GASOLINE/ALCOHOL BLENDS: A POSSIBLE FUEL RESOURCE FOR MINNESOTA

SAMUEL W. RANKIN

SEPTEMBER, 1977

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PREFACE

"Gasoline/Alcohol Blends: A Possible Fuel Resource for Minnesota" is a background paper prepared specifically for legislators. Its purpose is to introduce background information on Gasoline/Alcohol Blends, "Gasohol", and to assist initial discussions of directions and options for the Legislature.

The paper was written by Sam Rankin, with the assistance of Alan Hopeman. Both attended a conference on Nebraska's experience with Gasohol held in Lincoln, Nebraska in early August, 1977.

Comments on the paper are encouraged. A form is provided for that purpose. Specific questions regarding the subject should be directed to Sam Rankin, 296-5047.

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SUMMARY

The rising cost and uncertain availability of petroleum fuels and the low prices currently being offered for agricultural grains have stimulated widespread interest in using grain alcohol as a motor fuel. The Nebraska Legislature has authorized research and testing of a gasoline/alcohol fuel blend known as Gasohol. Tests to date indicate that Gasohol performs without problems in highway vehicles and that fuel mileage is increased slightly.

The use of straight alcohol will not be cost competitive with petroleum fuels during the forseeable future, but a blend of gasoline and alcohol appears to have qualities that could make it nearly competitive. The economics of producing grain alcohol for blending with gasoline are uncertain but seem to be encouraging--in Nebraska at least. Before alcohol production and blending can be economically feasible, effective marketing arrangements must be established for both the cattle feed by-product of alcohol production (distillers dried grains plus solubles) and for the blended fuel itself.

If a blend of gasoline and grain alcohol could be produced and sold economically in Minnesota, it would provide new markets for agricultural production, would allow for the full utilization of stressed and below-market-grade grains which are currently wasted, and would somewhat reduce our dependence on imported petroleum fuels.

This paper provides background information on some of the considerations relating to gasoline/alcohol fuel blends in Minnesota.

GASOLINE/ALCOHOL BLENDS:
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INTRODUCTION

Alcohol is an energy source and has for centuries found limited application for cooking and lighting. During recent times periodic thought has been given to the possibility of using alcohol as a motor vehicle fuel. Indeed, some types of racing automobiles are designed to operate on a pure alcohol fuel.

Historically, the high cost of alcohol relative to petroleum fuels has precluded its use as a motor vehicle fuel. During the past few years, however, the market prices of gasoline and diesel fuel have increased rapidly and the price difference between these fuels and alcohol has narrowed. Furthermore, increasing attention has been given to the limited availability of petroleum fuels and the desirability of a partial substitute for liquid petroleum.

On several occasions during the past 20 to 30 years, low grain prices have stimulated interest in the possibility of using alcohol from grain crops (ethanol) as a motor fuel, or at least as an additive to petroleum motor fuels. However, in every case before 1970, research projects begun during periods of low grain prices were abandoned when prices rose again a few years later.

RECENT HISTORY OF ALCOHOL/GASOLINE BLEND STUDIES

In April, 1971, the Nebraska Legislature passed a bill setting up a study of GASOHOL, the state's registered trademark for a gasoline/alcohol fuel. As part of the legislation the motor fuel tax on Gasohol was reduced by three cents per gallon. Also, 1/8 of a cent per gallon of the motor fuel taxes refundable to non-highway users was retained for funding the program. The actual study was to be administered by the Agricultural Products Industrial Utilization Committee (APIUC).

Besides studying the available literature on gasoline/alcohol blends, the APIUC determined in December, 1974, that a highway test program was needed to field test Gasohol. It was decided that the fuel would be a blend consisting of 10 percent grain alcohol (200 proof) and 90 percent unleaded gasoline. The highway test was to involve the exclusive use of Gasohol for two million miles of driving by a fleet of vehicles operated by the Nebraska Department of Highways. By mid-August, 1977, some 1.85 million miles of the two million mile road test had been completed.

The only other state known to have enacted legislation dealing with the use of alcohol as a motor fuel is Iowa. The 1973 session of the Iowa Legislature passed a bill authorizing the Iowa Development Commission to ". . . pursue the development of an Iowa grain alcohol motor fuel industry."

REPORTED PERFORMANCE OF GASOLINE/ALCOHOL FUEL BLENDS

The only significant field study of the performance of gasoline/alcohol blends has been conducted by the state of Nebraska in its Two Million Mile Road Test. Other information has resulted from laboratory tests in both Europe and the United States. Reliable reports on the blended fuel indicate the following:

a) Adding 1/10 gallon of alcohol to 9/10 gallon of gasoline produces more than one gallon of blended fuel. The volume increase is not particularly large--peaking at 100.55 percent in a blend containing 12.5 percent alcohol--but is beneficial. At a ratio of 10/90, the blend yields 100.23 percent of a gallon.

b) Grain alcohol (ethanol) has an average heat value per gallon of 75,600 Btu. Gasoline has a heat value per gallon of approximately 125,000 Btu. This makes gasoline a more concentrated energy source.

c) The "octane" rating of gasoline/alcohol blends is higher than that of the gasoline stock used in the blend. Gasoline engines require a certain minimum octane rating for optimal performance. The best octane rating for any given engine is determined by engine design and operating conditions. During refinery processing the octane rating of gasoline must be increased to an average minimum level, usually to at least 92 for "regular" grade and higher for premium grades. Grain alcohol has a very high natural octane rating (around 106) and when blended with gasoline, even in relatively low ratios, imparts this desirable quality to the blend. A blend containing 10 percent alcohol will have an octane rating approximately 3 points higher than the gasoline stock used for the other 90 percent of the blend. This quality permits the use of a gasoline stock which has a lower octane rating and is somewhat less expensive to refine than a gasoline stock having the "regular" grade octane rating of 92.

d) Fuel mileage of vehicles using a 10 percent alcohol blend is generally about 5 or 6 percent higher than for vehicles using regular gasoline. Performance during starting, acceleration, and at other times is reportedly unaffected.

e) At least one component of vehicle exhaust emissions is somewhat reduced; other components remain unchanged. Quantities of carbon monoxide are reduced by approximately one-third while quantities of other exhaust components such as oxides of nitrogen and unburned hydrocarbons remain unchanged with alcohol-blended fuels.

f) The Nebraska Two Million Mile Road Test has included periodic inspections of engine components such as valves, spark plugs, piston rings, and cylinders for abnormal wear. Gasohol used in the test has not significantly affected engine component life. Fuel systems of vehicles used in the Nebraska test have shown no unusual deterioration.

g) The storage of alcohol prior to blending with gasoline has been acomplished without incident. The alcohol is blanketed with dry nitrogen gas. No accumulation of water has been reported when the nitrogen blanket is used.

h) The storage of blended Gasohol has been completely uneventful, involving only standard handling techniques which have long been used in the gasoline distribution industry.

ECONOMICS OF GASOLINE/ALCOHOL FUEL BLENDS

To be economically feasible, gasoline/alcohol blends must meet several criteria. First, production and blending costs must place the blend in close competition with alternative fuels (presumably gasoline and diesel fuel). Second, a market must be found, consumer resistance overcome, and an efficient distribution system organized and coordinated. Third, alcohol production and blending costs must not be overly sensitive to the cash market price for grain commodities. Fourth, gasoline for use as a blending stock must be available from petroleum refiners in sufficient quantity and without constant threat of curtailment.

It should be noted at this point that alcohol can be produced from potatoes or sugar beets by much the same process that is used for grains. At the present time, however, the technology for mass-producing alcohol from these root crops is less developed and indications are that the economic feasibiliy of using potatoes or sugar beets is distinctly unfavorable. In this paper, therefore, consideration will be given only to alcohol produced from grain crops.

If agricultural grains were converted to alcohol and alcohol were the only saleable by-product of the process, gasoline/alcohol fuel blends would not be economical until the price of gasoline has increased several fold from present prices. Fortunately, processing grain for alcohol yields a by-product known as distiller's dried grains plus solubles (DDGS). DDGS is usable as a cattle feed and currently has an FOB market value of approximately $120 per ton. Sale of DDGS from an alcohol plant operation has the effect of decreasing the cost per gallon of alcohol produced.

Grain that is stressed or below market grade can be used in an alcohol plant without significant reduction in output. Typical yields from 100 bushels of grain are as follows:

YIELD FROM 100 BUSHELS

Grain	200 Proof Ethanol (Gallons)	DDGS Cattle Feed (Pounds)
Corn	260	1850
Milo	248	1990
Wheat	252	2430

Source: Personal conversation with Dr. Wm. Scheller, Department of Chemical Engineering, University of Nebraska, Lincoln, Nebraska. August 3, 1977.

Reducing the moisture content of DDGS from its initial value of 75 or 80 percent to around 20 percent requires considerable energy. The by-product is dried only to facilitate economical shipment over fairly long distances. It therefore seems logical to assume that if markets could be found for the DDGS within a relatively short distance of the alcohol plant (perhaps 50 miles), drying to 20 percent moisture would be unnecessary.

Stone and Webster Engineering Corporation has analyzed the economics of locating a grain alcohol plant in Nebraska. They have concluded that the initial cost of a plant designed to produce 20 million gallons of alcohol per year would be about $23 million (plus or minus 30 percent). A plant of larger size would cost somewhat more but would result in per-gallon alcohol production costs that are lower. The table that follows summarizes per-gallon production costs, assuming that: a) DDGS has a FOB price at the plant of $120 per ton, b) no costs are included for operating profit, corporate taxes, or the cost of capital (which would add approximately 22 cents per gallon to the cost).

Plant Size (Million Gal/Yr)	Cost of Milo ($/CWT)		
	2.60	3.60	4.60
	Alcohol Cost (Cents/Gal)		
20	46.4	69.1	91.6
35	40.6	63.1	85.6
70	35.5	58.0	80.5

The cash price of milo (#2) in Kansas City on August 26, 1977 was $2.99 per hundredweight. A year earlier the price had been $4.45.

Reducing the motor fuel tax on gasoline/alcohol fuel blends (as Nebraska has done) has a significant impact on the value of the alcohol that goes into the blend. When 10 percent of the blend is alcohol, a one cent reduction in the motor fuel tax has the effect of decreasing the cost of the alcohol by $.10 per gallon. This means that 50 cent per gallon alcohol could be blended with 40 cent per gallon gasoline stock and there would be no increase in the pump price of the blend (assuming a 1 cent tax break per gallon of blend).

Public acceptance of a gasoline/alcohol fuel product is essential for the economic success of a blending program. In Nebraska, at least, that acceptance seems to have been demonstrated. The Holdrege Gasohol Consumer Acceptance Test and Marketing Survey was begun in June, 1975. The Holdrege

Cooperative Association Service Station agreed to make Gasohol available to the public. It was anticipated by the survey designers that Gasohol sales would amount to approximately 20,000 gallons during the first year. In fact, the marketing survey had to be discontinued after 2-1/2 months because 93,000 gallons of the blend had been sold to the public and remaining supplies were needed for continuation of the Two Million Mile Road Test. Over 1,600 customers purchased Gasohol during the summer of 1975 and some 700 reported on their impressions of the fuel. Reports were overwhelmingly favorable. In fact, some customers who had tried Gasohol indicated that they would be willing to pay an extra two cents per gallon for the blend.

It should be noted that some economists, in Nebraska and elsewhere, have disputed the optimistic economic estimates commissioned by the Nebraska Gasohol Committee. It seems that a more thorough analysis of the profitability of both alcohol production and gasoline/alcohol blending must be completed before the economic facts can be considered conclusive.

Other economic considerations regarding alcohol production and the blending of gasoline/alcohol fuels include the following:

a) Grain alcohol production could result in more stable grain prices for farmers. The cash price of grains would be somewhat linked to the value of petroleum, and as oil prices rise in the years ahead, blends of gasoline and alcohol may actually be less expensive than straight gasoline.

To the extent that energy production from grains competes with traditional uses for grains, crop prices will be supported.

b) DDGS produced as by-product by an alcohol plant may compete with raw grains as livestock feed. If DDGS partially replaces whole feed grains in livestock operations, each bushel of grain sold to an alcohol plant may represent only part of a bushel of "new" market for the grain.

c) There may be some reluctance on the part of oil companies to supply blenders with gasoline stock that will be used to produce a fuel that is 90 percent or less gasoline. It is not yet clear how gasoline refiners will view this potential competition.

d) Grain alcohol can be produced using damaged or spoiled grain, for which there is presently a very limited market. Such grain can be purchased at prices far below those for market quality grain, which enhances the economic feasibility of alcohol production.

ENERGY CONSIDERATIONS FOR GASOLINE/ALCOHOL BLENDS

Grain alcohol is a renewable energy resource. It is a domestic energy source that is not threatened by embargos imposed by energy exporting nations. The use of domestic alcohol fuels would somewhat reduce our dependence on imported fuels and would slightly improve our balance of trade situation. Ethanol can be made from low quality grains unsuitable for human or animal consumption, and a by-product of alcohol production (even from low quality grain) is valuable as livestock feed. These positive factors concerning the production and use of grain alcohol are definitely attractive.

When grain alcohol is produced in a modern plant having an output of 20 million gallons per year, considerably more energy is needed to process the alcohol and its by-products than is contained in the alcohol. A gallon of ethanol contains an average energy value of 75,600 Btu. Producing the gallon of ethanol (and drying the DDGS) requires an estimated 126,200 Btu. It appears that the ratio of output energy to input energy is not significantly different for alcohol plants of other types and sizes.

Even though the net energy balance of an alcohol plant is negative, the type of energy produced (and its usability for important applications) may be of more value than the type of energy used. If coal (relatively abundant but impossible to use in certain applications) is the major input fuel and clean, liquid alcohol is the output fuel, society's best interests may be served.

CONCLUSIONS AND LEGISLATIVE OPTIONS

Gasoline/alcohol fuel blends could provide a new, potentially large market for agricultural grains in Minnesota. The blended fuel could also reduce our dependence on conventional petroleum fuel, much of which is imported. Facilities for making grain alcohol would make possible the conversion of currently unusable stressed and below-grade grains into energy and livestock feed.

Before a gasoline/alcohol fuel blend can be considered a viable alternative fuel for Minnesota, however, consideration should be given to several factors:

a) The apparently favorable economics of the Nebraska Gasohol program may not be transferable to the Minnesota situation. The Nebraska program should be subjected to rigorous, objective economic analysis with particular attention paid to all differences between Nebraska and Minnesota that might alter the economic projections.

b) Nebraska has conducted fairly extensive tests on the performance of gasoline/alcohol blends in highway vehicles. These tests probably should not be replicated in Minnesota, but it would be desirable to conduct field tests of blended fuels in engines used for irrigation pumps, tractors and combines, emergency electrical generation, etc.

c) The availability of stressed grains in Minnesota should be analyzed. It appears that the availability of stressed grains varies greatly from year to year and from region to region within the state.

d) To make alcohol production profitable, a market must be found for the by-product, DDGS. The potential competition between whole grains and DDGS should be analyzed in light of the Minnesota situation.

e) A distribution and marketing network for gasoline/alcohol fuel blends must be established well in advance of actual distillation and blending.

f) Any state-funded study of grain alcohol as an additive to petroleum fuels should probably be coordinated with the diesehol study authorized and funded by the 1977 session of the Minnesota Legislature.

Legislative Options

If the Legislature deems it advisable to encourage the development of a grain alcohol blended fuel industry in Minnesota, several options are available. Given the relative costs of gasoline versus blended fuel, and the state of technical knowledge of blended fuel production, it appears unlikely that private industry on its own initiative will begin to produce blended fuel in Minnesota in the near future.

Three basic legislative options exist. One is to do nothing at the present time, waiting for significant market changes and for more definitive results to come from Nebraska's pioneering work in this area. A second option would be to fund research into the production and marketing of blended fuels. A third option would be to provide a monetary incentive to potential producers of blended fuel. Nebraska has selected both of the latter options.

Research into blended fuel production could be funded either with a direct appropriation or by following the Nebraska model--reserving a portion of the refundable highway users tax for research. Another possibility might be the institution of a "checkoff" tax on certain grains, similar to the promotion fees now levied on soybeans, potatoes, and other commodities. The Minnesota Legislature in 1977 opted for a direct appropriation for blended fuel research, giving $50,000 to the University of Minnesota for research into the feasibility of utilizing a fuel consisting of diesel fuel and alcohol.

The success of the third option, that of providing a monetary incentive to potential producers of blended fuel, depends in part on the magnitude of the incentive. Nebraska's three cents per gallon reduction in the highway users tax on Gasohol effectively reduces the cost of the alcohol used in the blend by 30 cents. It is impossible to state with certainty at this juncture the level at which the monetary incentive would have to be set for blended fuel production to be economically attractive in Minnesota. Considerably more research in the technological aspects of grain alcohol production and the long-term market outlook in Minnesota will be required before the optimum level of incentive can be estimated.