MINNESOTA OFFICE OF THE LEGISLATIVE AUDITOR

Ethanol Programs

SUMMARY

In comparison to other midwestern corn-producing states, Minnesota has pursued an aggressive, multifaceted strategy to promote the production and use of ethanol as an automotive fuel. Since the mid-1980s, Minnesota has developed a sizable ethanol industry that, by October 1996, had the capacity to produce about 92 million gallons of ethanol per year. Additional production facilities are now in planning or under construction.

This study, requested by the Legislative Audit Commission, addresses the following questions:

- **How much do Minnesota's ethanol programs cost?**
- **Have the programs succeeded in promoting the establishment and growth of an ethanol industry?**
- **What are the economic and environmental benefits of ethanol production and use?**
- **What are the major risks to the future viability of ethanol production in Minnesota?**

In carrying out this study, we interviewed officials in the Minnesota Department of Agriculture (MDA) and other state agencies. We visited the six major Minnesota ethanol plants in operation during the summer of 1996 and talked to managers about their experiences in building and operating the plants. We also reviewed the national literature relating to environmental and economic issues of ethanol production and examined other states' ethanol programs.

Minnesota is one of the nation's leading corn producers. Most ethanol is produced from corn.

ETHANOL PROGRAMS

Over 95 percent of ethanol in Minnesota and in the nation is produced from corn. Minnesota is the nation's fourth leading corn producer, and like many major corn-producing states Minnesota promotes the use of ethanol as an automotive fuel through various activities. The state also operates a fleet of about 270 flexible-fuel vehicles that can use up to 85 percent ethanol mixed with gasoline.

The production and use of ethanol is promoted through various state incentives and requirements.

Like some other states, Minnesota offers subsidized loans for development of ethanol production facilities. However, Minnesota goes beyond other states in the scope of its support of the ethanol industry. Minnesota currently provides a 5 cent per gallon tax credit, called the "blender's credit," to distributors of "gasohol" (ethanol mixed with gasoline at a concentration of 7.7 to 10 percent[1]), and it pays a subsidy of 20 cents per gallon for ethanol produced in Minnesota. Minnesota also requires the use of oxygenated gasoline year round in the Twin Cities area, and statewide starting next October. [2]

Ethanol production has also been promoted through several subsidized loan programs, including economic recovery grants administered by the Department of Trade and Economic Development, and two programs administered by the Minnesota Department of Agriculture that provide loans to producers and to farmers who wish to purchase shares in ethanol-producing cooperatives. The largest state loans are those to producers through the Ethanol Production Facility Loan Program; this program provides low-interest loans of up to $500,000 per plant.

PROGRAM COSTS

The producer payment program pays ethanol producers 20 cents per gallon up to a maximum of $3 million per plant and a statewide limit of $30 million. The payments last until 2000 in some cases, and, in others, 10 years from the start of production or expansion of production. In fiscal year 1996, two plants reached the $3 million limit. Producer payments totaled $22.1 million in the three year period, fiscal years 1994 through 1996. The Minnesota Department of Agriculture estimates that annual producer payments will reach about $26 million in fiscal year 1999.

As the producer payment is expanded, the blender's credit is being phased out. The blender's credit cost $61.2 million in foregone tax revenue in fiscal years 1994 through 1996, but will end in October 1997, and is projected to cost $8.7 million in fiscal years 1997 through 1999.

The cost of the mandate to use oxygenated gasoline, which becomes a statewide requirement in October 1997, will be borne by consumers paying higher prices at the pump. The exact size of the premium is difficult to determine. Nevertheless:

- **We estimate that the retail price of gasohol will exceed the price of conventional gasoline by about 2 to 3 cents per gallon over the next several years.**

Our estimate of the higher cost of gasohol considers retail prices in October and December 1996 and January 1997, and wholesale prices 1994 through 1996.

1 The credit is 5 cents per gallon of pure ethanol, not per gallon of ethanol-gasoline mix.

2 The federal Clean Air Act requires the use of oxygenated gasoline in areas that are out of compliance with federal air quality standards. The Twin Cities Area is out of attainment with carbon monoxide standards and is required to use oxygenated gasoline from October through January. Ethanol is the only oxygenate currently in use in Minnesota.

Over this period, oxygentaed gasoline has generally cost at least 2 to 3 cents more than nonoxygenated gasoline nationally, regionally, and in Minnesota, as far as the numbers can be determined from available data.

Minnesotans use about 2 billion gallons of gasoline each year, so each penny of additional price is equal to $20 million in costs attributable to the oxygenated fuel requirement. But since the Twin Cities area (about half the state's population) is under a federal Clean Air Act requirement to use oxygenated gasoline from the first of October through January each year, the cost of the state requirement is only five-sixths of $20 million for each additional penny that oxygenated fuel costs. If we take this into consideration, and if we split the difference between two and three cents per gallon:

- **We estimate that the statewide requirement to use oxygenated gasoline will cost consumers about $42 million each year.**

The programs just described were designed to promote the production of ethanol in Minnesota, and the evidence suggests that:

- **Minnesota's ethanol industry has come into existence largely in response to Minnesota's ethanol programs, especially the producer payment. Very little production existed prior to 1987 when the producer payment was enacted.**

Minnesota has eight ethanol plants with a production capacity of about 92 million gallons per year.

As of September 1996, Minnesota had eight plants on line with a capacity of about 92 million gallons per year. One plant is a large "wet mill" that produces about 30 million gallons of ethanol, but could produce a lot more if it devoted more of the corn it grinds to ethanol production.[3] There are two small plants of around one million gallon capacity each. One produces ethanol from dairy whey, the other from food processing waste. The five remaining plants are "dry mills" of 8 to 15 million gallon per year capacity. Several plants are under construction and additional plants are being planned.

The total capitalization of a 15 million gallon per year dry mill ethanol plant is about $25 to $30 million. While the exact terms of each Minnesota project have varied, the sale of common stock financed about 40 to 50 percent of the cost of the four plants built between 1994 and 1996, and bank loans or other debt with a term of 7 to 10 years financed most of the remaining cost. All but one of Minnesota's major ethanol plants are farmer-owned cooperatives where ownership of a share of common stock requires delivery of one bushel of corn to the plant each year. In the case of each of the four dry mills, the plants received a low-interest Minnesota ethanol facility production loan of $500,000, as well as up to $1 million in tax increment financing.

Agriculture department officials, plant managers, and lenders all told us that the role of the producer payment was critical to financing the production facilities,

3 Wet mills separate the germ from the remainder of the corn kernel and can refine corn oil from the germ as well as ethanol and higher-value products from the starch content of the kernel. Dry mills grind the entire corn kernel and are limited to the production of ethanol and Distillers Dried Grain and Solubles (DDGS) an animal feed.

because it provides a secure revenue stream for ten years that is about equal to the cost of constructing the plant and starting production. A 15 million gallon plant receives $3 million per year (at 20 cents per gallon of ethanol production). Over ten years this provides $30 million which, as we have seen, is enough money to build the plant and capitalize the company. Banks have been willing to lend money for 7 to 10 years to finance about half the project costs. Under these terms bankers do not have to assume that the plant will be profitable over the long run.

ECONOMIC BENEFITS

Most of the communities in which ethanol plants are located, and the surrounding counties, are struggling with problems of limited economic diversity and declining populations. We found:

- **Construction and operation of ethanol plants are a boon to the communities in which they are located, and there are significant benefits for the state as a whole.**

Ethanol plants have a significant local and statewide economic impact.

Ethanol plants improve the economic climate in small cities by providing new job opportunities. Ethanol plants typically employ around 27 people and provide good wages and benefits.

In addition to jobs and tax revenue, small cities receive other benefits from ethanol plants. Most cities improved their roads or utility infrastructure as a part of ethanol plant development. All of the most recent plants have received tax increment financing, however, so local governments have subsidized these infrastructure improvements. Officials in these cities hope that these improvements will increase their ability to attract and retain other business ventures.

All but one of the major ethanol plants have been organized as farmer-owned cooperatives. The benefits of the cooperative structure are two-fold. First, any profits from ethanol production are distributed among the farmer-owners. This allows farmers to participate in the profits from processing the raw commodities they produce. Second, cooperatives may be better able to withstand periods of high corn prices, making them more stable forces in the community. Farmers can provide corn at below market rates during such periods.

Unlike local benefits, statewide impacts cannot be measured directly. We estimated the statewide economic impacts of ethanol production using a method called "input-output analysis." This method allows us to estimate the ripple effects that are created in the economy by a project such as the expansion of the ethanol industry in Minnesota.

In fiscal year 1997, the Department of Agriculture projects that the ethanol industry will manufacture 99 million gallons of ethanol. Using a long term average price for ethanol of $1.30, this represents about $129 million in revenue. We estimate an additional $41 million in revenue will come from sales of animal feed

byproducts, again assuming average prices. The department projects producer payments will total $17 million in fiscal year 1997. Thus, industry revenues for fiscal year 1997 are expected to total to $187 million.

Economic Impact of Ethanol Production

Ethanol production has an overall economic impact that is greater than the value of plant revenues. Firms that supply goods and services to the plant, such as corn growers and trucking companies, receive benefits and local shopkeepers profit from increased economic activity. Input-output analysis uses the economic relationships between industry sectors in the overall economy to estimate the indirect and induced effects, for example, in the transportation and retail sectors.

We estimate the annual statewide economic impact of ethanol production to be $211 to $327 million, as shown in the accompanying table. The range of values represent different assumptions about the value added per bushel of corn by ethanol production over the market price for the raw commodity.

We also estimated the economic costs of public subsidies using the input-output method, in order to calculate net statewide impacts. Ethanol programs such as the producer payment and blender's credit have implications for the taxes paid by Minnesotans, while oxygenated fuel requirements in excess of federal requirements raise fuel prices for consumers.

Economic Impact of Ethanol Production and Use

		Output Impact (Millions)	Employment Impact (Jobs)	Personal Income Impact (Millions)
ANNUAL BENEFITS AND COSTS[1]				
Ethanol Industry		$211 - 327	1,132 - 1,618	$37 - $51
Producer Payment		(20)	(314)	(8)
Blender's Credit		(7)	(102)	(3)
Metro Area Summertime Use:				
Higher Fuel Cost[2]	2 to 5 cents per gallon	(16) - (39)	(246) - (633)	(6) - (15)
Lower Fuel Economy[3]	2.3 to 3.5 percent decrease	(24) - (36)	(373) - (575)	(9) - (14)
Total		$109 - $260	(492) - 583	$(3) - 25
ONE-TIME NET BENEFITS				
Construction Impacts:	1/2 Local Content	174	1,146	38
	2/3 Local Content	232	1,537	50
	3/4 Local Content	261	1,733	57

[1]All benefits and costs are based on fiscal year 1997 projections, except as noted.

[2]Assumes 667 million gallons annual consumption.

[3]Assumes 667 million gallons annual consumption and $1.30 per gallon fuel costs.

Economic Impact of Producer Payments

The Department of Agriculture projects producer payments to total $17 million in fiscal year 1997. We estimate the "cost" of this public expenditure by calculating the impact of an equivalent increase in middle income household spending. Input-output analysis uses data on past consumption patterns to estimate the economic impact of a spending change.

If the producer payments were not made, and instead taxes on middle income households were reduced by an equivalent amount, the impact would be a $20 million increase in statewide economic output, as shown in the table. In other words, paying the $17 million subsidy costs the state $20 million in consumer expenditure impacts.

Economic Impact of the Blender's Credit

The positive impacts from ethanol production are partly offset by the costs of ethanol incentives and requirements.

The impact of the blender's credit is also estimated as the impact of an equivalent increase in middle income household expenditures. The Department of Revenue projects the value of credits for fiscal year 1997 to be $6 million. As shown in the accompanying table, we estimate the total impact to be a cost of $7 million.

Economic Impact of Year-Round Ethanol Use

Consumers also incur costs as a result of the year-round oxygenated fuel requirement in the Twin Cities area. We assume that about 2 billion gallons of gasoline are used in the state, and about one-half of that total is used in the Twin Cities area. Federal law requires use of an oxygenate in four winter months in the Twin Cities, so only two-thirds of the annual costs associated with use are attributable to state policy.[4] Thus, about 667 million gallons are to be affected in fiscal year 1997. The effects of oxygenated fuel are measured in higher fuel prices and lower fuel economy.

We estimate oxygenated fuel costs at 2 to 3 cents more than conventional gasoline, but other estimates put this premium at 5 to 6 cents or higher. The impact of raising the price of this portion of gasoline by 2 cents per gallon, and alternatively, by 5 cents per gallon, are shown in the table. We estimate that year-round ethanol use in the Twin Cities costs the state between $16 and $39 million annually.

Furthermore, vehicles travel fewer miles per gallon of oxygenated fuel as compared with conventional gasoline. This results in 2.3 to 3.5 percent more gasoline being consumed, and (assuming a price of $1.30 per gallon) an annual loss of $24 to $36 million in statewide economic impacts.

4 Starting in October, 1997, oxygenated gasoline will be required statewide, increasing the cost factor to five-sixths.

Economic Impact of Ethanol Plant Construction

Construction of an industrial facility such as an ethanol plant has a large, but short-lived, impact on the state's economy. The impact on the state's economy of constructing ethanol facilities is presented in the table. This impact differs from the annual estimates just presented in that it represents a one-time boost to the state's economy.

Plant records indicate that construction of a dry milling ethanol production facility costs roughly $2 per gallon of production capacity. Using this figure, the cost to build the state's 99 million gallons of capacity was around $198 million. Assuming two-thirds of this total supports Minnesota construction firms, the total one-time output impact from facilities construction is estimated to be $232 million. The table also shows estimates derived under the assumptions of one-half and three-fourths local content of $174 million and $261 million, respectively.

Ethanol production generates economic activity each year of $109 to $260 million.

Net Benefits

Adding up the benefits and costs discussed above:

- **We estimate the ethanol industry generates a net annual impact of between $109 and $260 million, statewide. In addition, we estimate a one-time benefit of $174 to $261 million from plant construction.**

Employment and Personal Income Impacts

Our estimates also include the impacts of ethanol production on statewide employment and personal income. The sectors that gain employment directly from increased ethanol production are mostly manufacturing sectors. In general, these sectors are highly mechanized and levels of output per worker are high. Hence, a given change in output supports a relatively small number of jobs. In contrast, decreases in household spending due to the cost of ethanol programs affect workers mainly in the retail sectors, where output per worker is lower. Thus for a given transfer of income from households to the ethanol industry, more retail jobs are lost than there are jobs created in manufacturing. The net result depends on specific assumptions, but job impact estimates range from a loss of 492 jobs to a gain of 583 jobs for fiscal year 1997.

The ethanol industry has a net positive impact on total state personal income under all but the most unfavorable combination of assumptions. Estimates range from a negative $3 million to a positive $25 million.

ENVIRONMENTAL BENEFITS

Ethanol is one of two oxygenates commonly used as a gasoline additive to control carbon monoxide (CO) emissions during the winter. The Twin Cities area is one

of 39 areas across the nation out of compliance with federal standards for atmospheric carbon monoxide. In such "non-attainment" areas, gasoline containing 2.7 percent oxygen (by weight) is required from October 1 to January 31 each year. We examined the scientific literature on the benefits of wintertime use of oxygenated gasoline. We asked whether ethanol use allowed Minnesota to meet federal carbon monoxide standards, and to what extent there are positive environmental benefits to summertime use of ethanol in Minnesota.

Wintertime Ethanol Use

From a review of scientific studies and interviews with state and federal pollution control officials, we learned:

- **While atmospheric carbon monoxide has declined dramatically over the last 25 years, much of the decline occurred prior to the start of the oxygenated fuel program in 1991.**

By 1990, CO emissions nationally had declined to about 30 percent of their 1970 levels.

The effect of oxygenated gasoline was examined in a recent report of the National Research Council (NRC).[5] The NRC is an operating agency of the National Academy of Sciences which was established under a congressional charter to advise the federal government on scientific and technical matters. Although their advice is not infallible, the NRC appoints distinguished panels to objectively assess scientific studies in areas of concern to policy makers.

The NRC report, which reviewed hundreds of studies on the use of oxygenates to reduce wintertime carbon monoxide, is far more comprehensive and authoritative than any review we could have conducted, and we relied heavily, but not exclusively, on its conclusions about the environmental effects of oxygenated gasoline. The NRC study concluded:

- **Most of the reduction in atmospheric CO in recent years has been due to improved vehicle emissions equipment. The use of oxygenated gasoline cannot be linked to a significant reduction in atmospheric carbon monoxide.**[6]

The National Research Council, reviewing other studies, concluded that little or no reduction in ambient CO levels is due to the use of oxygenated fuels in newer vehicles with properly operating emissions systems. The NRC reviewed studies

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5 National Research Council, *Toxicological and Performance Aspects of Oxygenated Motor Vehicle Fuels*, Washington, D. C., National Academy Press, 1996.

6 The following are direct quotes from the report: ". . . the effects of oxygenated fuels on reduction of ambient CO levels are small at best; in some locations, increases in ambient CO have actually occurred." ". . . the major problem is a lack of thorough, statistically defensible analysis of ambient data . . ." National Research Council, 1996, 40.

reaching divergent conclusions on the efficacy of oxygenated gasoline, and called for more and better research on key questions.[7]

Minnesota has not recorded any violations of United States Environmental Protection Agency (EPA) carbon monoxide regulations in recent years and, according to the EPA, there have been few violations anywhere in the country. EPA foresees the time that wintertime oxygenate use will only be required in a few problem areas rather than the 39 metropolitan areas in which it is now required.

The National Research Council was very critical of the lack of cold-weather tests of oxygenated gasoline in light of some studies that show big differences in the effectiveness of oxygenated gasoline in cold weather, and some studies that actually show increased CO emissions at low temperatures. The EPA tests oxygenated gasoline at 75 degrees, and this obviously limits the applicability of test results to Minnesota wintertime conditions.

Summertime Ethanol Use

There are serious concerns about the adverse effects of using ethanol in warm-weather months.

Minnesota now mandates year-round use of oxygenated gasoline at 2.7 percent oxygen content in the Twin Cities area and will require oxygenated gasoline statewide starting in October 1997. We found:

- **There is a serious question in the literature and among pollution control officials in Minnesota about the environmental benefits of summertime use of ethanol in areas, such as Minnesota, that meet federal ozone standards.**

Ethanol raises the volatility of the fuel with which it is mixed, and summertime use requires a waiver from the federal volatility standards that apply to the use of gasoline mixed with methyl tertiary butyl ether (MTBE), the most commonly used oxygenate across the country. Controlling the volatility of gasoline is important in the summer, since gasoline is naturally more volatile at higher temperatures, and gasoline contains harmful volatile organic compounds that cause human health problems directly and also lead to ozone (smog) formation.

The Minnesota Pollution Control Agency (PCA) was concerned with summertime pollution effects of ethanol and sponsored a consultant study which concluded that summertime ethanol use is neither beneficial nor harmful.[8] Ethanol reduces tailpipe emissions of CO and certain toxins, but increases the release through evaporation of other harmful compounds. Based on a review of this study and interviews with PCA and EPA, we conclude that:

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7 The Minnesota Department of Agriculture referred us to a January 1997 consultant study sponsored by the Oxygenated Fuels Association and the Renewable Fuels Association that purports to show a positive effect of oxygenated gasoline on atmospheric CO. (Systems Applications Inc., 1997.) This study and others in the future may cause the scientific consensus to change. Nevertheless, we think the NRC report is curently the most independent, authoritative document available to policy makers.

8 Whitten, Gary Z., Austin, Barbara S., and O'Connor Karina, *Ozone Impact of Year-Round Oxy-Fuel Program in Minnesota*, Systems Applications International, June 30, 1994.

- **The net environmental benefits of ethanol use are minimal or non-existent in the summer.**

OTHER ISSUES

Ethanol use has been viewed by some as the cause of a variety of engine performance problems in automobiles, recreational equipment, and various small engines. We reviewed the best and most recent studies and conclude:

- **There is no substantial evidence of mechanical problems in modern engines from the use of 10 percent ethanol blends, although in some cases, carburetted engines need minor modification for optimal performance.**

Ethanol contains a third less energy than gasoline. Use of ethanol blends reduces fuel economy 2.3 to 3.5 percent.

A gallon of ethanol contains about 33 percent less energy than a gallon of gasoline, and fuel economy directly reflects the energy content of fuel, so,

- **There is a 2.3 to 3.5 percent drop in fuel economy when motor vehicles are run on ethanol blends.**

The exact loss of mileage varies with the concentration of ethanol in the fuel and the density of gasoline used which varies with the season. Ordinarily the drop in fuel economy will not be noticed by drivers, because it is less than one mile per gallon in a car getting 25 miles per gallon, and is less than the tank-to-tank variation that occurs because of changing driving conditions. On a statewide basis, however, a 2.3 percent reduction in fuel economy translates to 46 million additional gallons of gasoline each year.

Advocates of ethanol use point out that ethanol substitutes for petroleum and does not contribute to global warming. Advocates also point out that imported petroleum use carries hidden costs in the form of spending on military protection and environmental cleanup of oil spills.

Indeed, while burning ethanol puts CO2 into the atmosphere, the corn or other biomass from which ethanol is produced recently took this CO2 out of the atmosphere. On these grounds ethanol is preferable to fossil fuel; however, substantial energy, much of it derived from fossil fuel, is used in growing corn and producing and distributing ethanol.[9] Also,

- **Ethanol consumes about 7 percent of U. S. corn production and contributes a very small amount, about one-tenth of 1 percent, to United States energy consumption.**

There is no realistic scenario under which ethanol produced from corn or other grain can contribute much to independence from imported oil or contribute mean-

9 Studies suggest that the net energy value of ethanol is 24 percent, meaning that ethanol contributes 24 percent more energy than is required for its production.

ingfully to reduction in greenhouse gasses in the atmosphere. About 39 percent of national energy needs are provided by petroleum. If ethanol were to contribute as much as 1 percent of national energy needs, it would use about 70 percent of United States corn production, and long before this happened food prices would increase unacceptably. Under any realistic ethanol scenario, oil imports will continue at substantial levels, so all the military and environmental costs associated with petroleum will continue.

RISKS TO FUTURE VIABILITY

We have seen that there are sizable local and statewide economic benefits to increased ethanol production. However, we urge policy makers to consider several risks to the future of the industry in Minnesota. The projected economic benefits of ethanol require an industry that can prosper under future conditions. The major contingencies include:

- **The risk that ethanol producers will not be able to make money at prevailing prices for corn and ethanol;**
- **The possibility that Minnesota plants will lose out in competition with larger, more efficient producers;**
- **The possibility that the federal government will withdraw all or much of its current 54 cent per gallon tax credit for ethanol.**

PROFITABILITY

The future profitability of ethanol production is subject to several risk factors.

The most fundamental question faced by any business is its profitability under conditions that will prevail in the future. The profitability of the ethanol industry depends chiefly on prices for corn, ethanol, distillers grains, and on the future of state and federal subsidies to ethanol production.

We collected production cost data from all the major operating ethanol plants in Minnesota, all but one of which are dry mills. We also reviewed published data on the same type of ethanol factories as the major dry mills currently operating in Minnesota. These sources allowed us to gain an accurate understanding of the economics of ethanol production and the range of prices for corn and ethanol under which production will be profitable.

We estimate that variable costs of ethanol production, excluding corn, are 37 cents per gallon and fixed costs are 29 cents. Variable costs include energy, water, supplies and certain employee payroll costs; fixed costs include management, insurance, depreciation and other expenses that do not vary with production. The price of corn is the biggest factor in determining the cost of ethanol, generally representing between one-half and two-thirds of total costs. Corn prices have varied

widely in the last several years, and per-gallon corn costs have ranged from 73 cents to $1.77. (About 2.6 gallons of ethanol can be produced from a bushel of corn.) Our analysis shows:

- **Minnesota's ethanol plants will be profitable at long-term average prices for corn and ethanol, assuming continued federal subsidies.**

Average prices for corn and ethanol over the period 1988 through 1995 were about $2.25 per bushel and $1.30 per gallon respectively. At these prices, we estimate the net profit per gallon of ethanol production to be 40 cents. This corresponds to a return of about $1.00 per bushel of corn processed. At an ethanol price of $1.30 per gallon, the plants can break even with a corn price as high as $3.25 per bushel. Our analysis also shows:

- **Profitable ethanol production was possible (with the producer payment) at the prices prevailing in 15 of the 24 months ending October 1996. Without the producer payment ethanol production would have been profitable in 7 of 24 months.**

Prices in the corn and ethanol markets have been volatile in recent years. We looked at historical price data to reach conclusions about profitability under real-world conditions. Much of 1995 saw moderate corn prices coupled with below average ethanol prices, and 1996 saw near-record high prices for both. Corn prices were over $5.00 per bushel and peaked at $5.54 at the Chicago Board on July 12, 1996. The price of ethanol was also high during this period, around $1.60. At corn and ethanol prices of $4.75 and $1.60 respectively, the estimated per gallon profit is a negative 26 cents per gallon.

Risk factors include prices for corn and ethanol and continuation of state and federal ethanol subsidies.

As we learned during our plant visits during the summer of 1996, plants were losing money, although the ethanol co-ops' ability to pay less than full market price for corn (most try to make an initial payment of 80 percent of the market price) helped them to keep the factories going.

FEDERAL AND STATE SUBSIDIES

The federal government pays ethanol distributors 54 cents per gallon of ethanol in the form of a highway tax credit. Minnesota pays a 5 cent tax credit, and also pays producers 20 cents per gallon of ethanol. Our production model, presented in our full report, can be used to estimate the effect on ethanol plant profitability if all or part of these subsidies are eliminated. The producer payment is scheduled to be phased out by 2000 or ten years after the start of production. By itself,

- **The loss of the producer payment means that profits will be reduced 20 cents per gallon.**

Without the producer payment, the per-gallon profit of 40 cents at long term prices would be reduced to 20 cents. The "profit" of minus 26 cents during the high price environment of 1996 would be reduced to a minus 46 cents per gallon.

The possible loss of the 54 cent federal tax credit has to be calculated another way. The loss of the credit has the same effect as reducing the price of ethanol by 54 cents per gallon. If we do this using any realistic price assumptions for corn and ethanol, our model shows:

- **The loss of the 54 cent federal subsidy would be catastrophic to the ethanol industry, and Minnesota (and national) ethanol production would decline to near zero. Ethanol plants cannot make money if the price of the product declines by 54 cents under any realistic price assumptions.**

The federal tax credit expires in 2000 and a vote by Congress will be necessary to renew it. The Minnesota ethanol producers we talked to cite the possible loss of the federal credit as the biggest risk to their future profitability that they can see. The nation's largest ethanol producer is Archer Daniels Midland whose four plants have an annual production capacity totaling 750 million gallons per year, or half the nation's total production capacity. Archer Daniels Midland has recently paid a $100 million fine for conspiring to fix the price of two products it produces from corn, and opposition to corporate subsidies, and to the ethanol subsidy, appears to be growing in Congress. This is not to say we think it is likely that the entire credit will disappear. A reasonable speculation is that it will be reduced. Minnesota policy makers need to consider the risks to further public investment in the Minnesota ethanol industry under these circumstances.

Minnesota's ethanol plants face competition from larger, more efficient dry mills, and from wet mills that can produce a wider variety of products.

COMPETITION

A key risk to the Minnesota ethanol industry which consists mainly of dry mills under 15 million gallon capacity is:

- **Smaller plants have higher average production costs than larger plants, and dry mills produce a narrower and less valuable mix of products than do wet mills. The size and adaptability of wet mills may enable them to be profitable under conditions where dry mills cannot survive.**

- **The highly concentrated ownership of ethanol production may also pose risks for Minnesota producers.**

Minnesota producers face competition from large companies with large plants. One of Archer Daniels Midland's plants produces twice as much ethanol as all Minnesota producers put together. The top five companies produce nearly 75 percent of the nation's ethanol. This concentrated ownership means that large producers can set a price for ethanol that smaller companies might have to take.

Dry mills produce only ethanol and animal feed while wet mills can produce a variety of higher value products including corn oil, corn syrup, high fructose corn syrup and other products. An analysis prepared by the Minnesota Department of Agriculture shows that dry mills can produce as much ethanol from a bushel of corn as wet mills, but that a wet mill can add much more value to a bushel of corn than a dry mill. At April 1996 prices, MDA estimates that a dry mill produces products worth $5.12 from corn priced at $4.80. The wet mill can produce mixes of products with values ranging from $5.04 (if they produce only ethanol and animal feed) to $8.42 if they maximize high fructose corn syrup production.

This illustration suggests that wet mills can be profitable under a wider range of market conditions than dry mills. When ethanol prices are low, corn syrup prices could be high, for example. The advantage held by dry mills is that they are significantly cheaper to build, about $2 per million gallon capacity for a 10 to 15 million gallon per year factory. A wet mill costs several times this amount.

According to our interviews with plant managers, Minnesota's dry mills are not efficiently-sized in terms of staffing requirements. A substantial increase in production in these mills would require little or no increase in employees. Minnesota's cap on the producer payment at 15 million gallons of annual production may be partly responsible for limiting the size of recently-built plants. Some plants are attempting to achieve greater economies of scale through cooperative marketing agreements. An important issue is whether Minnesota producers can compete with larger dry mills and large wet mills in an environment where the large companies can set the price for ethanol and could underprice Minnesota producers if they needed or chose to do so.

Finally, there are other risks to the future of corn-based ethanol production. The federal government, for example, is funding a major research effort on production of ethanol from cellulose sources such as grasses and fast-growing trees. Commercial application of this technology could threaten Minnesota's corn-based production facilities. Minnesota's investment in ethanol is considerable compared to its other economic development programs. Given the risks to future profitability discussed above, we think that:

- **Policy makers should consider whether so much of Minnesota's rural economic development effort should go to one industry.**

Minnesota's ethanol programs should not be based on the premise that profitable ethanol production is a sure bet. There are plausible scenarios for both success and failure.