ETHANOL FUELS FOR ALBERTA

A Discussion Paper

Prepared For

The Honorable Peter Elzinga

Minister Of Agriculture

Prepared By

Ethanol Fuels Committee

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COMMITTEE REPRESENTATION

Representatives of the following government organizations contributed to the preparation of this report:

Alberta Agriculture

Alberta Economic Development and Trade

Alberta Energy

Alberta Grain Commission

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SUMMARY

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In September of 1987, the Honorable Peter Elzinga requested Alberta Agriculture and the Alberta Grain Commission to conduct an examination of the fuel ethanol concept with the objective of providing guidelines which could direct the Government of Alberta in developing related policy. Alberta Energy and Alberta Economic Development and Trade were subsequently invited to join in this examination.

Many individuals and organizations encourage government incentives for biomass ethanol production. In Alberta, this encouragement is based most often on the premise that ethanol production would provide a market for low priced and surplus feed grains, and that this ethanol would be a substitute source of octane to compensate for the gradual elimination of tetraethyl lead in gasoline. The fact that government incentives exist in other provinces of Canada and in other countries lends apparent support to the merits of such encouragement. There are other individuals and organizations who, with equal fervour, point out that there are sound reasons for allowing the marketplace to determine the form of our transportation fuel source.

This examination determined that there are positive and negative environmental effects from displacing hydrocarbons with alcohol in low-percentage alcohol-gasoline fuel blends in Alberta.

It was concluded that ethanol is technically suitable for a transportation fuel. Nonetheless, there are significant incompatibility problems with the existing fuel distribution system.

Ethanol is judged to be an unsuitable fuel source on the basis of economics when the wholesale price of gasoline is $0.20/litre and the price for barley if $80/tonne. It is clear that our domestic grain industry would benefit from the market provided to grain by an ethanol industry and that potential benefits would be available to our livestock industry. However, other groups could incur costs and evidence does not exist to demonstrate that fuel ethanol would provide a net positive economic benefit to the province.

Production costs for ethanol are at least twice as great as those for petroleum-based fuel and, even on an equivalent cost basis, ethanol will not be accepted by more than a small portion of Alberta's fuel marketers. The cost of government incentives required to make biomass ethanol attractive to either fuel refiners, fuel marketers, or the fuel-buying public is greater than the benefits that our agriculture industry would receive. It was also concluded that government incentives to biomass ethanol could not be temporary if ethanol-blended fuels were to continue to play a role in Alberta's transportation fuel needs.

Notwithstanding the foregoing, it may well be possible for aggressive fuel marketers to build market share by offering ethanol/methanol blended gasolines. This situation, where alcohol fuels develop on their own merit, should not be discouraged.

CONCLUSIONS

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1. The market for grains grown in Alberta will increase proportional to the production of ethanol. Ethanol production is dependent upon market acceptance of ethanol-blended gasoline.

2. Based on the information available, there are positive and negative environmental effects from displacing hydrocarbons with alcohol in low-percentage alcohol-gasoline fuel blends in Alberta.

3. The use of fuel ethanol does not reduce the level of safety associated with the handling of fuels.

4. Ethanol-blended gasoline can comply with current government regulations and legislation.

5. The minimum cost to the public treasury is greater than the maximum benefit to agriculture, and evidence does not exist to demonstrate that fuel ethanol would provide a net positive economic benefit for Alberta.

6. If fuel ethanol were to be cost competitive with gasoline, long-term net public financial support would be required.

7. Financial support greater than that currently offered for alternative transportation fuels would be required to support an ethanol industry in Alberta.

8. An ethanol industry would not be viable in Alberta when grain feedstock prices are equivalent to $75-80/tonne and the wholesale price of gasoline is $0.20/litre.

9. At these prices and in the absence of subsidies, the use of ethanol would result in an increase in fuel costs to the driving public.

10. Economic diversification and balanced regional growth within Alberta could be enhanced with an ethanol industry.

11. Although regional employment opportunities would be created by an ethanol industry, it has not yet been determined that the establishment of a fuel ethanol industry in Alberta would result in an increase or decrease in provincial employment.

12. Current refining and distribution procedures are not compatible with alcohol-blended fuels.

13. Vehicle manufacturer approval for ethanol blends has been increasing until only one manufacturer in 1986 was known to be prepared to void warranties if related mechanical problems developed.

14. There do appear to be some marketing barriers to larger gasoline marketers offering ethanol-gasoline or ethanol-methanol-gasoline fuel blends to their customers, such as concern about the method and cost of distribution, compatibility with other gasolines, current economics and a need to maintain a high level of customer satisfaction.

15. Subsidy criteria in other provinces and the U.S. make it unlikely that fuel ethanol producers in Alberta would be able to export their production.

RECOMMENDATION

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Based on the information available, the committee is of the opinion that the commercial or social economic considerations do not support the development through government incentives of a grain-based fuel ethanol industry in Alberta at this time.

A definitive answer would require additional information in the following areas:

1. More information is needed about the likely environmental and health effects of alcohol-gasoline fuel-blend volatility and emissions such as hydrocarbons, benzene, aldehydes and unburned alcohol. (Standards for oxygenated gasoline now are under development and, when complete, should resolve some concerns about alcohol-gasoline blend volatility.) More study of alcohol-gasoline fuel blend volatility and emissions concerns by Alberta Environment and Environment Canada may be appropriate.

2. A specific cost/benefit study for the Province of Alberta would be required to determine if a net economic benefit would result from an ethanol industry. A precise answer would require a complex and comprehensive examination.

3. Although the level of subsidy required to make ethanol equivalent to the wholesale cost of gasoline is less uncertain, the levels of additional subsidy required to entice different petroleum marketers to actually use ethanol is not known.

INTRODUCTION

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The concept of producing fuel ethanol from biomass and, more specifically, from cereal grains has captured the imagination of many people. Technology to accomplish the conversion of biomass starch to ethanol is certainly not a recent development and improvements to this technology are neither rapid nor dramatic. The reason for the resurgence of interest in the conversion of cereals to ethanol is not due to advances in process technology that have suddenly altered the economics of such conversion but rather are due to several unrelated factors.

1) A belief that a new market can be created for domestic cereal grains;
2) A perception that price levels for domestic grains would rise;
3) The recognition that regional development and diversification in non-urban areas would result;
4) Government environmental policy;
5) Concern over high petroleum-based fuel prices;
6) Discomfort with our national dependence on light oil imports.

All the foregoing are arguments that have provided the impetus at one time or another for increased interest in the fuel ethanol concept.

1) New markets for cereal grains - There is intense competition among grain exporting nations for international markets. New markets are increasingly difficult to find and established markets are increasingly difficult to preserve in the current competitive environment. An additional factor which limits market opportunities is the trend among many major grain importing countries to increase their level of domestic self-sufficiency. Given an uncertain future for export

grain markets, many grain growers view the market that a domestic fuel ethanol industry would provide as an attractive hedge against the international market risk.

2) Increased price levels for cereal grains - The current marketplace for grains is depressed, with market share being pursued by both traditional and new grain exporting nations. The tactics of nations engaged in this market share pursuit are simple--prices are lowered until the damage to national treasuries becomes too uncomfortable to continue further. Western Canadian grain farmers are among the most seriously affected by price declines because they are relatively less protected than farmers in many other grain exporting nations. The magnitude of the price decline for grains may best be illustrated using petroleum prices for comparison. Since 1970 cereal grain prices have increased by approximately 50%, whereas petroleum prices have increased 900% (both measured in current dollars). Many believe that, by creating a new domestic market for cereal grains by utilizing grain for ethanol production, increased demand will act to increase the general level of cereal grain prices.

3) Diversified regional development is a constant goal in Alberta. A widespread view is that ethanol production activity would be located in rural regions of the province since the transportation costs for grain used as the feedstock would be higher than the transportation costs of the ethanol and dried distillers grains (DDG) produced by the plants. Construction and permanent operating jobs would therefore be created in rural Alberta, providing economic strength to local communities.

4) Government environmental policy - Concern was raised during the last decade over deterioration in quality of our environment due to increased levels of air and soil-borne pollutants. These pollutants include carbon monoxide, hydrocarbons, nitrous oxides and lead which were all found in exhaust emissions of vehicles using petroleum-based fuels. A rigorous program of reducing exhaust emissions with the use of lean-burning engines fitted with catalytic converters was undertaken and this has substantially reduced the level of some pollutants entering the environment. The use of tetraethyl lead in gasoline as an anti-preignition agent, however, acts to foul catalytic converters and render them inoperative. In addition, lead itself is a persistent pollutant in our environment and is considered highly toxic. Because of these effects of leaded gasoline, national policy is to reduce lead levels gradually with the aim of eliminating lead from the national gasoline pool by the end of 1992. Since lead acts to increase the octane level of gasoline, removal of lead will result in gasoline with insufficient octane levels for adequate engine performance unless new sources of octane are developed. Since ethanol has an octane rating of 115 and it has the potential to reduce the emission level of some exhaust pollutants, it is viewed by many as a possible answer to the octane deficiency.

5) High petroleum-based fuel prices - Fuel buyers experienced ever-increasing fuel prices during the 1970's and early 1980's. To many it appeared that fuel price escalation was a persistent phenomenon and it appeared that, if increases in grain prices languished behind the rate of increase of petroleum prices, grain-based ethanol might become a cost-competitive alternative fuel option.

6) Dependence on oil imports - Canada's remaining supply of conventional and/or light oil reserves is in decline and our

dependence on imports of light oil to supply our domestic transportation needs is increasing. Although enormous reserves of tar sands and heavy oils exist, limited capacity is in place to convert these oils into transportation fuels. Ethanol produced from biomass sources is a domestic renewable source of energy and is believed to have the potential to reduce our national dependence on imported petroleum fuels.

If there are compelling reasons for the current interest in fuel ethanol, why has the opportunity not been seized by established chemical producers, petroleum or agricultural businesses or visionary entrepreneurs? Alberta has all of these groups, yet does not have a foundation fuel ethanol industry. The answer lies in a list of obstacles to fuel ethanol that are as convincing as the reasons favoring fuel ethanol.

1) Hesitation by petroleum refiners and marketers;
2) High production costs for ethanol;
3) Price variability for grains;
4) Opposition from some car manufacturers;
5) History of development problems in the United States;
6) Lack of evidence to show economic benefits to Alberta.

These reasons, alone and in concert with each other, have instilled a large measure of caution in the attitude of potential developers of a fuel ethanol industry.

1) Petroleum industry caution - Whether used as a fuel extender or primarily as an octane source, ethanol is different from gasoline and has different technical characteristics than gasoline. These differences can require adjustments in the manner in which petroleum is refined and marketed and these adjustments have associated costs which will require compensation.

2) High ethanol production costs- Ethanol cannot be produced at a cost equivalent to the cost of producing petroleum-based gasoline.

3) Price variability for grains - Domestic and international grain price levels respond to the degree of balance between production and consumption and in our current grain marketing environment to government intervention in those markets. The petroleum industry is decidedly uncomfortable with that variability even though petroleum prices are subject to similar variability. There are imperfect links between price trends in grain and petroleum and, in the absence of a unified industry adoption of alcohol fuels, petroleum marketers view the price risk as acceptable.

4) Car manufacturer opposition - Car manufacturers do not oppose the use of ethanol blended fuel in their products, but are not always enthusiastic with the use of methanol blends or methanol/ethanol blends. Some car manufacturers specifically state that warranties will be voided if methanol-blended fuels are used.

5) Development problems - Development of the ethanol fuel industry in the United States has included the involvement of promoters whose intent may have been to profit from the construction of ill-conceived and poorly designed plants rather than from the on-going operation of efficient and effective production facilities. There is ample recognition of this part of the U.S. experience and this adds to the hesitant attitude in Alberta.

6) Economic benefits - There has been no analysis based on current markets for grain and petroleum products to identify and quantify the benefits that may arise from a fuel ethanol industry, nor has there been an analysis to identify and

distinguish between those who benefit and those who might experience greater costs. It must be noted that experience in other countries is not necessarily easily applied to the Alberta situation because industry structure, practices and pricing levels are seldom completely comparable between different countries, and even between regions of this country.

The foregoing description of the issues incorporated in the fuel ethanol concept has been designed as a synopsis rather than a rigorous examination. The arguments listed are as stated by interested groups, and are not necessarily supported by the committee. Each issue will be addressed in detail elsewhere in this report. This synopsis illustrates the complexity of the fuel ethanol concept and should demonstrate that a convincing argument can be formulated either favoring or disfavoring the idea. It is the objective of this report to separate the real from the imagined and to do so in the context of the situation in Alberta.

PROCESS:

This report is designed:

To provide guidelines to direct the potential development of an agriculture-based fuel ethanol industry in Alberta.

It was agreed that these guidelines would be consistent with the goals of relevant Alberta Government departments and agencies. The goals of Alberta Agriculture, Alberta Economic Development and Trade, Alberta Energy and the Alberta Grain Commission were therefore examined, and our guidelines to direct the development of a grain-based fuel ethanol industry are consistent with these goals. Six basic criteria were developed upon which the

guidelines are judged. These basic criteria were considered to be inviolate. These criteria are;

1) Must maintain or increase the markets for agricultural products;

2) Must equal or improve the level of environmental protection;

3) Must retain or improve the safety associated with the handling of fuels;

4) Must comply with current government regulations and legislation;

5) Must achieve a net positive economic benefit for Alberta;

6) Must not require long term net public financial support.

Subsidiary criteria, as outlined in Appendix 1 were developed as well and were used to measure the relative merits of different policy options.

An extensive literature review was conducted of both Canadian and foreign, current and historical sources. These included government reports, industry positions, independent agency studies and consultant studies conducted for a broad range of clients. Interviews were conducted with petroleum refiners, petroleum marketers, methanol producers, potential ethanol industry developers, farm organizations, grain companies and industry consultants. These interviews were often wide-ranging but were sometimes limited to specific item of interest. It was not the intent of the committee to justify the development of a grain-based ethanol industry in Alberta nor to demonstrate the folly of such development, but to present a balanced view of the

supportable facts and develop policy guidelines from that balanced view. The committee was constantly cognizant of both the potential for opportunity and the risk to the province and it's population that fuel ethanol might represent.

OTHER JURISDICTIONS

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Although fuel ethanol costs more to produce and distribute than petroleum fuels several countries have programs which encourage the replacement of petroleum fuels with ethanol produced from biomass.

United States

- Federal tax exemptions and credits are equivalent to $0.26 Cdn/litre.
- 28 states provide some level of tax exemption or credit for ethanol, ranging from $0.004 to $0.481 Cdn/litre.
- Total U.S. tax relief therefore varies from $0.21 Cdn/litre in 22 states to $0.687 Cdn/litre in Louisiana. (See Appendix 2)

European Economic Community

- No official policy yet exists, although ethanol is being used as a motor fuel in regional tests to determine its suitability as a transportation fuel.

Brazil

- Approximately 1/3 of Brazil's transportation fuel needs are served by ethanol, both neat and in blends. Brazil's subsidies and incentives to ethanol ensure that ethanol fuels are priced at a level only 2/3 the level of petroleum fuels.

Canada

- There is no federal incentive program for ethanol fuels.

British Columbia

- Provides $0.02/litre tax exemption for fuel containing ethanol.

Alberta

- Provides $0.05/litre tax exemption for the oxygenate portion of motor fuels (e.g. methanol, ethanol, MTBE, etc.).

Saskatchewan

- Provides $0.04/litre tax exemption for fuel containing ethanol.

Manitoba

- Provides $0.025/litre tax exemption for fuel containing ethanol.

Ontario

- Provides $0.08/litre tax exemption on the alcohol portion of motor fuels.

ENVIRONMENTAL CONSIDERATIONS

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BACKGROUND:

Concern about Tetraethyl Lead in Gasoline

Tetraethyl lead has been used to raise the octane of vehicle fuels for many years. Because lead is a metal, its derivative compound used in this application is referred to as a metallic octane enhancer.

The widespread use of lead in gasoline has distributed this heavy metal throughout the environment, and prompted concern because this metal in sufficient concentrations in the body is considered to be a health hazard. Lead changes human blood chemistry even at very low concentrations. A relationship has been observed between higher blood lead levels in children and adverse learning and behavioral effects. Elevated blood lead levels has been correlated with high blood pressure in adult males. The Royal Society of Canada's Commission on Lead in the Environment concluded that the evidence justifies taking precautionary measures to reduce blood lead concentrations in the general population (Royal Society, 1985).

The introduction of unleaded gasoline into the Canadian market in 1974 was followed by a decline in automotive lead emissions, from approximately 14,000 tonnes of lead annually in 1973 to about 6000 tonnes in 1985 (Royal Society, 1985).

Regulations of May 16, 1984, under the Clean Air Act, reduced the allowable lead content in leaded gasolines from 0.77 grams per litre to 0.29 grams per litre, effective January 1, 1987. (This has not resulted in a significant corresponding increase in the

production and sale of alcohol-gasoline fuel blends.) Use of lead in gasoline in Canada is to be phased out entirely by the end of 1992.

National lead emissions are expected to continue to drop to 700 tonnes per annum (5 per cent of the 1973 peak value) by the turn of the century, according to the Royal Society's Commission on Lead in the Environment.

ALCOHOL-GASOLINE BLENDS: AIR QUALITY AND HEALTH EFFECTS:

Regulations of August 3, 1985, under the Canadian Motor Vehicle Safety Act, limit the emissions of carbon monoxide, hydrocarbons and nitrogen oxides from all new light-duty vehicles, including passenger cars, effective September 1, 1987. Limiting these emissions will help reduce a number of environmental and health concerns. More information on these pollutants, other health and safety considerations, and the impact of ethanol-gasoline blends is given in the following:

Carbon Monoxide

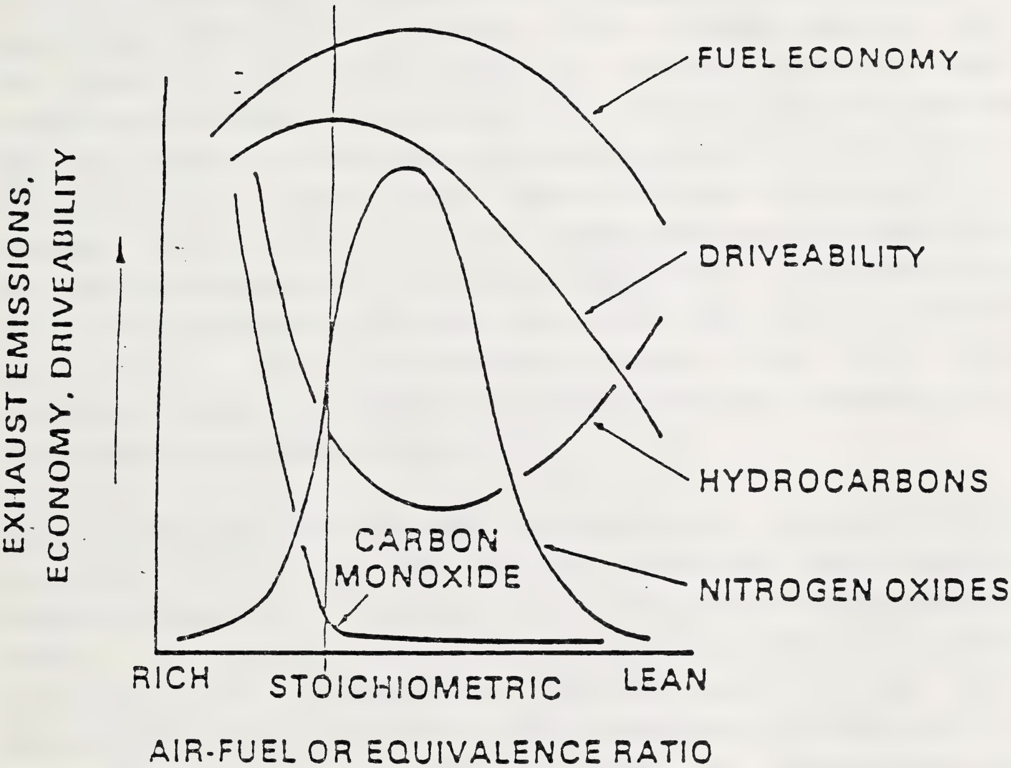
Introduction:

Carbon monoxide is a colorless, odorless, poisonous gas. It is discharged as a pollutant in vehicle exhaust and is due to the incomplete combustion of gasoline, or other carbon-containing fuels. Carbon monoxide is regulated for human health-related reasons. Carbon monoxide has been shown to have an adverse effect on the functioning of the cardiovascular system, especially in the elderly, infants, fetuses, and in individuals with severe cardiac or respiratory disease (U.S. EPA, 1987). It has not been shown to have significant negative effects on forests or wildlife.

Based on U.S. data, transportation sources account for over two-thirds of all carbon monoxide emissions (U.S. EPA, 1987,1979). Further, cars account for about two-thirds to three-fourths of all vehicle emissions. In 1985, over 90 per cent of automotive carbon monoxide emissions came from vehicles over four years old (MVMA, 1985). Reducing the carbon monoxide emissions from gasoline-fuelled vehicles can effectively reduce the ambient carbon monoxide levels (Gushee, 1987).

The Impact of Ethanol Blends on Carbon Monoxide Levels:

The use of ethanol blends results in leaning the air/fuel mixture (i.e., providing more oxygen for fuel combustion) due to the oxygen in the ethanol itself. Some fuel metering devices on vehicles meter fuel and air volumetrically. Examples are carburetors or fuel injectors without an oxygen sensor or with an oxygen sensor operating in the "open loop" mode, during which the oxygen sensor does not operate. The oxygen in the ethanol results in less fuel and more oxygen reaching the engine for combustion. The additional oxygen in the fuel "leans out" the air/fuel mixture resulting in reduced exhaust carbon monoxide and hydrocarbon emissions and increased nitrogen oxides emissions (see Figure 1). The amount of carbon monoxide decrease depends on the car's emissions control technology and the altitude at which the car is driven. At higher altitudes where the air is thinner, lower oxygen concentrations cause carbon monoxide emissions to increase.



from: Oxygenated Fuels Task Force, 1986, figure 3

Figure 1

A closed-loop (feedback) pollution control system with an operating oxygen sensor in control of the engine will try to compensate for the additional oxygen present in an oxygenated fuel by increasing the fuel flow or decreasing the air/fuel ratio. Therefore, a vehicle with closed-loop technology would experience little or no leaning of the air/fuel mixture due to the ethanol in the fuel blend, and we would expect a smaller reduction in carbon monoxide and hydrocarbon exhaust emissions. However, simple closed-loop vehicles operate in the open-loop mode (without an oxygen sensor functioning and in control of the engine), during certain driving conditions such as cold starts and heavy acceleration. A closed-loop vehicle also produces most of its carbon monoxide during these occasional open-loop modes of operation. Thus, an ethanol blend could still have a significant positive impact on carbon monoxide emissions during these open-loop modes of operation.

Some closed-loop vehicles are equipped with "adaptive learning" technology which uses the air/fuel settings from closed-loop modes of operation to adjust the air/fuel ratio during open-loop modes. A vehicle with closed-loop and adaptive learning technology can be expected to benefit less from the use of ethanol fuel since the system would compensate for the additional oxygen in the fuel in both the open- and closed-loop modes. However, the overall emissions from vehicles with these systems would be lower than expected from older vehicles in any case. Figure 2 shows the effect of improvements in pollution control technology on vehicle carbon monoxide emissions for vehicles fuelled on gasoline and ethanol blends. This figure shows that in newer vehicles, the carbon monoxide pollution control benefit of using ethanol-gasoline fuel blends is now very small, about one gram per mile. Thus, while adding alcohols to gasoline generally reduces exhaust emissions of carbon monoxide in older vehicles, which is beneficial, in newer vehicles the effect is very small.

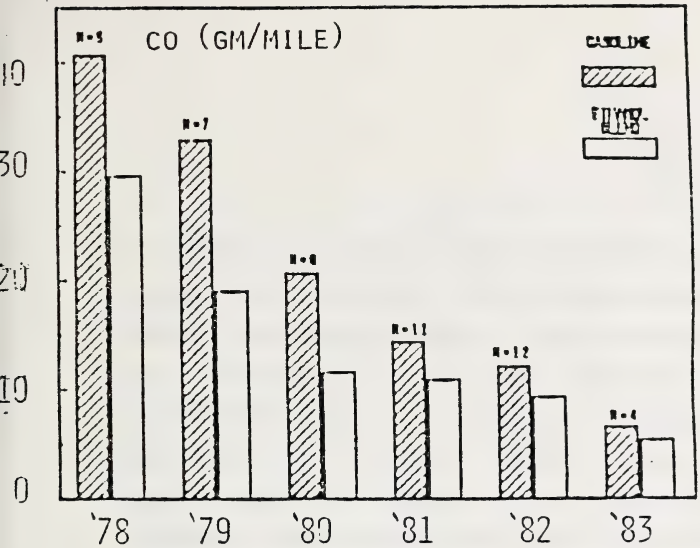


Figure 2

Effect of Improvements in Pollution Control Technology on Carbon Monoxide Emissions for Vehicles Fuelled on Gasoline and Ethanol Blends

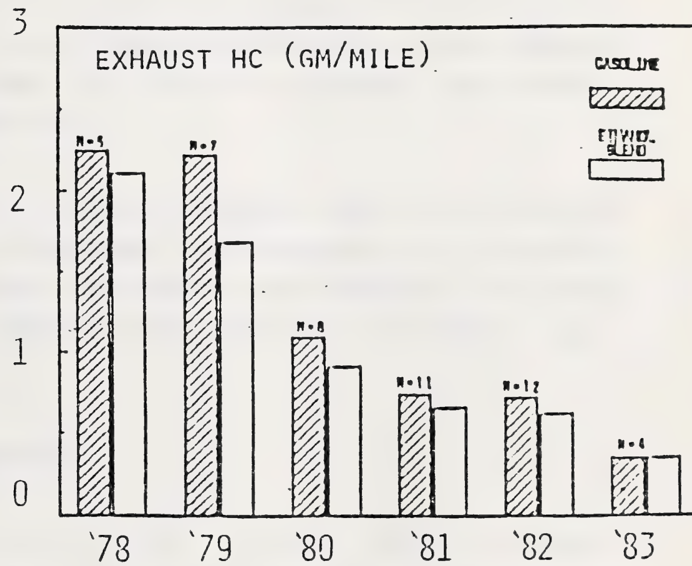


Figure 3

Effect of Improvements in Pollution Control Technology on Hydrocarbon Emissions for Vehicles Fuelled on Gasoline and Ethanol Blends

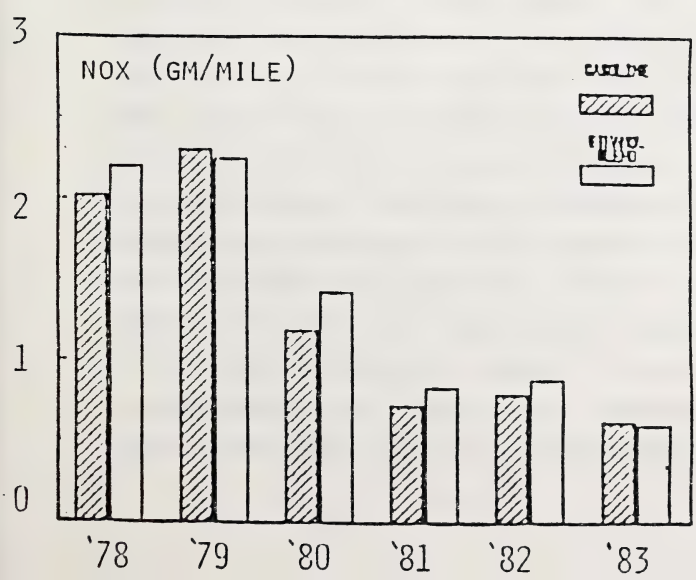


Figure 4

Effects of Improvements in Pollution Control Technology on Nitrogen Oxides Emissions for Vehicles Fuelled on Gasoline and Ethanol Blends

from: SAE, 1986, 4-5

Attempts to reduce ambient carbon monoxide levels in the United States by mandating fuel requirements has not gone unopposed by public interest groups. For example, the Centre for Auto Safety has threatened a law suit against the EPA if the EPA approves Colorado's plan to establish oxygen-content standards for all gasoline sold in that state's Front Range in winter. The Centre argues that the Clean Air Act specifically prohibits the EPA from allowing emissions from one pollutant to increase in order to reduce another one. The State of Colorado argues that the carbon monoxide levels are so high that they can afford to allow another vehicle emission to increase in order to reduce the carbon monoxide emissions (GRC, 1987,11).

Steady improvement in ambient carbon monoxide levels is expected (U.S. EPA, 1987). This expected improvement is primarily attributed to vehicle turnover, as use of new vehicles with more efficient emission control systems displaces use of older, less efficient vehicles.

Hydrocarbons and Nitrogen Oxides

For newer vehicles, hydrocarbon and nitrogen oxides exhaust emissions appear to be about the same whether a vehicle is fuelled with gasoline or an ethanol-gasoline blend, there being a difference of less than one tenth of a gram per mile. There is some variation on emissions from older vehicles depending on the type of pollution control system. For example, emissions of nitrogen oxide from older vehicles fuelled with ethanol-gasoline blends are sometimes significantly higher than if those vehicles were fuelled on gasoline. Overall, vehicle exhaust emissions from newer vehicles have been reduced significantly, whether or not ethanol blends are used. Figures 3 and 4 show the effect of improvements in pollution control technology in reducing hydrocarbon and nitrogen oxide emissions over a number of years.

As noted in the next section, hydrocarbons as well as nitrogen oxide emissions contribute to ozone formation.

Gasoline Volatility and Ozone

Introduction:

Ozone near ground level ("tropospheric ozone") is the primary component in smog over cities such as Edmonton and Calgary and has been shown to impair respiratory function for exercising persons at levels as low as 0.12 ppm. Ozone also damages vegetation. In fact, scientists are becoming increasingly concerned that ozone may be a more important factor in forest and agricultural crop damage than acid rain (Zinn, 1987). Ozone is not emitted in automobile exhaust; it is formed in air when hydrocarbons and nitrogen oxide react in the presence of sunlight and heat. This is why ozone levels are highest in warmer weather. Hydrocarbons are the important part of the equation, as their presence both speeds up the production of ozone, and inhibits its destruction as well. Transportation sources account for 30 to 50 per cent of these hydrocarbon emissions (NAQETR,1985), (Wilson, 1987).

Hydrocarbons are the primary components of gasoline. Automobiles emit hydrocarbons into the atmosphere through three routes: 1) exhaust or tailpipe emission; 2) evaporative emission, both from the fuel tank and the fuel metering system (fuel line and carburetor or fuel injection system); and 3) refuelling operations. The volatility of the fuel (a measure of its tendency to evaporate) is one of the primary factors affecting the magnitude of evaporative fuel emissions. The higher the volatility of the fuel, the greater the level of evaporative emissions.

The allowable volatility of vehicle fuel is restricted by practical, technological limits (Federal Register, 1987). A fuel with too low a volatility or vapour pressure can cause starting problems at low ambient temperatures. A fuel with too high a volatility or vapour pressure can, particularly in hot weather, vaporize prematurely in the fuel system, causing the engine to stall.

The Impact of Ethanol Blends on Volatility and Ozone:

Blending ethanol with gasoline changes the fuel volatility. While the hydrocarbons emitted from pure ethanol react less in the atmosphere than gasoline hydrocarbons, and therefore do not help ozone formation as readily, most of the increased evaporative hydrocarbon emission from ethanol blends will originate from the gasoline component. Higher evaporative emissions from alcohol-gasoline blends could be an environmental problem, if oxygenated fuels are allowed with higher vapour pressures than ordinary gasoline. The use of ethanol-blended fuels can result in higher evaporative fuel emissions and an increase in ambient ozone levels could occur. In areas where the climate is generally colder, the effect will be less pronounced, except during hot weather periods. More research on this subject is needed.

Aldehydes

Aldehyde emissions increase when ethanol blends are used as fuels (Szwarc, 1985). Aldehydes are produced when alcohols are oxidized as occurs during combustion. During the combustion of ethanol, the most common aldehyde produced is acetaldehyde. Formaldehyde is also produced. At low concentrations, aldehydes can cause eye irritations and skin rashes. However, the amounts emitted from vehicles are generally considered too low to pose a

significant health risk to the general population (Szwarc, 1985)(Colorado Department of Health, 1985). Moreover, newer vehicles fuelled with low level ethanol-gasoline blends and equipped with catalytic converters emit significantly lower amounts of aldehydes than older vehicles (Colorado Department of Health, 1985).

The Benzene and MMT Octane Source Options

There has been concern that refiners might use more aromatics (e.g., benzene, toluene, and xylene) in gasoline to improve octane as lead is phased out as an octane enhancer (Canada EMR, 1986(1),3). One of the concerns, for example, is that benzene is a known carcinogen. It is reported that some refiners are stripping benzene from gasoline to use for other purposes. However, benzene is currently unregulated in Canada, and little is currently known about what a safe level in gasoline would be. The Royal Society has recommended "that the Government of Canada evaluate the health effects of increased benzene in motor gasoline, and consider establishing limits on the allowable concentration" (Royal Society, February, 1986). Investigative work has already started, in co-operation with industry and some results should be available within a year.

Methylcyclopentadienyl manganese tricarbonyl or MMT can also be used to increase octane, but is more expensive than lead. In Canada, MMT can be used in both leaded and unleaded gasolines in amounts up to 0.018 grams of manganese per litre of gasoline. MMT was banned for use in unleaded gasoline in the United States to avoid a catalyst poisoning problem with early catalysts. (MMT was allowed in leaded gasoline in the United States. Effective January 1, 1988, however, leaded gasoline was no longer sold in the United States (NPN, Oct. 1987, 50)).

MMT is not seen as a health hazard at the concentration currently allowed in Canadian gasoline, even if it is widely used as a gasoline octane enhancer (Canada EMR, 1986(1), 20).

HANDLING:

Occupational and public health and safety effects from producing, distributing and retailing oxygenated gasolines do not appear to be significant. Normal industrial handling procedures should be adequate.

SPILLS:

Effects of spills would require study if blends were used widely, even though alcohols degrade relatively quickly compared with spills of oil, for example. Alcohols do dissolve in water, which means spills would disperse quickly. This may be good because of the dilution that would result, or bad because of widespread exposure of ecosystems to the alcohols. It is expected that worry about spills of blended gasoline would probably be dominated by concern about the gasoline component (Canada EMR, 1986(2), 4-5).

WORK REQUIRED:

It has been reported in the United States that: "while gasohol advocates claim that alcohol fuels are less polluting than gasoline, these claims have yet to be proven by an impartial source. Data, thus far, is not totally conclusive, but the Department of Energy sees no significant advantage or disadvantage for gasohol as opposed to gasoline" (Hornbeck, 1987, 3).

More information about the likely environmental and health effects of hydrocarbons, benzene, aldehydes and unburned alcohol

emissions is needed. For example, information is missing on volatility concerns and control methods, the effectiveness of catalytic converters in controlling emissions particularly for higher percentage alcohol blends, the expected degree and effect of buildup of emissions (e.g. aldehydes and unburned alcohols) in ambient air and water, the effect of exhaust emissions on summer ozone levels and foliage, and the health risks from continuous exposure to low levels of emissions. More study of such environmental issues by Alberta Environment and Environment Canada may be appropriate.

SUMMARY:

Evidence to date, while not entirely conclusive, does indicate that low-percentage blends of alcohol in gasoline do not create any significant environmental problems. Evaporative emissions, for example, may be higher with alcohol blends, depending on the vapour pressure specifications for the blended fuel, but means could be developed to reduce such emissions and the problem may be less severe in Alberta than in other areas, except on very hot days. More research on this subject is needed.

For newer vehicles, particularly those with a closed-loop pollution control system, the level of exhaust emissions are very similar whether gasoline or low-percentage alcohol blends are used as a fuel. Additional study of environmental issues by Alberta Environment and Environment Canada is needed. At present, based on the information available, it appears that displacing hydrocarbons with alcohols in low-percentage alcohol-gasoline fuel blends results in some positive and some negative environmental effects in Alberta.

Alcohols for use in alcohol-gasoline blends are all well-known chemicals, and the environmental, health and safety aspects of their manufacture, handling and use are well understood. Few

additional environmental impacts are likely to arise from the manufacture of fuel alcohols using existing technology. In alcohol-gasoline fuel blends, however, some aspects of alcohol use have been less well researched. Some additional cleanup efforts may be required in the event of a spill, for example.

INDUSTRY ISSUES

PETROLEUM INDUSTRY ISSUES/CONCERNS

The committee met with most of the major refiners and marketers of gasoline and also a number of the smaller regional refiners and marketers. Mohawk Oil Co. was the only company marketing alcohol fuels that spoke to the committee. There were a number of similar concerns related to the marketing of gasoline and alcohol fuels that were raised by different companies in their discussions with the committee. These were:

1. Customer satisfaction
2. Compatibility with the present gasoline distribution system
3. Consumer demand
4. Environmental issues
5. Competitiveness
6. Economics

These are presented in more detail below:

1. Customer Satisfaction

The committee was told that the market for gasoline in Canada had shrunk by 25% since 1980. Current growth is 0.5% - 1.0% per year. In light of such a dramatic reduction in volume, all of the marketing companies have been involved in aggressive campaigns to maintain or increase their share of the market.

Customer satisfaction is the primary principle on which all of their marketing efforts are based. The committee was told that they would not voluntarily make changes to their fuel formulas that would, in their opinion, jeopardize customer satisfaction. They told the committee that they felt that their customers were not particularly concerned about how the fuel was formulated, the main concern was that it performed

well. They feel that the current formulations do that. They have invested a considerable amount of time and money building confidence in the market for their products and they are reluctant to do anything that will affect that level of confidence. Some even stated that they felt so strongly about customer satisfaction that, even if their competitors adopted alcohol-blended fuels, they would not adopt them, but would instead simply meet the competition's price.

Mohawk Oil Co. did not agree with the position of the major companies and they told the committee that their experience with alcohol fuels was very positive. They felt that their customers were satisfied with the fuels they bought from Mohawk. One particular point was that they felt that their customers recognized the advantages of alcohols as a de-icer in the winter and their sales of E-10 or EM reflected that. They also told the committee that they experienced very few performance complaints and that they felt the performance issue was not a serious one.

2. Consumer Demand

The gasoline marketers claim that their market surveys do not show very much consumer demand for alternate fuels. As an example it was noted that the promotion of gasoline detergents had very little effect on the market and was quietly dropped in company advertising. The surveys and their own experience suggest that presently available options to gasoline such as V-PLUS in Ontario, E-10 in Manitoba, and EM in Alberta and Saskatchewan have not reached significant market penetrations. The committee was told that the three main factors influencing the decision of consumers to patronize a particular retailer are:

- Relationship with the retailer
- Product satisfaction
- Price

Price however is the most significant factor in determining which brands customers patronize. No retailer can afford to be higher in price than his competitors and even very small price differences will cause customers to move to the lower priced fuel.

3. Compatibility with the Present Gasoline Distribution System

Since 1968, the major refiners, Esso, Gulf and Shell, have been consolidating prairie refining operations by installing large refining operations near Edmonton and shutting down older, smaller refineries elsewhere. Refined products, including finished gasoline, are delivered to product terminals by pipeline. Shipments go as far east as Gretna, Manitoba, for transshipment to Winnipeg and west to Kamloops. It is anticipated that shipments by pipeline will be extended to Vancouver as some older refineries in Vancouver are shut down. Alcohol-blended fuels are currently not accepted by common carrier pipelines so a completely separate system would be required at refined product terminals to blend and handle alcohol fuels. Due to water solubility concerns, all tankage systems where ethanol is present must be thoroughly dry as even relatively small amounts of water can cause the fuel to separate into two distinct phases. This requires separate tankage as traces of water are normal in petroleum product storage. This system would have to be repeated at every terminal handling alcohol.

To properly utilize alcohols for their octane properties, the base gasoline must be formulated to take the alcohol octane into account. Manufacturing and transporting a tailored

gasoline by pipeline requires large volumes. Without an identified market to absorb the tailored gasoline, such movements become difficult. Current practice is to ignore the octane of the alcohols and simply top blend onto regular unleaded gasoline. This results in fuels that simply use the alcohol as an extender and not an octane enhancer.

4. Environmental Issues

Discussion in the US relating to the vapour pressure standards for gasoline, if adopted, could affect standards in Canada. Alcohol-blended fuels, when simply top blended, cannot meet the proposed specifications unless the base gasoline is specially formulated. To achieve the proposed standards, high vapour pressure products currently used in gasoline such as butane would have to be reduced or removed. Since butane is one of the products produced when a barrel of crude oil is processed, any reduction in the amount allowed in gasoline would result in the surplus having to be sold off as fuel gas at a considerable reduction in price. That would have a corresponding increase in the cost of producing the gasoline used for alcohol blending. While regulations relating to vapour pressure are not yet a reality, they are of concern to refiners and dictate caution until a decision is made.

Fuel economy and emission control were other issues that were of concern when considering alcohol-blended fuels. Due to the lower energy value of alcohols compared to gasoline, the refiners claim that there is a 2 - 5 % reduction in fuel economy. While that may not be noticeable by the motorist, it is noticeable when the entire vehicle fleet is considered.

Emission control is improved with the addition of oxygenates to gasoline. The effect is most noticeable in vehicles made

before 1983. Newer, computer-controlled, fuel-injected cars can achieve emission levels that cannot be substantially improved upon by the use of oxygenates. Therefore, as the fleet ages and is replaced by newer vehicles, the need for oxygenates, except in localized areas, will not be of much value in improving tail pipe emissions.

5. Competitiveness

Marketers have told the committee that they do not see alcohol-blended fuels as an attractive opportunity for them at the present time or in the foreseeable future. The problems with vapour pressure regulations, concerns over product handling difficulties, customer satisfaction, and performance concerns with alcohols makes them very reluctant to be pioneers in the marketplace with alcohol-blended fuels. If alcohols were to be mandated and all of their competitors were forced to use them, the competitive aspect would be eliminated. They qualify that by saying that they do not want a mandated level of use for alcohols or any other oxygenate. They would prefer that standards be set and the companies be left to decide how to meet the standard for themselves. They see any unilateral decision to use alcohols as too much of a risk in the present market environment.

6. Economics

All of the companies that spoke to the committee claimed they had evaluated the economics of alcohol-blended fuels and, without some form of subsidy, they considered them to be unattractive. They also said that they felt that ethanol from biomass in particular was the least attractive of the options they had. If ethanol were to be used, they consider that it could be produced from petroleum sources more economically than from biomass.

THE LEAD PHASE DOWN ISSUE

The use of tetra ethyl lead in gasoline is scheduled to be progressively reduced until it is effectively removed in Canada by 1992. Ethanol and methanol have been suggested as the solutions for replacing the octane now provided by lead. The refiners told the committee that they had a number of options for replacing the octane now provided by lead. They pointed out that no two refineries presently operating in Canada are the same. They were all constructed at different times and with different technology and design criteria. They are also designed to operate on different feed stocks. Therefore the solution to the octane problem is different for each refinery. In general, they indicated that their preference from both a cost and performance point of view was to provide the octane from refinery sources. In order of increasing capital cost and complexity their preferences were:

1. Remove the bottlenecks from their present refinery operations.

2. Increase the temperature and pressure of their present operations (severity).

3. Replace the catalysts in their fluid catalytic cracker units and reformer units with new catalysts recently developed for the U.S. refining industry to help them meet the no-lead requirements by January 1, 1988.

4. Add an isomerization unit to the refinery.

If none of the above were attractive and the refinery decided to use additives to provide the required octane, then:

5. Use oxygenates. Of the oxygenates available, the preferred one is MTBE (methyl tertiary butyl ether) and at the bottom of the list is ethanol and methanol. The reason is that MTBE is compatible with the present distribution system and is in fact now being used in some products.

<u>**U.S. EXPERIENCE**</u>

1. Lead

The U.S. is ahead of Canada in mandating the elimination of lead from gasoline. As of January 1, 1988, the regulations concerning lead changed and effectively reduced lead levels in gasoline to relatively insignificant levels. The committee's information is that they have met that target and that it has not affected the volumes of ethanol sold to any appreciable extent. The committee understands that the market for gasohol in the U.S. peaked at approximately 8% in 1985 and now sits at around 7% of the market.

2. Subsidies

To the committee's knowledge, gasohol is not sold in any state that does not offer a subsidy on top of the $0.60/U.S. gallon subsidy offered by the federal government. Where those state subsidies have been dropped, the production of fuel ethanol has stopped soon after. It would appear that, once the subsidy drops below a certain threshold level, the use of ethanol as an octane enhancer is not as attractive as the other options available to the refiners. Regardless of the subsidies, in most cases, ethanol appears to be used more as a fuel extender than as an octane enhancer.

3. Oxygenate Mandate

The State of Colorado has mandated the use of oxygenates in gasoline, commencing on January 1, 1988, to lower carbon monoxide levels during the winter months, November 1 to March 1. The program is staged with the first year requiring 1.5% oxygen by weight in the finished gasoline and that level increasing to 2.0% in the second year. Most of the refiners appear to have selected MTBE as their oxygenate of choice, however, three distributors are using ethanol. The ethanol industry in Colorado suggests that MTBE may have difficulty meeting the 2.0% level set for year 2.

FUEL ALCOHOL PROPONENTS

Proponents of fuel ethanol suggest that there is a window of opportunity for alcohols as octane enhancers to replace tetra ethyl leads as it is progressively removed from Canada's motor fuels. The U.S., as of January 1, 1988, is now at such a reduced lead level that it can be considered essentially lead-free for practical purposes.

The main benefits that they see to the inclusion of ethanol in motor fuel are:

1. Energy security - a fuel made from a renewable resource to offset the projected need to import more oil.

2. Stabilization of grain prices due to a large local fixed demand and increased farm gate prices for grain.

3. Provide a market for low quality surplus grain.

4. Provide a high quality protein feed byproduct to compete with imported soybean meal.

5. Provide employment by creating new jobs.

6. Provide an environmentally safe and harmless fuel.

These are presented in detail below:

1. Energy Security

   It is estimated by some proponents that, by the early 1990's, Canada will be importing approximately 500,000 barrels of oil per day to satisfy approximately 35% of our domestic oil consumption. Ethanol from biomass can supply a portion of that imported oil demand. Ethanol can be produced from any source of carbohydrate such as grain and it can also be produced from cellulose.

2. Stabilization of Grain Prices

   Fuel alcohol will provide a new market for grain and can help relieve the present surplus/low price situation. A constant local demand for grains will raise the price to the grain producer and add stability to the market.

3. Provide a Market for Low Quality Grain

   Weather conditions often create problems at harvest and the resulting low quality (tough and damp) grain is difficult to store and has a low value. A fuel alcohol plant can take the grain as is without drying, thus reducing the costs of storing the grain. A fuel alcohol plant can also take spoiled grain unsuitable for feeding to livestock and utilize it.

4. Provide a High Quality Protein Feed

The byproduct from a fuel alcohol plant is a high protein, high fiber feed product. It can be sold wet to a nearby livestock feeder or it can be dried to produce dried distillers grains (DDG). DDG is equivalent to soybean meal in protein and it has some additional advantages soy does not have. The drying process changes the protein so that it is not assimilated by ruminants until it has passed through the rumen. This feature is particulary attractive to dairy producers. The large livestock feeding industry in this province can benefit from a local source of high quality protein supplement and it will reduce the imports of soybean meal from the U.S. There is also a strong export market for DDG.

5. Create Employment

The construction of a fuel ethanol plant would have a substantial effect on the local economy of the community or region in which it is located. It would create employment in both the construction phase and later permanent jobs in the operation of the plant. The spinoffs to the local and regional economy from the injection of income would be substantial. The abundant supply of feed ingredients would also stimulate the opportunity for beef cattle production.

6. Environmental Impact

Ethanol is biodegradable and water soluble which makes it environmentally harmless. The addition of ethanol to gasoline substantially reduces emissions of carbon monoxide

and nitrous oxide from engines. There is an increase in aldehyde emissions from burning ethanol, but these can be reduced by 90% by the catalytic converters on late model cars.

Methanol-Blended Fuels

Methanol fuel blends have been marketed in Alberta, Saskatchewan, British Columbia and Ontario for several years. In order to get methanol to mix with gasoline, it is necessary to add a cosolvent. Ethanol has been used as the cosolvent in all provinces except Ontario, where isopropyl alcohol is used because of its availability and lower price. In Alberta, Saskatchewan and British Columbia, the blend is 5% methanol and 3% ethanol, while in Ontario the blend is 4% methanol and 4% isopropyl alcohol. This fuel blend has been able to compete with gasoline without being subsidized beyond the rebate of the provincial road tax on the 8% alcohol portion of the blended fuel ($0.05/L in Alberta and $0.08/L in Ontario).

The incentive to develop the fuel market has been the depressed price for methanol on the world market over the last few years. The blended price of the low-cost methanol and the higher priced cosolvent, combined with the rebate of the provincial road tax, has been sufficient to make the blend competitive in the gasoline market. Methanol producers feel that, regardless of the recent increases in the price of methanol, the development of a large, stable, domestic fuel market is in the long term interests of their industry.

The producers have suggested that the price at which reinvestment in new capacity would be stimulated is approximately $0.15-$0.16/L. This could be considered as a possible long-term price for methanol. A blend of $0.15/L methanol and $0.45/L ethanol gives a blended price of $0.26/L. With the wholesale price of

gasoline at $0.20/L, the industry suggests that it would be necessary to provide support to methanol-blended fuels in the form of subsidies to help develop the market. The support being suggested is a rebate of the federal gasoline excise and sales tax which would amount to $0.10/L. This would be in addition to the rebate of the provincial road tax they presently receive.

Economics

The inclusion of ethanol in gasoline at current gasoline and ethanol prices would increase the price to the consumer. Therefore, a two-cent a litre subsidy at the pump for the next five years was suggested by ethanol proponents as the minimum needed to promote an increase in the use of ethanol. Proponents have suggested that government assistance could take the following format:

1. Reduce the excise tax on gasoline which has 3% or more ethanol by $.02/L;

2. Employ regional development grants to promote the production of ethanol;

3. The Federal Government should assist in research directed toward reducing ethanol production costs;

4. Speed up the lead phase down by changing the cut-off date to January 1, 1990, instead of the current December 31, 1992, date.

In relation to agriculture, it was proposed that the development of an ethanol industry would markedly improve the price of grain. The committee was unable to substantiate this claim and has acquired information from various sources including Agriculture Canada that the increase in the price of grain would be minimal.

Increased markets for grain were also cited as benefit which would occur with the development of an ethanol industry. Estimates presented to the committee suggest that the widespread use of ethanol could result in a market for 250,000-500,000 T of grain. Several proponents pointed out that, due to the large livestock feeding industry in Alberta, a ready market was available for the distillers dried grains (DDG's). It was pointed out that the value of the DDG's significantly affected the break-even sale price of ethanol. To attain the benefits of economies of scale, a minimum of 200,000 T of grain needs to be processed. At this level of production, 67,000 T of dried distillers grain would be available for sale. Because of this large volume of by-product, affiliation with a large feedlot was deemed desirable.

TECHNICAL ISSUES

TECHNICAL ISSUES

INTRODUCTION:

When alcohols or ethers, which are oxygen-containing compounds or oxygenates, are added in small percentages to gasoline, the resulting blend is called an oxygenated gasoline. There are six common oxygenates, ethanol, methanol, methyl tertiary butyl ether (MTBE), tertiary butyl alcohol (TBA), isopropyl alcohol (IPA), and isobutyl alcohol (IBA). Ethanol is made from cereals such as wheat, barley, and corn, and also petrochemicals. Methanol is made from natural gas, and can be made from coal or biomass. MTBE is made from methanol and isobutylene. TBA, IPA and IBA are made from natural gas derivatives. IBA is not made in Canada. TBA, IPA, and IBA can be blended with methanol and gasoline to help prevent the separation of methanol from gasoline in the presence of water. Ethanol can also be used.

The common oxygenate blends are: ten per cent ethanol in gasoline (called gasohol), five per cent methanol and three percent ethanol, five per cent methanol and up to five per cent IPA or TBA, and up to eleven per cent MTBE. The gasoline used is usually unleaded. In future, higher levels of methanol (up to 85 per cent) in gasoline could be of interest.

All of the blends just mentioned have been tested or sold commercially in different parts of the world. Gasohol is sold in Manitoba and the United States. All gasoline sold in Brazil is reported to contain 20 per cent ethanol and many vehicles use virtually pure ethanol. Vehicle engines are adjusted to run on these fuels. Methanol-cosolvent blends are sold by Mohawk Oil across Western Canada, and by other companies in the United States. Methanol-IPA blends are sold in Ontario at V-Plus fuelling stations. Much of the gasoline sold in West Germany and Austria contains three per cent methanol with TBA as a cosolvent.

MTBE is often added to gasoline in Europe, the United States and Canada. The blend is accepted as equal to gasoline.

In the following will be discussed a number of technical considerations in the use of alcohol fuel blends, including the production technology, standards, blending and distribution concerns, driveability, corrosion, and arguments for alcohol as a lead replacement, oil substitute, and fuel extender.

OXYGENATE PRODUCTION TECHNOLOGY:

The techniques for making the oxygenates just described are well established. One exception is the production of methanol and cosolvents together, known as "mixed alcohols". Another exception is the production of ethanol from biomass. For example, being able to use such feedstocks as waste forest products could make ethanol cheaper.

The technologies for blending, distributing and using oxygenated gasolines are quite well understood, although some technical concerns remain. These are described in the following sections.

STANDARDS:

Canadian standards for oxygenated gasoline are under development. An important subject that any standard must address is volatility -- how readily a fuel vaporizes at different temperatures. To burn properly in an internal combustion engine, the fuel must be vaporized well. Gasoline specifications are intended to ensure satisfactory vaporization over the range of normal ambient operating temperatures. The Reid Vapour Pressure, or RVP, is the common measure of fuel volatility.

Volatility or vapour pressure of the fuel affects not only the vehicle's driveability, but also evaporative emissions into the

atmosphere. Higher fuel volatility helps improve vehicle driveability in winter, but more readily leads to "vapour lock" on hot days.

Fuel vapour pressure changes most as the first few per cent of alcohol are added. The change in vapour pressure is usually greatest for methanol blending, less pronounced with ethanol, and least pronounced with the higher alcohols. A complicating factor is the ambient temperature, which can have a major effect on the fuel volatility. For example, alcohol-gasoline blends may evaporate more readily than unblended gasolines at higher ambient temperatures if the blend is not "tailored" to control the vapour pressure. At lower temperatures, the volatility of gasoline can decrease if alcohol is added. Butane can be removed from ("backed out") or added to the gasoline to help offset the change in volatility caused by adding alcohol (Mohawk, 1985).

The proposed Canadian General Standards Board oxygenated gasolines standards would keep volatility and octane specification the same for oxygenated fuel as for equivalent grades of gasoline. Some feel that this is restrictive and argue that alcohol-gasoline blends with different vapour pressures perform better than gasoline under some driving conditions. Others argue that oxygenated fuels should be interchangeable with regular gasolines and perform in an automobile engine like ordinary gasoline.

BLENDING AND DISTRIBUTION:

Alcohols can be blended with gasoline at refineries, at terminals, in delivery trucks or even at retail pumps. The last alternative is considered least satisfactory for fuel quality. Blending operations also require care to keep water out of the system. Distributing alcohol-gasoline blends poses some problems as well. For example, common-carrier oil product pipelines do

not generally accept alcohol-gasoline fuels because of potential problems with water and potential mixing with other products. MTBE-gasoline blends do not have these blending and distribution problems.

FUELLING STATION PREPARATION:

If too much water is present in a blended fuel, the alcohol and water can combine in a layer separate from the gasoline. Therefore, fuelling station tanks must be cleaned and dried out. Materials for pumps and other equipment must be upgraded to be compatible with the alcohol. Extra cosolvent might also be used during the introductory phase of using alcohol blends until water in tanks and lines is removed by the alcohol.

EXCHANGE AGREEMENTS:

Refinery product exchange agreements, which are widely used, inhibit wide commercial sale of alcohol-gasoline blends. Under an exchange agreement, Company X supplies gasoline to Company Y in one area, while Company Y returns gasoline to Company X in another area. This arrangement allows both companies to sell gasoline more cheaply, and should result in a greater choice of service stations for consumers. It is common for one company to have such arrangements with a number of other companies. This can lead to mixing of gasolines from different sources.

Common carrier pipelines ship gasoline for a number of different customers. Some mixing can occur when a gasoline from one refiner is shipped in a line next to gasoline from another refiner. This mixing usually causes no problems since gasolines made by conventional processes are compatible with one another. Gasolines containing alcohols should not be mixed with normal gasolines as this can cause volatility changes or phase separation under some circumstances.

Companies which want to sell an alcohol-gasoline blend will need to find reasonable cost methods to meet any existing exchange agreements. They will also need to find acceptable ways to use common carrier pipelines without creating mixing problems, or establish separate pipelines, and find means to supply independent marketers with a satisfactory product.

DRIVEABILITY:

Alcohol-gasoline fuel blends can affect vehicle performance, but the effect on most vehicles appears to be small. Some tests indicate that methanol-gasoline blends can cause some deterioration in starting ease, idling smoothness and sluggishness when compared to gasoline. Other tests show no significant changes. Test results for fuel consumption are similar. Although the energy content of alcohol-gasoline blends is slightly less than gasoline alone, fuel consumption in tests appears to vary from slightly better to slightly worse than gasoline.

An EPA report (U.S. EPA, 1987) evaluated a number of test programs conducted by vehicle manufacturers, oil companies, the Department of Energy, and others. These test programs generally concentrated on the problems sometimes attributed to ethanol use, such as cold start-ups, stalling, hesitation, rough idling, and vapour lock. The report found that driveability problems usually occurred in (generally older) vehicles with carburetors and no air/fuel ratio feedback systems. The report found little or no difference in driveability on (generally newer) vehicles with fuel injection and closed-loop fuel control systems.

CORROSION:

Alcohols, especially methanol, are more corrosive than gasoline. However, acceptance of alcohol fuels has been increasing among vehicle manufacturers. Almost all vehicle makers allow ethanol blends to be used in their 1986 and later vehicles although most have qualifiers. Chrysler permits ethanol blend use in their vehicles but does not recommend it. Chrysler advises owners not to use methanol blends. Some Japanese makers also recommend not using methanol blends. Other manufacturers approve methanol blends if cosolvents and corrosion inhibitors are used in the fuel (OFT, 1986, Tables 4 and 5). All vehicle makers permit use of MTBE-gasoline blends in their vehicles.

An EPA report (U.S. EPA, 1986) evaluated the results of a number of materials compatibility tests. The report found that 10 per cent ethanol blends appear to present few if any materials compatibility problems. However, some vehicles, especially older vehicles with old parts, could experience fuel tank corrosion, deterioration of fuel system hoses and carburetor accelerator pumps, and fuel filter plugging. It was found that component failure or malfunctions involved mostly small parts and were not catastrophic, and that the number of problems was small.

If an older vehicle was designed to use leaded gasoline, it should still be used. For example, one vehicle manufacturer advises owners of their pre-1971 model cars and trucks that "these vehicles need leaded gas to lubricate exhaust valves. The lead raises octane ratings and helps to avoid "knocking" and "pinging". The lead is most important during continuous high-speed, high load conditions such as towing a heavy trailer or large boat over along distance. In a pinch you can even use unleaded gas for normal driving. (General Motors Consumer Information Flyer #10).

LEAD REPLACEMENT ARGUMENT:

Octane rating is a measure of the antiknock properties of a fuel, that is, its resistance to detonation or spontaneous ignition in an engine. High compression engines require higher octane fuels to prevent detonation of the fuel-air mixture. Certain substances in a fuel can help suppress fuel detonation. Of these, tetraethyl lead is the least expensive, and consequently is preferred for boosting fuel octane ratings.

Refiners can also use small amounts of another metallic octane booster, methylcyclopentadienyl manganese tricarbonyl or MMT. This manganese compound can usually provide only part of an octane requirement, however, because it is substantially less effective than lead. MMT adds approximately one octane point at the concentration allowed in Canadian gasoline (0.018 grams of manganese per litre). It is typically used as a combustion promoter and for "topping up" the octane level of gasoline.

The alcohols and MTBE are good octane enhancers. Pure methanol, ethanol and MTBE have octane ratings of 120, 118, and 109 respectively (Mueller Associates, 1985). A five per cent methanol and three per cent ethanol mix add about two units of octane to the resulting gasoline blend (Hycarb, 1986). Ten per cent ethanol adds one to three units of octane to an alcohol-gasoline blend (Halbach, 1986, 6),(CRFA, 1987,24).

As of January 1, 1987, the Canadian standard for leaded gasoline was reduced to a maximum quarterly average of 0.29 grams of lead per litre; by December of 1992, the use of lead as a gasoline additive will effectively have been eliminated (Environment Canada, 1986). Sales of leaded gasoline already constitute a declining share of total gasoline sales. They now account for

about one third of all gasoline sales. In areas with a large per cent of new cars, the sales of leaded gas account for as little as ten per cent of all gas sales.

Refiners have been implementing their options for replacing the octane lost with the phase-down of lead in gasoline. For example, existing spare processing capacity can be used, the refining process can be modified to yield a larger fraction of higher-octane hydrocarbons or additional processing can be done. Catalytic reforming, improved catalysts and isomerization can increase octane. The method used at each refinery has varied depending on factors such as the capital cost of raising refinery yields of higher-octane hydrocarbons, the additional process energy required for refining, the type of crude being refined, the processes being used already, the age of the refinery and future plans for it. Once an investment in a new process unit is required, adding additional octane capacity can be cheaper than using oxygenates at all.

Finding substitutes for lead to achieve the current octane requirements for all gasolines has been achieved by all refiners in Canada without using ethanol. For most Canadian refiners, the future phasedown of lead is not likely to be a major problem as leaded gasoline sales already are only a small portion of their total gasoline sales.

ENERGY BALANCE:

Ethanol produced from biomass is promoted by some as a means of substituting a renewable energy resource for petroleum as a vehicle fuel. Through photosynthesis, energy from sunlight is stored in the form of plant starch and this starch can be converted to ethanol. Although conceptually true, this process is not without energy costs in the crop production, transportation and starch conversion stages and these energy

costs must be taken into consideration. Care must be taken in examining the energy balance in producing alcohol, that is, the energy input to produce the fuel versus the energy in the fuel produced. For example, using barley as the ethanol feedstock and assuming that crop residue from barley fields (straw) was to be used to supply all of the energy requirements of ethanol production and drying of distillers grains, the ethanol produced would yield nine times as much energy as was used in the form of liquid transportation fuels to produce the barley. No energy cost is included to provide for the correction of the soil quality deterioration that would result from the removal of crop residue, nor was an allowance included for the energy component of the capital development of the ethanol production facilities. If ethanol-process energy were to be provided from fossil fuel sources (e.g. coal or natural gas) instead of from crop residue, as little as 43% as much energy would be provided by ethanol as was used from fossil fuel sources to produce it. (Halbach, 1986, 23), (Litterman, 1978). Ethanol produced from crops grown in an energy-intensive agricultural system can and does use more energy from nonrenewable sources than would be saved in displacing crude oil for gasoline production and gained in energy credits from the by-products.

Use of ethanol cannot be justified as a means of substituting a renewable energy source for petroleum in vehicle fuel until production efficiency can be improved. Combining an ethanol plant with a methanol plant or with a source of process heat such as an electrical co-generation station would improve the energy balance (Agriculture Canada, 1980).

FUEL EXTENDER:

Alcohol blends are only attractive as a fuel extender to a gasoline reseller when the cost is less than the wholesale gasoline price.

Alcohols have a lower energy content ("heating value") per unit volume than gasoline. Methanol has a lower heating value than ethanol. Thus, a low-percentage alcohol-gasoline blend may contain 2-3 per cent less energy per litre than an unblended gasoline. Alcohol blends appear to burn somewhat more efficiently in an internal combustion engine than gasoline, however, offsetting some of the loss in heating value. The increase in fuel consumption for alcohol-gasoline blends appears to be small enough not to be noticed by the average driver. However, there is nonetheless an increase in fuel consumption.

SUMMARY:

There appear to be no major technical barriers to the use of ethanol-gasoline fuel blends, or the use of ethanol-methanol fuel blends.

There do appear to be some marketing barriers to larger gasoline marketers offering ethanol-gasoline or ethanol-methanol-gasoline fuel blends to their customers, such as concern about the method and cost of distribution, compatibility with other gasolines, current economics, and a need to maintain a high level of customer satisfaction.

Standards for oxygenated gasoline are under development and when complete should resolve some concerns about alcohol-gasoline blend volatility.

Driveability using ethanol-gasoline blends does not appear to be a problem on most newer vehicles.

Corrosion problems, if they occur, involve mostly small parts and are not catastrophic. Some manufacturers still do not recommend using methanol-gasoline blends in their vehicles.

Finding substitutes for lead to achieve the current octane requirements for all gasolines has been achieved by all refiners in Canada without using ethanol. For most Canadian refiners, the future phasedown of lead is not likely to be a major problem as leaded gasoline sales already are only a small portion of their total gasoline sales.

Use of ethanol cannot be justified as a means of substituting a renewable energy source for petroleum in vehicle fuel until production efficiency can be improved.

Alcohol fuel blends are only attractive as a fuel extender to a gasoline reseller when the cost is less than the wholesale gasoline price.

The fact that various alcohol-gasoline blends are being marketed in a number of areas, including Alberta, demonstrates that these fuels can apparently serve satisfactorily for transportation uses.

PRODUCTION COSTS

PRODUCTION COSTS

The committee reviewed seven studies on the cost of constructing and operating a fuel ethanol plant. The results from these studies cover a wide range on both the capital costs and the operating costs. All of the studies had to translate experience from the US or attempt to estimate the cost to construct a fuel ethanol plant in Canada from available data.

The Arthur D. Little study done for the Canadian Wheat Board compared the SLR and TECHTROL studies along with U.S. Experience and their own calculations.

The study prepared by the National Panel on Cost-Effectiveness of Fuel Ethanol was prepared for the U.S. Congress and the Secretary of Agriculture and is totally in U.S. terms.

The remainder of the studies were prepared for western Canadian locations. Most considered at least two alternative capacities to compare the effect of capacity on cost of production. All costs are in Canadian dollars.

Energy Mines and Resources Canada

Capacity	- 20 million Litres
Capital cost	- $7.8 million
	- $0.39/L
Cost of Ethanol	- $0.414/L

RTM Engineering Ltd.

Capacity	- 50 - 200 million Litres
Capital Cost	- $76.25 -$159.1 million
	- $1.525 -$0.795/L
Cost of Ethanol	- $0.696 -$0.492/L

<u>Techtrol Ltd.</u>

Capacity	- 20 - 200 million Litres
Capital Cost	- $22.85 -$109 million
	- $1.14 - $0.545/L
Cost of Ethanol	- $0.608 - $0.35/L

<u>SLR - Alberta Agriculture</u>

Capacity	- 40 million Litres
Capital Cost	- $22.5 Million
	- $0.5625/L
Cost of Ethanol	- $0.40/L
	Considered profitable at this price.

<u>SLR - PetroCanada</u>

Capacity	- 20 million Litres
Capital Cost	- $17.16 million
	- $0.858/L
Cost of Ethanol	- $0.40/L
	Not considered profitable at this price.

<u>National Advisory Panel - U.S.A.</u>

Capacity	- 57 - 226 million Litres
Capital Cost	- $0.80/L
Cost of Ethanol	- $0.62 - $0.28/L

<u>Arthur D. Little - Canadian Wheat Board</u>

Capacity	- 60 - 200 million Litres
Capital Cost	- $0.95 - $1.45/L
Cost of Ethanol	- $0.77 - $0.607/L

<u>Mohawk Oil Company</u>

Capital Cost	- $0.80 - $1.00/L

When considering the cost of ethanol as an octane enhancer it should be considered as a comparison to the cost of production of alternative oxygenates.

MTBE	- $0.285/L
Iso Propyl Alcohol	- $0.345/L
Tertiary Butyl Alcohol	- $0.302/L

* source EMR Discussion Paper on Oxygenated Gasolines.

BEST GUESS CAPITAL COST:

Based on the above estimates and independent information the committee has assumed a best guess figure for calculation purposes. Given the market size in Alberta and the barriers to export to both the US and neighboring provinces the committee felt that a small scale plant was the most practical. Accordingly a nominal scale of 50 million Litres was chosen.

The range of costs for a small scale plant on a per Litre basis were: $0.39/L - $1.525/L. The production cost estimates for ethanol ranged from $0.40/L to $0.696/L.

A capacity of 50 million Litres/year of ethanol with a capital cost of $0.80/L of capacity gives a total capital cost of $40,000,000. The cost of ethanol production for this scale of plant has been assumed at $0.45/L.

Mohawk Oil currently markets a 3 percent ethanol / 5 percent methanol blend. More independent marketers which purchase fuel from refiners for resale might be attracted to an ethanol / methanol blend at a subsidy of about $0.08/L for ethanol and $0.05/L for methanol. This assumes a wholesale price for gasoline of $0.20/L and a long-run methanol price of $0.15/L. If the existing $0.05/L fuel tax exemption for ethanol and methanol was not continued, the subsidy required for ethanol would be $0.17/L. This is a crude calculation only of the subsidization level which would make independent marketers, not refiner/marketers, indifferent strictly on the basis of input costs. There would also be other costs associated with conversion of their distribution systems to be alcohol compatible (costs A and B below). On the same input cost basis, independent marketers might be indifferent between straight gasoline and a 10 percent ethanol blend with a subsidy of about $0.25/L of ethanol.

There are other reasons such as concerns about market acceptance, product swap arrangements and additional refinery and distribution costs why refiners would be much more reluctant to adopt fuel ethanol. As well, the cost to refiners of producing gasoline is likely less than the wholesale price available to independent marketers. A much higher, unknown subsidy (represented by C below) would be needed to induce refiners to adopt ethanol. Given differing plant economics and attitudes across refiners, the greater the subsidy, the greater might be refiner acceptance. However, some likely would not adopt ethanol in all of their brands regardless of the level of subsidy. The committee can offer no estimates of what level of subsidy would result in what level of acceptance by refiners.

ROUGH ESTIMATES OF REQUIRED ETHANOL SUBSIDY
FOR INPUT COST EQUIVALENCE WITH GASOLINE

	Independent Marketers		Refiner/Marketers
	Indifference on input costs	Indifference on input plus marketing and distribution costs	Indifference on input, marketing and distribution costs
E10	$0.25/L	$0.25/L + A	C
3/5 blend	$0.08/L	$0.08/L + B	C

Note 1: Amounts A, B, and C are unknown. It is believed that B is greater than A, and C is much greater than B.

Note 2: Should blending and conversion costs increase the total cost of the blended fuel by $0.01/L, the required subsidy for ethanol in an ethanol/methanol blend would increase from $0.08/L to $0.42/L. The opposite effect would result if an independent marketer were able to attract a $0.01/L premium by marketing his product as a superior fuel. Because of the small component ethanol would represent in such a blend, the maximum price the blender could pay for ethanol, and hence the required level of subsidization, is highly "levered" against small changes in the weighted average price he can afford to pay for the three fuels blended together. The degree of risk this introduces means that, in the case of an ethanol/methanol blend, making blending attractive on a widespread basis would require a significantly higher subsidy than indicated by this simple calculation.

AGRICULTURAL IMPACTS

AGRICULTURAL IMPACTS

The primary reason for interest in fuel ethanol is the benefits that would flow to those who produce the grain that would be utilized as feedstock. Cereal grains are in abundant world supply and competition among grain exporting countries for markets is intense. This competition manifests itself in the form of price reductions, and feed grain prices in western Canada today are at a 50 year historic low level in real terms. Although the Canadian grain industry does not have burdensome levels of grain carryover at the present time, neither do we consume or export the volume that farmers would like to grow. There is also a constant concern and worry that our carryover level could quickly balloon into a problem, just as has happened in the past. The main aims of the cereal grain industry in supporting the ethanol concept are to assure a larger domestic market for its production and to increase price levels.

There is no doubt that fuel ethanol has the potential to utilize large quantities of domestic grain. If all gasoline in Canada were to contain 10% ethanol, the need for feed grains to supply this industry would be 8.5 million tonnes. If all gasoline were to contain an alcohol blend of 3% ethanol and 5% methanol, the need for feed grains would be 2.5 million tonnes. (Corresponding grain requirements for alcohol-blended gasoline used in Alberta are 1.12 and 0.34 million tonnes respectively.)

Feed grains normally produced in Canada are barley, corn, oats and wheat. The major feed grains are barley in Western Canada and corn in Eastern Canada. Ethanol can be produced from virtually any grain, but feed grains are generally considered the best feedstock because their market price and ethanol yield relationship permit lower ethanol production costs than food grains would permit. Higher yielding, low protein wheats might well provide an ethanol yield/price relationship superior to that

of barley or corn if sufficient volume of these wheats were to be produced on a consistent basis. Since barley and wheat are readily substitutable cropping options for most of Alberta, it is assumed that wheat could be an alternative to barley as an ethanol feedstock at some time. Barley is nonetheless considered to be the most likely feedstock in Alberta because of its historic production levels.

We must recognize that an increased demand for grain from an ethanol industry may create benefits for some agricultural sectors and costs to others. If grain price levels increase, for example, those who now use grain will have additional costs. The largest single market for Alberta barley is now the domestic livestock industry, and potential costs to it must be identified and balanced against any benefits that grain growers might experience. The effect on government programs, too, must be considered if an aggregate measure of the effects to our agricultural industry is to be calculated.

GRAIN INCOME EFFECTS:

- The principal benefits of ethanol production to the grain sector are the new markets and increase in prices that may accompany the creation of this industry. For the calculation of the extent of these benefits it is necessary to make some assumptions in regard to the degree of market acceptance that might be possible for alcohol fuels. Since market acceptance in some U.S. states approaches 30% (i.e. 30% of the fuel sold is blended with ethanol), that level is assumed to be an upper limit for the Canadian market. It is neither likely or even probable that market penetration would be as great as 30%, but that level will be used because it measures the maximum impact considered possible. Not coincidently, 30% market penetration of a 10% ethanol blend would represent the same market for grain as a 100% market penetration of a 3% ethanol,

5% methanol gasoline blend, so one calculation will provide the answer to two possible approaches.

It is not practical to identify potential benefits for an Alberta ethanol industry in isolation from the rest of Canada because feed grains move freely between the regions of Canada. The benefit to Alberta's grain industry can be measured, however, on the basis of an assumed consistent national policy and that approach has been followed here.

It was determined (Agriculture Canada Discussion Paper, November, 1987, Case 5) that, under the market penetration assumptions previously outlined, barley supply response in western Canada to the market increase would be 800,000 tonnes, and that the price response for barley would be $0.40/tonne. (Analysis by Alberta Agriculture indicates that this price response is a conservative estimate, and may be closer to $1.00/tonne.) If Alberta were to maintain its relative share of western barley production (52%), the increase in barley production for Alberta would be 52% of 800,000 tonnes, or 416,000 tonnes. Approximately 340,000 tonnes of that increase in supply would be used to produce ethanol in Alberta and the remaining quantity would be transferred into the Eastern Canadian ethanol industry.

The increase in revenue to Alberta farmers would be any increase in volume multiplied by the new price, and, since all domestically consumed barley would experience the $0.40/tonne price increase, an additional amount equal to the price response multiplied by domestic barley use. (Barley feed consumption in Alberta averages 3 million tonnes.)

The revenue increase would therefore be:

(416,000 tonnes) x ($80.40) + (3,000,000 tonnes) x ($0.40)
= $34.6 million annually.

It is not necessarily true to conclude that the same price response and a strictly proportional supply response would be accurate for an Alberta ethanol industry in the absence of a national industry. No model exists that would separate our provincial grain industry from the national grain industry with its essentially free flow of grain supplies.

The reader is urged to use caution in interpreting the revenue increase calculation for the following reasons:

1. Neither the increase in Alberta barley production (416,000 tonnes) nor the increase in barley price ($0.40) would occur unless an ethanol industry were to exist nationally;

2. Barley supply and price response would be smaller than the estimates roughly proportional to the degree that ethanol failed to meet the 30% (10% ethanol) or 100% (3% ethanol, 5% methanol) market penetration level. Lower market penetration would almost assuredly be the experience.

3. The revenue increase is a measurement of gross revenue increase and not net revenue increase. Net benefits to the Alberta grain industry would be lower than indicated to the extent that increased production costs were incurred to produce the additional barley.

LIVESTOCK INDUSTRY EFFECTS:

- There is a cost to the domestic livestock industry because of the $0.40/tonne barley price response. This cost is equal to the domestic feed use (3,000,000 tonnes) multiplied by the increase in open market barley price. ($0.40)

(3,000,000 tonnes)x $0.40 = $1,200,000 annually.

Since approximately 1/3 of the provincial barley use for ethanol production would be returned as high protein distiller's grains, there would be 340,000/3 or approximately 113,000 tonnes of new protein supplements in close proximity to our feeders. If, based on protein content, the value of distiller's grains were to be discounted relative to the value of imported soybean meal there may well be an advantage to our domestic feeders. We do not have sufficient quantities of distiller's grains in the Alberta market today to be able to judge with precision the value that feeders would place on this product compared to what is now paid for imported soybean meal. Alberta currently imports 92,000 tonnes of soybean meal per year (at an average price of $252/tonne) and barley distiller's grains appear to have a market value of $130/tonne. Barley distillers grains contain approximately 36% protein and soymeal contains approximately 49% protein. If the real value of barley distillers grains to feeders is proportional to its protein content when compared to soymeal, it should be valued at 73% of $252/tonne, or $184/tonne. The difference between this $184/tonne and the apparent market price of $130/tonne is a potential benefit to our feeding industry. It would become an actual benefit only if imported soymeal was replaced with an equivalent quantity of barley distillers grains. This potential benefit would be:

(113,000 tonnes) x ($184-130/tonne) = $6,100,000 annually.

The potential net benefit to the livestock sector would become the potential benefit from distillers grains availability minus the cost from the increase in feed grain costs.

$ 6,100,000 - 1,200,000 = $4,900,000 annual potential savings.

EFFECTS ON GOVERNMENT PROGRAMS:

- Western Grain Stabilization (WGSA) benefits are determined on a net revenue basis. WGSA payments to farmers would therefore decline in the short run by an amount proportional to the increase in revenue due to either increased sales or increased prices for barley. Longer term eligibility for WGSA payments would rise on the same basis.

- The Western Grain Transportation Act reduces the cost of exporting grain from Western Canada, including movement into Eastern Canada. Since the barley supply response in Western Canada is greater than the increased domestic use of barley in the western ethanol industry there are no savings to farmers or the federal government because of reduced export of barley. In fact, with a consistent national ethanol industry aggregate transportation costs would increase proportional to the net increase in feed grain movement. (The net increase is the increased movement to eastern Canada less the reduced export movement to foreign markets.)

- If the Crow Benefit Offset Program were to be extended to grain used in an Alberta ethanol industry, some cost to the Government of Alberta would be incurred. This would equal $13/tonne multiplied by approximately 350,000 tonnes, or $4.5 million. This would reduce the need for per litre subsidization by an equivalent amount, i.e. about three cents per litre of ethanol.

EFFECTS OF WESTERN GRAIN TRANSPORTATION ACT:

The Western Grain Transportation Act (WGTA) is a Government of Canada initiative designed to lower the cost to farmers of transporting grain out of the Canadian Wheat Board designated

area (i.e. Manitoba, Saskatchewan, Alberta, and the Peace River block of British Columbia). Certain sums, calculated annually, are paid by the Government of Canada to railway companies to offset some of the actual costs of transporting grain to British Columbia, Churchill and Thunder Bay ports. Only grain which is actually exported from the designated area is eligible for this transportation offset. The net effect for those industries which utilize prairie grain within the designated area is that the grain consumed is priced at a higher level than it would be if total real transportation costs were incorporated in the pricing equation.

This transportation subsidy paid to railways on behalf of grain growers for 1987 was $23/tonne and grain used within the designated area was, therefore, priced $23/tonne higher than it would have been if real transportation costs were used. For the 340,000 tonnes of grain that might be used in an Alberta ethanol industry, the total cost due to the artificial elevation in grain prices arising from the WGTA would have been 340,000 x $23/tonne = $7.8 million.

In summary, measured agricultural impacts from an ethanol industry are as follows:

$34.6 million	Gross revenue increase
$ 6.1 million	Potential benefit from distillers grain
($ 1.2 million)	Cost to domestic livestock industry due to price increase
----------------	
$39.5 million	Potential agriculture-related benefit

Note: See limiting qualifications on page 73.

ECONOMIC IMPACTS

ECONOMIC IMPACTS

INTRODUCTION:

This section discusses the economic implications for Alberta of developing a grain-based fuel ethanol industry. It addresses these questions as they apply to the provincial economy as a whole and in particular the agriculture sector. These social economic issues are broader than and should not be confused with the commercial plant economics which were dealt with in the section on production costs.

The pure plant economics of fuel ethanol are not attractive. There is no doubt that to bring about the use of fuel ethanol would require government action through either legislation mandating ethanol use or through direct subsidization or indirect subsidization such as tax concessions or special financing arrangements. The matter dealt with here is whether there are economic arguments to support this sort of action. Addressing this issue with a high degree of accuracy might well require a complex and time-consuming quantitative evaluation. However, in the absence of this, much can still be ascertained about the issues. This section will:

- describe the principle economic issues,
- discuss what can be determined about these issues without a full quantitative economic evaluation, and
- arrive at a judgement, in the absence of a quantitative economic evaluation, of whether economic arguments support developing a grain-based fuel ethanol industry.

DESCRIPTION OF ECONOMIC ISSUES:

The main issues which need to be addressed relate to the form and level of public financial support which would be required, the

expected duration of subsidization, the income distribution effects and the net economic impact on the provincial economy of such a policy intervention.

Form and Level of Public Financial Support

It should be determined what form and level of public financial support would be required to bring about the adoption of fuel ethanol with varying degrees of market penetration.

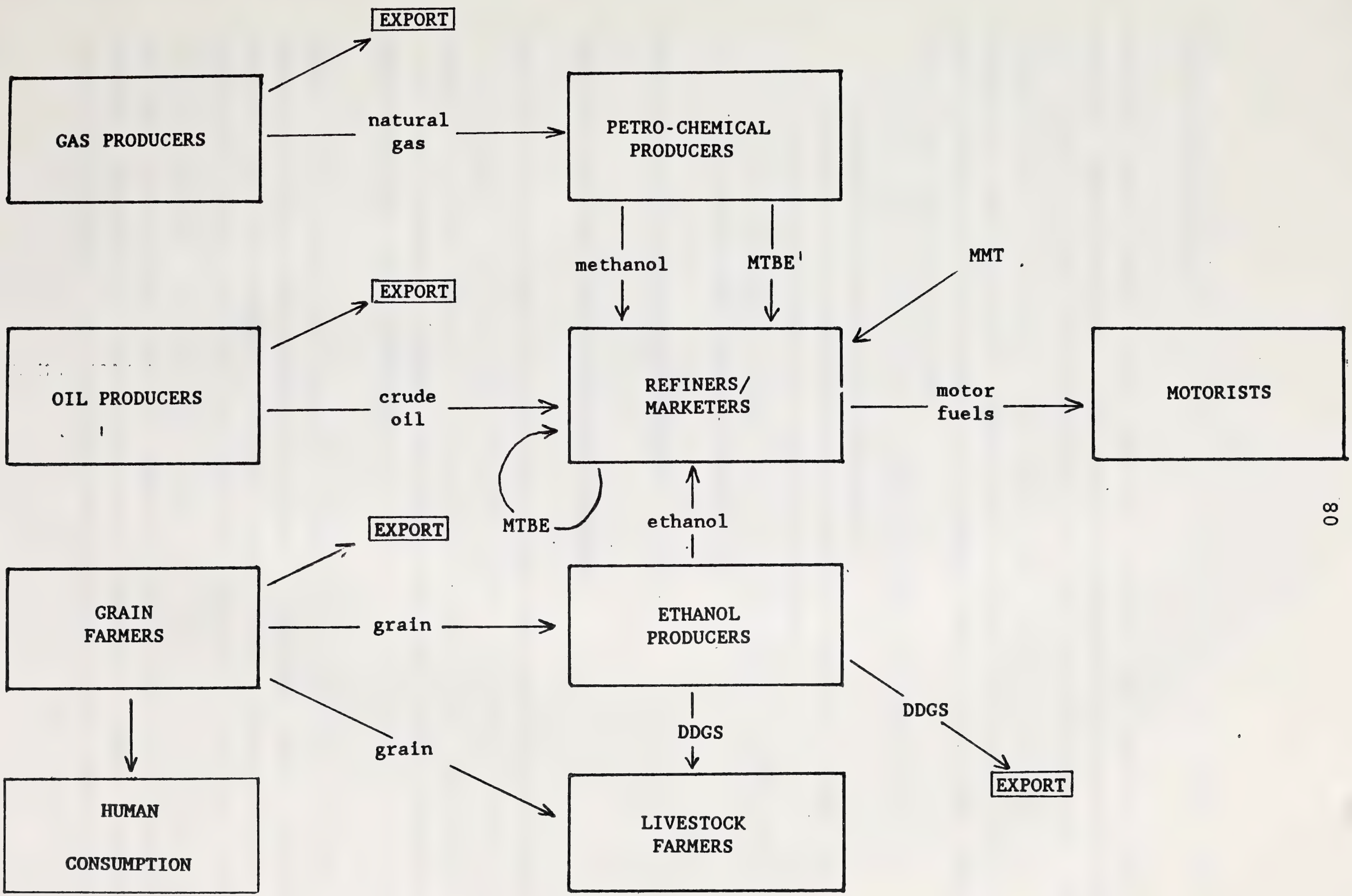
Duration of Public Financial Support

It is important to judge whether a fuel ethanol industry created through public financial support would become viable in an acceptable length of time or whether a continuing need for long-term subsidization would result. Can this industry be "kick-started"?

Income Distribution Effects

The diagram on the next page illustrates the market relationships in terms of the flows of inputs and outputs between the various groups which would be affected. The impacts would not be limited to the agriculture industry but would be quite wide-ranging. It is important which groups in Alberta would benefit and which would incur costs.

MARKET RELATIONSHIPS



Net Economic Impact

Whether there would be a negative, neutral or positive net economic impact relates to the sum, as measured in dollars, of all economic costs and benefits to the Alberta economy of inducing such a change in the production process for gasoline. Generally, benefits to an economy as a whole which might result from a change in its production processes would be derived from one or more of three sources:

- through a technically or economically more efficient production process or processes,
- through more advantageous patterns of external trade, or
- through employment of resources such as land, equipment, workers or other available inputs which otherwise would remain unemployed.

DETERMINATIONS POSSIBLE AT PRESENT:

Form and Level of Public Financial Support

This section discusses some of the issues surrounding what might be the appropriate form and required level of public financial support for fuel ethanol if it was determined that development of a fuel ethanol industry was desirable and that financial support was the way to develop it.

There are a number of possible forms of government financial support for the development of ethanol. As well there is the possibility of mandating ethanol use through legislation. Mandating ethanol use would be the most effective, but likely the least desirable. Putting this aside, it would be premature at this point to review all the possible variations of financial support. However, it is worthwhile to comment on where support might be targeted. Any implications the Canada/U.S. Free Trade

Agreement might have for these possibilities are not addressed here.

There are a range of points along the production process between grain and fuel where financial support could be targeted. These include:

- subsidies at the marketing/retail level through gasoline tax concessions,
- subsidies to refiners,
- subsidies to potential ethanol producers, and
- subsidies to grain farmers.

Targeting the marketing/retail level through gasoline tax concessions potentially would make fuel more attractive to motorists. (Some marketers argue that fuel ethanol would more successfully be marketed as a superior fuel with a higher price.) However, the problem of making production profitable for potential ethanol producers would remain and would require that the "price signals" be transmitted all the way back through the marketing structure and the refining industry to the ethanol producer. The ethanol producer has to share in the enhanced price in order to have an incentive to produce.

The same problem, to a lesser extent, would exist if the support were directed solely to refiners. As well, with support directed only to refiners, there would be no guarantee that the "price signals" would be visible at the pumps. Some refiners have stated that their cost structure is such that they would not use ethanol even if it was free and would require an additional subsidy beyond this to use ethanol.

Targeting support to potential ethanol producers would likely be the simplest and most direct means of offsetting the cost disadvantage of producing ethanol. Ethanol producers could purchase grain feedstock at market prices and sell ethanol to

refiners and/or marketers at less than its full cost of production.

Directing support only to grain growers would be another possibility but in order for the ethanol producer, without a subsidy of his own, to be able to sell at a price attractive to the refiner, the price for grain paid by the ethanol producer would have to be below market. The farmer would have to be compensated by subsidy for the difference between market price and what he was paid. This would not be the simplest and most direct means of providing support.

Of course, combinations of types of subsidies are possible and could potentially avoid some of the difficulties noted. The tendency in other jurisdictions is to target assistance to the marketing/retail level and to ethanol producers. It is significant that in other jurisdictions, only a portion of government assistance has gone to the grain farmer.

Regardless of where the subsidy might be targeted, it is possible to arrive at some crude estimates of what would be the annual cost to government of financial support sufficient to induce some degree of market penetration for fuel ethanol. A previous section outlined the available information on ethanol production costs and the gap between these and the ethanol price at which independent marketers would be indifferent, strictly on the basis of input costs, between straight gasoline and ethanol blends. The subsidy required to make an E10 blend attractive to independent marketers was estimated to be at least $0.25/L. The same figure for a 3 percent ethanol / 5 percent methanol blend is at least $0.08/L. No estimate is available of the subsidy level required to sway refiners. Two market penetration scenarios were used in the Agriculture Impact section. In Scenario 1 there is 30 percent market penetration of a blend using 10 percent ethanol. Coupled with Alberta gasoline demand of 4,410 million

litres per year, this implies annual ethanol demand of 132 million litres per year. In Scenario 2 there is 100 percent market penetration of a blend using 3 percent ethanol and 5 percent methanol also implying annual ethanol demand of 132 million litres per year.

It is not expected that there would be a cost to the provincial treasury in terms of revenue foregone as a result of any decrease in the demand for crude oil in Alberta. Any decrease in Alberta crude oil demand would be directly offset by an increase in exports at very much the same price and therefore royalty.

There would be revenue foregone on fuel tax. The province taxes gasoline at the rate of $0.05 per litre but this tax does not apply to the oxygenate component. To the extent that the oxygenate component became greater, this would reduce revenue. Assuming for simplicity no effect on gas mileage, with 30 percent penetration of a 10 percent ethanol blend, the revenue foregone would be about $7 million dollars annually. The tax revenue decrease which would result from a 100 percent market penetration of a 3 percent ethanol / 5 percent methanol blend would be about $18 million annually.

The table below sets out two estimates of government costs based on the two levels of per litre subsidy and market penetration scenarios. The calculation assumes that the Crow Benefit Offset Program is not extended to grain used to produce ethanol. If the benefit were extended, the need for per litre subsidization would be reduced by about three cents per litre, resulting in the same overall cost to the government.

LOWER BOUND ESTIMATES OF ETHANOL SUBSIDY COST

	ETHANOL SUBSIDY COST	METHANOL SUBSIDY COST	TOTAL COST TO GOVERNMENT
Scenario 1 30% penetration 10% ETOH $0.25/litre subsidy	$33 million	0	$33.1 million
Scenario 2 100% penetration 3%/5% blend $0.083/litre subsidy to ETOH $0.05/litre subsidy to MTOH	$11 million	$11 million	$22 million

Note: Calculations assume there are no additional costs for blending and that no premium can be captured on the retail price. A quarter cent per litre change in the blender's costs or the retail price would cause a change in the subsidy cost of $3 million for the ethanol blend (Scenario 1) and $11 million for the ethanol/methanol blend (Scenario 2).

<u>Duration of Public Financial Support</u>

Generally the need for government involvement in the start-up of a new industry or project is based on the expectation that the new endeavour would ultimately be economically viable if it could overcome some initial barriers. This is of course an application of the 'infant industry' argument. As they relate to major projects, such barriers often centre around financing. Financing

difficulties can be the result of project characteristics such as very lengthy construction periods before positive cash flow, the sheer size of a project being too much for one enterprise to "bet the company" on, or a significant risk that an important endeavour might not become economically viable despite the general expectation that it will. An important test of an endeavour's worth is whether it can reasonably be anticipated that after an acceptable period, the industry or project would likely become self-sustaining. This sort of inquiry needs to be applied to the issue at hand.

Given current prices and technology, it is acknowledged that producing ethanol for use as an octane enhancer is not economic. Were this not the case, likely the issue of government assistance would not arise. Prices of oil and grain currently are such that it is simply cheaper to make motor fuel from oil. Whether fuel ethanol would be judged likely to become economically viable depends on the expected future paths of grain and oil prices. Studies reviewed by the committee indicate that even at currently depressed grain prices, a very large increase in the price of oil (i.e. multiples) would be required before fuel ethanol would be viable. Such oil price increases certainly are not expected. At the same time, it is hoped that grain prices will rebound. While favorable for grain farmers, this would render fuel ethanol even less economical.

Financing hurdles such as project size, very lengthy construction periods or inherent risk are not the problem here; the endeavour is simply not economic and there is no reason to expect it might become so. There is every likelihood that using public financial support as a means of developing a grain-based fuel ethanol industry in Alberta would result in a continuing need for long-term subsidization. This does not appear to be an industry that can be "kick-started".

Income Distribution Effects

The effects on grain and livestock farmers were covered in the previous section. Grain growers would likely benefit. Livestock farmers might benefit but conceivably could disbenefit.

It is often possible based on economic principles to draw conclusions regarding, if not the magnitude, at least the direction of the economic impacts on the other groups which would be affected. This can be done with reference to the "Market Relationships" diagram (see page 80).

Motorists would be primarily affected by any gasoline price changes resulting from the adoption of fuel ethanol. Making fuel ethanol is clearly more expensive than making gasoline. Whether there were to be an effect on retail prices would depend both on whether the level of public financial support partly or more than offset the additional cost and whether refiners and retailers were able (or willing) to pass their higher costs (or savings) on to motorists.

Whether refiners would benefit or incur costs would depend on the same questions. However, it can be said with fair certainty that, short of mandating the use of ethanol through legislation, refiners would only adopt ethanol if the level of public financial support for its production was high enough that they would be better off using ethanol.

Petrochemical producers currently produce methanol which could be used as an octane enhancer either alone or as a blend with ethanol. As well, with capital additions, refiners could produce MTBE (another octane enhancer) for their own use. There are also tentative plans to build an MTBE plant in Alberta, primarily for export but also for use within Alberta. These plans are

currently on hold due to concern that the rapidly growing U.S. demand for MTBE may be short-lived as U.S. refiners find other means such as refinery debottlenecking, addition of isomerization units, etcetera to cope with U.S. no-lead legislation. This same problem could occur for ethanol in Canada if subsidized ethanol were to turn out only to be a short-term solution in the process of phasing out lead.

In terms of cost, both methanol and MTBE are currently viewed by refiners as preferable to ethanol and would be used before ethanol. If an MTBE plant were built, to the extent that subsidized ethanol pushed out sales of MTBE there would be costs to the petrochemical industry. To the extent that ethanol was used alone in, say, a 10 percent blend with gasoline, petrochemical producers making methanol would incur a cost. However, to the extent that 3 percent ethanol/5 percent methanol were prevalent, there would be a benefit to petrochemical producers. The direction of the effect on petrochemical producers is difficult to predict at this time.

Natural gas is an input to the process of producing petrochemicals. Therefore the fortunes of natural gas producers are effected directly by those of the petrochemical producers and hence also are indeterminate.

Oil producers likely would neither benefit nor disbenefit. Any effect adoption of fuel ethanol might have on the demand for crude oil in Alberta would be offset by a change in exports to the U.S. There would not be a significant difference in the netback the producer receives whether sales are into the U.S. or to Alberta refiners. For the same reason that the provincial treasury would not suffer from this effect, neither would the oil producer.

By virtue of public financial support, potential ethanol producers would be able to build and operate at apparent profit ethanol plants that otherwise would not be viable. This group would likely benefit the most of any.

Of course, taxpayers ultimately would have to bear the burden in one way or another of the public financial support to the ethanol industry.

The table below summarizes the tentative conclusions regarding income distribution effects.

Groups Likely To Benefit	Groups Likely To Disbenefit	Groups of Indeterminate Cost/Benefit
Ethanol producers	Taxpayers	Motorists
Grain farmers		Livestock farmers
Refiners (*)		Oil producers
		Petro-chemical producers
		Gas producers

(*) Assuming public financial support for ethanol rather than ethanol use mandated by legislation.

Net Economic Impact

By economic impact is meant the sum total of economic benefits and costs associated with using public sector support to develop a grain-based fuel ethanol industry in Alberta. Based on the available information and analysis, it is difficult to see how a net positive benefit could come about. The analysis in the previous section indicates that agriculture, the very group one might expect to benefit substantially from a fuel ethanol industry, gains little benefit. Against this, some groups could well stand to incur substantial costs while others would be affected to indeterminate degrees. The only group which would clearly stand to benefit would be those who built the ethanol plants, a group which as yet does not exist.

Viewed from another perspective, a net economic benefit to the Alberta economy would not be expected to derive from the three earlier-identified usual sources of gain from change in the economy's production processes: more efficient production, more advantageous patterns of external trade or new use of unemployed resources.

Given today's prices and technology, developing a fuel ethanol industry would not introduce either a technically or economically more efficient means of producing lead free gasoline. In fact, just the opposite would be the case resulting in substantial inefficiencies. These costs would have to be more than offset, if a net benefit were to result, by the other two potential sources of gain.

It does not appear that significant benefits would be derived through changes in external trade patterns. There is the potential benefit of livestock farmers being able to substitute domestically produced DDGS for more expensive imported soymeal protein supplements. However, the $6 million maximum annual

benefit seems far too small to outweigh the other costs to the economy generally.

There appears to be little potential for bringing into the production process resources which would otherwise remain idle. The supply response in agriculture to the small predicted price increase would in turn be small. No significant increase in employment could be expected from this source. The number of jobs directly associated with the construction and operation of the ethanol plant(s) could be significant to small communities if the plants were built there, but the impact on employment would be small in provincial terms.

Developing a fuel ethanol industry in Alberta when market conditions do not warrant is most unlikely to result in a positive net economic benefit for the province.

CONCLUSIONS:

Research papers dealing with the experience other jurisdictions have had with ethanol subsidization schemes tend to support the conclusions of the preceding sections.

In their study (The Economics of Ethanol Production and its impact on the Minnesota Farm Economy - March 1986), Daniel W. Halbach and Jerry E. Fruin of the University of Minnesota concluded that:

> "Ethanol production is economically inefficient and is relatively ineffective in aiding farmers. The state should withdraw from subsidizing ethanol production and employ its resources where they can be used more effectively. If fuel tax funds are to be used with the intent of developing alternative energy sources and/or aiding farmers they would be better spent on such things as energy conservation and

research programs, direct aid to distressed farmers and agricultural research programs."

In a study which did see a benefit to U.S. farmers (Fuel Ethanol and Agriculture: An Economic Assessment - August, 1986), the United States Department of Agriculture, Office of Energy states:

> "Increased fuel ethanol production from renewable resources like grain through 1995 would raise net farm income benefiting mainly corn and livestock producers. Production of additional by-product feeds would depress prices of soybeans. Large ethanol subsidies, which are required to sustain the industry, would offset any savings in agricultural commodity programs. Increased ethanol production would also raise consumer expenditures for food. Any benefits of higher income to farmers would be more than offset by increased costs and consumer expenditures. Direct cash payments to corn growers would be more economical than attempting to boost farm income through ethanol subsidies."

Differences do exist between jurisdictions both in terms of their fiscal regimes and their industrial structures so that experiences from one jurisdiction do not necessarily apply directly to another. However, they can serve as valuable guides.

The foregoing analysis has necessarily been based on a number of judgments regarding quantitative matters and further study could provide more definitive answers to some of the quantitative questions. Based on the available information, the committee concludes that:

- the annual level of subsidization required would be very high,

- there would be little reason to expect that the need for continuous subsidization would end in the foreseeable future,
- agriculture, the industry targeted for aid, would benefit little while other industries and groups would stand to incur substantial costs, and
- the likelihood of a net economic benefit for Alberta would be very low.

APPENDICES

APPENDICES

APPENDIX 1:

Subsidiary Criteria

A policy in respect to fuel ethanol should ;

- not require direct financial assistance from government greater than that which is currently offered for the development of alternative transportation fuels;
- develop an industry which is viable at a range of grain prices equivalent to barley at $75-80/tonne;
- not increase the cost of fuel to the driving public;
- increase economic diversification and balanced regional growth within Alberta;
- increase employment in Alberta;
- be compatible with current refining and distribution procedures;
- achieve product acceptance by car manufacturers and the consuming public;
- achieve product demand and acceptance by the fuel marketers;
- recognize the implications of developments in other provinces.

APPENDIX 2:

State Incentives for Ethanol, United States

State	Incentive (Cdn. cents/litre)
Alabama	0.4
Alaska	2.8
Connecticut	0.4
Hawaii	(4%)
Idaho	1.4
Illinois	(2%)
Indiana	Pending
Iowa	0.4
Kansas	6.9
Kentucky	1.2
Louisiana	48.1
Maine	1.1
Minnesota	7.6
Montana	10.3
Nebraska	1.1
New Jersey	2.8
New Mexico	2.8
North Dakota	1.4
Ohio	0.9
South Carolina	2.1
South Dakota	11.0
Tennessee	1.4
Texas	1.4
Utah	10.3
Virginia	20.6
Washington	1.0
Arizona	0
Arkansas	0
California	0

Colorado	0
Delaware	0
Florida	0
Georgia	0
Maryland	0
Massachusetts	0
Michigan	0
Mississippi	0
Missouri	0
Nevada	0
New Hampshire	0
New York	0
North Carolina	0
Oklahoma	0
Oregon	0
Pennsylvania	0
Rhode Island	0
Vermont	0
West Virginia	0
Wisconsin	0
Wyoming	0

Source - National Advisory Panel on Cost-Effectiveness, 1987

APPENDIX 3:

Oxygenated Fuels

Six oxygenates are of interest in fuel blends. Two of these are the alcohols, ethanol and methanol. The third oxygenate is an ether, methyl tertiary butyl ether (MTBE). Three are more complex alcohols: isopropyl alcohol (isopropanol or IPA), isobutyl alcohol (isobutanol or IBA) and tertiary butyl alcohol (tertiary butanol or TBA).

Gasoline is a mixture of hydrocarbons. Adding an oxygenate to gasoline modifies the characteristics of the blended fuel.

1. Ethanol:

Ethanol distilled from grains can be used as a beverage. Ethanol is also made from ethylene, a product made from ethane which is a constituent of natural gas. Ethanol is also sometimes a product of oil refining. Ethanol can be added blended with gasoline on its own to produce "gasohol". It can also be added to gasoline as a cosolvent for methanol. A cosolvent is used to help prevent methanol separating out from gasoline if water is present. When gasoline is blended with methanol in small quantities, the presence of water can cause the methanol and gasoline to separate into distinct layers or phases, as methanol has a strong affinity for water. To prevent separation, the fuel is kept as dry as possible and other alcohols are added. These alcohols used to prevent phase separation in methanol-gasoline blends are referred to as cosolvents. Ethanol, isopropyl alcohol (IPA), isobutyl alcohol (IBA) and tertiary butyl alcohol (TBA) can be used as cosolvents.

Commercial Alcohols Ltd. of Montreal can make about 225 cubic metres per day of ethanol from ethylene. Mohawk Oil Ltd. at a distillery in Minnedosa, Manitoba, produces about 25 cubic metres per day from cereals. St. Lawrence Reactors Ltd. of Mississauga is selling a limited quantity of ethanol to Mohawk as well.

Ethanol is being blended in U.S. gasoline at a rate of more than 5,000 cubic metres per day, because of incentives introduced with the National Energy Act of 1978 and state incentives. These incentives apply only to ethanol derived from agricultural feedstocks.

The Brazilian Government has developed a fuel ethanol industry based on sugarcane. Approximately 15 per cent of Brazilian motor vehicles now operate on neat (essentially pure) ethanol and the remainder use a blend of 20 per cent ethanol in gasoline.

2. Methanol:

Methanol is made mainly from natural gas. It can be made from other carbon-rich materials such as coal or wood at higher cost. Three Canadian plants produce methanol: Celanese Canada Ltd. and Alberta Gas Chemicals Ltd. in Alberta and Ocelot Industries in British Columbia. They can produce 6,300 cubic metres per day. Most production is exported.

Mohawk Oil sells a blend of 5 per cent methanol, 3 per cent ethanol and 92 per cent unleaded gasoline in Saskatchewan, Alberta and British Columbia, under the name "EM Unleaded". In Ontario, Alberta Gas Chemicals and Sunoco sell a blend of 4.75 per cent methanol, 4.75 per cent IPA and 90.5 per cent unleaded gasoline in their "V-Plus" fuelling stations.

Methanol blends have been sold at two Domo stations in Winnipeg as a demonstration.

Methanol is used in gasoline as a blending agent in the United States. ARCO has an "Oxinol" blend of 4.75 per cent methanol and 4.75 per cent TBA in unleaded gasoline. Methanol is also blended into gasoline in West Germany (3 per cent methanol with up to 3 per cent TBA cosolvent), and in Austria (3 per cent methanol, 2 per cent TBA as cosolvent and 5 per cent MTBE).

3. Methyl Tertiary Butyl Ether (MTBE):

MTBE is made from methanol and isobutylene. Isobutylene is made from butane. MTBE is used as a gasoline octane enhancer and blending component. As its vapour pressure is lower than that of ethanol, MTBE can be added to gasoline without having to remove butane. Several oil companies now make MTBE in the United States for blending into their own gasoline. Only limited amounts of MTBE are available for sale to others. There are no Canadian MTBE plants.

4. Isopropanol (IPA):

Isopropyl alcohol is made from propylene. Propylene is made from propane or as a byproduct of oil refining.

Shell Chemical in Sarnia can make 300 cubic metres per day and exports about half of its output. Increased capacity would be needed for any significant use of isopropyl alcohol as a gasoline blending agent. Commercial Alcohols also makes IPA.

5. Isobutanol (IBA):

Isobutyl alcohol or IBA is a chemical byproduct. BASF Canada Inc. in Montreal used to make about 100 cubic metres per day but stopped because of a lack of demand for the primary chemical product.

6. Tertiary Butyl Alcohol (TBA):

Tertiary butyl alcohol is made by ARCO, at one plant on the U.S. Gulf Coast and a second one in Western Europe. TBA could be made in Canada from butane.

ARCO in the United States produces an oxygenated gasoline called "Oxinol" made with TBA and methanol. About one-third of ARCO's American production is required for the Oxinol blend; most of the remaining TBA goes into gasoline alone, as a fuel extender.

Oxygen Content

Automobile engines require oxygen to burn fuel. Too much oxygen results in low combustion efficiency. Tests of engines designed to use ordinary gasoline suggest that up to 3.7 per cent oxygen by weight can be in the fuel without adversely affecting combustion. Because of this, the amount of oxygenates added to gasoline should be limited unless engine adjustments are made.

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