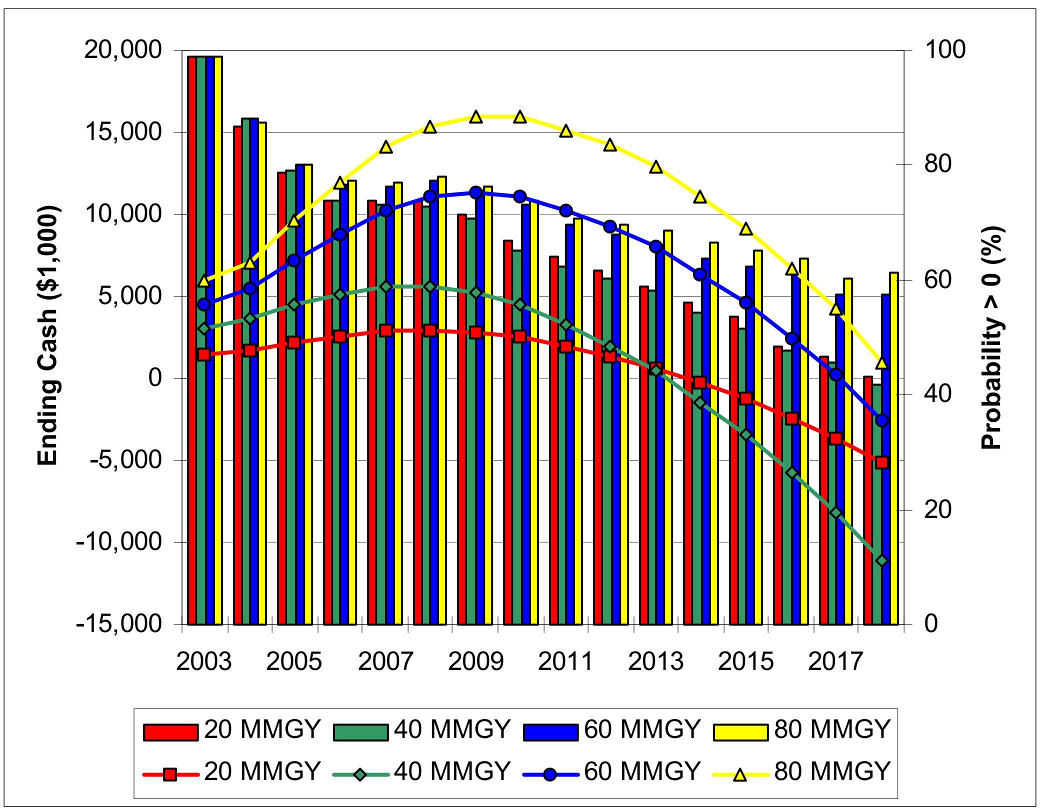

Figure 4.30. Projected Average Annual Ending Cash and the Probability of Ending Cash > 0 for an Ethanol Plant using Grain Sorghum in the Central Texas Region.

2018. The likelihood of a positive ending cash for the 40 MMGY plant declines from 79 percent to 42 percent from 2005 to 2018. The 60 MMGY declines from 80 percent to 57 percent from 2005 to 2018 and the 80 MMGY plant goes from a 80 percent chance of positive ending cash in 2005 to a 61 percent chance in 2018.

Figure 4.31 indicates the risk in projected ending cash balances for each plant size. Notice, as plant size increases the chances of debt spiraling out of control is greater. This is indicated by the widening in the range of projected outcomes throughout the period. None of the plant sizes are projected to have an average ending cash balance greater than zero by the end of the analysis.

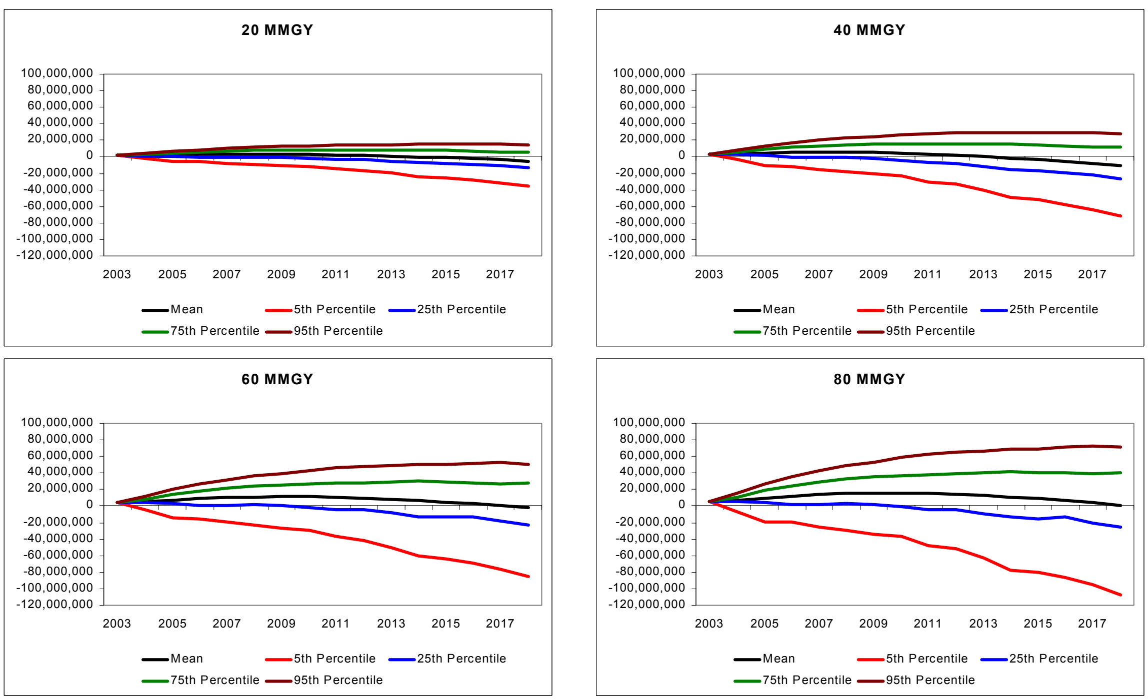

Figure 4.31. Projected Annual Ending Cash for an Ethanol Plant using Grain Sorghum in the Central Texas Region by Plant Size.

Dividends Paid

The 20, 40, 60 and 80 MMGY plants pay on average $700,000, $1.4 million, $2.2 million, and $3.0 million in dividends, respectively, in 2005 (**Figure 4.32**). The average dividend is projected to decrease slightly each year with dividends at $550,000, $1.1 million, $1.8 million, and $2.6 million for the four plant sizes by 2018. The probabilities of paying a dividend decrease over time for each plant size, but fall to no less than 61 percent by 2018.

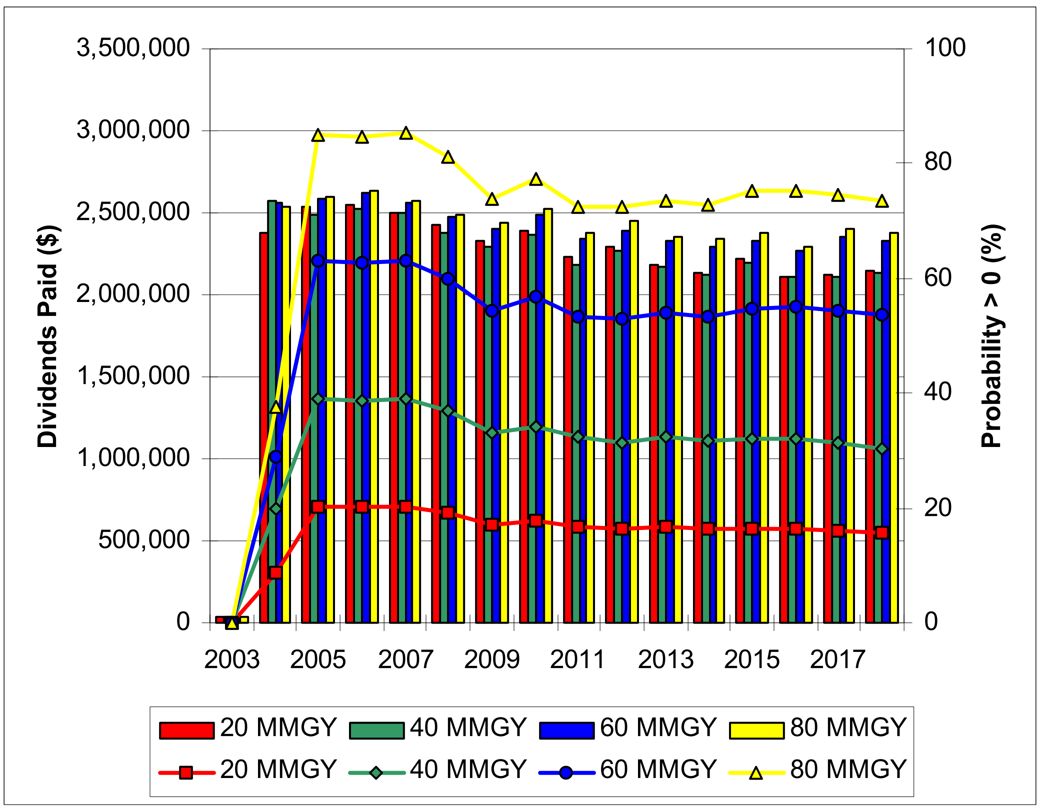

Figure 4.32. Projected Average Annual Dividends Paid and Probability of Dividends Paid > 0 for an Ethanol Plant using Grain Sorghum in the Central Texas Region.

Figure 4.33 indicates the risk in projected dividends paid by plant size. The 20 MMGY plant is projected to pay dividends ranging from $0 to $1.8 million in 2018. This same pattern holds for all plant sizes with projected dividends paid increasing for each plant size.

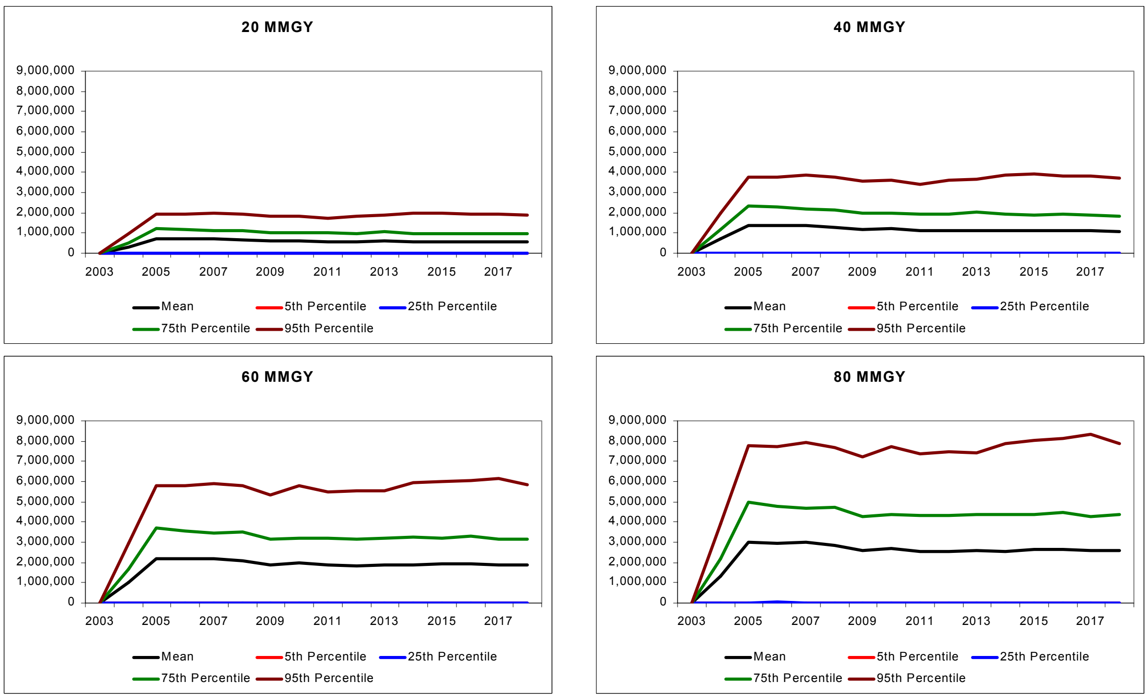

Figure 4.33. Projected Annual Dividends Paid for an Ethanol Plant using Grain Sorghum in the Central Texas Region by Plant Size.

Real Net Worth

The 20, 40, 60, and 80 MMGY plants have an average real net worth of $13.7 million, $25.4 million, $36.7 million, and $47.2 million, respectively, in 2005 (**Figure 4.34**). Average real net worth is projected to decrease over the analysis period. By 2018, average real net worth for the 20, 40, 60, and 80 MMGY plants is expected to be $5.9 million, $10.5 million, $19.2 million, and $26.1 million, respectively.

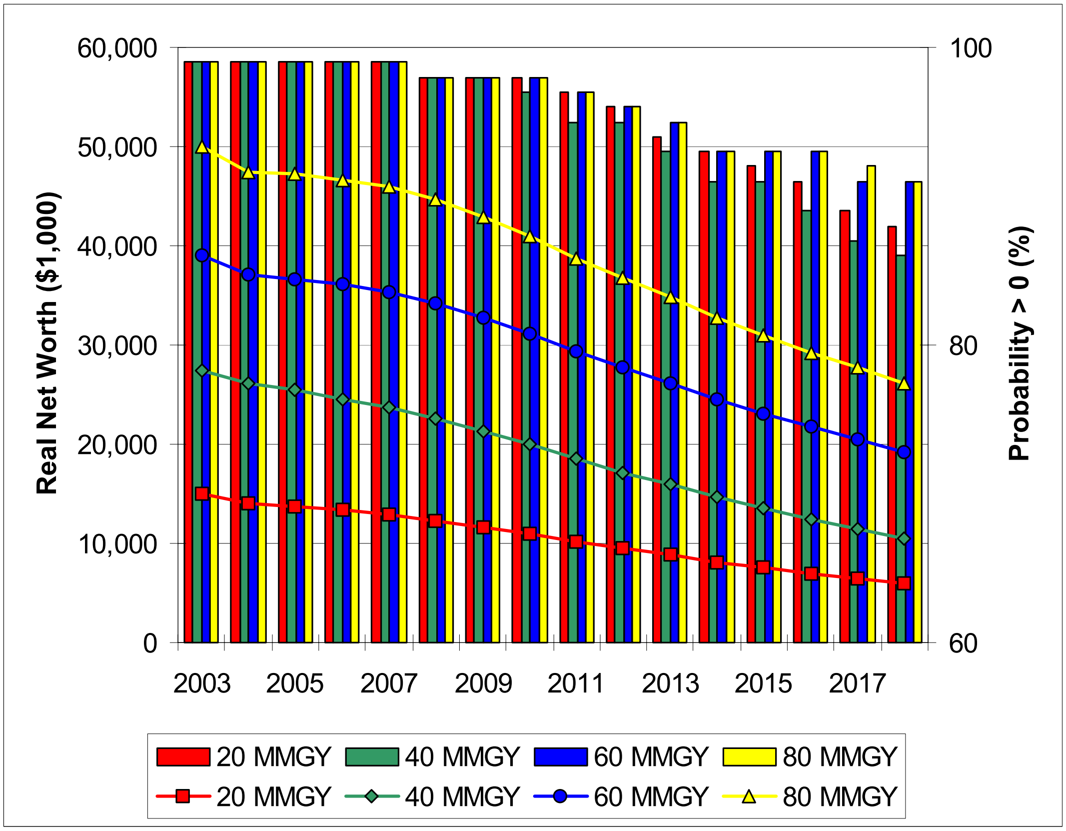

Figure 4.34. Projected Average Annual Real Net Worth and Probability of Real Net Worth > 0 for an Ethanol Plant using Grain Sorghum in the Central Texas Region.

The probabilities of positive real net worth also decrease over time for each plant size. Each plant size has a 99 percent chance of a positive real net worth in 2005 but all decline slightly ending at 88, 86, 91, and 91 percent, respectively by 2018.

Figure 4.35 indicates the risk in projected annual real net worth for each plant size. All are projected to decline over the period with the all plant sizes staying positive even at the 25 percent level. This means that real net worth is positive at least 75 percent of the time in the analysis.

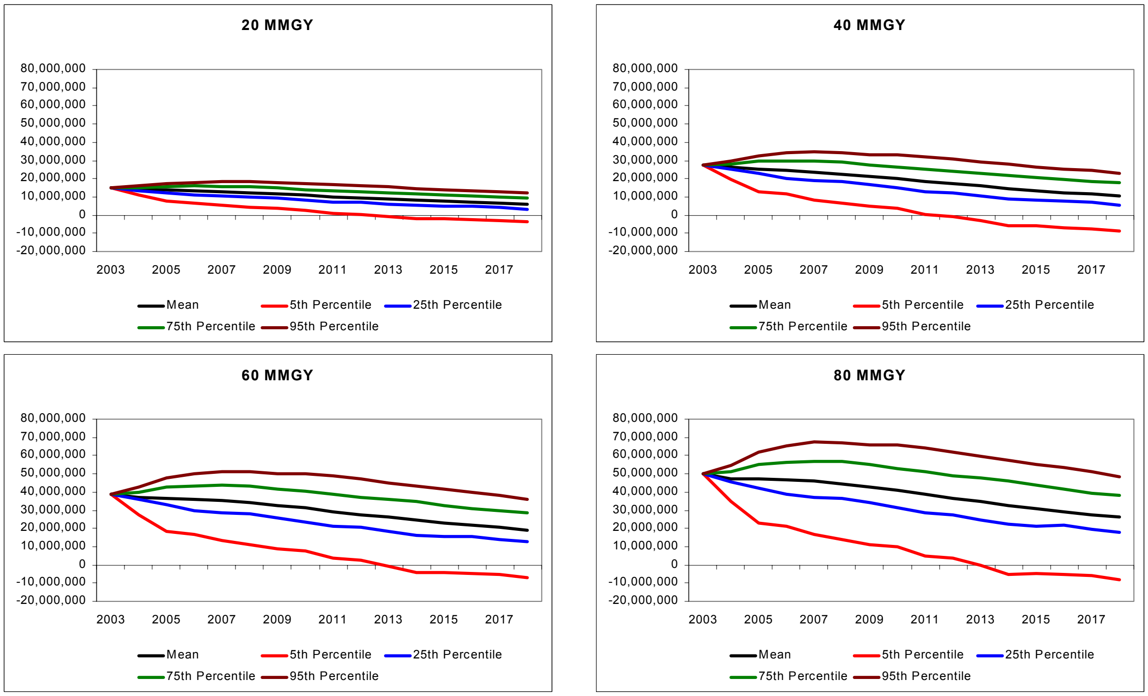

Figure 4.35. Projected Annual Real Net Worth for an Ethanol Plant using Grain Sorghum in the Central Texas Region by Plant Size.

Net Present Value

The analysis indicates that there is an above average chance (roughly 50 percent) that the 60 and 80 MMGY plants would return a zero or positive NPV (this is measured by the portion of the line at and to the right of the vertical axis ($0)) and a 25 percent chance that the 20 MMGY plant would return a zero or positive NPV (**Figure 4.36**).

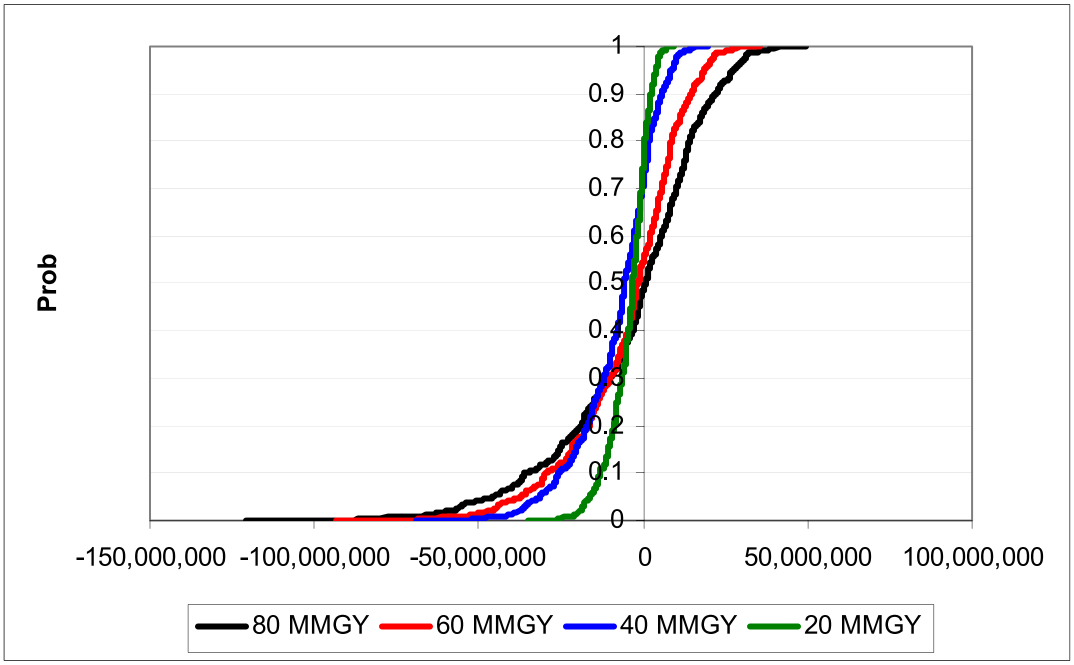

Figure 4.36. Cummulative Density Functions (CDFs) of Net Present Value for an Ethanol Plant using Grain Sorghum in the Central Texas Region by Plant Size.

Southeast Results

Grain Sorghum

The results for an ethanol plant based in southeast Texas using grain sorghum as its major feedstock are included for all four plant sizes, 20, 40, 60, and 80 MMGY. Grain sorghum is the only feedstock analyzed for the Southeast region. Rice is not examined as a potential feedstock due to a lack of information about the value of the co-product as feed. While ethanol can be made from rice, rice has typically been more valuable as a food crop than for other purposes. Corn is not evaluated due to the few acres grown.

Net Income

Feedstock costs reflect higher prices relative to other regions due to their location near to international ports. The 20, 40, 60, and 80 MMGY plants have a net income on average of -$275,000, -$750,000, -$125,000, and $150,000 respectively, in 2005 (**Figure**

4.37). The average net income is projected to decrease to -$4.1 million, -$8.3 million, -$9.8 million, and -$12.2 million for the 20, 40, 60, and 80 MMGY plants by 2018.

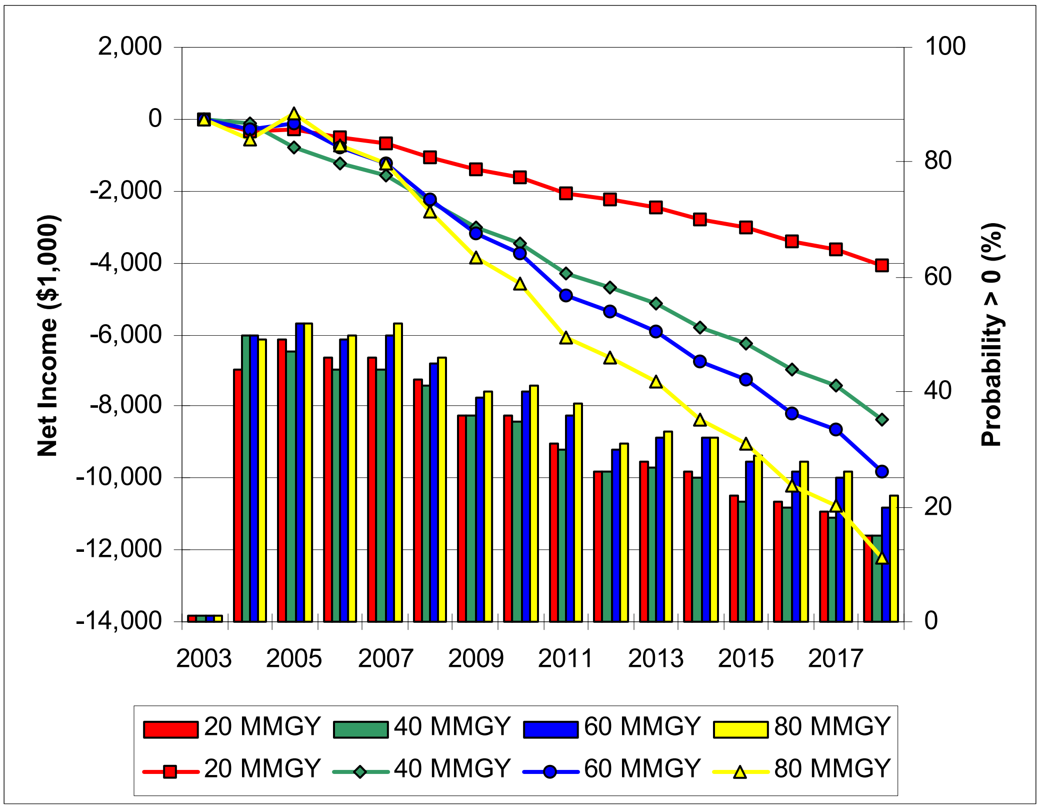

Figure 4.37. Projected Average Annual Net Income and Probability of Net Income > 0 for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region.

The probabilities of positive net income also decrease over time for each plant size. The probability of a positive net income for the 20 MMGY plant declines from 49 percent in 2005 to 15 in 2018 percent. The probabilities for the 40, 60, and 80 MMGY plants drop 33, 31, and 30 percentage points from 47, 52, and 52 percent over the 2005 to 2018 period.

Figure 4.38 indicates the risk in projected annual net income for each plant size. In 2005, 90 percent of the projected net income results for the 20 MMGY plant range from -$6.6 million to $5.9 million, with an average of -$275,000. In 2018, 90 percent of the projected net incomes would range from -$11.5 million to $2.2 million, with an average of -$4.1 million. The 40 and 60 MMGY plants also indicate negative net incomes beginning in 2005.

The projected outcomes in 2005 for the 80 MMGY plant range from -$25.3 million to $24.7 million 90 percent of the time and -$9.3 and $10.3 million 50 percent of the time, with an average of $150,000. By 2018, the ranges widen to -$43.7 million to $12.3 million and -$20.7 million and -$350,000, with an average of -$11.5 million.

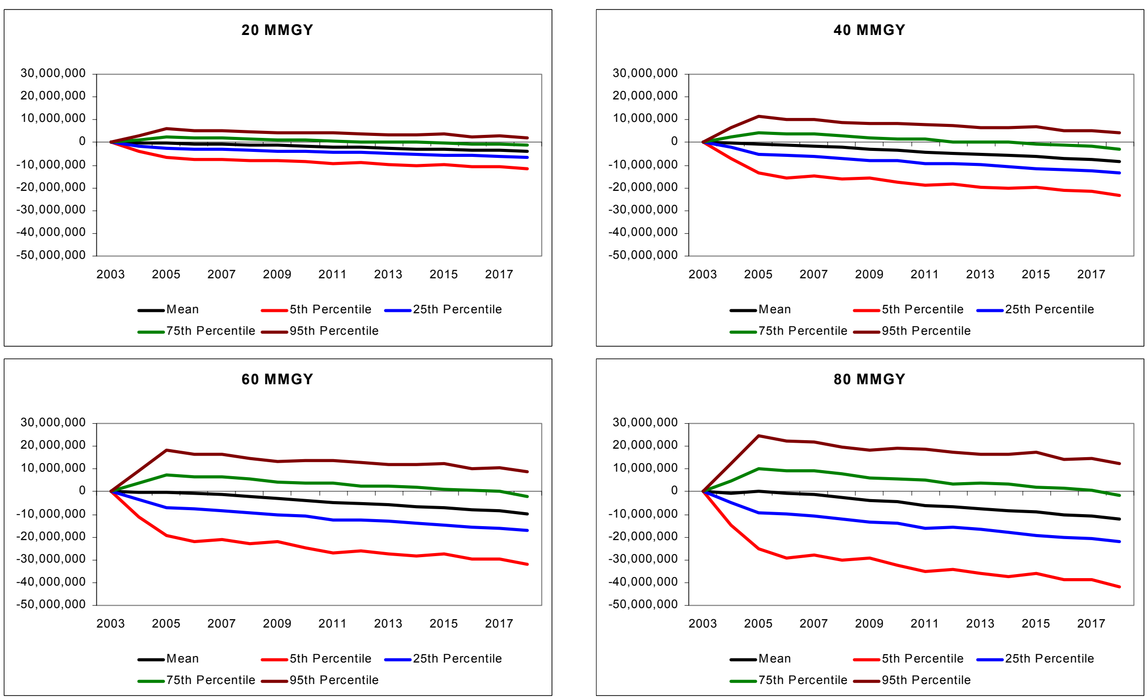

Figure 4.38. Projected Annual Net Income Risk for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region by Plant Size.

Ending Cash Before Borrowing

As the negative net income grows, ending cash will decline at an increasing rate. The 20, 40, 60, and 80 MMGY plants would have an average ending cash values of -$175,000, -$175,000, $425,000, and $625,000, respectively, in 2005 (**Figures 4.39 and 4.40**). Average ending cash is projected to decrease to -$42.2 million, -$85 million, -$106 million, and -$134 million, respectively, by 2018.

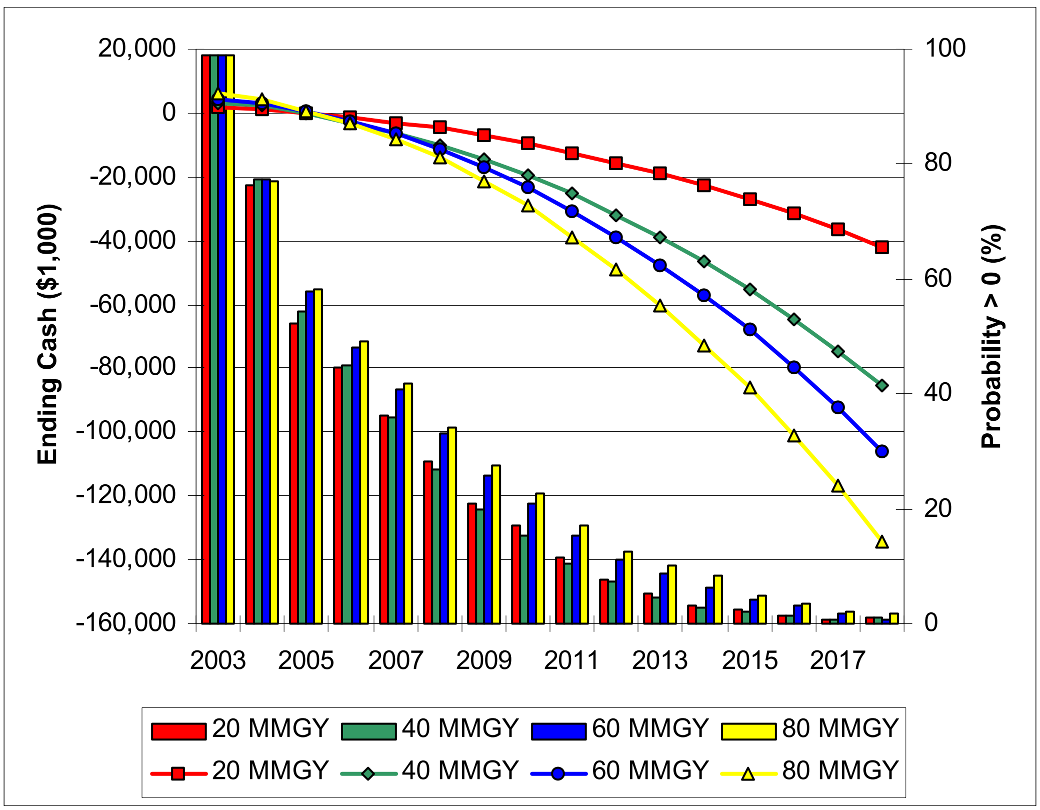

Figure 4.39. Projected Average Annual Ending Cash and the Probability of Ending Cash > 0 for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region.

The probability of having a positive ending cash balance decreases over time for each plant size. None of the plants have better than a one percent chance of positive ending cash by 2018.

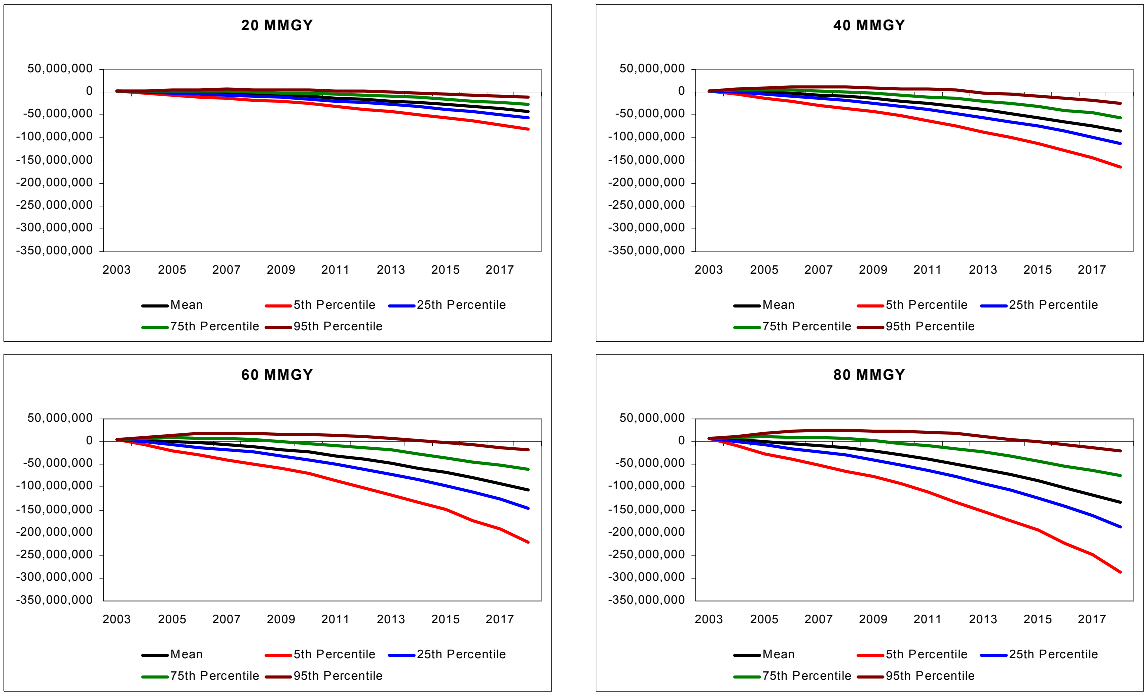

Figure 4.40. Projected Annual Ending Cash for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region by Plant Size.

Dividends Paid

The 20, 40, 60, and 80 MMGY plants would average of $350,000, $675,000, $1.1 million, and $1.5 million in dividends, respectively, in 2005 (**Figure 4.41**). The average dividend is projected to decrease each year with dividends of $75,000, $150,000, $350,000, and $525,000 for the four plant sizes in 2018.

Figure 4.41 also indicates the probability of paying dividends for each plant size. In 2005, 49, 47, 52, and 52 percent are the probabilities that the 20, 40, 60, and 80 MMGY plants would pay a dividend. By 2018, the probabilities decline to 15, 15, 20, and 22 for each of the four plant sizes.

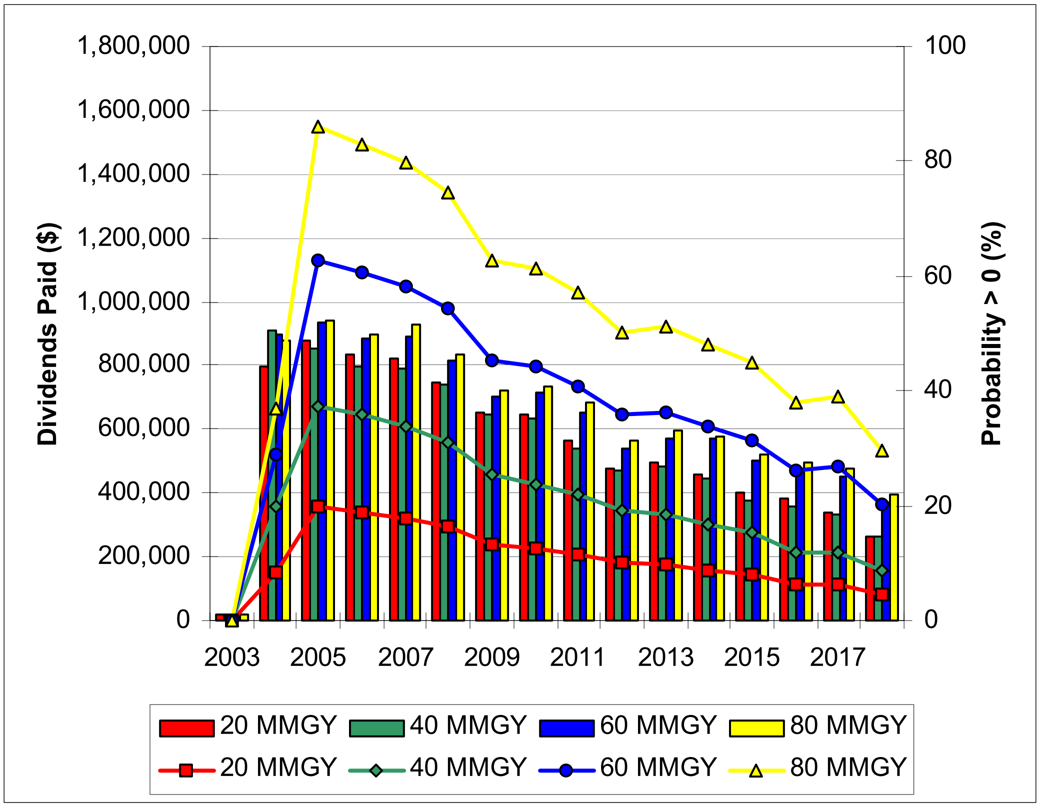

Figure 4.41. Projected Average Annual Dividends Paid and Probability of Dividends Paid > 0 for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region.

Figure 4.42 indicates the risk in projected dividends paid by plant size. The dividends projected to be paid by the 20 MMGY plant range from $1.5 million to no dividends early in the period and $650,000 to no dividends by 2018. This same pattern holds for all plant sizes with projected dividends paid increasing for each plant size.

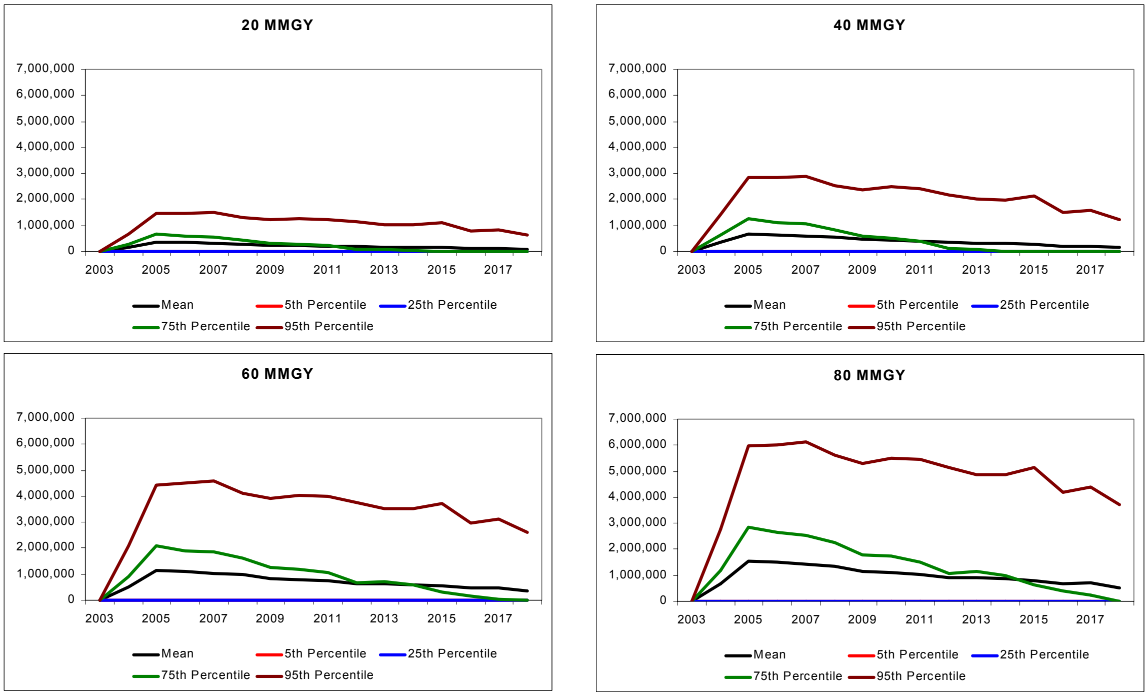

Figure 4.42. Projected Annual Dividends Paid for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region by Plant Size.

Real Net Worth

Figure 4.43 contains the projected real net worth results and the probability that real net worth will be greater than zero. The 20, 40, 60, and 80 MMGY plants would have an average real net worth of $11.7 million, $21.4 million, $30.8 million, and $39.5 million, respectively, in 2005. The average real net worth is projected to decrease each year of the analysis. By 2018, average real net worth for the 20, 40, 60, and 80 MMGY plants is expected to be -$5.7 million, -$12.9 million, -$13.3 million, and -$16.5 million, respectively.

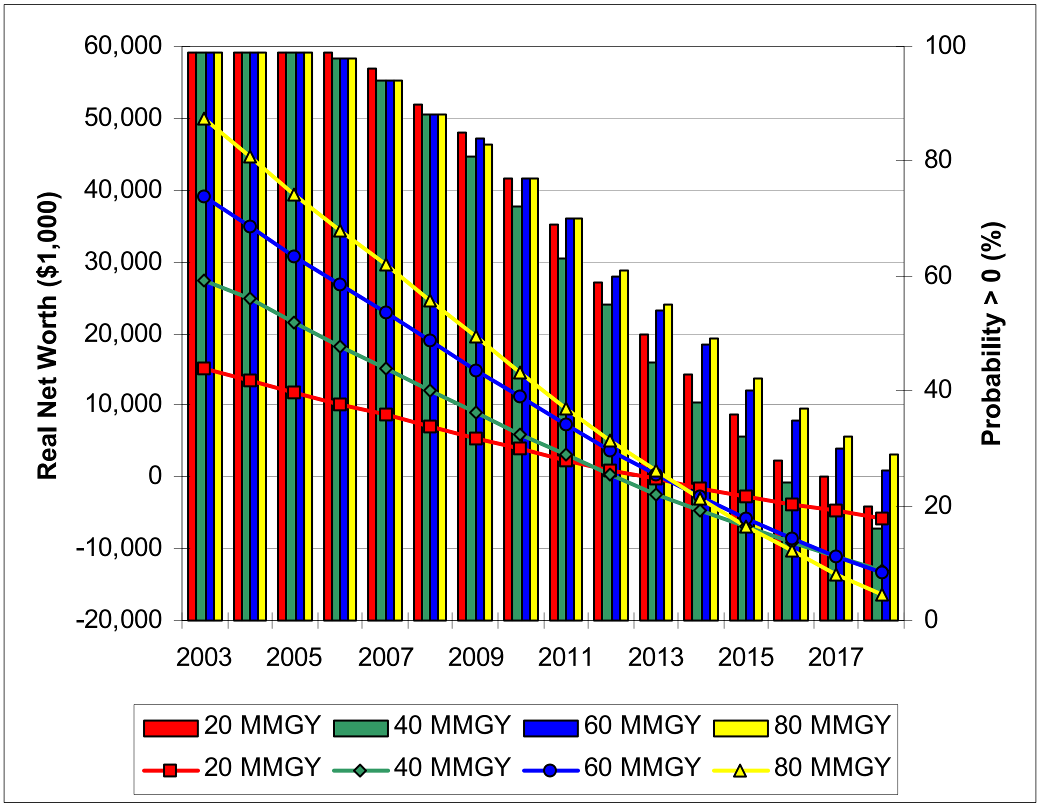

Figure 4.43. Projected Average Annual Real Net Worth and Probability of Real Net Worth > 0 for an Ethanol Plant using Corn in the Southeast Texas Region.

The probabilities of positive real net worth also decrease over time for each plant size. Each plant size has a 99 percent chance of a positive real net worth in 2005 but all decline annually ending at 20, 16, 26, and 29 percent, respectively by 2018.

Figure 4.44 indicates the risk in projected annual real net worth for each plant size. All are projected to decline over the period with all four plants sizes, on average, becoming negative by 2014.

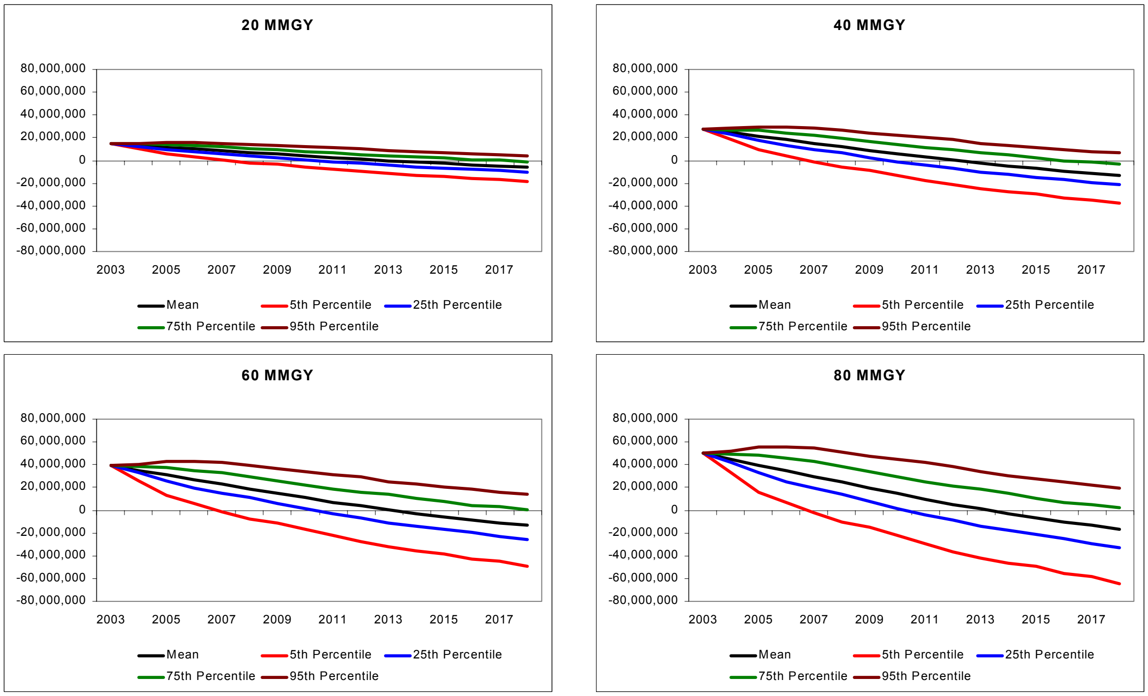

Figure 4.44. Projected Annual Real Net Worth for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region by Plant Size.

Net Present Value

Net present value (NPV) provides a summary of much of the information presented earlier in one number. That is, does the investment return more than the discount rate over time? If this number is positive it does, and negative it does not. **Figure 4.45** provides a cumulative density function of NPV for the four plant sizes.

The analysis indicates that there is a very small chance (roughly 1 percent) that any of the alternatives would return a zero or positive NPV (this is measured by the portion of the line at and to the right of the vertical axis ($0)). Which means that there is a 99 percent chance that none of the four plant sizes will provide a return greater than the discount rate.

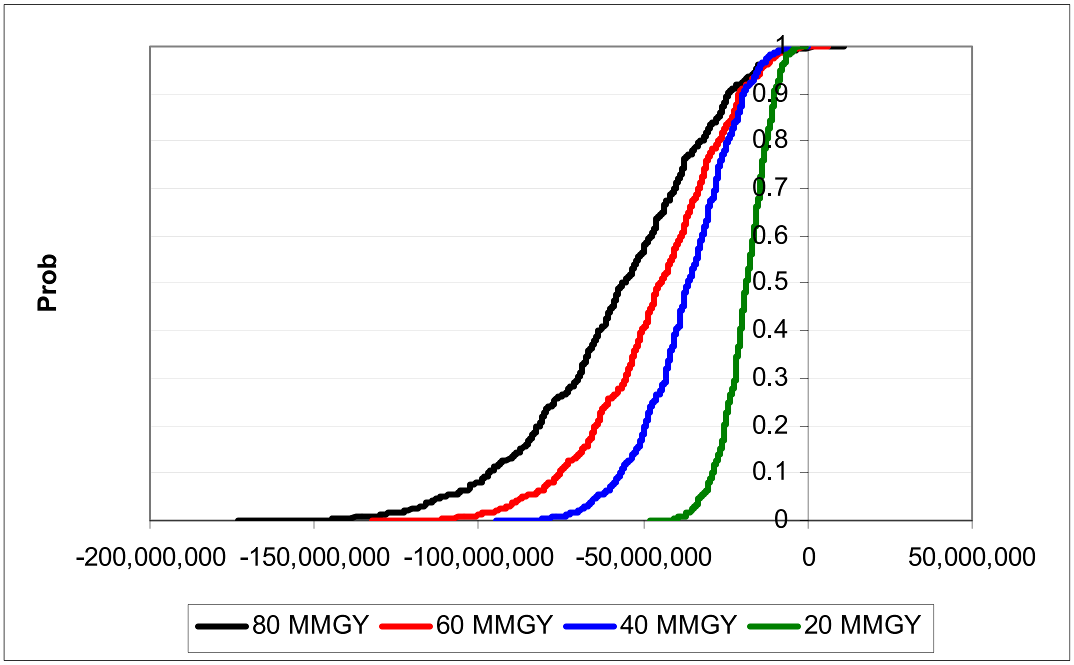

Figure 4.45. Cumulative Density Function (CDFs) of Net Present Value for an Ethanol Plant using Grain Sorghum in the Southeast Texas Region by Plant Size.

Table 4.2 provides a summary of the expected net present value (NPV) for each plant size and location and how likely the plant will generate a positive NPV. The only location with greater than a 50 percent chance of a 20, 40 or 60 MMGY plant generating a positive NPV is the Panhandle area using grain sorghum as the feedstock. For the 80 MMGY plant, the Central Texas and Panhandle areas using grain sorghum both have greater than a 50 percent chance of generating a positive NPV.

Table 4.2. Average Net Present Value and Probability of Net Present Value Greater than Zero for 20, 40, 60 and 80 MMGY Ethanol Plants Using Corn and Grain Sorghum as Feedstocks, by Region.

	20 MMGY		**40 MMGY**		**60 MMGY**		**80 MMGY**	
	Average	Prob. NPV>0	Average	Prob. NPV>0	Average	Prob. NPV>0	Average	Prob. NPV>0
Corn								
Panhandle	-11.9 M	2.2%	-22.9 M	2.8%	-25.8 M	9.0%	-31.1 M	10.6%
Central Texas	-18.2 M	0.4%	-35.5 M	0.4%	-4.1 M	1.0%	-55.1 M	1.2%
Grain Sorghum								
Panhandle	-.5 M	51.4%	-180,000	56.8%	6.2 M	71.0%	11.0 M	75.2%
Central Texas	-4.3 M	25.4%	-8.0 M	29.2%	-4.4 M	45.4%	-3.0 M	51.4%
Southeast	-18.9 M	0.1%	-37 M	0.2%	-46.2 M	0.4%	-57.9 M	0.4%

Table 4.3 indicates the annual increase in net income that each plant size would need to generate a zero net present value (e.g., generate an 8 percent return on the investment). The increase in net income could come from site specific factors that have not been considered in this report. For example, the 20 MMGY corn based plant in the Panhandle would need $2 million per year in additional revenue or cost savings (about $0.10 per gallon) to achieve a zero net present value. The 80 MMGY corn based plant in the Panhandle would need to increase revenue or decrease costs by less than $0.07 per gallon to achieve a zero net present value. Negative values indicate the amount of revenue a plant could lose annually and still achieve a zero net present value.

Table 4.3. Annual Increase in Net Income Related to Site Specific Advantages Required to Generate a Zero Net Present Value for 20, 40, 60 and 80 MMGY Ethanol Plants Using Corn and Grain Sorghum as Feedstocks, by Region.

	20 MMGY	40 MMGY	60 MMGY	80 MMGY
Corn				
Panhandle	2,040,584	3,898,585	4,530,574	5,472,831
Central Texas	2,829,157	5,475,731	6,896,293	8,627,122
Grain Sorghum				
Panhandle	384,560	586,537	-437,499	-1,151,266
Central Texas	721,660	1,260,736	573,801	197,133
Southeast	3,087,387	5,992,173	7,670,957	9,660,008

Note: a zero net present value would mean the plant would exactly earn an 8 percent return on the investment.

Sensitivity Analysis

<u>Corn</u>

Panhandle

Sensitivity analyses were performed on the 20 and 80 MMGY size plants in the Panhandle using corn as the feedstock to determine what levels of key variables were required to achieve at least a net present value of zero. A sensitivity analysis allows "what if" questions to be asked about each key variable to ensure a reasonable chance of success. For example, the base scenario has an ethanol price of $1.086 per gallon. For the 20 MMGY panhandle corn plant, a $0.099 increase in ethanol price to $1.185 per gallon ethanol price would make the NPV equal to 0 (**Table 4.4**). Each variable was tested holding all of the others at the base level. The change in value required to generate a NPV equal to 0 over the 15 year planning horizon is reported in **Table 4.4**.

Table 4.4. Sensitivity Analysis of Change in Input and Output Prices Necessary to Generate a NPV=0, holding all other factors constant, for Corn Based Ethanol Production in the Texas Panhandle.

Variable	Base	20 MMGY	80 MMGY
Corn ($/bu.)	2.61	-0.29	-0.21
Natural Gas ($/Mcf)	2.39	-1.49	-1.00
Ethanol ($/gal)	1.086	0.099	0.066
DDGS ($/ton)	106.40	32.45	21.63
Discount Rate (percentage point change)	8.00	-11.40	-6.74

The base annual average corn price that is used in the panhandle region is $2.61 per bushel. When all other input costs and output prices are held constant, a $0.29 per bushel lower price is needed for the 20 MMGY plant to have a net present value equal zero. Which means the plant would achieve an eight percent return. The corn price for the 80 MMGY would need to be $0.21 lower than the base to have a net present value equal to zero. That the larger plant can earn an 8 percent return with a smaller reduction in corn price illustrates the returns to size in the industry. This plant can withstand higher prices and still generate the desired return.

The base natural gas cost is $2.39 per Mcf. Holding all other costs and prices constant, a $1.49 per Mcf lower natural gas price ($0.90) for the 20 MMGY plant is required for the net present value to equal zero. Natural gas price would have to be reduced by $1.00 per Mcf for the 80 MMGY plant to earn an 8 percent return holding all other factors constant.

The base ethanol price is $1.086 per gallon. A price of $ 1.185 per gallon, an increase of $0.099 per gallon, is required for the 20 MMGY plan to have a NPV equal to

0 if all other prices are held constant. For the 80 MMGY plant, a $0.066 increase in the ethanol price is necessary to have a NPV equal to 0. Neither of these prices are far from the base assumed in the model, in fact ethanol prices were above $1.30 per gallon as recently as two years ago.

The dried distillers grain with solubles price in the base analysis is $106.40 per ton. With all other prices held constant, the 20 MMGY plant would need to receive an additional $32.45 per ton to achieve a NPV equal to 0. This price increase would seem less likely given the abundance of relatively cheap feedstuffs. Given that DDGS sales generate a much smaller portion of the total revenue than ethanol, it takes a relatively larger increase in price to move the plant to a positive NPV.

Another sensitivity analysis was conducted to find the level of return expected for various plant sizes and locations. The discount rate that generates a NPV equal to zero is the internal rate of return, or expected return of the plant. When all prices are held constant at the base, the 20 MMGY plant has an internal rate of return of –3.40 percent, 11.4 percentage points below the base level of 8 percent. The internal rate of return for the 80 MMGY plant is 1.2 percent, 6.74 percentage points below the base.

It’s important to note that the firm would not need to have a single cost or price change to generate the whole amount indicated in **Table 4.4**. A combination of some or all of the variables would suffice. A combination of a lower corn price and a higher DDGS price could have the same affect as a lower natural gas cost and a higher ethanol price. The combined effect of multiple price changes due to site specific factors could make the NPV equal to or greater than zero.

Central Texas

The values that generated a NPV equal to 0 over the 15 year planning horizon for 20 and 80 MMGY Central Texas corn ethanol plants are reported in **Table 4.5**.

Table 4.5. Sensitivity Analysis of Change in Input and Output Prices Necessary to Generate a NPV=0, holding all other factors constant, for Corn Based Ethanol Production in the Central region of Texas.

Variable	Base	20 MMGY	80 MMGY
Corn ($/bu.)	2.71	-0.39	-0.30
Natural Gas ($/Mcf)	2.39	-2.07	-1.58
Ethanol ($/gal)	1.086	0.138	0.115
DDGS ($/ton)	106.40	45.23	34.41
Discount Rate (percentage point change)	8.00	N/A	N/A

The base annual average corn price that is used in the Central region is $2.71 per bushel. Holding all other input costs and output prices constant, a reduction in corn price of $0.39 per bushel is needed for the 20 MMGY plant to have a net present value equal zero. The corn price necessary for the 80 MMGY to have a net present value equal to zero is $2.41 per bushel, or a $0.30 reduction in corn price. The larger plant can withstand higher prices and still generate the desired return. However, even for this large plant, corn prices would have to decline 11 percent from the base to generate an 8 percent return, holding all other factors constant.

The base natural gas cost is $2.39 per Mcf. Holding all other costs and prices constant, the natural gas price would have to decline by $2.07 per Mcf for the 20 MMGY plant to have a net present value to equal zero. The 80 MMGY plant would need a $1.58 per Mcf price reduction. Changes of this magnitude are required because, while important, natural gas inputs and prices are less important than are corn and ethanol prices in the overall economic feasibility of a plant.

The base ethanol price is $1.086 per gallon. Price increases of $0.138 per gallon and $0.115 per gallon, for the 20 and 80 MMGY plants, respectively, are required to achieve a NPV equal to 0, holding all other factors constant. Ethanol prices have been up over $1.30 per gallon as recently as two years ago, but for the plant to achieve a NPV equal to 0, the price increase would need to be realized on average throughout the projection period.

The dried distillers grain with solubles price in the base analysis is $106.40 per ton. The price increase needed, holding all other prices constant, for the 20 and 80 MMGY plants to obtain a NPV equal to 0 is $45.23 and $34.41 per ton, respectively. This price would seem less likely give the abundance of relatively cheap feedstuffs. Given that DDGS amounts to a much smaller portion of revenue than ethanol it takes a relatively larger increase in price to move the plant to a positive NPV.

The discount rate used in the model is 8 percent, meaning that when the NPV is equal to 0 the internal rate of return is 8 percent. Due to the high probability of large financial losses, a feasible discount rate can not be calculated that delivers a NPV equal to 0 for either size plant.

It's important to note that the firm would not need to have a single cost or price change to generate the whole amount indicated in the Table. A combination of some or all of the variables would suffice. A combination of a lower corn price and a higher DDGS price could have the same affect as a lower natural gas cost and a higher ethanol price.

Grain Sorghum

Panhandle

Sensitivity analyses were performed on key variables for the 20 and 80 MMGY size plants in the Panhandle using grain sorghum as the feedstock. The values that generated a NPV equal to 0 over the 15 year planning horizon are reported in **Table 4.6**.

Table 4.6. Sensitivity Analysis of Change in Input and Output Prices Necessary to Generate a NPV=0, holding all other factors constant, for Grain Sorghum Based Ethanol Production in the Texas Panhandle.

Variable	Base	20 MMGY	80 MMGY
Grain sorghum ($/bu.)	2.38	-0.06	0.03
Natural Gas ($/Mcf)	2.39	-0.27	0.22
Ethanol ($/gal)	1.086	0.018	-0.014
DDGS ($/ton)	106.40	5.90	-4.59
Discount Rate (Percentage Point Change)	8.00	-0.97	0.83

The base annual average grain sorghum price used in the panhandle region is $2.38 per bushel. The grain sorghum price would have to be $0.06 lower than the base for the 20 MMGY plant to generate a net present value equal zero. The 80 MMGY could pay an additional $0.03 per bushel over the base for grain sorghum and still generate a net present value equal to zero. The larger plant can sustain even more expensive average feedstock prices and still generate an 8 percent return.

The base natural gas cost is $2.39 per Mcf. Holding all other costs and prices constant, a natural gas price reduction of $0.27 per Mcf would be necessary for the 20 MMGY plant to achieve a net present value to equal zero. The 80 MMGY plant could pay an additional $0.22 per Mcf.

The discount rate used in the model is 8 percent, meaning that when the NPV is equal to 0 the internal rate of return is 8 percent. When all prices are held constant, for the 20 MMGY plant to obtain a NPV equal to 0, the internal rate of return is 7.03 percent, or a 0.97 percentage point reduction in the discount rate. If an investor was satisfied with a 7.03 percent return then the plant would generate a NPV equal to zero. The internal rate of return for the 80 MMGY plant is 8.83 percent, or an 0.83 percentage point increase. The large plant can sustain an even higher rate of return on investment and still generate a NPV equal to 0. In other words, these results also suggest this size plant could incur higher borrowing costs and still generate the 8 percent return on investment.

Central

Sensitivity analyses were performed on the 20 and 80 MMGY size plants in the Central Texas Region using grain sorghum as the feedstock to determine the levels of key variables required to achieve a NPV of zero. The values that generated a NPV equal to 0 over the 15 year planning horizon are reported in **Table 4.7**.

Table 4.7. Sensitivity Analysis of Change in Input and Output Prices Necessary to Generate a NPV=0, holding all other factors constant, for Grain Sorghum Based Ethanol Production in the Central region of Texas.

Variable	Base	20 MMGY	80 MMGY
Grain sorghum ($/bu.)	2.43	-0.11	-0.02
Natural Gas ($/Mcf)	2.39	-0.53	-0.03
Ethanol ($/gal)	1.086	0.035	0.002
DDGS ($/ton)	106.40	11.47	1.26
Discount Rate (percentage point change)	8.00	-1.93	-0.15

The 20 MMGY plant requires lower input prices (grain sorghum, natural gas, and discount rate) and higher output prices to generate the needed 8 percent return. In this

case, the ethanol price needed is only $0.035 greater than the base price of $1.086. The results imply that without any changes in other input or output prices the plant is generating a 6.07 percent return. By accepting this rate of return instead of the 8 percent, the plant is feasible.

The large 80 MMGY plant can generate an 8 percent return with only small changes in input and output prices. For example, an ethanol price only $0.002 higher than the base of $1.086 would generate a NPV equal to zero.

Southeast

Table 4.8 contains the results of a sensitivity analysis of prices necessary to generate an 8 percent return, or NPV equal to zero, for ethanol plants in Southeast Texas.

Table 4.8. Sensitivity Analysis of Change in Input and Output Prices Necessary to Generate a NPV=0, holding all other factors constant, for Grain Sorghum Based Ethanol Production in the Southeast region of Texas.

Variable	Base	20 MMGY	80 MMGY
Grain sorghum ($/bu.)	2.75	-0.43	-0.34
Natural Gas ($/Mcf)	2.39	-2.26	-1.77
Ethanol ($/gal)	1.086	0.15	0.117
DDGS ($/ton)	106.40	49.16	38.35
Discount Rate (percentage point change)	8.00	N/A	N/A

Both size plants would require lower input prices and higher output prices than in the base to generate a NPV equal to zero, holding all other factors constant. Grain sorghum prices $0.43 and $0.34 lower than the base, for the 20 and 80 MMGY plants, respectively, would be necessary to generate a zero NPV given an 8 percent return (or discount rate). Ethanol prices would have to be $0.15 higher than the base price of $1.086 per gallon for the 20 MMGY plant. In each case a feasible discount rate could not be calculated that would generate a NPV equal to zero holding the other factors at the baseline levels. That is due to the high probability of negative returns. Even considering the negative returns the ethanol price needed to generate the NPV equal to zero is only 14 percent higher than the base. Prices of that level are within the range of prices experienced over the last couple of years, and so are not out of the question.

Factors Influencing Plant Success

In this analysis, feedstock costs are the primary factor influencing success. The cheaper grain sorghum relative to corn with the same ethanol productive value dictates that the grain sorghum feedstock plants have the greatest probability of success, assuming that the presence of a plant does not impact the feedstock price.

Economies of size are reflected in labor, administrative, and maintenance costs. Lower costs per unit for plant construction costs also contribute to the probability of success for larger plants. In some cases the 80 MMGY plant loses much more money than the other size plants. However, on a per unit basis, it loses less per gallon of ethanol than the smaller plants.

None of these factors take into account specific situations (site costs, organizational plan, financial arrangements, and feedstock procurement contracts) that a group planning to build a plant could face. Site specific factors such as co-location with a user, proximity to rail lines, natural gas lines, incentives contributed by local communities, and many others may make a particular site more or less feasible.

Potential Size of Incentive

This study analyzed one incentive level: $0.20 per gallon of ethanol up to a maximum of $3 million for any plant. This structure is similar to that of other states with incentive programs. The analysis indicates that grain sorghum fueled plants in the Panhandle and Central Texas have some chance of success. Alternative incentive levels would make corn fueled plants more competitive. An incentive structure that did not necessarily cap payments at a small size could encourage larger plants that would be able to produce at more efficient, lower production costs per unit.

Community Impacts

The broader economic impacts of building and operating an ethanol plant are provided for a corn based plant located in the Texas Panhandle (**Table 4.9**). The impacts of each of the four plant sizes are divided between the construction and operations phase. Capital spending associated with constructing a 20, 40, 60 and 80 MMGY plant would add $72.8, $133.5, $189.3 and $242.7 million, respectively to the final demand in the local economy. New household income would also be generated ranging from $23.6 million for the 20 MMGY plant to $78.8 million for the 80 MMGY plant.

Table 4.9. Estimated Economic Impact of the Construction and Operation of a Corn Based Ethanol Plant in the Texas Panhandle.

	U.S. RIMS II Multiplier	20 MMGY Plant	40 MMGY Plant	60 MMGY Plant	80 MMGY Plant
Plant Costs ($)		30,000,000	55,000,000	78,000,000	100,000,000
Output ($)	2.4266	72,798,000	133,463,000	189,274,800	242,660,000
Earnings ($)	.7878	23,634,000	31,431,159	64,448,400	78,780,000
Employment (No.)	24.607	738	1,353	1,919	2,460
Sales Tax ($)		719,813	982,224	1,920,263	2,461,875
Shipment Value		32,380,125	62,051,759	90,060,628	118,678,383
Output ($)	1.9623	63,569,520	121,764,167	176,725,970	232,882,591
Earnings ($)	.349	11,300,663	21,656,064	31,431,158	41,418,756
Employment (No.)	10.5623	342	655	951	1,253
Sales Tax ($)		353,146	676,752	982,224	1,294,336

Total output during the operation phase is estimated to be $63.6, $121.8, $176.7 and $232.9 million annually for the 20, 40, 60 and 80 MMGY plants. The economic benefit from profitable operation would result in an additional $11.3 (20 MMGY) to $41.4 million (80 MMGY) in household income for the community each full year of operation.

Sales tax revenue comes from two sources, those generated during the construction phase and those generated during the annual operations of the plant. The sales tax estimates in **Table 4.9** may be considered the upper bound. They are calculated from the increased earnings, or income, in the community. It is assumed that only 50 percent of income is spent on sales taxable items. The state sales tax rate is 0.0625.

State sales tax revenue during the construction phase of a 20 MMGY plant is estimated to be $719,813. An 80 MMGY plant would generate $2,461,875 during construction. Once operating, the 20 MMGY plant would generate an estimated $353,146 annually in sales tax revenue. The 80 MMGY plant would generate almost $1.3 million in sales tax revenue per year.

In the event that three plants were online, the impacts would simply be three times higher (**Table 4.10**).

Table 4.10 Estimated Economic Impact of the Construction and Operation of Three Corn Based Ethanol Plants in the Texas Panhandle.

	U.S. RIMS II Multiplier	20 MMGY Plants	40 MMGY Plants	60 MMGY Plants	80 MMGY Plants
Plant Costs ($)		90,000,000	165,000,000	234,000,000	300,000,000
Output ($)	2.4266	218,394,000	400,389,000	567,824,400	727,980,000
Earnings ($)	.7878	70,902,000	94,293,477	193,345,200	236,340,000
Employment (No.)	24.607	2,214	4,059	5,757	7,380
Sales Tax ($)		2,159,439	2,946,672	5,760,789	7,385,625
Shipment Value		97,140,375	186,155,277	270,181,884	356,035,149
Output ($)	1.9623	190,708,560	365,292,501	530,177,910	698,647,773
Earnings ($)	.349	33,901,989	64,968,192	94,293,474	124,256,268
Employment (No.)	10.5623	1,026	1,965	2,853	3,759
Sales Tax ($)		1,059,438	2,030,256	2,946,672	3,883,008

This analysis assumes that inputs such as corn and grain sorghum are derived locally. As such, the number of jobs needed to support an ethanol plant includes farm employment and employment in other input businesses. The results should be considered an upper bound. To some extent, the jobs supporting the plant may already exist, as in the case of a corn producer. Additionally, some inputs will be purchased outside the region or state. For example, to the extent feedstocks are purchased outside the state, the benefits and jobs indicated in **Tables 4.9 and 4.10** would accrue to the other states. Further, as in all impact analyses, the benefits indicated in **Tables 4.9 and 4.10** include those industries providing inputs to the ethanol plant and the ethanol plant itself. They do not include downstream benefits of the plant.

An Ethanol Checklist

There are a significant number of issues that need to be considered before the decision is made to build an ethanol plant. The following is an attempt to provide a complete list in one place. These points have been gleaned from various publications and researched during this project. A no or negative answer to any one of these questions would not necessarily eliminate an area from entering the ethanol market, however, one would be wise to thoroughly research whether or not an alternative location would be more feasible.

- Is there demand for ethanol currently and what is the outlook for the future?
- Are there local markets for co-products, such as DDGS or CO_2?
- Are there state incentives?
- Are there sufficient utilities at the potential site? Proximity to natural gas lines is an important consideration. Site choice may change based on location of utility sources?
- Is there rail or truck service? Many communities have rail lines. They may not have been used in 30 years. Their presence does not mean that they are adequate.
- What are future prices and availability of feedstocks?
- Is there access to local waste water effluent treatment?
- Is there suitable property in the right location relative to the local community? Is there room for expansion, feedstock storage and traffic movement?
- What is the prevailing wind direction relative to the community?
- Is there broad based community support?
- Are there sufficient mechanical and electrical services available?
- Is there sufficient labor availability?
- Is the right leadership in place to lead the project through completion and management during operation?
- What is the seasonality of feedstock availability?
- What is the competitive market situation for feedstocks?
- What is the transportation cost to have ethanol shipped to a market?
- If ethanol is to be shipped by truck are there sufficient back-hauling opportunities?
- What is the proximity to ethanol users, such as fuel formulators? Can the plant be co-located with a user?
- What permits and regulations must be obtained?
- Have you obtained a feasibility study based specifically for your community?

Results Summary

The projected financial feasibility results show little economic incentive to entice equity investment in Texas ethanol production using corn. The projected average net present value (NPV) of any size plant is well below zero, and shows low probabilities of being positive under the best of conditions. In addition, the strain on the operation's cash flow is beyond manageable. For both the Panhandle and Central Texas regions, investment in a plant using corn does not appear to be profitable. However, as expected, in the volume-driven production of ethanol, only slight changes in average assumptions are needed to project a profitable situation. For example, the 80 MMGY corn plant in the Panhandle region would need to average only $0.06 per gallon higher ethanol price relative to the base assumption of $1.086 per gallon. The higher ethanol price would generate on average an NPV of zero--an acceptable 8 percent return on investment. With uncertain changes in future demand and the potential for substantial increases in ethanol supply, the market price of ethanol could generate a profit for an 80 MMGY plant. Unfortunately, the uncertainty could also generate prices lower than $1.086 per gallon.

The financial projections for plants using grain sorghum show greater potential for generating interest in equity investment. The different sized grain sorghum plants in the Panhandle show a 50 to 75 percent probability of realizing a positive NPV. The two larger plants show a positive NPV on average. The Panhandle region appears to be the most likely area to attract grain sorghum based ethanol production in Texas. The results for the Central Texas region show a 25 to 50 percent chance of earning a positive NPV, but the average NPV for each size plant is still negative. The Southeast location projects average NPVs well below zero and limited probabilities for positive NPV.

The promising results for the grain sorghum based plant in the Panhandle region should be viewed with caution. The analysis assumes the presence of a plant would not significantly change the local market price for grain sorghum. The assumption is reasonable, given the likelihood of a particular region increasing the acreage of grain sorghum to match the added demand. However, it is possible that a plant may have to pay higher prices for grain sorghum to encourage continuous supply. Higher grain sorghum prices would certainly dampen the financial outlook for the grain sorghum based ethanol plant. In the event that grain sorghum prices increase due to the presence of a grain sorghum ethanol facility, the financial projections for the grain sorghum plant would more closely match the corn plant projections.

The additional business activity associated with additional jobs and output can generate increased household income and consumer demand, boosting a local economy and the sales tax base. An increase of $24 and $79 million in household income could be expected from the construction phase of a 20 MMGY and 80 MMGY plant, respectively. The operating phase of an ethanol facility could increase household income by $11 million annually for a 20 MMGY plant and as much as $41 million for an 80 MMGY plant. Expected sales tax revenue generated from a 20 MMGY plant would be approximately $700,000 during construction and roughly $350,000 annually during operation. An 80 MMGY plant could boost the sales tax revenue by as much as $2.4 million during construction and $1.3 million annually during operation.

The extended economic benefits from the business of an ethanol production facility can be significant. However, it is important to note these benefits assume continued profitable ethanol production. As a direct reflection of the risky financial outlook for the equity investor, the overall benefits to the local economy are also quite risky. Financial failure of an ethanol plant would obviously preclude the realization of any benefits to the local economy.

Chapter 5.
Summary and Conclusions

The recent resurgence of interest in ethanol production has prompted various stakeholders in the State to call for an unbiased analysis of the potential in Texas. Unlike the experience with ethanol during the 1980s which found it to be a relatively expensive fuel alternative, there appears to be a number of plants operating in the U.S. that are significantly more cost effective. Two major changes have occurred that have aided ethanol production. First, EPA regulations on non-attainment cities have increased the demand for ethanol. And second, technological innovations in the production of ethanol have resulted in lower costs of production.

Many state governments, as well as, the Federal government have provided various financial incentives intended to assist in the development of production facilities leading to an increase in ethanol production.

Much like the push in the 1970s and 1980s to revitalize rural areas by attracting industry, locating an ethanol plant in a rural area is seen as a major boost to rural communities and their tax base.

The ethanol industry in the United States tends to be located in the Midwest. This is primarily due to the abundant supply of relatively low priced corn used as the primary feedstock. This means that to compete with plants located near cheap feedstocks, a plant located in another area will need to have some other advantage.

This project was designed to assess the feasibility of ethanol production and its economic impact in Texas. While not intended to determine the feasibility of a specific site, the feasibility of constructing a plant in several regions of the State was assessed. This study should not be viewed as a replacement for a specific feasibility study that would include site specific factors, situations, and relationships. An attempt was made to focus on both the positives and negatives for various regions of the state in terms of the economics of locating an ethanol plant in the area and on the economic feasibility of the plant.

The impact of any major business activity on the local, regional, and state economy can be significant. In fact, the primary interest in bringing ethanol production to Texas lies in the extended economic benefits to rural communities and regional economies. While the focus of stakeholders calling for this analysis is not the profit potential of ethanol equity investors, that potential is a primary focus of this study. The reason for this focus is that regardless of plant size, economic activity, or number of jobs affected, the potential economic benefits will not be realized if the equity investor, seeing no profit potential, does not support development of the industry in Texas.

One major contribution of this study is the use of risk analysis which has not been performed in any of the previous feasibility studies. Risk analysis incorporates variability in input (e.g., corn, grain sorghum, natural gas) and output (ethanol and DDGS) prices. Understanding this variability and incorporating it in the analysis is critical to understanding the feasibility of ethanol production in Texas.

The portrayal of financial results for an ethanol plant in a probabilistic framework gives decision makers much more information than singular estimates of annual outcomes. This report contains annual averages and probabilities of reaching a required return. A critical risk assessment of feasibility is more powerful than previous feasibility studies.

The projected financial feasibility results show little economic incentive to entice equity investment in Texas ethanol production using corn. The projected net present value (NPV) of any size plant is well below zero, and shows only slight probabilities of being positive under the best of conditions.

The financial projections for plants using grain sorghum show greater potential for generating interest in equity investment. The different sized grain sorghum plants in the Panhandle show a 50 to 75 percent probability of realizing a positive NPV. The two larger plants show a positive NPV on average. The Panhandle region appears to be the most likely area to attract grain sorghum based ethanol production.

The promising results for the grain sorghum plant in the Panhandle region should be viewed with caution. The analysis assumes the presence of a plant would not significantly change the local market price for grain sorghum. The assumption is reasonable, given the likelihood of a particular region increasing the acreage of grain sorghum to match the added demand. However, it is possible that a plant may have to pay higher prices for grain sorghum to encourage continuous supply. Higher grain sorghum prices would certainly dampen the financial outlook for the grain sorghum based ethanol plant. In the event that grain sorghum prices increase due to the presence of a grain sorghum ethanol facility, the financial projections for the grain sorghum plant would more closely match the corn plant projections.

The additional business activity associated with new and existing jobs and output can generate increased household income and consumer demand, boosting a local economy and the sales tax base. An increase of $24 and $79 million in household income could be expected from the construction phase of a 20 MMGY and 80 MMGY plant, respectively. The operating phase of an ethanol facility could increase household income by $11 million annually for a 20 MMGY plant and as much as $41 million for an 80 MMGY plant. Expected sales tax revenue generated from a 20 MMGY plant would be approximately $700,000 during construction and roughly $350,000 annually during operation. An 80 MMGY plant could boost the sales tax revenue by as much as $2.4 million during construction and $1.3 million annually during operation.

The extended economic benefits from the business of an ethanol production facility can be significant. However, it is important to note these benefits assume continued profitable ethanol production. As a direct reflection of the risky financial outlook for the equity investor, the overall benefits to the local economy are also quite risky. The financial failure an ethanol plant would obviously preclude the realization of any benefits to the local economy.

References Cited

Avant, B., S. Fuller, B. Gardner, R. Griffin, R. Kay, R. D. Lacewell, L. Makus, S. Masud, J. Richardson, C. R. Taylor and T. J. Taylor. "The Production and Sale of Gasahol in Texas." Texas Agricultural Experiment Station, College Station, TX, May 1981b.

Bernard, R. "MTBE's Fall From Grace: Ethanol's Savior?" *Landowner*. August 23, 1999.

Birtle, S. Personal Communication, November 4, 2002.

Bryan and Bryan International. "Ethanol Info: Ethanol Plant Production Lists." Cotopaxi CO: Bryan and Bryan International, Available at http://www.bbiethanol.com/ethanol_info/,November 25, 2002.

Bryan and Bryan International. *Dumas Texas Area Ethanol Feasibility Study.* Cotopaxi CO: Bryan and Bryan International, August 2001a.

Bryan and Bryan International. *Ethanol Plant Development Handbook: Points to Consider*. Cotopaxi, CO: Bryan and Bryan International, 2001b.

Davis, Kelly S., "Co-Products for the Feed Industry from Ethanol Production", National Corn Growers Association Southwest Distillers Grains Conference, October 30-31, 2002, Amarillo, Texas.

DiPardo, J. *Outlook for Biomass Ethanol Production and Demand*. United States Department of Energy, Energy Information Agency, November 2001.

Evans, M. K. "The Economic Impact of the Demand for Ethanol." Presented at the Midwestern Governors' Conference, Lombard, IL, February 1997.

Gill, R. C. *A Stochastic Feasibility Study of Texas Ethanol Production: Analysis of Texas State Legislature Ethanol Subsidy.* Texas A&M University, M.S. thesis, December 2002.

House Agriculture Committee. *Farm Bill Conference Summary*. U.S. House of Representatives, April 30, 2002.

ICIS-LOR Inc. "FUEL in US Gulf SPOT 200 PROOF (FOB)." Houston, TX. June 2002.

Kistner, J. Personal Communication, November 8, 2002.

Littlepage, L. "Estimating the Economic Impacts of an Ethanol Plant." Indiana Department of Commerce, Research Office, April 1992.

Long, E., and J. Creason. "Ethanol Programs: A Program Evaluation Report." St. Paul, Minnesota: Office of the Legislative Auditor, State of Minnesota, Report (97-04), February 1997.

McGinnis, M. "Ethanol Plants Assess California MTBE Delay." DTN AgDaily, March 26, 2002.

NGCA, Southwest Distillers Grains Conference, October 30-31, 2002, Amarillo, Texas.

Otto, D. "The Effects of Expanding Ethanol Markets on Ethanol Production, Feed Markets, and the Iowa Economy." Department of Economics, Iowa State University, Ames, IA, June 30, 2001.

Petrulis, M., J. Sommer and F. Hines. "Ethanol Production and Employment." U.S. Department of Agriculture, Economic Research Service, Agriculture Information Bulletin No. 678, July 1993.

Richardson, J.W. *Simulation for Applied Risk Management with An Introduction to the Software Package SIMETAR©: Simulation for Excel to Analyze Risk.* Department of Agricultural Economics, Agricultural and Food Policy Center, Texas A&M University. January 2002.

Shapouri, H., J. A. Duffield and M. Wang. "The Energy Balance of Corn Ethanol: An Update." U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 813, July 2002.

Urbanchuk, J. M. "An Economic Analysis of Legislation for a Renewable Fuels Requirement for Highway Motor Fuels." AUS Consultants, Moorestown, VT, November 7, 2001.

U.S. Department of Agriculture. Agriculture Statistics *Database*. Available at http://www.nass.usda.gov:81/ipedb/

U.S. Department of Agriculture. *Feed Grains Data Delivery Service.* Available at http://www.ers.usda.gov/db/feedgrains. Washington DC, June 2002.

U.S. Department of Energy (DOE). *Alternative Fuel Vehicle Fleet Buyer's Guide: Incentives, Regulations, Contacts.* Washington DC, June 2002.

Van Dyne, D. L. "Employment and Economic Benefits of Ethanol Production in Missouri." Dept. Agr. Econ., University of Missouri-Columbia, February 2002.

Appendix A

Alcohol Fuels Committee. "Ethanol Fuels and Feed By-Products." Cooperative Extension Service, Clemson University, Clemson, SC, September 3, 1979.

Allsup, J. R. and D. B. Eccleston. "Ethanol/Gasoline Blends as Automotive Fuel." U.S. Department of Energy, Washington, D.C., BETC/RI-79/2, May 1979.

Anderson, M. "Ethanol Production, Corn Gluten Feed, and EC Trade." U.S. Department of Agriculture, Economic Research Service, AIBN Number 677, July 1993.

Archer Daniels Midland Company. *Fuel Ethanol as an Octane Booster*. Technical Bulletin, Decatur, IL, November 1986.

Avant, R., S. Fuller, B. Gardner, R. Griffin, R. Kay, R. Lacewell, L. Makus, S. Masud, J. Richardson, C. Taylor and T. Taylor. "Factors Affecting the Production and Sale of Gasohol in Texas." Texas Agricultural Experiment Station, College Station, TX, February 1981a.

Avant, B., S. Fuller, B. Gardner, R. Griffin, R. Kay, R. D. Lacewell, L. Makus, S. Masud, J. Richardson, C. R. Taylor and T. J. Taylor. "The Production and Sale of Gasahol in Texas." Texas Agricultural Experiment Station, College Station, TX, May 1981b.

Berg, C. "World Ethanol Production 2001." Available at http://www.distill.com/world_ethanol_production.htm, July 31, 2001.

Bernard, R. "MTBE's Fall From Grace: Ethanol's Savior?" *Landowner*. August 23, 1999.

Blackburn, B., T. MacDonald, M. McCormack, V. Tiangco, P. Perez, and S. Brown. *Evaluation of Biomass-to-Ethanol Fuel Potential in California (draft).* Sacramento CA: California Energy Commission, Report P500-99-011, August 1999.

Bryan and Bryan International. "Ethanol Info: Ethanol Plant Production Lists." Cotopaxi CO: Bryan and Bryan International, Available at http://www.bbiethanol.com/ethanol_info/,November 25, 2002.

Bryan and Bryan International. *Dumas Texas Area Ethanol Feasibility Study.* Cotopaxi CO: Bryan and Bryan International, August 2001a.

Bryan and Bryan International. *Ethanol Plant Development Handbook: Points to Consider*. Cotopaxi, CO: Bryan and Bryan International, 2001b.

Campbell, J. B. "New Markets for Bio-Based Energy and Industrial Feedstocks: Biodiesel - Will There Be Enough?" Paper presented at the USDA Agricultural Outlook Forum 2000, February 25, 2000.

Cargal, J. R. and J. C. Whittemore. "Legal and Policy Issues in Ethanol Production." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

Coble, C. G., J. M. Sweeten, R. P. Egg, E. J. Soltes, W. H. Aldred and D. A. Givens. "Biological Conversion and Fuel Utilization: Fermentation for Ethanol Production." In *Biomass Energy: A Monograph*. E. A. Hiler and B. A. Stout eds., Texas A&M University Press, College Station, TX, 1985.

Committee on Animal Nutrition. "Feeding Value of Ethanol Production By-Products." National Academy Press, Washington, D.C., 1981.

Converse, J. C., R. H. Reed, O. I. Berge, E. A. Brickbauer, F. H. Buelow, R. H. Vilstrup, P. S. Myers, L. L. Maurer, R. Jensen and C. H. Amundson. "Ethanol Production From Biomass with Emphasis on Corn." University of Wisconsin-Extension, Madison, WI, September 1979.

Corbus, D. and V. Putsche. "Environmental Analysis of Biomass-to-Ethanol Facilities." U.S. Department of Energy, Golden, Colorado, December 1995.

Crooks, A. C. "Co-op Involvement in Ethanol Industry Grows Despite Uncertainty." Rural Cooperatives. pp. 28-33, July/August 1997.

Da Silva, J. G. and G. E. Serra. "Energy Balance for Ethyl Alcohol Production from Crops." *Science.* 201(1978):903-906.

Davison, R. R. and W. B. Harris. "Ethanol Versus other Alternate Fuels." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

DiPardo, J. *Outlook for Biomass Ethanol Production and Demand*. United States Department of Energy, Energy Information Agency, November 2001.

Doering III, O. C. and W. E. Tyner. "Alcohol Production from Agricultural Products: An Update on the Facts and Issues." Cooperative Extension Service, Purdue University, West Lafayette, IN, EC-511, May 1980.

Downs, H. and B. L. Clary. "Alcohol-Fuel." Agriculture Engineering Department, Oklahoma State University, Stillwater, OK, 1980.

Downs, H. W. and B. L. Clary. "Alcohol-Fuel." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

Elander, R.T., and V.L. Putsche. "Ethanol From Corn: Technology and Economics." *Handbook on Bioethanol: Production and Utilization.* C.E. Wyman, ed., pp. 329-349. Washington DC: Taylor and Francis, 1996.

ENERGETICS and NEOS Corporation. "Economic Impact of Ethanol Production Facilities: Four Case Studies." Columbia, MD: ENERGETICS and Lakewood CO: NEOS Corporation, June 1994.

Energy Information Administration. "Short-Term Energy Outlook." Department of Energy, Available at http://www.eia.doe.gov, November 6, 2001.

Ernst, M., J. Rodecker, E. Luvaga, T. Alexander, J. Kliebenstein and J. Miranowski. "The Visibility of Methane Production by Anaerobic Digestion on Iowa Swine Farms." Department of Economics, Iowa State University, Ames, IA, Staff Paper No. 328, October 1999.

Evans, M. K. "The Economic Impact of the Demand for Ethanol." Presented at the Midwestern Governors' Conference, Lombard, IL, February 1997.

FAPRI. "Baseline Projections, July 2002." Food and Agriculture Policy Research Institute University of Missouri-Columbia, July 2002.

FarmLine. "Ethanol Producers Strive to Cut Costs." pp. 16-17, March 1989.

Fialka, J. J. "EPA Investigates Emissions From Ethanol Manufacturing." The Wall Street Journal Online, May 7, 2002. Available at: http://online.wsj.com.

Fischer, L. K. "The Economics of Producing Fuel Alcohol in Farm Size Plants." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

Food and Agricultural Policy Research Institute. "Impacts of Increased Ethanol and Biodiesel Demand." University of Missouri, Columbia, MO, FAPRI-UMC Report #13-01, October 2001.

Fruin, J. "An Application of Geographic Information Systems to Alfalfa Bio-Mass Energy and Marketing Coops." Presented at the Sixth Joint Conference on Food, Agriculture and the Environment, Minneapolis, MN, August 31-September 2, 1998.

Fruin, J., and D.W. Halbach. "The Economics of Ethanol Production and Its Impact on the Minnesota Farm Economy." Staff Paper (P86-12), Dept. of App. Econ., University of Minnesota, March 1986.

Fruin, J., K. Rotsios, and D.W. Halbach. “Minnesota Ethanol Production and Its Transportation Requirements.” Staff Paper (P96-7), Dept. of App. Econ., University of Minnesota, April 1996.

Goering, C. E. “Tapping a Renewable Energy Source.” *Illinois Research*. Spring/Summer 1992, pp 10-14.

Gulati, M., K. Kohlmann, M. R. Ladisch, R. Hespell and R. J. Bothast. “Assessment of Ethanol Production Options for Corn Products.” *Resource Technology*. 58(1996):253-64.

Hertzmark, D., S. Flaim, D. Ray and G. Parvin. “Economic Feasibility of Agricultural Alcohol Production within a Biomass System.” *American Journal of Agricultural Economics*. 62(1980), pp. 965-71.

Heuer, R. “The Ethanol Bandwagon: A Primer for Financiers.” *Ag Lender*. Volume 6, Issue 1, January 2002.

Hiler, E. A., C. G. Coble, R. P. Egg, J. M. Sweeten, R. S. Etheredge, J. T. Lawhon, J. W. Jenkins, J. J. Dolande, K. A. Hall, G. T. Schelling, G. G. McBee, H. P. O’Neal, W. H. Aldred, M. J. Prebeg, W. A. Thompson, R. C. Griffin, J. M. Bower and R. D. Lacewell. “Ethanol Production in Small - to Medium-Size Facilities for Use in Internal Combustion Engines.” Texas A&M University, College Station, TX, August 1983.

Hill, H and R. H. Griggs. “Energy Policy in the 1990's: Where Does Agriculture Fit In?” Presented to the Senate Finance Committee’s Special Subcommittee on Energy, Taxes and Agriculture, College Station, TX, April 21, 1994.

Hudson, W. J. “Multi-Client Study: Market Value of Distillers Grains.” The ProExporter Network. Olathe, KS, January 7, 2002.

Johnston, J. “Galva, Iowa, Ethanol Plant in Business.” Agweb.com, March 7, 2002.

Johnston, J. “Study: Ethanol has Positive Net Energy Balance.” AgWeb.com, July 3, 2002.

Jordan, H. “Gasohol: A Timely Revival of an Old Idea.” Texas Department of Agriculture Quarterly, Austin, TX, August 1978.

Kane, S. and M. LeBlanc. “Ethanol and U.S. Agriculture.” Economic Research Service, U.S. Department of Agriculture, Agriculture Information Bulletin Number 559, January 1989.

Kane, S. M. and J. M. Reilly. "Economics of Ethanol Production in the United States." U.S. Department of Agriculture, Economic Research Service, AER No. 607, March 1989.

Kennedy, R. "Family Bagging Sweet Sorghum Stalks for Gasohol Conversion." Southwest Farm Press, p. 44, March 20, 1980.

Kinoshita, C. and J. Zhou. "Siting Evaluation for Biomass-Ethanol Production in Hawaii." Department of Biosystems Engineering, University of Hawaii at Manoa, Hawaii, October 1999.

Lacewell, R. D., E. A Hiler, S. Masud and R. D. Kay. "Assessment of Agriculture and Energy Production Systems." Research Report prepared for the Texas Energy and Natural Resources Advisory Council, February 1981.

LePori, W. A. and R. R. Davison. "Ethanol as a Fuel for Internal Combustion Engines – Spark Ignition and Diesel." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

Littlepage, L. "Estimating the Economic Impacts of an Ethanol Plant." Indiana Department of Commerce, Research Office, April 1992.

Long, E., and J. Creason. "Ethanol Programs: A Program Evaluation Report." St. Paul, Minnesota: Office of the Legislative Auditor, State of Minnesota, Report (97-04), February 1997.

Lorenz, D. and D. Morris. "How Much Energy Does it Take to Make a Gallon of Ethanol?" Institute for Local-Self Reliance. Washington, D.C., August 1995.

Lynd, L. R., J. H. Cushman, R. J. Nichols and C. E. Wyman. "Fuel Ethanol from Cellulosic Biomass. *Science.* Volume 251, March 1991.

MacDonald, T., G. Yowell., and M. McCormack. "U.S. Ethanol Industry: Production Capacity Outlook." Sacramento CA: California Energy Commission, Staff Report P600-01-017, August 2001.

Martin, Jr., N. R. and G. D. Hanson. "Ethanol Cogeneration and Farm Program Costs: Gasohol as a Policy Variable." Selected Paper at the AAEA Annual Meeting, Ithaca, NY, August 1983.

McCarthy, J. E. and M. Tiemann. "MTBE in Gasoline: Clean Air and Drinking Water Issues." Congressional Research Service, Washington, D.C., May 3, 2002.

McNutt, B., P. Bergeron, M. Singh and K. Stork. "Making the Transition to Large Scale Ethanol Use in the U.S. Transportation Sector." Presented at the XI International Symposium on Alcohol Fuels, Sun City, South Africa, April 14-16, 1996.

Meekhof, R. L., W. E. Tyner and F. D. Holland. "U.S. Agricultural Policy and Gasohol: A Policy Simulation." *American Journal of Agricultural Economics*. 62(1980), pp. 408-15.

Meekhof, R., M. Gill and W. Tyner. "Gasohol: Prospects and Implications." U.S. Department of Agriculture, Agricultural Economic Report No. 458, Washington D.C., June 1980.

Michigan Biotechnology Institute. "Cost of Ethanol Production From Lignocellulosic Biomass -- A Comparison of Selected Alternative Processes." Lansing, MI, April 30, 1993.

Middaugh, R. P. "Small Scale Fuel Alcohol Production: Energy and Economic Study." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

Miles, J. "Small-Scale Production of Alcohol Fuel: Not Feasible for the Farmer." Voice of the Federal Reserve Bank of Dallas, Dallas, TX, pp. 12-13, October, 1980.

Miller, F. R. and R. A. Creelman. "High Energy Sorghums – and other Possibilities – for Energy Production." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

National Technical Information Service. "Analysis of the Economic and Environmental Effects of Ethanol as an Alternative Fuel." Springfield VA: Report (PB90-222522), April 1990.

Novack, N. "The Rise of Ethanol in Rural America." Center for the Study of Rural America, Federal Reserve Bank of Kansas City, Kansas City, MO, March 2002.

O'Neal, H. "Ethanol Production and Use." Texas Agricultural Extension Service, Texas A&M University, College Station, TX, January 1980.

O'Neal, H. P. "Ethanol Production System Design." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

O'Neal, H. "Ethyl Alcohol Production." Texas Agricultural Extension Service, College Station, TX, B-1374, 1980.

Office of Scientific and Technical Information. "National Energy Strategy -- Powerful Ideas for America." Washington D.C., February 1991.

Office of Technology Assessment. "Gasohol: A Technical Memorandum." Washington, D.C., September 1979.

Office of Technology Assessment. *Energy From Biological Processes*. Volume II – Technical and Environmental Analyses, Congress of the United States, Washington, D.C., OTA-E-128, September 1980.

Otto, D. "The Effects of Expanding Ethanol Markets on Ethanol Production, Feed Markets, and the Iowa Economy." Department of Economics, Iowa State University, Ames, IA, June 30, 2001.

Otto, D., M. Imerman and L. Kolmer. "Iowa's Ethanol and Corn Milling Industries: Economic and Employment Impacts." Department of Economics, Iowa State University, Staff Paper #238, December 1991.

Petrulis, M., J. Sommer and F. Hines. "Ethanol Production and Employment." U.S. Department of Agriculture, Economic Research Service, Agriculture Information Bulletin No. 678, July 1993.

Pryor, B. "Resistence Still Heavy in California: Renewable Fuels Standard Gets Wide Support." *Southwest Farm Press*. p 12, April 4, 2002.

Rose, D. W. and S. A. Husain. "Biomass Electric Power Plants: Land Use Impacts For Forestry and Agriculture." Presented at the Sixth Joint Conference on Food, Agriculture and the Environment, Minneapolis, MN, August 31-September 2, 1998.

Rotsios, K. "Ethanol Production in Minnesota and It's Impact on Transportation." M.S. thesis, University of Minnesota, November 1995.

Sanderson, F. H. "Gasohol: Boon or Blunder?" The Brookings Bulletin, Volume 16, Number 3, Winter 1980.

Sanderson, F. H. "Benefits and Costs of the U.S. Gasohol Program." Resources for the Future. No. 67, July 1981.

Schake, L. M. "Prospects for Ethanol Stillage as a Cattle Feed." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

Science. "Gasohol: A Choice That May Buy Grief." Volume 207, March 28, 1980.

Shapouri, H., J. A. Duffield and M. S. Graboski. "Estimating the Net Energy Balance of Corn Ethanol." U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 721, July 1995.

Shapouri, H., J. A. Duffield and M. Wang. "The Energy Balance of Corn Ethanol: An Update." U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 813, July 2002.

Shapouri, H., P. Gallagher, and M. Graboski. "USDA's 1998 Ethanol Costs of Production Survey." U. S. Department of Agriculture. Report 808. January 2002.

Slaughter, B. "A Refiner's Perspective on Biofuels." Paper presented on the USDA Agricultural Outlook Forum, February 25, 2000.

Smith, E. G., J. W. Richardson, D. P. Anderson, R. D. Knutson, A. W. Gray, S. L. Klose and J. L. Outlaw. "Effects on Representative Feed Grain Farms From Elimination of the Excise Tax Exemption For Fuel Ethanol." Agricultural and Food Policy Center, Texas A&M University, College Station, TX, AFPC Working Paper 97-3, April 1997.

Solar Energy Research Institute. "Alcohol Fuels Bibliography: 1901 - March, 1980." Golden, CO, April 1981.

Soltes, E. J. "Alternative Feedstocks for Ethanol Production." Presented at the Alcohol-Fuel Symposium at Texas A&M University, College Station, TX, July 1-2, 1980.

Stampe, S. and T. S. Chisholm. "Ethanol Production Energy Analysis." Agricultural Engineering Department, South Dakota State University, Brookings, SD, July 1981.

Sweeten, J. M., J. T. Lawhon, G. T. Schelling, and R. S. Etheredge. "Grain Sorghum Stillage Processing: Nutrient Recovery and Pollution Control." Transactions of the ASAE, pp. 1158-70, 1983.

Texas Energy and Mineral Resources. "High-Octane Fuel From Plant Residues." Texas A&M University, College Station, TX, October 1981.

Thimsen, D.P., M. S. Litterman, V. R. Eidman and H. Jensen. "Production and Use of

Urbanchuk, J. M. "An Economic Analysis of Legislation for a Renewable Fuels Requirement for Highway Motor Fuels." AUS Consultants, Moorestown, VT, November 7, 2001.

U.S. Department of Agriculture. "Gasohol from Grain – The Economic Issues." Economics, Statistics, and Cooperative Service, Washington, D.C., ESCS No. 11, January 19, 1978.

U.S. Department of Agriculture. "USDA Advises Guarantees, Safety Points for Fuel-Alcohol Stills." News Feature, Washington, D.C., July 10, 1980.

U.S. Department of Energy. "Alternatives to Traditional Transportation Fuel: An Overview." Energy Information Administration, Washington, D.C., June 1994.

U.S. Department of Energy. "The Energy Consumer: Alcohol Fuels." Office of Consumer Affairs, January 1980.

U.S. Department of Energy. "The Report of the Alcohol Fuels Policy Review." Washington, D.C., DOE/PE-0012, June 1979.

U.S. Department of Energy, Alternative Fuels Fleet Buyers Guide. *Alternative Fuel Vehicle Fleet Buyer's Guide: Incentives Regulations, Contacts.* Available on line (http://www.fleets.doe.gov). Washington DC, June 2002.

United States General Accounting Office. "Alcohol Fuels: Impacts From Increased Use of Ethanol Blended Fuels." Resources, Community, and Economic Development Division, Washington, D.C., July 1990.

United States General Accounting Office. "Motor Fuels -- Issues Related to Reformulated Gasoline, Oxygenated Fuels, and Biofuels." Resources, Community, and Economic Development Division, Washington, D.C., RCED-96-121, June 1996.

United States Senate. "Ethanol, Clean Air, and Farm Economy." Hearing of Committee on Agriculture, Nutrition, and Forestry, 104^{th} Congress, S. Hrg. 104-549, September 28, 1995.

USA Today. "Despite Grand Plans, Ethanol Falls Short as 'Miracle Fuel'." May 16, 2002, p. 11A.

Van Dyne, D. L. "Employment and Economic Benefits of Ethanol Production in Missouri." Dept. Agr. Econ., University of Missouri-Columbia, February 2002.

Warkentin, M. E. "Fuel Ethanol Production in Nebraska: An Economic Impact Analysis." Pepared for the Nebraska Energy Office and Nebraska Gasohol Committee, Lincoln, NE, September 1983.

Weller, C. L, M. P. Steinberg and E. D. Rodda. "Fuel Ethanol From Raw Corn." Transactions of the ASAE. pp. 1911-1915, 1984.

Wilkie, D. "More Ethanol May Mean Less Money for Roads." *San Diego Union*, April 4, 2002.

Wilson, M. "Six Tips for Ethanol Investors." *Prairie Farmer*, February 2002, pp. 28-29.

Womack, A. and W. Meyers. "Effects on Agriculture of Elimination of the Excise Tax Exemption for Fuel Ethanol." Food and Agricultural Policy Research Institute, University of Missouri, FAPRI Policy Working Paper 01-97, April 8, 1997.

Wyman, C. E. and N. D. Hinman. "Ethanol: Fundamentals of Production from Renewable Feedstocks and Use as a Transportation Fuel." *Applied Biochemistry and Biotechnology*. Volume 24/25, pp. 735-53, 1990.

Yacobucci, B. and J. Womach. "Fuel Ethanol: Background and Public Policy Issues." Congressional Research Service Issue Brief, National Council for Science and the Environment, Washington, D.C., March 22, 2000.

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