# ALTERNATIVE FUELS AND US AUTOMOBILE MANUFACTURERS

Field Study Series on Environment and Industrial Competitiveness

*Office of Policy, Planning and Evaluation*

US Environmental Protection Agency

**prepared by**
**The Management Institute for Environment and Business**
**1220 Sixteenth Street, NW**
**Washington, DC 20036**
**(202) 833-6556**

## DISCLAIMER

Although prepared with EPA funding, this report has neither been reviewed nor approved by the U.S. Environmental Protection Agency for publication as an EPA report. The contents do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

**ALTERNATIVE FUELS AND US AUTOMOBILE MANUFACTURERS**

TABLE OF CONTENTS


| | *PAGE* |
|---|---|
| Abstract | 1-2 |
| 1. Alternative Fuels Technology Development | 2-14 |
| A. Reformulated Fuels | 2-5 |
| B. Flexible-Fuels Vehicles | 5-7 |
| C. Natural Gas Vehicles | 8-10 |
| D. Electric Vehicles | 10-14 |
| 2. Driving Forces in Alternative Fuels Vehicle Development | 14-18 |
| A. Legislation | 14-16 |
| B. Consumer Demand | 16-17 |
| C. International Markets | 17-18 |
| 3. Importance of Alternative Fuels Vehicles to Corporate Strategy | 18-19 |
| 4. Global Considerations | 19-20 |
| Appendix A: Federal and State Provisions Relating to Alternative Fuels Vehicles | 21-24 |

**THE MANAGEMENT INSTITUTE FOR ENVIRONMENT AND BUSINESS**

---

*This note was prepared by the Management Institute for Environment and Business, 1220 16th Street, NW, Washington DC 20036.*

---

## ALTERNATIVE FUELS AND US AUTOMOBILE MANUFACI'URERS

As of 1987, mobile sources of air pollution accounted for between twenty and seventy percent of emissions in the U.S., depending upon the pollutant. Although there has been a significant reduction in both the absolute amount and percentage share of mobile air emissions since the Clean Air Act of 1977, mobile emissions are still a primary concern of regulators, industry and the consuming public. The increasing emphasis placed by these stakeholders on alternative fuels and the vehicles that they power is quickly outpacing vehicle size and efficiency of combustion as the most promising source of mobile emission reductions. The appearance of alternative fuel and alternative vehicle requirements in state and federal regulation, the rise in related corporate research and development expenditures, and the recent appearance of alternative vehicles in the marketplace, collectively indicate a long-term trend which may be the most significant single issue facing the automotive industry in the next two decades.

Although alternative fuel technologies have been a minor dalliance of petroleum and automobile manufacturers (hereafter called "manufacturers") for more than a decade, the technologies have never been developed to full maturity. Hence, the current trend is marked by comprehensive research and development by all industrial players, with no single technology emerging as the best, cheapest, most environmentally benign, or most predominant. The fuels that are the current focus in the U.S. include reformulated gasolines, methanol/ethanol blends, compressed natural gas and electricity. Japanese manufacturers are focusing on electricity, the Europeans on electricity and hydrogen.

Thus far in the rapidly developing technology race, there are no clear sources of competitive advantage. It remains uncertain whether first-movers will derive any advantage through "learning-curve" effects or by ensuring the presence of their technology in regulatory standards. The market for alternative fuels is currently fairly small, but its growth could be

dramatic. Markets overseas appear to be developing more quickly than in the U.S.,though that may be altered through rigorous state regulation.

This inquiry will examine the development of alternative fuels technologies by US automobile manufacturers in order to suggest answers to three overriding questions:

- What are the characteristics of the US technology developments?
- What are the factors influencing these programs?
- How important are alternative fuels development programs to US manufacturers as a business strategy?

Early indications suggest that although these efforts remain somewhat external to each manufacturer's corporate strategy, they are becoming increasingly important to manufacturers' long-term strategies and market success.

## 1. Alternative Fuels Technology Development

The three US manufacturers are each undertaking parallel efforts in technology development and in marketing to test audiences. First, they are examining a number of fuels and producing vehicles for each fuel. Due to the somewhat premature state of technological development, it is unclear which fuels and vehicles will emerge as the dominant market technology, nor does legislation mandate the use of a particular fuel. Cautious industry analysts believe that each new technology will find a niche in the passenger ear or truck market. Furthermore, the relative state of technological advancement at the different manufacturers may change the emphasis given to each individual program, but clearly all programs are being supported. Second, in the initial production phase, manufacturers are targeting government and private fleets as the initial markets and testing grounds for alternative fuels vehicles. They pose that success and exposure in fleet application will trigger public interest and demand. Manufacturers feel that both methods are essential if they are to develop superior alternative fuels vehicles in an economically-attractive way.

### A. Reformulated Gasolines

#### *A.1 Technology*

Reformulated gasolines are simply cleaner substitutes for unleaded gasoline that can be used in conventional vehicles. Oil refiners have typically reformulated blends of their commercial gasolines for different climates, seasons, and elevations in order to maximize performance. The new movement toward reformulated fuels has been mounted by both refiners and manufacturers to ensure that reformulation programs target environmental performance as their primary goal.

Any gasoline with a different content from conventional gasoline that results in lower comprehensive, or wrap around, emissions levels can be considered a reformulate.[1] Emissions reductions result from reduced volatility of fuels and improved fuel combustion, in the engine chamber. Refiners can accomplish these objectives by limiting fuel volatility, formulating hydrocarbons that are less complex and therefore easier to bum, using oxygenates to raise oxygen levels which produces a cleaner burn, and adding better deposit-control additives which limit engine and valve deposits. Reformulated blends are then created by adding ingredients such as ethanol, methyl tertiary butyl ether (MTBE) and methanol. Manufacturers have been actively involved in these programs in order to prescribe the qualities they would like to see in the blends and to road-test the blends in a variety of vehicles.

### *A.2 Environmental Performance*

Although unconvinced that reformulated fuels will produce the very best emissions performance, EPA and the California Air Resources Board (CARB) have both supported the introduction of reformulated fuels. Testing has shown that reformulated fuels used in conjunction with an advanced electrically heated catalytic converter have yielded better emissions levels than methanol, ethanol, propane and even natural gas.[2] ARCO has emerged as the leader in reformulated fuels, and has released the following data regarding emission performance:[3]

- Exhaust hydrocarbons reduced by 21%
- Evaporative hydrocarbons reduced by 36%
- Carbon monoxide reduced by 28%

Although these reductions are modest, the hydrocarbons emitted in the exhaust are less reactive than gasoline hydrocarbons, and therefore are less likely to form ozone. Therefore, net reductions of the constituents of ozone does not fully determine the whole picture--the reactivity of emissions must also be examined.

Currently, most mobile source emissions accrue from older cars without catalytic converters. As new blends are being developed, fuel analysts project that emissions will continue to drop even for these older cars.

---

1. Wrap around emissions are comprised of three elements: tailpipe exhaust; refueling losses which occur during normal refueling operations; evaporative losses which occur during the normal operations of any vehicle as a function of fuel volatility.

2. Jack Keebler, "New Recipe," *Automotive News,* November 4, 1991, p. 3, 42.

3. "ARCO Introduces Reformulated Premium," *The Energy Daily,* September 14th, 1990. Note, the reductions are relative to standards performance of the same vehicles using conventional unleaded gasoline.

### *A.3 Economic Performance*

Currently oil company officials are trying to determine how much consumers are willing to pay for cleaner fuels. Although it is commonly assumed that the price premium per gallon will be between 5-10 cents, a combination of factors may push prices up even further. First, the capital investment required to produce reformulated fuels may be significantly prohibitive driving some oil companies out of the market. Second, the additional costs of fuel additives such as ethanol, MTBE and methanol may keep prices high. Third, the limited size of the market could eliminate economies of scale in production, which would keep costs high. Although companies may artificially hold prices down in order to influence consumer purchases, the long-term price will be higher than gasoline. ARCO estimates that its reformulated fuels will cost 15 to 20 cents more to produce whereas an SRI study estimates that the additional costs will rise to 32 cents by 2010.[4] Such premiums may prohibit widespread purchase of reformulated gasoline.

### *A.4 Relationship to Current Regulation*

Although price may inhibit widespread demand, supply is rapidly becoming guaranteed in metropolitan nonattainment areas and California. Currently, the CAA amendments of 1990 require reformulated gasoline for the nine most severe nonattainment areas nationwide beginning in 1995. Under this provision and if the program is successful, 13 other severe nonattainment areas will likely be required to make reformulated gasoline available. Under California legislation, reformulated fuels are required for sale throughout the state beginning in 1996. Other states have also opted to adopt the California program. Hence, if these regulations are fully implemented, reformulated fuels will become available throughout the country by the mid-1990s.

### *A.5 Industry Initiatives on Reformulated Fuels*

Although reformulated fuel production and sale is managed by oil companies, manufacturers have worked in conjunction with oil companies to make reformulated fuels a valid and effective means of reducing mobile source emissions. The Auto/Oil Air Quality Improvement Research Program represents a major undertaking by GM, Ford, Chrysler and 14 oil companies to investigate reformulated fuels. Joe Colucci, head of GM's fuels and lubricants department and now co-chairman of the auto/oil consortium's task force, initiated the program in order derive a common set of emissions figures for reformulated fuel blends.

US manufacturers have been interested in this program for three reasons. First, if changes in fuel blends can yield reduced emissions, manufacturers would not have to alter current conventional vehicle designs. Second, changes in fuel blends can help shift the burden of

---

4. SRI International, "1991 Oil Report, Chapter 13: Motor Vehicle Fuels of the Future," in "Alternative auto fuels pose cost or technical challenge, Oil and Gas Journal, December 9th, 1991, p. 59.

emissions compliance to oil refiners.[5] Third, according to Chevron's Auto/Oil Task Force Representative Mike Ingum, anticipation of upcoming regulation has catalyzed the movement. Manufacturers from the task force continue to provide critical data to EPA and CARB through extensive on-road testing of different fuel blends at GM and Ford testing facilities.

Currently, eight oil companies have offered nine reformulated fuels on the market. The pilot introduction area is the Los Angeles Basin, although oil companies are beginning to introduce these products in some of the eight other required cities. Reformulated fuels will arrive in other nonattainment areas and throughout California by the mid-1990s.

## B. Flexible-Fuel Vehicles and Methanol

### *B.1 Technology*

Flexible-Fuel Vehicles (FFVs) or Variable Fuel Vehicles (VFVs) allow the use of a variety of different fuels and fuel blends-conventional gasoline, reformulated fuel blends, some ethanol blends and methanol blends.[6] FFV determine what fuel mixture is entering the engine chamber and automatically adjust the engine cycle to maximize vehicle and emissions performance. Special materials, such as ceramic or stainless steel, are required to help counteract the corrosiveness of methanol.

### *B.2 Environmental Performance*

Currently, there is great debate over the potential emission performance of alcohol blends, such as methanol and ethanol. Initial reports indicated that methanol reduces emissions of three criteria pollutants--carbon monoxide, oxides of nitrogen and hydrocarbons. One major advantage of methanol emissions is that exhaust and evaporative emissions are less photochemically reactive, which reduces their ozone forming potential. However, recent studies have questioned earlier findings. Not only have studies found that reductions of the primary pollutants have been limited, but that formaldehyde (an air toxic) emissions were

---

5. Up to this point, the oil industry has been required to help reduce vehicular emissions on only two occasions: first, in 1975, EPA called on the industry to reduce lead content of gasoline; second, it was required to reduce vapor pressure. Now there is a third. Recently EPA relaxed a provision of CAA that would have required vehicle manufacturers to install refueling loss prevention canisters near the fuel tank opening. Instead, EPA will require the appropriate nozzles on gas pumps.

6. Differed manufacturers refer to the same technology with different names (i.e., Ford and GM use VFV, whereas Chrysler uses FFV). For the purposes of this note, FFV will be used to refer to this type of engine and fuel designation technology.

up from 200 to 500%.[7] Ethanol, it seems, provides little environmental benefits and may increase formation of aldehydes (a similar air toxic).[8] Hence, further examination of emissions performance is required to determine the likely effects of expanded use of methanol blends.

### *B.3 Economic Performance*

One of the major advantages of FFVs is the lower cost of development and new equipment. Because FFVs are essentially conventionally designed vehicles with flexible-fuel technology, manufacturers do not need to undertake design changes and can offer vehicles at a reasonable price to the public. The current price premium for FFV technology from US manufacturers is approximately $2,000. Chrysler has indicated that it will not charge a price premium for the technology, which Doug Teague, Alternative Fuels Development Director at Chrysler says is "reflective of the costs of the technology."[9] As production numbers rise, firms will be able to realize economies of scale, which will lower the cost to consumers.

Both operating and maintenance costs are expected to be higher than conventional vehicles. How much higher depends on the cost of new fuels, which is still being debated, and whether the methanol engine deposit/corrosiveness problem can be handled. Operating and maintenance costs should become more clear within the next few years.

### *B.4 Relationship to Current Regulation*

One of the distinct benefits of FFVs is their relative independence from the regulatory structure. In an uncertain and changing regulatory world, dedication to a vehicle program that could become obsolete is a disincentive to investment. While oil companies may face continual changes in the form of fuel requirements, FFVs will be able to run on any of the myriad of blends and formula produced. This independence will provide reassurance for commitment to these programs.

Current federal and state legislation does not require the use or sale of FFVs. However, governmental programs have provided research grants for their examination and development. FFV and methanol programs began in 1978 in California, and many still believe that there is a legislative bias toward methanol in California. Despite these apparent links, FFVs and methanol are not tightly coupled with federal and state regulation.

---

7. SRI International, p. 59; American Gas Association (AGA), *Comparison of Alternative Vehicular Fuels with Conventional Gasoline,* Issue Brief 1991-12, August 15th, 1991, p. 2.

8. AGA, p. 2.

9. Interview with Doug Teague, Alternative Fuels Development Director, Chrysler Corporation.

### *B.5 Industry Initiative on Flexible-Fuel Vehicles*

Each manufacturer is pursuing an FFV program as a part of its overall alternative fuels program. Manufacturers are actively seeking to transfer the momentum of conventional vehicles to their introductory FFV program and demonstrate that there is little difference between FFVs and conventional-fueled vehicles. Manufacturers feel that highlighting the similarity between FFVs and conventional vehicles is central to consumer acceptance and will be a central component to their marketing strategies.

GM's initial offering, the FFV Chevrolet Lumina, fits in with this industry-wide strategy. The initial production run will be 4,000 vehicles, which will be offered with a price premium of $2,000 over the gasoline-powered Lumina. Half of these vehicles are already committed to California under agreement between Chevrolet and the state energy commission, but they will be offered on special order for other interested fleets. GM's next entry into the FFV market will be the Chevrolet Corsica, which signals a shift in focus away from fleets to the consumer market. GM will await initial buyer and public response to the program, and for the infrastructure to develop further, before it creates any new production plans.

Ford's program mirrors that of GM. It is using the success of its gasoline-powered model to springboard into the FFV market. The Ford Taurus Sedan, which has been its top-selling vehicle in the medium-size passenger car market, will serve as its first FFV offering. Ford is targeting delivery of 2,500 1993 models to California in November, 1992. Ford is still reluctant to discuss the issue of additional costs of the additional equipment required by FFVs and is not convinced the these "cleaner" cars will find buyers in a tight market."

Unlike the other two manufacturers, Chrysler will not charge an FFV premium and instead is committed to making FFVs and conventional vehicles the same in every way, including sticker price. Francois Castaing, Vice President of Vehicle Engineering, is firmly behind the FFV program. "Last May, we introduced our methanol concentration smart sensor, making possible the production of true flexible fuel vehicles that will be totally transparent to the owner. Now I'm proud to tell you we are putting our money where our mouth is and will, unlike some competitors, offer these environmentally friendly vehicles with no price premium."

Chrysler's product line is similar to those of GM and Ford. Chrysler's initial offering is the Plymouth Acclaim/Dodge Spirit. The initial production run will be 2100 cars, which temporarily will be slated for fleet orders. Chrysler's program gets underway with delivery of 100 fleet vehicles to government fleets for use in California and Washington, D.C.in May, 1992. In July, a second wave will be offered to fleets and for retail sale. Chrysler's commitment to the program is firm, but it too will let the marketplace dictate future production plans.

---

10. Jim Henry, "Ford finds buyers like flex-fuel for the other guy," *Automotive News,* January 6, 1992, p. 30.

## C. Natural Gas Vehicles and Natural Gas

### *C.1 Technology*

NGVs require important design and materials choices in order to maximize vehicle performance. The basic problem with natural gas is that unlike liquid fuels, it must be stored under pressure above 2,000 psi in order to enrich its energy content. Vehicle range is largely a function of this pressurization. Moreover, in order to maintain gas pressure and extend vehicle range, NGVs must accommodate large, heavy fuel tanks on the vehicle.

Investigation into NGV technology, says Bill Raymundo, Director of Technology at the Natural Gas Vehicle Coalition, is in its earliest stages. Despite its short history (since 1988), comparison to conventional gasoline technologies is made without reference to the difference in development times.

### *C.2 Environmental Performance*

To date, the results of the development process are showing significant gains in emissions performance. The American Gas Association (AGA) estimates that NGVs will reduce hydrocarbon emissions by a minimum of 80%, carbon emissions by 90%, air toxics by 90%, and NOx by a slight percentage relative to conventional fuels.[11] The problem of NOx emissions is thought to be controllable through the addition of a specialized catalytic converter.

### *C.3 Economic Performance*

Although the initial cost for NGVs will be higher than both conventional vehicles and FFVs, the operating and maintenance costs are projected to be much lower. When these costs are plotted over time, industry analysts believe that the initial cost premium has a break-even time of 3 years.

The current price premium for NGVs will be between $2,000 to $3,000. However, industry analysts feel strongly that these prices will drop as production runs begin to achieve economies of scale. The AGA estimates that the price premium will drop to $600 to $800, which may still serve as a deterrent to the mass-market.

Operating and maintenance costs are expected to be much lower than those for gasoline for two reasons. First, a combination of studies projecting fuel costs into the 21st century have predicted that natural gas will emerge as the cheapest fuel in 15-20 years. Second, initial research indicates that use of natural gas reduces engine wear and maintenance requirements relative to gasoline and methanol-powered vehicles.

---

11. AGA, p. 2.

### *C.4 Relationship to Current Regulation*

Although NGVs are not explicitly promoted by current legislation, some regulatory programs are doing so indirectly. First, state deregulation of utilities allows utilities to expand into new markets. Hence, they have made significant investment in the natural gas refueling infrastructure and NGV research and development. Despite a recent slowdown in the natural gas market, utilities and natural gas associations such as the AGA and NGVC have catalyzed research and expansion efforts. Second, state public utilities commissions have also provided funding for utilities to become involved in these research and expansion efforts. Recently, the California Public Utilities Commission set out over $ 10 million to help cover research costs. Both of these actions have aided NGV and infrastructure development.

### *C.5 Industry Initiatives on Natural Gas Vehicles*

Manufacturers are again targeting fleet sales as their primary market. Fleet applications reduce common NGV problems, such as accommodation of fuel tank size and weight, limited driving range and the need for central refueling of the vehicles due to lack of infrastructure development. [12]

Manufacturers are undertaking a different strategy for vehicle introduction than with FFVs. Instead of trying to mask differences between conventional vehicles and NGVs, according to NGVC's Raymundo, manufacturers are attempting to create NGVs that outperform the conventional version of the same model. In order to stimulate purchases of NGVs over conventional and other alternative vehicles, manufacturers will downplay problems such as refueling difficulties by highlighting vehicle performance.

Industry analysts feel that GM is the farthest along in NGV technology and development.[13] "Natural gas is our fuel of choice at GM truck," say GM's Sharon Hines.[14] GM has linked up with the Gas Research Institute (GRI) on a $40 million project to develop NGVs, which has received support from Southern California Gas and Pacific Gas and Electric. In July, 1991, GM announced a contract from a consortium of natural gas utilities from California, Texas, and Colorado. GM has subsequently received more orders and has increased its production beyond its original levels. GM's earlier stated goal is to have 3,000 dedicated vehicles operating in 1992.

GM's first mass produced NGV, the Sierra pickup, rolled off the assembly line in California in November; 1991. The Sierra 3/4 ton is GMC Truck's best-selling light-duty pickup, a good

---

12. Currently there are less than 400 natural gas refueling stations around the country, the bulk of which are located in California.

13. Jack Keebler, "Clean air rules renew interest in natural gas, *"Automotive News,* November 4, 1991, p. 16.

14. Interview with Sharon Hines, GMC Truck Product Information Manager.

fleet vehicle and provides an adequate frame to support additional fuel tanks. The initial production commitment was 2,000 vehicles, but as GM has since received over 2,000 orders, the production run may be increased up to 10,000 vehicles. GM intends to charge an anticipated price premium of $3,200 and begin production on April 1, 1992. GM will also offer Kodiak medium-duty pickups in 1992. These trucks are scheduled for production on April 1, 1993. GM will also move into the passenger vehicle market starting in 1993 with the Chevrolet Caprice/Buick Roadmaster.

Ford has adopted a fairly aggressive NGV program, although its vehicles will be available later than GM's. Ford is developing light-duty trucks on a $23 million joint venture program with Southern California Gas and GRI. Roberta Nichols, Ford's manager of alternative fuels vehicles, says that Ford engineers are "shooting for a minimum range of 200 miles in combined city and highway driving." Hence, Ford is waiting to provide a functionally superior product to the market.

Ford announced in May, 1991 that it would have a 100 pickup test fleet in operation by the end of 1992. This fleet is expected to number 700 by late 1993. Ford is taking slow steps toward a production vehicle but hopes that its execution of the technology will attract consumers. Ford also has planned Crown Victoria and Econoline Van demonstration programs for 1992. However, as with the pickup program, it has not announced any production plans.

Chrysler will attempt to transfer the momentum of its successful van program into its natural gas program. Chrysler intends to create 2,000 full-sized Dodge B-vans by late 1992 or early 1993 in conjunction with GRI. In a test project sponsored by the U.S. Department of Energy and the General Services Administration, Chrysler will operate 50 of these vans in a test project in Washington, D.C. Standard Dodge B-vans cost between $18,000 and $20,000. Chrysler estimates that it incurs an additional cost of $3,750 for NGV technology, but will charge the public a $5,000 price premium. Chrysler intends to build production line vehicles beginning in early 1994. Also, Chrysler recently announced plans to create a demonstration fleet of minivans based on the Plymouth Voyager/Dodge Caravan starting early in 1993. The minivan will serve both as a fleet vehicle and be offered for consumer sales.

## D. Electric Vehicles and Electricity

### *D.1 Technology*

The basics of EV technology have been around for the 30 odd years of its history. Essentially, fuel cells, instead of liquid fuel, store electric current and channel current into a DC engine. At present, EVs have a number of problems that limit their capabilities both for fleet and consumer use, but manufacturers seem confident that most of these problems can be overcome either through technological advancement or changes in consumer

behavior. In short, the problems are limited performance, limited driving range, excessive battery size and weight, long and inconvenient recharging time, and high cost.

Accordingly, battery research has been the central focus for vehicle manufacturers. Currently there are eight different battery technologies that are under development. Only elimination of battery problems will spur the acceptance of EVs for public use.

### *D.2 Environmental Performance*

When evaluated as a product, EVs are the only zero emissions vehicles (ZEVs) that will be available on the market in the coming years.[15] The electricity needed to charge EVs is created by regional electric power plants. Studies of electric vehicle emissions (i.e., the stationary source emissions from energy consumed by EVs), have been undertaken. An Electric Power Research Institute (EPRI) study is considered one of the best yet performed. The results are documented below:

Total Emissions Associated with Electric and Gas-Powered **Vehicles**[16]

| Pollutant | Electric | Gasoline |
|---|---|---|
| VOCs | 0.003 | 0.5 |
| NOx | 0.03 | 0.6 |
| CO | 0.003 | 7.0 |
| $CO_2$ | 105 | 275 |
| $SO_2$ | 1.0 | 0.08 |

The results show that EVs are environmentally-favorable to conventional vehicles. However, the emissions of EVs vary depending upon the method of electricity generation. Moreover, the environmental externalities of mobile source emissions become more localized around the point of generation.

### *D.3 Economic Performance*

The cost of electric vehicles will be higher than that of similar conventional vehicles. The price differential is a function of both battery costs and materials costs. Battery costs are high due to the early stages of battery development, but are expected to drop as the technology matures. The costs of the ultra-light materials required for EVs will remain high through production. Currently, manufacturers arc tight-lipped about EV expenses, but it is widely believed (and upheld by current data) that initial offerings will be approximately twice

15. Hydrogen vehicles are also considered to be ZEVs, yet they will not be available for at least a decade. Very few manufacturers are currently pursuing hydrogen vehicle technology.

16. Tim Yau of the Electric Power Research Institute, Gasoline vs. Electric Vehicles, 1990.

as expensive as conventional versions. These prices are likely to drop as battery technology enters the production stage.

The limited lifetime of batteries is also a source of additional costs. Currently, the best developed battery systems require replacement after 2-3 years. GM predicts that the price for new batteries will be approximately $3,000, yet outside observers feel that this estimate is highly optimistic. Finally, EVs will have higher energy costs than conventional vehicles, but will have dramatically lower maintenance costs.

All this taken together, many industry analysts fear that the additional costs of EVs will inhibit sales.

### *D.4 Relationship to Current Regulation*

EVs are the only alternative fuels vehicles that have been specified by current state air quality legislation. CARB requires a certain percentage of ZEV sales for any manufacturer doing business in California beginning in 1998 (see Appendix A). By 2003, manufacturers will be required to. sell over 170,000 EVs in California. Furthermore, a multitude of states have adopted the California provisions. The Northeast States for Cooperative Air Use Management (NESCAUM) and Illinois have each adopted the program, raising the required sales number four-fold."

In addition to the state mandates, EV research has and will continue to be supported by the US Department of Energy (USDOE) through the US Advanced Battery Consortium (USABC), and partnership projects such as its $14.5 million drivetrain program with Ford.

### *D.5 Industry Initiatives on Electric Vehicles*

The USABC is comprised of GM, Ford, Chrysler, the U.S. DOE and a number of other utilities, electric research groups and battery companies that will spend $100 million annually in order develop a competitive edge for US EVs. The effort represents the "second largest consortium outside of the semiconductor industry," (second to Semi-Tech) notes Ken Baker, GM's director of EV development and the leader of the consortium.

Other interested parties, such as foreign manufacturers and battery producers, have inquired about joining the consortium, but each has been turned down. "It was taken from the beginning that the purpose of the consortium was to improve the competitiveness of the U.S. auto industry. There was never any intention to expand management of the consortium to include foreign makers," said John Brogan, director of the office of propulsion systems at the

---

17. NESCAUM is currently comprised of Delaware, Massachusetts, Maryland, Main, New Hampshire, New Jersey, New York, Pennsylvania, Virginia, and Washington, D.C. Rhode Island, Connecticut and Vermont are currently considering adopting similar measures.

U.S. DOE. Manufacturers have also made a great deal of headway on EV technology working outside of the consortium. Each has chosen a different battery technology for their introductory vehicles.

GM has made the most explicit commitment to EV technology, asserting that it will be the first to make electric vehicles commercially available in the US. GM has chosen lead-acid as its battery of choice. Lead-acid technology is perhaps the most basic and predictable technology, and has been the focus of the greatest amount of research to date.

GM's EV program unveiled its Impact concept car in January, 1990. The overwhelming response led GM to mass-produce the Impact, ostensibly for Southern California and European markets. Although GM is still unwilling to project its price, various leaks have set the figure at $26,000, double the cost of a conventional vehicle of similar size, styling and performance. Although the production date has not been formally set, vehicles are expected to be ready in early 1994.

As opposed to the Impact, which is primarily designed for the commercial market, the G-Van will largely be utilized as a fleet vehicle. The G-Van development program has been going on for four years under the direction of the Electric Power Research Institute (EPRI) based in Palo Alto, CA, with support from Vehma International, Chloride EV Systems of Great Britain, and Southern California Edison. Currently, the vehicle sells for $34,500--twice the cost of the conventional version. Demand has been slim.

Ford has not been as concerned with market entry or demonstration fleet creation as it has been with obtaining sound battery technology and performance. Ford determined early in its research and development that it would not work with inefficient batteries. Instead, it has targeted sodium-sulphur technology as its battery of choice, as reports indicate that sodium-sulphur batteries provide maximum vehicle range at the lowest life cycle cost. Therefore, Ford is determined to produce a superior battery and is not rushing market entry. Ford's work for the U.S. DOE to standardize EV drivetrains is also expected to yield technological dividends.

The Ecostar minivan will be Ford's first demonstration vehicle, intended for Southern California private and public fleets. The Ecostar is based on the Escort minivan, which has been the best-selling van in Europe for the past three years. Ford intends to develop 70 to 100 vehicles and have them on the road starting in late 1992, although production has not been scheduled. In addition, Ford recently announced its Connecta concept car program, a wagon targeted for family use. Ford has not released any other plans for the program.

As for Chrysler, EV research has been underway since the mid-1980's, primarily in a collaborative project between one of Chrysler's subsidiaries, Pentastar Electronics, and EPRI. The four year effort developed the initial concept vehicles and yielded a maintenance-free nickel-iron battery. However, Chrysler has been unsuccessful at eliminating its high cost. Chrysler began more focused work on its EV program in January, 1991 as it formally

established phase two of the project, with two specific goals: incorporate EV research inside of Chrysler and, in conjunction with EPRI, refine the battery technology and drive-train of Chrysler's TE Van. To date, battery performance has been limited and Chrysler has had problems with its battery suppliers.

The TE Van will be targeted for the minivan market with applications for commercial and fleet use. Based on Chrysler's best selling minivans, the Dodge Caravan/Plymouth Voyager, the TE Van represents Chrysler's primary entry into the EV market. In this phase of the project, 10 experimental vehicles that will be used for performance and safety testing. Without a major setback, Chrysler expects to bring the operation on line in mid-1993 in hopes of creating a full-size demonstration fleet in California in 1993 or early 1994. Second, Chrysler and Westinghouse recently unveiled the EPIC, a new performance/commuter vehicle, targeted for California markets. Although Chrysler has not specified a demonstration program or production plans, it hopes that the EPIC will be ready for development in the mid-1990s.

## 2. Driving Forces in Alternative Fuels Vehicle Development

Companies have been developing alternative. fuels programs for decades, but they have remained peripheral to corporate business. Concerns about dependence on foreign oil have spurred interest in alternative fuels vehicles in the 1970s and 1980s, yet these concerns have tended to recede as quickly as they appeared. It is the continued tightening of legislation that has moved alternative fuels vehicles into the forefront. While potential consumer demand and emerging international markets also factor into alternative fuels vehicle development, legislation which mandates alternative fuels vehicles is the predominant driver behind industry efforts.

### *A. Legislation*

Examination of federal and state air quality legislative programs produces some important findings:

- *Both federal and state legislation prescribe goals that make alternative fuels vehicles an essential part of manufacturer's product lines.*

Federal legislation, primarily through the CAA, creates stringent emissions standards and fleet purchasing requirements. Although the legislation attempts to create demand for alternative fuels vehicles through a California fleet pilot program, it does not promote the adoption of specific alternative fuels vehicle technologies and does not force manufacturers to produce alternative fuels vehicles.

Some analysts, such as CARB's Liwen Kao, feel that CAA provisions are essentially neutral, as they "don't really affect ... actively promote or incentivise" specific alternative fuels

**vehicles.**[18]

California legislation contains similar provisions to those in the CAA, but takes them one step further. The state mandates production and introduction of alternative fuels vehicles as well as adoption of specific alternative fuels vehicles, such as EV technology (see **Appendix A).**

- *California is the major playing field for alternative fuels vehicles.*

Southern California has historically had the most intractable air quality problems. Due to its size, the state is the most important market to vehicle manufacturers, representing over 10% of the US market and roughly 5% of the world market. Therefore, California legislation has tended to be the most stringent and it has been necessary for manufacturers to meet its specifications.

California has also tended to set a legislative example for other states. However, manufacturers insist that transplanting the California program to other environments may not be the most cost-effective way to achieve air quality goals. Although they may quibble over implementation, US manufacturers are on the whole fairly satisfied with the regulatory concept for California. However, they are not convinced of the need for "California-like" programs in Northeastern states. GM and Ford both argue that the benefits to northeastern air quality do not warrant the costs to consumers or manufacturers, as is again stated by Ford's Buist: "Once you get outside Los Angeles, it's hard to see the benefits (of the program). It's hard for me to see the state of Maine, for instance, needing electric vehicles for air pollution." In spite of this, NESCUAM and Illinois have both adopted legislation similar to that of California.

- *Legislation has established timetables into the next decade, indicating a long-term commitment to alternative fuels vehicles.*

For instance, California's regulation has four phases of technology requirements that extend to 2003. This timetable effectively creates a roadmap for alternative fuels vehicles development, leading manufacturers ultimately to EVs. CARB legislation sets forth two far reaching goals: 100% low emissions vehicle (LEV) sales by 2000 and 10% ZEV sales beginning ill **1998.**[19]

---

18. Interview with Liwen Kao, CARB Regulator.

19. The theoretical definition of a LEV is any vehicle that can meet particular emissions standards. The practical definition is any vehicle that can run on alternative fuels.

• *The clarity of these timetables provides flexibility for manufacturers to pursue a variety of alternative fuels programs.*

When the CARB legislation was announced, says Kao, "the industry was very surprised at the stringency of the standards," although it "generally supported the [timetable] concept" because it allowed manufacturers the flexibility to meet the standards. CARB will review the status of new technology to assure that manufacturers' development schedules match sales timetables.

• *While federal and state legislation generally support the same goals, they can be in conflict with each other. These areas of conflict along with variations in state to state regulation do significantly complicate manufacturers' strategies.*

Federal guidelines collectively promote a variety of alternative fuels programs, whereas state legislation emphasizes EV programs.

The difference between federal and state programs, along with the differences from state to state, does complicate the market for manufacturers. These sentiments are echoed by Don Buist, director of Ford Director of Auto Emissions and Fuel Economy: "We'll never meet those standards if we have to do it based on the mix in all those different states. From every point of view, it's impossible." The difference in requirements could block manufacturers' ability to realize economies of scale in production and may keep prices of alternative fuels vehicles high relative to conventional vehicles. Should this emerge as the case, consumer acceptance would be dramatically reduced.

Moreover, there is a discrepancy over how to achieve air quality goals in the most cost-effective fashion. Manufacturers argue that removing older cars that have less sophisticated emissions control equipment and increasing vehicle maintenance requirements would achieve air quality goals at a lower cost. They argue that this solution is more cost-effective than raising prices of new vehicles in order to eliminate incremental percentages of pollution.

Regardless of the differences, it is clear that legislation, especially state legislation, is promoting the development of alternative fuels vehicles through emissions standards and market incentives. The concreteness of regulation is catalyzing the efforts of manufacturers to move their programs from concept to implementation.

### *B. Consumer Demand*

Although consumer demand is not currently a driving factor in development, many industry analysts feel that consumer demand will rise through the next decade. Consumers purchase cars based on a large number of criteria, all of which vary in importance from consumer to consumer. As Chrysler states in its 1991 10-K report, the market is competitive "with respect to product quality, price, appearance, size, special features, distribution organization,

warranties, reliability, fuel economy and financing terms."[20] Currently, emissions performance and refueling convenience are not listed as criteria for sales.

The primary environmental factor in new car sales is fuel economy. Buyers are largely unaware of the emissions performance of their own vehicles, let alone the growing movement toward alternative fuels vehicles. Yet, interest in alternative fuels car programs is rising, buoyed by the ground-swell of concern about the environmental and the price and convenience of alternative fuels vehicles. NGVC's Raymundo believes that with public demonstration programs and infrastructure development, the general public will respond favorably to new vehicles. He is frequently asked to speak at town meetings about natural gas refueling stations, and the first question asked after each presentation is "where people can purchase NGVs?" Similarly, John R. Dabels, Marketing Director of GM's EV Program, has buyers lined up far in advance of production of its EVs. He claims that "there is increasing--scratch that--exploding interest in EVs."[21] Should mobile source emissions continue to be the primary determinant of air quality conditions, consumers may in the future devote 'as much attention to a vehicle's emissions as they currently do to its fuel economy, which may ultimately determine market success for alternative fuels vehicles.

However, alternative fuels vehicles will only be as successful as manufacturers' efforts at keeping initial prices down and industry-wide efforts at developing the supporting infrastructure. Although there are some tax incentives in place, widespread use of alternative fuels vehicles will be contingent upon lowering their cost premiums. Moreover, the lack of development of infrastructure for the majority of alternative fuels will limit convenience of use and dependability. Both of these problems need to be addressed in order to bolster consumer demand.

### *C. International Markets*

Although the domestic market is becoming attractive for manufacturers, they also see opportunities for alternative fuels vehicles in international markets. At present, there is no regulatory initiative promoting alternative fuels development in Europe or Japan. However, alternative fuels vehicles may be more attractive to European and Japanese audiences than to those in the US, due to key differences in their societies.

First, the high price of gasoline could enhance the attractiveness of alternative fuels vehicles compared to conventional ones. Across Europe and Japan, gasoline costs on the order of two or three times as much as in the US. Second, there are differences in geography and vehicle use. The shorter distance between cities and higher degree of city driving mean that consumers do not need long range vehicles. Alternative fuels vehicles, which have limited

---

20. Chrysler Corporation, Annual Report on Form 10-K, December 31, 1991, p. 6.

21. John R. Dabels, "GMEV Ride and Drive Presentation" from the Edison Electric Institute Chief Executive Conference, January 11th, 1991.

driving range, may become more attractive in this marketplace. Finally, Europeans and Japanese have always had a penchant for smaller cars and many of the early EVs will be small cars.

A recent study from Prognos AG in Switzerland predicted that gasoline and diesel fuel would remain the predominant fuels in Europe through 2010.[22] However, it stated that NGVs, EVs and hydrogen vehicles will become the alternative fuels vehicles of choice. Europe has significant natural gas reserves which could accommodate a large NGV population. In Japan, EVs are already available, but current products tend to compromise performance. Despite the absence of regulation targeted at alternative fuels vehicles, these unique characteristics of the European and Japanese markets suggest the potential for alternative fuels vehicles may be even greater than in the US.

## 3. Importance of Alternative Fuels Vehicles to Corporate Strategy

Alternative fuels development programs are in transition. Although previously ignored in corporate strategies, they are rapidly becoming a part of manufacturers' long-term development outlook. This assertion is predicated on two findings:

- *Mobile source emissions and fuel economy will remain the most significant environmental considerations for manufacturers.*

The primary method to reduce urban ozone concentrations is to reduce mobile source emissions. In 1987, 67 metropolitan areas did not meet National Ambient Air Quality Standards. As legislative timetables continue to tighten in order to meet air quality targets, the drive toward alternative fuels vehicles will continue.

- *Although alternative fuels vehicles are not at present part of short-term corporate strategies, development of alternative fuels program may be central to achieving stringent emissions standards and long-term market success.*

Given the present state of development and the lack of significant markets for alternative fuel vehicles, some manufacturers feel that it is premature to create long-term production plans. They wish to let fleet demonstration programs, growing consumer awareness and the emergence of international markets dictate their actions.

However, most manufacturers see the "writing on the wall." Standards will become more stringent and it will become increasingly difficult for manufacturers to meet these standards with incremental improvements in current technologies. As market demand rises and legislation takes effect, alternative fuels vehicles will become central to long-term success.

22. Prognos AG, *Driving Concepts 2010,* February, 1992.

GM states in its 1991 Corporate Environmental Report, "as part of its long-term strategy to improve air quality by reducing automotive emissions and to help develop alternative sources of energy, GM has actively investigated a wide range of alternative fuels for many years, and continues to do so."

Alternative fuels vehicles programs currently offer opportunities for innovation and experimentation that may have an effect on traditional corporate practices. Similar to GM's Saturn effort, the freedom from historical practices that alternative fuels vehicles programs provide is allowing manufacturers to undertake new and dynamic approaches to vehicle development. GM's EV program is a prime example. GM is utilizing the platform concept, which organizes all corporate functions around a single product platform (i.e., marketing, design). New to GM, it has been practiced by the Japanese for many years. Some industry analysts feel that it is the key to Japanese success. Ultimately, as these alternative fuels vehicles programs expand, the new practices and innovations resulting from alternative fuels vehicles programs may be fed back directly into the process of corporate strategy making.

## 4. Global Considerations

Given the world-wide potential of alternative fuels vehicles and the international competition that will try to meet it, US manufacturers need to incorporate a global perspective in developing their alternative fuels vehicles strategies. Ultimately, despite the early legislative impetus given to US manufacturers, international competition in the emerging alternative fuels markets should be severe. The following examples illustrate differences in short-term and long-term strategies throughout the industry.

- ***GM, Ford and Chrysler are all targeting Europe for EV rolls outs.***

GM has already engaged its European affiliate Adam Opel to help develop and market the American-made Impact. GM is targeting the European and Japanese commuter market for initial sales. Ford and Chrysler are both concentrating on electric minivans. Ford is basing its initial EV, the Ecostar, on the Escort Minivan, which was the top-selling minivan in Europe in 1991. Similarly, Chrysler, with a minivan market share of over 40% world-wide, is hoping for positive results from its EV minivan, the TE Van. Industry analysts at DRI/Europe and Euromotors Reports have projected that demand for minivans will grow in Europe by approximately 400% by 1995 and continue to grow throughout the decade.[23] Yet despite this emphasis on EV markets, similar international efforts have not been mounted for NGVs, because many feel the natural gas infrastructure will take decades to develop.

23. Diana T. Kurylko, "Minivans, wagons among Europe's rising stars," *Automotive News*, November 11th, 1991, p. 39.

US manufacturers will face heavy competition from European and Japanese manufacturers in the future. European manufacturers are concentrating primarily on EVs. Fiat, Volkswagen and Audi currently have EV offerings available, while Mercedes, BMW and Renault are all in the development stages. The Japanese are examining NGVs, but are putting most of their energy into EV research. Toyota, Nissan, and Isuzu are all planning development of natural gas trucks for delivery to California, but do not yet have production plans in place. After being barred from entry to the USABC, the Japanese recently formed their own consortium under MITI to develop EV technology. Many industry analysts feel that the Japanese have developed the most advanced battery technology. Nissan has developed a quick charge battery technology which allows users to charge batteries to 40% of capacity in as few as 12 minutes. Isuzu has developed what it is calling the "ultracapacitor" which can store 30 to 50 times more power than conventional capacitors and quickly release energy for faster acceleration. These developments potentially give the Japanese a competitive edge in EV markets.

• *Hybrid vehicles are also gaining favor among many automakers.*

GM, Audi and VW have created hybrid vehicles that are primarily EVs and have small internal combustion engines that perform as "range extenders." Currently, California legislation does not specify whether hybrid vehicles will be allowed under its ZEV requirements, which may leave the hybrid option open for manufacturers. Although GM intends to push CARB regulators not to allow hybrid vehicles, there may be an expanding market for these types of vehicles.

• *While US manufacturers are concentrating on FFVs, NGVs and EVs, many foreign automakers are investigating hydrogen vehicles.*

Currently, most believe that EVs and hydrogen vehicles, which emit only water and air, offer the best environmental performance relative to other options. At present, German manufacturers BMW and Mercedes are developing hydrogen vehicles and Mazda hopes to make hydrogen vehicles available in California by the year 2000.

• *Future international alternative fuels market will be competitive and comprised of a multitude of alternative fuels choices.*

Given their current development efforts, US manufacturers will be in a fairly strong position to exploit NGV and EV markets, but may have difficulty should hydrogen fuels take hold. Ultimately, the alternative fuels market will mirror the conventional vehicle market--many players, many choices and fierce competition.

[This note is intended to serve as an introduction to alternative fuels technologies and markets and as a background note to an in depth study on an alternative fuels vehicle development program at one US manufacturer. The subject will be GM's Electric Vehicles Program and its first offering, the Impact.]

## Appendix A: Federal and State Provisions Relating to Alternative Fuels Vehicles

### 1. Clean Air Act Amendments of 1990

CAA is a main source of motivation for alternative fuels development programs. The following are the provisions relevant to mobile sources and alternative fuels contained in Title II:

- *Emissions Standards:* CAA has created a timetable for reducing emissions levels for a number of criteria pollutants. In particular, tailpipe emissions standards specifically target non-methane hydrocarbons (NMHC), carbon monoxide (CO), and oxides of nitrogen (NOx). New emissions standards will be phased in beginning in the model-year 1994 through model-year 1996. The reductions are as follows: NMHCs reduced 35%; CO reduced 39%; NOx reduced 60%. Moreover, depending on the results of an EPA study of need for further reductions, Tier II will likely reduce levels for all three pollutants by 50% starting in 2004.

- *Fleet Emissions Standards and Purchasing Requirements:* f'leet vehicles covered by the program would be substantially cleaner than conventional vehicles. The program applies in 26 severe non-attainment areas to fleets of 10 or more vehicles that can be centrally-refueled. The standards target two separate classes of vehicles:

    - *Passenger cars and light/medium duty trucks:* the standards require reductions by 70% of HCs, 50% of NOX. The standards are intended to take effect in 1998. In the first year, 30% of new vehicles must meet these standards, rising to 70% by the third year.

    - *Heavy-duty trucks:* new standards require reductions of 50% for the above pollutants for purchases beginning in 1998.

These standards virtually mandates a switch to alternative fuels. Moreover, the fleet provisions outline two other programs:

- *California Sales Requirements:* the fleet provisions also outline a California pilot program which requires 150,000 clean fuel vehicles for sale annually beginning in 1996 rising to 300,000 beginning in 1999. Other areas may opt in to these provisions.

- *Tradeable Permits:* fleet operators covered under the program can earn air pollution credits which can be banked for future purchases or sold to fleet operators in the same nonattainment area. Credits are earned through purchases prior to deadlines, greater than the required percentages, or of vehicles that perform better than applicable standards.

• *Reformulated Fuels Sales Requirements:* clean fuels will also be required for 9 nonattainment areas. If successful, this program could expand to an additional 13 nonattainment areas. Clean fuels entail raising oxygen content and lowering air toxics and aromatics into order to improve fuel combustion.

**2. State Legislation**

A growing network of states is also promulgating emissions standards, sales requirements, and purchasing incentives for alternative fuels vehicles are promoting development. This legislation is technology forcing, creating specific regulatory requirements for electric vehicles (EVs). Following California's lead, many northeastern and midwestem states have adopted standards and provisions stronger than federal legislation.

*2.A California*

• *Emissions Standards:* the legislation creates tiered fleet purchasing requirements for different kinds of technology, phased in beginning in the mid-1990s. These standards are more stringent than federal standards.

• *Sales Requirements:* required sales move through a number of required technologies and percentages on the path toward the most environmental preferable technology-"zero emissions vehicles (ZEVs)."

1. TLEVs--"transitional low emissions vehicles"
2. LEVs--"low emissions vehicles"
3. ULEVs--"ultra low emissions vehicles"
4. ZEVs--"zero emissions vehicles"

Ultimately, these provisions mandate 100% LEV sales by 2000 and specify percentages of any manufacturer's sales in California must comprised of a specific percentage of ZEVs. Currently, the only ZEVs are EVs. The required percentages and projected sales of EVs in California are as follows:

Required ZEV Sales for **California**[24]

| | % Sales | Total Vehicles |
|---|---|---|
| 1998 | 2.0 | 34,500 |
| 2000 | 5.0 | 86,250 |
| 2003 | 10.0 | 172,500 |

Although the legislation does not provide consumers for these proposed sales, it does signal potential for market development.

- *Tax Credits:* tax credits have been implemented to help equate the vehicle and operational costs of alternative fuels vehicles and conventional vehicles. Because costs are expected to be higher for alternative fuels vehicles than for conventional vehicles, California has created tax incentives to offset **them.**[25] In addition, California has suspended its 6% gas tax for alternative fuels in order to stimulate the development of their infrastructure and use.

- *Program Subsidies:* funding for natural gas and electric utilities to get involved in vehicle development. programs has been provided, Moreover, a mandate for the California Public Utilities Commission (CPUC) has been created to push infrastructure development.

- *Emissions Fees:* in order to aid in funding these programs, provisions has been included that authorize the study of vehicle emissions fees.

- *Fuel Requirements:* reformulated fuels are required for sale throughout the state by April, 1996. These fuels must be 30-40% cleaner than current offerings.

*2.B NESCUAM and Illinois*

California's initial step set off a chain reaction. Subsequently, NESCAUM opted into the California program. The effect has been to more than triple the number of ZEVs required for sale at the end of the decade. The figures are as follows:

---

24. Jim Henry and Kristine Stiven Breese, "California air rules may cover Northeast," *Automotive News,* November 4th, 1991, p. 1. All calculations based on estimated US market of 15 million vehicles and a California market share of 11.5%, totalling 1.725 million vehicles. 1991 market size was approx. 12.5 million vehicles and 1991 California market share was 11.5%.

25. Maximum credits are $1,000 for conversions and $3,500 for dedicated vehicles.

**State-Implemented ZEV Minimum Sales Requirements[26]**

| | Market Share | 1998 | 2000 | 2003 |
|---|---|---|---|---|
| California | 11.5% | 34,500 | 86,250 | 172,500 |
| NESCAUM | 23.2% | 69,600 | 174,000 | 348,000 |
| Total | 34.7% | 104,100 | 260,250 | 520,500 |

The addition of Illinois to this program further increases required ZEV sales.

*2.C Texas, Louisiana and Colorado*

In addition, Texas, Louisiana and Colorado have also created programs aimed at fleets. In 1989, Texas promulgated legislation requiring shifts toward alternative fuels by state and school fleets in nonattainment areas (i.e.,Houston and Dallas/Fort Worth). Purchases after September 1,1991 must have clean fuel capacity (dual-fuel vehicles are allowed). Clean fuel capacity vehicles must comprise 30% of covered fleets by late-1994 and 50% by late-1996. Local government and private fleets will most likely come under regulation late this year. Louisiana also has created a tier of requirements for new fleet purchases of alternative fuels vehicles: 30% by 1994, 50% by 1996, and 80% by 1998. Colorado also requires alternative fuel vehicle purchases: 10% by 1992 and 20% by 1995. As a result of these provisions, these states are also potential markets for manufacturers.

26. Based on NESCAUM and Illinois affected states US market share data.