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JUNE 11, 1982

The Honorable Ron Wyden
Subcommittee on Health and the Environment
Committee on Energy and Commerce
House of Representatives

118921

Dear Mr. Wyden:

Subject: Assessing the Feasibility of Converting Commercial Vehicle Fleets to Use Methanol as an Offset in Urban Areas (PAD-82-39)

In your letter of February 3, 1982, you asked us to explore the feasibility and attractiveness of converting commercial gasoline-powered vehicles to methanol as a potential offset in urban areas for hydrocarbons, carbon monoxide, and nitrogen oxides. In order to meet Clean Air Act requirements, a company expanding its plant, or opening a new plant, may have to offset the associated increase in pollution by arranging for the reduction of pollution from another source. If methanol is a cleaner fuel than gasoline, the expanding company might find that paying other companies to convert their motor vehicles to use methanol--or adopting a methanol strategy itself--is an attractive way to offset its pollution. For a methanol offset strategy to be economically feasible, and therefore attractive, methanol must be both a less polluting fuel than gasoline and a more cost effective pollution abatement method than alternative methods.

Therefore, to explore the merits of a methanol offset strategy, we addressed three questions:

- Is an automobile burning methanol less polluting than one burning gasoline?
- How much does it cost to convert and operate an automobile using methanol relative to the pollution abatement achieved?
- How does the cost of methanol conversion compare with more conventional means of reducing air pollution?

In sum, methanol-powered vehicles emit less nitrogen oxides than gasoline-powered vehicles; however, for other regulated

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pollutants, the evidence is inconclusive. Depending on assumptions about current gasoline and methanol pump prices, as well as varying estimates of the amount of nitrogen oxide pollution reduction achieved using methanol, the costs of a methanol offset strategy involving the conversion of on-the-road automobiles could range from $20 per pound of nitrogen oxides abated to $760. Of course, in the future, it is possible that a number of events could occur which could drastically lower these costs. A large increase in the price of gasoline as compared to methanol would make a methanol offset strategy more attractive. Similarly, if one or more of the major automobile manufacturers were to mass-produce methanol-powered vehicles on the assembly line, this offset strategy could become more attractive. Nevertheless, a methanol offset strategy does not currently appear to be economically attractive. Its costs compare unfavorably with current costs ranging from $0.20 per pound to $8.50 per pound using more conventional methods of nitrogen oxide abatement.

We wish to stress that our assessment of the feasibility of methanol-fueled vehicles as an offset strategy is separate from the larger question of whether alcohol fuels make sense as a source of energy. For instance, the Bank of America embarked on its methanol fleet program not to obtain offsets but instead to counteract any future vulnerability to gasoline shortages. In the future, the Bank of America and the California Energy Commission will complete exhaustive testing of methanol vehicles. At that time, more information on the emissions characteristics and costs of methanol vehicles equipped with state-of-the-art pollution controls should be available.

The enclosure contains a detailed analysis of the use of methanol vehicles as an offset strategy compared to retrofitting stationary sources. The information which we gathered for this analysis came from sources available to the public.

At the request of your office, we did not obtain agency comments on this report. As arranged with your office, unless you publicly announce the contents earlier, no further distribution of this report will be made until 30 days after the report date. At that time, we will make copies available to others upon request. If we can be of further assistance, do not hesitate to contact us.

Sincerely,

Morton A. Myers

Morton A. Myers
Director

Enclosure

COST EFFECTIVENESS OF CONVERTING MOTOR VEHICLES TO USE METHANOL AS AN OFFSET STRATEGY

ASSESSING THE EMISSION REDUCTION POTENTIAL AND COSTS OF CONVERTING MOTOR VEHICLES TO METHANOL

Emission reduction potential

The evidence on pollution from methanol-fueled vehicles indicates that for nitrogen oxides (NOx) these vehicles are less polluting than their gasoline counterparts. For other regulated pollutants, the evidence is inconclusive. Table 1 summarizes the information which we have obtained on NOx emissions. The percentage of emission reduction using methanol-fueled vehicles relative to gasoline-fueled vehicles has been reported to range from 6 percent to 69 percent. Using methanol with oxidation catalysts on older automobiles appears to give greater NOx reductions than with three-way catalytic converters on newer vehicles.

The evidence on unburned hydrocarbons and carbon monoxide is mixed. For hydrocarbons, some studies indicate lower emissions from methanol-fueled vehicles equipped with pollution controls. 1/ On the other hand, the California Air Resources Board has stated that the most reliable studies suggest about the same level of hydrocarbons from either type of vehicle. However, it does appear that methanol-fueled vehicles emit "less photochemically reactive hydrocarbon emissions which suggests a beneficial impact upon urban atmospheres...." 2/ For carbon monoxide, a number of sources have stated that emissions should be about the same for either methanol or gasoline with pollution controls. However, it is possible to operate a methanol-fueled vehicle at leaner air-fuels ratios, which could lead to lower carbon monoxide emissions.

1/"A Brief Summary of the Technical Feasibility, Emissions and Fuel Economy of Pure Methanol Engines," J. Alson (Ann Arbor, Michigan: U.S. Environmental Protection Agency), December 1981; "End Use of Fluids from Biomass as Energy Resources in Both Transportation and Non-Transportation Sectors," H. Adelman et al. (Santa Clara, California: University of Santa Clara), January 1979; letter to GAO from California Air Resources Board, April 1982.

2/"Driving Cycle Economy, Emissions and Photochemical Reactivity Using Alcohol Fuels and Gasoline," R. Bechtold, J. Pullman (Warrendale, Pennsylvania: Society of Automotive Engineers, Inc.), February 1980, p. 18.

Table 1

Average NOx Emissions From Vehicles Converted to Use Methanol

Information Source	Vehicle Type	Pollution Control Device	NOx Reduction Relative to Gasoline	% Reduction Relative to Gasoline
California Air Resources Board (CARB) 10/81	1980 Ford Pinto—low compression	3-way catalytic converter (TWC)	0.04 grams/ mile a/	6%
CARB	1980 Ford Pinto—high compression	TWC	0.18 grams/ mile a/ b/	25%
CARB	1981 Ford Escort	TWC	0.29 grams/mile a/	41%
CARB	1981 VW Rabbit	TWC	0.1 grams/mile a/	33%
California Energy Commission (CEC) 12/81	1981 Ford Escort	TWC	0.27 grams/mile	45%
CEC	1980 Ford Pinto	TWC	0.05 grams/mile	6%
Bechtold, Pullman	1978 Ford Pinto	TWC	0.057 grams/mile	8%
Baisley, Edwards	1978 Ford Pinto	TWC	0.30 grams/mile	31%
Bechtold, Pullman	1976 Dodge	Oxidation catalyst	0.88 grams/mile	69%
CARB 4/82	1977-79 light duty vehicle	Oxidation catalyst		50%
CARB		TWC	"insignificant"	
EPA survey of literature				50%—general consensus 30%-65%—individual studies

a/Reductions in NOx based on comparison with factory-certified levels.

b/The low and high compression methanol vehicles are compared to low-compression gasoline vehicles.

Converting vehicles to use methanol is possible

In California, the Bank of America and the California Energy Commission have been experimenting with using methanol in modified motor vehicles. Table 2 lists conversion cost estimates for those vehicles by source of information. Future Fuels of America, Inc., listed in table 2, has done many of the conversions for the Bank of America. The California Air Resources Board notes that their low figure ($1,000) would pay for a "revised carburetor (or fuel injection modifications), electric grid addition below the carburetor for improved cold operation, and material modifications to the fuel tank and related system." 1/ Their high figure ($2,000) "reflects piston modifications to produce higher compression ratios for improved fuel economy."

Another cost component in the decision to convert vehicles is the price of fuel. Pump prices for methanol, quoted by a number of company and government officials, range from $1.00 per gallon to $1.40 per gallon. Those prices include the cost of isopenthane, which is added to the fuel to prevent cold start-up problems. More recently, spot prices for methanol on the Gulf of Mexico have been quoted as low as $0.51 per gallon. With distribution costs, this could mean methanol prices of about $0.70 per gallon. With isopenthane, the pump price could be as low as $0.90 per gallon. A California Energy Commission official reports quoted prices of $0.60 to $0.75 per gallon of methanol, delivered in bulk to Sacramento. By comparison, unleaded gasoline has been reported recently as low as $1.10 per gallon at the pump in California. 2/

Methanol provides less energy than gasoline. Most of our information suggests that two gallons of methanol must be used for each gallon of gasoline. However, a methanol-fueled engine may be more efficient than one powered by gasoline. Based on this possibility, the conversion ratio could be somewhat lower, at 1.7:1. Table 3 presents net cost estimates of retrofitting a motor vehicle and operating it with methanol. These estimates represent the added costs of converting and operating a vehicle using methanol as opposed to using gasoline.

Our results indicate that converting and operating a methanol-fueled vehicle could cost as little as $1,288 and as much as $6,657 more than a conventional gasoline-fueled vehicle, depending on prices of gasoline and methanol, the discount rate applied to the life cycle cost estimate, and whether a conversion ratio of 2:1 or 1.7:1 is assumed. 3/ These cost estimates assume a 5-year, 100,000-mile life to the automobile and a $1,500 conversion cost.

1/Letter to GAO from CARB, April 9, 1982.

2/All of these prices were quoted during the past 6 months.

3/The range of gasoline prices chosen represents recent fluctuations in price.

Table 2

Conversion Cost Estimates for Vehicles Modified to Burn Straight Methanol

Source of Information	Vehicle Type	Cost Per Vehicle (1981 dollars)
Bank of America	Light-duty Ford	$2,000 a/
Future Fuels of America	Light-duty Ford	$830-$1,500 b/
California Energy Commission (CEC)	1980 Ford Pinto	$1,500-$2,000 c/
CEC	1981 Ford Escort	$1,900-$2,000
CEC	1981 VW Rabbit	$4,000-$5,000
California Air Resources Board	1981 Ford Escort	$1,000-$2,000

a/Bank of America news release, June 2, 1981.
b/Future Fuels of America conference presentation, 1982.
c/The California Energy Commission incurred $8,900 per vehicle in retrofitting its first fleet, but believes that future conversion costs will be $1,500 to $2,000 per vehicle.

Table 3

Net Life Cycle Cost of a Methanol-Fueled Vehicle a/

	Total Cost (Discounted @ 10%)		Total Cost (Discounted @ 20%)	
	2:1	1.7:1	2:1	1.7:1
Methanol @ $0.90/gal. & gasoline @ $1.10/gal.	$3,623	$2,806	$3,175	$2,529
Methanol @ $0.90/gal. & gasoline @ $1.60/gal.	2,106	1,288	1,978	1,332
Methanol @ $1.40/gal. & gasoline @ $1.10/gal.	6,657	5,381	5,569	4,562
Methanol @ $1.40/gal. & gasoline @ $1.60/gal.	5,140	3,865	4,372	3,366

a/Assume a 2:1 or a 1.7:1 conversion ratio; 20,000 miles/year; 5-year life; 25 mpg on gasoline; $1,500 conversion cost per vehicle. We do not consider repair and maintenance expense, asset recovery, or tax effects.

In the future, it is possible that a large increase in the price of gasoline as compared to methanol would reduce the costs of operating a methanol-fueled vehicle. In addition, if one or more of the major automobile manufacturers were to mass-produce methanol-powered vehicles on the assembly line, the costs of conversion could be much lower. The cost estimates in table 3 should be weighed in light of these considerations.

Finally, the expense to a company or individual wishing to convert their on-the-road vehicle to methanol in the State of California is less than depicted in table 3. California offers a special tax credit equal to 55 percent of conversion costs, up to $1,000 per vehicle. Thus, our assumed conversion cost of $1,500 would be only $675 to the person incurring the conversion costs, in California. Focusing on the lowest and highest costs listed in table 3, California's tax credit would mean a low expense of $463 and a high value of $5,832.

Cost effectiveness of methanol-fueled vehicles

To determine cost effectiveness ratios for methanol-fueled vehicles, we chose NOx emission reduction values ranging from 0.04 grams per mile to 0.30 grams per mile, which have been reported using three-way catalytic converters. Assuming 100,000 miles driven in 5 years, the NOx reduction as compared to gasoline operation ranges from 8.8 pounds to 66.1 pounds. 1/ Table 4

Table 4

Cost-Effectiveness Ratios (Dollars per Pound of NOx Reduced) for Methanol-Fueled Vehicles a/

	Discounted @ 10%		Discounted @ 20%	
	2:1	1.7:1	2:1	1.7:1
Methanol @ $.90/gal. and gasoline @ $1.60/gal.	$31.90 to $239.30	$19.50 to $146.40	$29.90 to $224.80	$20.20 to $151.40
Methanol @ $1.40/gal. and gasoline @ $1.10/gal.	$100.70 to $756.50	$81.40 to $611.50	$84.30 to $632.80	$69.00 to $518.40

a/Ranges for each fuel cost comparison are dependent only on the estimated range of NOx reductions achievable.

1/The highest reduction in table 1 is 0.88 grams/mile, using an oxidation catalyst on a 1976 Dodge. We assumed that the option of converting older automobiles would be less attractive, given the remaining useful life of such vehicles.

displays the range of possible cost-effectiveness ratios, when the above reductions in NOx are matched against high and low incremental cost values in table 3.

Using somewhat different assumptions, the California Air Resources Board has estimated a cost-effectiveness ratio of $21 per pound of NOx reduced, in the most "cost-beneficial case." 1/

Accounting for California's special tax credit, the lowest value in table 4 becomes $7.00 per pound of NOx reduced and the highest value, $663 per pound, for the individual incurring the conversion cost.

CONTROLLING NOx FROM STATIONARY SOURCES IS AN ALTERNATIVE OFFSET STRATEGY

Data on the costs of controlling NOx from stationary sources suggest that retrofitting motor vehicles to use methanol is but one possible offset strategy. In a previous study of market incentive approaches to air pollution control, we obtained information on the potential costs of stationary NOx offsets in the Los Angeles area. 2/ Table 5 summarizes the range of costs and sources of these offsets.

Table 5

Estimated Costs of NOx Offsets in the Los Angeles Area

Source	Capital and Operating Costs a/ Using 10% Discount Rate		Using 20% Discount Rate	Cost/lb. of Reduction
Catalytic mufflers on internal combustion engines	$ 692,458	to	$ 672,941	$0.27
	1,683,643	to	1,465,035	0.50 to 0.44
	181,190	to	149,488	0.49 to 0.40
	266,725	to	221,084	0.33 to 0.32
	3,392,255	to	2,826,563	0.24 to 0.20

a/Equipment assumed to have a 5-year life, at 1980 prices. In December 1981 prices, these costs would be about 10 percent higher; for example, the low value of $0.20 would be about $0.22, and the high value of $0.50 would be about $0.55.

1/Letter to GAO, April 9, 1982; using an oxidation catalyst on a 1977-79 vehicle and assuming a 10-year, 150,000-mile life.

2/"A Market Approach to Air Pollution Control Could Reduce Compliance Costs Without Jeopardizing Clean Air Goals," U.S. General Accounting Office, PAD-82-15, March 23, 1982.

In addition, the National Commission on Air Quality has provided cost estimates of NOx control strategies which may be suitable for gauging the costs of offsets in the Los Angeles area. 1/ Table 6 indicates the source and estimated costs of such control strategies.

Table 6

Acurex Cost Estimates of Potential NOx Controls in the Los Angeles Area

Source	Cost Per Pound of Reduction a/
Combustion modification retrofit applications on industrial boilers (includes low excess air, staged combustion, flue gas recirculation, low NOx burners).	$0.25 to $5.00
Combustion modification (as described above) on refinery heaters.	$0.20 to $2.00
Selective catalytic reduction on refinery heaters	$4.00 to $8.50
Selective catalytic reduction on utility boiler retrofits	$4.00 to $5.00

a/At 1979 prices. At 1981 prices, these costs would be about 22 percent higher; for example, the low value of $0.20 would be about $0.24, and the high value of $8.50 would be about $10.37.

Another piece of evidence on retrofitting stationary sources for NOx control is an EPA report on economic incentives to reduce emissions of that pollutant. 2/ In that report, EPA estimated different emission charges necessary to meet a short-term NOx standard in Chicago. 3/ Based on these charges, the incremental

1/"Los Angeles Regional Study--SIP Process Review, Volume II: Assessment of Non-Attainment Plan Emission Control Measures," National Commission on Air Quality (Mountain View, California: Acurex Corp.), February 1980.

2/"An Analysis of Economic Incentives to Control Emissions of Nitrogen Oxides from Stationary Sources," U.S. Environmental Protection Agency, January 1981.

3/An emission charge is basically a tax assessed on each unit of pollution; higher taxes per unit of pollution are expected to produce lower emissions.

costs of curtailing NOx emissions were $1.75 per lb. of NOx reduced for industrial oil-fired boilers, $1.80 per lb. of NOx reduced for industrial coal-fired boilers, and $.40 per lb. of NOx reduced for industrial process units. 1/

The last piece of evidence which we have are estimates of the California Air Resources Board and of industry of the costs of retrofitting seven California refineries for NOx control. 2/ For these refineries, the California Air Resources Board estimated (using 1981 prices in all cases) a weighted average of $0.90 per pound of NOx reduced, using low NOx burners. The Board estimated a weighted average of $4.90 per pound, using selective catalytic reduction on steam boilers and process heaters. The weighted average cost estimate for all controls was $3.80 per pound of NOx reduced. By contrast, industry estimates ranged from about $2.04 per pound for low NOx burners to about $8.29 per pound for selective catalytic reduction, on a weighted average basis. Industry's weighted average cost estimate for all controls was about $6.42 per pound of NOx reduced.

CONCLUSIONS

Our results indicate that, at the present time, converting commercial fleets to use methanol does not appear to be a cost-effective strategy for obtaining offsets. Cost effectiveness estimates for such a strategy range from about $20/lb. of NOx reduction to about $760/lb. of NOx reduction, based on a number of assumptions. Though California's special tax credit for methanol conversions could reduce the expense of that strategy to $7/lb. of NOx reduced in that State, those special circumstances should not be used for purposes of reaching general conclusions about the relative feasibility and attractiveness of a methanol offset strategy. Obtaining offsets by retrofitting stationary sources could vary from about $0.20/lb. to $8.50/lb. of NOx reduction, according to our information.

1/Assumes 24-hour operation of the source, 365 days per year; 1979 prices. In 1981 prices, these costs would be about 22 percent higher.

2/These data came from a source available to the public; "Continuation of Public Hearing to Consider a Suggested Control Measure for the Control of Emissions of Oxides of Nitrogen from Boilers and Process Heaters in Refineries," State of California Air Resources Board, March 31, 1982.