

FIFTEEN YEARS OF FUEL METHANOL DISTRIBUTION

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Abstract

This paper examines how the distribution and marketing of fuel methanol has developed in the fifteen years since the California Legislature initiated the investigation into the "feasibility and cost-effectiveness" of alcohol fuel for transportation in 1979. California's ambitious policy initiative to reduce the use of imported petroleum encouraged the accelerated development of automobile technology and advanced the application of the existing fuel distribution system for alcohol fuels. The California Methanol Demonstration sponsored by the California Energy Commission is now the largest demonstration of its kind in the world.

The current state of development of the fuel methanol distribution infrastructure system (M85 and M100) is presented in terms of the adaptation of the petroleum fuel infrastructure for the storage, distribution and retail marketing of fuel methanol. Topics include:

- The cost-shared establishment of a network of methanol retail stations; limitations to station development, marketing efforts, station operation and maintenance, efforts to assure fuel quality and convenience of dispensing, including transaction billing services;
- Cooperative efforts of dispensing equipment manufacturers, automakers and the CEC to improve fuel quality by initiating a fuel sampling and testing regimen and by researching fuel methanol compatibility, new materials and the interaction of fuel methanol with gasoline fuel additives. This includes preventing both detrimental effects of methanol on equipment and any effect by the equipment on fuel quality;
- The analysis of in-use economics of fuel methanol including wholesale and retail pricing for both retail and fleet-operated dispensing, cost effectiveness of current methanol use and projections for the future cost-competitiveness and market growth of fuel methanol.

Background

The start of California's experience with alternative transportation fuels began, in response to oil shortages of 1973 and 1979, with the passage of Senate Bill 620- Statutes of 1979. SB 620 was a multi-faceted omnibus mass transit measure. Among its many provisions, it allocated the sum of ten million dollars "to investigate the practicality and cost-effectiveness of alternative motor fuel" (SB 620). This terse mention of alternative fuels was the first California public policy initiative for the development of alcohol fuels. The then-recently created Energy Resources Conservation and Development Commission, also known as the California Energy Commission (Commission), was given the responsibility for carrying out this investigation.

It is instructive to recall the historical context for this proposal. The year 1979 saw the second major energy crisis in the decade, which was evidenced by motor fuel scarcity and the resulting steep escalations in fuel prices paid at the pump, if and when fuel was available. Odd- and even-day fuel rationing, consumers topping-off vehicle fuel tanks at every opportunity, and government-imposed fuel allocation programs marked this period. A variety of measures were adopted in the attempt to alleviate the market disorder that was caused by the relatively small shortfall in world oil supply and exacerbated by the inability of oil companies to quickly augment supply.

Another, perhaps longer term result of this second "petroquake" was the response of United States society generally. An unprecedented array of programs were launched to adapt to the anticipated increases in oil prices. These programs sought to initiate lasting changes in the nation's energy mix and to educate the populace about energy issues, efficiency measures and alternative fuels. Significant societal changes with respect to energy policy, production, use and conservation occurred as a result. At that time state and national policy makers attempted to address the need to secure supplies and manage the demand for an essential commodity, the use of which pervades the fabric of industrial societies.

Nowhere is dependence upon petroleum more evident than and now than in the transportation sector.

It is worth noting that the issue of reducing vehicle emissions to improve air quality, which has been a central argument supporting the development of alternative fuels over the past ten years, was not the primary issue of concern when these initiatives were begun. Air quality was seen at the time to be an ancillary issue, although it was acknowledged that the adoption of alternative fuels should not exacerbate air quality problems and could in fact potentially help resolve them.

PROGRAM PLANNING

In planning its investigation into the practicality and cost-effectiveness of alternative motor fuels, the Commission used a three-element approach. The first element consisted of conducting an evaluation to identify and rank the most promising alternative fuels for California given the state's needs and characteristics, and the fuels' potential for domestic production and ability to substitute for gasoline and diesel. The alternative fuels evaluated included electricity, natural gas, methanol, ethanol, hydrogen and propane. At the time the evaluation was conducted, methanol stood out clearly as having the best potential for replacing petroleum on a widespread basis. Ethanol was also considered viable from the standpoint of use, although its supply potential for the state then was considered questionable.

The next element in the investigation of alternative motor fuels was the formation of a two-part demonstration: the demonstration on road of alcohol fuels, both methanol and ethanol, and the feasibility of and potential for the cost-shared establishment of ethanol production facilities in California. While the on-road demonstration showed that both alcohol fuels could be readily used in internal combustion engine (ICE) vehicles, the fuel ethanol production feasibility study for the most part indicated generally unfavorable economics, given the

ethanol production technology available at that time and the cost and availability of ethanol feedstocks.

The third element of the investigation of alternative fuels was comprised of initiatives undertaken with other state and local agencies to overcome institutional barriers and to explore potential incentives, both financial and regulatory, to advance the commercialization of alcohol fuels. The Commission ultimately sought partnerships with state and local agencies and in 1985 formed the Three-Agency Methanol Task Force (subsequently named the Clean Fuels Working Group) with the California Air Resources Board (CARB) and the South Coast Air Quality Management District (SCAQMD) as well as other local districts. This alliance was instrumental in coordinating efforts, preventing duplication and developing strategies for ground-breaking alternative fuels programs (California Energy Commission, 1986).

The investigation into incentives for alcohol fuels evaluated what initial measures should best be implemented to overcome barriers to the commercialization of these promising new fuels. For example, the study found that prior to any development and demonstration of the fuel, the State and Federal excise taxes on alcohol fuels should be modified to be equivalent to gasoline excise taxes on a tax-per-mile basis (this was simplified to adopting a rate equal to one-half the prevailing gasoline rate). This recommendation was adopted in California with the passage of SB 654 (Statutes of 1981), and the Federal excise tax rates for alcohol fuels soon followed suit.

First Demonstration Efforts

Alcohols as Fuel Extenders

The first efforts demonstrating the use of fuel methanol and fuel ethanol involved alcohol blends of 5%, 10% and 15% used in converted 1979 Honda Civics. This demonstration was undertaken to evaluate the use of alcohols as fuel extenders,

increasing the amount of fuel available in times when gasoline supply was curtailed or on allocation. In the course of this work, it was determined that certain blends could reduce the emission of some criteria pollutants, thereby enhancing air quality, while on the contrary other blends resulted in high evaporative emissions that could deteriorate air quality. The successful performance of both alcohols overall in these tests led to other, more ambitious vehicle/fuel demonstrations.

Dedicated Alcohol Test Fleet Program

The State of California then embarked on an Alcohol Fleet Test Program comprised of three separate fleets. These fleets consisted of vehicles produced by two different manufacturers and built or converted for dedicated (i.e., exclusive) alcohol fuel operation. The specific fuel blends used were near-neat blends, typically blended with iso-pentane rather than gasoline.

Fleet One consisted of eight 1980 Ford Pintos operating on ethanol and methanol and used in daily State fleet service with the Department of General Services and the Department of Transportation for approximately eighteen months. Fleet Two consisted of thirty-nine factory-produced methanol and ethanol Volkswagen of America Rabbits and light-duty pick-up trucks which logged over 350,000 miles in fleet service. These vehicles were the first fuel-injected and factory-produced alcohol vehicles in the United States.

Fleet Three consisted of forty Ford Escorts operating on methanol in the Los Angeles County fleet, which accumulated over 500,000 miles in reliable service. These vehicle were factory-produced as gasoline vehicles, shipped to California and then equipped by aftermarket converters for methanol use.

All three Fleets in the Alcohol Fleet Test Program were evaluated for fuel economy, emissions, driveability and durability. The results were conveyed to the California Legislature in a 1982 report (California Energy Commission, 1982).

The Dedicated Ford Escort Fleet

With the positive results of the preceding fleet tests verifying the potential of alcohol motor fuel technology, the Commission began to carefully plan a more ambitious and varied fleet test using dedicated methanol Ford Escorts. With funding from the California Legislature for the operation and testing of a 500-vehicle demonstration fleet, as well as funding for the establishment of methanol fueling facilities, the Commission set out to gather city, county and state fleet vehicle purchase commitments and to negotiate with independent fuel marketers to establish and operate methanol fueling facilities. The methanol facilities were to be located as proximately as possible to the participating fleets.

With the exception of two retail fueling facilities established for Fleet Two and one Los Angeles County fueling facility established for Fleet Three, the network of methanol fueling facilities established for the 500-vehicle fleet was the first such network of stations established in the United States. Over a two-year period eighteen retail methanol fueling facilities were established, and these stations continued to operate over a period of five years.

Lack of Acceptance of Dedicated Vehicles

The vehicles in the fleet demonstration performed well technically. However, the relatively small number of refueling sites provided limited opportunities for the drivers of the dedicated alcohol vehicles to refuel, despite the stations' proximity to the participating fleets. Overall the program was termed "a technical success, but an emotional failure," due to the comparatively sparse coverage provided by the 18 methanol fueling locations as compared to a statewide population of well over ten thousand retail gasoline stations.

The stress that drivers experienced when trying to locate a methanol station was exacerbated by the lower range experienced from fuel methanol (approximately 60% the range of gasoline from the same size fuel tank). Some drivers noted their anxiety as to whether they would be able to locate

a fueling location and complete their trips. The recognition of this difficulty prompted the development of a truly remarkable technological breakthrough--the fuel-flexible vehicle, or FFV.

The Advent of Fuel Flexible Vehicles

The first FFV, a prototype red Ford Escort, was assembled and delivered to California in 1987. This vehicle and the subsequent thousands of FFVs produced and delivered for sale by Ford, General Motors and Chrysler, were intended to alleviate drivers' concerns about finding fuel for their vehicles. FFVs were designed to operate on variable blends of methanol and gasoline, up to a standardized fuel methanol blend of eighty-five percent methanol and fifteen percent unleaded regular gasoline, designated as M85. Where it was available the driver could fill the vehicle with M85; otherwise, he or she could simply fill the vehicle with unleaded regular gasoline, thereby eliminating refueling worries.

The 5,000 Fuel Flexible Vehicle Demonstration

The momentum gained from the previous fleet tests and demonstrations continued with the subsequent proposal to produce, sell and operate FFVs in one of the largest commercial alternative fuel demonstration fleets in history. Despite the fact that these vehicles were "fuel flexible", capable of operating on methanol or gasoline, it would still be essential to work with the existing fuel retailing industry to make M85 available at as many retail outlets as possible in California.

Conditions for the FFV Demonstration

However, Ford Motor Company insisted that three key elements be put in place prior to its commitment to produce the large number of FFVs for the California demonstration:

1. Passage of Corporate Average Fuel Economy (CAFE) credits for the production of FFVs, based on FFVs being able to operate at least

half the time on methanol (thereby giving credit of one-half the otherwise expected volumes of gasoline);

2. Provision of funding to "buy down" the anticipated differential costs of FFV production; and
3. Cooperative Agreements with major oil retailers for the establishment and operation of a retail M85 fueling network in California.

The state quickly set about satisfying these three requirements. In 1988, fortuitous timing and the collective efforts of many individuals led to the passage of the Alternative Motor Fuels Act, which was signed into law by President Ronald Reagan. The AMFA granted CAFE credits to the car makers for the production of alternative fuel vehicles, including FFVs.

The second condition was met when the California Legislature approved the first of several funding bills for support of the 5,000 FFV demonstration, including funds to buy down the differential costs of FFVs and for the establishment of refueling facilities. A breakthrough on the third point was achieved when the Commission struck an agreement with ARCO Petroleum Products Company for the establishment of up to twenty-five M85 fueling facilities in the state.

Cooperative Agreements with Retailers

The agreement with ARCO broke open the retail fuel market to fuel methanol. As the first major fuel retailer to participate in the California Methanol Demonstration, ARCO was also the most prepared in terms of reformulated gasoline (RFG) development. ARCO had developed its own proprietary formula for RFG, which it

produced and tested in two grades called ECX and EC-1, one to replace the need for leaded gasoline for customers with older vehicles and one provided a reformulated premium gasoline for its premium gasoline customers. In addition, through its subsidiary Lyondell Petrochemicals (a large methanol producer), ARCO had its own supply of oxygenates in the form of methanol for the feedstocks needed to produce RFG.

Soon after the ARCO agreement was finalized, Chevron U.S.A. Inc. also sought and approved a similar agreement to establish and operate up to twenty-five M85 retail stations. Other companies (Mobil Oil, Exxon, Shell, Texaco and Ultramar Refining and Marketing) entered into such cooperative agreements over the ensuing two years, leading to the establishment of some 54 publicly accessible major retailer M85 fueling sites. The stations established under these Cooperative Agreements are shown in Table 1, "Major Fuel Retailer M85 Stations - January 1996." (This table shows 53 stations now operating; an additional station will soon be established by Chevron to replace a previously closed M85 site.)

In addition, large fleet operators were approached about siting stations to serve both their FFV fleets and the general public; one of these, GTE California, has established a public fueling site at its location in Thousand Oaks, CA. As the enthusiasm of the major fuel retailers to site methanol stations waned, the Commission sought assistance from the local air quality management districts and various independent fuel retailers to continue its station siting efforts. This has led to the establishment of an additional 13 sites, seven of which are open to the public. These are shown in Table 2, "Independent Fuel Retailers and Others M85 Stations - January 1996."

Company	Stations in operation	California Location	
		North	South
ARCO	14	2	12
Chevron	13	7	6
Exxon	5	5	
Mobil	3		4
Shell	12	4	8
Texaco	3	1	2
Ultramar	2	1	1
GTE Corp.	1		1
Total:	53	20	34

Company	Stations Operational or under Construction	California Location	
		North	South
Olympian Oil	1	1	
P.C.I.	1	1	
E.R. Vine & Sons	1	1	
Ramos Oil	1	1	
Hertz (private fleet)	6		6
City of Yorba Linda	1		1
Parallel Products	1		1
Brea Auto Spa	1		1
Total	13	4	9
	(7 retail)		

The Cooperative Agreements that were signed with the fuel retailers called for the Commission to purchase all the necessary equipment for each fuel methanol location. In turn, the fuel retailer was obligated to install, operate and maintain that equipment for a period of ten years. The equipment purchased included the underground

storage tank, fuel dispensing pump, all product and vapor recovery lines, flame arrestors, dispenser, filter, hose, nozzle and a stand-alone fuel card reader.

Retail Facility Selection and Siting

Initially, in order to determine the potential M85 fueling sites the Commission would search the retailer's listing of available station locations within their respective networks for those that matched the planned placement of the FFVs fleets. This process soon proved unworkable, since the retailers faced other constraints such as limited lot size, site parking configurations, lack of adequate ingress and egress for the site or other, proprietary reasons and hence would not always approve the specific stations requested.

Once a mutually acceptable site was agreed to, the locations of the tank and dispenser were then discussed. For the most part the location of the tank was an engineering decision, based, for example, on where there was adequate room for the 10,000-12,000 gallon underground M85 storage tank (UST). The dispenser locations, however, were another matter. Several of the major fuel retailers did not allow the placement of methanol dispensers on the regular fueling islands.

The Commission had little or no discretion in the final placement of the dispenser on the fuel retailers' property but nevertheless appealed for the most suitable locations with some limited, positive results. Perhaps the worst dispenser location was at the Santa Ana ARCO site where the tank was placed at the front of the facility near the fueling islands, but the dispenser and card reader position, where the actual methanol fueling took place, was relegated to the rear of the facility, in the back corner of the site next to the trash dumpster. Despite this particular dispenser location, the Santa Ana site remains one of the highest volume stations in the network.

Petroleum Industry Opposition to Fuel Methanol

The issue of dispenser location is noteworthy because it indicates how some of the retailers viewed this alternative fuel relative to the conventional diesel and gasolines which were always well displayed and actively marketed and advertised. Although some of the fuel retailers placed the methanol dispensers in appealing locations adjacent to the other fuels marketed at

these sites, none have undertaken marketing efforts for M85. Despite the cooperation received from station operators, the retailing companies have generally lobbied against methanol as an alternative fuel in various public forums.

Opposition soon emerged to the expanding demonstration programs for clean, non-petroleum alternative transportation fuels in California. Signs of this opposition appeared for example, at a dedication ceremony for the ARCO M85 fueling facility in Sacramento, the state capitol on March 21, 1990. On this occasion, Commission Chairman Charles Imbrecht, Governor George Deukmejian and ARCO President George Babikian took part in the dedication of an M85 fueling facility installed at an ARCO station located just nine blocks from the Capitol building.

After remarks from Chairman Imbrecht and Governor Deukmejian regarding fuel methanol and the state's efforts to develop the potential for this promising alternative, non-petroleum fuel, Babikian used the occasion to announce the commencement of the U.S. Auto/Oil Study, a reported \$2 billion cooperative effort between the three U.S. auto manufacturers and fourteen major oil companies. This research effort would study methanol and reformulated gasoline, among other things, and was expected to assert the probable ascendancy of reformulated gasoline as the favored motor fuel, in comparison mainly with fuel methanol.

Of the study's initial findings, California Air Resources Board (CARB) Chairwoman Jananne Sharpless said "The study compares air pollution from dirty gasoline that is already outdated in California with emissions from cars equipped with pollution controls that will be obsolete by the time any methanol cars are mass-produced" (National Petroleum News, 1992). The Auto/Oil study remains ongoing.

Non-Public Methanol Fueling Facilities in California

In addition to the publicly accessible M85 dispensing system described above, the Commission was active in assisting various other

fuel methanol demonstration participants to establish methanol storage and dispensing systems at their sites. Chief among these was the Safe School Bus Clean Fuel Efficiency Demonstration Program, initiated as a result of Assembly Bill 35 passed in 1988 and sponsored by Assemblyman Richard Katz. Under this program, modern, alternative fueled and clean diesel buses were provided to school districts throughout California, including some 150 methanol school buses operating on M85 or M100 (depending on engine configuration) (California Energy Commission, 1989, 1993a). Non-public methanol fuel storage and dispensing facilities were installed at a number of school district sites to serve these buses; in other instances, the districts utilized nearby public M85 stations. Several state and local agencies, most notably the California Department of Transportation (Caltrans), also established private methanol dispensing facilities to serve their own equipment.

M85 Electronic Point-Of-Sale System

As the fuel retailers turned their efforts toward the Auto\Oil Study, the Commission sought to perform essential functions for the distribution of fuel methanol including the development of an Electronic Point of Sale (EPOS) system to handle M85 sales transactions. In addition, it was deemed necessary by the fuel retailers to devise some fail-safe means of preventing misfueling of conventional gasoline vehicles from the methanol dispensers. The system that evolved was a dedicated magnetic stripe card reader network that is located at all methanol fuel retail sites.

At the outset of its Cooperative Agreement with the Commission to provide M85 for the 5,000 FFV demonstration, ARCO proposed the use of Gascard, Inc., a fuel-card access and management company with which ARCO had been doing business since terminating its own proprietary fuel credit card. The Gascard system performed well and has provided an effective means of preventing cross-fueling (dispensing M85 into gasoline or diesel vehicle). However, the need for drivers to

carry an additional fuel card just to access and pay for fuel methanol was seen as overly restrictive; it also entailed additional operational costs to the fleets and the Commission for maintenance and operation of the special M85 card reader network.

Prevention of Misfueling with M85

The M85 Fuel Retail Network continues to rely on the dedicated EPOS system for controlling access and managing fuel transactions for the fifty-three (soon to be sixty-one) retail sites. However, in an effort to reduce the residual inconvenience of the special EPOS system, some other means of preventing misfueling was sought, so that M85 transactions could be handled like those for conventional fuels. To this end, the Commission held a public workshop in December 1993 to investigate fuel nozzle configurations that could potentially be suitable for providing a simple alternative means of preventing cross-fueling, and to address the issues of methanol fuel compatibility with dispensing components and materials. The workshop was widely attended by dispenser manufacturers, automobile manufacturers, fuel retailers and staff from regulatory agencies including CARB and the U.S. Environmental Protection Agency.

Discussions at the workshop with regard to the nozzle configuration led to a consensus among the participants that an M85-specific fuel nozzle design would either be impractical or ineffective. The fuel retailers were concerned that if a specially-designed methanol fueling nozzle could be easily defeated, the lower-per-gallon price for M85 would induce unwitting customers to fuel their gasoline or diesel vehicles with M85 by use of an adapter, thereby subjecting the fuel retailers to a potential liability for misfueling. The retailers were adamant that warning signage on the dispensers would be inadequate as a protection and that some positive means of preventing misfueling was essential. A number of mechanical, optical and electronic interlock devices were suggested at the workshop for this purpose (California Energy Commission, 1993b). Subsequent to the workshop, the Commission began an investigation through its technical

support services contractor, Acurex Environmental Corporation, into what sort of interlock device would best meet the purposes of misfueling prevention. As a result of this inquiry, it appears that radio frequency identification (RFID) transponder technology will best meet these needs (Acurex Environmental, 1994).

Since the 1993 workshop, the Commission in conjunction with the Society of Automobile Engineers (SAE), Ford Motor Company, General Motors, Chrysler and fueling equipment components manufacturers, has been investigating the potential use of RFID technology to provide a safety system for the prevention of cross-fueling and develop a uniform standard for implementation. The SAE Misfueling Lockout Task Force effort will soon lead to the adoption by the SAE of standards for the M85 fueling technology application. The Commission hopes to test the technology in 1996-97 at one or more California M85 fueling locations. Once proven, with the support of the fuel retailers and automobile manufacturers, the Commission would like to apply the technology throughout the M85 retail network, thereby eliminating the inconvenience and additional costs of using the

segregated fuel access card.

The California Fuel Methanol Reserve

Another key component of the 5,000 FFV demonstration program was the creation of the California Fuel Methanol Reserve (CFMR), a mechanism developed to provide a constant fuel methanol supply from several suppliers to wholesale customers and the M85 Retail Network at stable, consistent pricing. Developed in February 1988, the CFMR was carefully designed to comply with anti-trust laws regarding pooled supply and fuel pricing.

The CFMR has sought supply commitments from suppliers, and the Commission has determined the threshold price on a quarterly basis and served as the CFMR Administrator. Clients of the CFMR were qualified by the Commission in order to assure that the methanol went to on-road fuel demonstration purposes only. Once accepted in the CFMR, the individual clients entered into their own credit relationships with

Calendar Year	Large users (over 5 million gallons/year)	Small users (5 million gal/year or less)	Total Demand
1990	- N/A -	1,082,206	1,082,206
1991	- N/A -	1,704,479	1,704,479
1992	- N/A -	2,697,861	2,697,861
1993	9,050,005	1,757,517	10,807,522
1994	10,000,822	2,025,110	12,025,932
1995	9,473,457	2,174,504	11,647,961

from: CFMR1995.xls JMT 1/8/96

all the suppliers. Fuel orders placed through the CFMR were rotated among the suppliers to provide an equitable distribution of fuel methanol sales among all suppliers. The annual volumes of fuel methanol to the light and heavy duty transportation sectors are shown in Table 3.

The CFMR and Methanol Price Stability

The CFMR has served as a successful means of providing a reliable supply of fuel methanol at consistent pricing. Figures 1 and 2, "Methanol Price History (1/90 - 12/95)" and "Effects of

Methanol Pricing (1/90-10/95)" show the extent to which the CFMR has stabilized fuel methanol prices in the face of commodity market swings, and how this has flowed through to fuel methanol prices at the retail pump, compared to gasoline.

Over the eight years of its operation the Reserve has met the methanol demands of its clients without significant interruption, even during times of tight or short supply. The methanol industry representatives participating in the CFMR worked together in difficult times, diverting rail cars to California or trucking methanol from northern California terminals to meet the needs of clients in southern California, particularly the Los Angeles County Metropolitan Transportation Authority (LACMTA), while absorbing the cost in order to meet their CFMR commitments. Overall the CFMR pricing has closely tracked the methanol market pricing. The principal exception to this pattern was the price run-up in 1994-95; whereas the spot market price of methanol exceeded \$1.60 per gallon during this time, the CFMR price never exceeded \$0.67 per gallon FOB terminals.

At the CFMR's inception, it was thought that supply interruptions and price swings would seriously hamper the effort to fairly demonstrate, evaluate and test this promising fuel. The CFMR may well provide a model for use by methanol and other new fuels on a national scale in the future as this supply mechanism successfully met all the expectations placed upon it from the start.

The Issue of Fuel Quality and Materials Compatibility

The definition of fuel methanol compatibility has broadened over the past several years, as a result of the experience in the California methanol demonstration. Initially, "methanol compatibility" meant that the fueling system hardware components would not deteriorate as a result of coming in contact with the fuel, since this alcohol is an aggressive solvent and is more corrosive than conventional gasoline or diesel, and even ethanol. Vehicle fuel system malfunctions, however, led to

an awareness that the fueling system parts could impair the quality of the fuel itself. As a result, the definition of methanol compatibility has been expanded to include the condition that the fuel quality not be deteriorated by coming into contact with components or materials which are not themselves methanol compatible. Based on discussions of this issue internally and at the 1993 Commission workshop discussed above, the American Automobile Manufacturers Association has proposed a standard definition of methanol compatibility which accounts for both sides of the issue (AAMA 1994).

FFV Fuel System Failures and Fuel Quality

Protecting fuel quality became a paramount concern among all participants in the California M85 program as FFV fuel filters and fuel pumps began to show deposits of unidentified substances which substantially affected the performance and reliability of the vehicles. The vehicle fuel system malfunctions quickly became a matter of great concern to the auto makers, who sought to bring high quality FFVs to market and who were now confronted with serious warranty repair and replacement costs. In response, the manufacturers contemplated scaling back efforts to produce the large number of FFVs required for the California market.

General Motors in particular noted high rates of fuel system failures on its vehicles, especially the California Department of Transportation (Caltrans) fleet of 299 FFV Lumina statewide, which it attributed to fuel quality problems. Over the past three years, tens of thousands of dollars have been spent by the Commission and the auto manufacturers to identify the substance(s) found on the filters and pumps, its origin and how to prevent the recurrence of such deposits. Researchers from the automobile manufacturers, fuel providers and fueling system component makers turned attention to the issue (CRC 1992). Some of these analytical efforts are described in more detail in another paper at this conference (McCormack, 1996).

Materials Compatibility

Investigations into the concerns surrounding fuel quality indicated at least three possible sources of contamination from fuel-wetted dispenser components: unprotected aluminum or certain other metals in the dispensing systems (such as the fueling nozzles), the elastomers used in conventional gasoline product hoses and other seals in the system, and the detergent additives used in the gasolines being mixed with the methanol. These three possible sources are discussed below.

Unprotected Aluminum and Other Metals

It had been well known that methanol would corrode unprotected aluminum, zinc and certain other metals and alloys, and the fuel system components on FFVs were designed with this in mind. Accordingly, attention was turned to the fuel dispensing equipment. It became necessary to perform complete inspections of all components, and the materials that made up those components, within the M85 fueling systems to determine whether and where they might include reactive metals that could be subject to attack by methanol.

The inspections revealed that not only the nozzle but the vapor recovery splitter valve and certain other dispenser internal parts were typically fabricated from cast aluminum. Since aluminum was one of the substance identified on filter and fuel pump deposits, Commission staff initiated joint efforts with the components manufacturers and Ford Motor Company to devise means of protecting the aluminum surfaces which came into contact with methanol. The component manufacturers responded quickly adopting electroless nickel-plating for their methanol dispenser components. Although this entailed the additional expense of plating, this measure proved effective in preventing fuel contamination from corrosion products, despite long dwell times in contact with the fuel.

Elastomers for Dispenser Product Hoses and Seals

Compounds used in the manufacture of gasoline and diesel product hoses were found on the filter and fuel pumps of the failing fuel flexible

vehicles, indicating that the fuel methanol was leaching contaminants from elastomers and/or filler materials. Consequently, the development of methanol-compatible hose material to replace the existing M85 dispenser hoses was essential.

In the early years of the California fuel methanol demonstration, methanol dispensers employed cross-linked polyethylene hoses in a two-hose configuration, one hose for the product and one for the vapor recovery. However, with the development and widespread adoption of coaxial hoses for Stage II vapor recovery fueling systems (an inner product hose inside a larger vapor return hose) the cross-linked polyethylene product hose ceased to be available for use in the M85 retail network or at private fueling locations.

At this point, Goodyear Tire and Rubber Company approached both Ford and the Commission to collaborate on efforts to providing more impervious and compatible product hose material for the demonstration. The initial hose material developed by Goodyear for use with methanol was better than the typical gasoline hose material, but it still leached material into the fuel to an unacceptable degree. After considerable development and testing, a breakthrough was achieved using a Nylon 11 veneer applied to the inner surface of the inner product hose, resulting in a reduction of hose leaching to nearly undetectable levels.

Goodyear continues to provide the Nylon 11-lined hoses for the demonstration program and has made this hose available for all fuel methanol systems in California. Replacement hoses are readily available through their California distributor, Titan Rubber of West Sacramento.

Gasoline Detergent Additives

During the investigation of fuel quality, fuel detergent additive residue was discovered along with other materials such as aluminum and hose compounds mentioned above. It was soon determined that one of the two most commonplace families of gasoline fuel detergent additives, the polyetheramines, was compatible with methanol, whereas the other one, the polybutylamines, was

not. Although it was not been conclusively demonstrated that the incompatible additive directly causes the deposits on vehicle fuel filters and fuel pumps, it was deemed prudent to recommend the use only of the compatible polyetheramines in the gasoline used to blend M85.

Some synergy between the polybutylamine additives and the other fuel contaminants has been theorized, however. It is thought that the other substances found on the vehicle fuel filters, aluminum and leached elastomers, once adhering to the filter medium in the form of a gelatinous substance, turned the filter into a sticky, sponge-like medium through which the fuel additives cannot pass, as they typically do. Further research may exonerate polyetheramines from a role in fuel contamination and filter plugging, and other detergent additives may be used in gasoline to blend M85.

It should be noted that many different gasoline additive packages are in practice blended with fuel methanol in the FFV fuel tanks, since these vehicles are often refueled with a variety of unleaded regular gasolines. The need to specify a particular gasoline additive may diminish in importance since the fuel additives, once thought to be significant problem for M85 fuel quality, is not now as large a concern.

Methanol Refueling Facility Inspection

Additionally, the Commission has now provided electroless nickel-plated M85 fueling nozzles, one plus one replacement, one vapor recovery splitter/adaptor, one Goodyear coaxial nylon 11 fueling hose and one cross-linked-polyethylene jumper hose to all retail fueling facilities in the Commission's M85 network as well as to all the school bus sites. Commission staff have conducted inspections at all fuel methanol retail and school bus fueling facilities as well; equipment discrepancies were noted and brought to the attention of the respective site operators. Further, similar site inspections are performed on a semi-annual basis and the current series of inspections, encompassing some 108 retail, school

bus and Caltrans fueling sites, will be completed in March 1996.

Much of this work has been continued by the Commission as many of the fuel retailers, with the exception of Exxon, have reduced their participation in the M85 fuel station program. Table 4 shows the number of stations proposed by each major fuel retailer, and how many have been established to date.

The first fuel retailer to withdraw their commitment was Chevron, U.S.A. on March 30, 1992 (Chevron 1992), with a letter to Governor Pete Wilson. ARCO notified the Commission that it too would establish no more M85 stations in a letter dated February 9, 1995, to Chairman Imbrecht, and Shell followed on October 17, 1995 (ARCO 1995). All three companies indicated, however, that they would continue to operate their existing M85 facilities. The other retailers declined to establish additional stations when requested by the Commission, which itself had budgeted funds sufficient to establish the full complement of all stations previously proposed.

**Table 4
Public-Private Agreements with
Oil Companies**

<u>Retailer</u>	<u>Total Proposed</u>	<u>Total Constructed</u>
ARCO	25	14
Chevron	13	13
Exxon	5	5
Mobil	10	4
Shell	14	12
Texaco	9	2
Ultramar	5	2
Total	81	52

Status of the California Fuel Methanol Market

At present the fuel methanol market in California is at a crossroads. While usage and therefore distribution volumes have decreased of late, there may still exist a significant market opportunity for the methanol industry, if a well developed and strongly supported business strategy is implemented soon.

Decreased Methanol Demand

One of the largest users of fuel methanol has been a large methanol-powered transit bus fleet, operated by the Los Angeles County Metropolitan Transportation Authority (LACMTA). For a variety of reasons, including the increased operational expense attributed to its heavy duty methanol bus engines, LACMTA has moved to convert its methanol bus fleet to ethanol or other fuels, leading to a major decline in CFMR throughput. The lower fuel usage volume for the LACMTA bus fleet is significant: once averaging in the range of 833,000 to 1,000,000 gallons per month when all 333 fuel methanol buses were running, to a current average of less than 600,000 gallons per month, as its methanol buses are converted to other fuels. Proposals have been made to convert the entire fleet back to diesel service.

Fuel methanol, once the only available certified low-emission alternative fuel technology for heavy duty applications, now suffers from unacceptably high maintenance costs coupled with reduced field support by engine manufacturers, compared to the other alternative fuels. At present there is little new methanol heavy- or light-duty engine development planned or under way.

The fuel usage volumes have also decreased through the M85 retail fuel network over the past two years, despite the fact that the number of FFVs operating in the state have grown steadily, as indicated in Figures 3 and 4, "M85 Monthly Retail Volumes (12/91-11/95)" and "Cumulative Population of FFVs in California." This odd paradox of increasing vehicle population and decreased fuel usage proves (unfortunately, in this case!) that fuel flexible vehicles are an outstanding technical success. The decline in light-duty methanol consumption may be due to some

combination of the following factors:

- FFVs purchased by fleets to fulfill regulatory requirements, such as the alternative fueled fleet rules under the Energy Policy Act of 1992, are not required to use M85.
- There is a nearly universal lack of M85 fuel access and availability information provided by vehicle manufacturers at the time of sale to fleets or individuals purchasing either new or previously owned FFVs.
- There are still too few M85 fueling locations for true convenience in competition with conventional fuels.
- A dearth of fuel retailer or methanol industry marketing, public education and outreach to fleets regarding the air quality and/or energy security benefits, and a lack of assurances regarding stable fuel supply and pricing.
- A common misperception that fuel methanol and M85 may be very costly, which is a lingering result of the price run-up of 1994-95. While prices have returned to levels existing prior to the increase, many customers may not have heard this and/or are concerned about the possibility of future price escalations.

At present, M85 is a premium fuel in terms of its octane value (102 octane, (R+M)/2) and it is more competitive price-wise with premium unleaded gasoline than with unleaded regular. Bringing the price down to at least match that of unleaded regular gasoline would doubtless help improve fuel utilization rates. Table 5 shows a typical price calculation for retail M85.

Opportunities with Rental Car Fleets

The reduced fuel demand by the heavy duty fleet may allow a better focus on the M85 retail opportunities. Along these lines, the rental car fleets have been an excellent mechanism for both bringing large numbers of fuel flexible vehicles into the state and introducing FFVs to the public on a trial basis, without the need to purchase the

vehicles. Historically, the rental fleets have been unable to assure a high M85 usage rate as it was not feasible to provide fuel access cards to their customers. Without the ability to refuel with methanol during the rental of the FFV, and in view of the conditioned need for drivers to return the cars fully fueled, these cars often operated primarily on gasoline rather than M85.

This situation shows signs of improvement, however. Hertz Rental Car has been a leader in the acquisition and operation of FFVs in their California operations and has been an outstanding example of corporate commitment, along with their parent company Ford Motor Company, the leader in FFV development and marketing. In a cooperative cost-sharing arrangement with the Commission and the South Coast Air Quality Management District (SCAQMD), Hertz has established eight M85

Table 5
Calculation of Nominal M85 Pump Price
from CFMR M100 Threshold Price

<u>Factor</u>	<u>Cost</u>
CFMR Threshold Methanol Price, gallon [1]	\$0.50
Rack price of unleaded regular gasoline [2]	\$0.69
Rack price of M85 [3]	\$0.53
Mark-up, gallon [4]	\$.15
Hauling & other distribution, gallon [4]	\$.04
Federal excise tax [5]	\$.113
State excise tax [5]	\$.09
Sales tax [5]	8.25%
M85 pump price	\$0.99
Energy equivalence factor [6]	1.6
MPG equivalent price to consumer	\$1.58
Avg. cost of gasoline, tax included [7]	\$1.35
Retail gasoline, Northern California [8]	\$1.08- \$1.15

[1] CFMR posted price for M100, FOB terminals, as of October 1, 1995.

[2] from PIIIRA reports for California, RAMIS output 7/17/95

[3] Blend of 85% methanol and 15% gasoline.

[4] Varies by retailer and station location; estimated from CEC M85 network data

[5] CEC Fuel Resources Office, January 1996

[6] Based on Auto-Oil data, best case.

[7] CEC value is from PIIIRA reports for California, RAMIS output 4/17/95; weighted avg. of untaxed retail (1991-2nd Q1994) = \$.9528, plus current taxes of \$.3640 = \$1.3469

[8] Sacramento Area, January 1996

fueling systems at their airport rental car facilities in California. In addition, Hertz has altered the customary "bring it back full or pay a premium"

policy to allow FFVs to be fueled with M85 upon return. This clearly gives priority to assuring high M85 fuel utilization in their FFVs.

Looking Ahead

At this point, the future of the California fuel methanol experience carries importance far beyond the numbers of FFVs purchased and operated or the actual fuel volumes distributed. The California demonstration effort, now at the stage of commercialization, continues to be the largest, most successful and most publicized fuel alcohol endeavor, linking the largest number of FFVs in a national region with the largest retail fuel station network.

Should the market development and growth of the fuel methanol market in California not be supported by both government and the methanol industry, one consequence could be reduced support and market for reformulated gasoline (RFG) oxygenate requirements, a new market now enjoyed by the methanol industry. In addition, other alternative fuel development efforts in general, and compressed natural gas (CNG) and ethanol specifically, could be adversely affected should the credibility and sustainability of alternative fuels generally be called into question.

The dominant petroleum fuels industry remains strongly competitive and it will not willingly relinquish market share to viable, competitive, non-petroleum transportation fuels. As the lessons learned from the oil embargoes and price escalations of the 1970s fade from memory, the efforts to develop beneficial and sustainable, non-petroleum alternative transportation fuels may be in danger. Meanwhile, California remains more than 99% dependent on petroleum for transportation fuel, and the U.S. as a whole now meets some 53% of its oil needs with imports, up from 35% in 1979.

The decline in fuel methanol demand points to a crossroads for the fuel methanol industry, and an industry focus on market development is urgently

needed. Despite this fall-off, the market growth potential for fuel methanol remains promising. But the potential market thus far created by the California initiatives, involving expenditure of over \$42 million for vehicles, school buses, vehicle purchase incentives and M85 retail fuel infrastructure, needs attention and additional investment now if it is to prosper.

The next steps are straightforward in concept, if not in the details of implementation. The methanol industry, which has been oriented historically towards wholesale commodity markets, needs to apply simple retail marketing strategies and to establish a strong California presence now. The result could be firmer markets for other methanol uses, more stable methanol prices, and a steady outlet for surplus methanol production.

If fuel methanol were priced in a manner directly competitive with unleaded regular gasoline as little as three months ago, the methanol price (competitive with unleaded regular gasoline) now in competition with RFG could enjoy a predictable and succinct value and price increase as the higher-priced RFG becomes ubiquitous in the California gasoline market.

The Commission will soon go out to bid for a contract to supply fuel methanol for the next 3-5 years. The bid proposal will seek wholesale fuel methanol pricing directly competitive with the wholesale gasoline pricing in California (RFG), on a volume weighted average across all grades of gasoline. Supply security and gasoline competitive pricing are essential components now to the continuation and growth of the fuel methanol market in California, and very likely, the nation. The fuel methanol industry can succeed in California but a new approach is needed. Close relationships must be formed with fuel retailers, many of which are now indirectly methanol customers for MTBE production and some of whom are now retailing M85 at a few stations. In addition, relationships with vehicle manufacturers must be re-formed and strengthened, to encourage further methanol vehicle and engine development. Finally, marketing, educating the public and lobbying the decision makers are keys to building

a cohesive and sustainable fuel methanol market in California.

Conclusions

The methanol demonstration program in California has resulted in a number of successes, due primarily to cooperative efforts involving the fuel retailing companies, the vehicle manufacturers, vehicle fleet operators and state and local governmental agencies. The program has demonstrated the feasibility of methanol as a transportation fuel in a variety of applications. The future of methanol as a motor fuel is now at a crossroads, poised as it is for further commercialization and yet facing strong competition from other fuels.

There are four principal conditions to the continued expansion and ultimate success of methanol as a transportation fuel. These are

- M85 priced and distributed to be competitive economically with conventional motor fuels;
- The establishment of business relationships between the methanol industry and existing fuel retailers to expand the availability and promote the use of fuel methanol;
- The establishment of relationships between the methanol industry and vehicle and engine developers and manufacturers;
- The cultivation of relationships with fleet customers, along with a program of public education, marketing and advertising and a presence in state and federal policy-making forums.

An extraordinary collaboration by vehicle makers, fuel retailers and state agencies has brought this market opportunity into being, and it will not be easily recreated, once allowed to lapse.

Disclaimer

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position of the California Energy Commission, its Commissioners, or the State of California, or any other party mentioned herein.

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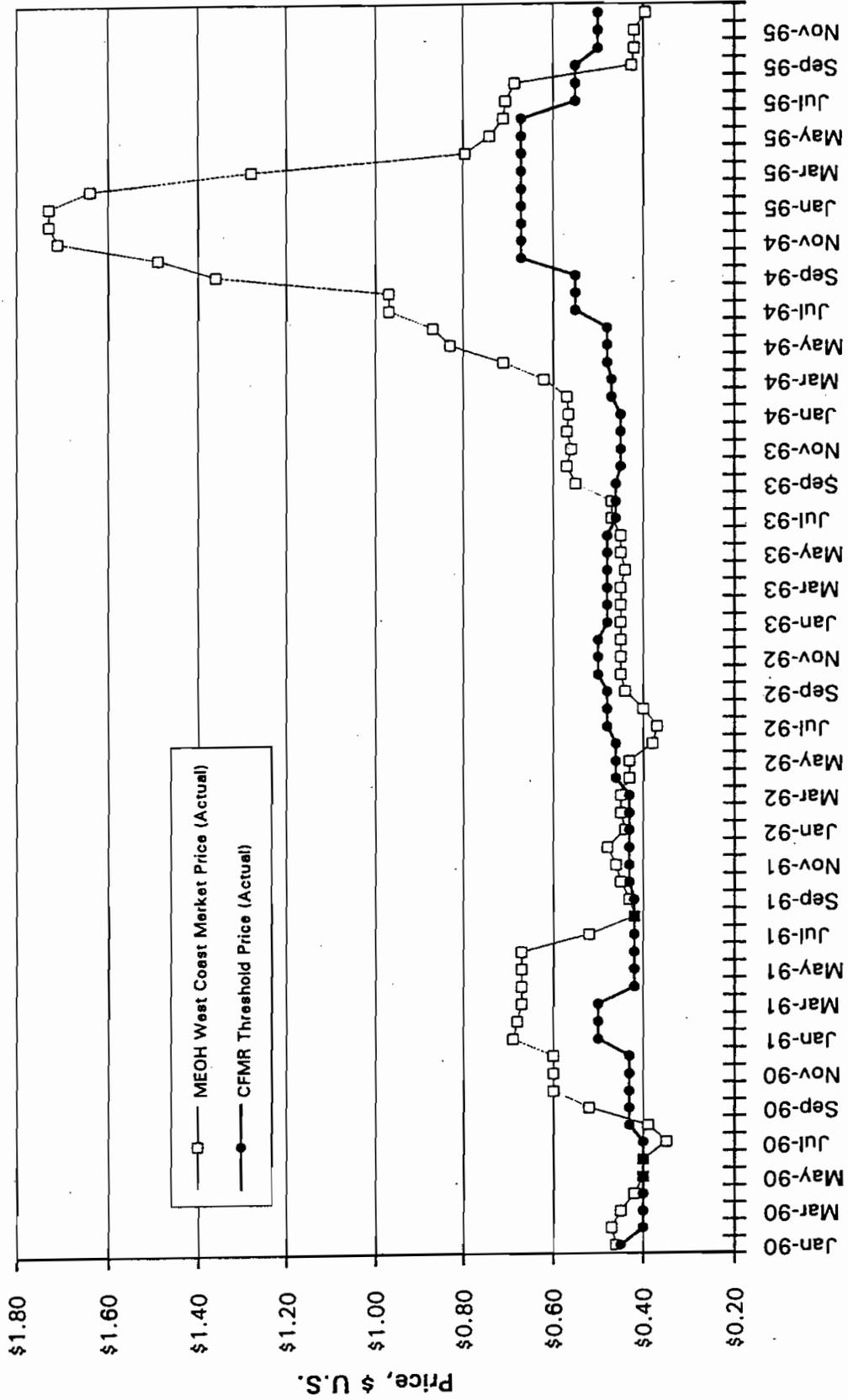
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Figure 1
Methanol Price History (1/90 through 12/95)



** MeOH Spot Price from New Fuels Report (1/24/90 - 4/14/94, 9/95 - 12/95); TECNON (5/1/94 - 8/11/95)

Figure 2
 Effects of Methanol Pricing (1/90 - 10/95)
 Energy Equivalent Prices, Compared to ULR Gasoline

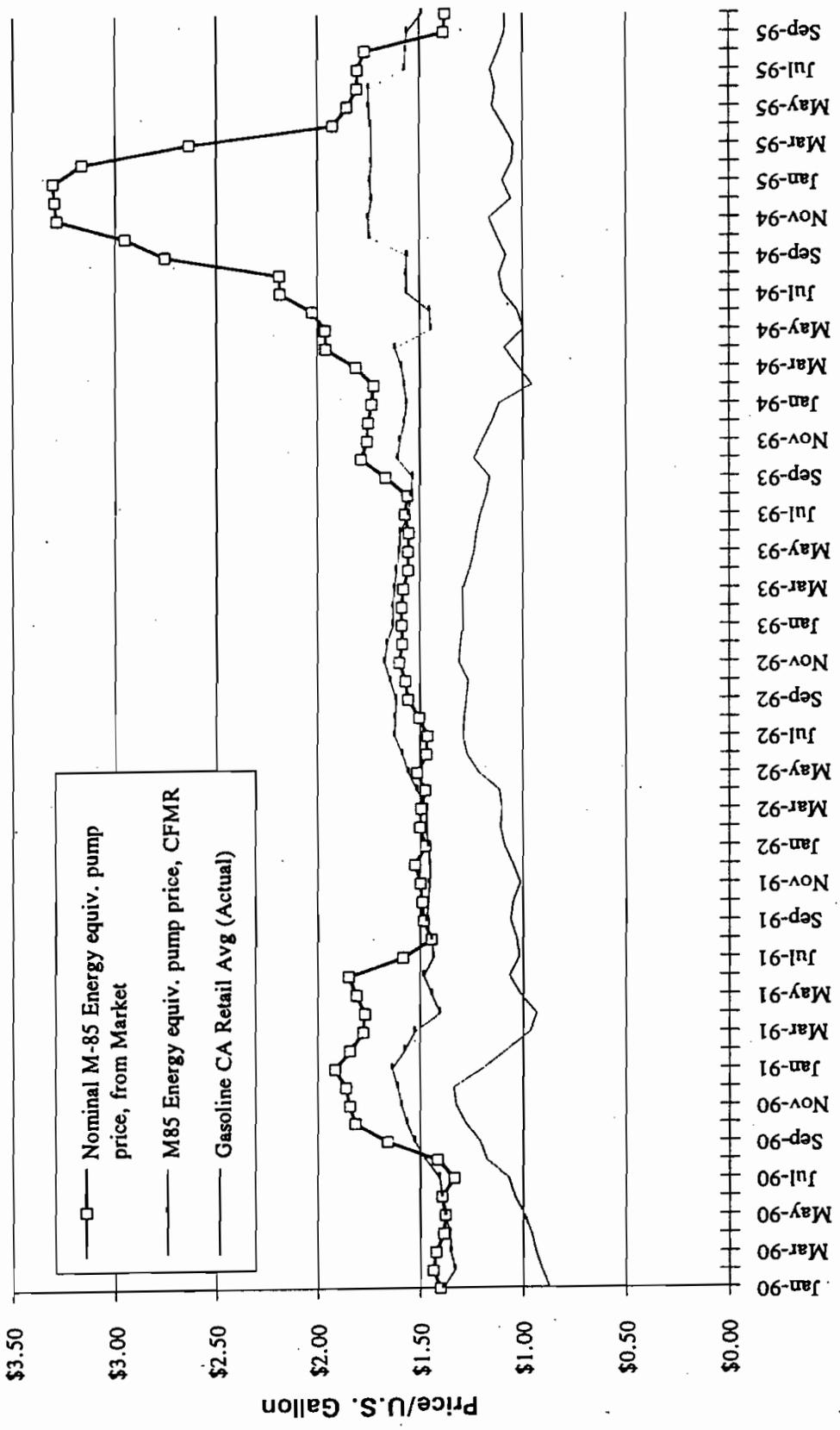


Figure 3
California M85 Monthly Retail Volumes (12-91 - 11/95)

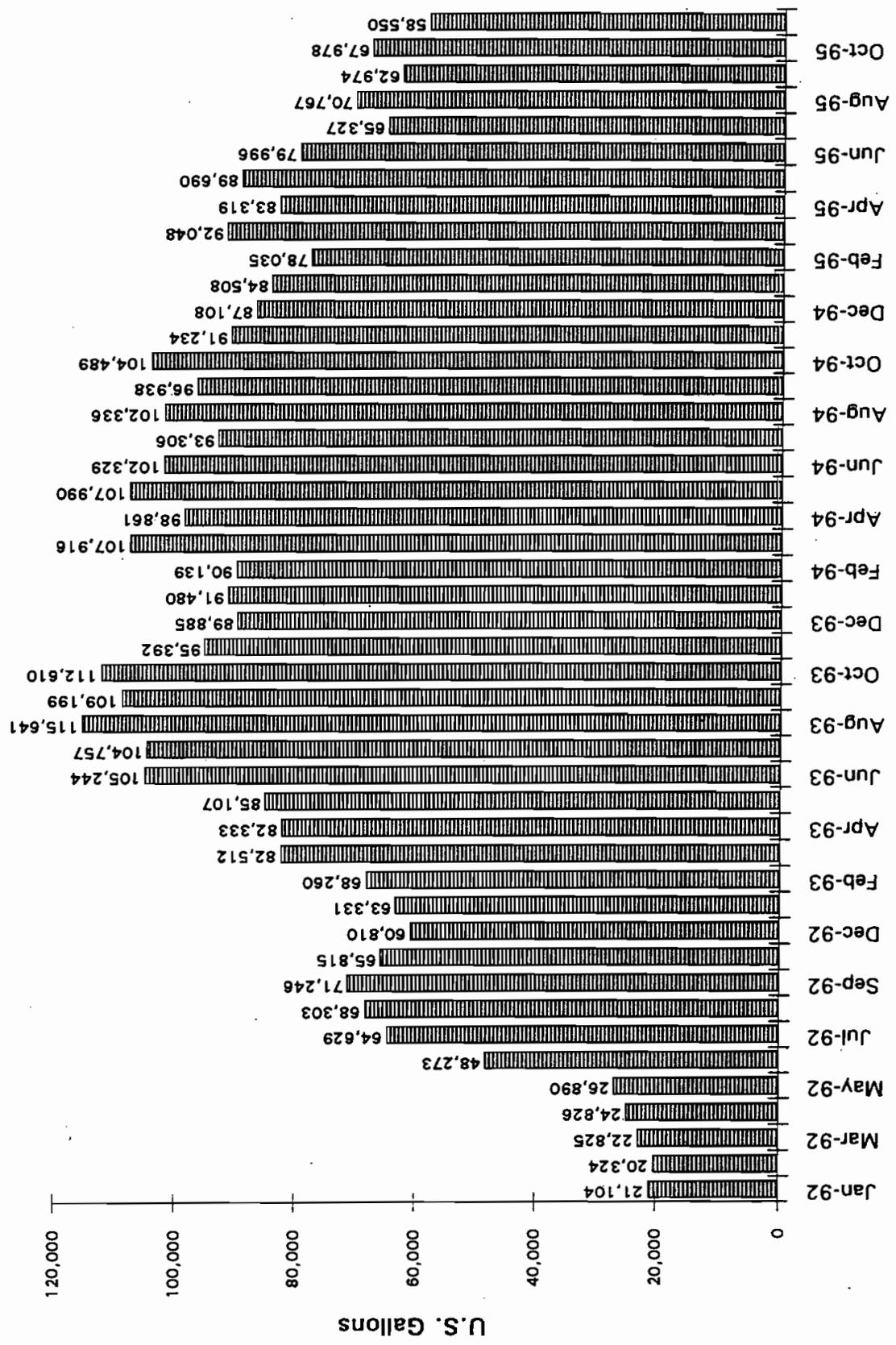
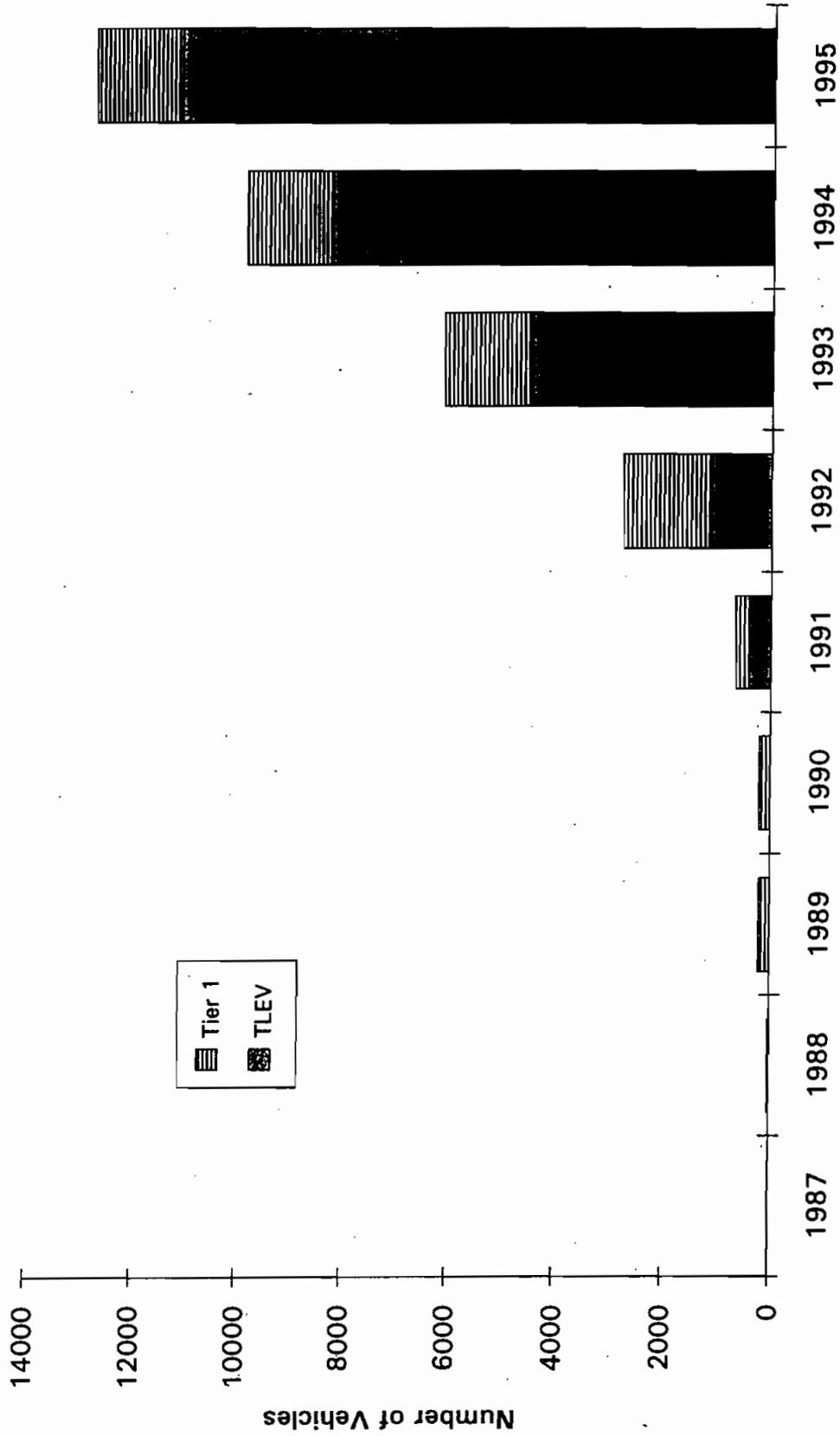


Figure 4
Cumulative Population of FFVs in California



Source: CEC Transportation Technology and Fuels Office, June 1995

Background

The start of California's experience with alternative transportation fuels began, in response to oil shortages of 1973 and 1979, with the passage of Senate Bill 620- Statutes of 1979. SB 620 was a multi-faceted omnibus mass transit measure. Among its many provisions, it allocated the sum of ten million dollars "to investigate the practicality and cost-effectiveness of alternative motor fuel" (SB 620). This terse mention of alternative fuels was the first California public policy initiative for the development of alcohol fuels. The then-recently created Energy Resources Conservation and Development Commission, also known as the California Energy Commission (Commission), was given the responsibility for carrying out this investigation.

It is instructive to recall the historical context for this proposal. The year 1979 saw the second major energy crisis in the decade, which was evidenced by motor fuel scarcity and the resulting steep escalations in fuel prices paid at the pump, if and when fuel was available. Odd- and even-day fuel rationing, consumers topping-off vehicle fuel tanks at every opportunity, and government-imposed fuel allocation programs marked this period. A variety of measures were adopted in the attempt to alleviate the market disorder that was caused by the relatively small shortfall in world oil supply and exacerbated by the inability of oil companies to quickly augment supply.

Another, perhaps longer term result of this second "petroquake" was the response of United States society generally. An unprecedented array of programs were launched to adapt to the anticipated increases in oil prices. These programs sought to initiate lasting changes in the nation's the energy mix and to educate the populace about energy issues, efficiency measures and alternative fuels. Significant societal changes with respect to energy policy, production, use and conservation occurred as a result. At that time state and national policy makers attempted to address the need to secure supplies and manage the demand for an essential commodity, the use of which pervades the fabric of industrial societies.

Nowhere is dependence upon petroleum more evident then and now than in the transportation sector.

It is worth noting that the issue of reducing vehicle emissions to improve air quality, which has been a central argument supporting the development of alternative fuels over the past ten years, was not the primary issue of concern when these initiatives were begun. Air quality was seen at the time to be an ancillary issue, although it was acknowledged that the adoption of alternative fuels should not exacerbate air quality problems and could in fact potentially help resolve them.

PROGRAM PLANNING

In planning its investigation into the practicality and cost-effectiveness of alternative motor fuels, the Commission used a three-element approach. The first element consisted of conducting an evaluation to identify and rank the most promising alternative fuels for California given the state's needs and characteristics, and the fuels' potential for domestic production and ability to substitute for gasoline and diesel. The alternative fuels evaluated included electricity, natural gas, methanol, ethanol, hydrogen and propane. At the time the evaluation was conducted, methanol stood out clearly as having the best potential for replacing petroleum on a widespread basis. Ethanol was also considered viable from the standpoint of use, although its supply potential for the state then was considered questionable.

The next element in the investigation of alternative motor fuels was the formation of a two-part demonstration: the demonstration on road of alcohol fuels, both methanol and ethanol, and the feasibility of and potential for the cost-shared establishment of ethanol production facilities in California. While the on-road demonstration showed that both alcohol fuels could be readily used in internal combustion engine (ICE) vehicles, the fuel ethanol production feasibility study for the most part indicated generally unfavorable economics, given the

ethanol production technology available at that time and the cost and availability of ethanol feedstocks.

The third element of the investigation of alternative fuels was comprised of initiatives undertaken with other state and local agencies to overcome institutional barriers and to explore potential incentives, both financial and regulatory, to advance the commercialization of alcohol fuels. The Commission ultimately sought partnerships with state and local agencies and in 1985 formed the Three-Agency Methanol Task Force (subsequently named the Clean Fuels Working Group) with the California Air Resources Board (CARB) and the South Coast Air Quality Management District (SCAQMD) as well as other local districts. This alliance was instrumental in coordinating efforts, preventing duplication and developing strategies for ground-breaking alternative fuels programs (California Energy Commission, 1986).

The investigation into incentives for alcohol fuels evaluated what initial measures should best be implemented to overcome barriers to the commercialization of these promising new fuels. For example, the study found that prior to any development and demonstration of the fuel, the State and Federal excise taxes on alcohol fuels should be modified to be equivalent to gasoline excise taxes on a tax-per-mile basis (this was simplified to adopting a rate equal to one-half the prevailing gasoline rate). This recommendation was adopted in California with the passage of SB 654 (Statutes of 1981), and the Federal excise tax rates for alcohol fuels soon followed suit.

First Demonstration Efforts

Alcohols as Fuel Extenders

The first efforts demonstrating the use of fuel methanol and fuel ethanol involved alcohol blends of 5%, 10% and 15% used in converted 1979 Honda Civics. This demonstration was undertaken to evaluate the use of alcohols as fuel extenders,

increasing the amount of fuel available in times when gasoline supply was curtailed or on allocation. In the course of this work, it was determined that certain blends could reduce the emission of some criteria pollutants, thereby enhancing air quality, while on the contrary other blends resulted in high evaporative emissions that could deteriorate air quality. The successful performance of both alcohols overall in these tests led to other, more ambitious vehicle/fuel demonstrations.

Dedicated Alcohol Test Fleet Program

The State of California then embarked on an Alcohol Fleet Test Program comprised of three separate fleets. These fleets consisted of vehicles produced by two different manufacturers and built or converted for dedicated (i.e., exclusive) alcohol fuel operation. The specific fuel blends used were near-neat blends, typically blended with isopentane rather than gasoline.

Fleet One consisted of eight 1980 Ford Pintos operating on ethanol and methanol and used in daily State fleet service with the Department of General Services and the Department of Transportation for approximately eighteen months. Fleet Two consisted of thirty-nine factory-produced methanol and ethanol Volkswagen of America Rabbits and light-duty pick-up trucks which logged over 350,000 miles in fleet service. These vehicles were the first fuel-injected and factory-produced alcohol vehicles in the United States.

Fleet Three consisted of forty Ford Escorts operating on methanol in the Los Angeles County fleet, which accumulated over 500,000 miles in reliable service. These vehicle were factory-produced as gasoline vehicles, shipped to California and then equipped by aftermarket converters for methanol use.

All three Fleets in the Alcohol Fleet Test Program were evaluated for fuel economy, emissions, driveability and durability. The results were conveyed to the California Legislature in a 1982 report (California Energy Commission, 1982).

The Dedicated Ford Escort Fleet

With the positive results of the preceding fleet tests verifying the potential of alcohol motor fuel technology, the Commission began to carefully plan a more ambitious and varied fleet test using dedicated methanol Ford Escorts. With funding from the California Legislature for the operation and testing of a 500-vehicle demonstration fleet, as well as funding for the establishment of methanol fueling facilities, the Commission set out to gather city, county and state fleet vehicle purchase commitments and to negotiate with independent fuel marketers to establish and operate methanol fueling facilities. The methanol facilities were to be located as proximately as possible to the participating fleets.

With the exception of two retail fueling facilities established for Fleet Two and one Los Angeles County fueling facility established for Fleet Three, the network of methanol fueling facilities established for the 500-vehicle fleet was the first such network of stations established in the United States. Over a two-year period eighteen retail methanol fueling facilities were established, and these stations continued to operate over a period of five years.

Lack of Acceptance of Dedicated Vehicles

The vehicles in the fleet demonstration performed well technically. However, the relatively small number of refueling sites provided limited opportunities for the drivers of the dedicated alcohol vehicles to refuel, despite the stations' proximity to the participating fleets. Overall the program was termed "a technical success, but an emotional failure," due to the comparatively sparse coverage provided by the 18 methanol fueling locations as compared to a statewide population of well over ten thousand retail gasoline stations.

The stress that drivers experienced when trying to locate a methanol station was exacerbated by the lower range experienced from fuel methanol (approximately 60% the range of gasoline from the same size fuel tank). Some drivers noted their anxiety as to whether they would be able to locate

a fueling location and complete their trips. The recognition of this difficulty prompted the development of a truly remarkable technological breakthrough--the fuel-flexible vehicle, or FFV.

The Advent of Fuel Flexible Vehicles

The first FFV, a prototype red Ford Escort, was assembled and delivered to California in 1987. This vehicle and the subsequent thousands of FFVs produced and delivered for sale by Ford, General Motors and Chrysler, were intended to alleviate drivers' concerns about finding fuel for their vehicles. FFVs were designed to operate on variable blends of methanol and gasoline, up to a standardized fuel methanol blend of eighty-five percent methanol and fifteen percent unleaded regular gasoline, designated as M85. Where it was available the driver could fill the vehicle with M85; otherwise, he or she could simply fill the vehicle with unleaded regular gasoline, thereby eliminating refueling worries.

The 5,000 Fuel Flexible Vehicle Demonstration

The momentum gained from the previous fleet tests and demonstrations continued with the subsequent proposal to produce, sell and operate FFVs in one of the largest commercial alternative fuel demonstration fleets in history. Despite the fact that these vehicles were "fuel flexible", capable of operating on methanol or gasoline, it would still be essential to work with the existing fuel retailing industry to make M85 available at as many retail outlets as possible in California.

Conditions for the FFV Demonstration

However, Ford Motor Company insisted that three key elements be put in place prior to its commitment to produce the large number of FFVs for the California demonstration:

1. Passage of Corporate Average Fuel Economy (CAFE) credits for the production of FFVs, based on FFVs being able to operate at least

half the time on methanol (thereby giving credit of one-half the otherwise expected volumes of gasoline);

2. Provision of funding to "buy down" the anticipated differential costs of FFV production; and
3. Cooperative Agreements with major oil retailers for the establishment and operation of a retail M85 fueling network in California.

The state quickly set about satisfying these three requirements. In 1988, fortuitous timing and the collective efforts of many individuals led to the passage of the Alternative Motor Fuels Act, which was signed into law by President Ronald Reagan. The AMFA granted CAFE credits to the car makers for the production of alternative fuel vehicles, including FFVs.

The second condition was met when the California Legislature approved the first of several funding bills for support of the 5,000 FFV demonstration, including funds to buy down the differential costs of FFVs and for the establishment of refueling facilities. A breakthrough on the third point was achieved when the Commission struck an agreement with ARCO Petroleum Products Company for the establishment of up to twenty-five M85 fueling facilities in the state.

Cooperative Agreements with Retailers

The agreement with ARCO broke open the retail fuel market to fuel methanol. As the first major fuel retailer to participate in the California Methanol Demonstration, ARCO was also the most prepared in terms of reformulated gasoline (RFG) development. ARCO had developed its own proprietary formula for RFG, which it

produced and tested in two grades called ECX and EC-1, one to replace the need for leaded gasoline for customers with older vehicles and one provided a reformulated premium gasoline for its premium gasoline customers. In addition, through its subsidiary Lyondell Petrochemicals (a large methanol producer), ARCO had its own supply of oxygenates in the form of methanol for the feedstocks needed to produce RFG.

Soon after the ARCO agreement was finalized, Chevron U.S.A. Inc. also sought and approved a similar agreement to establish and operate up to twenty-five M85 retail stations. Other companies (Mobil Oil, Exxon, Shell, Texaco and Ultramar Refining and Marketing) entered into such cooperative agreements over the ensuing two years, leading to the establishment of some 54 publicly accessible major retailer M85 fueling sites. The stations established under these Cooperative Agreements are shown in Table 1, "Major Fuel Retailer M85 Stations - January 1996." (This table shows 53 stations now operating; an additional station will soon be established by Chevron to replace a previously closed M85 site.)

In addition, large fleet operators were approached about siting stations to serve both their FFV fleets and the general public; one of these, GTE California, has established a public fueling site at its location in Thousand Oaks, CA. As the enthusiasm of the major fuel retailers to site methanol stations waned, the Commission sought assistance from the local air quality management districts and various independent fuel retailers to continue its station siting efforts. This has led to the establishment of an additional 13 sites, seven of which are open to the public. These are shown in Table 2, "Independent Fuel Retailers and Others M85 Stations - January 1996."

Company	Stations in operation	California Location	
		North	South
ARCO	14	2	12
Chevron	13	7	6
Exxon	5	5	
Mobil	3		4
Shell	12	4	8
Texaco	3	1	2
Ultramar	2	1	1
GTE Corp.	1		1
Total:	53	20	34

Company	Stations Operational or under Construction	California Location	
		North	South
Olympian Oil	1	1	
P.C.I.	1	1	
E.R. Vine & Sons	1	1	
Ramos Oil	1	1	
Hertz (private fleet)	6		6
City of Yorba Linda	1		1
Parallel Products	1		1
Brea Auto Spa	1		1
Total	13	4	9
	(7 retail)		

The Cooperative Agreements that were signed with the fuel retailers called for the Commission to purchase all the necessary equipment for each fuel methanol location. In turn, the fuel retailer was obligated to install, operate and maintain that equipment for a period of ten years. The equipment purchased included the underground

storage tank, fuel dispensing pump, all product and vapor recovery lines, flame arrestors, dispenser, filter, hose, nozzle and a stand-alone fuel card reader.

Retail Facility Selection and Siting

Initially, in order to determine the potential M85 fueling sites the Commission would search the retailer's listing of available station locations within their respective networks for those that matched the planned placement of the FFVs fleets. This process soon proved unworkable, since the retailers faced other constraints such as limited lot size, site parking configurations, lack of adequate ingress and egress for the site or other, proprietary reasons and hence would not always approve the specific stations requested.

Once a mutually acceptable site was agreed to, the locations of the tank and dispenser were then discussed. For the most part the location of the tank was an engineering decision, based, for example, on where there was adequate room for the 10,000-12,000 gallon underground M85 storage tank (UST). The dispenser locations, however, were another matter. Several of the major fuel retailers did not allow the placement of methanol dispensers on the regular fueling islands.

The Commission had little or no discretion in the final placement of the dispenser on the fuel retailers' property but nevertheless appealed for the most suitable locations with some limited, positive results. Perhaps the worst dispenser location was at the Santa Ana ARCO site where the tank was placed at the front of the facility near the fueling islands, but the dispenser and card reader position, where the actual methanol fueling took place, was relegated to the rear of the facility, in the back corner of the site next to the trash dumpster. Despite this particular dispenser location, the Santa Ana site remains one of the highest volume stations in the network.

Petroleum Industry Opposition to Fuel Methanol

The issue of dispenser location is noteworthy because it indicates how some of the retailers viewed this alternative fuel relative to the conventional diesel and gasolines which were always well displayed and actively marketed and advertised. Although some of the fuel retailers placed the methanol dispensers in appealing locations adjacent to the other fuels marketed at

these sites, none have undertaken marketing efforts for M85. Despite the cooperation received from station operators, the retailing companies have generally lobbied against methanol as an alternative fuel in various public forums.

Opposition soon emerged to the expanding demonstration programs for clean, non-petroleum alternative transportation fuels in California. Signs of this opposition appeared for example, at a dedication ceremony for the ARCO M85 fueling facility in Sacramento, the state capitol on March 21, 1990. On this occasion, Commission Chairman Charles Imbrecht, Governor George Deukmejian and ARCO President George Babikian took part in the dedication of an M85 fueling facility installed at an ARCO station located just nine blocks from the Capitol building.

After remarks from Chairman Imbrecht and Governor Deukmejian regarding fuel methanol and the state's efforts to develop the potential for this promising alternative, non-petroleum fuel, Babikian used the occasion to announce the commencement of the U.S. Auto/Oil Study, a reported \$2 billion cooperative effort between the three U.S. auto manufacturers and fourteen major oil companies. This research effort would study methanol and reformulated gasoline, among other things, and was expected to assert the probable ascendancy of reformulated gasoline as the favored motor fuel, in comparison mainly with fuel methanol.

Of the study's initial findings, California Air Resources Board (CARB) Chairwoman Jananne Sharpless said "The study compares air pollution from dirty gasoline that is already outdated in California with emissions from cars equipped with pollution controls that will be obsolete by the time any methanol cars are mass-produced" (National Petroleum News, 1992). The Auto/Oil study remains ongoing.

Non-Public Methanol Fueling Facilities in California

In addition to the publicly accessible M85 dispensing system described above, the Commission was active in assisting various other

fuel methanol demonstration participants to establish methanol storage and dispensing systems at their sites. Chief among these was the Safe School Bus Clean Fuel Efficiency Demonstration Program, initiated as a result of Assembly Bill 35 passed in 1988 and sponsored by Assemblyman Richard Katz. Under this program, modern, alternative fueled and clean diesel buses were provided to school districts throughout California, including some 150 methanol school buses operating on M85 or M100 (depending on engine configuration) (California Energy Commission, 1989, 1993a). Non-public methanol fuel storage and dispensing facilities were installed at a number of school district sites to serve these buses; in other instances, the districts utilized nearby public M85 stations. Several state and local agencies, most notably the California Department of Transportation (Caltrans), also established private methanol dispensing facilities to serve their own equipment.

M85 Electronic Point-Of-Sale System

As the fuel retailers turned their efforts toward the Auto\Oil Study, the Commission sought to perform essential functions for the distribution of fuel methanol including the development of an Electronic Point of Sale (EPOS) system to handle M85 sales transactions. In addition, it was deemed necessary by the fuel retailers to devise some fail-safe means of preventing misfueling of conventional gasoline vehicles from the methanol dispensers. The system that evolved was a dedicated magnetic stripe card reader network that is located at all methanol fuel retail sites.

At the outset of its Cooperative Agreement with the Commission to provide M85 for the 5,000 FFV demonstration, ARCO proposed the use of Gascard, Inc., a fuel-card access and management company with which ARCO had been doing business since terminating its own proprietary fuel credit card. The Gascard system performed well and has provided an effective means of preventing cross-fueling (dispensing M85 into gasoline or diesel vehicle). However, the need for drivers to

carry an additional fuel card just to access and pay for fuel methanol was seen as overly restrictive; it also entailed additional operational costs to the fleets and the Commission for maintenance and operation of the special M85 card reader network.

Prevention of Misfueling with M85

The M85 Fuel Retail Network continues to rely on the dedicated EPOS system for controlling access and managing fuel transactions for the fifty-three (soon to be sixty-one) retail sites. However, in an effort to reduce the residual inconvenience of the special EPOS system, some other means of preventing misfueling was sought, so that M85 transactions could be handled like those for conventional fuels. To this end, the Commission held a public workshop in December 1993 to investigate fuel nozzle configurations that could potentially be suitable for providing a simple alternative means of preventing cross-fueling, and to address the issues of methanol fuel compatibility with dispensing components and materials. The workshop was widely attended by dispenser manufacturers, automobile manufacturers, fuel retailers and staff from regulatory agencies including CARB and the U.S. Environmental Protection Agency.

Discussions at the workshop with regard to the nozzle configuration led to a consensus among the participants that an M85-specific fuel nozzle design would either be impractical or ineffective. The fuel retailers were concerned that if a specially-designed methanol fueling nozzle could be easily defeated, the lower-per-gallon price for M85 would induce unwitting customers to fuel their gasoline or diesel vehicles with M85 by use of an adapter, thereby subjecting the fuel retailers to a potential liability for misfueling. The retailers were adamant that warning signage on the dispensers would be inadequate as a protection and that some positive means of preventing misfueling was essential. A number of mechanical, optical and electronic interlock devices were suggested at the workshop for this purpose (California Energy Commission, 1993b). Subsequent to the workshop, the Commission began an investigation through its technical

support services contractor, Acurex Environmental Corporation, into what sort of interlock device would best meet the purposes of misfueling prevention. As a result of this inquiry, it appears that radio frequency identification (RFID) transponder technology will best meet these needs (Acurex Environmental, 1994).

Since the 1993 workshop, the Commission in conjunction with the Society of Automobile Engineers (SAE), Ford Motor Company, General Motors, Chrysler and fueling equipment components manufacturers, has been investigating the potential use of RFID technology to provide a safety system for the prevention of cross-fueling and develop a uniform standard for implementation. The SAE Misfueling Lockout Task Force effort will soon lead to the adoption by the SAE of standards for the M85 fueling technology application. The Commission hopes to test the technology in 1996-97 at one or more California M85 fueling locations. Once proven, with the support of the fuel retailers and automobile manufacturers, the Commission would like to apply the technology throughout the M85 retail network, thereby eliminating the inconvenience and additional costs of using the

segregated fuel access card.

The California Fuel Methanol Reserve

Another key component of the 5,000 FFV demonstration program was the creation of the California Fuel Methanol Reserve (CFMR), a mechanism developed to provide a constant fuel methanol supply from several suppliers to wholesale customers and the M85 Retail Network at stable, consistent pricing. Developed in February 1988, the CFMR was carefully designed to comply with anti-trust laws regarding pooled supply and fuel pricing.

The CFMR has sought supply commitments from suppliers, and the Commission has determined the threshold price on a quarterly basis and served as the CFMR Administrator. Clients of the CFMR were qualified by the Commission in order to assure that the methanol went to on-road fuel demonstration purposes only. Once accepted in the CFMR, the individual clients entered into their own credit relationships with

Calendar Year	Large users (over 5 million gallons/year)	Small users (5 million gal/year or less)	Total Demand
1990	- N/A -	1,082,206	1,082,206
1991	- N/A -	1,704,479	1,704,479
1992	- N/A -	2,697,861	2,697,861
1993	9,050,005	1,757,517	10,807,522
1994	10,000,822	2,025,110	12,025,932
1995	9,473,457	2,174,504	11,647,961

from: CFMR1995.xls JMT 1/8/96

all the suppliers. Fuel orders placed through the CFMR were rotated among the suppliers to provide an equitable distribution of fuel methanol sales among all suppliers. The annual volumes of fuel methanol to the light and heavy duty transportation sectors are shown in Table 3.

The CFMR and Methanol Price Stability

The CFMR has served as a successful means of providing a reliable supply of fuel methanol at consistent pricing. Figures 1 and 2, "Methanol Price History (1/90 - 12/95)" and "Effects of

Methanol Pricing (1/90-10/95)" show the extent to which the CFMR has stabilized fuel methanol prices in the face of commodity market swings, and how this has flowed through to fuel methanol prices at the retail pump, compared to gasoline.

Over the eight years of its operation the Reserve has met the methanol demands of its clients without significant interruption, even during times of tight or short supply. The methanol industry representatives participating in the CFMR worked together in difficult times, diverting rail cars to California or trucking methanol from northern California terminals to meet the needs of clients in southern California, particularly the Los Angeles County Metropolitan Transportation Authority (LACMTA), while absorbing the cost in order to meet their CFMR commitments. Overall the CFMR pricing has closely tracked the methanol market pricing. The principal exception to this pattern was the price run-up in 1994-95; whereas the spot market price of methanol exceeded \$1.60 per gallon during this time, the CFMR price never exceeded \$0.67 per gallon FOB terminals.

At the CFMR's inception, it was thought that supply interruptions and price swings would seriously hamper the effort to fairly demonstrate, evaluate and test this promising fuel. The CFMR may well provide a model for use by methanol and other new fuels on a national scale in the future as this supply mechanism successfully met all the expectations placed upon it from the start.

The Issue of Fuel Quality and Materials Compatibility

The definition of fuel methanol compatibility has broadened over the past several years, as a result of the experience in the California methanol demonstration. Initially, "methanol compatibility" meant that the fueling system hardware components would not deteriorate as a result of coming in contact with the fuel, since this alcohol is an aggressive solvent and is more corrosive than conventional gasoline or diesel, and even ethanol. Vehicle fuel system malfunctions, however, led to

an awareness that the fueling system parts could impair the quality of the fuel itself. As a result, the definition of methanol compatibility has been expanded to include the condition that the fuel quality not be deteriorated by coming into contact with components or materials which are not themselves methanol compatible. Based on discussions of this issue internally and at the 1993 Commission workshop discussed above, the American Automobile Manufacturers Association has proposed a standard definition of methanol compatibility which accounts for both sides of the issue (AAMA 1994).

FFV Fuel System Failures and Fuel Quality

Protecting fuel quality became a paramount concern among all participants in the California M85 program as FFV fuel filters and fuel pumps began to show deposits of unidentified substances which substantially affected the performance and reliability of the vehicles. The vehicle fuel system malfunctions quickly became a matter of great concern to the auto makers, who sought to bring high quality FFVs to market and who were now confronted with serious warranty repair and replacement costs. In response, the manufacturers contemplated scaling back efforts to produce the large number of FFVs required for the California market.

General Motors in particular noted high rates of fuel system failures on its vehicles, especially the California Department of Transportation (Caltrans) fleet of 299 FFV Lumina statewide, which it attributed to fuel quality problems. Over the past three years, tens of thousands of dollars have been spent by the Commission and the auto manufacturers to identify the substance(s) found on the filters and pumps, its origin and how to prevent the recurrence of such deposits. Researchers from the automobile manufacturers, fuel providers and fueling system component makers turned attention to the issue (CRC 1992). Some of these analytical efforts are described in more detail in another paper at this conference (McCormack, 1996).

Materials Compatibility

Investigations into the concerns surrounding fuel quality indicated at least three possible sources of contamination from fuel-wetted dispenser components: unprotected aluminum or certain other metals in the dispensing systems (such as the fueling nozzles), the elastomers used in conventional gasoline product hoses and other seals in the system, and the detergent additives used in the gasolines being mixed with the methanol. These three possible sources are discussed below.

Unprotected Aluminum and Other Metals

It had been well known that methanol would corrode unprotected aluminum, zinc and certain other metals and alloys, and the fuel system components on FFVs were designed with this in mind. Accordingly, attention was turned to the fuel dispensing equipment. It became necessary to perform complete inspections of all components, and the materials that made up those components, within the M85 fueling systems to determine whether and where they might include reactive metals that could be subject to attack by methanol.

The inspections revealed that not only the nozzle but the vapor recovery splitter valve and certain other dispenser internal parts were typically fabricated from cast aluminum. Since aluminum was one of the substance identified on filter and fuel pump deposits, Commission staff initiated joint efforts with the components manufacturers and Ford Motor Company to devise means of protecting the aluminum surfaces which came into contact with methanol. The component manufacturers responded quickly adopting electroless nickel-plating for their methanol dispenser components. Although this entailed the additional expense of plating, this measure proved effective in preventing fuel contamination from corrosion products, despite long dwell times in contact with the fuel.

Elastomers for Dispenser Product Hoses and Seals

Compounds used in the manufacture of gasoline and diesel product hoses were found on the filter and fuel pumps of the failing fuel flexible

vehicles, indicating that the fuel methanol was leaching contaminants from elastomers and/or filler materials. Consequently, the development of methanol-compatible hose material to replace the existing M85 dispenser hoses was essential.

In the early years of the California fuel methanol demonstration, methanol dispensers employed cross-linked polyethylene hoses in a two-hose configuration, one hose for the product and one for the vapor recovery. However, with the development and widespread adoption of coaxial hoses for Stage II vapor recovery fueling systems (an inner product hose inside a larger vapor return hose) the cross-linked polyethylene product hose ceased to be available for use in the M85 retail network or at private fueling locations.

At this point, Goodyear Tire and Rubber Company approached both Ford and the Commission to collaborate on efforts to providing more impervious and compatible product hose material for the demonstration. The initial hose material developed by Goodyear for use with methanol was better than the typical gasoline hose material, but it still leached material into the fuel to an unacceptable degree. After considerable development and testing, a breakthrough was achieved using a Nylon 11 veneer applied to the inner surface of the inner product hose, resulting in a reduction of hose leaching to nearly undetectable levels.

Goodyear continues to provide the Nylon 11-lined hoses for the demonstration program and has made this hose available for all fuel methanol systems in California. Replacement hoses are readily available through their California distributor, Titan Rubber of West Sacramento.

Gasoline Detergent Additives

During the investigation of fuel quality, fuel detergent additive residue was discovered along with other materials such as aluminum and hose compounds mentioned above. It was soon determined that one of the two most commonplace families of gasoline fuel detergent additives, the polyetheramines, was compatible with methanol, whereas the other one, the polybutylamines, was

not. Although it was not been conclusively demonstrated that the incompatible additive directly causes the deposits on vehicle fuel filters and fuel pumps, it was deemed prudent to recommend the use only of the compatible polyetheramines in the gasoline used to blend M85.

Some synergy between the polybutylamine additives and the other fuel contaminants has been theorized, however. It is thought that the other substances found on the vehicle fuel filters, aluminum and leached elastomers, once adhering to the filter medium in the form of a gelatinous substance, turned the filter into a sticky, sponge-like medium through which the fuel additives cannot pass, as they typically do. Further research may exonerate polyetheramines from a role in fuel contamination and filter plugging, and other detergent additives may be used in gasoline to blend M85.

It should be noted that many different gasoline additive packages are in practice blended with fuel methanol in the FFV fuel tanks, since these vehicles are often refueled with a variety of unleaded regular gasolines. The need to specify a particular gasoline additive may diminish in importance since the fuel additives, once thought to be significant problem for M85 fuel quality, is not now as large a concern.

Methanol Refueling Facility Inspection

Additionally, the Commission has now provided electroless nickel-plated M85 fueling nozzles, one plus one replacement, one vapor recovery splitter/adaptor, one Goodyear coaxial nylon 11 fueling hose and one cross-linked-polyethylene jumper hose to all retail fueling facilities in the Commission's M85 network as well as to all the school bus sites. Commission staff have conducted inspections at all fuel methanol retail and school bus fueling facilities as well; equipment discrepancies were noted and brought to the attention of the respective site operators. Further, similar site inspections are performed on a semi-annual basis and the current series of inspections, encompassing some 108 retail, school

bus and Caltrans fueling sites, will be completed in March 1996.

Much of this work has been continued by the Commission as many of the fuel retailers, with the exception of Exxon, have reduced their participation in the M85 fuel station program. Table 4 shows the number of stations proposed by each major fuel retailer, and how many have been established to date.

The first fuel retailer to withdraw their commitment was Chevron, U.S.A. on March 30, 1992 (Chevron 1992), with a letter to Governor Pete Wilson. ARCO notified the Commission that it too would establish no more M85 stations in a letter dated February 9, 1995, to Chairman Imbrecht, and Shell followed on October 17, 1995 (ARCO 1995). All three companies indicated, however, that they would continue to operate their existing M85 facilities. The other retailers declined to establish additional stations when requested by the Commission, which itself had budgeted funds sufficient to establish the full complement of all stations previously proposed.

**Table 4
Public-Private Agreements with
Oil Companies**

<u>Retailer</u>	<u>Total Proposed</u>	<u>Total Constructed</u>
ARCO	25	14
Chevron	13	13
Exxon	5	5
Mobil	10	4
Shell	14	12
Texaco	9	2
Ultramar	5	2
Total	81	52

Status of the California Fuel Methanol Market

At present the fuel methanol market in California is at a crossroads. While usage and therefore distribution volumes have decreased of late, there may still exist a significant market opportunity for the methanol industry, if a well developed and strongly supported business strategy is implemented soon.

Decreased Methanol Demand

One of the largest users of fuel methanol has been a large methanol-powered transit bus fleet operated by the Los Angeles County Metropolitan Transportation Authority (LACMTA). For a variety of reasons, including the increased operational expense attributed to its heavy duty methanol bus engines, LACMTA has moved to convert its methanol bus fleet to ethanol or other fuels, leading to a major decline in CFMR throughput. The lower fuel usage volume for the LACMTA bus fleet is significant: once averaging in the range of 833,000 to 1,000,000 gallons per month when all 333 fuel methanol buses were running, to a current average of less than 600,000 gallons per month, as its methanol buses are converted to other fuels. Proposals have been made to convert the entire fleet back to diesel service.

Fuel methanol, once the only available certified low-emission alternative fuel technology for heavy duty applications, now suffers from unacceptably high maintenance costs coupled with reduced field support by engine manufacturers, compared to the other alternative fuels. At present there is little new methanol heavy- or light-duty engine development planned or under way.

The fuel usage volumes have also decreased through the M85 retail fuel network over the past two years, despite the fact that the number of FFVs operating in the state have grown steadily, as indicated in Figures 3 and 4, "M85 Monthly Retail Volumes (12/91-11/95)" and "Cumulative Population of FFVs in California." This odd paradox of increasing vehicle population and decreased fuel usage proves (unfortunately, in this case!) that fuel flexible vehicles are an outstanding technical success. The decline in light-duty methanol consumption may be due to some

combination of the following factors:

- FFVs purchased by fleets to fulfill regulatory requirements, such as the alternative fueled fleet rules under the Energy Policy Act of 1992, are not required to use M85.
- There is a nearly universal lack of M85 fuel access and availability information provided by vehicle manufacturers at the time of sale to fleets or individuals purchasing either new or previously owned FFVs.
- There are still too few M85 fueling locations for true convenience in competition with conventional fuels.
- A dearth of fuel retailer or methanol industry marketing, public education and outreach to fleets regarding the air quality and/or energy security benefits, and a lack of assurances regarding stable fuel supply and pricing.
- A common misperception that fuel methanol and M85 may be very costly, which is a lingering result of the price run-up of 1994-95. While prices have returned to levels existing prior to the increase, many customers may not have heard this and/or are concerned about the possibility of future price escalations.

At present, M85 is a premium fuel in terms of its octane value (102 octane, (R+M)/2) and it is more competitive price-wise with premium unleaded gasoline than with unleaded regular. Bringing the price down to at least match that of unleaded regular gasoline would doubtless help improve fuel utilization rates. Table 5 shows a typical price calculation for retail M85.

Opportunities with Rental Car Fleets

The reduced fuel demand by the heavy duty fleet may allow a better focus on the M85 retail opportunities. Along these lines, the rental car fleets have been an excellent mechanism for both bringing large numbers of fuel flexible vehicles into the state and introducing FFVs to the public on a trial basis, without the need to purchase the

vehicles. Historically, the rental fleets have been unable to assure a high M85 usage rate as it was not feasible to provide fuel access cards to their customers. Without the ability to refuel with methanol during the rental of the FFV, and in view of the conditioned need for drivers to return the cars fully fueled, these cars often operated primarily on gasoline rather than M85.

This situation shows signs of improvement, however. Hertz Rental Car has been a leader in the acquisition and operation of FFVs in their California operations and has been an outstanding example of corporate commitment, along with their parent company Ford Motor Company, the leader in FFV development and marketing. In a cooperative cost-sharing arrangement with the Commission and the South Coast Air Quality Management District (SCAQMD), Hertz has established eight M85

<u>Factor</u>	<u>Cost</u>
CFMR Threshold Methanol Price, gallon [1]	\$0.50
Rack price of unleaded regular gasoline [2]	\$0.69
Rack price of M85 [3]	\$0.53
Mark-up, gallon [4]	\$.15
Hauling & other distribution, gallon [4]	\$.04
Federal excise tax [5]	\$.113
State excise tax [5]	\$.09
Sales tax [5]	8.25%
M85 pump price	\$0.99
Energy equivalence factor [6]	1.6
MPG equivalent price to consumer	\$1.58
Avg. cost of gasoline, tax included [7]	\$1.35
Retail gasoline, Northern California [8]	\$1.08- \$1.15

[1] CFMR posted price for M100, FOB terminals, as of October 1, 1995.

[2] from PIIRA reports for California, RAMIS output 7/17/95

[3] Blend of 85% methanol and 15% gasoline.

[4] Varies by retailer and station location; estimated from CEC M85 network data

[5] CEC Fuel Resources Office, January 1996

[6] Based on Auto-Oil data, best case.

[7] CEC value is from PIIRA reports for California, RAMIS output 4/17/95; weighted avg. of untaxed retail (1991-2nd Q 1994) = \$.9528, plus current taxes of \$.3640 = \$1.3469

[8] Sacramento Area, January 1996

fueling systems at their airport rental car facilities in California. In addition, Hertz has altered the customary "bring it back full or pay a premium"

policy to allow FFVs to be fueled with M85 upon return. This clearly gives priority to assuring high M85 fuel utilization in their FFVs.

Looking Ahead

At this point, the future of the California fuel methanol experience carries importance far beyond the numbers of FFVs purchased and operated or the actual fuel volumes distributed. The California demonstration effort, now at the stage of commercialization, continues to be the largest, most successful and most publicized fuel alcohol endeavor, linking the largest number of FFVs in a national region with the largest retail fuel station network.

Should the market development and growth of the fuel methanol market in California not be supported by both government and the methanol industry, one consequence could be reduced support and market for reformulated gasoline (RFG) oxygenate requirements, a new market now enjoyed by the methanol industry. In addition, other alternative fuel development efforts in general, and compressed natural gas (CNG) and ethanol specifically, could be adversely affected should the credibility and sustainability of alternative fuels generally be called into question.

The dominant petroleum fuels industry remains strongly competitive and it will not willingly relinquish market share to viable, competitive, non-petroleum transportation fuels. As the lessons learned from the oil embargoes and price escalations of the 1970s fade from memory, the efforts to develop beneficial and sustainable, non-petroleum alternative transportation fuels may be in danger. Meanwhile, California remains more than 99% dependent on petroleum for transportation fuel, and the U.S. as a whole now meets some 53% of its oil needs with imports, up from 35% in 1979.

The decline in fuel methanol demand points to a crossroads for the fuel methanol industry, and an industry focus on market development is urgently

needed. Despite this fall-off, the market growth potential for fuel methanol remains promising. But the potential market thus far created by the California initiatives, involving expenditure of over \$42 million for vehicles, school buses, vehicle purchase incentives and M85 retail fuel infrastructure, needs attention and additional investment now if it is to prosper.

The next steps are straightforward in concept, if not in the details of implementation. The methanol industry, which has been oriented historically towards wholesale commodity markets, needs to apply simple retail marketing strategies and to establish a strong California presence now. The result could be firmer markets for other methanol uses, more stable methanol prices, and a steady outlet for surplus methanol production.

If fuel methanol were priced in a manner directly competitive with unleaded regular gasoline as little as three months ago, the methanol price (competitive with unleaded regular gasoline) now in competition with RFG could enjoy a predictable and succinct value and price increase as the higher-priced RFG becomes ubiquitous in the California gasoline market.

The Commission will soon go out to bid for a contract to supply fuel methanol for the next 3-5 years. The bid proposal will seek wholesale fuel methanol pricing directly competitive with the wholesale gasoline pricing in California (RFG), on a volume weighted average across all grades of gasoline. Supply security and gasoline competitive pricing are essential components now to the continuation and growth of the fuel methanol market in California, and very likely, the nation. The fuel methanol industry can succeed in California but a new approach is needed. Close relationships must be formed with fuel retailers, many of which are now indirectly methanol customers for MTBE production and some of whom are now retailing M85 at a few stations. In addition, relationships with vehicle manufacturers must be re-formed and strengthened, to encourage further methanol vehicle and engine development. Finally, marketing, educating the public and lobbying the decision makers are keys to building

a cohesive and sustainable fuel methanol market in California.

Conclusions

The methanol demonstration program in California has resulted in a number of successes, due primarily to cooperative efforts involving the fuel retailing companies, the vehicle manufacturers, vehicle fleet operators and state and local governmental agencies. The program has demonstrated the feasibility of methanol as a transportation fuel in a variety of applications. The future of methanol as a motor fuel is now at a crossroads, poised as it is for further commercialization and yet facing strong competition from other fuels.

There are four principal conditions to the continued expansion and ultimate success of methanol as a transportation fuel. These are

- M85 priced and distributed to be competitive economically with conventional motor fuels;
- The establishment of business relationships between the methanol industry and existing fuel retailers to expand the availability and promote the use of fuel methanol;
- The establishment of relationships between the methanol industry and vehicle and engine developers and manufacturers;
- The cultivation of relationships with fleet customers, along with a program of public education, marketing and advertising and a presence in state and federal policy-making forums.

An extraordinary collaboration by vehicle makers, fuel retailers and state agencies has brought this market opportunity into being, and it will not be easily recreated, once allowed to lapse.

Disclaimer

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position of the California Energy Commission, its Commissioners, or the State of California, or any other party mentioned herein.

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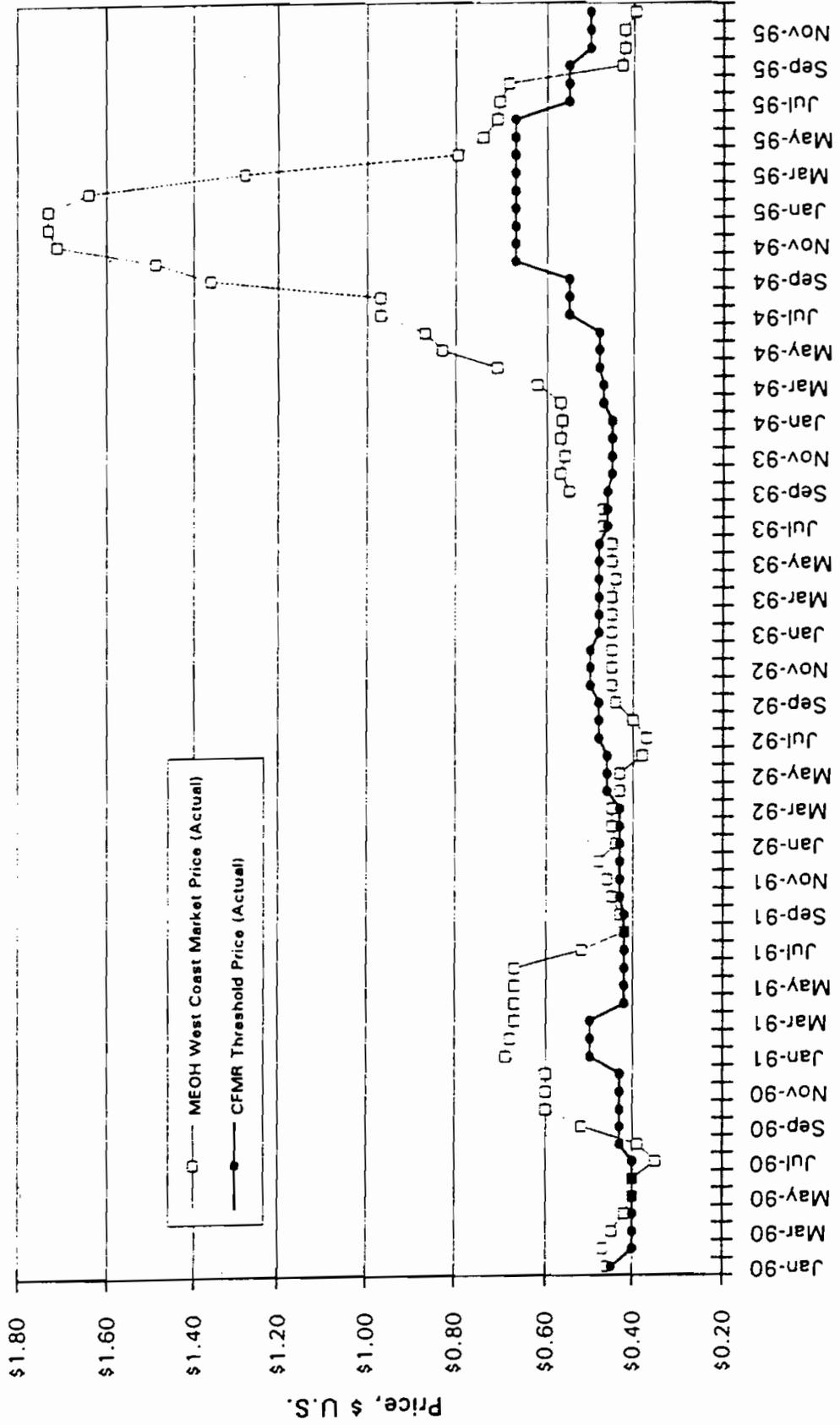
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Figure 1
Methanol Price History (1/90 through 12/95)



** MeOH Spot Price from New Fuels Report (1/24/90 - 4/14/94, 9/95 - 12/95); TECNON (5/1/94 - 8/11/95)

Figure 2
 Effects of Methanol Pricing (1/90 - 10/95)
 Energy Equivalent Prices, Compared to ULR Gasoline

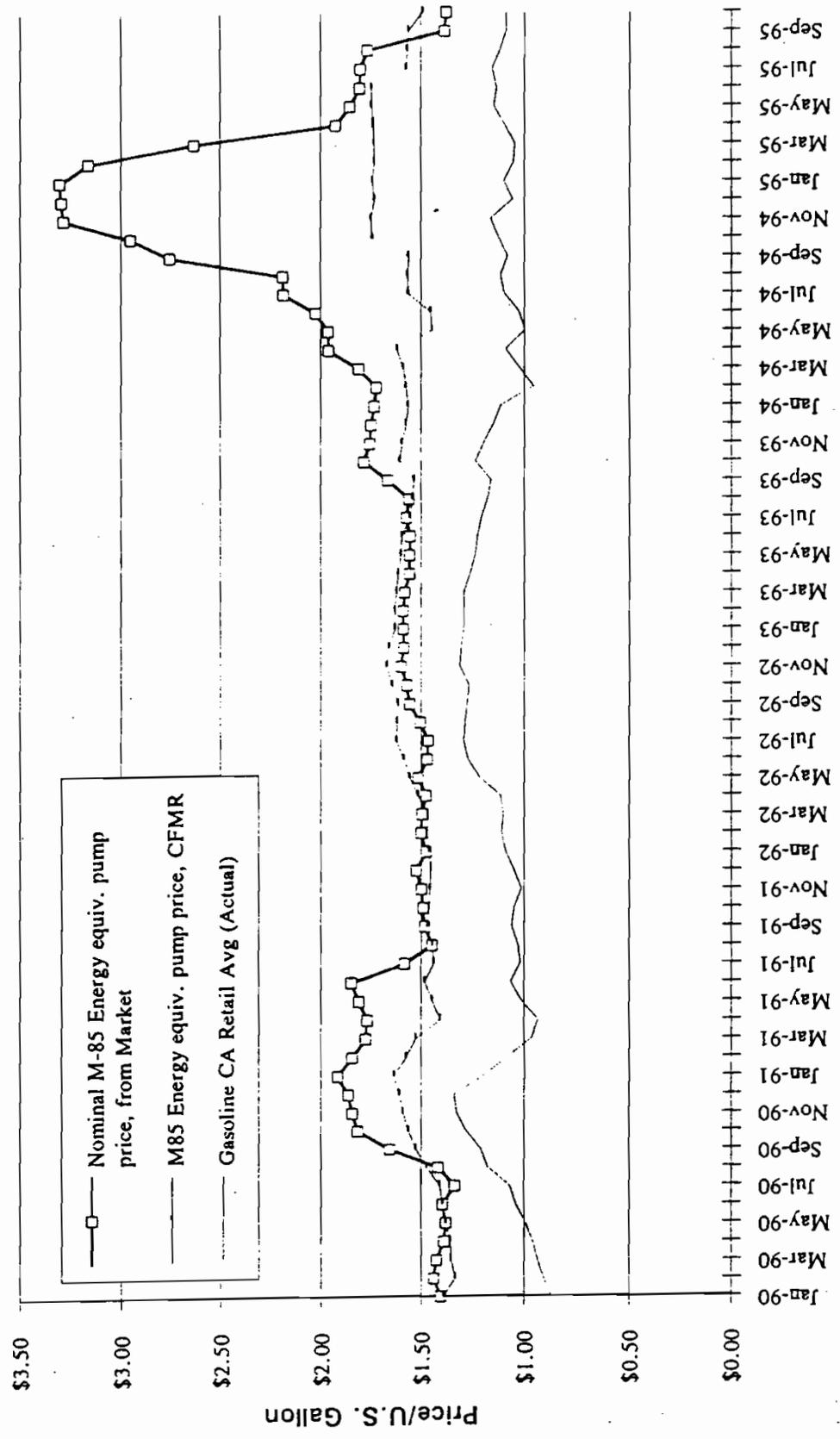


Figure 3
California M85 Monthly Retail Volumes (12-91 - 11/95)

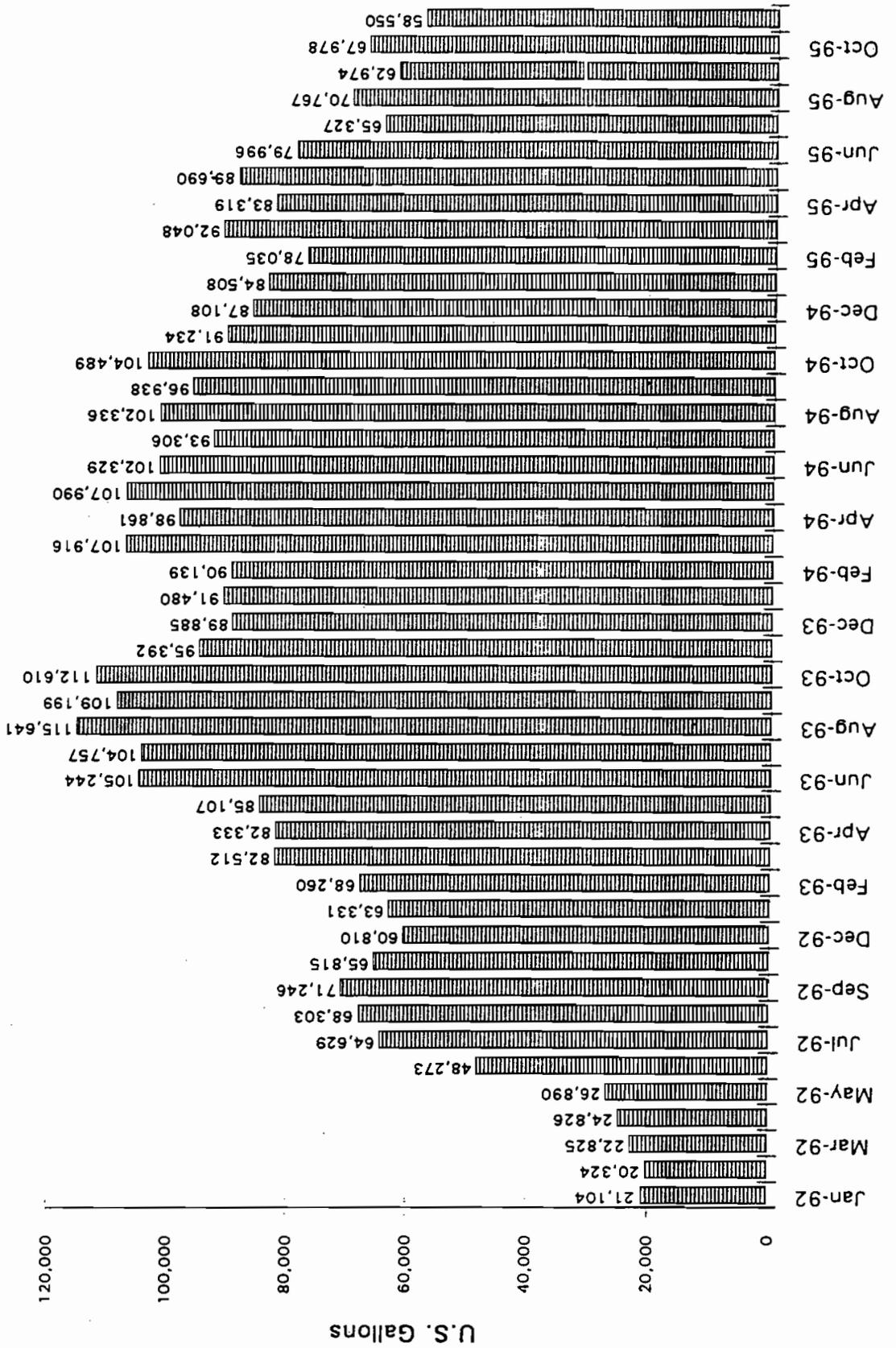
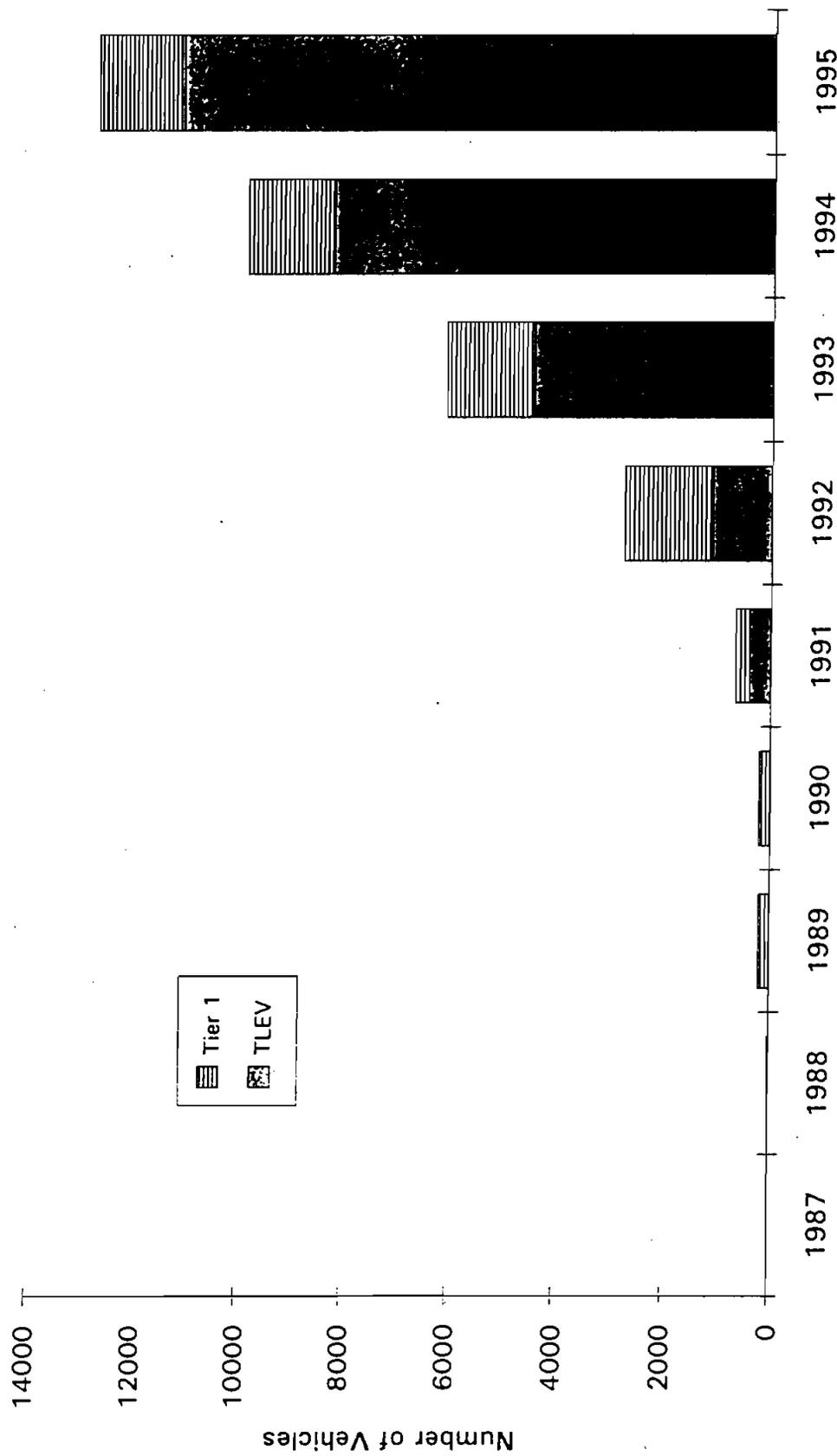


Figure 4
 Cumulative Population of FFVs in California



Source: CEC Transportation Technology and Fuels Office, June 1995