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THE CLEAN FUELS REPORT

J. E. SINOR CONSULTANTS INC.

Comprehensive Coverage of Business, Government and Technology Issues for Transportation Fuels

VOLUME 7, No. 1 FEBRUARY 1995

Compressed Natural Gas
Liquefied Natural Gas
Propane (LPG)
Methanol
Ethanol and Biofuels
Hydrogen
Electric Vehicles
Reformulated Gasoline

Editorial Statement

THE CLEAN FUELS REPORT was founded with the proposition that improvements to the conventional transportation fuels--gasoline and diesel fuel--are necessary to solve urban air pollution problems. We are dedicated to improving communications in the complex and expanding field of new cleaner fuels. **THE CLEAN FUELS REPORT** takes no position of advocacy for any specific fuel or technology. We believe that each fuel candidate should be subjected to thorough technical, economic and environmental comparison with all other candidates.

We welcome your comments concerning **THE CLEAN FUELS REPORT.**

J.E. Sinor Consultants Inc. has provided energy consulting services since 1985. We provide technical, economic feasibility and marketing analyses for industry and governments. For information regarding subscriptions to **THE CLEAN FUELS REPORT**, or for the consulting services that we offer, please contact:

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THE ENVIRONMENTAL BACKLASH--HOW FAR WILL IT GO?

The last few months have seen the development of a highly visible public backlash against environmental laws and regulations in the United States. This movement was accentuated by the landslide November election victories by the Republican Party, of which many members espouse a philosophy of less government regulation.

In the area of clean air rules, the end of 1994 and beginning of 1995 was the time when many citizens first began to realize that complying with these rules would actually cost them some money out of their own pockets rather than being an "invisible" tax on "big corporations."

New enhanced Inspection/Maintenance (I/M) rules and procedures required in many states were the first to arouse public ire. Rather than going to their local service station to obtain a yearly exhaust emissions certification, people are now being required to go to one of a few, large, centralized I/M stations, that may not be conveniently located, and that may require queuing in lines. Furthermore, the tests are more expensive than before, and if the vehicle fails, the citizen will be required to take it for repairs to a different location and spend up to $400 for repairs, then go back to the central I/M inspection station for another test. Although these rules and procedures have been under development for years, the average consumer was shocked at the result. A public outcry resulted in several state legislative assemblies taking action to delay the new program or modify it in any way that they could.

Similarly, the reformulated gasoline program has been debated for years, but as long as people thought it meant that oil companies would have to spend money to improve gasoline, they were all in favor. Several states volunteered to require the use of RFG in areas not legally mandated to do so under the Clean Air Act. But when it dawned on the average citizen that this meant he would be paying a few pennies more for each gallon of gasoline, the hue and cry was again raised. Several states hastily reconsidered their decision to "opt-in" to the federal RFG program.

After the November elections, some Republican members of the now Republican-dominated United States Congress suggested imposing a moratorium on issuing any new federal regulations. A number of scheduled actions under the Clean Air Act Amendments of 1990 and the Energy Policy Act of 1992 could be affected by the new attitude in Congress. Many other areas of environmental regulation, such as the Endangered Species Act, and attempts to reduce greenhouse gas emissions, are also under renewed attack. However, clean air rules seem to be drawing the most fire.

According to an article in the Wall Street Journal, "Motorists balk at everything from having to use gasoline nozzles that catch excess fuel vapors to buying a new blend of gasoline that trims tailpipe emissions. They refuse to subject their cars to a new type of exhaust test, even though the testing centers have already been built. And they don't want electric cars, either.

They just keep shouting, 'No, No, No,' no matter what's suggested.

In Maryland, angry motorists recently marched on the statehouse, demanding a halt to that state's new emissions-testing program. Drivers in the New York area can listen to radio talk-show hosts gripe about how reformulated gasoline may be harming their engines and is generally a dumb idea dreamed up by bureaucrats.

A push is on among corporate executives to halt a requirement that companies find ways to get more workers to join car pools.

As long as the fight for cleaner skies focused on big smokestacks, few people cared. They figured big companies could afford to make changes. But clean air rules are now biting into everyday life."

Facing heavy political pressure, the United States Environmental Protection Agency in December indicated it would drastically lower the enhanced I/M standards, (known as IM240) allowing states to retain their current test-and-repair stations. However, the emissions reductions that would have resulted from the implementation of IM240 would have to be found from other sources, which may be exceedingly difficult to do in some states.

Where does all this uproar lead to in the future? Will the Clean Air Act be repealed? Will alternative fuels disappear from the scene? It is unlikely that the answer to the last two questions will be a flat yes. There is still a strong core of support in the United States for clean air and for alternative fuels. However, the current mood among newly elected officials suggests a more cautious approach may well arise.

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COMPANY ACTIVITIES

CLEAN CITIES PROGRAM EXCEEDS MEMBERSHIP GOAL FOR 1994

The U.S. Department of Energy's (DOE) Clean Cities program has signed up 34 participants through the end of 1994.

The program brings public and private entities together to encourage clean fuel vehicle populations and refueling infrastructure. Being a member also gives member cities an edge when competing for federal money for their AFV programs.

The addition of the latest eight cities surpasses DOE Secretary O'Leary's goal of having 25 members in the program by the end of 1994.

The Clean Cities roster, in chronological order of date of sign-up, includes:

- Atlanta, Georgia (9/8/93)
- Denver, Colorado (9/13/93)
- Philadelphia, Pennsylvania (9/22/93)
- Wilmington, Delaware (10/12/93)
- Las Vegas, Nevada (10/18/93)
- Washington, D.C. (10/21/93)
- Boston, Massachusetts (3/18/94)
- Austin, Texas (4/18/94)
- Florida Gold Coast (5/3/94)
- Chicago, Illinois (5/13/94)
- Albuquerque, New Mexico (6/1/94)
- Wisconsin - SE Area (6/30/94)
- Colorado Springs, Colorado (7/13/94)
- Long Beach, California (8/31/94)
- Lancaster, California (9/22/94)
- Salt Lake City, Utah (10/3/94)
- White Plains, New York (10/4/94)
- Baltimore, Maryland (10/7/94)
- State of West Virginia (10/18/94)
- Louisville, Kentucky (10/18/94)
- Rogue Valley, Oregon (10/18/94)
- San Francisco, California (10/21/94)
- Sacramento, California (10/21/94)
- South Bay (San Jose), Calif. (10/21/94)
- Oakland, California (10/21/94)
- San Joaquin Valley, Calif. (10/21/94)
- Western New York (11/4/94)
- Portland, Oregon (11/10/94)
- St. Louis, Missouri (11/18/94)
- Waterbury, Connecticut (11/21/94)
- Norwalk, Connecticut (11/21/94)
- Norwich, Connecticut (11/22/94)
- New London, Connecticut (11/22/94)
- Peoria, Illinois (11/22/94)

Access: Clean Cities Hotline, phone 800 224 8437

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FLEET ADMINISTRATORS ASK FOR DELAY OF EPACT RULES

The National Association of Fleet Administrators (NAFA) has petitioned the U.S. Department of Energy (DOE) for an 18-month delay in enforcement of alternative fuel purchase requirements under the Energy Policy Act (EPACT). According to EPACT, state government fleets and fleets operated by providers of alternative fuels must begin purchasing alternative fuel vehicles by September 1, 1995. Yet significant deadlines have been missed by DOE in issuing rules spelling out how such purchases must be accomplished.

The EPACT required DOE to issue final regulations for fuel provider fleet mandates by January 1, 1994.

As of January 1995, no regulations have been issued by the department in either proposed or final form for either mandate. The EPACT envisioned an 18-month period between the final regulations and the effective date to provide for a reasonable period of time for vehicle manufacturers, fuel suppliers and fleets to plan for compliance.

NAFA notes that we are now less than eight months from the date when vehicles must be purchased and not even a proposed regulation has been published. By the time a rule is proposed for comment and then made final, there may be only weeks before the effective date.

The purchase and operation of alternative fuel vehicles requires substantial planning, says NAFA. For state fleets, authorization may be needed from a state legislature for the additional funding needed for compliance with this federal mandate. Decisions must be made on installation of fueling facilities, modifications to garages, training of mechanics, replacement cycles for vehicles, and budgeting.

Efficient planning is thwarted without the guidance of regulations. What is meant by a centrally fueled fleet? Is an individual state agency a separate fleet or part of a larger fleet? Which state vehicles are exempted? What is the exemption process for state fleets or for fuel provider fleets?

The failure of DOE to issue regulations on a timely basis puts state and fuel provider fleets in an untenable situation, says NAFA. Orders are being placed now for vehicles that will go into service after September 1.

Absent the proper advanced notice from the Department of Energy, fleets are already unable to meet the substantial requirements of the Act in an efficient and successful fashion. If mandates should result in perceived failures, the goals of expanding alternative fuels to other fleets and the public could be jeopardized.

Accordingly, NAFA requests that DOE provide assurances to state and fuel provider fleets that any purchase requirements will be postponed until 18 months from the date a final rule is promulgated.

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TEXACO ATTACKS POTENTIAL COSTS OF ALTERNATIVE FUELS

A careful reconsideration of costly programs that seek to force uneconomic alternative fuels and vehicles into the marketplace is urgently needed, according to Texaco's W. Tell, Jr. Tell told a national legislators' meeting that recent examples of the flood of unfunded federal mandates intended as incentives to buy alternative fuels and vehicles will result in increased utility bills, higher taxes and soaring costs for consumers, with little, if any, environmental benefit.

The programs of most immediate concern are those seeking to force costly alternative fuels and vehicles into the marketplace, Tell said. These programs that apply to cars that run on electricity, ethanol, methanol or compressed natural gas, were created under the federal Clean Air Act of 1992 and come in the form of direct subsidies, direct or matching grants and tax credits.

To that end, Tell urged legislators to support environmental solutions based on risk-assessment, sound science and market-based incentives, while rejecting government-mandated programs for which taxpayers, rate payers and consumers ultimately foot the bill. Already, he claimed, federal subsidies for alternative fuels exceed more than $1 billion annually and will cost motorists, rate payers and taxpayers an estimated $10 billion by the year 2010.

It is estimated that U.S. refiners will spend $37 billion--an amount greater than the current value of all refinery assets in the U.S.--between now and the year 2000 to comply with federal reformulated gasoline regulations. On top of that, the Energy Policy Act of 1992 seeks to reduce the use of oil as a transportation fuel by 30 percent by the year 2010. That means "refiners are required to spend $37 billion to make a fuel that the government aims to phase out," said Tell. He noted that:

- State and federal gasoline taxes will have to rise to make up for the loss of taxes on tax-exempt alternative fuels, if roads and highways are to be maintained.

- Utility rates may be increased to create a refueling infrastructure to duplicate the one that already exists for gasoline and diesel fuel.

- The costs of new gasoline-fueled cars may increase, to offset the increased costs incurred by automobile manufacturers in adapting to alternative fuel vehicles.

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GOVERNMENT ACTIONS

OZONE TRANSPORT COMMISSION WINS EPA APPROVAL FOR LEV PROGRAM

In February 1994, the Ozone Transport Commission (OTC) voted to submit a request to the United States Environmental Protection Agency (EPA) for an OTC Low Emission Vehicle (OTC LEV) program for 12 Northeastern and Mid-Atlantic States and the District of Columbia.

The OTC LEV initiative is based on the program developed by the California Air Resources Board. The program requires the introduction of several new categories of vehicles meeting increasingly stringent emission standards: Transitional Low Emission Vehicles (TLEVs) Low Emission Vehicles (LEVs), Ultra-Low Emission Vehicles (ULEVs) and Zero Emission Vehicles (ZEVs). See <u>The Clean Fuels Report</u>, September 1994, page 5, for a description of the OTC LEV proposal and alternatives to the OTC LEV proposal that have been presented by others.

In an alternative concept put forth by American automobile manufacturers, the industry would voluntarily build cars cleaner than required by law in the 49 states outside California, and do so in a timeframe that would introduce those vehicles to the market sooner than they would be if the EPA Tier II emission limits were to be implemented. The proposal would not require the use of California fuels in other states and would eliminate any electric vehicle requirement in those states.

Auto manufacturers have been worried about the prospect of making cars for the Northeast that meet California emission standards without using California Phase II reformulated gasoline. A federal district court judge ruled in October than New York had the legal authority to institute such an LEV program for the state.

On December 19, 1994, the EPA said it would approve the OTC request. EPA had delayed its decision beyond a November 10 deadline in hopes of forging a compromise solution, perhaps along the lines of the 49-state standard proposed by the auto industry.

The California program also includes a mandatory phase-in of electric vehicles, starting with 2 percent of sales in 1998. However, EPA's approval of the OTC LEV request does not address the issue of electric vehicles, leaving that up to the individual states. Massachusetts and New York have adopted electric vehicle requirements.

A majority of the 12 states in the OTC must now individually approve the OTC LEV plan within 12 months in order for it to take effect. The states of New York, Massachusetts and Connecticut have already enacted enabling legislation. Individual OTC states could choose not to join the LEV program if they can demonstrate equivalent emissions reductions by other means.

In the meantime, EPA officials have indicated they will continue working with the auto industry and the OTC states in attempting to come up with a last-minute 49-state compromise. Several new governors elected in OTC states in November are expected to favor a 49-state compromise over the OTC LEV program because they see it as being a less costly alternative for their states.

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FTC REVISES PROPOSED LABELING RULES FOR ALTERNATE FUELS AND VEHICLES

The Federal Trade Commission (FTC) has revised its proposed rule to require cost-benefit information labels on vehicles that run on alternative fuels--for example, compressed natural gas and electricity--and for the pumps that dispense these fuels. The new proposal substantially revamps the one announced by the FTC in May with regard to vehicle labels, most notably by substituting, in part, a cruising-range disclosure for the fuel-tank capacity disclosure on new vehicles that run on alternative fuels.

The new proposal also contemplates abbreviated labeling requirements for used AFVs. The requirements for alternative fuel-pump labels, which would have to disclose the commonly-used name of the fuel and its principal component, remain essentially the same as those proposed in May.

The FTC has undertaken this rulemaking pursuant to the Energy Policy Act of 1992, which requires the agency to issue a final rule by May 9, 1995. The changes announced in November were made as a result of the comments received, including those received both before and after a public workshop-conference the FTC held in July to explore issues raised by the May proposal.

Under the proposal as it now stands, retail non-liquid alternative-fuel dispensers would have to include a label, placed near the selling price of the fuel, disclosing the commonly-used name of the fuel--for instance, compressed natural gas, hydrogen, or electricity. The label for gaseous fuels also would have to disclose the fuel's principal component, and could disclose other components, with all components expressed as minimum percentages. (These requirements mirror those of the FTC's Fuel Rating Rule--formerly the Octane Rule--for gasoline and liquid alternative fuels.) For electric-vehicle fuel dispensers, the label also would disclose the kilowatt capacity, voltage, current (either AC or DC), amperes, and type of charge (either conductive or inductive).

The FTC also proposes to impose substantiation, record-keeping, and in some instances, certification requirements on importers, producers, refiners, and distributors of gaseous alternative fuels; on manufacturers of electric-vehicle fuel dispensers; retailers of non-liquid alternative fuels; and AFV manufacturers. (Again, the proposals for alternative fuel sellers are similar to those under the Fuel Rating Rule).

For AFVs, the new proposal contemplates that the labels for used AFVs be an abbreviated form of the label for new AFVs. The proposed labels consist of three parts: the first part would contain the estimated cruising range and any Environmental Protection Agency emissions standard (which relates to the vehicle's environmental performance); the second would list and explain factors consumers should consider in purchasing an AFV; and the third would direct consumers to additional sources of information. As AFVs often have a lower cruising range than gasoline-fueled vehicles, the Commission believes the cruising range disclosure is more useful than the fuel-tank capacity. The new proposal also contains minor modifications as to the second two parts of the label.

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NRC REVIEW CRITICIZES MANAGEMENT STRUCTURE FOR SUPER CAR PROGRAM

The Partnership for a New Generation of Vehicles (PNGV), often referred to loosely as the "super car" or "car of the future" program, is a 10-year collaborative effort between the U.S. government and domestic auto manufacturers. An overall review of the program was carried out by the National Research Council (NRC) and a report published in November.

The PNGV Program

The PNGV program is a cooperative research and development program between the federal government and the United States Council for Automotive Research (USCAR), which is made up of Chrysler Corporation, Ford Motor Company, and General Motors Corporation. The PNGV was initiated on September 29, 1993, by President Clinton with the purpose of enhancing the U.S. domestic automobile industry's productivity and competitiveness. The aims of the PNGV program are to improve automobiles over the next decade and develop technologies for a new generation of vehicles that could achieve fuel economies up to three times those of today's comparable vehicles. At the same time, these vehicles should maintain performance, size, utility, and cost of ownership and operation and should meet or exceed federal safety and emissions requirements.

The PNGV goals and the considerations underlying them are enunciated in the partnership's program plan, as follow:

- **GOAL 1: Significantly improve national competitiveness in manufacturing.** By upgrading U.S. manufacturing technology, including adoption of flexible manufacturing and reduction of costs and lead times, while reducing the environmental impact and/or improving quality.

- **GOAL 2: Implement commercially viable innovation on conventional vehicles.** Pursue advances in vehicles that can lead to improvements in the fuel efficiency and emissions of standard vehicle designs, while maintaining safety and performance.

- **GOAL 3: Develop a vehicle to achieve up to three times the fuel efficiency of today's comparable vehicle** (defined as the average of Concorde, Taurus, Lumina), with equivalent customer purchase price, adjusted for economics.

According to the schedule for Goal 3 that is described in the program plan, by 1997 the PNGV expects to assess system configurations for alternative vehicles and to narrow its technology choices, with the intent of defining, developing, and constructing concept vehicles by the year 2000 and production prototypes by the year 2004. The technology areas being addressed include advanced lightweight materials and structures; energy efficient conversion systems (including advanced internal combustion engines, gas turbines, and fuel cells); hybrid electric propulsion systems; energy storage devices (including high-power batteries, flywheels, and ultracapacitors); more efficient electrical systems; and energy recovery systems such as those for efficiently recovering and utilizing exhaust energy and braking energy.

NRC Review

The November report is the first report of the National Research Council's Standing Committee to Review the Research Program of the Partnership for a New Generation of Vehicles. The committee was established in July 1994 to conduct an independent review of the PNGV program at the request of the U.S. Department of Commerce.

The PNGV program establishes a government-industry partnership that is unprecedented within the U.S. automotive industry. It aims to apply joint resources to meet a set of three specific goals that provide benefits to the partners and to the nation. It relies on mutual trust and strong motivation of the partners to make the program succeed. The government funding for the PNGV will be applied primarily to developing technologies that involve high risk (Goal 3). The USCAR funding will be greater for technologies with a clear, near-term market potential (Goal 1 and Goal 2).

The committee considers the underlying concept of the PNGV program to be credible. The PNGV concept is to bring together the extensive research and development resources of the federal establishment (including its national laboratories and network of university-based research institutions) and the vehicle design, manufacturing, and marketing capabilities of the USCAR partners and of suppliers to the automotive industry. The committee finds the PNGV to be a serious undertaking that has made good progress in establishing itself in a relatively short period of time.

NRC says it appears that the broad priorities established for the PNGV program are reasonable. There is no indication at this point in time that the goals and requirements of the program cannot be met or closely approached, provided that well-managed and adequate resources are devoted to the program by the partnership in a timely manner.

The major recommendations of the committee are as follows.

National Commitment

If the PNGV program is to be successful as presently envisioned, it must be sufficiently supported and pursued with urgency as a national goal. Currently, the PNGV program is almost exclusively a Clinton administration-USCAR initiative. However, it is the committee's view that congressional and public support for the program is crucial. The committee recommends that the PNGV's public affairs groups be provided with adequate resources to inform the public about accomplishments and to help create and maintain a national commitment to the program.

Program Management

The PNGV does not, as yet, have program management structures that are adequately defined and staffed in either government or industry organizations. There is an apparent absence of specific program plans that are essential to the success of the program. It was disconcerting to the committee that the PNGV is essentially a year into the partnership and was unable to provide detailed and defined program plans, schedules, and milestones to the committee. In the absence of quantified goals and detailed schedules, and because of the confidentiality of the near-term programs conducted by the industry, the committee was unable to assess the suitability of the timing or adequacy of the industry funding and resources to successfully accomplish Goal 1 and Goal 2.

The management challenges in the PNGV program are enormous given the scope and complexity of the effort and the diversity of the participants. In the committee's view, the current organizational structure, while suitable for a governing body, is inadequate to perform the detailed program management function required for a complex program such as the PNGV.

The government, in particular, needs to have a strong and effective central program manager to coordinate the efforts of the many federal departments, agencies, and national laboratories involved in the PNGV program.

Government Funding and Support

Prior to fiscal year 1996, government support for the program is provided only within the context of existing budgets. This makes it very difficult to obtain support within the government for the PNGV program. The committee believes it is essential that, starting with fiscal year 1996, the government funding for the PNGV program be a line-item budget for which oversight responsibility is vested in the government's PNGV program manager. The Clinton administration has stated that it will not seek new funds for the

PNGV. Thus, a redistribution and reallocation of funds to the PNGV from existing projects and jurisdictions is imperative if the program is to be sustained.

Integrated Platform Development Team

The present structure of industry's technical team in the PNGV organization appears to have been effective during the formative phase of the partnership over the past year. It should continue to be effective in managing Goal 1 and Goal 2 if it continues to receive the support needed from Chrysler, Ford, and General Motors. However, the structure is too diffuse and its capability too limited for it to be effective in managing Goal 3. USCAR needs to be able to speak with a single, well-informed PNGV program voice it if is to marshal effectively the diverse technology development and support groups from government, suppliers, and universities.

The committee strongly recommends the appointment of a technical director of an integrated platform development team at USCAR.

The collection, analysis, and utilization of a vast and diverse quantity of cost and technology information can only be effectively optimized through a total systems approach to the objectives of the PNGV program. These objectives include the definition of the concept vehicle and of the production prototype vehicle in 1997 and 2000, respectively, leading to the construction of concept and production prototype vehicles in 2000 and 2004, respectively. Though both government and industry partners fully embrace the need for a total systems approach, the results cannot be fully optimized and understood in the absence of an integrated platform development team located at USCAR.

Technology Strategy

The committee feels that it is critical for the program to adopt an appropriate strategy to determine which technologies will be supported, when, and with what level of resources. Some material and powertrain technologies have very attractive potential applications for automobiles but not in the time frame of the PNGV program. The committee recommends that an analysis be made now to divide all technologies related to Goal 3 into two categories: current PNGV and post-PNGV technologies. The committee recommends that technologies that do not meet PNGV program objectives by 1997 but that have high long-term potential be funded and continued in development for post-PNGV applications.

Manufacturing process improvements will be important in determining the success or failure of the PNGV program in meeting its goals. At this time, it is not possible to identify all of the manufacturing improvements that may be needed, partly because of the large variety of component technologies under consideration. If there is insufficient lead time to develop capable manufacturing processes, the program could miss the Goal 3 intent.

Supplier and University Involvement

Substantial innovative resources that have potential to be very helpful to the overall success of the PNGV program exist within the supplier and university communities. The committee recommends that the PNGV workshop structure be quickly expanded to more effectively involve these constituents and to provide them with a link to the PNGV program.

Foreign Technology

Substantial leading-edge technologies are being investigated and developed worldwide by non-U.S. interests that are not involved in the PNGV program. It would be appropriate for the PNGV program to more fully evaluate applicable non-U.S. technology developments and to integrate selected developments into the program.

Infrastructure and Capital Needs

There is a very high probability that the PNGV concept vehicle will use technologies that will result in technological discontinuities with many of today's automotive product and manufacturing technologies. The long-term impacts of potential discontinuities in the road-vehicle-fuel infrastructure, vehicle service, and vehicle manufacturing sectors may be enormous. In the committee's view, these considerations, coupled with the associated capital investment issues, must be addressed as integral parts of the PNGV program systems analysis.

Peer Reviews of the PNGV

If the PNGV program is to be vigorously implemented and supported as a national goal, more-detailed reviews of the program's technological decisions, research results, and organizational structures should be actively pursued. The committee proposes conducting such expanded reviews in early 1995. As part of that process, the committee will examine the actions taken by the PNGV in addressing the recommendations of this report.

Access: NRC, phone 202 334 3344

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PANEL ON REDUCING GREENHOUSE GAS EMISSIONS FROM AUTOMOBILES EXAMINES POLICY OPTIONS

The advisory committee named by President Clinton to develop recommendations for cutting greenhouse gas emissions from personal cars and light trucks (see The Clean Fuels Report, November 1994, page 5) has until March 28, 1995 to produce an interim report. A final report is due next fall. The panel is charged with finding ways to reduce transportation-related greenhouse gas (GHG) emissions to 1990 levels by the years 2005, 2015 and 2025. Although no preliminary results have been released, the panel is known to be considering the following options that are potentially related to alternative fuels:

- Support for technical innovation in AF and AFV production and use; federal research and development in low-GHG AFs
- Subsidies for low-GHG AFVs; taxes on higher-GHG AFVs
- Fuel composition standards
- Public education on AF and AFV use
- Clean Cities Program (fuel infrastructure development)
- Carbon tax
- Overall GHG emission cap (with trading)
- Vehicle fuel carbon or GHG cap (with, without trading)
- Agriculture reform (Conservation Reserve)
- Other policies to expand biofuels supply
- Policies to reduce GHGs from electricity generation
- Broader energy market policies (including natural gas policies)
- Air quality and emissions standards
- Government purchases of AFVs
- AFV mandates

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DOE REPORTS PROGRESS AND PLANS UNDER ENERGY POLICY ACT OF 1992

The U.S. Department of Energy (DOE) has published an "Implementation Status Report" concerning its activities under the Energy Policy Act of 1992 (EPACT). A narrative section summarizes major accomplishments from October

1993 to October 1994 and lays out fiscal year 1995 program plans.

Titles III-VI of EPACT set aggressive goals for increasing the use of alternative fueled vehicles (AFVs), including electric vehicles, in the transportation sector. The Act authorizes the Department to design and implement programs that promote these technologies to achieve the important national benefits of energy security; reduced emissions from mobile sources; and more competitive U.S. vehicles and fuels industries.

Progress to Date

Over the past year, DOE has established numerous programs to accelerate the commercialization of AFVs under EPACT. The Department has:

- Initiated projects to develop AFVs that meet Ultra Low Emissions Vehicle standards; added biodiesel and LNG buses to the transit bus fleet test demonstrations; completed a safety video on M85 refueling.

- Produced a brochure and facts sheets for fleet owners, providing information on the various alternative fuels available today.

- Established a cost-shared partnership with industry to establish the Certification of Higher-learning in Alternative Motorfuels Program, known as CHAMP.

- Prepared a report on transportation control measures and AFVs.

- Developed guidance to federal agencies on measuring the percentage of alternative fuel used in dual-fuel vehicles.

- Initiated an analysis of methods and incentives for encouraging the use of electric motor vehicles.

- Expanded the federal study of heavy duty commercial applications of alternative fuels to include all alternative fuels.

- Prepared a draft Notice of Proposed Rulemaking establishing guidelines for state plans to promote alternative fuels.

- Established the Clean Cities Program to obtain voluntary commitments from fuel suppliers to build stations, from the automakers to build vehicles, and from fleets to use those vehicles.

- Coordinated and provided partial funding for the acquisition of over 8,500 alternative fuel vehicles for the federal fleet. Due to constraints on the availability of vehicles from automakers, acquisitions fell short of the 11,250 goal set by Executive Order 12844.

- Prepared a draft Notice of Proposed Rulemaking to implement an Alternative Fuel Providers Fleet Mandate, a State Fleet Mandate and a Credit Trading Program.

- Initiated preliminary analytical work to support rulemakings if the Secretary determines that a private/local fleet mandate is necessary to meet the goals of the Act.

- Published in the Federal Register a methodology for the study required to estimate the technological and economic feasibility of replacing 10 percent of motor fuels by the year 2000 and 30 percent by 2010, with at least half of the replacement fuels coming from domestic sources.

- Established a data collection program in two major cities for ascertaining consumer preferences regarding alternative fuel vehicles.

Planning for FY1995

Fiscal year 1995 plans for implementing alternative fuel vehicle provisions include the following activities:

- Solicit and award R&D contracts for light and heavy duty alternative fuel vehicle systems optimized for emissions and performance.
- Develop a liquid propane gas refueling safety video.
- Conduct a nationwide student competition on hybrid-electric vehicles using natural gas.
- Establish a long-range marketing plan for AFV information materials.
- Continue to assist the Federal Trade Commission in developing alternative fuel labeling requirements.
- Announce a National Certification Program for technician training on AFVs, focusing on gaseous fuel vehicles.
- Issue final reports on the use of alternative fuels in nonroad vehicles and engines, and on federal policies and practices that affect AFV purchases.
- Award additional state grants for innovative programs to accelerate the use of AFVs.
- Establish an Alternative Fuel Scholarship Program for vehicle technicians.
- Implement Executive Order 12844 to reach a 15,000 vehicle goal for the federal fleet.
- Publish final rules for the Alternative Fuel Providers Mandate, the State Fleet Mandate, and the Credit Trading Program.
- Publish a final report on the technical and economic feasibility of reaching the replacement fuel goals of EPACT.
- Require fuel and vehicle suppliers to report on supplies and plans for the current and following calendar year.
- Publish a final report on methods for encouraging the purchase and use of electric motor vehicles.

Access: Report DOE/PO-0029, GPO, phone 202 512 1800

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EPA PROPOSES EMISSIONS STANDARDS FOR MARINE ENGINES

The U.S. Environmental Protection Agency has proposed the nation's first exhaust emissions standards for new gasoline and diesel-powered marine engines. This should lead to a new generation of low-emission, high-performance outboard engines.

Currently there are 12 million marine engines in the United States. Of all categories of non-road engines, marine engines contribute the second highest levels of hydrocarbons and nitrogen oxide exhaust emissions, approximately 700,000 tons per year. For non-road sources, only lawn and garden engines emit higher levels of HC, according to a 1991 EPA study, and only farm and construction equipment emit higher levels of NO_x.

The standards proposed would apply to all new outboard and personal watercraft engines (such as Jet Skis and Wave Runners). Separate standards are proposed for sterndrive and inboard engines which have some components similar to those used in automobiles and light trucks, but are adapted for marine use. The emission reduction standards, which would be corporate average standards with inter-industry trading allowed, would reduce HC emissions 75 percent.

A cap on carbon monoxide emissions also is proposed. Agency officials said CO is primarily a wintertime problem and boating is negligible during the winter months in most areas of the country.

EPA is also proposing to amend its rules for non-road land-based diesel engines at or above 50 horsepower to include marine diesel engines. These engines are used in commercial vessels and some of the larger pleasure craft. The standards will reduce NO_x emissions by 37 percent.

Manufacturers would begin phasing in over a nine-year period the new standards beginning with the 1998 model year. Retrofit for older models is not required.

A 1991 EPA study of non-road engines showed that the exhaust from non-road engines such as marine engines, lawn and garden equipment, utility engines, and farm and construction engines is a significant source of ozone and carbon monoxide pollution in many areas of the United States. Non-road engine sources make up 10 percent of the total summertime urban HC emissions and 17 percent of the total summertime urban NO_x emissions.

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DOE AWARDS $2 MILLION TO ACCELERATE USE OF ALTERNATIVE FUELS

The U.S. Department of Energy (DOE) has announced plans to invest in pilot projects around the country that promote the increased use of alternative fuels and vehicles. DOE will award $2 million to 18 states and the District of Columbia for alternative fuel vehicle (AFV) projects that focus public attention on new ideas to help fuel vehicles, improve air quality and stimulate economic growth.

The 19 pilot projects will be geared to strengthening state transportation programs that address the way automobiles are fueled. The goals of the projects include:

- Put more AFVs on the road
- Create refueling stations and infrastructure
- Stimulate public interest and participation
- Link, advance environmental objectives
- Provide specialized training
- Construct alternative fuel corridors

Grants were issued to California, Colorado, District of Columbia, Florida, Illinois, Indiana, Kentucky, Massachusetts, Minnesota, Nebraska, New Jersey, New Mexico, New York, Nevada, Ohio, Oregon, Pennsylvania, Texas, and Wisconsin.

Access: DOE, phone 202 586 5806

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ENVIRONMENTAL AFFAIRS

EIA REPORT SHOWS INCREASE IN U.S. GREENHOUSE GAS EMISSIONS

Total U.S. anthropogenic (human-caused) greenhouse gas emissions grew by 0.6 percent, or 10 million metric tons of carbon equivalent, between 1990 and 1992, according to a report released in November by the Energy Information Administration (EIA). Emissions in 1992 totaled 1,597 million metric tons of carbon equivalent.

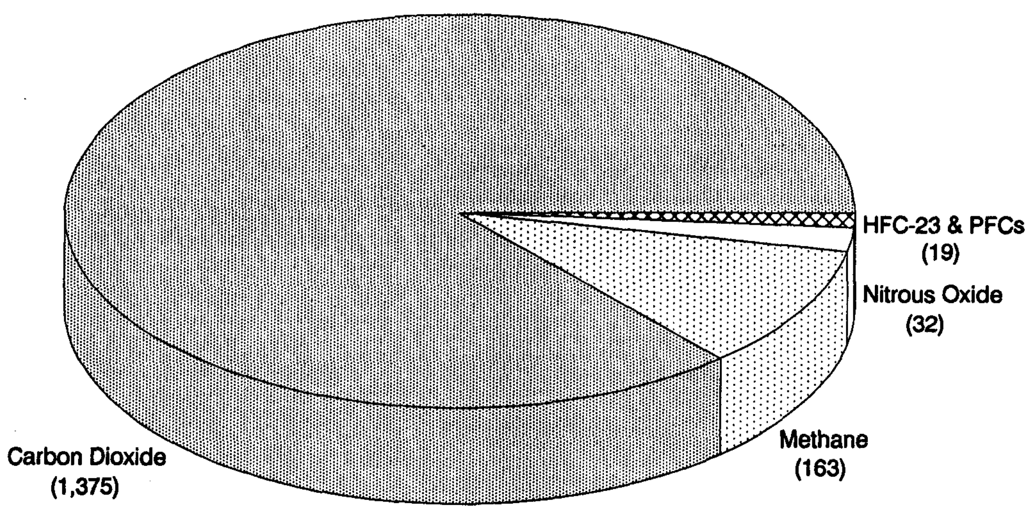
Almost all of the growth in emissions is attributable to increasing emissions of carbon dioxide, which compose 87 percent of the total (Figure 1). Emissions of methane and nitrous oxide were largely unchanged.

The report, <u>Emissions of Greenhouse Gases in the United States 1987-1992</u>, the second in an annual series, is mandated by the Energy Policy Act of 1992. The report estimates gross emissions, which exclude carbon dioxide sequestered by forests (about 120 million tons) and include

FIGURE 1

1992 EMISSIONS OF GREENHOUSE GASES IN THE U.S.

(Million Metric Tons of Carbon Equivalent)



Total Emissions = 1,597 million metric tons of carbon equivalent

emissions from international bunkers (about 21 million tons).

Emissions of carbon dioxide were 1,383 million metric tons of carbon in 1992, up 8 million tons or 0.6 percent, since 1990. Emissions rose because of increased energy consumption due to economic recovery and falling oil prices.

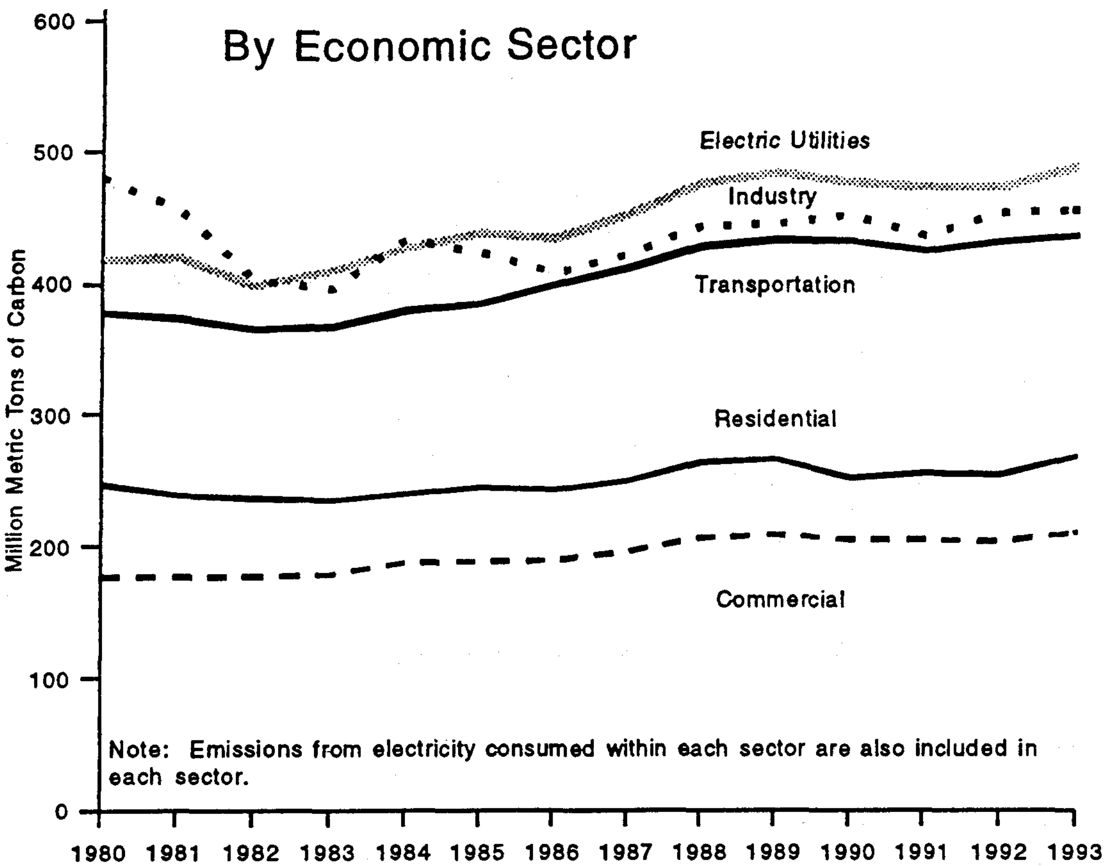
Emissions of methane in 1992 were unchanged from 1990 levels, at about 163 million metric tons of carbon equivalent or 10 percent of 1992 total U.S. greenhouse gas emissions. Methane from landfills is the most important source of methane emissions, followed by emissions from energy production and consumption, and from agricultural sources.

The report provides preliminary estimates of emissions of carbon dioxide (but not other gases) for 1993. Estimated 1993 carbon dioxide emissions were 1,409 million metric tons, up 26 million metric tons, or 1.9 percent, from 1992. Carbon dioxide emissions from fuel and electricity consumption in the residential and commercial sectors increased by five percent from 1990 to 1993, while emissions from the industrial and transportation sectors increased by less than one percent (Figure 2). In recent years, carbon dioxide emissions have grown more rapidly than population, but more slowly than either energy consumption or the U.S. economy.

Methods of estimating emissions used in the report have been extensively revised and im-

FIGURE 2

ENERGY-RELATED CARBON DIOXIDE EMISSIONS, 1980-1993

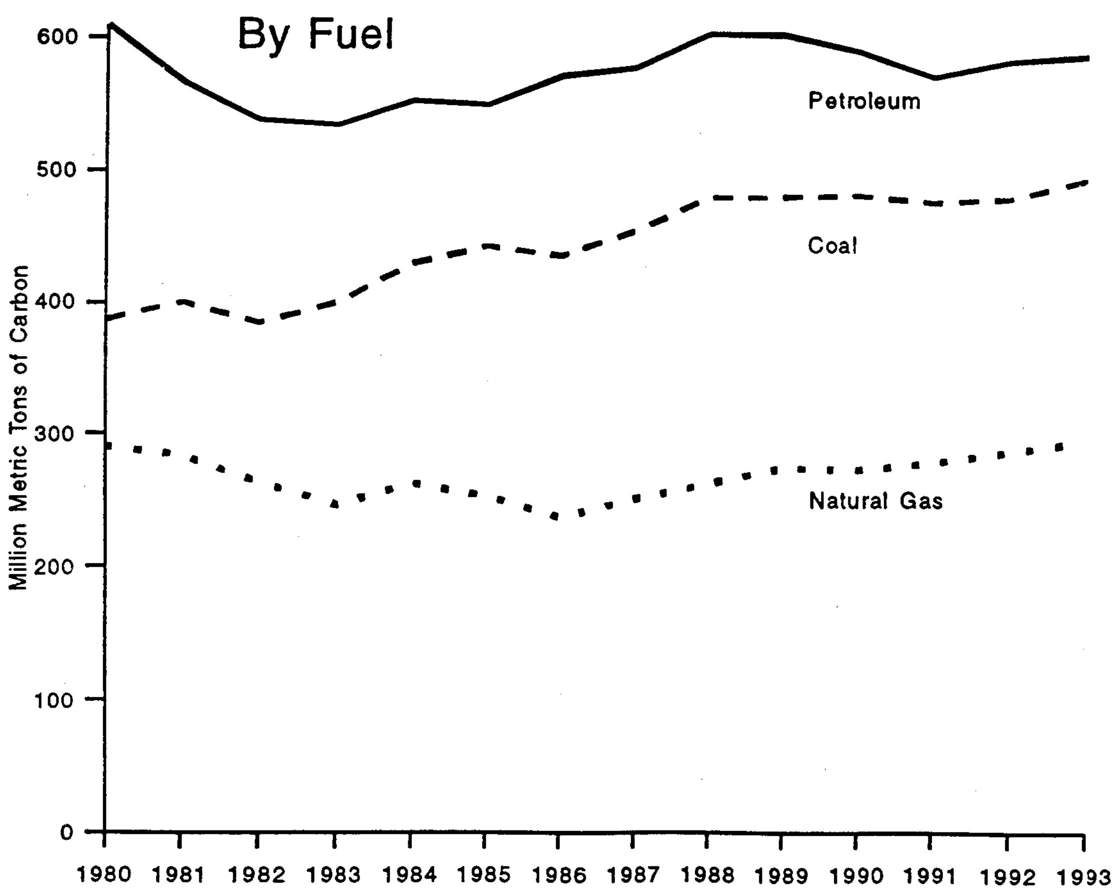


proved since last year. Estimates of carbon dioxide emissions have been revised upward by 0.6 percent for all years, compared with the estimates in last year's report. This result is due to the use of new emissions coefficients for certain petroleum products and revised estimates for the quantities of non-fuel use of fossil fuels. Estimates of methane emissions have been revised downward by about seven percent for all years when compared with last year's report. This result is primarily due to lower estimates of methane emissions from livestock, and use of a new method for estimating emissions from underground coal mines. Because these recalculations affect every year, they have no affect on estimated year-to-year changes in emissions. Petroleum consumption is still the largest carbon dioxide source among the fossil fuels (Figure 3).

Total emissions of greenhouse gases, measured in tons of carbon equivalent, are calculated by multiplying the emissions of each greenhouse

FIGURE 3

ENERGY-RELATED CARBON DIOXIDE EMISSIONS, 1980-1993



gas by its 100-year global warming potential. Global warming potential is an index of the relative impact of greenhouse gases on global warming compared to carbon dioxide.

Access: Government Printing Office, phone 202 512 1800

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ENVIRONMENTAL REGULATIONS FOUND NOT TO CAUSE JOB LOSSES

Do environmental regulations cause job losses in the overall national economy? Not according to the Economic Policy Institute. A new study says that two decades of research into the relationship between jobs and environmental protection shows that the number of layoffs and plant closures caused by regulations has been small.

The main point of the study is that at the national level, there is no trade-off between jobs and environmental protection. Even at the local level, actual layoffs that result from environmental and safety regulations have been quite small--on the order of 1,000 to 2,000 per year according to the study (Table 1).

On a national basis, the study indicates that environmental regulation has a small positive effect on overall employment. This is because environmental protection requires the intensive use of labor or domestically produced materials in such projects as recycling and construction of sewage facilities.

The jobs created by environmental regulation are heavily weighted to blue-collar sectors, not government- or private-service sectors. In 1991, 57 percent of jobs generated by environmental spending were in communications, manufacturing, transportation, and utilities.

Government jobs accounted for just 11 percent of environmentally related employment compared with 17 percent economywide.

Using data from 1987 through 1990, it was found that only four plants per year were shut down

TABLE 1

CAUSES OF MASS LAYOFFS

	1989		1990	
	Layoff Events	Job Loss	Layoff Events	Job Loss
Automation	11	1,378	11	1,688
Bankruptcy	81	18,599	100	26,428
Business Ownership Change	82	19,147	78	16,989
Contract Completion	225	50,971	201	40,167
Domestic Relocation	68	1,138	114	18,512
Environment Related	5	1,304	4	390
Import Competition	43	8,310	69	10,028
Labor-Management Dispute	47	40,387	na	na
Material Shortages	24	4,318	20	5,859
Model Changeover	17	9,089	15	3,039
Overseas Relocation	6	1,189	13	3,122
Seasonal Work	889	175,970	884	167,287
Slack Work	661	102,607	943	142,038
Other (incl. reorganization)	255	46,778	284	97,474
Not Reported	210	53,604	168	24,704
Total, All Reasons	2,764	572,570	3,078	586,690

because of environmental or safety regulations. This translates to less than 0.1 percent of all large-scale layoffs. More jobs are probably lost because of corporate downsizing, import competition, and defense cutbacks.

The tradeoffs between jobs and environmental protection are most apparent in extractive industries such as mining and logging where local job loss and unemployment can be significant. But even in these instances, new jobs dependent on a clean environment or providing substitute products for the "locked up" resource are generated elsewhere in the economy. Over time, job gains will generally balance job losses, "though national policy will have to address local problems of dislocation," the study states.

Neither has environmental protection been responsible for the decline of manufacturing jobs in the United States because companies have fled to pollution havens in countries where environmental regulation is lenient. Companies are relocating to less industrialized countries, but primarily because labor costs are low, according to the study.

It is suggested that expanded job training and adjustment assistance be undertaken to address job loss in manufacturing. In the long run, markets for clean manufacturing and energy technologies will provide the high-wage growth in the economy that car manufacturing and defense provided in the 1950s and 1960s.

"Demand for clean technologies will be the driving force behind industrial job creation," says the study's author. "Ensuring that United States firms develop and maintain the lead in these fields will allow the country to capitalize on high-wage employment opportunities in environmental protection."

Access: Public Interest Publications, phone 800 537 9359

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MARKET DATA

EIA SURVEY GIVES PRIVATE FLEET DATA FOR ATLANTA

In 1994, the Energy Information Administration (EIA) set up a program for collecting data on private fleets in the Atlanta air-quality nonattainment area. This is the first metropolitan area designated a "Clean City" under the Department of Energy's Clean Cities program.

The Energy Policy Act of 1992 (EPACT) directed EIA to develop information that will help marketers sell alternative fuel vehicles and help potential purchasers or users of such vehicles. The Atlanta survey is one of EIA's new fleet surveys that have been conducted in response to the EPACT legislation.

Survey data were collected on a sample of owned or leased on-road vehicles in private (nongovernmental) fleets of six or more. (A separate survey of municipal fleets was also administered in Atlanta.) The fleets had to be operating out of one or more locations within the Clean Air Act nonattainment area of Atlanta (the 13-county area immediately surrounding the city of Atlanta).

Alternative Fuel Vehicle Awareness

There are few comprehensive data on U.S. motor vehicle fleets, which are expected to compose the near-term market for alternative fuel vehicles (AFVs). Preliminary data indicate that, of an estimated 3,400 private (nongovernmental) fleets in the Atlanta area:

- Only 24 percent were "aware of any state or federal legislation that may require fleet use of clean or alternative fuels in the future"
- Only 2 percent had AFVs in their 1994 fleets

- Only 3 percent were planning to purchase AFVs in 1995

EPACT contains a number of programs directed at the increased use of alternative fuels. The Department of Energy is required to evaluate the progress in achieving the goals of replacement fuel use (10 percent replacement of the U.S. consumption of motor fuel by the year 2000 and 30 percent replacement by the year 2010) and determine whether private and municipal fleets will be required to convert to alternative fuels.

Conventional Fuel Vehicles

Of the approximately 93,000 gasoline and diesel fuel private fleet vehicles in Atlanta, 72 percent were light-duty vehicles (8,500 pounds or less), 76 percent of which were operating in fleets of 20 or more (Table 1). In private fleets in Atlanta, gasoline was used by the vast majority of light-duty vehicles. Diesel fuel was the fuel of choice for vehicles over 8,500 pounds.

Motor Gasoline Fueling Methods

The Atlanta survey collected data on the typical practices used by fleets to purchase gasoline. Of the 2,858 fleets that used gasoline, 90 percent (2,584 fleets) typically purchased gasoline by using only one method (Table 2).

Fleets purchasing motor gasoline typically used the following fuel-purchase practices:

- 56 percent fueled at public service stations without fuel-purchase agreements

- 25 percent fueled at public service stations under some form of purchase agreement

- 9 percent fueled at company-owned or private sites

- 10 percent fueled using a combination of the above methods.

TABLE 1

VEHICLES IN ATLANTA IN PRIVATE FLEETS
BY TYPE, FUEL AND FLEET SIZE CATEGORY
(Number of Vehicles)

	Fuel		Fleet Size		
Vehicle Type	Motor Gasoline	Diesel	6-19	20+	Total Vehicles
Vehicles <8,500 Lbs. (light-duty)	66,036	1,102	16,090	51,048	67,138
Trucks >8,500 Lbs.	3,472	21,815	7,318	17,968	25,287
Buses	154	363	240	276	517
Total	69,662	23,280	23,648	69,292	92,942

TABLE 2

PRACTICES USED BY PRIVATE FLEETS IN ATLANTA WHEN PURCHASING GASOLINE
(Number of Fleets)

Fuel-Purchase Method	Only One Method Used	More Than One Method Used
Company-Owned Sites	174	114
Private Sites with Fuel-Purchase Agreements	72	49
Public Service Stations with Fuel-Purchase Agreements	725	155
Public Service Stations without Fuel-Purchase Agreements	1,613	239
Total	2,584	274

A report containing detailed analyses and final data from the Atlanta Private Fleet Survey is planned for publication by EIA in the summer of 1995 and a similar survey of private fleet vehicles is to be conducted in 1995 in Denver, another "Clean City."

Access: EIA, phone 202 586 1132

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NAFA SURVEY PINPOINTS MEMBERS' INTEREST IN ALTERNATIVE FUELS

More than 500 members of the National Association of Fleet Administrators (NAFA) expressed their level of interest in alternative fuels, in a recent survey conducted by NAFA.

Some 32 percent of all responding fleet managers indicated they were "curious; just beginning to investigate alternative fueled vehicles." About 30 percent of all respondents already operate some AFVs; nearly all of those fleet managers intend to purchase more in the next two years. Only 14 percent of fleet managers expressed no interest at all in AFVs, at least for the next two years (Table 1).

The survey confirms the generally-held view that there is strong correlation between on-site fueling facilities and interest in alternative fuels, especially in the near term when so few public refueling facilities are available for alternative fuels. The fueling practices of survey respondents are summarized in Table 2. Utility fleets are most committed to using some alternative fuels, followed by governments, with business fleets demonstrating substantially less interest.

Natural gas earned the greatest vote of confidence, when fleet managers were asked to express their level of interest in all alternative fuels. Some 46 percent of respondents said they are very interested in CNG; 40 percent have some interest; and 14 percent have no interest, no matter what changes are made.

TABLE 1

INTEREST IN AFVs BY NAFA MEMBERS

Level of Interest	Percent			
	Total	Business	Govern't	Utility
No interest at all, at least for next two years	14	24	7	4
Curious; just beginning to investigate AFVs	32	44	24	12
Expect to acquire a few AFVs within the next two years	19	16	23	20
Intend to acquire AFVs in 1995 Model Year	6	3	9	7
Already operate some AFVs; do not expect to order more in next two years	5	4	4	8
Already operate AFVs, and plan to order more in the next two years	25	11	33	49

TABLE 2

FUELING PRACTICES AND PREFERENCES OF NAFA MEMBERS

Practice	Percent			
	Total	Business	Govern't	Utility
Completely on-site at own facility	24	3	52	18
Substantially on-site at own facility	23	6	34	48
Primarily at public refueling stations	22	30	11	23
Only at public retail fueling stations	31	61	3	11

Propane results were: 19 percent very interested, 49 percent some interest, and 32 percent no interest. Electricity earned 13 percent very interested, 47 percent some interest, and 40 percent no interest. Ethanol has 10 percent very interested, 47 percent some interest, and 43 percent no interest. For methanol, 7 percent voiced great interest, 51 percent some interest, and 42 percent no interest.

Most fleet managers expressed the view that every alternative fuel will cost more than gasoline, over the life-cycle of a vehicle. About one-third of respondents indicated that they do not know how costs will compare.

Fleet managers who participated in the study also identified specific vehicle types, fuels, and cities where they are most likely to desire AFVs.

A total of 503 NAFA members participated in this study. 237 manage fleets for businesses, 193 for governments, and 73 for utilities. Respondents manage a total of 571,402 vehicles, of which 258,127 are cars, 63,423 are minivans, and 247,852 are light/medium duty trucks.

Access: NAFA, phone 908 494 8100

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CONFERENCE CALENDAR

March 5-8, Seattle, Washington--16th North American Motor Vehicle Emissions Control Conference, phone 206 407 6841

March 6-7, Washington, D.C.--National Research Council, Transportation Research and Development, phone 202 334 2138

March 7-9, Alexandria, Virginia--National Hydrogen Association Sixth Annual U.S. Hydrogen Meeting, phone 202 223 5547

March 8-9, Houston, Texas--NGVs, Turning the Profit Corner, phone 713 460 9200

March 17-19, Medford, Massachusetts--17th Annual New England Environmental Conference, phone 617 627 3486

March 19-21, San Francisco, California--National Petroleum Refiners Association 93rd Annual Meeting, phone 202 457 0480

March 19-22, San Antonio, Texas--Third International Symposium on Fluid Flow Measurement, phone 312 399 8135

March 19-23, Houston, Texas--10th Intersociety Cryogenic Symposium, phone 908 771 6361

March 21-23, San Francisco, California--1995 World Conference on Reformulated Fuels and Refinery Processing, phone 703 528 2500

March 27-30, Santa Fe, New Mexico--Society of Automotive Engineers, Fuel Cells for Transportation, phone 412 776 4841

April 3-4, Maastricht, The Netherlands--LPG: A Clean and Efficient Motor Fuel, phone 31 55 78 6640, The Netherlands

April 3-6, San Francisco, California--Sixth Global Warming International Conference, phone 708 910 1551

April 9-11, Atlanta, Georgia--Third Annual Clean Air Vehicle Conference, phone 404 393 7470

April 10-12, Washington, D.C.--Society of Automotive Engineers, Government/Industry Meeting, phone 412 776 4841

April 10-12, Dallas, Texas--Gas Mart 95, phone 703 318 8848

April 20-22, Anaheim, California--Western Propane Gas Association Trade Show and Convention

April 30-May 2, Austin, Texas--Society of Automotive Engineers, LNG/NGV, phone 412 774 4841

April 30-May 2, Austin, Texas--Sixth Annual Alternative Vehicle Fuels Market Fair and Symposium, phone 512 463 5128

May 1-4, Vancouver, British Columbia, Canada--Council on Alternate Fuels, phone 703 276 6655

May 7-10, Orlando, Florida--National Association of Fleet Administrators, phone 908 494 8100

May 7-10, Las Vegas, Nevada--American Gas Association 1995 Operations Conference

May 7-11, Reno, Nevada--American Public Transit Association Bus Operations and Technology Conference, phone 202 898 4087

May 7-11, Vail, Colorado--17th Symposium on Biotechnology for Fuels and Chemicals, phone 303 275 4453

May 15-18, Interlaken, Switzerland--21st Congress of CIMAC, phone 41 1 384 4844, Switzerland

May 22-23, Washington, D.C.--The International Conference on Climate Change, phone 301 695 3762

May 22-26, Portland, Oregon--Community Transportation Expo, phone 800 788 7077

May 31-June 2, Cannes, France--Gas Marketing Congress, phone 33 1 43 80 96 60

June 4-6, Quebec City, Quebec, Canada--1995 Canadian Hydrogen Meeting, phone 416 978 2551

June 12-14, Toronto, Ontario, Canada--1995 Windsor Workshop on Alternative Fuels, phone 905 822 4111

June 14-15, Toronto, Ontario, Canada--Society of Automotive Engineers: Propane Technology TOPTEC, phone 412 772 7148

June 18-24, San Antonio, Texas--Air and Waste Management Association 88th Annual Meeting, phone 412 232 3444

June 27-29, Washington, D.C.--EPA Symposium on Greenhouse Gas Emissions and Mitigation Research, phone 919 544 4535

June 27-30, Milwaukee, Wisconsin--1995 International Alternative Fuels Conference, phone 800 447 5088

June 28-July 1, Chicago, Illinois--Gist-Brocades 1995 Fuel Ethanol Workshop, phone 704 527 9000, ext. 7506

July 3-6, Birmingham, England--11th International Conference on Liquefied Natural Gas, phone 44 71 228 8034

July 14-18, San Diego, California--Fifth World Congress of Chemical Engineering, phone 212 705 7373

July 15-20, Minneapolis, Minnesota--24th American Solar Energy Society Annual Conference, phone 303 443 3130

July 17-21, Columbus, Ohio--Cryogenic Engineering Conference and International Cryogenic Materials Conference, phone 303 499 2299

July 30-August 5, Orlando, Florida--30th Intersociety Energy Conversion Engineering Conference, phone 412 776 4841

CALENDAR

July 31-August 4, Istanbul, Turkey--Second International Conference on New Energy Systems and Conversions, FAX 90 212 233 7678

August 6-9, Hershey, Pennsylvania--American Public Gas Association Annual Conference

August 7-10, Costa Mesa, California--Future Transportation Technology Conference, phone 412 776 4841

August 15, Minneapolis, Minnesota--LNG 95--The Clean Air Vehicle Fuel Option, phone 612 321 5452

August 22-25, London, England--Greenhouse Gases: Mitigation Options, phone 44 242 68 0753

September 13-15, Milwaukee, Wisconsin--Society of Automotive Engineers International Off-Highway and Powerplant Congress and Exhibition, phone 412 776 4841

September 16-20, Rapid City, South Dakota--National Conference of State Fleet Administrators, phone 606 231 1887

September 19-22, Breckenridge, Colorado--11th Annual Mobile Sources Clean Air Conference, phone 303 491 7767

September 20-23, Istanbul, Turkey--World LPG Forum, phone 33 1 4053 7030, France

October 8-13, Tokyo, Japan--16th World Energy Council Congress, FAX 81 3 3437 4678, Japan

October 15-18, Los Angeles, California--13th National Natural Gas Vehicle Conference, phone 703 841 8446

October 16-18, Washington, D.C.--1995 Conference on Clean Air Act Implementation and RFG, phone 800 872 3835

October 16-19, Toronto, Ontario, Canada--Society of Automotive Engineers, International Fuels and Lubricants Conference, phone 412 776 4841

October 22-26, Gatlinburg, Tennessee--Ninth Symposium on Separation Science and Technology for Energy Applications, phone 615 574 4934

November 6-9, Cannes, France--International Gas Research Conference, phone 312 399 8300, USA

November 29-December 1, Arlington, Virginia--Electric Vehicles

December 6-8, San Diego, California--Society of Automotive Engineers: Alternative Fuels Conference, phone 412 776 4841

December 14-15, London, England--Metha-Motion 1995, phone 31 341025614, The Netherlands

1996

June 23-28, Stuttgart, Germany--11th World Hydrogen Energy Conference, phone 49 69 7564 241

CLEAN FUELS LEGISLATION DIRECTORY
(Underline Denotes Changes Since November 1994)

UNITED STATES FEDERAL LEGISLATION

THE CLEAN AIR ACT

The Clean Air Act of 1970, as amended, requires that the concentration of pollutants in exhaust gases from the nation's cars, buses and trucks fall below prescribed pollution limits. Toward this end, emission standards for different types of vehicles were established under the Act for carbon monoxide, hydrocarbons and nitrogen oxides. These emission standards were later tightened by Congressional revisions to the Act.

The Clean Air Act gave the Environmental Protection Agency (EPA) the authority to promulgate regulations affecting fuel quality for conventional and alternative fuels, performance of vehicles using alternative fuels, and emissions from categories of vehicles not regulated by the Act. The EPA exercised these powers in 1985 when it set stringent emission standards limiting nitrogen oxide and particulate emissions from truck and bus diesel engines.

The Clean Air Act also authorized the EPA to establish maximum concentration levels called National Ambient Air Quality Standards (NAAQS) for designated pollutants in the ambient, or open, air in order to protect public health "with an adequate margin of safety." Under the Act, the EPA established six NAAQS: three for major automotive exhaust pollutants--carbon monoxide, nitrogen oxides, and ozone or smog; two for pollutants emitted from the burning of diesel fuel in trucks and buses--particulate matter and sulfur dioxide; and the sixth for lead, which is gradually being controlled, largely through a phaseout of leaded gasolines.

The law requires areas where pollutant concentrations exceed the NAAQS to develop State Implementation Plans (SIP) to control emissions to reduce ambient air concentrations to the required levels. There are few states in the United States which do not include at least one urban area which is in violation of the NAAQS for either ozone or carbon monoxide. States not complying face possible bans or "sanctions," on new source construction and freezes in federal grants (e.g., clean air assistance and sewage treatment) and highway trust funds. The Clean Air Act also requires the EPA, where states fail to develop an adequate SIP for attaining NAAQS, to prepare and enforce a Federal Implementation Plan (FIP), in lieu of the SIP. The FIP may include disruptive controls such as downtown parking restrictions, staggered working hours, gasoline rationing, and other requirements.

The Act originally required NAAQS compliance by December 31, 1982. Congress extended NAAQS compliance to December 31, 1987, and then to August 30, 1988. In 1991 almost 100 urban areas still failed to comply with an NAAQS for at least one automotive pollutant.

CLEAN AIR ACT AMENDMENTS OF 1990

The Clean Air Act Amendments of 1990 (CAAA) contain 11 separate titles for which the EPA issues regulations. Under Title II, which contains the mobile sources provisions of the Act, the EPA issues regulations that delineate clean fuel requirements and vehicle emissions standards. For implementation purposes, the Act clarifies how areas will be designated as nonattainment and specifies procedures to define the boundaries of these areas. Nonattainment areas are classified for ozone, carbon monoxide, and particulate matter in accordance with the severity of the air pollution problem.

Table 1 indicates the pollution levels corresponding to the various classifications of nonattainment areas and shows the time allowed after 1990 for reaching attainment. The classification also governs the types of actions that must be taken to try to improve an area's air quality.

In November 1991 the EPA published its final rule identifying the urban areas in nonattainment for ozone (98 areas), for carbon monoxide (42 areas), for particulate matter (71 areas) and lead (12 areas) as of the date of passage of the CAAA. A complete list of the ozone and carbon monoxide nonattainment areas was given in *The Clean Fuels Report*, February 1992, pages 45-46. If the air quality of a city not currently on the nonattainment list declines in the future, it can be placed on the ozone nonattainment list after a period

TABLE 1

CLASSIFICATION OF AREAS

Class	Level - ppm	Attainment Date
Ozone		
Marginal	0.121 to 0.138	3 Years
Moderate	0.138 to 0.160	6 Years
Serious	0.160 to 0.180	9 Years
Severe 1	0.180 to 0.190	15 Years
Severe 2	0.190 to 0.280	17 Years
Extreme	0.280 and Above	20 Years
Carbon Monoxide		
Moderate	9.1 to 16.4	12/31/95
Serious	16.5 and Up	12/31/00

For ozone and CO: adjustment possible based on 5 percent rule; EPA may grant two 1-year extensions of attainment date

Class	Level - ppm	Attainment Date
PM-10		
Moderate	N/A	12/31/94 6 Years for Future Areas
Serious	N/A	12/31/01 10 Years for Future Areas

Possible extension of attainment date up to 5 years for serious areas

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of 1 year or on the carbon monoxide nonattainment list after a period of 2 years.

Reformulated Gasoline Rules

The states containing one or more of the 98 (as of November 1991) nonattainment areas for ozone are shown in Figure 1.

Title II mandates that only reformulated gasoline can be sold in areas classed as extreme or severe for ozone pollution beginning January 1, 1995. The 10 areas falling in this category in November 1991 are indicated in Figure 1.

The Act contains a recipe for reformulated gasoline; that is, it sets maximum and minimum requirements for a number of ingredients. The Act also specifies a set of performance standards in the form of percentages by which volatile organic compounds (VOCs) and air toxics must be reduced. EPA regulations require the fuel to comply with the stricter of these two standards. In addition, a refiner's gasoline sold outside the specified areas may not exceed the emission levels from its 1990 gasoline.

Reductions of VOCs are required only in the summertime. By 1995 reformulated gasoline will be required to have 15 percent lower emissions of VOCs and toxic chemicals. By the year 2000, the Act called for VOCs and air toxics to be reduced by 25 percent. The emission reduction requirements for air toxics applies year-round.

The minimum oxygen content for reformulated gasoline is set at 2.0 percent by weight year-round on a pool basis. The benzene content of reformulated gasoline can not exceed 1.0 percent by volume, averaged on a pool basis. The aromatic hydrocarbon content of reformulated gasoline may not exceed 25 percent by volume, on a pool basis.

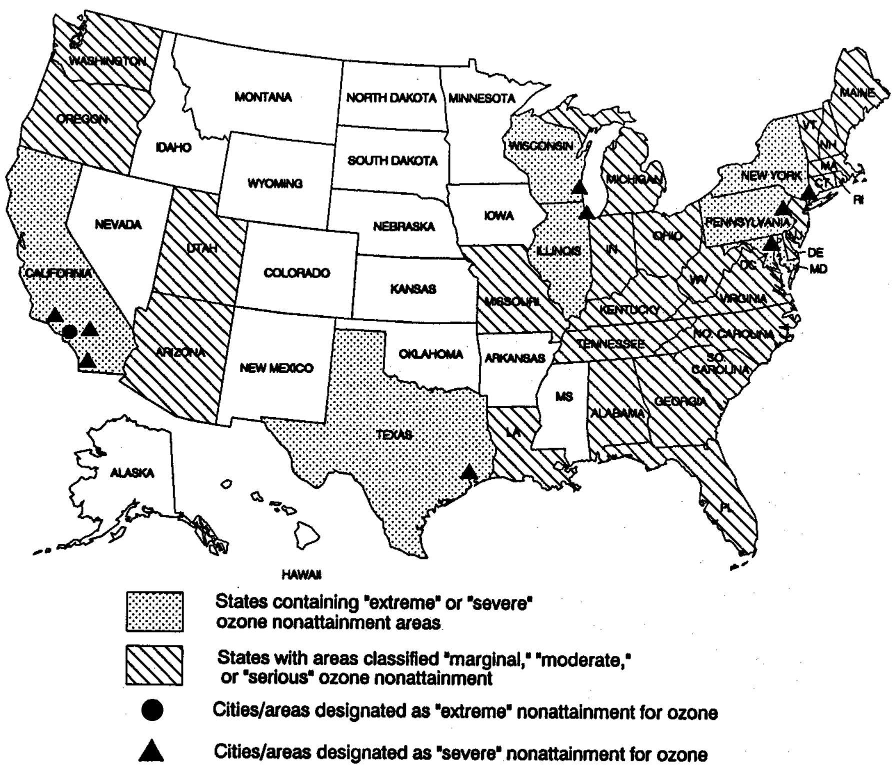
Emissions of oxides of nitrogen will not be allowed to increase over current levels of conventional "baseline" gasoline.

All gasoline is required to contain detergent additives to prevent the accumulation of deposits in engine fuel systems, effective January 1, 1995.

The EPA issued final rules and regulations governing the reformulated gasoline program in December 1993. The rules require a cut of only 20 percent in air toxics because a 25 percent reduction was determined to be not cost-effective. From 1995 to 1997 refiners may use a Simple Model to achieve the required emissions reductions by comparison to their own 1990 baseline fuel. For the years 1998 and later, all refiners must certify their gasoline by use of EPA's Complex Model, referred to a national baseline composition.

FIGURE 1

OZONE NON-COMPLIANCE AREAS



Although only those areas classified as extreme or severe for ozone nonattainment are required to use reformulated gasoline beginning in 1995, the governor of any state containing ozone nonattainment areas of lesser severity may petition the EPA to have the reformulated gasoline requirements apply to any or all of those areas as well. The states which have petitioned for reformulated gasoline are shown in Table 2.

Oxygenated Gasoline Rules

The cities classed in 1992 as serious or moderate nonattainment for CO pollution levels (Figure 2) were required to establish oxygenated fuels programs. For a period of not less than 4 months each year, the oxygen content requirement for gasoline sold in these cities is a minimum of 2.7 percent beginning November 1, 1992. If the federal air quality standard for CO has not been achieved by a specified attainment date, the minimum oxygen content will increase to 3.1 percent. On February 5, 1992 EPA published a list of 39 areas required to begin an oxygenated fuels program in November. As of September 1994, because certain cities are now in attainment for CO, and others are not complying with the program for one reason or another, the list of cities with active oxy-fuels programs contains only 32 areas. Table 3 gives the control periods for these CO nonattainment areas.

Other Rules Affecting Fuel Composition

Effective the summer of 1992, the maximum Reid vapor pressure (RVP) of all gasoline is set at 9.0 psi, but lower RVP limits can be adopted for both nonat-

TABLE 2

STATUS OF FEDERAL RFG PROGRAM

State	Area	Required	Opted-in	Opted-Out Jan. 1, 1995 (No. of Counties)
California	All	X		
Connecticut	Hartford	X		
	Rest of State		X	
Delaware	Entire State		X	
Dist. Columbia	All		X	
Illinois	Chicago, Gary-Lake County	X		
Kentucky	Louisville, Cincinnati Suburbs		X	
Maine	Lewiston, Portland, Bar Harbor, Lincoln/ Knox Counties		X	2
Maryland	Baltimore	X		
	Washington Suburbs		X	
Massachusetts	Entire State		X	
New Hampshire	Portsmouth-Dover-Manchester		X	
New Jersey	Most of State		X	
New York	New York City-Long Island	X		
	Marginal Nonattainment Areas Upstate		X	9
Pennsylvania	Philadelphia	X		
	Remainder of State		X	28
Rhode Island	All		X	
Texas	Houston-Galveston-Brazoria	X		
	Dallas-Ft. Worth		X	
Vermont	All		X	
Virginia	Nonattainment Areas		X	
Wisconsin	Milwaukee	X		
	Kewaunee, Manitowoc, Sheyboygan Counties		X	

tainment and attainment areas. Ethanol fuel is granted a 1.0 psi waiver for the RVP standard.

Effective October 1, 1993, diesel fuel must have a maximum sulfur content of 0.05 weight percent and a minimum cetane index of 40.

As of January 1, 1996, it will be illegal to sell gasoline which contains lead or lead additives for highway use.

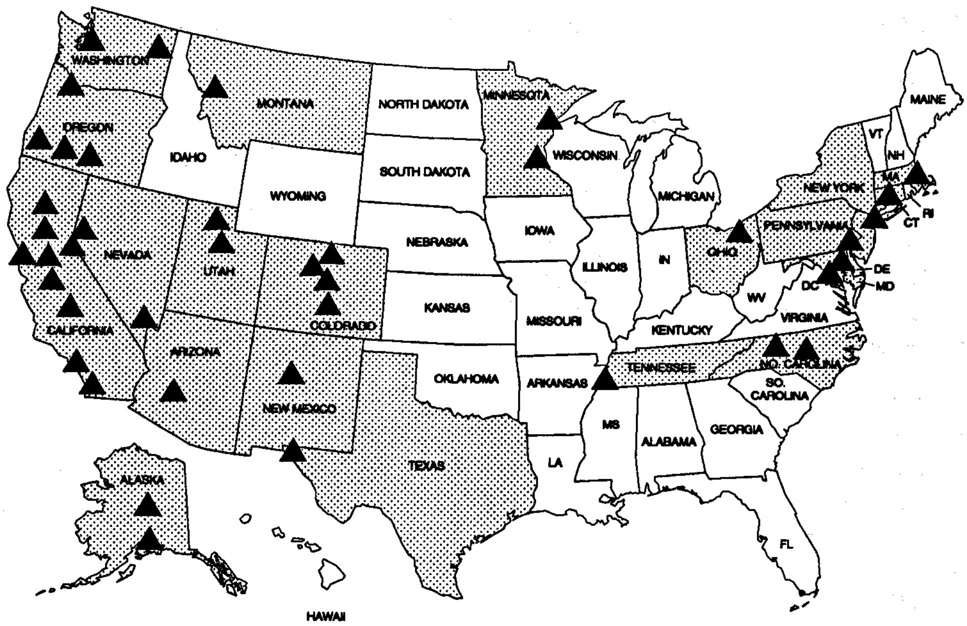
Emission Standards

The new law establishes tighter tailpipe emissions standards for hydrocarbons, carbon monoxide, and nitrogen oxides. The Tier I standards are to be phased in, beginning with vehicles produced in model-year 1994. Tier II standards could be required for vehicles produced in model-year 2004 and later. The Act also extends the useful life requirements for pas-

FIGURE 2

CARBON MONOXIDE NON-COMPLIANCE STATES

(As of November 1992)



▲ Cities classified as nonattainment for carbon monoxide

States containing cities classified as nonattainment for carbon monoxide

senger car emission control systems from 5 years/50,000 miles to 10 years/100,000 miles. Manufacturers must provide warranty coverage for 8 years or 80,000 miles.

The law also establishes lower emission standards for urban buses and heavy-duty and light-duty trucks. Urban buses could be required to operate on alternative fuels if they are unable to comply with the new standards. In 1993 the urban bus particulate standard is 0.1 gram per brake horsepower-hour. Beginning in 1994, all new urban buses must meet a 0.07 particulate standard, and heavy-duty trucks must meet a standard of 0.10 gram per brake horsepower-hour. For 1996 and beyond, new bus engines will meet a 0.05 gram standard.

The NO_x standard of 5 grams will be reduced to 4 grams in 1998 and later gasoline and heavy-duty diesel engines.

The Clean Fleets Program

The Act provides a nationwide program to introduce clean fuel vehicles (CFVs). By model-year 1996, automobile manufacturers must begin producing at least 150,000 clean-fueled cars and light trucks per year under a California pilot program. For model years 1999 and thereafter, manufacturers must produce 300,000 clean fuel vehicles each year.

Beginning with 1998 models, fleets with 10 or more vehicles capable of being centrally refueled in the

TABLE 3

CONTROL PERIODS FOR CO NONATTAINMENT AREAS

November 1-February 29 Control Area	October 1-January 31 Control Area	October 1-February 29 Control Area
Baltimore, MD	Fresno, CA	Las Vegas, NV
Greensboro, NC	Minneapolis, MN	Phoenix, AZ
Philadelphia, PA	Chico, CA	Los Angeles/Anaheim, CA
Raleigh, NC	Modesto, CA	
Washington, D.C.	Reno, NV	**September 1-February 29 Control Area**
Albuquerque, NM	Sacramento, CA	
El Paso, TX	San Francisco, CA	
Colorado Springs, CO	Stockton, CA	Spokane, WA
Denver/Boulder, CO		
Fort Collins, CO		**October 1-April 30 Control Area**
Missoula, MT		
Provo/Orem, UT		
Salt Lake City, UT		New York/Northern, NJ
Grant's Pass, OR		
Klamath County, OR		
Medford, OR		
Portland, OR		
Seattle, WA		
San Diego, CA		

22 smoggiest cities (the serious, severe and extreme ozone nonattainment areas plus Denver, Colorado for carbon monoxide nonattainment) must begin to buy clean fuel vehicles. The 75 marginal and moderate ozone nonattainment areas are not required to participate in the clean fleets program but may elect to do so. The law excludes emergency, off-road (farm and construction), rental, demonstration and privately garaged vehicles, plus heavy-duty vehicles over 26,000 pounds GVWR.

Beginning in the model-year 1998, 30 percent of new passenger cars and most categories of light trucks and vans (up to 8,500 pounds) bought for these fleets must be clean fuel vehicles. The percentage rises to 50 percent of purchased vehicles in the model-year 1999 and 70 percent in the year 2000 and beyond. For heavy-duty vehicles (up to 26,000 pounds), including school buses and delivery vans, the phase-in stays a constant 50 percent of new purchases beginning in the model-year 1998.

These provisions may be delayed if vehicles meeting the CFV standards are not offered for sale in California by 1998.

There will be a credit trading program established for vehicle fleets. Program acquisition requirements can be met through new vehicle purchases, conversions, or credits.

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

To meet the fleet program requirements, vehicles must be certified to meet any one of three different emission standards:

California Low-Emission Vehicle (LEV) standard. This is the minimum to satisfy the fleets program.

California Ultra Low-Emission Vehicle (ULEV) standard. These vehicles will earn credits.

California Zero-Emission Vehicle (ZEV) standard. These vehicles will earn credits.

The clean fleet standards are for exhaust emissions only. Other requirements are the same as for conventional vehicles.

All qualifying CFVs are proposed to be exempted from any time-of-day and day-of-week restrictions on vehicle travel.

Any SIP revisions required under this provision must be submitted by states on or before May 15, 1994. Should a state want to opt-out of the Clean Fleets Program, they must offer equivalent VOC and NO_X reductions by other means.

Inherently Low Emitting Vehicles

The Inherently Low-Emission Vehicle (ILEV) program proposes to offer additional exemptions from Transportation Control Measures (TCMs) in the affected cities. This program focuses on reductions in ozone precursors. An ILEV is defined as a vehicle which:

Qualifies as a CFV

Meets the ULEV standard for NO_X

Meets a low evaporative emissions standard without control devices

Is not allowed to run on higher emitting fuels

It is proposed that ILEVs be allowed to use High Occupancy Vehicle lanes and be exempt from certain other TCMs. Participation in the ILEV program is entirely voluntary for states.

Bus Testing Program

The amendments also call for a program to test urban bus fleets with the possibility of mandating cleaner fuel use in the future. EPA will begin testing buses in 1994. If it is found that the buses are not meeting the new standards in use, the EPA may mandate a switch to cleaner fuels. The policy covers 48 cities (with populations of more than 750,000) and can be delayed for 3 years if technology is not commercially available.

ENERGY POLICY ACT OF 1992

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

Alternative Fuel Provisions

Titles III, IV, V and VI address provisions regarding alternative fuels and alternative fuel vehicles. Title XIX addresses energy conservation and production incentives.

The Act defines alternative fuel as natural gas, LPG, alcohol (methanol, ethanol and higher alcohols), blends of alcohols with gasoline or other fuels containing 85 percent or more alcohol by volume, hydrogen, fuels derived from biomass, liquid fuels derived from coal, and electricity. A fleet is defined as at least 20 vehicles that can be centrally fueled, and are operated in a metropolitan area with a population of 250,000 or more (based on 1980 Census), and are controlled by an entity that controls at least 50 such vehicles in the United States. Exceptions include vehicles held for lease, dealer vehicles held for resale, law enforcement vehicles, emergency vehicles, defense vehicles, nonroad vehicles including farm and construction vehicles, and those normally garaged at personal residences at night. The Act affects directly the light-duty vehicle fleets of companies in the energy business, including alternative fuel providers, and federal, state and private fleets. Municipal and private fleets may be covered later.

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

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

These requirements do not apply to electric utilities until January 1, 1998, with respect to electric vehicles. Electric utilities planning to acquire electric vehicles must notify the Secretary of Energy by January 1, 1996 to comply with the Act.

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

5,000 in FY 1993
7,500 in FY 1994
10,000 in FY 1995
25 percent in FY 1996
33 percent in FY 1997
50 Percent in FY 1998
75 percent in FY 1999 and thereafter

In addition, federal fleets are mandated to use commercial fueling facilities that offer alternative fuels to the public as much as practicable.

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

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

One of the goals of the Act is to replace petroleum motor fuels used in light-duty vehicles with (at least 50 percent domestic) alternative fuels, on an energy equivalent basis, as follows:

At least 10 percent by the year 2000
At least 30 percent by the year 2010

If, by December 15, 1996, it has been determined that these goals will not be met through voluntary commitments, municipal and private fleet owners, not previously covered, may be required to purchase alternative fuel vehicles on the following schedule:

20 percent in model-years 1999, 2000,and 2001
30 percent in model-year 2002
40 percent in model-year 2003
50 percent in model-year 2004
60 percent in model-year 2005
70 percent in model-year 2006 and thereafter

If these fleet requirements are not implemented by December 15, 1996, further evaluation of progress toward the goals before January 1, 2000 may result in the following modified fleet requirements:

20 percent in model-year 2002
40 percent in model-year 2003
60 percent in model-year 2004
70 percent in model-year 2005 and thereafter

Law enforcement vehicles and urban buses may also be subject to the modified fleet requirements, if it is determined that this would contribute to achieving the overall goals of the Act.

Although the Act requires the purchase of alternative fuel vehicles, it does not necessarily prevent them from being run on gasoline if they are bi-fuel vehicles.

Under the State and Local Incentive Program, the DOE will administer a 5-year, $10 million per year assistance program for states that seek to develop and implement incentive programs for alternative fuel vehicles. The state must agree to provide at least 20 percent of the cost of activities for which assistance is supplied.

The Act authorizes the expenditure of $90 million ($30 million annually in 1993, 1994 and 1995) for an alternative fuel bus program aimed at joint ventures with transit authorities to demonstrate commercial applications of alternative fuels. The program will also provide funds to school districts for the incremental cost of school buses dedicated to an alternative fuel.

Another $75 million is authorized ($25 million in each year, 1993, 1994 and 1995) to establish a low-interest loan program, which gives preference to small businesses, for the cost of converting fleet vehicles to an alternative fuel or for the incremental cost of an OEM alternative fuel vehicle.

Under Title VI, 10 projects will be selected under an electric vehicle commercial demonstration program in which EV purchases are subsidized in amounts up to $10,000 of their incremental cost. At least 50 percent of the cost of each project must come from non-federal sources. Funding is authorized at $50 million over the next 10 years.

Ten projects will also be selected under an electric vehicle infrastructure and support system development program. Up to $4 million is authorized for each of 10 projects to subsidize the cost of servicing and recharging facilities for EVs over the next 5 years. At least 50 percent of the cost of each project must come from non-federal sources.

Additional financial incentives are provided for clean fuel vehicles and clean fuel support facilities. Clean fuel is defined as natural gas, liquefied petroleum gas, blends of alcohols with gasoline or other fuels containing 85 percent or more alcohol by volume, hydrogen and electricity.

Beginning June 30, 1993, a tax deduction (immediate depreciation) for the incremental cost of clean fuel vehicles is allowed in the year the vehicle is purchased: up to $2,000 for light-duty vehicles, up to $5,000 for medium-duty trucks and vans (10,000 to 26,000 pounds GVWR), and up to $50,000 for heavy-duty trucks and buses (over 26,000 pounds GVWR or more than 20 adults seating capacity).

The deduction limits will begin to phase out in the year 2002.

For individuals purchasing a clean-fueled vehicle, a tax deduction of up to $2,000 is available for vehicles with a GVW of 10,000 pounds or less. The deduction is only applicable to that portion of the vehicle cost due to its use of clean-burning fuel.

A tax credit (an offset against taxes owed) is provided for electric vehicles: 10 percent of the purchase price with a cap of $4,000. Both the deduction and the credit will be phased out beginning in 2002 and will no longer apply after December 31, 2004.

Between June 30, 1993 and December 31, 2004, providers of clean-fuel refueling facilities, including facilities dedicated to recharging EVs, are eligible for a tax deduction of up to $100,000 for the year the facilities are placed into service. The deduction will be phased out between 2002 and 2004.

Renewable Energy

Title XII addresses provisions regarding the production, utilization, and technological advancement of renewable energy.

In FY 1994, Title XII authorizes $50 million; through amendments to the Renewable Energy and Efficiency Technology Competitiveness Act of 1989, to fund energy efficiency and renewable energy technology demonstrations. Eligible technologies include:

- Conversion of cellulosic biomass to liquid fuels
- Ethanol and ethanol byproduct processes
- Direct combustion or gasification of biomass
- Biofuels energy systems
- Photovoltaics
- Fuel cells

The Act sets specific goals for the Alcohol From Biomass Program, as follows:

- Reduce the cost of alcohol to $0.70 per gallon.
- Improve the overall biomass carbohydrate conversion efficiency to 91 percent.
- Reduce the capital cost component of the cost of alcohol to $0.23 per gallon.
- Reduce the O&M component of the cost of alcohol to $0.47 per gallon.
- Reduce the cost of methanol to $0.47 per gallon.

Reduce the capital component of the cost of methanol to $0.16 per gallon.

Financial incentives for renewable energy technologies include incentive payments of $0.015 per kilowatt-hour for electricity generated and sold by a qualified renewable energy facility. Eligible technologies are solar, wind, biomass (excluding municipal solid waste), or geothermal.

In addition, the existing tax exemption for gasoline containing 10 percent ethanol is expanded to include blends of 7.7 or 5.7 percent ethanol.

Reduction of Oil Vulnerability

Title XX Subtitle B authorizes funding for technologies for reducing the demand for oil in motor vehicles. Funding (excluding EVs) is authorized at $119 million in FY 1993 and $160 million in FY 1994. This includes programs to improve automotive fuel economy and to improve alternative fuel vehicle technology (under this subtitle, alternative fuel is defined as natural gas, LPG, hydrogen, fuels other than alcohol derived from biomass, and any fuel which is at least 85 percent by volume alcohol).

This subtitle also establishes a biofuels user facility, to expedite industry adoption of biofuels technologies, and a program to evaluate the feasibility of production and use of diesel fuel from vegetable oils or animal fats.

The Act establishes a renewable hydrogen energy program to include at least one program to generate hydrogen from renewable energy sources; a program to assess the feasibility of existing natural gas pipelines carrying hydrogen gas; a program to develop a hydrogen storage system suitable for EVs powered by fuel cells; and a program to develop a fuel cell suitable to power EVs.

Funding for a 5-year research and development program on EVs and associated equipment is authorized at $60 million for FY 1993, $75 million for FY 1994, $80 million for FY 1995, $80 million for FY 1996, $90 million for FY 1997 and $100 million for FY 1998. Joint ventures with private industry are called for.

A 5-year program to develop fuel cell technology, including activities on molten carbonate, solid oxide, and advanced concepts, is funded with $51.5 million in FY 1993 and $56 million in FY 1994 under Title XXI.

THE ALTERNATIVE MOTOR FUELS ACT

The major provision of the Alternative Motor Fuels Act of 1988 amended the existing CAFE (Corporate Average Fuel Economy) program to allow auto companies to build less fuel-efficient gasoline cars and to avoid paying fines for violating the CAFE requirements if they also build and sell alternative fuel vehicles.

The CAFE standards came into effect in 1978 and require a minimum average fuel efficiency to be achieved by car makers.

Under the Act, CAFE fuel economy calculations will be based solely on the actual or assumed gasoline content in fuel. Thus, any alternative fuel used creates a "free" mileage extender. For example a dedicated methanol vehicle designed to run on M85 (85 percent methanol, 15 percent gasoline), and actually achieving 25 miles per gallon on M85, will be credited with 167 miles per gallon in the calculation of a manufacturer's overall CAFE rating. In the case of a dedicated natural gas vehicle, the vehicle is assumed to burn 15 percent gasoline for the purpose of calculating the CAFE rating. Multiple-fuel vehicles receive half the CAFE credit awarded to dedicated alternative fuels vehicles. The law provides a cap of 1.2 miles per gallon on the overall CAFE credit that can be awarded to any automobile manufacturer attributable to the production of alternative fuel vehicles. The NHTSA has set a minimum driving range for dual-fuel passenger vehicles as a requirement to take advantage of the new credits. For cars using methanol or ethanol, the range is 200 miles. For natural gas vehicles, the range is 100 miles.

The law also requires that government-owned refueling stations for alternative fuels be open for public use.

Published in the August 3, 1994 *Federal Register*, the EPA has issued the rule allowing automakers to receive CAFE credit for producing alternative fuel vehicles. The fuels covered are methanol, ethanol and natural gas. The CAFE credits can be counted for model-years 1993 through 1995; the EPA administrator has the authority to extend the credit program for a longer period of time.

INTERMODAL SURFACE TRANSPORTATION EFFICIENCY ACT

The Intermodal Surface Transportation Efficiency Act (ISTEA) was signed into law in December 1991. Titles I and III, the Surface Transportation Program and the Federal Transit Act, are of primary interest to alternative fuels issues. Title III funds can be used by transit agencies to implement their alternative fuels actions.

Under Title I, the Surface Transportation Program (STP), funded at $23.9 billion over 6 years with 80 percent federal share, has the broadest flexibility in that highway funds can be used for transit projects, as well as such projects as mitigation of wetlands loss, wetlands banking, management systems, planning, and various transportation enhancements, such as hiking and bicycle trails.

Also under Title I the Congestion Mitigation and Air Quality (CMAQ) Program is a program to combat transportation-related air pollution in nonattainment areas, funded at $6 billion over 6 years with an 80 percent federal share. CMAQ can fund projects and programs such as transportation control measures or transit projects that contribute to attainment of air quality standards. Current guidance from the Federal Highway Administration indicates that CMAQ funds can be used specifically for purchase and/or conversion of public vehicles to alternative fuels, where their primary purpose is to improve air quality.

If funds are to be used for alternative fuels purposes, such uses are to be determined through local and regional planning processes, which includes both transportation and air quality improvement plans.

Planning is to be funded by a percentage of the funds authorized. These funds are to be distributed to state and metropolitan planning activities, and can be used for alternative fuels planning activities, feasibility studies, and data acquisition, as they relate to air quality improvement.

The long-range transportation plan required by ISTEA must be coordinated with the State Implementation Plan (Clean Air Act required air quality improvement plan).

NHTSA STANDARDS FOR CLEAN FUEL VEHICLES

The National Highway Traffic Safety Administration is developing safety standards for vehicles and equipment using alternative fuels. Rules will be promulgated regarding the fuel system integrity of alternatively fueled vehicles. The NHTSA has published an advanced notice of proposed rule-making for the fuel system integrity of vehicles running on methanol, ethanol, compressed natural gas, and liquefied petroleum gas.

ETHANOL, ETBE AND METHANOL INCENTIVES

The $0.60 per gallon federal tax credit formerly allowed for blenders using ethanol has been reduced to $0.54 per gallon. The $0.06 ethanol producer tax incentive was reduced to $0.054 per gallon of ethanol produced. In 1990 the credit was made to include ethanol used in the making of ethyl tertiary butyl ether (ETBE). The tax credit has been extended to the year 2000.

There is a $0.10 per gallon income tax credit for certain producers of methanol. Many states also offer ethanol production incentives (Figure 3). State incentives and mandates for the use of ethanol are listed in Table 4.

EMISSIONS STANDARDS FOR ALTERNATE FUEL VEHICLES

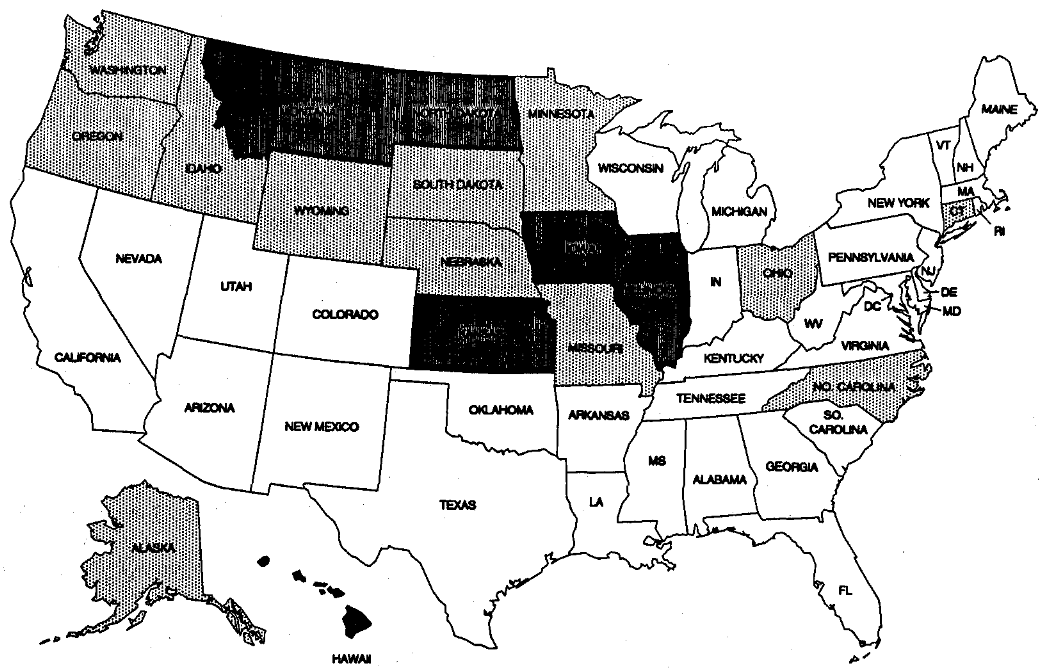
Methanol

On February 23, 1989, EPA announced emission certification standards for methanol-fueled vehicles. These standards cover passenger cars, light trucks, heavy-duty vehicles, and motorcycles in 1991 and later model-years.

These standards for methanol fueled vehicles are essentially the same as those for vehicles burning gasoline and diesel fuel. The major difference consists of the treatment of organic emissions.

FIGURE 3

STATES WITH FUEL ALCOHOL INCENTIVES AND/OR MANDATES



States with fuel alcohol incentives

States with fuel alcohol incentives and mandates

CNG and LPG

In September 1994, the EPA published its final rule on certification for propane and natural gas vehicles. With certain exceptions, the rule becomes mandatory with the 1997 model-year.

An entity that wishes to certify a vehicle type for production applies to EPA for a "Certificate of Conformity." A Certificate certifies that a specific vehicle type has been demonstrated to meet the requirements of the most current applicable emissions regulations. A new Certificate is required for each year of production. EPA issues Certificates for complete vehicles only (not, for example, for conversion kits). A separate Certificate is required for each vehicle design that is unique from an emission control perspective, or "engine family."

To establish the emissions performance of an engine family for certification, the certifier needs to have performed emissions testing using the Federal Test Procedure. In a prototype vehicle, the emission data vehicle is tested at low mileage. The pattern of deterioration of emissions is established by operating the prototype for 100,000 miles and testing emissions periodically.

EXECUTIVE ORDER 12844

Executive Order 12844, issued in April 1993, requires federal agencies to acquire, subject to the availability of funds and life-cycle costs, alternative-fueled vehicles in numbers that exceed by 50 percent the requirements for 1993 through 1995 set forth in the Energy Policy Act of 1992. It also establishes the Federal Fleet Conversion Task Force for 1 year to advise an im-

TABLE 4

STATES WITH ETHANOL INCENTIVES
(Dollars per Gallon)

State	Fuel Tax Exemption On Blended Fuel	Producer Incentive
Alaska	0.08	
Connecticut	0.01	
Hawaii	exempt from standard excise tax on retail sales (4%)	
Idaho	up to 10% of excise tax on gasoline	
Illinois	0.0185	
Iowa	0.01	0.20
Kansas		0.20
Minnesota	0.02	0.20
Missouri	0.02	0.20
Montana		0.30
Nebraska	--	0.20
North Carolina		income tax credit up to 30% of plant cost
North Dakota		0.40
Ohio	0.010	
Oregon	0.05	50 percent property tax exemption for in-state fuel ethanol production facilities
South Dakota	0.02	0.20
Washington	0.037	credit of 60% of tax rate for each gallon of alcohol blended
Wyoming	0.04	

plementation of the order, setting forth a recommended plan and schedule for implementation.

PUMP LABELS FOR LIQUID ALTERNATIVE FUELS

The Federal Trade Commission has ruled that a bright orange sticker will display the "common name" of the liquid alternative fuel and the amount of its principal component (gasoline stickers are yellow and show octane ratings).

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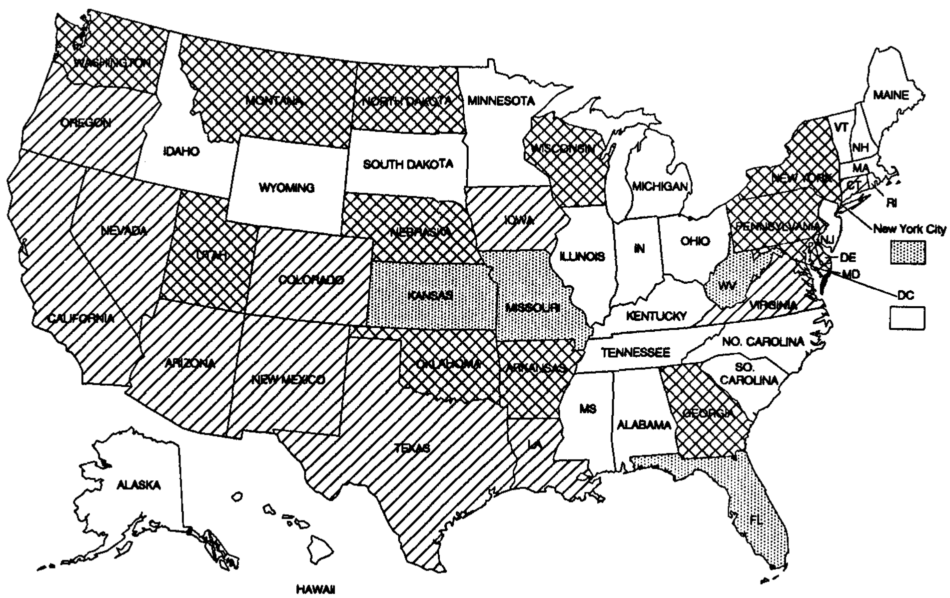
STATES WITH MANDATED FLEET CONVERSIONS AND/OR CONVERSION INCENTIVES

Figure 4 is a graphic guide to state legislation concerning conversions to alternative fuels. Shown are the various states that have mandated fleet conversions to alternative fuels, states that have conversion incentive programs in place, and states that have both.

Table 5 lists the states which have mandated the use of alternative fuels, vehicles or fleets affected by the mandate, and the effective year of implementation.

FIGURE 4

STATES WITH MANDATED FLEET CONVERSIONS AND/OR CONVERSION INCENTIVES IN PLACE



States with both mandated fleet conversions and conversion incentives.
States with mandated fleet conversions.
States with conversion incentives.

Table 6 lists the incentives offered by various states for converting vehicles to operate on alternative fuels, while Table 7 is a quick reference to different states' definitions of alternative fuels. Table 8 is a summary of state taxes on gasoline and alternative fuels.

Shown in Figure 5 are the states which have completed their SIPs. November 15, 1994 was the deadline for submission of SIPs to EPA. However, very few states met the deadline. Also shown in the figure are states which have adopted California-LEV standards. The specific provisions of the program differ for each state, such as when the program will be put into effect and whether or not implementation is contingent on other states implementing the program. The Northeast Ozone Transport Commission is in the process of trying to mandate a California-LEV program for all its member states and the District of Columbia.

ARIZONA

Alternative Fuel Use

HB 2433 establishes a solar energy projects fund. Included in the prescribed uses of this fund are solar transportation projects.

Vehicle Conversion Incentives and Mandates

Under HB 2433, vehicles powered by alternative fuels, defined as LPG, CNG, hydrogen, M85 to M100, E85 to E100, electricity or solar energy, are subject to a

TABLE 5

STATES MANDATING THE USE OF ALTERNATIVE FUELS

State	What Fleets Are Affected	When
Arizona	State agency purchases;	1992
	Buses purchased after January 1, 1993	1993
California	State agency purchases--25 percent LEVs;	1990
	Law requires minimum sales by manufacturers;	1994
	Minimum sales of EVs required;	1998
	Federal law requires sales of 150,000 AFVs annually;	1996
	Then 300,000 AFVs sold annually (CA Pilot Program)	1999
Colorado	State agency purchases--10 percent;	1991
	Percent increases annually to 40 percent	1994
	All fleets in Denver with 30 or more vehicles must convert 10 percent of the fleet	1992
Connecticut	Clean fuel alternatives required for state owned vehicles	1992
	10% of state fleet purchases must be natural gas or electricity powered	1993
Florida	State agencies in nonattainment areas	1992
Iowa	State agency purchases--5 percent;	1992
	State agency purchases--10 percent	1994
Kansas	State agencies--when it is cost effective	1992
Louisiana	State agency purchases--100 percent	1991
	At least 30 percent of state fleet must be converted;	1994
	Percentage increases biannually to 80 percent	1998
	Law also applies to all political subdivisions, i.e., counties and cities	
Missouri	State agencies with more than 15 vehicles must convert 10 percent;	1996
	Percentage increases 20 percent biannually to 50 percent	2000
Nevada	Public fleets in Las Vegas and Reno must convert 10 percent	1995
	Percentage increases to 50 percent	1998
	Percentage increases to 90 percent	2000
New Mexico	State agency purchases--30 percent;	1993
	Percentage increases to 60 percent;	1994
	Percentage increases to 100 percent	1995
New York	New York City purchases--30 percent;	1994
	Percentage increases to 60 percent;	1995
	Percentage increases to 80 percent	1996
Oregon	All public transportation vehicles	1993
	All state agency purchases	1994
Texas	All purchases by school districts with more than 50 vehicles	1991
	All purchases by state agencies with more than 15 vehicles	1991
	All purchases by public transportation authorities	1991
	- At least 50 percent of above fleets must be converted	1996
	- Law also applies to private fleets with 70 or more vehicles in nonattainment areas,	
	if fleet contains more than 25 vehicles, 30 percent must be converted;	1998
	Percentage increases biannually to 50 percent;	2000
	Percentage increases to 90 percent	2002

TABLE 5 Continued

STATES MANDATING THE USE OF ALTERNATIVE FUELS

State	What Fleets Are Affected	When
Virginia	Fleets in specified counties must convert 30 percent	1998
	Percentage increases to 50 percent	1999
	Percentage increases to 70 percent	2000
West Virginia	State and Local Agencies Aquisitions	
	20 percent;	1995
	30 percent;	1996
	50 percent;	1997
	If cost effective, 75 percent	1998 & thereafter

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reduced license tax at the rate of $4 for each $100 in value. During the first year of the life of the vehicle the tax rate is based on a vehicle valuation of 1 percent of the retail price. Conventional vehicles are taxed on a value that is 60 percent of the retail price. However, the minimum vehicle license tax is set at $5.00.

Legislation was passed in 1993 that allows tax payers to subtract 25 percent of the purchase price of an AFV (not to exceed $5,000 per vehicle) from their adjusted gross income for tax purposes. The purchase price of refueling equipment (not to exceed $5,000) and the cost of converting a vehicle to burn an alternative fuel (not to exceed $3,000 per vehicle) may also be subtracted. HB 2575 was passed in 1994, changing the deduction from gross income to a tax credit. The credit allowed is $1,000 for vehicles purchased in years 1994, 1995 and 1996. The credit falls to $500 for 1997 and $250 for 1998.

Fleet conversions are mandated under HB 2575, signed into law April 1994, for city-owned vehicles and school buses in counties with a population in excess of 1.2 million according to this schedule:

> 18 percent by December 31, 1995
> 25 percent by December 31, 1996
> 50 percent by December 31, 1998
> 75 percent by December 31, 2000 and thereafter

In response to this legislation the Arizona Department of Commerce Energy Office has awarded $2.9 million in Petroleum Violation Escrow funds to Maricopa County school districts to convert vehicles to alternative fuels.

A mandate for the conversion of state-owned fleet vehicles (with a number of state agencies excepted) is to follow this schedule:

> 40 percent by December 31, 1995
>
> 90 percent by December 31, 1997 of total fleet in high-population counties

However, it is stipulated that these mandates can be waived if they are found to be economically unfeasible.

Also under HB 2575, a $2 million fund was created to provide up to $100,000 grants to entities that build alternative fuel refueling stations that are accessible to the public. A grant program is also available to individuals who purchase and install home fueling; they may receive up to $1,000.

School districts are allowed, under this law, to use savings that result from the use of alternative fuels to convert or purchase more AFVs or to pay for fueling facilities.

TABLE 6

ALTERNATIVE FUEL CONVERSION INCENTIVES

State	Incentives
Arizona	Reduced License Tax, Tax Deduction on Purchase of AFV or Refueling Equipment
Arkansas	Rebate Program for Conversion & OEM Purchases
California	State Sales Tax Exemption State Income Tax Credit
Colorado	Tax Credit for Vehicle Conversion Fuel Excise Tax Exemption for CNG and Propane, but a Flat Fee is Assessed
Connecticut	State Sales and Use Tax Exemption Corporation Business Tax Credit
Delaware	Fuel Excise Tax Exemption for Vehicles in Alternative Fuel
Georgia	State Grants for Conversions
Iowa	Low-Interest Loans for Conversions
Louisiana	State Income Tax Credit
Maryland	Sale and Use Tax Exemption for Equipment used for Vehicle Conversion, Refueling Station Installation, Storage or Dispensing of Clean Fuels, Rechargin EVs
Montana	Tax Credit for Vehicle Conversion
Nebraska	No-Interest Loans for School Districts
Nevada	Credit System
New Mexico	State Loan Fund for Conversions of State Vehicles
New York	State Sales and Use Tax Exemption
North Dakota	Income Tax Credit for CNG Conversions
Oklahoma	State Income Tax Credit Interest-Free Loans to Government Agencies and School Districts
Oregon	Business Energy Tax Credit
Pennsylvania	State Grants for Conversions State Sales and Use Tax Exemption for EVs
Texas	Partial Fuel Excise Tax Exemption for Propane and Natural Gas Costs Financed by Alternative Fuel Supplier or Equipment Supplier Grants for Public and Private Fleet Conversions
Utah	Partial Fuel Excise Tax Exemption State Income Tax Credit State Loans for Public and Private Fleet Vehicle Conversions
Virginia	State Loans and Grants to Convert Publicly-Owned Vehicles Partial Sales Tax Exemption for Alternative-Fueled Vehicles
Washington	State Funds for Public Transit Authorities and School Districts
Wisconsin	State Funds for Cities

TABLE 7

ALTERNATIVE FUELS DEFINED

State	Definition
Arizona	LPG, CNG, LNG, Hydrogen, Electricity, Solar Energy, E85-E100, M85-M100
California	Methanol, Ethanol, Electricity, CNG, Propane or Other Low-Emission, Clean-Burning Fuel
Colorado	Propane, Natural Gas, Electricity, Hydrogen, Methanol, Ethanol and Other Fuels that Provide Comparable Air Quality Benefits
Connecticut	Natural Gas and Electricity
Delaware	Fuels Other Than Gasoline, Reformulated Gasoline, Diesel, Reformulated Diesel, Fuel Oil, Kerosene
District of Columbia	Methanol, Ethanol, M85, E85, Natural Gas, LPG and Electricity
Iowa	E85, CNG, Propane, Solar Energy and Electricity
Maryland	CNG, LNG, LPG, Hydrogen, Electricity, at Least 85 percent Methanol, Ehtanol, Other Alcohol or Ether
Louisiana	CNG, LNG, LPG, Reformulated Gasoline, Methanol, Ethanol, Electricity or any Fuels that Meet Federal Clean Air Standards
Missouri	E85-E100, M85-M100, Natural Gas, LPG, Hydrogen, Electricity or any Other Clean Fuel
Nevada	M85-M100, E85-E100, Other Alcohol Blends with 85 percent or More Alcohol, Reformulated Gasoline, Reformulated Diesel, Natural Gas, LPG, Hydrogen, Electricity, and Other Clean Fuels that Meet CARB Standards
New Mexico	Natural Gas, LPG, Electricity, Hydrogen, E85-E100, and M85-M100
New York City	E85-E100, M85-M100, Electricity, Natural Gas or any Other Fuel Determined to be Acceptable
Ohio	Ethanol, Methanol, Natural Gas, Propane, Electricity
Oklahoma	CNG, LNG, LPG, Ethanol, Electricity and any Other Clean Fuel as Defined by Emissions
Oregon	Reformulated Gasoline, Natural Gas, LPG, M85-M100, E85-E100, and Electricity
Pennsylvania	CNG, LNG, LPG, E85-E100, M85-M100, Electricity, Hythane, Hydrogen or any Fuel with Low Emissions
Texas	Natural Gas, Propane or Other Alternative Fuels with Emissions Comparable to Natural Gas
Utah	Propane, CNG, Electricity or Other Clean Fuels that Meet CAAA Standards
Virginia	Methanol, Ethanol, Other Alcohols, Reformulated Gasoline, Diesel, Natural Gases, LPG, Hydrogen, Electricity, and Other Fuels that Meet CAAA Standards
Washington	Clean Fuels are Not Defined; Vehicle Performance Standards will be Specified
West Virginia	CNG, LNG, LPG, M85-M100, E85-E100, Other Alcohol Blends with 85 percent or More Alcohol, Coal-Derived Liquid Fuels, Electricity

TABLE 8

STATE TAXES ON MOTOR FUELS

State	Gasoline	Diesel Fuel	Gasohol	CNG	Propane	Methanol	Ethanol	Electricity
Alabama	0.18	0.19	0.16	a.f.f.	a.f.f.	0.18	0.18	NA
Alaska	0.08	0.08	0.0	NA	0.0	0.0	0.0	NA
Arizona	0.18	0.18	0.18	0.01	0.18	0.18	0.18	NA
Arkansas	0.187	0.187	0.185	0.05	a.f.f.	0.185	0.185	NA
California	0.18	0.18	0.17	0.07	0.06	0.085	0.085	
Colorado	0.22	0.205	0.22	0.205[b]	0.205[b]	0.205	0.205	NA
Connecticut	0.30	0.18	0.29	0.29	0.18	0.28	0.28	NA
Delaware	0.22	0.19	0.19	0.19	0.19	0.19	0.19	NA
Dist. Columbia	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
Florida	0.118	0.21	0.118	a.f.f.	a.f.f.	0.118	0.118	NA
Georgia	0.075	0.075	0.075	0.075	0.075	0.075	0.075	NA
Hawaii	0.16	0.16	0.16	NA	0.11	0.16	0.16	NA
Idaho	0.21	0.21	0.21	0.21	a.f.f	0.21	0.21	NA
Illinois	0.19	0.215	0.19	0.19	0.19	0.19	0.19	NA
Indiana	0.15	0.16	0.15	a.f.f.	a.f.f.	0.15	0.15	NA
Iowa	0.20	0.225	0.19	0.184	0.20	0.20[c]	0.20[c]	NA
Kansas	0.18	0.20	0.18	0.17	0.17	0.20	0.20	NA
Kentucky	0.154	0.124	0.15	0.15	0.15	0.15[c]	0.154[c]	NA
Louisiana	0.20	0.20	0.20	a.f.f.	a.f.f.	0.20	0.20	NA
Maine	0.19	0.20	0.18	0.18	0.18	0.18	0.18	NA
Maryland	0.235	0.2475	0.235[d]	0.235	0.235[d]	0.235[d]	0.235[d]	NA
Massachusetts	0.21	0.21	0.21	0.21	0.096			
Michigan	0.15	0.15	0.15	0.0	0.15	0.15[c]	0.15[c]	NA
Minnesota	0.20	0.20	0.18	a.f.f.	a.f.f.	0.20	0.18	NA
Mississippi	0.182	0.182	0.182	0.182	0.17	0.182	0.182	NA
Missouri	0.1303	0.13	0.11	a.f.f.	a.f.f.	0.13[c]	0.1303[c]	NA
Montana	0.24	0.24	0.24	0.0749	a.f.f.	0.24	0.24	NA
Nebraska	0.244	0.244	0.244	0.244	0.238	0.244	0.244	NA
Nevada	0.23	0.27	0.23	0.23	0.17	0.23	0.23	NA
New Hampshire	0.187	0.187	0.18	0.18	0.18	0.18	0.18	NA
New Jersey	0.105	0.135	0.105	0.0525	0.0525	0.105	0.105	NA
New Mexico	0.20	0.18	0.20	0.18	0.18	0.18	0.18	NA
New York	0.2303[e]	0.2503[e]	0.2284[e]	0.2284[e]	0.08	0.2284[e]	0.2284[e]	NA
North Carolina	0.223	0.223	0.223	0.223	0.223	0.223	0.223	NA
North Dakota	0.17	0.17	0.17	0.17	0.17	0.17	0.17	NA
Ohio	0.22	0.22	0.21	0.22	0.22	0.22	0.22	NA
Oklahoma	0.17	0.14	0.16	a.f.f	a.f.f.	0.17	0.17	NA
Oregon	0.24	0.24	0.19	0.24	0.24	0.24	0.24	NA
Pennsylvania	0.224	0.224	0.12	0.12	0.224	0.12	0.224	NA
Rhode Island	0.28	0.28	0.26	0.0	0.28	0.28	0.28	NA
South Carolina	0.16	0.16	0.16	0.16	0.16	0.16	0.16	NA

TABLE 8 (Continued)

State	Gasoline	Diesel Fuel	Gasohol	CNG	Propane	Methanol	Ethanol	Electricity
South Dakota	0.18	0.18	0.16	0.18	0.16	0.16	0.16	NA
Tennessee	0.214	0.17	0.20	0.13	0.14	0.214	0.214	NA
Texas	0.20	0.20	0.20	a.f.f	a.f.f.	0.20[c]	0.20[c]	NA
Utah	0.19	0.19	0.19	a.f.f.	a.f.f.	0.19	0.19	a.f.f.
Vermont	0.16	0.17	0.16	a.f.f.	a.f.f.	NA	NA	NA
Virginia	0.175	0.16	0.175	0.10	0.10	0.175[c]	0.175[c]	NA
Washington	0.23	0.23	0.23	a.f.f.	a.f.f.	0.0	0.0345	NA
West Virginia	0.2535	0.2535	0.2535	0.2535	0.2535	0.2535	0.2535	NA
Wisconsin	0.232	0.232	0.232	0.232	0.232	0.232	0.232	NA
Wyoming	0.09	0.09	0.05	0.0	0.0	0.05[c]	0.05[c]	NA

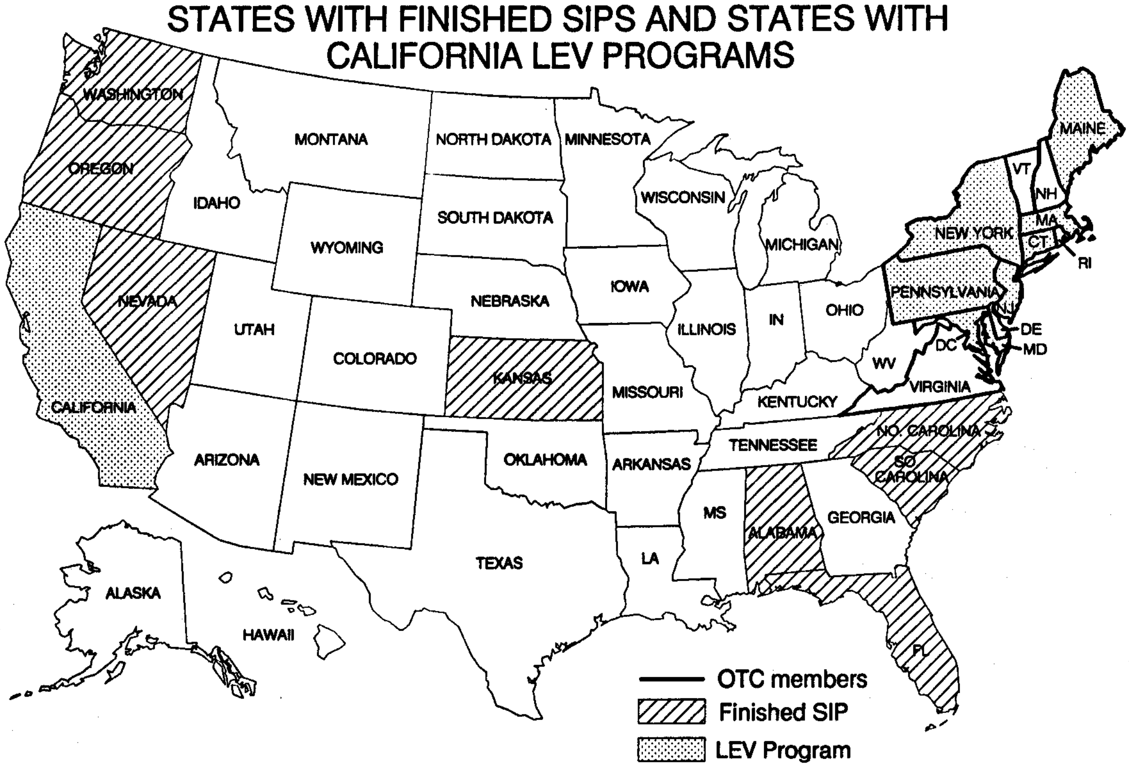
Federal Excise Taxes on Motor Fuels

		($/gal)
Gasoline		0.1840
Diesel*		0.2440
Gasohol	10% Ethanol	0.1300
	7.7% Ethanol	0.1424
	5.7% Ethanol	0.1532
Gasohol	w/ Methanol	0.1240
Propane		0.1830
Methanol	Qualified**	0.1295
	Partially Exempt***	0.1140
Ethanol	Qualified**	0.1235
	Partially Exempt***	0.1140
CNG		0.4854/mcf
LNG		0.1840

[a]Per gallon of gasoline equivalent
[b]An annual flat fee may be paid instead of the per-gallon tax
[c]Taxes on M100 and E100 have not yet been addressed
[d]Per gallon of gasoline equivalent
[e]Includes petroleum business tax
NA = Not addressed in tax code
a.f.f. = annual flat fee
All prices are per gallon or gallon equivalent
In some states, a state or local sales tax may be added
*Reduced diesel rates are specified for marine fleets, trains and certain inter-city buses. Diesel rates are also reduced for diesel/alcohol blends. Diesel used exclusively in state and local government fleets, non-profit organization vehicles, school buses and qualified local buses is exempt from federal taxes.
**Qualified - contains at least 85 percent methanol or ethanol or other alcohol produced from a subtance other than petroleum or natural gas
***Partially exempt - $\geq$85 percent alcohol and produced from natural gas

FIGURE 5

STATES WITH FINISHED SIPS AND STATES WITH CALIFORNIA LEV PROGRAMS



Other

HB 2001 takes effect September 1, 1994 requiring that ethanol-blended gasoline sold in the Phoenix area be a minimum of 10 volume percent with no waiver of the 10 psi maximum volatility limit.

ARKANSAS

In 1991, Arkansas' legislature created an Alternative Fuels Commission and an Alternative Fuels Advisory Committee to help government and private entities to increase their use of domestically produced motor fuels. The commission is charged with developing and promoting the use of alternative fuels and to help Arkansas implement a state energy strategy.

In January 1994, the Alternative Fuels Commission responsibilities were transferred to the Arkansas Energy Office.

Vehicle Conversion Incentives and Mandates

An Alternative Fuel Conversion Rebate Program was established as of December 1993. $250,000 have been allocated to the program to provide rebates to purchasers of converted and OEM vehicles (includes LPG-, CNG-, LNG-, electric-, ethanol- and methanol-powered vehicles). The rebates will cover 25 percent of the conversion costs up to $1,000. Rebates are handed out on a first-come first-serve basis until the funds are exhausted. As of mid-January 1994, several conversions had been made with the program funds.

CALIFORNIA

Alternative Fuel Use

AB 3049 mandates the south coast district to establish expedited permit review and project assistance mechanisms for facilities or projects which are directly related to R&D, demonstration, or commercialization of electric or other clean fuel vehicle technologies.

AB 3052 directs the California Energy Commission, in collaboration with other governmental agencies and private entities, to develop a consumer recharging and refueling infrastructure master plan by January 1, 1994.

Vehicle Conversion Incentives and Mandates

The Federal Clean Air Act Amendments of 1990 include the California Pilot Program which requires that a minimum of 150,000 clean fuel vehicles be produced, sold and distributed annually in the years 1996 through 1998. Beginning in 1999, 300,000 clean fuel vehicles are required annually.

CARB's standards initially require 90 Southern California service stations to provide alternative fuels for each fuel for which 20,000 vehicles are in use or for sale in California. The regulations require 200 stations for each fuel in the second year and 400 stations in the third year.

CARB has also mandated the production of electric vehicles, beginning with 2 percent of annual car sales in 1998 and increasing to 10 percent in 2003.

In 1994, AB 2910 was passed, specifying that the state shall purchase no less than the following percentages of alternative fueled vehicles for state fleet additions:

25 percent in 1996
33 percent in 1997
50 percent in 1998
75 percent in 1999 and thereafter

Sacramento County has implemented an LEV purchase requirement for fleets of 15 vehicles or more operating in Sacramento County. By year-end 1995 affected fleets will have to submit an inventory of their existing fleet. After that, total emissions from new purchases must meet or be below levels specified by the Sacramento Air Quality Management District. The levels are such that LEVs will be needed to meet them, but they are not required to be alternative-fueled. Credits will be issued to fleets whose average emission levels from new vehicle purchases are below the specified levels. Credits may be banked, sold and traded.

Other

SB 1006 requires the Energy Commission to determine the incremental cost difference between low-emission vehicles and similar gasoline or diesel-fueled vehicles. The incremental cost difference of eligible vehicles and retrofit devices is exempt from state sales taxes. The Air Resources Board is directed to identify eligible vehicles and retrofit devices. This sales tax exemption is repealed as of January 1, 1995.

SB 2600 provides a state income tax credit equal to 55 percent of the cost of converting a vehicle to a low-emission vehicle (LEV). The tax credit, limited to $1,000 per automobile or $3,500 for a commercial vehicle, also applies to the purchase of new vehicles equipped by the factory to be LEVs. The law is effective January 1, 1990 through December 31, 1994.

The South Coast Air Quality Management District (SCAQMD) has presented its management plan to bring the Los Angeles basin into attainment by the year 2007. The plan was approved by the California Air Resources Board and will be the basis of California's State Implementation Plan (SIP). The SIP must then meet EPA approval.

The plan is a three-tier strategy to gradually reduce emissions to the point where all federal air quality standards are met by the year 2007. The plan has no force of law, but significant departure from it would bring litigation and possible federal intervention.

The California Air Resources Board has adopted new standards as part of the Air Quality Management Plan. In 1994, the new standards will require the production of about 200,000 new low-emission vehicles, about 10 percent of the state's annual new car fleet. All new cars sold in the state will be required to emit 80 percent less hydrocarbon by the year 2000, and

50 to 75 percent less carbon monoxide and nitrogen oxide.

CARB has adopted specifications to define reformulated gasoline. Phase I reformulated gasoline standards, effective January 1, 1992, call for a statewide limit on Reid vapor pressure of 7.8 psi during the summer months. Detergent additives will also be required in reformulated gasolines and all grades of gasoline must be lead free.

Phase II reformulated gasoline standards, effective March 1, 1996, reduce the limit on Reid vapor pressure to 7.0 psi. Oxygen content is limited to the range of 1.8 to 2.2 weight percent. For all other parameters, which are listed in Table 9, refiners have the choice of complying with a flat limit standard or an averaging standard. The upper limit cap for each parameter applies to all refiners regardless of which standard they select for compliance.

Effective January 1, 1993, the CARB specifications for LPG motor fuel are a minimum of 80 percent by volume propane, and a maximum of 10 and 2.5 percent by volume propene and butane, respectively. Beginning January 1, 1995, the propene content is further reduced to 5 percent by volume.

CARB adopted new emissions standards as part of the Air Quality Management Plan.

The emission standards for criteria pollutants and air toxics for transitional low-emission vehicles (TLEV), LEV, and ULEV for light-duty vehicles are shown in Table 10. Federal CAAA Tier 1 and 2 standards are presented for comparison. The phase-in schedule is presented in Table 11. The California medium-duty vehicle emissions standards and phase-in schedule are summarized in Table 12. Standards for heavy-duty vehicles are anticipated by the end of 1993.

Vehicles operated for compensation--taxi cabs, buses, airport shuttles, etc.--must meet emission standards adopted by CARB. New light-duty vehicles purchased on or after January 1, 1997, and new medium-duty

TABLE 9

SPECIFICATIONS FOR CALIFORNIA PHASE II REFORMULATED GASOLINE

	Flat Limit Standard	Averaging Standard	Cap for All Gasoline
RVP, psi	7.0	-	7.0
Sulfur, ppmw	40	30	80
Aromatic HC, Vol%	25	22	30
Benzene, Vol%	1.00	0.80	1.20
Olefins, Vol%	6.0	4.0	10.0
Oxygen, Wt%	1.8- 2.2	-	2.7 (Max) 1.8 (Min)[a]
T_{90}, °F	300	290[b]	330
T_{50}, °F	210	200	220

[a]Wintertime Only
[b]Refinery Cap

TABLE 10

CALIFORNIA AND FEDERAL LIGHT-DUTY EMISSION STANDARDS
(Grams per Mile)

	TLEV	LEV	ULEV	CAAA Tier 1[a]	CAAA Tier 2[b]	CAAA 1993
NMOG	0.125	0.075	0.04			
NMHC				0.25	0.125	0.41[c]
CO	3.4	3.4	1.7	3.4	1.7	3.4
NO_x	0.4	0.2	0.2	0.4	0.2	1.0
Formaldehyde	0.015	0.015	0.008	-	-	

[a]Effective 1994
[b]Effective 2004 if adopted
[c]Total hydrocarbons

TABLE 11

REQUIRED IMPLEMENTATION RATES FOR LOW-EMISSION VEHICLES

Model Year	TLEV	LEV	ULEV	ZEV*
1994	10 %			
1995	15			
1996	20			
1997		25 %	2 %	
1998		48	2	2 %
1999		73	2	2
2000		96	2	2
2001		90	5	5
2002		85	10	5
2003		75	15	10

*The percentage requirements for ZEVs are mandatory.

TABLE 12

CALIFORNIA MEDIUM-DUTY VEHICLE EMISSION STANDARDS
(120,000 Mile Standards, Grams per Mile)

Vehicle Weight, Lbs	NMOG	CO	NO_x	PM
0 - 3,750				
Year 1995+	0.36	5.0	0.55	0.08
LEV	0.18	5.0	0.6	0.08
ULEV	0.107	2.5	0.3	0.04
3,751 - 5,750				
Year 1995+	0.46	6.4	0.98	0.10
LEV	0.23	6.4	1.0	0.10
ULEV	0.143	3.2	0.5	0.05
5,751 - 8,500				
Year 1995+	0.56	7.3	1.53	0.12
LEV	0.28	7.3	1.5	0.12
ULEV	0.167	3.7	0.8	0.06
8,501 - 10,000				
Year 1995+	0.66	8.1	1.81	0.12
LEV	0.33	8.1	1.8	0.12
ULEV	0.197	4.1	0.9	0.06
10,001 - 14,000				
Year 1995+	0.86	10.3	2.77	0.12
LEV	0.43	10.3	2.8	0.12
ULEV	0.257	5.2	1.4	0.06

Note: Beginning in 1998 a minimum percentage of all medium-duty vehicles will be required to be certified as low-emission vehicles according to the following schedule:

Year	LEV	ULEV
1998	25%	2%
1999	50%	2%
2000	75%	2%
2001	95%	5%
2002	90%	10%
2003	85%	15%

vehicles purchased on or after January 1, 1998 must be low emission vehicles.

SB 1123 requires that 25 percent of the vehicles purchased by the Department of General Services must be low-emission vehicles (as defined in 1989).

SB 2331 allows districts in nonattainment of state ambient air quality standards for ozone or carbon monoxide to adopt regulations requiring public and commercial fleet operators to purchase low-emission vehicles (LEVs) and to operate them on an alternative, cleaner burning fuel. The law defines fleets as 10 or more vehicles under common ownership or operation, but exempts rental vehicles and emergency vehicles. The state board (CARB) is directed to develop model regulations as a guide for the districts.

The San Francisco Bay area has petitioned the EPA to be reclassified as an attainment area for the national ozone standard.

AB 2766 authorizes a motor vehicle registration surcharge of $2.00 per vehicle, effective April 1992. These fees will be used to fund 14 alternative fuel projects in the SCAQMD. In 1993, the surcharge increases to $4.00 per vehicle.

AB 3236 provides up to $5 million of funding for special employment training research projects that encourage the development of new industries, including the electric, clean fuel, and advanced transportation industries, while contributing to highly-skilled employment.

COLORADO

Vehicle Conversion Incentives and Mandates

Between July 1, 1992 and June 30, 1998, HB 1191 provides a 5 percent tax credit to vehicle owners who convert their vehicles to run on an alternative fuel or purchase a clean fuel vehicle. The credit cannot exceed 50 percent of the actual cost of the conversion or the incremental cost of the manufacturer's original equipment, and is limited to a total of 50 cars and trucks for each taxable year. Until June 30, 1994, the credit may be taken only for vehicles used in connection with a business.

Regulation 17, effective June 30, 1994, establishes a Clean Fuel Fleet Program (CFFP) applicable to covered fleets of 10 or more in the Denver/Boulder nonattainment area. Beginning in model-year 1998, covered fleets must conform to the following schedule for new vehicle purchases:

- LDVs (<8,500-pound GVW)
  - 30% AFVs in 1998
  - 50% AFVs in 1999
  - 70% AFVs in 2000+
- HDVs (8,500 to 26,000-Pound GVW)
  - 50% AFVs in 1998+

RFG is included in the definition of alternative fuel. Exempt vehicles include (but are not limited to) emergency, off-road and law enforcement vehicles.

Purchasing requirements may be met through the use of converted vehicles or credits.

A credit program is established to allow eligible participants to earn, bank, trade, sell or purchase credits within the Denver/Boulder nonattainment area in order to satisfy the CFFP purchase requirements. Credits may be earned by purchasing/converting early, in excess, exempt vehicles, or ULEVs or ZEVs.

Denver's City Council has passed an ordinance requiring all fleets of 30 or more vehicles to convert 10 percent of their vehicles to clean burning fuels by December 31, 1992. The council banned the sale of leaded gasoline effective January 1, 1991.

Other

Regulation 14 calls for state certification of alternative fuels conversion systems for high altitudes.

The Colorado Department of Health has removed certification rights from one manufacturer's open-loop conversion kit for passenger vehicles, following a report that found converted CNG and propane vehicles were not consistently meeting EPA tailpipe emissions standards for gasoline-powered vehicles.

Announcement appeared in the April 1994 *Federal Register* that the Denver/Boulder area may increase summertime (May 1-September 15) gasoline volatility limits from 7.8 psi to 9.0 psi.

The governor asked the EPA in July 1994 to declare Denver a "serious" nonattainment area for CO pollution, so that it will have 5 extra years--until 2000--to achieve national air pollution requirements, which would otherwise have to be met by 1995.

State Implementation Plan

Colorado's SIP currently includes the use of RFG and clean diesel, and calls for an increase from 2.7 percent to an average of 3.1 percent in the oxygen content of motor fuels sold in winter months along the State's Front Range.

CONNECTICUT

Alternative Fuel Use

Under PA 92-188, natural gas and electricity may be given a price preference of up to 10 percent by the state in purchasing motor vehicles.

Vehicle Conversion Incentives and Mandates

PA 93-199, signed in June 1993 continues the 10 percent tax credit under the corporation business tax and the exemption from the sales and use tax, both enacted in 1991, for natural gas fill station equipment, conversion equipment or the incremental cost of a new vehicle powered by natural gas and electricity for income years and sales prior to January 1, 1998.

PA 93-199 also authorizes the state to provide loans or lines of credit, for working or development capital, to businesses which convert conventionally-fueled vehicles to a clean-burning alternative fuel. In this case clean-burning alternative fuel is not limited to natural gas and electricity.

PA 93-37 was passed in 1993, mandating that at least 10 percent of the state's fleet purchases in 1993-1994 be powered by either natural gas or electricity.

Public Act 94-170 takes effect July 1, 1994 and allows a corporate tax credit of 50 percent of construction costs for refilling stations that provide CNG, LPG or LNG. A corporate tax credit is also allowed for 50 percent of costs for converting vehicles to CNG, LPG, LNG or electricity. All incentives expire December 31, 1998.

Also under PA 94-170, it is required that any mobile emission reduction credits program the state comes up with must include all eligible vehicle conversions, even if the conversion took place before the credit program began.

Fuel Production and Tax Incentives

The state provides a $0.01 per gallon motor vehicle fuel tax exemption for gasoline blended with 10 percent volume ethanol or methanol through January 1, 1997. Propane is taxed at $0.18 per gallon, substantially lower than the tax on gasoline, under PA 93-93. Exemptions from the tax include cities, transit districts, farms, and the United States Government.

From July 1, 1994 until July 1, 1999 CNG, LPG and LNG are exempted from the motor fuels tax when sold for use in covered fleets, this under PA 94-170.

Effective October 1, 1994, under PA 94-101, gas companies shall exempt income from sales of natural gas as motor vehicle fuel from their gross income taxable under the utility companies tax. The exemption applies to income years starting before January 1, 2000.

Other

The governor has notified the EPA that it will opt-in to the federal reformulated gasoline program set for 1995 under the CAAA.

The Hartford carbon monoxide nonattainment area is seeking redesignation; the area has stopped enforcing the federal program to use oxygenated gasoline. If a CO violation occurs, the oxy-fuel program will be reinstated immediately.

DELAWARE

Alternative Fuel Use

HB 51, in effect from October 1993 through the end of 1995, authorizes a program to demonstrate the commercial feasibility of alternatively-fueled vehicles. Combustible gases and liquids used in these programs are exempt from Delaware's $0.19 per gallon motor fuel excise tax. Testing, pilot and demonstration programs in which fuel economy, performance and air emissions data are collected are authorized under the bill. The number of vehicles involved in the program is limited to not greater than 10 vehicles or 10 percent of the taxpayer's vehicles propelled by a fuel subject to the State Motor Fuel Tax. Alternative fuels are defined as those other than gasoline, reformulated gasoline, diesel fuel, reformulated diesel fuel, fuel oil or kerosene.

Vehicle Conversion Incentives and Mandates

The state has implemented a program to fund a limited number of AFV conversions for state and local government fleets utilizing oil overcharge funds.

Other

The governor has agreed to consider the adoption of the California Low Emission Vehicle program to satisfy provisions of the Clean Air Act Amendments of 1990.

The governor has agreed to opt-in to the federal reformulated gasoline program for nonattainment areas in the state.

DISTRICT OF COLUMBIA

Vehicle Conversion Incentives and Mandates

In 1990, the District of Columbia City Council adopted the Alternative Fuels Technology Act. This required fleet operators to phase in clean fuel vehicles beginning in 1993, but in 1993 the effective date was delayed 2 years. Only commercial vehicles powered by a clean alternative fuel were to be allowed to operate in the central employment area between sunrise and sunset from May 1 to September 15 starting in the year 2000.

In early 1994, the City Council rejected the Alternative Fuels Technology Act of 1990 and pledged to come up with a new act to meet the needs of the Clean Air Act Amendments of 1990 and the Energy Policy Act of 1992. The rejection was the result of pressure from fleet owners and operators who complained of the serious financial strain the Alternative Fuels Technology Act would have placed on them.

Other

The mayor has agreed to opt-in to the federal reformulated gasoline program for nonattainment areas.

FLORIDA

HB 1045, signed into law in 1993, authorizes funding to investigate opportunities for solar electric vehicles, as part of Florida's state energy policy.

Florida's governor, under Executive Order 93-278, has created the Florida Gold Coast Clean Cities Coalition. The coalition is mandated to submit a plan, by January 1994, for converting or replacing 30,000 conventionally-fueled vehicles with alternatively-fueled vehicles in Broward, Dade and Palm Beach Counties by December 31, 1996.

GEORGIA

Vehicle Conversion Incentives and Mandates

The Alternative Transportation Fuels Program offers incentives to local governments and public transit authorities to convert their vehicles to alternative fuels including CNG, LPG, ethanol, methanol and electricity. EPA has approved funding of $400,000 for the 3-year program, which began in 1993.

Guidelines of the Environmental Protection Division of the Georgia Department of Natural Resources require 75 percent of state-operated vehicles to be AFVs by 2000.

HAWAII

Ethanol Production and Tax Incentives

Hawaii has exempted gasohol from the 4.0 percent excise tax imposed on retail sales. The exemption for gasohol containing at least 10 percent by volume denatured biomass-derived ethanol has no set termination date.

Beginning July 1, 1996, gasoline sold in Hawaii will be required to be 10 volume percent ethanol-blends. Fines can be imposed on marketers who sell non-conforming fuel, up to a maximum penalty of $10,000.

IDAHO

Fuel Production and Tax Incentives

In 1994, HB 627 was passed, raising the excise tax on gasoline by $0.03, to $0.21 per gallon, and partially exempting ethanol-blended fuels from the excise tax. The tax rate for ethanol-blended fuels may be reduced by a maximum of 10 percent.

ILLINOIS

Ethanol Production and Tax Incentive

Under SB 1364, the Gasohol Fuels Tax Abatement Act, gasohol is exempt from 30 percent of the state sales tax on gasoline from January 1, 1990 through June 30, 1996 and from 15 percent of the tax from July 1, 1996 to July 1, 1999. However, the sales tax exemption will remain at 30 percent through 1999 if the total quantity of motor fuel sold in the state on average contains the following volume percentages of ethanol:

4 percent in 1995
4.6 percent in 1996
5.0 percent in 1997

The exemption means that purchasers of gasohol pay 4.4 percent sales tax instead of the levied 6.25 percent on gasoline purchases.

Other

HB 2368 requires all vehicles owned or leased by any state college or university to operate on gasoline blended with 10 percent ethanol whenever it is available, effective July 1, 1992. This is accomplished through centralized refueling facilities which stock gasohol. Actual gasohol use is tracked through the use of fuel log books in each vehicle.

INDIANA

Fuel Production and Tax Incentives

HB 1547, signed into law in April 1993, allows soydiesel to have price procurement preference of 10 percent for purchases by state and local governments of fuel that is at least 20 percent by volume soydiesel.

Other

SB 516 requires that the Indiana Department of Commerce establish specific goals for the use of alternative-fueled vehicles in state fleets by January 1, 1994. The department is also required to establish guidelines for achieving the goals. As of mid-1993, the plan is to meet the federal energy policy state fleets requirements. The department is setting up an alternative fuels testing and demonstration program to determine if Indiana should be more aggressive in alternative fuel mandates than federal law.

Published in the July 8, 1994 *Federal Register*, three marginal ozone nonattainment areas have been redesignated as in attainment: Evansville, Indianapolis, South Bend/Elkhart. Contingency measures for future exceedences include low-RVP gasoline, RFG and Stage II vapor recovery systems.

After reviewing comments on its proposed redesignation of several Indiana counties, EPA has affirmed attainment status for ozone for St. Joseph, Elkhart and Marion Counties. Notice was published in the October 31, 1994 *Federal Register*.

IOWA

SF 545 requires government vehicles to publicize (via stickers) that they are running on ethanol-blended gasoline.

Vehicle Conversion Incentives and Mandates

SF 508 signed in 1991 requires that beginning July 1, 1992, at least 5 percent of all new passenger vehicles and light pickup trucks purchased by state agencies must operate on an alternative fuel such as E85, compressed natural gas, propane, solar energy or electricity. The minimum goes to 10 percent on July 1, 1994. Iowa state agencies have 80 E85 (or higher ethanol) cars in operation or on order for FY 1994. This exceeds the 5 percent required by law.

The State's Energy Bank programs provide financing for the purchase of alternative fuel vehicles or vehicle conversions to: state and local government agencies, school districts, community colleges and nonprofit organizations. Financing is provided through low-interest loans. In May 1994, the state sponsored four high-blend ethanol vehicles in local government law enforcement fleets.

Other

SF 545, signed in June 1991, establishes a Renewable Fuels Office in the Iowa Department of Agriculture and Land Stewardship which will administer programs to promote, develop and research renewable fuels. The bill contains a requirement that all state owned and operated vehicles must use 10 percent or greater ethanol blend fuels. All other government agencies (county and city) must comply by January 1, 1993.

KANSAS

Vehicle Conversion Incentives and Mandates

Executive Order 92-152 directs all state agencies to use alternative fuels in state vehicles when it is cost effective to do so. Otherwise, state fleet vehicles are required to use ethanol-blended fuel.

Ethanol Production and Tax Incentive

Kansas provides a $2.5 million per year producer incentive, with a maximum of $0.20 per gallon, for Kansas ethanol producers. The incentive is valid until July 1, 1997.

Other

The Senate Transportation and Utilities Committee has designated the Kansas Corporation Commission (KCC) as the lead agency in matters pertaining to alternative fuels under SB 799. KCC is charged with developing a statewide plan and program for alternative fueled vehicles, including a timetable and criteria for the conversion of vehicles to alternative fuels. A final report and recommendations are due to the governor and legislature by the first day of the 1996 legislative session.

KENTUCKY

Kentucky's governor has announced that the state will require sale of RFG in nonattainment areas beginning in 1995. Federal approval has been granted.

The areas of Owensboro and Edmonson Counties have been redesignated as in attainment for ozone. They were "marginal" nonattainment areas.

HB 135, enacted March 1994, allows for a 1 psi increase in vapor pressure limit for 10 percent ethanol-blended gasoline.

LOUISIANA

Vehicle Conversion Incentives and Mandates

Act 927 of 1990 requires, beginning September 1, 1991 that all vehicles purchased or leased by state agencies must run on an alternative fuel. By September 1, 1994, at least 30 percent of the state's fleet must be converted to an alternative fuel. On September 1, 1996 the specified number is 50 percent, and on September 1, 1998 it goes to 80 percent. The target conversions can be reduced if an agency's vehicles will be operating primarily in an area where sufficient refueling infrastructure to provide the alternate fuel does not exist or if net costs of converting and operating alternative fuel vehicles would exceed the costs of using traditional gasoline or diesel fuels measured over the expected useful life of the equipment and facilities. The law applies to law enforcement vehicles and emergency vehicles as well.

Because the cost of converted vehicles is higher than conventional vehicles, only a handful of vehicles have actually been converted under this law (as of mid-1994).

In addition, a parallel law, Act 954 of 1990, has the same provisions for vehicles owned by political subdivisions in the state.

Senate Concurrent Resolution 79 requests that funding be prioritized to give first priority to long-term projects such as filling stations for alternative fuels, and as funding permits, short-term projects such as vehicle conversions.

Act 1060 of 1991, effective January 1, 1991, provides an income tax credit for alternative fuel vehicles and fueling infrastructure costs. A tax credit can be claimed for 20 percent of the cost of the equipment to convert a vehicle to an alternative fuel as well as property which is directly related to the delivery of an alternative fuel to such a vehicle (fueling infrastructure costs). In the case of a vehicle originally equipped to operate on an alternative fuel, the credit is an amount not to exceed the lesser of 20 percent of 10 percent of the cost of the vehicle or $1,500 or 20 percent of the cost of the portion of the vehicle related to fuel delivery, storage and use.

Executive Order EWE93-9, signed in March 1993, required the Louisiana Department of Natural Resources to prepare and issue Request for Proposals to solicit bids for conversion of 25 percent of the state motor vehicle fleet to CNG, LNG or LPG.

Ecogas, Inc. was selected as the successful bidder. The contract was signed in December 1993, calling for Ecogas to convert a minimum of 500 state vehicles to CNG or LNG and to build a minimum of eight CNG/LNG refueling stations. At its option, the state may extend the number of converted vehicles to 1,500.

As of September 1994, approximately 140 vehicles had been converted to CNG; two temporary CNG/LNG refueling stations were in operation, one in New Orleans and one in Baton Rouge.

In January 1994 a 5-year low-interest revolving loan program was set up to assist state and local governmental agencies (including school districts) to convert a portion of their fleets to CNG, LNG or LPG. Funds are provided from the Exxon Petroleum Violation Escrow Fund, administered by DOE. Loans of up to $100,000 are available for building refueling stations. Eligible vehicles include retrofits only and loans of up to $3,000 are available per vehicle.

Fuel Production and Tax Incentives

Louisiana law prohibits the state from subsidizing the production of compressed natural gas, liquefied petroleum gas, reformulated gasoline, methanol or ethanol. The state has also deregulated the direct sales of natural gas used for motor vehicle fuel Act 531 of 1990).

Act 666 of 1993 set the special fuels tax rate at $0.16 per gasoline equivalent gallon; the motor fuel tax on gasoline is $0.20 per gallon.

Act 7 of 1994 lowers the special fuels tax for school buses to one-half the rate specified for other vehicles.

MAINE

Chapter 358, signed into law in June 1993, outlines the conditions required for Maine to adopt the California LEV standards. The LEV emission standards may be adopted only when Massachusetts, Connecticut and at least one other New England State, excluding Maine, have adopted the LEV program.

In addition, jurisdictions comprising more than 60 percent of the total registrations of new passenger cars and light-duty trucks in the ozone transport region must have adopted the LEV program effective no later than motor vehicle model-year 1998. The ozone transport region includes the States of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont, and the consolidated metropolitan statistical area that includes the District of Columbia.

The LEV program cannot be implemented if it includes the adoption of any type of reformulated gasoline other than the federal reformulated gasoline that is certified for sale and use in states other than California.

The governor has elected to opt-in to the federal reformulated gasoline program for the entire state. Two counties opted-out just before the start of the RFG program January 1, 1995.

MARYLAND

Alternative Fuel Use

HB 1361 provides a sales- and use-tax exemption for equipment and machinery that is used for vehicle conversion, refueling station construction, and storage or dispensing of clean fuels. In addition, the exemption applies to the recharging of a motor vehicle propelled by electricity. Clean fuels are defined as natural gas, LNG, LPG, hydrogen, electricity, at least 85 percent methanol, ethanol, other alcohol or ethers. The exemption is in effect from July 1, 1993 through June 30, 1999.

SB 773 provides a property tax exemption for clean fuel (as defined above) refueling equipment or machinery. Such equipment is not subject to property tax for taxable years 1994 through 1997. After that the property tax for such equipment is the tax rate applied to 20 percent of the assessed value in 1998, 40 percent in 1999, 60 percent in 2000, 80 percent in 2001 and 100 percent in 2002 and thereafter.

Fuel Production and Tax Incentives

SB 775, signed in May 1993, changes the tax rate for alternative fuels, as defined under the Energy Policy Act of 1992, from $0.245 per gallon to $0.235 per gasoline equivalent gallon.

Other

The governor has agreed to adopt the California low emission vehicle program under provisions in the Clean Air Act Amendments of 1990. In May 1993, SB 345 was passed, permitting the California LEV program to be implemented under certain conditions.

The governor has agreed to opt-in to the federal reformulated gasoline program for nonattainment areas in the state. Beginning in 1992, all gasoline sold in nonattainment areas must contain a minimum of 2.7 weight percent oxygen during the control period of November 1 through February 29 of each year.

Maryland has put into effect a regulation to set a reduced distillation midpoint (T_{50}) for oxygenated gasoline blends at 150^{o}F (conventional gasoline is at 170^{o}F).

State Implementation Plan

Maryland's revised SIP establishes and requires the implementation of an Oxygenated Gasoline Program in three control areas: the Northeast, Baltimore and Washington Oxygenated Gasoline Control Areas. These areas will also be required to sell RFG as of January 1, 1995.

MASSACHUSETTS

Massachusetts has adopted the California low emission vehicle program under provisions in the Clean Air Act Amendments of 1990. The program is scheduled to begin in 1995.

The governor has notified the EPA that the state will opt-in to the federal reformulated gasoline program set for 1995 under the CAAA. The requirement will be enforced statewide.

It was announced that the state would not enforce an oxygenated fuels program in the Boston area during the 1993-1994 season. No program was enforced in the 1992-1993 season either, in conflict with EPA requirements. A wintertime oxygenated fuels program is proposed for the 1994-1995 season.

Included in the Massachusetts Innovative Market Program for Air Credit Trading are emission reduction credits for fleet conversions to clean fuels.

MICHIGAN

The state will not opt-in to the federal RFG program but will require low-RVP gasoline in ozone nonattainment areas.

MINNESOTA

Ethanol Production and Tax Incentives

Minnesota provides a $0.02 per gallon tax exemption for 10 percent ethanol blends. Minnesota ethanol producers receive $0.20 per gallon of ethanol produced to a maximum of $3 million per producer until June 30, 2000. The producer subsidy, paid from the Ethanol Development Fund, has an annual cap of $8.55 million. However, for the biennium beginning July 1, 1991 and ending June 30, 1993, the cap is reduced to $4.5 million per year. After 1993, the cap goes back to $8.55 million.

In lieu of the above tax credits, a distributor is allowed a tax credit of $0.80 for every gallon of ethanol blended with gasoline and sold to state or local governments and school districts.

During the winter months, all gasoline dispensed in the state must be blended 10 percent with ethanol.

Other

SB 771 and HB 931, signed in May 1993, raise the minimum oxygen requirements to at least 2.7 weight percent (from 2.0 weight percent) in carbon monoxide control areas, during carbon monoxide control periods beginning October 1, 1993, at any time in a carbon monoxide control area beginning October 1, 1995, and in all gasoline sold in the state beginning October 1, 1997.

Duluth has decided not to comply with the federal oxy-fuels program requirements for the 1993/1994 season. It has submitted a proposal to the EPA, asking to be allowed to quit the oxy-fuels program.

MISSOURI

Vehicle Conversion Incentives and Mandates

HB 45 requires state agencies with more than 15 vehicles to purchase alternative fuel vehicles or convert conventional vehicles to an alternative fuel on the following schedule:

- 10 percent by July 1, 1996
- 30 percent by July 1, 1998
- 50 percent by July 1, 2000

By July 1, 2002, 30 percent of state owned alternative fuel vehicles must operate solely on the alternative fuel. The cost of the vehicles may not exceed the cost of other vehicles by more than 5 percent, using life-cycle costing methods. Alternative fuels which best satisfy the goals of energy conservation and emissions reductions would be recommended for state use. Funding for the Missouri Department of Natural Resources to implement the alternative fuel provisions of this proposal was approved in FY 1994.

Other

HB 611 requires state owned vehicles equipped to operate on gasoline to use a fuel ethanol blend when available at a competitive price. This bill also establishes the Missouri Ethanol and Other Renewable Fuel Sources Commission to promote the continued production of ethanol and use of ethanol and ethanol blends.

Kansas City has won redesignation from EPA as an area that no longer violates federal ozone standards.

MONTANA

Vehicle Conversion Incentives and Mandates

A tax credit is available to individuals and businesses for converting vehicles to operate on alternative fuels. Up to 50 percent of the cost of conversion may be credited, but is not to exceed $500 for vehicles with a GVW of 10,000 pounds or less, or $1,000 for a vehicle with a GVW of over 10,000 pounds.

Ethanol Production and Tax Incentives

A $0.30 per gallon incentive for fuel ethanol produced in Montana is provided until the year 2001, if the state highway department is given 18 months notice of new facilities coming on-line. Funding of $6 million per year is provided.

Other

State vehicles are required to use ethanol-blended gasoline when economically feasible.

NEBRASKA

Vehicle Conversion Incentives and Mandates

In 1994, the Nebraska Energy Office expanded its no-interest loan program for public schools to convert to alternative fuel vehicles any vehicles used to transport students or staff, to include the purchase of AFVs.

The program also covers purchasing costs incurred in establishing an alternate fuel refueling facility. There are no maximum loan limits, but the loan must be paid within 10 years.

Under the Dollar and Energy Saving Loan Program, a low-interest (5 percent) loan may be obtained by individuals and entities for alternate fuel activities such as converting or purchasing alternative fuel vehicles or purchasing refueling equipment. The maximum loan amount is $150,000.

For both the Dollar and Energy Saving Loan Program and the School District Energy Efficiency Program, alternate fuels are defined as: ethanol, methanol, electricity, CNG, propane, and any other alternate fuel approved and recognized by the United States DOE.

Ethanol Production and Tax Incentives

Effective July 1, 1992, LB 754 extends the state $0.20 per gallon ethanol producer incentive through December 31, 2000, and provides a $0.50 per gallon incentive for ETBE.

Other

In 1987 a planning board was established to oversee the ethanol industry and an excise tax of up to 7.5 mills per bushel of wheat, 4 mills per bushel of corn and $0.01 per hundred weight of sorghum was levied to fund the program.

LB 364 became effective September 1, 1993, merging the Ethanol Authority and Development Board and the Gasohol Committee together under the new name, the Nebraska Ethanol Board.

Nebraska's LB 1124 requires all gasoline sold in nonattainment areas in Nebraska to be reformulated with a minimum oxygen content of 3.1 percent (weight) and a maximum aromatic content of 20 percent, effective January 1, 1992. However, as of mid-1993, Nebraska does not have any nonattainment areas.

NEVADA

Vehicle Conversion Incentives and Mandates

AB 812 mandates the use of alternative fuels in public fleets owned or operated in counties with a population of 100,000 or more. Counties affected must begin phasing in alternative fuel vehicles as follows:

FY 1995, 10 percent
FY 1996, 15 percent
FY 1997, 25 percent
FY 1998, 50 percent
FY 1999, 75 percent
FY 2000 and thereafter, 90 percent

Fleets affected include those with 10 or more vehicles, buses, and heavy-duty vehicles. The restrictions on AFVs allow flexible-fuel vehicles as long as the vehicles uses a clean fuel whenever possible.

A credit system is included in the regulation which encourages early phase-in and construction of refueling stations. The commission director has discretion on exemption when it is impossible for compliance. The definition of alternative fuel includes reformulated gasoline.

Other

Clark County (Las Vegas) and Washoe County (Reno) have both adopted winter oxy-fuels regulations. In Las Vegas, only fuels containing at least 2.7 percent (weight) oxygen shall be sold from October 1, 1991 to February 28. Reno has a requirement of 2.7 percent oxygen content to be sold from October 1 through January 31.

NEW HAMPSHIRE

The governor has agreed to propose and introduce legislation to adopt the California low emission vehicle program.

The governor has agreed to opt-in to the federal reformulated gasoline program for the entire state.

State Implementation Plan

Chapter 302 was passed in June 1994 and will be integrated into the State's SIP. It establishes an Inherently Low-Emissions Vehicle (ILEV) Program for the entire state. ILEV purchases are mandated for federal, state, local, and private fleets of 50 or more vehicles, and utility fleets of 10 or more vehicles. Heavy-duty vehicles will face purchase mandates also. Transitional ILEVs are allowed until the year 2000. The beginnings of the phase-in schedules are as follows:

LDV: Federal - 25% of 1995 model-year purchases

Utilities - 30% of 1997

State - 15% of 1997

Municipal/private - 30% of 1999

HDV: Federal - 25% of 1995

Rest - 50% of 1998

A heavy-duty vehicle is defined as a GVW of 8,501 to 26,000 pounds. Excess and advance vehicle purchases may be banked for use against future purchase requirements. Emission reduction credits may also be obtained for non-mandated conversions.

NEW JERSEY

In March 1993, with the passing of SB 1346, the California LEV program was adopted under provisions in the Clean Air Act Amendments of 1990. The program will take effect in 1998, but only if other states in the region have also adopted LEV programs.

The governor has asked the federal EPA to include all areas of the state in the federal reformulated gasoline program. This program is scheduled to take effect in 1995.

NEW MEXICO

Vehicle Conversion Incentives and Mandates

HB 404, the Alternative Fuel Conversion Act, mandates that at least 30 percent of new state vehicles be converted to alternative fuels beginning in mid-1993. The following year the percentage rises to 60 percent, and in the third year, 100 percent of new state vehicles must be capable of running on alternative fuels.

A loan fund was also enacted under HB 404 to finance conversions. However, as of May 1994, no money had yet been allocated to the fund which was originally proposed to be $5 million.

From July 1990 through December 1993, the Department of Energy, Minerals and Natural Resources, through its Transportation Program, awarded approximately $1.35 million in grants to convert municipal, state and school district vehicles to CNG and propane. Over 270 vehicles have been converted as of mid-1994 through the Transportation Programs and the CNG School Bus Program since 1990. The City of Santa Fe has one of the first totally dedicated CNG municipal transit systems in the nation, consisting of 17 buses.

State Implementation Plan

If the Albuquerque/Bernalillo County area has not reached CO attainment by December 31, 1995, the SIP calls for adoption of a 3.0 weight percent oxygen standard for ethanol blends (and 2.7 weight percent for MTBE blends) starting November 1, 1996.

NEW YORK

Alternative Fuel Use

The New York Port Authority has amended its regulations to allow vehicles fueled with CNG or methanol to travel through the tunnels and the lower level of the George Washington Bridge. Vehicles using these fuels are prohibited unless they display signs clearly indicating the type of fuel being used.

The state energy plan calls for a 50 percent increase in the use of natural gas by the year 2008. The plan advocates the acceleration of state government demonstrations of clean transportation fuels and encourages the use of CNG. A 6-year, $40 million program calls for the operation of 268 vehicles on alternative fuels.

New York City has adopted a plan to convert the city's vehicle fleet to alternative fuels. Public Law No. 6 calls for a 1 year demonstration program involving the purchase of 385 alternative fuel vehicles. The demonstration will include testing of compressed natural gas, methanol and electric vehicles. LPG is not being tested at this time because the City Fire Department does not allow LPG tanks to be filled in the city.

If an evaluation shows that the vehicles are 20 percent cleaner and that operating costs are within 5 percent of the conventional fleet costs, mandatory purchases of alternative fuel vehicles will commence. The goal for purchases as a percentage of total replacement purchases is:

- 30 percent by June 30, 1994
- 60 percent by June 30, 1995
- 80 percent by June 30, 1996 and each year thereafter

Vehicle Conversion Incentives and Mandates

S 7424 exempts from the state sales and use tax the cost of converting a vehicle to an alternative fuel. Also exempt is the incremental cost of a new alternative fuel vehicle. The law applies to dual-fuel and dedicated AFVs that run on M85 to M100, E85 to E100, propane, hydrogen, natural gas or electricity. The tax incentive will expire in 1997.

Other

In 1992, the state adopted California's low emission vehicle program to begin with 1995 model-year vehicles. This was done under provisions of the Clean Air Act. The American Automobile Manufacturer's Association filed a suit against the state for adopting the California LEV program and federal RFG standards, claiming that this would require the development of a third set of automobile design standards, which is prohibited under the CAAA. The United States District Court ruled in favor of the automobile manufacturers, temporarily barring the state from implementing its LEV program.

In February 1994, a Federal Appeals Court upheld the state's right to adopt the California program. However, the state will have to wait until the 1996 model-year before it can implement the first phase of the program.

The governor has agreed to opt-in to the federal reformulated gasoline program for nonattainment areas in the state. Just before implementation of the RFG program January 1, 1995, nine counties opted-out of the program.

Notice was published in the September 29, 1993 *Federal Register* of the EPA's action redesignating Syracuse as an attainment area. This is the first CO nonattainment area to be redesignated as an attainment area.

Poughkeepsie's ozone attainment status has been reclassified from marginal to moderate. An SIP must be approved for Poughkeepsie by November 15, 1995.

NORTH CAROLINA

Ethanol Production and Tax Incentives

North Carolina has a corporate or personal income tax credit (20 percent of the costs of installation and construction, with an additional 10 percent credit allowed if the plant is designed to use agricultural and forestry products, waste petroleum products, and peat as its fuel source) for the construction of new fuel ethanol plants in the state using agricultural or forestry products as feedstocks.

Other

SB 1197 implements the reformulated gasoline requirements of the Clean Air Act Amendments of 1990.

The Greensboro, Winston Salem section of North Carolina has won EPA redesignation as an area that no longer violates federal ozone standards.

For CO nonattainment areas, North Carolina requires oxygenated gasoline to contain a minimum 2.7 weight percent oxygen content from November through February.

NORTH DAKOTA

Alternative Fuel Use

Through the State Energy Conservation Program, the state will purchase or convert at least 10 public service vehicles to CNG operation.

Vehicle Conversion Incentives and Mandates

Chapter 555 was added to the laws of North Dakota in 1993, providing for a 10 percent income tax credit for vehicles converted to CNG.

Fuel Production and Tax Incentives

HB 1016 was signed into law in May 1993, providing funds for the alcohol motor vehicle fuel fund as well as an appropriation of $3,650,000 for defraying costs from ethanol production incentives.

Other

North Dakota state vehicle fleet operations have a policy of purchasing ethanol-blended fuel for use in state vehicles when the price is within $0.02 per gallon of the price for unleaded gasoline.

OHIO

Fuel Production and Tax Incentives

Under HB 154, the qualified fuel (ethanol) credit is extended from September 30, 1993 through September 30, 2000. However, the credit is now reduced from $0.15 per gallon to $0.10 per gallon ethanol.

Other

HB 201 created an Alternative Fuels Advisory Council to make a full and complete study of the potential for using alternative transportation fuels in Ohio. Alternative fuels include ethanol, methanol, natural gas, propane and electricity. The study's target completion date is June 30, 1994.

Cleveland has submitted a proposal to the EPA to quit the federal oxy-fuels program. It did not participate in the program in the 1993/1994 season although it has not yet received approval to quit.

OKLAHOMA

Vehicle Conversion Incentives and Mandates

Oklahoma provides interest free funds to government entities and school districts to convert vehicles to alternative fuels. Under the Oklahoma Alternative Fuels Act the Oklahoma Alternative Fuels Conversion Fund, a revolving fund, is established, providing no-interest loans for the conversion of government and school vehicles. Reimbursements to participants, up to $5,000 per vehicle, are paid back over a maximum 7-year period through a surcharge levied on the alternative fuel. The surcharge is an amount equal to the fuel cost savings over gasoline.

The conversion fund awarded in late-1994 a $558,720 loan to convert 102 vehicles to operate on CNG and to install two fueling facilities in the City of Ardmore.

HB 1193 authorized that installation of fueling facilities would be eligible for the no-interest loans in amounts up to $100,000. The bill increased the tax credit for conversions and fueling facilities to 50 percent (up from 20 percent allowed under HB 2169), or $1,500 in the case of a new OEM vehicle. In January 1997, the tax credit reverts back to 20 percent indefinitely.

Fuel Production and Tax Incentives

HB 1193 deregulated natural gas a a motor vehicle fuel and removed sales tax on natural gas sold as a motor vehicle fuel.

An annual CNG flat fee for motor fuel tax is set at $100. An annual flat fee tax of $150 is levied for AFVs over 1 ton.

Other

The state Vo-Tech system implemented a CNG installation training program in August 1991.

HB 1953 created the "Committee of Alternative Fuels Technician Examiners" responsible for testing, certifying and inspecting alternative fuels installers. The committee has the authority to establish standards for the industry.

HB 1063, effective September 1993, gives the Committee the authority to certify public and private fleet training programs and conversion centers.

OREGON

Vehicle Conversion Incentives and Mandates

SB 766 says that after July 1, 1993, "to the extent that it is economically and technologically possible," all public transportation vehicles purchased or leased by a transit district must be capable of using an alternative fuel. This law defines alternative fuels as reformulated gasoline, low sulfur diesel fuel, natural gas, liquefied petroleum gas, methanol, ethanol, M85, E85, or electricity.

SB 765 mandates that after July 1, 1994, state agencies shall acquire only motor vehicles capable of using an alternative, unless such a fuel is not available in a particular area. This law defines alternative fuel to mean natural gas, liquefied petroleum gas, methanol, ethanol, M85, E85 or electricity.

HB 2130, effective January 1, 1992 expands the state's business energy tax credit to include costs associated with acquiring and operating fleet vehicles powered by alternative fuels. The law applies to fleet vehicles and fleet vehicle fueling stations. Total tax credits may not exceed $2.5 million annually for fleet vehicles. The credit is 35 percent of the incremental cost to purchase manufactured or converted vehicles and to install fueling stations.

Chapter 496, passed in 1993, allows loans from a Small Scale Energy Loan Program for certain alternative fuel projects such as converting fleets or building facilities such as fueling stations.

Chapter 684 stipulates that up to, but not more than, $2.5 million of the annual amount set aside for tax credits by the Department of Revenue may be allocated to AFVs and facilities required to operate them.

Fuel Production and Tax Incentives

Under HB 2456 a $0.05 per gallon excise tax exemption for 10 percent ethanol-blended fuels was repealed. A 5-year, 50 percent property tax exemption was established under the bill for new ethanol production facilities that produce ethanol capable of blending with gasoline.

Other

HB 2175 also imposes an emissions fee on motor vehicles according to the following schedule:

$1 for vehicles manufactured in 1981 and thereafter

$2 for vehicles manufactured before or during 1980

Electric vehicles are exempt from this fee. The proceeds of the emissions fee program are to be put into the Public Transportation Development Fund.

The bill also authorizes a Public Transportation Development Program which includes the development of alternative fuels and refueling stations, the conversion or replacement of existing vehicles with vehicles operating on alternative fuels, research and demonstration projects on alternative fuels and alternative fuel vehicles.

PENNSYLVANIA

Vehicle Conversion Incentives and Mandates

The Pennsylvania Energy Office has provided $1.2 million in grants to convert selected municipal and business vehicles in the Commonwealth to operate on alternative fuels.

The net purchase price of electric vehicles, hybrid electric vehicles and zero emission vehicles is exempt from the state sales and use tax until the year 2000.

The net purchase price is the incremental price of these vehicles over the purchase price of a comparable vehicle, defined by the overall average list price in the United States. Electric vehicles also are entitled to one registration fee waiver.

Effective July 1, 1993, Act 166 provides an estimated $3.5 million annually for an Alternative Fuels Incentive Grant program. Grants will be made to any school districts, municipalities, non-profit corporations, partnerships or residents of the Commonwealth. The grant program will cover a percentage of the incremental costs to purchase OEM alternative fuel vehicles, to convert gasoline or diesel vehicles, and to install refueling/recharging infrastructure. Grants will cover 60 percent of eligible project costs for the first 2 years of the program. The percentage decreases by 10 percent every 2 years down to 20 percent.

Other

The governor has agreed to adopt the California low emission vehicle program under provisions in the Clean Air Act Amendments of 1990.

The state has opted-in to the federal RFG program for the 33 nonattainment counties in the state. <u>Just before implementation of the RFG program January 1, 1995, 28 counties opted-out of the program.</u>

RHODE ISLAND

The governor has elected to opt-in to the federal reformulated gasoline program for the entire state.

SOUTH CAROLINA

Fuel Production and Tax Incentives

On May 5, 1994 the legislature ratified a bill to allow CNG sold by retailers as a transportation fuel to be sold at unregulated prices.

Other

The 1992 legislature created an Alternative Transportation Fuels Study Committee to conduct a comprehensive study of clean alternative fuels. The fuels to be studied included natural gas, propane, electricity, ethanol, methanol, solar energy, hydrogen and reformulated gasolines. Following the study, the State Budget and Control Board Division of Motor Vehicle Management was directed to determine the extent to which the state vehicle fleet can be configured to operate on alternative fuels. The plan was submitted to the General Assembly March 1, 1993.

In December 1993, the report of the Alternative Transportation Fuels Study Committee was issued. The study prioritizes fuels according to environmental, economic, performance, availability, and technology factors, and contains 41 administrative and legislative recommendations.

The EPA has redesignated Cherokee County as an area that no longer violates federal ozone standards.

SOUTH DAKOTA

Ethanol Production and Tax Incentives

Gasohol is exempted from $0.02 of the motor fuel tax, effective through June 30, 1994. A $0.20 per gallon incentive is paid for ethanol produced from cereal grain and blended with gasoline if the ethanol is produced at a plant constructed after July 1986. Payment is capped at $2.5 million for any fiscal year.

With the passage of HB 1330 in March 1993, funding for the ethanol production payments is extended until June 30, 1994.

TENNESSEE

Memphis has refused to participate in the federal oxyfuels program and is asking the EPA to be allowed to leave the program.

<u>Memphis was redesignated as in attainment for carbon monoxide in September 1994.</u>

The EPA has redesignated Knoxville as an attainment area for ozone. Notice was published in the April 1994 *Federal Register* that Knox County may increase the gasoline volatility limits from 7.8 psi to 9.0 psi during the period of May 1-September 15.

TEXAS

Vehicle Conversion Incentives and Mandates

SB 740, signed in June 1989, requires state agencies with fleets of more than 15 vehicles and public transportation authorities and departments to purchase or lease after September 1, 1991 only vehicles that are capable of operating on alternative fuels. These fleets must have AFVs in a number equal to 30 percent of their entire fleet by September 1, 1994, 50 percent by 1996 and 90 percent by 1998 if there is a determination by the Texas Natural Resource Conservation Commission (TNRCC) (formerly the Texas Air Control Board) that the program is successful in reducing emissions.

SB 740 also originally mandated school districts with over 50 vehicles used for transportation of school children to meet these requirements as follows: AFV purchases are to begin September 1, 1993; 50 percent of these fleets are required to be AFVs by 1997 and 90 percent by the year 2001. School districts are only required to comply with these requirements if they find that it is cost-effective to run their fleet on an alternative fuel.

SB 769, also passed in 1989, parallels SB 740 and specifically targets the four nonattainment areas of Houston-Galveston, Dallas-Fort Worth, Beaumont-Port Arthur, and El Paso. It applies to metro transit authorities and to local governments and private fleets.

Under SB 769, if the TNRCC determines in 1996 that the Texas Alternative Fuels Program is effective in reducing emissions and is necessary in attaining federal ambient air quality standards, then the TNRCC shall adopt additional rules requiring local governments (with fleets of over 15 vehicles excluding emergency vehicles) to ensure that vehicles in their fleets are capable of operating on an alternative fuel. At least 30 percent of these fleets must be AFVs by 1998, 50 percent by 2000 and 90 percent by 2002.

The agencies shall also submit to TNRCC an annual report by December 31 of each year showing purchases, leases, and conversions of motor vehicles and usage of compressed natural gas or other alternative fuels and any other relevant information TNRCC may require.

Under the Texas plan, costs of converting to an alternative fuel are to be financed by the alternative fuel supplier or equipment supplier at a net rate equal to or less than the continued use of gasoline or diesel fuel. Otherwise the fleet operator may obtain a waiver from having to comply. For example, a natural gas supplier might convert a fleet and provide for refueling, then amortize the capital costs by charging the fleet operator the differential price between natural gas and conventional fuel over the life of the equipment.

Currently Texas requires that vehicle fuel conversion systems conform to the requirement of EPA Memorandum 1-A.

SB 737, signed into law in June 1993, allocates $50 million in revenue bonds, issued by the Texas Public Finance Authority, for natural gas and propane alternative fuel projects. It also creates an Alternative Fuels Council to oversee the projects and make funds available to school districts, state agencies, counties, cities and mass transit authorities to cover the capital costs of installing refueling systems, modifying engines or purchasing new vehicles that run on alternative fuels.

In 1994, the Texas Alternative Fuels Council approved a $4.5 million grant fund to provide assistance to public and private fleet owners for the costs of converting vehicles to use alternative fuels. The fund is supported by federal oil overcharge funds and will provide capital on a matching basis.

Fuel Production and Tax Incentives

The state has declared natural gas and propane exempt from sales taxes when sold as vehicle fuels.

Other

The governor has notified the EPA that the Dallas-Fort Worth nonattainment area will opt-in to the federal reformulated gasoline program set for 1995 under the CAAA.

Texas is proposing an alternative fuel fleet rule that is different from the federal clean-fleet program for its SIP. The proposed Texas rule is more limited than the federal program regarding which fuels are allowed as alternative fuels. However, it is less stringent than the federal program regarding which fleets are covered (fleets of 15+ vehicles versus the federal rule of 10+ vehicles).

State Implementation Plan

Texas has submitted to the EPA a revised SIP for substitution of the federal Clean Fuel Fleet program. Under the SIP, the Texas Alternative Fuels Fleet program requires all fleets of 15 or more vehicles registered in, or who operate more than 50 percent of their time within the nonattainment areas of Houston/Galveston, Beaumont/Port Arthur and El Paso to purchase AFVs certified to meet or exceed the LEV standards, beginning September 1, 1998. The new purchase requirement will not apply to fleets who follow this schedule instead: 30 percent of total fleet are LEVs by September 1, 1998; 50 percent of total fleet by September 1, 2000; and 90 percent by September 1, 2002. After much controversy, the program was written allowing RFG and clean diesel to be used to meet the requirements.

Mobile Emission Reduction Credits (MERC) can be earned after September 1, 1994, by fleets that exceed the fleet percentage requirements of vehicles meeting the LEV standards, or by the acquisition of vehicles that meet emission standards more stringent than the LEV standards, or by the acquisition of vehicles with certified levels of evaporative emissions less than 5 grams per test. MERCs can be redeemed, sold, traded or transferred to another party to satisfy the program's requirements within the same nonattainment area.

UTAH

Vehicle Conversion Incentives and Mandates

HB 206 authorizes $20,000 in FY 1992-1993 for the Clean Fuel Private Vehicle Conversion Fund. The fund provides up to $3,000 loans for the conversion of private fleet vehicles to clean fuels. The loans must be repaid within 7 years. Clean fuels are defined as propane, compressed natural gas and electricity, and a fleet is defined as 10 or more vehicles owned and operated by the same entity. HB 207 authorizes $20,000 for the Clean Fuel Public Sector Vehicle Conversion Fund. This funds conversions of state, county and city government fleet vehicles, as well as public transit authorities, under the same terms as the Private Vehicle Conversion Fund.

HB 1 provides for an income tax credit--20 percent of the cost of a new vehicle, up to a maximum of $500; and 20 percent of the cost of converting an existing vehicle, up to a maximum of $400. The credit is available for tax years 1992 through 1996.

HB 132 enables the Utah Air Quality Board to mandate conversion of fleet vehicles to clean-burning fuels as part of the State Implementation Plan, if such a mandate is required in order to meet federal health standards.

The Utah Clean Fuels Program provides low-interest loans to private businesses and no-interest loans to public fleet owners to convert vehicles to cleaner-burning transportation fuels, to purchase dedicated vehicles and to install fueling facilities. The maximum loan amount for vehicles is between $4,500 and $36,000, depending on vehicle weight. The maximum loan amount for fueling equipment is $250,000. Over $2 million is presently available for loans.

Fuel Production and Tax Incentives

HB 38 defines clean fuels that will qualify for a special fuel use permit and exempts them from $0.16 per gallon of the of the $0.19 per gallon gasoline tax.

HB 94, passed in 1994, calls for any increase in gasoline tax to be equally applied to special fuels taxes.

HB 43 states that franchise taxes may not be charged by cities and municipalities of fuels which meet the clean fuel definition, if those fuels are used to power a vehicle.

Utah Code 54-2-1 deregulates the distribution of CNG for use as a motor vehicle fuel.

The counties of Salt Lake, Davis and Weber have been granted a waiver from the oxygenated fuels program and will not be required to sell oxy fuels during the 1994-1995 winter season.

State Implementation Plan

Utah's SIP for CO in Utah County requires a continuing 2.7 weight percent oxygenated fuels program, an enhanced vehicle inspection and maintenance program, and a 3.1 weight percent oxygenate level for the 1995-1996 control season.

VERMONT

Vermont plans to adopt California's low-emissions vehicle program under provisions of the CAAA.

Vermont has opted into the federal reformulated gasoline program under provisions in the Clean Air Act Amendments of 1990.

VIRGINIA

Vehicle Conversion Incentives and Mandates

The legislature has created the Virginia Alternative Fuels Revolving Fund to provide loans or grants, with matching grants to be given preference, to reduce the costs of publicly-owned vehicles that operate on alternative fuels. These costs include those for fuel, vehicles and personnel. The law includes all kinds of alternative fuels, including electric vehicles. The fund was renewed in 1994 with an appropriation of $750,000.

SB 960 (Chapter 159) exempts vehicles manufactured to run on CNG, LPG, hydrogen or electricity from 1.5 percent of the 3 percent sales tax on motor vehicles sold in Virginia.

H 1727 (Chapter 562), effective January 1, 1993, provides a tax credit of 10 percent for clean fuel vehicles and refueling property to any corporation, individual or public service company.

HB 1788 (Chapter 234) specifies clean alternative fuel fleet standards for motor vehicles. Covered fleets include any centrally fueled fleet of 10 or more vehicles owned or operated by a single entity. The fleet phase-in requirements for light-duty vehicles and trucks up to 6,000 pounds GVWR are: 30 percent in Model-Year (MY) 1998, 50 percent in MY 1999 and 70 percent in MY 2000. For heavy-duty trucks over 8,500 pounds GVWR the requirements are: 50 percent in MYs 1998, 1999 and 2000. These standards apply only to fleet vehicles registered in specified localities.

Fuel Production and Tax Incentives

Under S 771 (Chapter 255), the tax rate on clean special fuels, defined as all products or energy sources used to propel a motor vehicle which, when compared to conventional gasoline or reformulated gasoline, will result in lower emissions or oxides of nitrogen, volatile organic compounds, carbon monoxide or particulates or any combination thereof, and includes compressed natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, Hythane (a combination of compressed natural gas and hydrogen) and electricity, will be reduced to $0.10 per gallon between January 1, 1994 and July 1, 1998.

Other

The governor has notified EPA that the state will opt-in to the federal reformulated gasoline program for nonattainment areas in the state set for 1995 under the CAAA.

Until July 1, 1997, owners of alternative fuel vehicles who obtain special AFV license plates are exempted from High-Occupancy Vehicle (HOV) lane restrictions, under Chapter 426, signed into law April 1994. They may use the HOV lanes, normally restricted to carpools during rush hour, at anytime.

WASHINGTON

Alternative Fuel Use

A section of the law HB 1028 directs the Utilities and Transportation Commission to identify and remove barriers to the development of CNG refueling stations.

Vehicle Conversion Incentives and Mandates

HB 1028 requires that at least 30 percent of new vehicles purchased by the state after July 1, 1992 will be clean fuel vehicles, with the required percentage increasing by 5 percent each year. The law states that preference will be given to dedicated vehicles, but if they are not available, conventional vehicles may be retrofitted to clean fuel or dual fuel use. The State of Washington Department of Ecology set standards for clean fuel vehicles in 1992.

Shortly after the passage of HB 1028, the state dismissed the clean-fuel-only approach due, in large part, to uncertain emission benefits as well as the high cost and limited availability of clean fuel vehicles. Instead, a low emission level has been implemented that the new vehicle purchases must meet. The low emission specification allows for the purchase of vehicles that do not exceed the average aggregate $(HC+CO+NO_X)$ emission levels within each vehicle class.

King County, which includes Seattle, passed an ordinance specifying that 50 percent of vehicles purchased by the county in 1992 must use an alternative fuel. The requirement goes to 75 percent in 1993. The county has also waived the licensing fee for taxis and other for-hire vehicles which use an alternative fuel. Funding of $132,500 was appropriated to implement the program.

Fuel Production and Tax Incentives

SB 5342, signed into law in May 1993, exempts any alcohol sold for use as a fuel from the motor fuel vehicle tax if the alcohol is manufactured by a company that sold less than 8 million gallons in the previous year. In addition, a tax credit of 60 percent of the tax rate is given for alcohol (eligible for the exemption) which is used in an alcohol-gasoline blend of at least 9.5 volume percent alcohol. The credit expires December 31, 1999. The exemption was terminated May 1, 1994.

The Department of Licensing has made a regulatory decision that ETBE is exempt from the motor fuels tax.

WEST VIRGINIA

Alternative Fuel Use

An executive order from West Virginia's governor directs the secretary of administration to implement a program to convert a test group of state vehicles to operate on compressed natural gas. The secretary is also directed to establish NGV refueling stations which are now operational in seven cities, with one under construction in 1993.

Vehicle Conversion Incentives and Mandates

SB 508 requires county, city, and local governments with fleets of 15 or more vehicles to acquire, through purchase or lease, alternative fuel vehicles for their fleets. SB 509 requires state government fleets to acquire alternative fuel vehicles under the same conditions. In FY 1995, 20 percent of vehicle acquisitions must be AFVs. In FY 1996 and 1997, the requirement increases to 30 and 50 percent, respectively. By the end of 1997 each government entity is required to review the cost of its alternative fuel program. If proven to be cost effective, fleets will be required to purchase at least 75 percent AFVs for their fleets from September 1, 1998 and thereafter. Alternative fuels include CNG, LNG, LPG, methanol (M85-M100), ethanol (E85-E100) and other alcohol blends with 85 percent or more alcohols, coal-derived liquid fuels and electricity.

WISCONSIN

Alternative Fuel Use

Wisconsin's Governor Thompson formed an Alternative Fuels Task Force in 1990 to explore the potential of alternative fuels to reduce vehicular air pollution. Four projects have been implemented to produce and test biodiesel, CNG, E85 and propane vehicles. As of mid-1994, Wisconsin has over 300 AFVs in state and local government fleets and over 160 alternative fuel refueling stations for CNG, propane and E85.

Vehicle Conversion Incentives and Mandates

A Local Government Alternative Fuels Program provides grants from oil overcharge funds to communities to offset costs of buying, operating and evaluating AFVs. Over $180,000 have been awarded recently to 17 municipalities to convert vehicles to propane and natural gas.

Effectively July 1, 1994, Act 351 directs all state-owned/state-leased vehicles to use gasohol or alternative fuels when feasible.

Other

Six severe ozone nonattainment counties are required to use RFG starting January 1, 1995. In addition, Wisconsin's three moderate ozone nonattainment counties have opted-in to the program.

NATURAL GAS

COMPANY ACTIVITIES

TNO ROAD-VEHICLES RESEARCH INSTITUTE DEVELOPING DEDICATED CNG CAR

European plans to exploit the excellent environmental credentials of natural gas-based fuels have been boosted by the launch of a major new research project to develop a dedicated CNG-powered car. The project, which has been accepted for inclusion in the European Union's Brite Euram program, is being undertaken by a consortium of European companies and research organizations, including TNO Road-Vehicles Research Institute of the Netherlands. Other participants include a car manufacturer, various vehicle component manufacturers (including suppliers of catalytic converters and composite fuel tanks), a natural gas distribution company, and a university known for its expertise in modeling complex chemical reactions.

The main aim of the project is to develop a dedicated methane-fueled car which will be capable of meeting the tightest emission standards. It is planned to equip the vehicle with a sophisticated gas injection system to ensure that an extremely narrow stoichiometric window is achieved and to fit a special methane-selective three-way catalytic converter for emission control purposes. Attention will also be focused on the design of the fuel tanks, the best way of accommodating them in the vehicle, and on how an intelligent control system can be used to regulate the storage of methane in the form of CNG.

To assess the suitability of the proposed options, it is planned to build two prototype cars which will be capable of running on CNG. These will be constructed in 1997 after the basic research studies have been completed. In a follow-up stage, the performance of the prototype vehicles will be evaluated with respect to fuel economy, driveability, regulated and non-regulated emissions, ozone effects and mutagenic potential. The results of this assessment will be used to optimize the design of the two prototypes, which will subsequently be tested on the road to validate the underlying technology.

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NATURAL FUELS CORPORATION COMPLETES 1,000th NGV CONVERSION

More than 1,000 vehicles have been converted to run on natural gas at Denver's Natural Fuels Corporation since 1990, helping to create one of the nation's largest centers for the clean, domestic alternative fuel.

Mile Hi Cablevision, a division of TCI Cable, operates the vehicle that put Natural Fuels at the 1,000 mark. The Denver cable-TV licensee converted five company service trucks to operate on natural gas, as part of a pilot program TCI is considering for its national fleet. TCI Cable has a national fleet of over 10,000 vehicles.

Founded in 1990, Natural Fuels Corporation was among the nation's first full-service companies promoting natural gas for vehicles by providing retail fueling, vehicle conversions and service and fueling station equipment. The company offers public fueling at more than 25 sites throughout Colorado.

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CUMMINS AND WARTSILA FORM JOINT VENTURE FOR GAS ENGINES

Cummins Engine Company Inc. and Wartsila Diesel International Ltd. Oy of Finland have formed a joint venture to design, develop and manufacture two new families of heavy-duty, high-speed diesel and natural gas engines. The natural gas engines will range up to 6,000 horsepower.

Cummins notes that it is the world's largest producer of high-speed diesel engines above 200 horsepower, with 1993 sales of more than

$4 billion. Wartsila, they said, is the world's leading producer of medium-speed diesel engines ranging from 1 to 16.5 megawatts and an important producer of high-speed engines, with 1993 sales of $1.5 billion. Wartsila Diesel is the largest subsidiary of the Metra Corporation of Finland.

"This new relationship furthers Cummins' strategic plan to achieve profitable growth in markets related to its core competencies," said Cummins Engine president J. Henderson.

The first of the new families of engines will be based upon the Wartsila 200 engine. Production is expected to begin in 1995 at the Wartsila SACM Diesel factory in Mulhouse, France.

Engines produced by the joint venture will be sold to worldwide markets for mining, power generation, rail, and marine propulsion and auxiliary applications. They will be marketed under the names of both Cummins and Wartsila.

Access: Cummins, phone 812 377 3524

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SUMITOMO CORPORATION TO DISTRIBUTE GFI PRODUCTS IN JAPAN

GFI Control Systems, Inc. has announced the signing of an exclusive distribution agreement, enabling Sumitomo Corporation to promote GFI's natural gas and propane vehicle conversion systems to Japanese automobile manufacturers. A number of gas companies and OEMs will be involved in testing, making OEM installations and aftermarket conversions.

The GFI conversion system consists of a fuel delivery system and electronic engine controls which convert gasoline-powered vehicles to natural gas or propane. The GFI NGV onboard fuel system has been certified by the California Air Resources Board for 1995 for specific engine families and recently passed the California durability testing requirements.

Access: GFI, phone 800 667 4275

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VINYARD CONVERSION SYSTEM CUTS DIESEL EMISSIONS

A converted 350-horsepower, dedicated CNG-powered tractor trailer has demonstrated dramatic emissions reductions compared to its original diesel configuration. The converted diesel engine, using a system by Vinyard Engine Systems reduced oxides of nitrogen emissions by over 70 percent while simultaneously reducing particulate emissions by a factor of over 30. Emissions testing was conducted by the Los Angeles County (California) Metropolitan Transit Authority on a 1985 Freightliner used by the Los Angeles County Sanitation District to haul waste sludge.

According to Vinyard Engine Systems the converted engine uses a modern electronic technology, closed-loop engine management system to equal diesel power and torque while providing high efficiency and low operating temperatures.

Access: Vinyard, phone 210 520 7924

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TRANSLATOR BIFUEL CONVERSION SYSTEM CERTIFIED

Synchro-Start Products, Inc. through its DAI Controls Division has received California Air Resources Board certification for its Translator Bifuel Conversion System for all pre-1994 General Motors passenger cars and light trucks on engines ranging from 2.5 to 5.7 liters.

According to the company the Translator is the first bifuel electronic CNG conversion system designed to work in conjunction with the vehicle's existing computer and diagnostic system. The Translator intercepts signals from the computer and translates them allowing the engine to run on either natural gas or gasoline.

Access: Synchro-Start, phone 708 967 7730

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TRI-FUELS RECEIVES AGA CERTIFICATION FOR CNG CONVERSION KITS

Tri-Fuels has been granted American Gas Association (AGA) certification for its conversion kit used to convert vehicles to operate on compressed natural gas. The AGA certification adds to the California Air Resources Board certification received in 1994.

In related news, Tri-Fuels announced that its conversion equipment has successfully met CARB emission standards even after over 100,000 miles of service. A Ford Taurus SHO with over 102,000 miles was tested and met the CARB standards.

Tri-Fuels' J. Tucker reported that the company is aggressively adding distributors for CNG station equipment and vehicle conversion equipment throughout the United States.

Access: Tri-Fuels, phone 405 359 6485

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MOOG ICE-BREAKER LNG COUPLING REACHES MILESTONES

Moog Inc. reports several milestones in Moog LNG coupling use. In the first milestone, Moog Ice-Breaker LNG couplings in use at Sun Metro (El Paso, Texas) have surpassed the 10,000 cycle fueling mark. According to Sun Metro, 20 dedicated fuel LNG buses are fueled twice a day, 7 days a week. The couplings are currently operating without any problems and are said to be one of the most reliable parts of the LNG station. An additional 57 dedicated LNG buses will be added to the Sun Metro fleet early this year.

In the second Ice-Breaker milestone, LNG couplings in use at the Roadway Express facility in Copley, Ohio are nearing their third year in operation. Prior to switching to the Moog hardware, the LNG program was in jeopardy because of failures of the earlier LNG couplings. Again, the couplings are operating beyond expectations with no problems to report.

Moog notes that, as in all of their LNG coupling installations, neither of the above sites require the use of costly nitrogen purging equipment. Patent pending features prevent freeze-on and leakage.

Access: Moog, phone 716 687 4889

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NATURAL GAS SUPPLY ASSOCIATION OPPOSES MANDATED USE OF NGVs

The Natural Gas Supply Association (NGSA) has issued a statement opposing mandated usage of natural gas vehicles. Representing independent energy producers and gas marketing companies that produce and market over 90 percent of United States domestic natural gas, NGSA says it strongly supports energy and environmental efforts to promote efficiency, foster market competition and achieve national goals cost-effectively and without discriminating between fuels. However, it is concerned over proposals that mandate using NGVs to reduce ground-level ozone in the Northeast.

NGSA members support voluntary initiatives to promote NGV market development. But they believe that requiring NGV usage can have detrimental effects on natural gas demand and add considerable costs to air-quality compliance strategies.

Costs to develop CNG-fueling infrastructure for passenger vehicles in the Northeast will range between $0.5 billion to $0.8 billion. Rate-basing these costs will add incremental costs for all consumers and make gas less competitive for other end-use applications, says NGSA. Industrial and commercial gas users may then switch to dirtier fuels or electricity, which is principally coal fired. Both situations are a net detriment to air quality and would reduce natural gas usage.

NGVs have a place in the matrix of emission reduction strategies, says the association. NGSA strongly supports their use and urges that regulators maintain the philosophy of sound economic, market-based solutions to environmental problems and reject short-sighted efforts involving mandates.

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GOVERNMENT ACTIONS

NHTSA RESPONDS TO INDUSTRY AND MODIFIES NGV FUEL TANK STANDARD

Manufacturers of carbon composite tanks were successful in their efforts to convince the National Highway Traffic Safety Administration (NHTSA) to amend their recently released standard on NGV fuel tanks using carbon fiber.

The NHTSA published a modification to Federal Motor Vehicle Safety Standard (FMVSS) 304 in the December 28, 1994 Federal Register. FMVSS 304 now specifies a 2.25 burst factor for carbon fiber tanks, which is consistent with the industry accepted standard, ANSI/AGA NGV2, and with international NGV tank standards such as the Canadian Standards Association and the draft ISO standards.

FMVSS 304, which was first released in September 1994 (see The Clean Fuels Report, November 1994, page 76), initially specified a 3.33 burst factor for carbon tanks. The Agency received over 130 petitions for reconsideration on FMVSS 304, most of which strongly encouraged the use of the 2.25 burst factor. These petitions detailed the rigorous testing that carbon fiber tanks at the 2.25 burst factor have completed. It was also noted that thousands of carbon fiber tanks at the 2.25 burst factor are in use, and have performed safely and without incident.

FMVSS 304 will take effect on March 27, 1995. NHTSA has stated that the 2.25 burst factor for carbon tanks is an "intermediate step" that they plan to review. However, if the agency does increase the 2.25 burst factor, they will provide at least two years notice before implementation.

Lightweight, all-composite tanks have opened new markets for NGVs which were previously limited by heavy steel and aluminum tanks. The use of carbon fiber results in a high strength, low weight tank.

NHTSA also released a supplemental notice of proposed rulemaking (SNPRM) regarding additional testing for NGV fuel tanks. A SNPRM is not a final ruling and is still subject to change. Comments will be accepted on the SNPRM, which was published in the Federal Register on December 19, 1994 until February 17, 1995.

The SNPRM includes the following fuel tank tests: internal and external environmental exposure, low temperature impact, gunfire, flaw tolerance, pendulum impact, and tank drop. These tests would be in addition to the cycle, burst, and bonfire tests already included in FMVSS 304.

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RESEARCH AND TECHNOLOGY

NEW GENERATION NATURAL GAS CONVERSION KITS WORK WELL

A technical paper by R. Gow, presented to the 10th Annual Mobile Sources/Clean Air Conference in Estes Park, Colorado last fall addresses the performance of natural gas conversion kits.

The fuel used by NGVs today is typically pipeline quality gas--which is a mixture of gases, primarily composed of methane. According to statistics from the Natural Gas Vehicle Coalition, the average natural gas is about 92 percent methane, 4 percent ethane, 1.5 percent heavier hydrocarbons and about 2.5 percent inert gases such as nitrogen, water vapor and carbon dioxide. The heating value varies a great deal but is in the range of 1,000 BTU per standard cubic foot. It is this variability which gives rise to issues in measurement and testing when natural gas vehicles are tested relative to gasoline.

The focus of Gow's paper is some recent research on second generation natural gas vehicle conversion kits performed at the National Center for Vehicle Emissions Control and Safety (NCVECS) in Fort Collins, Colorado. While the emphasis was on second generation kits, the paper includes data on test fleets and emission test results for three generations of natural gas conversion kits and discusses the test methods, differences among the conversion kits, difference in emissions between natural gas and gasoline and how cold weather affects performance.

The "first generation" of after-market natural gas conversion kits were developed using manual operations for tuning and set-up. There are no computer controls, the mixing valve and idle are manually set and there is no feed-back from the catalyst or the oxygen sensor to the mixing valve so that mixture is not adjusted to provide for optimum combustion at all times. The kits require periodic attention to maintain driveability and emissions levels at acceptable limits.

The "second generation" of vehicle conversion kits are closed loop kits which use an oxygen sensor in the exhaust to transmit information to an on-board computer which modifies the air-fuel mixture. The NGV kit computer works in conjunction with the manufacturer's computer controls to better adapt the engine's performance to dual fuel operation and to make constant adjustments in fuel flow to account for local operating conditions. Once set for a particular vehicle, these kits are sealed and are not adjustable.

"Third generation" kits which are currently under development and available in some markets, take computerization several steps further and use on-board diagnostics to help maintain peak engine performance and fuel management, regardless of the fuel used. They have the "adaptive learning" comparable to gasoline fueled vehicles because the same on-board computer is used to send signals to both natural gas and gasoline fuel systems. Such kits appear to make vehicle performance fuel transparent, in other words the differences between natural gas and gasoline are not noticeable.

Results--First Fleet

Gow cautions that care should be taken in any comparison of the test results presented, and comparisons may be valid only if done in very general terms. In September 1991 the first test fleet, consisting of 11 vehicles (three late model cars and eight trucks ranging from 1979 to 1991 model trucks) was assembled and tested at NCVECS. These vehicles were equipped with the "first generation" open loop, natural gas conversion kits. The results are presented in Table 1.

Though significant reductions in CO using natural gas were encountered as compared to indolene the driveability of the vehicles was questionable and NO_x performance deteriorated somewhat, though overall, was still better than gasoline.

Results--Second Fleet

The second test fleet, consisting of seven trucks and three cars of 1982 to 1992 vintage, was driven to Fort Collins in October 1993. The purpose of these tests was to certify two "second generation" natural gas conversion kits, look at three other kits and develop further knowledge and data.

Test results are summarized in Table 2. The kits were installed without a great deal of adjusting, and the individual results indicate some anomalies as far as natural gas is concerned. While the results for individual pollutants show some inconsistencies, the overall results in

TABLE 1

OVERALL RESULTS, FIRST TEST FLEET

	THC g/mi	NMHC* g/mi	CO g/mi	NO_x g/mi	CO_2 g/mi
Avg. Emissions Indolene	0.686	0.583	7.097	1.667	573.66
Avg. Emissions CNG	1.506	0.226	0.414	1.395	447.52
Reduction with CNG, %	-120	61	94	16	22

*Estimated
Note: Figures indicate reductions in CNG. A negative reduction is an increase

TABLE 2

OVERALL RESULTS, SECOND TEST FLEET

	THC g/mi	NMHC* g/mi	CO g/mi	NO_x g/mi	CO_2 g/mi
Avg. Emissions Indolene	0.966	0.821	11.355	1.982	596.75
Avg. Emissions CNG	1.265	0.190	7.753	1.108	471.79
Reduction with CNG, %	-31	77	32	44	21

*Estimated

Table 2 indicate significant reductions in all pollutants when the vehicles were run on natural gas as opposed to indolene. In aggregate, these kits show a more balanced reduction of all pollutants over the open loop kits and driveability was very good.

Where higher-than-expected CO was discovered, the increases correspond to decreases in NO_x. This is the usual trade off in the combustion cycle in which adjustments to reduce NO_x may result in increases in CO. Leaning the engine to reduce CO causes NO_x to rise. It is likely that adjustment could achieve an appropriate balance.

Results--Third Generation

A "third generation" conversion kit under development by Mogas was applied to four trucks and two cars, of 1990-1994 vintage, and tested in August 1994. The purpose of the tests was to gain Colorado certification of the kit. Kits were placed on the vehicles with little adjustment or modification and reacted well. The results are presented in Table 3. The overall picture shows a remarkably balanced reduction of all major air contaminants. This is true even in light of the cleanliness of the fleet when running on gasoline.

Cold Weather Results

Natural gas has an advantage over gasoline when the temperature drops because it is already in a gaseous state when it reaches the injectors or carburetor and no enhancement is required, unlike gasoline. The normal test temperature actually favors gasoline when compared to real life driving. In the Rocky Mountain West, as well as much of the rest of the nation, the temperature is much lower from October through April and emissions are affected.

The Congress recognized this factor and Section 202(j) of the Clean Air Act requires that, starting with the 1994 model year, all light duty vehicles will operate at 10 grams of CO per mile or less when operated at 20°F or lower. Furthermore, if by mid-1997 six or more nonattainment areas have design values greater than 9.5 parts per million for CO, cold weather performance for CO will be set at 3.4 grams per mile for light duty vehicles and 4.4 grams per mile for light duty trucks, starting with model year 2002.

In order to examine the performance of natural gas conversions at low temperatures, two vehicles were sent to the Environmental Testing Corporation facility in Aurora, Colorado and put through a cold weather test. The results of these tests are reported in Table 4. Significant reductions in CO were noted over gasoline with 91 percent and 81 percent for the LeBaron and the large pick-up truck respectively. There were also 50 percent and 29 percent reductions in total hydrocarbons and mixed results on NO_x, although the mass of NO_x from the LeBaron was well below the applicable standard. Because most problems of attaining the CO ambient standard occur in winter, the use of natural gas is indicated to be very helpful.

Conclusion

Gow concludes that natural gas conversion kits do work. The series of tests he reported are indicative of real world performance of such kits. They are illustrative of what can be accomplished when standard vehicles are subjected to conversion. Clearly, the different fleets of vehicles that were tested with different models, makes, engines and conversion kits lead to different sets of emissions. The major general conclusion to be drawn from the second and third test fleet is that when vehicles are run on natural gas, the kits tested provided a well balanced reduction of pollutants across the broad spectrum of air contaminants.

First generation kits are easy to adjust in order to change emissions and periodic adjustments are

TABLE 3

OVERALL RESULTS, THIRD TEST FLEET

	THC g/mi	NMHC g/mi	CO g/mi	NO_x g/mi	CO_2 g/mi
Avg. Emissions Indolene	0.452	0.382	6.353	2.096	652.40
Avg. Emissions CNG	0.789	0.205	2.984	1.444	512.07
Reduction with CNG, %	-75	46	53	31	22

TABLE 4

COLD WEATHER (20°F) TEST RESULTS

Make/Model		THC g/mi	NMHC g/mi	CO g/mi	NO_x g/mi	CO_2 g/mi
91 Chrysler LeBaron	Indolene	1.829	1.658	11.584	0.472	429.697
3.0L V6	CNG	0.908	0.109	1.009	-0.710	334.992
% Difference		50.5	93.4	91.3	-50.4	22.0
93 Chevy 1 Ton	Indolene	1.811	1.570	24.828	2.332	996.061
7.4L V8	CNG	1.293	0.161	4.624	1.469	820.051
% Difference		28.7	89.7	81.4	36.3	17.7

important for such kits to continue to provide acceptable emissions levels. Second generation kits are much harder to adjust and third generation kits work hand-in-glove with the manufacturers' original equipment. Dedicated vehicles are already in service and take advantage of the inherent low emissions and higher octane rating of natural gas but dual-fuel vehicles created with the use of conversion kits will have a major niche for years to come.

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NATURAL GAS ENGINE DEVELOPMENT REVIEWED FOR THE FLEET OPERATOR

At the SAE International Truck and Bus Meeting in Seattle, Washington in November, D. Vermet of Detroit Diesel Corporation and C. Ferrone of Americoach Systems, Inc. presented a review of natural gas engine developments for the benefit of fleet operators.

Engine Developments

Motivated by the standards set forth by the Clean Air Act Amendments of 1990, engine manufacturers have made numerous improvements to heavy-duty diesel engines. Specifically, engines have become more fuel-efficient, more durable, self diagnosing and cleaner burning. This leap of technology is not attributed to any one technical discovery. Instead, prudent refinement of design, manufacturing and quality control has brought heavy-duty diesel technology to where it is today. For example, in order to meet the emission standards, injection pressures had to be increased. This began a chain reaction of events. For instance, cam followers have been modified to use nontraditional materials such as ceramics to allow for these higher injection pressures. When a diesel engine is converted to spark ignition for natural gas service, the compression ratio must be lowered to reduce the tendency to knock in a spark ignition (SI) engine. This reduces the firing pressure as compared to a diesel engine which puts less mechanical stress on the cylinder components. However, thermal loads are higher than with a diesel engine.

Engine Operational Strategies

Within natural gas powertrains there are three varieties of engines to choose from; (1) spark ignition, (2) pilot ignition and (3) direct injection. Direct injection has only been done experimentally, and no production engines of this type are available. Most heavy-duty natural gas engines utilize a lean burn spark ignition concept. Specifically, the mass air-to-fuel (A/F) ratio of these engines is as high as 26:1 under loaded conditions versus the 16:1 stoichiometric natural gas engine.

With direct injection, the gas is injected near TDC and ignites via autoignition as in a diesel engine.

Pilot ignition introduces the gas near BDC where it then mixes with the air and becomes compressed. Diesel fuel is then injected near TDC igniting by autoignition therefore igniting the entire mixture.

Spark ignition uses components similar to that of automotive applications. A high energy spark ignition system initiates combustion for this scheme while gas is mixed into the air intake stream. Compression ratio varies significantly depending on which scheme is used (Table 1).

Beyond the combustion process the electronic control module, ECM, takes control of the remaining engine operating parameters. They are A/F ratio, spark timing, throttle position, speed governing, fuel flow and engine protection. In addition to these controls, further control over the A/F ratio is conducted by a turbocharger waste gate. This allows excess exhaust gases to by-pass the turbocharger reducing the overall boost pressure, maintaining the desired A/F ratio.

Fuel System Technology

In heavy-duty SI natural gas engines the low-pressure natural gas is introduced into the engine air intake stream downstream of the turbocharger and the air-to-air charge cooler. This reduces the tendency of the engine to knock and improves thermal efficiency. The gas metering valve is electronically controlled through the ECM which provides precise control of fuel delivery. The delivery pressure of the gas ranges between 50-140 psi depending on the specific type of fuel metering valve being used.

TABLE 1

COMPRESSION RATIOS

Diesel	17.0:1
Natural Gas (Direct Injection)	23.0:1
Natural Gas (Pilot Ignition)	15.0:1
Natural Gas (Spark Ignition)	10.0:1

The fuel system of a natural gas engine consists of many components which may be unfamiliar to today's diesel fuel users. They are:

- Gas mixer
- Natural gas fuel metering valve
- Pressure regulators
- Coalescing filters
- Fuel tanks

Providing precision control over the fuel system is the gas metering valve. It is controlled through the ECM and delivers the natural gas to the mixer.

As an example, the S50G spark ignited engine utilizes both Detroit Diesel Electronic Controls (DDEC) and the Gaseous Fuel Injection (GFI) system to provide engine control. DDEC provides ignition timing, throttle position and engine protection. The GFI system provides control and metering of the natural gas based on input from DDEC and GFI sensors mounted directly on the engine. The fuel system uses computer calculations for both fuel flow and air flow. The computer also maintains a lean air to fuel (A/F) mixture for low emissions and good fuel economy. Calculations are based on knowing the temperature and pressure of the air and fuel. The manifold absolute pressure, barometric pressure, fuel absolute pressure and fuel regulated temperature sensors are internally located in the metering valve. The intake air temperature sensor is mounted in the intake tube between the throttle and the air intake manifold.

The natural gas is stored in the fuel tanks under pressure (CNG) or at extremely low temperatures (LNG). A high pressure fuel line supplies natural gas from the fuel tank, through the primary filter, a 1 micron (98 percent efficient) coalescing gas filter, to the single stage regulator where it is reduced to an appropriate pressure of 140 psig at idle. Under all conditions, the fuel pressure should remain above 115 psig with the GFI system. From the regulator, the fuel passes through the secondary low pressure filter to the computer/metering valve or compuvalve. The compuvalve then regulates the fuel flow by means of a series of electronically controlled solenoids and injectors. Fuel is then passed to the gas mixing unit located in the air intake system upstream of the engine throttle.

The computer controls fuel flow. The computer section consists of a computer module inside the electronics cavity of the metering valve. For calibration and adaptive memory, the electronic control unit uses Static Random Access Memory, SRAM. Program memory is stored in Read Only Memory, ROM. The software is responsible for calculations for fuel flow based on calibration and sensor input.

Turbocharger

With SI natural gas engines it is important to maintain the ideal A/F ratio to prevent engine knocking. However, during certain operational modes the boost pressure from the turbocharger will be higher than the value permitted to maintain the prescribed A/F ratio. Unlike diesel fueled engines, too much boost air can affect performance of a natural gas engine. Therefore, the natural gas engine family has a turbocharger with a waste gate. The wastegate allows an amount of air, which would have otherwise imbalanced the A/F ratio, to by-pass. This feature is controlled by boost pressure and actuated by a diaphragm operated slave cylinder.

The turbocharger compressor recirculation valve permits some of the compressed charge air, which becomes trapped during engine throttling, to return back to the compressor intake system. This prevents or significantly reduces pressure pulsation otherwise experienced with turbocharger compressor surging. During acceleration and steady state operation the recirculation valve remains in its normally closed position.

Charge Air Aftercooling

Air-to-Air Charge Cooling (ATACC) is a long accepted method of lowering combustion air intake temperatures. Aftercooling, unlike the present water-to-air intercooling, uses air on both sides of the heat transfer process.

In a typical truck configuration, a radiator type core assembly sits in front of the conventional radiator similar in location to the automotive air-conditioning condenser application. This system uses air, provided from vehicle motion, to cool the core assembly. During this time outside air is drawn in from the air cleaner into the turbocharger whose compression produces heat. The air then needs to be cooled in order to provide the correct air mass for the combustion event. The hot compressed air is passed through the charge air core lowering the combustion air temperature by some 200°F, then into the intake manifold completing the process.

Ignition System

Historically, gaseous fueled engines, developed from automotive gasoline engines, have used automotive distributor (inductive) ignition systems. Larger industrial/stationary gas engines have used magneto generator powered capacitor discharge (CD) ignition systems. Often, ignition timing was either fixed or varied only with RPM (speed advance). Sometimes with ignition timing, shift was based on manifold vacuum of naturally aspirated engines. As electronically controlled ignition systems were developed for both automotive gasoline and industrial gas engines, distributorless ignition systems were introduced with timing control determined by simple timing curves. Eventually, calibratible speed and load based ignition timing using advanced microprocessor controllers were developed.

The major difference between inductive and CD systems is that CD systems generate higher secondary voltage and shorter spark duration compared to inductive systems. Because natural gas is more difficult to ignite than gasoline, it has long been considered beneficial to use the high secondary voltage CD system to ensure consistent spark initiation. However, inductive ignition systems continue to provide excellent performance and durability on field test and limited production engines. Currently, Detroit Diesel is using two different ignition systems. The first, to be utilized on early production 4-cylinder S50G engines, is comprised of two 4-cylinder spark coil modules commonly used on automotive 4-cylinder gasoline engines.

The other system, presently applied to the S30G engine, utilizes individual ignition coils mounted in the rocker cover directly above each platinum spark plug. It is planned to apply the direct mounted ignition coil arrangement to all DDC natural gas engines in the near future. Both of these systems are controlled by the DDEC III electronic control module. Optimum ignition timing for performance, fuel economy and low emissions are determined at each operating point by mapping the engine performance and emissions development.

Access: SAE Paper No. 942312, phone 412 776 4841

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TURBOCHARGING A BIFUEL ENGINE GIVES PERFORMANCE EQUIVALENT TO GASOLINE

At West Virginia University, a bifuel engine capable of operating either on Compressed Natural Gas (CNG) or gasoline is being developed for the transition to alternative fuel usage. This project was reviewed by C. Tennant et al. at the Society of Automotive Engineers (SAE) Fuels and Lubricants Meeting in Baltimore, Maryland last fall.

A Saturn 1.9-liter 4-cylinder engine was selected as a base powerplant. A control system that allows closed-loop optimization of both fuel delivery and spark timing was developed. Stock performance and emissions of the engine, as well as performance and emissions with the new controller on gasoline and CNG, have been documented.

CNG operation in an engine designed for gasoline results in power loss, yet such an engine does not take advantage of the higher knock resistance of CNG. The power loss associated with using CNG in an engine designed for gasoline is unacceptable if use of the alternative fuel is to be encouraged. Also, typical bifuel conversions make compromises in engine control parameters, for both fuels, that can cause losses in performance and increased emissions. In order to be a truly beneficial development and to promote the use of CNG, the optimized bifuel engine should make no compromises in engine controls and achieve performance on CNG equivalent to that of gasoline.

It is the goal of the West Virginia research to use the knock resistance of CNG to recover the associated power loss. The two methods considered for this include turbocharging with a variable boost wastegate and raising the compression ratio while employing variable valve timing. For the first method, which was the subject of the paper by Tennant et al; a turbocharger was installed to increase the density of the intake charge and thereby regain the volumetric efficiency lost with CNG. The wastegate was electronically controlled to allow precise control of the engine performance.

Power loss while operating an engine designed for gasoline on CNG has been well documented, and has been reported as ranging from 11.3 percent up to 22 percent. The reasons for this power loss include a loss of volumetric efficiency due to the volume of air displaced by

CNG and the lack of evaporative charge cooling from a liquid fuel. Charge cooling increases volumetric efficiency by increasing charge density. In the case of this particular engine, poor air/fuel mixing with the single point injection system may also be responsible for some of the power loss. Turbocharging will recover the lost volumetric efficiency directly, by raising the density of the intake charge. It may also aid in air/fuel mixing, because the CNG may be introduced upstream of the compressor.

Results

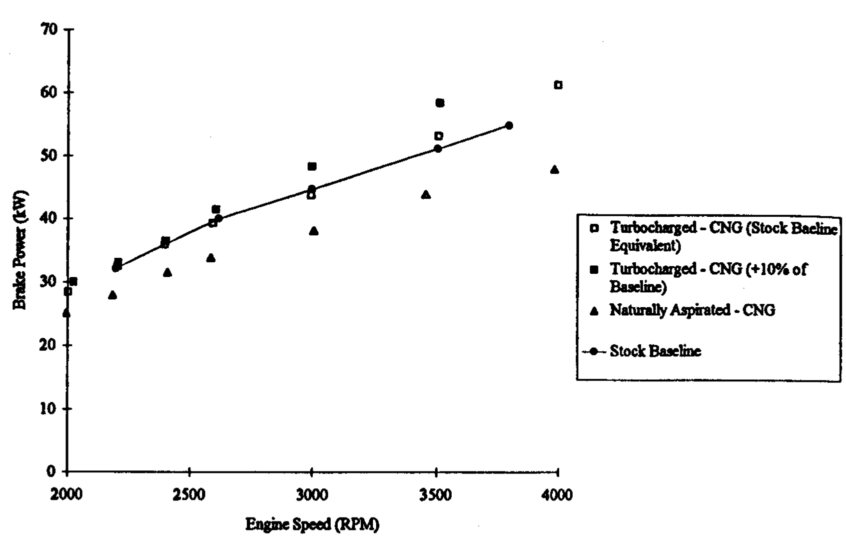
Figure 1 summarizes the main goal of this study, the achievement of performance equivalent to gasoline with CNG. To achieve this, the engine was operated at wide open throttle, and the boost pressure was raised by keyboard inputs on the real-time adjustment screen in the Bifuel Controller (BFC) until the load at that speed matched the stock baseline. Further boost was added in an effort to achieve 10 percent more power at each point, which was successful at the higher speeds.

Figure 1 clearly shows the power recovery that was achieved with the use of a turbocharger for CNG operation. It was possible to match stock gasoline performance at every operating point tested. Further gains in power were possible with additional turbocharging boost, with no audible knock, due to the high octane rating of natural gas. The extra 10 percent power desired, however, was not possible at lower engine speeds because the turbocharger could not supply sufficient boost.

Reductions in emissions of HC, NO_x, and CO_2 at part-throttle with the BFC and CNG fueling have been documented. Because the focus of this study was to regain wide open throttle performance, only emissions recorded at wide open throttle were presented. Reductions in total

FIGURE 1

WIDE OPEN THROTTLE PERFORMANCE



SOURCE: TENNANT ET AL.

hydrocarbon emissions were realized at full power with CNG. Figure 2 shows a reduction in NO_x emissions at lower power, but the stock baseline drops off sharply at higher power in what would seem to be the reverse of the expected trend. This is a result of the stock controller increasing the equivalence ratio.

Brake thermal efficiencies for all data sets were similar, as shown in Figure 3, and the differences between them may be within the range of experimental error. The stock baseline efficiency declines somewhat at the high power levels due to the extremely rich fueling. No gains in efficiency over the stock baseline were realized with the turbocharger installation, but of course the turbocharger boost was rather small, and efficiency improvements were not a goal. It is important that the installation of the turbocharger did not result in any significant losses of efficiency, which would be unacceptable.

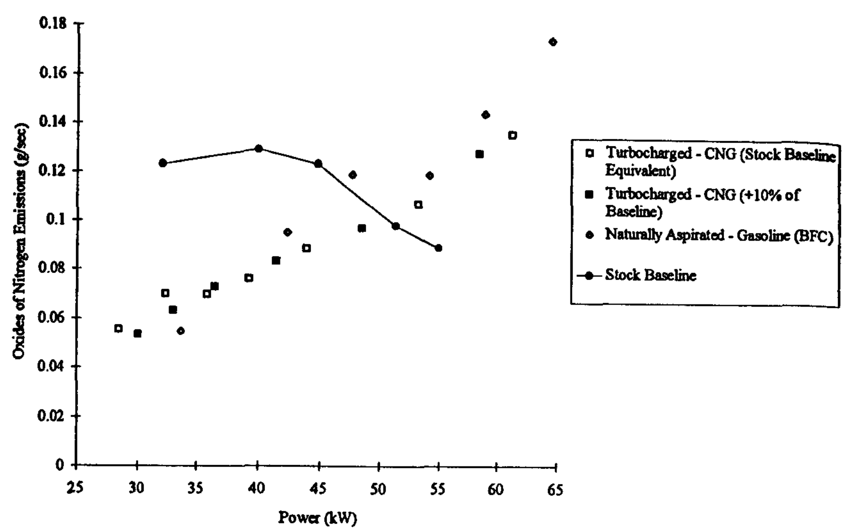
During operation on gasoline with the turbocharger installed, audible knock was experienced. Knocking occurred even under no-boost conditions with the wastegate open. This knock was thought to be the result of the heat transfer from the turbocharger casing to the intake air. It was necessary to bypass the intake air around the turbocharger compressor to avoid heat transfer and therefore knock. The use of EGR will be investigated on this engine for application as a knock suppressant.

Conclusions

Tennant et al. conclude that the installation of a turbocharger can directly recover power lost with CNG operation in an engine designed for gasoline. Further power gains are also possible. The level of turbocharger boost required to recover that power does not apparently subject the engine to any excessive level of stress not

FIGURE 2

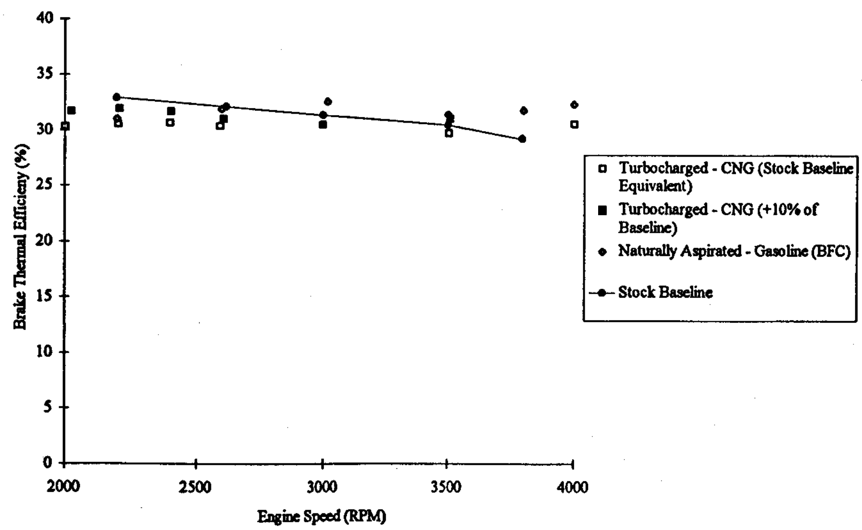
OXIDES OF NITROGEN EMISSIONS



SOURCE: TENNANT ET AL.

FIGURE 3

BRAKE THERMAL EFFICIENCY



SOURCE: TENNANT ET AL.

normally experienced with gasoline operation. Reduction of emissions of HC and CO_2 at all power levels is possible with turbocharged CNG operation. Reduction of emissions of NO_x and CO at some power levels is possible, depending on gasoline control strategy. No significant benefits or deficits in terms of brake thermal efficiency were found.

Access: SAE Paper No. 942003, phone 412 776 4841

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MARKET DATA

AGA DEVELOPS VEHICLE PURCHASE PROFILE FOR UTILITIES

Gas utilities engage in a number of activities promoting the development of the natural gas vehicle market. One of the most important of those market development functions is the purchase of NGVs. In fact, under the provisions of the Energy Policy Act of 1992 (EPACT) both gas and electric utilities are required to purchase alternate-fueled vehicles. Under the alternative fuel vehicle provisions of EPACT, gas and electric companies meeting certain fleet size and population criteria are required to purchase a percentage of light-duty (less than 8,500 pounds gross vehicle weight) AFVs. Beginning with model-year 1996 (late 1995), 30 percent of new light-duty vehicle purchases must be AFVs, increasing to 50 percent in model-year 1997 and reaching 90 percent in model-year 1999.

A Market Brief from the American Gas Association (AGA) gives the results of a survey that was conducted of gas and electric utilities to develop a better sense of the extent of NGV purchase plans in the near term. This data is valuable to a variety of interests in the NGV market, including original equipment manufacturers and NGV fueling and equipment suppliers. As in the previous survey, published in 1992, responses are from a sample of utility companies. The 47 gas and electric companies offer a cross-section of the industry in terms of geographic distribution and size. They have a combined total of nearly 66,000 fleet vehicles. Their total of 44,571 passenger and light-duty vehicles account for 46 percent of the passenger and light-duty fleets represented in an AGA/EEI Fleet Management Committee 1994 database compiled from 86 gas and electric utilities. Given that there are well over 150 utilities that are either subject to the EPACT provisions or have the intention of purchasing NGVs even if they are not, the responses from this survey can reasonably be increased by a factor of at least two and, possibly, four says AGA.

Summary Tables 1 and 2 indicate that for both 1994 and 1995 the utility fleets in the sample intended to acquire, through purchase or conversion, approximately 2,000 NGVs or about one-third of their intended annual vehicle acquisitions. These results are by no means definitive, but they do suggest a strong near-term demand for NGVs. Extrapolating from this sample, it appears that NGV purchases and conversions by all utilities in 1995 could range from 4,000 to 8,000 NGVs. As indicated in the survey the utilities are interested in acquiring a wide range of

TABLE 1

EXISTING UTILITY FLEET

	Fuel Type				
	Gasoline	Diesel	CNG	LPG	Totals
Passenger Cars					
Compact	7,286	0	399	0	7,685
Intermediate	4,631	0	317	0	4,948
Large	787	0	67	0	854
Total Cars	12,704	0	783	0	13,487
Vans					
Minivans	3,245	0	473	0	3,718
Standard	5,253	69	1,819	1	7,142
Large Vans	1,016	217	48	86	1,367
Total Vans	9,514	286	2,340	87	12,227
Trucks					
Light Duty	16,750	539	1,553	15	18,857
Medium Duty	6,270	6,549	452	36	13,307
Heavy Duty	1,079	6,417	98	96	7,690
Total Trucks	24,099	13,505	2,103	147	39,854
Grand Total	46,317	13,791	5,226	234	65,568

TABLE 2

PLANNED FLEET ACQUISITIONS FOR 1995

	Ded. CNG	Bi-CNG	Gasoline	Diesel	LPG	Totals
Passenger Cars						
Compact	0	161	781	0	0	942
Intermediate	10	205	324	0	9	548
Large	0	11	56	0	0	67
Total Cars	10	377	1,161	0	9	1,557
Vans						
Minivans	83	174	214	0	0	471
Standard	115	247	340	9	0	711
Large Vans	47	1	25	41	12	126
Total Vans	245	422	579	50	12	1,308
Trucks						
Light Duty	173	709	1,376	24	12	2,294
Medium Duty	0	80	427	482	1	990
Heavy Duty	0	31	15	396	0	442
Total Trucks	173	820	1,818	902	13	3,726
Grand Total	428	1,619	3,558	952	34	6,591

NGV sizes and types within the basic passenger car, van/minivan and light-duty truck categories.

Access: AGA, phone 703 841 8578

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GOLDEN RULES MARKETING STRATEGY FOR NGV STATIONS DEFINED

A strategy for NGV refueling stations of the future is the subject of a paper prepared by R. Filidoro of Italy's Nuovo Pignone for the Fourth International Natural Gas Vehicle Conference held in Toronto, Ontario, Canada last fall.

According to Filidoro, refueling stations are still the key to development and diffusion of natural gas vehicles. In economic terms, planning must compromise between the need to optimize investments by diluting them, as far as possible, in time and equally important requirements such as minimizing energy consumption, manpower and operating and maintenance costs and simplifying and automating refueling operations and station management.

As far as environmental issues are concerned, refueling stations must safeguard the environment by conserving the natural sound level and preventing deterioration of the air quality.

These conclusions are the results of Nuovo Pignone's latest experience in the NGV sector.

The economic advantages provided by natural gas as compared to conventional fuels in the gas-producing nations are not lost when gas is transported over a distance through pipelines. Advantages to the nations that utilize natural gas consist not only of savings, but also of being able to diversify their sources of energy.

As concerns the environment, natural gas is undoubtedly the least polluting automotive fuel after electricity but, as compared to the latter, it has the advantage of an industrially mature technology and immediately availability.

The conditions are thus ideal for rapid development of natural gas-fueled transportation. In spite of this, the projects being launched are frequently obstructed by previous negative experiences, some of which have been financially disastrous.

After years of waiting, the dream of producing vehicles specially designed to run on natural gas is now becoming a reality. With the guaranteed quality of their emissions, they will certainly give a new impetus to the sector.

Filidoro's paper describes the strategy implemented by Nuovo Pignone as a producer of equipment and refueling stations.

The Strategy

Sixty years of experience in the field of refueling stations has suggested 10 major objectives for attaining the ultimate goal of limiting costs without impairing either safety or quality and in full respect for the environment. These are 10 "Golden Rules" making it possible to find the correct compromise between investment costs and running costs:

- Select a strategic location
- Adopt an efficient refueling procedure
- Use systems that are modular, prefabricated
- Utilize versatile equipment
- Optimize efficiency
- Attain the maximum degree of reliability
- Minimize maintenance requirements
- Ensure maximum safety, protection and automation
- Dispense clean gas
- Safeguard the environment

Generally speaking, says Filidoro, there is a tendency to overestimate installation costs and to underestimate operating costs, as regards to:

- Energy consumption
- Cost of personnel
- Consumption of spare parts
- Consumption of lubricant

Respect for the 10 "Golden Rules" not only restores the correct balance between investments and running costs but also, in today's world, provides a guarantee of environmental safeguarding.

The Investment

Capacity being equal, the major factors influencing investment in an NGV refueling station are its location, the pressure of the gas pipeline to which it is connected, the refueling method used and its principles of construction.

The station should be built where the customers are. If it is to be used for refueling a fleet of vehicles, it should be located where the fleet is housed.

This principle, valid for urban and suburban transport in large metropolitan areas (buses, taxis, service vehicles, delivery vans, etc.) is no longer valid for fleets consisting of a few scattered vehicles, such as may be found in agglomerates of small- and medium-sized industries. In this case economy and efficiency dictate stations designed to serve the agglomerate, possibly associated in a consortium, rather than in many small independent company stations.

No entrepreneurial risks are involved in stations for fleets. How many vehicles are to be serviced and in how many years the investment will be amortized are known for a certainty in this case. On the contrary, opening a public service station is a financial undertaking that calls for careful preliminary verification of the number of potential customers. Car owners base their selection mainly on the financial results assured by using a certain fuel and on the relevant ease of servicing. It is the task of the feasibility study to evaluate the weight of each individual factor in the car-owner's decision (annual fuel consumption, difference in cost between gasoline and natural gas, legal incentives, autonomy, etc.) and, as a consequence, how many customers can be "captured" by a new NGV station.

For stations built in urban areas, locations with the highest network pressure available should be chosen, whenever possible. The pipeline pressure is the factor that most significantly influences investment and operating costs. With the same investment, a station connected to a gas pipeline with high pressure can have a capacity as much as 5 or 6 times greater than that of a station fed at low pressure. This also means that a station designed to refuel many vehicles each day or to dispense large amounts of natural gas, if fed at high pressure, could provide with a single compression unit the same service that, at low pressure, would require several units operating in parallel. Thus to say that a station must be strategically located means finding a site with high concentration of customers where only a minimum investment in machinery is required.

Ideally, a compression unit should be modular, skid-mounted, easily transportable, entirely prefabricated and equipped with all accessories, so that it need only be connected to the electric power network and the local gas pipeline on site. To keep up with market demand, station capacity should be designed to be increased by installing more modules in parallel.

Management

Good investments are those which ensure rapid amortization. At the same production levels, the most effective are those which minimize running costs for energy, personnel, maintenance and spare parts while making available equipment that is safe, versatile, reliable and able to provide unfailing performance over the years.

Among the running costs, one of the most important is that of energy consumption, which can range from a minimum of 15 percent for quick filling stations to a maximum of 70 percent for unattended overnight stations. This high impact on operating costs means that even a few more efficiency points can result in high energy savings, considering that stations are designed to operate for many hours each year and for many years.

Operating costs for the energy required by the compression service are strictly related to the inlet pressure of the natural gas fed by the pipeline. The specific consumption of energy by a compressor decreases in exponential manner with increases in the gas pipeline feed pressure. High inlet pressure allows substantial savings in energy costs. Thus an abrupt drop in efficiency, and thus an increase in energy consumption, occurs when the inlet pressure must be reduced by throttling, because the compressor is unable to tolerate the pressure of the gas pipeline. The natural gas compressor, then, must have double-acting cylinders to ensure more versatile operation. It must be capable of accepting abrupt variations in pressure in the gas pipelines, without the need for throttling the gas on inlet, with consequent lower loss of energy.

Environmental Safeguarding

Dispensing clean gas to vehicles is incompatible with the use of compressors having lubricated cylinders, because a significant quantity of oil is entrained in the gas. The oil can be eliminated by installing sophisticated and expensive oil removing filters downstream.

More simply, a crosshead compressor design allows oil-free operation of the compressor cylinders, providing the following functional advantages:

- Conserving the original quality of the gas

- Cleanliness and better operation of the vehicle gas system and engine due to the absence of oil and carbon deposits from its combustion

- Eliminating the need for periodic cleaning of the gas cylinder aboard the vehicle

Environmental safeguarding today should not be limited to controlling emissions from engines. Nuovo Pignone has demonstrated that refueling stations can operate without harming the environment through excessive noise, vibrations and gas leakage.

Conclusions

The favorable opportunities offered by the natural gas market for vehicles point to a redefinition of strategies for companies operating in the NGV field.

The criteria presented in this paper can apply to any country and can serve to weigh operational priorities or procedures.

The economy of an NGV project should not be an end in itself; equally important is guaranteed productivity of the service station, the only way to ensure pay-back of the financial resources invested.

The Ten Golden Rules help to consider systematically, all of the factors required for the success of an initiative of this kind.

The success of an initiative becomes a stimulus for the creation of a wide-spread network. Its failure, on the contrary, results in loss of credibility for ambitious plans for development, even the most valid ones.

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ECONOMICS

FINANCIAL ANALYSIS DEVELOPED FOR PUBLIC TRANSIT FLEETS

Natural gas is now the leading alternative choice to diesel for Canadian and United States transit fleets. The technical side of conversion to natural gas has been well explored, and proven to be sound. Nowadays transit system operators no longer need to ask "Will it Work?," but "Is it economically realistic for my fleet?." A paper by L. King and M. Bol at the International Conference on Natural Gas Vehicles held in Toronto, Ontario, Canada last fall gives some responses to this question, developed during studies for three major Canadian public transit fleets.

The terms of reference for the studies included compressed natural gas. However, many of the conclusions reached are equally applicable to the use of liquefied natural gas. Some analysis of the monetary value of emissions reductions was performed, using multiple account analysis, which indicated overall benefits to society. However, emissions credits are not available in Canada, and therefore emissions reductions would not result in a real financial return to an operating fleet.

Life-Cycle Cost Analysis

Switching a bus fleet to natural gas calls for high initial investment, but offers the greatest fuel cost savings given the present pricing and tax structure. The final cost of gas to the operating fleet is influenced by the volume consumed and the expected maximum daily demand. The cost of gas compression is a significant component. The analysis included provision for a fleet to purchase gas from a utility at an "all-in" price including compression, or to purchase gas at the property line and take responsibility for the installation and operation of its own compression plant.

Initial capital costs may also include provisions for modifications to fleet buildings and infrastructure, most often related to safety requirements. Upgrading of ventilation systems and attention to roof mounted electrical fixtures and heaters is often needed. Costs will vary widely from fleet to fleet. Many fleets already have extensive ventilation systems in-place in parking and servicing areas, to ensure rapid evacuation of diesel exhaust when buses are started and warmed up at the beginning of shifts. Indoor refueling has been approved for London Transit's natural gas program, which should set a positive precedent for other Canadian fleets. However, the safety requirements to allow indoor refueling can be costly, and fleets able to refuel outdoors may therefore enjoy a significant financial advantage. There may also be a need for some modification or reorganization of maintenance workshops. Ongoing operating costs will include maintenance for buses, compressors and infrastructure (e.g., ventilation plant etc.), and safety and operational training for staff.

The base case for the analyses was continuation with diesel fuel, and the costs for natural gas were assessed on an incremental basis.

The analysis did not cover the conversion of existing diesel buses to natural gas. It was assumed that all future replacements would be OEM natural gas buses.

The model constructed for the analysis used the annual fleet service distances to calculate annual fuel usage and cost, and bus maintenance cost changes. The incremental cost of each natural gas bus was treated as a one time cost in the year of bus purchase. The capital costs associated with refueling station construction and expansion, and any infrastructure modifications, were included in the year when they were planned to occur. Annual facility maintenance costs were adjusted in accordance with the changes to the refueling stations and garage infrastructure.

The analysis calculated the Net Present Value (NPV, in 1993 dollars) of the difference between the diesel base case and the natural gas alternative, at the end of a 20-year period. The residual value of assets was included in the final NPV, using straight line depreciation. The depreciation lives used were 20 years for the buses and refueling equipment, and 30 years for buildings and infrastructure.

Table 1 shows the primary input data used in the initial analysis for a fleet operating 640 buses out of three garages. The annual bus service distance was decreased as the buses became older, in accordance with the operating practice of the subject fleet.

Initial Analysis Results

The fleet related to the data in Table 1 requested independent analyses for its three garages. The options considered included filling each garage to capacity, and allocating only 125 natural gas buses. The results demonstrated that better returns were obtained by concentrating the greatest number of buses at a single location. Table 2 gives the individual results for the three garages.

To place these figures in perspective, the $6,955,000 savings predicted for the 240-bus garage resulted from $14,750,000 incremental costs over the 20-year analysis period, $20,890,000 savings in fuel costs, and $815,000 residual assets value. (All figures NPV.)

In an analysis for a second fleet of comparable size, which covered conversion of the entire fleet, the final NPV of the project after 20 years was in the range from $8.7 million to $11.7 million,

TABLE 1

ANALYSIS INPUT DATA

Factor	Input
Annual Service Distance	
Years 1 to 6	57,000 km
Years 7 to 11	51,000 km
Years 12 to 16	44,500 km
Years 17 to 20	38,000 km
Diesel Price	$0.35/L
Diesel Consumption	59 L/100 km
Natural Gas Price	$2.40/GJ
Natural Gas Efficiency Loss	0%
Natural Gas Consumption	2.03 GJ/100 km
Compression Cost Allowance	4 % of fuel consumption
NG Bus Maintenance Cost Increase	$0.00/km
Diesel Bus Price	$230,000
Natural Gas Bus Price (Years 1 to 5)	$280,000
Natural Gas Bus Price (Year 6 on)	$275,000
NPV Discount Factor	4.50%

TABLE 2

INDIVIDUAL GARAGE RESULTS

Garage Capacity	Fill to Capacity (NPV $)	125 Buses Only (NPV $)
240	6,955,000	2,850,000
250	6,935,000	2,717,000
135	3,321,000	2,859,000

depending upon refueling options selected, and the extent of infrastructure modifications. This fleet had different annual mileages and projected replacement schedules.

The third fleet included in the work ran approximately 340 buses out of two garages, and showed a project NPV return of $900,000. This was due to a higher local gas price, and the need for fairly extensive infrastructure upgrading.

Sensitivity Analysis

The price of natural gas may be influenced by future taxation. The provincial tax on diesel in Canada is typically around $0.10 per liter, which is roughly $3.00 per gigajoule. Assuming that any tax imposed would be based on energy equivalency, the sensitivity analysis was run with a test taxation rate between $0.00 and $3.00 per gigajoule. The result for the 240-bus garage scenario referred to in Table 2 is shown in Figure 1.

The final project NPV declined at a rate of approximately $3 million per $1.00 per gigajoule tax increase.

A sensitivity analysis for natural gas thermal efficiency effects was conducted over the range from equal to 20 percent less thermal efficiency than diesel. The worst case assumption showed no more than a $1.3 million drop in the final NPV. Because fully developed natural gas engines will achieve efficiencies very close to diesel, the analysis indicated that comparative engine efficiency is not a significant factor in any decision to convert to natural gas.

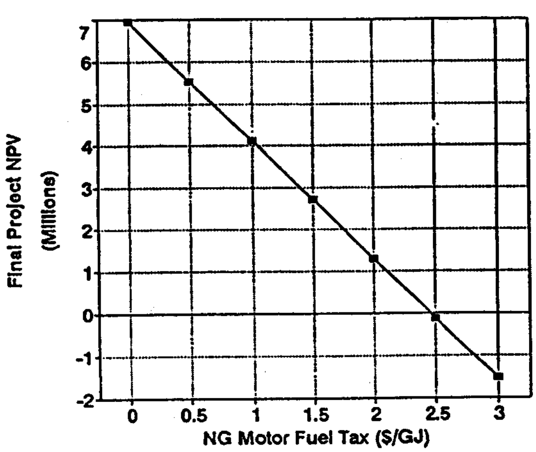
The effect of discount rate variation was tested over the range from 0 percent to 12 percent. The results are shown in Figure 2. Projects of this nature, in which the initial capital expenditure is high, and the resultant savings do not begin to build up until much later, are favored by low discount rates.

Summary

In general the analyses by King and Bol indicated that fleets can save money by conversion to natural gas. The way to maximize returns is to place as many buses in service as rapidly as possible, and maintain a high ratio of buses to refueling stations. However, individual fleet viability will vary considerably because of factors such as infrastructure modification costs, regional variations in gas prices, fleet replacement schedules and average annual mileages. As current fleet experience grows, more information about natural gas bus efficiency and maintenance costs will become available. This will allow more precise assessment of ongoing costs, including the question of whether natural gas may actually

FIGURE 1

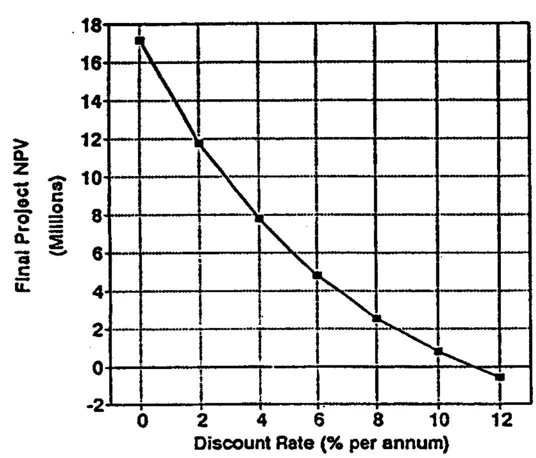
NATURAL GAS TAX SENSITIVITY



SOURCE: KING & BOL

FIGURE 2

DISCOUNT RATE SENSITIVITY



SOURCE: KING & BOL

provide maintenance cost savings in the long term. Capital costs and fuel price are major influences on financial viability. Some provinces will subsidize transit system capital costs. Ascribing monetary values to projected emissions reductions would also improve the rate of payback and the overall viability of natural gas fueling.

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VEHICLES

ARGENTINA CNG CONVERSIONS RUNNING OVER 5,000 PER MONTH

According to the publication Prensa Vehicular, over 5,000 vehicles per month are being converted to CNG in Argentina (see Table 1, next page). About two-thirds of these conversions are in the capital region of Buenos Aires, with the remainder scattered in the interior regions.

Average fuel prices are listed as:

- $0.60 per liter for regular gasoline
- $0.80 per liter for premium gasoline
- $0.28 per liter for diesel fuel
- $0.26 per cubic meter for CNG

Access: Prensa Vehicular, phone 304 7088, Argentina

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FLEET OF 360 BIFUEL NGVs OPERATING IN INDIA

Indian experience in the field of natural gas vehicles was recounted by P. Sarma and K. Sinha of Gujarat Gas Company Ltd. at the Fourth International Conference on Natural Gas Vehicles held in Toronto, Ontario, Canada last fall.

Gujarat Gas Company has been a pioneer in the distribution of natural gas to domestic, industrial and commercial establishments. The combined distribution of natural gas in the cities of Surat, Ankleshwar and Bharuch in the State of Gujarat is around 0.47 million cubic meters per day. Under a diversification and expansion program, the company is setting up port facilities for the import of LPG, and for the import of LNG for power projects.

The CNG project for bifuel gasoline/CNG vehicles began in 1991. The project scope is limited to bifuel operation because unless a wide network of refueling stations is established, mono fuel CNG conversion will not be a practicable solution. The project was totally planned on a retrofit basis and in order to ensure that the retrofit vehicles with CNG perform well in the field, the certifying and regulatory authorities formed a core team for evaluating the vehicle performance under the Ministry of Surface Transport of the Government of India.

In the absence of an Indian code of practice for use of CNG, it was decided to follow New Zealand Standard (NZS-5422 Part-II), until a suitable Indian code of practice is developed.

Four basic Indian models which are present in large numbers across the country were planned for certification tests. All these vehicles have gas carburetion systems (Table 1). Indian gasoline vehicles do not have any sort of exhaust emission control devices like catalytic converters.

Certification Tests

Each vehicle was tested with retrofitted conversion kits and test results indicated the following:

- The power loss associated with CNG was in the range of 10-20 percent.
- The exhaust emissions of CO and HC are significantly less with CNG as compared to gasoline in all the vehicles.
- The retrofitted vehicles successfully completed the chassis dynamometer test with the Indian Driving Cycle (IDC),

TABLE 1

ARGENTINA CNG CONVERSIONS BY MONTH

Year	Month	Monthly Total	Cumulative Total
1992	May	4,935	164,280
	Jun	4,720	169,000
	Jul	5,210	174,210
	Aug	4,942	179,152
	Sep	5,823	184,975
	Oct	5,057	190,032
	Nov	5,502	195,534
	Dec	2,633	198,167
1993	Jan	4,018	202,185
	Feb	2,510	204,695
	Mar	4,885	209,580
	Apr	4,403	213,983
	May	6,080	220,063
	Jun	6,710	226,773
	Jul	6,522	233,295
	Aug	8,403	241,698
	Sep	7,295	248,993
	Oct	8,480	257,473
	Nov	5,944	263,417
	Dec	4,948	268,365
1994	Jan	5,368	273,733
	Feb	3,692	277,425
	Mar	6,024	283,449
	Apr	5,240	288,869
	May	5,253	294,122
	Jun	5,128	299,250
	Jul	4,868	304,118
	Aug	5,080	309,198
	Sep	5,447	314,645
	Oct	5,500	320,145
	Nov	5,950	326,095

TABLE 1

CAR MODELS CONVERTED TO BI-FUEL CNG

Vehicle Models/ Manufacturer's Name	Engine Capacity/ No. of Cylinders	Horse Power	Carburetor Type
Premier Padmini (Premier Automobiles Ltd.) Bombay	1,089 CC (4 Cylinders)	42	Single Barrel Down Draught
Ambassador (Hindustan Motors Ltd.) Calcutta	1,489 CC (4 Cylinders)	48	Single Barrel Down Draught
Maruti Car (Maruti Udyog Ltd.) Delhi	800 CC (3 Cylinders)	39	Double Barrel Down Draught
Maruti Van (Maruti Udyog Ltd.) Delhi	800 CC (3 Cylinders)	39	Single Barrel Side Draught

which is similar to the 13-mode test in other countries.

- In both gasoline and CNG mode, the vehicle was able to maneuver the 1/7 gradient test.

- Road tests indicated that the conversion kit was well tuned for the car, with acceptable acceleration levels and no driveability problems.

Field Experience

So far 360 vehicles have been converted to bifuel CNG operation. According to Sarma and Sinha, the conversion kit was totally developed locally except for import of the refueling valve and pressure regulator. Initially the failure rate was quite high, but after a lot of effort the rates are coming down. Figure 1 depicts all the failures. Taking into consideration that this is the first time in the country the conversion kits were developed, the effort is commendable.

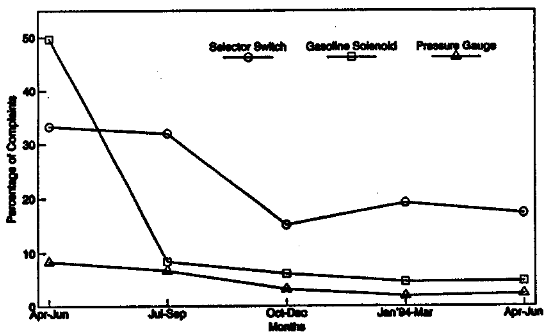
The average fuel consumption of the cars on gasoline is approximately 12-18 kilometers per liter and on CNG-mode the average is between 14-23 kilometers per cubic meter. The quantity of CNG filled in vehicle is approximately 8 standard cubic meters and the range per fill varies between 120-180 kilometers.

In the last 15 months of commercial operation the experience has been encouraging with not a single major leak found in the system. Three vehicles have met with accidents but still there was no leak from any high-pressure connection. On the cylinder, on a few occasions there was a failure of the burst disc but the gas was vented safely.

FIGURE 1

CONVERSION KIT QUALITY STATUS

(From April 1993 to June 1994)



SOURCE: SARMA & SINHKA

The biggest limitation for expansion of refueling facilities will be the return on investment which in initial years will be very low. High initial investments are required for setting up a refueling station and then the refueling load based on number of vehicles converted will rise slowly. It is clearly seen that any refueling station to reach its optimum utilization capacity will take a minimum of 2 years.

As far as the customer is concerned, after paying an initial price of around US$750 for the conversion kit and with a price differential between gasoline and CNG of $0.30 (1 liter of gasoline assumed to be equal to 1 standard cubic meter of CNG) and an increase in fuel economy of around 25 percent, the payback will be less than 2 years for 50 kilometers of travel per day.

Refueling Stations

The first CNG station is an online station with a compressor capacity of 287 cubic meters per hour. This is an air cooled, 5-stage, 6-cylinder machine with storage of 300 cubic meters in a cascade of cylinders.

As part of an expansion program, one mother station having a compressor capacity of 357 cubic meters per hour and three daughter stations each having a capacity on cascade of around 1,000 cubic meters are planned in and around the mother station within a radius of 40 to 50 kilometers.

Pricing and Economics of Operation

Gasoline is available at US$0.62 per liter against diesel which is available at US$0.23 per liter. Diesel is highly subsidized in India because it is mostly used in the public transport sector. CNG is priced around US$0.32 per standard cubic meter. The conversion kit prices available locally are around US$900-$950 per kit. At present the company is offering a discount of US$150-$200 as a project promotion.

Future for NGVs in India

In addition to Gujarat Gas Company Ltd., Gas Authority of India Ltd. is also trying to promote the use of CNG in vehicles. They have converted around 200 vehicles in different cities. They are using the mother/daughter refueling concept.

With the existing pricing policy of the government it will be possible only to convert gasoline vehicles to CNG. Diesel vehicles cannot be converted economically. In India most of the heavy vehicles like goods carriers, passenger buses, etc. are all diesel powered. Only the private transport vehicles are gasoline powered. Given a little more encouragement from the government in the form of incentives and subsidies, Sarma and Sinha believe the NGV program for gasoline vehicles could explode in India.

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MARYLAND MTA LNG TRANSIT BUS DEMONSTRATION COMPLETES ONE YEAR OF OPERATION

The Maryland Mass Transit Administration (MTA) is demonstrating the use of Liquefied Natural Gas

(LNG) as a low emission transit bus fuel. The overall objective of the project is to demonstrate LNG transit bus technology and quantify the technical and economic characteristics of LNG fuel relative to diesel fuel and compressed natural gas.

Funds for this demonstration were obtained from the Federal Transit Administration, the Baltimore Gas & Electric Company and the State of Maryland. EA Engineering, Science, and Technology, Inc. designed the LNG refueling facility and oversaw its construction. Hydra Rig, Inc. built the LNG trailer and supplied the LNG dispenser. An overview of the project was provided in a paper by R. Bechtold et al. at the Fourth International Conference on Natural Gas Vehicles, held in Toronto, Ontario, Canada last fall.

Bus Design

The MTA LNG transit buses are 40 feet long and made by Flxible Corporation. They are configured for typical urban use and include wheelchair lifts. The engine is the L240G version of the Cummins L10. Because of the space requirements for the engine catalytic converter, the bus air conditioning system was mounted on the roof. The LNG fuel system was made by CVI, Inc. and consists of three separate tanks with a total fuel capacity of approximately 180 gallons. This gives the LNG buses the same range (approximately 300 miles) as their diesel fuel counterparts. The LNG tanks are mounted behind the front axle of the bus whereas diesel fuel tanks are mounted in front of the rear axle of the bus. The LNG is pumped from the tanks using a hydro-mechanical pump served by an auxiliary power steering pump mounted on the engine. The LNG is vaporized downstream of the pump. Beyond the pressure regulators in the fuel system, the LNG fuel system is the same as a CNG fuel system. Methane detectors are mounted strategically around the bus fuel system and in the engine compartment to signal the presence of any leaks. Ultraviolet/infrared detectors are also present to identify fires and activate the onboard fire suppression system.

The buses have been in operation since December 1993.

Refueling Facility

Even though there are only four buses in the demonstration, it was desired that full-scale refueling operations be simulated to accurately estimate the labor and utility requirements of refueling LNG buses. The refueling process by necessity must be similar to that for diesel fuel buses and not require an increase in skill level of refueling personnel. It was hoped that the total refueling time would be similar to that required for diesel buses, otherwise additional refueling facilities and personnel would be needed.

LNG is the only fuel with a shelf life, i.e., after a period of days, enough heat has migrated into the system to cause an increase in tank pressure, and if fuel is not used, the vapor will have to be vented.

The MTA LNG refueling system directs vapor generated during refueling back to the storage tank where some of the vapor is reliquefied. To get an accurate measure of the amount of LNG put into each bus, it is necessary to measure both the liquid pumped to the bus and the vapor returned from the bus. Both liquid and vapor meters are in the dispenser to measure the net amount of natural gas delivered to each bus.

It was decided to use an LNG trailer for storage of LNG on-site instead of installing a semi-permanent or permanent storage tank. There were two main reasons for this decision: first, it eliminates one transfer of the fuel with its associated vapor losses and heat gains; and second, a trailer has much better resale value than a permanent storage tank. This approach also simplified acquisition of new supplies of LNG since it is much easier to contract with a local trucking firm for a tractor to move a trailer than it is to contract with a trucking company that has cryogenic trailers to move less than truckload quantities (10,000 to 13,000 gallons) of LNG.

The LNG refueling facility's major components include the dispenser, canopy, kiosk, LNG trailer, and fire suppression system. The dispenser includes a programmable logic controller that controls the cool-down and refueling processes. Mass flow meters are used to measure both the liquid LNG delivered to the buses and the vapor returned from the buses. Flexible, vacuum-insulated lines are used to connect the storage trailer to the dispenser, and to refuel the buses. A submerged pump in the trailer pumps LNG from the trailer to the dispenser, which in turn, controls the flow of LNG during bus refueling. Vapor generated during cool-down and bus refueling is returned back to the trailer where most of it is reliquefied. When the pressure in the tank reaches its design set point, vapor is released to the atmosphere. For a large-scale LNG refueling facility, the investment necessary to capture boil-off vapor would be justified in both economic and environmental terms.

The refueler must have both the liquid delivery nozzle and the vapor return nozzle securely mounted and enter the bus number to activate refueling. Sensors tell the dispenser when the nozzles are attached and opened. Without these signals, flow cannot occur. Two problems have been observed with these nozzles. First, freeze-on of the nozzles sometimes occurs when several buses are refueled in succession. This is believed to be caused by frost build-up on the nozzle which melts between refuelings and then refreezes during subsequent refuelings. A partial solution to this problem is to introduce a controlled flow of nitrogen gas in the annular space around the nozzle seal during refueling and to carefully remove any ice from the face of the seal before attaching the nozzle to refuel (a blast of nitrogen gas is one of the most effective means of removing ice from the face of the seal). The other problem has been leakage of the nozzles during refueling. The amount of leakage is typically small (dripping as opposed to a stream) and is believed to be caused by dirt or ice on the nozzle face seal, or damage of the face seal.

The refueling facility incorporates a dry chemical fire suppression system of 2,000-pound capacity. Ultraviolet/infrared sensors are mounted strategically to cover the entire refueling area and storage trailer. At least two of the sensors must signal a fire before the system will be activated. When a fire is sensed, an alarm sounds, and there is an 8 second delay to allow manual shutdown in the case of a false trigger.

Operating Summary

The LNG buses are now operating in revenue service. To date, the LNG buses have shown fuel economies of 2.5 to 2.9 miles per diesel gallon equivalent compared to approximately 3.5 miles per gallon for similar diesel buses using diesel fuel. The problems of most concern have been refueling nozzle freeze-on and leaks, and the fact that operating the refueling system is more complex than the typical diesel fuel refueling system.

A final report for the demonstration will be issued in March 1995. The MTA is currently in the process of deciding how to expand natural gas use throughout their fleet of vehicles.

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NEW YORK FLEET TEST OF CNG VANS REPORTS EMISSION RESULTS

The State of New York anticipated the intent of the United States Federal Clean Air Act Amendments of 1990 and the Energy Policy Act of 1992 (EPACT) by implementing the Alternative Fuel Vehicle Fleet Demonstration Program (AFV-FDP) in 1990 to investigate the impact of alternative fuel vehicles in New York for environmental, energy, and economic reasons. The program was designed to operate nearly 300 alternative fuel vehicles in public transit, state and municipal fleet service throughout the state. Light- and heavy-duty vehicles and a range of alternative fuels (natural gas, methanol, ethanol, LPG, and electricity) have been utilized in this voluntary cost-sharing program between the New York State Energy Research and Development Authority and various state and municipal agencies. The first of the AFV-FDP vehicles started operation in late 1991 and the data gathering effort will continue operation until the summer of 1995. By that time more than 200 emissions tests will have been taken to quantify the clean air capabilities of many of these bifuel and dedicated AFVs.

A paper by A. Vatsky et al. at the International Conference on Natural Gas Vehicles held in Toronto, Ontario, Canada last fall discusses a portion of the AFV-FDP fleet--a group of 12- and 15-passenger Dodge vans in urban service including vans converted to CNG, an OEM CNG dedicated van, and gasoline control vans. The fleet is operated by the South Beach Psychiatric Center in Staten Island, New York.

The available information from these vehicles is presented in the context of EPACT, which will impact this fleet by September 1995. Likewise, the Clean Air Act Amendments of 1990 (CAAA), will impose purchase restrictions by September 1997. Because this fleet is large (greater than 20), state-owned, and centrally fueled, 10 percent of any new vehicle purchases for 1996 must be AFVs under EPACT (15 percent and 25 percent respectively for 1997 and 1998).

Under the CAAA, metropolitan New York City is classified as a severe ozone nonattainment area. This classification requires that 30 percent of the light-duty (between 2,721-3,855 kilograms gross vehicle weight in New York) vehicle purchases in 1998 must be clean fuel vehicles, a classification which includes AFVs as well as vehicles using reformulated gasoline and clean diesel.

Description of Vehicles

The vehicles in this test fleet were all manufactured by the Chrysler Corporation. The Dodge Ram Van/Wagon model has been in production since the early 1980s, and is powered by V-8 engines of either 5.2 or 5.9 liter displacement. About 1 million of these vans have been on the roads of North America since they were introduced. It is a very common vehicle for both passenger and delivery/service fleets.

The State of New York purchased one of the approximately 450 1994-model OEM Dodge CNG Ram Vans (Van No. 30) made by Chrysler. The other vans were converted Dodge B-350 vans (Nos. 15, 40, and 48) from model-years 1989 and 1990. These vehicles had their gasoline fuel systems removed and replaced with four CNG tanks all mounted below the body giving a total fuel capacity of 53 equivalent gasoline liters. They were fitted with the IMPCO ADP (Adaptive Digital Processor) system which is designed and manufactured as an advanced electronic closed-loop fuel controller.

The catalytic converter was unchanged and there were no internal changes made to the 5.2 and 5.9-liter engines. The increase in empty weight due to the removal of the gasoline system and the installation of the CNG tanks was approximately 100 kilograms.

Fuel Consumption

There are two sources of fuel consumption rate information: fleet fueling and distance records; and the consumption rate calculations based upon dynamometer measurements during emissions testing using the Federal Test Procedure (FTP). Data from the latter source are shown in Figure 1.

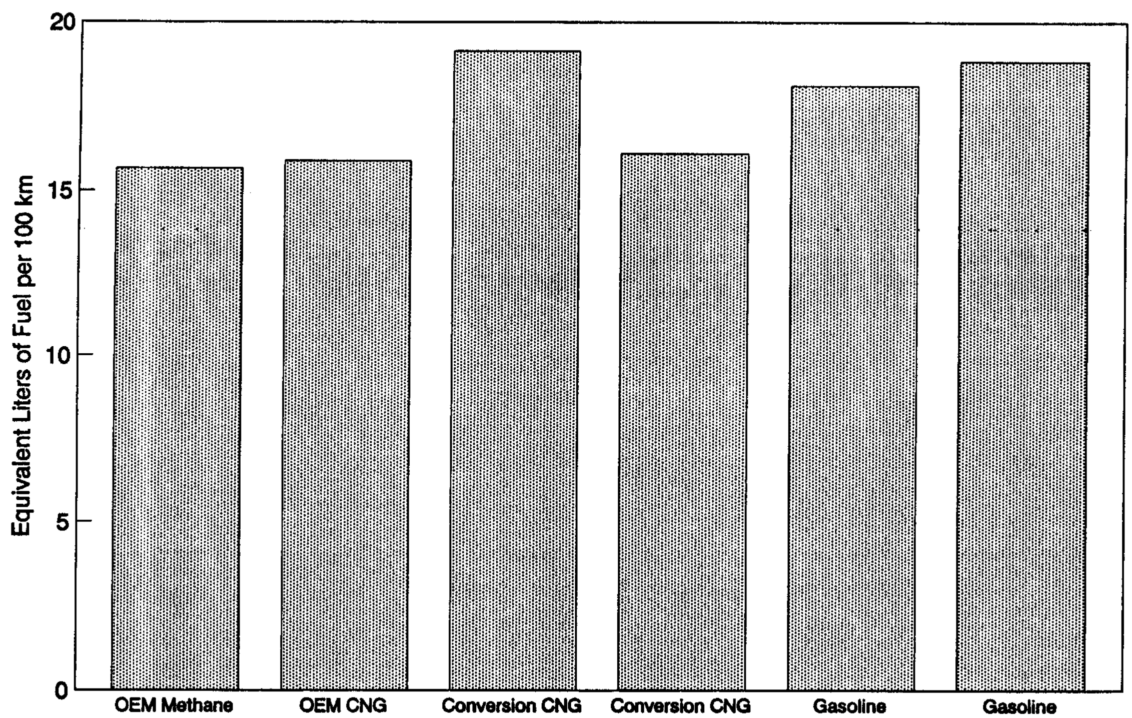
The OEM CNG van (12-passenger with 5.2-liter Magnum CNG engine) has the lowest fuel consumption, being 15.8 liters per 100 kilometers operating on CNG and 16.0 liters per 100 kilometers when operating on methane.

Serviceability/Driveability Comments

Drivers and the fleet manager strongly prefer on-site fueling but the local CNG refueling sites are 5 to 10 minutes away. The fuel injectors on the OEM van make a characteristic sound that sounds like valve clatter to drivers. Later models of the OEM van use quieter injector valves. As predicted, drivers report a reduction in power when the vans are heavily loaded.

FIGURE 1

FTP FUEL CONSUMPTION



SOURCE: VATSKY, ET AL.

Emissions Information

Van 15 (5.2-liter engine) was emissions tested using gasoline before conversion to dedicated CNG operation. Van 38 (5.2-liter engine) is the gasoline control van and was tested using gasoline. The data are a combination of 5.2-liter and 5.9-liter engine data, different model years, and widely varying vehicle emissions system deterioration. Finally, the tests were run in two different laboratories which, though well maintained and calibrated, have not been cross calibrated using the same vehicle.

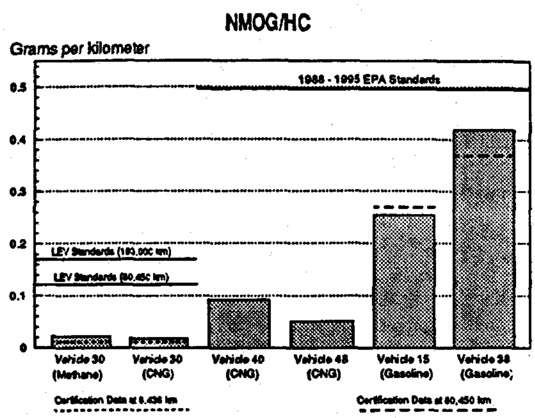
The available results do indicate the following, according to Vatsky et al.:

NMOG/HC (Figure 2): The OEM CNG Van 30 clearly had the lowest NMOG/HC emissions, as would be expected. Whether on CNG or pure methane, its NMOG/HC emissions were consistent and near published Chrysler values for California emissions levels. The IMPCO ADP converted CNG vans also operated below published (1994 gasoline) and actual preconversion HC emissions for gasoline. The IMPCO vehicles also were within the NMOG LEV standards.

CO (Figure 3): The OEM CNG Van 30 gave low and consistent values for CO. All six tests were well below United States Environmental Protection Agency (EPA) LEV requirements. The converted vans, however, were found to exceed ap-

FIGURE 2

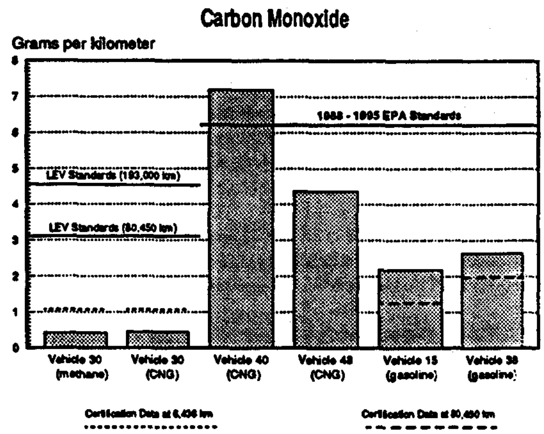
NMOG/HC LABORATORY RESULTS FROM FTP



SOURCE: VATSKY ET AL.

FIGURE 3

CARBON MONOXIDE LABORATORY RESULTS FROM FTP



SOURCE: VATSKY ET AL.

plicable EPA standards on Van 40 and exceed preconversion gasoline emissions on Van 48. These converted vehicles also would have exceeded the LEV CO standards. For the converted vans a possible ADP system adjustment should be able to reduce CO emissions without impacting NMOG/HC and NO_x emissions significantly.

NO_x (Figure 4, next page): NO_x values for the OEM CNG Van 30 were 0.23 grams per kilometer. These values are well within LEV requirements but much higher than the certification values for this vehicle. No obvious explanation exists for these results. NO_x levels for the converted vans averaged 0.54 grams per kilometer. The gasoline tests averaged 0.79 grams per kilometer. The gasoline baseline tests are within EPA standards for their years of manufacture but they do exceed their deteriorated EPA NO_x emission level.

The OEM van had the lowest emission levels in all the tests. Chrysler has been able to achieve LEV EPA certification so this model van can be sold and credited under the CAAA as an LEV.

Test data indicate the converted vehicles have the potential for reduced emissions levels if CO can be controlled. It seems unlikely, however, that these converted vehicles will be able to demonstrate LEV levels and so will not qualify for CAAA Credits.

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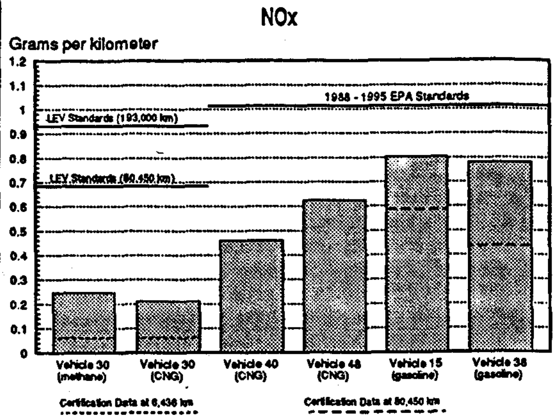
NATURAL GAS BUSES ON THE WAY TO INDONESIA

While in Indonesia in November, President Clinton praised a U.S./Indonesia joint venture that plans to demonstrate the use of natural gas in

FIGURE 4

NOx LABORATORY RESULTS FROM FTP



SOURCE: VATSKY ET AL.

transit buses in Indonesia. A prototype bus was on display at the Asia Pacific Economic Cooperation (APEC) Business Coalition meeting.

Indonesia's large cities have a serious particulate pollution problem resulting from widespread use of diesel engines and two-stroke motorcycles. Indonesia is also one of the world's largest exporters of liquefied natural gas. Thus, it makes sense to match a need with a resource.

The joint venture, known as the U.S./Indonesian Clean Natural Gas Bus Project, or Bis Tanpa Asap (smokeless bus), was conceived by Engines, Fuels and Emissions Engineering, Inc., and integrates an advanced technology, low emission natural gas engine, manufactured by Hercules Engine Company, a transit bus chassis, produced by Thomas Built Buses, and an aluminum bus body, assembled by P.T. Volgren Indonesia, a leading local bus maker.

The joint venture effort is coordinated through the American Embassy with the assistance of the United States and Foreign Commercial Service of the U.S. Department of Commerce and the United States-Asia Environmental Partnership's (US-AEP) Office of Technology Cooperation in Jakarta.

The US-AEP is a program that brings together the resources of 25 U.S. government departments and agencies and thousands of businesses and non-governmental organizations that work with 34 nations and territories in and around the Pacific. US-AEP assists in addressing environmental degradation and sustainable development issues in the Asia/Pacific region by mobilizing U.S. environmental experience, technology and practice.

The partnership has agreed to run a demonstration of 50 CNG buses that will contain parts supplied by United States firms, who hope to sell as many as 1,500 similar buses for fleets in Indonesia depending on the success of the project.

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INDUSTRY ANALYSES

LNG CALLED BEST CHOICE FOR SOME TRANSPORTATION FUEL MARKETS

Speaking at the 16th International LNG/LPG Conference in Kuala Lumpur, Malaysia in October, R. Nimocks of LNG Express said that liquefied natural gas (LNG) continues to gain momentum as a heavy-duty transportation fuel, primarily because it is inherently cleaner than the complex hydrocarbons that comprise gasoline and diesel, and yet, costs less per unit of energy. The key question is whether the worldwide push for cleaner air will be enough of a catalyst to encourage one or more markets within the transportation industry to invest in the technology and infrastructure necessary to switch to LNG.

Worldwide, slightly more than 140 million commercial vehicles consume roughly one trillion liters of diesel fuel (35 quadrillion BTU) each year, which is more than ten times the amount of energy traded in the global LNG market. A large percentage of these vehicles are centrally fueled, serving urban or suburban communities affected by tightening clean air regulations.

As cities such as Mexico City and Bangkok have been growing, their pollution levels have been rising to hazardous levels. Furthermore, due to growth in the transportation sector and advancements with stationary pollution controls, vehicles are emitting a greater proportion of total air pollution. In Mexico City, for example, more than 60 percent of total air pollution is believed to come from mobile sources; in California, 70 to 90 percent of ozone forming gases come from transportation. In an effort to stem this social cost, governments are imposing stricter tailpipe emissions standards on transportation, which in turn, increases the cost of conventional fuel operation.

Why LNG?

In recent years, there has been greater emphasis in Europe and North America on clean burning, alternative fuel development. Liquefied natural gas, or liquid methane, holds possibly more promise than any other alternative transportation fuel, says Nimocks, primarily for the following reasons:

- It is inherently cleaner than any other fossil fuel.
- It is abundant. Some geologists believe the world contains more natural gas than oil.
- It is less expensive than oil. LNG often sells for 50-80 percent of the price of wholesale diesel.
- It is dense. LNG contains more energy per pound than gasoline or diesel fuel. Vehicles can carry enough fuel without trading cargo capacity for added fuel tank storage.
- It has the highest octane rating of any common fuel. LNG can be purified to near 100 percent methane, a fuel with an octane rating of nearly 130.
- It is a liquid fuel. LNG can be transferred to vehicles as rapidly as diesel or gasoline, which is an advantage in comparison to CNG. Also, it can be compressed efficiently to high pressures for high pressure injection.

LNG, however, has limitations, primarily resulting from its cryogenic temperature, that present barriers to fleets who wish to convert to the fuel. Several are listed below:

- LNG requires a completely new fueling infrastructure.
- No natural gas engines have been developed that are as fuel efficient as diesel engines.
- As a transportation fuel, LNG has few codes and standards.
- LNG is controversial. Natural gas distribution utilities are sometimes opposed to LNG because it can be transported via common carrier, which opens the door to competition.
- Transportation managers are conservative, concerned that trying new technology or fuels could be costly.

Consequently, even though LNG has been proposed as a transportation fuel since the 1960s, it has yet to successfully capture a sustainable foothold in the transportation fuel market. This is likely to change in the next ten years, says Nimocks, as governments rachet down emissions limits, offering fleets the flexibility to reduce emissions where it is most cost effective.

Current Activity

As of mid-1994, there were at least 44 active or planned LNG vehicle projects globally. Outside of the United States, the most activity has been in: Russia, where trucks, locomotives and aircraft have been converted to run on LNG; Australia, where heavy-duty trucks have been converted to LNG; and Mexico, where several mid-sized buses and light-duty vehicles have been converted to LNG.

However, 38 of the active or planned LNG vehicle projects and more than 90 percent of the 400 or more LNG-powered vehicles are in the United States.

In the United States, projects fall into four major categories:

- Transit buses and other government vehicles. About 80 percent of the current vehicles fall into this category.
- Heavy-duty commercial trucks. About one-quarter of the projects fall into this category.
- Locomotives. Three major commercial railroads and one government commuter railroad are testing LNG locomotive operations.
- LNG/CNG medium and light duty vehicles. Four new projects will power mixed fleets with LNG or compressed natural gas made from LNG, commonly referred to as LCNG.

Key Issues

Several open issues will determine whether LNG can gain a sustainable foothold in the transportation market:

- Tough, but flexible emissions standards for centrally fueled fleets. Centrally fueled, urban fleets are the best candidates for LNG. In some areas, fleets may be able to use low emission vehicles to create tradeable credits that can be sold to other emissions sources to meet air quality compliance.
- Taxes. Due to a quirk in the tax law, LNG is taxed in the U.S. at a rate about 30 percent higher than diesel fuel, while CNG is taxed at a rate about 70 percent less than diesel fuel.
- Technology development. Only in the past year have all of the components for LNG storage and fuel delivery been assembled and put together so that vehicles can be fueled and run on LNG without significant difficulties.
- Engine efficiency. Almost all natural gas engine development has started with spark ignited gasoline technology, a technology that is inherently less efficient than diesel engine ignition.
- Codes and standards. Two associations, the National Fire Protection Association and SAE International, are writing standards for LNG-powered vehicles.

Conclusion

LNG holds the most promise as an alternative fuel for heavy-duty transportation where fuel consumption is high enough so that the savings of purchasing LNG rather than diesel will more than compensate for conversion costs. Several factors are improving these economics significantly and should continue to do so to the point that the fuel will capture one or more sustainable markets.

It is highly likely that LNG will succeed in attaining a sustainable foothold somewhere in the heavy-duty transportation industry, just as diesel attained a niche in the marine industry after

World War I. The most promising areas are heavy-duty, urban on-road and rail transportation--significant fuel markets.

Much is at stake. If LNG captures a sustainable foothold it could easily expand into other transportation sectors as technology improves, just as diesel expanded from marine transportation into rail and over-the-road trucking during the first half of this century.

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PROPANE (LPG)

OUTLOOK AND FORECASTS

PURVIN & GERTZ SEES CONTINUED STRONG GROWTH IN WORLD LPG MARKET

Speaking at the Seventh World LPG Forum in Vancouver, Canada last fall, R. Haun of Purvin & Gertz predicted continued steady growth in world propane demand (Figure 1). The increase by year 2000 will occur across all sectors, with vehicle use perhaps showing the greatest percentage increase.

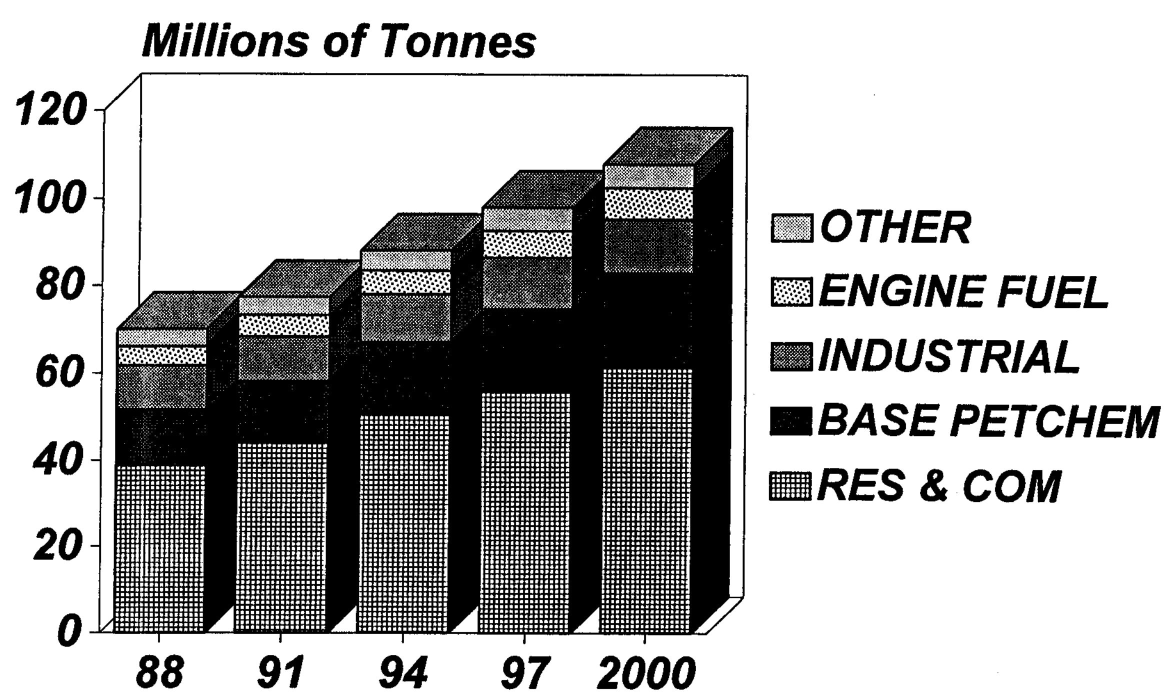
Economic reforms are stimulating rapid LPG infrastructure growth in the developing Far East markets. By contrast, there is stagnant demand in the mature Japanese market.

Haun says there has been a significant influence by U.S. market demand on international trade over the last two years. He believes that LPG growth prospects are strong in the developing countries of the Far East such as China and India, and in Latin America.

Geographic sources of LPG supply are shown in Figure 2. Haun notes that some clouds are starting to form on the horizon of major new supply projects (Algeria, Nigeria, and Iraq). Therefore a tighter supply/demand balance in the near future may reinforce an expected Middle East price increase.

FIGURE 1

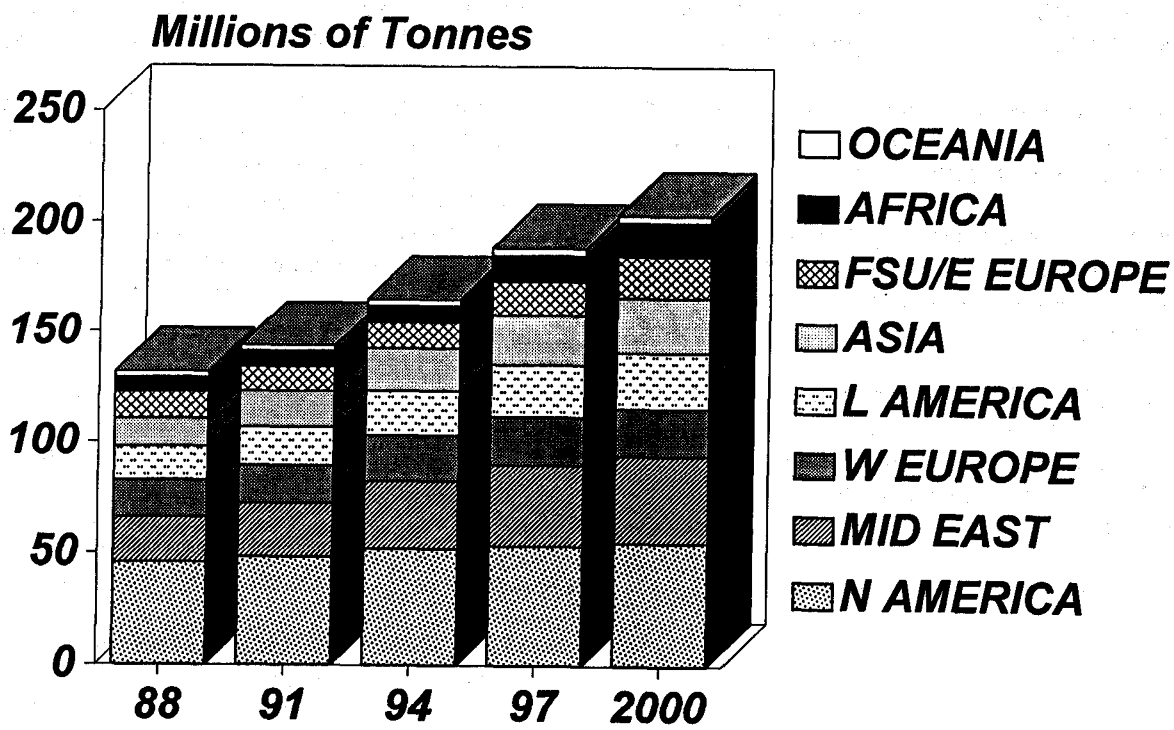
PROPANE DEMAND BY END USE



SOURCE: HAUN

FIGURE 2

WORLD LPG SUPPLY



SOURCE: HAUN

In general, international waterborne LPG trade will continue to increase and significant downstream business investment opportunities are emerging.

However, world market growth could be retarded if supply prospects are diminished due to problems in any major supply country. Thus the industry will face many challenges as it continues to expand in the medium term.

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COMPANY ACTIVITIES

LIQUID PHASE PROPANE INJECTION SYSTEM OFFERED

Liquiphase Management Pty Ltd of Kilkenny, South Australia is offering technology for direct, multipoint injection of liquid propane.

The Liquiphase system is claimed to set a new level of efficiency and economy for automotive LPG fuel systems.

Additionally, Liquiphase offers an environmentally friendly advantage: reduced greenhouse gas emissions.

The key to this achievement is the Liquiphase electronic control unit which represents the state-of-the-art in LPG engine management systems.

The Liquiphase liquid LPG injection system won the prestigious Australian National Energy Award for 1992 in the Transport Category.

Liquiphase Management Pty Ltd is 50 percent owned by the Energy Research and Development Corporation, an Australian Federal Government Agency.

Following intensive research and development, Liquiphase Management Pty Ltd was awarded numerous international patents and is currently launching this new product throughout international markets.

Access: Liquiphase, phone 618 345 3500, Australia

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OVERLAND CUSTOM COACH WINS ORDER FOR LPG BUSES

Overland Custom Coach of Thorndale, Ontario and ElDorado National, a Thor Industries company of Chino, California announced their recent award of orders for the new ELF series of low-floor fully accessible bus on display at the International Conference and Exhibition on Natural Gas Vehicles at the Metropolitan Toronto Convention Center in October.

The new contracts include 38 25-foot ELF 100 models fueled on propane to be produced for the Orange County Transit Authority of California. Delivery was scheduled to begin in December 1994.

Access: Overland Custom Coach, phone 519 461 1140

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PROPANE VEHICLE COUNCIL RESPONDS TO MOBIL CRITIQUE OF LPG VEHICLES

In January, the Propane Vehicle Council issued a news release to counter an advertisement run by Mobil Corporation criticizing the use of alternative fuels. Mobil's remarks concerning LPG were:

> "Liquefied petroleum gas (LPG). With around 250,000 vehicles nationwide running on LPG, it's the most common alternative to gasoline. Of the 185 million passenger cars on the road, however, LPG vehicles account for only 0.1 percent. LPG can yield reductions in emissions at a modest fuel cost, but it's a low-volume byproduct of producing and refining crude oil. As a result, there's no practical way to produce much more LPG in the U.S., and there are no facilities to import large volumes and no pipeline system to distribute them."

The Propane Vehicle Council responded that "Mobil's assessment of propane, for example, was nearly devoid of factual information. Even more fallacious was Mobil's contention that the availability of propane was problematic. In fact, a 1992 report of the Interagency Commission on Alternative Motor Fuels concluded that an additional 13 billion gallons of propane could be made available each year by the year 2010. That is a sufficient amount to fuel 12 million light-duty fleet vehicles.

A study released in December by the U.S. Department of Energy reaffirmed this assessment. The DOE study estimates that by the year 2010, up to 16 percent of the nation's light-duty vehicle fleet could be powered by clean-burning propane.

Contrary to the Mobil piece, propane is made available to consumers through one of the most extensive distribution networks in the country. It includes 70,000 miles of underground pipeline, 22,000 rail cars, 37,000 bulk fuel trucks, 8,000 large transport trucks and 13,500 bulk storage and retail facilities.

Alternative fuels like propane may not be the total solution to America's air quality concerns, but they can play a significant role in meeting our clean-air objectives. And while a single 'silver bullet' solution is not yet at hand, the absence of one ought not be used as a convenient excuse for either inaction or complacency."

Access: Propane Vehicle Council, phone 202 371 6262

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GOVERNMENT ACTIONS

LPG VEHICLES APPROVED FOR TAIWAN

According to a report carried in Oil and Gas Journal, LPG-fueled taxis and passenger cars are set to begin operating in Taiwan this year after several years of debate. Officials of the Taiwan Environmental Protection Administration (TEPA), which is promoting use of LPG as a fuel, say vehicles powered by LPG have emission levels that are 60 to 70 percent lower than those fueled by gasoline. The goal of TEPA is to convert all of Taipei's taxis to LPG within 2 years. If successful, the plan is expected to reduce the volume of carbon monoxide emissions by 24,000 metric tons per year and that of hydrocarbons by 1,100 tons per year. For owners who agree to convert their taxis to LPG, TEPA will pay half the cost of conversion.

At the same time, TEPA announced a new air pollution control tax on gasoline. The tax, expected to go into effect in July, will add about $0.04 per liter to the cost of gasoline at the pump.

Access: Oil and Gas Journal, January 16, 1995

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RESEARCH AND TECHNOLOGY

DEDICATED PROPANE ULTRA-LOW EMISSION VEHICLE BEING DEVELOPED

In February 1994, IMPCO Technologies, with the support of the National Renewable Energy Laboratory, started a four-phase program to develop a dedicated propane vehicle based on injection technology previously developed by IMPCO, which will meet or exceed the 1998 California Ultra-Low Emission Vehicle (ULEV) standards. The project was described by D. Smith et al. at the Annual Automotive Technology Development Contractors' Coordination Meeting held in Dearborn, Michigan last fall.

The vehicle selected for this project is a Chrysler LH sedan with a 3.3 liter V-6 engine. The first phase of this project is the system design, which includes:

- Fuel system and handling system design
- Engine system design
- Emission control system design
- Fuel/engine/vehicle system integration design
- System design optimization

Fuel composition can have a significant effect on the vehicle emissions, and the ability to meet ULEV standards. Throughout the project rigorous control of fuel composition, with adherence to HD5 specifications, will be followed.

The second phase of the project is the development and testing of the prototype system. The system designed in Phase 1 will be constructed and tested on an engine dynamometer. An important part of this phase will be the integration of the software and mechanical hardware, including the propane vapor injectors and pressure regulator. A special propane three-way catalytic converter will be designed and tested, and will be an integral part of the emissions control system. The design goal will be to achieve ULEV levels without the use of an electrically heated catalytic converter.

The third phase of the project is the integration of the prototype system to the test vehicle. Extensive vehicle testing will be conducted to determine baseline vehicle emission levels prior to system optimization. Standard EPA FTP emission tests will be used for all calibration work.

The technology approach involves the use of:

- Port propane vapor injectors
- A specially designed propane regulator
- Advanced 32 bit electronic control module that interfaces with OEM ECM
- IMPCO air mass sensor

The general California ULEV emission goals are shown in Table 1. For propane, the California Air Resource Board is proposing a reactivity factor of 0.47, so that propane ULEV HC standards will be 0.085 grams per mile and 0.117 grams per mile.

As of the meeting date, IMPCO had completed all Phase I work and started work on construction of the prototype system.

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DAF DEVELOPS HEAVY-DUTY LIQUID-INJECTION LPG ENGINE FOR BUSES

In the past, DAF says, it had not used LPG engines because of the low reliability level and the higher operating costs of the available heavy-duty LPG systems as compared to diesel engines. DAF is convinced that with the introduction of the LT 160 LPG engine these shortcomings have been eliminated.

The 11.6-liter LT 160 LPG engine is being introduced for applications requiring extremely low emission levels. This engine, which went into production at the end of 1994, was designed to meet the requirements of urban public transport operators. Particularly in stop-and-go city bus operations, the environmental advantages of the LPG engine are highly important: absolutely no acceleration smoke and no diesel smells.

TABLE 1

CALIFORNIA ULEV EMISSION GOALS

	HC (g/mile)	CO (g/mile)	NOx (g/mile)
50,000 Mile	0.040 NMOG	1.7	0.2
100,000 Mile	0.055 NMOG	2.1	0.3

The NO_x and particulates levels, which together with CO, CH and acceleration smoke, are subject to legal standards, remain far below the Euro 2 emission limits.

The lower efficiency level and more complex LPG fuel storage system as compared to the diesel engine, do not necessarily stand in the way of the use of LPG on economic grounds, says DAF. Recent changes in the Netherlands road tax tariffs, exempting heavy-duty gas engines from extra taxation, in combination with low LPG prices, fully compensate for the lower efficiency level and the higher cost of the total LPG vehicle. Operating cost calculations using data of a representative bus fleet, have shown that the cost per kilometer of a bus with an LPG engine in Belgium and the Netherlands is approximately 7 percent lower than that of a comparable bus with a diesel engine. On the basis of this difference in cost per kilometer, the break-even period for the extra capital expenditure involved in the use of LPG is estimated at approximately 6.5 years.

Furthermore, in the near future, buses with gas engines will in the Netherlands qualify for an allowance given by the Ministry of Transport and Public Works within the framework of a scheme promoting environment-friendly transport techniques.

The basic engine is derived from the LT 160 L horizontal engine. The outputs and torque curves of the LPG power plants are the same as those of the diesel versions.

The LPG injection system, combined with the electronic control system, allows a fine-tuning of the torque curve for the specific experience of customers. The main features of the LPG injection system developed by GENTEC are the timed multi-point liquid LPG injection and an electronic engine management system.

Modifications to the Basic Engine Required for LPG Application

A diesel concept cannot be changed into an LPG concept without major engine design modifications. An Otto engine (with spark ignition) is subjected to much higher thermal loads than a diesel engine. It therefore requires the use of materials which can withstand higher thermal loads. This mainly applies to the materials of the exhaust manifold, the turbine section of the turbocharger, the valves and valve seats. And, of course, design modifications were necessary for the fitting of the injectors, sensors and ECU.

The compression ratio of an LPG engine is considerably lower than that of a diesel engine. A compression ratio of 9:1 is expected to be the optimum proposition. A lower compression ratio requires a larger combustion chamber. The combustion chamber most favorable for the engine's performance is far deeper than that of the diesel engine. This means that a new piston design was needed.

An Otto engine has a throttle valve in the inlet channel. This means that during deceleration an underpressure is created on the inlet side, which may cause oil consumption along the valve guides. To prevent this, valve seals are used on the inlet valves.

Optimized efficiency and minimized blow-by of unburned LPG requires shorter valve overlap times than those of the diesel engine. Furthermore, the speed of valve opening and closing had to be substantially reduced to prevent valve wear. In summary: major modifications to the basic (diesel) concept were necessary to make the engine reliable and suitable for LPG application.

LT 160 LPG Injection System

The LPG injection system is a timed multi-point liquid LPG injection system. With liquid LPG injection, the vaporization of LPG in the inlet channel and cylinder reduces the temperature of the fuel/air mixture, which gives better thermodynamic efficiency and consequently reduces fuel consumption. The lower temperatures of the fuel/air mixture also have a cooling effect on the inlet valve.

Another important feature of this system, which is not found in other LPG systems, is the fuel cut-off during deceleration. Particularly in city bus applications, this has a major and positive effect on fuel consumption. It also reduces HC emissions and the risk of back-firing during switches from deceleration to acceleration. The position of the injectors near the entrance of the inlet ports results in an extremely small mixture volume in the inlet system. This has obvious advantages: rapid response to load changes, giving excellent driveability.

There are eight injectors. Each group of two injectors is fed from its own LPG tank. This brings the number of tanks to four, each with a capacity of 150 liters. Under normal operating conditions, this gives a range of approximately 520 kilometers. A connection between the separate tanks and the injectors ensures that the tanks are evenly emptied.

A lift pump is fitted in each LPG tank. The lift pump is required to ensure that irrespective of the LPG contents of the tank and the LPG temperature, etc., the LPG is kept in the liquid state until it reaches the injector and that the injection pressure is kept at a constant level.

Future Developments

DAF says the introduction of the LT 160 LPG engine is but the start of a new engine philosophy for service bus engines. The LPG technology, and CNG technology too, will be used in engine concepts still to be developed. Within the framework of the "SSZ" program (for quieter, cleaner and more efficient traffic and transport in urban areas) an application has been submitted to the Ministry of Transport and Public Works for a contribution toward the development of the 8.65-liter LPG engine for use in city buses and interurban buses. This engine is expected to reach the market in the fall of 1996.

To summarize, DAF states that the DAF LPG engine is the urban transport alternative for the future.

Access: DAF, phone 040 143 293, The Netherlands

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MARKET DATA

EIA PUBLISHES DATA ON PROPANE PROVIDER FLEETS

Information published by the Energy Information Administration (EIA) in November gives data on the fleets owned by U.S. companies in the business of providing propane to consumers. In 1993, these comprised 81,049 vehicles. The makeup of these fleets was as follows:

- 54 percent conventional-fuel vehicles, operating on motor gasoline or diesel fuel alone (Table 1)
- 41 percent dedicated propane vehicles, operating solely on propane
- 5 percent dual-fuel propane vehicles, operating on a combination of propane and either motor gasoline or diesel fuel
- Less than one percent compressed natural gas vehicles.

These preliminary estimates are based on data from the Propane Provider Fleet Survey, which the EIA conducted between June 1 and September 30, 1994. The survey consisted of (1) a mail survey of the 35 largest propane providers, and (2) a telephone survey of 100 companies, randomly drawn from 7,770 smaller providers.

TABLE 1

FLEET VEHICLES OPERATED BY PROPANE PROVIDERS BY TYPE OF VEHICLE, 1993

	Light-Duty Vehicles						Medium- and Heavy-Duty Trucks		
Type of Vehicle	Passenger Cars	Minivans	Full-Size Vans	Small Pickup Trucks	Large Pickup Trucks	Sport/ Utility Vehicles	8,501-26,000 Pounds	26,001 Pounds or More	All Vehicles
Conventional-Fuel	Q	Q	1,554	581	8,035	574	10,109	17,439	43,520
Motor Gasoline Only	Q	Q	1,529	580	6,356	570	7,684	2,248	24,195
Diesel Fuel Only	1	0	25	1	Q	4	2,426	15,190	19,326
Propane	224	14	Q	1,230	9,632	44	14,724	11,235	37,438
Dedicated	150	8	Q	1,053	6,995	44	14,040	10,502	33,115
Dual-Fuel	74	6	12	177	2,638	0	684	733	4,323
Compress. Nat. Gas	2	0	22	17	46	0	4	0	91
Dedicated	0	0	4	6	21	0	0	0	31
Dual-Fuel	2	0	18	11	25	0	4	0	60
Total	Q	Q	1,911	1,828	17,713	618	24,837	28,673	81,049

Q = Data withheld because of high levels of sampling error.

This survey was undertaken in partial response to Section 407 of the Energy Policy Act of 1992 (EPACT), which directs EIA to collect data that will be useful to those who wish to manufacture, convert, sell, own, or operate alternative-fuel vehicles or facilities. Propane is considered an alternative fuel under the provisions of EPACT. Propane providers will be among the first groups who will be required to buy alternative-fuel vehicles for their fleets in the future.

The companies were asked to provide information on their fleets, such as fleet size; distribution of fleet vehicles among size classes, fuel types, and alternative-fuel technologies; fleet-vehicle retirements, acquisitions and conversions planned in 1994; fleet-vehicle fueling practices; vehicle fuel consumption; vehicle miles traveled; availability of fleet vehicles for company employees; length of service for fleet vehicles; source of alternative-fuel vehicles (manufacturer or conversion); and vehicle costs.

Preliminary analysis of the data revealed that although the 35 largest propane providers supply almost two-thirds of the propane delivered in the United States, they operated only 29 percent of all the fleet vehicles operated by propane providers, while the smaller providers operated 71 percent of the total vehicle stock (Table 2).

The fleets of the 35 largest propane providers contained three times as many light-duty vehicles fueled by propane as light-duty vehicles fueled by motor gasoline or diesel fuel, and nearly five times as many medium- and heavy-duty trucks fueled by propane as medium- and heavy-duty trucks fueled by conventional fuels. In contrast, the fleets of the smaller providers contained twice as many conventional-fuel vehicles as propane vehicles.

TABLE 2

FLEET VEHICLES OPERATED BY PROPANE PROVIDERS BY SIZE OF COMPANY, 1993

Company Category and Type of Vehicle	Type of Vehicle			
	Motor Gasoline or Diesel	Propane	Compressed Natural Gas	Total
35 Largest Companies	4,515	18,712	91	23,318
Light-Duty Vehicles	1,598	4,797	87	6,482
Cars and Vans	1,266	340	24	1,630
Pickup Trucks and Sport/ Vehicles	332	4,457	63	4,852
Medium- and Heavy-Duty		44		
Trucks	2,917	13,915	4	16,836
All Other Companies	39,005	18,726	0	57,731
Light-Duty Vehicles	14,375	Q	0	21,057
Cars and Vans	Q	Q	0	Q
Pickup Trucks and Sport/ Vehicles	8,858	Q	0	15,307
Medium- and Heavy-Duty Trucks	24,631	12,044	0	36,674
Total	43,520	37,438	91	81,049

Q = Data withheld because of high levels of sampling error

Of the vehicles operated by the top 35 providers, 72 percent were medium- or heavy-duty trucks, 21 percent were light-duty trucks, and only 7 percent were passenger cars or vans. However, of the vehicles operated by the smaller providers, only 64 percent of the vehicles were medium- or heavy-duty trucks, and 36 percent were light-duty trucks, passenger cars and vans.

The data presented here are provisional because not all responses had been received. The final estimates of the Propane Provider Fleet Survey will be available in early 1995.

Access: EIA Monthly Energy Review, November 1994

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VEHICLES

LPG TRUCKS AND BUSES PROVIDING ENVIRONMENTAL BENEFITS IN FINLAND

Propane (LPG) is considered to be a viable alternative fuel for low-emissions heavy-duty vehicles in Finland, according to N. Nylund and T. Eklund of the Technical Research Centre of Finland (VTT). They presented a paper at the 27th International Symposium on Automotive Technology and Automation in Aachen, Germany last fall. They say that natural gas and propane have roughly the same potential for reduced exhaust emissions. Because natural gas and propane are both imported fuels in Finland, there is no preference between these two fuels in this respect. Propane, however, is much easier to distribute, refuel and store onboard the vehicle. This is why propane has received more attention than natural gas in Finland.

In the beginning of the 1980s a tax law was enacted that made it impossible to use gaseous fuels for transportation. This has now been changed. Now it is possible to use gaseous fuels for transportation in some applications. The following criteria have to be met:

- Heavy-duty vehicle (gross weight >3,500 kilograms)

- Monofuel vehicle

- Low emissions (Euro II emission level)

Gaseous fuel will be taxed with value added tax only, and no fuel taxes will be applied. The retail price of propane is roughly two-thirds of the price of diesel fuel including fuel taxes. With this scenario, propane will be a competitive alternative to diesel. What society will lose in reduced tax income, it will gain in improved urban air quality. It is expected that gaseous fuels will be used in buses and trucks for waste collection, deliveries and street maintenance.

Sisu Municipal LPG Truck

The first prototype vehicle, a 17,000 kilogram Sisu truck (Finnish manufacturer) was built in 1990. This truck was equipped with a 7.4 liter Valmet engine with a closed-loop IMPCO fuel system and a three-way catalyst.

Stoichiometric combustion was chosen for reasons of low emissions and good driveability. This combustion system, however, increases the thermal stresses on the engine considerably compared to diesel operation. Therefore certain measures such as improved cooling and materials have to be taken in order to guarantee engine reliability.

Encouraged by the good experience from the first prototype truck, the manufacturer Oy Sisu-Auto Ab decided to build a test fleet of seven propane fueled "Sisu City" trucks.

The first one was completed in September 1992, and the last one was delivered in May 1993. For these trucks, five refueling stations were built in the southern part of Finland. All trucks are operated from a depot.

Design gross vehicle weight of the truck is 21,000 kilograms. The engine output, 135 kilowatts, is sufficient for light and medium heavy operations.

Propane is stored in two 108 liter (gross) tanks attached to each side of the frame. The net volume of fuel stored is 173 liters, giving a driving distance of some 300 kilometers. The tank volume could easily be doubled. The energy consumption is some 25 percent higher compared to a corresponding diesel truck. However, if the whole lifecycle of the fuel from well to wheel is considered (both fuel production and utilization), propane is as energy efficient as diesel.

The LPG trucks are promoted with three arguments:

- Ultra low exhaust emissions

- Low noise level
- High level of occupational safety for the driver

All these arguments are very relevant for heavy trucks operating in urban areas, where diesel powered trucks generally are considered to be a big nuisance. The response to the trucks has been very good both from the operators and the public. All vehicles are painted and decorated in a spectacular way. The six trucks are all in normal everyday service. Listed in Table 1 is total driving distance and average fuel consumption of the vehicles up to mid-1994.

The experience from the seven trucks is used as feedback for the oncoming production version. Oy Sisu-Auto Ab has stated that they are prepared to sell LPG trucks on a normal commercial basis.

Valmet ECOBUS

Valmet Automotive, a company with a car assembly plant in Finland, started to design a completely new product, the ECOBUS, some two years ago. It was realized that the average loading in many bus applications is relatively low. Transporting 15 to 20 people in an ordinary full-size bus results both in high energy consumption and high emissions per passenger kilometer. The designers at Valmet Automotive therefore started to develop a new mid-size bus concept especially suited for city and suburban traffic. The bus is designed both for diesel and gas engine applications. Some of the design features are mid-size (8.5 meter), passenger friendliness including low-floor (32 to 35 centimeters), passenger car class comfort for the driver, versatility (seating etc.), modular structure, recyclable parts and low emissions.

The bus will be offered both with a catalyst equipped diesel engine meeting EURO II emission standards and a gas engine for either LPG or CNG. Both engine types are made by Valmet Engine Company. The gas engine is basically the same engine as used in the Sisu City truck, although it is somewhat derated in power for the ECOBUS application. For LPG, the fuel tanks are placed under the floor. For CNG, the gas cylinders will be mounted on top of the vehicle.

The first prototype vehicle was completed in April 1994. This vehicle, which was bought by VTT,

TABLE 1

DRIVING DISTANCE AND AVERAGE FUEL CONSUMPTION OF THE SISU CITY LPG TRUCK

Truck Number	Application	Driving Distance (km)	Fuel Consumption (l/100 km)
2	Refuse collection	27,000	45...90
3	Refuse collection, misc.	59,000	53
4	Distribution	17,000	50
5	Street cleaning	34,000	60
6	Street cleaning	13,000	85
7	Miscellaneous	18,000	53

will be used as a test and demonstration vehicle for promotion of the concept itself and for technical development. A pre-series of 10-16 vehicles is scheduled for 1994-1995. This pre-series will achieve readiness for full series production. The first commercial units are expected to be delivered in 1995.

To some extent ECOBUS uses common components with the Sisu truck. One of the ideas for the Finnish vehicle industry is to be able to supply a complete urban transportation system consisting of gas fueled low-emission buses and trucks.

MAN LPG Bus

The traffic company in Espoo (just outside Helsinki), Espoon Auto Oy ordered the first gas fueled bus for Finland in 1990. The chassis of the bus was bought from MAN/OAF in Austria. The bus has a rear mounted naturally aspirated 12 liter engine equipped with a TWC. The engine type is G 2866 DU. The LPG engine technology is the same as used by the transport authority of Vienna.

The MAN LPG bus met the expectations and surpassed them. Both the drivers and the passengers were satisfied with the silent, vibrationfree and odorless bus. No serious faults or damages appeared in the bus. On the other hand, the reliability of the bus was lowered by numerous minor faults.

Conclusions

In Finland alternative fuels will most probably be limited to heavy-duty urban vehicles. Most attention has been given to gaseous fuels, especially propane. Propane fueled heavy-duty vehicles are on the edge of commercialization in Finland. The driving force to use propane in heavy-duty vehicles is the desire to improve urban air quality and also to make public transportation by buses more attractive. In addition to city buses, vehicles like municipal waste collection trucks and delivery trucks are another field for gas applications.

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RENAULT TO MARKET LPG CAR

French auto manufacturer Renault has unveiled a city car called the Ludo. It is expected to become available in about three years. According to International Gas Report, Renault is studying the idea of a dedicated LPG engine.

Renault has already had the opportunity to point out the exceptional results obtained in the area of car emission standards with LPG, in particular at the Paris Congress of the European Association of LPG (AEGPL) in May 1993.

These excellent results were said to be due to the sensible combination of LPG, which has favorable combustion properties and speed of combustion, with good electronic control and the use of catalysis.

Since then, Renault has carried on with its activities in the area of LPG use in motor vehicles and small vehicles. According to Renault, these activities confirm the high quality results obtained earlier and show that progress has been made since the first adaptations.

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LPG BUSES MULTIPLYING IN THE NETHERLANDS

According to information received from BK Autogas in December 1994, the following city buses are running on LPG in The Netherlands.

Transport Authority of Amsterdam

Starting in early 1993 a comparative trial of new MAN low-floor city buses involved three on diesel, three on CNG and three on LPG. LPG seems to be most-preferred. An interim report is to be published in the first quarter of 1995.

Transport Authority of Eindhoven

The city has a total fleet of 80 buses. In conjunction with DAF/BK they started a pilot project (July 1994) with two city buses using the DAF LT 160 LPG engine. A decision regarding further conversion to LPG will be made in early 1996.

Transport Authority of Groningen

The Authority did a trial on CNG buses, which was unsuccessful. An extensive study and workshop procedure then chose LPG instead of CNG. All new buses will be LPG and plans are being developed to convert existing buses to LPG. Total city bus fleet is 70. In 1995 delivery will be taken on 6 new buses with DAF LT 160 engines. Through 1995, 30 existing buses will be converted to LPG.

Transport Authority of Hertogenbosch

The Authority has decided on LPG for its new city buses. Initially they will obtain a maximum of 40 LPG buses. Delivery of 18 LPG buses by Volvo will begin in the first quarter of 1995.

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METHANOL

OUTLOOK AND FORECASTS

METHANOL SUPPLY/DEMAND IMBALANCE EXPECTED TO MODERATE AFTER 1995

The year 1994 has clearly been a watershed year in the methanol industry, worldwide and in the U.S.A. alike. Methanol producers and consumers have had to struggle to keep plants running and product flowing while trying to cope with the reality of rapidly escalating prices and their impact on products made from methanol. At the 1994 World Methanol Conference held in Geneva, Switzerland at the end of November, T. Moger of Trammochem gave a perspective on the future for United States methanol supply and demand.

Methanol Demand Growth

As a general proposition, U.S. methanol demand increased at approximately 3.3 percent per year from 1984 through 1992. Demand surged by about 12 percent for 1993, a development that did not become clear in the marketplace until fairly late in the year. Indeed, methanol margins in the second quarter of 1993 were particularly depressed, even as methanol inventories in the U.S. were being drawn down to low levels. The 1993 demand growth came as a surprise to a methanol industry that had been disappointed several times over the preceding decade. Great expectations of significant demand growth "next year" had been dashed so many times that the industry was unable to recognize the physical signs when the growth finally arrived.

The 10-year supply/demand graph in Figure 1 shows accelerating demand growth over the last five years. U.S. demand grew by an amount equal to one worldscale methanol plant during the 1989-1992 period and then grew a similar amount in 1993 alone. It should be remembered that the depressed state of the market through the decade of the 1980s, with associated low prices, probably set the stage for the stronger growth in methanol-based products in the early 1990s.

Total domestic demand for methanol in the U.S. for 1994 probably increased by about 12 percent over 1993, an increase similar to that of 1993 over 1992. Once again, the biggest increase was in demand for production of MTBE, with most of the MTBE production increases coming in the second half of 1994. The demand strength in the first half of 1994 came from growth in derivatives other than MTBE.

Moger computes that a U.S. domestic demand level of about 6.7 million metric tons (million MT) in 1994 would reflect an increase in methanol demand into MTBE of about 460,000 metric tons and about 250,000 metric tons into other derivatives, totaling 710,000 MT, about the size of a worldscale methanol plant.

Demand by Derivatives

If the implementation of the Clean Air Act plays out as planned in 1995, it is likely that U.S. MTBE production will require an increase of more than 750,000 MT of methanol over 1994.

Formaldehyde plants are running at full rates in the U.S., so it would seem unlikely that dramatic increases can be realized out of existing capacity. Even if housing starts do not increase in the U.S. in 1995, a shortage of lumber has created a trend toward manufactured timber products which consume more formaldehyde than does dimensional lumber. Methanol demand could increase by 100,000 MT.

New worldwide capacity additions for acetic acid derivatives in 1995 (and again in 1996) should produce strong demand growth. Methanol demand should increase by 75,000 MT.

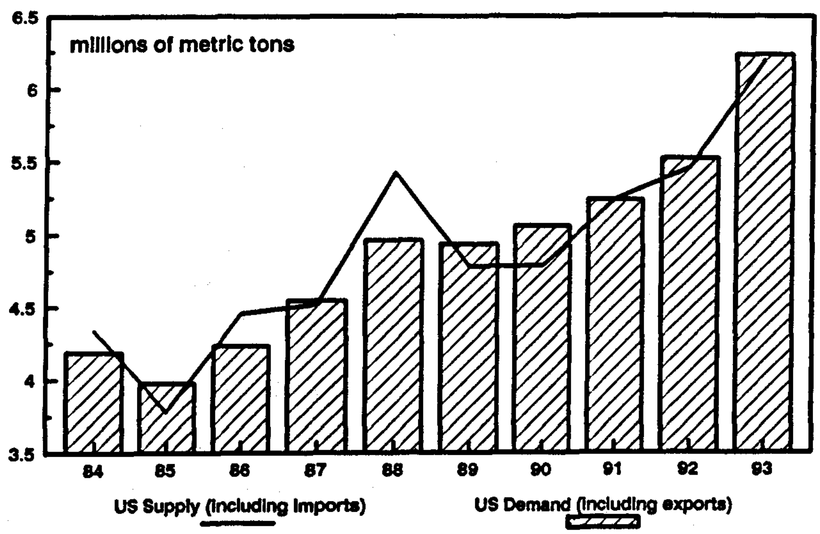
Some growth is expected in methyl methacrylate, with methanol demand up 25,000 MT.

These demand increments total 950,000 MT for 1995, up 14 percent over the estimated level of 6.7 million MT for 1994.

Can this level of demand growth carry far beyond 1995? Not according to Moger. The big in-

FIGURE 1

UNITED STATES METHANOL SUPPLY/DEMAND



SOURCE: MOGER

crease in MTBE production will be behind us then and the economic recovery will be beyond its life expectancy in the U.S. Thus the growth in U.S. methanol demand will tend back toward the 3-3.5 percent growth levels seen in the past, but clearly from a much higher starting point than before.

Supply

Can supply growth keep pace with current levels of U.S. demand growth? The simple answer is yes, says Moger, because only the U.S. has a virtually mandated market in the form of MTBE, which will buy methanol away from other world markets if necessary. However, the unprecedented profit margins in methanol production have also performed their economic function of encouraging more production facilities to be constructed. Most of these will be outside the U.S., but even in the U.S. there have been announcements of new, greenfield plants as well as a restart plan for a mothballed unit. Supply should remain tight through 1996, given the demand scenario outlined above, but a balance should be achieved after that.

Methanol as a Fuel

The uncertainties that flowed from tight methanol supplies in the U.S. in 1994 have obscured the future of methanol as M85 or M100 transportation fuel. The high spot price has made the California program uneconomic in the short-term and some U.S. suppliers had to drop out of the California Fuel Methanol Reserve Program due to tight supplies. As methanol markets stabilize and prices return to a more realistic level for transport fuel use, the development of this sector can resume. At that time, the creation of methanol filling stations will become the limiting factor for demand growth once again.

Access: Crocco & Associates, phone 713 875 5990

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COMPANY ACTIVITIES

METHANOL GIANT METHANEX TO GROW EVEN MORE

Methanex is a young company. It is a combination of the methanol businesses of Fletcher Challenge, NOVA, Ocelot Industries and Metallgesellschaft. Those businesses consisted of the methanol plants in Canada, Chile and New Zealand, the synthetic gasoline plant also in New Zealand, various marketing agreements, employees and management and a broad customer base. The core of the company came together in early 1993 with the merger of Fletcher Challenge Methanol and Methanex which then comprised the Ocelot and Metallgesellschaft methanol activities. The NOVA Canadian plants were acquired in January 1994. At the same time NOVA replaced Fletcher Challenge as the controlling shareholder.

An overview of Methanex's view on the methanol industry was given by outgoing CEO B. Hannan at the 1994 World Methanol Conference held in Geneva, Switzerland. He said that a major reason for bringing the methanol assets together was to benefit from the projected upturn in the methanol market. Methanex did not foresee the current level of methanol prices. No one did. However, the company devotes a lot of effort to understanding the industry and had a firm view that there would be a marked improvement in profitability, at least in the medium-term. That view was based on detailed analysis of the future supply and demand conditions.

The physical origins of Methanex are to be found in the over-investment in methanol in the 1980s. The Chilean, New Zealand and two main Canadian plants all came about because of the upheaval in world energy markets following the oil price shocks of the 1970s. There were essentially the same two justifications for each project, though their importance varied from plant to plant. One was that oil prices would continue to rise steeply, creating a surging demand for alternative fuels like methanol and synthetic gasoline. The second was to exploit large gas reserves for which there was insufficient domestic demand, taking advantage of the rise in natural gas prices in the United States and Europe which had greatly increased the competitiveness of production sites distant from the market.

Obviously, says Hannan, neither of these justifications proved correct. The 1986 collapse in oil prices undermined the economics of alternative fuels and the gas cost advantage at "remote" plants proved much smaller than expected. The worries in the 1970s that the United States would soon exhaust its gas reserves now seem absurd. U.S. and European natural gas prices followed oil prices down in 1986. While U.S. Gulf gas prices are unsustainably low at present--having dropped to $1.30 per MMBTU last fall--the cost of gas in remote locations is rising, as new reserves need to be developed and as alternative and higher-value uses for the gas start to compete with methanol. With their higher infrastructure cost and often greater country risk, the choice of a remote location over the U.S. Gulf Coast is not as obvious as it once was.

Except for one plant in Canada, the low oil and gas prices that were set in 1986 meant that none of the plants that now constitute Methanex returned their cost of capital to the original investors. The Waitara plant was sold in 1988 and was effectively valued at zero. The majority shareholder in Motunui, New Zealand paid to have the plant taken off its hands in 1990, in order to stem its cash losses. The Cape Horn, Chile project ran into financial difficulties during the construction stage and its debt had to be restructured. When it finally started up in late 1988, Cape Horn collapsed the methanol price. The plant was sold in 1991 at a discount to book value. Kitimat in Canada went through restructurings and write-downs before it became the kernel of Methanex.

Investing in greenfield methanol capacity is high risk. Yet there are always numerous proposals for new methanol plants in search of finance. Too often they are sponsored by developers, plant constructors or gas suppliers, who face little risk. The small number of proposals that do eventually proceed are likely to be project-financed, loading the debt and interest payments up-front and incurring a significant fee. And too often the equity-holders come to understand only too well what having the last claim on a company's cash means.

Hannan emphasized that Methanex has not built, and does not plan to build, greenfield methanol plants. Although the company is bringing on 1.2 million tonnes of methanol capacity now and is evaluating opportunities to add a further 1.6 million tonnes, none of it is greenfield. The projects all have significant savings in capital costs, operating costs and time-to-completion compared with the best greenfield projects.

Methanol remains a cyclical industry and in order to benefit from the periods of high prices, methanol producers have to be able to survive through the price troughs.

Dynamics of the Methanol Market

According to Hannan, that methanol prices have risen steeply is a clear indication of the poor returns that methanol producers were receiving and the large economic surplus that was being captured further down the methanol chain, whether by derivative producers, their customers, or the final end-users. The past inequitable sharing of the value-in-use of methanol has been a major contributor to the present supply-demand imbalance. For most of the last ten years, methanol producers were not receiving returns sufficient to justify the new investment that the growth in demand now requires.

Future Expansions at Methanex

Methanex is continuing to extend its commitment to the methanol industry, confident of the advantages of the product and the competitiveness of its operations. Two new capacity additions are under consideration. One is the construction of a fourth distillation tower in New Zealand, allowing all of the remaining crude methanol (700,000 MT) to be converted to chemical grade. That plant could be producing in the second half of 1995. The other project is a second train at Cape Horn, Chile, which would have a capacity of 900,000 MT and would be onstream by mid-1996. This $275 million project will take advantage of low-cost gas available from state energy group ENAP.

The expansion of the two plants will increase Methanex's global capacity to 6.4 million tons at the start of 1997, giving it 45 percent of the 12 million to 13 million tons of methanol traded on the world market.

Over the next year, the company plans to launch an open market program under which it will purchase up to 5 percent, approximately 10 million, of its common shares.

Access: Crocco & Associates, phone 713 875 5990

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GOVERNMENT ACTIONS

1995 WILL BE A CRITICAL YEAR FOR THE CALIFORNIA METHANOL FUEL SUPPLY PROGRAM

The California Energy Commission issued in December a Program Opportunity Notice (PON) seeking methanol fuel suppliers for the California Fuel Methanol Reserve (CFMR) to supply fuel methanol during 1995 for demonstration programs now underway in California. The CFMR was established in 1988 as a mechanism to provide a constant supply of fuel methanol at a consistent price to various programs and projects utilizing fuel methanol for its air quality and energy security benefits.

The Methanol Demonstration Program has grown dramatically. Current consumption of fuel methanol in California now stands at 12,000,000 gallons per year and is projected to increase in response to the growing population of methanol-fueled vehicles.

The 1995 year will be a critical period for the development of fuel methanol in California. The existing Flexible Fuel Vehicle (FFV) fleet (over 10,000 vehicles) will expand by over 25 percent and the 330 methanol transit buses operated by the Los Angeles County Metropolitan Transportation Authority are now all in service. The consolidation of these markets depends, however, upon the availability of a stable and reliable supply of fuel-grade methanol.

In order to respond to the dynamic conditions in the world methanol market, the CFMR Threshold Fuel Introduction Price Analysis has been greatly revised for this PON.

Because of the great increase in world market prices for chemical grade methanol in 1994 and the importance of maintaining the operational capability of dedicated vehicles operating on methanol, the California Energy Commission, in a process separate from this PON, intends to prepare a competitive solicitation to contract for a supply of methanol to the CFMR for a period of up to five years. Based upon such a solicitation, a proposed contract should be awarded before the end of calendar year 1995. In the meantime, the present PON seeks commitments from methanol suppliers to continue the operation of the CFMR through 1995, or until the award of the supply contract through competitive bidding, whichever occurs sooner.

The CFMR serves as a central fuel methanol pool for existing and potential methanol demonstration programs in California. Fuel methanol demonstration programs seeking fuel methanol supply from the CFMR must contract with Members of the CFMR for fuel supply, after meeting general guidelines established by the Commission.

California's current demand for fuel methanol is approximately 12 million gallons per year, with projected demands of 14 million gallons and 16 million gallons for 1995 and 1996, respectively. The Commission anticipates placing an additional 5,000-6,000 methanol vehicles in public and private fleets throughout California in 1996. The CFMR currently serves both commercial-scale users (defined here as those users consuming over 5 million gallons of fuel methanol annually) and non-commercial scale users. In 1994 the CFMR provided approximately 10 million gallons of fuel methanol to commercial users ("Tier 1") and approximately 2 million gallons of fuel methanol to noncommercial users ("Tier 2").

The Commission and seven major fuel retailing companies have implemented Cooperative Agreements for the establishment of retail M85 fueling facilities, with over fifty such stations now operating. Methanol dispensing equipment costs are borne by the Commission and operated by the fuel retail company for a period of ten years. These Cooperative Agreements require that fuel methanol be purchased from Members of the CFMR.

In brief, the commitments requested in the PON are:

- Providing a minimum annual volume of methanol

- Guaranteeing the nominated volumes of methanol at or below a specified threshold price of $0.75/gallon for "Tier 1" users (denominated "Tier 1") and a calculated threshold price, capped at $0.67/gallon, for "Tier 2" users, including transportation and storage costs, FOB terminals in northern and southern California

Fuel suppliers are requested to supply in aggregate at least 12 million gallons of fuel methanol for one year with a 4-million gallon minimum annual commitment. Amounts supplied by each individual producer will be allocated to Tier 1 and Tier 2 on a pro-rata basis in proportion to the current demands in each Tier.

Fuel Price Determination for Tiers 1 and 2

Fuel methanol for Tier 1 (commercial) CFMR clients must be provided at $0.75/gallon for the duration of this PON. Fuel methanol for Tier 2 (noncommercial) clients will be provided at a price established on a quarterly basis, within the bounds of the Tier 2 price floor and a ceiling determined from the current commercial spot price of methanol transactions and historical maximum threshold prices calculated by the Commission.

The floor (lower limit) price for Tier 2 fuel methanol for the period covered by this PON is $0.43/gallon. The ceiling price (upper limit) for Tier 2 fuel methanol will be $0.67/gallon. This price translates into a retail gasoline equivalent of $1.73/gallon.

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CARB BACKS AWAY FROM REQUIRING LUMINOSITY ENHANCEMENT FOR METHANOL

It was reported in the last issue (The Clean Fuels Report, November 1994, page 105) that staff of the California Air Resources Board (CARB) had proposed an amendment to the state's luminosity requirement for the sale of M100 (neat methanol) as a motor fuel. The proposal would have allowed the sale of M100 without a luminosity enhancer only if the vehicles in which it is used are equipped with either a system for automatically detecting and suppressing onboard fires or else an onboard luminosity enhancer.

At a public hearing on the proposal in December, the board itself rejected the staff proposal and instead accepted a proposal for a two-year study of methanol fire safety.

At the hearing, CARB heard testimony from G. Short, in support of the American Methanol Institute, which pointed out that methanol has fire-safety benefits because it is difficult to ignite and burns with a cool flame. A methanol fire creates no smoke inhalation hazard, spreads more slowly than a gasoline fire and is easier to put out. Short said that occurrences of a methanol-only smokeless fire would be extremely limited. Thus to forego all the fire safety and clean fuel advantages of M100 for the sake of a rare and relatively low hazard event would be unjustified.

C. Gray of the U.S. Environmental Protection Agency suggested that if the risks of fire warrant suppression systems on M100 vehicles such systems would be even more warranted on gasoline or diesel fueled vehicles.

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ENVIRONMENTAL AFFAIRS

MTBE HEALTH EFFECTS CONTROVERSY REFUSES TO DIE

Controversial arguments about the health effects of exposure to MTBE-containing gasoline were discussed in The Clean Fuels Report, November, 1994, page 106. The controversy had been centered in the two states of Alaska and New Jersey. The issue gets significant media attention in New Jersey because of the efforts of an anti-oxygenated fuels group called Oxy-Busters of New Jersey.

The controversy took a national turn in January of this year, with the airing of an ABC News segment on the "Day One" television magazine show. The television broadcast emphasized the health complaints received in Alaska and New Jersey. Numerous organizations such as the American Methanol Institute, the Oxygenated Fuels Association, American Petroleum Institute, The Clean Fuels Development Coalition, U.S. Environmental Protection Agency, and American Corn Growers Association issued comments highly critical of the program. These organizations pointed out that no attention was paid to the large number of studies which have found MTBE to present little risk.

The two studies carried out in Alaska which are often cited as showing a correlation between MTBE and general health complaints, have been criticized for the lack of a proper control group, for asking leading questions, and for use of biased volunteers. It appears that this controversy will run for some time.

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RESEARCH AND TECHNOLOGY

METHANOL REDUCES SLUDGE FORMATION IN ENGINE OIL

An article by H. Moritani et al., of Toyota Motor Corporation, published in JSAE Review notes the formation of sludge in a gasoline engine is caused by the reaction of unburned gasoline, nitrogen oxides and air, and it also depends on the gasoline composition. Toyota studied the effects of oxygenated fuel containing methanol or MTBE on sludge formation by using a laboratory-scale sludge simulator, and the mechanism of sludge formation was identified by analyzing the pyrolysis products of the fuel.

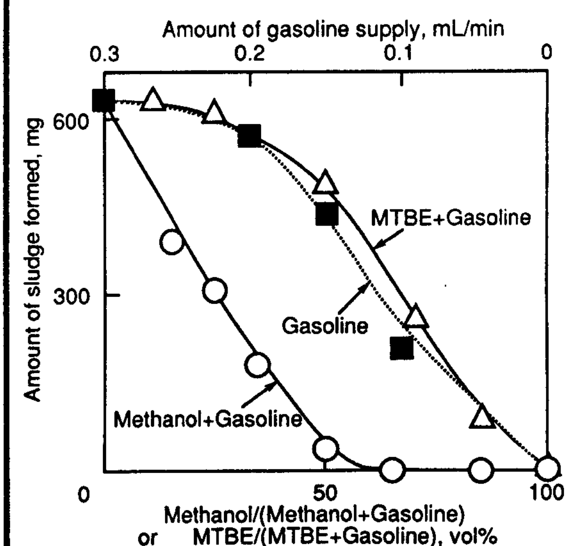
Figure 1 shows the amounts of sludge formed with oxygenated fuels. The amounts of sludge were found to decrease with increasing concentration of methanol or MTBE in gasoline.

In the case of a blend of methanol and gasoline, the amount of sludge formed was smaller than that obtained from neat gasoline (indicated with a dotted line). In particular, a very small amount of sludge was formed when the methanol concentration exceeded 50 volume percent. These results revealed that blending of methanol with gasoline restrained sludge formation, which corresponded to the results obtained in engine tests.

In the case of a blend of MTBE and gasoline, the amount of sludge was nearly equal to that obtained from neat gasoline in the same amount as the gasoline in the blend. It is considered, therefore, that the blending of MTBE did not affect sludge formation.

FIGURE 1

EFFECTS OF METHANOL AND MTBE ON SLUDGE FORMATION



SOURCE: MORITANI ET AL.

Pyrolysis Products

The composition of hydrocarbons, which affect sludge formation, in pyrolysis products was analyzed by gas chromatography to identify the mechanism of restraining sludge formation by blending methanol.

In the case of the blend of methanol and gasoline, the hydrocarbon concentration decreased with increasing methanol content, and was lower than that obtained from neat gasoline in the same amount as the gasoline in the blend. With neat methanol, the hydrocarbon concentration was practically zero. It is suggested, therefore, that the hydrocarbons generated from both gasoline and methanol reacted with the oxygen decomposed from methanol.

In the case of the blend of MTBE and gasoline, the hydrocarbon concentration was higher than that obtained from neat gasoline in the same amount as the gasoline in the blend. This is because excess hydrocarbons were generated from MTBE.

Access: Society of Automotive Engineers of Japan, JSAE Review, 15 (1994) p. 235

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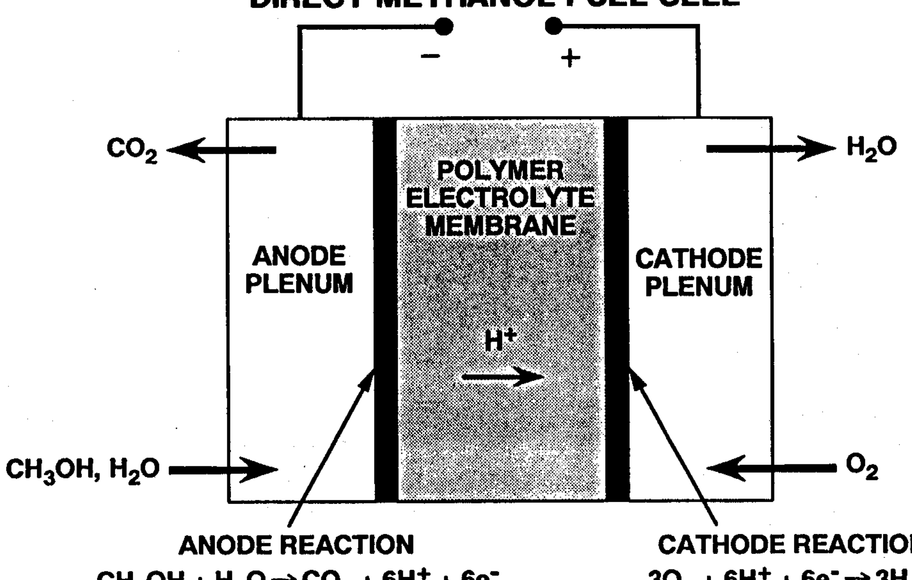
DIRECT METHANOL FUEL CELL MAKES PROGRESS

Los Alamos National Laboratory has been working on a direct methanol PEM (polymer electrolyte membrane) fuel cell. A schematic of such a fuel cell is given in Figure 1. A progress report on the Los Alamos work was delivered by T. Springer et al. at the Annual Automotive Technology Development Contractors' Coordination Meeting held in Dearborn, Michigan in October.

The advantage of a direct methanol fuel cell, of course, is that it eliminates the need for a reformer. For the PEM direct methanol fuel cell (DMFC), Los Alamos initially adopted the same approach developed by them for H_2/air fuel cells, of thin-film catalyst layers bonded to the membrane. They managed to obtain significant performances and high catalyst utilization in DMFCs with catalyst loadings significantly lower than ordinarily employed (<1 milligram Pt-Ru/cm^2 on anode and 0.4 milligram/cm^2 on cathode using supported catalysts). In these types of fuel cells, the researchers have shown that the temperature of the DMFC can be increased to 130°C thanks to the presence of liquid

FIGURE 1

DIRECT METHANOL FUEL CELL



SOURCE: SPRINGER ET AL.

in direct contact with the anode side of the membrane (to achieve this, the anode backing layer was eliminated).

More recently, they have experimented with high loadings of unsupported catalysts in wet-proofed electrode structures. While the catalyst utilizations in such structures are not particularly high, cell performances are significantly improved, apparently because of the much improved cathode tolerance to methanol crossover. Even subtle variations in the cathode structure appear to have a substantial impact on the overall cell performance. Los Alamos performed a detailed comparative evaluation of the two families of Pt-Ru anode catalysts--supported and unsupported--to determine the relative merits of lower loading versus higher performance in DMFCs.

As to the other important issue of methanol cross-over, the research team has experimented with membrane treatments which lower the flux of methanol through the membrane, achieving improved cell performance. In addition, the uptake and transport rates of methanol and water in ionomeric membranes and the methanol/water equilibrated membrane conductivities have been measured to provide a data base for further development of membranes for the direct methanol fuel cell. It is expected that the DMFC will eventually find widespread use in transportation.

Access: Society of Automotive Engineers, phone 412 776 4970

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HEAVY-DUTY FLEXIBLE FUEL ENGINE UNDER DEVELOPMENT AT CATERPILLAR

Light-duty, spark-ignited Otto cycle engine manufacturers have developed "flexible fueled" engines which use a fuel sensor and controls to permit operation on gasoline or methanol, or mixtures of the two. In such Otto cycle engines, modifications to account for differences in gasoline-methanol ignition characteristics and volumetric energy content are made by electronically adjusting spark timing and carburetor fuel-air ratio.

Although desirable, development of a heavy-duty diesel cycle flexible fuel (diesel-methanol) engine is much more difficult. The two fuels must be injected by a common high-pressure pump/injector system, even though over twice the volume of methanol must be injected to obtain the same power output as with diesel. The primary challenges are whether a common injection/combustion system designed to accommodate both fuels would produce acceptable performance through the wide diesel-methanol fuel range, and whether a suitably accurate fuel sensor system can be developed. These challenges are being met by a team of researchers at Caterpillar Inc. Their approach was outlined in a paper by A. Chan et al. at the Annual Automotive Contractors' Coordination Meeting held in Dearborn, Michigan in October.

In the initial feasibility phase of this heavy-duty flexible fuel program, fuel sensor bench tests and injection/combustion tests on a single-cylinder engine demonstrated the technical feasibility of the heavy-duty flexible fuel engine concept.

In the current phase, a single cylinder version of a prototype heavy-duty flexible fuel engine has been designed and is in the process of being demonstrated. A prototype fuel sensor system for the engine is also being demonstrated on a bench test. According to Caterpillar, the development to date continues to confirm the technical viability of the heavy-duty flexible fuel engine concept.

The laboratory work uses a model 3171 single-cylinder version of Caterpillar's 3176 six-cylinder, heavy-duty truck engine. The project is being cost-shared between Caterpillar and the Department of Energy through the Oak Ridge National Laboratory.

Bench-testing of a fuel sensor to see how well it can discriminate between diesel and methanol has been successful.

By early 1995, Caterpillar hopes to have enough data to decide whether to go to a six-cylinder test. If successful, this would be followed by road testing in a chassis.

Access: Society of Automotive Engineers, phone 412 776 4970

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INCREASED PERFORMANCE AND REDUCED NO_x EMISSIONS DEMONSTRATED IN METHANOL ENGINE

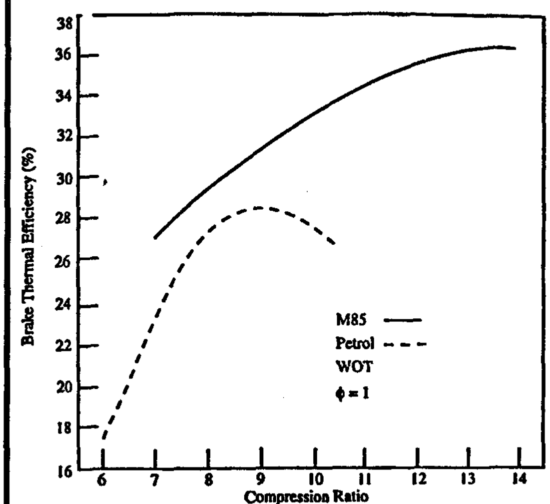
The combustion characteristics of M85 in a spark-ignition engine have been studied at the University of Coventry, United Kingdom. R. Abdel-Gayed et al. presented some results at the International Symposium on Automotive Technology and Automation held in Aachen, Germany at the beginning of November last year.

Tests were conducted on a Ricardo E6 single cylinder variable compression ratio engine. The bore was 76 millimeters and the stroke was 111 millimeters, giving a displacement of 0.507 liters. The engine was operated at a constant speed of 2,000 revolutions per minute, and MBT spark timing. The compression ratio could be varied between 4.5 and 20. The air passed through a downdraught Solex carburetor with a tapered needle in the main jet to vary the air-fuel ratio. The engine was fueled either with leaded gasoline or M85.

All performance measurements were obtained at wide open throttle (WOT) and minimum advance for best torque (MBT) spark timing and at an equivalence ratio of 1.0. In Figure 1, the brake thermal efficiency versus compression ratio is plotted for both M85 and gasoline. The figure indicates an increase of the highest useful compression ratio (HUCR) from 9.0 for gasoline to 13.0 for M85. This leads to an improvement of the engine's power output and thermal efficiency. This was possible because of the high octane rating of methanol. The figure also shows that

FIGURE 1

BRAKE THERMAL EFFICIENCY VERSUS COMPRESSION RATIO



SOURCE: ABDEL-GAYED ET AL.

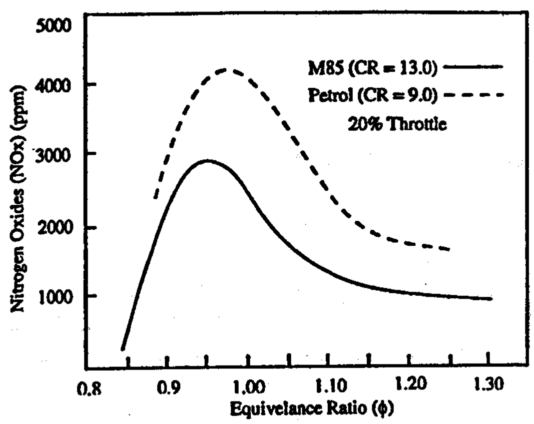
the brake maximum thermal efficiency for M85 is 28 percent higher than that of gasoline.

Figure 2 shows variation of the concentration of nitrogen oxides (NO_x) emissions versus the equivalence ratio for the two fuels. For these measurements the throttle setting was kept fixed at 20 percent throttle. This particular setting with an engine running at a speed at 2,000 revolutions per minute represents the part load condition for a car cruising at a speed of around 55 miles per hour. The figure indicates that when M85 was used, a significant reduction in NO_x emissions was obtained (approximately 30 percent). These results are in good agreement with those of other workers.

Oxides of nitrogen increase significantly with increasing flame temperature, also lower burning velocities provide a longer time for NO_x to form. The peak reduction in NO_x with M85 can be explained by both the lower peak gas temperature and methanol's higher burning velocity.

FIGURE 2

COMPARISON OF NITROGEN OXIDE EMISSIONS VERSUS EQUIVALENCE RATIO



SOURCE: ABDEL-GAYED ET AL.

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VEHICLES

WINDSOR METHANOL BUS FLEET DEMONSTRATES EMISSIONS REDUCTIONS

A 36-month trial of six methanol-powered transit buses in Windsor, Ontario, Canada was summarized by C. Kaskavaltzis et al. of the Ministry of Transportation of Ontario at the International Truck and Bus Meeting held in Seattle, Washington in November.

On the municipal level, Transit Windsor is considered a medium-size transit system in the province of Ontario. Maintenance on their fleet of 100 buses, including the rebuilding of engines and transmissions, is carried out in-house.

Program participants at the Ontario provincial government level are the Ministry of Transportation, which provides funding and overall project management, and the Ministry of Environment and Energy which also has provided funding. Natural Resources Canada has funded this project at the federal government level while Environment Canada has provided chassis dynamometer testing.

The Canadian Oxygenated Fuels Association (COFA) is one of the private sector partners in this program and has supplied M100 at a diesel equivalent rate. Motor Coach Industries (MCI) and Detroit Diesel Corporation (DDC), the other two private sector participants, have subsidized equipment as well as provided technical assistance.

Bus Description

Six MCI "Classic" 40-foot buses were ordered for this project equipped with DDC 6V-92TA engines. They began service in October, 1991. Six similarly equipped diesel buses were selected from the Transit Windsor fleet to serve as controls. Table 1 lists some characteristics of the two fleets.

The DDC methanol engines incorporate a two-stroke compression-ignition cycle and use scavenging via a Roots blower. Waste heat is retained by incorporating a bypass for the blower in order to control the amount of scavenging. Less scavenging is required at lower engine speeds and loads. Glow plugs, along with an electronic controller, have also been added as an additional source of heat, primarily when starting the engine. Other enhancements to the methanol engines included a 23:1 compression ratio (diesel 6V-92s operate at 19:1 compression) and higher flow fuel injectors. Modifications are also made to the camshaft profile and to the turbocharger. Furthermore, an oxidizing catalyst is supplied with DDC methanol engines. Engines supplied to Transit Windsor were rated at 189 kW (253 horsepower).

TABLE 1

METHANOL AND DIESEL CONTROL FLEET DETAILS

	Methanol Fleet	Diesel Fleet
Engine	DDC 6V92TA	DDC 6V92TA
Air Conditioning	Yes	No
Retarders	Hydraulic	Electric
On-Road Weight	12,500 kg	11,300 kg
Electrical System	Dual 12 & 24V	12V
Fuel Tank Capacity	1,000 L	400 L
Purchase Price	CDN$266,000	CDN$217,000

Special equipment was required in the rest of the vehicle in order to operate on methanol. Because of M100's lower volumetric energy density, the Windsor buses were supplied with higher capacity fuel tanks. Fuel is supplied to the engine with an electrically driven gear fuel pump. Because methanol's boiling point (65°C) is close to the engine coolant operating temperature, fuel returning to the tank from the engine passes through a fuel-to-air heat exchanger. This fuel cooler is mounted under the floor of the bus and is equipped with two electric fans.

Given the enhanced electrical requirements of the methanol option (primarily glow plugs and electric fuel pump), MCI chose to incorporate a dual voltage electrical system with two alternators. The 12V unit is gear-driven from the engine while the 24V unit is driven by a belt at the front of the engine. A 24V starter motor is used to crank the higher compression ratio engine.

Approximately 500 kilograms of the 1,200 kilograms heavier weight of the methanol coaches is attributable to the additional fuel.

Fuel and Oil Consumption

Fuel economy for the methanol fleet was 0.62 kilometers per liter (1.47 miles per gallon). Over the same period of time, the diesel control fleet's fuel economy was 1.57 kilometers per liter (3.70 miles per gallon). The 2.5:1 ratio between the two fleets compares favorably to the 2.3:1 ratio between the energy contents of the two fuels, on a volume basis.

Engine oil for the methanol fleet was a special order item from BP Petroleum at a total delivered cost of $2.20 per liter. Oil for the diesel fleet cost Transit Windsor $0.86 per liter. The methanol fleet averaged 830 kilometers per liter (488 miles per quart) while the six diesel buses averaged 292 kilometers per liter (172 miles per quart) over the same period.

Maintenance History

Examining the daily repair log for the period of October 1991 through March 1994, it was found that, discounting air conditioning (A/C) repairs, there were virtually the same number of maintenance actions for both fleets (768 for diesel versus 766 for methanol).

For the diesel fleet, engine-related items represent approximately 13 percent of the non-A/C daily repairs while they are 29 percent in the methanol fleet.

Batteries appear to be replaced approximately five times as frequently in the methanol fleet than in the diesel fleet. Diesel and methanol coaches each contain four batteries. One explanation for this higher replacement rate could be the increased electrical demand in the methanol coaches, primarily from the additional equipment which is inherent to the methanol package. Battery drain is particularly heavy prior to engine start during the glow plug warm-up cycle. A failed starting attempt would require a nearly identical glow plug cycle, further draining the batteries.

There is also nearly a 75 percent higher replacement frequency for alternators in the methanol fleet as compared to the diesel fleet. The increased electrical demand of the methanol buses could account for the higher replacement rate. Another explanation could relate to the fact that there are two alternators in a methanol coach compared to one in a diesel bus. This increases the probability that some alternator replacements will occur in the methanol bus, with all factors being equal.

Starter motors show a higher replacement frequency in the methanol fleet than in the diesel control buses, by a factor of over seven. An issue which could relate to frequent starter replacements is the considerably higher compression ratio found in the methanol engines and the inherently higher torque demands placed on the starter.

Fuel injectors were replaced on average every 30,500 kilometers in the methanol fleet. This compares to a single diesel fuel injector replacement in a total of 1.4 million kilometers. Injector replacements were initiated, for the most part, to cure complaints of rough running.

Comparison of Operating Costs

Maintenance costs are only one component of operating a bus. The use of consumables such as fuel and engine oil was considered in order to arrive at the cost of operating each type of bus for 100,000 kilometers. This comparison of operating costs is outlined in Table 2. The table

TABLE 2

TOTAL ESTIMATED OPERATING COSTS

Cost Component	Methanol Fleet $ For 100,000 km	Methanol Fleet %	Diesel Fleet $ For 100,000 km	Diesel Fleet %	Ratio: Methanol/ Diesel Costs
Maintenance	22,495	46.2	14,296	35.3	1.57
Oil	265	0.5	295	0.7	0.90
Fuel	25,949	53.3	25,949	64.0	1.00
Total	48,709	100.0	40,540	100.0	1.20

Notes: Fuel cost of $0.165/L and $0.410/L for methanol and diesel respectively
Fuel economy of 0.62 km/L for methanol and 1.58 km/L for diesel
Oil cost of $2.20/L and $0.86/L for methanol and diesel respectively
Oil economy of 830 km/L for methanol and 292 km/L for diesel

shows an estimated operating cost premium of 20 percent for the methanol coaches.

Three phases of emissions tests were performed on two methanol coaches (#545 and #546). Diesel bus #542 was also tested in the first phase in order to serve as a baseline.

Note that the engine for bus #545 had been overhauled prior to phases 2 and 3. Bus #546's engine was rebuilt prior to phase 3. Both methanol vehicles had new catalysts installed prior to the third phase.

Table 3 lists the results of this testing for the Central Business District cycle. Particulate emissions for the two methanol buses were considerably below those of the diesel bus, by approximately one order of magnitude. NO_x emissions in the methanol buses were also below those of the diesel bus, but by a smaller extent. CO emissions for the methanol buses were generally less than the diesel bus. Organic Matter Hydrocarbon Equivalents (OMHCE) emissions of the methanol buses were generally higher than the diesel bus. Formaldehyde emissions for the two methanol buses were several times higher than the diesel bus.

Conclusions

The authors conclude that initial concerns by Transit Windsor about increased tire and brake wear due to the methanol buses' increased weight appear to be unfounded. The relative repair frequency of tire replacement and brake relining appear equal to those of the diesel buses.

TABLE 3

EMISSIONS RESULTS FOR CHASSIS DYNAMOMETER TESTING
(Using CBD Cycle)

	Methanol Bus 545			Methanol Bus 546			Diesel Bus 542
Emission	Phase 1 @9,050 km	Phase 2 @35,900 km	Phase 3 @86,200 km	Phase 1 @7,000 km	Phase 2 @37,700 km	Phase 3 @88,200 km	Phase 1 @89,900 km
OMHCE (g/km)	0.55	2.30	1.57	0.24	1.02	2.59	0.49
CO (g/km)	13.48	7.16	4.40	2.50	7.63	9.29	12.95
NOx (g/km)	3.24	7.19	10.29	7.07	7.55	9.01	12.65
HCOH (mg/km)	226	575	778	184	310	603	68
PM (g/km)	0.08	0.20	0.23	0.10	0.12	0.29	2.06

Notes: Inertia Weight = 15,000 kg
OMHCE = Hydrocarbons + (0.433 Methanol) + (0.462 Formaldehyde)

Overall, there is at least an estimated 57 percent maintenance cost premium to the methanol buses, when compared to diesels. This appears to be the result of increased frequency of engine-related work, including fuel system repairs, and an increased frequency of electrical work. There is an estimated operating cost premium of 20 percent when the cost of methanol fuel charged for this project is considered.

The methanol buses have shown superior particulate and NO_x emissions performance relative to diesels. They do, however, have significantly more formaldehyde emissions.

It should be noted that the engines used were early production units (assembled in the spring of 1991).

Access: SAE Paper No. 942314, phone 412 776 4841

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ETHANOL AND BIOFUELS

OUTLOOK AND FORECASTS

FUTURE OF ETBE IN EUROPE DEBATED

The current status and outlook for ETBE as a motor fuel component in Europe depends on tax incentives, according to L. Chatin of Elf Antar France, who presented a paper at the Sixth European Fuel Oxygenates Association Conference in Brussels last October. Today ETBE is accepted as a gasoline blending component in France, with properties superior to MTBE.

In 1992, France granted duty relief on the ethanol used in fuels in demonstration units. Production was then initiated at the Elf Feyzin refinery (near Lyon, France) and 75,000 tonnes were produced in 1994. ETBE is blended into gasoline at concentrations of up to 15 percent with satisfactory technical results.

Chatin notes that ETBE Blending Motor Octane Numbers (BMON) are good and often better than MTBE values regardless of octane quality of base gasolines or basestocks used. The level of BMON varies with the composition of basestocks such that it is better with paraffinic or isoparaffinic basestocks than with highly aromatic or olefinic basestocks (Table 1).

ETBE is not as oxidizable as may be expected and need not to be stabilized when used in gasoline blends. However, long term storage of pure ETBE does need more precaution (addition of adequate quantities of antioxidant agents) to avoid the possible formation of high quantities of peroxides.

A complete toxicological study showed that:

- ETBE exhibits only slight skin irritation.
- ETBE exhibits only a slight eye irritation.
- ETBE does not lead to any cutaneous sensitization reaction on tested animals.

The acute oral toxicity, established with rats, is very low and ETBE does not present any mutagenic behavior in the Ames test.

The fleet tests performed show that ethers create no problem with the cleanliness of carburetors

TABLE 1

BLENDING MOTOR OCTANE NUMBERS OF ETBE AND MTBE FOR SEVEN DIFFERENT BASESTOCKS

Basestocks	BMON 15% ETBE	BMON 15% MTBE	Aromatics in Base	Olefins in Base
Isomerate	103.8	102.5	1.58	1.45
Alkylate	105.5	102.8	4.27	0
Total Reformate	100.1	96.1	67.8	0
FCC Heavy Gasoline	99.0	95.0	46.21	14.8
FCC Light Gasoline	97.3	94.6	3.53	43.16
Steam Cracked Gasoline	90.1	89.7	75.88	1.59
Heavy Reformate	89.0	86.3	99.68	0

and only increase slightly inlet valve deposits. A suitable additive technology can easily solve this problem.

All this confirms that the utilization of ETBE is an attractive blending component for gasoline in Europe.

Tests performed on catalyst-equipped and non-catalyst cars show a decrease of CO emissions with ETBE blended gasoline relative to the reference gasoline. The level of emissions is lower with the catalyst vehicle than with non catalyst vehicles, as expected. For hydrocarbons, NO_x and CO_2, no significant change was noted.

One of the main 1993 "Levy report on biofuel" conclusions was "the best solution to use ethanol as fuel is to produce and use ETBE."

Bioethanol has been rejected as a gasoline component in Europe by most oil and car industries due to poor technical properties (stability in presence of water, high vapor pressure...). The French car industry "cahier des charges" does not allow the use of ethanol as a gasoline blending component.

But Chatin notes that it is economically possible to produce and use ETBE only:

- In countries where there is an excise tax reduction
- Or if ethanol is available as a byproduct from agricultural production

Elf's position on ETBE use is that they are providing maximum cooperation with ethanol producers to use it as feedstock for an ether plant, if it is economically feasible.

Elf is considering another 75,000 tonne per year ETBE plant in Carling, depending on the French and European policies on the future of the biofuels.

Also, Total has announced that it intends, in a joint venture with ethanol producers, to build three ETBE plants (each one with a capacity of 50,000 tonnes per year) in their French refineries (Le Havre, La Mede, Flandres).

These projects will be come possible with a complete exemption of excise taxes. Total hopes to start ETBE production in 1995.

In Italy, Ecofuel (AGIP/ENI) has produced ETBE in a test run in its Ravenna plant, between April and June 1992. The final decision of Ecofuel is that, wherever ethanol (or surplus ethanol) is available on the market at prices competitive with those of methanol, it is possible to shift production toward ETBE without losing profits.

In the other European countries several companies or institutes have studied ETBE characteristics. So far, France is the only country offering tax incentives.

Chatin concludes that the following factors define the future of ETBE in Europe:

- ETBE is a good gasoline component.
- Large-scale ETBE production in Europe needs tax reductions to be competitive.
- Tax reduction on biofuels has been studied by the European Commission but has not been accepted.
- Tax reductions could be decided on a voluntary basis by individual countries.
- A tax reduction decision could possibly be taken as part of European agricultural policy.

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GOVERNMENT ACTIONS

GAO ANALYSIS SAYS HIGH PRICES CURTAIL THE USE OF ETHANOL BY FEDERAL FLEETS

A 1991 law intended to mandate the use of gasohol (10 percent ethanol) in federal fleet vehicles has been largely a failure, according to an analysis by the U.S. General Accounting Office (GAO).

Gasohol accounts for 1.6 percent of the government's bulk fuel purchases, up only slightly from its 1 percent share before 1991, says GAO. The general public buys gasohol at a far higher rate, 7.1 percent. The 1991 law requires agencies to buy gasohol any time it costs no more than unleaded gasoline.

Several factors including price have resulted in only modest success for the program. Those factors include gasohol's uncompetitive price compared with gasoline, its limited availability in some areas and its high cost of production, transportation and storage, the GAO said.

Adding to its cost is the fact that ethanol and gasohol sources are sometimes located far from fuel providers, requiring that it be transported great distances.

Also, gasohol cannot be moved through pipelines. Instead, it must be transported by railroad or truck, which is more expensive, GAO notes.

Those higher costs are not offset by the federal tax exemption for its production, the study shows.

The study cites Energy Information Administration statistics showing that in 1993, the average wholesale price of a regular unleaded gasoline was $0.51 per gallon. Gasohol made with 10 percent ethanol and blended with 90 percent gasoline cost $0.568 per gallon.

Even after receiving the $0.054 exemption from the $0.141 per gallon federal excise tax on gasoline, the average cost of gasohol was still $0.004 per gallon more than gasoline, the study shows.

Some fuel providers also said it is hard to get a steady supply of gasohol because the number of ethanol and gasohol suppliers is limited in some parts of the country.

Also, suppliers complain that indexing gasohol to gasoline prices, as required under the mandatory two-year government contracts, increases the risk that suppliers will not be able to recover their costs if the price of ethanol increases during the period, GAO says.

The study examines only bulk government purchases of gasohol. Data could not be acquired for purchases by individual employees using credit cards, which account for 54 percent of all government motor fuel purchases.

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ETHANOL COALITION REVEALS PLAN FOR 40 E85 FUELING STATIONS

The outgoing chairman of the 19-state Governors' Ethanol Coalition, Nebraska Governor B. Nelson, revealed late last year a $1.32 million plan to build up to 40 publicly accessible E85 fueling stations throughout the Midwest. The governor said that several federal programs had agreed to provide up to $510,000 provided the remaining $810,000 could be raised from state and private sources. As proposed, the effort would recondition existing fuel storage tanks or install new ones at filling stations in states with a large number of E85 cars in government fleets. The most likely states would be Nebraska, Iowa, Colorado, Illinois, Indiana, Minnesota, Missouri and Wisconsin.

The Governor said that the States of Nebraska and Iowa were ordering 24 and 51 E85 cars, respectively, to add to their fleets. This new order will bring Nebraska's total E85 fleet to 78 cars.

Nebraska's state roads department recently put two trucks fueled by 95 percent ethanol (E95) into service for routine maintenance operations and snow plowing.

This is the second test of heavy duty engines in Nebraska using nearly pure ethanol; the city of Lincoln began operating four buses on E95 in December 1993. The ethanol trucks will be evaluated for three years to test emissions, performance and durability of engines compared with similar non-ethanol trucks.

As of January 1, 1995, the new chairman of the Governors' Ethanol Coalition is Wisconsin Governor T. Thompson. Governor Thompson initiated a study at the University of Wisconsin-Stevens Point of the potential to produce ethanol in Wisconsin from waste byproducts such as paper mill sludge, cheese whey, municipal solid waste, potato waste, and forest products.

The Coalition's first official meeting of 1995 will immediately follow the National Association of State Energy Officials Conference in Washington, D.C. in February.

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CANADA TO EXTEND ETHANOL SUBSIDIES

The Canadian Government has said it will continue a tax incentive program to encourage the production and use of ethanol as an alternative motor fuel. Under its new National Biomass Ethanol Program, the government will extend a fuel tax exemption of C$0.085 per liter for fuel-grade ethanol until 1999. In addition, the government will provide up to C$70 million in guaranteed credit to companies building ethanol plants.

The announcement was welcomed by farmer-backed groups that plan to build facilities to produce ethanol from corn.

Commercial Alcohols Inc. said the government commitment should allow the company to proceed with a C$170 million project to build a 200 million liter per year ethanol plant in southwestern Ontario's corn belt. The partners in the project include Pekin Energy Company and a farm group.

In eastern Ontario, Seaway Valley Farmers Energy Cooperative Inc. said it is planning a C$43 million ethanol plant to produce 50 million liters per year. It could use as much as a third of the area's corn crop.

The Canadian Government also will encourage use of ethanol fuel blends in government vehicles and invest $1.6 million this year and the following 2 years on research into cutting ethanol production costs.

The program will be eliminated when ethanol sales reach $336 million per year, or about 1 percent of gasoline sales. Current use is about 26 million liters per year, of which about 4 million is imported.

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RESEARCH AND TECHNOLOGY

DEVELOPMENT SCHEDULE ACCELERATED FOR DEDICATED ETHANOL ULEV

Southwest Research Institute (SwRI), with funding from the National Renewable Energy Laboratory, is developing a dedicated, ethanol-fueled vehicle, with the objective of meeting California Ultra-Low Emission Vehicle (ULEV) standards. Some of the problems to be overcome with such a vehicle include:

- Low-temperature cold starts are a problem.

- Flammable vapors may exist in the fuel tank.

The approach being used at SwRI is to start with two 1993 Ford Taurus flexible fuel vehicles. The first vehicle is being modified minimally except for adding an advanced exhaust after-treatment system. The second vehicle will use the exhaust system developed on the first vehicle, but the engine will be modified to increase thermodynamic efficiency and cold startability.

Advanced after-treatment devices under test for vehicle Number 1 include:

- Electrically heated catalyst (EHC) and ethanol-optimized main catalyst

- EHC + main catalyst + hydrocarbon absorber

- Hydrocarbon adsorber/light-off catalyst + main catalyst

Engine modifications to vehicle Number 2 include:

- Increasing compression ratio from 9.3 to 11.0

- Fine-spray air-assist injectors to improve cold start

- PC-based engine controller

According to a status report by L. Dodge et al. at the Annual Automotive Technology Development Contractors' Coordination Meeting in Dearborn, Michigan last fall, the original 48-month development schedule for this project is being accelerated to 28 months. The air-assist injectors and the PC-based engine controller have been developed and engine testing is under way.

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EGR TESTED FOR EMISSIONS CONTROL IN ETHANOL-FUELED DIESEL ENGINE

At Lulea University, Sweden, E. Pettersson and W. Lindberg have studied the effects of exhaust gas recirculation (EGR) on exhaust emissions from an ethanol-fueled, direct-injection diesel-engine. Results were presented to the International Symposium on Automotive Technology and Automation in Aachen, Germany last fall.

In Sweden ethanol is said to be the preferred alternative fuel for diesel engines because ethanol can be produced from domestic wood waste. Another advantage is that biofuels decrease emissions of carbon dioxide. Alcohols also have the advantage of producing no fuel-related particles and give lower nitrogen oxide emissions compared to diesel fuel.

To further decrease NO_x emission, EGR can be applied. In diesel-fueled diesel engines it is well known that EGR lowers the formation of NO_x in the combustion zone in the cylinder by lowering the flame temperature. However, EGR on a diesel-fueled engine causes a substantial increase in soot emissions as well as total hydrocarbons (THC) and CO emissions. Among these drawbacks the major problems arise from soot particles because the recycled particles increase the wear of the engine. EGR on particulate-free alcohol-fueled diesel engines may therefore be a useful approach to reduce exhaust emissions.

The engine used was a DSI 11E bus engine from Scania developed for ignition-improved ethanol fuel.

The standard engine was modified to incorporate an EGR-loop. An EGR-cooler was added to make sure that the temperature was kept below 220°C before the intercooler. The engine was not optimized for the application of EGR.

Ethanol fuel with ignition improver was used, with composition shown in Table 1.

TABLE 1

COMPOSITION OF COMMERCIAL ETHANOL FUEL

Ethanol 95%	94.2 weight %
Avocet	2.8
MTBE	0.5
Isobutanol	2.5

The results of this investigation showed that EGR is an effective way to reduce NO_x emissions in ethanol fueled diesel engines. These results agree with results previously published on methanol-fueled diesel engines.

However, CO emissions were found to increase significantly with increasing EGR, most likely due to decreasing air-fuel ratios. It is possible that CO emissions can be reduced by improving the air-fuel ratio by matching the turbocharging.

Aldehyde emissions show a more complicated pattern than NO_x and CO. Aldehyde emissions increase with increasing EGR rates for intermediate loads but remain constant for maximum loads and are somewhat decreasing at idling. Low aldehyde emissions are also favored by advanced injection timing and high compression ratios. The results indicate that the increase in aldehyde emissions due to EGR will also decrease under those conditions.

According to the authors, this investigation shows promising results although the engine was not optimized for EGR. However, the practical application of EGR requires further investigations and a great deal of development work.

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BIODIESEL AND BIODIESEL BLENDS SHOW GOOD LUBRICITY

On October 1, 1994 the United States government mandated that low sulfur diesel fuel (0.05 percent sulfur) be used for all on-road vehicles. A variety of problems have been widely attributed to the refining process (hydrotreating) that is used to reduce the sulfur in diesel fuel to mandated levels. More severe hydrotreating is also used to reduce the aromatic level of diesel fuel for the market in California where a lower aromatic content of diesel fuel has been mandated (i.e. 10 versus 35 percent aromatics). In addition to reported increases in fuel consumption, concerns related to the lubricity of the new fuels and the reaction of the new fuels with existing fuel system elastomers have surfaced.

At the Sixth National Bioenergy Conference in Reno, Nevada last October, a paper by L. Schumacher and S. Howell reported on an investigation to examine the effect of biodiesel and biodiesel blends on the life of the injection pump and related fuel system components. Specifically, the investigation was designed to determine:

- The lubricating properties of biodiesel and biodiesel blends.

- The reaction of biodiesel with the diesel fuel injection pump and related fuel system components.

The lubricating properties of diesel fuel are important, especially for rotary and/or distributor type diesel fuel injection pumps. In these pumps, the moving parts are lubricated by the diesel fuel itself, not by the engine oil. The clearances between the moving components in rotary injection pumps are small and any fuel that exhibits low lubricating characteristics promotes the premature failure of the injection pump.

Schumacher and Howell note that lubricity has sometimes been mistakenly compared to the viscosity, or thickness, of the fuel. However, the lubrication of the fuel is not directly provided by the viscosity of the fuel, but by other components in the fuel which prevent wear on contacting metal surfaces. The lubricity of diesel fuel is an indication of the amount of wear or scarring that occurs between two metal parts covered with the fuel as they come in contact with each other. A fuel that is low in lubricity would cause high wear and scarring of adjoining metal surfaces. Fuels that are high in lubricity reduce wear and extend the life of the injection pump components.

Currently, there are no specifications or requirements for the lubricity of diesel fuel.

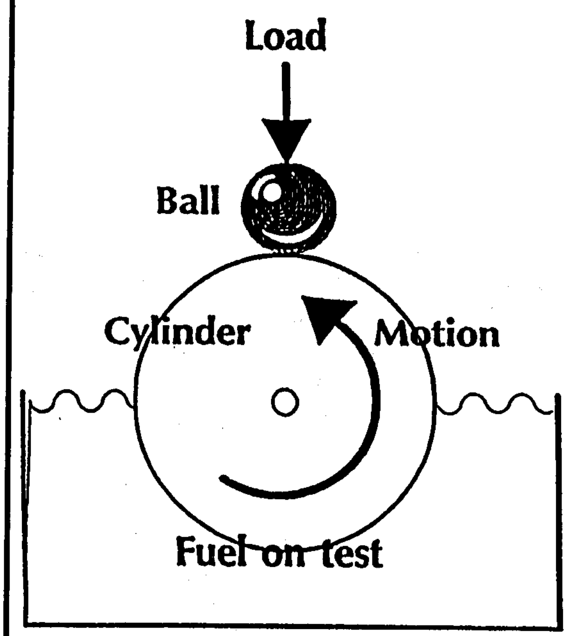
Three different lubricity measuring systems are currently used to determine the lubricity of diesel fuels. The "Ball On Cylinder Lubricity Evaluator" (BOCLE) was used in this study. A static ball is loaded onto the edge of a rotating disc (Figure 1) and the diameter of the subsequent scar on the ball is measured. Most lubricity tests conducted in the United States are run on the BOCLE machine.

Technicians at Southwest Research Institute added a total of 0, 0.2, 2, 5, 10, and 20 percent biodiesel to two different diesel fuels (low sulfur/low aromatics, low sulfur/high aromatics). The blended mixes, as well as the neat fuels, were subsequently tested using the BOCLE machine. The results for the BOCLE test are reported in grams of weight added to the apparatus before failure of the fuel to lubricate. The higher the weight added, the better the lubricity of the fuel (Table 1).

A diesel fuel with good lubricity provides BOCLE numbers in the 4,500-5,000 gram range. A diesel fuel low in lubricity will provide a BOCLE number below 3,000 grams. The precision of the BOCLE testing apparatus must also be considered when interpreting these results. It is considered that the BOCLE test provides results that are accurate to approximately plus or minus 200 grams. Therefore, two fuels with readings differing by 300 grams (say 4,000 and 4,300) may not be statistically different.

FIGURE 1

BOCLE APPARATUS



SOURCE: SCHUMACHER AND HOWELL

The results with a 20 percent biodiesel blend, and especially the neat (100 percent) biodiesel, are statistically significant and show an improvement in lubricity (Table 1). The BOCLE results at low biodiesel concentrations show no statistically significant improvement in lubricity. There currently is no lubricity standard for petrodiesel fuel but, as a reference point, the BOCLE number presently used as a temporary standard in the State of California is at or above 3,300 grams.

According to the authors, the BOCLE results from the neat (100 percent) petrodiesel fuel and the neat (100 percent) biodiesel fuel show that

TABLE 1

BOCLE MACHINE RESULTS

Percent Biodiesel Added	Low Aromatic Fuel BOCLE Result (grams)	High Aromatic Fuel BOCLE Result (grams)
0 (neat petrodiesel)	3,500	4,200
0.2	3,300	3,900
2.0	3,500	4,400
5.0	3,600	4,500
10.0	3,800	5,200
20.0	4,100	5,200
100.0 (neat biodiesel)	6,100	6,100

biodiesel exhibited superior lubricity. Given that a fuel with high lubricity yields BOCLE results of 5,000 grams, neat biodiesel with BOCLE results of 6,100 may be superior to much of the petrodiesel supplied in the U.S. today. Further conclusions were:

- Biodiesel in concentrations less than 5 percent appear to have no measurable improvement concerning the lubricity of diesel fuel.

- Biodiesel concentrations of 20 percent show significant lubricity improvement when blended with both low sulfur/high aromatic and low sulfur/low aromatic diesel fuel.

- Biodiesel improved the lubricity of low sulfur/high aromatic diesel fuel more than it improved the lubricity of low sulfur/low aromatic diesel fuel.

- Results from field tests indicated that the use of biodiesel/diesel fuel blends did *not* reduce the length of service normally provided by a diesel fuel injection pump.

Findings of the investigation indicated that concentrations of 20 percent biodiesel provide protection from lubricity related failure just as well as some of the diesel fuel lubricity additives that are currently available commercially.

The authors are in the process of testing a 20/80 blend of biodiesel/diesel fuel over an extended period of time and miles. Stanadyne has cooperated by providing six injection pumps that have been pre-inspected and tested for use in Mayflower buses at St. Louis, Missouri. Control vehicles fueled with 100 percent diesel fuel will be monitored to provide a solid baseline with which to compare the biodiesel data. At the end of the test, the injection pumps will be evaluated by Stanadyne to determine wear, deposits, and other data. This test will conclude in approximately 15 months. A similar project has been planned using BOSCH diesel fuel injection pumps.

Access: NEOS Corporation, phone 510 284 3780

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BIOMASS-TO-ETHANOL PILOT PLANT INSTALLED AT NREL

The National Renewable Energy Laboratory (NREL) in Golden, Colorado, with the assistance of Amoco Corporation, has developed a 100 gallon per day pilot plant using a new process for the conversion of biomass and waste to ethanol. The unit, which can accept up to one ton per day of a variety of municipal and agricultural wastes, is an integrated, start-to-finish, process based on the use of enzymes to effect the breakdown of the biomass into sugars.

The basic process, developed by NREL, includes pre-treatment and hydrolysis of the hemicellulose fraction, xylose fermentation, enzyme production, simultaneous enzymatic saccharification and fermentation of the cellulose fraction and ethanol purification.

Feedstock flexibility comes from the ability to modify the pre-treatment stage. The plant is being made available for industry collaborators to test their own enzyme-based processes. Even alternative acid-type bioconversion processes could be part tested in the pilot: for example, the fermentation and distillation sections, which are similar in both processes.

Conventional ethanol is made when biomass materials are converted to a 6-carbon sugar, glucose, that is then fermented by yeast. However, a large part of the starting biomass ends up as 5-carbon sugars that are not utilized by yeast. NREL developed the new process by genetically modifying a bacterium, *zymomonas mobilis*, to make a process capable of fermenting both 5-carbon and 6-carbon sugars to ethanol.

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VEHICLES

TRUCKING ASSOCIATION BEGINS BIODIESEL FIELD TEST

The American Trucking Association is cooperating with a Midwestern grain processing company in an extensive field test of a biodiesel blend in a heavy-duty truck fleet. Omaha-based Ag Processing Inc. (AGP) will use a blend of 35 percent soy-based biodiesel/65 percent petroleum diesel in a fleet of nine trucks operating from its facility in Sheldon, Iowa for a full year. Data on driveability, mileage, emissions, maintenance and repair will be analyzed by the Trucking Research Institute, a branch of the American Trucking Association.

The project is sponsored by the National Renewable Energy Laboratory, with support from the Iowa Soybean Promotion Board. AGP's company-wide truck fleet includes 90 power units. The Sheldon terminal has 30 units, which operate within a 200-mile radius. The company says it is interested in biodiesel because it is a practical alternative fuel option.

The nine heavy-duty trucks participating in the demonstration are divided into three sets of three vehicles. Each set has two vehicles fueled by a 35/65 biodiesel blend and a third control vehicle fueled by 100 percent petroleum diesel. The sets also represent three different engines (see Table 1). AGP's fleet often hauls payloads of up to 80,000 pounds gross vehicle weight.

Earlier biodiesel field tests have found biodiesel blends provide similar torque, horsepower and miles per gallon as petroleum diesel, while significantly reducing emissions of particulate matter, carbon monoxide and total hydrocarbons.

Access: National Biodiesel Board, phone 800 769 3437

TABLE 1

DEMONSTRATION FLEET PROFILE

Engine	Model	HP	Make	Year
Group 1:				
Detroit Diesel	Series 60	365	IHC	1994
Detroit Diesel	Series 60	365	Kenworth	1994
Detroit Diesel	Series 60	365	Kenworth	1994
Group 2:				
Mack	E-6	350	Mack	1989
Mack	E-6	350	Mack	1989
Mack	E-6	350	Mack	1989
Group 3:				
Cummins	855	315	Freight	1989
Cummins	855	315	Freight	1990
Cummins	855	315	Freight	1990

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INDUSTRY ANALYSES

BIODIESEL FROM OIL SEED CROPS IN ITALY ASSESSED BY MULTICRITERIA APPROACH

At the International Symposium on Automotive Technology and Automation, held in Aachen, Germany in November, a paper by S. Ulgiati and S. Bastianoni of the University of Siena, L. Nobili of the University of Milan and E. Tiezzi of the International Foundation for Ecological Economics presented a thermodynamic assessment of biodiesel production from oil seed crops, considering energy analysis and environmental loading. The area considered is Southern Tuscany, Italy.

Crops production and their transformation process were considered, accounting for energy, land and carbon balance. Furthermore, an emergy (spelled with an m) analysis was performed, in order to take into account, on the same basis, inputs coming from renewable and nonrenewable energy sources as well as from minerals, goods and labor involved in the process. Topsoil used up was also considered.

Indices based on energy, emergy, carbon and land balances were compared, in order to provide a Bio-Physical Multicriteria Approach (BPMA) for the analysis of energy conversion processes.

The authors note that fuels from biomass have been alternatively exalted and criticized, depending upon the methodology used for the analysis and the assumptions and goals of the analysis itself. It is not possible here to discuss the energy and emergy methodology that they have used. However, Table 1 shows a comparison between biodiesel produced from two different crops,

TABLE 1

BPMA RESULTS FOR BIODIESEL PRODUCTION FROM OIL SEEDS IN CENTRAL ITALY

Index	Biodiesel from Rapeseed	Biodiesel from Sunflower
Energy and Carbon Analysis		
Yield (J/ha/yr) Without Residues	3.59E+10	3.70E+10
Energy Values of Residues (J/ha/yr)	3.65E+10	6.91E+10
Applied Fossil Energy (J/ha/yr)	2.15E+10	3.36E+10
Carbon Dioxide Released (g/ha/yr)	2.47E+06	3.51E+06
Output/Input Energy Ratio Without Residues	1.67	1.10
CO_2 Avoided (g/ha/yr) (residues not included)	2.69E+06	2.78E+06
CO_2 Released/CO_2 Avoided	0.92	1.26
Output/Input Energy Ratio Including Residues	3.36	3.16
CO_2 Avoided (g/ha/yr) (including residues)	5.43E+06	7.96E+06
CO_2 Released/CO_2 Avoided	0.45	0.44
Land Required for Italy's Fossil Energy Needs (ha)	8.56E+07	5.84E+07
Land Ratio (total/required)	0.20	0.29
Emergy Analysis		
Transformity of Fuel (sej/J)	1.58E+05	1.39E+05
Emergy yield ratio	1.53	1.62
Environmental Loading Ratio	3.60	3.17
Empower Density (sej/m^2)	5.66E+11	5.14E+11
Investment Ratio	1.88	1.61

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sunflower and rapeseed. Yields have been calculated on the basis of the energy content of the main product; a figure including agricultural residues is also included, for comparison. Agricultural residues could be used as process energy, yielding process heat and electricity, thus contributing to save fossil energy. Emissions of CO_2 when biodiesel is produced is compared with CO_2 avoided from saving fossil fuels. Finally, a Land Ratio is introduced, as the ratio of total fertile land of the country to the amount of land that would be needed to meet the requirements of fossil energy of the country itself. The lower this ratio, the higher the competition between food and biofuels production.

The practical feasibility of a process can be fully assessed by a favorable energy balance, but no indications can be obtained in this way about cost of production and sustainability from the point of view of the ecosystem. Policy decision makers should be provided with reliable data about all the aspects involved in an economic process, in order to be able to weigh all factors and take decisions while being aware of possible consequences.

As shown in Table 1, a higher absolute yield of biodiesel per hectare emerges for sunflower in comparison with rapeseed both with and without considering residues. Yet, the fossil energy applied to sunflower production is also larger, resulting in a very small energy ratio (E.R. = 1.10) when residues are not accounted for; the ratio increases when residues are included (= 3.16), but remains still lower than rapeseed (= 3.36). It clearly appears that the feasibility of biodiesel from sunflower is very doubtful without a suitable use of residues, while rapeseed still offers a possibility (E.R. = 1.67). This is not a negligible issue, because residues are sometimes difficult to collect and require suitable operational conditions to be stored until use. Furthermore, part of them should not be harvested, so as to prevent the decrease of organic matter in soil.

Anyway, no CO_2 decrease can be obtained without considering residues use. Actually, sunflower is a CO_2 producer (released/avoided ratio = 1.26 for sunflower) while rapeseed shows a nearly balanced situation (release/avoided = 0.92). More favorable ratios can be obtained for both crops when residues are included (= 0.45). Therefore, residues use is crucial and unavoidable for biodiesel production, both for practical feasibility and for decreasing the greenhouse effect.

If biofuels should be used to meet all Italy's fossil energy requirement, more than 5 times the available fertile land would be needed (Land Ratio = 0.20 to 0.29). Considering biofuels only as substitutes for energy used in the transport sector (about 25 percent of total fossil energy needs), the ratio would rise up to 0.80, still showing a strong competition with food production.

A comparison between emergy indices in Table 1 shows small differences between the two crops. Emergy yield ratios of about 1.6 are still much lower than ratios calculated by other authors for fossil fuels (4 to 6). This relatively low ratio indicates that biodiesel still cannot compete with fossil fuels as a primary energy source: a choice in favor of biofuels cannot be based only on yield considerations. However, as oil, gas and related products become scarcer and more precious, their value as emergy sources will be reduced and the importance of agriculture as a potential net emergy provider will increase.

In emergy terms, a lower "loading ratio" and "empower density" result for sunflower compared with rapeseed. These measures of environmental stress seem to disagree with the results from applied fossil energy and CO_2 released. The reason can be found in the fundamentals of emergy analysis: more emergy inputs, other than fuels, have been required for rapeseed production and processing (also showing a higher investment ratio). The larger the emergy input required, the larger the "embodied space and time activity" of the biosphere needed to support the process, which is therefore less sustainable in the long run.

It is concluded by the authors that a moderate production of biofuels from oil seeds would be sustainable and not competing with food production, provided that the agricultural residues are also processed. The methodology presented is still in the course of development, but it shows a potential ability to evaluate very different aspects of natural resources exploitation.

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HYDROGEN

COMPANY ACTIVITIES

FORD BEGINS WORK ON DIRECT HYDROGEN-FUELED PEM FUEL CELL FOR TRANSPORTATION

In July 1994 the United States Department of Energy (DOE) awarded a contract to Ford Motor Company for the research and development of a "Direct-Hydrogen-Fueled Proton-Exchange-Membrane Fuel Cell (PEMFC) for transportation applications." The objectives of the contract are: (1) to develop and demonstrate on a laboratory propulsion system a fully functional PEM fuel cell power system, (2) to select and demonstrate an onboard hydrogen storage method, (3) to analyze the hydrogen infrastructure components (production, distribution, refueling), and (4) to identify future R&D needs in direct-hydrogen-fueled PEMFC technology to achieve cost and performance goals.

The project was described by Ford's D. Oei at the Automotive Technology Development Contractors' Coordination Meeting held in Dearborn, Michigan in October. According to Oei, there are two important reasons to develop the direct-hydrogen-fueled PEMFC power system. First, hydrogen can be generated from non-petroleum-based sources and may ultimately provide lower cost per vehicle-mile. Second, the direct-hydrogen-fueled PEMFC power system is a zero pollution-emitting energy source. This will be an important contribution to the Partnership for a New Generation of Vehicles (PNGV).

The contract will be carried out in 3 phases, Phase I and Phase II will be 12 months each, and Phase III is 6 months. In Phase I the propulsion system requirements, vehicle trade-offs and technical and economical issues will be studied concurrently with the hydrogen infrastructure issues. At the end of Phase I, Ford's PEMFC subcontractors will deliver a 12 kilowatt PEMFC stack to be tested at Ford's facilities. In Phase II the testing and delivery of the total fuel cell subsystem including control and ancillary subsystems will occur. Additionally, an onboard hydrogen storage tank, fabricated and tested according to specification, will be on-site at Ford. Hydrogen safety issues are to be studied during this phase and at the end of Phase II the selected PEMFC subcontractor(s) will deliver a 50 kilowatt PEMFC system to be integrated and tested in the automotive test bed.

In Phase III the 50 kilowatt PEMFC power system will be tested and put through automotive drive cycles in the test bed. Total funding for the three phases is $13.8 million.

Currently Ford's potential PEMFC stack subcontractors include: Energy Partners, H Power Corporation, International Fuel Cells, Mechanical Technology Inc., and Tecogen. For the hydrogen infrastructure, Ford's subcontractors are: Directed Technologies Inc. (DTI), Airco Gases, Air Products and Chemicals Inc., the Electrolyser Corporation Ltd., Praxair Inc., and Structural Composite Industries. DTI is the coordinator for the hydrogen infrastructure activities.

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BALLARD AND NEW FLYER FORM ALLIANCE FOR FUEL CELL BUSES

Ballard Power Systems Inc. has announced an agreement with New Flyer Industries Limited to develop and market a new generation of urban transit buses to be powered by the Ballard zero emission fuel cell engine.

Under the agreement, a 275 horsepower fuel cell engine designed by Ballard will power a New Flyer 40LF low floor bus. This commercial prototype bus is scheduled to be completed by mid-1995. In June 1993, Ballard, together with B.C. Transit developed a bus based on a 125 horsepower Ballard fuel cell engine. Since then, this zero-emission vehicle has been tested for thousands of kilometers, demonstrating the value and feasibility of using such engines for mass transit across North America.

Ballard and New Flyer are expected to begin jointly marketing the commercial version of the zero emission bus to transit authorities and transportation companies in North American cities.

With power output slightly more than double that of the first Ballard prototype the new engine is compact enough to fit into the existing diesel engine compartment of the 40LF model.

The new prototype will use compressed hydrogen gas and be equipped with an advanced, light weight, carbon filament wound, polymer composite storage vessel made by EDO Canada Ltd. The tanks will be rated at 3,600 psi. It is expected to have a range of 250 miles.

In December Ballard introduced its first prototype at a demonstration at Los Angeles International Airport.

Marine Applications

Ballard Power Systems has also signed a collaboration agreement to supply Ballard fuel cell power plants for use in marine vessels built by the German shipbuilder Howaldswerke-Deutsche Werft AG (HDW).

Under the first phase of this multi-year agreement, Ballard has been awarded a U.S. $6.7 million contract to supply a prototype fuel cell power plant that will provide propulsion and auxiliary power for marine vessels such as submarines and merchant ships. The first phase will be completed by December 1995.

Access: Ballard, phone 604 986 9367

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GOVERNMENT ACTIONS

U.S. COMMITMENT TO HYDROGEN VEHICLE RESEARCH REACHES ALL-TIME HIGH

A review of United States government programs related to hydrogen vehicle research was presented by J. Cannon at the International Symposium on Automotive Technology and Automation, held in Aachen, Germany last November. The paper was adapted from Cannon's forthcoming book, From Horses to Hydrogen.

Until the 1990s the United States had not been among the world leaders in the development of hydrogen vehicle technologies. Since 1990, however, interest in hydrogen-powered transportation in the U.S. has grown dramatically. The federal research and development program for hydrogen transportation technologies, although still minuscule, has doubled several times in recent years. Moreover, several new initiatives have been established by the Clinton administration that may involve hydrogen vehicles.

Since 1990, the national hydrogen program has been guided by the Spark M. Matsunaga Hydrogen Research, Development and Demonstration Act. This law provided the first major federal impetus to consolidate, coordinate, and expand upon the small number of hydrogen projects scattered among federal agencies at the time. The law established three objectives, the first of which was development by the Department of Energy (DOE) of a 5-year hydrogen research and development plan to "identify and resolve critical technical issues necessary for the realization of a domestic capability to produce, distribute and use hydrogen economically within the shortest time practicable."

The other two objectives established in the 1990 law were "to develop a technology assessment and information transfer program among federal agencies" regarding hydrogen and "to develop renewable energy resources as a primary source of energy for the production of hydrogen." The Matsunaga Act further directed the DOE to initiate research and demonstration projects for "critical technical issues...including use of hydrogen in surface transportation."

A total of $20 million was authorized over a three-year period to carry out the provisions of the Matsunaga Act. Three million dollars was authorized for expenditures in 1992, $7 million in 1993, and $10 million in 1994. Federal government appropriations, however, did not match the authorized levels until 1994.

The objective of the National Hydrogen Program is to attain a level of hydrogen use in the U.S. between 0.1 and 0.5 quadrillion BTU by 2000 and between 2.0 and 4.0 quadrillion BTU by 2010 and up to 10.0 quads by 2030. Total U.S. energy use is now about 85 quadrillion BTU. To achieve these goals, the National Hydrogen Program plan conducts activities in three areas; core research and development, system studies, and demonstrations.

The largest program element under the core research and development area, accounting for more than one-third of all program expenditures under the National Hydrogen Program, has focused on hydrogen storage projects. The objectives of this effort are to develop hydrogen storage systems that are 75 percent energy efficient, that do not add more than $2 to $3 per million BTU to the cost of hydrogen ($0.25 to $0.35 per equivalent gallon), that meet a weight criterion of 4,000 BTU per pound, and that meet a volume criterion of 2 equivalent gallons of fuel per cubic foot. Under this component of the national plan, hydrogen storage research funded in 1994 is underway at Syracuse University, the National Renewable Energy Laboratory, the University of Hawaii, the Florida Solar Energy Center, the Lawrence Livermore and Sandia National Laboratories, H-Power Corporation, Energy Conversion Devices, and A.D. Little Company.

Fuel production technologies are the second component of the core research and development program area, targeted for about one quarter of expenditures under the National Hydrogen Program. Research projects addressing various hydrogen production processes--with a focus on biological and chemical photoconversion technologies--are funded in 1994 at the Universities of Miami and Hawaii, Oak Ridge and Livermore National Laboratories, and National Renewable Energy Laboratory.

Hydrogen utilization projects funded in 1994 include three projects that relate directly to hydrogen vehicle development. This work is being done at three national laboratories, Lawrence Livermore, Sandia and Los Alamos.

Within the hydrogen system analysis program element, projects are funded in 1994 to study fuel cycle energy efficiency, safety, transportation and fueling infrastructure, and industry involvement in hydrogen development. This work is taking place at Princeton University, the National Hydrogen Association, the University of Miami, the Florida Solar Energy Center, Lawrence Livermore and Oak Ridge National Laboratories, the Energetics, Inc.

The hydrogen demonstration project element of the National Hydrogen Program is scheduled to begin in 1997 with a project to build and test a hydrogen vehicle. Later demonstrations are planned to showcase hydrogen technologies in industrial and utility applications.

National Fuel Cells in Transportation Program

The National Hydrogen Program initiated under the Matsunaga Act has been supplemented by and, in terms of federal dollars spent, surpassed by the National Fuel Cells in Transportation Program. Total funding for fuel cell research for transportation at the Department of Energy has risen steadily in the 1990s, from $8.9 million in

1991 to $19.5 million in 1994, with a budget increase to $24.6 million in 1995 proposed by the Clinton administration. The program is managed as part of the activities of the Office of Transportation Technologies at the Washington DOE headquarters.

Fuel cell programs partially fulfill two requirements of the National Energy Policy Act of 1992. Section 2025(j) of this Act directs the DOE to "develop and implement a comprehensive program of research, development, and demonstration of fuel cells and related equipment for transportation...as the primary power source for private and mass transit vehicles and other mobile applications." Moreover, Section 2026 of the Acts directs the DOE to conduct a 5-year study of "renewable hydrogen energy systems...to supplement ongoing activities of a similar nature" at DOE. Specific directives include demonstrations of "at least one program to develop a fuel cell suitable to power an electric vehicle" and another effort "to develop a hydrogen storage system suitable for electric motor vehicles powered by fuel cell."

The National Fuel Cells in Transportation Program includes four components: fuel cell engine development for passenger vehicles, engine development for heavy-duty applications including buses and locomotives, basic research and development of fuel cells and energy storage systems, and supporting analyses of such issues as safety and environmental impacts of fuel cell use.

Of the four components, the Urban Transit Bus Program, co-funded by the U.S. Department of Transportation, the California South Coast Air Quality Management District, and a group of companies, is the most ambitious. The objective of this effort is to develop and demonstrate a bus powered by a phosphoric acid fuel cell and fueled by methanol reformed to hydrogen on board the vehicle. Phase I of the project, designing the bus, was completed in 1991. In Phase II, scheduled for completion in 1995, three prototype 30-foot buses will be built and road tested. Future project stages will include the design and testing of small fleets of 40-foot fuel cell buses.

The passenger vehicle component of the National Fuel Cells in Transportation Program centers around the development of a proton exchange membrane fuel cell small and light enough to be used in light-duty vehicles. The prime contractor for this effort is the Allison Gas Turbine Division of General Motors. Much of the work is being done at Los Alamos National Laboratory in New Mexico. Other subcontractors include Ballard Power Systems and Dow Chemical Company.

Other projects underway as part of the National Fuel Cells in Transportation Program include studies of steam reforming technology capable of converting methanol into high-purity hydrogen and technical assessments of a variety of onboard energy storage. Arthur D. Little, Inc. of Cambridge, Massachusetts is the prime contractor for both projects.

New Federal Advanced Vehicle Initiatives

Hydrogen transportation could enjoy increased support from other federal programs which are collateral to the National Hydrogen Program and the National Fuel Cells in Transportation Program. They all include projects that potentially or actually involve applications of hydrogen in transportation.

Programs of note include the Electric/Hybrid Vehicle Program directed by the Department of Energy; the Technology Reinvestment Program directed by the Department of Defense; and the Partnership for a New Generation of Vehicles, coordinated by the Department of Commerce. These new programs were either created or greatly expanded during 1993.

The Electric/Hybrid Vehicle Program is managed by the Office of Propulsion Systems within the Department of Energy. A $138 million, 5-year project between General Motors and the Midwest Research Institute has been initiated. The objective of the project is to develop a hybrid vehicle equipped with both an electric motor and an internal combustion engine.

A second hybrid vehicle development project is a $122 million contract between Ford Motor Company and the Midwest Research Institute. Both projects are still in the planning stages and no decisions have been finalized about which hybrid engine designs to use in the prototype vehicles to be developed.

The Department of Defense also conducts research programs involving electric and hybrid vehicle development through its Technology Reinvestment Program, managed by the Advanced Research Projects Agency (ARPA). In the first round of grants in 1993, ARPA awarded $23 million in support of six all-electric vehicle and hybrid electric vehicle development consortia. Each grant includes a 2-year vehicle demonstration program at an Air Force Base. None of the 1993 grants specify development of hydrogen fuel cell vehicles, although development of hydrogen engines is likely to be included in several projects.

The second round of projects funded by ARPA as of mid-1994 included 50 grants from 2,800 applications. Only one involves hydrogen energy. A $1.2 million grant was awarded to support a hydrogen vehicle demonstration project led by the Xerox Corporation and Clean Air Now, a public interest group.

While the Partnership for a New Generation of Vehicles (see article elsewhere in this issue) does not designate the use of hydrogen as a specific goal, it is intended to "demonstrate radical new concepts such as fuel cells."

Conclusion

Compared to the National Hydrogen Program and the National Fuel Cells in Transportation Program, much larger federal financial commitments are part of the Partnership for a New Generation of Vehicles, the Technology Reinvestment Program, and the Hybrid Vehicle Program. These latter efforts do not focus on hydrogen vehicle technologies, although hydrogen fuel cells may emerge as a preferred technology as the programs proceed. Thus, at the end of 1994, it appears that federal involvement in hydrogen vehicle development is at an all time high. It is unclear whether this enthusiasm for hydrogen will continue in the face of competition from technologies, such as electric batteries and advanced conventional engines, which are also represented in these programs.

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RESEARCH AND TECHNOLOGY

DEVELOPMENT OF A MULTI-FUEL POX REFORMER UNDER WAY AT ADL

Arthur D. Little, Inc. (ADL) is conducting a multiphase Department of Energy-sponsored program to develop hardware solutions which promote diverse fuel options for fuel cell vehicles. This work has included development and evaluation of hydrogen storage technology and development of multi-fuel reformer technology. The reformer work was reviewed by J. Bentley et al. at the Annual Automotive Contractors' Coordination Meeting in Dearborn, Michigan last October.

During the first phase of the program three reforming options (steam reforming, autothermal reforming and partial oxidation), as well as several fuel cell and fuel options, were comprehensively evaluated against transportation-specific criteria such as: rapid operation from a cold start; capability to use multiple fuels; compact, lightweight construction; high system efficiency; and potential for low-cost fabrication. Apart from methanol, all other potential fuels require high-temperature reforming. For multi-fuel use, this makes partial oxidation an attractive alternative to steam reforming. Partial oxidation (POX) provides fuel flexibility, simplicity, and rapid start-up. In the second phase of the DOE program, ADL is developing a catalytic partial oxidation-based multi-fuel processor. The prototype system is targeted at an ethanol-fueled, phosphoric acid fuel cell-powered bus and the current phase of the program will culminate in the development of a prototype multi-fuel 25 kilowatt hybrid POX reactor.

Work to date has concentrated on the development of a bench-scale partial oxidation experiment to yield fundamental ethanol partial oxidation kinetic data and on the use of a detailed chemical kinetic model to predict the performance of the bench-scale reactor and to aid in the design of the prototype reactor.

Thermal Versus Catalytic Partial Oxidation

A kinetics model was used to screen and evaluate design options for the prototype reformer. Effects of such operating parameters as air and fuel preheat, reactant mixing characteristics, air and fuel staging, reactor residence time, heat loss, pressure, and fuel/air equivalence ratio on the hydrogen yield were evaluated using the model. One principal conclusion for thermal partial oxidation is that in order to approach equilibrium yields at an efficient equivalence ratio (>3) in a reasonable reactor volume, the reactor temperature must be above 1,700°K, which in turn means that the air and fuel preheat must be very high (700-800°C).

Such preheat levels place several stringent constraints on the on-board fuel processor design. Principal among these are: severe materials compatibility problems; inability to premix fuel and air (required for effective soot control); and requirement for the anode exhaust gas to supply heat for preheat duty. A more attractive option is to use a catalyst to accelerate the "tail" of the partial oxidation process (i.e., the reactions occurring past approximately 20 milliseconds). The tail of the process is essentially high-temperature steam reforming of the trace unconverted hydrocarbons and can be accelerated using conventional steam reforming catalysts. The performance of various catalysts in this application was investigated in a modified bench-scale reactor.

Two catalysts were evaluated in the bench-scale reactor. First, a conventional nickel steam-reforming catalyst (United Catalyst C11-9-02), supported on Raschig rings, was tested. Second, a conventional automotive three-way catalyst, supported on a honeycomb monolith, was tested. Either catalyst enabled close to equilibrium product compositions to be obtained at high equivalence ratios (3 to 3.8). Figure 1 (next page) shows the reactor yield (moles of H_2+CO per mole of fuel) compared to the theoretical maximum yield. At high equivalence ratio, the catalyst temperature was significantly below its design operating temperature. Data for operation without a catalyst is compared to that for both catalyst types.

Prototype Reactor Design

Based on bench-scale testing and modeling, two options for achieving the desired performance goals were evaluated. These were a simple POX reactor configuration with high reactant preheat and a catalytic POX reactor with modest reactant preheat. According to Bentley et al., the catalytic POX reactor is the preferred option because of its higher system efficiency, low preheat requirements, use of fuel/air premixing, the lack of material compatibility problems, avoidance of fuel cracking and coking, use of conventional catalyst materials, and the fact that the fuel cell anode gas is not required to be integrated into the reactant preheat system.

A prototype reactor is now being tested at ADL.

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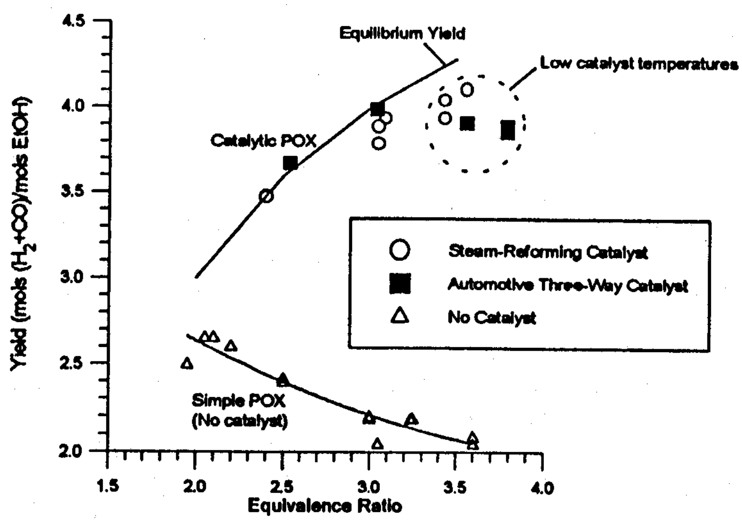
VEHICLES

HYTHANE BUS UNVEILED IN CANADA

NovaBUS Corporation recently unveiled its prototype urban bus that runs on hythane. Hythane is a blend of 80 percent natural gas and 20 percent hydrogen.

FIGURE 1

PERFORMANCE DATA FOR CATALYTIC AND SIMPLE POX REACTOR



SOURCE: BENTLEY ET AL.

The Societe de Transport de la Communaute Urbaine de Montreal, one of the project's development partners with Hydro-Quebec, the Quebec Government and the engineering firm SNC-Lavalin, will test this first model on one of its regular routes. A second bus of the same type will be put into service in February 1995.

The experiment is part of the Euro-Quebec Hydro-Hydrogen Pilot Project, a research and development program on uses for hydrogen.

The bus used for the experiment is a "Classic" model manufactured by NovaBUS Corporation in Saint-Eustache, Quebec.

It is driven by a 240 horsepower modified Cummins engine. Four tanks on the vehicle's roof hold about 1,500 liters of hythane gas, allowing the bus to travel 400 kilometers between refuelings.

The basic idea behind Hythane-powered bus transportation is to meet California's ultra-low emission vehicle (ULEV) requirements--0.005 grams per kilometer of hydrocarbons, 0.4 grams per kilometer of carbon monoxide, 0.1 grams per kilometer of NO_x--at an acceptable price level.

Hydrogen will be provided via a Montreal company, Industries Electrolyseurs du Quebec, Inc., from a plant in Becancour.

Safety equipment includes a gas detection system and automatic extinguisher, electronic status controls and monitors for the driver, and a system shutting down the gas flow in case of an emergency.

The demonstration is expected to last about nine months.

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EUREKA FUEL CELL BUS HITS THE STREETS OF BRUSSELS AND AMSTERDAM

A consortium of European companies has built a fuel cell bus that is currently being tested by the Transport Authority in Brussels, Belgium.

The companies that are involved in the fuel cell bus project include:

- Ansaldo (Italy)--electric traction system
- Air Products Nederland--hydrogen fuel equipment
- Saft (France)--nickel-cadmium batteries
- Elenco (Belgium)--fuel cells

The bus has an Elenco alkaline fuel cell system that uses hydrogen for fuel.

The electric traction system is based on an AC motor with associated power electronics. The fuel cell supplies the basic power, and during acceleration additional power is provided by the series of nickel-cadmium batteries. The batteries are recharged from the fuel cell and by a regenerative braking system. The hydrogen is stored in a liquid form in an onboard tank.

The bus has a driving range of 250 to 300 kilometers. It has a governed top speed of approximately 62 kilometers per hour.

The basic vehicle was supplied by Belgian busmaker Van Hool.

Another set of test runs is scheduled for Amsterdam, beginning most likely in mid-1995.

The "EUREKA" label is awarded to projects with advanced technologies, developed in cooperation among several European countries.

Total cost of the project so far is on the order of $8 million, with about 60 percent paid for by the four partners and the rest by the four respective national governments.

Initially, the EUREKA bus had been designed to employ a flywheel for energy storage. But because of "technical and financial difficulties," the flywheel concept was dropped in favor of NiCad batteries.

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HYDROGEN-POWERED VEHICLES TO BE TESTED AT MUNICH AIRPORT

According to a report in The Hydrogen Letter, the Bavarian State Ministry for Economics and Transportation has awarded a DM329,000 contract to Deutsche Aerospace AG (DASA) for a conceptual study of a decentralized hydrogen supply system for airport support vehicles at Munich's two-year-old airport.

The pilot project is scheduled to begin this year. The first hydrogen-powered ramp vehicles could start operating in 1997 or 1998.

Bavaria's Economics Minister believes the project will enable German industry to test hydrogen technologies under the tough operating conditions at a large airport and at the same time to gain experience in handling hydrogen for future use with hydrogen-powered aircraft. The hydrogen is expected to be produced at the airport, at or near the refueling station, from off-peak electricity but also from photovoltaics-generated electricity, according to the ministry's announcement.

Still to be decided is whether the project will use liquid or gaseous hydrogen.

Of the hundreds of different vehicles operating at the airport, which operate both on the ramps and aprons and inside the hangars, only a few are likely to be converted initially.

Access: The Hydrogen Letter, phone 301 779 1561

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INDUSTRY ANALYSES

HYDROGEN ENERGY NETWORK STARTUP SCENARIO PROPOSED

The hydrogen energy network concept first came into discussion more than 25 years ago, but hydrogen has so far failed to achieve a breakthrough into widespread commercial use. A study has been carried out at Germany's Deutsche Aerospace AG in order to evaluate the boundary conditions, either political or economical, which would give hydrogen the necessary push, that is, create an advantage over conventional fuels. This study was discussed in a paper by S. Weingartner and H. Ellerbrock at the 29th Intersociety Energy Conversion Engineering Conference held in Monterey, California last year.

A start-up scenario has to fulfill the following criteria:

- It has to be based on state-of-the-art technology.

- The complete system has to be competitive with alternatives after a short introductory phase with regard to costs, practicability, safety, environmental impact and public acceptance.

- It has to have a consistent long term perspective.

With these criteria in mind, the study at Deutsche Aerospace has been focused on the niche production of hydrogen via electrolyzers and its application as fuel for automobiles. Consequently, the purpose of the study was to identify scenarios where the environmental advantages of hydrogen cars are important and possible disadvantages concerning economics or others can be reduced to a minimum.

Hydrogen Production

In order to establish an area-wide supply of hydrogen it is necessary to produce hydrogen locally. This can be done in an economic way by a new type of alkaline electrolyzer.

Short-term spinning reserves of power stations can be used efficiently and with little additional primary energy to produce hydrogen with an electrolyzer which has a wide range of operation and can be switched off whenever power reserves are needed for other consumers.

Such an electrolyzer has been developed by Deutsche Aerospace in a joint venture with Linde AG and Hamburgische Electricitats-Werke, and it is currently being tested in a prototype version with excellent results.

Due to its high efficiency of about 80 percent, a gallon gasoline equivalent of hydrogen could be produced for about $2.50 per gallon or $0.70 per liter gasoline equivalent. This value is not competitive with the gasoline price in the United States, but can compete with the high-taxed gasoline in Europe which costs about $3 to $4 per gallon or $0.80 to $1.10 per liter.

With the described concept an economic hydrogen infrastructure can be established, only depending on water and electricity.

The accessible reserves of power plants in Europe have been estimated to be on the order of 3 gigawatts. This would allow a yearly production of 6 billion cubic meters of hydrogen corresponding to 400 million gallons or 1.5 billion liters of gasoline which would be sufficient to operate 1 million passenger cars. This amount is considered as being sufficient for a start-up scenario.

Cars with Hydrogen Combustion Engines

In order to minimize nitrogen oxide emissions hydrogen engines should be operated at a mixture ratio of 2 (twice the air as needed for stoichiometric combustion). This results in a small reduction of efficiency and performance on the order of 15 percent compared to gasoline engines.

The small amounts of HC and CO emitted by hydrogen cars result from lubricant oil combustion.

Zero emissions can only be achieved by electric cars either with battery systems or fuel cells. Nevertheless, the emissions of hydrogen combustion engines are on the order of a few percent compared to today's passenger cars.

Furthermore, the range of battery cars is unacceptably small if heating or cooling is required. Adding a fossil fuel burning heater will inevitably increase emissions well above those of a vehicle with a hydrogen combustion engine.

Cars with Hydrogen Fuel Cells

A fuel cell driven vehicle combines zero emissions and low noise levels with good performance and range. With an onboard reformer, methanol could be used as primary fuel, transformed to hydrogen and then fed to the fuel cell, thus increasing range but causing low CO_2 emissions.

Europe's first fuel cell car was presented to the public by Daimler-Benz in mid-April 1994.

The fuel cell car has tremendous advantages, but today is far too expensive and can be seen as the long term solution only.

Cost of Hydrogen Vehicles

The difference in operational costs of hydrogen vehicles compared to gasoline cars only depends on the fuel prices. Maintenance costs, insurance, etc. are assumed to be comparable.

The cost today for a hydrogen combustion engine vehicle would be on the order of 150 percent of that for a standard car with comparable comfort. This extra cost could be reduced when increasing the number of produced hydrogen cars. A small extra charge on hydrogen cars will remain due to the more expensive storage tank. This extra charge is expected to be on the order of 10 percent, depending on the selected storage.

Attractive Niches

One major handicap of hydrogen cars is the nonexisting infrastructure, i.e. there are no filling stations available today. This again is not a technical problem, but no gasoline station will offer hydrogen unless there is a reasonable hydrogen demand.

The following attractive niches have been identified:

- Car fleets which require few central filling stations

- Car fleets with moderate ranges and constant operating distances

- Vehicles which have to operate in-door and out-door and need strong engines

- In areas where air pollution is critical, e.g. urban areas or recreational resorts

In Germany laws are under consideration in order to reduce traffic-caused air pollution. This could result in a temporary closure of certain cities for conventional cars and therefore increasing the advantages of hydrogen vehicles which would still be allowed to enter the city. Tax legislation could also be a method to improve the economic situation of clean fuels like hydrogen.

Another important support could be given by financing demonstration programs in which a complete system, including a filling station with an electrolyzer and a fleet of hydrogen cars, is operated. Such programs are necessary to demonstrate the technical feasibility and safety and to gain public acceptance.

Conclusions

The authors conclude that vehicles with hydrogen combustion engines and metal hydride storage tanks are today technically feasible. Their cost could be reduced to 110 percent of conventional cars when produced in higher quantities. Hydrogen can be produced locally by electrolyzers for costs competitive with gasoline prices in Europe. The emissions of hydrogen combustion engines can be reduced to one percent of today's gasoline engines. Emissions of fuel cell cars are zero but they are not cost competitive today.

Government can support the introduction of hydrogen as fuel by emission related laws, by taxes on polluting alternatives and by financially supporting demonstration programs. Demonstration projects are attractive where the environmental advantages of hydrogen are important and the required hydrogen infrastructure can be built up with a small number of filling stations.

All this requires a lot of small actions to be taken by a variety of institutions and industries which today are not interconnected with each other. Therefore it requires a new cooperative and proactive network between, e.g., energy utilities, car industries, those who have a sound experience with hydrogen (space industry, chemical industry) and last but certainly not least, the government.

Access: AIAA, phone 202 646 7528

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GOVERNMENT ACTIONS

NEW JERSEY BACKS AWAY FROM OXYGENATED FUEL REQUIREMENT

The U.S. Environmental Protection Agency has approved New Jersey Governor Whitman's request to allow New Jersey to reduce the oxygen content of gasoline two months ahead of schedule in the northern part of the state.

For New Jersey's portion of the New York metropolitan area, the oxygen content as of March 1 will drop to 2.0 percent by weight instead of 2.7 percent.

For next winter, the 2.7 percent specification will not start until November 1, rather than October 1 as it did last year. Thus EPA gave approval to shorten indefinitely the oxyfuel season to four months from seven months.

The four-month minimum is specified by the Clean Air Act Amendments for areas that violate federal standards for carbon monoxide. Northern New Jersey is one of those areas.

The change will cut gasoline's content of MTBE to 11 percent from 15 percent.

Whitman acted after complaints of some citizens that exposure to MTBE made them ill. The anti-oxygenated fuels group Oxy-Busters of New Jersey has been claiming that MTBE in New Jersey has made thousands of state residents ill. In the past, the group has said it will accept nothing less than a total MTBE ban. The organization's efforts have spurred some state legislators to propose banning the fuel additive.

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RESEARCH AND TECHNOLOGY

CONCAWE HEAVY ENDS RESEARCH FINDS LITTLE EFFECT ON EUROPEAN CARS

CONCAWE is the oil companies' European organization for environment, health and safety. The emphasis of its work lies on technical and economic studies relevant to oil refining, distribution and marketing in Europe.

CONCAWE has conducted a study to investigate the effects of heavy gasoline components on exhaust emissions from a fleet of modern European fuel-injected catalyst cars (The Influence of Heavy Gasoline Components on Exhaust Emissions of European Vehicles: Part I, Regulated Emissions, report 94/59). The CONCAWE study was initiated following a report from the AQIRP which says that a reduction in the amount of heavy ends in U.S. gasoline somewhat reduced vehicle exhaust emissions of hydrocarbons and air toxics. As a result, the amount of heavy ends, indicated for example by the temperature at which 90 percent of the gasoline is distilled (T_{90}°C), became one of the features in the complex model procedure used for U.S. reformulated gasoline.

The CONCAWE study was done to establish whether the emissions effects would be reproduced with European cars and fuels. In CONCAWE's program, seven fuels were tested on ten European vehicles. The investigation was conducted using a standard European driving test cycle. By far the largest differences found in the measured emissions resulted from a variety of vehicle design and operation factors. Hence, the analysis has required the use of powerful statistical techniques to identify the relatively small effects of changing the chemical species and reducing the amounts of heavy-end components of the fuels tested. Some of the fuel effects, although statistically significant in a mathematical sense, may be of little practical importance because they are so small compared with car-to-car variability, says CONCAWE.

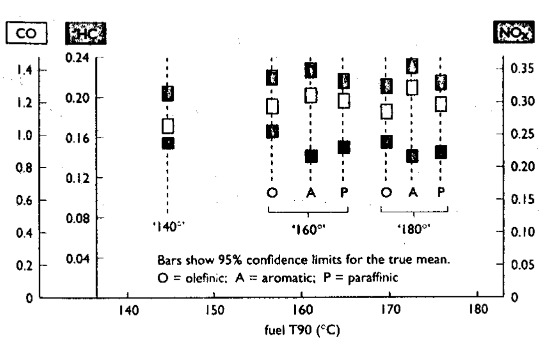
Some of the cars were more sensitive to fuel differences than others but no clear relationship between emission level and vehicle response was evident. Both the gasoline heavy ends amounts and the different compositions had some very minor effects on the emissions of regulated substances. Figure 1 shows that the effects are hardly discernible.

For hydrocarbon and carbon monoxide emissions, reducing the amounts of heavy ends had a slightly greater effect overall than the composition changes. For nitrogen oxide emissions however, the compositional effects were, fractionally, the greater. Also, the fuel effects were discontinuous. A first step reduction in amounts of heavy ends (nominal T_{90} from 180°C to 160°C) had no measurable effect on hydrocarbon or carbon monoxide emissions. A second step (T_{90} from 160°C to 140°C) decreased total hydrocarbon emissions by a few hundredths of a gram per kilometer and carbon monoxide emissions by a tenth or so of a gram per kilometer. The nitrogen oxide emissions changed in the opposite direction to those for hydrocarbons and carbon monoxide, i.e. as the heavy ends reduced, the NO_x emissions increased, which is not a favorable effect.

FIGURE 1

TOTAL CO, HC AND NOx EMISSIONS BY FUEL T90

(Ten–Car Geometric Mean)



SOURCE: CONCAWE

This opposite NO_x response suggests an effect of fuel composition on engine air/fuel ratio (AFR). Additional research will therefore be needed to address the AFR aspects. Furthermore, it has not yet been possible to decouple emissions effects due to the other differences in test fuel distillation profiles between T_{50} and final boiling point. It is therefore difficult to be absolutely sure that the effects accorded to T_{90} are not, in fact, partly due to these other boiling point differences.

When making a judgement on whether T_{90} is a sensible control parameter for Europe, it will also be borne in mind that, because the level of T_{90} in European gasoline has traditionally been much lower than in the USA anyway, the potential of any such measure is inevitably smaller.

Access: CONCAWE, phone 32 2 220 3111, Belgium

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AQIRP COMPLETES 5-YEAR LABORATORY TESTING EFFORT

The Auto/Oil Air Quality Improvement Research Program (AQIRP) is drawing to a close. All testing and data collection was to have been completed by the end of 1994. Over 5,100 automobile emissions tests on different fuels have been carried out. The last two test series to be completed were the Off-Cycle Emissions Study and the completion of CNG and E85 testing. Data analysis and reporting is under way and will continue into 1995.

Over 100 publications are available on the findings of AQIRP. These reports have been published in a variety of formats, including AQIRP Technical Bulletins, Society of Automotive Engineers papers, Air and Waste Management Association papers, and journal articles.

Access: Coordinating Research Council, phone 404 396 3400

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INDUSTRY ANALYSES

U.S. ERA OF REFORMULATED GASOLINE OFFICIALLY BEGINS

Reformulated gasoline may be considered to have been born when Arco announced the availability of EC-1, the first RFG, in 1989. The concept was then formally incorporated into the Clean Air Act Amendments of 1990 (CAAA). After four contentious years of arguments over the regulations to implement the CAAA, RFG finally came of age on January 1, 1995, when it became legally required in the nine most severe ozone nonattainment metropolitan areas. It is estimated that approximately 30 percent of the gasoline sold in the U.S. is now reformulated. Some 70 million consumers will be using RFG, and there will be a reduction in total pollutants released to the atmosphere by almost 100 pounds per car per year (Table 1).

Despite early concerns over the ability of the gasoline production and distribution system to accomplish the massive changeover on schedule, few problems were evident. It had been projected that the loss of a single RFG-producing refinery in the Northeast or West Coast could result in regional shortages. The RFG program is the most complex program that the oil industry has ever had to implement.

December data showed wholesale RFG prices to be about $0.06 per gallon above those for conventional gasoline, consistent with the higher costs underlying the product.

Many organizations issued comments marking the official start of the RFG era.

TABLE 1

ESTIMATED 1995 PER VEHICLE EMISSIONS REDUCTIONS ASSOCIATED WITH REFORMULATED GASOLINE

Pollutant	1995 Baseline	Percent Reduction	Actual Reductions (per car/yr)
VOCs	75 lbs/yr	15	11.25 lbs
CO	557 lbs/yr	15	83.50 lbs
NO_x	39 lbs/yr	2.5	1.00 lbs
Air Toxics	1.74 lbs/yr	24	0.41 lbs
Total			96.16 lbs

U.S. Environmental Protection Agency

"This new gasoline program is the most important environmental fuels program since lead was banned from gasoline. It will provide immediate health benefits by reducing smog-producing emissions by more than 300,000 tons in the first year alone--a reduction which is equivalent to taking more than 8 million cars off the road. Over the first five years, nearly 1.3 million tons of air pollution will be removed from the skies."

American Lung Association

"Because the message of the health benefits of reformulated gasoline sometimes gets obscured in squabbling about cost, convenience and conventional practices, the American Lung Association, in cooperation with the EPA, will conduct an outreach campaign this year...We believe that a successful reformulated gasoline program will pave the way for the implementation of other components of the Clean Air Act."

American Automobile Manufacturers Association

"America's Car Companies--Chrysler, Ford and General Motors--support the reformulated gasoline program for three reasons. First, it reduces vehicle emissions for all cars, not just new ones. Second, it does not impact the personal mobility of consumers, choice of vehicles or convenience of operation. And third, it is a cost-effective way to further reduce mobile source emissions."

National Petroleum Refiners Association

"This new fuel, RFG, represents the most comprehensive change in fuel parameters over the last two decades. It is an advance toward 21st century fuels which produce environmental benefits without massive, costly retrofits of automobile fleets and fuel distribution systems. The petroleum refining industry will continue to develop and market new improved environmentally beneficial fuels as we enter the 21st century."

American Petroleum Institute

"The move to RFG represents another stage in the tightening specifications on motor fuels. Lead phasedown began in early 1970s, the summer gasoline volatility program in 1989, the winter oxygenate program in 1992, and low sulfur diesel in 1993. In 1998 and again in 2000, the RFG specifications are due to change further."

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LAST-MINUTE OPT-OUTS BY STATES MUDDY THE PICTURE FOR RFG

As of January 1, 1995, all gasoline sold in the nine worst ozone air-quality regions in the United States is required to meet the reformulated gasoline specifications developed under the Clean Air Act Amendments of 1990 (CAAA). However, the boundaries of the ozone nonattainment areas do not generally conform to state boundaries. Therefore the CAAA allow states containing RFG-required areas to choose to require that gasoline sold in other, less-severe nonattainment areas of the state also be reformulated gasoline. A number of state governors had made such opt-in choices for areas within their states. Some 14 states and the District of Columbia made opt-in choices. However, an apparently widespread backlash against the costs of clean air regulations, coupled with the November election of many politicians opposed to all forms of regulation, led to the last-minute decision to reverse several such opt-in decisions. This has created uncertainty in the refining industry about the ultimate refining capacity need for RFG.

On December 1, Pennsylvania Governor R. Casey signed a bill that removed 28 counties from the RFG program--reversing his own 1991 decision to include them in the program. Twenty of these counties are designated "marginal" for ozone nonattainment and eight are "moderate." Only five Pennsylvania counties in the Philadelphia area are legally required to participate in the

RFG program. The RFG measure became an issue in the 1992 state elections because of media reports of higher fuel costs and possible engine troubles for RFG users. By December 1, of course, the petroleum industry had already been shipping RFG into Pennsylvania in anticipation of it being required statewide on January 1. In addition to the Pennsylvania decision, New York State also indicated a desire to withdraw one county from the program and Maine indicated an interest in withdrawing of two counties. Other states said to be considering such action include Virginia and Maryland.

If all opt-in areas in the country were to reverse their decision, the total requirement for RFG would be only 20 percent instead of 30 percent of the total gasoline market. Prices for RFG slumped on the New York Mercantile Exchange after news of the withdrawals prompted fears of an oversupply.

The CAAA regulations contain no specific provisions allowing for an "opt-out' decision. However, the U.S. Environmental Protection Agency (EPA) said it would not enforce the RFG programs in those counties having formally stated a desire to opt-out, while the agency developed regulatory procedures to cope with such opt-outs. To formally remove counties from the program, EPA must go through an official rule-making procedure. EPA told states in late December that they would have to give 30 days notice if they wanted to withdraw, and that temporary opt-outs would not be accepted.

In late December, New York requested opt-outs for eight more counties in the Albany and Buffalo areas.

In January EPA announced that the 39 counties in New York, Pennsylvania and Maine that had requested opt-outs would be exempted from RFG compliance until July 1, giving EPA time to develop a formal procedure for opt-outs.

Addition Opt-Ins

In the meantime, additional areas not required to use RFG are still opting in to the program. Three Wisconsin counties will opt-in as of June 1. Another area expecting to opt-in is San Antonio, Texas.

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ELECTRIC VEHICLES

OUTLOOK AND FORECASTS

JAPANESE AUTO COMPANIES DESCRIBE STRATEGIES FOR THE CALIFORNIA EV MARKET

Interviews with Japanese auto manufacturers have given K. Maruo of the University of Gothenburg, Sweden some insights into possible outcomes for the California EV market. Maruo described these insights at the 27th International Symposium on Automobile Technology and Automation, held in Aachen, Germany last fall. California requires that 2 percent of auto sales (for large manufacturers) in 1998 be electric vehicles. According to Maruo, the following are key characteristics of the Japanese industry:

- The Japanese auto manufacturers can develop a new EV model in 2 years.

- Toyota, Honda, Nissan and Mazda must comply with the 2 percent sales mandate in 1998. Altogether, more than 10,000 Japanese EVs must be sold annually.

- The Japanese auto manufacturers are not beginners in the EV business.

- When the Japanese auto industry declares some targets to reach, the industry knows that it will reach these targets.

- The Japanese auto manufacturers do not believe in the Japanese EV market. They are not interested in the European EV market. They will make EVs at present only for the California market.

- EVs are very easy to assemble. It is possible that traditional auto manufacturers may not dominate the coming California EV market.

- Toyota has already declared (in May 1994) that it will produce EVs for the California market. This is enough of a reason for the other manufacturers to begin investing in EVs.

Toyota and Honda are well prepared for 1998. They have already finished their tests of EV converted models, and they now have newly designed preproduction EVs.

Nissan and Mazda do not have as large a market share in California as Toyota and Honda have, and both are tackling severe economic problems. They have at present only EV converted models.

Lesser manufacturers like Mitsubishi, Suzuki and Subaru, who are not affected by the 1998 ZEV mandate, will begin to sell EVs before 2003, probably in 1999 or 2000.

Daihatsu, the most experienced EV maker in the world, apparently does not believe in EVs as generally usable vehicles. Daihatsu is staking its plans on a light-weight hybrid. Daihatsu believes that this hybrid vehicle can become cheaper than an EV.

1998 and Beyond--Four Scenarios

Following are four possible scenarios visualized by Maruo.

1. EVs will be introduced in 1998 and many people will buy them. Customers will be satisfied. In this case Ford and Chrysler will be the losers. They have only heavy vans. They have no chance to reach 2 percent of sales. They will be forced to buy credits or to pay penalties.

2. Customers will buy EVs at first but will be dissatisfied. They will cease to use EVs. They will then choose either conventional vehicles (LEVs or ULEVs, gasoline-powered or gas-powered) or hybrids. Daihatsu believes in this scenario. It depends on hybrids being accepted either as ZEVs or as less polluting than ULEVs.

3. EVs will not find many customers. No manufacturer will clear the 2 percent sales mandate. The California Air Resources Board must then present some kind of rescue plan.

4. EVs will find many customers, but customers will not buy EVs that are produced by the Big Three or by the Japanese manufacturers. They will buy EVs that are produced in many small factories.

The EV Revolution

Maruo's opinion is that the last scenario above is most probable. He sees an EV revolution being born.

The Japanese auto manufacturers are going to produce very good EVs that have everything a customer wants: air conditioning, power steering, power windows, heated seats, stereos, navigation systems, solar cells on the roof, etc. Their EVs will not be cheap.

GM may convert its Geo Prism into an EV. It may buy credits from small EV manufacturers to clear the 2 percent sales mandate. Ford and Chrysler have only heavy vans. They have never seriously attempted to develop EVs.

Many small venture EV firms in California and elsewhere are already selling thousands of simple EVs. These EVs are not sophisticated. However, the manufacturers and customers know each other. The Japanese auto manufacturers do not have this feel for their customers.

Intricate social networks are going to be woven around EVs. The Japanese are not a part of these networks, says Maruo. The Japanese want to sell their EVs to rich, educated, environmentally conscious, suburban dwelling middle-class Americans. The Japanese EVs therefore have everything that makes car driving comfortable, but this also means more expensive EVs. Maruo thinks the first EV customers will not be so affluent. They will not buy any luxurious EVs. The "EV revolution" will occur not because of any revolutionary new technologies to be introduced, but because of the ease of making EVs. In the ultimate outcome of such a revolution, the major automotive manufacturers may be reduced into only car body makers.

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COMPANY ACTIVITIES

EV AMERICA FINISHES VEHICLE EVALUATIONS

EV America is an electric utility-led program to accelerate the introduction of electric vehicles into the marketplace through the placement of as many as 5,000 electric vehicles into utility, commercial, government and transit fleets by the end of 1997.

EV America has three major goals: (1) demonstrate the reliability of today's technology; (2) show that there is a market for a vehicle with a 60-mile range; and (3) determine what is required to support electric vehicles.

Targets have been established for placing 500 vehicles in fleets by the end of 1995 and 5,000 by the end of 1997.

EV America developed a common set of specifications for battery-powered cars, vans and light-duty trucks. Vehicle specifications included requirements for warranties, federal safety certification and performance guarantees. In June, EV America invited eight qualified manufacturers to submit proposals to provide the electric vehicles for Phase I of the program. Five of the qualified manufacturers provided vehicles for testing in Phoenix, Arizona. The vehicles were evaluated through a series of tests, including acceleration, braking, road handling, range, cold weather performance and overall durability, against the EV America specifications.

BAT International, Chrysler Corporation, Solectria, Unique Mobility, and U.S. Electricar submitted nine compact pickups, sedans and minivans for the 30 day evaluation. Results of the evaluation were released in November.

Highlights of the test results include:

- Five of the vehicles achieved maximum speeds of 70 miles per hour or greater.

- Four of the vehicles achieved ranges of 70 miles or more at a constant speed of 45 miles per hour on the track.

- All of the vehicles showed stability during the braking test.

- A charge time of less than four hours was achieved by one of the vehicles at 208/240 volts.

- None of the vehicles were able to meet the acceleration goals stated in the EV America specifications.

- Several of the vehicles outperformed their gasoline-powered counterparts in the road-handling test.

Cold weather testing was completed in November. Vehicles were left plugged in for 12 hours in a room with an average temperature of 19 degrees and then run on a dynamometer to test the impact of exposure to cold weather. It was found that the vehicles with thermal management systems designed to address cold weather issues had only minor range reductions.

After completion of the tests, orders for a total of approximately 50 vehicles were placed with Solectria Corporation and U.S. Electricar. These vehicles will be used to conduct a series of on-road tests.

A total of 500 electric vehicles are planned for purchase by the consortium this year. After purchase of the 50 vehicles for continued field testing, the other 450 for utility use will be purchased later this year.

Access: EV America, phone 202 508 5016

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ZINC AIR POWER CORPORATION DEVELOPING ELECTRIC VEHICLE BATTERY

Recently renamed Zinc Air Power Corporation was incorporated in 1993 as DEMI Vehicle Systems, Inc. to develop and manufacture rechargeable zinc/air batteries based on the technology developed by Dreisbach Electromotive, Inc. (DEMI) of Santa Barbara, California. According to the company a car equipped with a prototype rechargeable zinc-air battery already has achieved a range of 250 miles. In addition, the company has increased the number of recharge cycles to a level which would result in a practical battery life of nearly 50,000 miles.

In addition to its long range and operating life, the rechargeable zinc/air battery is claimed to have several other important advantages compared to different types of batteries:

- Power drain is minimal when the battery is idle, so a vehicle can be driven after being left at the airport for 3 weeks.

- Unlike other batteries, zinc/air has no recharge "memory effect," so the battery can be restored to full capacity at any time without fully discharging first.

- The materials used in the battery are relatively inexpensive and environmentally benign.

- The battery performs through normal temperature ranges, so vehicles can be driven easily in winter or summer.

Zinc Air plans to unveil a prototype vehicle in 1995 to demonstrate a fully developed zinc/air battery in normal driving situations.

Zinc Air Power says that its battery is exceeding most mid-term industry targets (Table 1).

Access: Zinc Air Power, phone 313 454 5450

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UNIQUE MOBILITY PROVIDING MOTORS FOR CARS, TRUCKS AND BUSES

Unique Mobility, Inc. of Golden, Colorado is providing electric motors for a variety of EV applications.

The New York State Energy Research and Development Authority and Unique Mobility have announced that a natural gas-fueled hybrid-electric bus will be placed in demonstration service with selected Metropolitan Transportation Districts throughout New York State over a 6-month period beginning in the summer of 1995.

The bus to be demonstrated is an Orion II, built in original form by Bus Industries of America with Unique Mobility converting it to hybrid-electric drive. The bus design allows for a lower floor, due to the elimination of the rear-drive axle, which allows improved passenger access without an expensive hydraulic suspension. The hybrid-electric version uses regenerative braking to capture and recycle energy normally dissipated during braking.

Neoplan Hybrid Electric Buses

Unique Mobility and Neoplan USA Corporation have entered into a cooperative agreement to develop lightweight, hybrid-electric buses. A finished product is expected to be ready for testing by June 1995.

Neoplan USA is the Colorado-based licensee of Neoplan in Germany. The European company has already established itself as a builder of electric buses. There are Neoplan electric buses on Germany's Rugen Island as part of that ongoing EV experiment.

There are approximately 5,000 Neoplan buses currently in operation in the United States.

Neoplan in Europe has developed an all-composite bus body, made of carbon fiber.

TABLE 1

BATTERY PERFORMANCE COMPARED TO ABC GOALS

	Current Zinc-Air Battery R&D Results	U.S. Automotive Battery Consortium Mid-Term Criteria
Energy Density (wh/l)	250	135
Specific Energy (wh/kg)	130	100
Power Density (W/l)	300	250
Specific Power (W/kg)	140	150
Battery Life (miles @ 250/cycle)	50,000	100,000
Cost ($/kWh)	125-72	<150

Unique will install its natural gas hybrid drive system into the Neoplan bus.

Clean-Air Ranger Pickup

Unique Mobility has unveiled an electric-powered version of the Ford Ranger pickup. The conversion trucks will be assembled at the company's Golden engineering and research facility. They are to be powered by Unique's permanent magnet brushless motor, which has been installed in more than 100 vehicles throughout the world.

The truck has a range of 50-plus miles, a top speed of 73 mph and can accelerate from 0 to 60 mph in about 20 seconds.

Price of a single unit is $39,000.

Pininfarina Ethos Car

Unique Mobility and Pininfarina of Turin, Italy plan to collaborate on the design, development and manufacture of electric and hybrid-electric vehicles.

The plan is to present their designs to manufacturers to try to interest them in producing the vehicles for mass production.

The first project will be to install one of Unique's most recent electric drive systems in the Pininfarina Ethos 3EV prototype car. The Ethos project at Pininfarina has focused on developing a lightweight vehicle with recyclable composite body panels attached to an extruded aluminum space frame.

The Ethos vehicle is designed to carry up to six adults.

Access: Unique Mobility, phone 303 278 2002

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ELECTRIC FUEL CORPORATION WILL SUPPLY ZINC/AIR BATTERIES TO GERMAN POSTAL FLEET

Electric Fuel Corporation announced in December that the company has finalized with the Deutsche Bundespost Postdienst all of the necessary contractual arrangements to begin the previously announced German field test of its "refuelable" zinc/air battery system in more than 50 vans and light pickup trucks.

Partners in the field test, which has a total budget of $14.8 million, currently include Deutsche Bundespost Postdienst (the German Postal Service), its sister company Deutsche Bundespost Telekom, Mercedes Benz, Webasto AG and several German municipalities. Postdienst and Telekom have stated their intentions to equip up to 25,000 and 15,000 of their respective vehicles with the Electric Fuel technology upon successful completion of the field test.

According to the now-completed agreement, Electric Fuel will supply all of the test batteries, along with equipment for refueling and regeneration of the discharged batteries. Mercedes-Benz will supply 15 MB 410 vans, and Adam Opel AG has agreed in principle to supply up to 44 Corsa Combo light pickup trucks, subject to final contract negotiations. It is expected that electric motors and their controllers will be supplied by Siemens. The test program will be managed by Deutsche PostConsult GmbH, a Postdienst subsidiary, and supervised by TUV Bayern Sachsen, a German testing and standards institute.

In connection with the field test, the vehicles will be used in normal fleet operation by Postdienst, Telekom and the municipalities in the cities of Bremen, Koln, Hamm and Mainz. The batteries will be refueled using an automated battery refueling machine. Discharged Electric Fuel cassettes will be regenerated, (i.e., recharged and recycled) at a pilot regeneration plant planned to be built in Bremen by the company in conjunction with Hoechst AG and planned to be operated by Stadtwerke Bremen, the utility company of that city.

According to Electric Fuel, battery and vehicle production is planned to run through 1995, as is engineering and construction of the pilot plant for regeneration of the discharged battery anodes. In the spring and summer of 1995, the various system elements are expected to go through a run-in period, and full-scale operation of the test fleet is expected to run by the end of 1996.

With the battery's high energy density--over 200 watt-hours per kilogram--it is expected that these batteries will be able to deliver as much energy as the original fuel tank. Having this energy content, electric vehicles should, for the first time in history, be able to cover the same mileage in practical day-to-day fleet service as conventional vehicles.

Electric Fuel Corporation has corporate offices in New York City and manufacturing and research and development facilities in Jerusalem, Israel.

Electric Vehicle Covers 428 Miles on a Single Charge

Electric Fuel said in December that its zinc/air battery system had powered a 3.8-ton van a record distance of 428 miles on a single charge. At a constant speed of 40 mph, the vehicle ran for over 10 hours on a single charge while on a dynamometer.

The battery and vehicle package used in the test are the same size and design as that selected by the Deutsche Bundespost Postdienst for the upcoming field test.

Construction of Production Facility

In January 1995 Electric Fuel Corporation announced that it has begun construction of a $2 million dollar plant which will produce zinc/air battery packs and related components of its "Electric Fuel" system.

The new facility, located near its offices in Jerusalem, is scheduled for completion in the spring of 1995. The plant will produce both 80 kilowatt-hour and 160 kilowatt-hour batteries for use in the Opel and Mercedes vehicles participating in the Postdienst field test. In terms of energy content, these will be the largest EV batteries in production anywhere in the world.

When fully operational, the 20,000-square foot plant will have the capability to produce the equivalent of 60,000 kilowatt-hours of zinc cassettes and 20,000 kilowatt-hours of battery cells annually.

The Electric Fuel batteries operate on cassettes filled with zinc that must be replaced when all of the available zinc is oxidized. The use of the zinc in such a manner requires a facility to renew the used zinc and provide motorists with fresh cassettes.

Access: Electric Fuel, phone 212 230 2172

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SOLECTRIA UNVEILS PROTOTYPE OF MASS-PRODUCIBLE ALL-COMPOSITE EV

Solectria Corporation unveiled its Sunrise sedan at the 12th annual Electric Vehicle Symposium in Anaheim, California. The Sunrise is claimed to be the first mass-producible, all-composite electric vehicle to be manufactured in the United States. Solectria plans to have the Sunrise available during model-year 1997 and intends to sell the Sunrise for under $20,000 based on initial orders for 20,000 vehicles or more.

The Sunrise is a lightweight, ground-up, all-composite, four-passenger, full-size vehicle. It is powered by Solectria's AC induction drive system, incorporates an inductive charge port and an on-board 1.5 kilowatt inductive charger. The

Sunrise batteries are recharged with an inductive charging system developed by Hughes Power Control Systems.

Solectria's development of the Sunrise is an ongoing regional effort coordinated by the Northeast Alternative Vehicle Consortium with funding provided by the Advanced Research Projects Agency and the Boston Edison Company. Boston Edison holds the marketing rights to the Sunrise in the nine Northeast states and all markets foreign to the United States.

Solectria also offers two conversion vehicles, the Force sedan and the E-10 pickup. The Force has won the electric stock division of the Arizona Public Service Electric 500 in Phoenix, Arizona for the past 3 years. The E-10 holds the distance record for electric vehicles, traveling 831 miles in 24 hours.

Massachusetts Demonstration

As part of Phase I of the Massachusetts Electric Vehicle Demonstration Project launched last year, Solectria manufactured all 20 EVs for the first phase of the program. Twenty-five percent of the vehicles are powered by Saft nickel/cadmium batteries. These batteries are designed to be cold temperature resistant. At freezing temperatures, nickel/cadmium batteries lose only 5 percent of capacity, whereas lead/acid batteries have been known to lose 25 to 50 percent of their capacity.

Access: Solectria, phone 508 658 2231

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BANK OF AMERICA LAUNCHES PRIVATE EV SHUTTLE BUS

Bank of America has introduced into service an electric shuttle bus in downtown Los Angeles, California. The zero-emission vehicle replaces a diesel bus currently in service and will transport bank employees on a route that includes three downtown Bank of America facilities as well as Union Station.

According to U.S. Electricar, the manufacturer of the bus, the bank is the first private company in the United States to purchase and put into operation an electric-powered vehicle for its public road transportation fleet.

The electric shuttle bus was developed with the support of two cosponsors, the South Coast Air Quality Management District (SCAQMD) and the Los Angeles Department of Water and Power (DWP). The SCAQMD shared the cost of building the vehicle, and the DWP has provided the recharging site at the bank's downtown garage.

The vehicle is powered by 40 heavy-duty batteries delivering 120 volts to each of two motors. The bus can travel 35 miles before recharging, and carries a maximum of 22 passengers. Features include a solar-powered, ozone-safe air conditioning system.

Access: Bank of America, phone 213 228 3258

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RESEARCH AND TECHNOLOGY

VOLVO ASKS WHICH IS BETTER: THE EV OR THE HYBRID?

In a paper prepared for the 1994 International Congress on Transportation Electronics, held in Dearborn, Michigan in October, W. Mason and U. Kristiansson of Volvo Car Corporation explored the relative benefits between hybrid electric vehicles (HEVs) of the range-extender type and EVs. The two were compared for state-of-the-art and mature battery technologies. All comparisons were based on a specified performance demand, which included accelerations, hill-climbing and driving range. Battery mass, life and cost; vehicle mass; energy consumption and fuel economy; operating cost per mile for energy and the battery; and sales cost were determined and compared for each specific concept.

The authors note that the question of which gives greater benefit, HEVs or pure EVs, is a complex issue. The answer is dependent on the type of HEV, i.e. parallel versus series (and on what type of series HEV), and on the time-frame addressed.

The biggest stumbling block to satisfying customer expectations with EVs seems to always come down to inadequate battery technology, the main problems being energy storage and cost. Also, acceleration performance is very dependent upon the peak-power characteristics of the battery.

On the other hand, HEVs have the ability to complement any short-comings of battery technology. An on-board auxiliary power unit (APU), which fulfills emission regulations, can supplement both the energy storage and peak power in order to meet various performance demands. Of course, an on-board APU retains some of the unwanted characteristics of conventional powertrains; however, the degree of undesirability depends on the type of HEV concept chosen (parallel versus series), type of heat engine in the APU, size of the APU versus size of the battery, and the frequency and duration of operation of the APU. Also, the size of the battery and its combined cost with the APU might be competitive compared to the size and cost of the larger battery needed in an EV, and at the same time the HEV could provide customers with the user-friendliness they associate with conventional-powertrain vehicles.

Characterization of HEVs

For HEVs, it would be advantageous to match their range in the EV mode and their performance characteristics to the daily driving habits of the majority of customers. Most desirable would be a scenario where the HEV is plugged in at home and recharged at night, and driven back and forth to work and for miscellaneous errands during the day, all within the range of the EV mode.

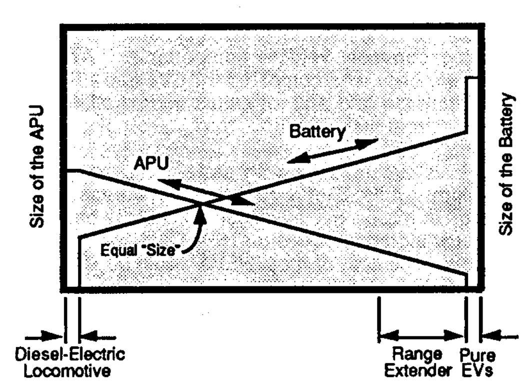
With adequate fuel-tank volume, the total HEV range (EV and HEV modes) might equal that of today's cars for less frequent occasions like business trips and vacations. As a result, customers would be able to use HEVs basically the same way as they use their present vehicles.

The relative size between the APU and the battery is an important design variable. If the battery is not large enough to supply the power needed to follow the road-load power requirement, the APU will have to provide the extra power. This is illustrated toward the left side of Figure 1. An extreme HEV of this type has no battery, e.g. a diesel-electric railroad locomotive. As the battery size increases toward the right side of Figure 1, the battery is able to supply more and more of the power needed to meet the road-load demand, and the APU becomes relatively small. When the battery has increased in size to the point where all performance demands can be met with power from the battery, the only remaining purpose of the APU is for recharging the batteries, and the HEV is called a range extender.

The difference between series and parallel HEV concepts is related to how the power from the

FIGURE 1

THE SPECTRUM OF HEVs



SOURCE: MASON & KRISTIANSSON

APU is transferred to the road. In a series HEV, the power from the APU can never be transmitted mechanically to the road; it is only the electric drive unit which can transmit power to the road. In a parallel HEV, the power from the APU can be transmitted mechanically to the road, i.e. both the APU and the electric drive unit can transmit propulsion power to the road, and there are a number of possible mechanical arrangements.

In a series HEV, the heat engine can operate over a very narrow range of speed and power, preferably selected so that the efficiency is highest.

Combined Operating Cost

Most of an HEV's driving would be done in the EV mode from the grid, since the primary purpose of the APU is to provide on-board-generated range for added "peace of mind" and security. So the combined cost per mile for energy and the battery was compared between EVs and HEVs in the EV mode from the grid. The combined cost is shown in Table 1. These numbers include the amortized capital cost of the batteries but not the APU.

If the cost of the battery for the HEVs is subtracted from that for the EVs, the resulting difference is shown in Table 2. For all of the state-of-the-art batteries (except worst-case NiMH), the cost of the battery in the EVs is much higher than that in the HEVs. There should be little doubt that such cost differences could more than cover the cost of an APU in the HEVs. For the mature battery technologies, the cost margin is less. For the Pb/PbO_2 and NiCd batteries, the margin is

TABLE 1

COMBINED COST PER MILE
(ELECTRICITY AND BATTERY)
FOR DRIVING IN THE EV MODE
($/Mile)

Battery	State-of-the-Art Worst-Case	State-of-the-Art Best-Case	Mature Solution
EVs			
Pb/PbO_2	0.341	0.101	0.045
Pb/PbO_2 (bipolar)	-	-	0.036
NiCd	0.491	0.137	0.046
NiMH	0.236	0.089	0.033
USABC Mid-term	-	-	0.097
USABC Long-term	-	-	0.043
HEVs			
Pb/PbO_2	0.186	0.070	0.035
Pb/PbO_2 (bipolar)	-	-	0.029
NiCd	0.268	0.113	0.038
NiMH	0.249	0.084	0.033
USABC Mid-term	-	-	0.097
USABC Long-term	-	-	0.044

TABLE 2

DIFFERENCE IN BATTERY COST BETWEEN EVs AND HEVs
(Dollars)

Battery	State-of-the-Art Worst-Case	State-of-the-Art Best-Case	Mature Solution
Pb/PbO_2	10,615	4,725	1,936
Pb/PbO_2 (bipolar)	-	-	2,716
NiCd	53,074	14,310	3,692
NiMH	(2,215)	8,856	773
USABC Mid-term	-	-	1,087
USABC Long-term	-	-	1,006

comparable to the cost of an APU; for the NiMH and USABC batteries, the margin may be insufficient to cover the cost of the APU.

Vehicle Mass

The mass of a state-of-the art, 5-passenger family car with two occupants is about 1,500 kilograms. The vehicle mass for EVs and HEVs with mature battery technologies are compared in Figure 2.

For the EVs, only the mature NiMH and USABC long-term battery technologies yield a total vehicle mass under 1,500 kilograms.

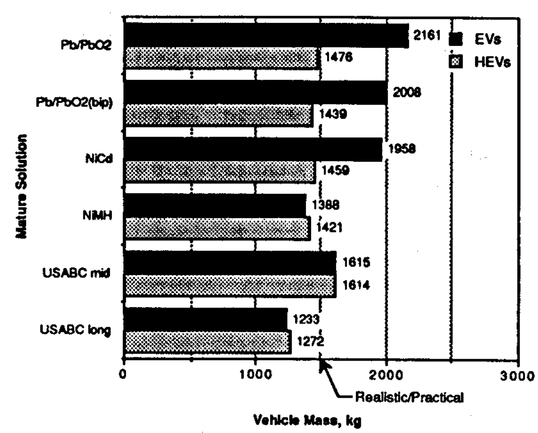
For the HEVs, many of the battery technologies give a total vehicle mass under 1,500 kilograms.

Conclusions

Mason and Kristiansson conclude that HEVs tend to make up for deficiencies in battery technology and are feasible with state-of-the art batteries; however, EVs would require heroic efforts in mass reduction. For advanced battery technologies, the energy storage needed for a total range of 150 miles is about the same for EVs and HEVs.

FIGURE 2

VEHICLE MASS FOR EVs AND HEVs WITH MATURE BATTERY TECHNOLOGIES



SOURCE: MASON & KRISTIANSSON

For several HEVs, the battery mass was power-determined, so the range demand for the EV mode from the grid, 60 miles, was exceeded--in some cases by a considerable margin. On the other hand, for all of the EVs, the battery mass was energy-determined, so the acceleration demands will be exceeded as long as the electric drive unit is capable.

An advantage for HEVs compared to EVs is that it might be possible to use the APU to supplement the power from the battery during periods of high power demand such as acceleration and hill climbing.

With increased fuel-tank volume, HEVs could easily exceed the assumed 150 mile range of EVs, and even match the range of conventional vehicles.

The sales cost of most HEVs would be less than that of EVs because the battery in an EV will cost more than the battery plus APU in a HEV.

EVs and HEVs operating in the EV mode from the utility grid are at least three times as efficient as HEVs operating from the APU. And when operating from the APU, series HEVs are twice as efficient as parallel HEVs.

For all battery technologies (except mature NiMH and USABC mid- and long-term), the operating cost per mile will be lower for HEVs compared to EVs. For the mature NiMH and the USABC mid-long-term batteries, the operating cost will be almost equal for EVs and HEVs.

Access: SAE Paper No. 94C017, phone 412 776 4841

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SAFETY CRITERIA FOR ELECTRIC VEHICLES LISTED

"Safety First" is the title of a paper prepared by B. Batson of Electric Vehicles of America and M. Beebe of EV Motor Sports for the Solar and Electric Vehicles Symposium organized by the Northeast Sustainable Energy Association and held in Providence, Rhode Island last fall. The paper lists a number of recommended practices for EV construction and operation.

Electrical System Recommendations

All control and power circuits should be fused near the source of power.

Two fuses should be considered based on "single failure" criteria.

The wire size should be adequate and must be automotive wire.

Wiring should be protected against mechanical damage.

The power system should not be grounded through the vehicle frame. This is unacceptable and unsafe for voltages greater than 24 volts.

Upon actuation by the key an indicator light should indicate that the power system is connected.

Opening any vehicle front door with the key in the "on" position should activate an audible alarm.

A contactor is recommended as an electrical disconnect. Circuit breakers are not designed or recommended for this service.

Flexible wire is recommended in place of solid buss bars for the battery interconnects.

All EVs require an auxiliary battery. This ensures operation of the warning flashers, brake lights, headlights, etc. if the converter fails.

If the regenerative braking system is actuated upon throttle release, the brake lights on the vehicle should be lit.

The wiring system in the vehicle should be protected from the effects of high humidity, salt and water spray.

The accelerator potbox should not be placed in a crush zone of the vehicle. This is to prevent the possibility of causing full power to the motor in a crash.

The power system should be automatically disconnected in the event of a crash.

The controller, motor, and other large components should be located such that they do not penetrate or significantly damage the passenger compartment in the event of a crash or roll-over.

Battery System Considerations

In a vehicle with flooded lead/acid batteries, contractors and other components that can create an arc should not be located above or near batteries where they might cause a hydrogen gas explosion.

In a vehicle with flooded lead/acid batteries, the battery box should be vented.

A warning signal should alarm or a fuel gauge should indicate when the battery is at minimum state of charge.

The batteries should be located in enclosed compartments designed to prevent any electrolyte leakage into the passenger compartment during a crash or roll-over event.

The batteries should be restrained inside the battery compartment sufficiently to prevent their leaving the compartment during a crash or roll-over event.

Conclusions

The authors conclude that safety is essential in any vehicle. We accept the explosive risk associated with gasoline vehicles because manufacturers have designed the vehicle to minimize the risk and everyone is aware of the risk. Similarly, everyone should be aware of the risk of electrical shock in an EV.

Individuals, conversion shops, and manufacturers should design their vehicles to minimize the risk. They should also inform and educate the EV user about the risk and how to identify an unsafe condition. Just as it is the responsibility of a gasoline vehicle's owner to understand that a gasoline leak is a hazard, the EV owner must be aware of corresponding hazards in an EV and the appropriate actions to take.

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MARKET DATA

NUMBER OF ELECTRIC VEHICLES IN U.S. EXCEEDS 2,000

As a result of the first major national-level effort to determine the number of electric vehicles currently operating in the United States, the Electric Vehicle Association of the Americas (EVAA) announced that the number of EVs on United States roads is between 2,075 and 2,376. The range reported by EVAA does not include "neighborhood," non-highway-capable EVs, off-road EVs, or EVs under development but not yet operating.

In arriving at its estimate, EVAA surveyed by telephone and facsimile a number of original equipment manufactures, EV converters and upfitters, and bus manufacturers, as well as hobbyist organizations. The association found that 316 OEM vehicles are operating in the United States and include EVs from Chrysler Corporation, Ford Motor Company, General Motors Corporation and American Honda Motor Company. In addition, EVAA determined that the number of converted vehicles assembled by conversion companies is 794, while the number of EVs hand-built or purchased by hobbyists ranges as high as 693.

EVAA also identified 58 electric buses operating in the United States, with another 60 buses under development nationwide. Of the 58 buses extant, 20 are transit coaches and 6 are school buses.

Finally, EVAA attempted to assess the number of EVs built before 1990 and still operating. Assuming a 10 percent survival rate for these older vehicles, the association estimates 390 to 515 pre-1990 EVs.

The EVAA survey also revealed that California, Arizona, Michigan, New York and Washington are the five most EV-populated states.

Access: EVAA, phone 415 249 2690

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VEHICLES

ZURICH HYBRID CAR FIELD TRIAL CALLED A SUCCESS

From 1991 to 1993 a field trial with 20 Volkswagen Golf II hybrid (parallel) vehicles was conducted in the town of Zurich and its surroundings. Results of this trial were reviewed by M. Eberle of the Swiss Federal Institute of Technology for the 12th International Electric Vehicle Symposium, held in Anaheim, California in December.

The internal combustion engine was of the diesel type with swirl chamber, turbocharged and further equipped with an oxidizing catalyst. The electric part of the drive train was jointly developed between Volkswagen AG and Bosch GmbH.

The 20 vehicles were equipped with three different battery types (Table 1).

The diesel engine is started by the electric motor which is part of the flywheel. Operating in the diesel mode, one can use the inertia of the flywheel to restart the diesel, which is stopped whenever the accelerator pedal is not pressed down. In this way one can save fuel.

Fleet Energy Consumption

Figure 1 shows the energy consumption data of the 20 vehicles. The fuel consumption figures are approximately the same whereas there are great differences in electricity consumption data. Particularly, the Na-S batteries produce very poor results. This battery type has to be kept at a temperature of around 300°C with the consequence of heating losses during times the battery is not

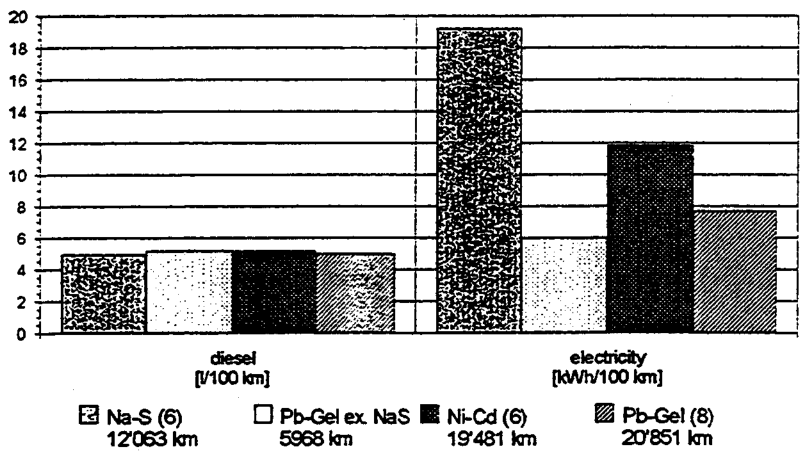
TABLE 1

BATTERY TYPES IN THE VOLKSWAGEN HYBRID

Battery		lead/gel	Ni/Cd	Na/S
Voltage	V	72	72	72
Capacity	Ah	50	55	100
Mass	kg	198	120	110
Recharging Time	h	5	5	8
Operating Distance	km ca.	20	22	40
Cost (1991)	DM	3,000	16,000	27,000

FIGURE 1

FLEET ENERGY CONSUMPTION



SOURCE: EBERLE

in use. These losses amount to some 100 watts. The bigger the relative time the battery is not used, the higher the losses.

Failure Statistics

During two years, all failures were recorded. The results are shown in Figure 2. In principle, these data are quite good considering the fact that all these vehicles were "hand made." Predominantly, mechanical failures related to the couplings showed up. Furthermore, the battery chargers, including transformers, were trouble spots. Amazingly enough, the Pb-gel batteries were not too reliable. The Ni-Cd batteries showed the best results whereas the Na-S batteries performed poorly.

Reactions of Customers

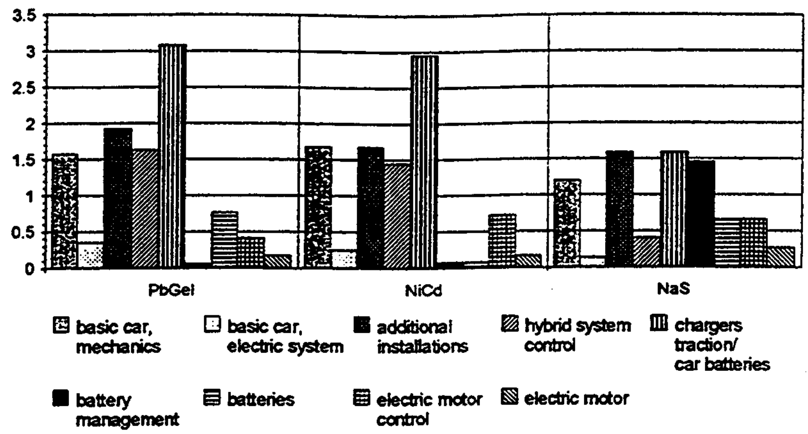
Generally speaking, says Eberle, the customers (drivers) were happy; the acceptance by other drivers and pedestrians was good. Everybody was able to adjust readily to the somewhat different vehicle. However, the automatic coupling combined with the manual shift proved to be somewhat irritating. Fine tuning of the whole shifting procedure is needed. The vehicle, because of its weight, requires power steering.

The winter heating capacity was considered to be insufficient. Furthermore, the electric power as well as the electric range was too small. With a vehicle weight of nearly 1,200 kilograms an electric power of a minimum of 10 kilowatts would be required, in comparison to the 7 kilowatts available. Concerning battery power, the Na-S battery was inferior compared to the other batteries because of its high internal resistance (overheating).

The very silent operation in the electric mode was considered to be dangerous.

FIGURE 2

FAILURE STATISTICS



SOURCE: EBERLE

Conclusions

According to Eberle, the hybrid car field trial in Zurich was a success. Disregarding some problems encountered at the beginning, the vehicle performed very well. Emissions and diesel fuel consumption, measured using the FTP 75, the ECE-R15, and the inner city-cycle were cut in half, compared to conventional vehicles, with an additional electricity consumption of 9 to 19 kilowatt hours per 100 kilometers.

If one wants to drive locally with zero emissions, only the hybrid technology--so far--allows for a vehicle which is fully usable with high customer value. If there is not a problem with high local air pollution, the overall preferred solution would be a light-weight vehicle with internal combustion engine fulfilling the ULEV emission standard.

Access: EVAA, phone 415 249 2609

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FIRST 10 EVs IN PROGRAM 1000 NOW RUNNING IN GOTEBORG

The City of Goteborg, Sweden has started its Program 1000, with a target of 1,000 electric or hybrid vehicles. The so-called Start Project within the Program 1000, was presented by S. Liljemark of the Goteborg Traffic and Transit Authority, at the 12th International Electric Vehicle Symposium, held in Anaheim, California in December.

The cars in the Start Project--10 light vans--are all equipped with high performance batteries, and comprise the largest fleet of its kind in Sweden so far. The EVs mainly serve commercial users and run on a leasing basis.

A following project phase is being formed. The new phase will include more EVs, mainly passenger cars. The project will be an important part of a new national 4-year demonstration program for EVs and hybrid vehicles.

The Action Program for EV Introduction in Goteborg

Within the activities to reach the targets of "Program 1000," the main project to date is "Project 200," a cooperation project between the City of Goteborg, the car manufacturer Volvo, and the energy companies Vattenfall and Goteborg Energi. The Swedish state has joined the project to take part in the financing, through the national board for industrial and technical development, NUTEK.

The Start Project is the first part of Project 200.

The general objectives of Project 200 are to, prior to the year 1998, demonstrate the usefulness of the EV so that by the end of the decade it is probable that EVs can and will compete with other alternatives.

The budget for the Start Project is SEK9.45 million or US$1.25 million.

The Start Project comprises 10 electrically propelled light distribution vans, delivered by Volvo and manufactured by Renault of the model Renault Express Electrique 94. They are equipped with NiCd traction batteries which approximately double the performance, compared to EVs previously tested in Goteborg.

The vehicle capital cost is reduced by the project. Approximately 50 percent of the real price of the electric car, including the battery, is initially paid by the project partners. Still, the remaining price (SEK150,000 = US$19,480) to be paid by the user, is higher than the price of a conventional car.

The Renault vehicles used in the project are all equipped with an onboard charger with a maximum power of 4.5 kilowatts, to be connected to a single-phase socket with a 32 A fuse, 230 volts. Because these sockets are not very common in Sweden, a suitable socket has been installed at the home base of each car.

A specially designed charging station has been built in the city center, placed at a public parking site situated at the middle of the most well-known street of Goteborg.

The Electric Vehicles

Liljemark notes a positive trend in the development of EVs, technically and economically. During recent years Goteborg has owned a number and tested a variety of EVs. The Renault Express Electric (NiCd) offers payload, range and acceleration that significantly exceeds that of the Volkswagen CitySTROMer tested only 2 years ago, and at a similar price even though the Renault battery costs up to 5 times more than the lead/acid battery of the CitySTROMer.

The Start Project has proved that a willingness exists to pay a significant extra cost for an EV, but it does not reach the full price of the EV. It is not likely that the acceptable price will rise. To get the prices down, the market must grow, and must get help to do it. Goteborg is assisting.

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FIAT CINQUECENTO BUYERS CAN NOW CHOOSE ELECTRIC ENGINE

According to Fiat USA Inc., the new Fiat Cinquecento is the first car in the history of the automotive industry to be launched with a choice between a conventional power unit, available with catalytic converter, and an electric engine. This is believed to be a unique offer, and that no other manufacturer has adopted a similar strategy before.

The Fiat Cinquecento Elettra

This electrically propelled version was designed and built for use primarily in big cities where its environmental advantages are most desirable. The power unit, consisting of a 9.2 kilowatt (12.5 brake horsepower) electric motor controlled by an 18 kilohertz solid-state chopper and a five-speed gearbox, is designed to run on two alternative energy supply systems. These are respectively:

- A pack of 12 6V lead/gel recombination batteries weighing 350 kilograms
- A pack of 12 6V nickel/cadmium batteries weighing 270 kilograms

Lead/Gel Batteries

The recombination batteries used on the Cinquecento do not need any type of maintenance. During recharging, they produce very small amounts of hydrogen and thus they can be recharged in a closed garage without danger.

They last for about 600 discharge/recharge cycles.

Nickel/Cadmium Batteries

Though these have the same volume as lead batteries, they offer greater specific energy and weigh much less (about 25 percent). The combined effect of these two properties gives the vehicle much greater range (about 50 percent more). On average they last more than twice as long as lead batteries (about 2,000 discharge/recharge cycles) and this counterbalances the significantly higher cost.

Elettra Specifications

The electrically propelled Cinquecento can carry two people and a load up to 150 kilograms.

The battery charger is located inside the front engine bay and runs off alternating current from household (European) 220-volt mains. The batteries take 8 hours to recharge fully.

The special tires used on the Cinquecento Elettra have low rolling resistance.

A small gasoline burner supplies warm air to the heater.

The Cinquecento Elettra can reach 80 kilometers per hour if fitted with a lead/gel battery and 85 kilometers per hour with a nickel-cadmium battery.

The Fiat Zic

Fiat, which put its first electric car (the Panda Elettra) on sale in 1990, has also added the Zic to its electric auto line. The 10.6-foot-long Zic weighs just 1,892 pounds, batteries included. It accelerates from 0 to 60 mph in about 14 seconds, has a top speed of 62 mph and covers 100 miles at top speed or 143 miles at 30 mph.

Access: Fiat, phone 212 207 0947

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AUSTRIAN FLEET TEST WITH 150 EVs COMPLETED

Since 1992 EVs have been supported in Austria by lowering the value added tax to 10 percent, abolishing the motor vehicle tax and insurance tax, and by additional promotion of ATS10,000 (about US$800) per vehicle. Accompanied with these incentives a monitoring program was carried out, which was finished in 1994. An overview of the results was given by W. Streicher of Graz University of Technology at the 12th International Electric Vehicle Symposium held in Anaheim, California in December.

The monitoring program was carried out by ARGE Warmetechnik, the Austrian Road Safety Board, and two traffic researchers. The aim was to find out whether EVs available today can be used satisfactorily in normal traffic by private and commercial users, what technical or infrastructural problems occur and what has to be done to achieve a wider market for EVs.

Most of the Austrians questioned know about EVs. Only 4 percent stated that they had not heard anything about them. About 70 percent have seen them on television, and 42 percent of the men and 27 percent of the women have seen them already on the road. The most important parameters listed by the 2,000 people questioned are safety, environmental benefit, energy demand and handling. Of very little importance seems to be maximum speed, design and outfit. EVs therefore do not have to have very good driving performances but must have low energy consumption and should be as comfortable and reliable as other vehicles.

A discrepancy occurs when questions are posed about necessary improvements to buy an EV again. More than 80 percent of all owners of EVs stated that there must be technical improvements. Most often the small range (less than 50 kilometers, often only 20 kilometers in wintertime), better price/performance ratio and higher reliability are given as reasons. Safety, space in the car, infrastructure and maximum speed were said to be sufficient.

The EV with the highest market share of 78 percent is, like all over Europe, the one-seated City-el from Denmark. About 10 percent were small two-seaters with purpose designed bodies like Kewet (Denmark), Puli City (Hungary, Switzerland) or Microcar (France). The rest were converted conventional cars like the Fiat Panda Elettra or Nissan Micra. Three of the EVs investigated were converted by their owners.

The 40 kilometer per hour version of the one-seated City-el can be driven in Austria without a drivers license. Therefore it is of interest for people who normally do not drive any car or drive some drivers-license-free three-wheel micro car with a gasoline or diesel engine (these very small cars are relatively uncomfortable and even more expensive than the City-el). About 60 percent of all City-el owners do not have a drivers license.

Maximum Range

The maximum range of the EVs corresponded very well to the manufacturers' data (see Figure 1). Of course one must note that the maximum range can only be achieved with new batteries in summer (high outside temperature) and with low speed and "smooth" driving. In winter the range can drop significantly due to a decreasing performance of the batteries with decreasing ambient temperature.

Energy Consumption

The energy consumption was higher than predicted by EV sellers. This is mostly not the fault of the manufacturers, says Streicher, but can be explained with a fundamental difference in the total energy demand for EV operation compared to conventional cars. When EVs are not used for driving, they are normally plugged in to the grid. The charging time varies between hours and many days. In the described project, 13 percent of all charges lasted longer than one day and 8 percent longer than two days. More than 60 percent of the charges were longer than the 8 hours that are needed for full recharging of a battery. Figure 2 (page 179) shows the distribution of charging times recorded. The batteries need not only energy to be recharged, but when fully charged, also need energy to compensate their self-discharge (this is about 1 percent of the total capacity per day for lead/acid batteries).

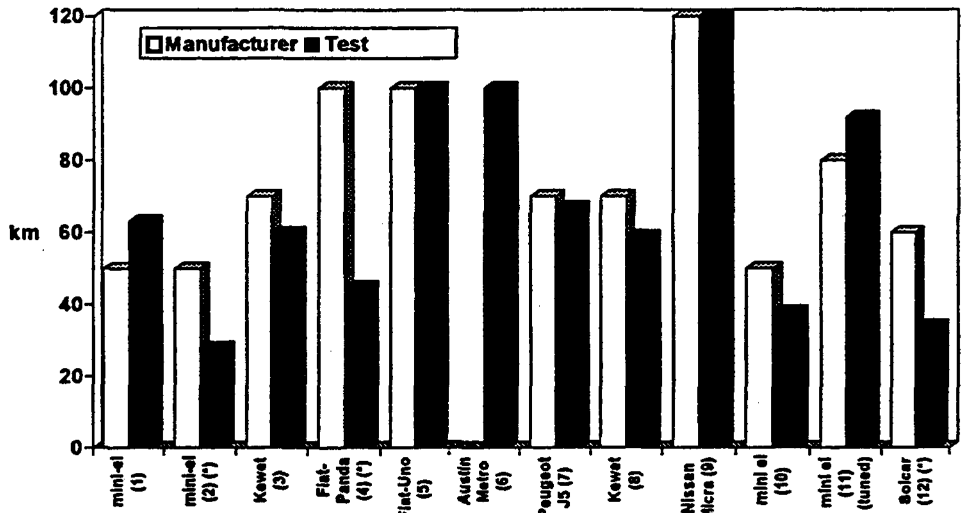
The battery charger itself also has an energy demand when in operation. When the City-el is being charged for two days, the charger itself needs the same amount of energy as can be put into the battery when being fully discharged. Thus, the energy demand of an EV is not only dependent on the weight of the vehicle and the driving characteristic of its owner but also, to a high degree, on the efficiency of the battery charger.

Malfunctions and Costs of Today's EVs

The running/repair costs of the EVs was generally very high. The lifetime of the batteries was less than predicted by the battery manufacturers. This is partly due to battery chargers and motor controls that do not take care of the bat-

FIGURE 1

MAXIMUM RANGE ACHIEVED DURING THE TEST COMPARED TO MANUFACTURERS DATA



(*) Maximum range not tested

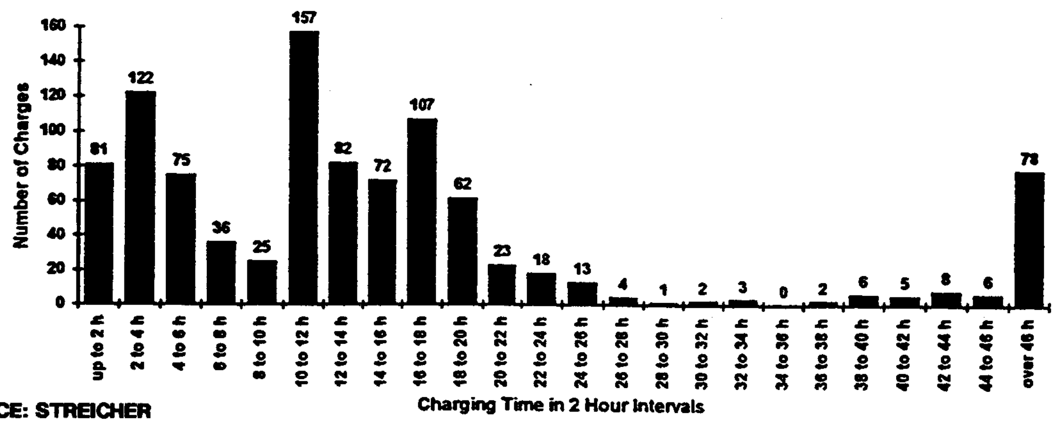
SOURCE: STREICHER

teries. During the project described, the costs of renewing the battery varied between zero and about US$1.10 per kilometer. Of course a monitoring time of 10 months and only 12 vehicles is too small of a sample to give exact results but it can be stated that the battery lifetime should be increased in any case.

Access: EVAA, phone 415 249 2609

FIGURE 2

DISTRIBUTION OF THE CHARGING TIME FOR ALL TESTED VEHICLES



SOURCE: STREICHER

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GLOSSARY

A/F	Air to fuel ratio
AFV	Alternative fuel vehicle
ASTM	American Society for Testing and Materials
ATDC	After top dead center
BCF	Billion cubic feet
BHP	Brake horsepower
BPD	Barrels per day
bsfc	Brake specific fuel consumption
BTDC	Before top dead center
BTU	British thermal unit
BTX	Benzene, toluene, xylene
CA	Crank angle
CAFE	Corporate average fuel economy
CARB	California Air Resources Board
cc	Cubic centimeter
CEC	California Energy Commission
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CV	Conventional vehicle
DCF	Discounted cash flow
DCFROI	Discounted cash flow return on investment
DDGS	Distillers dried grain and solubles
DI	Direct injection
DOE	Department of Energy
DOT	Department of Transportation
E10	10 percent ethanol, 90 percent gasoline (referred to as gasohol)
E85	Mixture of 85 percent ethanol, 15 percent gasoline
E95	Mixture of 95 percent ethanol, 5 percent gasoline (or water)
E100	100 percent ethanol
EC	European Commission, also European Community
EEC	European Economic Community
EFI	Electronic fuel injection
EGR	Exhaust gas recirculation
EIA	Energy Information Administration
EPA	Environmental Protection Agency
ETBE	Ethyl tertiary butyl ether
EU	European Union
EV	Electric vehicle
FERC	Federal Energy Regulatory Commission
FFV	Flexible fuel vehicle
FOB	Free on board
FTP	Federal test procedure
FSU	Former Soviet Union
GAO	General Accounting Office
GDP	Gross domestic product
GGE	Gasoline gallon equivalent (defined as 5.6 lbs CH_4 by NCWM
GH_2	Gaseous hydrogen
GJ	Gigajoules (10^9 joules)
GNP	Gross national product

gpm	Grams per mile
GVW	Gross vehicle weight
GVWR	Gross vehicle weight rating
GWI	Global warming index
HC	Hydrocarbon compounds (emissions)
H/C	Hydrogen to carbon ratio
HDV	Heavy-duty vehicle
HHV	Higher heating value
HOV	High Occupany Vehicle
hp	Horsepower
HV	Hybrid vehicle
IC	Internal combustion
ICE	Internal combustion engine
IEA	International Energy Agency
I/M	Inspection and maintenance
ISO	International Standards Organization
kPa	Kilopascal
kph	Kilometers per hour
kWh	Kilowatt-hour
LDV	Light duty vehicle
LEV	Low emission vehicle
LHV	Lower heating value
LH_2	Liquid hydrogen
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
M85	Mixture of 85 percent methanol, 15 percent gasoline
M100	100 percent methanol
MCF	Thousand cubic feet
MMBTU	Million BTU
MON	Octane number, motor method
MPa	Megapascal
mpg	Miles per gallon
mph	Miles per hour
MTBE	Methyl tertiary butyl ether
MW	Megawatt
NAAQS	National ambient air quality standards
NASA	National Aeronautics and Space Administration
NCWM	National Conference on Weights and Measurements
NGL	Natural gas liquids
NGV	Natural gas vehicle
NHTSA	National Highway Traffic Safety Administration
NMHC	Non-methane hydrocarbons (does not include alcohols)
NMOC	Non-methane organic compounds (includes alcohols, not CH_4 or CO)
NMOG	Non-methane organic gases (includes alcohols, not CH_4 or CO)
NO_x	Nitrogen oxides
NPGA	National Propane Gas Association
O_3	Ozone
OECD	Organization for Economic Cooperation and Development

OEM	Original equipment manufacturer
OMHCE	Organic material hydrocarbon equivalent (includes methane, not oxygen)
O&M	Operating and maintenance
PEM	Proton exchange membrane
PEMFC	Proton exchange membrane fuel cell
PJ	Petajoules (10^{15} joules)
PM	Particulate matter
PM_{10}	Particulate matter less than 10 microns diameter
psi	Pounds per square inch
psia	Pounds per square inch, absolute
ppb	Parts per billion
ppm	Parts per million
ppmv	Parts per million volume
PV	Photovoltaic
quad	Quadrillion (10^{15}) BTU
RAF	Reactivity Adjustment Factor
R&D	Research and development
RD&D	Research, design & development
RFG	Reformulated gasoline
RLM	Refrigerated liquid methane
(R+M)/2	Octane number, average
ROG	Reactive organic gas (VOC other than CO, CH_4 etc.)
RON	Octane number, research method
rpm	Revolutions per minute
RVP	Reid vapor pressure
SAE	Society of Automotive Engineers
SCAQMD	South Coast Air Quality Management District
scf	Standard cubic feet
SI	Spark ignition
SIP	State Implementation Plan
TAEE	Tertiary amyl ethyl ether
TAME	Tertiary amyl methyl ether
TBA	Tertiary butyl alcohol
TCF	Trillion cubic feet
TDC	Top dead center
THC	Total hydrocarbons
TLEV	Transitional low emission vehicle
TOG	Total organic gases
TW	Terawatt (10^{12} watts)
TWC	Three-way catalyst
ULEV	Ultra-low emission vehicle
UMTA	Urban Mass Transportation Administration
UN	United Nations
USDA	United States Department of Agriculture
VFV	Variable fuel vehicle
VMT	Vehicle miles traveled
VOC	Volatile organic compound (may or may not include CO)
ZEV	Zero emission vehicle