Gasoline: The Unclean Fuel?

The President's plan for cutting air pollution calls for a revolution in the auto fuel business; the oil refiners see it as naive and loaded with "wishful thinking"

PRESIDENT BUSH may be no revolutionary, but his agenda for improving air quality certainly has a radical plank. It labels gasoline an obsolete fuel and seeks to replace it in smoggy cities with something entirely new.

The idea is simple: in the nine cities where smog (ozone) is worst, the President has said, that officials should clean up auto exhaust by cleaning up the fuel that goes into auto engines. The plan would do this by creating a special market for clean fuels and helping the best competitor win.

The initial response of the oil refiners was that the scheme was naive, dangerous, and hugely wasteful because it would require a duplicate fuel distribution system. Now they are saying it deserves study—very long and careful study—while they lobby to weaken its goals. But even skeptics in the industry believe it will trigger significant new research into clean fuel chemistry.

Defenders of the President's plan are confident that it will work. They say the plan is technically sound and should be relatively inexpensive to carry out compared to other methods of reducing air pollutants. Based on their knowledge of chemistry, they say it could sharply cut back on the release of volatile hydrocarbons, which combine with nitrogen oxides to make ozone. The Administration claims that if 9 million "clean fuel" cars are sold in nine cities by 2004, as its plan would require, the contribution to ozone from motor vehicles in those cities would drop from the present level of 40% to 10%. It is important to begin moving, they say, to make a dent in air pollution before it gets worse. Already more than 80 districts violate the federal health standard for ozone (*Science*, 5 May, p. 517).

Congress is rewriting the Clean Air Act now and has just moved into this battlefield of auto fuels. So far it has stuck to the traditional approach, proposing tough new emission controls for cars in 1994 and later.

These strict controls may help, but they won't reduce ozone levels as much as is needed, says Charles L. Gray, Jr., a chemical engineer at the Environmental Protection Agency (EPA). Gray was one architect of the President's clean fuels plan. We are reaching the limits of what can be done by trapping and recirculating pollutants in the engine, Gray says. As the sheer number of cars on the road increases, he believes, it will be necessary to create—not just encourage—a change in fuel chemistry. (Last year Congress passed a law that encourages companies to experiment with new approaches by exempting new clean fuel cars from EPA's auto efficiency standards.) Gray would follow the example of California, which has already begun to replace volatile, high-carbon gasoline with nonvolatile fuels.

The leading candidate—because of its low retail price and the low cost of adapting cars to its use—is methanol, or wood alcohol, a clear, odorless liquid, produced mainly from natural gas and sold as a chemical feedstock. Although it has about half the energy content of gasoline per gallon and is more corrosive, methanol has many compensating virtues. It has a low vapor pressure of 4.7 pounds per square inch (psi), half that of gasoline, indicating that it evaporates at a much slower rate. (EPA now limits gasoline to 10.5 psi.) In addition, because methanol contains oxygen (gasoline doesn't) and less carbon, it burns more completely and creates no soot. Methanol is also less reactive, mixing in sunlight with nitrogen oxides to make ozone more slowly. These qualities make it a superior transportation fuel, Gray argues.

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Methanol muscle. *The President's counsel, C. Boyden Gray, poses in his ecologically pure hot rod, powered by methanol.*

As chief of EPA's Motor Vehicle Emissions Laboratory in Ann Arbor, Michigan, and a former employee of Gulf and Exxon, Gray claims to know what will succeed in the real world and what will not. "Just tightening the tailpipe standards doesn't give you significant additional emission reductions," he says, "because our problem today is not the design capability" of control systems. Rather, it is to keep the systems working as they age. Cars rely on several hundred components to sense, trap, recirculate, heat, filter, or burn off pollutants. If any fail, he says, pollutants leak out.

Based on data from several thousand private cars, EPA finds that most "real world" vehicles, even with excellent pollution control devices, are quite leaky. For example, the agency calculates that with a less volatile gasoline (9 psi), tailpipe hydrocarbon emissions are in reality about 0.7 gram per mile for a car certified to meet a standard of 0.41 gram per mile, or almost twice the theoretical limit. In addition, cars leak unburned fuel from tanks and fuel lines, releasing more hydrocarbons (about 1 gram per mile). The premise of the clean fuels idea is that it is easier to clean the vapors that come out of leaky cars than to stop all the leaks.

The President's Domestic Policy Council bought this idea last spring. However, the oil industry objected that it would be too expensive and the benefits would be slight. Henson Moore, the deputy secretary of energy who represented the Department of Energy (DOE) in White House negotiations, brought similar criticisms to a Cabinet meeting in late May, according to officials who were involved. The President asked his chief economic adviser, Michael Boskin, to serve as referee. Boskin spent a day probing the numbers, asking EPA to respond to each of the criticisms made by DOE and the oil industry. He reviewed several price studies

and concluded that the position taken by the industry and DOE—that the nearest clean fuel that could compete with gasoline would cost twice as much—was out of line. According to EPA's data, methanol could be manufactured and sold as an auto fuel for about the same price as gasoline if there were a market for it, even taking into account its lower energy content. Boskin found EPA's numbers sound. After this vetting, the President put the scheme in his clean air plan, which he unveiled on 12 June.

Oil refiners responded at first by issuing negative studies on methanol, but recently they have begun to develop a more positive message. Ronald Jones, refining director at the American Petroleum Institute in Washington, D.C., and head of the industry's Alternative Fuels Task Force, confirms that "nine or ten chief executive officers" of major U.S. oil and auto companies have been assembling a major research and development program aimed at producing a clean, low volatility gasoline. They also want to investigate less polluting engine designs. No details have been released.

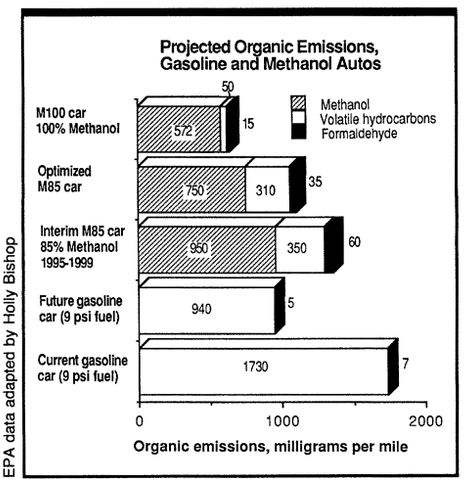
The industry, Jones says, hopes to bring common sense to a scheme that is now loaded with "wishful thinking." "We support the President's goals" for clean air, he adds, "but we think he was given some bad advice on how to achieve them."

Jones ticks off the major faults in the EPA plan, which he calls the "methanol mandate." It was written by a few "methanol enthusiasts," he says, who are wildly optimistic about the price and availability of natural gas as a feedstock for methanol production. Most importantly, Jones says, the advocates exaggerate the good and downplay the bad qualities of methanol.

Jones is correct in saying that the godfather of EPA's clean fuels plan is a methanol advocate: he is none other than Charles Gray. He and his deputy at the Ann Arbor lab, Jeffrey Alson, coauthored a book in 1985 entitled *Moving America to Methanol*, in which they promoted methanol as the answer to acid rain pollutants. Now they offer it as the answer to ozone. As one analyst at the Office of Technology Assessment quips: "Charles knows what the solution is; he's just taken a while to attach it to the right problem."

Other methanol fans who worked on the President's clean air bill are William Rosenberg, an Ann Arbor businessman appointed by President Bush to head EPA's clean air office in Washington, and C. Boyden Gray, the President's counsel. Boyden Gray even drives a methanol car to work.

Enthusiasm is no vice, but the critics argue that it has skewed the government's



message. For example, oil company adviser Thomas Austin of Sierra Research in Sacramento, California, objects to labeling methanol "clean" in the first place. It's wrong, he says. On an equivalent volume basis, it is more toxic to humans than gasoline. Drinking it or breathing its fumes can cause blindness. Because methanol is an alcohol, unlike oil-derived gasoline, it penetrates the skin and is metabolized quickly. Methanol is soluble in water, and tank spills could penetrate deeply into the water table, the oil industry says, whereas oil-based fuels tend to float. A study performed for the oil industry by toxicologists at Georgetown University concluded that if methanol replaced gasoline, it would cause 195 additional fatal poisonings each year.

However, according to EPA's Gray, the acute toxicity risks are slight compared to methanol's clean air benefits. The chief gain could come from reducing the amount of unburned fuel that escapes and forms ozone. According to the President's plan, methanol use would be phased in slowly, beginning with a fuel called M85, a mix of 85% methanol and 15% gasoline. Cars running on this mix would actually leak more organic vapors per mile than new ones using gasoline (1.3 grams per mile as opposed to 0.94). But, according to EPA, most of the leakage from M85 cars (0.95 gram per mile) would be in the form of methanol, which makes ozone at less than half the rate of gasoline. Taking everything into account, EPA predicts that the M85 cars would emit 30% less ozone-forming vapor, perhaps 50% less.

The plan also calls for a shift to pure methanol, or M100 cars, after 5 years. EPA predicts that these cars would emit about two-thirds as much organic vapors as gasoline cars and nearly all would be in the form of methanol. The result would be an 80% drop in ozone-forming compounds. It is this 80% figure that is advertised as the long-term goal of the clean fuels program.

Oil industry spokesmen see several problems in the scenario. One is that it relies heavily on computer modeling and very little on hard data. EPA concedes that "there is a very small database with dedicated M100 vehicles" and that most of that information comes from EPA, not a disinterested party. Jones of the American Petroleum Institute says that as far as he can tell, the data all come from one EPA test car. It is a rare animal: no company has plans to manufacture M100 cars right now. One drawback of using pure methanol in M100 cars is that they don't start well in cold weather. This is another nuisance that can be remedied but hasn't been as of now.

There is also the problem of formaldehyde, which Tom Austin calls the "Achilles' heel" of methanol. Formaldehyde is a carcinogen formed by the incomplete combustion of alcohol. According to EPA, future gasoline cars will emit a small amount of formaldehyde (0.005 gram per mile); M85 cars will emit much more (0.6 gram per mile); and M100 cars, EPA predicts, will emit a modest amount (0.015 gram per mile). In addition to being a carcinogen and a powerful irritant for hypersensitive people, formaldehyde forms ozone at a rapid rate—five times faster than gasoline.

Gray says that with special new standards for formaldehyde, emissions from M85 and M100 cars will be brought down to "about the same or less" than those from gasoline cars, if necessary, for a cost of $50 per vehicle. The auto companies are not yet certain that they can meet a very low formaldehyde standard. Roberta Nichols, principal research engineer in the fuel systems department at the Ford Motor Company, says it will be "tough" to develop catalytic converters that will keep formaldehyde to 0.015 gram per mile, as both EPA and the state of California will require in the 1990s. But she says, "We are accepting it," and the company expects to be able to certify devices that will be warranted for at least 50,000 miles.

EPA points out that the net effect of switching to methanol should be positive. Gasoline fumes contribute indirectly to formaldehyde formation in the atmosphere, and these would be reduced. In addition, toxic compounds from gasoline (benzene and butadiene) should diminish.

Whether all these efforts will lead to a major reduction in city ozone levels remains unclear. Computer models have been used to estimate what is likely to happen 15 or 20 years hence, and the results span a wide spectrum. Bruce Beyaert, a chemical engineer and planner at Chevron USA, says, "The earliest studies made very unrealistic assumptions" and came out with predictions that methanol cars could bring about a

major reduction (around 20%) in peak ozone levels. Recent studies have been more conservative, he says, and, as a result, the predicted benefits "have been coming down." He thinks they may come down further.

The most often quoted findings today are those of Armistead Russell at the Carnegie Mellon University, showing that a switch to M85 cars in Los Angeles beginning in 1990 could reduce peak ozone levels in a 3-day smog attack in year 2000 by 8%. A switch to M100 cars could reduce the peak levels 16%. Benefits like these are significant and worth pursuing, if they remain credible, says Robert Hahn, a former White House economist who worked on the President's plan.

Faced with pressure from the White House, Congress, and, importantly, from the state of California (which has already agreed to buy several thousand M85 cars), the petroleum industry may decide that it is best not to fight but to join the clean fuels brigade. This strategy has worked well for the ARCO petroleum company of Los Angeles, which introduced a reformulated "gasoline" last summer called EC-1. Although ARCO won favorable publicity for its eco-consciousness, executives at other companies point out that it was acting under a state mandate to clean up a leaded regular gasoline it was selling to owners of old cars. EC-1 was designed for a limited market, and the chemical engineering involved does not have broad application, competitors say.

Nevertheless, leaders in the petroleum industry are talking about making reformulated gasolines to compete with methanol. No specifics have been revealed as yet, and many observers are skeptical that refiners can change traditional gasoline without running up the cost.

In all likelihood, the clean gasoline campaign will not yield a product any time soon but will give birth instead to a major research program. Says Eugene Spitler, general manager of product engineering at Chevron USA, "We have only rather preliminary data indicating what might be done." It might be possible to lower the aromatic content, if aromatics are what contribute most to ozone formation. But it isn't clear that they are at fault. Perhaps fuel injection systems can be improved, he says. There is the possibility of reducing the butane to lower volatility, but that would lead to octane loss that would not be easy to remedy. Spitler concludes: "Our position is that all of this ought to be looked at. There needs to be more research."

This is a message Congress will hear more than once in the next few weeks as it weighs the pros and cons of methanol as an auto fuel. ■ ELIOT MARSHALL

A Catbird's Seat on Amazon Destruction

Brazil's space agency is playing an expanded role in monitoring the nation's environment; four new satellites planned

São Jose dos Campos, Brazil

"THE EFFECTS ARE MUCH WORSE than those from saturation bombing. You end up with massive smoke clouds spread over millions of square kilometers. In some places, visibility is so bad you have to wait days for things to clear up if you want to travel by plane or car. There are literally thousands of fires, and I'm just talking about the larger ones, at least 50 meters across."

The speaker is not an impassioned environmentalist visiting from the United States, but a cool and respected Brazilian space scientist, Alberto Setzer, head of Amazon studies for the National Space Research Institute (INPE). Though all too many Brazilians still seem cavalierly indifferent to the destruction of the rain forest—indeed actually favor it—a growing number of Brazil's scientists are becoming increasingly concerned by it. Nowhere is the sense of alarm more pronounced than at INPE, popularly known as the Brazilian NASA.

In fact, INPE's scientists are doing more than expressing alarm. The institute has recently been given expanded powers to monitor the destruction and assist in efforts to curb illegal burning. And its technical capabilities to keep track of Brazil's environment will soon be dramatically expanded with the launch in the 1990s of four remote sensing satellites of its very own.

Based in a suburb of São Paulo, INPE is headquartered in a palm-fringed compound of starkly modern low-slung buildings that wouldn't look out of place at the Kennedy or Johnson space center. Since 1973 INPE has been receiving images from the American space agency's Landsat satellites, whose infrared sensors can provide fresh views of Brazil's vast land area—as big as the continental United States—every 16 days.

The satellites also offer a unique catbird's

Frederic Gokden

Amazonian mosaic. *Remote sensing head Robert Pereira da Cunha figured that 5% of the Amazon region has been deforested. The World Bank had touched off a bitter dispute with an estimate that 12% of the rain forest had been lost by fire and flooding since 1978.*