DISTRIBUTION OF METHANOL FOR MOTOR VEHICLE USE IN THE CALIFORNIA SOUTH COAST AIR BASIN

ENERGY AND ENVIRONMENTAL ANALYSIS, INC.

1655 NORTH FORT MYER DR ARLINGTON, VIRGINIA 22209

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Prepared by:

ENERGY AND ENVIRONMENTAL ANALYSIS, INC.
1655 North Fort Myer Drive, Suite 600
Arlington, Virginia 22209

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1. SUMMARY

1.1 STUDY SCOPE

The transition to methanol as a significant motor vehicle fuel in the United States requires the simultaneous implementation of vehicle product and fuel distribution system changes. To understand better the costs and impediments to the fuel supply transition, a study focusing on a single urban region distribution system was funded by EPA and DOE (through an interagency agreement). The greater Los Angeles metropolitan area (known as the California South Coast Air Basin for air pollution control purposes) was chosen for this study for several reasons:

- California has an existing methanol vehicle demonstration program with practical small scale experience.
- The state and local governments of the basin are considering conversion of some subset of vehicles to methanol as part of an air pollution control program.[1/]
- Results for the South Coast Air Basin should be transferable to other coastal urban areas where a substantial portion of U.S. vehicle use occurs.

This document describes a methanol distribution system (equipment, logistics, and costs) for the South Coast Air Basin which will provide up to 250 million gallons per year of fuel methanol (an upper bound for methanol requirements in the Basin in the year 2000).[2/]

1.2 FINDINGS

Over 200,000 gallons per year of "near-neat" methanol currently is distributed for motor vehicle use in the South Coast Air Basin. The methanol arrives by rail tank car at an existing chemical storage terminal. The methanol is "splash" blended with 2 to 15% gasoline in dedicated tank trucks and is distributed through eleven specialized fleet service outlets in the area.

This existing distribution system can be expanded to a volume of 50 million gallons per year with the addition of more trucks and outlets for an estimated cost of $1.2 million to $9 million. Most of the cost is associated with modifications at the service stations. While demand is below 50 million gallons per year, too few service station owners may be willing to commit capital to a methanol service capability unless they can take a very substantial mark-up on the product or they are provided separate incentives by outside parties.

Expanding the distribution system from 50 million to 250 million gallons per year probably will require the modification of at least one existing petroleum product terminal to methanol handling. Changes could include dedicated handling and storage systems at a cost of $7 million to $8 million. Distribution to service stations would continue through the use of a dedicated truck fleet. The use of local petroleum product pipelines would not be economically justified. The number of service stations would have to expand to 500 (ten percent of all outlets in the basin). At a volume of 250 million gallons per year, there would be both a sufficient number of outlets (from a customer perspective) and a sufficient sales volume (from the service station owners' perspective). The total capital cost of the terminal modifications, outlet changes and the tank truck fleet are on the order of $5 million to $27 million. The wide range in cost is due to uncertainties about the adaptability of existing petroleum product equipment to a limited methanol market.

EEA estimates that distribution activities (terminals, trucks, and service stations) will add 9¢ to 19¢ to the price of a gallon of fuel methanol. Taxes on methanol add an additional 12¢ to 13.5¢ to that price. Using an imported wholesale methanol price of 35¢ to 45¢ per gallon (as estimated for EPA by Jack Faucett Associates) this analysis would indicate a retail after tax price between 55.5¢ and 77.5¢ per gallon. The "equivalent" gasoline price, taking into account the difference in methanol energy density and its potentially higher energy efficiency, is $0.93 to $1.29 per gallon.

While this paper prescribes one system for distributing methanol in the South Coast Air Basin, several large uncertainties exist which will influence the design and cost of an actual distribution system. These uncertainties include the standardization of methanol fuel specifications, the regulatory treatment of methanol as a pollutant, the means by which the first outlets are established, and the extent to which existing equipment can be adapted to methanol service. (In line with these uncertainties, EEA received additional information from the staffs at the California Energy Commission and Chevron U.S.A., after the completion of this study. Chevron's cost estimates for service station modifications were slightly higher than the ones in this report. The Commission's costs are substantially higher but they translate into a methanol price impact of only 2.5¢ per gallon. The project schedule and budget did not allow for a follow-up investigation of this new information by EEA).

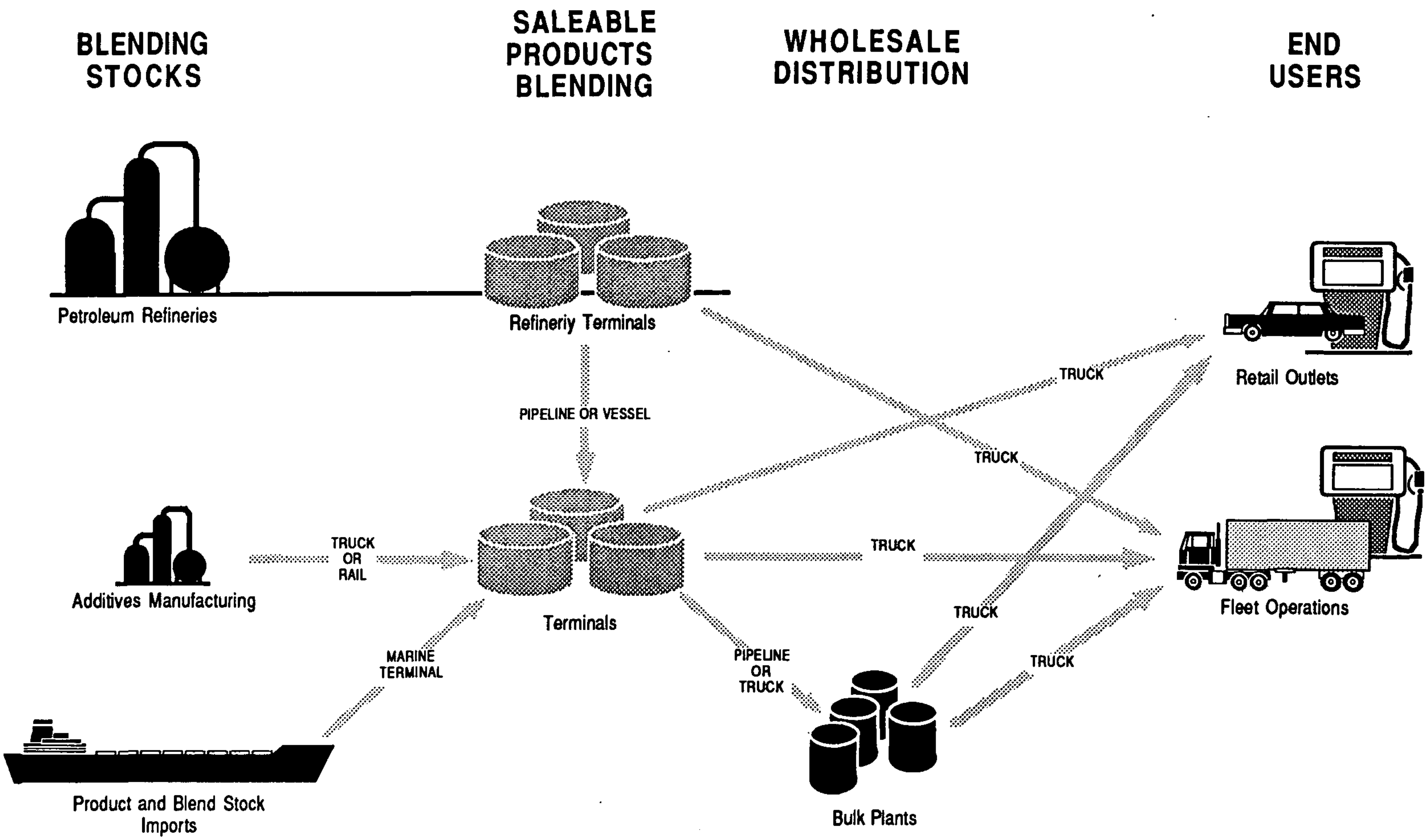
2. EXISTING GASOLINE AND DIESEL TRANSPORT AND DISTRIBUTION SYSTEMS

2.1 GENERAL DISTRIBUTION SCHEME FOR REFINED PETROLEUM PRODUCTS[3/]

Motor diesel and gasolines produced in petroleum refineries move from the refineries by pipeline, tanker and barge to storage tanks at terminals. The product from domestic refineries is augmented by imported products and domestically produced alcohol blending stocks. From terminals, motor diesel and gasolines move by truck directly to large commercial customers and retail outlets which are principally service stations and convenience stores. Product may also move to intermediate distribution "bulk" tank storage plants, where it is reloaded in a truck and taken to a service outlet. An overview of the movement of petroleum products from refineries to wholesale distributors, retail outlets and commercial customers is given in Figure 2-1.

A single refinery may supply products to many terminals. By means of barge, tanker, pipeline and truck shipments, the terminals can transfer fuels to other terminals or bulk plants. In turn, truck shipments from terminals to retail outlets and distributors, as well as to direct purchasers, complete the movement of gasoline and diesel from its point of manufacture. Often, wholesalers (jobbers) of gasoline and diesel may operate (chains of) retail gasoline outlets. There are even wholesalers who obtain some of their gasoline from their own refineries and sell through their own retail outlets while simultaneously supplying retail outlets owned by others. A majority of the outlets supplied by jobbers are operated by independent dealers.

FIGURE 2-1
Production and Distribution of Motor Vehicle Fuels



Retail distribution of gasoline is made through outlets of various types, including large volume self-service pumpers, traditional service stations and convenience stores. Retailers of gasoline may be single-site dealers, operators of retail chains, jobbers, small refiners or larger integrated oil companies.

2.2 SOUTH COAST AIR BASIN GASOLINE AND DIESEL SOURCES

There are 13 operating refineries (see Table 2-1) in the South Coast Air Basin, most of which produce gasoline and diesel for the local market.[4/] Another six refineries in the Basin have shutdown since 1980 due to a highly competitive market and no demand growth.[5/] At the refineries various process units create blending stocks which are combined to meet the specific specifications for motor diesel and unleaded regular, unleaded premium, and leaded regular gasolines.

Most of the area's gasoline and diesel demand (approximately 6 billion gallons each year)[6/] is met with locally produced products by the network of refineries and pipelines depicted in Figure 2-2. Some domestic and imported (Indonesia, Chinese, etc.) blending stocks and finished products are brought into the South Coast by ship and barge, by companies without local refineries or when market prices are lower overseas. The vast majority of gasoline and diesel product blending is done at the refineries; however, some product is blended at local terminals or directly in a tank truck as it is loaded.[7/]

Each type of motor vehicle fuel (regular, unleaded regular, unleaded premium, No. 2 diesel) sold in the Basin are blended to the same general specifications for that type of motor vehicle fuel. Product is frequently commingled or exchanged between companies before it reaches the fuel pump. The gasoline specification is changed during part of the year (from April 1 to October 31) to a lower vapor pressure (from 13.5 psi to 9.0 psi) as required by state and local air pollution control

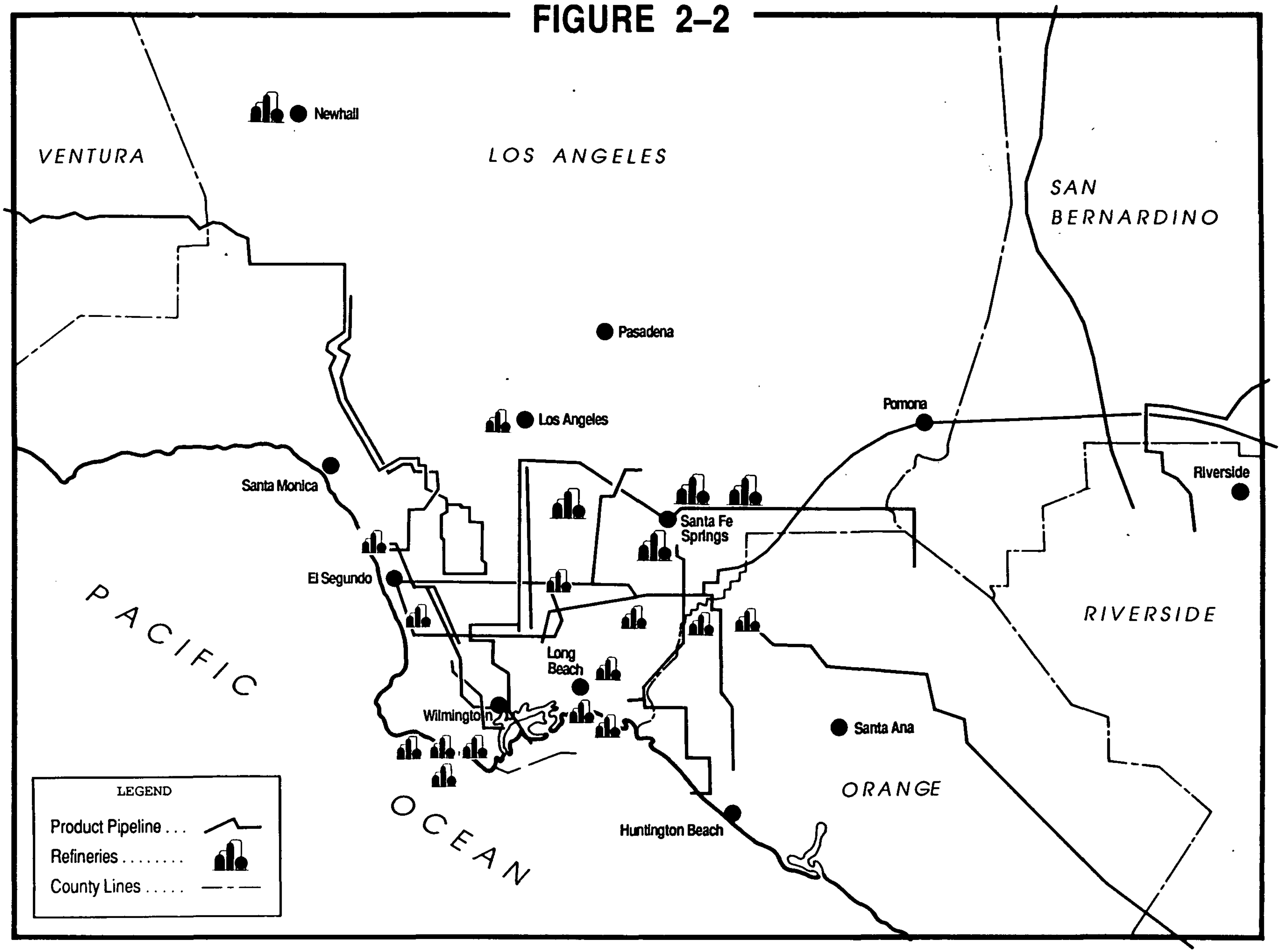
TABLE 2-1

PETROLEUM REFINERIES IN THE SOUTH COAST BASIN

Company	Crude Capacity (barrel/calendar day)
Operating	
Chevron U.S.A., Inc.	405,000
Atlantic Richfield Company	211,000
Mobil Oil Corporation	123,500
Shell Oil Company	111,000
Unocal Corporation	108,000
Texaco, Inc.	75,000
Champlin Petroleum Company	60,000
Superior Processing Company	44,000
Edgington Oil Cl.	41,600
Golden West Refining Company	40,600
Fletcher Oil and Refining Company	29,500
MacMillan Ring-Free Oil Cl.	13,000
Huntway Refining Company	5,500
Shutdown	
Douglas Oil Company	46,500
Marlex Oil and Refining Company	18,000
Golden Eagle Refining Company	16,500
DeMenno-Kerdoon	15,000
Lunday-Thagard Oil Company	10,000
ECO Petroleum, Inc.	5,600

SOURCE: References 4 and 5.

FIGURE 2-2


VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
ORANGE
PACIFIC OCEAN
Newhall
Pasadena
Los Angeles
Pomona
Riverside
Santa Monica
Santa Fe Springs
El Segundo
Long Beach
Wilmington
Santa Ana
Huntington Beach
LEGEND
Product Pipeline . . .
Refineries . . . .
County Lines . . . . .

agencies (the California Air Resources Board and the South Coast Air Quality Management District).[8/] Otherwise, the specifications are held constant. Some additives, detergents for example, which are company specific are added during the loading of the tank truck.[9/]

2.3 SOUTH COAST AIR BASIN PETROLEUM PRODUCT TERMINALS

There are over 30 harbor and in-land terminals and bulk plants for crude oil, petroleum products and petrochemicals in the South Coast Air Basin.[10,11/] Many of these are at or near the Los Angeles and Long Beach Harbor and they are capable of receiving and shipping material by ship or barge. Most of them are also capable of shipping or receiving by pipeline, rail car or tank truck. Basin-wide, there is probably an excess of terminal capacity due to recent chemical and refinery plant shutdowns and continuing efforts of all petroleum product handlers to minimize inventories. Nationwide figures indicate that existing petroleum product tankage is only 50 percent utilized for these same reasons.[12/]

With the exception of the four harbor terminals operated by GATX, the other harbor terminals are in dedicated service to refineries, individual fuel marketers or users, and chemical companies. It is unusual for an outside interest to contract for the services of dedicated facilities.[7/]

The GATX harbor terminals are specifically designed to serve the general terminaling needs of the South Coast Air Basin; meeting the short-term needs for additional storage and shipping capacity of those with their own terminals or servicing those businesses without their own facilities. The four GATX terminals specialize; one for chemicals, two for petroleum products (gasoline and diesel), and one for crude and fuel oil. They have a total storage capacity in excess of five million barrels (see Table 2-2).[13/] The gasoline and diesel harbor terminal is integrated directly with GATX in-land terminal (with over three million barrels of

TABLE 2-2

GATX SOUTH COAST AIR BASIN TERMINALS[13/]

Name	Primary Product Handled	Storage Capacity	Number of Tanks	Receipt Services	Delivery Services
L.A. Marine	Crude and fuel oil	980,000 bbls	19	Pipeline, vessel, barge, tank truck	Pipeline, vessel, barge
L.A. Harbor	Gasoline and diesel	592,000 bbls	18	Pipeline, vessel, barge, tank car, tank truck	Pipeline, vessel, barge, tank car, tank truck
San Pedro	Chemicals	578,000 bbls	111	Vessel, barge, tank car, tank truck	Vessel, barge, tank car, tank truck, drums
Carson	Petroleum products and crude	3,319,000 bbls	42	Pipeline, tank car, tank truck	Pipeline, tank car, tank truck

additional capacity) and the whole GATX products and crude oil system is connected by pipeline to several of the large refineries and the common carrier product pipelines operated by the Southern Pacific Pipeline Company (SPPL). Charges for terminaling product at the GATX terminal are on the order of 1¢ per gallon. GATX's product terminals are used in a limited way for gasoline blending but are not set up for large scale blending of gasoline.[7/]

Larger refiners and retailers (Chevron, ARCO, Shell) have one to six truck loading terminals in the Basin.[14,15/] The truck terminals are adjacent to their refineries or at a distance of 50 miles or more, where the pipeline transport cost is sufficiently better than trucking rates to justify double handling of the product (pipeline and truck rather than trucking directly from the refinery).

2.4 SOUTH COAST AIR BASIN PRODUCT PIPELINES[7,14,16/]

The product pipeline system in the Basin includes three large common carrier lines to move product out of the Basin to Las Vegas, San Diego and Arizona and smaller privately-owned lines to move product between refineries, harbor terminals and in-land truck terminals.[17/] In the common carrier lines and most private lines, diesel and all three grades of gasoline are carried in a single line. They are batched into the pipeline in minimum volumes and are separated at the destination by careful monitoring of flow rates and delivery schedules, with limited mixing between batches.

SPPL accepts material from any party in minimum tenders of 5,000 to 10,000 bbls and minimum rates on the order of 2,000 bbl/hr. SPPL also operates a large terminal and product handling facility in Colton (60 miles east of the Los Angeles Harbor). This terminal gathers product for shipment out of the Basin and services truck loading racks operated by several major oil companies. SPPL does not handle methanol,

ethanol or unfinished gasoline stocks in its pipeline system. To handle methanol, SPPL would require a substantial volume of traffic in comparison to existing products. Also SPPL and its clients would consider and resolve, through hardware and procedure changes, concerns about methanol water contamination and materials compatibility before methanol would be moved in the SPPL pipeline system.

2.5 SOUTH COAST AIR BASIN TRUCK DELIVERIES[7,18/]

Gasoline and diesel are delivered to retail outlets and commercial fleet operators by tank truck. Most trucks pull two tank trailers and each tank trailer can have one, two or three compartments. Each compartment can be used for a separate fuel so that one truck can deliver all the products (unleaded regular, unleaded premium, lead regular, and diesel) to a service station. The total truck practical capacity is about 8,700 gallons and a truck takes about one-half hour to load at a terminal. Trucks may be owned by the integrated oil company or the retailer, but are most often owned by an independent firm. One can readily hire the services of a trucking firm to move product within the Basin. Trucks are typically operated two ten-hour shifts or three eight-hour shifts per day, seven days a week to maximize their utilization. Within the Basin, trucks are the exclusive means of delivering gasoline and diesel to service stations and outlets. At distances of 50 to 100 miles, trucks are marginally more expensive than the combined use of a pipeline, in-land terminal, and short haul truck delivery (this alternative is only practiced by the large volume integrated firms). Using trucks to deliver at distances over 50 miles can increase costs of delivery by 1/2¢ per gallon. Trucking services are on the order of 1¢ per gallon.

2.6 SOUTH COAST AIR BASIN SERVICE OUTLETS[3/]

There are approximately 5,000 retail outlets in the South Coast Air Basin.[19,20/] The traditional service station typically possesses two (or three) pump islands, each with three pumps and six nozzles. Underground, the station has three tanks with total storage capacity of approximately 25,000 gallons of gasoline, suitable for holding three grades (leaded regular, unleaded regular, and unleaded premium).

A new station is more likely to contain more pump islands. Also, many stations have added a fourth underground tank and fourth grade or kind of fuel, for example, diesel fuel or gasohol. Over the last 20 years there has been a general nationwide decline in the number of terminals and service stations while demand has been steady or rising. Economics are favoring fewer, higher volume facilities. Nationwide, major oil companies are shutting down several thousand service stations annually and replacing them with fewer higher volume "super stations" which average over 150,000 gallon/month of sales (compared to current average levels below 100,000 gallons/month). Self-service capacity is being added and service bays are being replaced by convenience stores.[21-28/]

The product slate at retail outlets is in transition. Due to EPA lead regulations and the attrition of older cars, leaded regular is being phased out over the next two years. Most refiners and retailers are contemplating the introduction of a mid-grade unleaded gasoline to replace leaded regular. Also, diesel availability should drop off, due to the drastic slow down in diesel car sales. Except in areas of high truck traffic volume, diesel is not being provided at new service stations and it is likely to be phased out at some existing stations.[29,30/]

Retail mark-up on gasoline in the South Coast Air Basin is currently between 30¢ and 35¢ per gallon of which 9¢ per gallon is Federal tax and 13¢ per gallon is State and local tax.[9,31,32,33/] The California state fuel tax on gasoline is presently 9¢ per gallon. The remaining 4¢ per gallon is the result of state and county sales taxes totalling 6.5%.[34/]

The overall breakdown of the components of gasoline retail prices in the South Coast Air Basin are estimated in Table 2-3.

TABLE 2-3

GENERAL COMPONENTS OF GASOLINE PRICES
IN THE SOUTH COAST AIR BASIN

Cost Component	Cents per gallon
Wholesale price	52.5
Terminaling	1
Trucking	1
Service station	7
State sales tax	4
State fuel tax	9
Federal fuel tax	9
Total	83.5

3. EXISTING METHANOL DISTRIBUTION SYSTEM

3.1 METHANOL SUPPLIES[35/]

Methanol is not manufactured in California. In the United States, most methanol is manufactured in the Gulf Coast area. There is also substantial production capacity in Western Canada. Methanol for chemical use is supplied to California from the Gulf Coast or Canada by drum, truck load, or rail tank car.

Under contract to the California Energy Commission (CEC), Celanese Corporation supplies methanol from its Alberta, Canada plant for use in the state-sponsored demonstration methanol fueled fleets. Celanese also supplies bulk volumes of methanol to the Los Angeles area for direct purchases by Los Angeles County and Bank of America for use in their methanol vehicles.[36/]

3.2 TERMINAL AND BLENDING OPERATIONS[7/]

The methanol supplied by Celanese arrives in the South Coast Air Basin by rail tank car and is off loaded into a dedicated tank at GATX Terminaling Corporation's San Pedro Chemical Terminal. The tank has a cone roof with an internal floating roof. This combination protects against rain entry through the roof and controls air emission as well. A dedicated connection to the truck loading rack minimizes the chances of product contamination.

In general, chemical terminals are better suited than petroleum product terminals for preventing water contamination. However, the typical low volumes, the segregation, and the cleanliness of the chemical terminal add 2-4¢/gal to the cost of methanol handling relative to gasoline.

Also, the hours of operation are restricted. This limits the efficiency of the downstream blending and trucking operations. Table 3-1 compares the characteristics of a chemical terminal to those of a typical gasoline and diesel terminal.

The "near neat" methanol distributed by the California Energy Commission is 85 percent methanol blended with gasoline with a high aromatics content.[35/] Blending is done in the truck. The truck loads methanol at the chemical terminal and splash blends the 15 percent gasoline at a local petroleum products terminal.[7/]

The methanol fuel used by Bank of America is blended to a higher methanol content, 90-95 percent, depending on the time of year. The blending is accomplished in the same way.[36/]

3.3 DISTRIBUTION

The blended methanol fuel is delivered in a dedicated truck fleet. (In general, petroleum product distribution tank trucks change tank service, as needed, to optimize distribution efficiency. Tank compartments are rinsed and flushed with the upcoming product before service is switched.)[18/] The cost of distribution by truck is on the order of 1.5¢ per gallon.[37/]

No methanol is distributed by pipeline or through bulk plants. Even if one were not worried about contamination, the volume of methanol sales is too small to justify pipeline use. (Nationwide there is only one pipeline transporting methanol. That pipeline is a 2.5 mile long, six inch diameter line in dedicated service between two chemical plants in Lake Charles, Louisiana).[38/]

TABLE 3-1

CHARACTERISTICS OF TERMINAL FACILITIES

	Petroleum Products	Chemical
Pipelines	Common lines Large diameter 6"-42"	Dedicated lines Small diameter 4"-8"
Loading racks	Bottom loading Driver loaded	Top loading Operator loaded
Tanks	Large tanks (80MB-300MB) Floating roofs	Small tanks (30MG-25MB) Cone roofs
Operating hours	24 hrs/day	7:00-5:00
Operating modes	Pipeline Vessel Tank car Tank truck	Vessel Tank car Tank truck No pipeline
Products handled	6-10 Commingled Large volume	50-75 Dedicated Small volume
Costs	Low (1¢/gal)	High (3-5¢/gal)

SOURCE: Reference 7.

The GATX chemical terminal is only open between 8:00 and 4:30 daily and, as a result, the truck fleet is under utilized. In petroleum product service trucks typically operate 20 to 24 hours a day, seven days per week.[7/]

3.4 METHANOL FUEL OUTLETS[35,39,40,41/]

There are eleven methanol fuel outlets in the South Coast Air Basin. Five outlets have been established by the California Energy Commission (CEC) at existing service stations and more are planned in the area. At these stations, the CEC installed all new tanks and pumps, designed specifically to be compatible with methanol. The equipment changes instituted by the CEC included the replacement of all pump seals with methanol compatible ones, the use of a chemical type hose, the replacement of the aluminum fuel screen with a stainless steel one, and installation of a flame arrestor on the system. Access to the CEC self-service pumps is provided using state-issued credit cards. Two fleet operators also have their own dedicated pumps. Bank of America has two outlets and the County of Los Angeles has four.

Under the CEC's current program, CEC pays all costs of installing these automated methanol outlets and the retailer is not provided any mark-up. However, the new equipment becomes the property of the retailer within two years. The California and Federal fuel taxes for methanol are one half those which apply to gasoline.[73/34/] Each is 4 1/2¢/gallon. The state and county sales tax of 6 1/2% applies to fuel methanol just as it applies to gasoline.[34/]

CEC has encountered one fuel quality problem in the operation of its state-wide demonstration methanol supply network. A desiccant air drier on a storage tank accidentally filled with methanol when the tank was overfilled. The methanol reacted with the calcium chloride in the desiccant to create a corrosive mixture which drained back into the storage tank. Several vehicles were damaged by the contaminated fuel before the problem was identified.

The CEC now believes that the desiccant system is unnecessary and that water contamination up to one percent presents no problem in fuel stability or vehicle performance.

4. METHANOL DISTRIBUTION SYSTEM EQUIPMENT REQUIREMENTS

4.1 TERMINAL FACILITIES

As methanol use in the Basin increases, rail tank car deliveries will be augmented or replaced by vessel and barge deliveries. Just as chemical terminals are characterized by smaller volumes and greater segregation than petroleum terminals, chemical vessels and barges provide segregated, cleaner handling than the petroleum product counterparts.

Any methanol terminalling facilities must be capable of receiving and handling the methanol without any substantial contamination with water, grit, or oil products (although some contamination with gasoline is acceptable). A chemical type terminal such as GATX's San Pedro Terminal is capable of handling methanol in a segregated clean system. Other private chemical terminals in the Los Angeles and Long Beach Harbor complex may have similar capabilities.

Use of a conventional petroleum product terminal carries with it some risk of product contamination. At this point in the development of methanol as a vehicle fuel, it is not possible to be certain that there will be acceptably low water contamination in a conventional petroleum products terminal. The reasons are several:[42-45/]

- Different products are moved through common pipelines and manifolds. The products have traditionally contained small amounts of water (in part because water would cause no problem).
- In some terminals, pipelines are flushed with water between changes in service.[15/]

- Water will separate and segregate in low spots when the handling system is in petroleum product service. This water will be taken up when the system is switched to methanol service.
- Water heels (bottoms) are often kept in petroleum product tanks. A tank placed in methanol service must be drained and may require cleaning.
- Environmental regulations require that gasoline tanks in the South Coast Air Basin have floating roofs with double seals or an internal floating roof under a cone roof. The more common floating roof tanks, without a cover, have some risk of rain water leakage into the tank.[38/]

Many of these potential water sources can be eliminated by changing the operating practices at the product terminal. Particularly in the South Coast Air Basin, where rainfall is limited, it is likely that high volumes of methanol can be handled in conventional gasoline pipelines and tanks with acceptable levels of contamination. However, the necessary safeguards, if that is not the case, should be identified and may be required while the market is in its infancy (as insurance against any possible problem while the fuel is being introduced).

One option would be to install separate lines and tankage for methanol handling at a petroleum product terminal. Another option would be to treat all material entering the terminal with a dehydration unit. (In the past, Phillips Petroleum used dehydrators on some of its product lines to keep the system "dry").[15/]

If 100 percent methanol is not used and blending is required, meeting the prescribed "near neat" methanol specification can be accomplished in one of three ways:

1) <u>Splash blending in the truck (the current practice):</u> This approach is time consuming and may result in insufficient mixing in the truck. Product quality cannot be checked before shipping.[7,46/]

2) **In-line blending as material is pumped to the truck:** This minimizes the opportunities for the methanol to become contaminated but it does not allow product testing before shipping (the current practice in gasoline blending). This method is used by most gasohol producers.[47,48]

3) **In-line blending to tankage:** This is the common practice at refineries. Its key advantages are the ability to fine tune a blend to use the least cost components while meeting product specifications and testing and verifying product quality before shipment.

The second option is now favored for methanol product blending.

4.2 METHANOL DISTRIBUTION

As mentioned earlier, methanol is not handled in any product pipelines in the Basin. The SPPL common carrier lines in the basin will not handle methanol until the volumes handled are very large (10-30 percent of the product traffic in the region), commingling of methanol product among shippers is acceptable, and the concerns about water contamination are resolved.

At the relatively small volumes of methanol traffic in the early years of its use, pipeline service offers no economic benefit in distributing it within the Basin. Even at large volume the benefit of pipeline use (to supply in-land terminals) is on the order of 1/2¢/gal for the in-land markets.[46]

Direct truck deliveries to service outlets is expected to be the predominant delivery method for methanol even when the sales volume is large. A fleet of dedicated tank trucks will minimize contamination but is marginally less efficient than the current practice of carrying multiple products in compartmentalized tanks, allowing the delivery of all products to a station in one truck.[18]

4.3 METHANOL OUTLETS

The primary consideration in specifying methanol outlet equipment is materials compatibility. Underground storage tanks must be made of carbon steel or specially formulated fiberglass (conventional fiberglass can soften and deteriorate in the presence of methanol).[49/] State environmental laws require that service station tankage be monitored for leaks.[50/] As a result, some outlet tanks are being replaced with double wall tanks,[51,52,53/] and at other locations groundwater monitoring wells are being installed. The leading fiberglass tank manufacturers indicate that they are not getting many orders for methanol compatible fiberglass tanks, which cost $1,000 to $2,000 more due largely to the small volume of production of methanol compatible tanks.[54,55/] Also, current regulations do not require that tanks be both gasoline and methanol compatible. If an existing carbon steel tank is converted to methanol service, tank cleaning is recommended and a fuel filter is added to remove rust particles, which may be loosened from the tank walls by the methanol.[56/]

Service station pumps, pipes, and hoses need to be equipped to meet methanol's unique qualities, avoiding methanol contact with zinc or aluminum (corrosion) and certain plastics and rubbers (swelling or deterioration).[35/] A major California service station equipment supplier under contract to the CEC identified the changes necessary to pump methanol and successfully outfitted CEC's outlet pumps for methanol service.[57/]

5. DISTRIBUTION SYSTEM EXPANSION SCENARIO

To identify prospective costs and logistical problems that might arise in the expansion of a fuel methanol supply system in the South Coast Air Basin, one technically feasible means of expanding the supply network has been developed. This expansion scenario is not intended to be a recommendation nor is it intended to imply that alternatives will be more expensive or less likely. In particular, this scenario focuses on a single terminaling operation serving the Basin. If methanol use grows substantially, one would expect several companies to enter the market and distribution would likely occur through several of the dozens of tank farms and terminals in the Basin.

The expansion scenario targets a sales volume of approximately 250 million gallons per year of methanol for vehicle use. This level of methanol use could be achieved by the year 2000 through an aggressive program of car, truck, and bus fleet conversions and private purchases of methanol automobiles rising gradually to 8% of new car sales by 2000 (new car diesel sales at their peak reached 6.2% in the early 1980's). A sales volume of 250 million gallons per year is equivalent to methanol cars penetrating to 6% of the automobile population or a combination of 4% of the automobile population, 1 1/2% of the light and medium duty trucks and 50% of the bus fleet.[58/]

The distribution system has been specified in two phases. Phase I reflects an expansion of the current GATX chemical terminal operation. Phase II involves the installation of a large methanol distribution system at an existing petroleum product harbor terminal such as the GATX Carson Terminal. Table 5-1 outlines the modes of transport and storage

TABLE 5-1

PROSPECTIVE EXPANSION OF METHANOL DISTRIBUTION SYSTEM IN THE SOUTH COAST BASIN

<u>Current System</u>

Volumes:	Less than 500,000 gal/yr of methanol.
Terminal Receipts:	Rail tank cars or tank trucks.
Terminal:	GATX chemicals terminal with a dedicated tank and truck rack.
Blending: (if necessary)	Splash blended in the tank truck; truck makes a separate stop at a gasoline terminal.
Distribution:	Trucked directly to the outlets.
Outlets:	State leased space at service stations (5); privately owned fleet fuel stations (6).

<u>Phase I Expansions (Maximum Use of Chemical Type Terminal)</u>

Volumes:	500,000 to 50,000,000 gal/yr of methanol.
Terminal Receipts:	Chemical vessel, chemical barge or rail tank cars.
Terminal:	GATX or similar chemical terminal operation with dedicated lines from wharf to tank to trucks. Move to round-the-clock operation to meet increased volumes. Utilizes at least 15 percent of GATX chemical tankage and two of seven truck racks.
Blending: (if necessary)	Splash blended in the tank truck; truck makes a separate stop at a gasoline terminal.
Distribution:	Five dedicated trucks (tractor with two tank trailers) deliver directly to the outlets.
Outlets:	100 to 250 new outlets (at existing stations) -- represent two to five percent of all basin outlets.

TABLE 5-1 (cont'd)

PROSPECTIVE EXPANSION OF METHANOL DISTRIBUTION SYSTEM IN THE SOUTH COAST BASIN

<u>Phase II Expansion (Development of a Dedicated Methanol Terminal)</u>

Volumes:	50,000,000 to 250,000,000 gal/yr of methanol.
Terminal Receipts:	Vessel, barge and railcar.
Terminal:	Expansion or modification of an existing L.A. harbor petroleum products terminal. Dedicated internal floating roof tanks and truck loading rack (three bays). Wharf to terminal pipeline may or may not be dedicated.
Blending: (if necessary)	Gasoline and methanol blended in-line during truck loading.
Distribution:	Dedicated truck fleet, delivers directly to outlets. No use of in-land terminals or common carrier pipelines.
Outlets:	Total of 500 outlets (methanol as a high volume product at ten percent of all basin outlets).

in the current distribution system and the hypothesized Phase I and Phase II expansions.

In Phase I, the distribution system is expanded up to 50,000,000 gallons/year (versus less than 500,000 gallons per year at present). At this upper limit, loading of trucks is carried out round-the-clock and at least 15 percent of the GATX terminal storage capacity is in methanol service.[7,13] At the level of 50,000,000 gallons per year, the addition of methanol service at 100 to 250 service outlets is required. (There are currently about 5,000 service outlets in the Basin. Diesel cars were sold in the South Coast Air Basin when only one percent of the stations sold diesel,[20] and Canada has demonstrated that fuel availability has not been a question in their propane vehicle program where ten percent of the station carried propane.[59] The Phase I target of 100 to 250 or two to five percent of all outlets should be acceptable.) With 250 stations handling 50,000,000 gallons/year, methanol volumes at each station will be about half the volume now targeted per product for new stations. However, the volume is typical for the smaller volume existing outlets.[21]

The Phase II system will handle at least 250,000,000 gallons per year of methanol. Any existing harbor product terminal can be modified to meet this requirement and a dedicated three bay truck loading rack would handle the associated round-the-clock truck loading.[18] With the number of service outlets expanded to about ten percent of all outlets, methanol would be a high volume product at those 500 outlets, at or above the target throughput rates for new service stations. If the volume of methanol traffic in the South Coast Air Basin were to exceed 250,000,000 gallons/year, the system layout and cost per gallon would not change dramatically from that described for Phase II.

6. COST OF THE METHANOL DISTRIBUTION SYSTEM

Based upon the supply and distribution system expansion scenario in the previous section, EEA developed estimates of the capital investment and likely operating costs for both phases.

6.1 PHASE I CAPITAL COSTS

Table 6-1 presents EEA's estimate of the capital costs of creating a methanol distribution system handling 50,000,000 gallons/year. No additional capital investments are required for terminal operations. The GATX chemical terminal can receive by vessel, barge, or rail car these volumes, store the methanol in tankage with internal floating roofs and load trucks without any hardware changes. The volume will call for a switch to round-the-clock operations, however.

In distribution this volume of methanol can be handled easily by a dedicated fleet of five trucks (each delivering three to four truckloads per day). A single truck tractor with two tank trailers costs about $140,000.[18/]

The largest potential cost will occur at the service outlets. A range of costs has been developed, keyed to the availability and suitability of in-place storage tanks. If an existing underground tank is suitable, the costs of cleaning it and modifying the pump are on the order of two thousand dollars.[56,57/] This lower cost case is credible (but not assured) for several reasons:

- Most stations will be phasing out leaded gasoline and will have a pump and tank available for an alternate product (medium octane unleaded is probably preferred).[46/]
- Methanol is a high octane product which logically could displace premium unleaded from its slot at a station.[60/]

TABLE 6-1

CAPITAL COSTS, METHANOL DISTRIBUTION - PHASE I EXPANSION
(at 50,000,000 gal/yr)

1. Terminal and Blending Operations

Existing chemical terminal facilities are adequate; no capital investment required.

2. Truck Fleet

Five trucks with tank trailers (8,500 gallon capacity)

5 x $140,000 = $700,000

3. Service Station Modifications

Low Cost Case: Uses existing tankage and pump. Costs are due to tank cleaning, new fuel screen, new fuel filter, and replacing seals and pump hose.

$2,000 per station x 250 stations = $500,000

High Cost Case: New double wall storage tank, new pipe to pump, and one new pump (methanol compatible)

$33,000 x 250 stations = $8.25 million

4. Total Capital Cost

Total capital cost = $1.2 million to $9 million

- Carbon steel and a special type of fiberglass tank are neat methanol compatible. Some tankage in the Basin is being replaced with double walled storage tanks (for environmental reasons). However, one major oil company serving the Basin indicates all of its tankage will be only ten percent methanol compatible.[30/]
- In Phase I and Phase II, only five and ten percent of all service stations, respectively, are expected to handle methanol.

To present the full range of service station costs, however, EEA has included the cost of a new underground storage tank, pipe and a service pump. In EEA's review of the cost of a new tank, piping and pump resulted in a cost of $33,000 per outlet.[50,51,57,61,62,63/] At $33,000 per station, this accounts for over $8 million of potential costs related to the Phase I expansion.

The total estimated capital cost of Phase I is $1.2 to $9 million.

6.2 PHASE II CAPITAL COSTS

Capital costs for Phase II as presented in Table 6-2 include a substantial investment in terminal equipment. A high and low cost case were developed to reflect outstanding uncertainties. For the low cost case, terminal investments were limited to installing a new truck loading rack and an in-line blender. The low cost case assumes the use of existing tankage and harbor facilities. This case is credible (but not assured) for several reasons:

- The GATX Carson Terminal has sufficient tank capacity with internal floating roofs to handle the target 250,000,000 gallons/year. These tanks are used, on a short-term basis, by GATX clients and might be made available for methanol service in the future.
- While gasoline is comingled in most large product marine terminals, even "neat" fuel methanol can tolerate some gasoline addition (up to several percent) and can tolerate up to one percent water.[63/]

TABLE 6-2

CAPITAL COSTS, METHANOL DISTRIBUTION - PHASE II EXPANSION*
(at 250 million gal/yr)

1. <u>Terminal and Blending Operations</u>

<u>Low Cost Case:</u> Use existing wharf facilities (comingling with gasoline acceptable) and existing tankage. Install new truck rack and in-line blender.

Truck loading rack (three bays) = $900,000
In-line blender = $150,000[48/]
Total = $1,050,000

<u>High Cost Case:</u> New dedicated pipeline from wharf to terminal, 500,000 bbls of new tankage with internal floating roofs, in-line blender, pumps and new three bay truck rack.

Pipeline to wharf = $1.2 million[65/]
500,000 bbls storage = $5.0 million[15,66/]
In-line blender and pumps = $0.2 million[66/]
Truck rack = $0.9 million[18/]
Total = $7.3 million

2. <u>Truck Fleet:</u> Trucks with tank trailers - 22 x $140,000 = $3,080,000

3. <u>Service Station Modifications</u>

<u>Low Cost Case:</u> Using existing tankage.

500 stations x $2,000 = $1 million

<u>High Cost Case:</u> New tankage and two new pumps

500 stations x $36,000 = $18 million

4. <u>Total Capital Cost</u> = $5.13 million to $26.88 million

*Includes Phase I components.

- There is generally an excess of product storage capacity in the refining industry.[64/]

However, the costs of all new tankage and a five mile dedicated pipeline to the harbor has been included in the higher cost case.

For the Phase II expansion, the costs include 22 tank trucks and twice as many service outlets as specified in Phase I (each one handling more volume). The cost per station is $3,000 greater to reflect the installation of a second pump.

The total capital cost associated with completing Phase II is between $5 million and $27 million.

6.3 IMPACT ON PRODUCT COST

The price of methanol at the retail outlet is expected to reflect the operating and capital costs of terminal, truck and service station operations. The current mark-up on gasoline, excluding taxes, is approximately 1¢/gallon for terminaling, 1¢/gallon for truck delivery and 7¢/gallon for service station operations. Of this seven cents per gallon approximately 1 to 2¢ per gallon represents the outlet operator's profit.[74/] Methanol distribution costs are likely to be higher early in the market development due to capital investment requirements and smaller sales volumes.

Several independent retailers have indicated that generally they will not make a capital investment unless it can be recovered in three to five years.[67-70/] Table 6-3 shows the cost per gallon of methanol to recover the capital investments associated with both Phases over 5 years. Total cost for Phase I is 0.8¢ to 3.9¢ per gallon. For Phase II the total cost per gallon drops to between 0.4¢ and 2.2¢ per gallon.

TABLE 6-3
IMPACT OF DISTRIBUTION SYSTEM CAPITAL
IMPROVEMENTS ON THE COST OF METHANOL

Phase I: Capital costs recovered over 5 years at an annual sales rate of 50 million gallons/year

Terminal Costs	=	0¢/gallon
Truck Costs	=	0.3¢/gallon
Station Costs	=	0.5-3.6¢/gallon
Total	=	0.8-3.9¢/gallon

Phase II: Capital costs recovered over 5 years at an annual sales rate of 250 million gallons/year

Terminal Costs	=	.08-0.6¢/gallon
Truck Costs	=	.25¢/gallon
Station Costs	=	.08-1.4¢/gallon
Total	=	0.4-2.2¢/gallon

These figures are based upon steady sales volumes of 50 million and 250 million gallons per year, for each phase respectively.

Capital cost recovery during the transition from current sales of less than 500 thousand gallons/year to the target Phase I volume of 50 million gallons/year could be substantially higher. However, there are no real economies of scale in the terminal and trucking operations specified for Phase I (the terminal incurred no capital costs and the five truck fleet could be brought into service gradually). Only the service station costs could be substantially higher in the early part of the transition to vehicle methanol use. EEA estimates that methanol sales could progress as follows if an aggressive fleet conversion and new car introduction program were initiated:[58/]

Year 1	10 million gallons/year
Year 2	20 million gallons/year
Year 3	40 million gallons/year
Year 4	60 million gallons/year
Year 5	80 million gallons/year

If 250 service stations (5% of all outlets) were required in the South Coast Air Basin to supply the introduction of methanol vehicles and each station owner sought to recover a $33,000 investment during that five year period, the capital recovery mark-up alone would be:

$$\frac{\text{250 stations x \$33,000}}{\text{210 million gallons}} = \text{3.9¢/gallon}$$

This figure is reasonably close to the higher steady state figure for Phase I in Table 6-3. This estimate is very sensitive to the acceptable time period for capital investment recovery. If a three year capital recovery period is applied, this figure rises to:

$$\frac{\text{250 stations x \$33,000}}{\text{70 million gallons}} = \text{12¢/gallon}$$

Table 6-4 provides an estimate of the total cost to be incurred in distributing methanol under Phase I and Phase II. Terminaling, distri-

TABLE 6-4
METHANOL SUPPLY AND DISTRIBUTION ESTIMATED COSTS*

Phase I (50 million gallons/year)

Terminaling	3-5¢/gal
Trucking	1-2¢/gal
Service Station	10-12¢/gal
Total	14-19¢/gal

Phase II (50 million-250 million gal/yr)

Terminaling	1-2¢/gal
Trucking	1-1.5¢/gal
Service Station	7-9¢/gal
Total	9-12.5¢/gal

* Excluding Federal, State and Local taxes. Based on the current mark-up for gasoline and estimates of costs to cover capital investments.

bution and retail services for Phase I are estimated at 14-19¢/gallon not including taxes. In Phase II, per gallon costs are expected to drop to between 9 and 13.5¢/gallon, excluding taxes. These cost estimates combine qualitatively the current costs of petroleum and chemical product distribution and some premium to recover the added capital requirements for methanol distribution over a five year period. These costs may be low if current rates do not include any significant capital recovery and if the methanol equipment purchaser requires a very quick payback. Alternatively, these costs may be too high (on the "per gallon" basis) because methanol sales volumes eventually will be higher than gasoline volumes due to energy intensity differences.

7. COMPARISON OF METHANOL AND GASOLINE RETAIL PRICES

As the foregoing sections have indicated, the cost and tax structure of the methanol and gasoline markets differ considerably. In addition, methanol has a lower energy density (a gallon of methanol contains about half the energy in a gallon of gasoline) but a potentially higher energy efficiency (up to 20%) than gasoline, making a price comparison on a straight cents-per-gallon basis inappropriate.

Using the results of a companion study for EPA by Jack Faucett Associates,[71/] which estimated the delivered price of methanol imported into the U.S., this section will estimate the equivalent price of gasoline at which methanol can be competitive in the South Coast Air Basin.

The Jack Faucett study indicates, that while the current import price of methanol is 26¢ to 31¢/gallon, these prices do not appear to include a reasonable recovery of methanol production capital costs. The study estimates that a price of 35¢ to 45¢/gallon is more appropriate in evaluating a transition to methanol use in motor vehicles, based on overseas production of methanol from natural gas.

When the costs of distribution as shown in Table 6-4 and the applicable taxes for methanol are added to this base methanol cost, the retail cost of methanol (at the pump) is estimated at 61.2 to 77.2¢/gallon in Phase I and 55.9 to 71.3¢/gallon in Phase II (see Table 7-1). To determine an "equivalent" gasoline price, one must adjust for the differences in energy intensity and expected energy use efficiency.

As stated earlier, a gallon of methanol contains about one-half as much energy as a gallon of gasoline. However, it is expected that methanol

TABLE 7-1
"EQUIVALENT" GASOLINE PRICES
BASED UPON THE
RETAIL COST OF NEAT METHANOL

Cost Component	Cents per Gallon of Methanol (Range)	
	Phase I	Phase II
Methanol Production and* Delivery to L.A. Harbor	35.0 - 45.0	35.0 - 45.0
Methanol Terminaling**	3.0 - 5.0	1.0 - 2.0
Truck Distribution**	1.0 - 2.0	1.0 - 1.5
Service Station**	10.0 - 12.0	7.0 - 10.0
State Sales Tax	3.2 - 4.2	2.9 - 3.8
State Fuel Tax	4.5	4.5
Federal Fuel Tax	4.5	4.5
Total	61.2 - 77.2¢/gal.	55.9 - 71.3¢/gal.
"Equivalent" Gasoline Prices ($/gal.)***	$ 1.02 - 1.29	$ 0.93 - 1.19

* From Reference 71.

** Taken from Table 6-4.

*** Based upon an equivalency factor of 0.6 gallon of gasoline per gallon of methanol (reflects energy density and prospective efficiency differences).

vehicles will ultimately be 20% more efficient (on a unit of energy basis). Under those circumstances, a gallon of methanol is equivalent to about 0.6 gallon of gasoline. Based on this figure, Table 7-1 shows a range of "equivalent" gasoline prices in Phase I and Phase II, between 93¢ and $1.29 per gallon. This price range reflects no incentive to the consumer to use methanol. If one were to provide a 1¢/mile (15¢/gallon of methanol) incentive to the consumer using methanol, the "equivalent" gasoline price would rise by 25¢ to a range of $1.18 to $1.54 per gallon.

8. OUTSTANDING UNCERTAINTIES AND CONCERNS

While this report prescribes methanol fuel distribution transition for the South Coast Air Basin from less than 500,000 gallons/year to over 250 million gallons/year, several large uncertainties exist which will influence the ultimate costs and acceptability of the distribution system. The key concerns identified in the conduct of this study are outlined below:

- Standardizing fuel methanol specifications: A variety of neat and "near neat" methanol blends have been tested and demonstrated. A uniform specification will improve handling efficiency and insure proper equipment specification.
- Treatment of methanol toxicity: Air emissions permitting regulations are very strict in the South Coast Air Basin. In addition, the state has implemented an elaborate new program to control toxics. An early indication of how methanol will be treated in that permitting context will improve the commitment of private interests to implementing methanol distribution systems.[72/]
- Establishing the initial outlets: While demand is well below the 50,000,000 gallon/year target, few service station owners will be willing to commit to methanol unless they take a substantial mark-up (as is done with low volume sales of propane) or they are provided separate economic benefits by outside parties.
- Adaptability of existing equipment: The question of water take-up when methanol is placed in existing gasoline pipelines and tanks will be resolved only after additional experience is gained handling methanol as a fuel. If the existing petroleum product systems are dry enough and clean enough, substantial cost savings will occur. For underground service station storage a "window of opportunity" exists to make tanks methanol compatible. Specifically, some tanks are being replaced over the next couple of years to meet environmental regulations. For modest additional costs, methanol compatible tanks can be specified. However, it is not required or recommended by government.

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