Clean Fuels

Paving the Way for America's Future

A Source for Information on Clean Burning Alternative Transportation Fuels

Second Edition

Dear Friends:

As we inch closer to the conclusion of a century, never has there been more public attention directed to the preservation of our environment. Key among these concerns is the deterioration of our air quality and the resulting health hazards of air pollution. This is, however, an area where we can make significant improvements through readily available technologies and common sense practices.

The *Clean Air Act Amendments* of 1990 and the *Energy Policy Act* of 1992 will result in sweeping changes in the motor fuel business in the United States as they attempt to address mobile source pollutants. The very composition of motor fuels will be affected and there has been an increasing emphasis on putting cleaner fuels into the gasoline pool. One of the most immediately available changes that can be made to gasoline is to increase the oxygen content by adding alcohols and their ether derivatives. A higher oxygen content allows for a more complete combustion of the fuels and results in significant decreases in a variety of pollutants. The oxygenated fuels and reformulated gasoline programs of the *Clean Air Act* will result in improved emissions in nearly 60 percent of the nation's gasoline.

Ethanol from domestic renewable resources like corn is one immediate asset this country can call on to increase gasoline's oxygen level. It can also be used in its pure, or "neat," form to displace gasoline and reduce our dangerous dependence on imported oil. The Clean Fuels Development Coalition and its member companies, which participated in the production of this document, believe ethanol offers a wealth of benefits to the United States and should be a cornerstone of our nation's energy and environmental policy. President Bill Clinton echoed these sentiments in November 1992:

> "My Administration is committed to encouraging the production and use of domestically produced renewable fuels. If our nation is to have a secure, environmentally sound energy supply, we must sustain a diverse domestic energy industry. Ethanol plays an important role in our nation's effort to build the domestic market for renewable fuels."

With so many alternative fuels being promoted by various groups, however, it is important for legislators, the public and all interested parties to understand the different fuels that are available, how they are made, how they are used and their impact on the environment. We recognize that a variety of these alternative fuels are going to be required to meet all our needs and hope that this edition of *Clean Fuels: Paving the Way for America's Future* will enable lawmakers at all levels of government to make informed decisions. In addition, the media, with a responsibility of informing the public, can also be educated on these issues through this document.

Thousands of copies of the first edition of this document have been distributed. Cooperation and support for continuing to provide such information has been extended by the Governors' Ethanol Coalition and the U.S. Department of Energy who share the Clean Fuel Development Coalition's goals of developing ethanol and other alternative fuels to their full potential.

We are entering an exciting era in the evolution of motor fuels and all American agriculture can be a major contributor to improving our nation's air quality and energy security by providing the resources to produce clean, renewable ethanol. These and other alternatives, as part of our energy and environmental mix, can lead the way to a new era of opportunities.

Sincerely,

Douglas A. Durante
Executive Director
Clean Fuels Development Coalition

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Special thanks to the
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Keturah Sawyer
Research Coordinator
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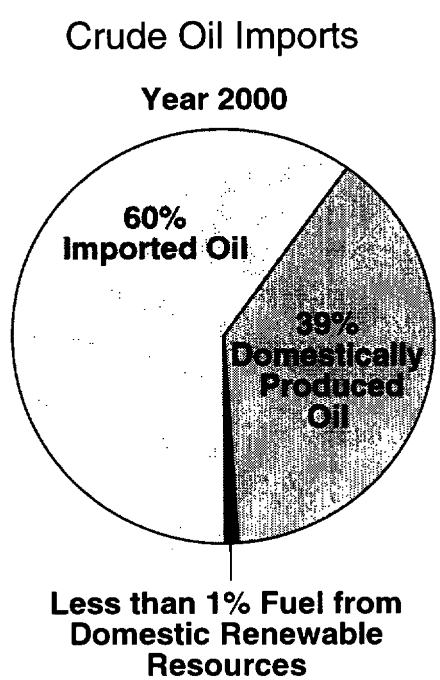
Overview

The United States is faced with a series of public policy challenges that can be favorably addressed with the accelerated development of a domestic transportation fuels industry with a clear and defined role for biomass and other renewable technologies.

The policy challenges include:

- Deteriorating environmental quality caused by increased emissions from the combustion of fossil fuels, including such pollutants as air toxics, greenhouse gases, carbon monoxide and ozone-forming volatile organic compounds.
- Forty-five billion dollars in health care related costs from air pollution.
- Crude oil imports to the U.S. which now exceed 50 percent of the U.S. consumption of oil. The U.S. Department of Energy projects crude oil imports to reach nearly 70 percent in the next decade.
- A corresponding decrease in U.S. crude oil production and a decline in proven reserves of domestic oil and natural gas.
- Surplus U.S. agricultural production and shrinking commodity exports markets.
- Continuing $100+ billion per year trade deficit, half of which is attributed to oil imports.

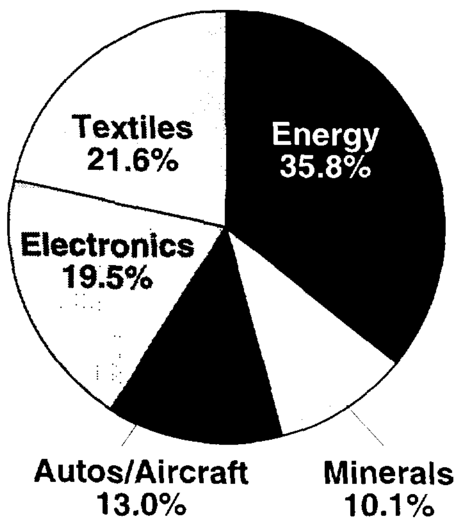


Source: U.S. Department of Energy

- Losing between 1-2.5 million U.S. jobs as a result of crude oil imports.
- Growing industrial and consumer waste with limited disposal options.
- Declining rural economies and rising social costs associated with this trend.

For 100 years, the hydrocarbon-based economy has contributed to make the United States the premier industrialized nation in the world. The nation's investment in the hydrocarbon transportation infrastructure, including over $100 billion in oil and gas subsidies, helped create the world's most dynamic and fastest growing economy in this century. However, the rapid economic growth and resulting depletion of natural resources has pushed the nation's nearly single-minded hydrocarbon-based economic investment to a point of diminishing returns. Since the nation's first oil crisis in 1973, the United states has spent an estimated $1.2 trillion on crude oil imports. Since the end of the Vietnam War, the U.S. has also been involved in four military conflicts in which petroleum resources were at issue.

Trade Deficit 1993



Source: U.S. Commerce Department

Nearly 70 percent of the oil imported into the United States is consumed in the transportation sector. The transportation sector is also responsible for over half of the nation's air pollution. To date, the world's automobile manufacturing industry, primarily U.S. manufacturers, have shouldered most of the burden of blame and investment responsibility for simultaneously resolving the fuel consumption and motor fuel related emissions dilemma.

Recognizing the vital importance of liquid fuels for transportation, energy diversity, domestic production, economic stimulation and environmental enhancement, the U.S. Congress passed a series of energy investment incentives between 1978 and 1980. These legislative actions created investment opportunities for the production of alcohol from agricultural products and biomass. These initiatives were part of a national goal that ten percent of the nation's motor fuel would contain ethanol derived from biomass by 1990.

Since the adoption of the original initiatives and supplemental initiatives in both the Reagan and Bush Administrations, private industry has invested over $2 billion in renewable alcohol fuel production. The United States currently has the capacity to produce 1.4 billion gallons of ethanol per year. While this 15 year growth pattern is considered generally successful, it is very modest from what Congress originally envisioned. Renewable ethanol still represents only 1.2 percent of the nation's annual demand of 115 billion gallons of gasoline.

Passage of the *Clean Air Act Amendments* of 1990 and the *Energy Policy Act* of 1992 reinforced the nation's commitment to energy security, economic development and ensured the pursuit of an environmental equilibrium. As the nation plans for economic growth and domestic investment, the motor fuel market remains one of the most obvious sectors that can absorb the necessary investment, sustain long-term growth, simultaneously provide numerous and diverse benefits to nearly every facet of the economy.

Motor Vehicles, Fuels and the 1990 *Clean Air Act*

The *Clean Air Act* of 1970 set a national goal of clean and healthy air for all. It established for the first time specific responsibilities for government and private industry to reduce emissions from vehicles, factories and other pollution sources.

In many ways, the far-reaching law has been a great success. Today's cars, for example, typically emit 70 percent to 90 percent less pollution over their lifetimes than their 1970 counterparts.

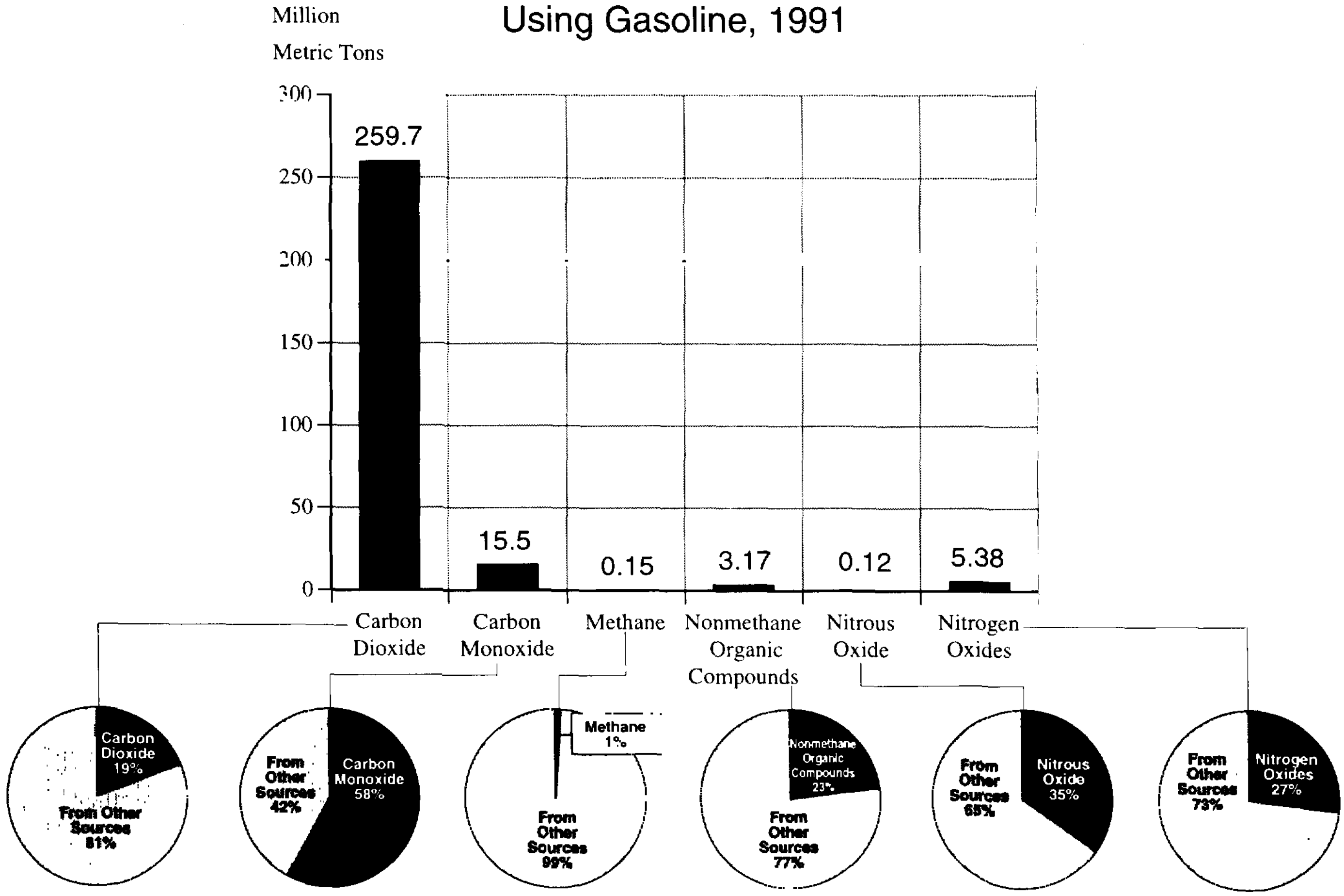
Despite considerable progress, the overall goal of clean and healthy air continues to elude much of the country. Unhealthy air pollution levels still plague virtually every major city in the United States. This is largely because development and urban sprawl have created new pollution sources and have contributed to a doubling of vehicle travel since 1970. Furthermore, scientists and now the public have become concerned about previously unrecognized environmental threats such as acid rain and air toxics.

With these issues in mind, Congress in 1990 amended and updated the *Clean Air Act Amendments* for the first time since 1977. The 1990 *Clean Air Act* includes provisions to further control urban smog, carbon monoxide and diesel particulates and to address air toxics and acid rain. Motor vehicles contribute to all these problems. The mobile source provisions of the 1990 law are targeted to reduce most vehicle-related pollutants by more than 40 percent.

Gasoline and diesel fuel are both produced from crude oil. Together, gasoline and diesel fuel power 99 percent of this country's motor vehicle fleet. Past efforts to reduce vehicle emissions ignored petroleum fuels and focused on the development of sophisticated engine and vehicle emission control systems involving catalytic converters, on-board computers and other hardware. It became apparent, however, that fuel composition and type are also critical factors in the clean vehicle equation.

The *Clean Air Act* of 1990 explicitly recognized that changes in fuels as well as vehicle technology must play a role in reducing air pollution from motor vehicles.

Air Pollution Emissions from
U.S. Passenger Cars and Light-Duty Trucks
Using Gasoline, 1991



Percent of Greenhouse Gases Caused by
Passenger Cars and Light-Duty Trucks Using Gasoline

Source: Energy Information Administration, 1993

The recognition that fuels are significant opened up an interesting debate about the relative merits of petroleum and nonpetroleum fuels. Petroleum fuels have many advantages as vehicle fuels. Oil can still be discovered and pumped from the ground in many parts of the world for as little as ten or twenty cents per gallon. Gasoline and diesel fuel pack more energy per gallon than other fuels. Most importantly, our country's vast transportation infrastructure — refineries, pipelines, service stations and vehicle assembly plants — has been designed and optimized for petroleum fuels.

On the other hand, petroleum fuels have certain drawbacks. Emissions of reactive hydrocarbons, carbon monoxide and oxides of nitrogen from gasoline and diesel vehicles contribute significantly to smog and other air pollution that plague most large American cities. Carbon dioxide emissions from petroleum fuel combustion add to the atmospheric buildup of greenhouse gases that cause global warming. The United States consumes far more oil than it can produce domestically, leading to concerns about our energy and national security.

There are several alternatives to nonpetroleum fuels such as methanol, ethanol, natural gas, propane, electricity and hydrogen that could reduce vehicle emissions of conventional and greenhouse pollutants and could be produced from domestic feedstocks. These fuels are all discussed in this report.

CLEAN FUELS PROGRAM

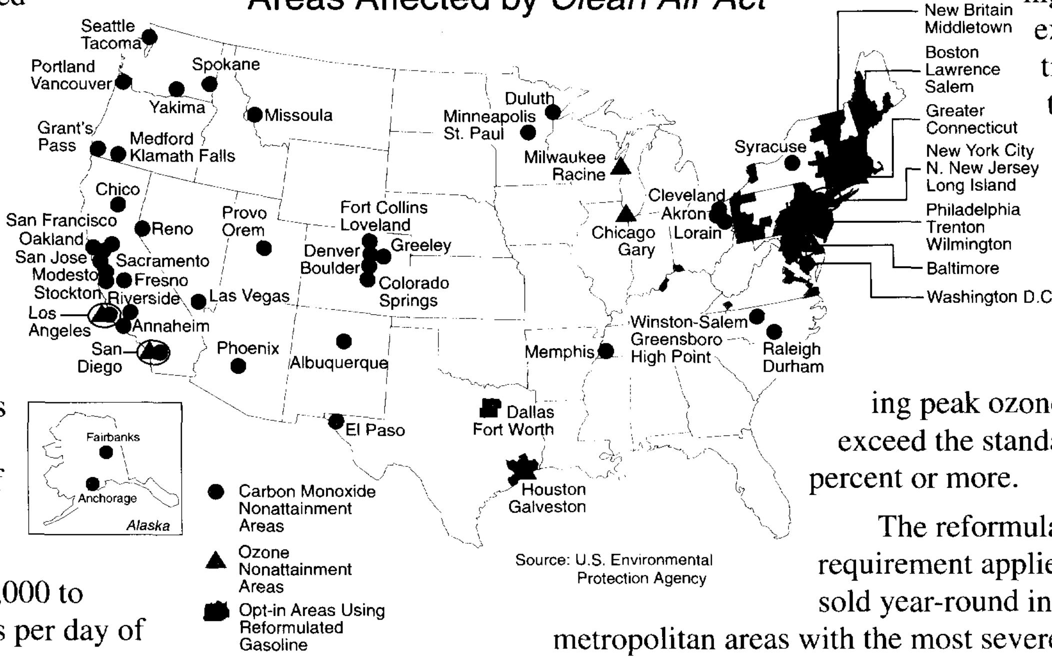
The final version of the *Clean Air Act* stopped short of mandating the sale or use of alternative fuels, but the *Act* includes several programs that will require cleaner fuels and will open up the fuel market to nonpetroleum gasoline additives. These include provisions that force modifications in gasoline composition and establish more stringent emission standards for vehicles in certain polluted areas. There are several major fuel-related provisions of the 1990 *Clean Air Act,* but the two most important to gasoline composition are the oxygenated fuel and reformulated gasoline programs.

Oxygenated Fuels

The oxygenated fuels program affects 39 metropolitan areas that have high levels of carbon monoxide pollution. Beginning in November 1992, gasoline sold in the winter in these areas must contain a minimum of 2.7 percent oxygen. The oxygen helps vehicles burn fuel more completely and this program is expected to reduce vehicle carbon monoxide emissions by 15 to 20 percent.

Fuel additives will supply the extra oxygen for these oxygenated gasolines. The most likely additives are ethanol and methyl tertiary butyl ether or MTBE, a methanol derivative. These additives will be used in about a third of the nation's gasoline, displacing 100,000 to 200,000 barrels per day of oil.

Areas Affected by *Clean Air Act*



This program is specifically designed to combat carbon monoxide which is a colorless, odorless, poisonous gas. A product of incomplete burning of hydrocarbon-based fuels, carbon monoxide consists of a carbon atom and an oxygen atom linked together.

In 1990, 42 urban areas in the United States exceeded the Environmental Protection Agency's National Ambient Air Quality Standard for carbon monoxide. The oxy-fuel program is clearly working for the approximately 22 million people who live in these areas. In the first year of the program there was a 95 percent reduction in the number of days exceeding the health standard.

Reformulated Gasoline

The other major type of pollution addressed by alternative fuels and reformulated gasoline is ozone. Ozone in the upper atmosphere — the "ozone layer" — occurs naturally and protects life on earth by filtering out ultraviolet radiation from the sun. But ozone at ground level is a noxious pollutant. It is the major component of smog and presents this country's most intractable urban air quality problem.

Unhealthy ozone levels are a problem across the United States, with nearly 100 cities exceeding the EPA's National Ambient Air Quality Standard. The standard is based on the highest ozone exposure sensitive persons can tolerate. Nine cities, home to 57 million people, are considered "severely" polluted, experiencing peak ozone levels that exceed the standard by 50 percent or more.

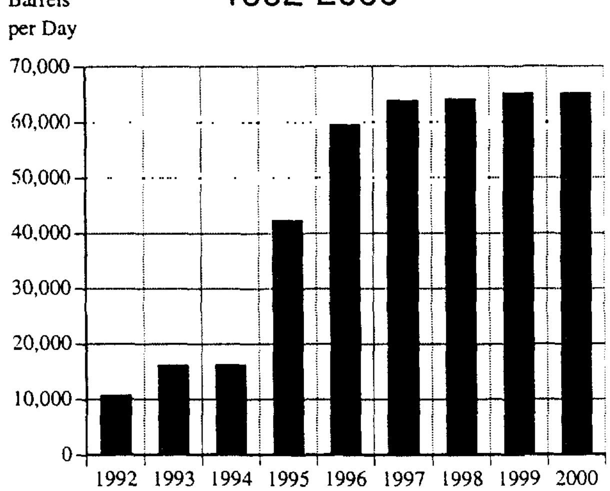
The reformulated gasoline requirement applies to gasoline sold year-round in the nine metropolitan areas with the most severe ozone pollution. Beginning in 1995, reformulated gasoline specifications include a minimum oxygen content of two percent and a maximum one percent benzene content. Heavy metal additives are prohibited. Overall emission performance standards for reformulated gasoline call for at least 15 percent hydrocarbon and toxic emission reductions by 1995 and at least 20 to 25 percent reductions of hydrocarbons and toxic emissions beginning in the year 2000.

In addition to the use of oxygenates to boost fuel oxygen content, refineries will have to restrict or delete certain high-volatility compounds, aromatics, olefins and sulfur from gasoline.

The base requirement will reformulate 22 percent of the country's gasoline supply and displace between 100,000 and 350,000 barrels of oil per day. However, the *Clean Air Act* permits other polluted cities — up to 87 across the country — to voluntarily join, or "opt-into," the program which could result in reformulating more than half of the nation's gasoline.

The oxygenated fuels program and the reformulated gasoline program are aimed at cleaning up gasoline rather than literally replacing it. Alcohols and their ether derivatives will be the alternative fuels used in these programs because they increase the oxygen content and are easily mixed with gasoline, requiring no modifications to motor vehicles or the petroleum infrastructure. Both the *Clean Air Act* and the *Energy Policy Act* also address the opportunity for directly substituting petroleum with alternative fuels.

Estimated U.S. Carbon Monoxide and Reformulated Gasoline Market, 1992-2000



Source: Information Resources, Inc. and Clean Fuels Development Coalition Inc., 1994

Fleets and Alternative Fuel Program

The *Clean Air Act Amendments* of 1990 created a Clean Fleets Program to introduce clean fuel vehicles nationwide. By model-year 1996, automobile manufacturers must begin producing at least 150,000 clean-fueled cars and light trucks per year under a California pilot program. For model years 1999 and thereafter, manufacturers must produce 300,000 clean fuel vehicles each year.

Beginning with 1998 models, fleets with ten or more vehicles capable of being centrally refueled in the 22 smoggiest cities — the serious, severe and extreme ozone nonattainment areas plus Denver, Colorado for carbon monoxide nonattainment — must begin to buy clean fuel vehicles. Marginal and moderate ozone nonattainment areas are not required to participate, but may elect to do so.

Beginning in the model year 1998, 30 percent of new passenger cars and most categories of light trucks and vans — up to 8,500 pounds — bought for these fleets must be clean fuel vehicles. The percentage rises to 50 percent of purchased vehicles in the model year 1999 and 70 percent in the year 2000 and beyond.

The *Act* defines clean alternative fuels as methanol, ethanol, other alcohols, reformulated gasoline, reformulated diesel — for trucks only — natural gas, liquefied petroleum gas or propane, hydrogen or electricity. Vehicles can be flexible-fuel or dual-fuel, but if so, must use clean fuel within the nonattainment areas.

The *Energy Policy Act* of 1992 provides federal mandates for alternative fuel vehicles. The primary aim of the *Act* is to reduce the United States' dependence on crude oil imports.

This legislation defines alternative fuel as natural gas, propane, alcohol — methanol, ethanol and higher alcohols — blends of alcohols with gasoline or other fuels containing 85 percent or more alcohol by volume, hydrogen, fuels derived from biomass and liquid fuels derived from coal and electricity. A fleet is defined as at least 20 vehicles that can be centrally fueled, being operated in a metropolitan area with a population of 250,000 or more — based on 1980 Census — and controlled by an entity that owns at least 50 such vehicles in the United States.

Private-sector companies that make alternative fuels, such as natural gas companies or electric utilities, are required to introduce alternative fuel vehicles into their fleets as follows:

- 30 percent in model-year 1996
- 50 percent in model-year 1997
- 70 percent in model-year 1998
- 90 percent in model-year 1999 and thereafter.

The minimum federal fleet requirements for light-duty alternative fuel vehicles are as follows:

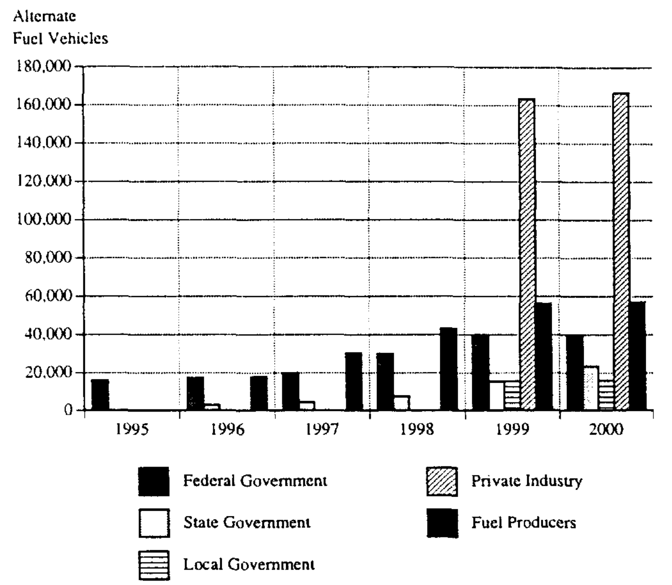
- 5,000 in fiscal year 1993
- 7,500 in fiscal year 1994
- 10,000 in fiscal year 1995
- 25 percent in fiscal year 1996
- 33 percent in fiscal year 1997
- 50 percent in fiscal year 1998
- 75 percent in fiscal year 1999 and thereafter.

Purchases of light-duty vehicles by state governments are required to be alternative fuel vehicles in the following amounts:

- 10 percent in model-year 1996
- 15 percent in model-year 1997
- 25 percent in model-year 1998
- 50 percent in model-year 1999
- 75 percent in model-year 2000 and thereafter.

There are currently 12 million vehicles in 91,000 fleets of ten or more in the United States. Fleets are growing at a rate of 1.6 percent annually, while the number of fleet vehicles is growing at a rate of 3.2 percent.

Fleet Purchases Mandated by the *Energy Policy Act,* 1995-2000



Source: U.S. Department of Energy, 1994

Most of these fleets are under 500 vehicles. The incremental cost of a light-duty truck or van fueled with natural gas over a conventionally-fueled vehicle is $2,500, so there is no economic incentive to convert. The economic attractiveness of conversion to a natural gas vehicle depends on rapid payback through fuel cost savings. In response to federal and state legislation, 38,500 natural gas vehicle fleets — mostly small — will be mandated for conversion by 2000. A total of 861,000 natural gas vehicles are projected to be purchased between 1995 and 2000 to meet these mandates.

The Clinton Administration has expressed a desire to accelerate the use of alternative fuels as evidenced by an Executive Order signed by President Clinton on April 21, 1993, directing the federal government to increase the rate of conversion of the federal fleet beyond that required by the *Act.* The Order calls for federal government purchases of 7,500 alternative-fuel vehicles in 1993, 11,250 in 1994 and 15,000 in 1995. These purchases are 50 percent higher than those called for in the *Act.* The administration has expressed particular interest in utilizing more compressed natural gas as a motor fuel.

The Role of Automobile Manufacturers

Major automobile manufacturers continue to examine a variety of alternative fuel vehicle options in an effort to provide vehicles to meet the fleet requirements of the *Clean Air Act* and the *Energy Policy Act*. The current generation of alternative fuel vehicles available to consumers is somewhat limited as the auto industry attempts to respond to what is at present a limited market demand while also engaging in research and development programs in anticipation of future demand.

Automakers have repeatedly indicated that their ability to manufacture reliable and clean-running automobiles that are also capable of high fuel mileage using existing technology is diminishing. As witnessed by their comments on the fuel volatility issue, the automakers need reduced volatility fuels to make their vehicles run cleaner and more efficiently. Generally, they are supportive of oxygenated fuels as a means of replacing volatile petroleum-based components. In fact, former General Motors Corporation Chairman Roger Smith announced in late 1989 that he would recommend the use of oxygenated fuels in their 1990 model automobiles, which they are now doing. The automobile manufacturers have been particularly supportive in the development of reformulated gasoline, providing much needed technical support and testing. As reiterated in a January 1995 press conference, the American Automobile Manufacturers Association stated:

> "America's car companies — Chrysler, Ford and General Motors — support the reformulated gasoline program for three reasons. First, it reduces vehicle emissions for all cars, not just new ones. Second, it doesn't impact the personal mobility of consumers, choice of vehicles or convenience of operation. And third, it is a cost-effective way to further reduce mobile source emissions. This program demonstrates that clean air **can** be achieved with simple, cost-effective solutions that protect consumers' freedom of mobility."

All major manufacturers honor warranties for these EPA approved fuels containing oxygenates. An Appendix of automobile owner's manual oxygenated fuel recommendations can be found starting on page 44.

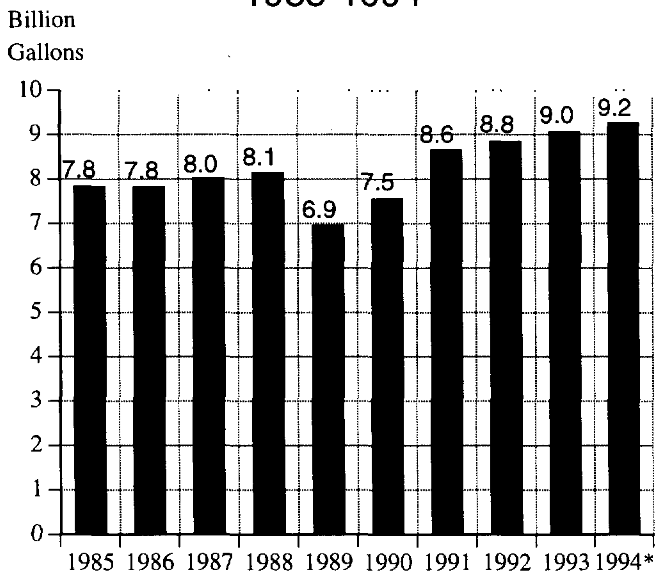
Ethanol

Ethanol has been recognized as a quality motor fuel since the design of the first automobiles because of its high octane and British thermal unit content. The original Ford Model-T was designed to run on ethanol which has been used as a motor fuel for nearly three-quarters of a century.

The potential of gasoline supply disruption and shortages during World War II resulted in a heightened interest in ethanol as a motor fuel in the United States while, at the same time, it was successfully being used by the Germans as an aviation fuel. Eventually low oil prices made it impossible for fuel-grade ethanol to compete and the market all but disappeared. The oil shortages of 1973 and 1978 again gave rise to the use of ethanol as a motor fuel as Congress looked to diversify our resource base.

Since its inception in 1978, the U.S. ethanol industry has continued to develop through deliberate public policy incentives created by the Congress in an effort to reduce foreign oil purchases, create new markets for grain and improve air quality. Commercial investment and business development have depended upon a variety of production and marketing incentives, primarily the exemption of ethanol blends from a portion of the federal excise tax on gasoline. When ethanol is more widely accepted by the petroleum industry, then it can be used in its highest value

U.S. Ethanol Blend Gasoline Sales, 1985-1994*



*1994 Projected Sales

Source: U.S. Department of Transportation, 1993 application — as an octane enhancer in premium and midgrade motor fuels and as a feedstock for the production of ethyl tertiary butyl ether or ETBE. Ethanol also has great value as an air pollution control strategy, particularly for carbon monoxide.

Historically, the ethanol industry's support among the various executive agencies and Congress has been favorable. Analyses by such diverse entities as the Congressional Research Service, the National Advisory Panel on the Cost Effectiveness of Ethanol Production — convened by the Secretary of Agriculture — the Senate Environment and Public Works Committee, the General Accounting Office and the President's Task Force on Regulatory Reform all conclude that the ethanol industry's government incentives to stimulate production and marketing are a cost-effective "investment" of government tax dollars. They conclude the investment is justified on the basis of ethanol production's contribution to agricultural program cost reductions, carbon monoxide emission reductions and imported oil trade balance improvements.

Ethanol was originally used as a gasoline extender and an octane enhancer. Ten percent volume ethanol blends, in addition to displacing gasoline often derived from imported crude oil, also increased octane by two to three points, thereby providing a valuable additive to mid to low octane gasolines. Although the original tax incentives available to ethanol required that it be used in ten percent volume increments, there is no underlying technical need for that amount and ethanol is used successfully in various concentrations up to ten percent volume or 3.5 percent by weight oxygen content. Ethanol blends are universally approved at up to ten percent volume by every automobile manufacturer selling cars in the United States.

As the U.S. Environmental Protection Agency and Congress began to fully appreciate the value of oxygen content in gasoline in the late 1980s, interest in ethanol production continued to grow. The partial exemption of ethanol blends from the Federal Motor Fuel Excise Tax is now applied proportionately to blends of less than ten percent in order to encourage its use in oxygenated fuel programs across the country. (A number of states also provide tax related incentives which are discussed beginning on page 35.) While one of ethanol's most positive characteristics is that it can be blended with gasoline, it also has the potential to be used in its pure or "neat" form, or in concentrations ranging from 85 to 100 percent.

Ethanol is an approved alternative fuel as defined in the *Energy Policy Act* and in certain locations throughout the country could potentially compete with other fuels for use in fleets, urban buses and heavy-duty engines. The use of ethanol in fleet applications may be limited due to the lack of automobiles designed to operate on ethanol. The current generation of variable or flexible fuels can operate on any concentration of ethanol or methanol mixtures and may provide additional near term opportunities for ethanol.

A significant improvement in performance and mileage and consequently in the economic competitiveness of ethanol as a neat fuel would result from its use in engines that are optimized to take advantage of its fuel properties. This would include modifications to timing and compression as well as the replacement of some parts such as stainless tanks and non-corroding hoses.

ECONOMIC IMPACT OF INCREASED ETHANOL PRODUCTION

The perceived economic benefits of ethanol as a transportation fuel are significant. Increased ethanol production has the potential to create a positive economic impact on employment, personal and business income creation, as well as on the federal budget.

The U.S. Department of Agriculture, the Department of Commerce, the Department of Economics at Iowa State University and the Western and Great Lakes Regional Biomass Energy Programs have produced four different case studies in the past four years on the job and income creation from increased ethanol production. Each analysis concluded that the construction and operation of a 50-100 million gallon wet milling ethanol production facility would result in a significant increase in job and income creation.

Through these four different studies, it can be estimated that the actual construction of such a facility would produce from 370 local jobs to 5,604 person-years of work with an income creation of $60 million to $130 million. Jobs created during the operation of the facility are estimated to range from approximately 900 to more than 4,000, with an estimated created income of $47 million to $100 million.

> CORN GROWERS WILL RECEIVE A SIGNIFICANT INCREASE IN INCOME BECAUSE OF HIGHER CORN PRICES AND HEIGHTENED DEMAND FOR THEIR PRODUCT.

A 1990 analysis by the National Corn Growers Association of America concluded that the projected expansion of the ethanol industry between the years 1992 and 2000 could create over 273,000 jobs nationwide while increasing consumer income by $3.8 billion. The report also estimated that for every person employed in an ethanol plant at least two jobs in related industries are created.

Corn growers will receive a significant increase in income because of higher corn prices and heightened demand for their product. A 1990 study by the U.S. General Accounting Office concluded that doubling ethanol production to 2.2 billion gallons in an eight year period or tripling it to 3.3 billion gallons in the same time frame, would result in an increase of corn prices over baseline projections by 19 cents a bushel — nine percent — and 32 cents per bushel — 15 percent — respectively.

However, the study suggests that because protein rich feed and corn oil byproducts compete with soybean meal and soybean oil, soybean producers and processors would be negatively affected by increased ethanol production. Higher corn prices raise livestock-feed costs which would have a negative impact on cattle ranchers as well. According to the study, higher corn prices could lead to a ten percent increase in feed costs over an eight year period during which time ranchers would need to reduce the number of cattle by four percent.

In general, the increase in corn production and prices will result in the reduction of federal outlays to cover loan defaults and deficiency payments of farmers. According to the study, by doubling ethanol production in 1998 to 2.2 billion gallons, expenditures for the federal farm programs would decrease by $930 million. Increased corn production for ethanol would also reduce federal motor fuel tax revenues, but this reduction would be more than counterbalanced by reduced farm subsidies in land diversion, acreage control and loan programs.

Presently, ethanol contributes positively to the U.S. trade balance by approximately $1.5 billion a year. If ethanol production increased to two billion gallons per year, the USDA predicts it would make an additional contribution of one billion dollars. The use of ethanol as a gasoline additive displaces imported MTBE and some imported petroleum products. According to the Corn Refiners Association, the EPA's Renewable Oxygenate Requirement, which would increase the use of ethanol, could displace 600 million gallons of imported MTBE and reduce the trade deficit by as much as $604 million.

ETHANOL AND AGRICULTURE

Ethanol can be produced from a variety of feedstocks, but the most efficient and widely used of these feedstocks is corn. A significant amount of research continues in both the public and private sector regarding the production of ethanol from such products as sugar beets, potatoes, agriculture and municipal wastes and various forms of biomass. For the foreseeable future, however, the continued growth of the ethanol industry will result in the increased utilization of corn and other agricultural based products. This could address many chronic problems facing the American agriculture industry.

According to the National Corn Growers Association, 1.6 billion bushels of corn have been used in ethanol production during the last decade. This has resulted in significant rural economic growth and stimulation as well as the reduction of government farm program costs. An additional element to producing ethanol from corn is the variety of co-products derived from the process that are used in many sectors of the economy. The ethanol production process converts the starch content of the corn, leaving a high protein co-product that is a quality animal feed.

Beneficial impacts on American agriculture resulting from increased ethanol production include the following:

- Ethanol production is estimated to increase the market price for corn by a minimum of 15 cents per bushel and could increase corn prices by as much as 50 percent over the next decade as a result of new demand created by the *Clean Air Act.*
- For each 100,000 bushels of corn used in ethanol production, more than two thousand new jobs are created, resulting in revenue flow back to the government in the form of increased personal and corporate income taxes at both the federal and state levels.
- Increased ethanol production offsets diminishing export markets.
- Corn used in ethanol production provides both fuel and feed through co-products used for livestockfeeding.

MANY BELIEVE THE FEDERAL GOVERNMENT SHOULD ENCOURAGE AND SUPPORT PROGRAMS THAT ALLOW AMERICAN AGRICULTURE TO SUPPLY BOTH FOOD AND FUEL.

Each year, U.S. farmers can potentially plant approximately 80 million acres of corn. Estimating an average yield of 125 bushels of corn per acre over the next five years shows that the U.S. farmer has the capacity to produce ten billion bushels of corn annually.

Uses for that corn are broken down as follows:

- 4.5 billion bushels for domestic livestock, hog and poultry feed;
- One billion bushels for processing, including starch, sweeteners and ethanol; and
- One-two billion bushels for export, depending on world conditions and U.S. subsidy.

This suggests that more than two billion bushels of corn could be grown for the sole purpose of converting it to ethanol. Many believe the federal government should encourage and support programs that allow American agriculture to supply both food and fuel, particularly considering ethanol's environmental advantages.

Ethyl Tertiary Butyl Ether

The potential for significantly increased ethanol use in the future may be in its application as a feedstock for Ethyl Tertiary Butyl Ether or ETBE.

ETBE is an oxygenated fuel that can be blended with gasoline to make it burn more cleanly and thus improve overall air quality. ETBE is produced by mixing ethanol and isobutylene and reacting them with heat over a catalyst. The promise of ETBE is that it eliminates many of the historical impediments to the greater use of ethanol such as increased volatility of gasoline and incompatibility with gasoline pipelines. This would allow ETBE to be used at the refinery level and economically transported to areas that previously had not been able to utilize ethanol.

ETBE attains the overall goals of reducing the health impacts of motor fuel because it can utilize excess butanes in the refining industry resulting from the phase-out of lead. These butanes can be converted to isobutylene which, when combined with ethanol, produce an environmentally superior motor fuel. The State of Nebraska's Ethanol Board, Arco Chemical Company, Sun Refining Company and others are conducting in-depth research and development of full commercialization of ETBE.

The use of ethanol as a fuel extender and octane improver in U.S. motor fuel has fallen short of expectations since the initiation of the *Energy Tax Act* of 1980 which established the federal gasohol program. The target was ten percent ethanol in U.S. gasoline by 1990. Currently less than one tenth of that potential for ethanol/gasoline blending has been realized. Similarly, less than one tenth of the potential to convert grain surplus to fuel has been realized.

Many experts in the motor fuel industry believe the problem has been lack of acceptance of ethanol by the petroleum refining industry and common carrier pipelines. The automobile manufacturers, while they accept alcohol and gasoline blends, have done so with reservations and have expressed a strong preference for ETBE.

Fundamental issues detrimental to the acceptance of ethanol at the refinery operating and marketing levels are:

- Ethanol represents a blending agent not manufactured at the refinery site.
- Ethanol-hydrocarbon blending requires the elimination of water from the refinery tank farm and product delivery systems. This includes common carrier pipelines which have not accepted alcohol/gasoline blends.
- In cases where ethanol-gasoline blends are accepted by one oil company, they are usually

not accepted by that company's exchange partners. Therefore marketing is restricted.

The problem can be simply stated as a lack of approval of ethanol as a universally accepted blending agent in gasoline. One solution is to convert ethanol to ETBE, a blending agent that would be manufactured at the refinery. ETBE is water insoluble and thereby eliminates objections attributed to ethanol. This would compliment the existing ethanol blend market while opening up new market opportunities since each gallon of ETBE contains 42 percent ethanol.

An analogy can be made with the petroleum industry's rejection of methanol and cosolvents. By contrast, the industry has widely accepted Methyl Tertiary Butyl Ether, or MTBE, for gasoline blending on the same terms as a hydrocarbon. MTBE plant capacity in the United States is now approaching 215,000 barrels per day and represents a dramatic increase over previous levels.

The MTBE and ETBE processes are similar although reaction rates and operating conditions vary. MTBE units now in operation in the U.S. petroleum industry could probably be readily converted to ethanol feedstock for ETBE production.

Ethanol could become a cost competitive feedstock for ethers currently manufactured with methanol. ETBE, because of its ethanol base, has better blending properties, thus making it superior to MTBE for both octane improvement and motor fuel volatility control. Methanol is currently dependent on natural gas as a feedstock leading some analysts to believe that methanol demand could approach effective capacity by the mid 1990s. Ethanol based on grain and other biomass feedstocks is renewable as well as being available worldwide and could help fill the demand that may result from dramatic increases in methanol production. Projections suggest an increasing supply of worldwide grain surpluses in the future.

Common Carrier And Refiner Acceptance Of Ethers

MTBE is manufactured by several major oil companies and MTBE/gasoline blends are completely accepted by the product pipeline systems.

MTBE represented the petroleum refiners' first step away from total hydrocarbon operation within the refinery itself. MTBE is a high-octane, water tolerant ether made by combining refinery isobutylene and methanol supplied from sources outside the refinery. Isobutylene is currently derived from two major sources: steam cracking for ethylene manufacture; and fluid cat cracking for gasoline and distillate manufacture. Additional isobutylene supplies can be made available by isomerizing surplus n-butane to isobutane, then dehydrating the isobutane to isobutylene.

Because the basic process chemistry is the same, ETBE can be manufactured with the same catalytic reaction and essentially the same process unit as MTBE. Reaction rates will differ, but modest operational changes should be able to accommodate the ethanol feedstock in essentially the same refinery equipment.

Importance Of Greater Volatility Control in Refinery Gasoline Blending

A serious problem facing petroleum refiners in the near term involves gasoline volatility. Refinery operations have increasingly generated more light material with the shift from lead antiknocks to processing to meet gasoline-pool-octane requirements. Adding to the need for more unleaded octane quality is the growing demand for premium fuel. The basic refining problem relates to a creeping imbalance between conversion and condensation processing.

Butanes generated in petroleum refining are traditionally either blended to gasoline or used as feed for condensation or petrochemical operations. Additional n-butane purchased from natural gas processors also is absorbed in gasoline. The increasing surplus of light ends — which is symbolized by n-butane the "swing-hydrocarbon" for volatility control — is being absorbed in the gasoline pool. The economic incentive to absorb a gallon of butane in gasoline ranges from ten to 20 cents depending on geography and season. The octane incentive is equally attractive and, as a gasoline component, butane is several blend numbers above regular unleaded gasoline.

Oxygenates, primarily ethanol and methanol-cosolvent mixtures, have excellent octane blending values. However, alcohols complicate volatility blending. The seriousness of the situation is verified by trends that show a steady rise in the volatility of gasoline reaching the market place. As discussed previously, EPA has focused on gasoline volatility from the standpoint of readily available hydrocarbon emissions reductions.

Blending Values* of Oxygenates in Typical Unleaded Gasoline

Oxygenates	Octane $\frac{\text{Research Octane Number} + \text{Motor Octane Number}}{2}$	Reid Vapor Pressure Pounds per Square Inch
Methanol	116	61.0
Ethanol	113	21.5
Arconol	98	12.7
Oxinol 50	106	33.5
MTBE	106-110	8.0-9.3
ETBE	109-113	4.0-6.0
N-Butane	92	60.0
Toluene	106	0.5

* Blending values vary depending on gasoline hydrocarbon type and exact composition of the oxygenate or hydrocarbon blending agent.

In terms of etherification, ETBE would even be more attractive than MTBE for volatility control. Not only would refinery butanes be displaced from the gasoline pool, but ethanol could be more fully integrated in the gasoline pool when converted to ETBE. In addition, refineries may be inclined to incorporate ETBE into the refining operations due to a comparatively low blending Reid vapor pressure in gasoline.

With reformulated gasoline requiring a minimum of 2.0 percent oxygen, ETBE becomes even more effective.

Comparison of Butyl Ethers at 2.0 Percent Oxygen in Reformulated Gasoline

	MTBE	ETBE
Reid Vapor Pressure*	+0.02	-0.48
Octane	+2.4	+3.1
Volume Percent	11.0	12.8

*At 7.1 pounds per square inch.

As noted by the above table, ETBE actually lowers gasoline volatility even when blended in low volatility summer grade reformulated gasoline. When blended for oxygen, it also provides 23 percent more octane. With this added flexibility, refiners may significantly reduce the capital investment necessary to meet reformulated gasoline volatility and aromatic requirements. As an example, refiners must decrease their summer grade of gasoline in the south from 7.8 pounds per square inch to 7.2 pounds per square inch. ETBE will provide 0.4 pounds per square inch of that 0.6 pounds per square inch reduction when blended for oxygen in reformulated gasoline.

In addition, the higher volume of ETBE necessary to meet the oxygen content specification for reformulated gasoline will result in a greater displacement of other gasoline compounds such as benzene, sulphur, olefins and high boiling compounds currently in gasoline. The combination of greater displacement and higher octane will assist the refiners in reducing aromatics such as benzene, toluene and xylene, thereby assisting refiners in meeting the required 15 percent reduction in toxics. This will enable refiners to produce reformulated gasoline without sacrificing gasoline performance or quality.

Finally, it is important to note numerous studies by industry, the EPA and other institutions which conclude that ETBE compares quite favorably to MTBE on both emissions and performance.

ETBE ECONOMICS

Given the superior blending, performance and emissions characteristics of ETBE, a refiner's decision to use ethanol as a feedstock for ethers, as opposed to methanol, would appear to be both obvious and simple. Unfortunately, the economic advantage for methanol, which has been imported from foreign energy sources for as little as 25 cents per gallon, makes the manufacture of ETBE produced from American grain-derived ethanol uneconomic. A change to the existing ETBE credit is necessary for commercialization to continue. Although ethanol used in ETBE is eligible for existing tax credits, those credits are then taxed. This serves as a disincentive to use ethanol in this manner. Legislation in the U.S. Senate would address this problem and make the existing tax credit more applicable to ethers.

ENVIRONMENTAL IMPACT OF ETHERS

The substitution of ethers for alcohols and butanes in gasoline blending would have a positive effect on emissions, in a number of specific areas:

- Reduction of carbon monoxide.
- Reduction of aromatic content of gasoline and resulting toxics.
- Reduction of olefin content of gasoline.
- Reduction of volatile organic compounds.
- Reduction of carbon dioxide.

Aromatics in gasoline have become a concern at both the national and local levels and restrictions on this class of hydrocarbon — specifically benzene — are being required. The ethers, particularly ETBE, would be well suited for this purpose. ETBE, with a boiling point of 176 degrees Fahrenheit and an octane blending value of over 100 octane $\left(\frac{\text{Research Octane Number} + \text{Motor Octane Number}}{2}\right)$ would be an ideal replacement with very little variance from the basic American Society for Testing and Materials' distillation curve. ETBE could also replace toluene and heavier aromatics with the necessary adjustments for Reid vapor pressure and other gasoline specifications.

Current octane improvement units now being planned and under construction in the United States will further increase overall gasoline volatility. Considering future EPA volatility controls, it will be necessary to counteract isomerization with more condensation such as etherification, alkylation and polymerization.

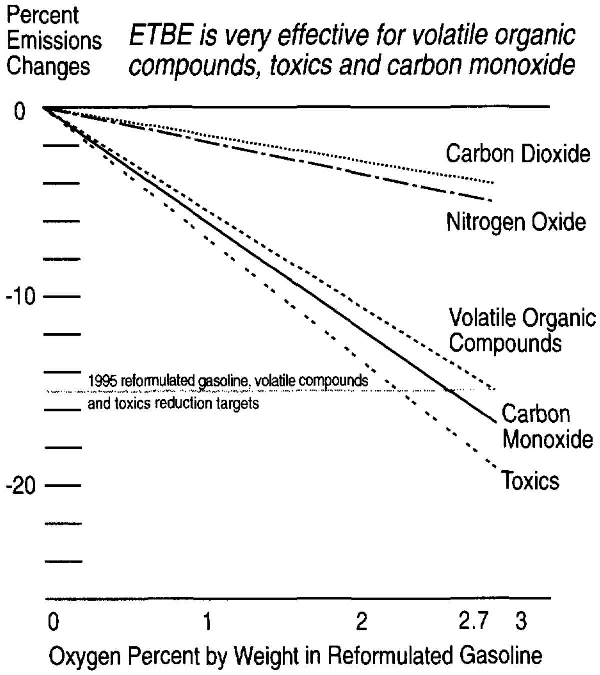
Olefins can also be reduced or replaced in gasoline by substituting ethers. Again the necessary volatility adjustments would have to be made.

SUMMARY

The following points summarize the advantages of ETBE:

- Chemically combines ethanol into the gasoline pool in a manner acceptable for refinery gasoline blending, for gasoline exchange and for transport through common carrier pipelines.
- Increases the octane number of the gasoline pool. Allowing two percent oxygen by weight would accommodate 12.5 volume percent ETBE. Allowing 3.5 percent oxygen by weight — same as gasohol — would accommodate almost 23 volume percent ETBE.
- Reduces the overall volatility of the gasoline pool. This would be beneficial to the refinery industry in the event Reid vapor pressure restrictions on all gasoline are stipulated by EPA.
- Can reduce overall evaporative emissions and carbon monoxide tailpipe emissions.
- Can reduce aromatic and/or olefin content of motor fuel.
- Opens the door for an acceptable fuel component to absorb the growing surplus of grain and other biomass — a fuel component completely compatible with hydrocarbons.

Potential Decreases in Auto Emissions from ETBE Blended in Reformulated Gasoline



Source: ARCO Chemical Company

"And take a look at ETBE. It's made from ethanol, which I've long supported — and ethanol's made from corn and other grains we grow in abundance. And that's good for American farmers — and it's good for all American taxpayers..."

President George Bush
June 1989
Lincoln, Nebraska

Methanol

Methanol is a colorless, odorless and nearly tasteless alcohol with the simplest chemical structure of all the alcohols.

It is used as a chemical feedstock, extractant, solvent, a "neat" — 85 percent by volume or more — gasoline replacement and/or a feedstock for the manufacture of methyl tertiary butyl ether or MTBE.

Methanol has been seen as a possible large volume motor fuel substitute at various times during gasoline shortages. It was often used in the early part of the century to power automobiles before inexpensive gasoline was widely introduced. In the early 1920s, some viewed it as a source of fuel before new techniques were developed to discover and extract oil. The World War II era saw wide use of synthetically produced methanol as a motor fuel in Germany. Wartime fuel shortages throughout Europe prompted the use of the fumes produced by wood-burners as a source of fuel to power vehicles.

The use of methanol as a motor fuel received attention during the oil crises of the 1970s due to its availability and low cost. Problems occurred early in the development of gasoline-methanol blends. As a result of its low price some gasoline marketers over blended. Others used improper blending and handling techniques. This led to consumer and media problems and the eventual phase out of methanol blends. However, there is still a great deal of interest in using methanol as a neat fuel. Many tests have shown promising results using 85-100 percent by volume methanol as a transportation fuel in automobiles, trucks and buses. The flexible-fuel vehicles currently being manufactured by General Motors, Ford and Chrysler can run on any combination of ethanol, methanol and/or gasoline. Neat alcohol fuels will become more prevalent as more flexible-fuel automobiles are manufactured.

Before modern production technologies were developed in the 1920s, methanol was obtained from wood as a co-product of charcoal production and, for this reason, was commonly known as wood alcohol. Methanol was often used as a fuel for cooking, lighting and to power early automobiles. However, the yield from this method of production was very low. One ton of hardwood would only yield one or two percent, or about six gallons of methanol —softwoods only half as much. This led to its eventual replacement by less expensive alternatives.

Methanol from coal could be a very important source of liquid fuel in our future. Although the costs are prohibitive at this time, the technology is fairly simple and easily implemented. The coal is first pulverized and cleaned, then fed to a gasifier bed where it is reacted with oxygen and steam to produce the synthesis gas. Once these steps have been taken, the production process is much the same as with the other feedstocks with some variations in the catalyst used and the design of the converter vessel in which the reaction is carried out.

NATURAL GAS WILL REMAIN THE LEAST EXPENSIVE FEEDSTOCK FOR METHANOL IN THE SHORT TERM.

Although coal's cost on a British thermal unit basis is less expensive than natural gas, it is not enough to offset the high capital cost associated with coal conversion plants. Some research projects are paving the way for making the coal-to-methanol process more economical, including efforts by the U.S. Department of Energy. Methanol from coal is attractive because coal reserves in the United States — known and undiscovered — are estimated to be about four trillion tons. A coal-to-methanol fuel industry producing one million barrels per day would require about 150 to 200 million tons of coal per year. Recent concerns about sulfur oxide emissions from coal combustion can be mitigated because, in coal-to-methanol gasification, sulfur is removed as a routine part of the process.

Natural gas will remain the least-expensive feedstock for methanol in the near term. Natural gas resources in the United States are estimated to be from 300 to 500 trillion cubic feet. Current U.S. consumption of natural gas is about 20 trillion cubic feet per year. The technology for making methanol from natural gas is already in place and requires only efficiency improvements and scale-up to make methanol an economically viable alternative transportation fuel.

Biomass resources can be used to produce methanol. Estimates of biomass resources available for use in the production of alcohol fuels range from one million to 4.7 million dry tons per day — one ton equaling 100 gallons of methanol when biomass is also used to fuel the processing plant. Biomass resources include crop residues, forage, grass, crops, wood resources, forest residues, short-rotation wood energy crops and the cellulosic components of municipal solid waste. As a renewable resource, biomass represents a potentially inexhaustible supply of feedstock for methanol production. Contrary to popular belief, methanol is eligible for the same federal tax incentives as ethanol, in fact even a greater amount, if made from renewable resources. Current natural gas feedstocks are so inexpensive that even with tax incentives renewable methanol has not been able to compete economically. Technologies are being developing that may eventually result in commercial viability of renewable methanol.

Leading Methanol Producing Regions

	Billions of Gallons per Year
Europe	2,616
USA	1,805
Australia/Asia	900
Canada/Mexico	837
Far East/Asia	733
South America	713
Middle East	628
Africa	266
Total World	**8,498**

Source: Information Resources, Inc. and Clean Fuels Development Coalition, Inc.

Methanol use in current-technology vehicles has some distinct advantages and disadvantages. On the plus side, methanol has a higher octane rating than gasoline. This reduces "knock" in today's engines and can result in greater fuel efficiency with proper adjustment of the engine's compression ratio. Methanol's high heat of vaporization results in lower peak flame temperatures than gasoline and lower nitrogen oxide emissions. Its greater tolerance to lean combustion — higher air-to-fuel equivalence ratio — results in generally lower overall emissions and higher energy efficiency. Dedicated-methanol-fuel vehicles would increase this advantage even further.

THE AVAILABILITY OF 85 PERCENT METHANOL IS LIMITED, BUT STEADILY GROWING THROUGH A NETWORK OF DOZENS OF GASOLINE STATIONS IN KEY, HIGH POPULATION AREAS.

However, several disadvantages must be studied and overcome before neat methanol is considered a viable alternative to gasoline. Methanol's energy density is about half that of gasoline, reducing the range a vehicle can travel on an equivalent tank of fuel. Current-technology vehicles using neat methanol at temperatures below 45 degrees Fahrenheit are difficult to start because of methanol's lower vapor pressure and single boiling point. However, engineering solutions to these problems have been identified and are under development. For example, 85 percent methanol solves the cold start difficulties because of its 15 percent-gasoline component. The availability of 85 percent methanol is limited, but steadily growing through a network of dozens of gasoline stations in the key, high-population areas of California.

Because methanol is a liquid fuel, fueling modes are consistent with those already used for gasoline. As DOE, other agencies and industry continue their demonstration and evaluation, answers will be found to mitigate barriers to the use of methanol as an alternative transportation fuel.

Methyl Tertiary Butyl Ether

The methanol industry overcame many of the obstacles faced by gasoline-methanol blends in the 1970s when it developed MTBE or Methyl Tertiary Butyl Ether. MTBE is a relatively new blending component for the U.S. petroleum refiner.

Because its blending characteristics are close to those of hydrocarbons, MTBE is the only oxygenate generally accepted for blending at the refinery and subsequently transported through pipelines.

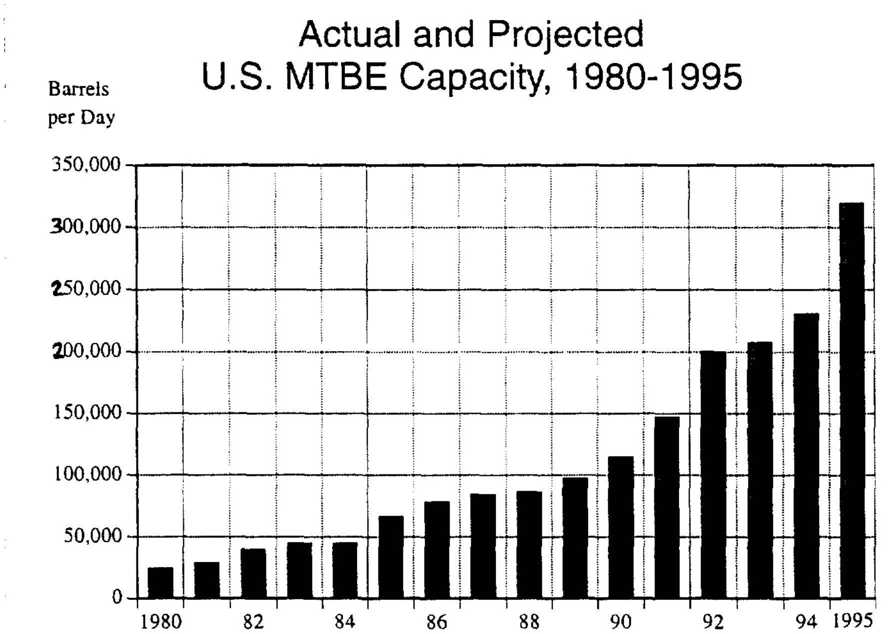
The first MTBE plant went on stream in the United States in 1979. EPA permitted a concentration of seven percent by volume in finished unleaded gasoline. Later, the oxygen limit was raised, allowing approximately 15 percent by volume MTBE in unleaded gasoline providing 2.7 percent oxygen by weight.

Current U.S. production capacity of MTBE is over 259,000 barrels per day and is expected to grow to nearly 300,000 barrels per day by the end of the decade. These projections are based on demand for high-octane unleaded gasoline and regulations to reduce vapor pressure. The recent demand for oxygenated fuels for environmental reasons is considered "frosting on the cake" by the petroleum industry and has not been factored into the current demand scenario for projected MTBE growth trends.

Many analysts project MTBE growth at 15 percent per year over the next five year period. There will be a 50 percent increase in the number of MTBE plants in the United States and individual plant capacities will also increase. The increased growth in world production of MTBE will be consumed by countries such as France, Italy and Spain as they begin lead reduction programs in their respective countries.

MTBE was first manufactured commercially in Europe by Chemische Werke Huls in West Germany and ANIC in Italy. Produced by the reaction of isobutylene and methanol, it is one way to use methanol indirectly in motor fuel without the problems associated with adding a light alcohol as a blending component. MTBE was especially attractive to European refiners in the 1970s because of its ability to contribute both low-boiling and high-octane quality to gasoline. This quality is particularly desirable for low-speed performance in the manual transmission vehicles prevalent in Europe. Further, the typical gasolines from the many hydroskimming refineries in Europe were lacking in high-octane olefins in the front end.

Interest in MTBE developed in the United States because of EPA's lead phasedown and the prospect of a future shortage of octane quality in unleaded gasoline. MTBE can be quite attractive for those refiners that have a special economic incentive, e.g., low cost methanol, a petrochemical incentive to separate isobutylene from mixed butylenes, or octane limitations. MTBE also can be attractive as a replacement octane component which, for example, can thus free toluene from its use as a gasoline component and allow it to be used as a petrochemical feedstock.



Source: Information Resources, Inc. and Clean Fuels Development Coalition, Inc.

Biodiesel

Biodiesel is a clean-burning, renewable, non-toxic, biodegradable and environmentally-friendly transportation fuel that can be used in neat form or in blends with petroleum-derived diesel.

As generally defined, "biodiesel" refers to alkyl or esters made by transesterifying vegetable oils and animal fats as well as used vegetable oils, fats and waste products for use in compression-ignition diesel engines.

In the United States, commercialization of biodiesel is supported by oilseed and other potential biodiesel feedstock producers and processors. Additionally, USDA and DOE have taken an active interest in biodiesel development, as have land grant colleges and universities, original equipment manufacturers and diesel fleet operators.

The wide variety of potential feedstocks including soybean oil, rendered animal fats and used vegetable oils — yellow grease — means that some type of biodiesel could be produced in every region of the country. In recognition of the fact that soybeans are in great abundance in the U.S. and that new uses for agricultural commodities is a priority, in March 1992 a group of soybean farmers formed the National Soy Fuels Advisory Committee to explore ways of commercializing "SoyDiesel," one of many types of biodiesel. The Committee concluded that commercialization of biodiesel would greatly benefit both the soybean industry and American agriculture generally. However, bringing this concept to fruition would require a major effort of research, demonstration, fleet testing and promotion.

To carry out this mission, in October 1992 the group formed the National SoyDiesel Development Board, a not-for-profit corporation, now known as the National Biodiesel Board. The main priorities of the this Board include development of fuel standards for biodiesel, determination of its engine performance and emissions in various blends with diesel fuel and the requirements for commercial acceptance of the fuel. The Board has committed substantial funding in an unprecedented effort to fully test and evaluate a motor fuel prior to its full commercialization.

Stricter U.S. Environmental Protection Agency emissions requirements for heavy-duty engines, both on- and off-road, including urban buses, have generated substantial interest in biodiesel. Its performance similarities to conventional "petrodiesel" have moved biodiesel into consideration as a clean-burning alternative fuel or fuel component that will be required in fleets and other applications well into the next century. EPA enforcement of the *Clean Air Act Amendments* of 1990 has increased support for alternative fuels and stricter emissions requirements and set the tone for these procedures to a degree unknown just a decade ago.

Since 1992, the Board will have allocated nearly $10 million of farmer check-off funds for the development of biodiesel. This unprecedented grass-roots support for a fuel that has yet to be fully commercialized will make biodiesel the most thoroughly tested and evaluated motor fuel in history. Specifically designed to ensure the success of biodiesel, the current priorities of the group are:

- Establishing a fuel standard and testing methods for biodiesel so that producers and purchasers will have a uniform, high-quality product for all testing and commercial applications.
- Working to have EPA certify that biodiesel is "substantially similar" to diesel fuel so that the fuel can be legally sold for on-highway use once EPA's "substantially similar" diesel regulations are adopted; and
- Conducting research, testing and demonstrations to meet data requirements and to encourage the expanded use of biodiesel.

The National Biodiesel Board has funded a number of emissions tests of biodiesel blends in several mass transit bus engines at EPA-certified laboratories using the EPA-approved Federal Test Procedures. The Board has also initiated near-term demonstration projects. The principal studies to date in the U.S. involve ten - 40 percent by volume blends of biodiesel with conventional diesel fuel.

The principal bus engine manufacturers, Detroit Diesel Corporation, Cummins and Navistar, are cooperating with the Board in testing their engines. In blends of biodiesel of up to 30 percent by volume, no instances of fuel system degradation have been identified. In cooperation with the U.S. Bureau of Mines, the Board is also investigating engines operated in underground mines, as well as inside buildings such as warehouses.

BIODIESEL, A RELATIVE LATECOMER AS AN ALTERNATIVE FUEL, IS BEING TESTED EXTENSIVELY IN COOPERATION WITH THE EPA AND DOE.

Liquefied natural gas or propane, compressed natural gas, methanol and ethanol fuels have been under consideration and tested for over a decade. Biodiesel, a relative late-comer as an alternative fuel, is being tested extensively in cooperation with EPA and DOE. The National Biodiesel Board and other supporters believe that biodiesel will penetrate this market because it can be more cost-effectively integrated into existing fleet operations and infrastructures. By optimizing existing engines for biodiesel, the Board believes that these vehicles can comply with new federal requirements while saving metropolitan areas the costs of developing new infrastructures and buying new vehicles/engines.

The next five years will be crucial for the development and expanded use of biodiesel in the United States. The National Biodiesel Board's objectives for biodiesel include developing higher oil-yielding soybean and alternative feedstocks — tallow, yellow grease and other oilseeds such as rape, peanut, cotton, sunflower, safflower and Chinese tallow tree — and engineering different blends of oils to reduce the cost to the end-user. There will also be a focus on specific high value, niche market uses that justify higher prices, such as in environmentally sensitive areas — forests, marshlands and waterways. Conversion technology will also be examined to determine the least-cost way of producing quality fuels. Finally, the development of new uses for glycerine, meal and other co-products is inherent in reducing the net cost of biodiesel.

To make this possible, the National Biodiesel Board is taking advantage of public policy initiatives for alternative and cleaner-burning fuels enacted since 1988. As with other alternative fuels, these energy and environmental policy initiatives form the nucleus for the expanded use of biodiesel in key markets.

Gasoline Additives and Combustion Modifiers

The trend in the U.S. car population toward more critical fast burn or lean burn engines is expected to continue for the foreseeable future.

Therefore, the need to prevent deposits from forming in engines, particularly in the combustion chamber and on intake valves, will grow in importance. With such advances, the problem of octane requirement increase will be overcome by a new class of additives. Octane requirement increase reduction may emerge as a strategy to lessen the refining constraints imposed by marketplace and regulatory forces — the "octane race" and EPA and statewide regulations on gasoline volatility and aromatics reduction.

The demand for high-quality fuels has resulted in the use of many different additives which are introduced to the gasoline at refineries and product terminals. Additives injected at the refinery are designed to help the product meet American Society for Testing and Materials gasoline specifications, provide retail brand differentiation and meet the individual requirements of multiple customers.

Since 1985, when automakers began making a wholesale switch from carburetors to fuel injectors, gasoline engine cleanliness has come to the fore as a major issue within the industry — first for the control of fuel injector deposits and later for the prevention of intake valve deposits.

Gasoline additives are designed to perform a wide variety of specific functions. The two broad applications of gasoline additives are:

To meet specifications whether external or internal, protect distribution systems and automotive parts and meet possible competitive gasoline performance.

To provide an advantage to gasoline, particularly for advertising purposes, by differentiating one's product from being fungible or common to non-fungible or unique.

Among classes of additives, which include antiknocks, corrosion inhibitors and antioxidants, performance additives are expected to experience the greatest growth in the coming decade. Performance additives include detergents, dispersants, anti-icers, combustion enhancers/modifiers, fluidizer oils and flow improvers. All these additives improve either fuel or engine efficiency or durability. Within the category of performance additives, detergents and dispersants are known collectively as deposit control additives.

COMBUSTION MODIFIERS

This group includes those additives that in some way alter or enhance combustion in the engine. In the broadest sense, it would include those anti-knocks such as tetraethyl lead which are added in minute portions. However, the more accepted definition would apply to products called scavengers such as ethylene dibromide used to convert combustion products of lead alkyls to other products that can be removed in the exhaust gas.

Deposit modifier additives also can be used to raise the glow temperature of deposits to avoid pre-ignition. However, this additive group is more common to leaded gasolines — a shrinking market.

FUTURE CHALLENGES, NEEDS AND MARKET OPPORTUNITIES

Emissions requirements continue to become increasingly more stringent and because intake valve deposits have an effect on vehicle warm-up performance, detergent and detergent-dispersant additives will be needed to control this problem. New, emerging additives should possess both "keep clean" and "clean up" properties. As of January 1, 1995, no gasoline in the United States will be marketed without a good detergent additive package. In general, future gasoline performance additive formulation requirements can be broken down into the following categories:

- Reduced Vapor Pressure
  - -Lower evaporation
  - -Refueling and running loss elimination
- Composition Varied
  - -Reduce reactivity of vehicle emissions
  - -Improve flame speed
- Reduced Aromatics
  - -Lower hydrocarbon emissions
  - -Reduce engine deposits
  - -Lower exhaust as reactivity
- Improved Additives
  - -Reduce engine deposits
  - -Lower octane requirement increase
  - -Enhance catalyst performance
- Use of Oxygenates such as Ethers and Alcohols
  - -Reduce carbon monoxide emissions
  - -Improve octane quality

In summary, the importance of limiting octane requirement increase will be increasingly accepted by motorists as well as fuels specialists. New engine designs will pressure researchers to develop increasingly sophisticated packages. Marketing opportunities will arise for those who develop additives that clean engines, keep them clean and reduce octane requirement increase.

Electric Vehicles

Electric vehicles represent perhaps the most environmentally benign form of transportation that can be attained in terms of air pollution. Like many alternatives to petroleum, however, the widespread use of electricity to power automobiles faces a number of impediments.

Many of these relate to the existing infrastructure of the transportation system while others relate to the price, production and availability of the vehicles themselves.

America's first four-wheel electric vehicle was built in 1892. It could run for 13 hours before it needed to be recharged and it could reach speeds of 14 miles per hour. By the late 1890s, electric vehicles dominated the automobile market with a typical range of 50 miles. By 1900, 38 percent of new American automobiles ran on batteries. In 1912, some 6,000 electric cars and trucks were manufactured each year by 20 U.S. companies.

Eventually greater range and increasingly easy access to gas stations made gas-powered vehicles more attractive to consumers than electric vehicles. However, interest in electric vehicles resurfaced in the 1960s and in 1982, Denver, Colorado put six 40-foot battery-powered shuttle buses into service.

California's Low Emission Vehicle Program requires automakers to manufacture zero emission vehicles by 1998. In that year, two percent of new light-duty vehicles must be of this type, five percent in 2001 and ten percent in 2003. Assuming a 1.5 percent per year growth rate of new vehicles, by 2003 there will be 460,000 new electric vehicles registered annually nationwide and 1.4 million on the roads in California and the northeastern states.

Most of the obstacles facing electric vehicles relate to the development of batteries capable of sustaining an electric charge for long range use. An additional challenge in the development of these batteries is to avoid significantly adding to the weight of the vehicle while maintaining sufficient power for acceleration and speed. General Motors estimated a battery life lasting 20,000 miles and costing $1,500 to replace.

Undeveloped infrastructure, frequent battery replacement as well as a low production rate contribute to the considerably high cost of electric vehicles. A study by the Electric Vehicle Development Corporation concluded that large scale manufacturing of electric vehicles would greatly reduce the price the consumer has to pay. The G-Van electric vehicle costs $57,000 when 100 are manufactured. When a cumulative volume of 50,000 vans is produced, the price is expected to decrease to $18,100, which is comparable to a gasoline-powered van.

ELECTRIC VEHICLES USING COAL-FIRED POWER PLANTS WOULD STILL PRODUCE 17 TO 22 PERCENT FEWER CARBON DIOXIDE EMISSIONS THAN GASOLINE POWERED CARS.

Electric vehicles themselves produce virtually no emissions, thereby offering great promise in controlling carbon monoxide, ozone and other pollutants. Some concerns exist, however, regarding pollutants emitted in the generation of the electricity, particularly with coal. However, recharging electric vehicles using coal-fired power plants would still produce 17 to 22 percent fewer carbon dioxide emissions than gasoline powered cars. Natural gas plants would produce 48-52 percent fewer.

General Motors, Ford Motor Company and Chrysler Corporation have all been actively involved in electric vehicle development. In an effort to introduce electric vehicles to the consumer market, all three have unveiled prototype vehicles—GM's Impact two-seat electric vehicle, Ford's Ecostar delivery van and the electrified TE Van by Chrysler. The three automakers have joined together through the U.S. Council for Automotive Research to design, develop and possibly manufacture electric vehicle components. They formed the U.S. Advanced Battery Consortium as well, through which the U.S. automotive utility industries support the development of advanced batteries.

Electric vehicles require the development of an entirely new infrastructure support system. Battery weight, energy density and life also heavily influence electric vehicles' performance. To store the equivalent energy of 12 gallons of gasoline would require a 7,000-pound lead battery. However, in fiscal year 1994, the Department of Energy will spend approximately $3.6 million on electric vehicle battery research and development, including funding for the U.S. Advanced Battery Consortium.

Electric vehicle technology is constantly improving. The Impact, the two-seat electric car from GM, can go from zero to 60 mph in 8.5 seconds and can maintain a highway speed of up to 80 miles per hour. With a driving range of 60 to 90 miles per charge, the average electric vehicle is ideal for commuters, delivery, shuttle and service applications. The goals of the industry are to increase the current two to three year life of a battery and to improve the range to more than the current 100 miles.

The technology exists for electric vehicles to compete in speed with gasoline powered vehicles. Like many alternative fuels, the likely short term application may be in urban areas for fleet use to address problems of recharging and limited range. A number of considerations such as cost and consumer acceptance will also need to be addressed before widespread use of these vehicles can occur. It is estimated that electric vehicles will not be competitive with conventional vehicles for at least the next decade. They may, however, find limited markets in the interim.

Natural Gas

Natural gas is one of several fuels that can help ease our dependence on imported petroleum for transportation. Extracted from underground reservoirs, natural gas is a fossil fuel composed primarily of methane, along with other hydrocarbons such as ethane, propane, butane and inert gases such as carbon dioxide, nitrogen and helium.

Its composition varies and depends on its source. Natural gas is distributed in an extensive pipeline system after it is cleaned and purified and an odorant is added.

The United States is one of the world's largest producers and consumers of natural gas. The fuel accounts for about one quarter of the energy consumed in the United States, primarily in the industrial, residential, commercial and electric utility sectors. The transportation sector consumes only three percent of our natural gas, primarily to power compressors on natural gas pipelines.

Interest in using natural gas as a transportation fuel has increased in recent years, particularly in urban areas, for two main reasons. First, natural gas burns cleanly, emitting little carbon monoxide or reactive gases that pollute the air. Second, our nation has very large resources of natural gas, so this fuel can help us reduce our dependence on foreign oil at a competitive cost. Converting as little as ten percent of America's 200 million cars and trucks to natural gas can reduce oil imports by 570 million barrels each year or about 20 percent of our imports.

Most gasoline-powered cars and trucks can be converted to operate on compressed natural gas or liquefied natural gas in either a single-fuel — natural gas only — or a dual-fuel — either gasoline or natural gas — configuration. Modifications include changes to the fuel delivery and carburetion systems. Diesel vehicles can also be converted to use either diesel fuel or natural gas in a dual-fuel configuration.

The physical and chemical properties of natural gas provide good performance in these modified vehicles. Natural gas has a higher octane number than gasoline. In addition, because it is introduced into the engine as a gas — rather than as a liquid that must first be vaporized — natural gas can provide quicker cold starts with lower emissions.

> ADVANTAGES OF NATURAL GAS INCLUDE THAT IT CAN BE USED DIRECTLY AS IT IS TAKEN FROM THE GROUND, WHILE OTHER FUELS MUST BE REFINED.

Natural gas vehicles are refueled at stations specially designed to deliver compressed or liquefied natural gas. Compressed natural gas stations use either the "slow-fill" or "fast-fill" methods. Slow-fill stations are simpler in design and less costly than fast-fill stations, but they take several hours to refuel a vehicle in comparison to the two-five minutes associated with fast-fill stations. Liquefied natural gas stations require cryogenic storage vessels to maintain the natural gas in a liquid state and refueling times are comparable to those of conventional gasoline stations. Liquefied natural gas vehicles generally provide a longer driving range between refuelings than compressed natural gas vehicles; however, the driving range of both is shorter than that of gasoline-powered vehicles because of the lower energy density of natural gas fuels.

An estimated 30,000 natural gas vehicles are in use today in the United States and nearly a million operate worldwide. Most of these are compressed natural gas dual-fuel vehicles. Public and private fleets are especially good candidates for natural gas conversion because of their relatively short driving ranges and centrally located refueling facilities. Transit authorities are also introducing hundreds of natural gas buses into their urban transportation systems.

In response to federal and state legislation, 38,500 natural gas vehicle fleets will be mandated for conversion by 2000. A total of 861,000 natural gas vehicles are projected to be purchased between 1995 and 2000 to meet these mandates. The American Gas Association projects that there will be 11 million natural gas vehicles on the road by 2010.

Advantages of natural gas include that it can be used directly as it is taken from the ground, while other fuels must be refined. It has an octane rating of about 130 as compared to 90 for gasoline and costs less on a per-gallon equivalent basis than gasoline or diesel. Natural gas leads to reduced engine maintenance and to longer engine life. In general, natural gas vehicles burn 80 percent cleaner than conventional vehicles.

However, there are several disadvantages to using natural gas as well. Natural gas occupies about four times the space of an energy equivalent of gasoline resulting in added weight and space of fuel storage tanks. New fuel tanks and some fuel system modifications are required on retrofits. At the present time, there is limited availability of refueling stations and natural gas vehicles experience a shorter driving range between fill-ups.

Propane

Liquefied petroleum gas or propane is a type of fuel that can be used in the transportation sector to help improve our nation's air quality and ease our dependence on imported petroleum. About two-thirds of the propane available today is a by-product of natural gas processing; the remainder comes from crude oil refining.

Propane, composed primarily of propane and butanes with smaller amounts of propylene and butylenes, is supplied in four grades of different composition. HD-5, the only grade appropriate for automotive applications, is 95 percent propane and five percent butanes. The terms liquefied petroleum gas and propane are often used interchangeably.

Engines have been powered with propane gas since 1912. Interest in using propane as a transportation fuel has continued to increase in recent years. Today, propane is the most widely used alternative motor fuel and the third most widely-used motor fuel overall, ranking right behind gasoline and diesel. The Department of Energy estimates that there are approximately 350,000 propane-fueled vehicles are on our nation's roads and more than 3.5 million in service throughout the world.

The United States is one of the world's largest producers of propane, generating about 230 million gallons in 1992. Almost 92 percent of the U.S. demand for propane gas is sourced domestically, therefore the supply is reliable and free from political upheaval. In addition, propane is readily available in regions with natural gas production or petroleum refining. Propane's dual source supply—65 percent is extracted from natural gas production, 35 percent is a by-product of crude oil refining—protects against shortage.

There are currently more than 10,000 public propane refueling stations in the United States and refueling a propane vehicle takes about the same amount of time as refueling a gasoline vehicle. Most gasoline-powered cars and trucks can be converted to operate on propane in either a single-fuel — propane only — or a dual-fuel — either gasoline or propane — configuration. Modifications include changes to the fuel delivery and carburetion system.

Propane's infrastructure has the benefit of being well established. Storage and transportation of propane gas in sealed, extra strength, pressurized tanks eliminates evaporative emissions or spillage. Propane does not pollute wells and underground water sources because it vaporizes when released and is not water soluble.

Propane can be burned directly in modified automotive engines. The gas is stored on-board in liquefied form in tanks pressurized to 160 pounds per square inch. Propane has about 80 percent of the energy of gasoline on a volumetric basis, however, so it requires more storage volume to provide the same driving range as a gasoline-powered vehicle.

PROPANE HAS 100+ OCTANE AND LEAVES NO LEAD VARNISH OR CARBON DEPOSITS; THE ENGINE IS CLEANER AND LASTS LONGER THAN GASOLINE ENGINES.

Although the driving range of propane is still somewhat shorter than gasoline, it provides the longest driving range of any alternative fuel — more than 250 percent further than compressed natural gas, about 60 percent further than methanol and 25 percent further than ethanol. Propane has 100+ octane and leaves no lead varnish or carbon deposits; the engine is cleaner and lasts longer than gasoline engines, which helps explain its popularity as fuel for fleet vehicles and industrial engines.

The chemical and physical properties of propane give it good driveability compared to gasoline. In addition, because it is introduced to the engine as a gas — rather than as a liquid that must first be vaporized — propane can provide quicker cold-starting with fewer emissions in a properly designed system.

Propane gas has the potential to produce less carbon monoxide and smog-causing reactive hydrocarbons than gasoline does. It is clean-burning, producing virtually no particulates or sulfur emissions. California Air Resources Board and U.S. EPA tests have shown that emissions of hydrocarbons and carbon monoxide are consistently reduced 50 to 80 percent and nitrous oxide emissions are reduced five to 30 percent after installing a propane conversion system.

Summary of Regional and State Clean Fuel Policies and Regulations

The pace of motor fuel regulatory change at the regional, state and local levels has accelerated sharply since the mid-1980s.

The State of California continues to exert substantial influence over the development of national motor fuel standards, especially with respect to environmental issues. However, the state's aggressive mobile source regulatory agenda has created occasional problems, as was the case with the required introduction of low sulfur/low aromatics diesel fuel in late 1993.

Northeastern states, led by the Ozone Transport Commission and the Northeast States for Coordinated Air Use Management, have moved into a position of influence similar to California in setting stricter emissions standards for motor fuels and vehicles.

Many other states are moving forward with clean air/clean fuel programs to encourage the use of non-petroleum fuels. Although fewer in number, many states still provide incentives for alcohol fuels to encourage their production and use.

California Phase II Reformulated Gasoline Clean Fuels and Vehicle Emission Requirements

California has set the most stringent motor fuel quality requirements in the world. For example, beginning March 1, 1996, producers and importers of gasoline for sale in the state must comply with its Phase II reformulated gasoline regulations. All "facilities," including refineries, terminals, bulk plants and service stations, must be in compliance with the "cap limits" on reformulated gasoline by April 1, 1996.

These reformulated gasoline regulations were approved by California Air Resources Board in 1991

Properties and Specification of "Typical" California Gasoline and Phase II Reformulated Gasoline

Fuel Properties	Units	Typical California Average	Flat Limit	Averaging Limit	Cap Limit
Reid Vapor Pressure	pounds per square inch	7.8	7.0[1]	—	7.0[1]
Sulfur	parts per million by weight	150	40	30	80
Aromatics	percent by volume	32	25	22	30
Benzene	percent by volume	2.0	1.0	0.80	1.20
Olefins	percent by weight	9.9	6.0	4.0	10.0
Oxygen	percent by weight	0	1.8-2.2	none	2.7(max) 1.8(min)[2]
T_{90} Distillate Temperature	degrees fahrenheit	330	300	290[3]	330
T_{50} Distillate Temperature	degrees fahrenheit	220	210	200	220

1 Summertime only
2 Wintertime only
3 Refinery Cap = 310°F

Source: Information Resources, Inc. and Clean Fuels Development Coalition Inc., 1994

and are designed to "achieve the maximum reductions in emissions of criteria pollutants and toxic air contaminants from gasoline-powered vehicles." Phase II reformulated gasoline specifications allow producers the option of meeting either "flat" or per gallon limits or "averaging" limits. These requirements are set forth in the table above. These requirements are as strict as federal Phase II reformulated gasoline regulations that do not take effect until 2000.

Northeastern States for Coordinated Air Use Management

Northeastern States for Coordinated Air Use Management member states are second only to California in proposing and implementing mobile source air quality regulations to take advantage of options available under the *Clean Air Act Amendments* of 1990. Including the clean vehicles program provided in the *Act*, the Northeastern states are taking separate action on reformulated gasoline.

Cities of New York, Philadelphia and Hartford are three of the nine cities in which the federal reformulated gasoline program will be required for sale starting in 1995.

The states of Massachusetts, Maine, Rhode Island, Connecticut, New Hampshire, New York and New Jersey have joined the Mid-Atlantic states of Pennsylvania, Delaware, Maryland, the District of Columbia and Virginia in requiring the sale of reformulated gasoline in all or parts of each state beginning in 1995.

The Northeastern states' organization adopted policies through a series of workshops in 1992 involving air quality officials from across the region, especially in New York, New Jersey and Connecticut, to review issues associated with implementation of the oxygenated fuel program for New York City. All three states were involved because the New York City consolidated metropolitan statistical area includes 12 counties in northern New Jersey and parts of Connecticut.

Consideration of Low-Emission Vehicle Program

The Ozone Transport Commission, a group of Northeastern states whose membership overlaps that of the air management organization's, has made a recommendation to EPA that would require adoption of a low-emission vehicle program throughout the ozone transport region which encompasses an area from northern Virginia to Maine beginning in 1999.

Under the *Clean Air Act*, the Commission is established to develop region-wide recommendations for ozone control, including the authority to propose a low-emission vehicle program similar to that established in California, to EPA. In early 1994, the Commission members voted to approve the low-emission vehicle recommendation which must be approved by EPA before the states can legally adopt it. Since then, EPA has conducted several hearings, which culminated in the agency deciding to approve the recommendation in late 1994.

Earlier, U.S. automakers filed suit against the states of New York and Massachusetts challenging their virtually identical low-emission vehicle regulations which they had adopted. A U.S. District Court overturned the New York regulations, while the federal court in Massachusetts upheld that state's law, creating a conflict to be resolved in the U.S. Circuit Court of Appeals.

Studies mentioned in testimony presented to EPA suggest that the low-emission vehicle program will only address the region's increase in volatile organic compounds expected early in the next century when vehicle miles traveled are projected to increase in the region. However, the American Lung Association and others urged EPA to adopt the low-emission vehicle program quickly and more importantly, that EPA should move with more speed to tighten the ozone standard from 0.12 parts per million because of recent research that has shown permanent loss of lung function among many U.S. children with no history of tobacco smoking.

Evidence is also emerging that incidences of emphysema, previously associated only with smoking tobacco, are increasing in the non-smoking population exposed to high ozone levels.

In December 1994, the EPA approved the Commission's petition to adopt the low-emission vehicle program, giving the region another means of reducing ozone-forming volatile organic compounds in the region. How effective — and when and for how much — such a program will be remains very controversial.

Other State and Local Air Quality Actions

Enhanced Volatility Restrictions

The petroleum industry, mainly through the American Petroleum Institute , has been active in trying to persuade several states not to exercise their option to participate in the nation's reformulated gasoline program beginning as early as 1996. The only option to reformulated gasoline that is being suggested is the required use of lower volatility conventional gasoline in lieu of a reformulated gasoline requirement.

The first state to consider options other than reformulated gasoline was Michigan. In early 1993, a study commission recommended to Gov. John Engler that Michigan should reduce Reid vapor pressure instead of adopting the federal reformulated gasoline standards to lower volatile organic compounds and meet the *Clean Air Act*'s state requirements. Other states such as Georgia, Missouri, Ohio and Indiana are considering similar moves.

Individual States' Ethanol Production and Blending Incentives

At present, 15 states provide some form of incentive for ethanol production, use or sale. These incentives take the form of tax credits for different purposes — sales or excise tax exemptions or direct producer payments. Several states combine producer incentives and tax exemptions for blended sales.

The following is a summary of state provisions:

Connecticut: The state exempts gasohol defined as "consisting of a blend of gasoline and a minimum of ten percent by volume of ethanol or methanol" from one cent per gallon of its motor fuel excise tax. This provision has no expiration date.

Hawaii: The state exempts "gasohol" from the four percent sales tax imposed on gasoline products containing "at least ten volume percent denatured biomass-derived ethanol."

Idaho: The state provides an excise tax exemption for the non-petroleum portion of gasoline or diesel sold in the state effective July 1, 1994. Thus, a ten percent by volume ethanol blend would receive a tax exemption of 2.1 cents per gallon. This incentive has no expiration date.

Illinois: Gasohol, defined for tax purposes as a "motor fuel containing at least ten percent alcohol which alcohol contains no more than 1.25 percent water by weight and is obtained from agricultural products or by-products," is taxed at the rate of four percent per gallon, or a two percent sales tax exemption, from the date of enactment of the new law through December 31, 1992. In 1991, a bill was enacted to extend this tax incentive until July 1, 1999, with modifications that include market penetration target requirements.

Iowa: "Motor fuel containing at least ten percent alcohol distilled from agricultural products grown in the United States" has been exempt from a portion of the motor fuel excise taxes. The exemption for "gasohol" from the above taxes is one cent per gallon, through June 30, 1999.

IN 1987, THE GENERAL ASSEMBLY ADOPTED A BILL TO ESTABLISH A CORPORATE OR PERSONAL INCOME TAX CREDIT FOR THE CONSTRUCTION OF NEW ETHANOL PLANTS...USING AGRICULTURAL OR FORESTRY PRODUCTS AS FEEDSTOCKS.

Kansas: Effective July 1, 1987, the state provides a maximum 20 cents per gallon incentive for qualified Kansas ethanol producers which is limited by state appropriations to about nine cents per gallon for current production in the state. In 1993, this incentive was extended through June 30, 1997.

Minnesota: In 1994, the Minnesota legislature revised the state's two cents per gallon tax excise tax exemption for ten percent ethanol blends, reducing it by one-half cent per gallon on October 1, 1994, through 1997, after which this incentive will expire. Ethanol producers currently receive 20 cents per gallon of ethanol, which increases to 25 cents per gallon on July 1, 1995, through June 30, 2010, up to a maximum of $3.75 million per producer per year.

In addition, legislation adopted in 1993 establishes a minimum 2.7 percent by weight oxygen content in gasoline sold in carbon monoxide nonattainment areas during the wintertime control period starting October 1, 1993. Beginning October 1, 1995, the oxygen content requirement is year-round in those areas. Finally, the requirement is extended statewide on October 1, 1997.

Missouri: The state established a 20 cents per gallon ethanol producer incentive, effective July 1, 1989, through December 31, 1995, and a two cents per gallon motor fuel excise exemption for qualified ethanol through July 1, 1996, during the 1988 legislative session. The producer incentive will be paid to Missouri ethanol producers using Missouri-produced agricultural commodities. The tax exemption will only become effective upon Missouri receiving more than the 85 percent "minimum allocation" from the Federal Highway Revenue Trust Fund.

Montana: The state provides an "ethanol producer payment" of up to 30 cents per gallon of ethanol produced in the state from Montana agricultural products, if funding is available. In 1991, the incentive was extended until the year 2002. The incentive has a $6 million cap with a $1.5 million per company restriction. However, the $1.5 million per company cap is lifted if there are no other companies claiming the exemption. This allows the remaining funds to be passed on to ethanol producers until the $6 million limit, if available, is reached.

Nebraska: The state provides a 20 cents per gallon direct producer incentive for ethanol produced in the state "from cereal grains or domestic agricultural commodities" at facilities having a capacity of no more than 25 million gallons annually. The exemption expires on January 1, 1998. In 1992, the state extended the producer incentive through the year 2000 and added a 50 cents per gallon tax credit for ETBE made from ethanol produced in the state.

North Carolina: In 1987, the General Assembly adopted a bill to establish a corporate or personal income tax credit for the construction of new ethanol plants in the state using agricultural or forestry products as feedstocks.

The amount of such a credit is 20 percent of the costs of installation and construction, with an additional ten percent credit allowed if the plant is designed to use "agricultural and forestry products, waste petroleum products and peat" as its fuel source, but not "other petroleum products, coal or natural gas."

Total tax credits cannot exceed $2.5 million in any one year with a total ceiling of $5 million per year. A qualified individual or corporation can carry forward the amount of the credit for ten taxable years. This provision is effective for costs incurred in taxable years from January 1, 1988, through January 1, 1994.

North Dakota: The state provides a 40 cents per gallon incentive for state producers of ethanol if it is derived from agricultural products. This incentive, passed in 1989, was originally effective July 1, 1989, through December 31, 1992. Funding for the incentive has been extended through July 1, 1997.

Ohio: Since July 1, 1981, Ohio had provided a tax credit for ethanol or methanol not produced from natural gas or petroleum. It restricts the credit to ethanol produced at a facility which is coal-fired or has a capacity of less than two million gallons per year from "wood or the grain of a cereal grass." The tax credit reduction is based on a formula which adjusts the credit inversely with the federal motor fuel tax exemption. This incentive was reduced to 20 cents per gallon on July 1, 1988, and 15 cents per gallon on July 1, 1990.

South Dakota: The state exempts "gasohol," if the ethanol component is 98 percent pure and is derived from cereal grains, from two cents of the motor fuel taxes otherwise imposed, through June 30, 1994. In addition, a direct payment of 20 cents per gallon is paid to in-state ethanol producers for ethanol produced from cereal grain and blended with gasoline, if the ethanol was produced at a plant constructed after July, 1986.

THE EPA SAID IT EXPECTS THAT VEHICLES MEETING THE NEW STANDARDS WILL BE FOR SALE IN CALIFORNIA BY 1998.

Wyoming: Effective July 1, 1989, the state enacted legislation reestablishing a four cents per gallon tax incentive for ten percent ethanol-blended fuels. This incentive has no expiration date.

Low-Emission Vehicle Programs

On December 9, 1993, EPA published final requirements for states to revise their state implementation plans to include clean-fuel fleet program requirements in those areas which the *Clean Air Act Amendments* of 1990 required fleet use of cleaner-burning fuels beginning with 1998 model year vehicles. This regulation establishes definitions for such terms as "covered fleet operator," "centrally-fueled," and "capable of being centrally-fueled" which EPA suggested are "pivotal in determining which vehicles and ultimately which fleets will be covered by the fleet program." Under the *Clean Air Act*, states may require the sale of clean fuel fleet vehicles as another strategy to reduce emissions of volatile organic compounds and carbon monoxide.

As discussed above, the states of the Ozone Transport Commission plan to adopt the program throughout the Mid-Atlantic and Northeast region. The states of New York, Maine and Massachusetts have adopted the requirement and it has been provisionally adopted in Maryland.

The regulation defines "covered fleet operator" as a person who operates a fleet of at least ten covered vehicles which is operated in a single "covered area, even if the covered fleet is garaged outside of it." Regarding the meaning of "centrally-fueled" vehicles, EPA defines the term as "that part of a fleet consisting of vehicles that are fueled 100 percent of the time at a location that is owned, operated, or controlled . . ., or is under contract with the covered fleet operator."

The term "capable of being centrally fueled" means all or part of a fleet "that could be refueled 100 percent of the time at a location that is owned, operated, or controlled . . . or is under contract with the covered fleet operator," according to the EPA regulatory definition.

Under the *Clean Air Act*, the clean fuel fleet vehicle provisions may be delayed by states if such vehicles are not offered for sale in California by 1998. EPA said it expects that "vehicles meeting the clean fuel fleet vehicle standards will be offered for sale in California" by 1998.

The state implementation plan revisions required under this provision were to be submitted by states on or before May 15, 1994. The regulation became final on January 10, 1995.

THE STATES HAVE A PIVOTAL ROLE TO PLAY IN IMPROVING AIR QUALITY IN THE UNITED STATES..

This program is being developed in conjunction with the "Clean Cities" initiative launched on September 9, 1993. In conjunction with the implementation of the *Energy Policy Act*, the program is to encourage the most efficient development and use of alterative fuels as part of these policies and priorities. By improving the vehicle refueling infrastructure available to public and private fleets, the program seeks to enhance use of alternate fuel vehicles in a given area including, but not limited to, the cities on page 5.

Fleet owners may earn transferrable credits if they purchase clean fuel vehicles earlier, in greater numbers, or that meet more stringent emissions standards than those set forth in the *Act*. The requirements for such purchases are indicated below.

Clean Fuel Fleet Credit/ Trading Program

Sections 246 and 247 of the *Clean Air Act* require EPA to develop and implement a program for states that includes the conversion of fleets to clean fuel-powered vehicles used in serious, extreme or severe ozone or carbon monoxide nonattainment areas with populations of 250,000 or more. EPA has identified 22 areas that are covered under this program.

EPA has developed regulations governing the program, including definitions and general provisions, credit program regulations, exemptions from transportation control measures, emissions standards and vehicle conversion rules. Then, EPA must review the revised state implementation plan submissions by the affected states to ensure compliance with the regulations, as well as state petitions to become involved in the program. States must revise their state implementation plans to include this program, if required.

State [illegible]

In 1991, the California Air Resources Board adopted the nation's strictest regulations to phase-in vehicle and fuels requirements which has served as a model for other states as well as the clean fuel requirements of the *Clean Air Act Amendments* of 1990. The plan establishes exhaust emission standards in four progressively more stringent categories:

- Transitional Low-Emission Vehicles
- Low-Emission Vehicles
- Ultra-Low-Emission Vehicles and
- Zero-Emission Vehicles.

The hydrocarbon emission standards, expressed as non-methane organic gases, include non-methane hydrocarbons, aldehydes, ketones and alcohols.

In the light-duty vehicle category, starting with the 1994 model year, vehicle manufacturers must meet a fleet average non-methane organic gases standard. Manufacturers could certify any combination of transitional low-emission vehicles, low-emission vehicles, ultra-low-emission vehicles, zero-emission vehicles and conventional vehicles as long as the sales-weighted non-methane organic gases emissions do not exceed fleet average non-methane organic gases standards.

A system for earning marketable credits to comply with the fleet average standard will also be established. Credits could be earned by having a sales-weighted emission average lower than the fleet average standard and would be discounted if not used in the next model year.

CLEANER BURNING TRANSPORTATION FUELS ARE AN IMPORTANT ELEMENT OF STATE PLANNING STRATEGIES THAT ARE REQUIRED UNDER THE *ACT*.

Although the light-duty vehicles phase-in schedule is based on non-methane organic gases emissions, the transitional low-emission vehicle, low-emission vehicle and ultra-low-emission vehicle standards categories would also have emission standards for nitrogen oxide, carbon monoxide, formaldehyde and particulate matter ten microns or greater.

Zero-emission vehicles are defined as vehicles that have no exhaust or evaporative emissions of any pollutant. For the 1998 model year, two percent of a manufacturer's production would have to be zero-emission vehicles. The percentage increases in successive years, reaching ten percent in 2003. Small volume manufacturers are not subject to this requirement and intermediate volume manufacturers would not have to meet it until 2003.

The regulations provide for intermediate in-use standards which are up to 30 percent less stringent than the corresponding certification standards for transitional, low and ultra-low emission vehicles. These in-use standards would be applicable for only two model-years after the introduction date of each vehicle emission category. Compliance with full useful life standards or 100,000 miles for light-duty vehicles would be suspended for the initial two years as well. Fuels that could be used to meet these standards include ethanol, methanol, propane, compressed natural gas, hydrogen and electricity.

OTHER STATE ACTIVITIES

The Northeast States for Coordinated Air Use Management, an eight-state air quality advisory organization that develops policies to improve the air quality of the region, is second only to California in proposing and implementing mobile source air quality regulations. Including the clean vehicles program provided in the *Act*, the eight states are taking separate action on a broad range of clean fuels programs.

Many other states are also developing new alternative fuel programs and incentives.

STATE OPTIONS FOR ATTAINMENT OF AMBIENT OZONE STANDARDS

The states have a pivotal role to play in improving air quality in the United States. This role was significantly increased as a result of the passage of the *Clean Air Act Amendments* of 1990. Led by California, Colorado, Massachusetts, Minnesota, Nebraska, New York, Texas and Wisconsin, state efforts have made the alternative fuels provisions of the *Clean Air Act* a reality.

The role of the states is a continuing and indispensable part of the *Clean Air Act*'s regulatory development and implementation process. The states are provided aggressive new timetables to achieve attainment of ozone and carbon monoxide attainment standards and new means at their discretion to meet the deadlines set forth in the *Act*. Cleaner-burning transportation fuels are an important element of state planning strategies that are required under the *Act*.

In their state implementation plans, states are required to submit detailed air quality plans that demonstrate how they will attain federal standards within the applicable deadlines set forth under Title I of the *Act* (Section 182). Under the *Act*, these plan revisions were to have been submitted to EPA no later than November 15, 1993. Many states are still in the process of revising their state implementation plans, with almost all expected to be in place during 1995.

In addition, states are free to adopt legislation or regulations that are stricter than federal requirements for motor fuels as necessary to maintain attainment of these standards. Among the steps that could be taken by the states in the control of mobile source emissions include, but are not limited to:

1. Implementing state fleet vehicle and fuels programs, both public and private, to include alternative fuels;

2. Increasing oxygen content requirements in reformulated gasoline programs;

3. Acting to increase the number of areas that will "opt-in" to the federal reformulated gasoline program;

4. Requiring the use of enhanced vehicle inspection and maintenance programs;

5. Expanding carbon monoxide control periods as a means of lowering air toxics and expanding regional economic development and making cleaner-burning fuels more widely available; and

6. Developing programs to reduce overall vehicle miles traveled and other transportation control measures.

Glossary of Terms

American Society for Testing and Materials or ASTM A non-profit technical organization that provides a management system to develop published technical information. Standards, test methods, specifications and procedures developed by this group are recognized as definitive guidelines for motor fuel quality as well as a broad range of other products and procedures.

Aromatics A group of hydrocarbon fractions that form the basis of most organic chemicals so far synthesized. Benzene, toluene and xylene are the principle aromatics — commonly referred to as the BTX group. They are one of the heavier fractions in gasoline.

Biodiesel An oxygenated fuel, primarily alkyl (methyl or ethyl) esters, produced from a range of biomass-derived feedstocks including oilseeds, waste vegetable oils, cooking oil, animal fats and trap grease, which can be used in blends or in "neat" form in compression-ignition engines to reduce emissions and improve engine performance.

Biomass Any renewable organic matter such as agricultural crops, crop-waste residues, wood, animal and municipal wastes, aquatic plants and fungal growth used for the production of energy.

Bromine Number Bromine, a halogen element that is a dark-reddish, fuming, toxic liquid, used chiefly in the manufacture of anti-knock compounds, pharmaceuticals and dyes. Bromine number is the number of graphs of bromine which will react with 100 grams of the sample under the conditions of the test.

Carbon Monoxide A colorless, odorless gas. It is poisonous if inhaled because it combines with blood hemoglobin to prevent oxygen transfer. It is very slightly lighter than air. It is produced by the incomplete combustion of fuels with a limited oxygen supply, as in auto engines. It is a major component of urban air pollution, which can be reduced by the blending of an oxygen-bearing compound such as ethanol into hydrocarbon fuels.

Clean Air Act The first modern environmental law to be enacted by any nation, going into effect initially in 1963. Since then, a series of amendments to this original law has been enacted; in 1970 with the creation of the U.S. Environmental Protection Agency and again in 1977 and 1990. This law has established certain targets, standards and procedures for reducing human and environmental exposures to a range of pollutants generated by industry and transportation, including certain "criteria pollutants" such as lead, ozone, carbon monoxide, sulfur dioxide, oxides of nitrogen and particulates, as well as air toxics. The law has set emissions standards for stationary sources such as factories and mobile sources such as automobiles and trucks.

Environmental Protection Agency or EPA A U.S. agency, established in 1970, responsible for the protection of the environment, air and water, regulation of radiation, toxics and solid wastes, including motor fuels and fuels additives such as ethanol-gasoline blends.

Ethanol Otherwise known as ethyl alcohol or "alcohol," or "grain-spirits." Ethanol can be produced chemically from ethylene or biologically from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood. Used in the United States as a gasoline octane enhancer and oxygenate, it increases octane 2.5 to 3.0 numbers at ten percent concentration. Ethanol also can be used in higher concentration in vehicles optimized for its use.

Ethyl Tertiary Butyl Ether or ETBE A colorless, flammable, oxygenated hydrocarbon. The chemical formula is $C_2H_5OC_4H_9$. It may be produced from ethanol and tertiary butanol, or isobutylene. It is of similar structure to methyl tertiary butyl ether or MTBE and has similar octane-enhancing properties.

Fungible Literally means "interchangeable in trade." Commonly used to denote products which are suitable for transmission by pipeline. Ethanol is not considered fungible in this sense, in that it would absorb any water accumulating in pockets in a pipeline.

Lead, Tetraethyl Lead, Lead Alkyls A poisonous metallic anti-knock which is added to gasoline to increase the octane properties of the fuel. The chemical formula is $Pb(C_2H_5)_4$.

Methanol or Methyl Alcohol A colorless poisonous liquid, with essentially no odor and very little taste. It is the simplest alcohol and has a formula CH_3OH. It boils at 64.7°C. It is miscible with water and most organic liquids, including gasoline. It is extremely flammable, burning with a nearly invisible blue flame. Methanol is produced commercially by the catalyzed reaction of hydrogen and carbon monoxide. It was formerly derived from the destructive distillation of wood, which caused it to be known as "wood alcohol."

Methyl Tertiary Butyl Ether or MTBE A colorless, flammable, liquid, oxygenated hydrocarbon. The chemical formula is $(CH_3)_3COCH_3$. It contains 18.15 percent oxygen and has a boiling point of 55.2°C. It is produced by reacting methanol with isobutylene. Its use as an octane enhancer in gasoline has been approved by the EPA, at levels of up to 15 percent.

Neat Alcohol Fuels This refers to the use of straight alcohol — not blended with gasoline — which may be either in the form of ethanol or methanol. In the case of ethanol as a neat alcohol fuel, there isn't a need for ethanol to be at 200 proof, so very often it is used at 180-190 proof or 90-95 percent. There is no advantage in making it anhydrous if it is not being mixed with gasoline. In Brazil, ethanol is sold at 180 proof for use as a neat alcohol fuel. In the case of methanol, most methanol fuels are not strictly "neat" as five-ten percent gasoline is usually blended in to improve its operational efficiency.

Nitrogen Oxides Air-polluting gases contained in automobile emissions, which are regulated by the EPA. They comprise colorless nitrous oxide — otherwise know as di-nitrogen monoxide or as the anesthetic "laughing gas," a colorless nitric oxide and the reddish-brown-colored nitrogen dioxide. Nitric oxide is very unstable and on exposure to air it is readily converted to nitrogen dioxide, which has an irritating odor and is very poisonous. It contributes to the brownish layer in the atmospheric pollution over some metropolitan areas. Other nitrogen oxides of less significance are nitrogen tetroxide and nitrogen pentoxide. Nitrogen oxides are sometimes collectively referred to as "NOx" or "Nox" where 'x' represents any proportion of oxygen to nitrogen.

Nonattainment Area A region, determined by population density in accordance with the U.S. Census Bureau, which exceeds minimum acceptable National Ambient Air Quality Standards for one or more "criteria pollutants" as established in the *Clean Air Act*. Such areas are required to seek modifications to their state implementation plans, setting forth a reasonable timetable using EPA-approved means to achieve attainment of air quality standards for these criteria pollutants by a certain date. Under the *Clean Air Act*, if a nonattainment area fails to attain the standards, EPA may superimpose a federal implementation plan with stricter requirements or impose fines, construction bans, cutoffs in federal grant revenues, or other means, until the area achieves the applicable air quality standards.

Octane A flammable liquid hydrocarbon with a chemical formula of C_8H_{18}, which is found in petroleum. One of the eighteen isomers of octane, 2,2,4-trimethylpentane is used as a standard in assessing the octane rating of fuels.

Octane Rating The research octane number of a fuel plus the motor octane number of a vehicle divided by two equals the octane rating.

Octane Enhancer Any substance such as ethanol, methanol, MTBE, ETBE, benzene, toluene or xylene, which raises the octane rating when blended with gasoline.

Olefin Content A class of unsaturated hydrocarbons containing one or more double bonds and having the general chemical formula C_nH_{2n}.

Oxygenated Fuels Literally meaning any fuel substance containing oxygen, the term is commonly taken to cover fuels containing such oxygen-bearing compounds as ethanol, methanol, MTBE or other oxygenate. Oxygenated fuel tends to give a more complete combustion of its carbon into carbon dioxide — rather than monoxide — to reduce air pollution from exhaust emissions.

Ozone A form of oxygen molecule with three oxygen atoms with the chemical formula O_3. Ozone occurs as a blue, toxic, pungent-smelling gas at room temperature. The ozone layer is a concentration of ozone molecules six-30 miles above sea level. The layer is in a state of dynamic equilibrium. Ultraviolet radiation forms the ozone from oxygen, but can also reduce the ozone back to oxygen. The process absorbs most of the ultraviolet radiation from the sun, shielding life from radiation's harmful effects. Certain air pollutants can drift up into the atmosphere and damage the balance between ozone production and destruction, resulting in a reduction of the concentration of ozone in the layer. Ozone is normally present at ground level in low concentrations. In cities where a high level of air pollutants are present, the action of the sun's ultraviolet light can, through a complex series of reactions, produce a harmful concentration of ozone in the air. The air pollution caused is called photo-chemical smog.

Reid vapor pressure A measure of the vapor pressure in pounds per square inch, of a sample of gasoline at 100°F. It is an indication of the volatility of a gasoline. The blending of ethanol with gasoline tends to increase the Reid vapor pressure, while the blending of MTBE and more particularly, ETBE, tends to reduce the Reid vapor pressure.

Tax Incentives In general, a means of employing the tax code to stimulate investment in or development of a socially-desirable economic objective without the direct expenditure from the budget of a given unit of government. Such incentives can take the form of tax exemptions or credits.

United States Department of Agriculture or USDA A federal government department with the mission to improve and maintain farm income and to develop and expand markets for agricultural products. Through such agencies as the Farmers Home Administration and the Commodity Credit Corporation, the USDA has been involved in assisting the development of the ethanol industry.

United States Department of Energy or DOE A department of the federal government, established by the Carter Administration in 1977, to consolidate energy-orientated programs and agencies. The Department's mission includes the coordination and management of energy conservation, supply, information dissemination, regulation, research, development and demonstration. The Department includes an Office of Alcohol Fuels.

Volatility The tendency of a solid or liquid to pass into the vapor state at a given temperature. With automotive fuels, the volatility is determined by measuring the Reid vapor pressure.

Volatile Organic Compounds Air pollution gases contained in automobile emissions regulated by EPA. Volatile organic compounds are carbon-based emissions, released through evaporation and/or combustion, that combine with nitrogen oxide in the presence of sunlight to form ozone.

1995 Automaker Fuel Recommendations

Octane Rating and Oygenates

Manufacturer	Octane Rating*	Oxygenates (Maximum limits and percent by volume)

As clean air and clean fuel issues become the focal point for state implementation plans, the issue of fuel quality and composition is now being addressed by the nation's automakers, environmentalists and state regulators.

A review of the 1993 model year warranty statements from the nation's top three automakers reveals that all now recommend the use of reformulated gasoline and fuels containing oxygenates such as MTBE and ETBE.

Manufacturer	Octane Rating*	Oxygenates
Acura	91 minimum	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Alfa Romeo	"the higher the rating the higher the ability to resist 'knock'" 90 minimum (164 model)	Ethanol to 10% Methanol with cosolvents and corrosion inhibitors
Aston Martin	91 or higher	No statement
Audi	91 minimum	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
BMW	87 minimum 750IL and 850CI 91 for all other models	MTBE to 15% Ethanol to 10% Methanol to 3% with 3% cosolvents Oxygenates to 2.8% by weight
Chrysler	87 minimum	MTBE to 15% ETBE to 17% Ethanol to 10% Do not use methanol

"Many gasolines are now blended that contribute to cleaner air, especially in those areas of the country where pollution levels are high. These new blends provide a cleaner burning fuel and some are referred to as reformulated gasoline.

In areas of the country where carbon monoxide levels are high, gasolines are being treated with oxygenated materials such as MTBE, ETBE and ethanol. The use of gasoline blended with these materials also contributes to cleaner air.

Chrysler Corporation supports these efforts toward cleaner air and recommends that you use these gasolines as they become available."

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Manufacturer	Octane Rating*	Oxygenates
Ferrari	91 recommended	No statement
Ford	87 minimum	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors

"Several petroleum companies have announced the availability of reformulated fuels. These fuels are specially designed to further reduce the emissions from today's automobiles. More and more reformulated fuels will become available as refiners move to meet the new *Clean Air Act* requirements for 1995. We encourage our customers to use these fuels."

1993 Owner's Manual

$$* \frac{\text{Research Octane Number} + \text{Motor Octane Number}}{2}$$

Manufacturer	Octane Rating*	Oxygenates (Maximum limits and percent by volume)
General Motors	87 minimum	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors

"Many gasolines are now blended with materials called oxygenates. General Motors recommends that you use gasolines with these blending materials, such as MTBE and ethanol. By doing so, you can help clean the air, especially those parts of the country that have high carbon monoxide levels.

In addition, some gasoline suppliers are now producing reformulated gasolines. These gasolines are specially designed to reduce vehicle emissions. General Motors recommends that you use reformulated gasoline. By doing so, you can help clean the air, especially in those parts of the country that have high ozone levels."

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Manufacturer	Octane Rating*	Oxygenates (Maximum limits and percent by volume)
Honda	86 or higher	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Hyundai	87 minimum	Ethanol to 10% Do not use methanol
Infiniti	87 minimum 85 minimum at altitudes greater than 4,000 ft.	MTBE to 15% Oxygenates to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Isuzu	87 minimum 85 minimum at high altitudes	Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Jaguar	91 recommended	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Land Rover	90 to 92 recommended	MTBE to 15% ETBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Lexus	91 minimum	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors — **Not Recommended**
Mazda	87 minimum 91 recommended	Ethanol to 10% No methanol No additives

$$* \quad \frac{\text{Research Octane Number} + \text{Motor Octane Number}}{2}$$

Manufacturer	Octane Rating*	Oxygenates (Maximum limits and percent by volume)
Mercedes-Benz	91 minimum	MTBE to 15% Ethanol or other oxygenates to 10% Methanol to 5% with cosolvents Gasohol 9 to 1 ratio
Mitsubishi	87 minimum 91 recommended	MTBE to 15% (11% in Precis) Ethanol to 10% No methanol
Nissan	87 minimum 85 minimum at altitudes greater than 4,000 ft.	MTBE to 15% Oxygenate blends to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Porsche	91 minimum	"Oxygenated fuels including ethanol, methanol and MTBE may be used with proper octane requirements."
Rolls-Royce	91 minimum	MTBE to 15% Ethanol to 10% Methanol to 3% with cosolvents
Saab	87 minimum	Ethanol to 10% Oxygenates may be used
Subaru	87 minimum 91 recommended	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Suzuki	87 minimum	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors
Toyota	87 minimum (4 cylinder) 91 minimum (6 cylinder)	MTBE to 15% Ethanol to 10% Methanol to 5% with cosolvents and corrosion inhibitors — **Not Recommended**
Volkswagen	91 minimum	MTBE to 15% Ethanol to 10% Methanol to 3% with more than 2% cosolvents
Volvo	87 minimum	MTBE to 15% Ethanol to 10%

$* \dfrac{\text{Research Octane Number} + \text{Motor Octane Number}}{2}$

The Clean Fuels Development Coalition is an innovative not-for-profit organization that actively supports the development and production of fuels with the demonstrated ability to reduce air pollution.

By combining the efforts of a variety of industry interests, the Coalition has played a crucial leadership role in the development of a national energy strategy, passage of clean fuel legislation and regulation and the fostering of new fuel technology and manufacturing processes.

The Clean Fuels Development Coalition is dedicated to an "energy mix" of environmentally sound fuels in the United States. At this time, Coalition efforts are focused primarily on renewable alcohols and their ether derivatives. The group is also supportive of other "alternative" fuels such as compressed natural gas, propane, electricity and hybrids or combinations of these.

The Coalition is comprised of ethanol producers, ether manufacturers, refiners, automobile manufacturers, agricultural organizations, design and engineering firms and others interested in the development of clean fuels.

Thanks to its broad-based membership, the Coalition has been an important player in the development of this country's energy strategy in recent years. The Coalition has

- Helped draft and support the oxygenated fuels, reformulated gasoline and "deposit control additives" provisions in the *Clean Air Act Amendments* of 1990.
- Worked with General Motors, Chrysler and Ford to have oxygenated fuels included in reformulated gasoline provisions and to coordinate auto maker language recommending the use of oxygenated fuels.
- Supported corporate average fuel economy incentives for dedicated "neat" or variable fuel-powered vehicles as part of the *Alternative Motor Fuels Act* of 1988.
- Testified in support of oxygenated fuels programs in Colorado, New Mexico, Arizona, Nevada, Oregon and Texas.
- Worked for the extension of the excise tax exemption and the blender tax credit for ethanol through 2000.
- Assisted in the implementation of the fuels provisions of the *Clean Air Act* as a committee member of the Environmental Protection Agency's Regulatory Negotiation.
- Served as a primary proponent of ETBE, including organization of the campaign to obtain Internal Revenue Service clarification regarding ethanol's eligibility for the blender tax credit when manufacturing ETBE.

The Clean Fuels Development Coalition has also published educational materials, successfully worked for the approval of uniform product labeling and specifications and led cooperative educational efforts with the U.S. Department of Energy, Environmental Protection Agency, the U.S. Department of Agriculture and many environmental groups.

In September 1991, Governor Ben Nelson of Nebraska asked other governors interested in creating a group devoted to the promotion and increased use of ethanol to join him in Lincoln, Nebraska. From that meeting, the **Governors' Ethanol Coalition** emerged.

In just a few years, the Coalition has:

- Proposed the *Domestic Renewable Oxygenate Initiative* which served as the basis for the U.S. Environmental Protection Agency's proposed renewable oxygenate rule. The proposed rule was announced December 15, 1993, and may increase the annual demand for ethanol by about 630 million gallons.
- Undertaken the development of a comprehensive report of ethanol's economic benefits.
- Increased the awareness by local and national policy makers of ethanol's environmental and economic benefits, including global warming benefits.
- Cooperated on the development of marketing activities, including building an 85 percent ethanol fueling infrastructure.
- Coordinated the purchase of over 500 flexible-fuel vehicles, capable of operating on up to 85 percent ethanol, for use in member states.
- Created the National Ethanol Research Institute.
- Served as an authoritative source for ethanol and its uses.
- Provided a public forum for key ethanol topics.
- Provided testimony or information to Congress, the U.S. Environmental Protection Agency and other policy-making forums.
- Supported the expanded use of ethanol and renewable ether derivatives such as ethyl tertiary butyl ether or ETBE.

GOVERNORS' ETHANOL COALITION MEMBERS

WISCONSIN GOVERNOR TOMMY G. THOMPSON CHAIR

MISSOURI GOVERNOR MEL CARNAHAN, VICE CHAIR

NEBRASKA GOVERNOR BEN NELSON, PAST CHAIR

ARKANSAS GOVERNOR JIM GUY TUCKER

COLORADO GOVERNOR ROY ROMER

HAWAII GOVERNOR BEN CAYETANO

ILLINOIS GOVERNOR JIM EDGAR

INDIANA GOVERNOR EVAN BAYH

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KENTUCKY GOVERNOR BRERETON JONES

MICHIGAN GOVERNOR JOHN ENGLER

MINNESOTA GOVERNOR ARNE CARLSON

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NEW MEXICO GOVERNOR GARY JOHNSON

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OHIO GOVERNOR GEORGE VOINOVICH

SOUTH DAKOTA GOVERNOR BILL JANKLOW

TEXAS GOVERNOR GEORGE W. BUSH

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American Biofuels Association
Phone: 703-522-3392

National Biodiesel Board
Phone: 800-841-5849

National Renewable Energy Laboratory
Phone: 303-231-1000

CLEAN FUELS LEGISLATIVE AND REGULATORY DEVELOPMENTS INCLUDING ETHANOL AND ETHERS

Clean Fuels Development Coalition
Phone: 301-913-9636

ELECTRIC VEHICLES

Edison Electric Institute
Phone: 202-508-5000

Electric Power Research Institute
Phone: 202-872-9222

ETHANOL

Governors' Ethanol Coalition
Phone: 402-471-2867

Nebraska Ethanol Board
Phone: 402-471-2941

U.S. MOTOR FUELS & OXYGENATES

Information Resources, Inc.
Phone: 703-528-2500
800-USA-FUEL

GENERAL ALTERNATIVE FUELS INFORMATION

Clean Cities Hotline
Phone: 800-C-CITIES

National Alternative Fuels Hotline
Phone: 800-423-1DOE

Reformulated Gasoline Hotline
Phone: 800-GO-TO-RFG

METHANOL

American Methanol Institute
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Oxygenated Fuels Association
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PROPANE VEHICLES

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