United States General Accounting Office

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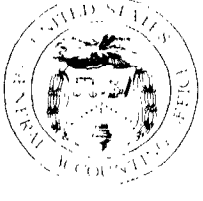
Report to the Chairman, Subcommittee on Energy and Power, Committee on Energy and Commerce, House of Representatives

June 1990

GASOLINE MARKETING

Uncertainties Surround Reformulated Gasoline as a Motor Fuel



GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-227776.5

June 14, 1990

The Honorable Philip R. Sharp
Chairman, Subcommittee on Energy
and Power
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

The administration's July 1989 proposed legislation for amending the Clean Air Act included an initiative to promote the use of cleaner-burning alternative fuels for motor vehicles, such as ethanol, methanol, and compressed natural gas, to reduce motor vehicle emissions. Shortly after the proposal's introduction, officials from the petroleum and automobile industries suggested that gasoline could be reformulated to burn as cleanly as alternative fuels. Because little is known about reformulated gasoline, you requested that we provide the Subcommittee with information on (1) what reformulated gasoline is, (2) when reformulated gasoline could be made available and how it will be produced, and (3) what the impacts will be of producing and using reformulated gasoline.

Results in Brief

Reformulating gasoline generally refers to changing the chemical makeup of gasoline for a specific purpose. Reformulated gasoline, as it is being discussed today, involves changing the composition of gasoline to improve its emissions characteristics. While some petroleum companies have recently begun selling limited quantities of a reformulated gasoline to meet specific markets, the most effective formulations for reducing emissions have yet to be determined. The petroleum and automobile industries have only recently undertaken in-depth research of possible reformulations which could lead to several recipes of reformulated gasoline. Much remains to be learned about the benefits and costs of various possible compositions; therefore, the exact formulations and likely dates of availability are uncertain.

In general, government and industry officials agree that reformulated gasoline could make a positive contribution to air quality by helping reduce some vehicle emissions. In addition, reformulated gasoline offers advantages over other clean-burning alternative fuels because it can use the existing petroleum distribution system. However, producing reformulated gasoline in large quantities and in the more effective formulations would require at least several years' lead time and large

investments in new refinery equipment. These officials also believe it could adversely affect small refiners, increase the cost of gasoline to consumers, and require additional imports of crude oil.

With the uncertainties concerning the composition and potential impacts of reformulated gasoline, it would be premature to draw conclusions about the potential of reformulated gasoline in comparison to other alternative fuels.

Background

Air pollution from motor vehicle emissions has been a major environmental issue over the past 2 decades. Thus far, the automotive industry has achieved emission reductions primarily with engine modifications and exhaust system improvements, most notably by equipping vehicles with catalytic converters (devices that transform vehicle exhaust constituents into relatively benign substances).

During the same time frame, federal regulations required changes in gasoline composition that helped reduce vehicle emissions. For example, regulations established in 1973 directed the petroleum industry to produce unleaded gasoline to reduce the health hazard from toxic lead emissions. In addition, 1989 regulations imposed limits on gasoline volatility to reduce amounts of evaporative vehicle emissions (gasoline vapors escaping from a vehicle's fuel system when the vehicle is not in use).

Also during this time frame, tax incentives were introduced by federal and state governments to encourage the blending of ethanol in gasoline. Ethanol is one of several oxygenates (fuels containing oxygen) which help reduce carbon monoxide emissions. Four states require the use of oxygenates in certain areas during heavy pollution periods.

Despite these actions to lessen the impact of emissions from motor vehicles, the problem has not been solved. The Environmental Protection Agency (EPA) has identified 101 areas in the United States which have not met the National Ambient Air Quality Standards for various pollutants which are primarily the product of vehicle emissions.

An alternative fuels program was included in the administration's July 1989 Clean Air Act proposal which recognized the need to further regulate motor fuel composition to reduce vehicle emissions. The proposal required, among other things, the sale of specified numbers of vehicles using alternative fuels—such as methanol, natural gas, and ethanol—in areas with the most serious air pollution. The Senate, on April 3, 1990,

and the House of Representatives, on May 23, 1990, passed their versions of the Clean Air Act amendments, which advocate the use of reformulated gasoline to meet vehicle emission performance standards in cities with severe air pollution problems.

Composition of Reformulated Gasoline Is Uncertain

In a broad sense, reformulated gasoline may refer to any past changes in the chemical composition of gasoline which were done for a specific purpose. However, in the context of the debate over new clean air legislation, reformulated gasoline now specifically refers to new formulations of gasoline which industry is developing in response to the administration's alternative fuels proposal. In this sense, the composition of reformulated gasoline is yet to be determined.

Recently, Atlantic Richfield Company (ARCO) began marketing a reformulated gasoline called Emission Control-1 (EC-1). Beginning in September 1989, EC-1 replaced ARCO's leaded regular gasoline in southern California. ARCO's tests indicate that it reduces emissions from pre-1975 vehicles without catalytic converters. Two other companies, Conoco and Diamond Shamrock, subsequently began marketing limited quantities of reformulated gasolines similar to EC-1 in parts of Colorado. Since our review work, other companies have also announced that they have begun or plan to market limited quantities of a reformulated gasoline in specific areas. For example, in April 1990 Shell Oil Company began marketing a reformulated premium gasoline in nine metropolitan areas having the most severe ground level air quality problems, as well as in Washington, D.C.

While gasoline has previously been reformulated to improve its emissions characteristics, government and industry officials said that with research, more effective new gasoline formulations intended to reduce emissions should be identified. They said that more information is needed about the emissions resulting from new gasoline compositions. To obtain this information, as well as emissions data on other alternative fuels, the automobile and petroleum industries are currently engaged in a joint research program studying reformulated gasolines, methanol, and ethanol. (See app. I for a description of the research program.) Until the results of this program become available (Phase I is expected to be completed in late 1990 and Phase II at least 2 years later), industry officials said the composition of reformulated gasoline remains uncertain. These officials said a number of new gasoline recipes may emerge from this industry effort. (App. II discusses reasons why multiple recipes for reformulated gasolines are possible.)

Reformulating gasoline in the future to help reduce vehicle emissions could involve changing the concentrations of numerous components of current gasoline. Candidates for reduction include the aromatics, such as toxic benzene, the olefins, and hydrocarbons with high boiling points. (These and other gasoline components are described in app. III.) Also, a reduction in sulfur content could increase the effective life of catalytic converters. Increasing the oxygenate content of gasoline through the addition of ethanol or ethers such as methyl tertiary butyl ether (MTBE) and ethyl tertiary butyl ether (ETBE) is yet another possibility. Finally, removing more butane from gasoline could further reduce evaporative emissions.

We asked officials at the Department of Energy (DOE) and EPA to comment on the likely composition of reformulated gasoline. Officials of both agencies said it was too early to predict the precise composition of the new fuel. However, EPA officials told us that two of the proposed measures for reformulating—adding more oxygenates and further reducing volatility—could reduce emissions from gasoline in the near-term. EPA is planning an analysis of reformulated gasoline as part of its series of reports on alternative fuels but is awaiting definite specifications from industry before proceeding with this effort.

When and How Reformulated Gasoline Will Be Produced Is Uncertain

At this time, it is uncertain when reformulated gasolines intended to help meet more stringent vehicle emissions standards will be widely available. While several firms are marketing reformulated gasolines, these products represent only a limited portion of the total gasoline sales of these companies and are produced with only minor changes in refinery operations. Industry officials told us that other companies could also produce limited amounts of reformulated gasoline within a short time. However, these officials pointed out that the production of larger amounts of reformulated gasoline in the more effective formulations would require substantial changes in refinery operations and would appear to be several years away at a minimum. Generally, they told us that the more severe the composition changes undertaken and the greater the percentage of the total gasoline pool affected, the longer it will take to make reformulated gasoline available.

Government and industry officials said that reformulating all gasoline could not be accomplished quickly. This would entail significant changes at existing refineries, including the reduction or complete elimination of some processes and the construction of new processing units to replace them. For example, an ARCO spokesman estimated that his firm will need

to invest approximately $2 billion over the next 5 years in improvements to existing facilities to reformulate all its gasoline. Mobil Oil Corporation officials told us that 3 to 4 years would be needed to obtain necessary permits, and design and install new refinery units following a decision to produce reformulated gasoline in quantity.

The fact that several firms were able to quickly introduce reformulated gasolines to replace leaded gasoline does not necessarily demonstrate whether large quantities of reformulated gasoline could be made available in a short time. For example, ARCO's EC-1 represents only a limited portion of its gasoline. An ARCO official told us that the firm was able to offer EC-1 for sale within a month of completing emissions tests on the new fuel because EC-1 is produced by changing the blending of existing refinery products rather than by adding new refinery processes. For instance, aromatics have been reduced in EC-1 by moving some of them into unleaded regular gasoline, where ARCO contends they are burned more cleanly by vehicles with catalytic converters. Officials of Diamond Shamrock and Conoco told us that their firms' reformulated gasolines are produced in a manner similar to EC-1.

The above three reformulated gasolines on the market replaced leaded gasolines only in portions of California and Colorado. Furthermore, an official of the Lundberg Survey, Inc., told us that leaded regular sales currently account for about 8 percent of the total U.S. gasoline sales. Given these limitations, the share of the total U.S. gasoline market that could be affected by these reformulated gasolines is small at this time.

An official of the National Petroleum Refiners Association observed that the movement toward reformulated gasoline has been influenced by petroleum companies' perception that further government regulation of motor fuels is inevitable. However, in the absence of an actual government mandate, there is no guarantee that these companies and others will decide to reformulate all gasoline. Thus, government and industry officials believe the decision to reformulate larger volumes of gasoline is not likely to occur until after the passage of new clean air legislation and the issuance of implementing regulations.

Potential Impacts of Reformulated Gasoline

We identified several potential positive and negative impacts of reformulated gasoline. Potential positive impacts include an improvement in air quality and no necessity to develop a new motor fuel distribution system. Possible negative impacts include increased production costs for refiners, the financial failure of some small refiners and independent

gasoline marketers, increases in the consumer cost of gasoline, and an increase in crude oil imports. The severity of these impacts is unclear at this time because of uncertainties about the composition of reformulated gasoline and the amount of gasoline to be modified. Generally, the more severe the reformulation and the greater the volume of gasoline affected, the more significant the impacts will be. A brief discussion of each potential impact follows.

Air Quality

Many government and industry officials agreed that the widespread introduction of reformulated gasoline would have a positive impact on air quality. While the extent of the benefit is uncertain at this time, officials we contacted believe that reducing concentrations of gasoline components such as aromatics and olefins will result in some decreases in the ozone and air toxics attributable to motor vehicles. They told us that the current joint research program should provide the data necessary to estimate these benefits.

Industry officials pointed out that some of the emissions benefits of reformulated gasoline could, in a relatively short time, be achieved by the existing vehicle fleet, unlike other alternative fuels for which new distribution systems and new vehicles may need to be developed. According to these officials, this would make significant emissions reductions possible from older vehicles—the most serious polluters. For example, an ARCO research report states that pre-1975 cars and trucks without catalytic converters make up about 15 percent of the vehicles in southern California. The report concludes that using EC-1, a reformulated gasoline, in those older cars could reduce vehicular pollutants in that area by an amount equivalent to removing 20 percent of those vehicles from the road altogether.

An EPA official told us it is possible that reformulated gasoline may be able to match the automotive emission reductions that may be achieved by an M85 methanol fuel (85 percent methanol, 15 percent gasoline). The agency has estimated that using an M85 fuel would reduce current automotive emissions by 30 percent. On the other hand, EPA believes it unlikely that reformulated gasoline can match the potential emission reductions of a pure methanol fuel (M100), which it believes may reduce emissions by approximately 80 percent. Eliminating the last remaining amounts of gasoline can provide substantial emission benefits.

In spite of this limitation, EPA and DOE officials view the development of reformulated gasoline as a positive step. They told us it signals a new

willingness on the part of the petroleum industry to seriously examine fuel composition as a part of the solution to vehicle emissions. They also said that reformulated gasoline could make a modest, short-term contribution to cleaner air because of its potential to reduce emissions from older cars. According to an EPA official, this benefit of reformulated gasoline would be useful during a period of transition to fuels which EPA considers to be inherently cleaner, such as M100 or compressed natural gas.

Fuel Distribution System

Petroleum industry officials said that reformulated gasoline has an advantage over other alternative fuels in that it can make use of the existing petroleum distribution system. Changes to pipelines, storage facilities, and service stations would not be necessary. A petroleum industry official claimed that the cost of replacing or modifying the distribution system to accommodate other alternative fuels would be far higher than the increased costs of producing reformulated gasoline.

Cost of Reconfiguring Refineries

According to government and industry officials, the more extensively that refiners have to change their operations to produce reformulated gasoline, the more expensive it will be to produce. They told us it will be very expensive to construct the necessary new refinery equipment. Two industry officials estimated that this reconfiguring of refineries might require capital investments of $20 billion to $30 billion to reformulate all gasoline.

Several petroleum industry officials told us they would incur an additional cost from reformulated gasoline in the form of reduced value for some refinery products. For example, as gasoline blending components, aromatics have relatively high value. To reduce the aromatics content of gasoline, refiners would need to find other uses for them or reduce the amount of aromatics produced during the production of gasoline. They could be sold to the chemical industry as feedstocks. However, government and industry officials said the market would have difficulty in absorbing the large surpluses of aromatics that would likely result from reformulating all gasoline. These officials said depressed prices for aromatics would probably result from this oversupply situation.

Viability of Small Refiners

Government and industry officials said they believe that some small refiners may be forced out of business if required to produce significantly reformulated gasoline. Currently, there are approximately 75

small U.S. refiners with crude oil processing capacity of 100,000 barrels per day or less, representing approximately 13 percent of total U.S. gasoline production. Officials of trade associations representing small refiners told us that their members generally lack the processing flexibility to adjust to a demand for a significantly different product. Furthermore, they tend to operate on small profit margins and would have difficulty in attracting investors if expensive new equipment were required to produce a new gasoline formulation.

Viability of Independent Gasoline Marketers

Officials of the Society of Independent Gasoline Marketers of America (SIGMA) told us that reformulated gasoline could create difficulties for their members. They explained that independent marketers supply or operate chains of high- volume/low-price gasoline retail stations. These officials indicated that their members' ability to stay in business depends upon a competitive wholesale gasoline market. Currently, competition is ensured by the availability in that market of numerous supply options, including the small domestic refiners and foreign refiners. If these sources were to be eliminated, independent marketers believe wholesale gasoline prices would rise and they would lose their competitive advantage.

According to SIGMA officials, reformulated gasoline could threaten these wholesale sources. As discussed above, reformulation could cause small refiners to fail. Furthermore, the independent marketers believe foreign refiners would seek other markets for their finished gasoline rather than alter their refineries to produce reformulated gasoline for the U.S. market. SIGMA officials said such changes in the wholesale market would likely cause the failure of some independent gasoline marketers.

Cost to Consumers

According to government and industry officials, the costs related to new capital investments incurred by petroleum companies and the decreased value of components removed from gasoline would be passed on to gasoline consumers. It appears that limited reformulations would not result in large increases. For example, ARCO officials told us that EC-1 costs 2 cents more per gallon to produce than leaded regular, but ARCO is not passing this increase on to the retail level. However, more extensive reformulation would likely cost more. While petroleum industry officials did not speculate on possible price increases, a preliminary EPA estimate of aromatics reductions may give some indication of the magnitude of potential price increases. The estimate, based on EPA assumptions about current gasoline composition and refinery operating costs, suggests that

aromatics levels can be reduced from the current industry average of 35 percent of gasoline volume to 15 percent, for a cost of about 10 cents a gallon.

The potential failure of independent gasoline marketers could have an additional impact on consumer prices. Representatives of these companies said that their competitive pricing helps hold down the retail price of gasoline. Without this competition, they believe that the marketers of major brand gasoline would have greater freedom to raise their prices.

Energy Security

Reformulated gasoline could negatively affect the nation's energy security. Energy Information Agency reports show a trend toward increasing U.S. energy consumption and declining domestic crude oil production in recent years, to the point where the United States is becoming more dependent upon foreign oil sources to satisfy the growing demand. Petroleum industry officials stated that the production of reformulated gasoline is likely to exacerbate this situation.

According to government and industry officials, severe gasoline reformulations would probably result in the production of lower volumes of gasoline per barrel of crude oil. Although uncertainty about the composition of reformulated gasoline precludes precise estimates of the volume loss, some increase in the supply of crude oil would be required to maintain the current volume of gasoline production. As indicated by several officials we interviewed, it is likely that this additional crude will have to be imported.

Furthermore, government officials expressed concern that the emergence of reformulated gasoline might discourage the development of alternative fuels such as methanol and ethanol, which are not made from petroleum. Currently, the United States is almost totally dependent upon petroleum-based fuels to operate its motor vehicles. Other alternative fuels may improve energy security because they use raw materials that can either be domestically produced or obtained from a wider variety of foreign suppliers compared with petroleum.

Conclusions

The benefits and costs of reformulated gasoline are yet to be quantified with any degree of certainty. Preliminary indications are that reformulated gasoline can offer reductions in some vehicle emissions that could help to achieve the goals of the proposed Clean Air Act. Furthermore, reformulated gasoline would not require major changes in the petroleum

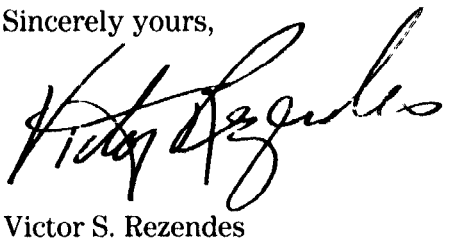
distribution system. Industry officials contend that this represents a significant savings in comparison to other alternative fuels. On the other hand, while these officials acknowledge that increased production costs will probably cause consumers to pay more for reformulated gasoline than conventional gasoline, it is not yet known how reformulated gasoline will compare in cost with other alternative fuels. However, price increases cannot be quantified until the type and quantity of reformulations are known.

The automotive and petroleum industries are conducting extensive research on the emissions characteristics and cost-effectiveness of reformulated gasoline. Initial results are expected in late 1990. At least until then, there is insufficient evidence to indicate how reformulated gasoline compares with other alternative fuels.

The scope and methodology of our review are discussed in appendix IV. We discussed the information contained in this report with DOE and EPA officials. They offered some technical comments, which we have incorporated in the report. As you requested, we did not obtain official written agency comments on this report. Our work was conducted from October 1989 through March 1990.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to the appropriate congressional committees; the Secretary of Energy; and the Administrator, EPA. We will also make copies available to others upon request. Should you need further information, please contact me on (202) 275-1441. Other major contributors to this report are listed in appendix V.

Sincerely yours,



Victor S. Rezendes
Director, Energy Issues

Contents

Abbreviations

ARCO	Atlantic Richfield Company
DOE	Department of Energy
EC-1	Emission Control-1
EPA	Environmental Protection Agency
ETBE	Ethyl Tertiary Butyl Ether
MTBE	Methyl Tertiary Butyl Ether
SIGMA	Society of Independent Gasoline Marketers of America

Industry Research Program on Motor Fuel Composition and Emissions

On October 17, 1989, the 3 major domestic auto companies and 14 of the major petroleum companies announced plans for a joint research program designed to provide new information on the relationships between motor fuel composition and vehicle emissions. Officials involved in planning the program provided the following information about its objectives and methodology:

- The program is designed to provide results that will permit the assessment of relative reductions in vehicle emissions and improvements in urban air quality, especially ozone, achievable with reformulated gasolines and with methanol fuels. The program will also evaluate ethanol as an additive to reformulated gasoline.
- The first phase of the program, expected to cost approximately $14 million, will test 26 gasoline formulations in vehicles with older emissions control technology (model years 1983-85) and in vehicles with current technology (model year 1989). It will also test two methanol fuels and an industry-average gasoline in flexible-fuel vehicles. In addition, the research program will measure the emissions impacts of adding 10 percent ethanol to reformulated gasoline, the effects of adding ethers—methyl tertiary butyl ether (MTBE) and ethyl tertiary butyl ether (ETBE) to gasoline—and the effects of sulfur content on catalytic converter activity.
- The gasoline composition portion of Phase I will include measuring the emissions impacts of various concentrations of aromatics, olefins, and hydrocarbons with high boiling points. Many compounds in these three groups of gasoline components are highly reactive and are considered the most likely contributors to the formation of ozone, the chief ingredient in urban smog. Moreover, these components contribute various toxics to the atmosphere such as the carcinogen benzene, a member of the aromatics family.
- Researchers will make use of sophisticated equipment and new test procedures to identify the individual components in vehicle emissions rather than just measuring total emissions. This detailed information will be used in atmospheric chemistry and air quality models to determine the potential reductions in urban ozone from the use of the tested fuels.
- Phase I will include an economic analysis aimed at determining the cost-effectiveness of producing various new gasoline reformulations. Part of this effort will involve a survey of petroleum companies by the National Petroleum Refiners Association. Survey results, expected in the early spring of 1990, are expected to provide information on refiners' ability to reconfigure their refineries to produce selected recipes of reformulated gasoline. The survey data will be used by a private consulting firm

to estimate the amount of investment required to produce reformulated gasoline and the increased cost per gallon to consumers.

- Phase I testing was originally scheduled to begin in January 1990 and to conclude by approximately August 1990. However, as of mid-February, difficulties in establishing test procedures had delayed the start of actual testing. A program official could only tell us that testing would begin as soon as possible, with completion now expected near the end of 1990.
- Final plans for the second phase of the research program have not been approved. Treating vehicles and the fuels they burn as a total system, Phase II will test the best of the new gasoline formulations identified in Phase I in future prototype vehicles designed to optimize the benefits of the new fuels. Phase II (originally projected to begin early in 1990) has, like Phase I, been delayed. New target dates for the beginning and end of Phase II had not been established as of mid-February. A program official speculated that it might begin in the fall of 1990 and continue for at least 2 years.

Multiple Recipes for Reformulated Gasoline Are Possible

According to industry and government officials, differing refinery processes and market needs affect the formulations of gasolines. For example, the percentages of various hydrocarbons in the crude oil feedstocks that industry uses vary, and the combination of refinery processes that industry employs to convert the crude to gasoline differs considerably from one refinery to another. Furthermore, different petroleum companies produce gasolines to meet the specific geographical and seasonal requirements of their marketing areas, such as the requirement for higher volatility gasolines in the winter in northern areas. If gasoline is eventually reformulated, according to industry and government officials we contacted, these factors will continue to be in force, so that a number of different recipes for reformulated gasoline are possible.

Glossary of Gasoline Components

Modern gasoline is a complex mixture of hundreds of different components, mostly hydrocarbons (compounds of hydrogen and carbon), blended in many different combinations. A refiner has many choices regarding what components to include in the mixture to get the desired combination of properties, and many different refinery processes may be used to produce those components. Such factors as the cost and contents of crude oil feedstocks, equipment available at each refinery, and desired product slate affect each refiner's choices regarding the composition of the gasoline produced. Thus, gasolines available today in the United States vary widely in their concentrations of numerous components.

Those proposing to reformulate gasoline suggest that vehicle emissions may be reduced by changing the concentrations of certain gasoline components. Given the variations in gasoline composition, any change would be relative to an overall industry average. A brief discussion of the components being discussed as candidates for change in reformulated gasoline is given below.

Aromatics

A class of high-octane hydrocarbons that currently constitutes about 35 percent of gasoline. This percentage has increased in recent years, as refiners have blended more aromatics into gasoline to replace the octane lost as a result of lead reduction. The chief aromatics in gasoline are benzene, toluene, and xylene. In addition to concerns about the toxicity of benzene, some aromatics are highly reactive chemically, making it likely that they are active in ozone formation.

Benzene

A member of the aromatics family that currently constitutes about 1.5 percent of gasoline. EPA has identified benzene as a carcinogen and has regulated exposure to it in the workplace. EPA has not yet regulated benzene emissions from gasoline but is currently considering doing so.

Butane

A light hydrocarbon added to gasoline to raise octane and increase volume. Since it has high vapor pressure, adding or removing butane is the common method by which refiners raise or lower the vapor pressure of gasoline. Removal of butane was made necessary by imposition of gasoline volatility limits set by EPA.

Ethanol	An alcohol produced from starch or sugar crops such as corn or sugar cane. Ethanol may be used as a fuel by itself, as is done in Brazil, or blended into gasoline to boost octane and increase volume. In the United States, ethanol is usually blended in a 10-percent mixture with gasoline to form gasohol. As an oxygenate, ethanol supplies oxygen to gasoline, which reduces carbon monoxide emissions from vehicles. However, ethanol cannot be transported in the same pipelines with gasoline, so it must be blended into gasoline outside the refinery. In addition, ethanol increases the volatility of gasoline. These drawbacks can be overcome if ethanol is converted to its ether form, ETBE.
Ethyl Tertiary Butyl Ether	An ether compound made using ethanol. Although not yet produced in commercial quantities, it could be used as a gasoline additive to boost octane and provide oxygen. Since it has low vapor pressure, it could also be useful in helping to comply with volatility controls on gasoline. Unlike alcohols, ETBE could be produced and blended with gasoline at the refinery and shipped in gasoline pipelines.
Hydrocarbons With High Boiling Points	Many of the hydrocarbons in gasoline with high boiling points are very reactive chemically and are considered to be likely contributors to ozone formation. These hydrocarbons are the last to boil away as gasoline is subjected to high temperatures. The group of hydrocarbons being tested by the auto/oil joint research project is referred to as "the T_{90} Boiling Point group." This means the group consists of the last 10 percent of hydrocarbons that remain after 90 percent of the gasoline has already vaporized.
Methanol	An alcohol made primarily from natural gas. Methanol may be used as a pure (or neat) fuel, in which case it is called M100 (100 percent methanol). However, since M100 vehicles are hard to start and are still under development, some gasoline is usually added to methanol to form M85 (85 percent methanol and 15 percent gasoline) for M85 vehicles. Methanol itself is not currently used as a gasoline additive for several reasons, including its adverse effects on fuel system components in conventional vehicles. However, when converted to its ether form, MTBE, it is widely used as a gasoline additive.

Methyl Tertiary Butyl Ether	An ether compound made using methanol. MTBE has been widely accepted by refiners as a gasoline additive, and its use has been steadily increasing over the past several years. As an oxygenate, it supplies oxygen to help reduce carbon monoxide emissions. MTBE boosts octane, while having little effect on vapor pressure. Unlike alcohols, MTBE can be produced and blended with gasoline at the refinery and shipped in gasoline pipelines.
Olefins	A group of highly reactive and volatile hydrocarbons that currently constitute about 12 percent of gasoline. Olefins are considered to be likely contributors to ozone formation.
Oxygenate	This term applies to any gasoline additive containing oxygen. Oxygen in gasoline tends to reduce carbon monoxide emissions from vehicles. Therefore, four states (Arizona, Colorado, Nevada, and New Mexico) have mandated the use of oxygenated gasoline during winter months in areas with high carbon monoxide emissions levels. Oxygenates include the alcohols, such as ethanol and methanol, and the ethers, such as MTBE and ETBE. Each of these compounds also boosts the octane of gasoline, while their effects on volatility vary.
Sulfur	A contaminant found to varying degrees in crude oil. Most of it is removed during refinery processing so that the amount remaining in gasoline averages only about 300 parts per million. However, industry researchers believe that even this amount may adversely affect the durability of catalyst material in catalytic converters.

Scope and Methodology

In performing this assignment, we reviewed pertinent legislation, publications, testimony, technical literature, and reports by various interest groups. However, because the concept of reformulated gasoline is relatively new, the existing documentation was limited. Therefore, we relied heavily on information obtained through discussions with officials from the three domestic automobile manufacturers, seven petroleum companies, four trade associations, and a research firm. We also discussed the concept of reformulated gasoline with officials from DOE and EPA and the California Air Resources Board. To obtain views on reformulated gasoline from a non-petroleum perspective, we interviewed an official from a major methanol-producing company. The companies, associations, and government agencies we contacted are shown below.

Companies, Associations, and Government Agencies Contacted

Automobile Manufacturers	Chrysler Motors Corporation Ford Motor Company General Motors Corporation
Petroleum Companies	Amoco Corporation Ashland Oil, Inc. Atlantic Richfield Company (ARCO) Conoco, Inc. Diamond Shamrock, Inc. Mobil Oil Corporation Sun Refining and Marketing Company
Trade Associations	American Independent Refiners Association American Petroleum Institute National Petroleum Refiners Association Society of Independent Gasoline Marketers of America

Research and Technology Company	Talbert Fuel Systems, Inc.
Methanol Company	Hoechst Celanese Corporation
Government Agencies	California Air Resources Board U.S. Department of Energy U.S. Environmental Protection Agency

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