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Factors Associated with Success of Fuel Ethanol Producers

by

Douglas G. Tiffany and Vernon R. Eidman

DEPARTMENT OF APPLIED ECONOMICS
COLLEGE OF AGRICULTURAL, FOOD, AND ENVIRONMENTAL SCIENCES
UNIVERSITY OF MINNESOTA

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This research was funded by the U.S. Department of Agriculture and the Minnesota Agricultural Experiment Station.

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Acknowlegements

The authors greatly appreciate the time and patience of the following individuals in helping us to understand plant operations, financing, and marketing of products of dry mill ethanol plants.

Dr. Jerry Thompson, Agribank, St. Paul, MN
Mr. Jim Jones, Agribank, St. Paul, MN
Mr. Ben Brown, Heartland Corn Products, Winthrop, MN
Mr. Todd Kruggel, Renewable Products Marketing Group, Winthrop, MN
Ms. Kelly Davis, Chippewa Valley Ethanol Company, Benson, MN
Mr. Joe Johansen, Minnesota Energy, Buffalo Lake, MN
Mr. Gerald Rust, Denco LLC, Morris, MN
Mr. Jim Highum, Denco LLC, Morris, MN
Mr. Terrance Kulesa, Ace Ethanol, Stanley, WI
Mr. Jim Bisek, Ace Ethanol, Stanley, WI
Ms. Jeanne Scharf, AgStar, Mankato, MN
Mr. Mark Schmidt, AgStar, Northfield, MN
Dr. David Bullock, Minnesota Department of Agriculture, St. Paul, MN
Mr. Ralph Groschen, Minnesota Department of Agriculture, St. Paul, MN
Ms. Su Ye, Minnesota Department of Agriculture, St. Paul, MN
Mr. Matt Janes, Verasun Corporation, Brookings, SD
Mr. Richard Eichstadt, Pro-Corn LLC, Preston, MN

Thanks are also offered to the following University of Minnesota staff and faculty who reviewed this work and offered suggestions:

Mr. Wynn Richardson, Department of Applied Economics
Mr. Rann Loppnow, Department of Applied Economics
Mr. Ed Usset, Department of Applied Economics
Dr. Glenn Pederson, Department of Applied Economics
Dr. Rob King, Department of Applied Economics
Mr. David Schmidt, Department of Biosystems and Agricultural Engineering
Dr. Vance Morey, Department of Biosystems and Agricultural Engineering

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Abstract

Economic factors associated with success or failure of dry-mill ethanol plants utilizing corn as a feedstock are analyzed and discussed. A spreadsheet model is used to conduct the analysis based on the assumptions and interactions of various factors. Plant managers and bankers were interviewed in the process of establishing baseline conditions of operation including capital cost per gallon of capacity, ethanol yield per bushel of corn ground, percentage of debt capital, operating expenses of natural gas, electricity, enzymes, chemicals, repairs, labor, and management. Sensitivities were determined and graphed to demonstrate the respective influence of corn price, ethanol price, natural gas price, ethanol yield, capacity factor, and interest rate-debt percent interactions. The model was used to predict the financial performance of a modern, well-sized, dry-mill plants if the prices that occurred over the past decade with respect to corn prices, ethanol prices, prices of DDGS and CO2, natural gas prices, and interest rates were to re-play. Rates of returns on equity of dry-mill ethanol plants were compared to rates compiled in the last decade for a group of 200 farmers in southwestern Minnesota. Patterns of loan repayment, influence of technological changes, and the role of government subsidies are discussed.

Executive Summary

* Dry mill ethanol plants represent the vast majority of growth in ethanol production capacity built in the U.S. since the mid-1990's with most additional plant capacity located in the Midwest and relying on corn as the feedstock.

* Advances in enzymes, yeasts, and process controls have improved ethanol plant efficiencies, especially in modern plants exceeding 40 million gallons per year in nameplate capacity.

* Dry mill ethanol plants have experienced great volatility in their net returns over the last decade of operations.

* Ethanol prices, corn prices, natural gas prices, and ethanol yields can each drastically affect net margins for ethanol plants.

* The profitability of ethanol plants is enhanced by locating them in areas of low corn prices, on sites with access to excellent highway and railroad transportation, and at locations with access to low cost natural gas supplied by high capacity pipelines, and ample electrical power service. Although many plants have back-up propane supplies for times of natural gas interruptions, use of this fuel is much more costly than natural gas.

* Starting from baseline assumptions (including $1.15 per gallon of ethanol, $2.20 per bushel of corn, $ 4.50 per dekatherm of natural gas, and an anhydrous ethanol yield of 2.75 gallons per bushel), reducing the ethanol price to $1.07/gal., or increasing the corn price to $2.43 per bushel, or increasing natural gas price to $6.85 per dekatherm, or reducing the ethanol yield to 2.36 gallons per bushel can each reduce the net margin of a modern, well-scaled plant to zero. Multiple factors acting in concert can also reduce net margins to zero.

* Smaller ethanol plants of less than 20 million gallons per year capacity are highly reliant upon state and federal subsidies to survive, especially when they carry higher levels of debt. Few plants of this scale have been built in recent years.

*   Dry mill ethanol plants are high volume, commodity-based enterprises, requiring excellent management, high ethanol yields, and modern ethanol marketing strategies. Clever managers and competent staff are needed to stay competitive in this business.

* Ethanol plants must strive to utilize risk-management techniques, especially with respect to marketing their ethanol and DDGS products, procuring their corn, and purchasing their natural gas.

*The history of plant profits modeled through a decade of price shifts of various factors such as ethanol price, corn price, natural gas price, and interest rates offers insight into the gains from utilization of risk management strategies in marketing co-products and pricing inputs at dry mill ethanol plants.

*If the last decade's prices of ethanol, DDGS, CO2, corn, and natural gas were to replay, a modern, well-sized plant would be unprofitable 8.3% of the time.

*A replay of the last decade's prices of ethanol, DDGS, CO2, corn, and natural gas in a modern, well-sized plant would fail to return 12% on equity investment 16.7% of the time.

* The return of higher real interest rates may harm smaller plants and those plants that have been unable to reduce their debt levels in early years of operation.

* Dry mill ethanol plants built in recent years on the fringe of the established Corn Belt will be vulnerable to greater variation in the available supply of corn due to weather-based risk.

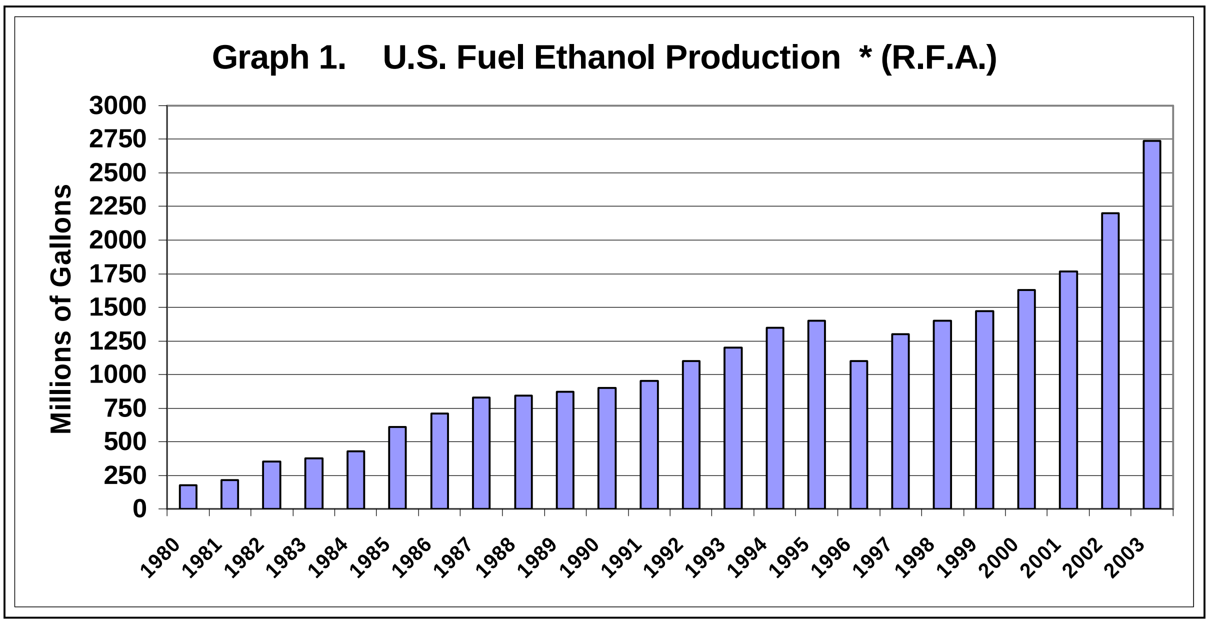
*The spreadsheets developed and utilized in this study may have lasting usefulness to ethanol plant managers, bankers, and policymakers seeking to understand the volatile nature of net returns of producing ethanol in dry mill plants.

Introduction: Rapid Growth, Price Volatility Dominate Industry

This report identifies the major factors associated with financial success of dry mill fuel ethanol plants and estimates the impact of each of these factors on profitability of the business. This information and the methods of analysis described in this report can be used in planning new operations as well as evaluating the impact of improving an existing plant's performance and the effect on profitability.

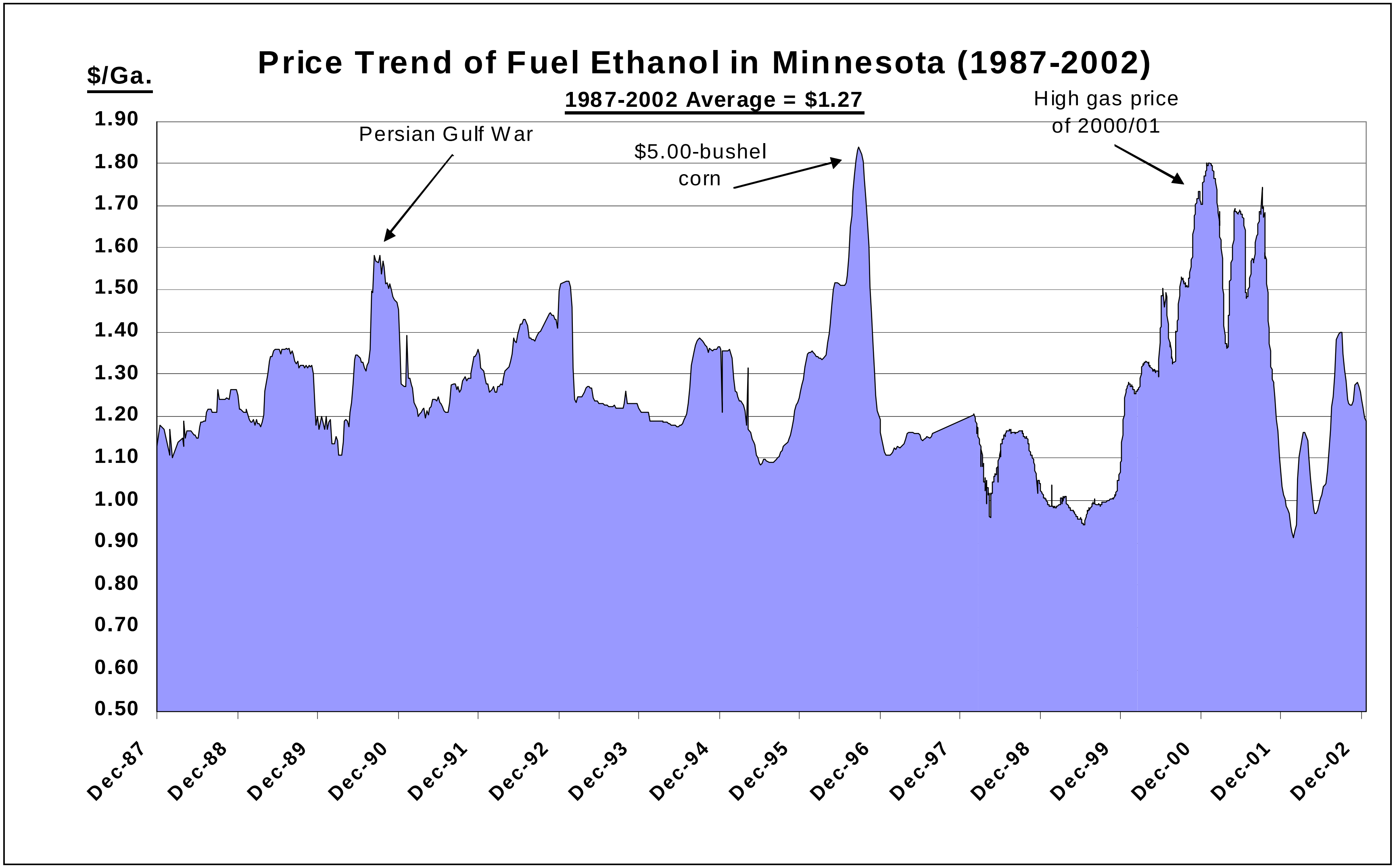
Growth in capacity of the fuel ethanol production has been dramatic in recent years as the oxygenate methyl-tertiary-butyl-ether (MTBE) has been found to contaminate groundwater and has been banned in many states. Numerous groups and individual investors have sought to invest in fuel ethanol production as gasoline suppliers around the country have substituted ethanol for other oxygenates to comply with state clean air standards as well as those of the U.S. Environmental Protection Agency (EPA).

Capacity to process fuel ethanol grew rather steadily from 1980 through 1995 as noted in **Graph 1**. (Renewable Fuels Association-1) High corn prices caused ethanol production to decline in 1996, but industry growth resumed as corn prices declined in later years. Growth during 2002 and 2003 has been very dramatic due in part to the increased pressure to produce a substitute for MTBE.



Fuel ethanol prices received by producers have been quite variable over the past 15 years. "Rack" fuel prices recorded at Minnesota refineries are plotted in **Graph 2**. Peak ethanol prices occurred in times of high corn prices and in times of high gasoline prices. The volatility of fuel ethanol prices over the period makes the fuel ethanol business quite risky unless firms take action to manage marketing risk of this co-product, which often represents 80% of the producer's revenue stream.

Graph 2. Price Trend of Fuel Ethanol in Minnesota (1987-2002) (Source: Minnesota Department of Agriculture)



Current agricultural policy seeks to improve farm income and rural economic conditions while encouraging the development of value-added agricultural processing and renewable energy businesses. There is public support for the use of renewable fuels (including ethanol) to reduce harmful emissions and, in the case of biodiesel, enhance engine life. Favorable net energy balances have been reported for fuel ethanol derived from corn processed at dry mills by several studies with 1.34 units of fuel energy returned for each unit of fossil fuel energy expended. (Shapouri, Duffield, and Wang) The strongest support for use of fuel ethanol appears to occur during periods of high petroleum prices.

Several pieces of federal legislation under consideration could be instrumental in dramatically encouraging further growth in ethanol production. Most prominent in this regard are several versions of National Renewable Fuels Standard (RFS) legislation being sponsored by several members of Congress. Adoption of this legislation would target ethanol use at a specified percentage of the nation fuel usage. While not every gallon of fuel would need to be blended, the legislation would require that a stated percentage of national fuel consumption be made up of ethanol. Most current projections of national fuel use with RFS legislation anticipate ethanol production to double from current levels. If this were to occur before 2012, the target date in this legislation, the industry would need to expand ethanol production. Experience to date suggests the increased ethanol production would occur by building a number of new plants around the country, generally close to their principal feedstocks.

While RFS legislation would encourage market penetration for ethanol, it may be difficult for ethanol production capacity to grow at the same rate as additional demand. In addition, greater supplies of distillers dried grains with solubles (DDGS), the major by-product from dry mill ethanol production, could glut the market for this feed. Although DDGS is a feed of proven merit for dairy, beef, pork, and poultry, it generally requires some time and experience before livestock producers embrace its usage. In addition, plentiful supplies of cheap soybean meal from expanded world soybean production may continue to put downward pressure on the prices of mid-level protein feeds, including DDGS. In this time of exuberance for renewable fuels, some in this industry are registering concern about the ability of government to manage growth in ethanol production capacity and to keep production in line with demand for fuel ethanol.

Project Scope Defined

This study focuses on an analysis of dry mill ethanol production because 1) the smaller plants that are more likely to benefit from this analysis tend to be dry mill operations, 2) much of the future expansion is expected to occur in the form of dry milling capacity and 3) many plants employing this technology are owned by cooperatives. Dry mill plants with some of the longest histories of operation are found in Minnesota, a state with low corn prices, and strong levels of governmental support for ethanol production. Dry mill ethanol processors in other states have also been contacted to gauge their perspectives on factors of success in profitably producing ethanol. Many of these dry mill operations are organized as cooperatives or limited liability corporations comprised of cooperatives. These types of firms are more willing to share financial and technical data than corporate or private firms.

The investigators familiarized themselves with the terminology and technology of modern dry mill ethanol production by studying literature on ethanol plant financing (Bryan & Bryan -1) and plant design (Bryan & Bryan-2). They attended two local renewable energy conferences and the winter meeting of the Renewable Fuels Association. They also visited several ethanol plants to discuss the types of data that plant managers have available. With this background the investigators developed a personal interview survey to collect data on individual dry milling operations.

The investigators toured four ethanol plants and interviewed five managers of Minnesota plants during early 2003. Each of the five plants had undergone substantial expansion during 2002. Questions were directed toward topics related to the economic performance of the plant, including capital costs, feedstock procurement, sales of ethanol, sales of DDGS, process technologies, ethanol yields per bushel of corn, energy usage in processing, operational challenges, coop membership attitudes, business organizational structures, and plant location considerations. The investigators also interviewed four loan officers from two large banks with considerable experience financing ethanol cooperatives and limited liability corporations. These are two of the four major lenders (AgStar Financial Services, CoBank, AgCountry Farm Credit Services, and First National Bank of Omaha) that originate ethanol plant loans in the U.S.

Primer on Dry Mill Ethanol Production

The diagram on the following page shows the processing steps and products in dry mill ethanol plants. Appearing below are brief descriptions of the processing steps and machines labeled in the diagram:

Grinding: The corn is ground to a fine powder called meal by hammer mills.

Liquefaction: The meal is mixed with water and the enzyme alpha-amylase. It is then heated in cookers in order to liquefy the starch in the mash. The cookers typically have a high temperature stage (120-150 degrees C.) and a lower temperature holding period (95 degrees C.). The temperatures attained and the duration of heating reduce bacteria levels in the mash.

Saccharification: The mash from the cookers is cooled and the secondary enzyme gluco-amylase is added to convert liquefied starch to fermentable sugars in a process called saccharification.

Fermentation: Yeast is added to the mash to ferment the sugars, producing ethanol and carbon dioxide. In batch fermenters the mash stays in the tank for about 50 hours. Heat is produced by the activity of the yeast, and efforts must be made to cool this tank and adjust the pH of the mash as fermentation progresses. Carbon dioxide is collected, chilled to a liquid and often sold for use in carbonated beverages or for flash freezing in food processing.

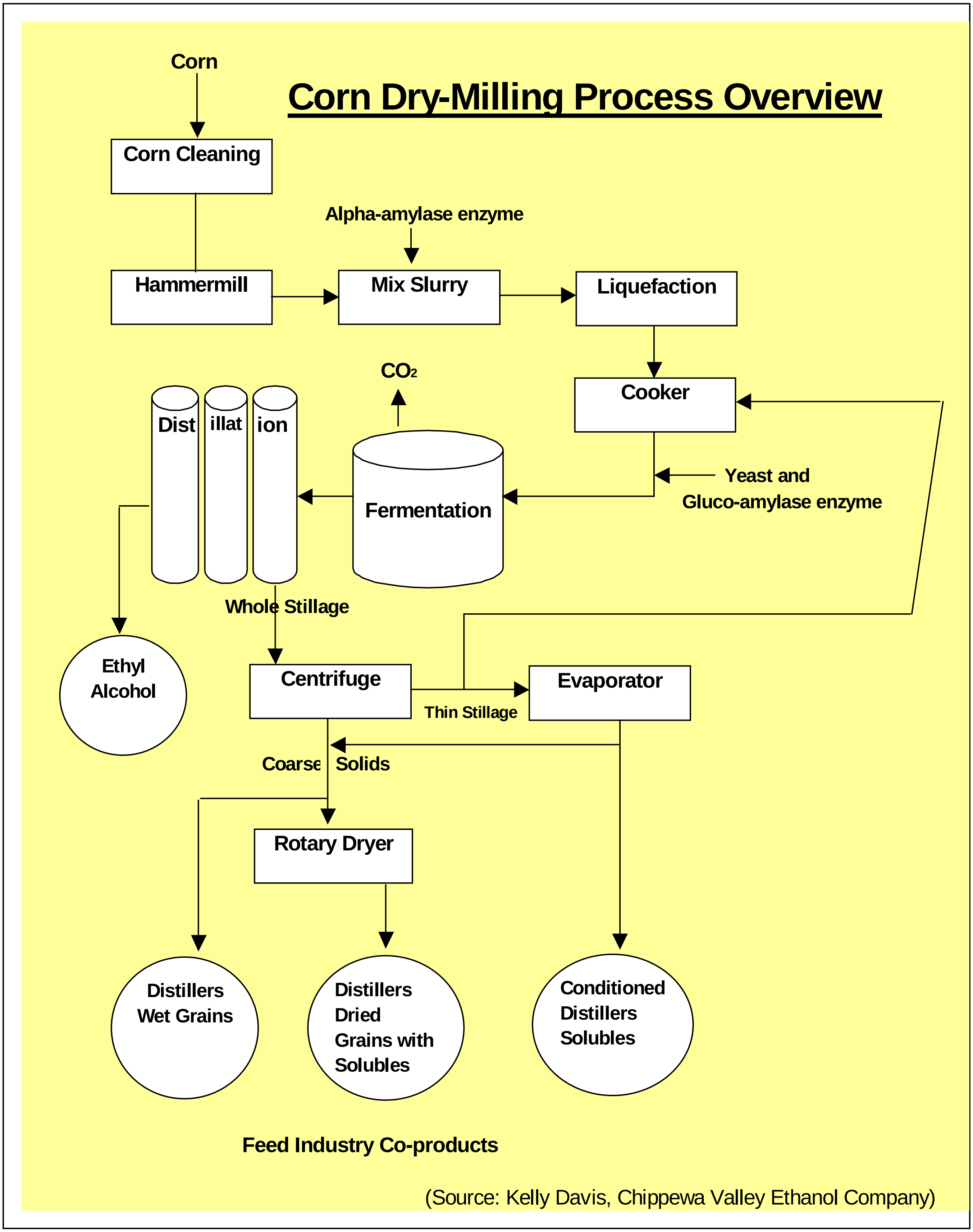
Distillation: The fermented mash, called "beer," contains about 10 percent alcohol as well as all the non-fermentable solids from the grain and the yeast cells. The mash is pumped to a continuous flow, multi-column distillation system where the alcohol is removed from the solids and water. The alcohol leaves the top of the final column 95% pure. The residual mash, called stillage is transferred from the bottom of the distillation column to the centrifuge for further processing.

Dehydration: The alcohol solution from the top of the distillation column is passed through a system to remove the remaining water (approximately 5%). Molecular sieves, consisting of ceramic beads, capture the remaining water as vaporized ethanol solution is passed by. After the molecular sieves the ethanol is called anhydrous (without water) and is 200 proof.

Denaturing: Ethanol used for fuel is denatured by adding a poison (2-5%) to make it unfit for human consumption. Natural gasoline, derived from natural gas, or raffinate are often used because these are low octane and can be cheaply obtained and blended with high-octane ethanol.

Distillers Dried Grains and Solubles (DDGS): The residual mash is centrifuged to separate liquid from grain residues or distillers grains. The liquid is heated to remove water and concentrate the soluble materials. The distillers grains can be sold after centrifuge or pressing and fed wet (65% moisture) within a short period of time to cattle. Typically distillers grains are dried in rotary drum driers and concentrated syrup, containing solubles, is mixed in for further drying. In some cases the syrup is sold as livestock feed alone. DDGS are typically sold at 11% moisture and test 26% crude protein, 10% crude fat, and 12% crude fiber. Amino acid content and balance of DDGS depend on processing methods.

(Source: Agricultural Marketing Resource Center-1)



Corn Dry-Milling Process Overview
Corn
Corn Cleaning
Alpha-amylase enzyme
Hammermill
Mix Slurry
Liquefaction
CO2
Cooker
Dist illat ion
Fermentation
Yeast and
Gluco-amylase enzyme
Whole Stillage
Ethyl Alcohol
Centrifuge
Thin Stillage
Evaporator
Coarse Solids
Rotary Dryer
Distillers Wet Grains
Distillers Dried Grains with Solubles
Conditioned Distillers Solubles
Feed Industry Co-products
(Source: Kelly Davis, Chippewa Valley Ethanol Company)

Development of the Ethanol Success Spreadsheet "BuGal"

The data obtained have been integrated into a spreadsheet that demonstrates the importance and sensitivity of various factors on the profitability of an ethanol plant. The accuracy and ~~t~~he veracity of the spreadsheet have been confirmed with plant managers and the loan officers interviewed. Ethanol plant managers and bankers critiqued the underlying assumptions and relationships built into the spreadsheet. Plant managers evaluated how accurately the spreadsheet represents the profitability of their plant (with its unique attributes) under various economic operating conditions. The spreadsheet was tested with managers of "new" ethanol plants being established in neighboring states, as well as with representatives of firms marketing DDGS and ethanol. The conclusion is that the spreadsheet reported here is a very good representation of the "state of the art" dry mill ethanol plant.

It is important to distinguish between anhydrous and denatured ethanol in discussing costs and profitability of the ethanol industry. Anhydrous ethanol is pure ethanol with the water removed. Anhydrous ethanol is typically denatured by adding natural gasoline (regular lead-free gasoline made from gaseous hydrocarbons collected at natural gas wells) or raffinate to poison the ethanol, making it unfit for human consumption. Typically, denatured ethanol is 5% denaturant, or .05263 gallons of denaturant are required per gallon of anhydrous ethanol (.05/. 95). Denatured ethanol is the product that is sold for fuel use.

A copy of the spreadsheet "BuGal" showing the calculations on both "per bushel of corn ground" and "per denatured gallon of ethanol" bases is presented on the following page, with a detailed discussion of the spreadsheet following. Farmer-investors seem to prefer the analysis conducted on a per bushel basis because their investment in ethanol plants and value-added dividends are based on shares of stock denominated in bushels of corn to be delivered. In contrast, the ethanol production industry usually compares plant efficiency, costs and revenues on a "per denatured gallon basis." Typical ranges in the amounts of energy required, ethanol yields, capital costs, expense items and other factors are listed in Column D of the spreadsheet. A version of this spreadsheet with three replications (Multiscen), appearing on page 17, allows the user to compare the effect of multiple scenarios on profits. By testing multiple scenarios, one can readily learn the sensitivity of particular variables to the assumptions chosen.

1	B	C	D	E	F	G	H	I
2	**Ethanol Dry Mill Spreadsheet**		by Douglas G. Tiffany, University of Minnesota					
3	7/21/03 22:30	Cost/Denat. Gal. Ethanol	Ranges for Column C					Plant Totals
4	Nameplate Ethanol Prod. (Denat. Gal.)	40,000,000						
5	Investment per Nameplate Gallon	$1.5000	$1.00- $2.00				Plant Cost	$ 60,000,000
6	Factor of Nameplate Capacity	1.2000	(80%- 150%)					
7	Debt-Equity Assumptions							
8	Factor of Equity	0.40						
9	Factor of Debt	0.60					Initial Debt	$ 36,000,000
10	Interest Rate Charged on Debt	0.07						
11	Rate of Return Reqd. by Investors on Equity	0.12						
12								
13	Conversion Efficiency Assumptions				Annual Production			
14	Anhydrous Ethanol Extracted (Gal. per Bu.)	2.750	2.5-2.85 gal/bu		Bushels Ground		Denat. Gallons	
15	DDGS per Bushel (lb. per Bu.)	18	15-22 lb./bu		16,581,843		48,000,000	
16	CO2 extracted per Bushel (lb. per Bu.)	18	15-22 lb./bu					
17								
18	Establishment of Gross Margin	Price per Unit			Revenue/Bu. Ground		Revenue/Gal. Denatured Sold	Plant Totals
19	Ethanol Price (denatured price) $/gal.	$1.15	$.80 to $1.60		$3.3289		1.1500	$ 55,200,000
20	DDGS Price $/T	$80.00	$60-$120		$0.7200		0.2487	$ 11,938,927
21	CO2 Price ($ per Ton liq. CO2)	$6.00	$2- $12 / liq.Ton		$0.0540		0.0187	$ 895,420
22	MN Prod. Subsidy/gal.Denat. Ethanol	$0.00			$0.0000		0.0000	$ -
23	Federal Small Producer Subsidy							$ -
24	CCC Bioenergy Credit							$ -
25	Revenue per Unit				$4.1029		$1.4174	$ 68,034,347
26	Corn Price Paid by Processor ($ per bu.)	$2.20	$1.70---$3.25		$2.2000		$0.7600	$ 36,480,055
27	Gross Margin				$1.9029		$0.6574	$ 31,554,292
28								
29	Operating Expenses Per Bushel	Price per Unit			Cost /Bushel Ground		Cost /Gal. Denatured Sold	Plant Totals
30	Natural Gas Price ($ 1,000,000 Btu)	$4.50	($1.50-$9.00/Dtherm)					
31	LP (Propane) Price ($ per gallon)	$0.70	$.55-$.72 / gal.					
32	Factor of Time Operating on Propane	0.02	0-.12					
33	BTU's of Heat fr Fuel Req./ Denat. Gal.	35,000	28,500-55,000					
34	Combined Heating Cost				$0.4623		$0.1597	$ 7,665,569
35	Electricity Price ($ per kWh)	$0.05	$.025-$.090/kwh					
36	Kilowatt Hours Required per Denat.Gal.	1.090	(.85-1.2 kWh/denat. gal.)					
37	Electrical Cost				$0.1578		$0.0545	$ 2,616,000
38	Total BTU's of Fuel and Electricity	45,900						
39	Total Energy Cost				$0.6200		$0.2142	$ 10,281,569
40		Cost/Denat. Gal. Ethanol						
41	Enzymes	$0.0480			$0.1389		$0.0480	$ 2,304,000
42	Yeasts	$0.0220			$0.0637		$0.0220	$ 1,056,000
43	Other Proc.Chemicals & Antibiotics	$0.0200			$0.0579		$0.0200	$ 960,000
44	Boiler & Cooling Tower Chemicals	$0.0050			$0.0145		$0.0050	$ 240,000
45	Water	$0.0060	$.005-.010		$0.0174		$0.0060	$ 288,000
46	Denaturant Price per Gal.	$0.7000			$0.1013		$0.0350	$ 1,679,952
47	Total Chemical Cost				$0.3937		$0.1360	$ 6,527,952
48								
49	Depreciation based on C49 asset life	15	Years		$0.2412		$0.0833	$ 4,000,000
50	Maintenance & Repairs	$0.0125			$0.0362		$0.0125	$ 600,000
51	Interest Expense				$0.1520		$0.0525	$ 2,520,000
52	Labor	$0.0450	$.04--$.06		$0.1303		$0.0450	$ 2,160,000
53	Management & Quality Control	$0.0136	$.010-$.022		$0.0394		$0.0136	$ 652,800
54	Real Estate Taxes	$0.0020			$0.0058		$0.0020	$ 96,000
55	Licenses, Fees& Insurance	$0.0040	.0030-.0050		$0.0116		$0.0040	$ 192,000
56	Miscellaneous Expenses	$0.0135	$.01-$.03		$0.0391		$0.0135	$ 648,000
57	Total of Other Processing Costs				$0.6555		$0.2264	$ 10,868,800
58	Total Processing Costs				$1.6692		$0.5766	$ 27,678,321
59	Net Margin Achieved Per Unit				$0.2337		$0.0807	$ 3,875,971
60	Farmer-Investor Reqd. Return on Equity	12.00%			$0.1737		$0.0600	$ 2,880,000
61	Increment of Success/Failure to Meet Required Return				$0.0601		$0.0207	$ 995,971
62								
63	Ethanol Plant Profits for Shareholders and Principal Reduction				$3,875,971		$3,875,971	$ 3,875,971

Understanding the Spreadsheet "BuGal"

The Excel spreadsheet on the preceding page is designed for users to enter data that describe their operation and estimate the profitability of their proposed or established dry mill ethanol plant. The data in cells shaded in yellow or pink in **Column C** and that are in **bold** print can be adjusted to conform to the conditions of a particular plant**. Brief descriptions of the thirty-four items of input data entered in Column C (pink and yellow) are explained in the box on page 11.**

The output that results from data input and the formulas embedded in the spreadsheet is recorded in **Column F** (per bushel basis), **Column H** (per denatured gallon basis), and **Column I** (whole plant basis). The bushels ground, five critical measures of cost and profitability are shaded in blue in **Column F**. Corresponding figures in the same rows are shaded in green in **Column H**. Whole plant figures are recorded for the same categories in **Column I**. The five measures of cost and profitability receive a great deal of scrutiny from those familiar with the industry. The five measures typically considered in analyzing the success of a dry mill ethanol plant include the following:

Gross Margin per Bushel **(F27),** or per Denatured Gallon **(H27)**
Total Energy Cost per Bushel **(F39),** or per Denatured Gallon **(H39)**
Total Chemical Cost per Bushel **(F47),** or per Denatured Gallon **(H47)**
Total Processing Cost per Bushel **(F58),** or per Denatured Gallon **(H58)**
Net Margin Achieved per Bushel **(F59),** or per Denatured Gallon **(H59)**

For simplicity, readers and users of the spreadsheet should realize that the following discussion, written on a per bushel basis and referencing figures in Column F, applies equally to figures found in the same rows in Column H, but on a per denatured gallon of ethanol basis.

Ethanol plant managers often calculate these five values for their plants by batch of ethanol, by month, and by year as part of their effort to monitor their operation. Their incentives and job security depend upon the level of Net Margin Achieved per Bushel **(F59)**. By judicious marketing and possibly hedging activities, managers can exert some control over Gross Margin per Bushel **(F27)**, which is simply the summed value of the products sold by the plant (ethanol, DDGS, carbon dioxide, and subsidies) minus the cost of the key feedstock, which is corn. By adopting worthy control technologies, maintaining throughput, and hedging the prices of energy inputs, managers can affect the costs per bushel processed.

The amount of corn ground, **F15,** is the number of bushels required to produce the total gallons of denatured ethanol, 48 million in the example. **F15** is calculated by multiplying the nameplate capacity by the factor of nameplate capacity and the anhydrous ethanol yield.

The operating costs are divided into energy, chemical, depreciation, maintenance, interest, labor, management, and other expenses. The primary energy sources are natural gas and electricity. Most plants purchase an interruptible supply of natural gas as the primary fuel for heating, and substitute propane during any interruptions in the natural gas supply. The spreadsheet lists total energy cost per bushel ground in **F39.** The other processing costs include depreciation of plant and equipment, maintenance and repairs, interest on the debt capital, labor, management and quality control costs, real estate taxes, licenses, insurance, and miscellaneous expenses. Total processing cost per bushel, **F58**, is the sum of Total Energy Cost **(F39),** Total Chemical Cost **(F47)** and the "Total of Other Processing Costs" **(F57).**

Establishment of Gross Margin

The establishment of the gross margin per bushel **(F27)** is determined by entering the prices for denatured ethanol sold by the plant (**C19),** the price per ton of the DDGS sold **(C20),** the price per ton of carbon dioxide **(C21),** and in the case of Minnesota and other states, the level of state subsidy per denatured gallon produced. (This level had been $.20 per gallon in Minnesota in recent years; however, the 2003 Legislature lowered the level of state subsidy to $.13 per denatured gallon for the next four years.) The spreadsheet was designed to accommodate the possibility of other subsidies, such as the Federal Small Producer Subsidy and the CCC Bioenergy Credit if these apply for a particular year of production of a particular plant. The sum of revenue from sales of products and subsidies, on a per bushel basis, minus the price of corn (**C26)** equals the gross margin per bushel **(F27**)

Measures of Financial Success

As mentioned previously, cell **F59** contains the net margin achieved per bushel of corn processed, which turns out to be a very useful way for farmer investors to think about their investment in a fuel ethanol plant. Usually farmer-investors are asked to invest a certain number of dollars per bushel of corn to be delivered by or on behalf of a particular farmer. **F60** contains the return needed per bushel to provide the rate of return on equity investors specified in **C11.** Subtracting **F60** from **F59** equals **F61,** the amount of net margin in excess of required return on equity capital. **F63** contains the ethanol plant's total net profits available to the owners of the business after payment of all cash expenses, interest, and depreciation. **F63** results from multiplying the net margin per bushel by the number of bushels ground and processed in the plant.

Input Data for the Spreadsheet

Scale and Capacity Parameters
C4 lists the nameplate ethanol production capacity of the plant in denatured gallons. This represents the capacity that the design engineers will warrant. **C5** is the average capital cost per gallon of denatured ethanol capacity, including the investment in land, buildings, equipment and the initial operating capital used during the start-up period. **C6** is the multiple of nameplate capacity the manager expects to produce. In the example, the manager expects to produce 120% of the nameplate capacity per year.

Financing Factors
C8 – C10 list the proportion of equity and debt, and the blended interest rate paid on the debt capital. **C11** provides a place to enter the desired rate of return on equity capital. By entering a positive number in **C11**, the return to equity capital is deducted from the net margin per bushel to determine the increment of success in **F61.**

Conversion Efficiency Assumptions
C14 lists the number of gallons of anhydrous ethanol produced per bushel of corn processed. It is important to distinguish between this figure, which is frequently called “yield,” and the number of denatured gallons that are produced per bushel of corn. Cells **C15** and **C16** list the number of pounds of distillers dried grains with solubles (DDGS) and the number of pounds of liquid carbon dioxide produced per bushel. Plants may produce between 15-22 pounds of each of these products with 17 or 18 pounds of each being the levels typically reported. As ethanol yield increases, DDGS output declines. Typical DDGS are sold at 91 percent dry matter.

Revenue Data
Revenue from products sold and subsidies received are entered in **C19** through **C25,** and the price of the feedstock is entered in **C26.** The prices are listed per gallon of denatured ethanol (**C19),** per ton of the DDGS **(C20),** and per ton of liquid carbon dioxide **(C21).** The state subsidy (if any) per denatured gallon produced is listed in **C22**. (This level had been $.20 per gallon in Minnesota, but the 2003 Legislature set $.13 per denatured gallon for the next four years.) Cells **C23** and**C24** provide a place to include other subsidies, such as the Federal Small Producer Subsidy and the CCC Bioenergy Credit if these apply for a particular year of production for a particular plant.

Energy Data
The quantities and prices of energy used to run the plant are entered in cells **C30** through **C33**, **C35** and **C36**. Cell **C30** contains the price per dekatherm (1,000,000 BTU’s) of natural gas, $4.50 in the example. Most ethanol plants buy natural gas on contract with interruptible service provisions. That is why the spreadsheet includes cell **C31**; the cost per gallon of propane, the typical back-up fuel, and **C32** lists the proportion of time that the plant operates using the back-up fuel. **C33** lists the number of BTU’s the plant uses for heating, in the example **---** 35,000 BTU’s per denatured gallon. **C35** lists the price the plant pays for electricity. **C36** contains a figure for the number of kilowatt-hours required per denatured gallon, 1.09 in the example. Some of the more modern plants report all processing for .85 kWh per denatured gallon, while older plants may use as much as 1.2 kWh of electricity per denatured gallon.

Chemical Costs
Cells **C41,** through **C46** list chemical costs per gallon of denatured ethanol produced by the plant. **C41** lists the cost of enzymes for liquefaction and saccharification. **C42** lists the cost of yeasts, which are generally between one-third and one-half of enzyme costs. **C43** lists the cost of other processing chemicals and the antibiotics that are sometimes needed to kill bacteria that might infect a particular batch of mash or piece of equipment. Cell **C44** contains the cost of boiler and cooling tower chemicals, inputs used to remove scale and residues from the pipes, boilers, and condensation coils. Cost of water is listed in **C45.** Finally, the price of 100% denaturant per gallon is listed on **C46**

Data to calculate Depreciation, Maintenance, Interest, Labor, Management, and Other Expenses
The length of life in years is recorded in **C49,** 15 years in this example. Depreciation on the plant and equipment is calculated on “straight line basis” using this length of life. Data in **C50,** and **C52** through **C56** are entered per denatured gallon**.** Comments from individuals with experience examining financial records of dry mill ethanol plants suggest that management and quality costs, **C53,** should be approximately one third of production labor costs, **C52**.

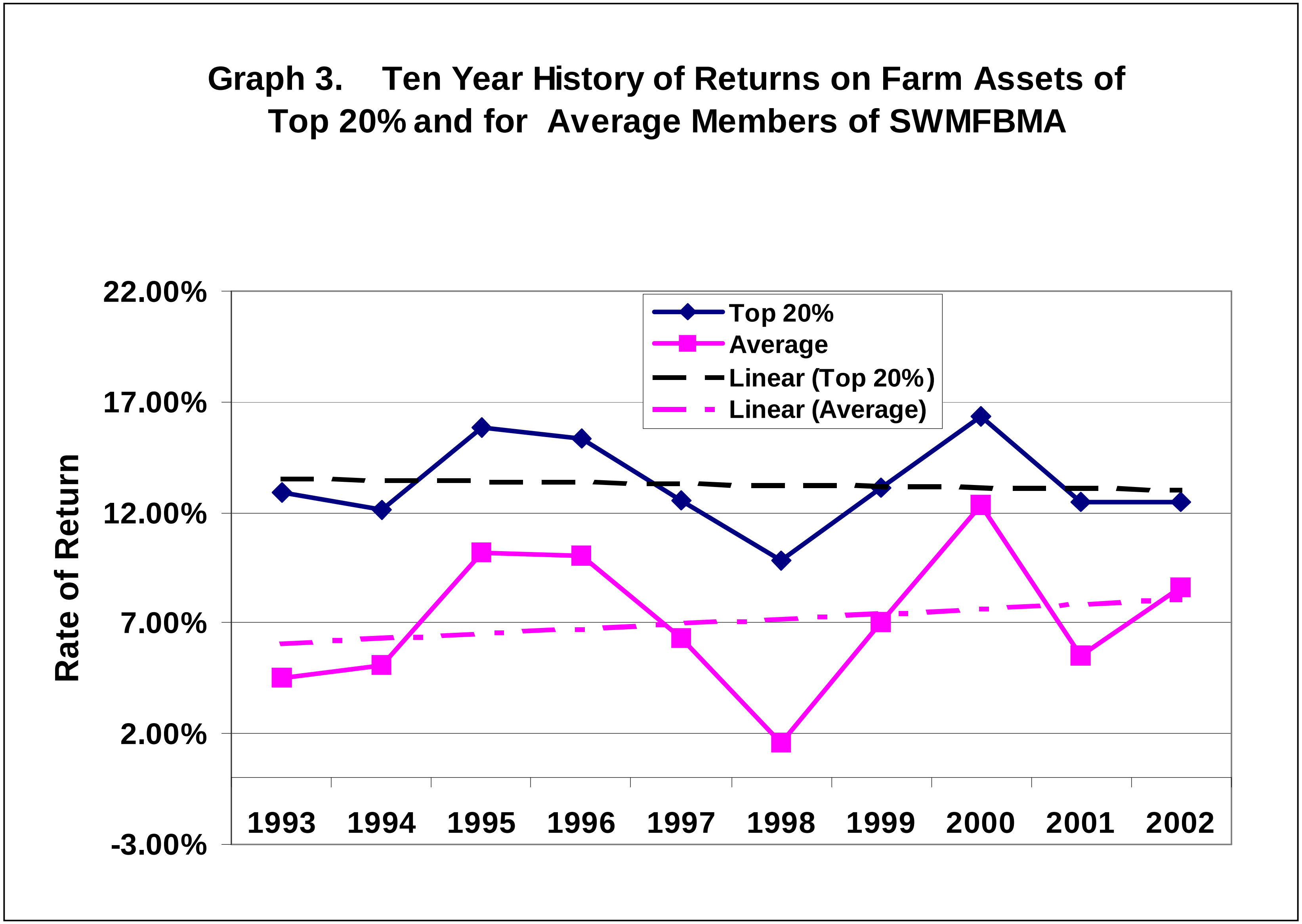
Discussion of Input Data and Assumptions for Baseline

The baseline example on page 8 portrays the level of profits that can be expected from a 40MM gallon dry mill plant, which cost $1.50 per nameplate gallon of capacity (**C5**). It is assumed that this plant is being operated 20% above nameplate capacity, or 48,000,000 million gallons of denatured ethanol per year. **C8** designates that there is 40% equity in the plant, which is typical of the equity levels on start-up projects. **C10** identifies that 7.0% interest is charged on the 60% debt. **C11** identifies a rate of return of 12% that the investors are seeking as a target on their equity. In the event of business failure, the investors will likely face greater problems recovering their investment than will the bankers; hence the investors should logically seek a higher rate of return on their equity. Depending upon the state of their individual portfolios, some investors would be rational in seeking rates of return on equity of 12%.

Review of annual reports of the Southwestern Minnesota Farm Business Management Association reveal that the top 20% of farmers in their sample have achieved returns on farm assets on a cost basis greater than 12% in nine out of the last ten years, as demonstrated in **Graph 3**. (SWMFBMA) For comparison, average rates of return for all farmers in the management association are also graphed. Average returns for the "top 20% group" for the decade were 13.30% and 7.11% for the average of all members. The "top 20% group" is determined based on net farm income of each year. It is possible for individual farmers to move between the "top 20% group" and the "average group," depending especially upon crop yields, commodity prices for crops and livestock, and the mix of agricultural enterprises of the individual farms. The twenty–year history of returns on farm assets reveals a similar pattern of returns for the two groups of producers with a 13.70% rate of return on assets of the "top 20% group" and 7.83% for the average of all producers.

Revenue Assumptions

The conditions set for conversion efficiency in the baseline scenario include 2.75 gallons of anhydrous ethanol per bushel, 18 pounds of DDGS per bushel and 18 pounds of liquid CO2 collected. Prices used to establish the gross margin include ethanol at $1.15 per denatured gallon, a conservative plant gate price, and $80.00 per ton for DDGS, a level slightly higher than the value of corn at $2.20 per bushel ($78.57/T.). Carbon dioxide is priced for sale at $6.00 per ton as liquid. Few plants less than 40MM in capacity find it economical to capture and refine the CO2 released in the fermentation process due to the high fixed costs of equipment. Generally sales of CO2 are based on "net-back" arrangements with the plant being paid a price such as $6.00 per ton and the firm buying the CO2 assuming investment, maintenance, and operating expenses for the equipment to clean and liquefy the CO2. This model plant is assumed to receive <u>no state subsidies</u> in order to give the baseline conditions broader geographic applicability. The corn price assumed is $2.20 per bushel.


Graph 3. Ten Year History of Returns on Farm Assets of Top 20% and for Average Members of SWMFBMA
Top 20%
Average
Linear (Top 20%)
Linear (Average)
Rate of Return
22.00%
17.00%
12.00%
7.00%
2.00%
-3.00%
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002

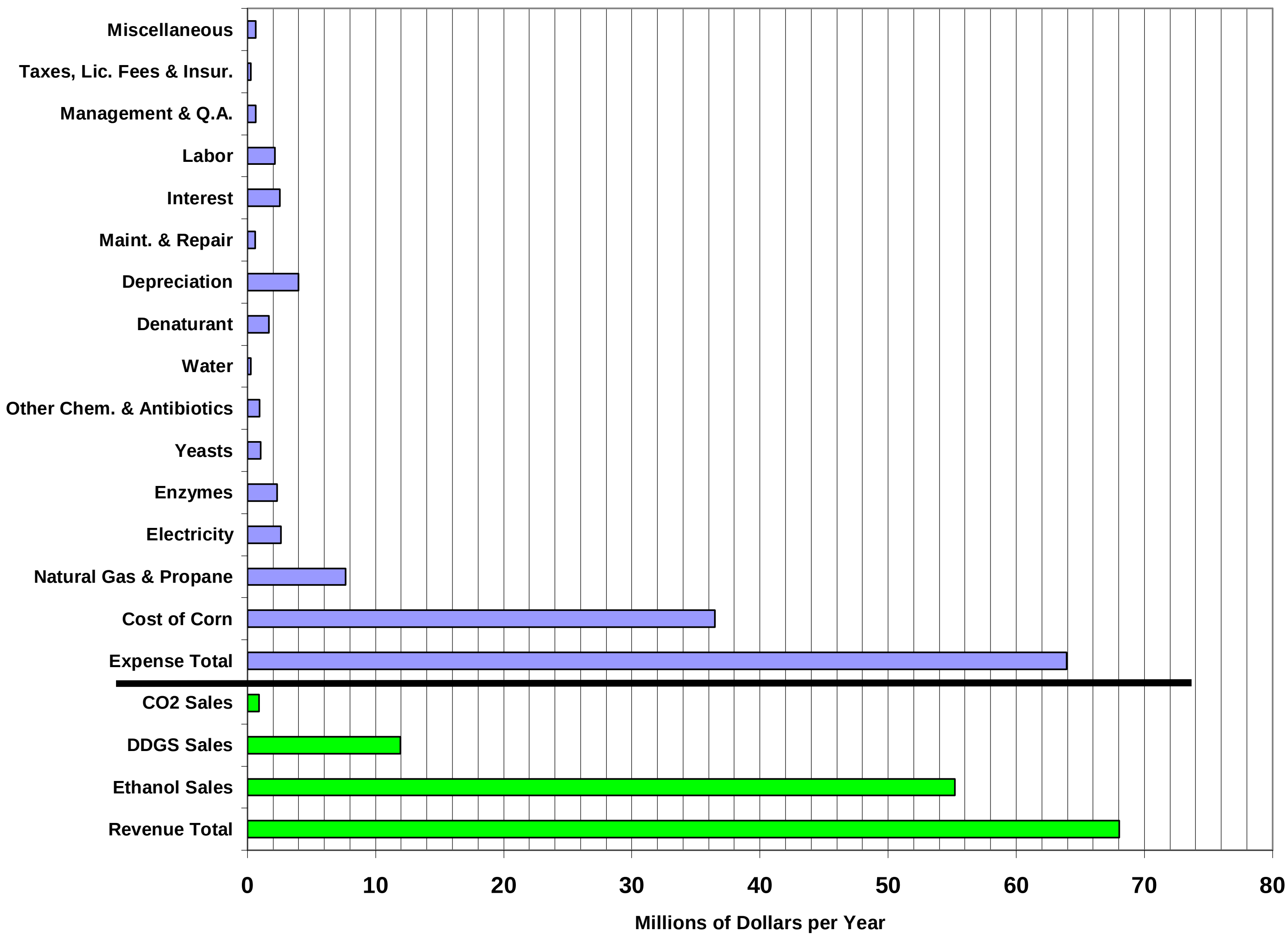
Expense Assumptions
The key expense item, natural gas, is priced at $4.50 per dekatherm (1,000,000 BTUs). This plant requires just 35,000 BTUs per gallon of denatured ethanol, similar to the 36,000 BTUs recorded in the U.S.D.A. survey of ethanol producers based on 2001 production. (Shapouri, Duffield, and Wang) Comments by plant managers indicate that plants continue to become more efficient in their use natural gas and the resulting heat produced. Electricity is charged at $.050 per kilowatt-hour with 1.09 kWh assumed to be used per gallon of denatured ethanol produced. Continuing on with operating expenses, yeast is assumed to cost 31% of the amount spent on enzymes. Yeast costs are similar in magnitude per bushel processed to costs of other processing chemicals and antibiotics. Whether or not a plant propagates yeast on-site or uses fresh yeast cultures for new batches can greatly affect yeast costs. The baseline case assumes no propagation of yeast on-site, a more costly approach, but one that reduces opportunities for bacterial infection of the yeast. Denaturant is assumed at $.70 per gallon wholesale and without tax. The ethanol derived from a bushel of corn will require about $.10 worth of denaturant. The plant is assumed to be depreciated over 15 years on a straight-line basis, resulting in $.08 of depreciation per denatured gallon produced, or $.24 per bushel processed. Interest expense is $.152 per bushel, which is very similar in magnitude to the figure for production labor ($.1303) per bushel processed. The category “management and quality control” is approximately one third of the amount spent on production labor. The other expenses are minor and are self-explanatory.

Baseline Conclusions

The baseline assumptions result in a net profit of $.2337 per bushel of corn processed. If the investors were paid the 12% on equity that they had chosen as a threshold level of return on equity, they would take $.1737 per bushel from the net profits, resulting in $.0601 after satisfying their required rate of return. Based on the $.2337 per bushel, the plant would have net profit of $3,875,971 per year with all these assumptions. Translating these returns to a per denatured gallon basis, net profits are $.0807 per denatured gallon produced, (also including revenue and expenses from DDGS and CO2) or just $.0207 per denatured gallon above the required rate of return.

Graph 4 displays revenue and expenses from the baseline example. In overall terms, the difference in total revenue and total expense appears small under baseline conditions for this capital intensive, high volume business. In the revenue category, the importance of ethanol sales dominates, although DDGS sales are large enough to be very important, especially when net margins are so small. The cost of corn dominates the expenses followed by natural gas and then, the non-cash item, depreciation. Electricity, interest expense, enzymes and labor complete the categories of expense greater than $2,000,000 per year. Denaturant and yeast expense are two categories between $2,000,000 and $1,000,000 per year for the baseline plant. The annual expense for antibiotics and other chemicals approaches $1.0 million. The sum of the expenses for the remaining categories of water, taxes, licenses, fees, insurance, miscellaneous, management & quality, and repair totals $2.5 million, nearly equal to the amount of interest charged.

Graph 4. Revenues and Expenses for 40MM Dry Mill Plant at Baseline Conditions



Discussion of Multiple-Scenario Spreadsheet

In order to test sensitivity of dry mill ethanol plants to various influences, a multiple-scenario spreadsheet was developed called "MultiScen". This spreadsheet offers the opportunity to establish and test three scenarios simultaneously for easy comparison. In addition to analysis on a per-bushel basis, analysis is also developed on a per-denatured-gallon basis. The data entry are identical to those described on page 11, which direct the user to enter conditions in cells in **Column C**. The multiple-scenario spreadsheet uses **Column C** for establishing "Best Case" conditions, **Column D** is used to establish "Middle Case" conditions, and **Column E** is used for "Poor Case" conditions. The net profits are shown in **Row 63** for the multiple scenarios with per-bushel profits found in **H63**, **I63**, and **J63** for Best, Middle and Poor Cases, respectively. Conclusions on a per-gallon basis are presented in cells **M63**, **N63**, and **O63** for Best, Middle and Poor Cases, respectively.

In the example shown on the following page, the effect of corn prices at $1.90, $2.20, and $2.50 per bushel for "Best", "Middle", and "Poor" cases are shown. Individuals might similarly wish to see the effect of ethanol yields by trying 2.75, 2.65, and 2.55 gallons per bushel in the "Best", "Middle", and "Poor" cases. The effect of natural gas prices can be readily demonstrated with prices at $4.50, $5.50, and $6.50 per dekatherm for "Best", "Middle" and "Poor" cases. MultiScen offers the chance to vary multiple factors at the same time. For example, one could compare a high-cost energy scenario with the best case by including higher prices for natural gas and ethanol in the middle or poor columns. Use of the multiple-scenario spreadsheet allows one to quickly understand the volatility in profits for dry mill ethanol plants that can occur with several minor changes in key assumptions.

1	B	C	D	E	F	G	H	I	J	M	N	O	1
2	**Ethanol Dry Mill Spreadsheet**		by Douglas G. Tiffany, University of Minnesota										2
3	6/30/03 15:00	**Best Case**	**Middle Case**	**Poor Case**	Ranges for Column B								3
4	**Nameplate Ethanol Prod. (Denat. Gal.)**	40,000,000	40,000,000	40,000,000									4
5	**Investment per Nameplate Gallon**	$1.5000	$1.5000	$1.5000	$1.00- $2.00								5
6	**Factor of Nameplate Capacity**	1.2000	1.2000	1.2000	(80%- 150%)								6
7	**Debt-Equity Assumptions**												7
8	Factor of Equity	0.40	0.40	0.40									8
9	Factor of Debt	0.60	0.60	0.60									9
10	Interest Rate Charged on Debt	0.07	0.07	0.07									10
11	Rate of Return Reqd. by Investors on Equity	0.12	0.12	0.12			**Best Case**	**Middle Case**	**Poor Case**	**Best Case**	**Middle Case**	**Poor Case**	11
12													12
13	**Conversion Efficiency Assumptions**						Annual Production			Annual Production			13
14	Anhydrous Ethanol Extracted (Gal. per Bu.)	2.750	2.750	2.750	2.5-2.85 gal/bu		Bushels Ground	Bushels Ground	Bushels Ground	Denat. Gallons	Denat. Gallons	Denat. Gallons	14
15	DDGS per Bushel (lb. per Bu.)	18	18	18	15-22 lb./bu		16,581,843	16,581,843	16,581,843	48,000,000	48,000,000	48,000,000	15
16	CO2 extracted per Bushel (lb. per Bu.)	18	18	18	15-22 lb./bu								16
17													17
18	**Establishment of Gross Margin**	Price per Unit	Price per Unit	Price per Unit			Revenue/Bu. Ground	Revenue/Bu. Ground	Revenue/Bu. Ground	Revenue/Gal. Denatured Sold	Revenue/Gal. Denatured Sold	Revenue/Gal. Denatured Sold	18
19	Ethanol Price (denatured price) $/gal.	$1.15	$1.15	$1.15	$.80 to $1.60		$3.3289	$3.3289	$3.3289	1.1500	1.1500	1.1500	19
20	DDGS Price $/T	$80.00	$80.00	$80.00	$60-$120		$0.7200	$0.7200	$0.7200	0.2487	0.2487	0.2487	20
21	CO2 Price ($ per Ton liq. CO2)	$6.00	$6.00	$6.00	$2- $12 / liq.Ton		$0.0540	$0.0540	$0.0540	0.0187	0.0187	0.0187	21
22	MN Prod. Subsidy/gal.Denat. Ethanol	$0.00	$0.00	$0.00			$0.0000	$0.0000	$0.0000	0.0000	0.0000	0.0000	22
23	Federal Small Producer Subsidy												23
24	CCC Bioenergy Credit												24
25	Revenue per Unit						$4.1029	$4.1029	$4.1029	$1.4174	$1.4174	$1.4174	25
26	Corn Price Paid by Processor ($ per bu.)	$1.90	$2.20	$2.50	$1.70---$3.25		$1.9000	$2.2000	$2.5000	$0.6564	$0.7600	$0.8636	26
27	Gross Margin						$2.2029	$1.9029	$1.6029	$0.7610	$0.6574	$0.5537	27
28													28
29	**Operating Expenses Per Bushel**	Price per Unit	Price per Unit	Price per Unit			Cost /Bushel Ground	Cost /Bushel Ground	Cost /Bushel Ground	Cost /Gal. Denatured Sold	Cost /Gal. Denatured Sold	Cost /Gal. Denatured Sold	29
30	Natural Gas Price ($ 1,000,000 Btu)	$4.50	$4.50	$4.50	($1.50-$9.00/Dtherm)								30
31	LP (Propane) Price ($ per gallon)	$0.70	$0.70	$0.70	$.55-$.72 / gal.								31
32	Factor of Time Operating on Propane	0.02	0.02	0.02	0-.12								32
33	BTU's of Heat fr Fuel Req./ Denat. Gal.	35,000	35,000	35,000									33
34	Combined Heating Cost						$0.4623	$0.4623	$0.4623	$0.1597	$0.1597	$0.1597	34
35	Electricity Price ($ per kWh)	$0.05	$0.05	$0.05	$.025-$.090/kwh								35
36	Kilowatt Hours Required per Denat.Gal.	1.090	1.090	1.090	(.85-1.2 kWh/denat. gal.)								36
37	Electrical Cost						$0.1578	$0.1578	$0.1578	$0.0545	$0.0545	$0.0545	37
38	Total BTU's of Fuel and Electricity	45,900	45,900	45,900									38
39	**Total Energy Cost**						$0.6200	$0.6200	$0.6200	$0.2142	$0.2142	$0.2142	39
40		Cost/Denat. Gal. Ethanol	Cost/Denat. Gal. Ethanol	Cost/Denat. Gal. Ethanol									40
41	Enzymes	$0.0480	$0.0480	$0.0480			$0.1389	$0.1389	$0.1389	$0.0480	$0.0480	$0.0480	41
42	Yeasts	$0.0220	$0.0220	$0.0220			$0.0637	$0.0637	$0.0637	$0.0220	$0.0220	$0.0220	42
43	Other Proc.Chemicals & Antibiotics	$0.0200	$0.0200	$0.0200			$0.0579	$0.0579	$0.0579	$0.0200	$0.0200	$0.0200	43
44	Boiler & Cooling Tower Chemicals	$0.0050	$0.0050	$0.0050			$0.0145	$0.0145	$0.0145	$0.0050	$0.0050	$0.0050	44
45	Water	$0.0060	$0.0060	$0.0060	$.005-.010		$0.0174	$0.0174	$0.0174	$0.0060	$0.0060	$0.0060	45
46	Denaturant Price per Gal.	$0.7000	$0.7000	$0.7000			$0.1013	$0.1013	$0.1013	$0.0350	$0.0350	$0.0350	46
47	**Total Chemical Cost**						$0.3937	$0.3937	$0.3937	$0.1360	$0.1360	$0.1360	47
48													48
49	Depreciation based on B48 asset life	15	15	15	Years		$0.2412	$0.2412	$0.2412	$0.0833	$0.0833	$0.0833	49
50	Maintenance & Repairs	$0.0125	$0.0125	$0.0125			$0.0362	$0.0362	$0.0362	$0.0125	$0.0125	$0.0125	50
51	Interest Expense						$0.1520	$0.1520	$0.1520	$0.0525	$0.0525	$0.0525	51
52	Labor	$0.0450	$0.0450	$0.0450	$.04--$.06		$0.1303	$0.1303	$0.1303	$0.0450	$0.0450	$0.0450	52
53	Management & Quality Control	$0.0136	$0.0136	$0.0136	$.010-$.022		$0.0394	$0.0394	$0.0394	$0.0136	$0.0136	$0.0136	53
54	Real Estate Taxes	$0.0020	$0.0020	$0.0020			$0.0058	$0.0058	$0.0058	$0.0020	$0.0020	$0.0020	54
55	Licenses, Fees& Insurance	$0.0040	$0.0040	$0.0040	.0030-.0050		$0.0116	$0.0116	$0.0116	$0.0040	$0.0040	$0.0040	55
56	Miscellaneous Expenses	$0.0135	$0.0135	$0.0135	$.01-$.03		$0.0391	$0.0391	$0.0391	$0.0135	$0.0135	$0.0135	56
57	**Total of Other Processing Costs**						$0.6555	$0.6555	$0.6555	$0.2264	$0.2264	$0.2264	57
58	**Total Processing Costs**						$1.6692	$1.6692	$1.6692	$0.5766	$0.5766	$0.5766	58
59	**Net Margin Achieved Per Unit**						$0.5337	$0.2337	($0.0663)	$0.1844	$0.0807	($0.0229)	59
60	**Farmer-Investor Reqd. Return on Equity**	12.00%	12.00%	12.00%			$0.1737	$0.1737	$0.1737	$0.0600	$0.0600	$0.0600	60
61	**Increment of Success/Failure to Meet Required Return**						$0.3601	$0.0601	($0.2399)	$0.1244	$0.0207	($0.0829)	61
62													62
63	**Ethanol Plant Profits for Shareholders and Principal Reduction**						$8,850,524	$3,875,971	($1,098,582)	$8,850,524	$3,875,971	($1,098,582)	63

Key Factors Associated with Financial Success

The spreadsheet was used to identify the most important parameters associated with financial success. The following five factors, with their established baseline values, emerge as the most crucial for ethanol plant profitability in <u>all localities</u>.

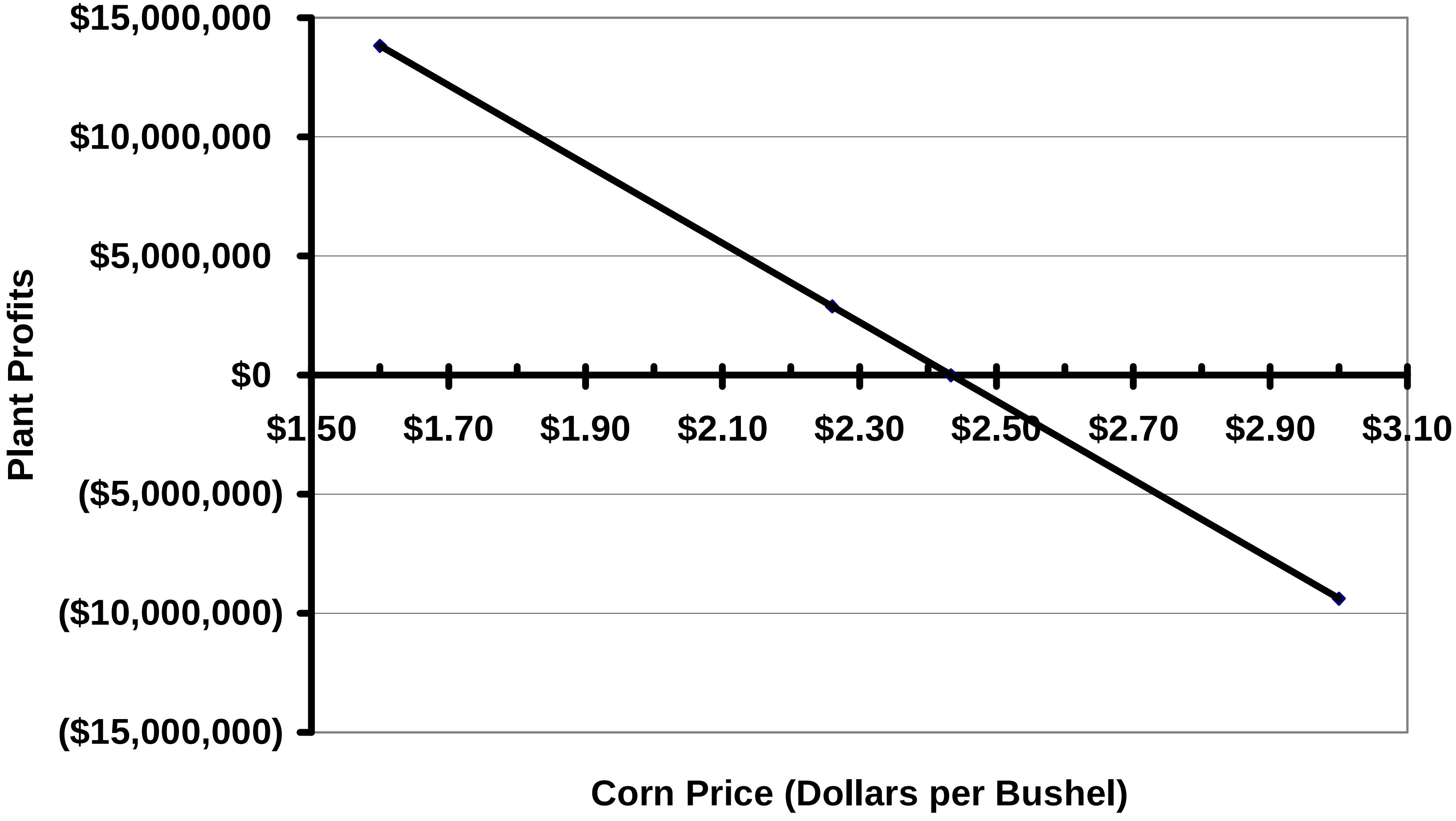
Corn Price	\$2.20 per bushel
Ethanol Price	\$1.15 per denatured gallon
Natural Gas Price	\$4.50 per dekatherm
Conversion Factor	2.75 gallons anhydrous ethanol per bushel
Capacity Factor	1.20 X Nameplate Capacity

The discussion and graphs that follow demonstrate how dramatically each of these five factors can influence the profitability of a dry mill ethanol plant with a nameplate of 40 million gallons per year, but operating at 20% above guaranteed capacity. Analysis was completed by setting baseline conditions and then varying one of the five key factors at a time, holding all other conditions constant.

Corn Price

Graph 5 demonstrates that ethanol dry mill plants enjoy higher levels of profits with lower corn prices. Iterative runs with the dry mill model operating under baseline conditions reveal that the profits of a 40 million gallon per year plant are enhanced \$165,818 for each \$.01 **decline** in corn price. This illustrates the importance of locating ethanol plants in areas of the country with relatively low corn prices. Plant profits drop to zero when corn price rises to \$2.4337 per bushel. Some farmer-investors probably look on their investment in dry mill ethanol plants as a hedge against low corn prices for part of their production because ethanol plants are most profitable with low corn prices. Ironically, farmers who are heavily invested in ethanol plants may logically cheer for lower corn prices to support their investments in the plants. In the event of corn prices greater than \$2.4337 per bushel, some farmers may be reluctant to deliver their contracted amounts of corn to their plants. This situation occurred in a few instances during the period of high corn prices in 1995-96 with the ethanol coops expending money and effort to gain compliance.

Graph 5. 40 MM Gal. Dry Mill Profits Sensitivity to Corn Price



Ethanol Price
As **Graph 6** demonstrates, dry mill ethanol plants are very sensitive to changes in ethanol price, their most valuable product, and the product, which often comprises 80% or their total revenue stream. When ethanol prices rise, ethanol plants benefit. Our model indicates that additional profits of $480,000 per year are returned for each $.01 increase in fuel ethanol prices. Examination of the graph reveals that profits become zero when ethanol prices drop to $1.0693 and below. As **Graph 2** on page 2 shows, there were notable periods during 1998, all of 1999, and periods in 2002 when "rack" ethanol prices were at these low levels. Net plant-gate ethanol price actually received is often $.10 less than the "spot" price quoted at the nearby refineries due to freight, short-term storage, commissions, etc.

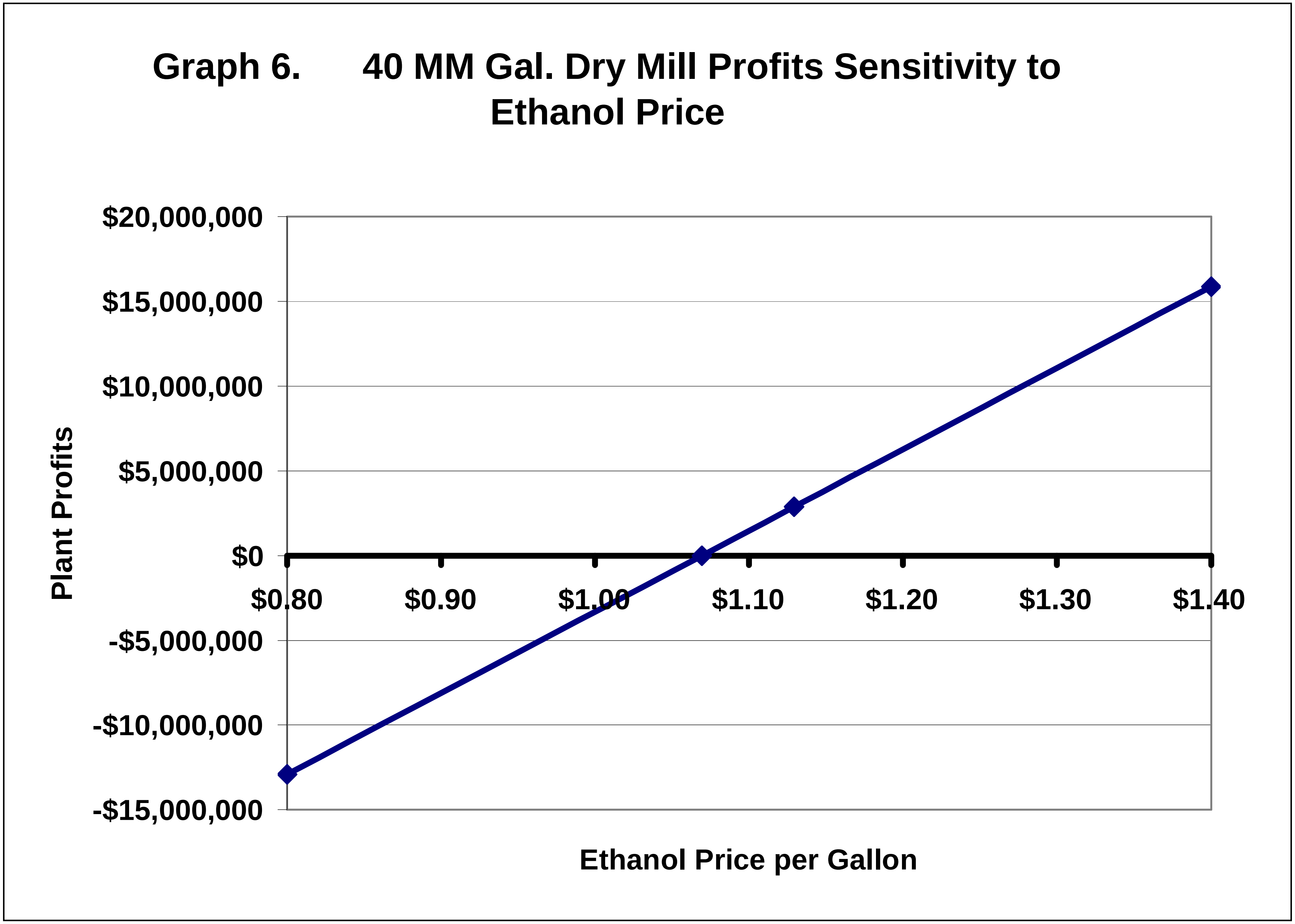
The ethanol market includes fewer transactions than the markets of many farm commodities or agricultural products, making price discovery more difficult, like some other commodities. Prices for ethanol have locational and seasonal dimensions that correspond to the areas of the country that are required to use ethanol as an oxygenate in gasoline, particularly in the winter months. In addition, gasoline prices go through their own locational and seasonal price changes as well when refineries switch their output mix to produce more heating oil and less gasoline from a barrel of crude oil.

The marketing year for fuel ethanol is commonly divided into two, six-month contracting periods. The first period is October 1 through March 31, the "oxygenate season" when many urban areas are forced by local and national clean air standards to include ethanol in their gasoline. The second period is the remainder of the year, which is the "non-oxygenate season" (April 1 through September 30). Buyers of fuel ethanol are most interested in securing adequate supplies of ethanol during the oxygenate season. The buyers of ethanol have more potential suppliers of product in the non-oxygenate season. The market is more competitive during the oxygenate season. During the non-oxygenate season, prices behave as if ethanol is a substitute for high-octane gasoline. (Redding)

Dry-mill ethanol plants typically employ one or more of three pricing strategies for their principal product. The first and simplest is to sell at the **rack price** at nearby refinery and fuel blending sites. Daily prices and transactions can occur between a plant (or a group of plants) and the refiner or blender. The second alternative is **fixed contract pricing for future delivery**. In this case ethanol plants agree to deliver a certain quantity of ethanol to the refiner or blender over a certain period of time at an agreed price. The third pricing strategy is called **gas-plus contracts.** These are contracts in which the price of ethanol is based on the prices negotiated for monthly futures contracts for wholesale lead-free gasoline listed on the NYMEX exchange. For example, an ethanol plant might agree to sell a quantity of ethanol at its plant gate based on the nearby NYMEX contract price plus $.40 per gallon. Sometimes the contracts are NYMEX gas price plus $.20 per gallon. The strategy of most marketing directors for pools of ethanol plants is to develop a marketing plan with a balance of the three pricing strategies.

Ethanol producers indicate there are few good opportunities to stockpile product for later marketing opportunities. Marketing managers attempt to price all of their expected production over the next six months, and to actively contract production anticipated in the interval six to twelve months out. Depending upon the attitudes of the buyers and sellers of fuel ethanol, some contracts are made for the production that will occur twelve to twenty-four months in the future. Minimum quantities of ethanol sold range from one to two million gallons for delivery in a particular month.

Answering the question, “What is the effective market price of ethanol for a particular plant?” involves weighting pricing decisions for various portions of the plant’s production through the year. Marketing groups and ethanol coops, themselves, regularly calculate the net weighted price of ethanol received at the plant gate. A related problem is the difficulty of determining industry-wide price of ethanol for any period.


Graph 6. 40 MM Gal. Dry Mill Profits Sensitivity to Ethanol Price
$20,000,000
$15,000,000
$10,000,000
$5,000,000
$0
-$5,000,000
-$10,000,000
-$15,000,000
Plant Profits
$0.80
$0.90
$1.00
$1.10
$1.20
$1.30
$1.40
Ethanol Price per Gallon

Natural Gas Price

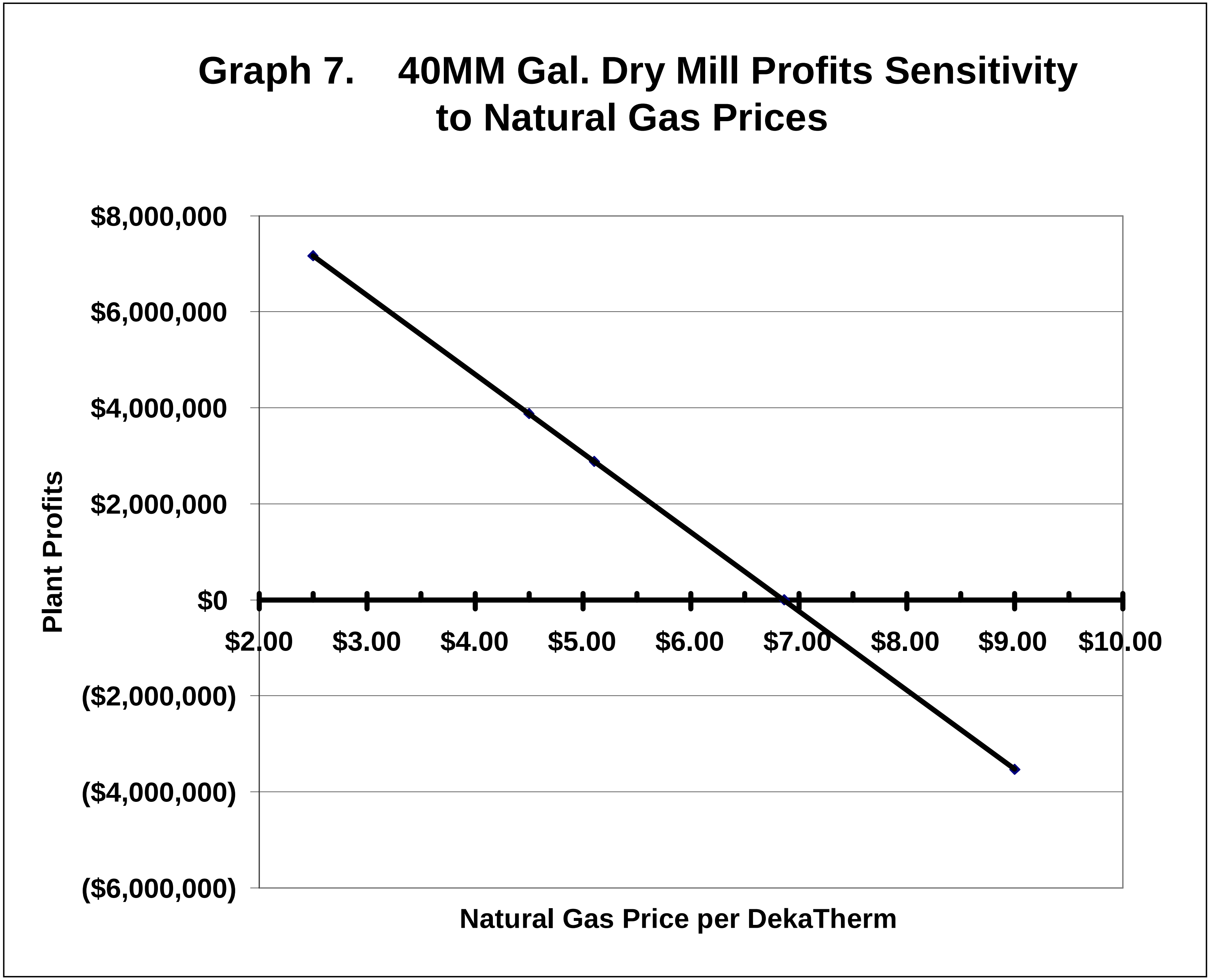
Natural gas prices are a constant area of concern for ethanol plant managers, particularly in the fall and winter months. As mentioned previously, most plants use this fuel for the majority of their needs to heat the mash, distill the ethanol, and dry the DDGS. Natural gas expenditures frequently represent 30% of the operating budget of dry mill plants. Most plants are on interruptible service arrangements with the natural gas companies, so it is necessary to have propane as a stand-by fuel when natural gas is interrupted. Plant managers report that it is important to be located on natural gas distribution lines with adequate capacity in order to reduce the likelihood of interruptions requiring the use of more costly propane. **Graph 7** portrays the effects of changes in natural gas prices based on the baseline conditions in the model. As natural gas prices decline by $.01 per dekatherm from the baseline condition of $4.50 per dekatherm, profits for the plant rise by $16,464 over a year of operation. Thus a $1.00 increase in natural gas prices reduces profits by $1,646,400 per year. When natural gas prices rise to $6.8542 per dekatherm with all other conditions at baseline values, the model ethanol plant makes zero profit. Review of natural gas prices for Minnesota industrial users over the past decade reveals that natural gas prices exceeded $6.00 per dekatherm only for the five months from December of 2000 to April of 2001. (Minnesota Dept. of Commerce) However, this fact may be of little solace for a plant manager located on a natural gas line that interrupts his use of gas with high frequency.

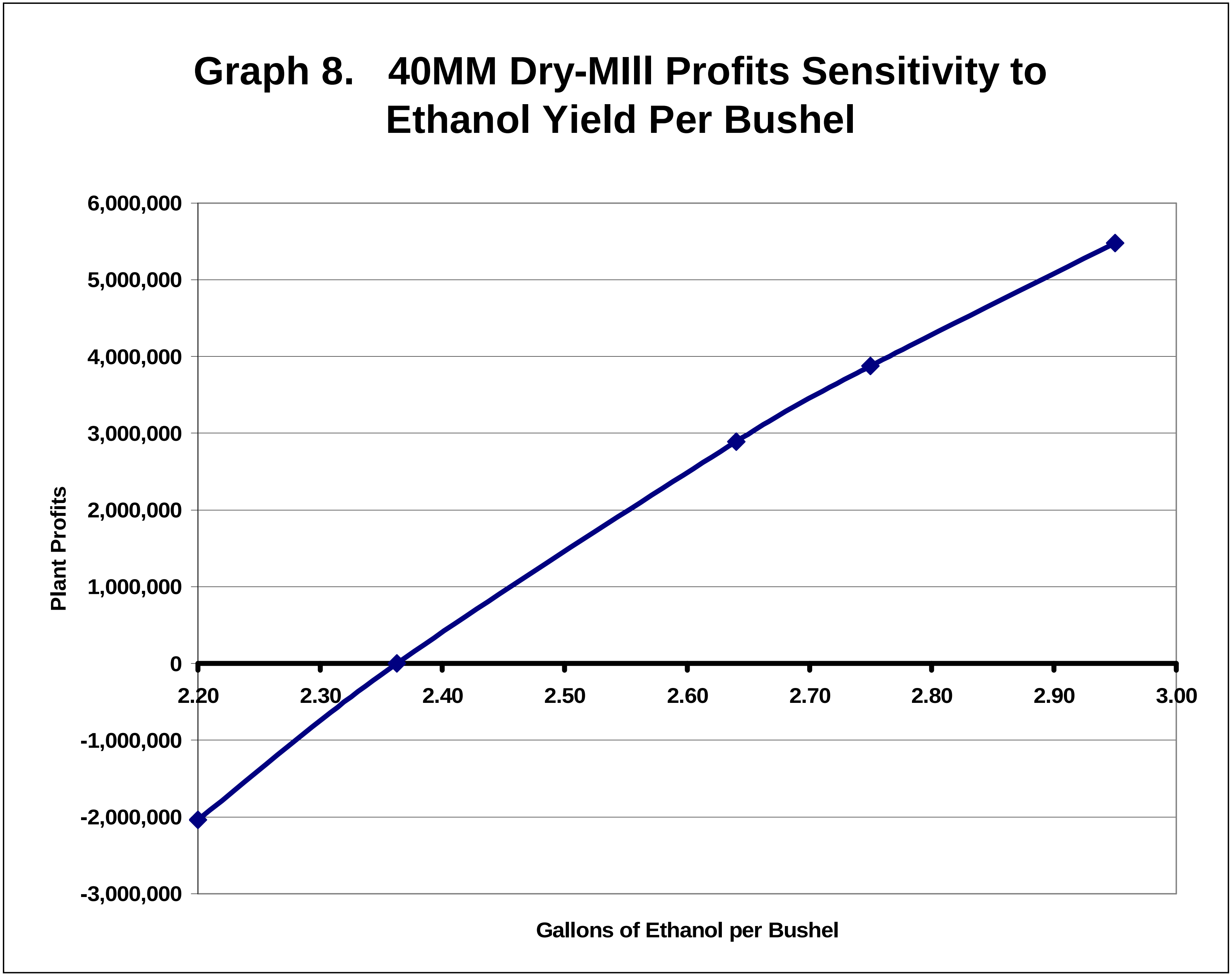
Ethanol Yield Per Bushel

Ethanol yield per bushel of corn processed is a ratio that ethanol plant managers watch carefully. Baseline conditions include the level of 2.75 gallons of anhydrous ethanol per bushel processed. This represents substantial progress over levels reported for the industry just five years ago that centered on 2.50 gallons/bushel. More effective enzymes, sophisticated process controls that seek to foster yeast activity, and better yeast strains have contributed to this improvement**. Ironically, improvements in yield for a fixed capacity to distill product will require that lesser quantities of corn be ground to reach the established maximum number of denatured gallons produced. Many plant designs may be unable to utilize higher and higher yield technologies due to limitations in distillation capacity.** Late in the year of 2002 several companies offered some very vigorous yeast strains that represented further improvements. **Graph 8** represents the sensitivity of ethanol yield on the baseline conditions for the model dry mill plant. As ethanol yield rises, so do profits. According to the model, an increase in the annual ethanol yield of .10, for example from 2.70 to 2.80, would improve profits by $829,674 per year. This sensitivity explains the economic interest of yeast companies, enzyme companies, engineering companies, and seed corn companies as they all seek to sell products with the potential to improve plant efficiency.

Consider an example of field corn whose kernels have 4% higher total fermentables that can be recovered. If the plant is currently operating at 2.75 gallons/bushel, this improvement would raise ethanol yield to 2.86, which could generate $909,450 per year for the plant, or about $.067 for each bushel processed under baseline conditions. If attributes of a variety of corn result in 6% greater yield, the model estimates this gain could generate $1,338,436 for the plant, or $.086 per bushel processed. Plant managers and boards of directors must continually ask what such technological changes imply for changes in plant investment and operating costs over time. Technological changes in yeasts and enzymes impact operating costs, while processing "designer" corn varieties may require new investments to segregate feedstock corn as well as DDGS in drying and storage facilities.

Ethanol yield is a factor that can demonstrate the ability of plant managers and biochemists to successfully manage numerous subtle factors in their operations. Boards of directors must not assume that high ethanol yields are guaranteed, for these efficiencies can only be captured by thoughtful, motivated personnel making appropriate us of the plant's equipment. The model demonstrates that when ethanol yield drops to 2.3627 gallons per bushel under baseline conditions, plant profits become zero. In the course of a year plant managers must contend with disruptions in corn quality, bacterial infections, poor sanitation, mechanical failures, and failures of monitoring equipment----any of which, singly or in concert, may harm ethanol yield levels.


Graph 7. 40MM Gal. Dry Mill Profits Sensitivity to Natural Gas Prices
$8,000,000
$6,000,000
$4,000,000
$2,000,000
$0
($2,000,000)
($4,000,000)
($6,000,000)
Plant Profits
$2.00
$3.00
$4.00
$5.00
$6.00
$7.00
$8.00
$9.00
$10.00
Natural Gas Price per DekaTherm


Graph 8. 40MM Dry-MIll Profits Sensitivity to Ethanol Yield Per Bushel
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
-1,000,000
-2,000,000
-3,000,000
Plant Profits
2.20
2.30
2.40
2.50
2.60
2.70
2.80
2.90
3.00
Gallons of Ethanol per Bushel

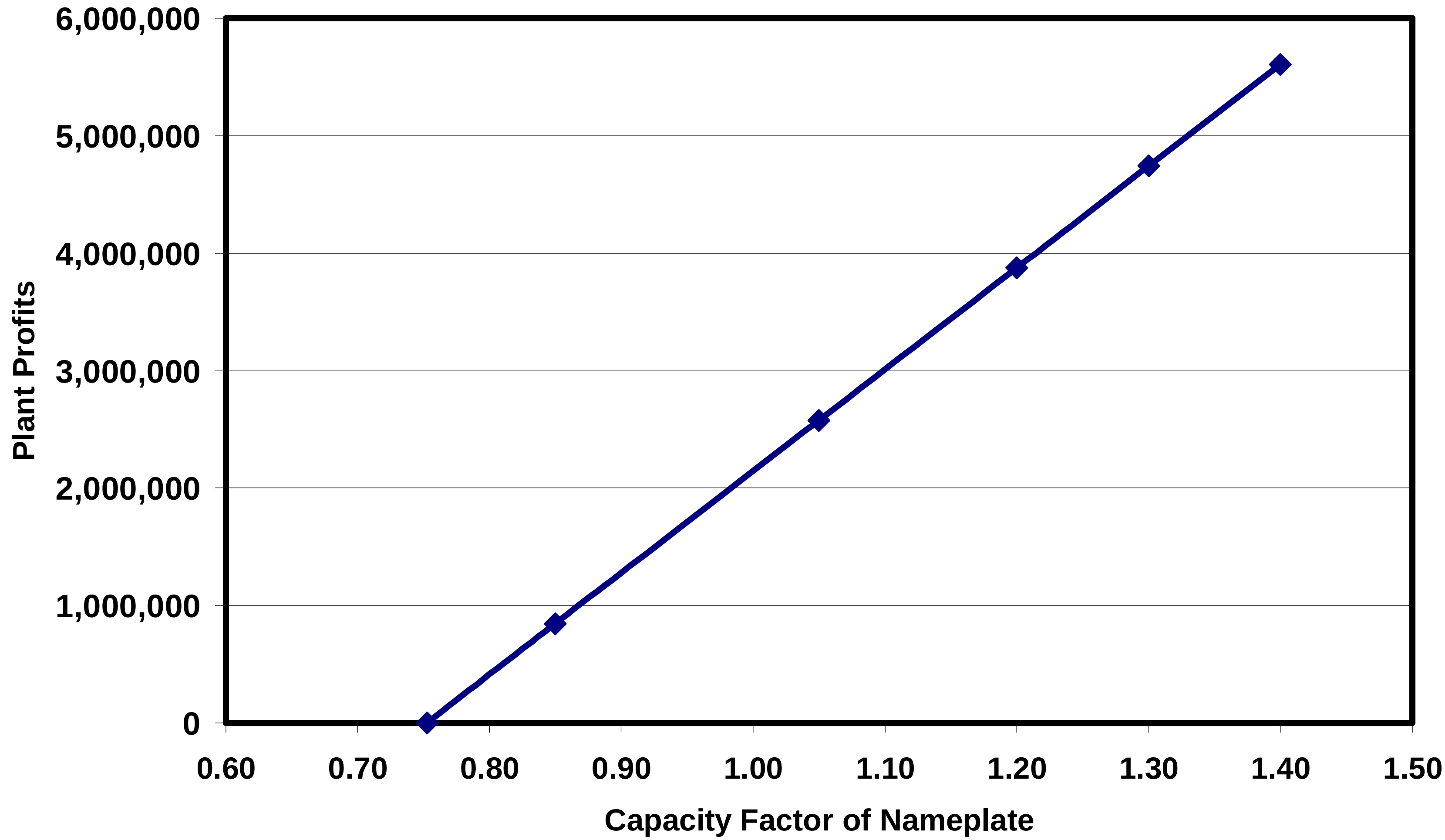
Capacity Factor

Capacity factor refers to the ability of managers to expand capacity of their plants beyond the bonded, warranted nameplate capacities cited by the contracting engineers at construction. Gains in capacity, for example the 1.20 factor used in the baseline case, are captured by de-bottlenecking and optimizing existing plants. In some cases these gains cannot be fully realized because individual component capacities in one part of a plant may be unable to handle the additional capacity demanded by increased capacity in another area of the plant.

For example, distillation capacity may be unable to handle the additional demands of higher conversion rates of sugars to ethanol obtained through the use of better yeast strains. In other cases, capacity at the molecular sieves may be limiting. The molecular sieves are responsible for removing the last 5% of water from ethanol coming from the distillation units. The molecular sieves are designed to precise engineering specifications and are produced in a limited number of capacities. A plant can add molecular sieve capacity only by buying another standard-sized unit. Thus, molecular sieves are an example of a "lumpy input." Another example of a technology change that influences capacity factor is the usage of yeasts that more rapidly convert sugar to ethanol. Over the last five years fermentation times have been shortened from 72 hours to 51 hours, a reduction of 30%. (Davis) Despite theoretically having greater capacity to ferment ethanol in a plant due to more active yeast, some plants may find it beneficial to use slack time between fermentation batches with additional maintenance, cleaning and sanitation activities. In other situations, additional ethanol production at the fermentation level could overwhelm the capacity of the distillation columns to process ethanol. In certain cases, theoretical gains in efficiency must be ignored because additional investments to capture them are too costly. It takes thoughtful engineering and excellent management to enhance the capacity factor above nameplate, but many plants report success attaining capacity factors of 1.25 or more. Once the decision has been made to de-bottleneck a plant, a new level of total capacity becomes the base of expectations and other factors may emerge as limiting.

Of course, higher capacity factors have favorable impacts on interest charges per bushel processed as well as depreciation, labor, and management charges. **Graph 9** shows the influence of capacity factor on profitability. For every 0.01 increase in capacity factor, for example from 1.20 to 1.21, annual profits increase by $86,633 . After a plant is thoroughly tested during its shakedown period, decisions must often be made concerning how best to expand capacity above nameplate. **Graph 9** offers some assurance to managers and boards of directors that investments that result in a higher capacity factor have excellent payoffs. For example, a plant going from 1.00 to 1.10 would realize enhanced profits of $656,331 per year. Once again, the manager and board must weigh the investment and operating costs before attempting to grasp this "low-hanging fruit."

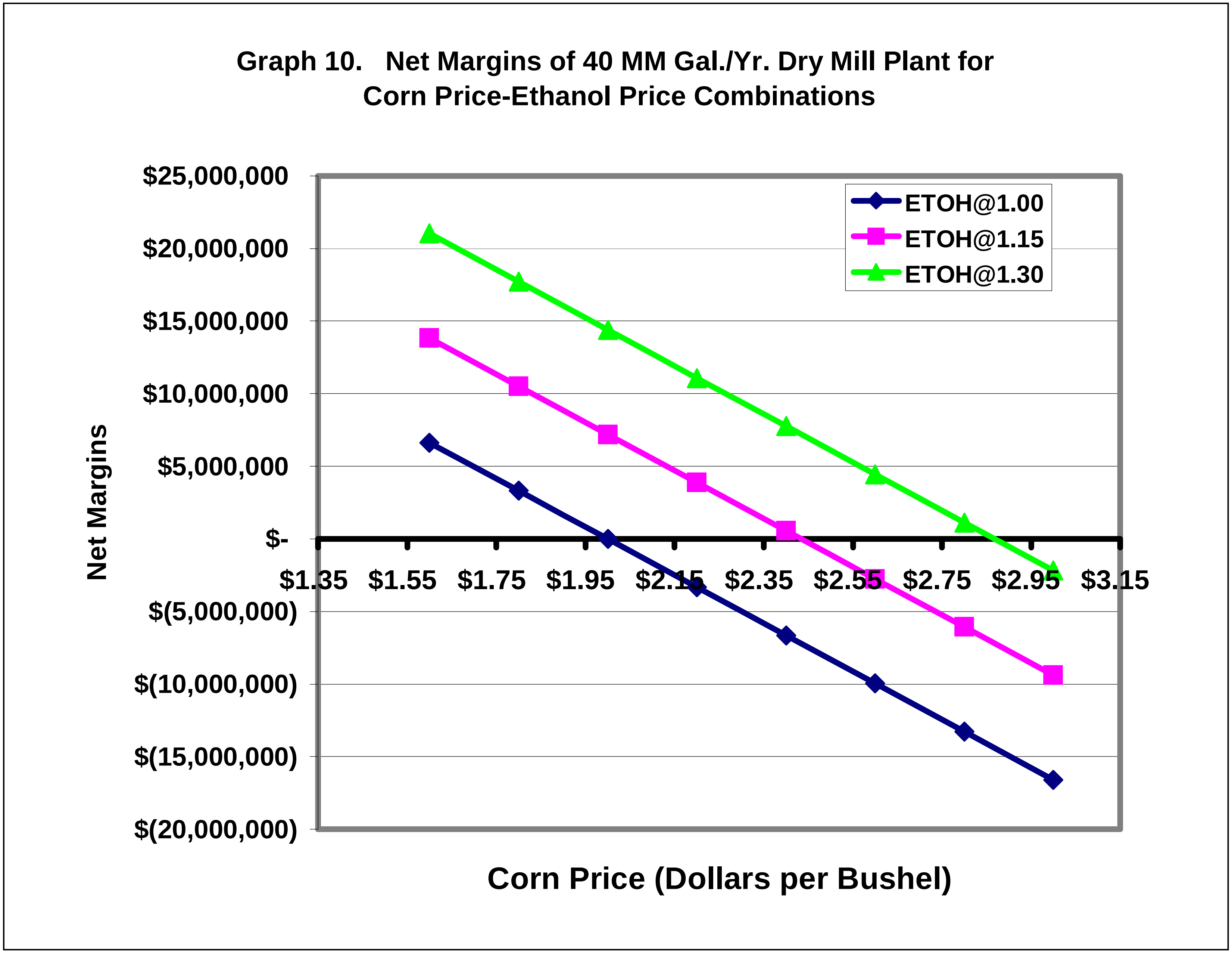
Graph 9. 40MM Gal. Dry-Grind Profits Sensitivity to Capacity Factor of Nameplate



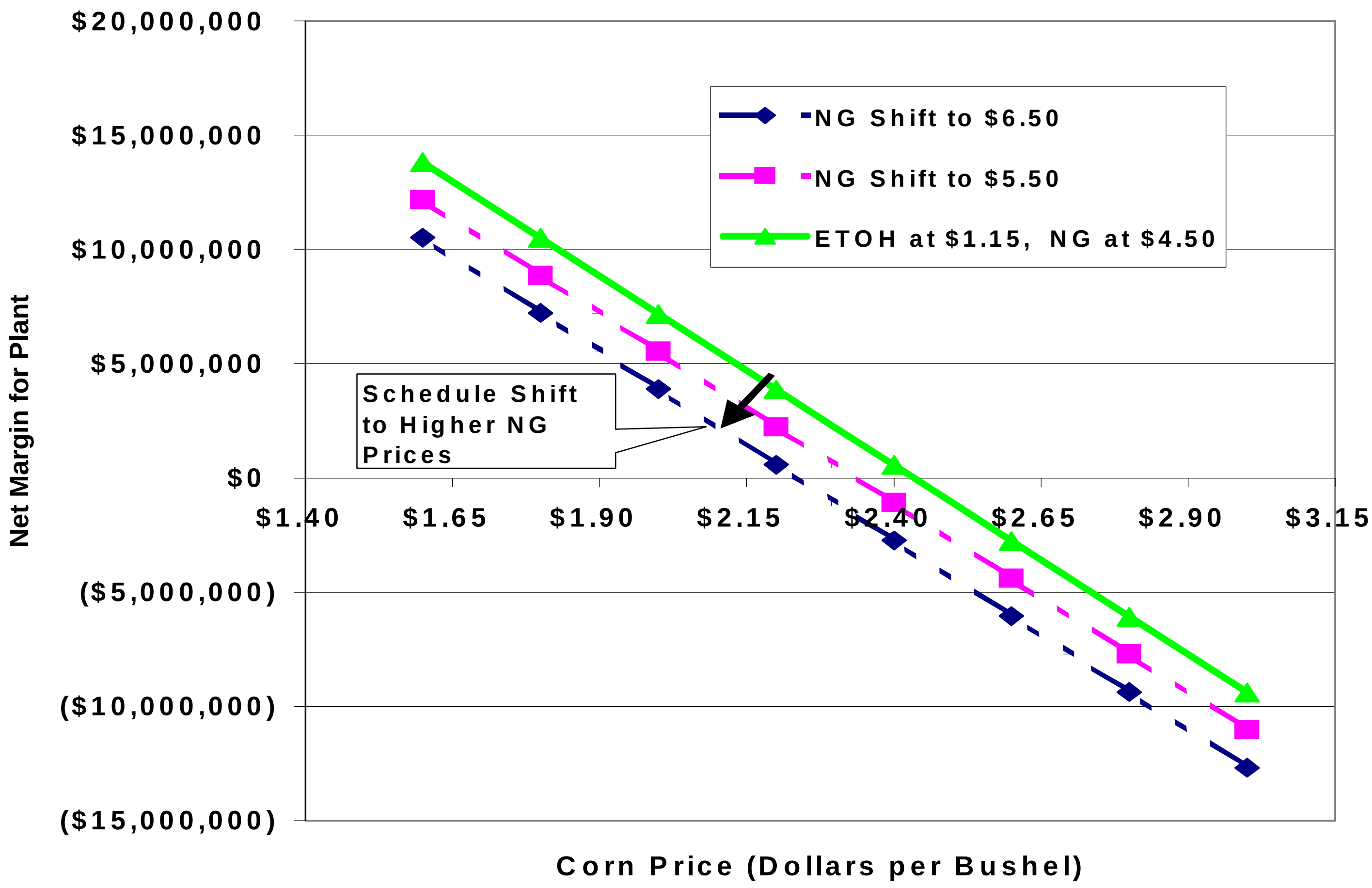
Multiple Factor Interactions

The previous discussion has focused on the impacts of individual factors on the profitability of dry mill ethanol plants. It is useful to determine the influence of simultaneous changes in several of the dominant factors, while holding other factors at baseline levels. Consider the effects of varying corn price and ethanol price, holding ethanol yield at 2.75 to 1.0 and natural gas price at $4.50 per dekatherm and other conditions at the established baseline levels. **Graph 10** shows how changes in corn and ethanol prices can influence the net profits for the predominant-sized dry mill ethanol plant. Each of the three lines represents a schedule of net margins to the plant that result for a given fuel ethanol price as corn prices vary. There are lines representing these relationships when fuel ethanol is priced at $1.00, $1.15, and $1.30 per gallon. Substantial differences in net margins are realized for the different prices of ethanol. When ethanol is low in price, profits are much more vulnerable to increases in corn prices. Note how dry mill plants operating at break-even conditions can tolerate higher corn prices when ethanol prices are higher. In the case portrayed, break-even corn prices are $2.00, $2,43, and $2.87 per bushel for ethanol prices of $1.00, $1.15, and $1.30 per gallon, respectively.

Another variation of multiple factor interactions is shown in **Graph 11**, which shows how net profits are affected with changes in corn price for three levels of natural gas price-- $4.50, $5.50, and $6.50 per dekatherm. The fuel ethanol price is held at $1.15 per gallon. Shifts to higher natural gas costs are shown as distinct schedules parallel and to the left of net margin levels established at $4.50 per dekatherm natural gas and various corn prices. Note how dramatically higher natural gas prices change the price of corn needed to maintain a given level of net return. Break-even corn price of $2.43 per bushel of corn required at $4.50 natural gas is forced to $2.33 and $2.24 for natural gas costing $5.50 and $6.50 per dekatherm, respectively. In this case one can see how sudden, unhedged prices for natural gas can reduce net returns.


Graph 10. Net Margins of 40 MM Gal./Yr. Dry Mill Plant for
Corn Price-Ethanol Price Combinations
ETOH@1.00
ETOH@1.15
ETOH@1.30
$25,000,000
$20,000,000
$15,000,000
$10,000,000
$5,000,000
$-
$(5,000,000)
$(10,000,000)
$(15,000,000)
$(20,000,000)
Net Margins
$1.35
$1.55
$1.75
$1.95
$2.15
$2.35
$2.55
$2.75
$2.95
$3.15
Corn Price (Dollars per Bushel)

Graph 11. Dry Mill Net Margins for Various Corn Prices Shift as Natural Gas Rises to $5.50 , $6.50 from $4.50 per Dekatherm; Ethanol @ $1.15/Gal.



Six Factors of Lesser Importance

The previous discussion and graphs demonstrate how five key factors affect sensitivity of the overall profitability of virtually all dry mill ethanol plants. These six factors may only affect certain dry mill ethanol plants due to their individual situations. Other factors may be critical as well, and should be appreciated, particularly in situations of plants that carry higher percentages of debt in initial years of operation. The influence of the following factors, singly or in concert with others can also strongly affect dry mill profitability and survivability:

Capital Costs
Percentage of Debt
Interest Rates
DDGS Price
Electrical Price
Federal, State, or Local Production Subsidies or Incentives

Capital Costs
Baseline capital costs utilized in the model plant analysis were established at $1.50 per denatured gallon of annual nameplate ethanol capacity. This figure is widely reported for the modern plants of 40 million gallon nameplate of annual capacity. Few ethanol plants smaller than 40 million gallons of capacity have been built or are planned in the near term. Many of the older, smaller plants that were built in Minnesota in the mid-1990's around 15MM gallon capacity have been expanded in the last two-year period. In some cases these smaller plants were built for $2.00 per denatured gallon of annual capacity. One Minnesota plant with capacity between 15-20MM gallons reports $1.85 of capital cost per gallon of annual capacity. A plant of this size could neither afford CO2 collection and sales nor attract a buyer of CO2 to invest in equipment at that location. Net margins for a smaller plant without CO2 sales would be $.0285 per bushel processed at capital costs of $1.85 per denatured gallon. A 40 million gallon per year plant built for $1.50 per denatured gallon of capacity at 1.20 capacity factor and CO2 sales delivers net returns of $.2337 per bushel ground. Forty million gallon plants have a clear advantage in economies of scale in this case. For baseline plants with 40 million gallons of nameplate capacity and conforming to other baseline conditions, additional capital costs of $.01 per gallon of capacity reduce annual net returns by $43,467. Thus, increasing the investment from $1.50 to $1.60 per nameplate gallon reduces net returns $434,670 per year.

A 100 million gallon plant is being built in Eastern South Dakota, with anticipated operation starting in early 2004. The Chief Operating Officer for this plant reported that this plant would be built with capital costs substantially below the lowest levels reported for 40 million gallon plants of $1.37 per nameplate gallon. In the case of some of the plant components, such as distillation columns, larger sizes will be used in this new plant. In other cases, tanks and fermenters of the sizes used in the 40 million gallon plants will be used in series. (Janes) The lower capital costs reported in this case conform to the pattern of capital costs reported in research comparing dry mill scale economies in Texas for plants of 15, 30, and 80 million gallons per year. (Gill, Richardson, et al)

Percentage of Debt

Typical percentages of debt incurred by new ethanol plants seeking financing are 60% to 55%. Senior lenders are finding their loan portfolios heavy in the ethanol-processing category, so are demanding higher levels of equity than were the case several years ago. The bankers are instituting loan provisions called "cash flow sweeps," which allow them to claim higher levels of principal retirement, especially in the early years of a loan. Because of risk in ethanol financing, senior lenders use cash flow sweeps to effectively reduce the period of loan repayment from ten-years to seven or eight years. Lenders maintain appropriate diversification of portfolios by selling some of the ethanol plant loans to commercial bankers. The commercial banks, unfamiliar with ethanol plant loans, typically seek 50% levels of equity in loans on which they participate. Varying the level of debt from 60% to 0% with baseline conditions in the model, increases profit $42,000 for each one percent reduction in the level of debt. Reducing a baseline plant's debt percentage from 60% to 50% adds $420,000 to net margins for a model plant. Reducing the debt level of the base case plant to 0% increases profits $2,520,000 per year.

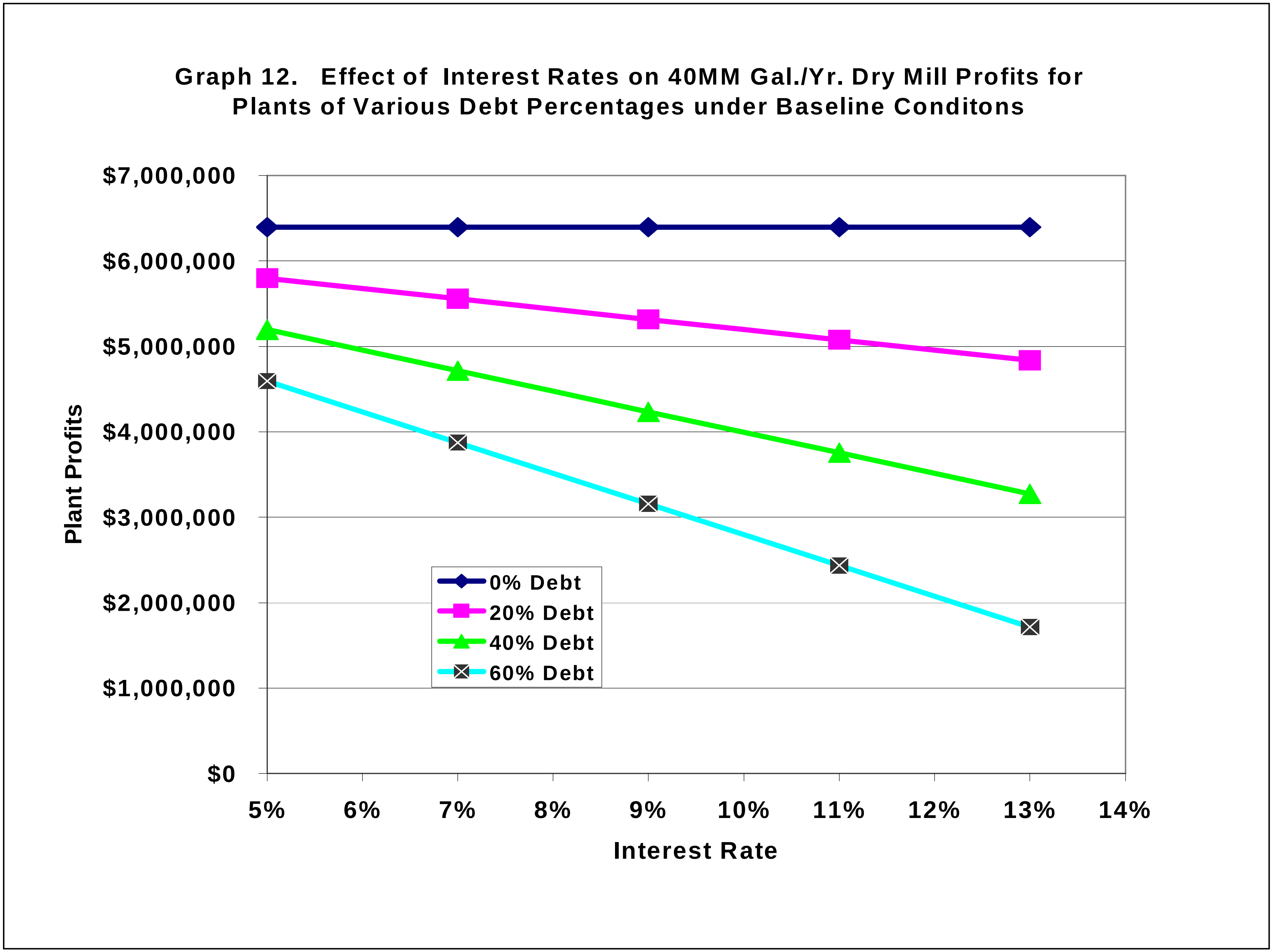
Interest Rates

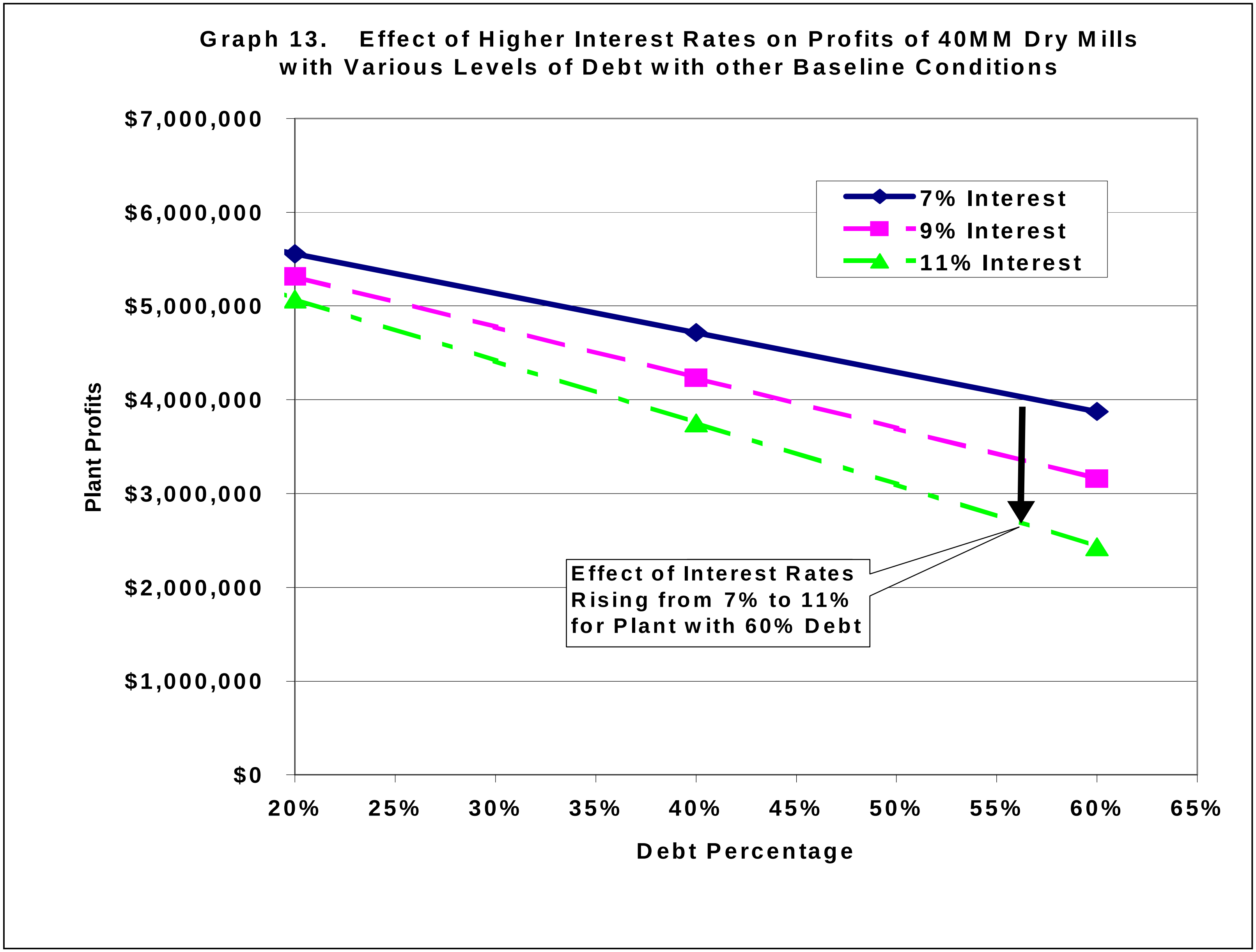
The baseline blended interest rate suggested by lenders on ethanol loans for use in the model is currently 7.0%. There is a split in the banking industry in the use of rates for financing ethanol plants. It appears that about half of the lenders tie their loans to the LIBOR (London Interbank Overnight Rates) interest rates, while about half base their loans on the prime rate plus 75 basis points. Commercial interest rates are at historical lows. If one considers that higher interest rates might return over time, the model can help predict how profits would be affected. For each 100 basis points of increase in interest rates from baseline conditions of 7.00%, (at 60% debt) profits decline by $360,000.

Debt-Interest Rate Interactions

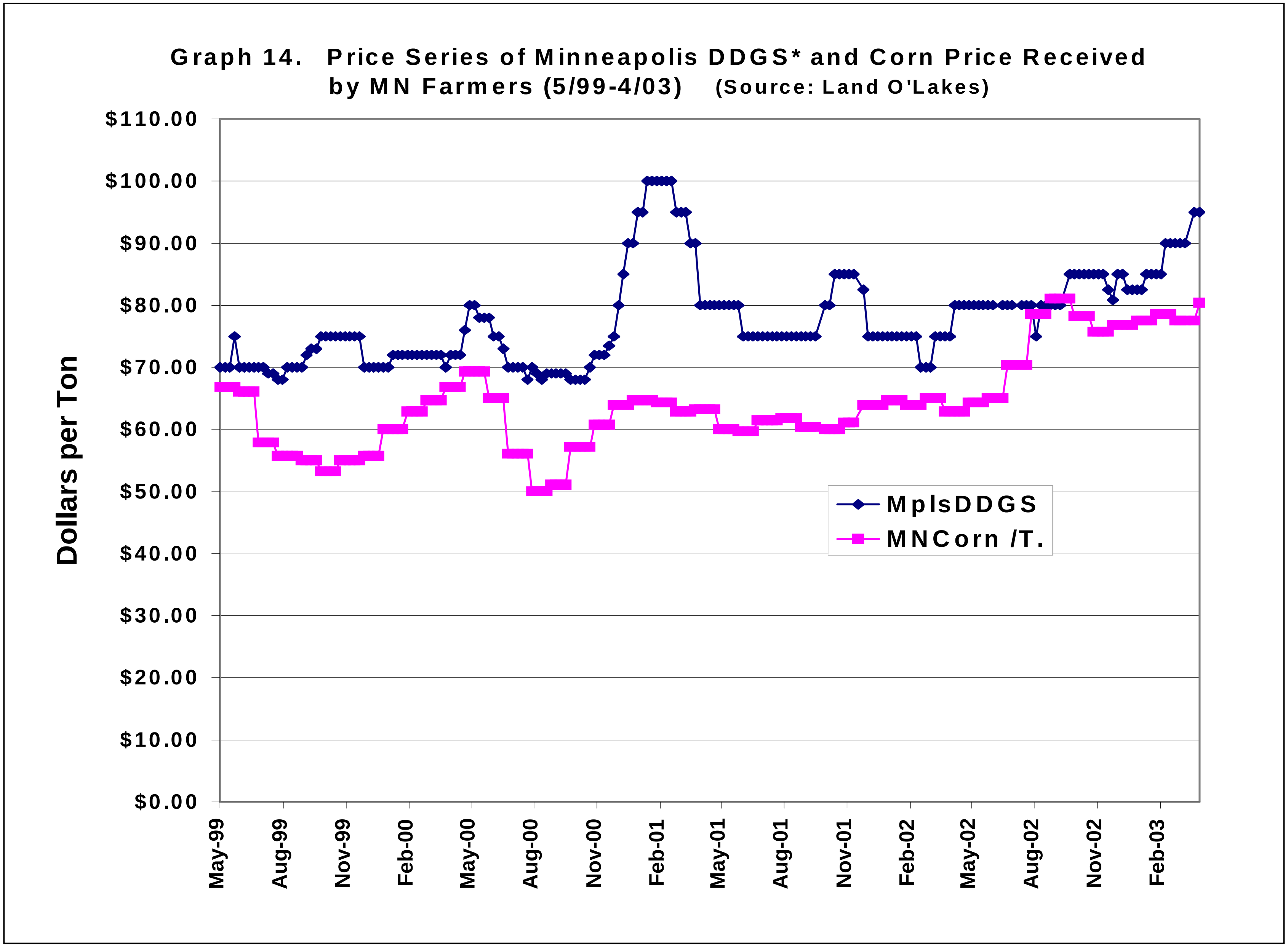
Graph 12 shows the effect of interest rates on profits for 40 Million gallon per year dry mill plants with various levels of debt. The line plotted across the top of the graph shows the obvious, no effect of interest rates on plants with zero debt. The lowest schedule represents plants with 60% debt, which is the starting point for most of the modern plants built in recent years. The graph shows how much profits are affected for plants carrying higher debt levels, especially between 40% and 60% . This graph helps explain why bankers are eager to implement "cash flow sweeps" and rapidly advance the plants they finance to lower levels of debt. (Further discussion of cash flow sweeps applied to loans on ethanol plants and their implications for bankers and investors for up to ten years occurs on pages 44-48.) In addition, **Graph 12** shows the vulnerability of high debt ethanol plants if they must endure periods of lower net returns.

Graph 13 uses the same data derived from the spreadsheet to emphasize how increases in interest rates would affect individual plants with their unique debt percentages. For example, if interest rates were to rise to 11% from 7%, profits on the baseline model plant 60% debt) would be reduced by $1,440,000 per year ($3,875,971 minus $2,435,971). In the case of a plant with debt reduced to 40%, the effect of this interest rate rise would be a reduction of profits of $960,000 ($4,715,971 minus $3,755,971).


Graph 12. Effect of Interest Rates on 40MM Gal./Yr. Dry Mill Profits for Plants of Various Debt Percentages under Baseline Conditons
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
Plant Profits
5%
6%
7%
8%
9%
10%
11%
12%
13%
14%
Interest Rate
0% Debt
20% Debt
40% Debt
60% Debt


Graph 13. Effect of Higher Interest Rates on Profits of 40MM Dry Mills
with Various Levels of Debt with other Baseline Conditions
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
Plant Profits
7% Interest
9% Interest
11% Interest
Effect of Interest Rates
Rising from 7% to 11%
for Plant with 60% Debt
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
Debt Percentage

DDGS Prices
Prices for distillers dried grains and solubles were established in the baseline conditions at $80.00 per ton. The share of the total plant revenue typically contributed by sale of DDGS ranges from 15% to 20%. Some observers of the dry mill ethanol business express worries that the price levels for DDGS might fall with the addition of more and more ethanol plants in the next few years. However, few individuals think that the price of DDGS will drop below the per ton price of corn even with increased supplies of cheap soybean meal. At baseline corn price of $2.20 per bushel, corn price on a **per ton basis** is $78.57. If DDGS were priced as low as $60.00 per ton (because of a massive oversupply of this feed), net margins for the baseline plant would decline by $2,984,732. A decline in DDGS price from the baseline level of $80.00 per ton to $70.00 per ton would reduce net returns for the plant by $1,492,366 or $149,237 for each decline of one dollar per ton of DDGS. **Graph 14** shows DDGS prices for Minneapolis (Land O' Lakes) and Minnesota corn prices (NASS) converted to a per ton basis. A pronounced narrowing of the gap between these two feeds can be seen as more DDGS have come to market since the middle of 1999.


Graph 14. Price Series of Minneapolis DDGS* and Corn Price Received by MN Farmers (5/99-4/03) (Source: Land O'Lakes)
Dollars per Ton
$110.00
$100.00
$90.00
$80.00
$70.00
$60.00
$50.00
$40.00
$30.00
$20.00
$10.00
$0.00
May-99
Aug-99
Nov-99
Feb-00
May-00
Aug-00
Nov-00
Feb-01
May-01
Aug-01
Nov-01
Feb-02
May-02
Aug-02
Nov-02
Feb-03
MplsDDGS
MNCorn /T.

Electrical Prices

The price of electricity in the baseline case is $.05 per kWh. The trends in electricity prices in the U.S. have generally been down over the last decade with the development of additional capacity. However, virtually all of the additional capacity built in recent years arises from natural gas burning generators. Therefore, increases in natural gas prices will increase electrical prices, depending upon the fuel mix of electrical generation capacity in a particular region. Use of the model and baseline conditions indicates that if electrical prices, alone, rose from $.05 per kWh to $.08 per kWh, net profits would decline by $1,569,600 for a year, or a reduction in net profits of $532,200 for each increase in electrical prices of $.01 per kWh.

Usage of the newer strains of yeasts may require the use of additional electricity when operating in the warmer months of the year. When fermentation occurs, the yeast produces heat. If temperature levels exceed 90 degrees F. the yeast cells become less active in making ethanol or die. The engineering solution to the greater heat produced by the more robust yeast strains is to judiciously use cooling coils to keep the temperatures down in the fermenting chambers. Higher cooling costs could become particularly important during the summer months of plant operation, and would increase electricity consumption per gallon of ethanol on the hot days of summer with peaking demand.

Federal, State, or Local Production Subsidies or Incentives

Various subsidies or incentives may increase ethanol plant profits. The federal government offers credits for purchases of feedstock through the Bioenergy Program, which encourages expansion in production and use of U.S. agricultural commodities. An ethanol plant would typically qualify for this only in the year when expanded production occurs. In addition the Small Ethanol Producer Subsidy may be amended to provide assistance to plants as large as 60 million gallons per year. If this provision becomes law, many ethanol plants will quality for this subsidy. The state of Minnesota has provided cash payments to Minnesota ethanol plants of $.20 per gallon of denatured ethanol for up to 15 million gallons per year for ten years of operation. Due to state financial distress, Minnesota ethanol production subsidy payments were suspended for six months at the start of 2003. The Legislature later restored this program at $.13 per denatured gallon. Complete loss of this state subsidy would have resulted in a reduction of annual income of $3,000,000 per year for most Minnesota plants producing 15 million gallons or more. The reduction of this subsidy has occurred at a time when gross margins in dry mill operations are much lower than experienced in 2000 and 2001. Establishment of the subsidy at $.13 per denatured gallon will typically add $1,950,000 to eligible Minnesota ethanol plants for the remainder of their first ten years of operation.

Calculating Cash Flow Sweeps and Debt Repayment of Dry Mills

To this point the discussion has been framed on an annual basis. One can use the spreadsheet discussed in previous sections to analyze the first year of operations, a later year after part of the debt has been repaid, or to analyze profitability under the average economic conditions one expects to prevail in the future. This section of the report illustrates how to use the spreadsheet to analyze the plant's ability to repay debt over a period of years.

The four banks originating loans for the majority of dry mill ethanol plants in the U.S. typically schedule repayment of principal in ten equal annual payments. As mentioned earlier in the discussion of interest rates and percentage of debt, these banks also use cash flow sweeps to increase the amount of principal payments under certain conditions. Ethanol plants may experience large returns in a year because of favorable economic conditions and revenues received from Bioenergy Credits and state subsidies. When favorable operating conditions occur, cash flow sweeps are applied to increase principal payments, eliminating the opportunity for the ethanol plant to pay large cash dividends to members or investors until debt has been reduced to levels specified in the loan.

The following discussion illustrates a commonly used cash flow sweep and the way it would be applied to reduce principal on a loan for the model plant described under the baseline assumptions. Recall that the plant has nameplate capacity of 40,000,000 denatured gallons, costing $1.50 per denatured gallon to build, financed with 60% debt, charged 7% blended interest, and depreciated over 15 years. These are the most important assumptions for bankers because they remain in effect for the entire period of the loan. Other key assumptions, such as ethanol yield (assumed at 2.75) and factor of nameplate capacity (1.20) are developed and remain in effect for periods longer than a year. Assumptions for market-driven factors such as corn price of $2.20 per bushel, ethanol price of $1.15 per gallon, DDGS price of $80.00 per ton, natural gas priced at $4.50 per dekatherm, and the other baseline assumptions for labor, chemicals, and other expenses are given as averages over the years.

In addition to the baseline assumptions established in this paper, bankers define three more categories of expenditures: 1) management bonuses, 2) capital expense & maintenance expenditures (Cap-X), and 3) dividends. The amount of the potential sweep depends on the "free cash flow" (FCF) available after each year's operations. The starting point in calculating FCF is to reduce profits by any bonuses awarded to management. In the baseline example that follows, 5.0% of profits, or $193,799 (.05 X $3,875,971) is the amount of management bonuses. Capital expense and maintenance expenditures represent the expenditures on long life, depreciable equipment or items that improve the capacity of the plant beyond nameplate operating conditions. Cap-X expenditures differ from the repair and maintenance figures reported in the spreadsheet that merely keep the existing plant operational. In the baseline example that follows, the "Cap-X" expenses are assumed to be 1.0% of initial cost, or $600,000 per year, every year. Finally, there are dividends, which are assumed to be 40% of the profits as previously calculated by the spreadsheet. These dividends arise in order to satisfy the tax burdens of partners who invest in ethanol plants with local cooperatives and to satisfy the tax requirements and by-laws of the cooperatives, themselves. In this example $1,472,869 is calculated for dividends in the baseline case ((profits – bonuses) X 40%). The calculation of the cash flow sweep for Year 1 of the baseline case follows:

Ethanol Plant Profits	$3,875,971	
Less Bonus to Management	-193,799	
Net Income minus Bonus	$3,682,173	
Plus Depreciation	$4,000,000	($60,000,000 / 15 years)
Less Cap-X	- 600,000	
Less Dividends	-1,472,869	
Less Scheduled Principal	-3,600,000	($36,000,000 / 10 years)
Free Cash Flow	$2,009,304	
Sweep Factor	75.00%	
Potential Sweep Calculated	$1,506,978	

The baseline case above shows how this particular method, which is very popular among banks financing ethanol plants, sweeps 75% of the "Free Cash Flow" and applies it as an additional principal payment. This makes the total principal payment during the year $5,106,978 ($3,600,000 + $1,506,978). Cash flow sweeps are made according to these conditions as long as the principal balance of the borrower is between 60% and 40% of the cost of the plant plus working capital. When debt percent drops to less than 40%, sweeps are not applied and only regularly scheduled principal is paid to the lender.

Page 44 contains a printout entitled "Baseline Example" from the spreadsheet named "LoanCalc," which identifies the conditions and amounts of cash flow sweeps applied to a loan for a dry mill starting with the profits computed for Year 1 (baseline conditions). LoanCalc is linked to the spreadsheet "BuGal" that establishes assumptions for ethanol operations that have already been demonstrated on an annual basis. Coupled with BuGal, LoanCalc calculates payments over the period required to repay the loan, or ten years, whichever is shorter. LoanCalc calculates the amount of interest to be paid each year based on the loan balance at the start of the year. In this example "Ethanol Plant Profits" rise from the Year 1 level **(C6)** of $3,875,971 to $4,233,460 in Year 2 **(D6).** This additional income can be attributed to reduction of interest expense due to the total principal paid at the end of Year 1 ($5,106,978 X .07 = $357,488). The upper section of the table contains the figures necessary to compute the "Potential Sweep Calculated" in **Row 17**. In each succeeding year the spreadsheet calculates the potential sweep that may be taken.

Whether or not the sweep calculated for a particular year is taken, depends on figures and formulas in cells under the heading "Projected Principal and Interest for Loan."
In **Row 22**, principal balances are shown for the start of each year. **Row 23** shows the amount of scheduled principal payment, while **Row 24** (Sweep Exercised) shows the amount of the sweep, if and only if, the percent of debt is greater than 40%. **Row 25** contains the total principal paid, which is the sum of scheduled principal and sweep exercised. **Row 26** contains the interest actually paid for each year based on the principal

balance in **Row 22** above it. **Row 27** contains the percent of debt at the beginning of each year.

Review of the LoanCalc spreadsheet on page 44 (Baseline) reveals that cash flow sweeps are applied in Years 1, 2, and 3. The amount of the three sweeps grows in each year because there is more free cash flow due to lower interest expenses from reduced loan balance. In this baseline case the ethanol plant has reduced its percent debt to less than 40% in Year 4, so no further cash flow sweeps are applied in the remaining years. In this example, the loan is paid off in Year 9, due to the effect of the cash flow sweeps taken in the first three years.

LoanCalc contains two special rows that may be helpful to bankers or boards of directors studying repayment patterns for a planned ethanol plant. **Rows 7 and 8**, which are shaded in yellow**,** allow one to build in the effect of changes in annual revenues and/or expenses, either (+) or (-) , starting in Year 2. Usage of **Rows 7 and 8** is demonstrated in the LoanCalc spreadsheet on page 45. For example, if a reduction in revenue is expected as a consequence of the Minnesota Legislature scrapping all ethanol subsidies, this change could be entered as <u>negative</u> $1,950,000 in **D7**. If natural gas prices are expected to rise by one third in Year 2, the effect could be analyzed by entering these additional expenses as a <u>positive</u> $2,500,000 in **D8**. **All figures entered in Rows 7 and 8 are considered as changes from the baseline conditions and should be signed either plus or minus (+/-).** For emphasis:

> Increases in revenue are (+); decreases in revenue are (-).
> Increases in expense are (+); decreases in expense are (-).

If the user of the LoanCalc thinks prices of ethanol will rise by $.05 per gallon in Year 3, revenues will change by + $2,400,00 (48,000,000 gallons X +$.05) which should be entered in **E7**. If the user thinks corn price, the principal expense, will decrease about $.21 per bushel from the baseline level of $2.20, in Year 4, then expenses will decline, so - $3,494,446 (16,581,843 bu. X -$.2107393) should be entered in **F8**. With this feature LoanCalc allows one to establish operating conditions in Year 1, accept additional income from principal retired in a previous year, and introduce changes expected for revenues and expenses. If the user cannot identify changes in revenue or expense from the baseline, no figures or zeros may be entered in **Rows 7 and 8**.

Rows 7 and 8 of Loan Calc can be used to analyze the effects of unforeseen or shock changes in revenues and expenses from any source during the life of loan. Surprise windfalls or enhanced revenues from high ethanol prices will result in enhanced sweeps and earlier loan repayment. Surging expenses such as higher natural gas prices or high corn prices during the life of the loan will reduce and may eliminate sweeps, prolonging loan repayment. Bankers and boards of directors can use **Rows 7 and 8** of LoanCalc to determine the overall effect of shocks of various magnitudes at various times in the life of the loan.

The revenue and expense change examples mentioned above are presented in the spreadsheet on page 45. Year 1 cash flow sweep calculation and utilization are identical in the "Baseline" case and the "Rev/Exp Change" case because changes can only be made in Year 2 and later years. With the adverse changes expected in revenue and expense in Year 2, no bonus is awarded to management (**D9**). In fact, the combination of events results in Free Cash Flow of negative $416,540 in Year 2. Looking to cell **D25** one can see that the plant is unable to make its full, scheduled principal payment, only $3,183,460. Of course the plant is able to make its interest payment as noted in **D26**. These two adverse changes in Year 2 combine to reduce principal payment for year two from $5,259,804 in the baseline example to $3,183,460. In Year 3 the situation improves with a plus $2,400,000 change in revenue due to higher expected ethanol prices. This improves things dramatically, with management bonuses and dividends being paid. A potential sweep is calculated and exercised in **E24** because the percent of debt at the beginning of the year is still greater than 40% (**E27**). Total principal retired in Year 3 is $6,381,069. Year 4 has more good news for the dry mill with a reduction in the price of corn forecast, resulting in reduced expense of minus $3,494,446. This favorable turn of events would have resulted in a cash flow sweep, except that the plant had its percentage debt below 40% at the start of Year 4. Therefore, only scheduled principal is paid in Year 4. By comparing the two examples, one can see that despite the more erratic FCF experienced, the "Rev/Exp Change" example loan is also completely paid off in Year 9.

Further Use of the Rev/Exp Change Feature

Because the BuGal Spreadsheet is linked to LoanCalc, loan repayment figures are always available for any Year 1 scenario portrayed with the assumptions the user inserts in Column C of BuGal. If the user is familiar with the Excel feature "Goal Seek" in "Tools," that feature can be handily used to answer "what if?" situations. For example, if one wanted to know the price of ethanol needed to result in zero cash flow sweep in Year 1, one would click on the cell **C17** in LoanCalc (Baseline), which is $1,506,978, and select "Tools", then "Goal Seek", setting **C17** value to -0-, by changing the price of ethanol. The price of ethanol is brought into play in the linked spreadsheet BuGal, so one identifies the cell for the price of ethanol as "BuGal!C19". "Goal Seek" determines the price of ethanol needed on BuGal that results in a sweep of zero in Year 1, which is $1.0766 and is recorded on the BuGal spreadsheet in cell **C19** as $1.08 per gallon. Thus one realizes that a reduction of $.0734 in the price of ethanol removes the sweep. "Goal Seek" can be utilized to determine the price of corn necessary to result in zero cash flow sweep. In this case the user clicks on **C17** and selects "Tools" then "Goal Seek" and requests that the value of cell C17 (Potential Sweep Calculated) becomes zero by varying the price of corn, which is specified as "BuGal!C26". The price of corn necessary to wipe out the cash flow sweep is $2.4126 per bushel. This can be seen by clicking the BuGal spreadsheet. Therefore a corn price rise of $.2126 per bushel from baseline will wipe out the sweep. It is important to reset the values in BuGal to their baseline values before running a "Goal Seek" on another variable. In the event of very adverse FCF conditions, Loan Calc will correctly calculate a negative figure for principal paid (**Row 25**), which would necessitate the advance of further funds from the banker. This tool and others can be used to understand the dynamics of loan repayment on dry mill ethanol plants under uncertain conditions.

1	"Baseline Example"		D	E	F	G	H	I	J	K	L
2	Cash Flow Sweep Calculations										
3			by Douglas G. Tiffany,		University of Minnesota						
4	7/23/03										
5		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
6	Ethanol Plant Profits	$3,875,971	4,233,460	4,601,646	4,980,850	5,232,850	5,484,850	5,736,850	5,988,850	6,240,850	6,395,971
7	Revenue Change (+/-)		-	-	-						
8	Expense Change (+/-)		-	-	-	-					
9	less Bonus to Management of 5.0%	(193,799)	(211,673)	(230,082)	(249,043)	(261,643)	(274,243)	(286,843)	(299,443)	(312,043)	(319,799)
10	Net Income minus Bonus	3,682,173	4,021,787	4,371,564	4,731,808	4,971,208	5,210,608	5,450,008	5,689,408	5,928,808	6,076,173
11	plus Depreciation	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
12	less Capital Exp.& Maint. (Cap-X) 1.0%	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)
13	less Dividends	(1,472,869)	(1,608,715)	(1,748,625)	(1,892,723)	(1,988,483)	(2,084,243)	(2,180,003)	(2,275,763)	(2,371,523)	(2,430,469)
14	less Scheduled Principal	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)
15	Free Cash Flow (FCF)	2,009,304	2,213,072	2,422,938	2,639,085	2,782,725	2,926,365	3,070,005	3,213,645	3,357,285	3,445,704
16	Sweep Factor of 75.0%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%
17	Potential Sweep Calculated	1,506,978	1,659,804	1,817,204	1,979,313	2,087,043	2,194,773	2,302,503	2,410,233	2,517,963	2,584,278
18											
19											
20	Projected Principal and Interest for Loan										
21		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
22	Beginning Principal Balance	36,000,000	30,893,022	25,633,218	20,216,015	16,616,015	13,016,015	9,416,015	5,816,015	2,216,015	0
23	Scheduled Principal Payment	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	2,216,015	0
24	Sweep Exercised	1,506,978	1,659,804	1,817,204	0	0	0	0	0	0	0
25	Principal Paid	5,106,978	5,259,804	5,417,204	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	2,216,015	0
26	Interest Paid	2,520,000	2,162,512	1,794,325	1,415,121	1,163,121	911,121	659,121	407,121	155,121	0
27	Percent Debt Beginning of Year	60.0%	51.5%	42.7%	33.7%	27.7%	21.7%	15.7%	9.7%	3.7%	0.0%

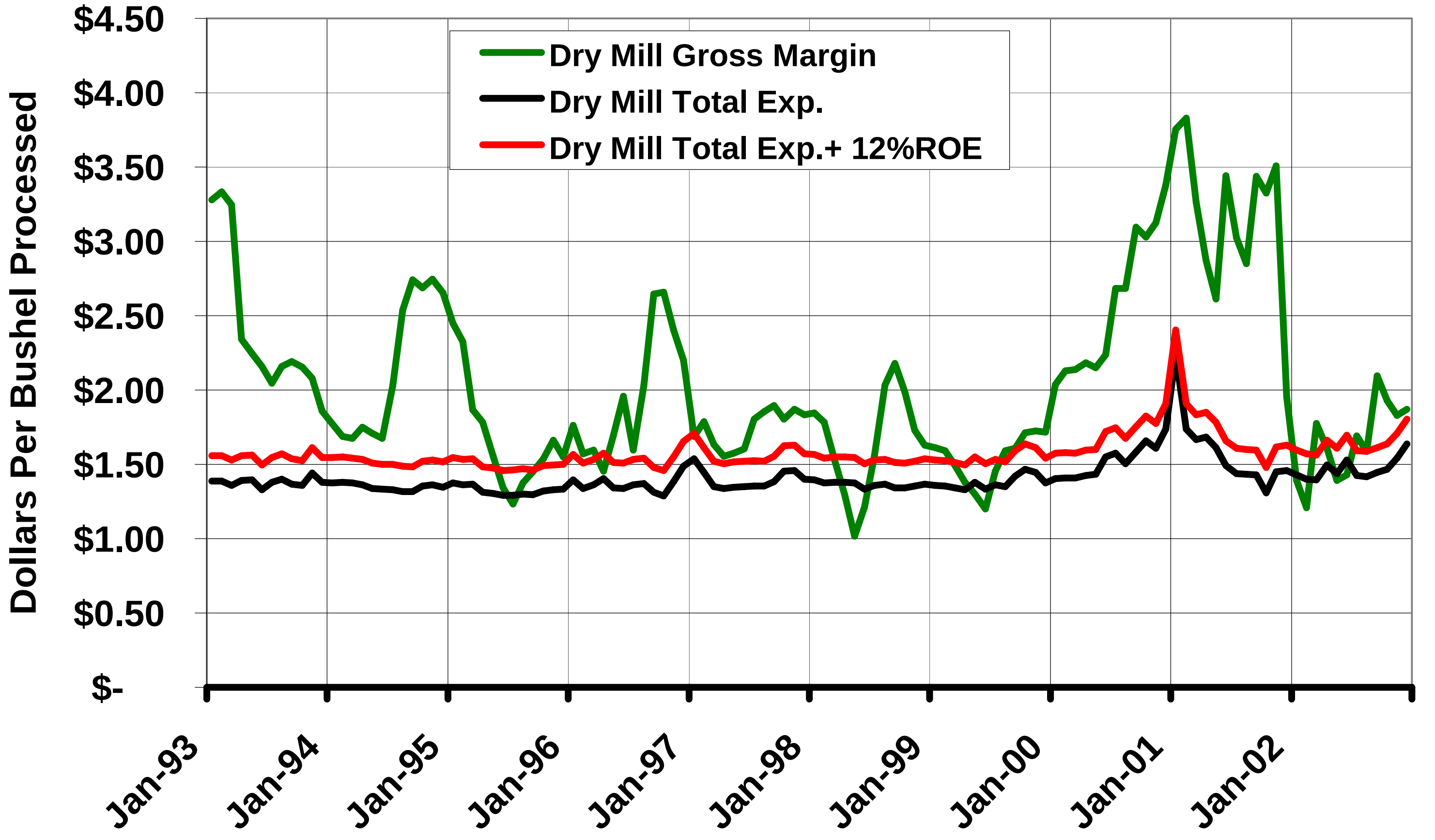
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	"Rev/Exp Change Exampl		D	E	F	G	H	I	J	K	L
2	Cash Flow Sweep Calculations										
3			by Douglas G. Tiffany,		University of Minnesota						
4	7/23/03										
5		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
6	Ethanol Plant Profits	$3,875,971	4,233,460	4,456,302	4,902,977	5,154,977	5,406,977	5,658,977	5,910,977	6,162,977	6,395,971
7	Revenue Change (+/-)		(1,950,000)	2,400,000	-						
8	Expense Change (+/-)		2,500,000	-	(3,494,446)	-					
9	less Bonus to Management of 5.0%	(193,799)	-	(342,815)	(419,871)	(257,749)	(270,349)	(282,949)	(295,549)	(308,149)	(319,799)
10	Net Income minus Bonus	3,682,173	(216,540)	6,513,487	7,977,551	4,897,228	5,136,628	5,376,028	5,615,428	5,854,828	6,076,173
11	plus Depreciation	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
12	less Capital Exp.& Maint. (Cap-X) 1.0%	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)	(600,000)
13	less Dividends	(1,472,869)	-	(2,605,395)	(3,191,021)	(1,958,891)	(2,054,651)	(2,150,411)	(2,246,171)	(2,341,931)	(2,430,469)
14	less Scheduled Principal	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)	(3,600,000)
15	Free Cash Flow (FCF)	2,009,304	(416,540)	3,708,092	4,586,531	2,738,337	2,881,977	3,025,617	3,169,257	3,312,897	3,445,704
16	Sweep Factor of 75.0%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%
17	Potential Sweep Calculated	1,506,978	(312,405)	2,781,069	3,439,898	2,053,752	2,161,482	2,269,212	2,376,942	2,484,672	2,584,278
18											
19											
20	Projected Principal and Interest for Loan										
21		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
22	Beginning Principal Balance	36,000,000	30,893,022	27,709,563	21,328,494	17,728,494	14,128,494	10,528,494	6,928,494	3,328,494	0
23	Scheduled Principal Payment	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,328,494	0
24	Sweep Exercised	1,506,978	0	2,781,069	0	0	0	0	0	0	0
25	Principal Paid	5,106,978	3,183,460	6,381,069	3,600,000	3,600,000	3,600,000	3,600,000	3,600,000	3,328,494	0
26	Interest Paid	2,520,000	2,162,512	1,939,669	1,492,995	1,240,995	988,995	736,995	484,995	232,995	0
27	Percent Debt Beginning of Year	60.0%	51.5%	46.2%	35.5%	29.5%	23.5%	17.5%	11.5%	5.5%	0.0%

If the Last Decade's Price History Were to Replay…

In addition to the examination of baseline assumptions, the authors sought to examine the economic returns of fuel ethanol plants by re-playing a decade of historic prices for products and inputs of dry-mill fuel ethanol production. This type of analysis shows how a modern 40 million gallon per year plant with current scale economies, investment costs, enhanced ethanol conversion factors, etc. would fare with a replay of the last decade's corn prices, ethanol prices, natural gas prices, DDGS prices, CO_2 prices, interest rates, etc. This period includes much more favorable prices for DDGS than witnessed in recent years.

Monthly gross margins, plotted in **Graph 15,** were obtained by subtracting monthly Minnesota corn prices from the value of ethanol products for that month. Minnesota ethanol prices at the refinery rack were utilized minus $.10 per gallon for freight and storage. Prices of distillers dried grains and solubles (DDGS) were based on the monthly U.S.D.A. series for Lawrenceburg, Indiana from January of 1993 through April 1999. (USDA-ERS) Monthly prices of DDGS from May 1999 through December 2002 were Minneapolis- based prices. (Land O' Lakes) Carbon dioxide was assumed to be sold for $6.00 per ton on a net-back basis to the plant. Natural gas prices, electrical prices, and interest charged have been allowed to vary each month. However, chemical prices, depreciation, labor & management, repairs & maintenance, and miscellaneous expenses have been fixed at the baseline levels for each month. Finally, a 12% imputed return on investor equity was added to the total plant expenses to learn how satisfied investors might be with a plant using current technology and encountering a replay of the past decade's prices and economic conditions.

Graph 15. Retrospective Ethanol Gross Margins, Operating Expenses, and 12% ROE of 40MM Dry Mill Plant from 1/93-12/02



The green line in **Graph 15** shows the tumultuous pattern of gross margins (value of dry mill products minus corn price) experienced by dry mill ethanol plants in the last decade. The black line represents total plant expenses. At times when the green line is below the black line, dry mill ethanol plants are losing money. When the green line is above the black line, there are profits. Using a replay of the decade's prices of products and expenses, losses occur for periods in 1995, 1999, and in portions of the first half of 2002. If one assumes that investors in ethanol plants expect at least 12% return on their equity in the plants, then one can see that the times when the red line is higher than the green line represent times when investors are disappointed in their rate of return on equity. There were more months when investors were not achieving a 12% rate of return, particularly periods in 1995, 1996, 1998, 1999, and 2002

Prominent is the evidence of good times in dry mill ethanol processing during 1993, the second half of 1994, and the second half of 1996. Exceptional profits occurred during 2000 and 2001. Review of the monthly data reveals that in 10 months out of the 120 months (8.3% or the time) from January of 1993 through December of 2002 there were losses based upon ethanol gross margins minus total costs. If a 12% rate of return on investor equity is added to total costs, deficiencies would occur in 20 months out of 120, approximating investor discontent 16.7% of the time. Despite the periods of negative net returns, overall profitability of a modern, 40 Million gallon per year plant operating under baseline conditions would occur in a re-play of the last decade's product prices, energy costs and interest rates. The months of positive net returns of the last decade overwhelm the negative periods of the 120-month period with the very high returns of 2000 and 2001 having extraordinary influence. Indeed, the glory years of 2000 and 2001 strongly affected the overall financial performance the last decade and set the stage for the expansion in fuel ethanol production that is still underway.

Relatively small movements in corn, ethanol and natural gas prices can result in dramatic shifts in net returns of dry mill plants. Gross margins set the economic stage for the ethanol production industry; however, the disciplines of engineering, biochemistry, and business management must act in concert to plan processing plants possessing scale economies and execute business plans for success. In particular, management must develop a management style that fosters care for fragile microscopic organisms in a large-scale industrial setting. Failure to appreciate the subtleties of yeast management and quality control can result in low yield of ethanol per bushel of corn. From gross margins, plant operating costs are subtracted in order to determine net returns. The plant manager must control important cost categories such as energy for heating, electricity, interest, depreciation, enzymes, repairs, maintenance, and other items.

Specific Items Learned

--- Dry-mill ethanol processing is a commodity-based processing business, taking corn, which has certain price volatility and natural gas, which has its own level of volatility, to produce ethanol, which has a niche in the large market for transportation fuels. Price levels of gasoline in the U.S. have been low in real terms, but have been somewhat volatile in the last decade.

---Success in dry-mill ethanol processing requires thoughtfulness in determining plant locations with good access to cheap utilities and with good access to transportation. The ethanol plant should be located in an area with historically low corn prices (wide basis) and plentiful, stable supplies. Clever management is required in order to maintain throughput of product and high ethanol yields per bushel in any successful plant.

--- Many plants have recently been built in areas on the edge of the traditional Corn Belt and construction of others is underway. Several years of poor corn production, resulting in tight, expensive corn supplies could severely test the staying power of ethanol plant investors and their bankers. On the other hand, dry mill plants in non-traditional areas may succeed by emphasizing marketing of wet distillers grains to nearby livestock producers.

--- Ethanol demand is driven by government mandates and incentives. The federal blender's credit expires in 2007. (Ag. Marketing Resource Center-2) This provision provides incentives for blenders to use fuel ethanol by subsidizing it $.53 per denatured gallon. Loss of this provision would be devastating to the industry. The Minnesota Ethanol Production Subsidy of $.20 per gallon of fuel ethanol for up to 15 million gallons a year for ten years was reduced by state budget cuts to $.13 per gallon by the 2003 Legislature. The fiscal situation in Minnesota and other states in the Corn Belt suggest weaker levels of state sponsorship of ethanol production.

--- Dry-mill ethanol plants are operating in an industry dominated by large firms. Archer, Daniels & Midland (ADM), Cargill, and Williams Bio-Energy represent over 46% of total national capacity in ethanol production. (Renewable Fuels Association-2) Small ethanol plant managers interviewed have commented "that the large firms could build supply for a time and later flood the market with cheap ethanol in an effort to drive the smaller firms out of the business." This concern suggests that this area of agricultural processing may require more vigilance by the anti-trust division of the U.S. Justice Department. The existence of the large firms cannot be disputed; their behavior may need to be monitored and analyzed.

--- All fuel ethanol producers will continue to represent a small share of domestic fuel supply. In 2002 the 2.2 Billion gallons of fuel ethanol produced in the U.S. represented just 1.62% of the volume of gasoline consumed in the U.S. (Energy Information Agency)

--- Expansion in fuel ethanol production is occurring in Canada with wheat as the feedstock. Production of fuel ethanol in Canada is expected to serve the Canadian market for oxygenated gasoline. Canada has chosen to comply with provisions of the Kyoto Accord, and levels of provincial sponsorship of ethanol facilities financing are designed to achieve national goals with respect to emissions. (Bailey)

--- Expansion of South American soybean production and ample quantities of cheap soybean meal may temper the opportunity to successfully market DDGS, a mid-level protein. Some observers expect DDGS to approach the price of corn on a per ton basis.

--- Ethanol plants have funded research to improve the ultimate nutritional value of DDGS fed to livestock, with poultry and swine and their particular dietary needs receiving special attention. Interest has been shown in standardizing the quantity of solubles returned and the method of drying the DDGS to retain adequate amino acid levels. Other research seeks to develop protocols to measure amino acid levels of DDGS. In addition, the higher availability of phosphorous in DDGS must be recognized by swine feeders to avoid phosphorous overfeeding, which may result in phosphorous pollution. Research is being considered to evaluate the effect of yeast cell wall constituents to reduce Salmonella levels endemic in poultry. Nutritional research on DDGS should help maintain the trend of non-ruminants in utilizing more and more of the burgeoning supply of DDGS.

---- Dry mill ethanol plants represent the rapid growth that has occurred in U.S. ethanol capacity in the last three years since the groundwater contamination issues of MTBE were reported. Access to funding for expansion of existing firms or start-up is getting difficult due to the fact that many of the major lenders are reaching their own internal capacity to finance activity in this industry. Many of the existing lenders for this industry are requiring higher and higher levels of equity before making loans. By advancing borrowers to 50% equity or greater, it will be possible for the lenders to originate ethanol processing loans and then market levels of participation among commercial lenders who are currently unfamiliar with ethanol financing. (Thompson)

--- Access to funding sources will be exacerbated if Renewable Fuel Standard Legislation is passed in 2003, which should encourage further expansion of ethanol production. (Urbanchuk)

--- Ethanol processors often find that they have difficulties obtaining insurance for their operations with only a few companies willing to insure these operations. (Elfes)

--- Some dry-mill ethanol firms will fail. The model demonstrates that even a well-located plant will experience difficult operating conditions and gross margins. Plants with high debt, high capital costs per unit of capacity, in high priced corn locations (Gallagher et al.), with poor access to transportation or with inadequate supplies of natural gas or water will be even more vulnerable.

--- Returns in Ethanol Processing can be very volatile. Staying power and risk management strategies are critical for survival of ethanol plants, particularly in times of high prices for corn and natural gas.

--- Most dry-mill ethanol plants could benefit from greater utilization of risk management tools in the marketing of ethanol and DDGS. Cross-hedging corn and gasoline futures may be carefully utilized to establish and preserve gross margin levels for ethanol processing. In addition, plant managers may hedge portions of their projected natural gas purchases.

--- Training and software should be developed to facilitate utilization of hedging programs for dry- mill ethanol plants.

--- Analysis should occur on the feasibility and quantities necessary to develop a financially liquid, well-functioning futures market in fuel ethanol.

--- Interviews with plant managers and bankers reveal the existence of skilled and thoughtful individuals ready to adopt more efficient process technologies. Many of the ethanol plants are sponsored by organizations or form organizations that market their products of ethanol, DDGS, and CO2 or purchase their enzymes and yeasts. Most ethanol plants operating today or in the future will be in alliances or contracted with organizations to market their products and purchase inputs.

--- Interviews with plant managers suggest that corn varieties with attributes more favorable for dry mill processing will be grown and segregated for use in ethanol production. Dry mills and wet mills operate optimally with corn varieties of vastly different fermentable characteristics.

--- Contacts with biochemists and yeast geneticists suggest that the higher capital costs for wet-mill plants may be feasible with perfection of yeasts and processes to produce bio-plastics as a co-product. Further economic analysis of wet-mill technology choices and product mixes should be initiated to gain an appreciation for the economic opportunities resulting from the production of the wider range of co-products from such plants.

--- Investors in new dry-mill ethanol plants should realize that experienced managers and technicians with the skills and temperament to manage yeast populations might be difficult to find. Without key personnel, a plant cannot be profitable, even under times of high gross margins and favorable operating and capital costs.

Summary

Our study of factors of success in fuel ethanol production has concentrated on dry mill technology, which has dominated the rapid growth in this industry over the last five years. Our study of production economics existing in modern plants of 40 million gallons per year or more has revealed levels of sensitivity in prices of co-products, feedstock, and operating expense items. A replay of the last decade's prices of feedstock, co-products and operating expenses revealed that dry mill ethanol producers have recently left some very profitable times in 2000 and 2001. Survival of the new entrants to the ethanol production industry will be tested in times of higher corn prices, higher natural gas prices, higher interest rates, and curtailed state subsidies. Regional crop failures could prove disastrous for plants located with poor access to cheap corn. Concerns have been raised about the ability of DDGS prices to rise above the price of corn on a per ton basis as many more ethanol plants come on line.

Successful managers and boards of directors must seek strategies to control costs while adopting new technologies and upgrading plants in terms of throughput and ethanol yield. Risk management strategies are becoming increasingly important. Analyzing profitability of a modern plant under the economic conditions that occurred over the last decade suggests many managers will have the challenge of riding-out some time of low or negative margins due to a variety of drivers. Some managers may find the opportunity to manage dry mills that have failed. If failed plants can be purchased cheaply enough and the plants lack "fatal" flaws in engineering or siting, some will return to profitable operations. With such a rapid expansion of ethanol production capacity occurring in a business that betrays great volatility in returns, some financial calamities will certainly occur, particularly among young firms carrying higher percentages of debt.

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