United States Department of Agriculture

Rural Business-Cooperative Service

Research Report 148

Cooperatives and New Uses for Agricultural Products:

An Assessment of the Fuel Ethanol Industry

Abstract

This report provides an overview of the ethanol fuel industry and documents involvement of farmer cooperatives in it. The market demand for ethanol is analyzed. Other factors influencing ethanol fuels development are also discussed, including the impact on profitability should Federal and/or State processing/production subsidies be reduced.

This report suggests that potential investors examine the prospects carefully prior to involving themselves in the fuel ethanol industry at any time in the near future. The virtual existence of the fuel ethanol industry depends upon Government subsidies and commensurate political support. Neither of these conditions has gone unchallenged.

Keywords: Farmer cooperatives, ethanol, Government policy

Cooperatives and New Uses for Agricultural Products: An Assessment of the Fuel Ethanol Industry

Anthony C. Crooks
Agricultural Economist
Rural Business-Cooperative Service

RBS Research Report 148

September 1997

Preface

Over the past decade, the notion of energy production using renewable resources has commanded considerable discussion and excitement. Various programs at the State and Federal level have provided subsidies to start businesses in this industry. Simultaneously, technological advances have lowered production costs and continue to promise economically viable production, “just around the corner.”

Since the early 1970s, many farm groups, including farmer cooperatives, have been studying the economic possibilities of producing ethanol, methane, and oil/fat-based fuels. A number of representative organizations have been formed to encourage the use of “renewable fuels,” and to promote policies that would provide an economic climate suitable for the industry’s growth. Currently, a number of new facilities are under construction, or are in the planning stage, with intentions to produce and market fuel ethanol as a way of adding economic value to corn and other feedstocks.

Despite the possibilities of renewable energy from the heartland, loan analysts from the several banks for cooperatives remain cautious. For example, while the St. Paul Bank for Cooperatives, St. Paul, MN, has assessed the viability of ethanol projects for 15 years, because of the complexities involved, it has chosen to finance very few. Government policies regarding tax credits and exhaust emission regulations, among others, remain as important issues of concern. In particular, the sunsetting of the Federal excise tax reimbursement in the year 2000 creates an aura of uncertainty around the industry and especially any new fuel ethanol production venture.

Nevertheless, fuel ethanol production continues, albeit as an infant and subsidized industry. And while the renewable energy field represents new opportunities and challenges for cooperative interests, particular attention should be given to the assumptions that build a case for economic viability and marketing opportunities expected for any new venture.

Contents

Highlights

Farmer-owned cooperatives held about 397 million gallons per year (mgy) of actual and potential fuel ethanol production capacity in 1996-l 47 mgy in production, 56 mgy under construction, and 194 mgy in various stages of planning. Nearly one-third of the 397 mgy was controlled by a single cooperative in two plants in Nebraska and Minnesota.

Four fuel ethanol production plants, totalling 108 million gallons in capacity, went out of business in 1995, citing high corn prices and locally weak ethanol prices as the reason for shutdown. These circumstances reflect national trends.

Presently, the industry depends upon the continued $0.054 per gallon Federal gasoline excise tax exemption. The exemption is equivalent to $0.54 per gallon of ethanol produced and essentially the cornerstone of the Nation's ethanol policy. The policy was scheduled to expire in 1993 but was extended to December 2000. There is concern among some in the industry, however, that, given the politically conservative sentiments that currently prevail among policy makers, the policy may be allowed to expire.

The future success of the ethanol industry greatly depends on technology that lowers the cost and improves the efficiency of ethanol production process. In the next 2-5 years, a range of innovations may save from $0.054 to $0.073 per fuel ethanol gallon produced. Longer term production cost savings ranging from $0.089 to $0.154 are projected possibilities.

Given a reasonably favorable business climate, **i.e.,** the appropriate mix of higher petroleum prices, lower corn prices, higher co-product prices, and an extension of the excise tax exemption, production capacity could expand significantly.

In absence of the excise tax exemption, it has been estimated that oil prices must exceed $40 per barrel and corn prices remain under $2.50 per bushel to assure reasonable profitability. Furthermore, if the excise tax subsidy were discontinued, ethanol would be unable to compete, at any corn price, with crude oil prices below $25 per barrel.

Cooperatives and New Uses For Agricultural Products:

An Assessment of the Fuel Ethanol Industry

Anthony C. Crooks
Agricultural Economist
Rural Business-Cooperative Service

Industry Overview

The ethanol industry has passed some significant milestones in the U.S. fuel marketplace. Recent recognition of ethanol and ethyl tertiary butyl ether (ETBE) as high-quality fuel additives capable of delivering significant environmental, economic, and energy benefits to the consumer has spurred industry production to its highest historical levels.

Forty-three plants produced 1.4 billion gallons in 1994, up substantially from the 1979 production of 20 million gallons. Production has increased 420 million gallons since the onset of the Federal oxygenated fuels program in 1992. Ethanol-blended fuel now represents about 11 percent of fuel sales in the United States.

Cooperatives are major players in providing energy products for farm production, having a 41-percent market share in 1993 (Eversull and Dunn). That year, more than 2,500 cooperatives sold $5.2 billion worth of energy products to rural America. Around 29 percent of the gasolines sold by cooperatives contained ethanol. Thousands of cooperative members are already producing feedstocks that can be used for biomass fuels such as ethanol. Farmer-members logically expect their cooperatives to investigate the potential of producing these fuels as an alternative feedstocks market.

Prominent Industry Actors

The most influential actors in the ethanol industry are Federal and State Governments. The industry was created by a mix of Federal and State subsidies and loan guarantees and today remains dependent upon that support (LeBlanc and Reilly).

In particular, the industry depends upon continuation of a Federal gasoline excise tax exemption of SO.054 per gallon, which is equivalent to SO.54 per gallon of ethanol produced. This is essentially the cornerstone of the Nation's ethanol policy.

While often cited by the American Petroleum Institute as a "huge special interest subsidy," the policy has traditionally held widespread public support (Johnson, 1994). The policy was scheduled to expire in 1993 but was extended to its present sunset date of December 2000. There is concern among some in the industry, however, that given the politically conservative sentiments that currently prevail among policymakers, the policy may be allowed to expire.

Other Federal and State subsidy/incentive programs are available to ethanol producers. A Federal tax credit of SO.10 per gallon produced, up to $1.5 million, is available to producers of less than 30 million gallons per year (mgy).[1] In 1995, 15 States provided additional production and/or blending incentives to qualified producers in their respective State. These provisions are generally awarded on a per-gallon-produced basis and are, therefore, potentially quite substantial (table 1).

Supported by such a policy framework, as of August 1996, 42 plants had collective production capacity of about 1.54 billion gallons per year of fuel ethanol. About one-half (48.7 percent) of that capacity, 750 million gallons per year (mgy), belonged to Archer Daniels Midland (ADM) and was distributed among its four plants in Iowa and Illinois. Minnesota Corn Processors (MCP; 115 mgy) and Pekin Energy Co. of Indiana (100 mgy) were the second and third largest producers, respectively. The top three producers, therefore, controlled about 63 percent of all U.S. ethanol production capacity in 1995.

Farmer-owned cooperatives held about 397 mgy of actual and potential ethanol capacity in 1996-147 mgy in production, 56 mgy under construction, and 194 mgy in various stages of planning. Nearly one-third of the 397 mgy was controlled by MCP, in two plants in Nebraska and Minnesota.

[1] Unfortunately, this is no current pass-through benefit available to member-owners of ethanol cooperatives.

Table 1— Individual States' ethanol production and blending incentives with expiration dates

State	Production incentive	Expiration date	Blending incentive	Expiration date
Connecticut			$.01/gal. excise tax exemption on 10% blend	none
Hawaii			$.04/gal. excise tax exemption on 10% blend	none
Idaho			$.021/gal. excise tax exemption on 10% blend	none
Illinois			2% excise tax exemption on 10% blend	July 1, 1999
Iowa			$.01/gal. excise tax exemption on 10% blend	June 30, 1999
Kansas	$0.09/gal. to qualified producers	June 30, 1997		
Minnesota	$0.20/gal. to qualified producers $0.25/gal. up to $3.75 mil.	June 30, 1995 June 30, 2010	$.015/gal. excise tax exemption on 10% blend	December 31, 1997
Missouri	$0.20/gal. to qualified producers	December 31, 1995	$.02/gal. excise tax exemption on 10% blend	July 1, 1996
Montana	$0.30/gal. to qualified producers up to $1.5 mil.	December 31.2002		
Nebraska	$0.20/gal. to producers of no more 25 mil. gal./yr.	January 1, 2001	$0.50/gal. tax credit for ETBE made from ethanol	January 1, 2001
North Carolina	Income tax credit up to 30% of construction cost if plant uses agric. or forestry products, not to exceed $2.5 mil./yr. or $5 mil. total	none		
North Dakota	$0.40/gal. to qualified producers	July 1, 1997		
Ohio	$0.15/gal. tax credit to producers of less than 2 mil. gal./yr	none		
South Dakota	$0.20/gal. to plants constructed afler July, 1986	none	$0.02/gal. exemption from state motor fuels tax	June 30, 1994
Wyoming	$.04/gal. excise tax exemption on 10% blend	none		

Source: Clean Fuels Development Coalition, Spring *1995.*

Corn prices rose to and remained at historically high levels throughout 1995 and 1996, placing the industry under increasing duress. Consequently, several plants reduced production or ceased operations.

South Point Ethanol of South Point, Ohio, one of the Nation's oldest plants and the sixth-largest producer (65 mgy), permanently closed its doors in June 1995. The plant's manager cited increasingly higher corn prices and downward spiraling ethanol prices as the reason. In August 1995, ADM temporarily closed its 25-mgy wet-mill plant in Wallhalla, ND. A vice-president for the company said the situation reflected national trends. Other plant closings in 1995 included Giant Industries (25 mgy) of Portales, NM, and Alco-Tech (2.5 mgy) of Ringling, MT.

As of August 1996, other operational plants had temporarily reduced or ceased production because of cost/price pressure-Decatur, IL; Louden, TN; York, NE; and Torrington, WY.

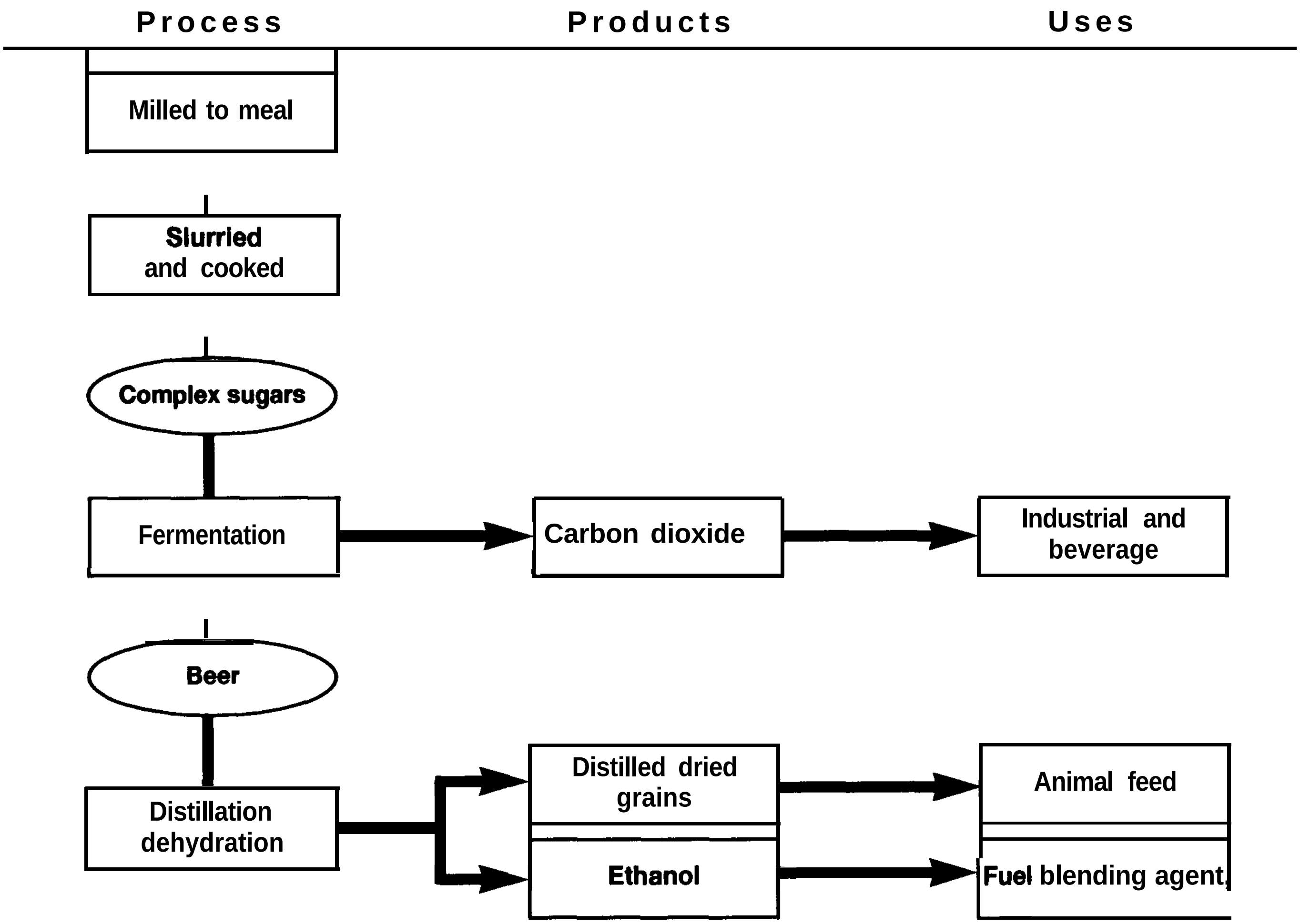
However, some hope appears to remain regarding the future of fuel ethanol production. Five plants totalling about 36.5 mgy in production capacity and employing state-of-the-art technology were scheduled for startup by early 1997: Spring Green and Plover, WI; Buffalo Lake and Little Falls, MN; and Blairstown, IA.

Production Technology

The basic technology for producing fuel ethanol is similar to that used by the traditional beverage and industrial alcohol industries and, as such, has a long history. However, the fuel ethanol industry itself only originated in 1978.

Dry-milling and wet-milling are the two main processing methods for ethanol production. The dry-mill process grinds corn and slurries it in water to be cooked (see figure 1). Enzymes are then added to convert starch into sugar (a process called saccharification, and common to both dry- and wet-mill process), then

Figure l- Dry-Mill Processing, Products, and Uses



yeast is added to ferment the sugar. This process produces a mixture of alcohol, water, and suspended solids. The alcohol and water mixture is distilled and dehydrated (reducing the water content to about 5 percent) to create fuel-grade (anhydrous) ethanol. The remaining solids are dried and sold as a livestock feed supplement known as distillers dried grain (DDG).

The wet-mill process removes the entire corn kernel before converting starches to sugar (figure 2). This procedure generates a greater variety of byproducts, some of which have high market values.[2] A more refined sugar and water mixture (for fermentation) is also possible by removing the solids early. The ethanol wet-mill process is identical to fructose production through the starch production phase. Wet-mills are able, therefore, to combine ethanol and fructose production to their financial advantage.

The byproduct streams from both processes require drying. Carbon dioxide is also a minor coproduct of both processes.

Production Costs

Research on ethanol production suggests that

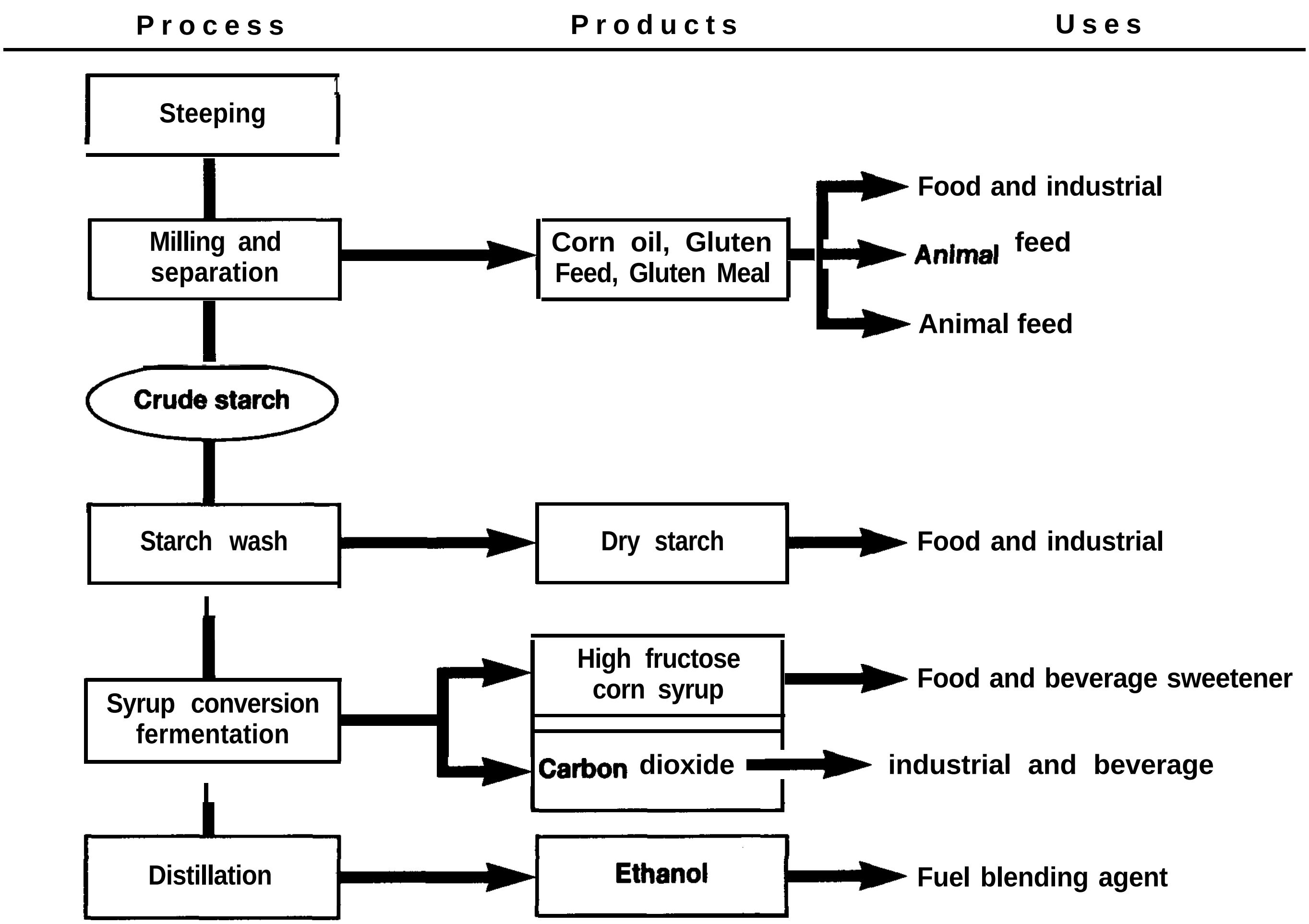
according to size, location, age and type of technology, and input costs, As a result, gene duction estimates for such a heterogeneous industry are difficult to obtain.

A widely regarded study (Kane and Reilly, 1989)

11 representative ethanol plants provides the basis for esti-

[2] Generally, the solids are used to produce three coproducts: corn gluten feed, corn gluten meal, and corn oil.

Figure 2—Wet-Mill Processing, Products, and Uses



mates in this report.[3] Kane and Reilly's cost-of-production estimates are updated for this report by using producer price indices and information obtained from prominent engineering firms.

As in Kane and Reilly, costs are reported in three categories-feedstock costs, cash operating costs, and capital costs, for odd years, 1989-95. Where appropriate, cost estimates are reported for large (greater than 30 mgy) and small firms (30 mgy or less) as well as for wet- and dry-mill processes.

Feed stock costs are reported net of prices received for byproducts (table 2). Corn prices ranged from $2.04 to $2.55 per bushel during the 5-year period. Net feed stock costs ranged roughly from SO.47 to SO.65 per gallon produced for wet-mill plants and $0.45 to $0.62 for dry, Distillers dried grain prices ranged from $96.80 to $120.20 per ton during the same period.

Table 3 reports cash operating costs for energy, ingredients, personnel, maintenance, management, administration, insurance, and taxes.[4] Cash operating costs were less variable than net feed costs for both sizes of plant. For plants producing less than 30 mgy, total cash costs ranged from $0.43 to $0.52 per gallon produced. Plants producing greater than 30 mgy incurred about 5 percent less in total cash costs per gallon at $0.48 to $0.64 per gallon produced.

Small plants had lower cash operating costs for ingredients, and for management, administration, insurance, and taxes. Large plants had lower costs on personnel and energy. Energy was the largest single cost factor for the large plants (about 30 percent of cash operating costs). However, large plants still paid less for energy per gallon than the small plants did.

Investment costs and capital charges on new or additional capacity for fuel ethanol plants are reported in table 4. Investment costs include the so-called "soft" or startup costs associated with a plant after construction or refurbishing. Capital charges (interest costs) assume that 50 percent of the investment cost on additions, adoption, or construction is financed. Reported values are updated Kane and Reilly estimates.

Investment costs varied widely among plants in the original report because of differences in construction and accounting among firms. Some firms overdesigned plant components, but boosted production above original-rated capacity with minimal additional investments. Others achieved low initial investment but were forced to increase their investment after plant startup to meet planned capacity expectations and to improve plant operation efficiencies.

[3] Six of these plants comprise about 77 percent of the industry's operating capacity.

[4] Ingredients costs include enzymes, chemicals, yeasts, and miscellaneous materials. Taxes are non-income, non-fuel, based taxes, e.g., property tax, general business taxes, etc.

Table 2— Net feedstock costs for wet- and dry-mill ethanol processing, selected years, 1987-95

	1987	1989	1991	1993	1995
Corn cost ($/bu.)	2.04	2.46	2.45	2.55	2.49
Distillers Dried Grains price ($/ton)	97.03	119.51	120.20	117.00	96.60
Wet-mill [1]			*Dollars per gallon*		
Corn	0.616	0.964	0.960	1.021	0.997
Coproducf credit	-0.349	-0.430	-0.433	-0.421	-0.346
Net feedstock cost	0.467	0.554	0.547	0.600	0.646
Dry-mill [2]					
Corn	0.765	0.946	0.942	0.962	0.956
Coprcduct credit	-0.336	6.414	-0.416	-0.405	-0.335
Net feedstock cost	0.449	0.532	0.526	0.577	0.623

[1] CO, recovery was not included in wet-milling coproduct recovery credit. High fructose corn syrup (HFC) is not a coproduct of wet-mill ethanol processing because ethanol is produced during the months that HFC is not. Assumes ethanol yield of 2.5 gal./bu.

[2] Assumes fuel ethanol yield of 2.6 gal./bu. One bushel of corn yields 18 lbs. of distillers dried grains.

Sources: USDA, Economic Research Service and USDA, Agricultural Marketing Service.

Table 3— **Cash operating costs for fuel ethanol processing, net feedstock costs excluded, 1987-95**

	1987	1989	1991	1993	1995
			Dollars *per gallon*		
Plants producing 30 million gallons per year or less					
Energy	0.135	0.141	0.165	0.166	0.154
Ingredients	0.069	0.100	0.101	0.103	0.105
Personnel and maintenance	0.156	0.177	0.186	0.201	0.206
Management, administration, insurance and taxes	0.047	0.050	0.052	0.055	0.060
Total cash operating costs	0.430	0.467	0.504	0.524	0.522
Plants producing greater than 30 million gallons per year					
Energy	0.123	0.129	0.151	0.151	0.140
Ingredients	0.110	0.123	0.124	0.126	0.130
Personnel and maintenance	0.116	0.130	0.137	0.148	0.152
Management, administration, insurance and taxes	0.060	0.062	0.065	0.068	0.070
Total cash operating costs	0.409	0.444	0.477	0.494	0.493

Sources: Kane and Reilly, *Economic Report of the President, selected* **years. Cash** operating costs as reported in Kane and Reilly are updated using the producer price indices from the *Economic Report of the President.*

Table 4— **Investment costs and capital charges on capacity addition for fuel ethanol plants selected years, 1987-95**

	1987	1989	1991	1993	1995
			Dollars per gallon		
Incremental addition to operating facilities					
Investment cost	1.50	1.99	1.55	1.31	1.10
Capital charge	0.29	0.33	0.38	0.35	0.30
Adoption of abandoned facilities					
investment cost	2.00	2.27	2.65	2.44	2.06
Capital charge	0.31	0.36	0.41	0.38	0.32
Construction of new facilities— Dry-mill					
Investment cost	2.35	2.34	2.00	1.85	1.75
Capital charge	0.38	0.43	0.48	0.45	0.39
Construction of new facilities- Wet-mill					
Investment cost	2.50	2.45	2.45	2.30	2.28
Capital charge	0.48	0.54	0.84	0.59	0.49

Sources: Kane and Reilly, *Economic Report of the President,* **selected years.**

Capital may be expanded either by incremental additions to existing capacity, adopting abandoned capacity, or by building new facilities. Table 4 reports the investment cost per-gallon-of-capacity-added and capital charge required to finance the expansion for all three types.

Investment costs for incremental addition to operating facilities ranged from $1.10 per gallon of installed capacity in 1995 to its highest mark in 1989 of $1.99. Capital charges for incremental addition ranged from SO.29 per gallon in 1987 to SO.38 in 1991.

Investment costs for adopting abandoned facilities ranged from $2 per gallon of installed capacity in 1987 to $2.65 in 1991; capital charges $0.31 in 1987 to SO.41 in 1991.

Investment costs for new dry-mill facilities construction ranged from $2.35 in 1987 to its lowest mark in 1995 of $1.75. Capital charges were highest at SO.48 per gallon of capacity in 1991 but receded to SO.39 by 1995.

Investment costs for new wet-mill facilities construction stayed between $2.28 to $2.50 per gallon of production capacity during the 8-year period. Capital charges to finance wet-mill construction peaked in 1991 at SO.64 per capacity gallon but declined to $0.49 in 1995.

Future of Fuel Ethanol Industry

Future success of the ethanol industry greatly depends on technology that lowers the cost and improves the efficiency of ethanol production. The state-of-the-art technology used in ethanol plants in 1997 includes continuous processing in each of the four production phases, recycled yeast, and fully computerized processing control. The starch conversion and fermentation phases have also been combined for higher yields. Large plants can produce enzymes on site and wet-mills now separate fine fiber from gluten mill and feed. Standard dehydration techniques are being replaced with reverse osmosis or molecular sieve technology.

The most significant design feature in a state-of-the-art plant, however, involves a completely integrated use of waste energy within the plant. Presently, some plants are bypassing cogeneration and use direct steam drive to replace electric motors. Plants using these technologies can expect to reduce their costs by as much as SO.10 per gallon compared with vintage plants.

Emerging Technologies

Opportunities for improving the cost and efficiency of fuel ethanol involve speeding the process time and lowering operating costs. Such opportunities arise in the four basic processes of its production—saccharification, fermentation, distillation, and energy production.

In the next 2 to 5 years, cost-saving innovations will be available to the industry as it expands and chooses to invest in new capital (table 5). Near-term opportunities involve improved enzymes and fermenter designs that reduce the conversion time from corn (or other feedstocks) to ethanol.

Two such applications in the saccharification process are currently under trial. The use of gaseous sulphur dioxide (SO,) and special corn hybrids shorten steeping time (wet-milling). Plants that adopt gaseous injection may lower production costs between $0.013 and SO.017 per gallon of ethanol produced. Special corn hybrids that reduce steeping time are quite likely to sell at a premium above standard corn. If a SO.02 premium is awarded the hybrid corn, then its use could save a new wet-milling plant from SO.01 to SO.018 per gallon of ethanol produced (Hohmann and Rendleman).

Another technique currently being tested would significantly reduce fermentation time. Membrane filtration allows water and ethanol to pass through a semi-permeable membrane that traps the starch and yeast in the fermenter. By retaining the yeast, fermentation proceeds at a fraction of the conventional 40 to 50 hours required. However, reducing the fermentation time also reduces the ethanol concentration and increases the energy cost per gallon. Nevertheless, continuous fermentation with membranes is expected to significantly reduce capital costs for new plants (Hohmann and Rendleman).

Membranes are also likely to be used in the saccharification stage. This technology, which allows glucose and water to passed through as the enzymes and starch are retained, has two benefits. Saccharification time may be reduced by as much as 10 to 15 hours. Enzyme requirements may be reduced by a factor of 10. Consequently, operating costs may be reduced by SO.012 to SO.015 per gallon (Hohmann and Rendleman).

Improving the fermenting organism can also cut operating costs in the fermentation stage. Yeasts are currently under development that work in higher concentrations of ethanol. Use of these high-tolerance organisms is estimated to lower the energy costs of

Table 5—**Emerging** ethanol production technologies and their estimated **cost** savings

	Process	Type of mill	Cost savings per gallon of ethanol produced			
			Feed stock	Operating	Capital	Total
			dollars			
Near-term technology						
Gaseous SO,	Saccharification	Wet			0.013-0.017	0.013-0.017
Corn hybrids	Saccharification	Wet	0.005–0.008		0.01 O-0.01 8	0.092-0.01
Membrane filtration	Saccharification	Wet				
	Fermentation	Dry/Wet		0.012–0.015	0.01	0.022–0.025
High tolerance yeasts	Fermentation	Dry/Wet		0.008-0.012		0.008-0.012
Yeast immobilization	Fermentation	Dry/Wet				0.020-0.270
Total near-term savings'			0.01-0.014	0.025-0.032	0.019-0.027	0.054-0.073
Long- term technology						
Z. mobilis bacteria	Fermentation	Dry/Wet			0.02	0.02
Cellulose conversion	All	Dry/Wet	0.02-0.035		0.01–0.04	0.03-0.045
Pervaporation	Dehydration	Dry/Wet				
Total long-term savings'			0.01–0.047	0.027-0.034	0.052-0.073	0.089-0.154

[1] Near and long-term savings totals are also estimates, not sums of their respective categories.

Source: Hohmann and Rendleman, 1993.

distilling alcohol from SO.008 to $0.012 cents per gallon produced (Hohmann and Rendleman).

Longer-term research focuses on the use of bacterial fermentation, on technologies that allow the substitution of other cellulose materials for feedstocks, and development of high-value coproducts from alcohol production.

Substituting Zymomonous mobilis bacteria for yeast in the fermentation stage is a technology whose potential has been demonstrated, although at less than the commercial level. Z. mobilis in laboratory testing has quickened fermentation, raised alcohol yields, and allowed fermentation at higher temperatures vis-a-vis conventional yeast. (Busche, et al.) These benefits would reduce energy costs and increase feedstock savings. Although the bacteria are presently less stable than yeast and more sensitive to changes in the pH and temperature, these problems will hopefully be resolved in the next 3 to 5 years. Production costs savings from such a breakthrough could be as high as SO.02 per gallon produced (Texeira and Goodman; Hohmann and Rendleman).

Converting corn fiber to ethanol is desirable because current ethanol recovery is approaching the theoretical limit available from the starch portion of the kernel. Conceivably, yields may be raised from 2.6 to almost 3 gallons per bushel if the hull and other fibrous portions of the kernel could be converted into ethanol. Coincidently, such a process would improve the quality of the feed coproduct because its protein content would be increased. However, the fiber acts as a binding agent in the feed matter. Therefore, drying the coproducts without the fiber content may present some integrity problems that must be overcome. Converting corn fiber to ethanol should lower feedstock and capital costs. Total cost savings have been estimated to range from SO.03 to $0.075 per gallon produced Hohmann and Rendleman).

Because the value of ethanol is closely tied to the price of other energy sources, coproduct sales are potentially the most profitable area of research. This is particularly true as long as the price of feedstock is driven by alternate uses, and production cost reductions are constrained by the physical limitations of the conversion processes under present and near-term technologies. Coproduct revenues remain unbounded by such restrictions.

Membrane technology provides greater control over the production process by allowing greater separation of various components within the product stream (Hohmann and Rendleman; Kane and Reilly). And as membrane technology becomes more sophisticated, high-value coproducts, such as citric acid and sorbitol, may be removed in greater volumes.

However, at some point in the production, it may prove more economical to produce these valuable coproducts in a separate fermentation.

Semi-permeable membrane technology may allow plants to recover high-value coproducts such as lactic acid. Costs associated with drying the coproducts may be reduced by running liquid components through a micro-filtration unit to absorb excess water.

Coproduct research continues on high-value uses for carbon dioxide. While carbon dioxide is produced in quantities nearly equal to ethanol,5 its present market value is less that $0.01 per pound. However, a bacterium has been discovered that converts carbon dioxide and hydrogen into acetic acid (Wood). Presently, acetic acid production costs about $0.75 per gallon of ethanol produced and returns about $1.50 per gallon. While price would probably fall under mass production, this process indicates the potential that lies in coproduct development.

The U.S. Department of Energy, National Renewable Energy Laboratory conducts research, or manages the research of others, on a host of projects with the goal of cutting the cost of fuel ethanol production from biomass. In particular, researchers are developing biochemical processes that convert cellulosic biomass to ethanol. A list of these goals and their respective cost savings is shown in figure 3. These goals anticipate that fuel ethanol production costs will not exceed SO.70 per gallon when they are attained.6

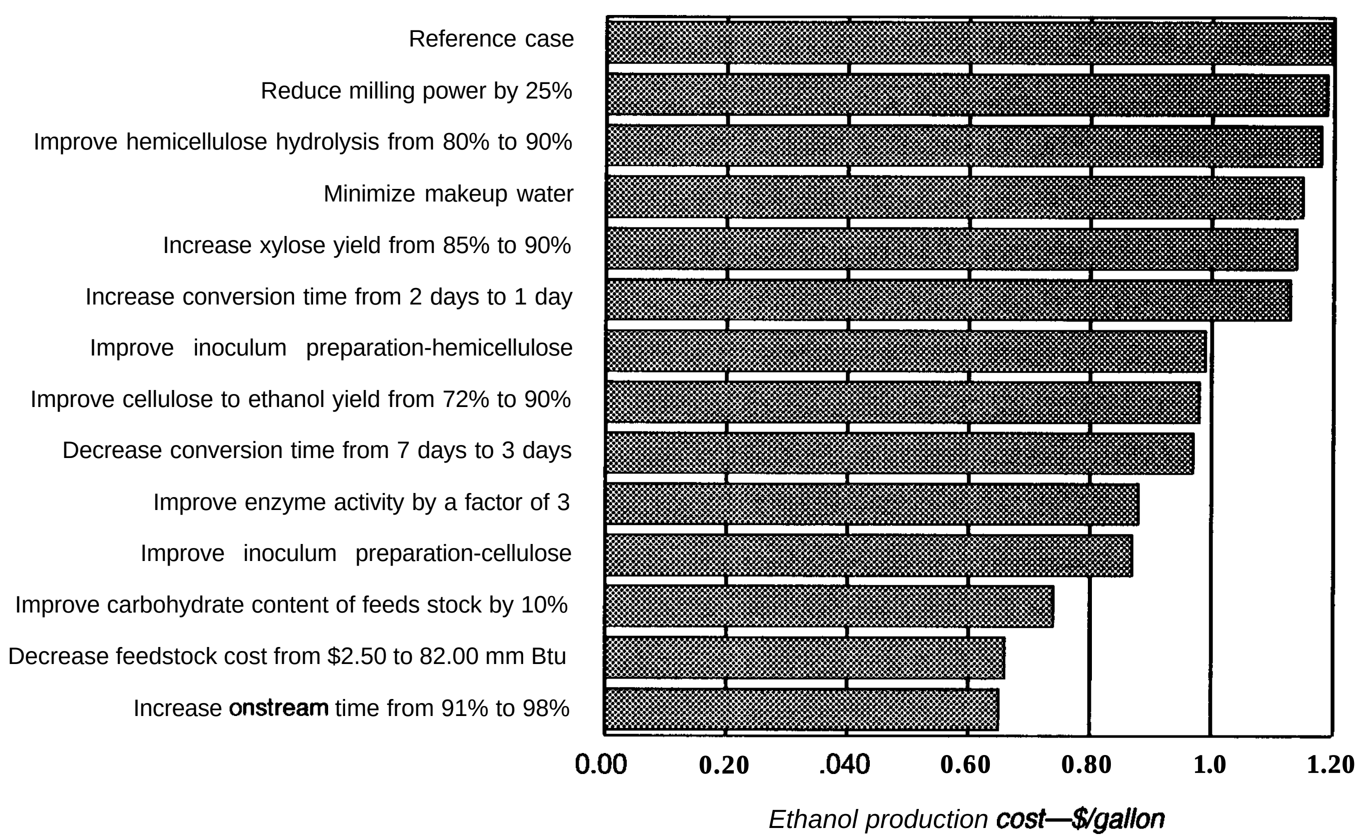
Market Demand for Fuel Ethanol

Ethanol competes in the transportation fuels mar-

[5] As a rule of thumb, a plant will produce about 10 tons of carbon dioxide for each million-gallons of annual capacity. For example, a IO-million-gallon plant would produce on average 100 tons of raw carbon dioxide gas per day. However, the carbon dioxide market is closely controlled by three national companies who sell 90 percent of the all the gas sold in the United States. It is a very concentrated business and companies attempting to break into it on their own should expect difficulty.

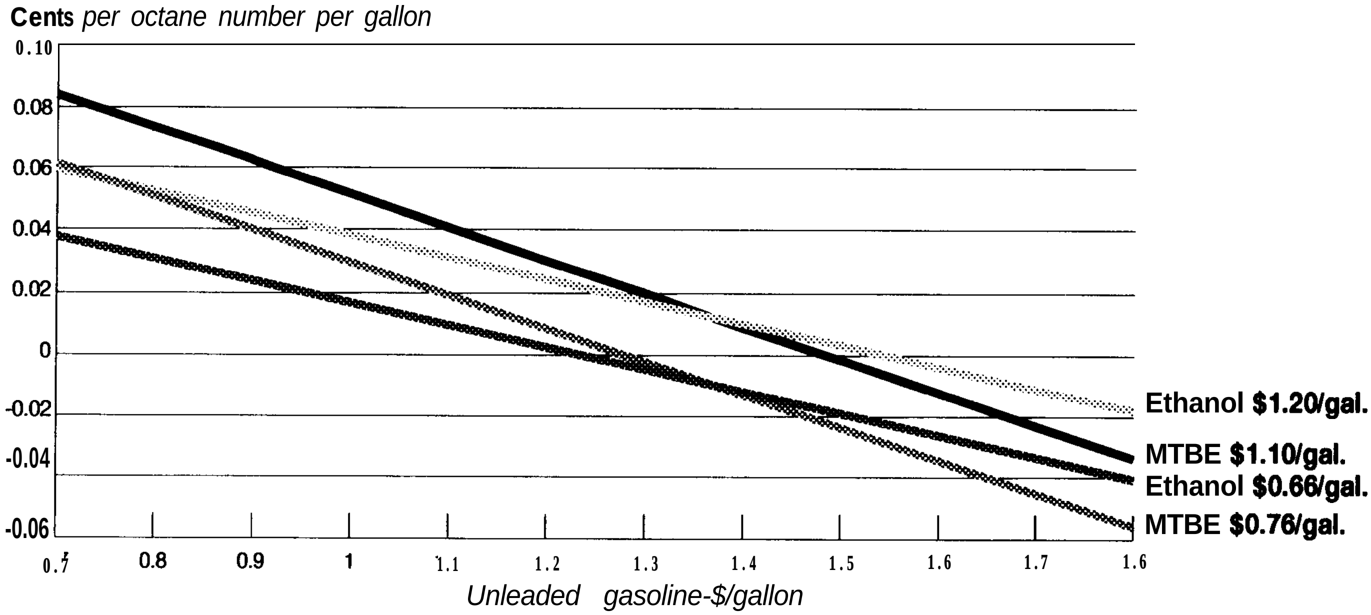
[6] Coincidentally, this value is about the same as the expected price of fuel ethanol when the Federal excise tax reimbursement is allowed to sunset.

Figure 3— **Fuel Ethanol Production Cost Goals from Biomass Research**



Source: U.S. Department of Energy, National Renewable Energy Laboratory

Figure 4— Octane-Enhancement Cost Relationships, Ethanol v. MTBE



Source: Kane, et al.

ket as a blending agent with gasoline (LeBlanc and Reilly). In the early 1980s, ethanol was marketed as a fuel extender in response to a perceived demand for a domestically derived fuel source to substitute for imported petroleum. While engines designed to burn gasoline require significant modifications to burn neat (pure) ethanol, they can tolerate ethanol-gasoline blends of up to 20 percent ethanol. As a fuel extender, however, ethanol contains around two-thirds the energy content of gasoline. As a result, it must compete at two-thirds the price of gasoline, given Federal and State excise tax concessions (LeBlanc and Reilly).

Ethanol has a 30 percent higher octane rating than gasoline (110 to 112 versus 87 for regular unleaded) and rates 7 percent higher than its nearest competitor in the octane enhancer market MTBE (methyl tertiary butyl ether). Because octane enhancers sell at a 40-percent premium above retail gasoline prices, ethanol's value as an enhancer is significantly greater than as a gasoline extender/replacement. The actual octane value reflected in the price of ethanol varies with the demand for octane and the availability and pricing of refinery-based octane petrochemicals.

Figure 4 illustrates the competitive relationship that exists between fuel ethanol and MTBE under present and future economic conditions. For unleaded gasoline prices less than $1.35 per gallon, ethanol is less expensive than MTBE when the Federal excise tax reimbursement of SO.54 per gallon is considered. MTBE presently sells from SO.70 to $1 per gallon. The cost difference between the two is increased when State exemptions are included. For unleaded gasoline prices above $1.29 per gallon, blending costs are negative for both additives, because both are less expensive per gallon than gasoline and offer a relatively cheap way to extend gasoline volume. Ethanol and MTBE would be closely competitive if the Federal excise tax expired or if methanol were produced at full cost from domestic coal.

Ethanol contains 37 percent oxygen when blended with gasoline. Adding oxygen to gasoline reduces automobile exhaust levels of carbon monoxide and other polluting hydrocarbons. Fuel ethanol developed an oxygen value when municipalities began to require an oxygen content in gasoline to reduce carbon monoxide pollution during the winter months. In 1990, the Federal Clean Air Act Amendments required an oxygen content in the majority of all gasoline sold by 1995.[7] Crude oil and gasoline do not contain any oxygen. Ethanol, methanol, and their respective derivatives are presently considered to be the only economical sources of oxygen.

In December 1993, the U.S. Environmental Protection Agency (EPA) proposed the Renewable

---

Presently, 39 metropolitan areas have high levels of carbon monoxide pollution. Gasoline sold during the winter in these areas must contain a minimum of 2.7 percent oxygen.

Oxygenate Standard (ROS) rule to require that 30 percent of all oxygenate used in the ozone non-attainment areas be derived from renewable sources. The ROS became a final rule in June 1995 and called for a l-year phase-in with 15-percent oxygenate level mandated for January 1, 1995, and the full 30-percent requirement to begin January 1, 1996.

The American Petroleum Institute and the National Petroleum Refiners Association filed a lawsuit against the EPA in response to the ROS. The appeals court ruled that the EPA had exceeded its authority under the Clean Air Act. It said EPA has no authority to mandate "the manner of compliance or the precise formula for compliance (Sutherland, Washington Post, May 16, 1995)." The oil industry has invested heavily to reconfigure refineries to produce reformulated fuels using MTBE. Consequently, the reformulated gasoline market is presently dominated by MTBE. The ROS-ruling was estimated to have provided an assured market of about 500 million gallons of ethanol or about one-third of the 1.5 billion gallons of ethanol presently produced annually in the United States (Milling and Baking News, May 9 1995).

On March 18, 1996, the EPA finalized a ruling that increases the oxygen content in summer reformulated gasolines to 3.5 percent of weight, up from 2.7 percent. Fuel ethanol at the 10 percent-by-volume level equals 3.5 percent oxygen by weight. Some suggest this allows ethanol to be used at its most effective blend level and allows gasoline marketers to take full advantage of ethanol's octane, oxygen, and toxic displacement benefits (Minnesota Department of Agriculture, 1994). Presently, no legislative assurances, such as the ROS, are under consideration or review.

An export market for ethanol has been under development since 1991 when Brazil could no longer produce sufficient neat ethanol to satisfy its domestic demand. Brazil's primary feedstock, cane sugar, has since been principally directed toward the world sweeteners market, creating local shortages of fuel ethanol. In addition to Brazil, Mexico, the Republic of Korea, Japan, and many European countries are expressing an increased interest in oxygenated gasoline (Johnson 1994; Minnesota Department of Agriculture).

Despite these marketing opportunities, the fuel ethanol industry may have sufficient cause for concern regarding a breakthrough motor fuel innovation. The so-called "A-21" fuel (aqueous fuel for the 21st century), which is comprised of naptha, tap water, and a blending agent, has passed rigorous testing. Results indicate that it outperforms gasoline and diesel as a clean, cheap, and safe fuel. A-21 can be used in most combustion engines.

In November 1995, the State of Nevada certified the water-based fuel as a "clean alternative fuel," i.e., it may be used to satisfy Federal mandates requiring clean fuels in municipal fleets and other similar vehicles. Nevada emission trials demonstrated that A-21 passed not only EPA standards for that State, but also the much tougher standards set by the California Air Resources Board for well into the 21st century. It also improves mileage. Should A-21 enter the marketplace, and disinterested outsiders who have tested it say it has a strong chance, it could cut the price of gasoline in half. Because naptha is a clear liquid produced in the early stages of oil refining, it is more available and cheaper to produce than gasoline (Miller).

The most frequently cited concern about A-21 is that it can freeze in cold weather. A potential blending opportunity for the ethanol industry may develop in this regard. If A-21 replaces gasoline as the motor fuel of convention, ethanol's role as fuel extender will be suspect, it's use as an octane enhancer will be unnecessary, and its value as a fuel oxygenator will be trivialized by the water content of A-21. So, the widespread adoption of A-21 as a motor fuel will almost certainly reduce ethanol's future role from a significant fuel additive to that of 'fuel anti-freeze'. Ethanol's market could be substantially reduced, although not totally lost.

Ethanol and U.S. Energy Policy

The principal goal of U.S. energy policy is "energy security," the assurance of a stable and reliable supply of energy in both the near- and long-term. Energy security embraces not just the Nation's ability to defend itself in time of war but also the broader concern of reducing our dependence upon foreign energy sources and the implicit threat of a disrupted supply. Ethanol subsidies reduce foreign oil dependence by encouraging ethanol's production and gasoline substitution.

Fuel stockpiles offer the most effective energy security strategy. In 1982, Congress authorized a stockpile program for ethanol Strategic Alcohol Fuel Reserve. However, a petroleum reserve is the primary response to energy security threats. And while a fuel ethanol reserve is considered feasible, its cost effectiveness has been questioned (US.GAO, 1984).

The major policy initiatives for long-term security involve research and development on and assuring a commercial supply of alternative fuels (mainly shale and coal). Near-term policy initiatives are directed toward minimizing the impacts of global energy market disruptions to the U.S. economy. Significant production subsidies to all energy industries, including ethanol, result from our national policy to foster energy security (LeBlanc and Reilly).

The value of energy independence is limited when pursued for its own sake. However, the development of cost-effective, fuel-producing technologies may offer significant advantages for overall U.S. competitiveness. Support for ethanol, synfuels, and other advanced energy technologies when viewed from this perspective do not appear unreasonable.

From a national economics standpoint, however, the relative level of support for any particular fuel-producing technology should be a function of its potential supply availability and its cost-of-production structure. In this regard, a number of fuel technologies may compare favorably to ethanol.[8] Nevertheless, the fuel-ethanol industry does operate commercially, employs a known technology, and produces in a relatively certain cost environment (at least, when compared with liquid coal and shale oil).

However, the more successfully ethanol contributes to long-term energy supplies, the more it drives up feedstock prices and consequently its own cost. Ethanol production, in this regard, will limit itself to the role of a small fuel contributor that uses temporary agricultural surpluses and organic waste.

Public-sector support for the ethanol industry depends on the Nation's interest in the production and use of the fuel and is unrelated to the market prices. Fuel prices are set by worldwide supply and demand conditions. U.S. energy policies have a negligible impact on world fuel prices (LeBlanc and Reilly).

While the Federal Government provides significant subsidies toward the development of all energy resources, ethanol production is highly subsidized when compared with other fuels. Tax expenditures related to ethanol production were nearly $1 billion in 1986 and surpassed all research expenditures toward synthetic fuels or nuclear fusion. In 1984, the ethanol industry received almost $15 per million Btu. In the same year, petroleum, natural gas, and coal received less than $1 per million Btu.

[8] Liquid fuels from coal and shale oil are considered by some to be less expensive than biomass fuels and supplies are unlimited (LeBlanc and Reilly).

Ethanol and U.S. Agriculture

Commodity market conditions, the nature of farm policy programs, and the relative size of the ethanol industry will determine how important ethanol production is to the future of U.S. agriculture. In times of corn scarcity, ethanol production will have relatively more influence on commodity prices than when corn stocks are large and prices low. When the export and domestic demand for corn is low, ethanol production may increase in importance as an alternative use for corn.

Ethanol production mainly affects the corn and soybean markets. Increased ethanol production will, generally, raise corn prices and depress oilseed and protein market prices (as more corn oil, DDG, corn gluten feed, and meal are supplied). Because the production decisions for livestock and other crops are linked by interrelated markets, they are also affected, albeit much less significantly, by ethanol production. It is estimated, however, that until annual ethanol production exceeds 3 billion gallons, livestock production and prices will remain largely unaffected by the impacts of ethanol production on corn and oilseeds markets (LeBlanc and Reilly).

Ethanol and Corn Prices

An expanded ethanol industry was once suggested as a partial substitute for traditional agricultural programs to manage corn supplies and prices (LeBlanc and Reilly). In general, it was believed that increased ethanol production may slightly offset farm program costs. As corn prices, raised by increased ethanol production, approached the target price, farmers would be paid lower deficiency payments, would be less likely as a consequence to default on non-recourse loans, and would be less willing to participate in Government set-aside programs. And because increased corn prices generally push other grain prices up, program outlays would also have been reduced for wheat, sorghum, oats, and barley.

However, it was estimated that fuel ethanol production had to exceed 2 billion gallons annually (which it never did) before it would notably influence corn prices and would have had to exceed 3 billion to 4 billion gallons annually (almost three times the highest production level) to raise traditional corn prices above historical target levels (LeBlanc and Reilly). Given the production, market, and policy circumstances of marketing year 199596 and the foreseeable future, fuel-ethanol production's influence on corn prices is at best insignificant. Corn prices are expected to remain at historically high levels because of reduced carryover, increased export demand, and no anticipated increases in production.

Therefore, any farm program savings resulting from increased corn prices from ethanol production are nil, and will certainly be offset by lost tax revenues associated with ethanol use. Until the year 2000, or a change in the law, every gallon of fuel ethanol consumed amounts to $0.054 in lost revenue to the Federal Highway Trust Fund. (The trust receives $0.13 per gallon in taxes for fuel ethanol instead of $0.184 for gasoline.) At current use (1.6 billion gallons per year), this amounts to about $810 million annually or $4.05 billion for 1996 thru 2000 in lost tax revenue.

Farm Bill Implications

The argument for encouraging ethanol production as a way to reduce farm program costs has been moot since the Federal Agriculture Improvement and Reform (FAIR) Act of 1996 was enacted. More commonly known as "Freedom to Farm," the Act largely "decouples" the connection between market price movements and the level of crop payments. Planting decisions for wheat and feed grains are now made irrespective of crop acreage base. The legislation also eliminates the U.S. Secretary of Agriculture's ability to use acreage reduction programs or annual set-asides as a condition for receiving program benefits (Ray, et al., F.A.P.R.I.).

When compared with continuing the former policy, these bills are expected to increase both planted acreage and crop prices. Overall acreage planted for wheat, corn, and soybeans is expected to increase over the next several years as contracted acreage in the Conservation Reserve Program (CRP) expires and domestic and world demand expands. Corn and wheat prices are expected to increase, relative to baseline projections, by as much as SO.10 per bushel, while soybean prices are projected to decline between $0.57 and SO.81 per bushel depending on the portion of CRP acres that will return to production (Ray, et al., F.A.P.R.I.).

Ethanol and U.S. Rural Economic Development

A number of reports are presently available that discuss the rural economic development implications of increased ethanol production. These studies, both national and regional in scope, describe the impacts on employment, business and personal income, and indirect economic influences of increased production and capacity.

Research on National Impacts

In general, national studies base their economic estimates on U.S. Government Accounting Office (GAO) projections of 2-billion-gallons-per-year ethanol production by 1995. This level would have required production to double between the years 1990 to 1995 (table 6). Actual production in 1995 was less than to 1.5 billion gallons.

House, et al., using the 2-billion-gallon-per-year fuel assumption, estimated that U.S. farm income could increase by as much as $172 million. Income gains would largely be distributed in the Corn Belt region ($102 million), the Northern Plains ($39 million), and the Lake States ($31 million).

Petrulis, et al., examined the job creation implications for increasing fuel ethanol production to 2 billion gallons by 1995. Employment gains were based on full use of existing or idled plants and the construction of new capacity. Increased production was projected to create jobs-first among plants currently operating at excess capacity (4,580 jobs); then among reactivated plants now idle (4,000 jobs); then among plants now planning expansion (9,860 jobs); and finally, among new plants being proposed (9,200). The report projected 27,640 employment opportunities-2,770 construction related, 9,570 in plant operations, and 15,300 agricultural (including nonfarm employment from increased grain production and decreased soybeans).

Research on Regional Impacts

An assessment of the economic impacts of a 50-million-gallon fuel ethanol plant in an "average" Midwestern State was jointly performed by the Western Regional Biomass Energy program and the Great Lakes Biomass Energy program (ENERGETICS, 1994).[9] An estimated 3,000 jobs would be created directly and indirectly by the construction (1,608) and operation (1,264). The plant is expected to generate more than $47 million in direct and indirect income and tax revenue exceeding $7 million to the State and local treasuries and $11.5 million in Federal tax revenue.

A study performed for the State of Illinois summarized the major impacts (not all of them economic) of ethanol production in the State. Eight hundred plant operation jobs and 4,000 additional jobs (in industry-related services) were created by the State's $1-billion

[9] The "average" ethanol producing State being an approximation by use of a simple average of the economic multipliers of those States involved with the analysis: Colorado, California, Illinois, Indiana, Iowa, Kansas, Minnesota, Nebraska, New Mexico, North Dakota, South Dakota, and Texas.

Table 6— National and regional impacts of increased fuel ethanol production on employment, income, and taxes

Source	Employment		Income		Taxes	
	Construction	Operations	Direct	Indirect	State/Local	Federal
	------- Number of new jobs -------		$ millions			
National impacts						
GAO[1]			415			7,400
House, et. al.[2]			172			7
Petrulis, et. al.[3]	2,770	24,870				
Regional impacts						
ENERGETICS[4]	1,608	1,264	3.1	44	7.3	11.5
Illinois[5]	4,800					
Nebraska[6]	2,872	2,509	325	23	2.4	
Iowa[7]	51	1,380	55	246.2		
Indiana[8]	——— 5,604 ———		- 418.2 ———		16.5	
Minnesota[9]	4,597-5,576		111-135	431-435	19-21	

Sources:
[1] U.S. Govt. Accounting Office, RECD-90-156, July 1990.
[2] U.S. Dept. of Agric., Economic Research Service, AIB-667, May 1993.
[3] U.S. Dept. of Agric., Economic Research Service, AIB-678, July 1993.
[4] "Economic Impact of Ethanol Production Facilities: Four Case Studies," June 1994.
[5] "Benefits to Illinois in Developing and Utilizing Ethanol Fuels," March 28,1992.
[6] Nebraska Dept. of Economic Development, "Nebraska's Ethanol Industry." October 1993.
[7] Iowa State University, Dept. of Economics, Staff Paper no. 238. December 1991.
[8] Indiana Dept. of Commerce, April 1992.
[9] Minnesota Dept. of Agriculture, May 1995.

investment in the industry. An estimated 2,250 new rural jobs were created for every 100 million bushels of corn used for ethanol production.

The Nebraska Department of Economic Development (October, 1993) used an input/output economic model to provide information on the ethanol industry in their State and linkages with other Nebraska companies. Expansion of fuel ethanol production capacity from 63 million gallons in 1993 to 213 million gallons per year in 1995 was estimated to create 5,381 jobs in plant construction and operations. This would also generate an additional $348 million in income (both directly and to other Nebraska firms), and add $2.4 million to the State and local treasuries.

Otto, et al., describe the economic and employment impacts of the fuel ethanol industry in Iowa as significant. About 2,550 people are employed by wet-corn mills and 620 by dry-corn mills in the State. A total of $2.4 billion in products and $1.09 billion in value-added-product processing is also related to Iowa ethanol production. A plant using 75 million to 100 million bushels per year would require 300 employees and add 1,431 jobs, $55 million in personal income, and $246.2 million in indirect income to the State.

Littlepage (1992) examined the economic impacts of ethanol production by estimating the revenues expected to be generated by a plant planned in South Dakota. A wet-mill plant of about 50 million gallons annually in capacity would cost $117 million to construct and create $418.2 million in earnings, 5,604 jobs, and increase State and local revenues by as much as $16.5 million.

A report prepared by the Minnesota Department of Agriculture describes the economic and fiscal benefits of a statewide production of 200 million gallons annually.[10] Estimates of increased employment, income, and tax revenue were developed to account for both wet- and dry-mill production processes.

[10] Two hundred-million-gallons per year is the supposed level that gives ethanol a "full market penetration" of a 10 percent blend of ethanol with gasoline sold in Minnesota filling stations.

Between 4,597 and 5,576 new jobs, including construction, operations, and support/service related, would be created (the range accounts employment differences required by dry- and wet-mills). Between $111 million and $135 million in direct income would be added. Indirect income would range from $431 million to $475 million depending on the dry- and wet-mill process, respectively. Furthermore, State and local revenues would increase from $19 million to $21 million.

A strong argument can be made for the economic/community development contribution of a fuel-ethanol processing plant. Reports suggest construction and operation of a plant may bring nearly 5,600 full-time jobs, $135 million in direct and $435 million in indirect income, and up to $21 million in State and local tax revenues to a region. To date, however, no report compares the relative regional contribution of a fuel ethanol plant vis-a-vis another processing plant of similar magnitude and scope. Nor has the relative contribution of an ethanol plant been compared with several businesses whose total capital investment is equivalent to that of a single fuel ethanol plant. Prudent regional planners and other community development leaders will want to research information on these types of comparisons to get the best return on their investments.

Fuel Ethanol 'New-Use' Opportunity

Some guidelines for evaluating potential opportunities follow. Potential investors will want an objective assessment, to the extent possible, of the risks and uncertainties associated with the project. They will also need to understand the growth potential of the market they plan to enter. They have a right to expect accurate capital estimates required to begin operations and of how much they reasonably can expect to finance. Finally, potential investors will need to appraise their potential competition and the relative access they can expect to the marketplace. Particular attention should be paid to discover and disclose any potential barriers that might impede market entry.

Potential Returns

An assessment of the potential returns of a prospective fuel ethanol venture involves comparing total expected receipts against total expected expenses. This exercise not only amounts to examining input costs and output prices (corn/ethanol, net of coproduct credits), but should also include an accounting of Federal and State incentives.

A 15-million-gallon-per-year dry-mill ethanol plant is used to illustrate the patronage returns paid given relative price changes of fuel ethanol, corn, and the coincident price changes in DDG. Patronage returns were generated by calculating a series of pro-forma profit and loss statements after assuming a range of output and input values for fuel ethanol and corn, respectively. Production information was obtained from three separate sources[11] (appendices 1 and 2). Constant prices were assumed for each commodity; $1.20 per gallon for ethanol and $2.25 per bushel for corn, when not used to generate its own patronage schedule. DDG prices are typically set at between 120 percent and 130 percent of the price of corn (dry basis). In this analysis, DDG prices were calculated using 124 percent of the price of 10 percent moisture corn.[12]

Table 7 demonstrates the potential profitability of a 15-mgy-dry-mill ethanol plant (producing 17,067,000 gal. of denatured ethanol; yielding 15 mgy undenatured ethanol), when the price of fuel ethanol varies from $0.90 to $1.50 per gallon in $0.15 increments. Corn and DDG prices are set at $2.25 and $106.11 per ton, respectively. The plant is assumed to yield more than 17 million gallons of fuel ethanol and 58,497 tons of DDG. Sales costs, general administration, and overhead are set at SO.0789 per gallon.

Annual corn use, 6.5 million bushels, is valued at the corn price. Operating costs, ingredients, and depreciation are fixed at $5,193,000, $1,625,000, and $1,867,000, respectively. (Total operating costs equal $8,685,000.) Per-bushel returns before interest, taxes, and incentives range from -$0.45 to $0.63. A separate schedule demonstrates the impact of production and tax incentives provided to ethanol producers. When the $0.20 per gallon (up to $3 million per year) is combined with the Federal small business tax credit of $0.10 per gallon, up to $1.5 million per year, per-bushel returns range from -$0.21 to $0.97.[13]

---

[11] Economic Research Service, Kane and Reilly, March 1988, updated, see tables 3-5; Minnesota Ethanol Commission, Larry Johnson, March 18, 1994; Carroll Kiem estimate, for the Iowa House Agric. Committee on Feb. 8, 1994.

[12] The DDG price is calculated by multiplying a coefficient of 47.16 by the corn price (Johnson, Minnesota Department of Agriculture).

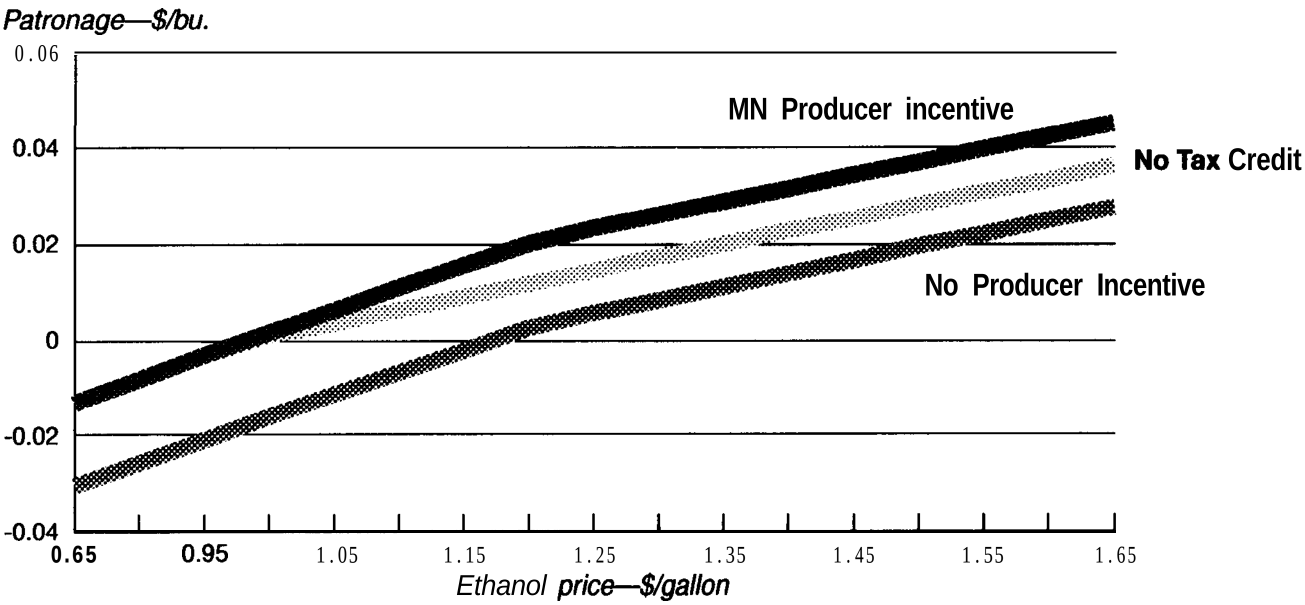
[13] Ethanol plants organized as cooperatives are exempt from double taxation and would not be subject to the 38 percent Federal income tax. They may also be exempt from State income tax obligations depending upon the State in which they are incorporated. Cooperatives must, however, pay taxes on all business with non-members. All tables will therefore present tax obligations in the interest of full disclosure.

Table -r-Potential profitability of a M-million-gallon/year dry-mill ethanol plant, ethanol price variation

Price assumptions

Ethanol price $/gallon	**0.90**	**1.05**	**1.20**	**1.35**	**1.50**
Corn price **$/bushel**	2.25	2.25	2.25	2.25	2.25
Distillers dried grains price $/ton	106.11	106.11	106.11	106.11	106.11
Ethanol sales **(17,067,000 gal/yr** @ ethanol price/gal.)	17.920.350	**20,480,400**	**23,040,450**	**25,600,500**	**25,600,500**
Coproduct sales (58,497 tons @ DDG price/ton)	**6,207,435**	**6,207,435**	**6,207,435**	**6,207,435**	**6,207,435**
Total plant sales	**24,127,785**	**26,687,835**	**29,247,885**	**31,807,935**	**31,807,935**
Corn cost **(18,000/day @** corn **price/bu.)**	**12,025,000**	**14,625,000**	**17,225,000**	**19,825,000**	**21,775,000**
Operating costs (personnel, maint.. mgt., insur., etc.)	**5,193,000**	**5,193,000**	**5,193,000**	**5,193,000**	**5,193,000**
Cost of other ingredients	**1,625,000**	**1,625,000**	**1,625,000**	**1,625,000**	**1,625,000**
Depreciation	**1,867,000**	**1,867,000**	**1,867,000**	**1,867,000**	**1,867,000**
Total plant costs	**20,710,000**	**23,310,000**	**23,310,000**	**23,310,000**	**23,310,000**
General admin., sates, and overhead	1347,000	1347,000	1347,000	1347,000	1347,000
Net returns before interest, taxes, and incentives	**2,070,785**	**2,030,835**	**4,590,885**	**7,150,935**	**7,150,935**
Returns per bushel before interest, taxes, and incentives	0.32	0.31	0.71	1.10	1.10
Interest expense	**1,287,531**	**1,287,531**	**1,287,531**	**1,287,531**	1'287,531
State producer's incentive **($0.20/gal** up to 15 mgy)	**3,000,000**	**3,000,000**	**3,000,000**	**3,000,000**	**3,000,000**
State income tax (8%)	0	94,860	299,464	504,268	709,072
Federal income tax (38% **)**	0	449,637	**1,422,456**	**2,395,275**	**3,368,094**
Small producer tax credit (SO.1 O/gal up to $1.5 million)	0	449,637	**1,422,456**	1500,000	**1,500,000**
Returns to producers after interest, taxes, and incentives	**(1,376,796)**	**1,088,594**	**3,443,840**	**4,903,811**	**6,286,238**
Returns per bushel after interest, taxes, and incentives	(0.21)	0.17	0.53	0.75	0.97
Returns per bushel -- No small business credit	(0.21)	0.10	0.31	0.52	0.74
Returns per bushel -- No producer incentive	(0.67)	(0.29)	0.07	0.29	0.51

Figure 5— Ethanol Prices and Patronage Returns [1]



[1] *15 million gallon/year dry-mill ethanol processor including State and Federal incentives: Corn price—$2.25/bu.; Minnesota producer incentive—$0.09675/bu. on 6.5 million bu.; small business tax credit - $0.03875/bu. on 6.5 million bu.*

Figure 5 graphically illustrates the patronage returned to Minnesota producers on a per-bushel basis from a 15-mgy-dry-mill plant as fuel-ethanol prices vary from $0.85 to $1.50 per gallon. The Minnesota-producer incentive amounts to $0.09675 per bushel on 6.5 million bushels of corn. The effect of the small business tax credit is progressive and amounts to almost 4 cents a bushel on the 6.5 million bushels of corn needed for the 15-million-gallon plant.

Table 8 demonstrates the potential profitability of a 15-mgy-dry-mill ethanol plant when the prices of corn and DDG are varied from $1.85 to $3.45 per bushel and $87.25 to $162.70 per ton, respectively, and fuel ethanol is fixed at $1.20 per gallon. Annual operating costs, ingredients, and depreciation remain fixed, as before, at $8,685,000. Per-bushel net returns after interest, taxes, and incentives range from -$0.06 to $0.67.

Figure 6 illustrates the relationship between patronage returned to investors (per bushel) and the price of corn. Per-bushel patronage ranges from -$0.46 to $0.97 and -$1.01 to $0.51, for subsidized and unsubsidized production, respectively, as the corn price ranges from $1.55 to $3.15 per bushel

In absence of the small business tax credit, annual patronage returns are reduced by almost $0.03 per bushel for corn prices less than $2.05 per bushel. When the effects of the Federal excise tax subsidy are excluded (fuel ethanol is priced at $0.90 per gallon), annual patronage returns are reduced by almost $0.75 per bushel compared with their full incentives level.

It is important to note that each of these schedules assumes no price variability, once the levels have been set for an entire year's production. In actuality, ethanol and corn prices vary greatly over time, while DDG prices remain tied to their relative corn value. For example, while average annual prices of $1.20 per galion and $2.25 per bushel were assumed for ethanol and corn, respectively, actual prices during the time this report was prepared ranged from $1.00 to $1.20 per gallon for ethanol and $2.78 to $4.25 per bushel for corn.

Capital Required and Financing

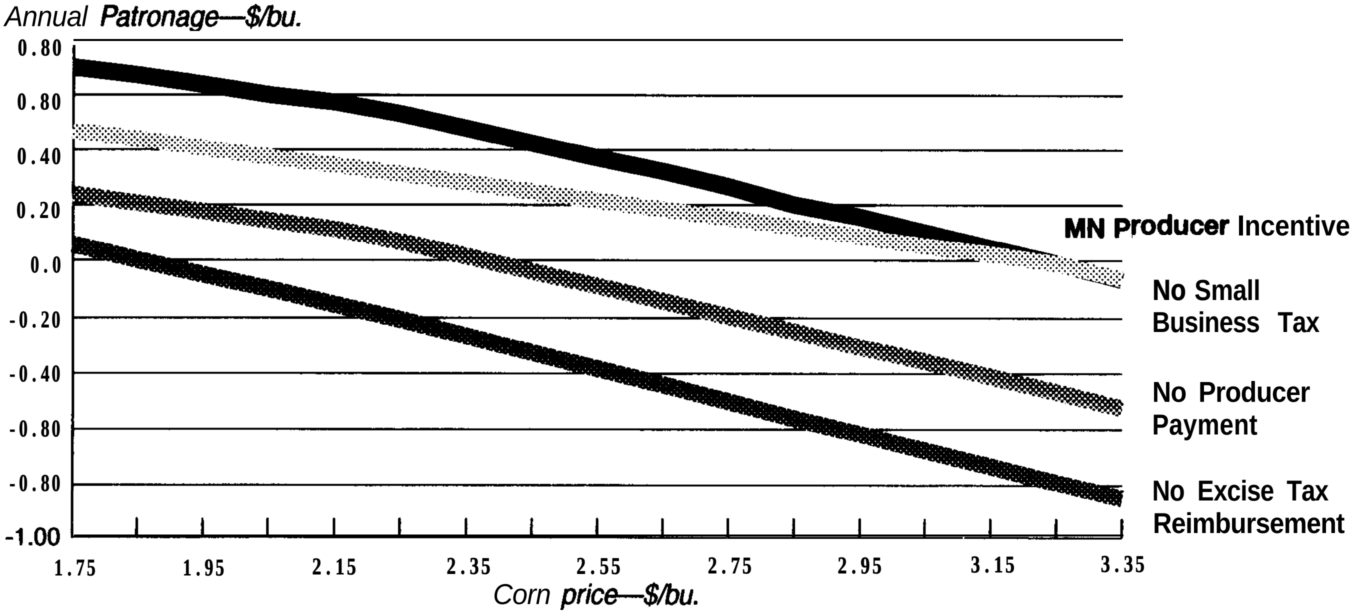
The permanent assets to be financed in a new fuel-ethanol venture generally include land, plant, equipment and other assets, startup losses, and minimum operating capital. Investment in these assets is generally equally shared among owners and lenders, i.e., 50-percent equity and 50-percent debt financing. Lenders look favorably upon risk-reducing activities such as project feasibility studies, firm marketing contracts, grower-pooling, turn-key construction costs, and quality management and may sometimes lower their equity requirements. However, the equity portion of the total financing package will almost always be at least 35 percent.

It is also important to have sufficient working

Table 8— **Potential profitability of a 15-million-gallon/year dry-mill ethanol plant, corn price Variation**

Price assumptions					
Ethanol price $/gallon	1.20	1.20	1.20	1.20	1.20
Corn price $/bushel	**1.85**	**2.25**	**2.85**	**3.05**	**3.35**
Distillers dried grains price $/ton	**87.25**	**198.11**	**124.97**	**143.84**	**157.99**
Ethanol sales (17,067,000 gal/yr @ ethanol price/gal.)	20,480,400	20,480,400	20,480,400	20,480,400	20,480,400
Coproduct sales (56,497 tons @ DDG price/ton)	5103,891	6,207,435	7,310,979	8,414,523	9,241,707
Total plant sales	25,584,291	26,687,835	27,791,379	28,894,923	29,722,107
Corn cost (18,000/day @ corn price/bu.)	12,025,000	14,625,000	17,225,000	19,825,000	21,775,000
Operating costs (personnel, maint., mgt., insur., etc.)	5,193,000	5,193,000	5,193,000	5,193,000	5,193,000
Cost of other ingredients	1,625,000	1,625,000	1,625,000	1,625,000	1,625,000
Depreciation	1,867,000	1,867,000	1,867,000	1,867,000	1,867,000
Total plant costs	20,710,000	23,310,000	25,910,000	28,510,000	30,460,000
General admin., sales, and overhead	1,347,000	1347,000	1,347,000	1,347,000	1,347,000
Net returns before interest, taxes, and incentives	4,874,291	3,377,835	1,881,379	384,923	(737,893)
Returns per bushel before interest, taxes, and incentives	0.44	0.37	0.24	0.06	(0.12)
Interest expense	1,287,531	1,287,531	1,287,531	1,287,531	1,287,531
State producer's incentive ($0.20/gal up to 15 mgy)	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000
State income tax (6%)	419,181	299,464	179,748	60,031	0
Federal income tax (38%)	1,991,109	1,422,456	853,802	285,149	0
Small producer tax credit ($0.1 O/gal up to $1.5 million)	1,500,000	1,422,456	853,802	285,149	0
Returns to producers after interest, taxes, and incentives	4,329,471	3,443,840	2,067,100	690,361	(372,424)
Returns per bushel after interest, taxes, and incentives	0.67	0.53	0.32	0.11	(0.06)
Returns per bushel — No small business credit	0.44	0.31	0.19	0.06	(0.06)
Returns per bushel — No producer incentive	0.20	0.07	(0.14)	(0.36)	(0.52)
Returns per bushel — No Fad. excise tax reimbursement	0.00	(0.21)	(0.44)	(0.67)	(0.85)

Figure 6—Corn Prices and Annual Patronage Returns [1]



[1] *15-million gallon/year dry-mill ethanol processor including State and Federal incentives: Ethanol-$1.20/gal with motor fuel excise tax subsidy; $0.90/gal. without subsidy; DDG—$120/ton; Minnesota producer Incentive—$0.09675/bu. on 6.5 mil. bu.; Small business tax credit—$0.0387/bu.on 6.5 mil. bu.*

capital necessary to either "zero out" for 30 days, or to margin loan advances of about 65 percent of acceptable inventories and 80 percent of receivables. Short-term seasonal loans are often used to finance fluctuations in current assets. However, seasonal loans are generally no greater than three times the level of permanent working capital.

Term loans for new plant and equipment are generally repaid within 15 years. Annual principal repayments should amount to no more than 65 percent of the new venture's annual cash flow (after tax earnings less patronage refunds received plus depreciation). Interest rates are generally 2 percent to 2.5 percent above the prime rate for capital borrowed for new venture construction projects. Some fixed-rate options and rate-reduction incentives may also be offered to a project for successful construction management and startup.

Market Growth Potential

Assessing a prospective venture's potential for market growth involves shifting from present circumstances to reasonable expectations for the future. In addition to noting current trends, it will be important for the market growth discussion to emphasize any changes that might occur in preferences, technology, or prices of inputs and/or competing products.

Expanding the ethanol industry will depend on the relative cost competitiveness of ethanol as a gasoline blending agent. Both petroleum prices and the factors that affect net ethanol costs are subject to variability. Net ethanol costs are determined largely by corn prices, Federal and State ethanol subsidies, coproduct prices, and technology.

As of August 1996, four new ethanol plants with a combined capacity of 36.5 million gallons per year were under construction. This is considerably less than the expansion pace of 1995 of 250 mgy or 0.15 percent total industry capacity at the time.

The reason for this dropoff may lie beyond present concerns of higher feedstock prices. More ominous issues lie ahead:

- the industry's anticipation of the sunsetting of the Federal motor fuel excise tax exemption in 2000;
- expectations that petroleum prices will increase only slightly in the next 10 years; and
- corn prices are likely to be increasingly volatile given the absence of any Government storage programs.

When taken together, these concerns provide less than favorable conditions for any significant expansion in production capacity. Unless the excise tax exemption is extended beyond 2000, it is estimated that petroleum will have to increase above $40 a barrel and corn prices decline below $2.50 per bushel to reasonably assure industrial profitability (LeBlanc and Reilly).

In general, industry expectations include modest increases in crude oil prices and only slightly higher, if somewhat more volatile, corn prices. These conditions, while not altogether favorable to industry expansion, would not necessarily hinder it. The biggest hindrance to ethanol competitiveness and industry expansion, however, is the anticipated sunsetting of the Federal excise tax exemption in 2000. Under current industry norms, a plant would open in 1997, operate profitably for 3 years, and endure losses until crude oil prices rose again around the year 2007 (LeBlanc and Reilly).

Competition and Market Access

Entry into a market or industry is generally regarded to be "barrier free" (sufficiently competitive) if there are no artificial restrictions on entry (such as patents or Government restrictions) or if the capital costs of entering the market are not exceedingly high. And while the $60 million necessary to turn the key on a 20-million-gallon-per-year ethanol plant is not insignificant, when compared with the petroleum industry, entry into the fuel ethanol market is relatively unimpeded.

Despite the relative ease of market entry, the fuel ethanol industry is heavily concentrated. Seventy-one percent of the industry's production capacity of 1.4 billion gallons per year is controlled by four firms. Moreover, the top two firms control 60 percent of the industry's capacity.[14]

Although ethanol production is heavily consolidated, the marketing of ethanol and coproducts is dominated by the cost of transportation. Distillers dried grain has long been valued as a relatively cheap substitute for high-protein meal and has a number of significantly valuable nutritional attributes. Given that coproduct prices are essentially bounded by shipping costs, spatial markets for distillers dried grain and other coproducts may exist and prove profitable even to managers of relatively small ethanol plants.

Other potentially profitable marketing opportunities for ethanol plants may lie in forming supply alliances with local gasoline refineries. If refinery requirements exceed the supply capacity of the local fuel ethanol plant, marketing alliances may be formed among additional plants to provide a consistent supply in support of refinery needs. This also presents opportunities for plants to consolidate market territories, share services and purchasing, and possibly, provide for the formation of a common marketing agency with a membership comprised of cooperatives.

Each of these ideas is a response to the single basic fact about the ethanol industry-fuel ethanol competes with gasoline and gasoline-blending agents. Market entry and market expansion are tied directly to the cost competitiveness of ethanol as a gasoline blending-agent (USDA, AER-585). Gasoline prices and blending agent prices are linked closely to the uncertain price of crude oil. Wholesale gasoline sells at about 25 percent above the crude oil price.

Summary and Conclusions

Cooperative involvement in the biomass fuels industry is currently substantial and growing. Given the right set of circumstances of low corn prices, and higher ethanol and DDG prices, profit opportunities may still exist. The fact remains, however, that the economic landscape of this industry is fraught with uncertainty.

And despite a growing interest in fuel ethanol plants as a value-added opportunity among Midwest corn producers, industry plans for capacity expansion have remained modest for at least 5 to 8 years. Expansion plans have generally been dampened by anticipation of the scheduled sunsetting of the motor fuel excise tax exemption in 2000. Given a reasonably favorable business climate, i.e., the appropriate mix of higher petroleum prices, lower corn prices, higher byproduct prices, and an extension of the excise tax exemption, production capacity could expand significantly.

However, in absence of the excise tax exemption, it has been estimated that oil prices must exceed $40 per barrel and corn prices remain under $2.50 per bushel to assure reasonable profitability. Furthermore, if the excise tax subsidy is discontinued, ethanol is unable to compete at any corn price for crude oil prices below $25 per barrel.

Therefore, this report urges potential investors to take a hard look prior to involving themselves in the fuel ethanol industry.

[14] Plants owned by the prominent producers, however, are wet-mill processors which are dedicated to the production of high-fructose corn syrup (HFCS). HFCS is principally used by the carbonated beverage industry and its demand is quite seasonal, falling off in the winter months. Wet-mill plants produce fuel ethanol during slack demand periods for HFCS.

References

Busche, Robert M., Charles D. Scott, Brian H. Davison, and Lee R. Lynd. "The Ultimate Ethanol: Technoeconomics Evaluation of Ethanol Manufacture, Comparing Yeast vs *Zymomonas* Bacterium Fermentations." ORNL/TM-11852, Oak Ridge National Laboratory, Oak Ridge, TN, August 1991.

Economic *Report of the President,* Washington, D.C., U.S. Govt. Printing Office, February 1995.

ENERGETICS, "Economic Impact of Ethanol Production Facilities: Four Case Studies," Columbia, Md., June 1994.

Eversull, E.E. and J.R. Dunn, "Petroleum Cooperatives, 1993," Washington, D.C., U.S. Department of Agriculture, Rural Business-Cooperative Service, Research Report 143, July 1995.

Food and Agricultural Policy Research Institute, "Overview: Federal Agriculture Improvement and Reform (FAIR) Act of 1996," Columbus, MO, University of Missouri, June 12, 1996, http://ssu.agri.missouri.edu/SSUFAPRI/reports/fair/text/overview.html.

Hohmann, N. and C.M. Rendleman, "Emerging Technologies in Ethanol Production," Washington, D.C., U.S. Dept. of Agric., Economic Research Service, Agricultural Information Bulletin, Number 663 January 1993.

House, C. "Corn prices blamed for demise of Ohio ethanol plant," *Feedstuffs,* Minnetonka, Minn., vol. 67, no. 27, July 3, 1995, p. 1.

__________ "Citing high corn prices, ADM to close ethanol plant," *Feedstuffs,* Minnetonka, Minn., vol. 67, no. 35, August 21, 1995, p. 3.

__________, Peters, H. Baumes, and W.T. Disney, "Ethanol and Agriculture-Effect of Increased Production on Crop and Livestock Sectors," Washington, D.C., U.S. Dept. of Agric., Economic Research Service, Agricultural Information Bulletin Number 667, May 1993.

Illinois Dept. of Agriculture, "Benefits to Illinois in Developing and Utilizing Ethanol Fuels," Springfield, Illinois, March 28, 1992.

Johnson, L., "Policy Initiatives for the Fuel Ethanol Industry: A History and Rationale," St. Paul, Minn., Minnesota Dept. of Agriculture, October 15, 1994.

__________ "Estimated Fuel Ethanol Costs-15 mgy dry-milling plant," St. Paul, Minn., Minnesota Dept. of Agriculture, March 18, 1994.

__________ "Organizing and Ethanol Plant Project," Cologne, Minn., Presented to the Ethanol Coproducts Feeding Seminar, Iowa State University, Ames Ia., March 7, 1995.

LeBlanc, M. and J. Reilly, "Ethanol: Economic and Policy Tradeoffs," Washington, D.C., U.S. Dept. of Agric., Economic Research Service, Agricultural Information Report Number 585, April 1988.

Littlepage, L. "Estimating the Economic Impacts of an Ethanol Plant," Indianapolis, Ind., Indiana Dept. of Commerce, April 1992.

Kane, S.M. and J.M. Reilly, "Economics of Ethanol Production in the United States," Washington, D.C., U.S. Dept. of Agric., Economic Research Service, Agricultural Economics Report Number 607, March 1989.

Minnesota Dept. of Agriculture, "Marketing Products from a Dry-mill Ethanol Plant," St. Paul, Minn., unpublished report, July 29, 1994.

Miller, Ken, "Super-clean Fuel, half gas, half water, nears market," *Potomac News,* reported by Gannett News Service, Feb. 18, 1996.

Milling & Baking News, "Ethanol industry 'disappointed' but not beaten by court ruling," Kansas City, Mo., vol. 74 no. 10, May 9, 1995, p. 14.

Milling & Baking News, "Secretary Glickman decries ruling's threat to production of ethanol," Kansas City, Mo., vol. 74 no. 10, May 9, 1995, p. 14.

Minnesota Dept. of Agriculture, "Economic Impact of the Ethanol Industry in Minnesota: Present Situations and Future Opportunities," St. Paul, Minn., May 1995.

Minnesota Ethanol Commission, "Ethanol-Fuel for Clean Air," St. Paul, Minn., Minnesota Dept. of Agriculture, undated.

Nebraska Dept. of Economic Development, "Nebraska's Ethanol Industry," October 1993.

Otto, D., M. Immerman, and L. Kolmer, "Iowa's Ethanol and Corn Milling Industries: Economic Employment and Impacts," Iowa State University, Dept. of Economics, Staff Paper no. 238, December 1991.

Petrulis, M., J. Sommer, and F. Hines, "Ethanol Production and Employment," Washington, D.C., U.S. Dept. of Agric., Economic Research Service, Agricultural Information Bulletin, Number 678, July 1993.

Ray, D.E., M.R. Dicks, D.G. De La Torre Ugarte, and R.L. White, "The 1995 Farm Bill: Comparing the FFA (Freedom to Farm Act) and Senate Bills," Agricultural Policy Analysis Center, University of Tennessee, Institute of Agriculture, Knoxville, No.2, Nov. 1995.

Southerland, D., "Clinton Mandate on Cleaner Gas Rejected-Court Dismisses Requirement of Corn-Based Ethanol as Additive," *Washington Post*, vol. 118, no. 228, May 16, 1995, p. cl.

Texeira, R.H. and B.J. Goodman, Eds. *Ethanol Annual Report :FY1990. TP-231-3996*, Solar Energy Research Inst., Golden, CO, March 1991.

U.S. Government Accounting Office, Report to the Chairman, Subcommittee on Energy and Power, Committee on Energy and Commerce, House of Representatives, "Alcohol Fuels: Impacts From Increased Use of Ethanol Blended Fuels," GAO/RCED-90-156, July 1990.

U.S. Dept. of Agric., Office of Energy, "Fuel Ethanol and Agriculture: An Economic Assessment," Washington, D.C., Agricultural Economic Report Number 562, August 1986.

U.S. Dept. of Agric., Economic Research Service, "Ethanol-Economic and Policy Tradeoffs," Washington, D.C., Agricultural Economic Report Number 585, April 1988.

Wisconsin Energy Bureau, Dept. of Admin., Div., of Energy and Intergovernmental Relations, "The Economic Impacts of Renewable Energy Use in Wisconsin," Madison, Wis., April 1994.

Wood, H.G., "Life with CO or CO, and H_2 as a Source of Carbon and Energy," *FASEB Journal*, vol. 5, February 1991, pp. 156-163.

Appendix I-Estimated fuel ethanol costs for 15-million-gallon/year dry-mill plant

	ERS[1]	MEC[2]	CK[3]
Total Investment- *millions of dollars*	44	28	36.4
Investment- *dollars/gallon*	***2.58***	1.64	2.13
Corn processing requirement- *bu./day*	18	18	18
Production rate— *gallons/bushel*	***2.709***	***2.709***	***2.709***
Annual production capacity- *gallons/year*	17,067	17,067	17,067
		Thousands of dollars	
Total annual corn cost	15,687	14,175	13,230
Co-product credit for distillers dried grains	5,489	7,088	6,133
Net annual corn costs	10,198	7,087	7,097
Energy costs	2,628	3,023	3,023
Ingredient costs	1,792	1,625	1,625
Personnel & maintenance costs.	3,516	1,610	2,378
Management, administration, insurance, and taxes	973	560	728
Total cash costs	19,107	14,393	15,339
Depreciation (15 year)	2,933	1,867	2427
Total plant costs	22,040	16,260	17,766
		Dollars	
Plant cost per bushel used	3.39	2.50	2.73
Plant cost per gallon produced	1.29	0.95	1.04

[1] Economic Research Service, Kane and Reilly, March 1988, updated, see tables 3-5.
[2] Minnesota Ethanol Commission, Larry Johnson, March 18, 1994
[3] Carroll Kiem estimate, as presented to Iowa House Agric. Committee on February 8, 1994.

Appendix 2—**Pro-forma** profit and loss statements for **15-million-gallon/year** dry-mill plant

	ERS[1]	MEC[2]	CK[3]
		Thousands of dollars	
Ethanol sales	20,480	20,480	20,480
Less:			
General administration, and overhead	1,000	1,000	1,000
Total plant costs	**2,2040**	16,260	17,766
Pre-tax margin	(2,560)	3,220	1,714
State producer incentive			
(MN-$0.25/gal on 15 mgy)	3,750	3,750	3,750
Federal small producer tax credit			
($0.1 O/gal up to $1.5 mil)	428	1,500	911
Subtotal	1,190	7,188	3,661
Less:			
State tax (8%)	**95**	455	220
Federal tax (36%)	428	1,500	911
After-tax income	667	4,849	2,530
Statement of cash flow:			
Depreciation add-back (15 yrs.)	**2,933**	1,867	2,427
Less loan Payment	2,200	1,400	1,820
Net Cash flow	1,400	5,316	3,137
		Dollars	
Net cash flow per gallon produced	-0.08	0.31	0.18
Net cash flow per bushel used	-0.22	0.84	0.50

[1] **Economic Research Service, Kane and Reilly, March 1988, updated, see tables 3-5.**
[2] **Minnesota Ethanol Commission, Larry Johnson, March 18, 1994**
[3] **Carroll Kiem estimate, as presented to Iowa House Agric. Committee on February 8, 1994**

U.S. Department of Agriculture
Rural Business-Cooperative Service
1400 Independence Ave., SW, Stop 3257
Washington, D.C. 20250-3257

Rural Business-Cooperative Service (RBS) provides research, management, and educational assistance to cooperatives to strengthen the economic position of farmers and other rural residents. It works directly with cooperative leaders and Federal and State agencies to improve organization, leadership, and operation of cooperatives and to give guidance to further development.

The cooperative segment of RBS (1) helps farmers and other rural residents develop cooperatives to obtain supplies and services at lower cost and to get better prices for products they sell; (2) advises rural residents on developing existing resources through cooperative action to enhance rural living; (3) helps cooperatives improve services and operating efficiency; (4) informs members, directors, employees, and the public on how cooperatives work and benefit their members and their communities; and (5) encourages international cooperative programs. RBS also publishes research and educational materials and issues Rural Cooperatives magazine.