Determining Alternative Fuels Strategies

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These are the most challenging of times imaginable for those involved in fuels research and development and in the refining and marketing of transportation fuels. While rapid changes are taking place, often in a highly political context, it should be remembered that the oil industry is no stranger to change. Throughout its history as the predominant motor fuel, for example, gasoline has constantly been reformulated to meet varying demands—from automotive manufacturers and customers alike.

The changes demanded in the past were primarily to meet vehicle performance requirements. U.S. drivers consistently sought high-performance, high-octane products. During the 1980s, performance demands came to include cleaner-burning fuels that were more responsive to increasingly complex automotive technology. The gasoline additives that were developed cleaned not only carburetors but also fuel injection systems and entire fuel intake systems.

At the same time, gasoline was adapted to growing environmental concerns, most

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notably with the removal of lead. In 1970, 98 percent of gasoline contained lead, and about 700 million pounds of lead were used annually in gasoline. By 1989, lead consumption had dwindled to about 5 million pounds, less than 1 percent of 1970 levels.

Advanced engine technology, introduction of the catalytic converter, and improved gasoline have combined to reduce emissions from the individual modern automobile by about 95 percent in comparison with the lowest-emitting models 20 years ago. The introduction of unleaded gasoline demonstrates the importance of treating both vehicle emission controls and fuel as a single, interrelated system. Because catalytic converters would not work without the use of lead-free gasoline, it was a combination of vehicle and fuel controls that led to reducing pollution. Although the U.S. vehicle fleet and the number of vehicle miles traveled have increased, the percentage that mobile sources (such as vehicles) contribute to total pollution has been reduced.

Despite these reductions, ozone level improvement has been slow. As a result, the attention of industry and government on air quality has continued to focus on tighter emissions standards. Because of the concern over the expense to achieve these standards, consumers need full knowledge of potential benefits if they are to be expected to pay the costs of these improvements.

Although the Bush Administration supports alternatives to gasoline in its clean air proposal, it has endorsed a fuel-neutral and market-oriented playing field in the drive toward cleaner-burning fuels. So-called "alternative" fuels are claimed to burn more cleanly and create fewer emissions than conventional fuels, thus improving air quality. The fuel industry supports the Bush Administration's intent to accomplish its goals on a competitive economic basis within the framework of a freely functioning, dynamic marketplace.

It should be noted that the Administration plan clearly identified methanol as the alternative fuel of choice. The technical support document for the Clean Air Act proposal of 1989 was essentially a methanol manual. The fuel industry has expressed concern that major questions about methanol remain unanswered. Its representatives believe that further data regarding methanol's costs, benefits, and risks are required before making legislative and capital decisions that will significantly affect the transportation and energy industries as well as society as a whole.

Better Data Required for Informed Legislation

To ensure that properly informed decisions about the cleanest-burning, most cost-effective fuels would be made on the basis of the best available scientific evidence, the petroleum and automobile industries announced a major joint research effort for 1990. The purpose of this effort is not to create an industry position on alternative fuels but to develop a larger, more comprehensive data base about the environmental benefits and costs of reformulated gasoline blends and methanol fuels. Methanol and reformulated gasoline blends are the focus of the study because these are the two fuels currently receiving the most attention.

"Reformulated gasoline" means blends of gasoline that are produced with lower percentages of certain components so that emissions are reduced. Three additives for gasoline will also be studied in Phase I of the research effort: methyl tertiary butyl ether (MTBE), ethanol, and ethyl tertiary butyl ether (ETBE). Other alternative fuels will be studied during Phase II of the program.

Scope of Joint Research

The first phase of the proposed research will examine automobile emissions and effects on air quality. Also to be considered are the costs and benefits of various methanol blends in prototype vehicles and of various gasoline formulations in 1983–1985 and 1989 vehicles. Three methanol fuels will be tested in 20 prototype flexible-fuel vehicles, and 26 reformulated gasolines will be tested in 34 gasoline-fueled vehicles.

Vehicle Tests

The tests will be conducted in laboratories certified by the Environmental Protection Agency on existing cars that have been driven 10,000 miles or more. More than 2,200 tests will be carried out to measure hydrocarbons, nitrogen oxides (NO_x), and carbon monoxide (CO) precursors to ozone, smog, and airborne toxic chemicals. In addition, the researchers will conduct the largest number of gas chromatographic analyses ever carried out in order to obtain information on the reactivity of the emissions and on amounts of potential air toxics. The first phase of tests was planned for completion by mid-1990, in time for results to provide important information to those charged with forming the Clean Air Act.

Air Quality Modeling

As part of Phase I, air quality modeling will use data from the emissions program to determine the effects on air quality of various gasolines and methanol fuels. Simple modeling of several cities will be performed to allow the researchers to choose the most promising fuels. Detailed models will be used for three cities (Los Angeles and two other cities yet to be determined). Economic studies will be combined with the air modeling studies to determine the most cost-effective method of reducing ozone.

Additional Input

Concurrently, the National Petroleum Refiners Association will survey refiners to determine costs and methods for producing reformulated gasolines. Models will be used to develop industry investment costs. Parallel work will determine investment and operating costs for manufacturing and distributing methanol in areas that are not currently attaining federal air quality standards.

The advice of EPA and such regional public agencies as the California Air

Resources Board (CARB) and the Northeast States for Coordinated Air Use Management was solicited and has been received. Reaction to the program has been generally favorable. Researchers from academia will also advise the automobile and oil industry researchers.

Phase I of the program is one of the largest vehicle emissions programs ever run—and on a very ambitious schedule. The estimated cost of Phase I is $14.5 million. Some new emissions test procedures have been established, and sophisticated laboratory techniques are being turned into day-to-day operations. The results should provide a valuable data base for future use in improving urban air quality.

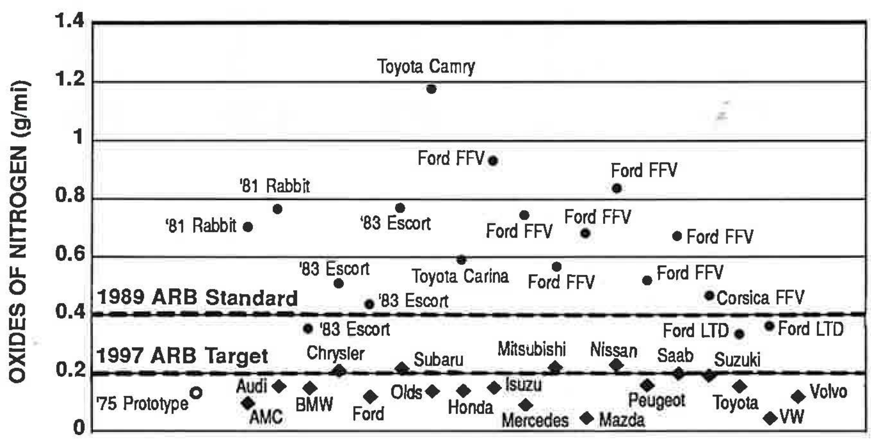

FIGURE 1 Comparison of nitrogen oxide emissions from gasoline and methanol vehicles.

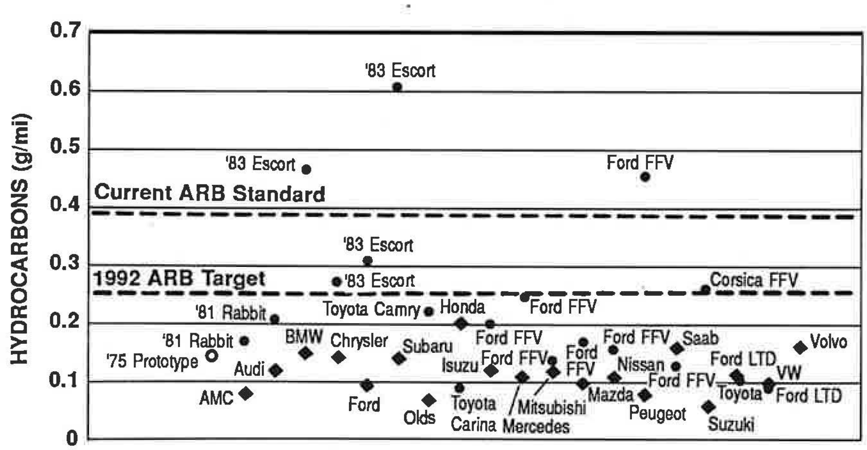

FIGURE 2 Comparison of hydrocarbon emissions from gasoline and methanol vehicles.

• Methanol

◆ Gasoline

NOTE: Methanol vehicle emissions data are best Air Resources Board test results after catalyst stabilization (generally 4,000 miles). Gasoline vehicle emissions are 50,000 mile certification values. Methanol vehicle emissions are based on Organic Material Hydrocarbon Equivalent technique recommended by EPA. Gasoline vehicle emissions are non-methane hydrocarbon.

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Analyzing Advanced Technology

Phase II of the program, also scheduled to begin in 1990, is still in the planning stage. In addition to studying advanced gasoline vehicles and fuels, Phase II will also include tests with other alternative fuels and vehicles, such as advanced methanol flexible fuel vehicles, dual fuel compressed natural gas/gasoline, and dedicated M-85, M-100, and compressed natural gas (CNG) vehicles. M-85 is a mixture of 85 percent methanol and 15 percent gasoline and is the primary form of methanol. M-100 is 100 percent methanol.

CNG is an alternative fuel that has not received much attention. It appears to have considerable potential for fleet operations in major metropolitan areas, an application that could reduce ozone in many areas not yet in compliance with or attaining federal air quality regulations (noncompliance and nonattainment areas). In addition, CNG is believed by the oil industry to offer potential advantages over other alternative fuels and to have a significant market potential.

Natural gas for CNG is supplied domestically. Its use could enhance U.S. energy security and potentially displace a percentage of growing U.S. oil imports. In contrast, under current conditions, processed methanol would be largely supplied by foreign sources. CNG has about 1.5 times the energy of methanol, thus offering better fuel economy. Oil industry representatives claim that methanol would require a system that duplicates most of the existing petroleum manufacturing and delivery system, at considerable cost. But much of the infrastructure for CNG is in place, and use of this fuel could take advantage of the vast delivery system for natural gas.

Methanol poses considerable safety risks: ingesting as little as one ounce can cause blindness; two ounces can be lethal; and it is 20 times as toxic to humans as gasoline. CNG is essentially nontoxic.

Preliminary CNG and Methanol Data

Actual road experience indicates that CNG vehicles provide clean air benefits. Although more research is needed, EPA data show that current-technology CNG vehicles when compared with current-technology M-85 vehicles emit one-third fewer reactive hydrocarbons, have similar NO_x emissions, and have about one-eighth the CO emissions. Emissions estimates for advanced-technology methanol vehicles are based on computer modeling techniques, not actual vehicle test experience. Even so, advanced technology CNG vehicles are estimated to emit the same amount of reactive hydrocarbons as M-100, one-third less nitrous oxide, and two-thirds less CO. CNG engines emit fewer particulates than those burning either methanol or gasoline.

Although considerably more research on methanol is required, a great deal is already known. One independent study group, Sierra Research (*1*), has demonstrated that use of methanol in existing vehicles offers no clear advantage over gasoline in reducing vehicle emissions. Preliminary data from the Office of Technology Assessment (2) indicate that methanol offers the lowest percentage of reductions in the emission of volatile organic compounds (VOCs), but at the greatest cost. Gasoline volatility reductions, already under way at U.S. refineries, offer greater potential for emissions reductions. These preliminary studies appear to demonstrate that use of methanol fuels may be the least cost-effective VOC emission control method.

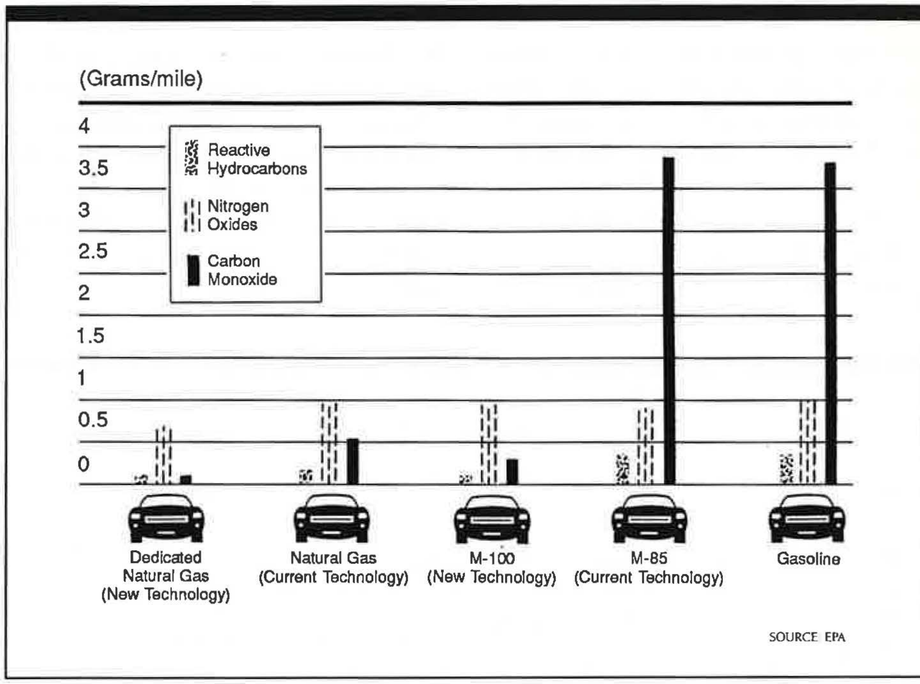

FIGURE 3 Pollutant emissions by vehicle type.

CNG Vehicles Today

Dedicated methanol vehicles are still prototypes. Fewer than 1,000 vehicles use methanol sporadically. CNG, on the other hand, is routinely used in 700,000 vehicles throughout the world. Some 30,000 CNG vehicles currently operate in the United States. Numerous small- or medium-sized fleets also are operating on CNG in Canada, New Zealand, Italy, the Soviet Union, and Australia. Equipment to convert vehicles to CNG and to fuel them is well developed and currently available from several suppliers.

Most CNG vehicles are converted by the owner-operators themselves or by contractors, generally at a cost of about $1,500. Conversion of vehicles is permissible in the United States if the conversion equipment, which does not interfere with existing engine systems, meets CARB standards. It is estimated that a vehicle manufacturer should be able to provide a new CNG vehicle for about $200 over the cost of a similar gasoline vehicle if the CNG vehicles were being produced in sufficient volume.

CNG is typically stored in a tank at 2,400 psi. Vehicle tanks are made of steel or a composite of aluminum and glass-reinforced plastic. The process of refueling a CNG vehicle, although strange to users at first, has become readily accepted by users in industrial settings and by consumers in other countries.

During delivery in pipelines, natural gas is normally pressured at 500 to 1,000 psi. Pressure is dropped to 100 psi or less for distribution and is reduced further before delivery to the customer. It is usually necessary to recompress the gas to 2,400 psi at a CNG facility. A typical CNG fueling facility would consist of a compressor, a small amount of CNG storage, vehicle connectors, and the necessary safety devices and controls. It would cost about $250,000, depending on anticipated use.

Both slow-fill and fast-fill technologies exist. Currently, most CNG fleet vehicles are slow-filled overnight or during idle periods. However, in Canada and Italy, where there is a large private consumer CNG fleet, fast-fill facilities are widely available. Typical refueling takes three to five minutes.

At equivalent prices of $1.00 per gallon for gasoline and $3.00 per million Btu, operating costs with gasoline and CNG are roughly equal if vehicles are converted economically. State taxes on CNG use vary, but the federal tax is equivalent to the excise tax on gasoline.

CNG and Safety

CNG vehicles are sufficiently safe to use in commercial vehicle fleets. Disneyland, in Anaheim, California, has used CNG to power vehicles for more than 21 years. To date, these CNG engines have operated for over 3 million hours (140,000 to 150,000 per year) and traveled nearly 130 million miles without a fuel-related incident. The vehicle fleet includes 59 water craft, for which fuel/vehicle safety is of even greater concern than for land vehicles. Disney plans to convert the rest of its 400-vehicle fleet to CNG at a rate of 5 to 10 percent per year.

CNG vehicle operating characteristics are similar to those of gasoline-powered vehicles. In comparison with gasoline vehicles, CNG vehicles experience approximately a 10 percent power loss because the gas displaces air to the engine. The engine size can be increased or turbocharged to compensate, but this adaptation will tend to increase NO_x emissions. An appropriate balance will have to be struck. Both EPA and CARB define CNG as a clean fuel, and presently both view substitution of CNG for conventional fuels as part of their long-term air quality attainment strategy in many urban areas.

Fleets that could be converted rapidly to CNG include those operated by schools, state agencies, and local transit authorities. Some states have already started this conversion. Texas, for example, will require conversion to some alternate fuel by 30 percent of state and local government fleets by 1994, 50 percent by 1997, and 90 percent by 1998.

Reformulated Gasoline's Potential

The oil industry also claims that reformulated gasolines could help reduce VOC emissions and ozone levels. Gasoline reformulation has the advantage of being usable in the existing fleet. This characteristic is important because older vehicles contribute a disproportionate share of pollutants. Although the use of reformulated gasoline will require substantial new investments in refining equipment, its manufacturers will be able to take advantage of existing capacity.

Although the jury is still out on the ultimate benefits of reformulated gasoline blends in comparison with methanol, it is likely that conversion to alternative fuels will take time. Gasoline probably will remain the dominant motor fuel for passenger cars and light trucks well into the next century. Gasoline quality and composition will continue to evolve, driven by environmental requirements and vehicle performance demands. As an example, the industry is currently in the process of reducing gasoline vapor pressure (volatility).

Cost-Benefit Ratios and the Public

The oil industry historically makes decisions in an intensely competitive environment in concert with ever-increasing governmental and environmental regulation. The U.S. public may not always know the true costs of meeting changing standards. For example, EPA estimates that from 1986 to 1990, lead phasedown cost the refining industry \$500 million per year. Volatility reductions offered to date cost in excess of \$500 million, and further reductions could impose additional costs as high as \$1 billion per year.

The public understands that costs are eventually passed along to consumers. However, in exchange for paying these costs, the public expects to benefit from an improved environment. The oil industry believes that competition in the U.S. market system has proven to be the most effective method for bringing quality products and fair prices to consumers. For this reason, participants in the oil/automobile industry assessment of the cost-effectiveness of alternative fuels relative to potential benefits believe that their study is critical.

Transportation industry officials should be vitally concerned that air quality improvements be gained at realistic costs. Conversely, they may well ask if minute increments of benefits at high expense are really a benefit. Elected representatives and other public officials need to inform the public of the true costs (in the form of subsidies, taxes, and product costs) and relative benefits of the programs that industry is being encouraged to undertake.

Government/Industry Cooperation

In meeting future needs, government and industry must develop policies to improve the country's energy position by optimizing the strengths of both parties. These strengths include a sound and flexible refining industry, as well as extensive natural gas reserves. From an industry standpoint, the future will demand vital responses to air and health concerns, as well as the ingenuity and innovation that are the dynamic sphere of enterprise. Industry will have to find solutions to problems and, in turn, help governments identify the most viable alternatives.

On the basis of government/industry research results, it appears that some combination of fuels is likely in the future. The safest, most environmentally beneficial, and cost-effective fuel may vary for different parts of the country. Industry representatives believe that in the near term, reformulated gasolines and CNG, along with methanol, can contribute to cleaner air if they are allowed to compete on a level political playing field. In the distant future, electric-, solar-, and even hydrogen-powered vehicles may be viable.

Currently, 14 U.S. oil companies, along with 3 major U.S. automobile manufacturers, have joined in an unprecedented research effort. Although individual companies may differ on the specific approaches or preferred fuels to achieve desired results, they share in the commitment to developing a sound scientific basis on which to make future decisions.

References

1. *Potential Emissions and Air Quality Effects of Alternative Fuels.* Sierra Research, Inc., Sacramento, Calif., March 1989.
2. *Catching Our Breath: Next Steps for Reducing Ozone.* Office of Technology Assessment, U.S. Congress, Washington, D.C., Feb. 1989.

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