

THE NEBRASKA GASOHOL EXPERIENCE

by

Michael A. Perfater
Research Analyst

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

Virginia Highway & Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia
Department of Highways & Transportation and
the University of Virginia)

Charlottesville, Virginia

February 1979

VHTRC 79-R34

MR. J. T. WARREN, Chairman, Management Services Officer, VDH&T
 MR. G. W. ALEXANDER, Assistant District Engineer, VDH&T
 MR. F. C. ALTIZER, JR., Resident Engineer, VDH&T
 MR. M. C. ANDAY, Assistant Head, VH&TRC
 MR. R. J. BOYD, JR., Personnel Officer, VDH&T
 MR. A. S. BROWN, Secondary Roads Engineer, VDH&T
 MR. D. L. EURE, Programming and Scheduling Engineer, VDH&T
 MR. C. O. LEIGH, Maintenance Engineer, VDH&T
 MR. W. A. MCFARLANE, Deputy Attorney General for Transp., VDH&T
 MR. D. D. MCGEEHAN, Research Analyst, VH&TRC
 MR. J. P. MILLS, JR., Traffic and Safety Engineer, VDH&T
 MR. T. B. OMOHUNDRO, Fiscal Manager, VDH&T
 MR. E. T. ROBB, Assistant Environmental Quality Engineer, VDH&T
 MR. W. P. TUCKER, Right-of-Way Engineer, VDH&T
 MR. W. W. WHITE, District Environmental Coordinator, VDH&T
 MR. J. E. YEATTS, Assistant Location and Design Engineer, VDH&T
 MR. B. C. YOWELL, Realtor Officer, FHWA

ENERGY TASK GROUP

MR. M. H. HILTON, Chairman, Research Engineer, VH&TRC
 MR. E. D. ARNOLD, JR., Research Engineer, VH&TRC
 MR. F. L. BURROUGHS, Construction Engineer, VDH&T
 MR. R. E. CAMPBELL, Asst. Transportation Planning Engineer, VDH&T
 MR. R. V. FIELDING, Materials Engineer, VDH&T
 DR. L. S. FLETCHER, Professor of Mechanical & Aerospace Engineering, UVA
 MR. R. L. HUNDLEY, Environmental Quality Engineer, VDH&T
 MR. B. BOYD JOHNSON, Chief, Intergovernmental Branch, Division of
 Energy, State Office of Emergency & Energy Services
 MR. C. O. LEIGH, Maintenance Engineer, VDH&T
 MR. J. R. MILLER, Equipment Engineer, VDH&T
 DR. W. H. MASHBURN, Asst. Professor of Mechanical Engineering, VPI&SU
 MR. E. D. SLATE, General Services Supervisor, VDH&T
 MR. A. J. SOLURY, Div. Planning and Research Engineer, FHWA
 MR. R. P. STOCKDELL, Senior Electrical Engineer, VDH&T
 MR. M. E. WOOD, JR., District Engineer, VDH&T

ENVIRONMENTAL RESEARCH ADVISORY COMMITTEE

MR. E. T. ROBB, Chairman, Asst. Environmental Quality Engineer, VDH&T
 MR. M. C. ANDAY, Assistant Head, VH&TRC
 MR. R. E. BLASER, University Distinguished Professor, VPI & SU
 MR. L. E. BRETT, JR., District Engineer, VDH&T
 MR. W. L. BRITTLE, JR., Director of Engineering, VDH&T
 MR. A. R. CLINE, District Environmental Coordinator, VDH&T
 MR. R. V. FIELDING, Materials Engineer, VDH&T
 MR. R. L. HUNDLEY, Environmental Quality Engineer, VDH&T
 MR. A. B. JOHNSON, Assistant Construction Engineer, VDH&T
 MR. R. C. LOCKWOOD, Transportation Planning Engineer, VDH&T
 MR. D. D. MCGEEHAN, Research Analyst, VH&TRC
 DR. TOM STEPHENS, Associate Professor of Civil Engineering, VPI & SU
 MR. W. P. TUCKER, Right-of-Way Engineer, VDH&T
 MR. R. G. WARNER, Assistant Construction Engineer, VDH&T
 MR. ROBERT WELTON, Environmental Coordinator, FHWA
 MR. J. E. YEATTS, Assistant Location and Design Engineer, VDH&T

ABSTRACT

The political, social, and economic impacts of Nebraska's program promoting the use of an ethanol-gasoline blend as a motor fuel were examined and the literature on research and other activities relating to the use of alcohol as a motor fuel, including records of the deliberations of the National Gasohol Commission, were reviewed.

It was found that the objective of the 1972 Nebraska legislation on the use of Gasohol as a motor fuel was to promote the sale of grain while simultaneously helping reduce the United State's dependence on foreign oil. Since that time much research into all aspects of the use of Gasohol, which is defined as a blend of 10% ethyl alcohol (ethanol) and 90% unleaded gasoline, has been conducted throughout the Midwest. While there appears to be little debate over whether Gasohol will work in a car's engine, there is a great deal of debate concerning the economics and energy balance involved in its production and use. Most of the information now available on both issues is theoretical. There is a widely held feeling that until a full-scale ethanol plant is operating and producing in excess of 20 million gallons per year, answers to the economic and energy balance questions will not be forthcoming. There is widespread agreement that incentives, perhaps in the form of tax reductions, are needed to make Gasohol competitive with unleaded gasoline. The major opponents of Gasohol are the oil companies. Most feel that the United States is several years away from an economic conversion of agricultural products into fuel and are thus concentrating on fuel recovery from fossil sources such as shale oil, liquefied coal, and tar sands.

SUMMARY AND CONCLUSIONS

As a part of the Council's continuing efforts at evaluating opportunities for reducing energy consumption in transportation in Virginia, a study was undertaken of the experience of the state of Nebraska in encouraging a reduction in the use of petroleum through the use of alcohols as a motor fuel. A review of the travails of Nebraska as well as some two dozen or more other states has uncovered an energy and agricultural movement which is snowballing at a rapid rate. Arguments for and against alcohol fuels have made the production and marketing of Gasohol one of the most highly controversial energy issues in the nation.

A blend of 10% agriculturally-derived ethyl alcohol and 90% unleaded gasoline sold under the trade name Gasohol is being pumped at some 66 locations in the Midwest, has been road tested in Nebraska Department of Roads vehicles, and recently was placed on the market in Virginia. Similar alcohol fuels, some containing up to 100% alcohol, have been used for decades in racing cars and to power military vehicles during wartime, and, of late, have been tested in some half a dozen foreign countries.

There appears to be little debate over whether Gasohol will work in a car's engine. Blends of up to 20% ethanol and 80% unleaded fuel have been shown to provide high performance in unmodified engines. There is a bit of quibbling over fuel economy, emissions, engine performance, and overall driveability, but almost everyone agrees that Gasohol does work. Most sources do say that with Gasohol fuel economy is slightly better, emissions are slightly lower, and octane is slightly higher.

The major issue, however, is not engine performance. The two items most often argued are economics and energy balance. There are volumes of information on both; however, most of it is theoretical. A study by Dr. William Scheller of the University of Nebraska has indicated that ethanol reduced from corn has a positive energy balance and can be produced at a cost which will make Gasohol competitive at the pump with unleaded gas. While Dr. Scheller has many opponents both within and outside of the state of Nebraska who refute his claim, there is a widely held feeling that until a full-scale ethanol plant is actually operating and producing in excess of 20 million gallons of alcohol per year no one will be able to answer the economic and the energy balance questions. To help make Gasohol competitive at the pump Nebraska and Illinois have reduced the state motor fuel taxes on it by 5¢ and 3¢ per

gallon, respectively, and at the national level the recently enacted Energy Bill calls for a 4¢ per gallon reduction in the federal tax on all Gasohol sold. Such incentives, although necessary, will likely result in shortfalls in transportation funds on both the state and national levels. In the beginning, the shortfalls will not be great since there is such a small demand for Gasohol. However, in individual states shortfalls in tax revenues could reach as much as \$1 million per year if the demand for Gasohol grows. This is not to mention the tax loss due to the 4¢ reduction in the federal excise tax, which could also amount to nearly \$1 million annually. Many experts believe, however, that as the price of alcohol drops and/or the price of crude oil rises these tax incentives may be removed.

Consumer acceptance tests run at one site in Nebraska and one in Iowa have shown favorable public response to the use of Gasohol. In general, it appears that Gasohol has a market place in Nebraska and 10% to 15% of the motoring public in Iowa would use Gasohol one or more times. Many of the retailers of Gasohol throughout the Midwest report that a majority of their customers are repeat users, and that many of them refuse to use anything but Gasohol in their vehicles once they have made the conversion to it.

To say that Gasohol is a political issue would be an understatement. There are literally scores of bills in the legislative hoppers concerning alcohol fuels. One such bill calls for a National Alcohol Fuels Commission to study alcohol fuels and how they can best be put to use. Another calls for a timetable for bringing Gasohol into the market on a national basis. Passage of these bills would indeed indicate a national commitment to the production and use of alcohol fuels.

The major opponents of Gasohol are the oil companies. Several of the nation's largest are skeptical of Gasohol from the same standpoints as others who argue against it — poor economics, negative energy balance, potential distribution and operational problems, and not much help to the farmer. The oil companies as a group feel that the United States is several years away from an economic conversion of agricultural products into fuel. Most are concentrating on fuel recovery from fossil sources such as shale oil, liquefied coal, and tar sands. One of the major arguments which the oil companies lodge against Gasohol production and use is from the standpoint of the impact it would have on the nation's food supply. Their charge is that to have a Gasohol program of any magnitude, Americans would have to give up eating wheat and corn. Agricultural economists are also arguing this point back and forth, with one argument being that the United States currently has enough

acreage subsidized by the government to lie idle sufficient to produce some 4 million gallons of alcohol per year. That's about 40% of the projected 10 billion gallons needed to provide the addition of 10% alcohol to all gasoline pumped in the United States.

Gasohol proponents are hard at work trying to establish a nationwide program. Gasohol opponents are hard at work trying to convince the law makers that there are better domestic sources of fuel than agricultural products. Supporting the gasoholics is worldwide experience proving that Gasohol works in automobiles, an energy problem and a farm problem to be solved, interesting and promising new technology, and a goodly amount of political pull. Working against them are problems of economics, energy balance, and most of the nation's major oil companies.

RECOMMENDATIONS

Although no formal recommendations were intended to evolve from this study, there are certain suggestions which the author feels are appropriate. First, since the movement to establish the production and use of alcohol fuels in this country seems to have taken on added importance and has grown so rapidly in the past few years, it is suggested that the Department continue to keep abreast of the activities of the National Gasohol Commission; those states retailing Gasohol; the Congress, which is considering relevant legislation; and the Mar Cam Industries, which is the East Coast marketer of Gasohol. Continued monitoring of these activities is especially important since it is apparent that the retail sales of Gasohol may affect the Highway Trust Fund. Perhaps the best way to monitor these items is for a representative of the Department to become a regular subscriber to the oral and written deliberations of the Commission. Second, it would appear that the Commonwealth of Virginia should become at least peripherally interested in the activities of the National Gasohol Commission. It is suggested that additional state agencies be made aware of the Gasohol movement so they can follow the movement as they see fit.

THE NEBRASKA GASOHOL EXPERIENCE

by

Michael A. Perfater
Research Analyst

INTRODUCTION

Alcohol and alcohol-gasoline blends have been used intermittently for decades as motor fuels. It is said that Nikolaus August Otto, the German technician, first ran an engine on pure ethanol around 1867. In 1907 the U. S. Department of Agriculture published a report entitled "Use of Alcohol and Gasoline in Farm Engines."⁽¹⁾ A study published in 1909 showed that alcohol gave greater horsepower, higher compression, and the same mileage as gasoline.⁽²⁾ During those years, however, the high cost of alcohol as compared to that of petroleum made it noncompetitive. World War I resulted in many countries being cut off from petroleum supplies, thus the use of alcohol fuels became widespread and continued in some countries into the postwar years. In the United States, war surplus alcohol mixed with gasoline in a 20/80 blend was sold in some cities. In Sweden ethyl alcohol, or ethanol as it is often called, was sold in a 25/75 blend with gasoline. Germany used potatoes, molasses, grains, and sulfite liquors to produce ethanol and improve its balance of payments. In the late 1920's several documents were published hailing the use of alcohol fuel in internal combustion engines. Most of this sort of activity came to a halt during the depression when the prices for imported gasoline sank. During the 1930's the Nebraska legislature passed a law that would refund 2¢ per gallon to motorists who bought ethanol-gasoline blends, but pressure from the petroleum industry eventually led to its repeal. During World War II the United States, along with several other countries, used potatoes on a large scale for the first time in ethanol production, but the early 1950's saw an end to the use of farm products for the manufacture of ethanol. Since then, synthetic alcohol derived from fossil fuels has dominated the ethanol market.

To say the least, information on the use of alcohol-gasoline blends as fuel for motor vehicles is somewhat inconsistent and controversial. Many studies of the performance of ethanol blends have been conducted and several are reported herein. In 1976-1977 a study of a 10/90 methanol-gasoline blend was conducted by the Virginia Highway and Transportation

Research Council.⁽³⁾ That study concluded that the vehicles operating on the blend averaged 4% fewer miles per gallon and that regular use of such a blend would require specific vehicular adjustments as well as special attention to the storage and handling of the blends. The report on that study stated that from an economic and supply standpoint the use of methanol-gasoline blends in Department vehicles was not justifiable at that time.

As the price of grain falls and the price of oil rises interest in the use of grain alcohol as an automotive fuel additive escalates. When in 1973 the OPEC countries placed an embargo on crude oil shipments and increased the price of oil by a factor of about 4, ethanol derived from grain became a possibility as a competitor with synthetic ethanol (from ethylene) in the industrial market place and, with an increased gasoline price, it became an economical additive to unleaded automotive fuel.

In a threefold effort to take advantage of these economic changes, provide an alternative source of energy, and stimulate the state's agricultural economy, the 1971-72 Nebraska legislature passed bills establishing a program to aid in the development of a grain alcohol industry in Nebraska through the introduction of an automotive fuel containing a blend of 10% agriculturally-derived ethyl alcohol and 90% unleaded gasoline. To encourage the sale and use of the fuel, which was trade named "Gasohol", Nebraska taxes it at a 5¢ per gallon lower rate than is levied against gasoline. With this lower tax rate, the price of Gasohol is competitive with that of unleaded gasoline. To administer the program the state established the Agricultural Products Industrial Utilization Committee (APIUC), which in turn provided a grant to the University of Nebraska's Department of Chemical Engineering to direct and conduct, in cooperation with the Nebraska Department of Roads, a 2-million-mile-road test using 45 state owned vehicles fueled with Gasohol.

Interest in Gasohol as a fuel is growing rapidly, not only in the grain-producing states but also along both the East and West Coasts. A National Gasohol Commission has been formed to encourage the use of agriculturally-derived, alcohol-blended fuels as a viable energy source. It is the intent of this report to present information generated by that Commission and to relate the experiences of Nebraska. It is believed, that the report will be valuable from many standpoints, especially those of energy conservation and the possible stimulation of the agricultural economy of the Commonwealth. The fact that Gasohol is being sold at the pump in Alexandria, Virginia, also speaks to the timeliness of this study, and it has been learned that plans for additional Gasohol outlets in Virginia are in the offing.

PURPOSE AND SCOPE OF STUDY

The purpose of this study was to evaluate the Nebraska Gasohol program and its ramifications. Specifically, the objectives were to (1) examine the political, social, and economic impacts of the program promoting the use of an ethanol-gasoline blend as a motor fuel in Nebraska, and (2) keep the Virginia Department of Highways and Transportation apprised of current research and activities relating to the use of alcohol as a motor fuel. However, when the examination of the Nebraska program uncovered many Gasohol-related activities outside that state, these were also reviewed. In fact, information on activities relating to the use of Gasohol in more than two dozen states and several foreign countries was found. This report covers only the materials reviewed as of November 15, 1978.

It was not within the scope of the project to suggest means for establishing the production or use of alcohol as a motor fuel in Virginia. In planning the research it was decided that any detailed examination of the feasibility of establishing a Gasohol program in the Commonwealth, if found to be warranted, would be made in a separate study. The study does, however, include an extended bibliography which might be utilized by those interested either in establishing a Gasohol program or further studying many of the details of the Gasohol issue.

METHODOLOGY

All pertinent literature generated by Nebraska was obtained and perused, including that from the APIUC, the 82nd Nebraska legislature, the Nebraska Department of Roads, and the University of Nebraska's Department of Chemical Engineering. Several telephone conversations were held with Charles R. Fricke, administrator of the APIUC in Lincoln, Nebraska. Various news clippings pertaining to alcohol motor fuels were obtained as well as various publications from the U. S. Departments of Commerce, Energy, Agriculture, and Transportation. In addition, articles from certain scientific and other periodicals were obtained.

In the course of the study, the author was invited to attend the Third Organization Meeting of the National Gasohol Commission in Washington, D. C., June 12-14, 1978. Senators Birch Bayh of Indiana, Charles Percy of Illinois, and Frank Church of Idaho were in attendance, along with approximately

125 registered participants and speakers from 29 states and Washington D. C. The deliberations during the sessions of this meeting were taped by the author and provided much of the information contained in this report.

NEBRASKA GRAIN ALCOHOL PROGRAM

Political Setup

In 1972, the Nebraska legislature passed bills introducing the use of Gasohol as a motor fuel. To encourage the sale of this fuel, that legislation provided a 3¢ per gallon reduction in the state gasoline tax on the first 10 million gallons of Gasohol sold each year. In the spring of 1977, the legislature voted to raise the 3¢ tax credit to 5¢ credit on the first 20 million gallons of Gasohol sold each year. With this tax reduction, the price of Gasohol is competitive with that of unleaded gasoline.⁽⁴⁾

To administer the Grain Alcohol Program, the APIUC was established. The membership of this committee consists of four people actively engaged in farming, two in business, and one from the petroleum industry. The committee's primary responsibilities are to analyze and develop, in cooperation with private industry, the means to produce and market Gasohol and to sponsor research and development on industrial uses for by-products from the manufacture of agricultural ethyl alcohol. The ultimate goal of the committee is to have one or more ethyl alcohol plants constructed in the state of Nebraska. The committee is funded by a 1/8¢ per gallon withholding from the gasoline tax refund returned to users of gasoline as a fuel for vehicles used for off-highway purposes. The revenue generated by this tax measure has averaged \$82,000 annually.⁽⁵⁾ The committee began operations in 1972. Its administrative staff is small and it, therefore, awards grants for the necessary research and studies to public institutions or private entities. One such grant funded a project designed by the University of Nebraska in which Gasohol was used as a fuel in state owned vehicles.

The 2-Million-Mile-Road Test

A survey of the technical literature issued by the APIUC revealed that the committee had seen a need for a comprehensive fleet test program to investigate and document the suitability of Gasohol as a motor fuel under normal highway and city driving

conditions. As a result, the committee awarded a grant to Dr. William A. Scheller, chairman of the Department of Chemical Engineering at the University of Nebraska, to direct and conduct, in cooperation with the Nebraska Department of Roads, a 2-million-mile-road test (Dr. Scheller, incidentally, is credited with originating the name "Gasohol", which became an officially registered trade name in the state of Nebraska in November 1974.) In December of 1974 the road test involving 45 Nebraska owned fleet cars was begun to compare an unleaded fuel blend containing 10% anhydrous ethanol (200 proof) with regular grade unleaded gasoline. The study was completed in October 1977. The cars tested were 1973 AMC Ambassador Sedans with 360-CID V-8 engines and automatic transmissions. The odometer reading and quantity of fuel added were recorded at each fueling stop. Spark plugs were examined and compression measurements were made periodically. Also the engine heads were removed from 10 cars, the valve seats were examined, and micrometer measurements of the cylinder diameters were made.

No unusual wear or deterioration was found in the automobiles using Gasohol. In addition, the drivers of these cars reported good starting in winter months and no vapor lock problems in summer months, even at altitudes of 5,000 feet and temperatures of 100°F (38°C) and higher.⁽⁶⁾ Standard emission tests were conducted at the Energy Research and Development Administration's (ERDA) Energy Research Center in Bartlesville, Oklahoma. Total emissions from Gasohol were about 15.7/gm/mile lower than those from unleaded gasoline, and the cars fueled with Gasohol obtained up to 5.3% more miles per gallon and 8.7% more miles per Btu than the cars using unleaded fuel.⁽⁷⁾

Although at this writing the analysis of the road test data is only 95% completed, indications are that several factors make alcohol a desirable component for blending with unleaded gasoline. Along with reduced fuel consumption, fewer pollutants in the engine exhaust, and added driver satisfaction through easier starting of the vehicle under extreme weather conditions, it was determined that the addition of alcohol increases the octane number and adds value to the ethanol because it permits a less costly base unleaded stock to be used for blending Gasohol fuel of an octane number equivalent to that of unleaded fuel normally marketed.⁽⁸⁾ The Nebraska Gasohol Committee and the Bartlesville Energy Research Center have undertaken a joint study to evaluate this cost advantage.

Economic EvaluationValue of Ethanol As An Automotive Fuel Additive

The first item of value that 1 gallon of ethanol has in 10 gallons of Gasohol is the value of the 1 gallon of unleaded gasoline which it displaces (Table 1). Based on wholesale prices charged to Nebraska during the 2-million-mile-road test, this figure is \$0.38.5 per gallon of ethanol. It was determined during that road test that the unleaded base gasoline used in blending Gasohol fuel could have a lower octane number than the unleaded gasoline regularly marketed, because the introduction of ethanol into unleaded gasoline was found to boost the octane. With 10% ethanol in unleaded gasoline its blending octane number on the F-1 scale is 134. Thus, if Gasohol were marketed at the same octane number as unleaded gasoline, which in the research had an octane number of 92, the base unleaded stock for Gasohol could have an octane 4.67 F-1 numbers lower, or 87.33. (see Table 1.) Economists indicate that 1 octane number is worth about .45¢ per gallon of fuel. In 10 gallons of Gasohol the savings would be 18.9¢ in the cost of the unleaded base gasoline, which can be added to the value of the ethanol. (9)

The 2-million-mile-road test also determined that when blended into 90/10 mixture, the gasoline and alcohol expand in volume by about 0.23%. In 10 gallons of Gasohol this represents an added value of 1¢ per gallon of ethanol, assuming the gate price of unleaded fuel and that for ethanol is 88.4¢ per gallon. In Nebraska Gasohol is taxed at 5¢ per gallon less than automotive fuel which does not contain ethanol. In 10 gallons of Gasohol this represents a 50¢ tax reduction. Adding all of these figures together gives ethanol a value of \$1.084 per gallon. If credit for 5% less fuel consumption is added to the value of the ethanol at 32¢ per gallon, then the value of ethanol as a blending stock is \$1.40 per gallon. Since it is possible to adjust the markup permitted to the service station owner, it is possible to use ethanol purchased at a value between 88.4¢/gal and \$1.40/gal to blend a fuel which can compete in price with unleaded gasoline. (10) Table 2 shows details for such a fuel assuming sale in Lincoln, Nebraska. All figures are based on 1976 prices paid for Gasohol used in the 2-million-mile test.

Table 1

Component Contributing to the Value of Ethanol (ETOH) in Gasoline Fuel

Source: Scheller, Dr. William A., "Nebraska 2-Million Mile Gasohol Test Program", Sixth Progress Report, University of Nebraska, January 1977

	<u>¢/gal ETOH</u>
1. 1 gallon of no-lead displaced by alcohol	38.5
2. Credit for reduction in no-lead octane number ^(a)	18.9
3. Credit for expansion of mixture ^(b)	1.0
4. Credit for 5¢ tax reduction ^(c)	<u>50.0</u>
Subtotal	108.4
5. Credit for 5% less fuel consumption ^(d)	<u>32.0</u>
Total	140.4

(a) $(92 \text{ octane} - \frac{92 \text{ octane} - 134 \text{ octane} \times .1 \text{ ethanol}}{0.9 \text{ unleaded fuel}})$
 $.45¢/\text{gal} \times 9 \text{ gal} = (87.33)(.45)(9) = 18.9¢/\text{gal ETOH}$

(b) $(36.8¢/\text{gal} \times 9 \text{ gal} + 88.4¢/\text{gal} \times 1 \text{ gal}) \frac{.0023}{1.0023} =$
 1.0 ¢/gal ETOH

(c) $5¢/\text{gal fuel} \times 10 \text{ gal} = 50¢/\text{gal ETOH}$

(d) $639 \times 1.05 - 639 = 32¢/\text{gal ETOH}$

Table 2

Computed Pump Price for Gasohol
November 1976

Source: Scheller, Dr. William A., "Nebraska 2-Million Mile Gasohol Road Test Program", Sixth Progress Report, University of Nebraska, January 1977

<u>Item</u>	<u>¢/gal</u>	<u>¢/mile</u> ^(a)
No-lead base gasoline @ 34.3¢/gal	30.8	
Anhydrous Ethanol @ \$1.10/gal	11.0	
Transportation to Lincoln, Nebraska	3.3	
Station Markup	<u>9.3</u>	
Subtotal	54.4	3.5
Nebraska State Tax	5.5	
Federal Tax	<u>4.0</u>	
Pump Price of Gasohol	<u>63.9</u>	<u>4.1</u>
Current Median Price of No-Lead Gasoline in Lincoln, Nebraska (5 Major Brands)	<u>63.9</u>	<u>4.3</u>

Note: 1978 pump price for Gasohol in Nebraska is 69.9¢/gal
(a) Assumes 15 mi/gal on No-Lead and 5% better mileage for Gasohol

A recent study by Development, Planning and Research (DPR) Associates, Inc. of Manhattan, Kansas, found conclusive determinations regarding the enhancement of octane resulting from the addition of ethanol to gasoline. (11) The report on the study stated that, generally, the lower the octane of the base gasoline, the greater the enhancement of octane from the mixing of ethanol. At typical gasoline octane ratings, it says, enhancement is probably one or two octane numbers. If octane enhancement could be specified, the study concludes, savings in refinery costs might be realized by the processing of special base gasolines to be used in Gasohol. The findings

of the study agreed with those of Dr. Scheller in one respect, in that it concluded that the only justifiable adjustment for Gasohol stems from the 0.23% increase in volume from mixing Gasohol with gasoline. Further, the report on the study stated that a benefit of .001¢ per gallon (.01¢ per gallon of ethanol) should be taken for the volume increase resulting from mixing ethanol and gasoline. The study also determined that Gasohol increased fuel economy only in engines operated below ambient air temperatures of 67°F; above that level, there was a decrease in fuel economy. The report pointed out, however, that these fluctuations were only slight, and the researchers were of the opinion that differences in fuel economy are negligible. Therefore, they said, the available evidence on fuel economy does not warrant a positive or negative adjustment in fuel costs.

Economics of Ethanol Production from Grain

The process for making agricultural ethyl involves the action of enzymes and yeast on sugars or starch contained in grain, potatoes, or other agricultural products. Ethyl alcohol is separated from the residue with distillation columns. Food quality grain is not required for this process. Distressed (wet, moldy) grain works equally well and it has been estimated that sufficient distressed grain exists in Nebraska annually to feed a plant that makes 20 million gallons of ethyl alcohol per year. When distressed grain is in short supply, the plant would use the cheapest form of starch available such as milo (a feed grain) and produce cattle feed as a by-product.⁽¹²⁾

Nebraska's yearly gasoline sales are about 900 million gallons, thus the 20 million gallons of ethanol that could be produced annually by one plant would allow substitution of Gasohol for up to 22% of the state's automotive fuel. According to Dr. Scheller it takes 21,490 bushels of grain per day to produce this amount of alcohol. In addition, 210 tons per day of cattle feed and 174 tons per day of carbon monoxide would be produced as by-products.⁽¹³⁾

Table 3 presents a material balance and an economic evaluation for the production of 20 million gallons per year of anhydrous grain alcohol from milo, which is less expensive than corn. The cost of milo at \$3.50 per hundred pounds used in the table is higher than the current price of about \$3.00 per hundred pounds. The conversion cost is estimated to be 30¢ per gallon of ethanol produced using coal as a fuel. Working capital of about \$4 million is also required.⁽¹⁴⁾

Table 3

Material Balance and Economics of Producing
20 Million Gallons 200 Proof Ethanol per Year

Source: Scheller, Dr. William A., "The Production of Ethanol by the Fermentation of Grain", University of Nebraska, A paper presented at the International Symposium on Alcohol Fuel Technology - Methanol and Ethanol, Wolfsburg, Germany, November 1977

<u>Investment:</u>	<u>Conventional Plant</u>
Plant Investment	\$23,000,000
Working Capital	4,000,000
Total Investment	<u>\$27,000,000</u>
 <u>Income:</u>	
Ethanol, 20 Million Gallons/Yr @ \$1.10 per gallon	\$22,000,000
Distillers dried grains, 210 tons/day @ \$120 per ton	9,200,000
Carbon Dioxides, 174 tons/day @ \$2 per ton	130,000
Total Income	<u>\$31,330,000</u>
 <u>Expenses:</u>	
Milo, 21,490 Bushels/day @ \$3.50 per hundred pounds	\$15,370,000
Conversion Cost @ 30¢/gallon of Ethanol	6,000,000
Total Expenses	<u>\$21,370,000</u>
 <u>Depreciation</u> (10% straight-line)	\$ 2,300,000
 <u>Taxes</u> (50%)	\$ 3,830,000
 <u>Net Cash Flow</u>	\$ 6,130,000
 As percentage of investment	22.7

On the income side of the ledger, 20 million gallons per year of ethanol at \$1.10 per gallon would yield \$22 million. It should be noted that the income from the ethanol is only slightly more than the total expense of operations, which means that the profit for the operation will depend upon the income received from the by-products. Distillers grain is priced at \$120 per ton and carbon dioxide at \$2 per ton, which would yield \$9,200,000 and \$130,000, respectively. The difference between the income and expenses is \$9,960,000, which is the profit before taxes and depreciation. Expenses include the \$27 million capital investment, a 10% straight-line depreciation of the plant, and federal and local corporation taxes amounting to 50% of the profit before taxes, or \$3,830,000. This leaves a net profit of \$3,830,000 and a net cash flow of \$6,130,000 per year, or 22.7% of the total investment.⁽¹⁵⁾

This financial analysis appears to demonstrate an economic incentive for building and operating one or more ethanol plants, particularly in agricultural states. In addition to the investment returns mentioned, there is some speculation that protein fit for human consumption may be recoverable as a by-product.

Impact Upon Tax Revenues

As has been previously noted, the state of Nebraska has reduced its gasoline tax by 5¢ per gallon on the first 20 million gallons of Gasohol sold each year. At present 400,000-500,000 gallons of Gasohol are pumped annually in Nebraska, and this converts to a tax loss of between \$20,000 and \$25,000 per year. However, if the demand for Gasohol grows, it will be up to both the federal and state governments to investigate alternative methods of funding. A state selling 20 million gallons of Gasohol per year, which is the goal of Nebraska and many other states, would have a \$1 million shortfall to deal with if its tax incentive is 5¢ per gallon. This is not to mention the tax loss due to the 4¢ reduction in the federal excise tax, which could also come to nearly \$1 million annually per state.

The DPR study previously mentioned estimated that to make Gasohol competitive at the pump between a 7.5¢ and 9.0¢ per gallon tax incentive would be needed. That study found that fuel grade ethanol is not economically feasible without government incentives. The study also found that similar government incentives to stimulate energy production are used in the United States. A recent estimate, it determined, placed

the total federal outlays at \$123-\$133 billion since 1918 for all forms of energy.⁽¹⁶⁾ Regardless of the exact amount of the incentive, it appears that a tax shortage will exist if Gasohol usage continues to grow. On the other hand, since most reductions in motor fuel taxes are tentative, they can be lowered or even removed as the price of alcohol drops and/or the price of crude oil rises. Much economic talk centers around the feeling that while oil prices will rise, the price of alcohol will continue to drop, perhaps by as much as 20%, as methods of production become more efficient. However, most proponents of Gasohol feel that until an operating ethanol plant is producing 20 to 60 million gallons of ethanol per year the actual cost of ethanol production cannot be computed realistically. It is likely, say supporters of Gasohol, that production in such a volume will lower the price of ethanol enough that tax incentives can be removed.

One of Gasohol's most vocal opponents is Cloud L. Cray, Jr., president of Midwest Solvents of Atchison, Kansas. Cray refutes the claim that an operating plant will help determine and possibly lower the cost of production of ethanol. His company started with the operation of a Gasohol plant and produced a commercial product called Agrol. The plant now produces 15 million gallons per year of grain alcohol at a cost of about 98¢ per gallon. That's actual production cost with no profit.⁽¹⁷⁾ This is a far cry from Dr. Scheller's estimates of 43.0¢ to 78.5¢ per gallon. Such a difference, would require a much larger incentive than is currently being instituted. In their study of the economic feasibility of Gasohol DPR concluded that a 20 million gallon per year plant would require a 9.4¢ per gallon subsidy and one producing 100 million gallons per year would require a 7.5¢ per gallon subsidy.⁽¹⁸⁾ If the already enacted federal tax reduction of 4¢ per gallon is taken from these figures, these subsidies drop to 5.4¢ and 3.5¢, respectively. These subsidies, then, could be in the form of reduction in state gasoline taxes.

Energy Balance

The answer to the question of whether the conversion of grain into ethanol is energy-efficient is unclear. Dr. Scheller's research indicated that grain alcohol used as a fuel has the potential for adding new energy to the economy. Table 4 illustrates the overall energy balance associated with the production of grain alcohol from corn.⁽¹⁹⁾ Energy produced in the process comes from ethanol, from the by-products aldehydes and fuel oil, and from the assumption that 75% of the corn stalks, cobs, and husks will be used as an energy source. The remaining 25% of these field wastes must remain

on the soil to provide proper conditioning and replacement of trace elements. The total energy production is 201,100 Btu's per gallon of ethanol produced.

Energy is consumed in the farming operation, in the transportation of the stalks, cobs, and husks to the site where they are utilized, and in the operation of the alcohol plant. The alcohol production facility, according to Scheller, cannot operate at a profit without producing the by-product cattle feed from the residual solids in the grain. This is primarily a drying operation with a net energy consumption of 18,200 Btu's per gallon of ethanol produced. When the total energy consumed is subtracted from that produced, there remains a net energy gain of 27,700 Btu per gallon of ethanol produced.

Table 4

Energy Balance for Grain Alcohol Production
from Corn Using 75% of the Field Waste

Source: Scheller, Dr. William A., "The Use of Ethanol-Gasoline Mixtures for Automotive Fuel", University of Nebraska, 1977

<u>Energy Produced</u>	<u>ETOH</u> <u>(Btu per gallon)</u>	
Ethanol	75,600	
Aldehydes, fusel oil	1,100	
75% of stalks, cobs, & husks	<u>124,400</u>	201,100
 <u>Energy Consumed</u>		
Farming operation	46,000	
Transportation of stalks, etc.	1,200	
Alcohol plant	108,000	
Net consumption of by-product production	<u>18,200</u>	<u>173,400</u>
Net energy gain		<u><u>27,700</u></u>

The energy gain noted by Dr. Scheller can be realized only if the energy of 75% of the corn stalks is counted. If the stalks are left in the field, it would be incorrect to count their value; if they are removed and used as an energy source, the energy cost of replacing the soil nutrients lost would have to be included in the calculation. If the energy content of the corn stalks is excluded, the energy cost of ethanol produced from corn is greater than the energy content of ethanol. This statement reflects the opinions of both Dr. James Kendrick, an agricultural economist from the University of Nebraska, and C. L. Cray, Jr. of Midwest Solvents.⁽²⁰⁾ Kendrick believes the net energy loss in the operation of a grain alcohol plant is at least 122,000 Btu per gallon produced and that collecting 75% of the agricultural residue and using it for fuel is impractical. Collection problems alone rule this out, he says, and the likelihood of experiencing problems from erosion and loss in soil moisture is high if that much residue is taken off the land. This also is the opinion set forth in the DPR study previously mentioned. Cray says that Midwest consumes about 140,000 Btu for every gallon of ethanol it produces. This consumption takes into account the energy contained in the grain and the by-product animal feed. The gallon of ethanol produced contains only 85,000 Btu, which results in a 44% loss in total energy. Cray does admit that the fermentation and enzyme technology being developed may lead to improved energy balances. He adds, however, that it's the distilling process which uses most of the energy required to make alcohol and that this will likely continue to be the case.

Public Acceptance

In June 1975 the state of Nebraska began pumping Gasohol at a service station in Holdrege. This test marketing was called the Holdrege Gasohol consumer acceptance test and marketing survey and was conducted by the APIUC. Each purchaser of Gasohol recorded his or her name, address, occupation, age, make and year of vehicle, and number of gallons purchased on a data card. In addition, comparative sales records were kept comparing sales of Gasohol to those of regular, premium and no-lead gasolines. The station pumped its 20,000-gallon allotment of Gasohol within the first two weeks of June. An additional allotment of 20,000 gallons was ordered and sold before the end of June. It was decided to continue the experiment with an additional allotment of 63,000 gallons. By about mid-July, sales reached more than 1,900 gallons per day for almost a week. Sales then slacked off to a daily average of 1,000 to 1,300 gallons per day in mid-August. The majority of the time, the sale of Gasohol was double that of regular

gasoline and triple those of premium and no-lead gasoline. It was estimated that 1,600 to 1,700 people purchased some 93,000 gallons at Holdrege by mid-August.

The data cards were computerized into a mailing list. Each purchaser was then sent a questionnaire to ascertain attitudes, preferences, and details on performance and fuel consumption. Of the 1,425 questionnaires mailed 700 were returned. In general, the responses to specific questions on Gasohol and gasoline marketing were very favorable toward Gasohol. Customers reported increased mileage and good performance with Gasohol. The APIUC concluded from this project that there definitely was a market for Gasohol in Nebraska.

Since the Holdrege marketing survey was done, similar surveys have been conducted around the country and Gasohol is being sold in a number of states. The experiences of several of these states will be noted in subsequent sections of this report. As of March 3, 1978, Gasohol continued to be sold at the pump in Lincoln, Nebraska, for 69.9¢ per gallon, which compares with 62¢ to 72¢ per gallon for unleaded gas.

THE NATIONAL GASOHOL COMMISSION

The National Gasohol Commission was legally incorporated on June 5, 1978, as a corporation not for profit under Nebraska Revised Statutes 21-1901 ff., also known as the Nebraska Non-profit Corporation Act. The purpose of this corporation is to encourage use of agriculturally derived alcohol-blended fuels as a viable energy source by (a) developing, accumulating and disseminating information concerning alcohol-blended fuels; and (b) exploring, analyzing and coordinating federal and state legislature and administrative policies, programs, and procedures to maximize the use of alcohol-blended fuels. Members consist of state representatives (usually 3 to 7 individuals per state) and private persons or organizations who agree to contribute financially to the corporation. An annual meeting is held to elect officers and transact business. Management of the corporation is confided in a board of directors (3 persons from each state) who meet at least twice a year. The corporation has as its officers a president, vice-president, secretary, treasurer and a member-at-large.

At the June 14 meeting of the Commission, Holly Hodge of Nebraska's APIUC was elected president. The Commission headquarters is in Lincoln, Nebraska, and the office is open during regular business hours Monday through Friday. The Commission

has also achieved tax exempt status thus allowing businesses, corporations, or individuals to deduct membership contributions. As of this writing the Commission consists of 19 states but hopes to grow until eventually it includes all 50 states.

WHAT THE OIL COMPANIES SAY

The major opponents of Gasohol are the oil companies. Several of the nation's largest, including Amoco and Mobil, are skeptical of Gasohol on the basis of the same arguments advanced by other opponents — poor economics, negative energy balance, potential distribution and operational problems, and failure to give much help to the farmer. The American Petroleum Institute (API), which has been following the production and use of Gasohol for years, has reconstituted its alcohol fuels task force and recently commissioned Battelle Columbus Laboratories to make an "outside objective" analysis of alcohol fuels. In April 1978, API released its policy statement on alcohol fuels, stating that it favors developing all potential domestic energy sources, including alcohol fuels.⁽²¹⁾ It thinks that it's possible to reduce alcohol production costs and recommends more research. API and its member companies do not recommend that the use of alcohol fuels be mandatory, but rather that the choice of fuels be left up to the consumer.

The oil companies argue that the United States is several years away from an economical conversion of agricultural products into fuel. Amoco, for example, has been working on shale oil, liquefied coal, and tar sands, which it deems as better fuel source alternatives than agricultural products. It also pointed out at the recent senate committee hearings on the economic feasibility of Gasohol, however, that studies under way in the alcohol fuels area should continue. Amoco cited production expense, impact upon the nation's food supply, and energy efficiency as those issues which need to be resolved before alcohol fuels can become a marketable commodity.

Mobil Oil has generated much research concerning the use of methanol to fuel automobiles. Recently, it revealed a process for the conversion of methanol directly into gasoline, which it calls the final link between coal and gasoline.⁽²²⁾ Mobil points out that it has for several years been conducting research on alcohol fuels and feels confident that methanol produced from coal is more desirable as a fuel than is ethanol from grain at this time. It adds that the United States is several years away from substantial use of the latter fuel sources, but that eventually the marketing of grain alcohol fuels will be viable.

One of the major arguments which the oil companies lodge against Gasohol production and use is that it will adversely affect the nation's food supply. Their charge is that to have a Gasohol program of any magnitude, Americans would have to give up eating wheat and corn. Oil companies and other opponents of Gasohol estimate about three-fourths of the U. S. 1977 corn crop would have been needed to produce 10% of the nation's ethanol-gasoline fuel requirements for 1978. This point has been rebutted basically from two standpoints. First, Gasohol proponents point out that anywhere from 70% to 90% of all corn produced in this country is fed to livestock. That amount could be used in the production of alcohol without affecting the supply eaten by people, and the by-product remaining would be equal in nutrition and nearly equal in volume to the original corn grain and would be used as cattle food. Secondly, USDA figures show that 17.3 million acres are currently in the set-aside and diversion program sponsored by the United States government. Gasoholics contend that if this acreage were planted at 95 bushels per acre per year, the yield would be 1,600 million bushels of corn from which some 4 billion gallons of alcohol could be produced. That's about 40% of the projected 10 billion gallons needed for a 10% alcohol mixture in all U. S. gasoline pumped annually. (23)

ACTIVITIES OF OTHER STATES

In keeping with the objectives of the study it is felt that a brief state-by-state synopsis of nationwide Gasohol activities will help to point out the magnitude of the Gasohol movement.

Alabama

Albert Turner of the Southwest Alabama Farmers Coop Association has built an alcohol plant in Selma out of junk at a cost of less than \$12,000. The total cost for a 90-gallon batch of alcohol in this operation is approximately \$160 and the income is approximately \$167 per batch, which results in about a 9¢ per gallon profit. Turner envisions the day when a circular process for creating energy can be maintained whereby corn is processed in the distillery, the mash is fed to the livestock, and the manure from the livestock is used to produce methane gas, which would be used to heat the distillery. The CO₂ by-product would then be used in greenhouses to produce vegetables for marketing. The residue from the manure could then be used as fertilizer for the corn, thus renewing the cycle. Gasohol is being retailed in Alabama.

California

In California, an automobile which burns 100% alcohol has been tested with good results on exhaust emissions.

Colorado

In Colorado a Gasohol task force has recently been formed. Gasohol is being sold at the pump with a 5¢ per gallon reduction in the excise tax. A bill was recently passed formulating an official Gasohol Task Force Committee to be appointed by the Governor. The bill also appropriated \$80,000 to promote Gasohol. Several prospective developers are interested in building ethanol plants in Colorado, and it is expected that Colorado will be producing 50 million gallons of alcohol annually by 1981. The state presently has no filling stations selling Gasohol.

Idaho

A 40 member statewide Gasohol commission has been formed in Idaho. It consists of representatives of agricultural groups (potato growers, wheat commission, etc.), all farm organizations, and all educational institutions. Senator James McClure has introduced several bills to further the production of Gasohol. In addition, Senator Frank Church is sponsoring a bill calling for a nationwide Gasohol program in 1990 (see succeeding section of this report).

Indiana

Purdue University is devoting much time and money to research on cellulose conversion in which ethanol is extracted from biomass materials. In addition, Senator Birch Bayh has introduced a bill to establish a National Alcohol Fuels Commission (see succeeding section of this report).

Illinois

Gasohol is presently being sold at 70 locations in Illinois. Tipco, Inc. is supplying ethanol made from cheese whey from Janeau, Wisconsin. A state Gasohol commission has been established to promote Gasohol. Senator Charles Percy has taken an active roll in the Gasohol movement, noting in a recent address to the National Gasohol Commission that by 1985 the United States will need 48 million barrels of oil per day. Current projections are that the country will be short

about 6 million barrels per day. Senator Percy noted the inclusion of alcohol into our fuel supply would certainly help to alleviate such a shortage.

Iowa

From July 1 to September 15, 1978, Gasohol was marketed at 11 locations in Iowa. Five of these locations were chosen to be a part of a consumer acceptance study. Early results of that study indicated 10% to 15% of the motoring public in Iowa would use Gasohol one or more times. In addition, the Iowa legislature exempted Gasohol from the state's gasoline sales tax for the next five years. It continues to be sold at the pump at 49 locations.

Kansas

In Kansas, three pieces of legislation relating to Gasohol have been introduced. One calls for a 5¢ per gallon tax exemption, the second calls for the establishment of a commission similar to that in Nebraska, and the third calls for accelerated amortization of the costs of Gasohol plants.

Michigan

Michigan has established retail outlets for blends of 190 proof cheese whey alcohol from Peoria, Illinois, and unleaded gasoline. In early October farmers consulted with engineering firms regarding the construction of an agricultural alcohol plant. Sugar beets, potatoes, and corn are the feedstocks being considered for use.

Minnesota

The University of Minnesota is testing Diesohol in Diesel engines. There are negotiations under way with Conex and Land O'Lakes Cooperatives to supply a low octane fuel for Gasohol. Gasohol is being retailed in Olivia. Owners of one sugar beet plant are attempting to secure a \$16 million loan for the construction of a Gasohol plant. In addition, a group of private individuals are negotiating to build a Gasohol plant and 2 small plants are in the planning stages.

Missouri

A group of 200 farmers in Missouri recently formed a company called American Agri-Fuels, Inc. and voted to build the first ethanol distillery ever designed solely to produce alcohol for motor fuel. An engineering firm from Vienna, Austria, has contracted to do all necessary feasibility and engineering studies, which include construction of the plant. Four potential plant sites have been identified. State legislation is being proposed to exempt the 7¢ state gasoline tax for Gasohol users. Gasohol is being sold at 3 outlets in Missouri.

Montana

The W.I.F.E. (Women Involved in Farm Economics) organization spearheaded a Gasohol Caravan from Montana to Washington, D. C. to promote Gasohol in 1977. State Senator Harold Dover successfully obtained a grant from the Montana legislature in 1977 to promote and research alcohol production from wheat and other agricultural products. A state Gasohol committee has been formed. Gasohol is being sold at 15 retail outlets in Montana.

Nebraska

Besides spearheading the entire Gasohol movement, Nebraska is marketing Gasohol at 5 locations and continues to strive for the construction of an ethanol plant. Three entities have submitted final applications for the USDA Alcohol Pilot Plant Program. (The USDA office in Washington reports that 30 applications have been received.) All applicants are competing for four \$15 million guaranteed loans to build Gasohol plants. The Secretary of Agriculture and the Commodity Credit Board will make a decision before the end of the year as to whether any of the 30 applicants are eligible for the loan provided for in the 1977 Farm Act to build alcohol plants.

New York

In New York State a 90%-10% gasoline-alcohol blend would save 600 million gallons of petroleum per year. The state is examining the economic and technical feasibility of the use of alcohol blends. The state legislature has passed a bill to test Gasohol in state vehicles. If the test results are positive a mandate will follow requiring the use of Gasohol in the entire New York state vehicle fleet.

North Dakota

In North Dakota legislation has been introduced requesting an investigation of the feasibility of using Gasohol. A \$1,500 check sent to the National Gasohol Commission by the state of North Dakota was the first money the Commission received.

Pennsylvania

A Pennsylvania firm, MAR-CAM Industries, Inc., recently completed a 5,000-mile-road test using Gasohol in the eastern United States. That company is marketing Gasohol on the East Coast and has established a retail outlet in Alexandria, Virginia (see later section of this document).

South Dakota

Legislation was introduced to fund a program for Gasohol development in South Dakota but died in committee. A legislative research study was set up, however, and there are plans to reintroduce Gasohol legislation.

Texas

The Texas legislature has appropriated \$1.5 million to support research into alternative sources of energy. One project by the Dow Chemical Company is studying the manufacture of ethyl alcohol from algae. This product will be blended and used in Texas Department of Agriculture vehicles in the Houston area. A bill has been drafted calling for an exemption on the state gasoline tax for Gasohol users.

Washington

The Washington legislature has approved the construction of a Gasohol plant. This plant will probably be erected in one of the state's port cities.

Wisconsin

Wisconsin has established 6 retail outlets for dispensing blends of 190 proof cheese whey alcohol from Peoria, Illinois, and unleaded gasoline. A Gasohol marketing survey is being conducted by a large corporation.

Wyoming

The State Chamber of Commerce in Wyoming is investigating the feasibility of using Gasohol, and legislation to provide financing for Gasohol research was recently introduced. This bill, noting Wyoming's large mineral wealth, would put a 1/2 of 1% severance tax on all minerals in the state. This tax would provide \$20 million in the first biennium and \$40 million in the second biennium for financing Gasohol research and Gasohol plants.

ACTIVITIES OF FOREIGN COUNTRIES

West Germany

During 1975 and 1976, 45 Volkswagens and Audis were run some 1.5 million kilometers on a fuel called M15, which is 15% alcohol and 85% petroleum. The test cars were driven in extreme cold and extreme heat, and were found to run well on the mixture. Tests by Mercedes-Benz showed that an engine running on alcohol produces one-fourth the carbon monoxide and less than one-tenth the nitrous oxides of the same engine burning gasoline.

Sweden

The Swedish government and Volvo have set up a company whose sole function is to study the uses of alcohol fuel. Since two-thirds of the petroleum used in Sweden is imported, the Swedes feel a bit edgy about being so dependent on others for vital fuels. Volvo is running test cars on a blend of 18% methanol and 80% lead-free gasoline, with 2% isobuthanol added to help keep the two fluids properly mixed. Sweden is also working on a program to run methanol in diesel engines since 99% of their trucks are diesels.

Brazil

For the past year in Brazil, hundreds of state owned cars have been powered by alcohol. In half a dozen major cities Brazilians now fill their tanks with Gasohol which is a mixture of 80% gasoline and 20% ethyl alcohol. Use of the mixture requires no modification of the engine. By 1980, when alcohol production in Brazil is expected to reach 1 billion gallons annually, all pumps are to offer only Gasohol or alcohol. It is predicted that by 1981 more than 16% of all cars built in Brazil — currently 1 million per year — will come equipped with engines

that burn pure alcohol. The alcohol produced there is derived from sugar cane and manioc plants.

MARKETING GASOHOL ON THE EAST COAST:
THE MAR-CAM EXPERIMENTS

On Wednesday, June 14, 1978, Senators Charles Percy and Frank Church added the first alcohol to a car that was to be test driven by MAR-CAM Industries. The car was an unmodified 1978 Toyota and the mixture was 15% ethanol and 85% lead-free gasoline. The test drive covered over 17,500 miles in 25 states with no driveability problems whatsoever. Carbon monoxide emissions were cut to zero and hydrocarbons to 20 parts per million at idle and 10 parts per million on the open road. Those figures compare to normal emissions of 30 parts per million at idle and 60 parts per million on the highway for gasoline.

Noting that Gasohol has been retailed in Illinois for over a year and that there are 65 Gasohol stations in 8 midwestern states with no consumer complaints or problems, MAR-CAM decided to attempt to market Gasohol in the eastern United States, and established an office in Washington, D. C. to facilitate a plan for marketing Gasohol there. The first major East Coast delivery of alcohol for Gasohol use was received at Fannon Petroleum in Alexandria, Virginia, on October 31, 1978. The 192 proof alcohol was produced by the Archer-Daniels Midland Company in Decatur, Illinois, in conjunction with the Technical Industrial Products Company of Peoria. The retail price is 72.9¢ per gallon, which is comparable to the Washington area retail market price of 89.5 octane no-lead gasoline.

In a recent development, the National Gasohol Commission has let a contract to MAR-CAM Industries for the development of a fully integrated and coordinated marketing plan for Gasohol. Areas to be covered are 1) public relations, 2) public service media, 3) organization and development of direct mail solicitation of funds, and 4) a corporate development program.

FEDERAL LEGISLATIVE ACTIVITIES INVOLVING GASOHOL

The Gasohol Motor Fuel Act of 1978

The Gasohol Motor Fuel Act of 1978 was submitted by Senator Frank Church of Idaho. The bill establishes a timetable for bringing Gasohol into the market. It directs the Secretary of Energy to formulate a program which will commence blending alcohol

from renewable resources into gasoline by 1981. The percentage of alcohol blended is to be steadily increased until a 10% alcohol - 90% gasoline blend becomes available nationwide. Passage of such a bill will put the burden for production and distribution of renewable-resources alcohol directly on oil refineries.

Specifically, the bill calls for the Secretary of Energy, in consultation with the Secretaries of Transportation, Agriculture, Commerce and other appropriate agencies, to conduct a 6-month study to determine (1) the most suitable raw materials for the production of alcohol motor fuel, and (2) the nature of the alcohol motor fuel distribution systems and the various production processes using feedstock other than petroleum and natural gas that will be necessary for the rapid development of an alcohol motor fuel industry. The production goal for alcohol motor fuel beginning in 1981 shall be not less than 1% by volume of the projected consumption of gasoline used as a motor fuel in the United States for that year. That production goal shall proceed to 5% by 1985 and to 10% by 1990. Failure to meet these blend requirements shall result in a \$1 per gallon fine for each gallon that is not in compliance.

The National Alcohol Fuels Commission

A bill introduced by Senator Birch Bayh of Indiana proposes to form a National Alcohol Fuels Commission to help to formulate a comprehensive national policy in the development of alcohol fuels as an alternative energy source. The Commission will be comprised of 19 members - 12 members of Congress and 7 public experts appointed by the President of the United States. The Congressional delegation would comprise an equal number of members each from the House and Senate committees on agriculture, appropriations, and energy. This Commission will put together, for the first time, elected representatives and experts from industry, labor, agriculture and consumer groups to take a close look at alcohol fuels and how they can best be put to beneficial use.

Amendments to the Food and Agriculture Act of 1977

In May of 1977, Nebraska members of Congress introduced an amendment providing for guarantees on four loans of up to \$15 million each for the construction of industrial hydrocarbon or alcohol plants in the United States. The amendment also provides for \$24 million worth of grants to be allocated to land grant colleges and universities for research on the processes and by-products of hydrocarbon or agricultural alcohol

production. The USDA is presently implementing this program at a deliberate pace.

An amendment introduced by Senator James McClure of Idaho proposes to increase the number of guaranteed loans for pilot alcohol manufacturing facilities (see above) from 4 to 25. Providing loans for 25 plants rather than 4, the legislation states, seems a little more realistic when one realizes that it would take 500 plants producing 20 million gallons annually to furnish the alcohol needed for a 10% mixture with all gasoline used in the country. The proposed amendment will make it less likely that a decision concerning which four applicants will receive the loans will be based partly on the influence of their respective congressional delegations.

The Clean Air Act of 1977

According to the Clean Air Act of 1977, the marketing of alcohol fuel blends is prohibited after September 15, 1978. On September 6, 1978, the Environmental Protection Agency (EPA) convened a hearing to gather information on the effects of Gasohol on automobile emission control systems. The EPA, in a decision on September 15, 1978, decided not to enforce the mandatory ban on alcohol fuels until a final decision can be reached by December 16, 1978. The EPA also hopes to obtain clarification of the intent of Congress in passing this statute. Only fuels that are substantially similar to those fuel additives used in the 1975 or subsequent model year vehicle engines are affected by this amendment. If the statute is written as is, it restricts the manufacturers of gasoline to the use of only gasoline or products that are substantially similar, unless the auto industry certifies that additives can be used in their automobile engines or the EPA grants a waiver for the specific additive. The intent of the statute was to restrict the amount of manganese (an octane booster) which can be used in unleaded gasoline (lead has for years been used to boost the octane of leaded gasoline).

Opponents of this portion of the Clean Air Act plan to prove to the EPA that the intent of the Act was not to limit the use of Gasohol. They further plan to persuade Congress to either instruct the EPA to exempt Gasohol from this amendment or request that it pass legislation that will exempt Gasohol from the provisions of the Clean Air Act.

The National Energy Act of 1978

President Carter recently signed the National Energy Act, which consists of five separate bills. The Energy Tax Act of 1978 contains a provision exempting gasoline containing 10% alcohol made from renewable resources from the 4¢ per gallon federal highway tax. The tax exemption is effective from December 31, 1978, to October 1, 1984, and should stimulate production and sale of Gasohol by giving it an economic advantage over gasoline. Although Gasohol is already priced competitively with premium grades of gasoline, the 4¢ exemption will no doubt expand the market for Gasohol by making it competitive with regular grades of gasoline.

Proposal to the National Gasohol Commission

A proposal was recently received at the Commission office in Lincoln, Nebraska, which would initiate a pilot test program that will allow every state to prove the technical and economical feasibility of Gasohol at a cost far below that for some of the ongoing energy programs in the United States today. Recommendations for the National Gasohol Program are as follows:

- 1) To enact federal legislation to provide each state with a \$20 million federal loan guarantee to build an alcohol plant.
- 2) To enact a 4¢ federal tax credit for each gallon of Gasohol sold in the United States.
- 3) To support legislation for tax credits in each state that will justify the economics of selling Gasohol in that state.
- 4) To appropriate the \$24 million for research on alcohol by-products that is in the present Farm Bill.

The Program further states that the federal loan guarantee will cost nothing if the Program works. The 4¢ tax credit will cost \$400 million for a production of 10 billion gallons of Gasohol per year. The Program indicates that this cost is far less than that for some of the ongoing energy programs by pointing out that the United States is currently paying Saudi Arabia over \$15 a barrel for oil that we are pumping into the ground as a strategic reserve. One billion barrels of this oil are being bought and it is expected that the total cost will be \$21 billion by the time the oil is pumped into salt domes.

REFERENCES

1. Scheller, William A., "Nebraska 2-Million Mile Gasohol Test Program", Sixth Progress Report, University of Nebraska, January 31, 1977, p. 1.
2. Lincoln, John Ware, Methanol and Other Ways Around the Gas Pump, Garden Way Publishing, 1976.
3. Sprinkel, Michael M., Investigation of the Use of Methanol-Gasoline Blends, Virginia Highway and Transportation Research Council, 1977.
4. The Nebraska Grain Alcohol Program, pamphlet published by the Agricultural Products Industrial Use Committee, Lincoln, Nebraska.
5. Ibid.
6. Scheller, William A., Tests on Unleaded Gasoline Containing 10% Ethanol - Nebraska's Gasohol, University of Nebraska, Presented at the International Symposium on Alcohol Fuel Technology - Methanol and Ethanol, Wolfsburg, Federal Republic of Germany, November 12-14, 1977, p. 2.
7. Ibid. p. 3.
8. Ibid. p. 2.
9. Scheller, William A., Sixth Progress Report, p. 9.
10. Ibid. p. 10.
11. David, Milton L., Geneva Hammaker, Robert J. Buzenberg, and John P. Wagner, Gasohol Economic Feasibility Study, Development Planning and Research Associates, Inc., Manhattan, Kansas, 1978, pp. 4-7.
12. Scheller, William A., The Nebraska Gasohol Program, Providing Food and Fuel for the Future, University of Nebraska, November 1976, p. 3.
13. Ibid.
14. Scheller, William A., The Production of Ethanol by the Fermentation of Grain, University of Nebraska, Presented at the International Symposium on Alcohol Fuel Technology - Methanol and Ethanol, Wolfsburg, Federal Republic of Germany, November 12-14, 1977, p. 2.

15. Ibid. p. 3.
16. David, et al., op.cit. p. 17.
17. Anderson, Earl V., "Gasohol: Energy Mountain or Molehill?" in Chemical and Engineering News, July 31, 1978, p. 9.
18. David, et al. op. cit., p. 18.
19. Scheller, William A., The Use of Ethanol-Gasoline Mixture for Automotive Fuel, University of Nebraska, Presented at the Symposium Clean Fuels from Biomass and Wastes - Institute of Gas Technology, Orlando, Florida, January 1977.
20. Committee on Agriculture, Nutrition and Forestry, Subcommittee on Agricultural Research and General Legislation, Hearing of December 12, 1977, Indianapolis, Indiana, U. S. Government Printing Office, 1978.
21. Anderson, op. cit. p. 12.
22. Ibid.
23. Gasohol, The Renewable American Liquid Solar Fuel, a pamphlet published by Mar-Cam Industries, 1978.

SELECTED BIBLIOGRAPHY

- "A Barrel of Trouble for the Whiskey Makers," Business Week,
March 10, 1973, 112-114.
- "A New Look at an Old Fuel-Alcohol," in New Concepts in Urban
Transportation, Transportation Research Board, April 1978.
- Agricultural Marketing Service. Grain Market News, USDA,
July 8, 1977.
- _____. Grain Market News, USDA, November 18, 1977.
- "Alcohol: A Brazilian Answer to the Energy Crisis," Science,
February 11, 1977, 564-566.
- Allvine, Fred C., and James M. Patterson. The Marketing of
Gasoline, Bloomington: Indiana University Press, 1972.
- American Petroleum Institute. Alcohols, A Technical Assessment
of Their Application as Fuels, Publication No. 4261,
July 1976.
- American Petroleum Institute. Income Tax Policy for the
Petroleum Industry During the 1970's, undated.
- _____. Petroleum Facts and Figures 1971 Edition. Baltimore:
Port City Press, 1971.
- _____. Petroleum Taxation and Energy Independence: Are
Percentage Depletion and the Foreign Tax Credit Obsolete?
June 1974.
- _____. Use of Alcohols in Motor Gasoline--A Review,
Publication No. 4082, August 1971.
- American Society for Testing and Materials. Significance
of Tests for Petroleum Products, Tallahassee, Florida:
American Society for Testing and Materials, January 1977.
- Anderson, Carl J. Bisolar Synfuels for Transportation,
Lawrence Livermore Laboratory, University of California,
ERDA, January 17, 1977.
- Anderson, Jack. "Exon charged with stall on Gasohol,"
Lincoln Star, August 13, 1977, 4.
- Bartlesville Energy Research Center. Interim Report "Gasohol"
Test Vehicles, DOE, August 1977.

- Battelle-Columbus Laboratories. Systems Study of Fuels from Sugar Cane, Sweet Sorghum, and Sugar Beets, Volumes II, III, IV, and V, sponsored by ERDA, December 1976.
- Battelle-Pacific Northwest Laboratories. An Analysis of Federal Incentives Used to Stimulate Energy Production, DOE, March 1978.
- Beresford, Hobart, and Leo M. Christensen. "The Production of Ethyl Alcohol from Culled Potatoes and Other Farm Crops," Bulletin No. 241, Agricultural Experiment Station, University of Idaho, September 1941.
- Bonner & Moore Associates, Inc. A Formula for Estimating Refining Cost Changes Associated with Motor Fuel Reform-illation, Draft, January 13, 1978.
- Breimyer, Harold F. "Industrial Alcohol from Crop Materials: The Gasohol Issue," Economic and Marketing Information for Missouri Agriculture, July 1978.
- Brinkman, N. D., N. E. Gallopoulos, and M. W. Jackson. "Exhaust Emissions, Fuel Economy, and Driveability of Vehicles Fueled with Alcohol-Gasoline Blends," Paper 750120, Society of Automotive Engineers, February 1975.
- Bureau of Alcohol, Tobacco and Firearms. Distribution and Use of Denatured Alcohol and Rum, June 1975.
- _____. Distribution and Use of Tax-Free Alcohol, November 1972.
- _____. Formulas for Denatured Alcohol and Rum, April 1977.
- _____. Regulations Under the Federal Alcohol Administration Act, July 1973.
- Cassady, Philip E. "A Review of the Use of Methanol as a Motor Vehicle Fuel," Mathematical Sciences Northwest, Inc., undated.
- Cassady, Ralph Jr., and Wylie L. Jones. The Nature of Competition in Gasoline Distribution at the Retail Level, Berkeley: University of California Press, 1951.
- Chevron Research Co., "Alcohols and Motor Fuels -- The Promises and the Problems," December 1977.
- _____. "Alcohols as Fuel for Highway Vehicles," Working paper, undated.
- _____. "Economics and Energy Use -- Alcohols for Motor Fuels," (table) December 1977.

- Colorado Gasohol Task Force. Production and Marketing of Alcohol Motor Fuels from Colorado Agricultural Commodities: A Tentative Description, January 31, 1978.
- . Production and Marketing of Alcohol Motor Fuels from Colorado Agricultural Commodities: A Tentative Description, Vol. 2, USDA, April 15, 1978.
- Colucci, Joseph M. Statement of General Motors Corporation to the Senate Appropriations Committee on Alcohol Fuels, January 31, 1978.
- A Compliance Guide for Domestic Crude Oil Pricing for Producers and First Purchasers, EEA, April 1977.
- "Corn-base Automobile fuel is promoted at Dayton Stop", Columbus Citizen-Journal, July 25, 1978.
- Corcoran, W. P., A. T. Brackett, and F. Lindsey. Indiana Grain Fermentation Alcohol Plant, Indianapolis Center for Advanced Research, 1976.
- Council for Agricultural Science and Technology. Energy Use in Agriculture: Now and for the Future, Report 68, August 1977.
- Cox, Tom. "Grow Your Own Gasoline," The Country Gentlemen, Winter 1976, reprint.
- Cray, Cloud L., Jr. (President of Midwest Solvents), remarks presented at Gasohol Seminar in Brazil, September 1977.
- Crop Reporting Board, "Potato Stocks," Economics, Statistics and Cooperatives Service, USDA, April 11, 1978.
- Crossland, Janice. "Ferment in Technology," Environment, December 1974, 17-20 and 25-30.
- Cummings, D. R., and W. M. Scott. "Dual Fueling the Truck Diesel with Methanol," Proceedings, International Symposium on Alcohol Fuel Technology -- Methanol and Ethanol, Wolfsburg, Germany, November 21-23, 1977.
- Development Planning and Research Associates, Inc. Economic Analysis of Effluent Guidelines--Miscellaneous Foods and Beverages Industry, Vol. 2, Beverage Industry, Environmental Protection Agency, March 1977.

- . Economic Impact of Proposed Effluent Limitation Guidelines on Beet Sugar Industry, EPA, Washington, D. C., August 1973.
- . Economic Impact of Water Pollution Controls on Selected Food Industries, Vol. 4, The Fruits and Vegetable Processing Industry, National Commission on Water Quality, November 1975.
- . Supplementary Economic Impact Analysis of the Wet Corn Milling Industry, EPA, Contract No. 68-01-3855, Task 1, October 1977.
- . Energy Efficiency Improvement Targets, Food and Kindred Products Industry, FEA, June 30, 1976.
- Domestic Technology Institute. Executive Summary and Support Materials of the Integrated Solar Food and Ethanol Fuel Production System, Department of Commerce, 1977.
- Duncan, Marvin, and Kerry Webb. "Energy and American Agriculture," Economic Review, Federal Reserve Bank of Kansas City, April 1978, 3-14.
- Ecklund, Eugene E. (ERDA), "Gasohol - An Alcoholic Dilemma?" Nebraska Midwest Regional Gasohol Conference, November 1, 1977.
- "Economic Feasibility of Gasohol," Hearing, the Subcommittee on Agricultural Research and General Legislation, Committee on Agriculture, Nutrition, and Forestry, United States Senate, December 12, 1978.
- "Energy: Brazil Sells a Strategy Among Options," Science, February 11, 1977, 566-567.
- "EOK Proposes Deregulation of Gasohol Prices," Chemical and Engineering News, April 24, 1978, 21.
- "EPA Letter Casts Shadow on Gasohol's Future as Motor Fuel," NPN Bulletin, March 6, 1978, 1.
- "Ethylene," Chemical and Engineering News, November 7, 1977, 11.
- Exxon Company. Competition in the Petroleum Industry, presented before the Senate Judiciary Subcommittee on Anti-trust and Monopoly, January 21, 1975.
- Federal Energy Administration. Monthly Energy Review, July 1977.

Federal Grain Inspection Service, 1976 Crop Quality Reports,
USDA, 1977.

. The Official United States Standards for Grain,
USDA, July 1977.

Fleming, Harold M. Gasoline Prices and Competition, New York:
Meredith Publishing Company, 1966.

Francke, Dan. "National and Regional Trends in Cropland Use
Under Alternative Demand Scenarios," Environmental
Implications of Trends in Agriculture and Silviculture,
Working Paper, Development Planning and Research
Associates, January 9, 1978.

Fricke, Charles R., "A General History of the Nebraska Grain
Alcohol and Gasohol Program," Proceedings of Symposium
on Utilization of Alternative Fuels for Transportation,
Santa Clara, California, June 19-23, 1978.

Fried, Edward R. and Charles L. Schultze, ed. "Living with
Higher Oil Prices," The Brookings Bulletin, Fall 1975.
Excerpted from Higher Oil Prices and the Work Economy:
The Adjustment Problem, Washington, D. C.: The Brookings
Institution, November 1975.

Fuels for Biomass Program: Program and Status Report, ERDA,
November 1976.

"Gas Guzzlers Becoming Alcoholics in Brazil," The Washington
Post, August 30, 1978.

Gasohol News, distributed at the Nebraska-Midwest Regional
Gasohol Conference, Nebraska Center for Continuing
Education, November 1-2, 1977.

"Gasohol Not Banned Yet", Richmond Times-Dispatch, September
29, 1978.

"Gasohol plan called a 'loser'," Spokesman-Review, November 13,
1977, B-14.

"Gasohol remains energy guzzler," The Iowa Stater, February 1978.

"Gasohol, Renewable Energy for America," Special Report prepared
by Senator Birch Bayh, distributed at National Gasohol
Commission Meeting, Washington, D. C., June 12-14, 1978.

Gasohol Task Force. Report on Use of Alcohol as Fuel:
Simplified Requirements, Bureau of Alcohol, Tobacco
and Firearms, May 1978.

- "Gasohol: Toyota dealer claims alcohol and driving can combine to clean air, cut oil imports, Dayton Ohio Journal Herald, July 25, 1978.
- "Gasoline Firms in Major Struggle," Kansas City Star, May 24, 1978, 16A.
- Glickman, Dan. "Glickman Blasts Attacks on 'Gasohol'," Congressional Press Release, December 5, 1977.
- "Grain Alcohol as Fuel," Amoco Issues Forum, March 9, 1978.
- Gratch, Serge, Chemical Science Laboratory, Ford Motor Company, Statement Before the Senate Committee on Agriculture, Nutrition, and Forestry, December 12, 1977.
- Gregory, Derek P., and Robert B. Rosenberg. "Synthetic Fuels for Transportation and National Energy Needs," Paper 730520, Society of Automotive Engineers, February 1975.
- Hagey, Graham, Andrew J. Parker, Daniel L. Raley and Thomas J. Timbario. "Methanol and Ethanol Fuels -- Environmental, Health and Safety Issues," DOE, undated.
- Heichel, G. H. "Agricultural Production and Energy Resources," American Scientist, February 1976, 64-72.
- Henze, Mark. "Alcohol: A Liquid Fuel for the Future?" Chemical News, January 1, 1978, 2-4.
- "Hill Passage of 'Gasohol' Tax Cut Seen," The Washington Post, June 29, 1978.
- Holmer, E. "Methanol as a Substitute Fuel in the Diesel Engine," Proceedings, International Symposium on Alcohol Fuel Technology -- Methanol and Ethanol, Wolfsburg, Germany, November 21-23, 1977.
- Holmes, Michael. "Gasohol called costly energy use," Omaha World-Herald, October 21, 1977.
- Hooks, R. W., K. H. Reders, and A. A. Reglitzky. "Gasoline-Methanol Fuels; Blending Optimization with Respect to Manufacturing Economics and Engine Performance," Deutsche Shell AG, PAE - Labor, Hamburg, Germany, undated.
- Iowa Development Commission, Consumer Acceptance and Market Potential of Gasohol, October 1978.

- "Iowa to sell gasohol to consumers in research test," Feedstuffs, June 12, 1978, 26.
- Kansas Motor Carriers. "Distance Commodity Rates, Feed and Feed Ingredients," Tariff Department, Topeka, Kansas, December 16, 1977.
- Kapita, Gary, "Several stations in U. S. are now marketing Gasohol", The Minnesota Messenger, March 3, 1978.
- "Distance Commodity Rates, Grain and Seed," Tariff Department, Topeka, Kansas, December 16, 1977.
- "Petroleum Products," Tariff Department, Topeka, Kansas, December 16, 1977.
- "Kansas to ponder gasohol proposals," Lincoln Star, November 9, 1977.
- Kelly, Robert W. "Alcohol Fuels--Probable Effect of Reduction in Federal Motor Fuels Tax", Memorandum, Department of Energy, October 20, 1977.
- Kendrick, James. "Gasohol and Basic Economics," Cornhuskers Economics, Cooperative Extension Service, University of Nebraska, Lincoln, June 8 and 15, 1977.
- Kendrick, James, and Pamel J. Murray. "Alcohol-Blended Fuels: A Review of Current Literature and Conclusion," University of Nebraska, 1977.
- Kendrick, James. "Grain Alcohol in Motor Fuels," Report 81, Department of Agricultural Economics, Agricultural Experiment Station, University of Nebraska--Lincoln, April 1978.
- Klopfenstein, Terry, Whitney Rounds, and John Waller. "Distillers Feeds as Protein Sources for Beef Cattle," Proceedings, The Distillers Feed Research Council, March 31, 1976, 52-57.
- Klosterman, M. J., O. J. Banasik, M. L. Buchanan, F. R. Taylor, and R. L. Harrold. "Production and Use of Grain Alcohol as a Motor Fuel - An Evaluation," report for 44th North Dakota Legislative Session, October 1975.
- Lipinsky, E. S., "Fuels from Biomass: Integration with Food and Materials Systems," Science, February 10, 1978, 644-651.

- McCann, D. J., and H. D. W. Saddler. "Photobiological Energy Conversion in Australia," Search, January, February 1976, 17-22.
- Markarian, Albert E., "The Energy Crisis is Over," "40 Magazine and the League of Presidents," February 1978.
- Massachusetts Institute of Technology Energy Laboratory, Policy Study Group "Energy Self-Sufficiency: An Economic Evaluation," Technology Review, May 1974, 22-58.
- Merritt, Richard F., "Overdue Alternations to the Automotive Enemies List", Car and Driver, February 1978.
- _____. "The fuel they can grow for your car - alcohol," Modern Motor, October 1977.
- Miller, Dwight L. "Cereals as a Future Source of Industry Energy," Proceedings, of Seventh National Conference on Wheat Utilization Research, Manhattan, Kansas, November 3-5, 1971.
- _____. "Ethanol Fermentation and Potential," excerpt from C. R. Wilke, ed., Cellulose as a Chemical and Energy Resource, New York: John Wiley and Sons, 1975.
- _____. "Fuel Alcohol from Wheat," Proceedings, Seventh National Conference on Wheat Utilization Research, USDA, 1972.
- Mitre Corporation. Survey of Alcohol Fuel Technology, Vol. I and II, prepared for NSF, November 1975.
- "Mobil Proves Gasoline-from-Methanol Process," Chemical and Engineering News, January 30, 1978, 26-28.
- Moriarity, Andrew J. "Toxicological Aspects of Alcohol Fuel Utilization," Biomedical Resources International, Toronto, Canada, undated.
- Most, W. J., and E. E. Wigg. "Methanol and Methanol-Gasoline Blends as Automotive Fuels," presented at The Combustion Institute, Central States Section, Spring Meeting, Columbus, Ohio, April 5-6, 1976.
- Nebraska Legislature, Executive Board of the Legislative Council. First Biennial Report of the Agricultural Products Industrial Utilization Committee, 1971-1976.
- _____. Legislative Bill 52. Passed May 31, 1977.

- _____. Legislative Bill 776. Legislature of Nebraska, 1st Session, Passed May 26, 1971.
- Panchapakesan, N. R., K. V. Gopalakrishnan, and B. S. Murthy. "Factors That Improve the Performance of an Ethanol-Diesel Oil Dual-Fuel Engine", Proceedings, International Symposium on Alcohol Fuel Technology--Methanol and Ethanol, Wolfsburg, Germany, November 21-23, 1977.
- Peer, E. L., and F. V. Marsik. Trends in Refinery Capacity and Utilization, FEA, June 1977.
- Petersen, Bruce L. A Critique of Two Assessments of the Synfuel Commercialization Program, American Petroleum Institute, Critique #003, August 8.
- Proceedings, International Symposium on Alcohol Fuel Technology--Methanol and Ethanol, Vol. I, II and III, Wolfsburg, Germany, November 21-23, 1977.
- Proceedings, The Nebraska - Midwest Regional Gasohol Conference sponsored by Agricultural Products Industrial Utilization Committee, Lincoln, Nebraska, November 1-2, 1977.
- "Propylene," Chemical and Engineering News, November 7, 1978, 12.
- Reed, Thomas B. "Alcohol Fuels -- The Clean Renewable Substitute for Petroleum," the International Symposium on Energy Sources and Development, Barcelona, Spain, October 19, 1977.
- _____. "Questions and Answers on Alcohol and Gasohol Fuels," Testimony before the Senate Appropriation Committee, January 31, 1978.
- Reilly, Peter J. "Economics and Energy Requirements of Ethanol Production," Department of Chemical and Nuclear Engineering, Iowa State University, Ames, January 1978.
- _____. "Report on Corn Alcohol as a Fuel Additive," Iowa Farm Bureau Federation Energy Conference, Des Moines, Iowa, October 20, 1977.
- "Remember When They Said Never Mix Gasoline and Alcohol? That Combination May be a Fuel in the Nations Future," Dodge Adventurer, March/April 1978.
- Republican Conference, U. S. Senate. Alcohol: The Renewable Fuel from our Nation's Resources, A Technical and Economic Report on the Use of Alcohol as a Motor Fuel, October 1977.

Rose, Sanford. "The Far-Reaching Consequences of High-Priced Oil," Fortune, March 1974, 106-111 and 191-193.

Satterlee, Lowell D. "Enhancement of Food Protein Quality Through Computer Blending - The Competitiveness of Proteins from the Alcohol Fermentation of Corn and Wheat," The Distillers Feed Research Council Proceedings, March 31, 1976, 58-64.

Scheller, William A. "Agricultural Alcohol in Automotive Fuel-Nebraska Gasohol", Proceedings, 8th National Conference on Wheat Utilization Research in Denver, Colorado, October 1973.

_____. "Cost of Producing Grain Alcohol," Working Paper, undated.

_____. "Energy and Ethanol," Testimony presented at the U. S. Department of Energy Hearing on Gasohol, April 6, 1978.

_____. "The Nebraska GASOHOL Program Providing Food and Fuel for the Future - A Summary," Department of Chemical Engineering, University of Nebraska, Lincoln, November 3, 1976.

_____. "Nebraska Statutes - The Basis for the Gasohol Program," Department of Chemical Engineering, University of Nebraska, Lincoln, 1974.

_____. "The Production of Ethanol by the Fermentation of Grain," Presented at the International Symposium on Alcohol Fuel Technology, Wolfsburg, Federal Republic of Germany, November 12-14, 1977.

_____. "Production of Industrial Alcohol from Grain," Symposium on Fermentation in Cereal Processing, 61st National Meeting of the American Association of Cereal Chemists, New Orleans, October 5-8, 1976.

_____. "Tests on Unleaded Gasoline Containing 10% Ethanol," Department of Chemical Engineering, University of Nebraska, Lincoln.

Scheller, William A., and Brian J. Mohr. "Gasoline Does, Too, Mix with Alcohol," Chemtech., October 1977, 616-623.

_____. "Grain Alcohol--Process, Price and Economic Information," Department of Chemical Engineering, University of Nebraska, Lincoln, revised September 1976.

- _____. "Nebraska 2 Million Mile Gasohol Road Test Program -- First Progress Report," Department of Chemical Engineering, University of Nebraska, Lincoln, April 2, 1975.
- b. "Second Progress Report"; July 2, 1975.
- c. "Third Progress Report," October 2, 1975.
- d. "Sixth Progress Report," January 31, 1977.
- _____. "Net Energy Analysis of Ethanol Production," 171st National Meeting of the American Chemical Society, Division of Fuel Chemistry, New York, New York, April 7, 1976.
- _____. "Performance of an Ethanol-Gasoline Blend in Automobiles and Light Trucks," 16th National Meeting of the American Chemical Society Division of Fuel Chemistry, Philadelphia, Pennsylvania, April 9, 1975.
- _____. "Production of Ethanol and Vegetable Protein by Grain Fermentation," Department of Chemical Engineering, University of Nebraska, Lincoln, April 1975.
- _____. "Protein Concentrates from Distillers By-Products," Presented at Ninth National Conference on Wheat Utilization Research, Seattle, Washington, October 8-10, 1975.
- Schrock, Mark. "Gasohol -- Myth or Miracle"? Energy Facts, Cooperative Extension Service, Kansas State University, Manhattan, Kansas, undated.
- Segal, Migdon R. "Methanol and Ethanol As Alternatives to Gasoline," Congressional Research Service, issue brief number 1B74087, updated, September 12, 1977.
- _____. "Methanol and Ethanol as Fuels--State of the Art as of July 1977," Congressional Research Service, undated.
- Sharp, Rodney L. "The Economic Feasibility of Converting Agricultural Commodities into Alcohol in Colorado," Colorado State University, (Agricultural Economics Staff Paper) August 1977.
- Simpson, Bruce H. "Improving the Measurement of Chassis Dynamometer Fuel Economy," Paper 750002, Society of Automotive Engineers, February 1975.
- Solomons, G. L. "Solvents from Carbohydrates: Some Economic Considerations," Process Biochemistry, April 1976, 32-33 and 37.

- Smith, Stephen M., M. L. Jackson, and Leonard Johnson. "The Feasibility of Gasohol: An Examination of the Issues," Report No. 202, Agricultural Experiment Station, University of Idaho, April 1978.
- Spencer, Warren H. "Fill'er Up - With Gasohol," Popular Mechanics, April 1, 1977.
- Steinhart, John S., and Carol E. Steinhart. "Energy Use in the U. S. Food System," Science, July 1974, 48-57.
- Stone and Webster Engineering Corporation. "Preliminary Economic Evaluation of Nebraska Grain Alcohol Plant," Agricultural Products Industrial Utilization Committee, State of Nebraska, December 1976.
- Stout, Bill A., Robert M. Peart, Wesley F. Buchele, and Edwin Finch. "Brazil Promotes PROALCOOL," Agricultural Engineering, April 1978, 30-33+.
- Stroup, Richard, and Thomas Miller. "Feasibility of Ethanol from Grain in Montana," Agricultural Experiment Station, Montana State University, Bozeman, Research Report No. 118, January 1978.
- "Synthetic Fuels: Where we Stand Today," Journal, Society of Automotive Engineers, October 1974, 38-43.
- Tinley, H. L. "Gasohol--It's in the Pumps in Brazil," Farm Journal, April 1978, H 8-9.
- Tsao, George T. "Utilization of Grain and Crop Residues for the Production of Fuel and Chemicals," Purdue University, West Lafayette, Indiana, undated.
- Turner, Mike. "The Nebraska Gasohol Program," Cornhusker Economics, Cooperative Extension Service, University of Nebraska, Lincoln, February 23, 1977.
- Tyner, Wallace E., and Martin R. Okos. "Alcohol Production from Agricultural Products: Facts and Issues", Cooperative Extension Service, Purdue University, January 1978.
- U. S. Department of Energy. Energy Information Administration. "Projections of Energy Supply and Demand and Their Impacts," Annual Report to Congress, Vol. 2, 1977.
- U. S. Energy Research and Development Administration, Alternative Fuels Utilization Report, No. 1, April 1977.

- University of Nebraska. "The Development of a High Protein Isolate from Selected Distillers By-Products," NSF, July 1975.
- Valmassei, Christine. "Gasohol: Boon or Boondoggle?" Illinois Farm Bureau Family, October 1977.
- Weaver, Rep. James, Oregon. "The 'Gasohol' Bill," Congressional Record, Extensions of Remarks, in the House of Representatives, March 7, 1978, E1097-E1099.
- Wigg, E. E. "Methanol as a Gasoline Extender: A Critique," Science, November 29, 1974, 785-790.
- Wise, John J. Statement by Vice President for Planning of Mobil Research and Development Corporation before the Senate Appropriations Committee, United State Senate, January 31, 1978.
- Wisner, Robert N., and Jerry O. Gidel. Economic Aspects of Using Grain Alcohol as a Motor Fuel, with Emphasis on By-Product Feed Markets, Iowa State University, June 1977.
- Zerschking, Lynn, "Gasohol Committee discusses study's due date," Lincoln Star, September 15, 1977.

