SR/O&G/2003-03

2003 California Gasoline Price Study

Final Report

November 2003

Office of Oil and Gas
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Contacts and Acknowledgments

This report was prepared by the Office of Oil and Gas of the Energy Information Administration (EIA) under the direction of John Cook, Director, Petroleum Division. Questions concerning the report may be directed to Joanne Shore (202/586-4677), joanne.shore@eia.doe.gov, Team Leader, Petroleum Division, or John Zyren, (202/586-6405), john.zyren@eia.doe.gov, Industry Economist, Petroleum Division.

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Executive Summary

California was scheduled to ban the use of methyl tertiary butyl ether (MTBE) in gasoline in January 2003, but a number of factors caused the State to delay the ban for one year to January 2004. Many California refiners chose to remove MTBE early,[1] however, and at the beginning of 2003, refiners switched about 45 percent of California gasoline production (about 500 thousand barrels per day) from the use of MTBE to ethanol. As refiners began the transition from winter-specification gasoline to the harder-to-produce summer-specification gasoline using ethanol, the State experienced a price spike. The coincidence of this winter-summer transition with the spring price spike prompted Congressman Doug Ose to request that the Energy Information Administration (EIA) explore whether the switch from MTBE to ethanol caused the price spike and what lay ahead for the California gasoline market. EIA produced a preliminary report in May addressing the specific questions asked by Congressman Ose.[2] This is the final report, in which EIA analyzes the spring price run-up and reviews the California gasoline market during the rest of summer 2003. Our findings regarding the reasons behind the spring run-up are unchanged from the preliminary report.

California uses a reformulated gasoline that meets stricter emission standards than those for Federal reformulated gasoline (RFG).[3] Prior to 2003, most of the State's gasoline contained MTBE, which was used to diminish the gasoline's air emissions and to improve engine performance. Federal RFG is also required to contain 2 percent by weight of oxygen. Although California does not have this requirement, some areas in the State must meet Federal requirements, and MTBE, which contains oxygen, was also used to meet the Federal oxygen requirement. However, detection of MTBE in some water supplies caused the State to ban its use in motor fuel by the end of 2003. As MTBE is eliminated, it is being replaced with ethanol, which, like MTBE, satisfies the Federal RFG standard for oxygen content, while also supplying needed octane. Major gasoline specification changes, such as the removal of MTBE and use of ethanol in its place, can create market dislocations that give rise to price spikes during the transition.

The spring price surge was quite large. After a period of relative stability for much of 2002, gasoline prices throughout the United States began to rise in December. The national average retail price for regular gasoline[4] rose 37 cents per gallon between

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[1] California refiners producing gasoline containing MTBE during spring 2003 will switch to ethanol-blended gasoline later in the year.

[2] Energy Information Administration, *2003 California Gasoline Price Study: Preliminary Findings*, SR/O&G/2003-01, May 2003.
http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2003/cagasoline/cagasoline.pdf

[3] Federal reformulated gasoline (RFG) is gasoline that, on average, significantly reduces Volatile Organic Compounds (VOC) and air toxics emissions relative to conventional gasoline. It is more difficult to produce than conventional gasoline and originally was required only in the nine cities with the worst ozone nonattainment (Los Angeles, San Diego, Chicago, Houston, Milwaukee, Baltimore, Philadelphia, Hartford, and New York City). Other areas that also have a history of air pollution problems joined the RFG program. Today, RFG represents about 1/3 of U.S. gasoline consumption.

[4] Retail prices used in this report are from Form EIA-878, "Motor Gasoline Price Survey," collected and published each Monday. Higher or lower average prices may have occurred between survey dates.

December 9, 2002, and March 17, 2003, reaching what was then an all-time record (nominal) price of $1.73 per gallon. Over roughly the same period (though beginning two weeks later), California retail regular gasoline prices rose 63 cents to an all-time high of $2.15 per gallon. After peaking on March 17, retail gasoline prices fell sharply through early June, with the U.S. average dropping to $1.47 by June 2, and California falling to $1.70 by June 9.

Gasoline price spikes are not unusual in California. Since the mid-1990s, California has experienced gasoline price run-ups that are more frequent and more severe than price spikes in most of the rest of the United States. Demand growth has caught up with the petroleum supply system in California. Refineries, ports, pipelines and distribution terminals are all experiencing constraints. Many times events, such as refinery outages, that in the past had little impact can push the system out of balance long enough to trigger large price increases. Major factors that contribute to higher prices and volatility in California include:

- The California refinery system runs near its capacity limits, which means there is little excess capability in the region to respond to unexpected shortfalls;
- California is isolated and lies a great distance from other supply sources (e.g., 14 days travel by tanker from the Gulf Coast), which prevents a quick resolution to any supply/demand imbalances; and
- The region uses a unique gasoline that is difficult and expensive to make, and as a result, the number of other suppliers who can provide product to the State are limited.

Because short-term supply responses are no longer available to California, when supply-demand imbalances occur, demand adjustments must play a larger role in returning the market to equilibrium. Consequently, prices rise higher than in other regions where quicker supply solutions exist. Gasoline price spikes are not unusual in California.

Another factor sometimes influences California prices – the Arizona and Nevada markets. California refiners also supply markets in Nevada and parts of Arizona, including fast-growing population centers such as Las Vegas and Phoenix. California prices can, therefore, experience extra upward pressure if these markets attract additional product from California.

Following the Spring gasoline price run-up, two other price surges occurred in 2003, one in June and the other in August. Average California retail gasoline prices rose 11 cents in 2 weeks to peak at $1.81 on June 23, and then took 6 weeks to decline to $1.70 by August 4. Prices began to rise strongly again in August, with the U.S. average retail regular gasoline price rising 23 cents from July 28 to August 25, peaking at a new record nominal high of $1.75. California prices climbed 40 cents from August 4 through August 25, but at $2.10 per gallon, fell short of their March record peak. Both U.S. and California average prices began to decline in September, and by mid-October, had fallen by 18 and 30 cents, respectively.

Price spikes occur when supply becomes tight, usually characterized by gasoline inventories falling rapidly and reaching abnormally low levels. Markets typically tighten for reasons such as loss of gasoline production from refinery outages, the spring transition from winter- to summer-specification gasoline, or unusually strong demand periods that can occur in the summer driving season. In addition, the transition to a new fuel specification, such as changing from MTBE to ethanol as described below, can cause upward price pressure.

Switching from MTBE to Ethanol Affected California Supply

Supply constraints arise in the distribution system when MTBE is replaced by ethanol in gasoline. Refiners produce a base unfinished reformulated gasoline mixture to which the ethanol is added. This base material is referred to as reformulated gasoline blendstock for oxygenate blending, or RBOB. In the case of California, the material is called CARBOB,[5] since it meets more stringent emission standards than Federal RBOB. Ethanol is transported and stored separately from other petroleum products because of its affinity for water in the gasoline distribution system, and the ethanol is only blended into CARBOB as the material is loaded onto trucks to be delivered to retail gasoline stations. CARBOB is also a separate product from MTBE-blended RFG. Terminals have a limited number of tanks and are generally unable to accommodate additional gasoline formulations that must be kept segregated. The result is that terminals that switch to ethanol-blended gasoline may no longer be able to supply gas stations that still require MTBE-blended gasoline, reducing supply system flexibility.

The switch from MTBE to ethanol affected California supply in three ways. As has been described in previous reports by the California Energy Commission (CEC) and EIA, the switch to ethanol reduces the volume of gasoline California refiners can produce. The reduction occurs because only about half the volume of ethanol is used to replace the MTBE removed, and because other light components must be removed to meet summer specifications, since ethanol has a higher blending vapor pressure than MTBE. The result is that for 8 months of the year refiners' gasoline production is reduced by over 10 percent, which must be replaced with supply from outside of the State.

This loss of production capability gives rise to the second supply impact of the switch to ethanol, which is California's need to import both more and different blending components for gasoline production. MTBE, which was largely shipped from outside the State, must be replaced with one-half the quantity of ethanol, which similarly comes from outside California. In addition, the other half of the MTBE volume lost, and the light ends removed when ethanol is added, must be replaced with high-quality components that will meet the rigorous California gasoline specifications. More CARBOB could also be imported, but in the past only a very few refiners around the world could produce the California-quality gasoline. The net result is that the switch pushes California, which has been mostly self-sufficient in meeting its gasoline needs, to require greater volumes of high-quality imports. Since supply is limited, this requirement puts upward pressure on California's gasoline prices.

[5] CARBOB stands for California reformulated gasoline blendstock for oxygenate blending.

The third impact of the switch to ethanol was that the switch in early 2003 was only a partial switch, with a still significant fraction of California gasoline being made with MTBE. This had both positive and negative aspects for the California market. On the positive side, it reduced the volume loss from California refiners and the need for imports. On the negative side, it created a market with two types of gasoline that had to be kept separated, which produced complications within the California distribution and logistics system, as discussed in more detail below.

March Price Run-up

Three factors contributed to the price spike in March:

- An increase in crude oil prices in the first quarter;
- The loss in gasoline production from refinery outages; and
- The loss of market balancing capability that resulted from the market splitting into two types of gasolines: MTBE-blended gasoline and ethanol-blended gasoline.

During the first quarter in California, gasoline production was reduced because of refinery outages for major maintenance. Some of these outages lasted longer than planned, and other unplanned outages added to unexpected production losses. EIA analysis found that the outage level was on the high side of historical outages, as was the reduction in first quarter gasoline production. Not surprisingly, in late February and early March, gasoline inventories were declining as demand exceeded production. However, the gasoline inventories did not fall to low enough levels as might be expected to cause the price increase that occurred. EIA looked for other factors contributing to the price rise and focused on the distribution and logistics market complications arising from the split gasoline market.

California has two major geographically separate gasoline markets. The first is the northern California market with five major refineries in the San Francisco Bay area, which also supply product to northern Nevada. Two refineries in Bakersfield satisfy local demand and also move product north by pipeline. In the south, six refineries located in the Los Angeles area provide product to southern California, Las Vegas, and Arizona. When the shift to ethanol occurred, three refineries in northern California still produced MTBE-blended gasoline, and only one in the south continued to use MTBE. The southern refinery using MTBE was smaller than any one of the three northern refineries using MTBE. On the market side, the independent marketers historically looked to the refiners that had not switched to ethanol-blended gasoline for most of their supply. Given the non-fungibility of the two fuels, retailers could not easily switch back and forth between MTBE- and ethanol-blended gasolines. EIA found from discussions with California gasoline producers, distributors, and retailers, and from analyzing price data, that the split market produced a much tighter supply situation than would be expected from only looking at the inventory data. In particular:

- A number of distributors & retailers reported that one refiner was buying CARBOB and blending it with MTBE in order to provide additional MTBE-

blended gasoline supply;
- Some distributors that initially bought MTBE-blended gasoline switched to buying ethanol-blended gasoline to obtain supply;
- Finally, the gasoline spot price in the Los Angeles region rose to exceed the San Francisco price by 7 cents per gallon, reflecting the tighter market in the south because of the short supply of MTBE-blended gasoline relative to demand and the proportionally larger outages in that area.

June and August Price Run-ups

In the summer months, two price spikes occurred: one smaller increase in June and a dramatic run-up in August. June through August are generally the highest gasoline demand months on the West Coast. Crude price changed little during these gasoline price increases, and thus, did not add to the June or August gasoline price surges. In both cases there were sharp inventory declines, and sharp gasoline price rises relative to crude oil prices. The inventory declines and price increases in June were mainly due to refinery outages as California entered what is typically one of its highest gasoline demand months.

From August 1 to August 20, California gasoline prices at the wholesale (spot) level rose about 65 cents per gallon, while retail price rose about 40 cents per gallon from August 4 to August 25 to peak at $2.10. In the first three weeks of August, finished gasoline and blending components were removed from storage at a rate in excess of 142 thousand barrels per day, which is 10 times the average draw rate of 14 thousand barrels per day seen at this time during the past 5 years. Refinery inputs were very high in August, but gasoline production was down 22 thousand barrels per day at the refineries that had shifted from using MTBE to ethanol. Gasoline demand in July in August was at its peak at about 1.02 million barrels per day, which was about 80 thousand barrels per day higher than in March and April. On top of this, a segment of the Kinder Morgan pipeline, which supplies Arizona with gasoline from Texas, ruptured on July 30 and was shut down for much of August. This line represented about one-third of supply into Phoenix, and made the Phoenix area almost completely dependent on supply from Los Angeles, increasing gasoline demand on that refining center by about 30 thousand barrels per day. The California refiners simply were not able to keep up with summer peak demand in California as well as the extra demand from Arizona. Imports or receipts from other U.S. regions could not respond quickly enough to keep inventories from falling rapidly and prices spiking.

Lessons Learned and Looking Ahead to 2004

A number of lessons emerged from this analysis:
- Transitions by their nature increase the potential for volatility. Smooth transitions cannot be assured.
- Government coordination among different departments, such as those issuing permits and those directing fuel change programs, can help make transitions go

more smoothly.

- Reducing regulatory uncertainty encourages early preparation by industry, which can reduce some of the last-minute changes that occur during a transition. For example, the potential for a waiver or removal of the oxygen requirement for Federal RFG provided a large incentive for some refiners and terminal operators to wait as long as possible before investing to use ethanol.
- A partial transition does not necessarily cause more price volatility than a full transition. While the partial transition created market problems this year, a full transition might have been more disruptive. A full transition would have shifted the problem from the distribution system to the production and import part of the supply chain. Instead of replacing a shortfall of 70 thousand barrels per day in the partial transition, the industry would have had to replace 105 thousand barrels per day. It did not seem possible for California to require a full transition in 2003, as some refineries had not received permits in time to make the necessary changes. Furthermore, it probably would not have been possible for California to require refineries that had prepared to eliminate MTBE to postpone their plans without other supply re-adjustments and dislocations. The resulting partial transition, while creating logistical complications, did allow the industry to identify and remedy smaller supply problems in advance of the total State MTBE ban in 2004.

As California looks ahead to 2004, further changes will take place. While the logistical system is expected to remain constrained, several factors should ease many of the logistics problems, including the return to mainly one gasoline[6] in 2004, when MTBE-blended gasoline can no longer be sold; the experience suppliers gained during 2003; and more importantly, the fact that the large refinery outages seen this past spring may not reoccur.

EPA's recent decision allowing the elimination of the requirement for an oxygenate in summertime Arizona Cleaner Burning Gasoline (CBG) may make it easier for the California refining industry to supply CBG because it reduces the constraints on the refiners' gasoline blending and may facilitate imports from abroad to serve Arizona.

Despite factors functioning to ease the strained system in 2004, other factors are working against smooth supply. These include:

- Total gasoline production capability will be reduced because all refineries will be producing CARBOB.
- More material must be brought in from outside the State, and port constraints, particularly those in southern California, may become more limiting than they were in 2003.
- MTBE bans in New York and Connecticut will create demand for high-quality, summer-grade gasolines, similar to CARBOB, in the second quarter of 2004. This will increase competition for the same type of gasoline and components required by California.

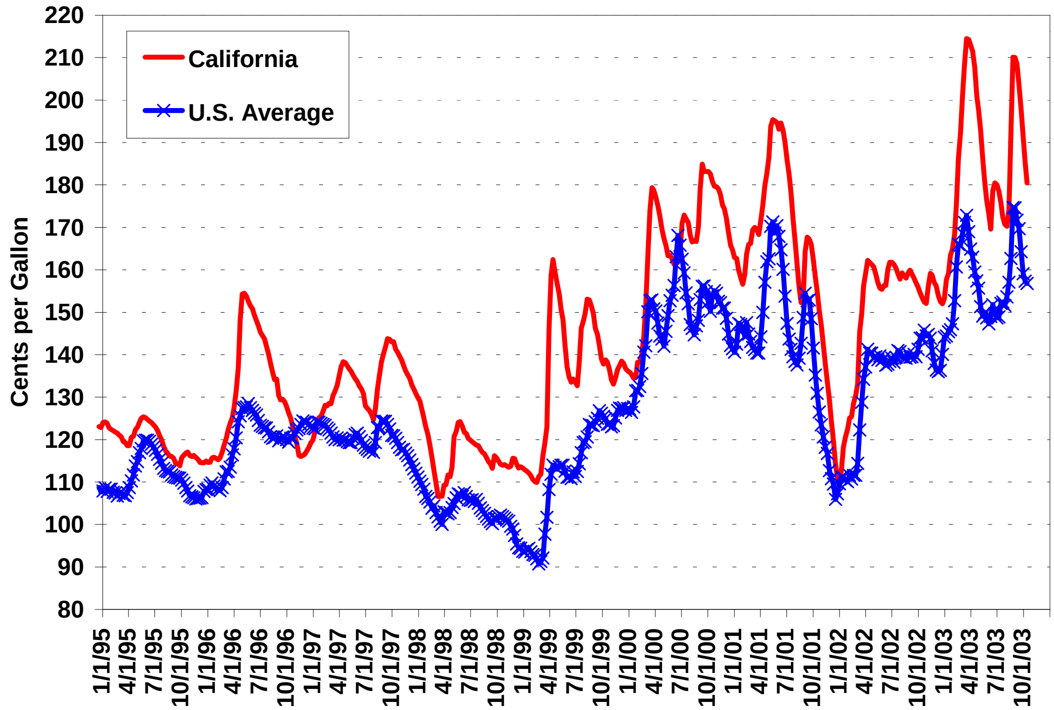
[6] Since not all of California is required to meet Federal RFG standards, some California gasoline can be produced without the use of oxygenates like MTBE or ethanol. A small volume of non-oxygenated RFG was being produced in 2003 and will likely be produced in 2004.

In 2004, factors such as reduced refining capacity and long supply chains will work to increase the probability of price volatility, while other factors will work to reduce market dislocations. Refinery outages, for example, may not be as large in 2004 as occurred in 2003, and with the move to a single fuel, supply-demand imbalances that occur may be resolved more quickly, tempering price surges. Which factors ultimately will dominate cannot be determined in advance.

1. Introduction

After a period of relative stability for much of 2002, gasoline prices throughout the United States began to rise in December. The national average retail price for regular gasoline rose 37 cents per gallon between December 9, 2002, and March 17, 2003, reaching what was then an all-time record (nominal) price of $1.73 per gallon (Figure 1-1). Over roughly the same period (though beginning two weeks later), California retail regular gasoline prices rose 63 cents to an all-time high of $2.15 per gallon. After peaking on March 17, retail gasoline prices fell sharply through early June, with the U.S. average reaching a low of $1.47 on June 2, and California falling to $1.70 on June 9.

Figure 1-1. U.S. and California Retail Gasoline Prices



Source: Energy Information Administration

Prices fluctuated within a relatively narrow range (5 cents) in most of the United States through June and July, while California experienced another, though smaller, price run-up. Average California retail gasoline prices rose 11 cents in 2 weeks to peak at $1.81 on June 23, then took 6 weeks to decline to $1.70 on August 4. Prices began to rise strongly again in August, with the U.S. average retail regular gasoline price rising 23 cents from July 28 to August 25, peaking at a new record nominal high of $1.75. California prices climbed 40 cents from August 4 through August 25, but at $2.10 per gallon, fell short of their March record peak. Both U.S. and California average prices began to decline in September, and as of October 13, 2003, had fallen by 18 and 30 cents, respectively.

On March 27, 2003, Congressman Doug Ose, Chairman of the House Government Reform Subcommittee on Energy Policy, Natural Resources and Regulatory Affairs, asked that the Energy Information Administration (EIA) examine the causes of the early 2003 increase in the price of California gasoline. His request letter (Appendix A) posed several specific questions, and asked for a preliminary response by early May. Our initial findings were provided in a prior report.[7] This report contains the findings of our final analysis.

The report is organized into 8 chapters. Following this introduction, **Chapter 2, Market Background**, provides an overview of the California market, highlighting the major features with which the reader should be familiar when reading the remaining chapters. **Chapter 3, Removing MTBE and Using Ethanol**, explains the reasons switching from MTBE to ethanol affects gasoline production, distribution and logistics. **Chapter 4, California Refinery Supply**, focuses on refinery supply during the first and second quarters of 2003, exploring the degree of outages and the impact that using ethanol may have had on gasoline production. **Chapter 5, California Gasoline Distribution and Logistics,** reviews the physical flows of gasoline in California and describes how constraints in the system affected supply availability during the switch to ethanol and coincident refinery outages. **Chapter 6, Gasoline Market Structure and Behavior**, provides an overview of price formation and market dynamics driving prices, including the factors that prompt price spikes. This chapter provides the background for **Chapter 7, California Gasoline Prices Spring and Summer 2003**, which explains what factors drove price surges in March, June, and August. **Chapter 8, Lessons Learned**, summarizes a number of areas that may provide insights for improving major fuel transitions in the future.

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[7] Energy Information Administration, *2003 California Gasoline Price Study: Preliminary Findings*, SR/O&G/2003-01.
http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2003/cagasoline/cagasoline.pdf

2. Market Background

California has historically seen some of the highest, and most volatile, gasoline prices in the United States. The reasons for the striking difference in the behavior of California gasoline prices compared to those in other parts of the United States are numerous and varied. Major factors that contribute to higher price volatility in California include:

- The California refinery system runs near its capacity limits, which means there is little excess capability in the region to respond to unexpected shortfalls;
- California is isolated and lies a great distance from other supply sources (e.g., 14 days travel by tanker from the Gulf Coast), which prevents a quick resolution to any supply/demand imbalances; and
- The region uses a unique gasoline that is difficult and expensive to make, and as a result, the number of other suppliers that can provide product to the State is limited.

Additionally, the partial phase-out of methyl tertiary butyl ether (MTBE) from California gasoline this year, and its replacement with ethanol, resulted in significant logistical changes and temporary mismatches between supply and demand. Originally, California was scheduled to ban MTBE in January 2003, but a number of factors caused the State to delay the ban for one year to January 2004. Many California refiners chose to switch from MTBE to ethanol in January 2003,[8] however, resulting in the market being segmented into two non-fungible products, since ethanol-blended gasoline cannot be mixed with other gasolines during the summer to ensure compliance with emission requirements. A further complicating factor was that the March price increase occurred about the time California refiners were changing from winter-grade gasoline to summer-grade,[9] which is harder to produce and, when using ethanol, requires a change in procedures or timing to ensure that uncontaminated summer-grade product is located at terminals on time.

The remainder of this chapter provides background on the global markets during the first part of 2003 as well as a brief overview of California supply and demand to provide a context for the detailed chapters that follow.

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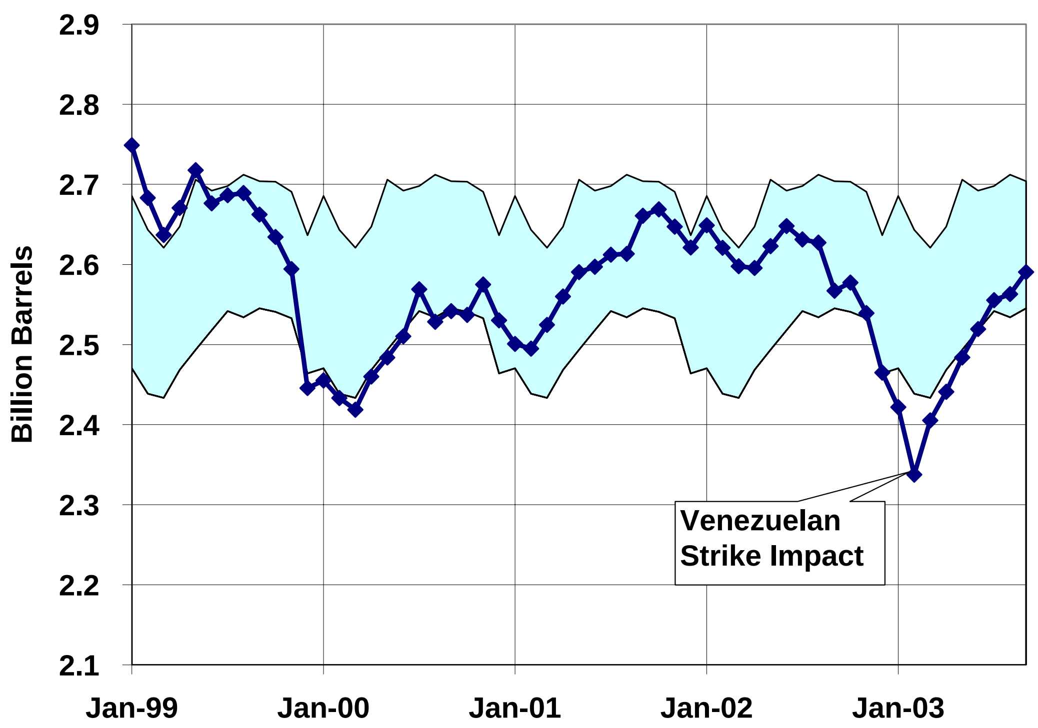
[8] Some refiners had switched to ethanol before 2003, and refiners that were still producing MTBE-blended gasoline in January 2003 will switch to ethanol-blended gasoline later in 2003.

[9] Federal RFG regulations require refiners to be producing summer-grade gasoline by May 1, but California requires some southern areas to switch by March 1. This year, the State delayed the start date to April 1 to ease the winter-summer transition when using ethanol. Pipelines, however, require summer-grade product even earlier to ensure State compliance. This year, California refiners began producing summer-grade product in February to meet early March pipeline schedules.

2.1 World Petroleum Market Conditions Produced a Backdrop for Volatility

During 2002, international petroleum markets were gradually tightening as a result of petroleum demand outpacing supply, as evidenced by Organization for Economic Cooperation and Development (OECD) inventories dropping relative to their mean value (Figure 2-1). Prices were generally rising over the course of the year. OECD inventories ended November 2002 at the low end of the normal range for that time of year. Then in early December 2002, a general strike against the government of Venezuelan President Hugo Chavez sharply cut petroleum exports from that country, significantly affecting the global oil supply/demand balance. The loss of almost 3 million barrels per day of crude oil production from Venezuela resulted in an increase of about $5 per barrel in crude oil between early December 2002 and January 2003. The strike affected all facets of the Venezuelan petroleum industry, including production, refining, and transportation, and virtually halted exports for much of December.

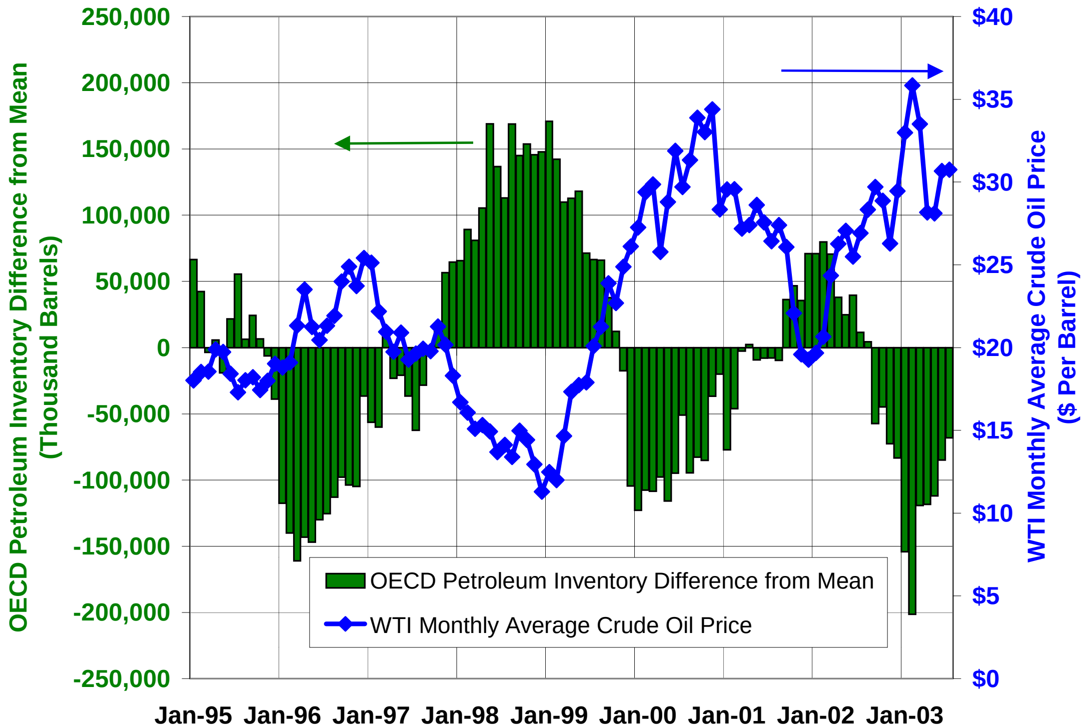
Figure 2-1. OECD Petroleum Inventories



Note: The colored band represents the mean for each month plus or minus one standard deviation, calculated using data from 1995 through 2002.
Source: International Energy Agency, *Oil Market Report*, November 13, 2003.

Little inventory cushion existed in the United States (or in the rest of the world) to absorb a large supply disruption at the end of 2002. Even as Venezuelan production began to slowly return by late January 2003, inventories continued dropping as demand outstripped supply. With increased production from the Middle East, inventories began to recover after February. However, the Iraq war and turmoil in Nigeria further eroded supply, and additional volumes from the other producing countries were not adequate both to meet increasing demand as the U.S. economy began to recover and to return inventories to their more typical levels. Additionally, after the former Iraqi regime was removed and the rebuilding of the Iraqi oil industry began, the Organization of the Petroleum Exporting Countries (OPEC) met and decided to cut production levels effective June 1.

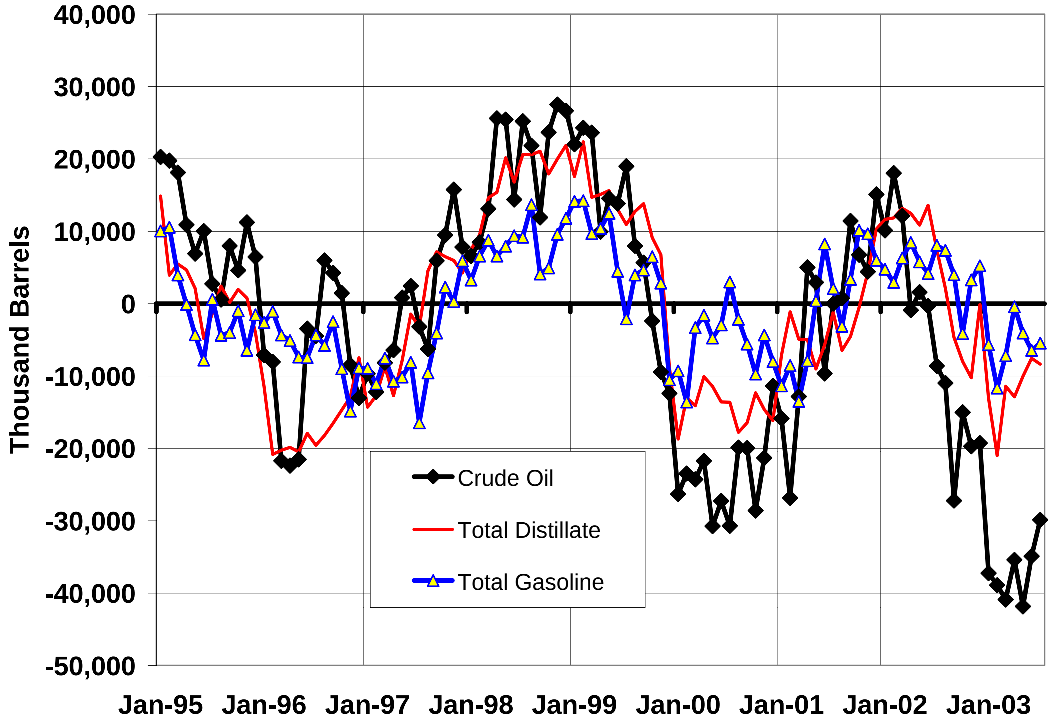
Figure 2-2. Crude Oil Price and OECD Inventory Deviation from Average



Note: The mean value was calculated for each month using data from 1995 through 2002.
Source: Inventories: International Energy Agency, *Oil Market Report*, November 13, 2003; West Texas Intermediate crude oil price (WTI): Reuters Cushing spot prices.

As crude oil markets tighten and prices rise, product markets also tend to tighten. Figure 2-3 shows how U.S. inventories for crude oil, gasoline and distillate tend to cycle together above and below average values. For example, as the crude market tightens and prices rise, refiners usually have financial incentives to reduce crude purchases. Initially they may keep refinery runs up, using crude oil inventories to help meet demand. However, as their crude oil inventories are drawn down, they will need to reduce crude runs and use product inventories as well as production to meet demand as they wait for the market to adjust. The net effect is that both crude oil and product inventories are drawn down. As can be seen in Figure 2-3, U.S. petroleum markets tightened considerably after the loss of Venezuelan petroleum exports, as measured by how low inventories fell.

Figure 2-3. U.S. Petroleum Inventories' Deviation from Average



Note: The mean value was calculated for each month using data from 1995 through 2002.
Source: Energy Information Administration, *Petroleum Supply Monthly*, various issues.

This tight world petroleum market was the environment in which California was making its shift from MTBE-blended gasoline to ethanol-blended gasoline. The United States was facing a tight petroleum market with low inventories at the beginning the gasoline season, and low inventories increase the chances for price volatility. While the West Coast was not affected directly by the loss of crude oil from Venezuela, the price incentives existed to postpone crude oil purchases and use inventories. West Coast inventories, like those in other parts of the country dropped more than usual early in the year. California, however, was in much better condition to weather the shortage than other parts of the country, as will be discussed further in Section 7.2. A number of companies were planning major maintenance at their California refineries, and had increased California gasoline inventories at the beginning of 2003 to levels well above normal, providing extra cushion.

2.2 California Demand and Supply Overview

Gasoline price volatility in California can be better understood by recognizing several features that make this market vulnerable to large price swings. First, the area uses a unique gasoline that few suppliers outside the State can currently produce. Thus, alternative supply sources are limited. Second, California is geographically isolated from other supply sources. It takes weeks for a tanker to move a cargo of product from the Gulf Coast (12 to 18 days) or Asia (23 to 30 days) to California. Third, the region does not have much excess capacity to replace supply that is lost when a refinery experiences an unexpected outage. The State's switch to ethanol-blended product exacerbates these problems, as described below.

Demand

In 2002, California drivers used about 15 billion gallons of gasoline, or 980 thousand barrels per day, representing 11.2 percent of U.S. gasoline demand. The State is projecting annual gasoline demand to increase to 17.3 billion gallons by 2010, growing at an average 1.8 percent per year. If California demand grows at this pace in 2003, it will be using close to 1 million barrels per day of gasoline, an increase of 18 thousand barrels per day over its 2002 requirements. In addition, demand is rapidly growing in the much smaller Arizona and Nevada markets, which California suppliers serve.[10] As described in Chapter 3, California's move from MTBE to ethanol results in a loss of gasoline production capability. Thus, suppliers in 2003 must both find additional supply to meet growing demand, and make up for the loss of productive capability.

Supply

The State of California requires a unique blend of gasoline to help meet its clean air goals. It is unique in that the emission specifications required by the California Air Resources Board (CARB) are more stringent than those for any other gasoline in the world, which in turn, makes CARB gasoline cleaner burning than other gasoline. However, the stringent specifications also make it both more difficult and more expensive to produce.

Refineries located within California produce almost all of the State's gasoline.[11] Historically, this was mainly due to California's distances from the major refining centers on the Gulf Coast and from export refineries in other countries. When California began requiring a unique gasoline, the number of potential suppliers declined. Few refineries outside of the West Coast are able to make CARB gasoline. Refiners must make additional investments to be able to produce this unique gasoline, and despite California's higher margins, most refiners outside the region are unwilling to spend those resources for the occasional cargo they would ship to the region. While few refiners can make CARB gasoline, more are able to produce blending components, such as alkylate or iso-octane, of sufficient quality for California refiners to use to supplement their production.

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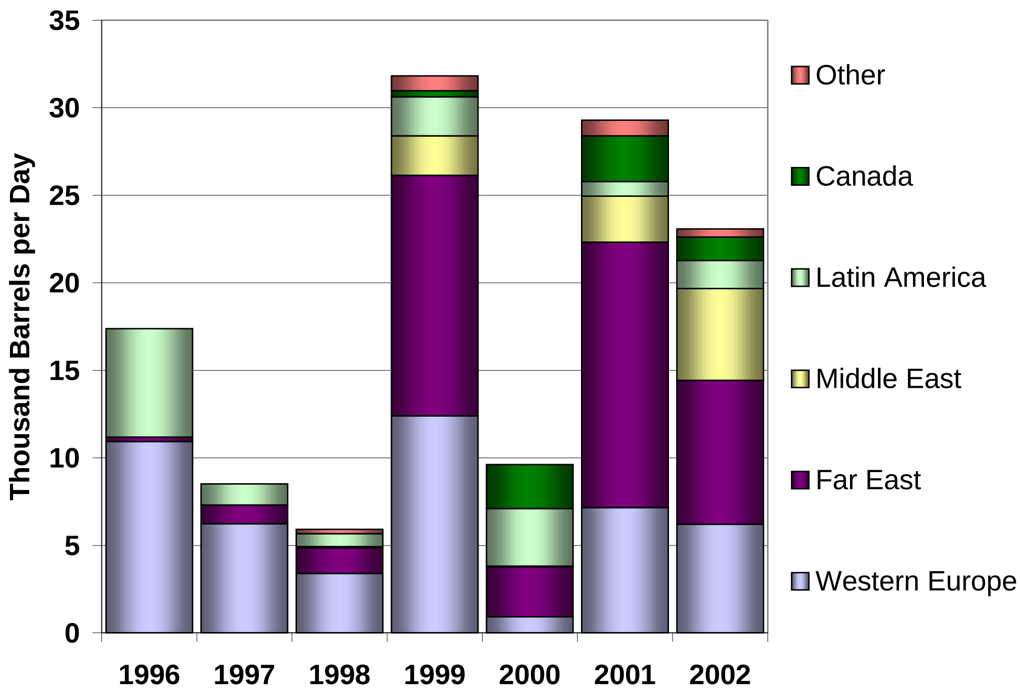
[10] Nevada State Energy Office and Arizona Department of Economic Security estimates cited in "California Strategic Fuels Reserve" California Energy Commission Document P600-02-017D, July 2002

[11] California refiners supply both California and areas in Arizona and Nevada, but they also bring in product from out of State. In 2002, suppliers brought in more than 21 thousand barrels per day of gasoline and gasoline components from foreign sources. Based on a CEC report, they also probably brought in at least 30 thousand barrels per day from other areas in the United States. Not all of these out-of-State volumes are for the California market, which is about 1 million barrels per day.

Still, the list of available suppliers is limited due to the high quality of components required.

Figure 2-4 shows that, while foreign import volumes are not large relative to California's roughly 1-million-barrel-per-day demand, they have met larger amounts of the State's demand during the past several years. Traditionally, Asia and Western Europe have been major sources of gasoline imports during the summer driving months in California, while the Middle East has grown in importance more recently. However, import sources are generally too far away to make up for an unexpected supply loss. Table 2-1 shows travel time from various locations. In addition to actual travel time, a refinery that can make CARB gasoline may not be making it at the time a shortfall occurs, and, therefore, would have to make some refinery adjustments prior to beginning production. It also takes time to produce enough to fill a tanker, which could add another week to the delivery time.

Figure 2-4. Source of Total Gasoline Imports to California During Summer Months (March – October)



Source: Energy Information Administration, Form EIA-814

California refineries run at or near capacity during the peak summer demand months. Because of the tight product specifications for CARB gasoline, these refineries do not have a lot of flexibility to work around problems when a single refining unit is not functioning. Thus, problems with one unit can affect most, if not all, of the gasoline production from a specific refinery. Neither import sources nor neighboring California refineries may be able to respond quickly enough or with adequate volumes to make up for an unexpected outage.

Table 2-1. Transportation Costs and Time Required to Import Fuels to California

Supply Source	Cost (Cents per Gallon)	Shipping Time (Days)	Initial Lead Time[1] Plus Shipping Time (Days)
Washington State	3 to 4	4 to 6	11 to 16
Gulf Coast/Caribbean	5 to 10	14	21 to 24
Other U.S.	8 to 12	14	21 to 24
Foreign	10 to 12	23 to 30	30 to 40

Source: California Energy Commission, California Air Resources Board, Motor Vehicle Fuel Price Increases, January 1997, p. 13.
[1] Initial lead time of 7 to 10 days would typically be needed to produce California gasoline for shipping.

3. Removing MTBE and Using Ethanol

All of California uses reformulated gasoline that must meet the State's emission requirements, and about 80 percent must also meet Federal reformulated gasoline standards, which require that the gasoline contain 2 percent oxygen by weight.[12] MTBE and ethanol are both oxygenates (i.e., contain oxygen), and are added, among other reasons, to satisfy the Federal oxygen requirement.

Prior to the California MTBE ban, California gasoline contained significant quantities of ethers, mostly in the form of MTBE, which satisfied both emission and engine performance needs. With the ban on MTBE, refiners are switching to ethanol, which is an alcohol. The physical and chemical differences of these two materials have an impact both on the refinery capability to produce gasoline and on the distribution system. (See Appendix B for more information on the physical and chemical properties of the fuel components.)

3.1 Distribution System Segregation

Supply constraints arise in the distribution system when replacing MTBE in gasoline with ethanol. One issue is that water is present throughout most of the gasoline storage and distribution chain. Gasoline does not mix with water, but ethanol has a much stronger affinity for water. If ethanol-blended gasoline comes into contact with water in the distribution system, the ethanol can be pulled into the water. The remaining gasoline without the ethanol is not useable, and the ethanol cannot easily be separated from the water. Therefore, ethanol is transported and stored separately from the base gasoline mixture to which it will eventually be added.

Ethanol's affinity for water is not the only reason ethanol-blended product must be kept segregated. Mixture of ethanol-blended gasoline with other gasolines can increase emissions. Movement of even a small amount of ethanol (from the ethanol-blended mixture) into gasoline without ethanol can substantially increase the vapor pressure of that commingled gasoline, potentially pushing it above required volatile organic compound (VOC) limits during the summer months.

Refiners produce a base unfinished reformulated gasoline mixture to which the ethanol will be added. This base material is referred to as reformulated gasoline blendstock for oxygenate blending, or RBOB, in the case of Federal RFG, and California reformulated gasoline blendstock for oxygenate blending, or CARBOB, in the case of California RFG.

When trucks delivering gasoline to retail stations are filled at the terminal rack, base gasoline materials (RBOB or CARBOB) are combined with the appropriate quantity of ethanol. This is the first place in the distribution system where the two products are

[12] Gordon Schremp, "California's Phaseout of MTBE – Background and Current Status," Presentation for UC TSR&TP Advisory Committee Spring Meeting, March 17, 2003.

blended to create a finished gasoline product. During the summer months, VOC emission limitations prevent retail stations from mixing ethanol-blended gasoline with other gasoline. Thus, retail dealers receiving one type of gasoline cannot practically switch to another during the summer.

3.2 Refinery Yield Loss when Switching from MTBE to Ethanol

EIA explored the impacts on gasoline production capability[13] of switching from MTBE to ethanol in CARB gasoline in a prior study.[14] Refiners typically add 11 volume percent of MTBE to meet the 2-weight-percent oxygen requirement. Ethanol, however, has about twice the oxygen content per unit volume as does MTBE, so only half as much is needed. In practice, 2-weight-percent oxygen content is met using about 5.7 volume percent of ethanol.[15] Thus when switching from MTBE to ethanol, refiners producing winter-grade gasoline experience the following volume impact before any other changes are made:

- Loss from eliminating MTBE -11%
- Gain from adding ethanol +6%
- Net Volume Loss -5 %

The situation is different for summer-grade gasoline, because it is subject to stricter emission standards for ozone-forming volatile organic compounds and nitrogen oxides during the summer high ozone pollution season. Ethanol increases gasoline's tendency to evaporate more than does MTBE, as measured by Reid vapor pressure (RVP). Put another way, ethanol has a higher blending RVP than does MTBE. Even though less ethanol is used in the gasoline, a switch from MTBE to ethanol, with no other changes, would cause the gasoline to exceed summer emission requirements. To counter the emissions effect of switching to ethanol, other gasoline components are removed to lower the RVP and bring the mixture into compliance.

Increasing the ethanol content from 5.7 to 10 volume percent to make up for some of the lost volume in California may not be an option. In EIA's study, ethanol could only be increased from 5.7 to 6.0 volume percent before the blend failed the California nitrogen oxide (NO_{x}) emission limitation. With purchase of additional alkylate or iso-octane, a refinery might be able to use 7.0 percent ethanol and meet California clean-fuel requirements, but 10 percent did not seem practically achievable. When producing summer-grade CARB gasoline, refiners would experience a loss of gasoline production

[13] Note that the losses described in this section are not "capacity losses" but rather gasoline production capability losses. The MTBE that is being lost does not come from the refinery capacity, but from outside the facilities, as does the ethanol replacement. From a practical standpoint, gasoline production capability (rather than capacity) is what is described in this section.

[14] *Supply Impacts of an MTBE Ban*, Energy Information Administration, September 2002, http://tonto.eia.doe.gov/FTPROOT/service/question1.pdf.

[15] Refiners outside of California face an additional constraint in the Mobile Source Air Toxics Rule (MSAT). The MSAT caps refiners at their average toxic emission level achieved in 1998-2000 to prevent "backslidking." The replacement of MTBE with ethanol contributes to an increase in toxics emissions, particularly acetaldehyde, which requires refiners to make further adjustments to their gasoline pool or possibly reduce their production of RFG.

capability of about 10 percent, which occurs as follows:

• Loss from eliminating MTBE	-11%
• Gain from adding ethanol	+6%
• Loss of other gasoline components to adjust for the RVP and distillation impacts that occur from the first two steps	-5%
• Net Volume Loss	-10 %

In order to meet demand, the loss of volume is made up with materials such as alkylate or CARBOB from the Gulf Coast or other countries. As will be shown in Chapter 4, this estimate of yield loss is consistent with what EIA is seeing from refineries that have moved to producing RBOB for blending with ethanol.

3.3 Increased Product Needs from Outside the State

Historically, California has brought most of its MTBE, as well as some finished gasoline and other gasoline components, in from outside the State. Even though less oxygenate will be brought into the State in the near future (assuming 11 percent MTBE is being replaced by about 6 percent ethanol), the State would likely see an increase in the amount of material that must be brought in from outside during the months when summer gasoline is produced:

• Decrease in MTBE out-of-State volumes[16]	-11%
• Increase in ethanol out-of-State volumes	+6%
• Increase in out-of-State volumes to replace lost refinery capability	+10%
• Net increase in product and blending component flow from outside the State	+5%

Some of these "outside" product needs will likely be met by increased CARBOB and blending component volumes from refineries in the Northwest, and some by flows from the Gulf Coast and other countries.

3.4 Supply of Ethanol

Ethanol production in the United States has increased substantially as California refiners have begun eliminating MTBE from gasoline and replacing it with ethanol. Ethanol production in the second quarter 2003 averaged 178 thousand barrels per day, equivalent to 2.7 billion gallons per year, which was 65 percent higher than production in the second quarter of 2001. The Renewable Fuels Association[17] estimates ethanol production

[16] This simple illustration assumes all MTBE came from out of State. Although most did, some MTBE was produced inside the State, which means the 5 percent increase in product needs from outside the State is understated.
[17] A national trade association for the domestic ethanol industry.

capacity as of June 2003 to be 2.9 billion gallons per year, implying the industry was running at 93 percent utilization.[18]

Next year, as New York and Connecticut and the remaining California refiners eliminate MTBE, ethanol demand could increase to between 3.3 and 3.5 billion gallons per year, depending on the percent of ethanol blended into reformulated gasoline. The Renewable Fuels Association estimates that about 650 million gallons per year of additional capacity is currently under construction, which would put total ethanol capacity at almost 3.6 billion gallons per year. While this implies tight capacity to meet next year's needs, should extra supply be needed for California or East Coast reformulated gasoline, it can be bid away from its discretionary use in conventional gasoline in the Midwest. Thus, it would appear that ethanol capacity should be adequate to meet California, New York, and Connecticut's additional needs in 2004.

[18] Ethanol Production Facilities, published on the Renewable Fuels Association website: http://www.ethanolrfa.org/eth_prod_fac.html

4. California Refinery Supply

EIA's preliminary report in May indicated that gasoline production in California was reduced early in the year, partially due to high levels of refinery maintenance, contributing to unusually high prices during the period. The preliminary report stated "the impact of the maintenance was greatest in February, with gasoline production down over 150 thousand barrels per day below what it would have been had those refineries been operating normally." With more data available, a more detailed analysis of California gasoline production in the first quarter of 2003 was performed, in addition to an analysis of production during the second quarter, when all refiners were producing summer-grade gasoline.

The updated analyses explored whether the level of refinery unit outages during the first quarter was unusual, and if the reduction in gasoline production was what would be expected for that level of outages. An attempt was also made to determine if the impact of the shift from MTBE to ethanol gasoline production could be separated from the impact of the refinery unit outages during the first quarter and if the magnitude of the impact of the shift could be estimated during the second quarter when all refineries were producing summer-grade gasoline.

4.1 Refineries Shifting from MTBE to Ethanol

In 2003, both MTBE- and ethanol-blended gasoline were being produced in California. Originally, California was scheduled to ban MTBE in January 2003, but a number of factors caused the State to delay the ban for one year. Many California refiners chose to switch from MTBE to ethanol in January of 2003, however. The refiners still producing MTBE-blended gasoline will convert to ethanol-blended fuel sometime during the fourth quarter 2003 after summer-grade gasoline is no longer required. Table 4-1 summarizes the status of refiners producing ethanol-blended gasoline during spring and summer 2003.

In the first half of 2003, about 450 to 500 thousand barrels per day, or about half the volume of California gasoline production, was switched from MTBE to ethanol. Figure 4-1 shows the volume growth of CARBOB[19] production and Figure 4-2 shows the decrease in MTBE use and the increase in ethanol use in California. The California Energy Commission (CEC) estimated that most of the gasoline in southern California, but less than half in northern California, was being supplied without MTBE during the first half of 2003.

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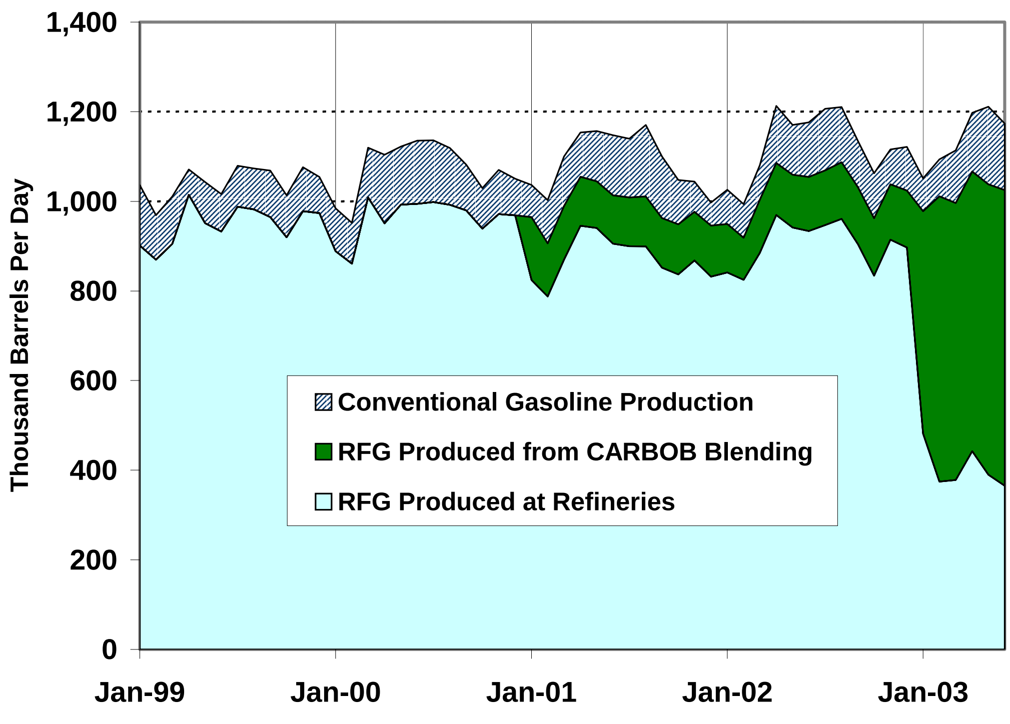
[19] California reformulated gasoline blendstock for oxygen blending, or CARBOB, is the material that is produced before ethanol is added to create the finished CARB gasoline.

Table 4-1. California Refinery Status for Shifting from MTBE to Ethanol Spring and Summer 2003

Northern California Refiners	Location	Notes
ChevronTexaco	Richmond	Complete phaseout later this year
ConocoPhillips	Rodeo	Using ethanol for more than one year
Kern Oil	Bakersfield	Currently Blending ethanol
Shell	Bakersfield	Currently Blending ethanol
Shell	Martinez	Currently Blending ethanol
Tesoro	Concord (Avon)	Complete phaseout later this year
Valero	Benicia	Phaseout later this year
Southern California Refiners	**Location**	**Notes**
BP	Carson	Currently Blending ethanol
ChevronTexaco	El Segundo	Currently Blending ethanol
ConocoPhillips	Wilmington	Using ethanol for more than one year
ExxonMobil	Torrance	Currently Blending ethanol
Shell	Wilmington	Currently Blending ethanol
Valero	Wilmington	Phaseout later this year

Source: California Energy Commission, "California's Phaseout of MTBE – Background and Current Status," Presentation by Gordon Schremp to UC TSR&TP Advisory Committee Spring Meeting, March 17, 2003, p. 13.

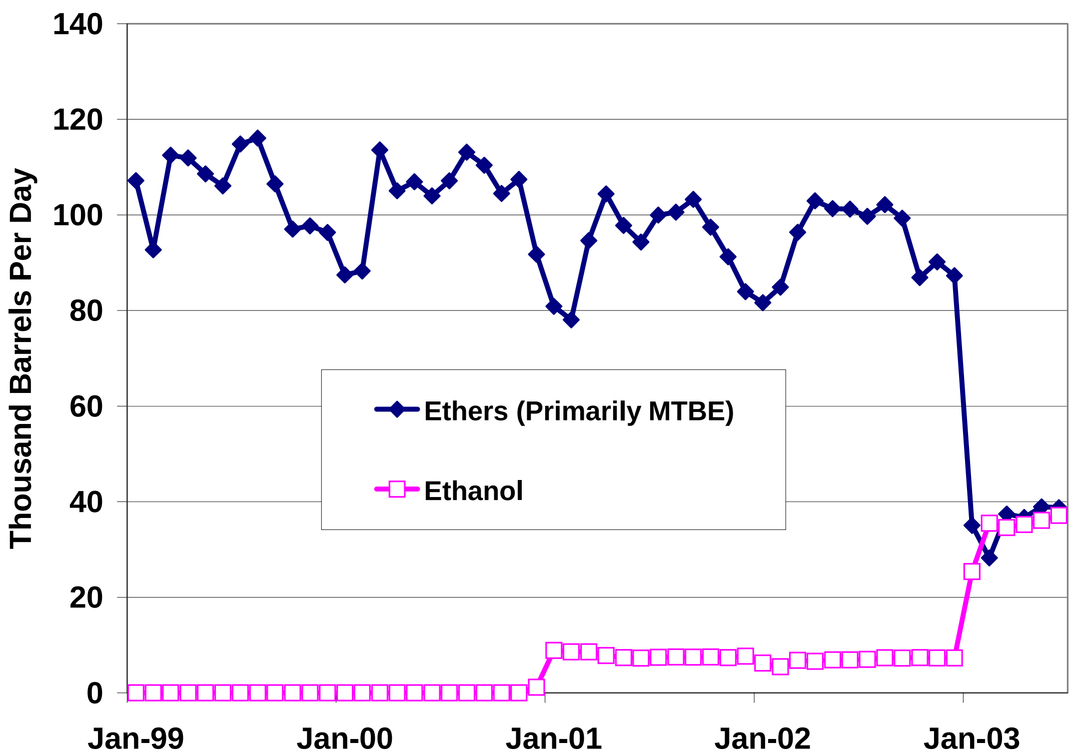
Figure 4-1. California Gasoline Production



Source: Energy Information Administration, Form EIA-810

Typically, California summer gasoline production would begin sometime in January for many refiners, in order to meet pipeline summer specification requirements in February. This timetable is driven by the State's requirement that all refiners and terminals supply summer-grade product beginning in March.[20] This year, a one-month extension was allowed to cushion the winter-summer transition because so many refiners were using ethanol for the first time for the 2003 summer season. Most refiners began summer gasoline production in 2003 sometime in February in order to be on schedule to meet the pipeline summer specification requirements for shipment by March 10. Thus, the first quarter winter production was probably from January through about mid-February, with summer production taking place in the second half of the quarter.

Figure 4-2. Oxygenate Use in CARB Gasoline



Source: Energy Information Administration, Form EIA-810.

[20] California requirements for summer-grade gasoline production vary by region. Normally producers and importers must provide summer-grade gasoline to southern areas of California in March through October. Other regions are allowed shorter summer schedules of April through October, April through September, May through October, and May through September. Pipelines will generally require producers to be providing summer-grade product in advance of all of these schedules to assure compliance, and the practicalities of segregation and fungibility result in the State basically following the March through October schedule. This normally requires refiners to be producing summer product in January in order to meet pipeline schedules in February for March compliance dates. This year, that schedule was allowed to slide back one month, so refiners began producing summer-grade product in February to meet pipeline schedules in early March.

4.2 Impact of Refinery Unit Outages on First Quarter Gasoline Production

Gasoline production changes across the year as demand varies and refinery outages occur. As refinery capacity gets tighter and refineries operate at higher utilization rates to meet demand, refinery outages can have a larger impact on the market, such as during the high-demand summer season when utilization is highest.

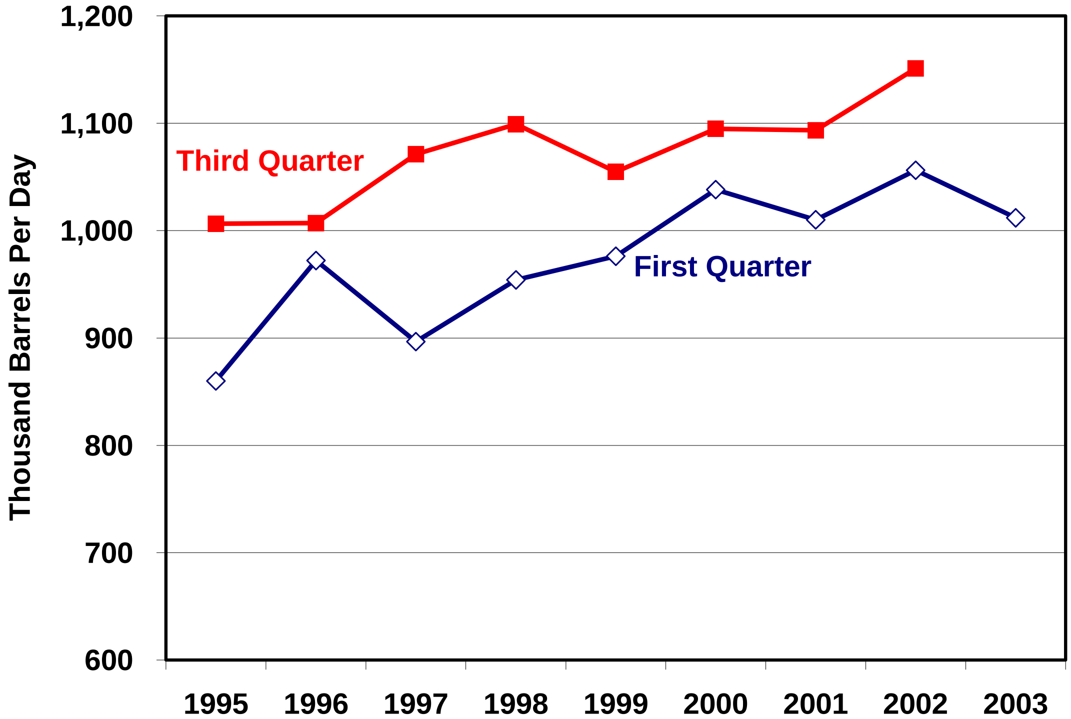
Typically, refiners plan to take some of their operating units out of service for maintenance during the fourth and first quarters of the year because seasonal gasoline demand is lowest during those times. Maintenance activities vary from year to year for a given refinery, as do the impacts on gasoline production. For example, refiners plan to shut down their fluid catalytic cracking (FCC) units every 4-5 years for 5-8 weeks to do planned major maintenance. The FCC unit is very important to gasoline production, so major maintenance on this unit has a larger impact on gasoline production than maintenance on, for instance, a coking unit.

In Figure 4-3, gasoline production is shown for the 13 California gasoline-producing refineries for the first and third quarters from 1995 (when Federal RFG was first required) to 2003. On average, gasoline production is 100 thousand barrels per day higher in the third quarter than the first quarter. A major part of this difference results from two factors: refiners with unit outages in the first quarter, and refiners' demand-based decisions to lower throughput of crude oil and unfinished feedstocks during the lower demand months. Two additional observations can be made from Figure 4-3. First, there has been a clear upward trend in gasoline production from the 13 refineries since 1995, and second, first quarter 2003 production was about 75 thousand barrels per day below that which would be expected from a trend line. Both greater outages and the transition to ethanol may have contributed to the low gasoline production volumes in 2003, as described below.

In order to explore how outages may affect production, EIA had to separate production changes due to outages from those due to other effects. EIA analyzed refinery outages in the 13 California refineries that produce gasoline from 1995 to 2003. The objective was to develop a measure of the severity of outages over time that could be used to observe both how outages varied year to year as well as how outages related to changes in gasoline production.

A refinery unit outage means that a refinery unit is temporarily taken out of service and input to the unit is zero. When input to the unit is zero, the unit shows no output of material that can contribute to the refinery's production of gasoline and other products. Outages are a part of refinery operations. Some are planned to do periodic maintenance on units and some are unplanned – the result of a fire, a loss of electricity, a mechanical failure, etc. In EIA's analysis, the objective was to develop a measure that would capture the severity of unit input losses from outages across the 13 refineries. Gasoline production was analyzed separately to determine how actual production levels in a given month compared with estimated production levels had all units been operating in that month.

Figure 4-3. California Refinery Gasoline Production in First and Third Quarters



Source: Energy Information Administration, Form EIA-810.

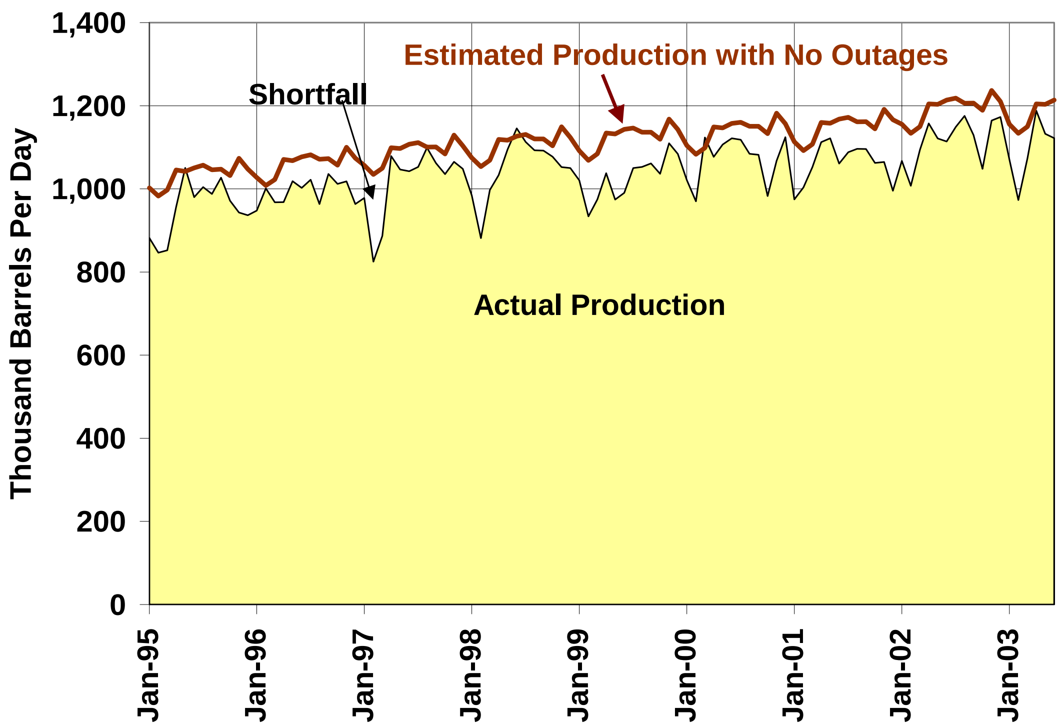
To gauge the overall impact on input losses from outages, the following attributes of the unit outages in each refinery were taken into account and then aggregated across all refineries for each month:

- Outages vary in the size of unit that is affected and the length of time the unit is out of service.
- The impact on gasoline production is different for the various types of units in the refinery. The loss of an FCC (fluid catalytic cracking) unit, for example, may have a more severe impact on gasoline than other units. FCC gasoline is about 35 percent of the gasoline pool, and when the FCC unit is down, feed is lost for the alkylation unit as well. The combined loss of those two units can reduce by half the material for making gasoline.
- Refineries vary in size, but care must be taken with total size when assessing unit outages, as some large refineries have one large FCC unit, but others may have two moderate-sized units. Thus, an FCC outage at a large refinery must take into consideration the number and size of the FCC units at the facility.
- Unit inputs vary seasonally. During winter months, the normal unit input level is lower than in summer months when petroleum demand is higher.

Using the factors listed above, EIA developed an "overall outage severity factor" that will provide a means of comparing the level of outage for a given month to similar months in other years.

Next, EIA assessed gasoline production levels. First, a level of production had to be determined for each refinery that represented a typical production volume for each month when no outages occurred. This was the normal "no-outage" level. Actual production for the month was then compared to the normal no-outage level. The difference between the normal no-outage level and the actual is a measure of the production shortfall (Figure 4-4). The estimated production with no outages was calculated for each refinery and aggregated. As Figure 4-4 shows, the aggregate value will almost always be above actual, since at any one time, some refineries will experience outages.

Figure 4-4. California Refinery Actual Production Compared to Estimated Production Had No Outages Occurred



Source: Energy Information Administration, Form EIA-810 and EIA estimates.

When production falls short of the normal no-outage level, it cannot be assumed that the difference is due to an outage. Furthermore, the outage severity factor will not capture outage effects perfectly. For example, the outage factor does not represent all units in a refinery. Thus, a perfect correlation will not exist between these two measures – production shortfall and outage factor. However, as shown below, the measures have adequate quality to compare outages in one year with those in another year, and to indicate if other factors may be impacting gasoline production.

The analysis specifically involved the following three steps:

1) Identifying Outages: Press reports are available that indicate refinery maintenance plans as well as unplanned outages. However, based on EIA data and conversations with refiners, these reports are not complete and are not always accurate. As a result, EIA survey data were used to identify major outages. EIA collects unit input data for primary distillation and the major conversion units (FCC, hydrocracking and coking units). An outage can be recognized by a significant drop[21] in a refinery's monthly unit input volume. It is also possible to gauge the severity of the outage by the magnitude of decline in input level. (The specifics are described in Appendix C.)

2) Devising an Outage Metric: The second step was to devise an overall outage severity factor to indicate how the level of severity of particular unit outages can affect a refinery's ability to produce gasoline. The length of time a unit is down is an important factor determining the amount of reduction in gasoline production. The duration of an outage is reflected in the volume of input to the unit in a month compared to input when the unit is operating at full capability. Since the impact on gasoline production of a unit outage varies by type of unit, an outage index was developed that combined the various unit input losses beyond a given threshold, giving most weight to high gasoline-production units like the FCC unit. The result was a single metric that combined all EIA unit input data in an attempt to measure severity of all outages across all refineries.

   Various issues limit the accuracy of such an outage severity factor. EIA does not have monthly input data for reformers, alkylation, isomerization, and gasoline hydrotreating units, all of which can impact gasoline production. Refiners vary inputs somewhat, depending on market conditions and specific product needs. This variation also affects gasoline production in months when there is no apparent outage activity. Still, consistent application of the methodology provides some insights into relative impacts of outages on a year-to-year basis.

3) Estimating Typical No-Outage Production and Comparing to Actual Production: After determining the months in which significant outages were observed, the third step was to determine what the normal production would be for each refinery for a given month assuming no outages occurred. Using only those months when no significant outages were evident, seasonal input variation across the twelve months and changes in gasoline yield over the years were estimated. By focusing on base yield and seasonal patterns, the effects of demand increases and capacity increases over time are removed.

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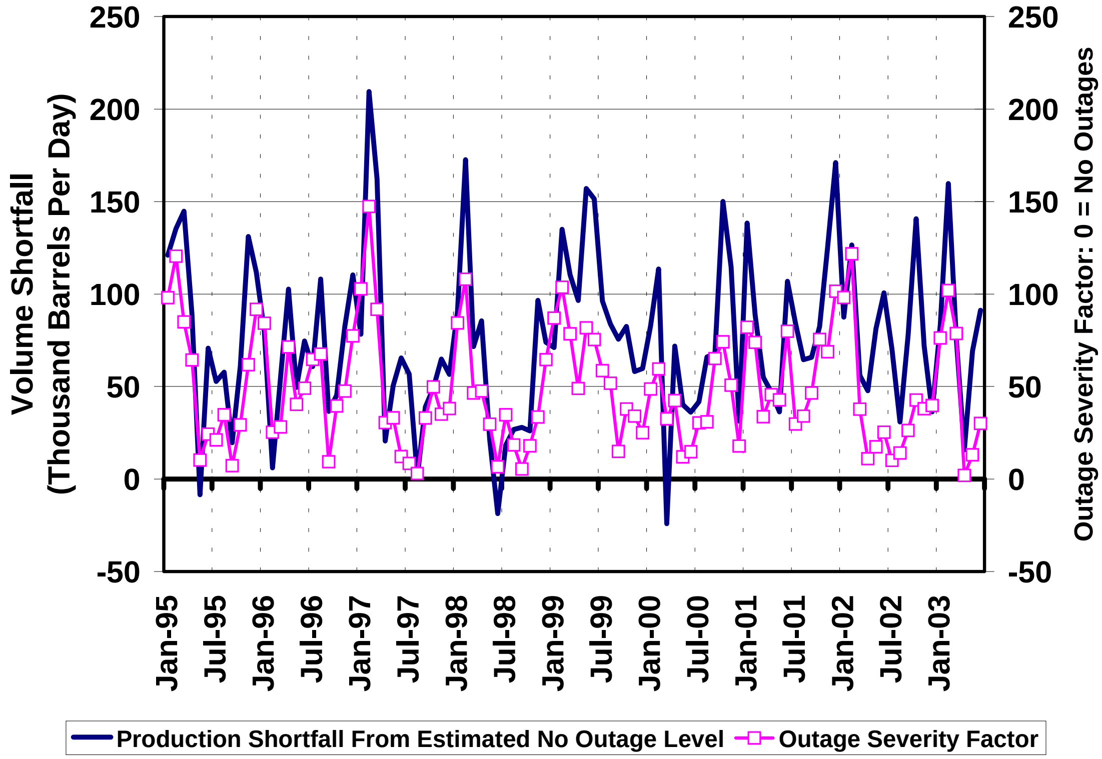
[21] A unit could go down for a day or two, and the volume loss would not be discernable in EIA's monthly data. Such outages would not be counted in this analysis.

In Figure 4-5, the outage severity factor is compared to the "shortfall" in actual production from what might have been produced with no outages. The upper solid line is the difference between the normal gasoline production level with no outages for each month and the actual gasoline production for the month, which is shown in Figure 4-4 as the shortfall area. The higher the value of this line, the greater is the observed shortfall. This shortfall may not entirely be due to outages, but may also be due to economic decisions to reduce production. The second line, which is the outage severity factor, provides a means of observing the degree of outage impact over this time. This factor is not an actual volume, but it provides a measure of outage activity in one month compared to another.

Figure 4-5. Outage Severity Factor Compared to Production Shortfall from Estimated Level with No Outages



Source: Energy Information Administration calculations using Form EIA-810 data.

The two lines show a strong relationship, and illustrate that February is usually the month with the highest level of outages and with actual production levels falling well below potential no-outage levels. In six of the nine years shown in Figure 4-5, the outage factor exceeded 100 in February, and for those February months, the production shortfall between estimated no-outage gasoline production and actual gasoline production rose to between 127 and 210 thousand barrels per day.

The graph illustrates the magnitude of gasoline loss and outage effect in 2003 relative to prior years. The difference between actual and no-outage gasoline production for February 2003 was 160 thousand barrels per day (14 percent of the potential 1,133 thousand barrel per day no-outage production), and is the third largest shortfall; the largest shortfall of 210 thousand barrels per day occurred in February 1997. The gasoline production difference in first quarter 2003 compared to the outage index is also relatively high. That is, the outage factor increase does not seem to be as high as the production loss, which leads to the question of whether the transition to ethanol is also a factor in the reduced production. Given that the outage severity factor is an inexact estimator of outage impacts, the next step was to explore if the data could offer any insights into whether the transition to ethanol was also a factor in reducing gasoline production volumes during the first quarter.

The conclusion was that the data were not adequate to separate the MTBE-to-ethanol impact from the unit-outage impact on gasoline yield during the first quarter (or even during the second quarter). Recall that the estimated impacts of the shift to ethanol on refinery gasoline production were a 5-percent loss in the winter season and a 10-percent loss in the summer. Outages may reduce a refinery's gasoline production by over 50 percent in a month, and neither the outage impact calculation nor the estimated no-outage production calculation has enough accuracy to determine if, in the first quarter of 2003, the yield was reduced by about 5 percent because of a switch to ethanol. The few refineries that had no outages and made the switch to ethanol were analyzed and did have lower gasoline production than estimated from prior years' data, but the data were too sparse to come to a quantitative conclusion.

The refinery supply conclusions for the first quarter were that outages, gasoline production declines, and the gasoline price spike that occurred during the first quarter of 2003 were not unique in comparison to events in the California gasoline market since 1995. There were high outages, large first quarter gasoline production reductions, and significant gasoline margin increases in California in 1997, 1999, and 2001. The planned maintenance outages in the first quarter of 2003 were large, but not unusual. However, with both additional unplanned outages and extensions of planned outage downtime during the first quarter, total outages were definitely high for the major conversion units and other gasoline-making units. The high outage level in February 2003 began to tighten California gasoline supply, and when some outages extended into March and other unplanned outages also occurred in March, the supply-demand balance continued to tighten, increasing supply pressures. Unplanned outages are a normal aspect of refinery operations, but they don't occur at an even rate in a population of only 13 refineries. The total outages in first quarter 2003 were high enough to create tight supply conditions and increased gasoline margins.

4.3 Impacts of Switch to Ethanol in CARB Gasoline in Second Quarter

Before studying the detailed impacts on refiners producing ethanol-blended gasoline during second quarter 2003, it is helpful to examine historical supply changes at

California refineries to understand the context for the effects of the MTBE ban on refinery gasoline production capability. Table 4-2 shows annual average data for California refineries since 1995, when reformulated gasoline was first produced. Gasoline production from California refineries increased during this period. Refinery gasoline production can increase either from increases in throughput of crude oil and other unfinished oils or from an increase in the yield of gasoline that can be obtained from a barrel of crude oil and unfinished feedstocks. Table 4-2 shows that California refineries increased inputs of crude oil and unfinished oils only slightly since 1995; however, yield improvements have contributed to significant gasoline production growth. The yield increased from about 51 to 54 percent. A 3-percent increase in yield for these refineries results in about 50 thousand barrels per day of increased supply. During this time, refiners also increased gasoline production by adding more oxygenates, mainly MTBE. Oxygenate volume rose from 67 thousand barrels per day in 1995 to over 100 thousand barrels per day in 1999.

Table 4-2. California Gasoline Trends (Thousand Barrels per Day Except as Noted)

	1995	1996	1997	1998	1999	2000	2001	2002
Crude Input	1,745	1,759	1,749	1,753	1,699	1,754	1,760	1,786
Net Unfinished Oils Input	43	23	25	33	51	56	42	64
Total Crude & Unfinished Oils	1,789	1,783	1,774	1,786	1,750	1,809	1,803	1,850
Adjusted Gasoline Production	912	905	918	949	923	971	968	1,023
Adjusted Gasoline Yield (Percent)	51	51	52	53	53	54	54	55
Oxygenates to Gasoline	67	94	102	103	106	103	102	101
Total Gasoline Production Blenders and Refiners	978	1,017	1,038	1,072	1,040	1,075	1,090	1,126

Source: Form EIA-810
Notes: Adjusted gasoline production is refinery gasoline production excluding oxygenates and blending components from outside the refinery. Adjusted Gasoline Yield is the ratio of Adjusted Gasoline Production over Crude and Unfinished Oils Input.

The situation is now changing. The switch from MTBE to ethanol is reducing both the yield of gasoline per barrel of refinery crude oil input and the volume of oxygenate used in gasoline production. Recall that 11 percent by volume MTBE is being replaced with about 6 percent by volume ethanol in California, and that removal of additional gasoline components to compensate for ethanol's properties reduces total production volume. To compensate for these losses during the first half of 2003, refiners are increasing the use of blending components brought in from outside the State, as described below.

The larger volume losses to correct vapor pressure and distillation properties when switching from MTBE to ethanol did not occur until refiners began to produce summer-grade gasoline. Refiners began the change during the first quarter, but by the second quarter, they were all producing summer-grade product.

Section 3.2 provided a general description of the impacts on gasoline production when switching from MTBE to ethanol. EIA also analyzed actual refinery production data for six California refineries that began producing CARB gasoline using ethanol in 2003. The summer gasoline production (April through August) at the six refineries compared to the same period in 2002 provides an early indication of the actual impact of the MTBE ban on California refineries.

Summer gasoline production before and after the six California refineries switched to ethanol use in 2003 is compared in Table 4-3. Inputs of crude oil and other feeds and inputs to major units are at similar levels for summer 2002 and 2003. The six refineries brought into the State 51 thousand barrels per day more blending components, which exceeded their reduction in oxygenate use of 36 thousand barrels per day. Despite the net increase in receipts of oxygenates and other blending components, total production of CARB gasoline and other gasoline in summer 2003 was 22 thousand barrels per day less than in summer 2002 due to elimination of light gasoline components needed to counter ethanol's high vapor pressure.

Table 4-3. California Refineries Switching to Ethanol in 2003 (Thousand Barrels Per Day)

	April-August 2002	April-August 2003	Difference
Six Refinery Inputs to Major Units			
Crude & Unfinished Oils Input	945	938	-7
Major Refinery Unit Inputs			
FCC Units	334	331	-4
Hydrocrackers	190	203	+14
Cokers	258	266	+8
Six Refinery Receipts of Oxygenates and & Other Blending Components			
MTBE & Other Ether Inputs	66	1	-65
Ethanol (estimate of volumes added at terminal)	0	29	+29
Refinery Blend Stock Receipts	16	67	+51
Six Refinery and Associated Blender Gasoline Production			
RFG(CARB gasoline)	579	550	-29
Other	49	56	+7
Total	629	606	-22

Notes: Six California refineries switched from using MTBE in 2002 to using ethanol in 2003 when producing CARB gasoline. Numbers may not add due to rounding.
Source: Form EIA-810 and EIA estimates

4.4 Projected Gasoline Supply When Switch to Ethanol Is Complete

An additional 350 thousand barrels per day of gasoline production remain to be switched from MTBE use to ethanol to complete the transition by the beginning of 2004. Similar types of volume changes as were shown in Table 4-3, above, will occur as the remaining CARB gasoline production switches from ethers to ethanol. The estimated net use of oxygenates will decline another 17 thousand barrels per day, in addition to the 36-thousand-barrel-per-day loss shown in Table 4-3. There will also be an additional 20- to 25-thousand-barrel-per-day loss of light and heavy ends. These reductions will have to be made up with increased receipts of blending components or CARBOB from other

States or foreign sources, which increases the share of gasoline traveling long distances and not readily available to remedy unexpected supply-demand imbalances next summer.

EIA is aware of three methods being used by refiners to replace the volumes lost both from the reduction in oxygenate use and from the lower yields resulting from light and heavy ends losses. These approaches are being implemented now and are expected to continue during 2004:

- Tesoro has invested in equipment to convert some prior conventional gasoline production to CARB gasoline;

- Some companies are converting MTBE production facilities, both inside refineries as well as at an MTBE plant in Canada, to produce additional gasoline blending components such as iso-octane or alkylate; and also expanding alkylate production if additional feedstock is available at California refineries.

- Companies are receiving increased imports and receipts from other States of blending components and CARBOB.
  - There are indications that refineries in the State of Washington will be an increased source of California supply. Tesoro stated publicly[22] that its Anacortes, Washington refinery will be able to ship up to 15 thousand barrels per day of CARBOB to California this year.

  - Also, BP recently announced a $110 million clean gasoline project at its Cherry Point, Washington refinery.[23] The Cherry Point project will include an isomerization unit and a gasoline hydrotreater that will allow it to produce some CARBOB. However, the BP project will not be completed until June 2004, so these expansions will not be available for additional supply during the first quarter of 2004, but will be able to provide increased volumes to California in the future.

When the switch to ethanol is complete by the beginning of 2004, an additional 80-100 thousand barrels per day of blending components and CARBOB will be brought into the State to meet increased demand. Some of this product will likely be volume that California suppliers normally move to Arizona and Nevada, but most will be high-quality components for CARB gasoline, which are costly and which few suppliers outside of California can provide.

With refiners having lost gasoline production capability and needing to import more expensive blending components or CARBOB, they will likely run the refineries at maximum gasoline production capacity. If all refineries run at higher utilizations for longer periods, unexpected refinery outages would generally have a greater impact, as other refiners could not increase output to compensate, thereby increasing the probability

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[22] Carol Cole, "Tesoro Completes Major Gasoline Expansion at California Refinery," *Octane Week*, April 7, 2003, p. 3.
[23] "BP to Build Clean Fuel Plant," *Oil Daily*, March 21, 2003, p.8.

of price volatility in the future. Thus, while in an immediate sense we can point to refinery outages as the cause for price spikes, the shift to ethanol and the accompanying reduction in California gasoline production capability has contributed to a fundamental tightening of the supply situation. Looking into the future, if refineries serving California continue to expand at the low rates seen historically, this will tighten gasoline supply even more.

On the one hand, the complete transition to ethanol in 2004 may not be as difficult as the partial transition this year. Suppliers gained experience during 2003, and more importantly, the large refinery outages seen this past spring may not reoccur. Product segregation problems will also be reduced. Some non-oxygenated reformulated gasoline may still be in the market outside of Federally-required RFG areas, but the volumes will likely be small compared to the segregation requirements this year. On the other hand, the main difficulty will likely be the further adjustments needed to compensate for lost production capacity. In addition, California suppliers may find increased competition for those extra supplies they will be seeking. As New York and Connecticut shift from MTBE to ethanol, they also will be seeking high-quality gasoline volumes from outside their regions.

5. California Gasoline Distribution and Logistics

This chapter describes the main features of the California distribution and logistics system relevant to gasoline flows. As part of this study, a number of traders, jobbers,[24] and marketers were interviewed to determine what distribution and logistical issues might have arisen this past spring and summer to contribute to the price pressures. These industry participants are referred to as stakeholders in the following discussion.

5.1 Distribution and Logistics Overview

Fuel distribution on the West Coast originates in the three major refining centers on Puget Sound, in the San Francisco Bay area, and in the Los Angeles Basin (Figure 5-1). A smaller production center around Bakersfield has two small refineries and only limited capacity to produce gasoline and distillates. The petroleum product market for California and the other West Coast States is insular in nature, isolated from the main U.S. continental markets by the Rocky Mountains to the east and from most other major fuels markets by the Pacific Ocean on the west. Even within the California market, a certain amount of insularity occurs. The northern California market, centered on the San Francisco Bay area, and the southern California market, structured around Los Angeles, are not linked together by petroleum product pipelines. Tanker and barge movements normally keep the two markets in balance.

In the past, California exported excess quantities of gasoline, distillate and residual fuel oil. Since 1999, however, the State has become a net importer of all petroleum products, including finished gasoline, blending components, diesel fuel and jet fuel. The shortfall is expected to increase significantly over the coming years.[25] The State receives limited supplies from refineries in nearby Washington State, but California has to cover the bulk of its shortfall of petroleum products with volumes from remote sources such as the U.S. Gulf Coast, the Canadian East Coast, the Caribbean, Europe, Asia, and the Middle East.

Foreign import flows into California vary considerably from month to month depending on the State's refinery production, demand, and gasoline prices relative to other areas (Figure 5-2). The irregular need for imports other than oxygenates is also reflected in the economic incentive to bring in extra products as shown by the difference in gasoline prices between California and the Gulf Coast in Figure 5-3. Transportation cost alone may require a 10-cent-per-gallon premium to Gulf Coast product. Higher cost to produce CARBOB over Federal RFG and a risk incentive adds even more. One report indicated the price premium must be over 20 cents per gallon to attract product.[26] As Figure 5-3 shows, California prices are not typically this much higher than Gulf Coast prices.

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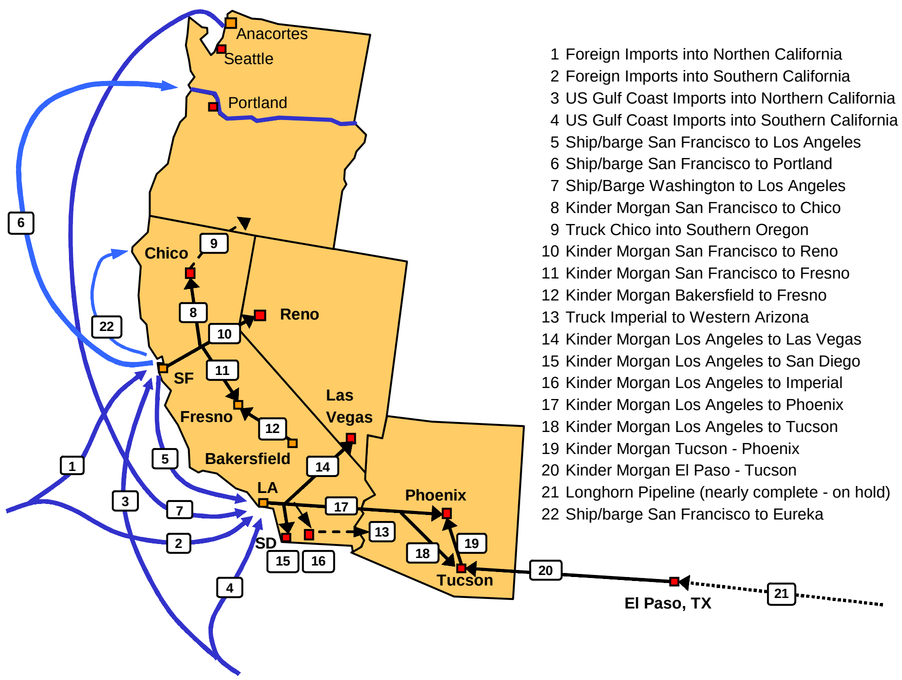
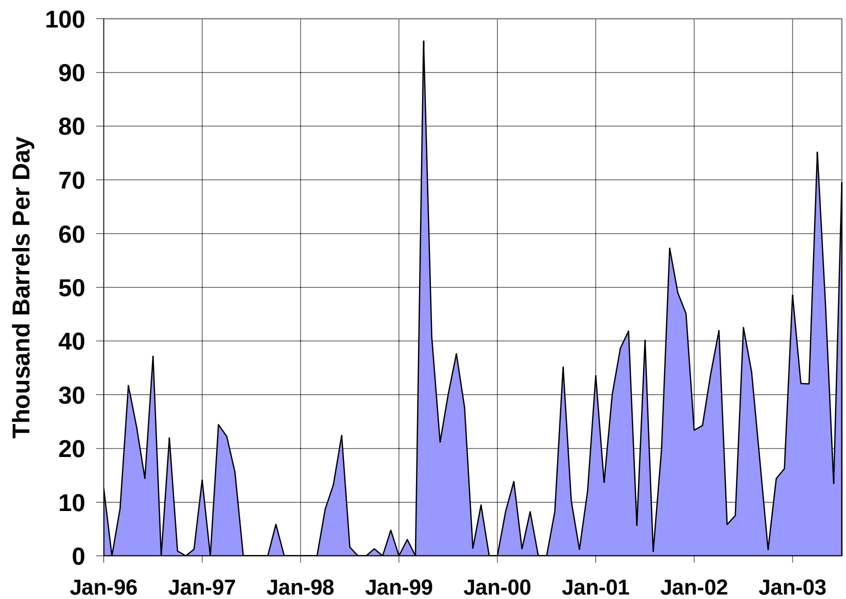
[24] A jobber buys product from refineries and resells it to retail station owners.
[25] *Energy Outlook 2020*, California Energy Commission Staff Report, Docket No. 00-CEO-Vol II, August 2000.
[26] "Review of the Stillwater Report on California Strategic Fuel Reserve," prepared for Western States Petroleum Association, Purvin & Gertz, January 2003.

Figure 5-1. Overview of Product Flows on the West Coast



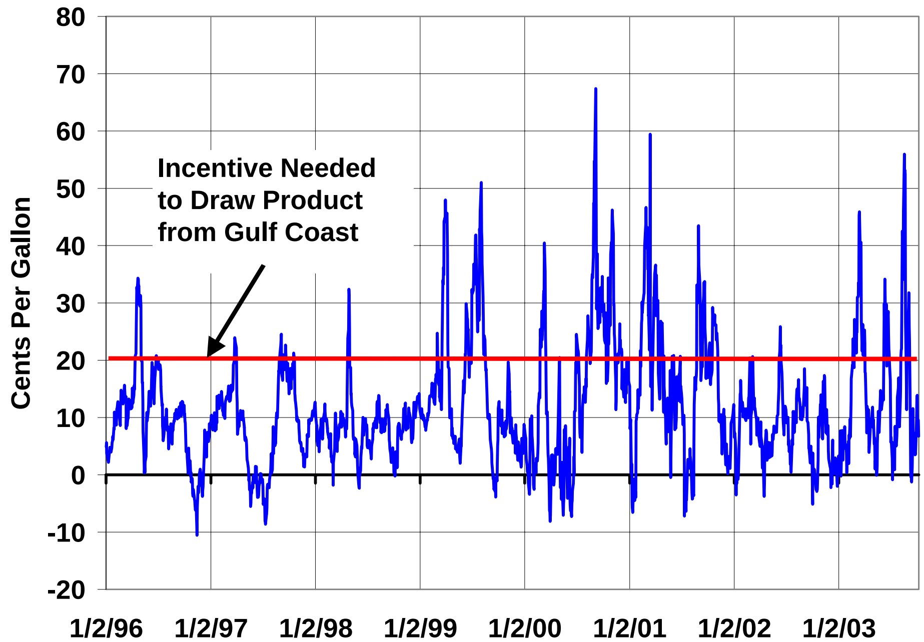
Source: California Energy Commission, *California Strategic Fuel Reserve*, P600-02-017D, July 2002

Figure 5-2. Monthly Finished Gasoline and Blending Component Imports to California



Source: Energy Information Administration Form EIA-814.

Figure 5-3. RFG Spot Price Difference Los Angeles – Gulf Coast



Source: Reuters

Over 60 percent of the ethers (mostly MTBE) used by California refiners between 1995 and 2000 were provided by imports from foreign countries. California refiners produced less than 15 percent and the balance came from shipments from other States. MTBE has been the largest volume of import material contributing to gasoline supply in the State.

With the ban on MTBE, the import picture is changing as shown by the data of Table 5-1. MTBE imports in 2003 dropped significantly as some refineries switched to ethanol, and MTBE imports may drop close to zero next year.[27] Imports of blending components rose, but foreign imports increased less than the decline in MTBE. While Table 5-1 only shows shipments of foreign imports, when shipments of blending components coming from other States are taken into consideration, the total marine flow into California in 2003 exceeded the level in 2002.

Table 5-1. Foreign Imports into California January through July (Thousand Barrels per Day)

	2000	2001	2002	2003
Blending Components	2.2	16.5	10.6	35.4
Finished Gasoline	2.3	12.8	15.0	10.2
Oxygenates (Mostly MTBE)	61.1	62.3	60.2	25.9
Total	65.6	91.7	85.9	71.5

Source: Form EIA-814

[27] Some MTBE may be imported for gasoline to be produced for Arizona or Nevada.

It is important to note that the California refiners also supply markets in Nevada and parts of Arizona, including fast-growing population centers such as Las Vegas and Phoenix. As will be discussed later, these markets can influence California gasoline prices.

The next several sections highlight areas of growing tightness in California's distribution and logistics systems. As demand has grown and the variety of products that need to be carried in the California system has increased, logistics capacity and flexibility have diminished. Constraints in the petroleum system are at a point where it may be becoming economically feasible to expand. Some of that expansion is taking place now, but the bottlenecks that remain continue to contribute to price spikes.

5.2 Northern California Region

San Francisco Bay Refining Center

The refining and distribution infrastructure in the San Francisco Bay area is concentrated in the northeastern parts of the Bay, in Richmond, the San Pablo Bay and the Carquinez Strait, and consists of five major refineries and eight marine terminals. Three separate clusters exist, separated from each other by approximately 10 miles:

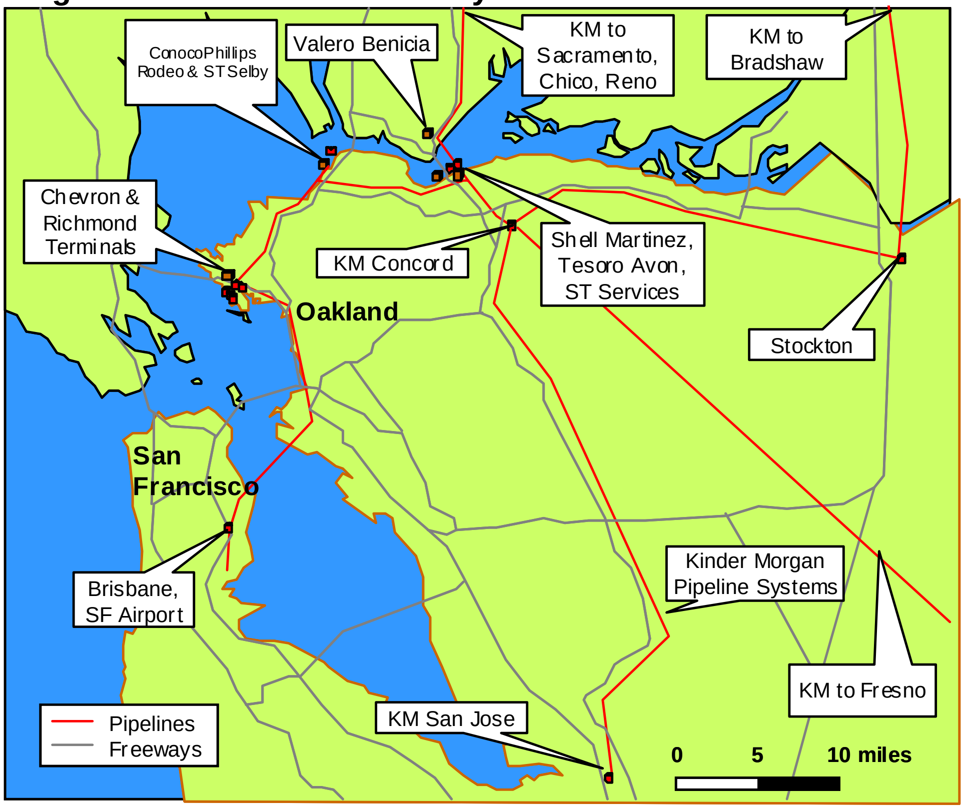
- The ChevronTexaco refinery in Richmond and five terminals on the Richmond inner harbor operated by ARCO Terminal Services Co., IMTT, ST Services, Kinder Morgan, and ConocoPhillips.
- The ConocoPhillips Refinery in Rodeo, with the marine terminal of ST Services in Selby, near Crockett.
- The Valero refinery at Benicia on the north side of the Carquinez Strait, and the Shell refinery in Martinez on the south side, with the marine terminals of ST Services in Martinez and the Tesoro refinery and Amoco terminal in Avon.

An overview of the Bay Area petroleum infrastructure is given in Figure 5-4. The Bay Area refiners and terminals are connected to each other by proprietary pipeline systems for products and crude oil owned by refiners and ST Services, in addition to the Kinder Morgan pipeline systems that use the Concord station as a hub for further distribution.

Northern California Marine Infrastructure

The San Francisco Bay area has historically been a region of net product exports, supplying gasoline to Portland, Oregon, as well as gasoline and, more recently, ethanol to Los Angeles. However, product imports are increasing into the Bay area, and this location will likely become a net product importer in the near future.

Figure 5-4. San Francisco Bay Area Petroleum Infrastructure



Source: California Marine Petroleum Infrastructure, Stillwater Associates LLC presentation at California Energy Commission Workshop, April 2003.

With only one exception, product flow into the Bay area has not been an issue. A draft limitation[28] exists for the Pinole Shoals, which mainly affects large crude oil tankers, rather than product tankers. Current draft restrictions on tankers of the size used most frequently in the Bay represent 30,000 to 50,000 barrels of additional cargo, or up to 10 percent of the tanker's capacity. Although crude oil tankers are most often affected, a trading company reportedly had to divert a gasoline tanker into Los Angeles to discharge enough cargo to be able to send the ship into the Bay to finish its discharge when authorities realized that the allowable draft had to be further restricted. Such constraints can slow down response time for resolution of any supply problems.

The San Francisco Bay area had surplus storage capacity several years ago, but with growing demand and an increasing number of products to store, that excess has disappeared. In northern California, the large Selby terminal is operating at maximum tankage, electricity and pipeline capacity. Growth is currently occurring at the Martinez terminal as ST Services constructs additional tankage.

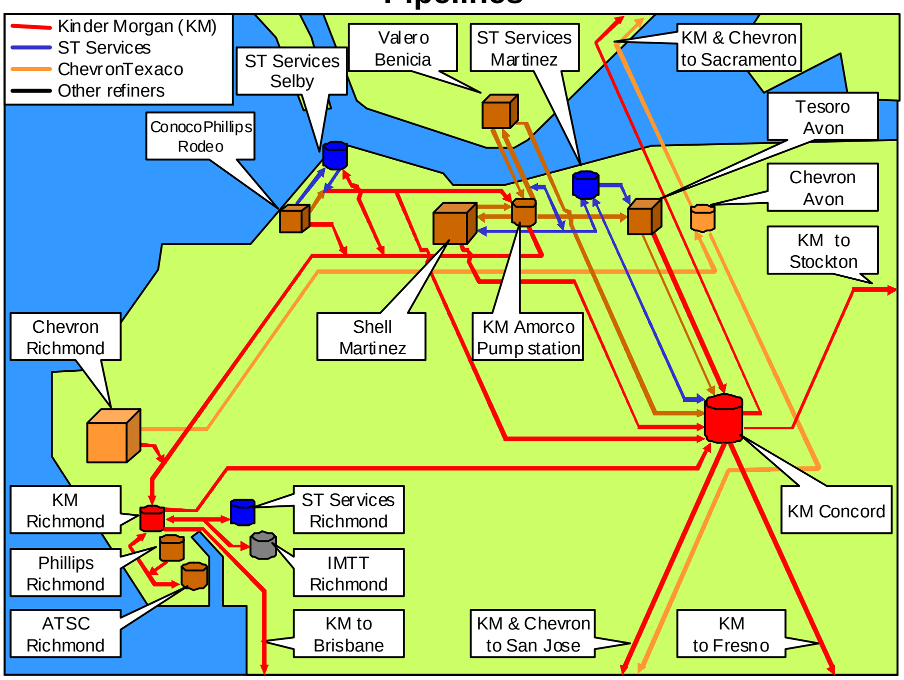
[28] The draft is the depth of a vessel's keel below the water line. Silt has decreased the depth of the harbor in places, creating limits on vessel drafts. As a result, some tankers have had to carry less than a full cargo to decrease their draft.

Northern California Pipelines

The clean product pipelines in northern California serve San Francisco Bay area demand and function as a gathering system to bring products to the Kinder Morgan terminal at Concord, which is the starting point for the long distance common carrier pipeline system. The Kinder Morgan pipeline system then takes product from Concord north to Chico and east to Reno, Nevada. Additionally, the system moves product to Stockton, San Jose and Fresno. Fresno also receives product from the Bakersfield area via the Kinder Morgan line.

The gathering system into Concord may at times constrain the ability of the area to surge product flow when needed. This part of the delivery system is not part of the common carrier system, and tariffs and throughput allocation on these lines are not subject to Government oversight. Several companies with whom EIA spoke felt that bottlenecks in the gathering lines from some of the refineries and terminals into Kinder Morgan Concord contribute to the severity of price spikes. Figure 5-5 below gives an overview of the pipeline infrastructure for clean products in the Bay Area.

Figure 5-5. San Francisco Bay Area Clean Product Pipelines



Source: California Marine Petroleum Infrastructure, Stillwater Associates LLC presentation at California Energy Commission Workshop, April 2003.

Overall, the gathering system in the Bay area has little or no spare capacity. Reasons for bottlenecks vary from low flow rates for certain products by individual users to overall hydraulic restrictions because of line diameter and length at maximum pressure ratings for the system. For example, Los Angeles area refineries pump to pipelines at a rate of

10,000 barrels per hour or more, while some San Francisco Bay area refineries can only pump at 1,500 barrels per hour.

5.3 Bakersfield Area

The Bakersfield refining center consists of two refineries in the Bakersfield area: Shell and Kern Refining. Each has truck racks, while only Shell is connected to the Kinder Morgan pipeline. Most of their pipeline volume is moved north to the Fresno terminal.

5.4 Southern California Market

Los Angeles Refining Center

The Los Angeles refining center is composed of 6 large fuel refineries and 3 small plants that are primarily dedicated to asphalt production, in addition to marine facilities used for the import and export of crude oil, finished products, and unfinished oils (Figure 5-6). Los Angeles is the origin for pipeline deliveries of gasoline, jet fuel, and diesel to San Diego, Las Vegas, Phoenix and Tucson.

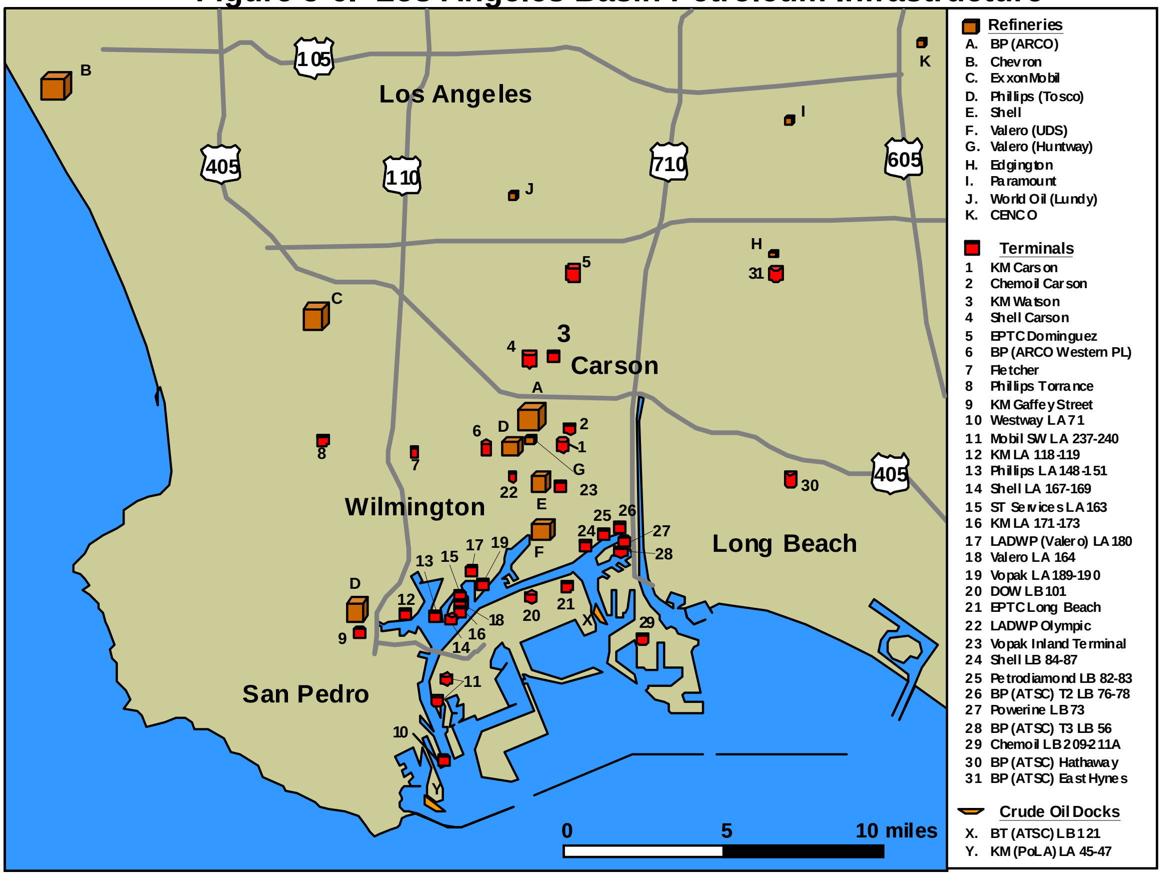
As can be seen in Figure 5-6, the Los Angeles refining industry is concentrated north of the port, some 2 to 5 miles inland. BP, ConocoPhillips, Shell, and Valero refineries are located near one another in Carson and Wilmington. ChevronTexaco's El Segundo refinery is located on Santa Monica Bay, and ExxonMobil has its refinery in Torrance. The refineries are connected to Kinder Morgan's Watson Station (#3 in the diagram), which is the origin point for all pipeline deliveries out of the Basin.

Southern California Marine System

Southern California has been a net gasoline import area, and will see increases in volumes coming into the region as demand grows faster than onshore refinery production. Historically, imports have fluctuated considerably, but California's growing need for blending components may result in a steady underlying base load of import volumes in the future.

Refiners are able to bring finished gasoline and blending components into their terminal and refining systems. The import capacity constraint falls on the independent trader segment because they cannot easily land gasoline cargoes. Tankage is tight and can hinder traders' ability to bring in speculative cargoes. Stakeholders described one trader who had to put a ship into PetroDiamond's small terminal three times before they got it completely discharged because there was no capacity available to unload the ship in one stop. Only one independent trader in California controls enough storage capacity to unload an entire gasoline tanker, and that capacity is in the San Francisco Bay. Other traders have been able to share tankage in order to get a tanker unloaded, but that solution is awkward. Kinder Morgan's Berth 118, the main public berth in Los Angeles, was fully booked during the summer. This lack of berth space in Los Angeles is frequently cited by traders as another a barrier to supply that contributes to price spikes. Uncertainty as to discharge timing adds another level of uncertainty to the decision process of would-be importers. With ship-demurrage rates[29] above $25,000 per day, offshore suppliers must assume an added risk when delivering to California.

Figure 5-6. Los Angeles Basin Petroleum Infrastructure



Source: California Marine Petroleum Infrastructure, Stillwater Associates LLC presentation at California Energy Commission Workshop, April 2003.

Bulk oil storage capacity in the Los Angeles port area has been getting tighter as volumes have increased, and oil terminals face challenges to expansion. The trend in the Ports of Los Angeles and Long Beach over recent years has been to favor shorefront land use for containers and car imports, at the expense of bulk liquid terminals. The need to create mega-terminals for container handling, with footprints in excess of 500 acres, has forced the ports to rethink the land use. As a result, several marine petroleum terminals have lost tankage or have closed. Kinder Morgan, which is the only third party facility with ship unloading, truck racks, and access to the pipeline system, cannot get the Port Authority of Los Angeles to extend its lease for its shipping berth.

[29] Demurrage cost is the cost of waiting while a cargo is loaded or unloaded.

Continuing operations have also run into resistance in the local communities. The Westway terminal, for example, is being pressured by city politicians to move out of San Pedro, even though their lease is not close to expiration.

The need for more import logistics facilities is relatively new. The fact that the California market had likely transitioned from export to import had not been well quantified until the CEC reported on the issue in 2001.[30]

Rental rates for tank capacity have doubled since the late 1990's, providing sufficient economic incentive if the terminal operator can find a customer willing to commit to a long-term contract. The economics are affected by the time it takes to gain permits (3 years by one estimate), by local political resistance, and by the indeterminate amount of time that the extra capacity would actually be used.

Generally, opportunistic traders are the most interested in additional tankage, but they have been unwilling to sign the 10-year commitments that operators historically wanted. The fluctuation in historical price differences between California and other regions and in import volumes illustrates that, while having extra marine tankage from time to time could be very beneficial, there may be periods of time when it would not be needed.

Progress is slowly being made toward building some additional tankage in Los Angeles, however. Kinder Morgan has begun the permitting process at Carson to increase pipeline capacity and build tanks. They estimate that permitting could take another year or so. PetroDiamond is working to build another small tank but is having a difficult time getting that tank permitted. Stakeholders reported that tankage refurbishment programs are underway at several facilities and that some shorter-term contracts for new tankage capacity have been signed.

Regional Pipeline Distribution

The Los Angeles market is served mainly by trucks that load directly from refinery racks and by proprietary pipelines that deliver product from the refineries to terminals in the Los Angeles metropolitan area, which includes Santa Barbara, Ventura, and Orange Counties. Kinder Morgan's southern California hub, Watson Station, connects the refineries with the South Line to San Diego and the West Line out to Colton in Riverside County. From Colton, Kinder Morgan delivers product north to Las Vegas and east to Phoenix and Tucson.

Gasoline demand in Arizona is met primarily from two Kinder Morgan pipelines – the West Line from California and the East Line from El Paso, Texas. The West Line delivers about 65 percent of the supply to the region, and the East Line delivers most of the remainder. Some regions of the State are supplied by trucks from California, Nevada, and New Mexico supply sources.

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[30] "MTBE Phaseout Update - Costs, Supply, Logistics & Key Challenges", presentation by Gordon Schremp at the California Air Resources Board Hearing, San Francisco, California, July 26, 2001.

Currently, the East Line runs full, but extra capacity exists on the West Line. As the system stands today, a supply disruption on the East Line (as occurred in August 2003) creates the incentive for southern California supply to surge to meet Arizona demand. Unless the East Line is expanded, demand growth in Arizona will continue to be met from southern California. Increased imports into the southern Californian ports may supply much of that increased demand. Increased volumes flowing from southern California will, therefore, supply near-term demand growth in both Nevada and Arizona.

The Longhorn Pipeline project is designed to bring Gulf Coast product to El Paso. With an expansion of the East Line, it would be possible for Gulf Coast gasoline to flow all the way to Phoenix. This would reduce demand on the southern California supply system. As of the date of this report, the completion of the Longhorn Pipeline remains in question due to permitting and financial constraints.

5.5 Spring and Summer 2003 Distribution and Logistical Issues

As discussed earlier in this chapter, the major problems affecting price volatility in California stem from its isolation from other supply sources, its unique, hard-to-produce gasoline, and limited excess refining capacity available to meet unexpected supply shortfalls. California's tight distribution and logistical system was not designed to rebalance large volumes across the State quickly, and various constraints hinder rebalancing of local problems, thereby contributing to price spikes. Even if the State's distribution and logistics system were much more flexible, price spikes would still occur, since it takes time for new supply to reach the State.

One unique feature of California's distribution system has actually helped to smooth the transition to ethanol. Due to the need for product segregation, an individual company might not be able to switch to ethanol-blended gasoline (E-CARB) on its own if it needed to use a common carrier pipeline or other distribution system outside its control that was not able to handle the separate products. In California, an estimated 55 percent[31] of gasoline and diesel is trucked directly from the refineries or their nearby terminals to retail outlets. In addition, the Kinder Morgan pipeline, which is a common carrier, changed some parts of its system to deal with ethanol at the request of its customers. Thus, although some parts of the system had to remain with MTBE-blended gasoline (M-CARB) until all customers made the transition, many companies were able to change to ethanol in advance of the entire industry changing. The large volume of product in California that is moved directly from refinery areas to retail outlets without using common carrier systems is different than in much of the rest of the country, where refineries and consumers are separated by long distances.

Independent retailers, who do not produce gasoline, purchase from suppliers at terminal racks. Once they decide which type of gasoline they will be selling at their retail stations, they cannot easily switch back and forth between M-CARB and E-CARB. The two

[31] Conversation with Gordon Schremp of the California Energy Commission.

products cannot be commingled during the summer months for emission reasons, and even during the winter, companies may not want to mix one type of gasoline with another because of potential tracking problems. By being able to use only one type of gasoline, however, supply sources become limited for any given marketer. Most independent marketers decided to stay with M-CARB in 2003, rather than switching to E-CARB, because their primary suppliers, Valero and Tesoro, did not transition to large scale CARBOB production in early 2003.

The inability for retailers to switch back and forth created intra-State imbalances. In general, supply of M-CARB was greater than demand in northern California. When a disproportionate share of outages occurred in southern California in February and March, much gasoline was shipped down to southern California to meet that area's shortfall.

Trucking also may have slowed down re-supply times in 2003 with the addition of ethanol to the system. A number of jobber/distributors indicated that there were trucking constraints, which came about for a number of reasons. Demand for trucking increased in 2003, due to the volume of ethanol that must be trucked to terminals that once received their oxygenate supply (MTBE) mixed with gasoline via the pipeline. The volume was estimated at 40 to 45 thousand barrels per day of ethanol. From individual truck fleet surveys, this seems to represent 2 to 4 percent of tank truck capacity.

Beyond the increased demand for trucking, additional truck capacity was lost waiting in loading queues as truck rack capacity was constrained by construction work on racks being modified for ethanol blending. This was especially prevalent at the Kinder Morgan racks at Carson and Colton in southern California. One trucking company reported that they experienced a 12 percent increase in demurrage costs[32] when hauling out of Kinder Morgan's Carson terminal for an independent marketer. Such trucking constraints hinder the flexibility of the system to shift supply quickly when needed.

Specific distribution and logistical problems in the northern and southern California regions are described below.

Northern California

Jobbers reported problems with M-CARB supply from the Bradshaw terminal near Sacramento in March, as California moved from winter-grade gasoline to the harder-to-produce summer grade. As they explained it, the major marketers paid Kinder Morgan to install ethanol-blending facilities at the Stockton terminal. Once E-CARB blending began at Stockton, Kinder Morgan did not have enough pipeline capacity to maximize E-CARB deliveries to Stockton and M-CARB deliveries to Bradshaw at the same time. There were numerous reports of run-outs at Bradshaw as the pipeline could not keep up with M-CARB demand. Jobbers were forced to send trucks to other, more distant terminals to load.

[32] The costs were higher than usual due to extra waiting time in this case. In effect, a company would have to send out 8 trucks instead of 7 due to the extra time spent sitting in line waiting to load.

Logistical problems contributed to price increases in June and August, as well. Unlike February and March, refinery problems occurred in the San Francisco Bay area in June. Stakeholders reported that most of the marine equipment (tankers and barges) normally used to move product between northern and southern California refining centers was in the U.S. Gulf or positioned between Alaska and the Pacific Northwest. Spot prices rose rapidly in the Bay, but Los Angeles prices did not completely follow, as Bay refiners were unable to secure tonnage to move replacement volume from Los Angeles.

Southern California

In southern California, local imbalances developed between supply and demand for M-CARB. Several participants reported that an M-CARB refiner bought CARBOB and blended it with MTBE (and probably butane or pentane) to meet their contractual requirements to supply product.

Adding to logistical turmoil, when it became clear that M-CARB supplies were going to be tight, some independent marketers reported that they switched at the last minute from M-CARB to E-CARB. The marketers who switched to E-CARB seemed to have had a prior existing relationship with E-CARB suppliers. While the switch may have complicated logistics briefly, it should have helped ease the supply-demand imbalance by moving demand from the M-CARB refiners that were experiencing production problems to the E-CARB refiners.

There were no reports of problems with pipelines in southern California, although supply problems on Kinder Morgan's East Line from El Paso, Texas created shortages in Phoenix in early March, which spilled over into the southern California market. At that time of year, Arizona would be using MTBE-blended clean burning gasoline. While the additional volumes flowing from California in response to the pipeline problem were small (14 thousand barrels per day),[33] the extra demand on the Los Angeles refineries at a time when markets are tight may have exacerbated the March spike.[34]

In August, Kinder Morgan's East Line into Arizona went down between Tucson and Phoenix for an extended period, creating shortages in Phoenix. Additional volumes from the California refineries were insufficient to prevent service station run-outs. It is not clear whether California refineries could have provided any more gasoline to Arizona than they did. Supplies in California were clearly tight, as evidenced by sharp inventory declines during August (see Chapter 6).

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[33] California Energy Commission, *Causes for Gasoline and Diesel Price Increases in California*, March 28, 2003, p. VI-2.

[34] Oil Price Information Service (OPIS) began reporting supply problems in Phoenix on 2/27, and on 3/5 described the situation for unbranded retailers' supply as "desperate."

5.6 *Next Summer and Beyond*

As we look ahead to next summer and even beyond, the growing constraints in the California distribution and logistics system will still be present. However, during the fourth quarter 2003, MTBE will be phased out and California will be using mainly ethanol-blended CARB gasoline. While some refiners will continue to produce non-oxygenated CARB gasoline for attainment areas in northern California, volumes are not expected to be large. The return to mainly one gasoline should ease many logistics problems.

The required logistics improvements for ethanol handling and blending are already underway in order to be ready in time for a November 2003 implementation, and it is expected that the remaining transition to ethanol blending in 2003 should proceed relatively smoothly.

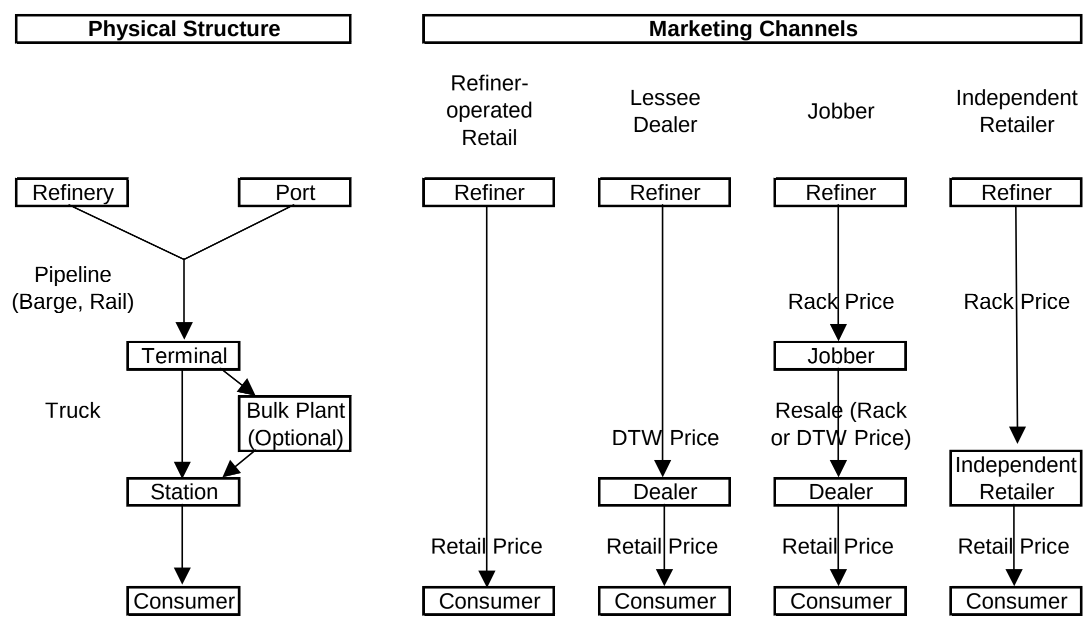
6. Gasoline Market Structure and Behavior

In order to understand the behavior of California gasoline prices, it is necessary to begin with a fundamental understanding of the structure of gasoline markets, and the ways in which California gasoline markets differ from those in other regions. This chapter, therefore, first examines the various elements of gasoline market structure, including the underlying physical infrastructure, the business entities participating in gasoline trade, and the types of transactions between participants. The primary components of gasoline prices are presented, highlighting the differences between California and other markets. Then, recent events and trends in California gasoline markets, including the changeover from MTBE to ethanol, are examined in terms of their impacts on many aspects of this complex system.

6.1 Industry/Market Structure

Gasoline markets in California and elsewhere involve multiple tiers of facilities, market participants, and price levels. Though in many ways the commercial aspects of the marketplace run parallel to the physical network of facilities involved, many firms participate in gasoline markets at more than one level.

Figure 6-1. Gasoline Physical Structure and Marketing Channels



Source: Energy Information Administration

Physical Structure

To a certain extent, the production and distribution infrastructure for petroleum products dictates the structure of the market for those products (Figure 6-1). Gasoline distribution and marketing begin at the refinery "gate," an industry term for the point from which finished petroleum products leave the refinery and enter the distribution system. For imported product, the analogous point is the port of entry. From the refinery or port, product is typically shipped in large quantities by pipeline, tanker, or barge to a terminal usually consisting of a tank farm and loading facilities (called a "rack") for transferring product to trucks and/or rail cars. For gasoline, the final delivery is usually by truckload directly from the terminal rack to the retail outlet at which the product is sold to end-use consumers. In some cases, gasoline, like home heating oil and some other products, may be delivered first to a "bulk plant," an intermediate storage and transshipment facility from which smaller deliveries are made to retail outlets or consumers with on-site storage tanks. There are other variations to this distribution structure, such as the loading racks located at many refineries to facilitate local distribution, and bulk plants served by rail. (The logistics of California petroleum markets are described more thoroughly in Chapter 5.)

Market Participants and Channels

As with the physical structure of the distribution system, the relationships between business entities involved in the marketing of gasoline from the refinery to the consumer are highly varied. However, gasoline marketing in the United States is largely conducted through four primary channels:

- Refiner-operated retail outlet – the most direct method of gasoline marketing, in which a refiner owns and operates its own retail outlets, thereby theoretically controlling the distribution and marketing process from end to end. In practice, however, the refiner may actually operate retail outlets in areas outside its own distribution system, obtaining product by exchange or purchase from another refiner or importer.
- Lessee dealer – a situation wherein a refiner owns a retail outlet, but leases it to a dealer, who operates the property and sets its retail prices. Under this arrangement, the lessee typically markets under the refiner's brand name, is required to obtain product only from that refiner, and purchases at a price called "dealer tankwagon" (DTW), which includes delivery into storage tanks at the outlet.
- Jobber – wherein a refiner sells product by the truckload to a distributor, or jobber, who in turn resells it to dealers. Typically, the jobber buys product from the refiner at a terminal, or "rack" price, and sells to a dealer at a DTW price. However, in some cases larger jobbers may purchase product at the refinery or pipeline level, and resell at rack, DTW, or even retail. Jobbers may buy and sell product as branded (under a refiner's brand name), unbranded, or both. Most branded and some unbranded jobbers will have contracts with their suppliers, providing assurance of product availability under most circumstances.

- Independent retailer – possibly the fastest-growing gasoline marketing channel in the United States, involving chains of retail outlets that purchase directly from refiners (at the rack, or in some cases, in bulk at the refinery or pipeline level) and resell to consumers. This channel includes many convenience stores, high-volume retailers, and so-called "hypermarkets," grocery and/or department stores with gasoline outlets on the same property. These marketers primarily sell unbranded gasoline.

A separate but comparatively very small channel is refiner sales directly to end users, such as commercial and government fleet accounts. Other variants of these channels include sales by larger to smaller jobbers, jobbers selling to independent retailers, and the inclusion of importers or traders participating at the refinery, pipeline, or terminal level.

Price Structure

The marketing channels described above and their variants typically involve four classes of prices:

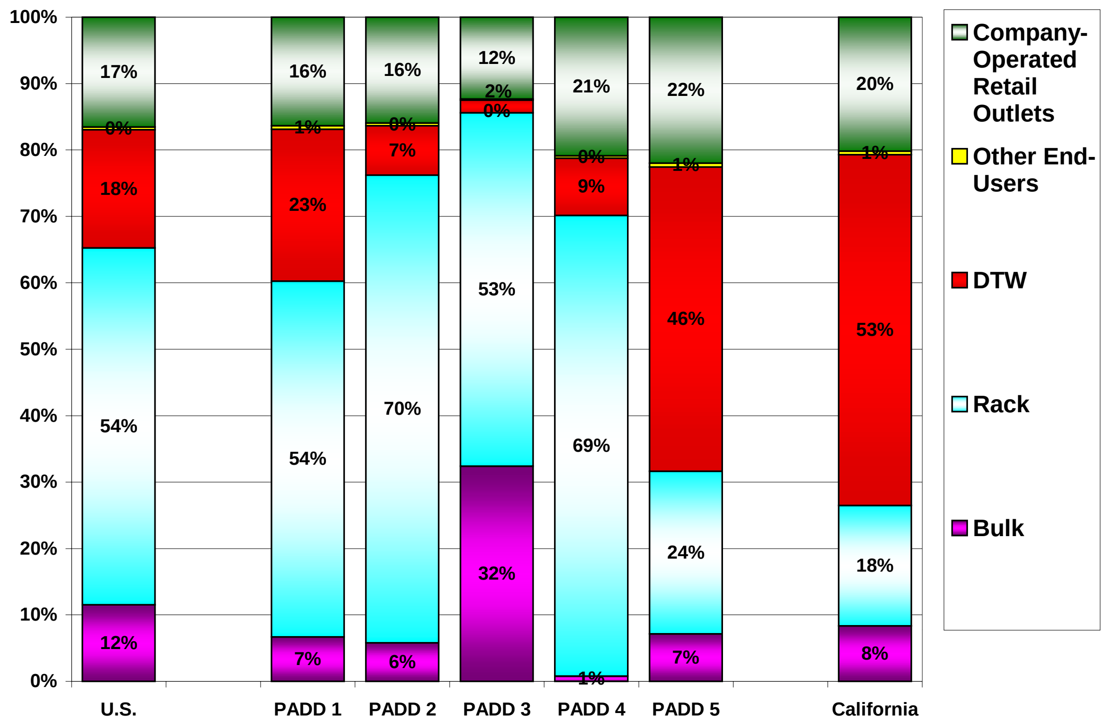
- Spot – technically a price for a one-time transaction conducted "on the spot," the term has become synonymous with large-volume bulk transactions between refiners, importers, traders, and large marketers or consumers, with product title transferring at the refinery, port, or pipeline. In practice, many bulk sales actually occur under contract, but because of constantly changing market conditions, such sales are often indexed to spot or futures prices. Spot prices are often used as a surrogate for "refinery gate" prices, representing the demarcation between costs and profits for the refining and distribution/marketing sectors of the petroleum industry.
- Rack – a price, normally by the truckload, for product transferring at the terminal loading rack. Many companies post separate branded (for customers reselling under the refiner's brand name) and unbranded rack prices.
- Dealer Tankwagon (DTW) – a price for product by the truckload or less, delivered into tankage at the retail outlet.
- Retail – the price paid by end-use consumers at the pump.

Because all marketing channels culminate in retail sales competing side-by-side on the street, it is possible for many analytical purposes to focus on spot and retail prices only, with the difference between them representing the costs and profits of the distribution/marketing sector, and ignore the intermediate rack and DTW prices as relevant only in terms of the comparative costs and profits seen by competitors in each channel.

The share of gasoline sold through each of the major channels, and at each price level, represents a significant difference between regional gasoline markets in various parts of the United States, and an aspect in which California markets are particularly unusual (Figure 6-2). The share of refiner sales made through company-operated retail outlets is fairly consistent across regions, and bulk sales represent a relatively small portion of refiner sales except in Petroleum Administration for Defense District (PADD) 3, the Gulf

Coast. The largest deviation between regions is in the relationship between rack and DTW sales, the shares of which in California (at 18 and 53 percent, respectively) are almost opposite those in the United States as a whole (54 and 18 percent). (The possible significance of this difference is discussed in Section 6.3.)

Figure 6-2. Share of Refiner Gasoline Sales by Class of Trade, 2002



Source: Energy Information Administration, *Petroleum Marketing Annual 2002*, Table 43.

6.2 Price Formation

<u>Spot Prices</u>

Spot prices are the most readily available measure of the market value of petroleum products at the point of origin, e.g. the refinery, or for imports, the port of entry. Although many refinery-level transactions occur under term contracts or other arrangements, and may not occur exactly at that day's reported spot price, the day-to-day spot market prices are widely viewed by market participants and observers as representative of the incremental value of available product at any point in time. For U.S. markets east of the Rocky Mountains, spot prices are often quoted in terms of a differential from the corresponding near-month futures contract on the New York Mercantile Exchange (NYMEX). Because NYMEX prices are widely available and verifiable, and provide hedging opportunities for buyers and sellers, they are a logical starting point for cash market trading where appropriate. However, the greater the separation between a given spot market and the corresponding futures price, in terms of distance, time, and physical specifications, the weaker the connection between those prices. Because California's gasoline markets are widely separated from NYMEX gasoline futures contracts in all of these dimensions, California spot gasoline prices are largely quoted independent of futures prices.

Nonetheless, spot gasoline prices are widely available for both the Los Angeles and San Francisco markets, and generally reflect sufficient liquidity of trading among refiners, importers, traders and marketers to be seen as providing price "transparency" for those markets. Daily and some intra-day quotations for regular and premium grades of conventional gasoline, CARB RFG, and CARBOB are published by price reporting services such as Oil Price Information Service (OPIS), Platt's, Reuters, and Bloomberg. These prices represent bids and offers by market participants, and as such reflect not merely costs or refiner-set selling prices, but open-market values based on supply and demand. Spot prices may rise and fall sharply in the course of a trading day, as news of events and other market information impact participants' perceptions of product values. The fluctuations of spot product prices, influenced by (but independent of) crude oil prices, can result in widely ranging refinery margins (approximated by "crack spreads," or the difference between a given product spot or futures price and the underlying crude oil price).

Terminal (Rack) Prices

The next level of pricing beyond spot markets occurs by the truckload at the terminal loading rack. Many companies post separate branded and unbranded rack prices. Changes in rack prices, particularly for unbranded product, are driven by the movement of spot prices. Because a trader or large jobber can buy product on the spot market, move it by pipeline or barge to a terminal, and sell it at an unbranded rack price, as long as spot product is available, the rack price will remain within a narrow range of the spot price plus the cost of moving and selling product into that market. This type of relationship across markets, called arbitrage, is a very important driver of petroleum prices worldwide.

Branded rack prices tend to move very similarly to unbranded racks, but with the additional nuance of a branded/unbranded relationship that is largely driven by product availability. Unbranded rack buyers, particularly those without a contract, are seen as "customers of opportunity" who will shop around for the best price when product is readily available, and as such represent a ready market for refiners who wish to sell volumes in excess of their own retail, DTW, and branded jobber needs. Under such conditions, unbranded rack prices will typically be lower than branded rack prices at the same terminal. However, when incremental supply is tight (such as when a major refinery outage occurs), refiners must continue to supply their own retail and contract customers, but have no obligation to serve most unbranded accounts. Under those conditions, refiners often raise their unbranded price at a terminal to a level well above the branded price, seeking to discourage demand since volumes are scarce, or to set them only at a price sufficient to cover the purchase of additional product.

Dealer Tankwagon (DTW)

Dealer tankwagon (DTW) pricing largely represents sales by refiners (and sometimes jobbers) to lessee dealers, and includes delivery by the whole or partial truckload into the dealer's tank. Although physically, a DTW delivery may involve a tanker truck loading at the same terminal and delivering to the same neighborhood as a rack sale by the same refiner to another customer, the prices charged for the sales may be significantly different. Unlike rack prices, which tend to be set *above*, and move in parallel to, underlying *spot* prices, DTW prices tend to be set at an approximate increment *below* the prevailing *retail* prices in the same market. This relationship arises because it is in the refiner's interest to ensure his captive customer, the lessee dealer, a reasonable margin on retail sales, while concurrently optimizing the refiner's own profit. This gives rise to the phenomenon of zone pricing, where refiners define zones comprising the relevant competitive retail markets in which their dealers operate. Each zone, reportedly some as small as a single station, will have an individually set DTW price, updated as needed based on a survey of the surrounding retail market.

Retail

Retail prices for each station, whether operated by a refiner, lessee dealer, jobber, or independent retailer, are generally set in response to a survey of nearby competing outlets. Depending upon such considerations as whether branded or unbranded, whether cash-only or honoring credit cards, and any number of other factors, the station operator may chose to price above, below, or the same as one or more competitors. This competitive relationship may vary over time, and under the influence of supply availability or other issues.

A dealer's cost of product is one consideration, but not necessarily the most important factor, in setting retail price in the short term. Assuming a typical competitive market (including other unrelated stations nearby, and adequate available supply), the primary drivers of a station's price will be those of its competitors. If a station operator raises his or her price too high above competition, the station's sales will presumably dwindle, and if the operator lowers the price too far below the local market, he or she will be giving away potential profitability on each gallon. Normally cost operates as a lower limiting factor in the long term. Although an outlet can sustain operating losses for short periods, if it cannot recover costs in the long term, it will go out of business unless it can offset its losses with profits from some other line of business.

6.3 Elements of Gasoline Prices

Definition of Gasoline Price Components

Retail gasoline prices in California, like those in all other markets, can be broken down into the following four basic elements:

- Crude oil costs – the average cost of crude oil or other inputs to refinery distillation units, such as unfinished oils, including transportation to the refinery.
- Refining costs and profits – as represented by the spread between crude oil costs and refinery gate (as approximated by spot market) product prices; any excess after covering refinery-operating costs represents profit to refiners and/or importers.
- Distribution and marketing costs and profits – as represented by the spread between spot and retail product prices (less taxes); any excess after covering transportation, storage, and marketing costs represents profit to companies within the distribution/marketing chain.
- Taxes – including Federal, State and local excise, sales, gross receipts or other taxes applied to petroleum products (taxes on crude oil are included under crude oil costs).

Table 6-1 shows the comparison between California and the U.S. average breakdown of retail regular gasoline prices into these four elements.

Table 6-1. Retail Regular Gasoline Price Breakdown (Cents Per Gallon)

	2002 Average		**March 2003**	
	U.S.	**California**	**U.S.**	**California**
Retail Price (including taxes)	134.4	151.4	169.3	210.3
Taxes	*42.0*	*47.6*	*42.0*	*52.0*
Retail Price (excluding taxes)	92.4	103.8	127.3	158.3
Distribution/ Marketing Costs and Profits	*17.0*	*20.7*	*25.5*	*28.0*
Spot Price	75.4	83.1	102.2	130.3
Refining Costs and Profits	*13.1*	*23.9*	*22.4*	*52.6*
Crude Oil Price	62.4	59.2	79.8	77.7

Sources: Retail prices and taxes, EIA; spot prices, Reuters.
Note: Crude oil price is represented by West Texas Intermediate (WTI) for U.S., Alaska North Slope (ANS) for California.

It is apparent from the numbers in Table 6-1 that higher retail gasoline prices in California are reflective of higher values for all of the price components with the exception of crude oil. These price components reflect a number of differences between California and other U.S. markets. California gasoline taxes, representing the sum of State excise and State and county sales taxes, were about 6 cents higher than the national average in 2002, but that differential expands as prices rise, because the sales taxes are calculated on a percentage basis. (This relationship will change as ethanol is phased in, because of a Federal excise tax credit when using ethanol in gasoline.) California distribution and marketing costs are also higher on average, possibly reflecting higher real estate and operating costs for marketing facilities. Crude oil costs for California refineries are, on average, lower than those for other U.S. refineries, resulting in higher "refining costs and profits" shown in Table 6-1. However, these crude oil prices are lower largely because many of the crude oils used by California refineries, including some indigenous California crude oil production and Alaska North Slope crude oil, are heavier and more sour (higher in sulfur content), and require more intense processing in the refinery. As such, the lower prices paid for those lower quality crude oils are offset by higher operating and/or capital costs at the refinery.

The largest difference between California and U.S. average gasoline prices lies in the refining costs and profits element, and this is the component most directly affected by the different gasoline formulation used in California. Refining costs for California include the higher average cost of producing CARB reformulated gasoline in comparison to the mix of conventional, oxygenated, and reformulated gasolines represented in the national average. Prior to the implementation of CARB gasoline, the California Air Resources Board estimated the additional cost of producing CARB RFG over conventional gasoline to be between 5 and 15 cents per gallon.[35]

Relative Movement Between Gasoline Price Components

An increase or decrease in either the refining or distribution/marketing component does not necessarily indicate a change in the underlying costs. For instance, if a major refinery goes out of operation temporarily, supply falls short of demand, and prices go up. Other refiners not experiencing production difficulties may see no change in cost, but a significant increase in profit due to the higher prices. Spot market prices, which reflect the supply-demand imbalance, are the result of a constant exchange of offers to buy and sell product. In practice, of course, both buyers and sellers have sufficient awareness of the existing situation, and experience with different market conditions, that both "bid" and "asked" prices continually adjust to reflect changing market conditions.

Although the refinery costs and profits element of retail gasoline prices has historically been the component showing the most variation, some discussion of the distribution and marketing element (retail-to-spot price differential) is appropriate. In a number of previous studies of gasoline price pass-through from wholesale to retail,[36] EIA has found that retail gasoline price changes are almost entirely a function of wholesale price changes over the previous weeks. This relationship takes the form of a "distributed lag," where a given movement in spot gasoline prices is passed through to retail over a period of several weeks. An updated examination of gasoline price pass-through in California (Appendix D) showed that, on average, a given change in spot prices is fully passed through to retail in about 8 weeks, with about half of the pass-through occurring in the first 2 weeks. While the speed and duration of pass-through varies regionally, it tends to be so consistent over time in a given region that retail price changes can be predicted, with a fair degree of accuracy, from prior spot price changes. Thus, the differential between retail and spot prices generally varies only according to the amount of wholesale price changes yet to be passed through to retail at any given time. When wholesale prices are rising, and retail has not caught up, the differential narrows; conversely, as prices fall,

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[35] California Energy Commission, *Causes for Gasoline & Diesel Price Increases in California*, March 28, 2003, p. 1-11.

[36] Energy Information Administration, *Gasoline Price Pass-through*, January 2003, http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2003/gasolinepass/gasolinepass.htm

the differential widens until prices stabilize and retail prices fully reflect the declines at the wholesale level.

The mechanisms by which gasoline price changes pass through from wholesale to retail are complex, and not fully understood. In EIA's analysis of gasoline price pass-through, it appears that a number of factors influence the speed of the process, including the distance between major refining and consuming areas and the relationships between entities involved in distribution and marketing of petroleum products. Specifically, prices may tend to pass through more quickly in areas with a large share of rack sales, such as the Midwest, because rack buyers see changes in their product cost, and thus some incentive to change their retail pricing, more quickly. By comparison, areas with a greater share of refiner-operated retail outlets and dealer tankwagon (DTW) sales, such as California, could find retail prices more insulated from changes in the spot and rack markets. However, because different markets may feature both longer or shorter supply distances and significantly different market shares by class of trade, the two factors may, to some degree, offset each other.

Consumers sometimes perceive that retail gasoline prices tend to rise significantly faster than they fall, a phenomenon referred to as "price asymmetry." Actually, retail gasoline prices typically follow wholesale prices (which, in turn, are driven by crude oil prices and other supply and demand factors) at virtually the same speed upward as they do downward. The idea that prices "seem" not to drop as fast as they rose appears to stem mostly from consumers having a keener awareness of prices when they are rising than when they are falling. Additionally, retail gasoline prices do not move in either direction as quickly as the underlying crude oil and wholesale gasoline prices. This is because retail price changes lag those in wholesale prices, as discussed above. After crude oil and wholesale gasoline prices peak and start to decline, retail prices may still be "digesting" the effects of the previous increase, even while starting to reflect the decrease as well. This can make it appear that prices drop more slowly than they rise, but actually the speed of the pass-through of wholesale price changes to retail tends to occur in a very consistent manner, regardless of whether prices are rising or falling.

The question of asymmetry in gasoline prices has been examined extensively by EIA and others, with mixed results. EIA's most complete study on asymmetry to date, *Price Changes in the Gasoline Market*,[37] found weak evidence of asymmetry in U.S. gasoline markets. However, this study focused on the Midwest, and did not address the specifics of the California market in detail. Differences in the speed of gasoline price pass-through between regions, and even over time within a specific region, raise the question of whether changes in the behavior of California gasoline prices in recent years may include a greater tendency toward asymmetry. EIA's analysis of California prices to date is inconclusive; it appears that data over a longer period will be needed to clarify recent observed changes in market dynamics.

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[37] Energy Information Administration, *Price Changes in the Gasoline Market*, DOE/EIA-0626, February 1999, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/price_changes_gas_market/pdf/price_change.pdf

Another controversial subject with regard to gasoline pricing is the issue of "price gouging," a term laden with emotion, and difficult to define objectively. In a technical sense, it refers to a situation where a seller attempts to extract a higher price (and profit) than would normally result from underlying supply and demand fundamentals. It is that last phrase, however, that makes gouging so hard to define, because in a free market, when supply and demand are out of balance, prices change to restore equilibrium. What consumers seem to expect is that no matter how much demand may exceed supply in the short run, prices should not rise to more than an "acceptable" level. The level acceptable to consumers, though, may leave sellers unable to cover their own increased costs, or fail to provide sufficient incentive to bring increased supplies into the market.

Price gouging, when it occurs (which is rare), is usually a very localized phenomenon, and only at the retail level. As long as retail prices conform to the predicted pattern of pass-through, it can be assumed that no significant gouging is occurring. Unfortunately, incidents of apparent gasoline price gouging have been seen, for example, in the wake of the terrorist attacks of September 11, 2001. In that case, a few local marketers quickly raised retail prices to exorbitant levels, apparently fearing that supplies would be interrupted, and/or that wholesale prices would rise dramatically, making replacement supplies much more expensive. Reassurances by major suppliers that they would hold the line on prices, quickly stabilized the markets, and reportedly some of those marketers that had briefly raised prices granted refunds to customers who had bought during that period. A number of States now have anti-gouging laws and enforcement programs in place to prevent this type of problem. Unfortunately, the greater test would come if there were indeed a major global, national, or even regional supply interruption. While anti-gouging laws, if enforceable, might keep prices under control, they cannot assure continuity of supply.

6.4 Factors Causing Prices to Rise and Fall in the Short Term

Chapter 2 described how international petroleum markets affect crude oil prices everywhere, including California, and how the shifts in tightness and looseness of the international markets affect U.S. product inventories as well as crude inventories. While California is an isolated market geographically, it is not immune to international fluctuations. The remaining sections deal with domestic gasoline factors influencing price fluctuations in California, but keep in mind that the world petroleum market provides a backdrop against which these local dynamics occur. If world petroleum markets have tightened, California markets and prices will shift as well, apart from local factors.

Supply/Demand Balance

In the long run, gasoline prices will keep pace with underlying costs of production plus some profit margin. But in the short term, gasoline prices rise and fall as the balance between supply and demand shifts. Inventories are a measure of the relative relationship between supply and demand at any one time, and as such, their levels are a good barometer of the tightness or looseness of the market. Flow of gasoline into any one region is generally not equal to demand. Inventories provide the balancing buffer between production and demand, rising when supply exceeds demand and falling when demand is greater than supply. Inventories have a normal variation pattern reflecting typical seasonal changes between supply and demand. For example, gasoline inventories in California normally increase in winter when gasoline demand is low and refinery production remains high to build stocks ahead of planned maintenance during the first quarter. Inventories are drawn down in summer as they are used to help meet the high demand of the summer driving season.

Markets are said to be tightening, with prices rising, when inventories are low relative to normal and falling rapidly. Under these circumstances, demand has been exceeding supply more than seasonal patterns would suggest, and since the stock level is still falling, the apparent shortfall has not been remedied. Under these circumstances, wholesale buyers would generally be having difficulty finding enough product to meet demand, and when product is found, would be increasing their bids for that supply, driving prices up. The reverse occurs when inventories are high and rising. As the spot and rack prices vary in this world of buying and selling, these prices are ultimately passed through to retail prices as described above.

In all market imbalances, large or small, prices provide the incentives to increase or decrease supply in order to move back into equilibrium. At the most simple level, if demand is exceeding supply, inventories will decrease as demand is met from stocks built up in the past. As inventories decline, prices rise, which encourages more production from area refiners if production capacity is available. But, as has been the case in California and at times in other U.S. regions, refineries in the region already may be producing at maximum rates, which means that additional product must come from other U.S. refining regions or from additional foreign imports. If added supply has to come from other U.S. regions or abroad, the additional volumes will take longer to arrive. In the meantime, stocks will decline even further, and prices will climb higher to encourage those distant suppliers to move volumes to the region were it is needed.

Crude oil price behavior, which is driven by the international petroleum market, adds another complication to the dynamics of refined product prices. Timing becomes an issue in this stage of the process. Refiners actually need higher margins to increase production. If crude prices are increasing rapidly, but product prices are lagging that increase, margins will actually be declining, discouraging refinery production increases. Such situations can happen during the initial stages of tightening in world petroleum markets. The gasoline supplier distant from California must look at the economic situation at some point in the future when the product is likely to reach its destination and be sold. In such cases, next month’s prices and margins might be a better indicator of production increases than current prices.

Refinery Outage Impacts on Market Balance

In California, refinery outages have been a factor affecting market balance and price, and merit more discussion to illustrate why this is so. California refinery outages are particularly important because these refineries supply nearly all the volume sold in the State. In other regions such as the Gulf Coast or East Coast, supplies from other U.S. regions and foreign sources play a larger role than do local suppliers.

Unexpected or unplanned refinery outages, as well as unexpected extensions of planned maintenance outages, probably have a larger impact than planned outages. Unexpected outages have the greatest impact at the beginning of and during the high gasoline-demand summer-driving season when other California refiners may not be able to increase production to help replace lost volumes. Planned outages such as those for routine maintenance do not present problems unless the time to perform the maintenance extends much beyond the scheduled time. Refineries usually schedule their maintenance during the fourth and first quarters when demand is low. The amount of maintenance and associated loss of production vary depending on what needs to be done. Similar to automobile maintenance, some scheduled maintenance is relatively minor. But every unit has the equivalent of an automobile’s 75,000-mile tune-up that requires more work. These large maintenance requirements can remove a unit from production for one or more months. Again, like an automobile, once a unit is taken down, more problems may be found than anticipated, and restarting the unit can sometimes be difficult. This can delay the return of the unit to operation beyond when it was planned.

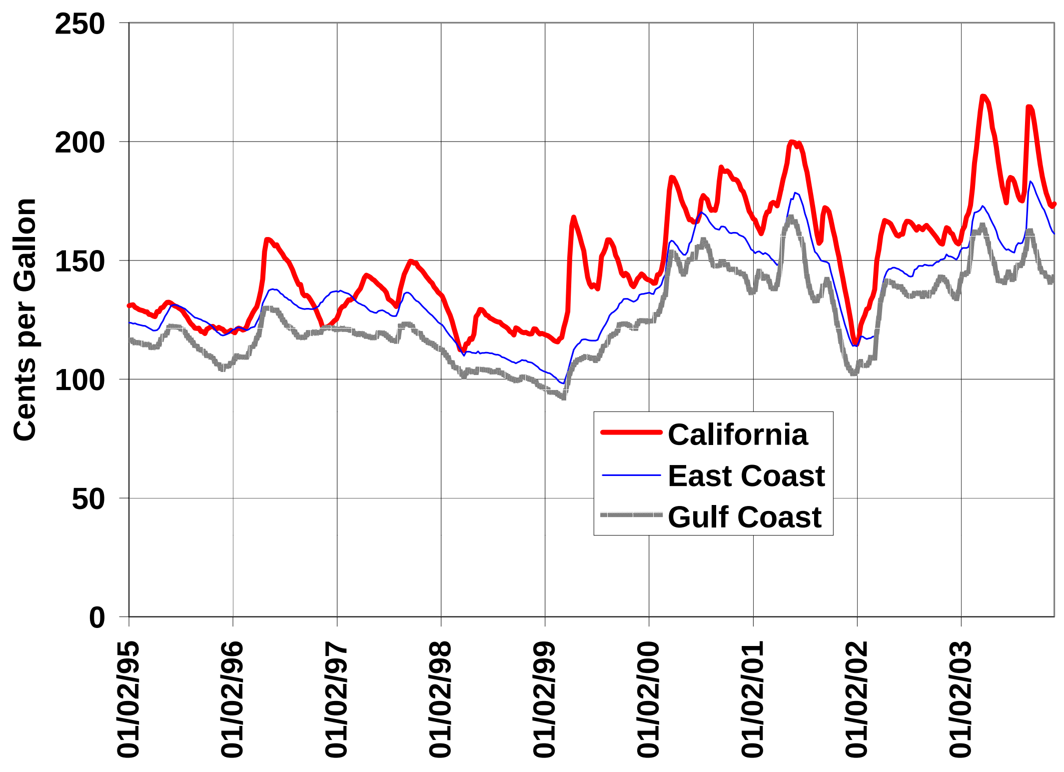
Refineries performing this maintenance before the summer gasoline season will generally make prior arrangements for product purchases, and build their own inventories to use while their production is reduced. However, if the maintenance period lasts longer than planned, a refiner may run short of planned purchases and inventories and begin buying product on the spot market. Generally, delays in restarts are not long, so a refiner in such a situation would not want to purchase extra product beyond that needed immediately. If the delay drags on, however, those spot purchases may begin to strain the markets’ ability to meet the refiners’ needs and prices would begin to rise sharply. However, the price response is highly dependent on market conditions. If other refiners have extra production capacity, little price response may occur.

Comparing California Market Dynamics to Other Regions

As mentioned throughout this report, California is an isolated market, both geographically and because it uses a unique gasoline that most refineries outside of the State cannot produce. It is constructive to consider the factors a buyer in California must weigh when looking at purchasing volumes from outside the region, following a shortfall in which prices are rising rapidly. First, there are not many suppliers capable of producing CARB gasoline, so the supply choices are limited. Knowing that it will take 3-4 weeks for a shipment of gasoline to arrive in California, the buyer must assess how long the shortfall may last. The price of that cargo must cover the shipping costs of perhaps 10 cents per gallon on top of the production costs. As discussed in Chapter 5, the price difference between California and the U.S. Gulf Coast may need to rise to about 20 cents per gallon to provide adequate incentive to move product from the Gulf Coast to the West Coast. Potential sellers are not going to be interested in taking the risk that their costs will not be covered. Furthermore, if the shortfall occurs during the peak gasoline demand months, the sellers may demand a premium to switch from their existing customer base.

On top of the time delay, buyers or sellers cannot easily hedge the price of that shipment of CARB gasoline, because California gasoline prices do not follow NYMEX gasoline prices very well. Historically, buyers and sellers in California have been left with the dilemma of potentially having a very expensive shipment of gasoline arrive 3 to 4 weeks after a shortage has occurred, possibly just after the shortage is resolved and the price of gasoline has fallen dramatically. Recently a forward paper swaps[38] market has grown large enough to reduce some of the price risk for importers.

Figure 6-3. RFG Regular Gasoline Prices



Source: Energy Information Administration, Weekly Retail Gasoline Prices

The distance and difficulty in hedging make Gulf Coast or imported gasoline unlikely stopgaps when an unexpected shortfall occurs in California. Until it is clear that a shortfall will persist for a long time, refiners are likely to try to increase production at the

[38] "Swaps" are a type of financial instrument, called "derivatives," that derive their value from that of some other underlying commodity. See http://www.eia.doe.gov/oiaf/servicerpt/derivative/index.html .

functioning California refineries and to purchase blending components from other suppliers in the area. The refinery having the problem will have to purchase expensive product from the other functioning refineries, both hurting their profitability and benefiting their competition, all of which provides economic incentive to fix the problem quickly.

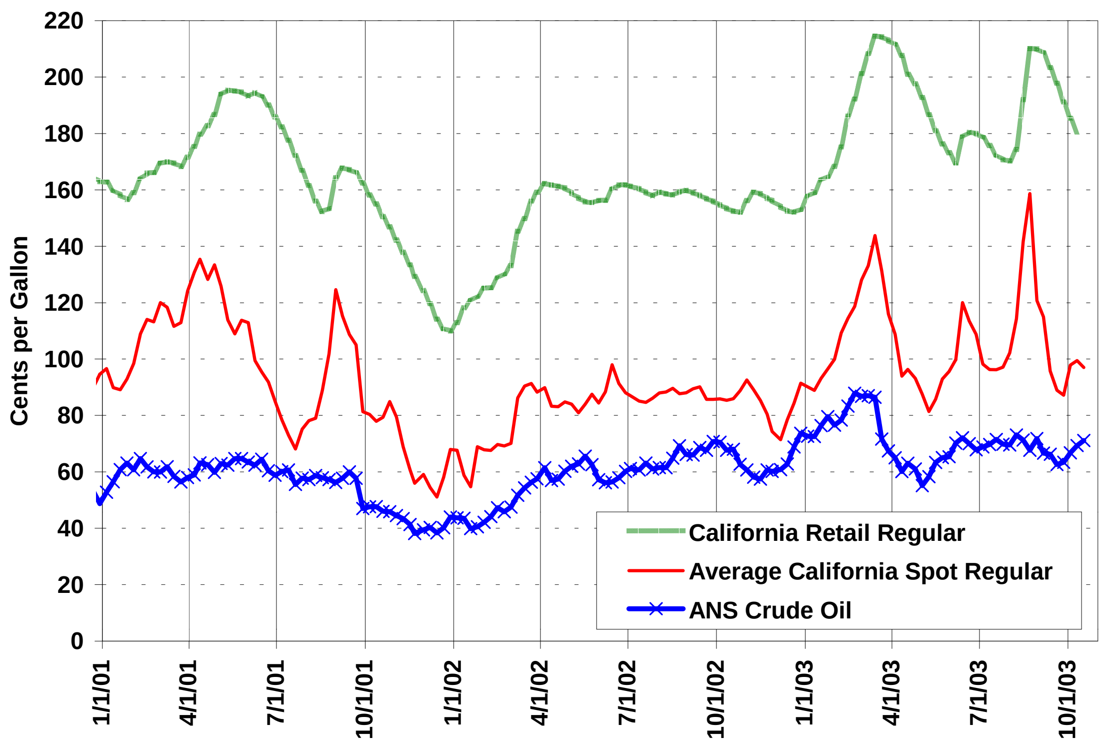
In the end, California's isolation delays resolution of any unexpected shortfalls. The magnitude and duration of a price spike during a supply shortfall is a function of both the size and duration of the shortfall. Not surprisingly, prices in California tend to exhibit higher price spikes than in the Gulf Coast and East Coast, as seen in Figure 6-3.

7. California Gasoline Prices in Spring and Summer 2003

7.1 Spring and Summer Price Overview

As described in Chapter 1, gasoline prices throughout the United States began to rise in December 2002, and continued upward for 3 months, nearly without interruption. The national average retail price for regular gasoline rose 37 cents per gallon between December 9, 2002, and March 17, 2003, reaching what was then an all-time record (nominal) price of $1.73 per gallon. Over roughly the same period (though beginning two weeks later), California retail regular gasoline prices rose 63 cents to an all-time high of $2.15 per gallon. Between early December 2002 and mid-March 2003, California spot gasoline prices (approximating the price at the "refinery gate") rose 72 cents per gallon, even more than the increase in retail prices (Figure 7-1), indicating that the sum of taxes and distribution/marketing costs and profits declined during this period. These two components can therefore be largely ignored as factors in the retail price run-up for the purposes of this analysis.

Figure 7-1. California Gasoline and ANS Crude Oil Prices



Source: Spot prices: weekly averages of Reuters daily prices; Weekly retail prices: Energy Information Administration

Retail prices fluctuated within a relatively narrow range (5 cents) in most of the United States through June and July, while California experienced another, though smaller, price run-up. Average California retail gasoline prices rose 11 cents in 2 weeks to peak at $1.81 on June 23, then took 6 weeks to decline to $1.70 on August 4. Prices began to rise strongly again in August, with the U.S. average retail regular gasoline price rising 23 cents from July 28 to August 25, peaking at a new record nominal high of $1.75. California prices climbed 40 cents from August 4 through August 25, but at $2.10 per gallon, fell short of their March record peak. Both U.S. and California average prices began to decline in September, and as of October 13, had fallen by 18 and 30 cents, respectively.

Spot gasoline prices are influenced by crude oil prices and by local market conditions. Crude oil prices are in turn driven mostly by global market conditions and directly affect product prices because they are the primary feedstock. As discussed in Chapter 3, however, crude oil prices also impact the tendency to build or draw down product inventories, which can add to or reduce product prices. Rising crude oil prices contributed significantly to increases in gasoline prices throughout the United States in early 2003. Alaska North Slope crude oil prices climbed $12.80 per barrel (over 30 cents per gallon) between mid-November 2002 and late February 2003.

In order to understand influences on California gasoline prices apart from the international crude oil market, the first step is to factor out crude oil prices, by subtracting them from spot gasoline prices. Second, when looking at different price behavior between regions, it is worthwhile to look at the price differential between those regions. Figure 7-2 shows average California spot regular RFG prices,[39] compared to both Alaska North Slope (ANS) crude oil and Gulf Coast regular RFG prices.

As can be seen from Figure 7-2, the California gasoline price spike of early 2003 was actually less severe than those seen in 2001 and the later spike in August 2003, both in terms of the spread between spot gasoline and crude oil prices, and between California and Gulf Coast spot gasoline prices. Consumers, however, saw the early 2003 price swing on top of high crude oil prices, which made the retail gasoline price higher than those in earlier years. As documented previously by EIA,[40] earlier price spikes were brought on largely by a combination of unexpected refinery problems and relatively low inventory levels, which left California gasoline markets with a temporarily tighter-than-normal supply/demand balance. In each past price run-up, including this year's, once the supply imbalance was corrected by the restarting of affected refinery units and/or the arrival of replacement product from other distant sources, California gasoline prices dropped back to more normal relationships with prices of crude oil and gasoline in other regions.

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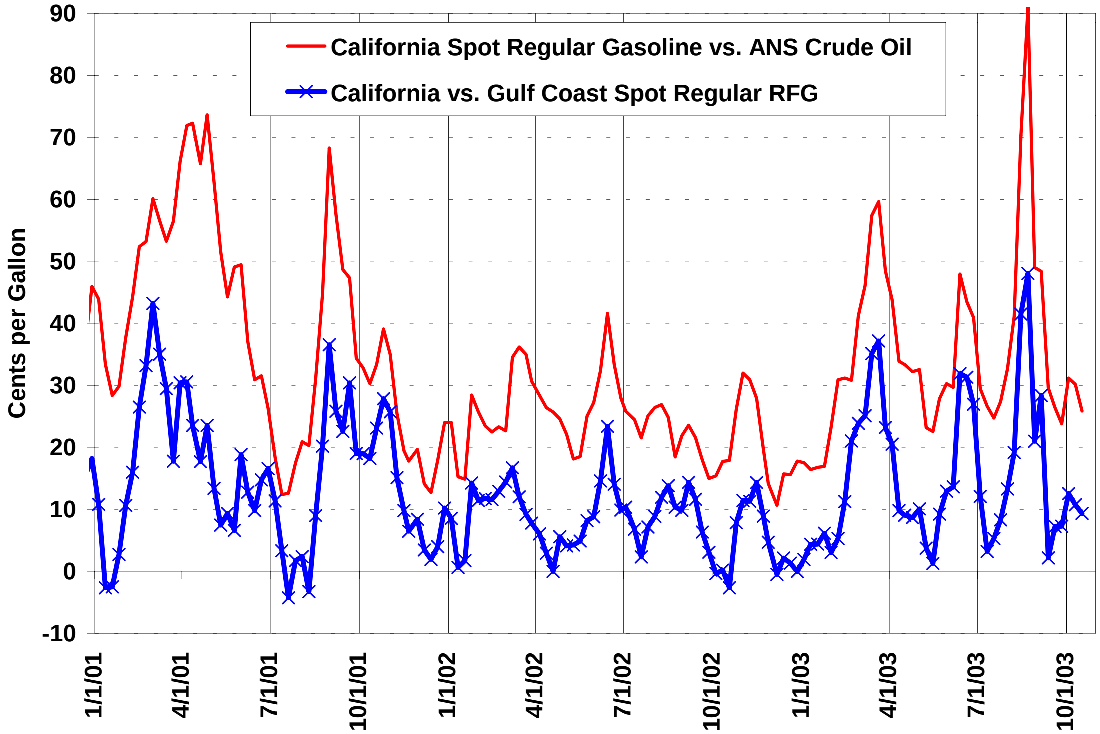
[39] The average California RFG spot price is approximated by a ratio of 2/3 Los Angeles and 1/3 San Francisco spot prices.

[40] Energy Information Administration, *Electricity Shortage in California: Issues for Petroleum and Natural Gas*, June 2001, Chapter 5, http://www.eia.doe.gov/emeu/steo/pub/special/california/june01article/caprices.html

Figure 7-2. Average California Regular RFG Spot Price Differential vs. Gulf Coast Gasoline and ANS Crude Oil

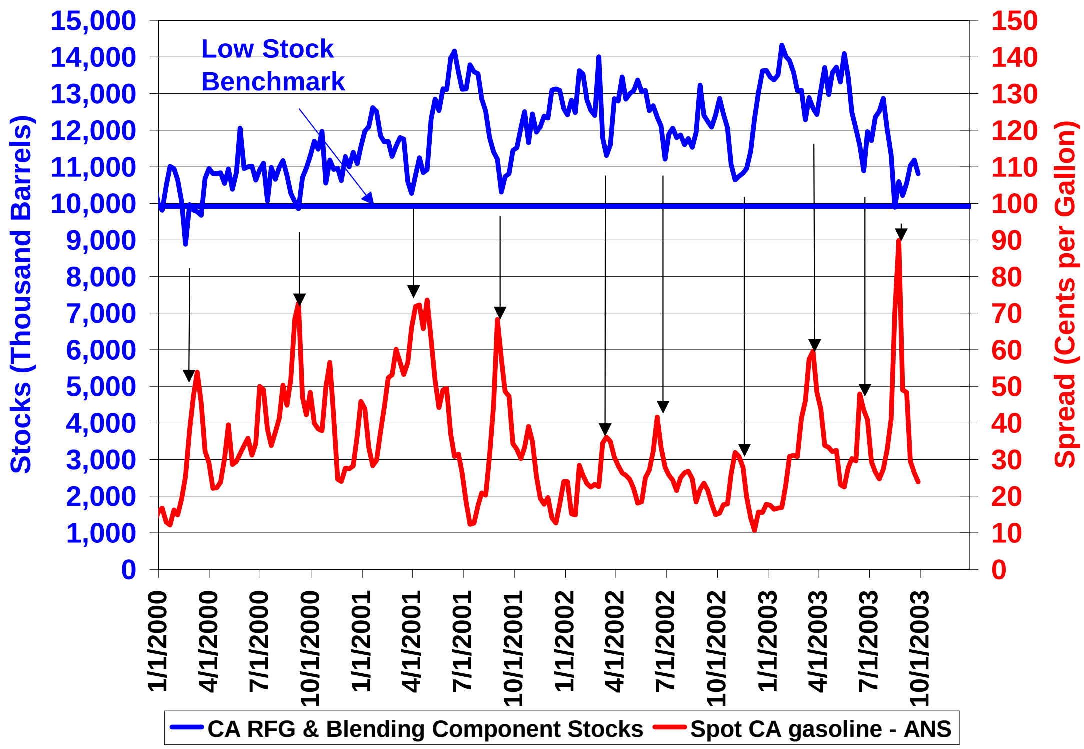


Source: Reuters

With the exception of the March price spike, the largest spikes historically occurred when RFG and blending component inventories were drawn down to around 10 million barrels (Figure 7-3). The price run-up in the first quarter 2003 was unusual in that total inventories, while drawing down in late February and early March, were still relatively high. As discussed in Chapter 4, refinery outages in the spring were significant, which contributed to the stock draw that occurred, but these outages, along with inventories that had not reached low levels, do not fully explain the spring price increase. The price increases in June and August, however, exhibited the more typical inventory draw-downs and associated price responses.

The next sections will discuss the factors affecting the three price run-ups in 2003. Generally, refinery outages, pipeline outages, and local demand swings resulting from the partial shift from MTBE to ethanol lie behind the increases, but these factors differ in relative importance among the three price surges.

Figure 7-3. California RFG & Blending Component Stocks and Crack Spread



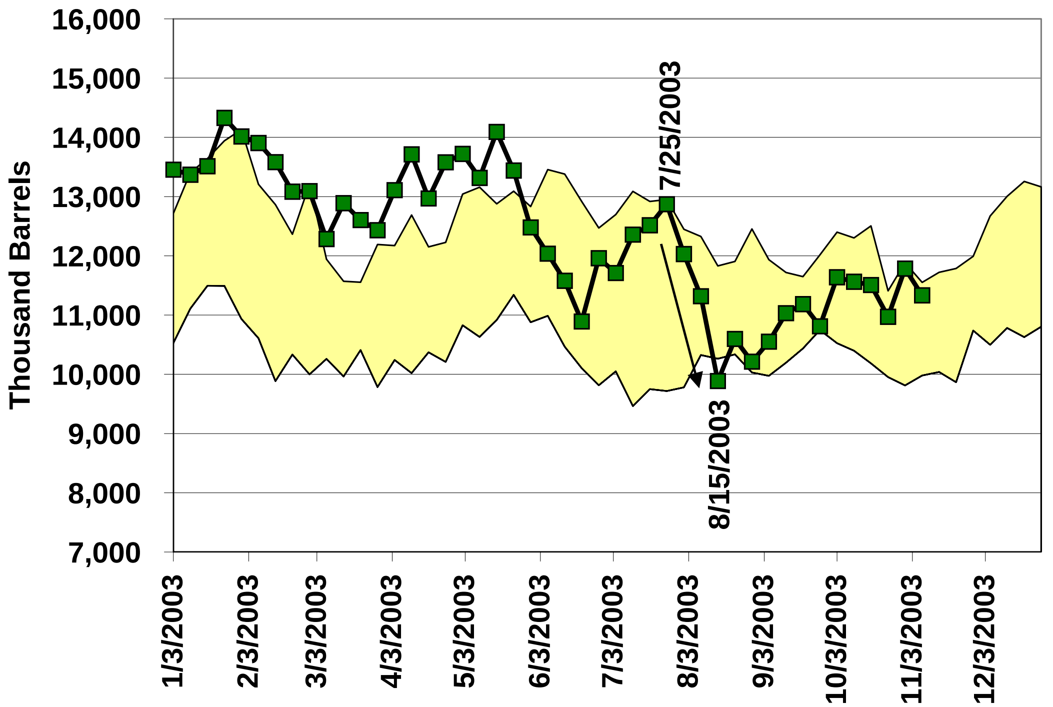
Source: Stocks, California Energy Commission; Prices, Reuters.
Note: ANS = Alaskan North Slope. Gasoline prices are a weighted average of Los Angeles and San Francisco spot RFG prices.

7.2 Explanations for March Price Increase

In February, refiners had to begin producing the low-RVP summer-grade gasoline, which is more difficult to produce than high-RVP winter-grade fuel. At the same time, RFG and blending component inventories began dropping as demand exceeded supply. Inventories, however, had been built to levels well above normal early in the year in order to accommodate major maintenance plans. Inventories fell 1.7 million barrels (49 thousand barrels per day) through February and the first week of March. The decline abated at about 12.3 million barrels, which is relatively high as seen in Figure 7-4.

Since the California gasoline inventory decline in February and early March did not remove the inventory cushion that normally would dampen price spikes, EIA looked for other factors that might have contributed to the price rise. The analysis revealed that several factors resulting from the newly split market for M-CARB and E-CARB added stress to the California gasoline market during this period and contributed to the price spike. The next sections discuss the reduction in gasoline production from outages and how the split market hindered the industry's ability to maintain supply.

Figure 7-4. California RFG & Blending Component Inventories 2003



Note: Band is the mean inventory value plus or minus 1 standard deviation between 1998 and 2002 for each week in a year.
Source: California Energy Commission.

Refinery Outages

The level of refinery outages and resulting reduction in gasoline production was high in the first quarter of 2003 and was a factor in the price spike in March. A number of refineries had planned maintenance, some of it substantial, during the first quarter. In preparation, they had made contractual arrangements for supply and built inventories, which explains in part the large inventory level at the beginning of the year. As described in Chapter 4, the shortfall in February production from what might have been achieved with no outages was 160 thousand barrels per day during the month. Still, the loss was not unique for February, as it was only the third largest shortfall shown in Figure 4.5. It was not possible to separate exactly how much of this shortfall was due to the refining loss that occurs when switching to ethanol-blended RFG or due to outages, but outages were the major factor, as analyzed in Chapter 4.

Outages were seen in both northern and southern California refineries, but southern California refineries had a much larger proportion of capacity affected. Both E-CARB and M-CARB saw impacts from the outages. Total outages in first quarter 2003 were high enough to tighten supply conditions and increase gasoline margins, but with the high inventory cushion in January, the outages alone do not explain the strong price surge.

Shift from MTBE to Ethanol

In 2003, the California market was split between M-CARB and E-CARB, which cannot be mixed at retail locations during the summer months. It is not easy for retailers to switch between these two types of gasoline, and as a result, a supply shortage for one product can raise prices even while there is adequate supply of the other.

As January unfolded, many refiners in the State were beginning to use ethanol for the first time. About 450-500 thousand barrels per day, or about half the volume of California gasoline production, had switched from MTBE to ethanol by then. The refiners that still were producing MTBE-blended CARB RFG provided much of their product to the unbranded gasoline market, which is estimated to represent about 15 percent of the State's gasoline sales.[41] Branded retailers were mainly selling E-CARB, and most unbranded retailers were selling M-CARB. Refiners producing M-CARB were unevenly split between northern and southern California, with Tesoro Golden Eagle (Avon), Valero Benicia, and Chevron Richmond in the north (total crude capacity of about 535 thousand barrels per day) and Valero Wilmington in the south (crude capacity of 81 thousand barrels per day). Much of the M-CARB clearly had to be shipped to southern California to meet demand in that part of the State.

When refiners had gasoline production problems prior to 2003, they could frequently buy gasoline from their local competitors. When the market fragmented into M-CARB and CARBOB producers, however, refiners discovered that they could no longer easily find the proper formulation. If the M-CARB producers had an unplanned outage, their CARBOB-producing competitors could not make the needed product because they had flushed MTBE out of their systems and could not or would not change back. There were some reports of an M-CARB producer buying CARBOB and blending it with MTBE, but in many cases, this can be logistically awkward unless sufficient tankage and pipeline connections are available. In addition, one refiner reported that it had imbalances in blending component inventories where it had high blending component stock levels but no way to quickly blend off those stocks into finished gasoline because it did not have the other components needed for the blends. This loss of ability to rebalance markets at the refinery level helps explain why prices spiked so strongly in March: Refiners discovered that their nearby competitors could not easily cover their needs, even though inventories were at high levels.

Not only were refinery market balancing actions limited in early 2003, retail stations could not simply switch back and forth between M-CARB and E-CARB gasoline as availability changed. As a result, a retailer's decision to use either one type of gasoline or the other limited the number of suppliers available to meet market needs. Branded

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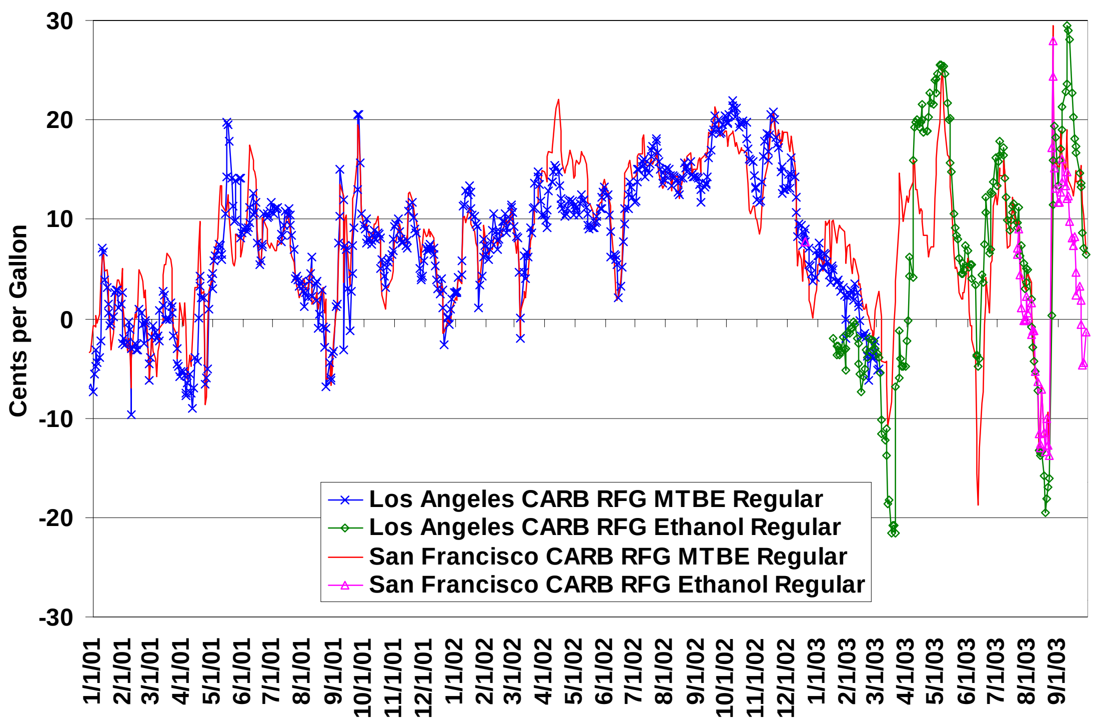
[41] David Hackett, Stillwater Associates, testimony given at the CEC Public Workshop on the Possible Impacts of MTBE Phase-Out on Gasoline Supplies, February 19, 2002.

stations have fixed contracts with suppliers, and most refineries switching to ethanol supplied the branded market. Many independent marketers historically relied on Valero and Tesoro for supply, and since these two companies continued to produce M-CARB, the independents decided, for the most part, to stay with M-CARB initially. Limitations in supply sources for independent marketers can raise extra hurdles to their meeting their own market needs and affect their gasoline prices. Unlike branded marketers that have supply contracts with various refiners, unbranded independent marketers usually do not have supply contracts, and thus are free to purchase from any supplier, but have no assurance of supply when product availability is tight. Because of this flexibility, the unbranded segment of the market is a significant source of marginal demand and, therefore, plays a pivotal role in price movements. When supply is ample, branded gasoline rack prices tend to be higher than unbranded prices, and the reverse occurs in times of tight supply.

As shown in Figure 7-5, the branded-unbranded gasoline price differential in California over the past several years has averaged about 10 cents per gallon, though it frequently rises as high as 20 cents, and drops below zero for short periods. The most notable periods when the difference fell below zero in recent years have occurred in 2003, corresponding to the March, June and August price spikes under examination.

Figure 7-5. California Branded–Unbranded Regular Gasoline Rack Price Differentials



Source: Oil Price Information Service

Because marketers cannot easily switch between E-CARB and M-CARB, they are limited in their choice of alternate suppliers to those who sell the same type of gasoline. And since, in the short run, unbranded marketers are the only ones who can (or need to) shop around, they are the ones most affected by the changeover. Thus, an unintended side effect of the partial changeover seen this spring is that unbranded marketers, which are often seen as some of the most aggressive in terms of reducing prices to gain market share, have seen a sharp reduction in available suppliers from which to shop for product. This, in turn, would likely reduce the downward pressure on prices that such marketers often provide.

As production of summer-grade gasoline began, the large refinery outages in the first quarter also affected southern California more than the northern region. Part of this tightness resulted from a pipeline problem in Arizona that seemed to increase demand for MTBE-blended product briefly over and above the usual demand in southern California. As the situation unfolded, some unbranded marketers switched to E-CARB. In addition to the tight-supply balance in southern California, tight logistics affected the region as loading delays developed at truck racks. Northern California experienced logistical problems during the spring. As described in more detail in Chapter 5, inadequate supplies of MTBE-blended CARB gasoline were available at the Bradshaw terminal near Sacramento, and marketers had to search for supplies elsewhere.

March Price Increase Summary

In addition to crude oil price increases, two factors seem to explain the price spike seen in California this past spring – large refinery outages and the addition of E-CARB to the State, creating two non-fungible markets from a supply perspective. Refinery outages were especially high during February, and extended into March, but the high inventory cushion in January prevented these outages from drawing down inventory to very low levels. As such, refinery outages alone would not explain the price increase seen. The partial change to E-CARB also interfered with the market balance in the first quarter.

The California logistical system is not set up to quickly re-balance local problems or dislocations between northern and southern California (Chapter 5). With the market split between M-CARB and E-CARB, refiners could not easily turn to local competitors to help with imbalances, and supply sources for marketers were limited.

Suppliers had no way to know in advance how much M-CARB volume versus E-CARB gasoline would be needed in total or at each terminal, and with inter-refinery sales and delivery constraints, it is not surprising that local problems occurred. M-CARB supply tightened in southern California, since most of the M-CARB was being produced in northern Californian refineries. There were reports in the south of refiners buying CARBOB and blending it with MTBE to provide supply, and some retailers made the switch to ethanol blended gasoline to find supply. Pipeline problems in Arizona drew additional MTBE-blended gasoline (14 thousand barrels per day) from southern California. Northern California also experienced some supply problems due to logistical constraints arising from handling the two fuels, such as the outage problems at the Bradshaw terminal near Sacramento. Thus, unbranded marketers, who would normally be expected to play a significant role in market re-balancing, had limited supply options with the split market, which constrained their ability to re-adjust. The net result was much tighter supply and greater price pressures than would be expected by looking only at inventory levels reached in early March.

No Price Impact from Oxygenate Prices or Winter-Spring Changeover

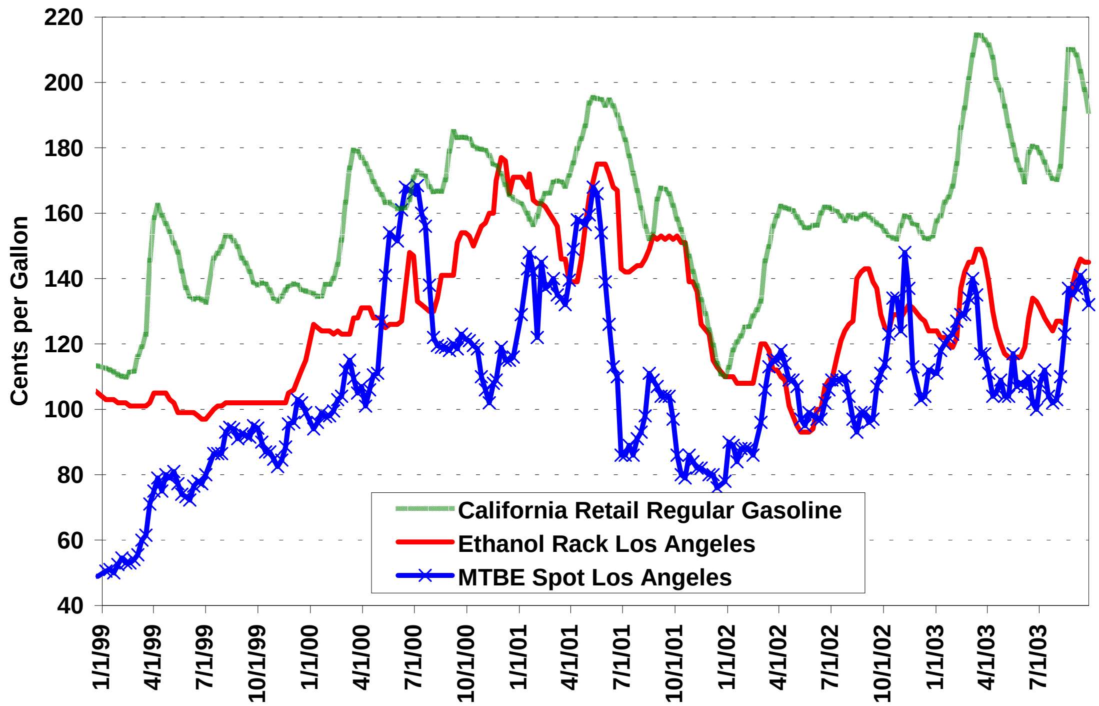
Neither oxygenate prices nor the changeover from winter- to summer-grade gasoline seem to have contributed significantly to the price increase. It should be noted that the supply of ethanol was sufficient, and that any price impact associated with the changeover from MTBE to ethanol would not have been brought on by the comparative cost of the two oxygenates themselves, but rather by other complicating factors relating to the logistics and market dynamics of the changeover.

As shown in Figure 7-6, West Coast prices for MTBE and ethanol were comparable throughout most of the period, and both peaked at significantly lower levels than during the price run-ups in 2000 and 2001. Additionally, while California spot and retail gasoline prices rose about 72 and 63 cents per gallon, respectively, between mid-December 2002 and mid-March 2003, West Coast prices for MTBE rose only 37 cents, and ethanol prices only about 30 cents. Although the average price per gallon of ethanol is typically somewhat higher than that of MTBE, the preferential tax treatment given to ethanol more than offsets that disadvantage. Because oxygenate represents a small percentage of the finished gasoline blend, the price of either additive, as long as it is near the price of gasoline, has a relatively small impact on the price of the blend. In fact, because gasoline blending represents the largest market for both MTBE and ethanol, their prices have historically tended to follow the trends in wholesale gasoline prices.

Rack prices for E-CARB and M-CARB were not significantly different, in spite of the lack of fungibility. This arose for several reasons. At the wholesale level, it was noted that producers of MTBE-blended gasoline were purchasing CARBOB and adjusting it to blend with MTBE rather than ethanol, thereby increasing the demand for E-CARB feedstock. At the retail level, competition would tend to equalize the price. To the consumer, M-CARB is no different from E-CARB. Thus, unbranded M-CARB retailers tried to push prices up to recover their costs, while branded E-CARB retailers pushed down on prices. Ultimately the market reached a point of equilibrium where prices were not much different.

The changeover from winter- to summer-grade gasoline also did not seem to be a significant factor in the unusual price run-up, beyond the typical price increase of about 5 cents per gallon that generally occurs when the market switches to the harder-to-produce summer-grade product. The change from winter to summer gasoline is more difficult when using ethanol than MTBE, due to the need to both produce and keep from contaminating the very-low-RVP blendstock (CARBOB) to which ethanol is added. The change in RVP from winter gasoline to summer is so great that it is impractical to blend down the RVP of winter gasoline by adding more low-RVP material. For these reasons, summer gasoline is more expensive to produce than winter gasoline, but neither of these issues appeared to play a large role in the price run-up.

Figure 7-6. California Gasoline, MTBE, and Ethanol Prices



Source: Retail gasoline prices: EIA; MTBE and ethanol prices: *Octane Week,* Hart Publications, Inc., various issues.

Suppliers anticipated the need for longer transition times in 2003 and began converting to summer-grade gasoline early, to allow adequate time to deal with any initial batches that might not meet specifications, and to allow for more tank turnovers.[42] This, in combination with the one-month extension allowed by the State,[43] prevented refiners from missing pipeline cycle deliveries. Had a refiner missed its opportunity to deliver

[42] Terminal tanks that cannot be drained dry will have some "heels" of winter-grade product in the bottom. This high-RVP winter gasoline will contaminate the first batch or two of summer-grade product that is put into the tank. However, as the tank is "turned" or refilled with more summer-grade product, the remaining winter-grade product will be adequately diluted to no longer contaminate the incoming batches.

[43] Federal RFG requires refiners to be producing summer-grade gasoline by May 1, but California requires some southern areas to switch by March 1. This year, the State delayed the start date to April 1 to ease the winter-summer transition when using ethanol. Pipelines, however, require summer-grade product even earlier to ensure State compliance. This year, California refiners began producing summer-grade product in February to meet early March pipeline schedules.

product during a cycle,[44] it would have had to wait until the next scheduled cycle, thereby delaying re-supply to its terminals. The mechanics of the shift from the winter to the summer blend went smoothly, and did not seem to contribute much to the price spike.

7.3 June Gasoline Price Increase

After both U.S. and California average retail gasoline prices reached all-time peak levels in mid-March 2003, they receded sharply through early June, with the U.S. average reaching a low of $1.47 on June 2, and California falling to $1.70 on June 9. Prices fluctuated within a relatively narrow range (5 cents) in most of the United States through June and July, while California experienced another, though smaller, price run-up. California retail gasoline prices rose 11 cents in 2 weeks to peak at $1.81 on June 23, then took 6 weeks to return to $1.70 on August 4.

California refineries were all running in April and production was 85 thousand barrels per day higher than in March. In May, Valero began to experience problems with its fluid catalytic cracking and hydrocracking units at Benicia. Valero's problems extended through June. When Shell Martinez also apparently experienced an FCC unit outage in June, gasoline production fell. Figure 4-5 showed that the gasoline shortfall in June over what would have been the case if no outages occurred was 124 thousand barrels per day. While most of this decline was the result of the outages, some of it was also due to refinery production limitations experienced when refineries switched from MTBE to ethanol.

Because of the drop in production in June, California RFG and blending component inventories fell sharply. In the first three weeks of the month, inventories dropped over 1.5 million barrels (76 thousand barrels per day). When gasoline inventories fell, gasoline crack spreads over ANS crude oil prices rose by about 20 cents per gallon.

All of the reported refinery problems in June were in northern California. As mentioned in Chapter 5, tankers were not in position to bring product to northern California at that time. This produced a tighter market in this region than in southern California. Wholesale prices in San Francisco jumped much higher than in southern California, rising at one point 25 cents per gallon over Los Angeles as shown in Figure 7-7. Finally refineries began to recover and gasoline inventories rebuilt by beginning of July.

7.4 August Gasoline Price Increase

Although California gasoline prices reached a peak in August similar in magnitude to the March price run-up, the sharp price increase in August differed in a number of respects. Unlike the March rise, where Alaska North Slope crude oil prices climbed $12.80 per

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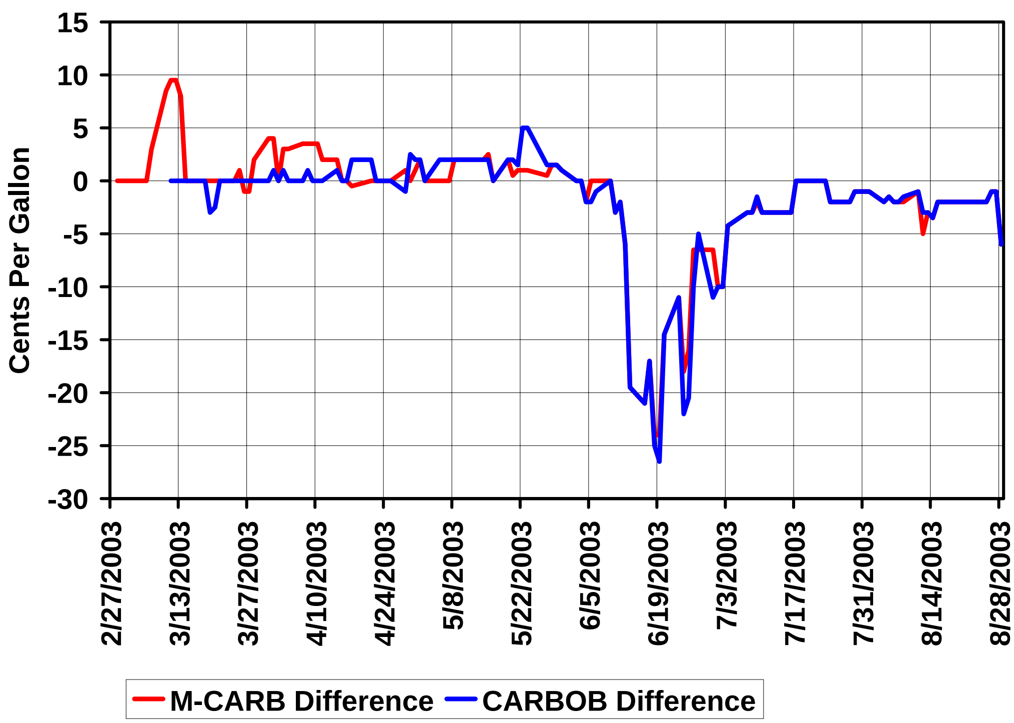
[44] The Kinder Morgan pipeline runs different products through the system in batches. The batches are scheduled on a regular basis or cycle. Thus, a supplier wishing to send gasoline through the pipeline to distant terminals would arrange to deliver its volumes to the pipeline in time for one of the gasoline cycles.

barrel (over 30 cents per gallon) between mid-November 2002 and late February 2003, the August 2003 increase had no underlying crude oil price component, as crude prices were relatively flat throughout that period.

Even more dramatically than in June, August inventories reflected a strong market imbalance with sharp declines (Figure 7-4). Over a three-week period from July 25 through August 15, gasoline and blending component inventories in California fell over 3 million barrels (about 142 thousand barrels per day), which is 10 times the average draw seen during that time during the past 5 years, and the gasoline crack spread over

Figure 7-7. Los Angeles – San Francisco Spot Price Differences



Source: Reuters spot price data

ANS crude oil increased 60 cents per gallon from 30 cents per gallon to 90 cents. From August 1 to August 20, gasoline prices at the wholesale (spot) level rose about 65 cents per gallon. With lagged pass-through, retail price rose about 40 cents per gallon from August 4 to August 25 to peak at $2.10. In Arizona, which depends on supply from both California and Texas, prices rose 45 cents per gallon during the same 3-week period due to an outage on the Kinder Morgan pipeline. Prices in Nevada, Washington, and Oregon rose 35, 34, and 33 cents, respectively, during August.

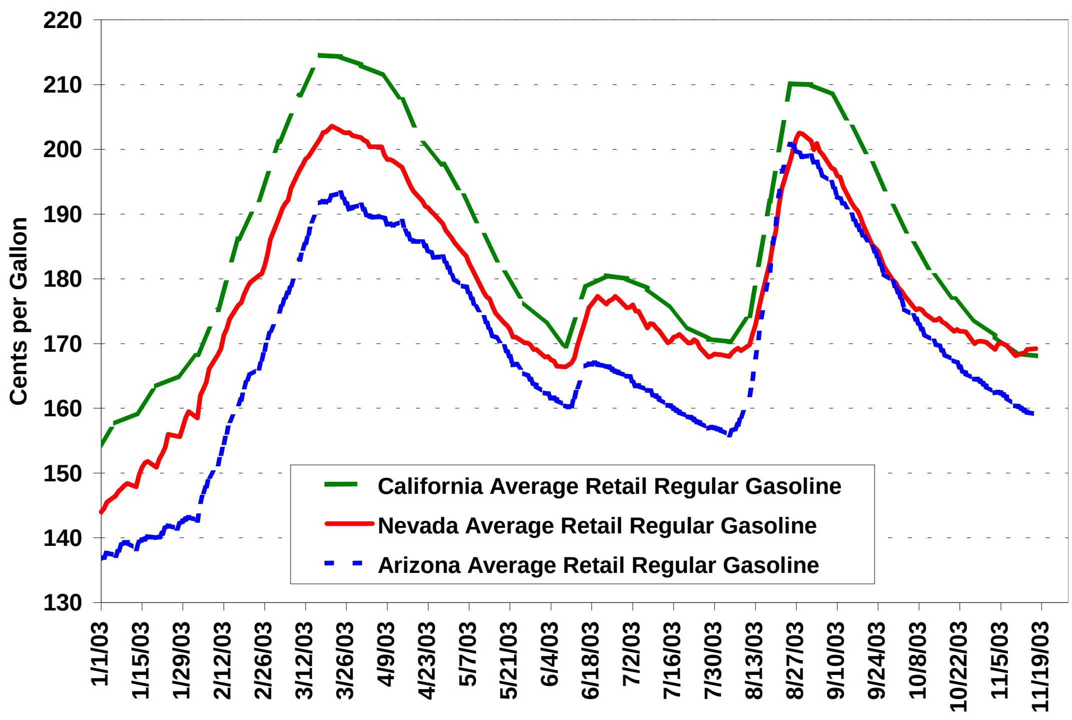
After peaking about August 25, California gasoline prices began to decline rapidly and steadily. As of October 24, California prices had dropped by 31 cents per gallon and

Arizona prices had dropped by 36 cents per gallon. Nevada, Washington, and Oregon prices dropped by about 30 cents each.

As was the case with the national average, retail gasoline prices on the West Coast this summer were merely reflective of even sharper movements in the underlying spot prices. CARB RFG spot prices at Los Angeles, for instance, rose 76 cents from July 7 to August 20, peaking at $1.67 per gallon, and those in San Francisco rose 75 cents over the same period. Prices at both refining centers dropped sharply after their late-August peaks, falling more than 80 cents in the next month.

California demand in both July and August had increased substantially from the low spring levels of about 940 thousand barrels per day to peak at about 1,020 thousand barrels per day. Refiners in California also supply parts of Arizona and Nevada. In Arizona, a segment of the Kinder Morgan pipeline, which supplies Arizona with gasoline from Texas, ruptured on July 30 and was shut down for much of August. This line represented about one-third of supply into Phoenix, and made the Phoenix area almost completely dependent on supply from Los Angeles. Pipeline flow was not fully restored until August 25. During this time, California refiners supplied about 30 thousand barrels per day more gasoline to Arizona than usual, and retail prices in both Arizona and California rose 40 cents in 3 weeks, while the Phoenix area saw outages at some gasoline stations and lines at others (Figure 7-8).

Figure 7-8. West Coast Retail Gasoline Prices



Sources: California, EIA; Nevada and Arizona, AAA.

While refinery outages played a major role in the March and June price increases, they played less of a role in August. Refinery unit outages affected some California refineries during August 2003, and Washington State refineries that supply California slightly reduced deliveries to California (5 thousand barrels per day) as a result of outages. Refinery unit operations and gasoline production in total, however, were maintained at typical summer levels.

The most serious outage was the hydrocracker problem at Valero's Benicia refinery. The *East Bay Business Times* reported on September 3, 2003; that "…the company's hydrocracking unit damaged by a July 10 fire wasn't brought back on line until August 28, costing Valero 35,000 barrels per day – 31.8 percent of the refiner's capacity – in gasoline production." Several other refineries experienced minor problems and showed a small loss of feedstock throughput.

EIA analyzed monthly refinery unit outages in California refineries since 1995. The study analyzed monthly outage levels for distillation, fluid catalytic cracking (FCC), hydrocracking, and coking units. Refiners do planned unit maintenance during the fall and winter months, in order to have full unit capability during the spring and summer months when demand is higher. In spite of these procedures, refinery problems occur in the spring and summer, and it is a rare month when no outage problems occur in any of the State's 13 gasoline-producing refineries. Outages in August 2003 compared favorably with the outages in the summer months from 1995 through 2002. Of the 48 summer months in that 8-year period, the outage levels were higher in 31 of those months and lower in 17. In the 17 summer months with outages lower than in August 2003, the production averaged 38 thousand barrels per day less than EIA's estimate of the production level that could have been achieved with no outages in any refineries.

Using a different comparison, the unit input levels for August 2003 are contrasted with input levels during the past three years (Table 7-1). In most cases, August 2003 inputs were at or near the three-year maximum values. The hydrocracker input rate was 416 thousand barrels per day compared to the highest rate of 462 thousand barrels per day, but historically, hydrocrackers do not seem to run steadily at high rates for extended periods. The second highest month for hydrocracker input in the three-year period was 432 thousand barrels per day, and the average for the 3 years was only 393 thousand barrels per day.

Table 7-1. California Refinery Unit Throughputs In August 2003 Compared to Three-Year Maximums (Thousand Barrels Per Day)

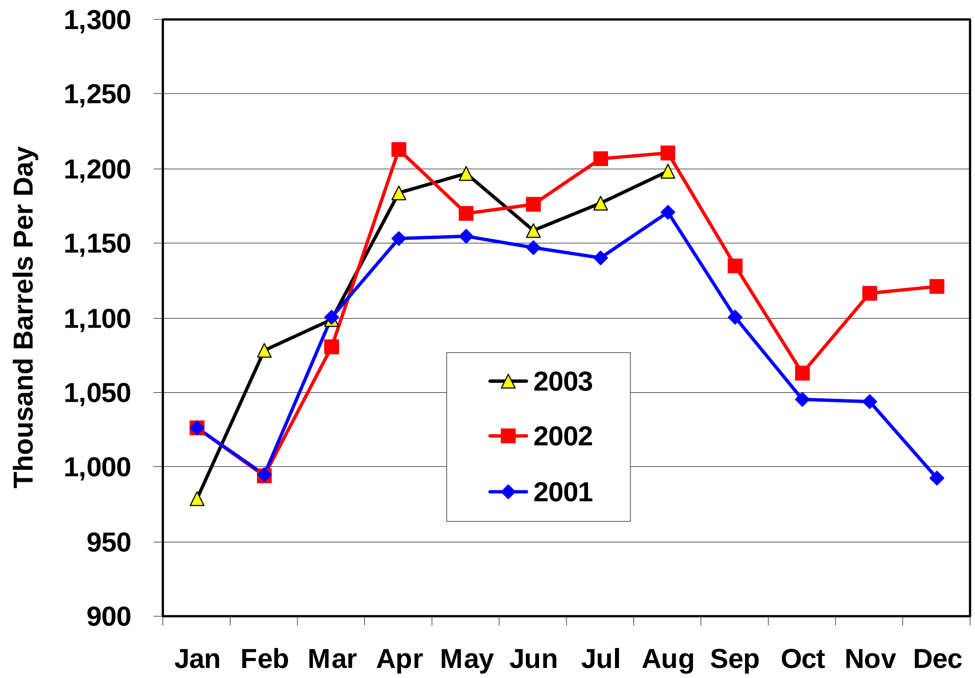
Unit	August 2003 Input	Maximum Monthly Input Since January 2000
Distillation	1,898	1,900
FCC	642	648
Hydrocracker	416	462
Coker	463	463

Source: Energy Information Administration, Form EIA-810

While refinery inputs were high in August, gasoline production in Figure 7-9 was down over 20 thousand barrels per day from what it might have been because of the transition of six refineries to ethanol from MTBE. Additionally, refiners had increased the production of gasoline to move to other States with the net result that CARB gasoline production was 46 thousand barrels per day less than volumes produced in August 2002.

In summary, the August price increase in California accompanied a quickly tightening supply-demand balance as measured by inventory levels. During July, gasoline stocks were rising to levels well above average, but then began to decline in the last week to end the month at about the same level as they began the month. The gasoline stock decline continued in August, falling rapidly to mid-month as prices rose. The cause of the unusual stock drawdown was mainly the result of strong demand in California in addition to increased movement of gasoline out of California to Arizona. California gasoline production increased 22 thousand barrels per day in August over July, and all of that increase was gasoline for export to other states. California refineries were unable to keep up with peak summer demand and the loss of Arizona supply from Texas. Imports or receipts from other U.S. regions could not respond quickly enough to keep inventories from falling rapidly and prices spiking.

Figure 7-9. California Refinery & Blender Finished Gasoline Production



Source: Energy Information Administration, Form EIA-810

7.5 Implications for Prices in 2004

As indicated in Chapter 5, changes are occurring that will both help and hurt the flow of product in the region. While the logistical system is expected to remain constrained, the return to mainly one type of gasoline in 2004, when all of the Federally mandated RFG supply will have switched to E-CARB, should ease many logistics problems. In addition, suppliers gained experience during 2003 and, more importantly, the large refinery outages seen this past spring may not reoccur.

EPA's recent decision allowing the elimination of the requirement for an oxygenate in summertime Arizona Cleaner-Burning Gasoline (CBG) may improve the capability of the California refining industry to supply CBG because it reduces the constraints on the refiners' gasoline blending and may facilitate imports from abroad.

Other factors are working against smooth supply. These include:

- Total gasoline production capacity will be reduced because all refineries will be producing CARBOB.
- More material must be brought in from outside the State, and port constraints, particularly those in southern California, may become more limiting than they were in 2003.
- MTBE bans in New York and Connecticut will create demand for high-quality, low-RVP gasolines, similar to CARBOB, in the second quarter of 2004. This will increase competition for the same type of gasoline and components required by California.

In 2004, factors such as reduced refining capacity and long supply chains will work to increase the probability of price volatility, while other factors will work to reduce market dislocations. Refinery outages, for example, may not be as large in 2004 as occurred in 2003, and with the move a single fuel, supply-demand imbalances that occur may be resolved more quickly, tempering price surges. Which factors ultimately dominate cannot be determined in advance.

8. Lessons Learned

8.1 Smooth Transitions Cannot Be Ensured

No amount of preparation can remove all uncertainties in advance of the transition to a new fuel. The supply system from refinery to end-user is very complex and involves many players. Changes in fuel specifications can change the relative competitive economics faced by suppliers. As a result, some may increase their supply, some may decrease, and a few may even abandon a market. Such shifts in supply sources may take time to sort out, and temporary dislocations can occur as a result, with accompanying price surges. But those very surges provide the signals for the market to realign quickly. Even with the Government acting as a central gathering and clearing house for information collected from individual players, the complexity of the system leaves much uncertainty prior to any fuel transition. Since MTBE bans require significant changes, industry, government and the public should expect some transitional problems that can result in temporary price spikes. Some of the remaining lessons that follow deal with topics that might help to mitigate the transition problems, but will not eliminate them.

8.2 Government Regulatory Body Coordination Helps

Coordination among government departments, particularly those involved in permitting and the environment, can help to increase the chances of a smooth transition. For example, MTBE bans necessitate construction work at many points along the supply chain. Since the entire industry responds to a specification change under new regulations such as an MTBE ban, it is likely that permitting requests would increase substantially. Government and industry should begin to address the permitting needs as early as possible, with government potentially taking the lead in alerting industry to the kinds of lead times needed. Furthermore, if government agencies learn that a significant surge in permitting requests will be forthcoming, appropriate plans for providing needed resources to deal with that surge may be in order.

8.3 Reducing Regulatory Uncertainty Encourages Early Preparation

Regulatory uncertainty can create large incentives for industry to delay preparing for an upcoming fuel specification change. For example, California requested a waiver from the Federal oxygen content requirement in RFG, and proposed Federal legislation to eliminate the oxygen requirement was being considered. The uncertainty over the oxygen requirement provided a large incentive for some refiners and terminal operators to wait as long as possible before investing to use ethanol. The potential for companies to make Federal RFG without an oxygen requirement provides suppliers with more options for gasoline production. Without the waiver, ethanol is the only practical alternative to MTBE, and as previously described, requires investments in the refinery and at terminals. Ethanol use also requires a different use of tanks both at the refinery and at terminals. Such uncertainties can create a larger incentive to delay preparation than might otherwise be the case. This did not seem to be a major problem in California since many refiners planned on using ethanol initially regardless of the oxygen content requirement.

Incomplete or ambiguous regulations can also encourage delay in preparation. An example of this occurred in the Northeast. Banning MTBE does not address the fact that extremely small amounts of MTBE may still be in the system. For example, import vessels will carry products containing MTBE as well as gasoline without MTBE. As a result, trace amounts of MTBE may be in gasoline delivered to areas with MTBE bans. Industry needs to know what trace amounts are allowable. Preparations and investments will be different depending on the level of trace material allowed. For example, new metering equipment may be needed and tank segregation plans may be different depending on the trace amounts of MTBE allowed. Also, in the early stages of the ban, most gasoline would likely contain trace amounts of MTBE simply because the entire system contained MTBE-blended gasoline in the recent past, and trace amounts clinging to walls and tank bottoms will get into the new product. Zero tolerance could place companies in an untenable position. Identifying and resolving such issues in advance will help to prevent last-minute changes or disruptions. Government coordination with industry well in advance of transitions can help to identify and resolve such issues, keeping them from adding to potential transition dislocations.

8.4 Partial MTBE Elimination is Not Necessarily Worse than a Full Ban

Product segregation in California resulting from only some refineries moving to ethanol-blended CARB gasoline caused distribution problems, but this does not imply that a full MTBE ban would have been better. A full ban would have shifted the problem from the distribution system to the production and import part of the supply chain. The partial removal of MTBE meant that California suppliers only had to replace a shortfall of 70 thousand barrels per day initially. A full ban would have required California suppliers to find 105 thousand barrels per day of extra product this summer. Trucking constraints might also have created more supply problems under a full ban. Recall from Chapter 5 that demand for trucking increased in 2003, as some volume of fuel (oxygenate) shifted from pipeline delivery to trucking. That is, MTBE was removed from gasoline traveling in pipelines, and was replaced by ethanol that had to be delivered by truck. With a full ban, additional ethanol would have been used, and trucking would have been even more strained. Finally, some refineries were not ready to produce ethanol-blended CARB gasoline. The partial elimination of MTBE that was implemented, while creating logistical complications, did allow the industry to identify and remedy smaller supply problems in advance of the full MTBE ban next year.

8.5 Factors Are Working Both For and Against Smoother Supply Next Year

As California looks ahead to 2004, further changes will take place. While the logistical system is expected to remain constrained, several factors should ease many of the logistics problems, including the return to mainly one gasoline[45] in 2004, when MTBE-blended gasoline can no longer be sold; the experience suppliers gained during 2003; and more importantly, the fact that the large refinery outages seen this past spring may not reoccur.

EPA's recent decision allowing the elimination of the requirement for an oxygenate in summertime Arizona Cleaner Burning Gasoline (CBG) may make it easier for the California refining industry to supply CBG because it reduces the constraints on the refiners' gasoline blending and may facilitate imports from abroad to serve Arizona.

Despite factors functioning to ease the strained system in 2004, other factors are working against smooth supply. These include:

- Total gasoline production capability will be reduced because all refineries will be producing CARBOB.
- More material must be brought in from outside the State, and port constraints, particularly those in southern California, may become more limiting than they were in 2003.
- MTBE bans in New York and Connecticut will create demand for high-quality, summer-grade gasolines, similar to CARBOB, in the second quarter of 2004. This will increase competition for the same type of gasoline and components required by California.

In 2004, factors such as reduced refining capacity and long supply chains will work to increase the probability of price spikes. Product that must travel long distances will not be readily available to resolve tight supply situations such as seen in August 2003. Other factors, however, will work to reduce market dislocations. Refinery outages, for example, may not be as large in 2004 as occurred in 2003, and with the move to a single fuel, supply-demand imbalances that occur may be resolved more quickly, tempering price surges. Which factors ultimately dominate cannot be determined in advance.

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[45] Since not all of California is required to meet Federal RFG standards, some California gasoline can be produced without the use of oxygenates like MTBE or ethanol. A small volume of non-oxygenated RFG was being produced in 2003 and will likely be produced in 2004.

Appendix A. Study Request

ONE HUNDRED EIGHTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON GOVERNMENT REFORM

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March 27, 2003

The Honorable Guy F. Caruso
Administrator
Energy Information Administration
Department of Energy
1000 Independence Ave, S.W.
Washington, DC 20585

Dear Administrator Caruso:

During the 107th Congress, the Government Reform Subcommittee on Energy Policy, Natural Resources and Regulatory Affairs held two separate hearings on gasoline prices. In June 2001, the Subcommittee reviewed the structure of gasoline markets nationwide, focusing on the boutique fuel problem. In April 2002, the Subcommittee focused on the effects of a 5 billion gallon ethanol mandate on the nation's gasoline markets. The Energy Information Administration (EIA) testified at both hearings.

In recent weeks, gasoline prices have risen sharply. California has seen the steepest rise in the nation, with prices increasing approximately 33 percent since the beginning of 2003. I am writing to request that EIA complete a study on the precise causes of the recent rise in gasoline prices in California. The study should address the following questions:

1. To what extent is the shift from MTBE to ethanol in California reformulated gas causing the price increase?
2. How much of the increase in California is due to the requirement to change from the winter to summer blend of reformulated gasoline?
3. MTBE constitutes 11 percent of California reformulated gasoline by volume. Ethanol only constitutes 5.5 percent. How is California making up for this loss of volume?
4. What effect is the shift to ethanol having on refinery capacity in California?
5. Given tight refinery capacity margins in California, what are EIA's estimations of price increases assuming California loses 5 percent of its refining capacity for one

week? What about a two-week loss of refining capacity? What about a 10 percent loss of refining capacity?

6. What types of problems (supply, blending, distribution), if any, has EIA witnessed in California due to the shift from MTBE to ethanol?
7. Once the phase out of MTBE is completed after December 31, 2003, what remaining supply and distribution problems will California face?

I recognize that a study of this scope could take several months to complete. However, please provide the Subcommittee with a preliminary report by May 2, 2003. If you have any questions about this request, please contact Subcommittee Staff Director Dan Skopec at 225-4407.

Sincerely,

Doug Ose
Chairman
Subcommittee on Energy Policy, Natural Resources and Regulatory Affairs

cc The Honorable Tom Davis
The Honorable John Tierney

Appendix B. Physical and Chemical Characteristics of MTBE and Ethanol Affect Emissions

MTBE is used in gasoline to satisfy emissions constraints and engine performance requirements. Most MTBE is used in reformulated gasoline, which is where the largest supply impact occurs when switching to ethanol. Both MTBE's physical and chemical properties relative to ethanol help to explain why switching from MTBE to ethanol use affects supply.

In order to understand the supply issues associated with switching from MTBE to ethanol use in gasoline, it is instructive to consider emissions differences between the two oxygenates. Federal reformulated gasoline requirements, for the most part, are stated in terms of emission reductions required from an industry base gasoline (Table B-1). Gasoline emissions regulated under the Clean Air Act Amendments of 1990 are volatile organic compounds (VOCs), nitrogen oxides (NO_{x}), and toxics. For reformulated gasoline, these emissions are determined from the California Air Resources Board (CARB) Predictive Model or the Federal Complex Model.

The physical properties of gasoline that drive these emissions are Reid vapor pressure (RVP) and the distillation profile[46] of gasoline. RVP indicates gasoline's tendency to evaporate. The higher the RVP, the more evaporation occurs at a given temperature, and the more volatile organic compounds are released into the air.

Distillation Profile
Gasoline is made up of many different chemical components, which boil at different temperatures. This characteristic can be measured in terms of the percent of material that has boiled or distilled at a given temperature. For example, T50 is the temperature at which 50 percent of gasoline would evaporate under certain conditions. T10, T50, and T90 are measures frequently used to describe a distillation profile for a given blend of gasoline. Similarly, the distillation profile can be described in terms of the percent of material that has evaporated at a given temperature. For example, E200 and E300 are the volume percents of material that would boil away at 200°F and 300°F, respectively.

The chemical properties that drive emissions are sulfur, olefin, aromatic, benzene and oxygen content. Higher oxygen content generally decreases polluting emissions, while higher sulfur, olefin, aromatic or benzene contents increase emissions.

MTBE and ethanol have good chemical properties from an emission standpoint. They add oxygen to gasoline, and dilute sulfur, olefin, aromatic and benzene content. In addition, Federal RFG must contain 2 percent oxygen by weight, which both materials can satisfy. However, ethanol's emission-related physical properties are not as good as

[46] Chevron's website contains a primer on gasoline that discusses characteristics that affect volatility, including the distillation profile and driveability index: http://www.chevron.com/prodserv/fuels/bulletin/motorgas/ch1a.shtml

MTBE's. Ethanol has a higher blending RVP than MTBE (i.e., the resulting gasoline blend has a higher tendency to evaporate and thus higher VOC emissions) and increases toxic emissions. Also, ethanol has twice as much oxygen content as does MTBE, which means only about half as much ethanol needs to be added to gasoline to meet Federal oxygen requirements. If this minimum level of ethanol is used, it has less dilution effect on other gasoline properties than MTBE. If 10 percent by volume ethanol is used, ethanol still creates higher toxic and VOC emission impacts than MTBE, which must be countered. But California refiners will not likely be using much more than 5.7 percent ethanol. The California Predictive Model has a larger NO_x emission impact when using ethanol than does the Federal Complex Model. As a result, refiners in California experience a NO_x constraint that will likely keep California RFG blends closer to the 5.7 percent by volume level.

Table B-1. Summary of Complex Model RFG Per Gallon Performance Standards for Phase II

Pollutant	Region (1)	Season	Standard
VOC (2)	Region 2 (Northern)	VOC control (3)	≥ 25.9% reduction
	Region 1 (Southern)	VOC control	≥ 27.5% reduction
Toxics	All	All	≥ 20.0% reduction
NOx	All	VOC control	≥ 5.5% reduction
		Non-VOC control	≥ 0.0% reduction (i.e., no increase)
Benzene (percent by volume)			≤ 1.0

Notes: (1)As defined in 40 CFR 80.71, VOC Control Region 1 covers: Alabama, Arizona, Arkansas, California, Colorado, District of Columbia, Florida, Georgia, Kansas, Louisiana, Maryland, Mississippi, Missouri, Nevada, New Mexico, North Carolina, Oklahoma, Oregon, South Carolina, Tennessee, Texas, Utah, and Virginia. VOC Control Region 2 covers: Connecticut, Delaware, Idaho, Illinois, Indiana, Iowa, Kentucky, Maine, Massachusetts, Michigan, Minnesota, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Vermont, Washington, West Virginia, Wisconsin, and Wyoming.
(2) 66 FR 37156; July 17, 2001 is the regulation that allows a small adjustment to VOC performance standard in the RFG areas of Chicago and Milwaukee for RFG blends that contain 10 percent by volume of ethanol. On a per-gallon basis, these regions must reduce VOCs by 23.9 percent.
(3) VOC control season refers to "High ozone season" as defined in 40 CFR 80.27(a)(1) and is the period from June 1 to September 15 for retail outlets and wholesale purchaser-consumers.
Source: 40 CFR 80.41(e)

Apart from emission properties, both MTBE and ethanol have high octane, which helps blenders and refiners meet the required level for engine performance standards. As MTBE is removed from gasoline, refiners will need to replace the octane lost, and ethanol can serve that purpose. Ethanol also has implications for distribution of gasoline. Ethanol has an affinity for water, and most pipelines and petroleum tanks have some water in the system. If gasoline blended with ethanol is run through this system, the ethanol will be pulled out of the gasoline into the water, rendering the gasoline unusable.

In summary, MTBE and ethanol both add octane to gasoline and have relatively good emission characteristics compared to other gasoline components. The challenge to switching from MTBE to ethanol arises because ethanol is not as clean as MTBE from an air emissions standpoint. It has a higher blending RVP, and thus higher VOCs emissions, it has higher toxics than MTBE, and if the minimum volume for an oxygen requirement is used, it has fewer dilution benefits from an emission standpoint. The net result is that refiners must change the formulation of the gasoline to which ethanol is added to counter these effects.

Appendix C. Estimating An Outage Severity Factor and Seasonal Production with No Outages

Estimating An Outage Severity Factor

The following steps describe the methodology used to estimate an outage severity factor for each month.

1) Using individual refinery data, unit inputs as percent of maximum input to unit were computed for each month during the year for each gasoline-producing unit reported to EIA.
2) An outage metric was devised to indicate the level of severity of the unit outage during the month based on the input during month as percent of maximum. The outage index contribution is shown in Table C-1. The FCC unit, an important unit for gasoline production, is weighted more heavily than are other units contributing to gasoline production.

Table C-1. Index Factor Ranges

Unit Input Percent of Maximum	Index Factor Applied	
	FCC	Atmospheric Distillation Unit, Hydrocracker, Coker
>80%	0.0	0.0.
70-80%	0.5	0.3
50-70%	0.8	0.5
<50%	2.0	1.0

Source: EIA estimates using data from Form EIA-810.

3) The Outage Indices were aggregated on a weighted basis based on the no-outage gasoline production for the individual refinery as a fraction of the total sum of no-outage gasoline production for all the refineries. Then the total of the weighted outage indices was multiplied by 100 to create the outage severity factors which can be compared to the difference between the actual gasoline production for the month and the estimated no-outage production for the month.

"No-Outage" Gasoline Yield and Production by Refinery by Month

In this analysis, the calculations deal with monthly changes in gasoline yield that occur as a result of changes in production specification requirements and in unit operation changes. Yields in some refineries have also changed over the years as changes have been made to refinery units and types of refinery crude oil feeds. The calculations used to estimate what production levels would be with no outages are described below.

1) Identify no-outage months in which little or no outage activity seems to be occurring. A month was assumed to be a no-outage month if the total outage index was less than 1.4, and if the FCC outage index was less than 0.9. Then a matrix of

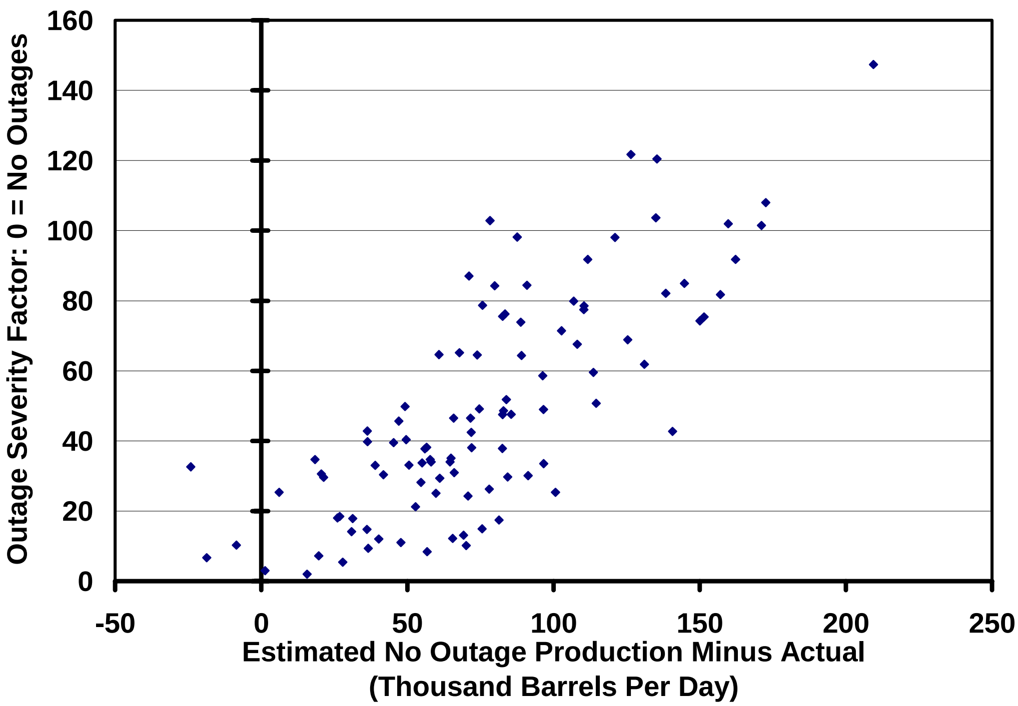
gasoline yields by months (columns) and years (rows) for the no-outage months was generated. A second matrix of crude oil plus unfinished oil inputs was also created.

2) Using the matrices created in step 1), the average yields and crude and unfinished input levels were calculated for each month of the year and for each year. From those results, the yield and input pattern across the months of the year was calculated, and any trend change over the years was identified.
3) Next, annual yield and crude and unfinished input values were estimated. These were used to generate monthly estimates of no-outage gasoline production for each year. For the yields, the annual average or a linear trend was used. For the annual input of crude oil and unfinished oils for some refineries, the annual averages were used, and in the remaining cases, the fourth highest input level for the year was used. The choices were made to get the average difference between actual and no-outage production to be near zero in no-outage months, and to eliminate any bias over the 1995-2003 time frame.
4) The no-outage gasoline production was then estimated as:

   No-Outage Production =
   Month/Year Ratio Factor for Input of Crude & Unfinished x
   Annual No-Outage Crude & Unfinished Input x
   Monthly/Annual Input factor x
   Annual Yield level for year and refinery.

A scatter plot for the aggregate outage index and the total difference of estimated no-outage gasoline production summed across the refineries is shown in Figure C-1.

Figure C-1. California Estimated Maximum Production – Actual Compared to Outage Severity Factor



Source: EIA Calculations Using Form EIA-810 data.

Appendix D. Quantitative Explanation of Gasoline Price Pass-Through

As part of EIA's study of the California motor gasoline market, an analysis was undertaken to explore the speed with which gasoline price changes pass through from spot to retail markets. This study uses industry and EIA data to analyze State and individual city markets. The results reported below utilize the analytical pass-through methodology initially developed for the motor gasoline market (as reported in *Assessment of Summer 1997 Motor Gasoline Price Increase,* (DOE/EIA-0621, May 1998)). These results can be used as the basis of a model to provide short-term forecasts of weekly retail gasoline fuel prices.

Estimates showed that the price pass-through from the spot to the retail market is complete in 7 to 9 weeks, with about 50 percent of the change occurring within 2 weeks and 80 percent within 4 weeks.

The speed of adjustment for retail prices as a function of spot prices was estimated using weekly EIA data from Form EIA-878 "Motor Gasoline Price Survey." The retail prices used included California State average price (RETCA) and the Los Angeles (RETLA) and San Francisco (RETSF) city average prices; the prices were adjusted to remove percentage-rate State and local sales and use taxes.[47] The daily spot prices used for this paper were obtained from Reuters. Weekly averages of the spot prices were calculated from the daily values (SPOTCA, SPOTLA and SPOTSF, respectively). Daily spot prices for the Pacific Northwest region were also obtained from Reuters, and the weekly average calculated (SPOTPNW).

Investigation of the time series properties of the price data was performed in order to assist in specifying the form of the forecasting model; for example, data with unit root properties are best analyzed in first differences, whereas stationary series can be estimated in level form. Unit root tests could not reject the hypothesis that the weekly retail and spot gasoline price series have a unit root; thus, first differences of all data series were used for the regression analysis. Statistical tests (using the Johansen and the Engle-Granger methodologies) indicated the presence of co-integration in most (if not all) the price series, so that error-correction terms (ECTerm) were included in all of the models. The retail prices and weekly averages of the spot prices were defined to correspond to the same week; since the retail data correspond to a Monday morning open of business price, the retail prices were estimated only as a function of lagged spot prices.

[47] This tax was removed because of its proportional impact in price, i.e., its absolute value rises as prices increase. After including local taxes, the tax becomes approximately 7.90 percent average for the State, 8.05 percent for the Los Angeles area, and 8.13 percent for the San Francisco area.

The symmetrical price response models estimated were:

Equation 1.

$$\Delta RETAIL_t = \sum_{i=1}^{k} \beta_i \ \Delta SPOT_{t-i} + D11MAR02 + ECTerm + \varepsilon_t$$

Where:

Δ	is the week to week change
$RETAIL_t$	is the (adjusted) Monday gasoline retail price for week t
$SPOT_t$	is the average gasoline spot price for week t
D11MAR02	is the dummy variable for an apparent regime change on or about March 11, 2002
ECTerm	is the Engle-Granger error-correction term
ε_t	is the random error term at time t.

Table D-1 shows the parameter estimates for the various regions using Ordinary Least Squares as the estimation method. The lag length was chosen by using the number of lags which minimized the Akaike information criterion value; this also provided parameter estimates which showed little or no change when an additional lag was added to the estimation. *A priori*, one would expect to see approximately 1:1 eventual pass-through of spot price changes and would also expect the influence of a spot price change to decrease monotonically over time after the first time period. Close examination of the estimation results show that, except for one or two isolated instances, the regression models for the various regions do display this expected behavior. The results show, depending on the regions, that anywhere between 112 and 117 percent (not statistically different from 100 percent) of the spot price change is passed through to retail within 2 months, and that lag effects decrease over time.

The cumulative price pass-through results are shown in Table D-2. This table shows the expected increase in downstream price over time resulting from a sudden 10-cent-per-gallon increase in the upstream price. Using the spot to retail pass-through for Los Angeles as an example, if the spot price increased by 10 cents per gallon during a particular week, then this would result in the retail price increasing by 5.3 cents per gallon within two weeks, 8.5 cents per gallon within 4 weeks and 10.7 cents per gallon within 6 weeks. Note that most of the retail price change occurs within the first three weeks and that all subsequent biweekly changes are much smaller.

Table D-1. Estimation Results for Retail Price Pass-through from Spot

CALIFORNIA		LOS ANGELES		SAN FRANCISCO	
Dependent Variable: D(RETCA) Sample: 6/05/2000 to 10/6/2003		Dependent Variable: D(RETLA) Sample: 6/19/2000 to 10/6/2003		Dependent Variable: D(RETSF) Sample: 6/19/2000 to 10/6/2003	
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**
DSPOTCA(-1)	0.266***	DSPOTLA(-1)	0.291***	DSPOTSF(-1)	0.138***
	(0.032)		(0.033)		(0.043)
DSPOTCA(-2)	0.221***	DSPOTLA(-2)	0.241***	DSPOTSF(-2)	0.205***
	(0.024)		(0.030)		(0.024)
DSPOTCA(-3)	0.170***	DSPOTLA(-3)	0.158***	DSPOTSF(-3)	0.153***
	(0.022)		(0.028)		(0.023)
DSPOTCA(-4)	0.155***	DSPOTLA(-4)	0.156***	DSPOTSF(-4)	0.147***
	(0.020)		(0.027)		(0.021)
DSPOTCA(-5)	0.125***	DSPOTLA(-5)	0.133***	DSPOTSF(-5)	0.117***
	(0.019)		(0.026)		(0.020)
DSPOTCA(-6)	0.078***	DSPOTLA(-6)	0.089***	DSPOTSF(-6)	0.086***
	(0.018)		(0.025)		(0.020)
DSPOTCA(-7)	0.063***	DSPOTLA(-7)	0.048*	DSPOTSF(-7)	0.048**
	(0.019)		(0.028)		(0.022)
DSPOTPNW(-1)	0.089***	D11MAR02	7.858***	DSPOTSF(-8)	0.040*
	(0.034)		(2.312)		(0.022)
D11MAR02	5.131***	EC_TERM	0.111***	DSPOTSF(-9)	0.053**
	(1.530)		(0.035)		(0.021)
EC_TERM	0.135***	AR(1)	0.534***	DSPOTLA(-1)	0.131***
	(0.037)		(0.066)		(0.040)
AR(1)	0.647***			D11MAR02	3.639*
	(0.059)				(1.870)
				EC_TERM	0.084***
					(0.027)
				AR(1)	0.458***
					(0.071)
Sum of Spot Lags	1.167	Sum of Spot Lags	1.117	Sum of Spot Lags	1.118
Adj. R^2	0.790	Adj. R^2	0.665	Adj. R^2	0.703
S.E. Regression	1.743	S.E. Regression	2.518	S.E. Regression	1.992
AIC	4.009387	AIC	4.741044	AIC	4.288291
D.W. statistic	2.03	D.W. statistic	2.05	D.W. statistic	2.03

Table D-2. Cumulative Pass-through Results Spot to Retail for a 10-cent Change in Upstream Price

Lagged Weeks	California	Los Angeles	San Francisco
1	3.55	2.91	2.69
2	5.77	5.33	4.74
4	9.02	8.46	7.74
6	11.04	10.68	9.77
8			10.65
Total	11.67	11.17	11.18
Lag Length	7	7	9

Notes: Numbers in the table are cumulative percentages.

It is important to note that these results are preliminary and subject to revision, pending additional data. It is also probable that additional regime changes occurred during this period, which were not accounted for.

Appendix E. Glossary

Alkylate: The product of an alkylation reaction. It usually refers to the high-octane product from alkylation units. Alkylate is used in blending high-octane gasoline.

Alkylation: A refining process for chemically combining isobutane with olefin hydrocarbons (for example, propylene, butylenes) through the control of temperature and pressure in the presence of an acid catalyst, usually sulfuric acid or hydrofluoric acid. The end product is alkylate, an isoparaffin, which has high octane value and is blended with motor and aviation gasoline to improve the anti-knock value of the fuel.

Aromatics: Hydrocarbons characterized by unsaturated ring structures of carbon atoms. The basic ring has six carbon atoms and is shaped like a hexagon. Heavier aromatics with two or more hexagonal rings with common sides (polycyclic aromatics) are also present in gasoline; some are formed during combustion. Some aromatics are ozone-forming; some are toxic. Benzene and polycyclics are toxic; xylenes and some of the more complex aromatics are active ozone-formers. Petroleum aromatics include benzene, toluene, and xylene.

Benzene: A hydrocarbon of the composition C_6H_6 and the initial member of the aromatic or benzene series. Its molecular structure is conceived as a ring of six carbon atoms with double linkage between each alternating pair and with hydrogen attached to each carbon atom. Benzene is a minor constituent of most crude oils and is produced mainly by the catalytic reforming of petroleum naphthas and from the various cracking processes. Benzene is a toxic compound.

CARBOB: California reformulated gasoline blendstock for oxygenate blending. This is the base mixture of gasoline components that is created at refineries and shipped to blending terminals to be blended with ethanol in order to meet California reformulated gasoline specifications. It becomes finished gasoline when the ethanol has been added.

E-CARB: Finished gasoline blended with ethanol that meets California gasoline specifications.

M-CARB: Finished gasoline blended with MTBE that meets California gasoline specifications

Nitrogen Oxides (NO_x): Chemical compounds containing nitrogen and oxygen; react with volatile organic compounds in the presence of heat and sunlight to form ozone. These compounds also contribute to acid rain.

Octane Number: A number used to indicate gasoline’s antiknock performance in motor vehicle engines. The two recognized laboratory engine test methods for determining the antiknock rating, i.e., octane rating of gasoline, are the Research method and the Motor method. To provide a single number as guidance to the consumer, the antiknock index

(R+M)/2, which is the average of the Research and Motor octane numbers, was developed.

Olefins: Olefins are highly reactive unsaturated organic compounds (that is, the carbon atoms in the molecule are able to accept additional atoms such as hydrogen or chlorine). Some are present in gasoline as a result of refinery manufacturing processes such as cracking. Some are created in the engine during combustion; most of these can be removed in the catalytic converter. They tend to be ozone-formers and toxic.

RBOB: Reformulated gasoline blendstock for oxygenate blending. This is the base mixture of gasoline components that is created at refineries and shipped to blending terminals to be blended with ethanol. It becomes finished gasoline when the ethanol has been added.

Reformate: The product of the reforming process, which runs at high temperature with a catalyst to convert paraffinic and naphthenic hydrocarbons into high-octane stocks, primarily aromatics suitable for blending into finished gasoline.

Reid Vapor Pressure (RVP): A measure of product volatility, measured in pounds per square inch (psi). The higher the RVP, the more volatile a gasoline is and the more readily it evaporates.

Volatile Organic Compounds (VOCs): Organic compounds which participate in atmospheric photochemical reactions.