United States Government Accountability Office

GAO

Report to Congressional Requesters

December 2007

ENERGY MARKETS

Increasing Globalization of Petroleum Products Markets, Tightening Refining Demand and Supply Balance, and Other Trends Have Implications for U.S. Energy Supply, Prices, and Price Volatility

GAO-08-14

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Highlights

Highlights of GAO-08-14, a report to congressional requesters

Why GAO Did This Study

To better understand how changes in domestic and international petroleum products markets have affected prices, GAO was asked to evaluate trends in (1) the international trade of petroleum products, (2) refining capacity and intensity of refining capacity use internationally and in the United States, (3) international and domestic crude oil and petroleum product inventories, and (4) domestic petroleum supply infrastructure.

To address these objectives, we reviewed numerous studies, evaluated data, and spoke to many industry officials and experts and agency officials.

What GAO Recommends

GAO is making recommendations aimed at improving the functioning of petroleum product markets, including that the Secretaries of Transportation and Energy coordinate with other agencies to (1) encourage more uniform biofuel and petroleum product blending practices, (2) conduct a study of infrastructure system adequacy, and (3) evaluate the assignment of a lead agency to coordinate permitting of infrastructure construction.

In commenting on the report, the Federal Energy Regulatory Commission generally agreed with the report's findings and recommendations, while the Departments of Energy and Transportation neither fully agreed nor disagreed.

To view the full product, including the scope and methodology, click on GAO-08-14.
For more information, contact Mark Gaffigan at (202) 512-3841, gaffiganm@gao.gov.

What GAO Found

International trade in petroleum products has expanded over the past two decades, making markets for gasoline and other petroleum products increasingly global in nature. Recent plans and mandates in the United States and other countries to greatly expand the use of biofuels blended with petroleum products—for example, ethanol blended with gasoline and biodiesel blended with petroleum diesel—may have the unintended effect of reducing opportunities for trade because blending different levels of biofuels with petroleum blending stocks will require changes to these blending stocks and thereby reduce their fungibility.

For most of the past 25 years, there has been excess refining capacity globally, but this excess has shrunk considerably in recent years as demand has increased faster than capacity growth, causing refineries to run closer to their production capacity, and contributing to recent increases in petroleum product prices, price volatility, and refining profits. However, experts say it is unclear whether or for how long the current market tightness will continue, in part because of uncertainties about how much additional refining capacity will actually be built in the face of rising construction costs and initiatives that may reduce future demand for petroleum products such as through the blending of large volumes of biofuels into the transportation fuels markets.

When measured as average days of consumption, inventories of petroleum products and crude oil in the United States indicate a general decline over the past 20 years. A number of factors have contributed to this decrease in the United States, including reductions in crude oil production and the number of refineries as well as efforts to reduce inventory holding costs by applying advances in technology. Lower operating costs associated with lower inventories may have translated into lower consumer prices during normal periods. However, lower than normal inventories can lead to higher or more volatile prices in the event of supply disruptions or surges in demand.

The nation's petroleum product supply infrastructure is constrained in key areas and is likely to become increasingly constrained, unless timely investments are made. A constrained supply infrastructure can exacerbate price effects and price volatility due to a supply disruption. However, no central source of data tracks system bottlenecks. While there is widespread recognition that a study is needed to fully identify the extent of infrastructure inadequacy and the impact on prices, to date, no such analysis has been undertaken, though such a study was mandated by Congress in 2006 with a June 2008 deadline. Significant infrastructure expansion plans in the private sector could alleviate the stresses. However, a complex permitting and siting process involving as many as 11 federal agencies and numerous state and local stakeholders has slowed or impeded the expansion and construction of new pipelines. Unlike in the case of natural gas pipelines, no central federal agency acts to coordinate this permitting process.

Contents

Abbreviations

BP	British Petroleum
DOE	Department of Energy
DOT	Department of Transportation
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FTC	Federal Trade Commission
IEA	International Energy Agency
MARAD	U.S. Maritime Administration
NYMEX	New York Mercantile Exchange
OECD	Organisation for Economic Co-operation and Development
SPR	U.S. Strategic Petroleum Reserve

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United States Government Accountability Office
Washington, DC 20548

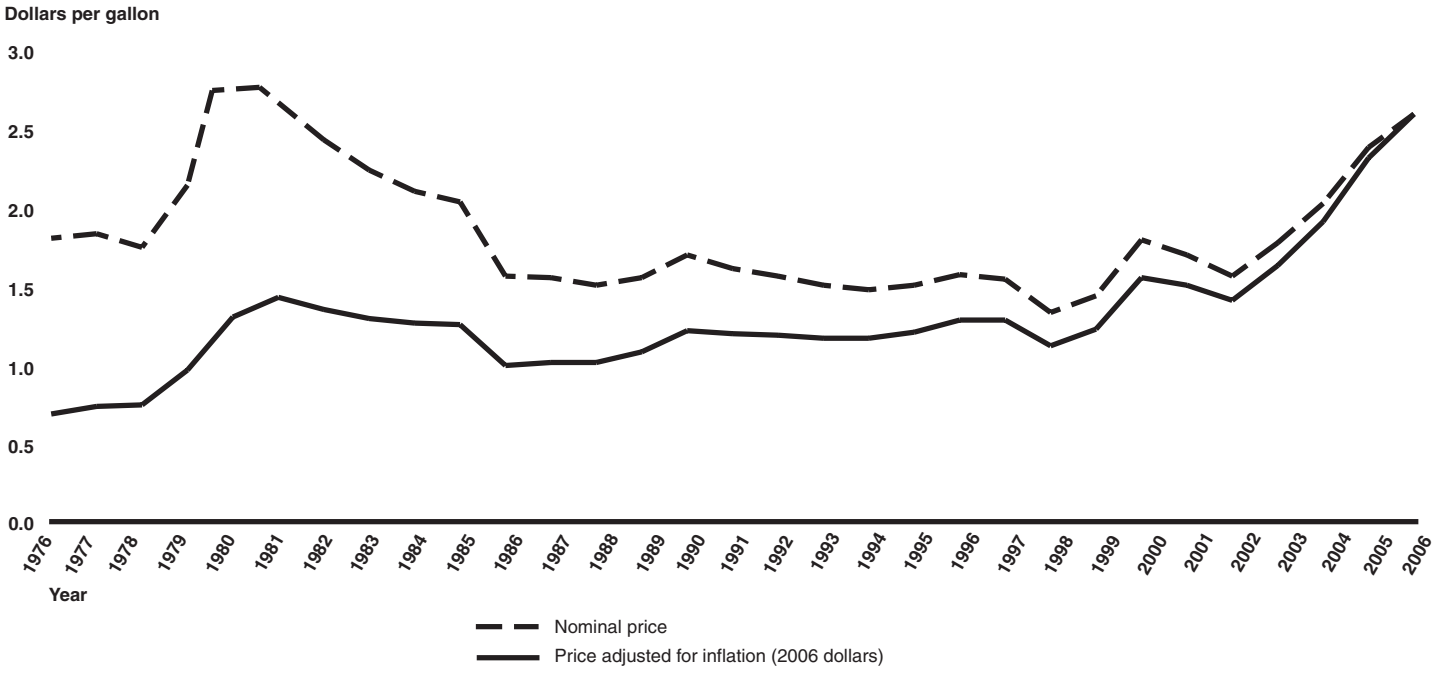
December 20, 2007

The Honorable Daniel Inouye
Chairman, Committee on
Commerce, Science, and Transportation
United States Senate

The Honorable Maria Cantwell
United States Senate

In 2003, the price of West Texas Intermediate crude oil, a widely watched benchmark crude oil price, averaged about $31 per barrel. By 2006, the average was about $66 per barrel, and in mid-November, 2007 the price rose to over $90 per barrel. Wholesale and retail prices of petroleum products refined from crude oil, including gasoline, diesel, and jet fuel, which normally rise and fall with crude oil prices, also generally rose over the period. For example, U.S. retail regular gasoline prices—equivalent to wholesale prices plus taxes, marketing costs, and retail profit margins—averaged $1.52 per gallon in 2003, but by August 2006, they had almost doubled to $3.00 per gallon, and as of July 2007, remained relatively high at $2.85 per gallon. Such large and sustained increases in gasoline prices have not been seen in the United States since the late 1970s and early 1980s, when the start of the Iran-Iraq war pushed prices up—even higher than today's prices when adjusted for inflation—causing severe economic hardship for many Americans and contributing to a global economic recession. While this more recent increase in petroleum product prices does not appear to have had such far-reaching economic effects, consumers want to know the reasons for the large and relatively sudden price increases. Figure 1 shows retail regular gasoline prices in the United States, in both nominal and inflation-adjusted terms during the past 30 years.

Figure 1: U.S. Retail Regular Unleaded Gasoline Prices, Annual Average, 1976 - 2006



Source: GAO analysis of EIA data.

In addition to crude oil prices, a number of factors affect the price of petroleum products. As we recently testified before Congress, these factors include domestic capacity to refine crude oil into petroleum products; inventories of these products; the proliferation of special blends of gasoline; the capacity and functioning of the crude oil and petroleum product supply infrastructure, which is composed of pipelines, barges, tanker vessels, marine terminals, rail, trucking and storage tanks; and mergers in the oil industry.[1] In addition, because the United States imports and exports petroleum products, events outside the United States can affect domestic petroleum product prices. Imports to or exports from the United States typically enter or leave through port facilities on tankers or across national borders via pipeline. Our imports of petroleum products

[1]GAO, *Energy Markets: Mergers and Other Factors That Influence Gasoline Prices*, GAO-07-894T (Washington, D.C.: May 23, 2007); GAO, *Energy Markets: Factors Contributing to Higher Gasoline Prices*, GAO-06-412T (Washington, D.C.: Feb. 1, 2006); GAO, *Energy Markets: Gasoline Price Trends*, GAO-05-1047T (Washington, D.C.: Sept. 21, 2005); GAO, *Motor Fuels: Understanding the Factors That Influence the Retail Price of Gasoline*, GAO-05-525SP (Washington, D.C.: May 2005).

come from all over the world into ports in the Gulf of Mexico and the east and west coasts, and by pipeline from Canada.

Refineries process crude oil into petroleum products through a variety of complicated processes, and a single barrel of crude oil produces a varying amount of gasoline, diesel, jet fuel, and other products depending on the configuration—or complexity—of the refinery as well as the type of crude oil being refined. Refineries can be optimized—or "upgraded"—to process different grades of crude oil through the addition of specialized refining equipment. U.S. refineries are generally optimized to produce large proportions of gasoline to meet domestic transportation demand. Cleaner-burning fuels have proliferated in response to legislation including the Clean Air Act Amendments of 1990, leading to additional investments in the refining equipment needed to produce the new fuels.

More recently, a number of European countries, the U.S. federal government, and a number of individual states and localities have proposed or mandated the use of biofuels—such as ethanol made from corn or biodiesel made from soybeans or other crops—partly in an effort to reduce greenhouse gas emissions and reduce consumption of petroleum products. These mandates call for biofuels to be blended in varying proportions with traditional gasoline or diesel. For example, U.S. federal biofuel standards call for a minimum proportion and volume of biofuels to be sold each year but do not specify how that proportion is met. In addition, a number of states and at least one city have requirements or plans to require use of biofuels in varying proportions, blended with gasoline and diesel. For example:

- Hawaii, Minnesota, and the city of Portland, Oregon, all currently require ethanol to be blended at a 10 percent by volume rate with gasoline, although Hawaii only requires this for 85 percent of the gasoline sold in the state.

- Minnesota and Portland, Oregon require 2 and 5 percent biodiesel, respectively, to be blended with diesel fuel. Minnesota also requires the expansion of ethanol blending to 20 percent by volume by 2013.

- Four other states—Missouri, Montana, New Mexico, and Oregon—have biofuel mandates that will require 10 percent ethanol blended into gasoline and/or varying blends of biodiesel: Missouri and Montana have no mandated plans for biodiesel; New Mexico calls for 5 percent biodiesel blending and Oregon for 2 percent.

- Other states have "flexible standards." For example, Iowa provides tax credits if at least 10 percent of the fuels used by 2009 are renewable, with the threshold rising to 23 percent in 2018. Yet this can be achieved in a flexible way, using a blend consisting of 85 percent ethanol and 15 percent gasoline, while other gasoline would be blended with less or no ethanol at all. Louisiana will require both ethanol and biodiesel to be blended at 2 percent, but only when state production reaches certain levels and prices of ethanol and biodiesel are sufficiently low. Finally, Washington will require that at least 2 percent of diesel sold be biodiesel by November 30, 2008, or when a determination is made that state biodiesel production can meet the 2 percent requirement.

  Automakers and refiners told us that these varying biofuel blends will require changes to the gasoline and diesel blendstocks—the fuels that will be mixed with the ethanol or biodiesel—to maintain engine performance and emissions requirements. The production of these new blends may also require further refinery changes as well as changes to automobile engines. Automakers also told us that in addition to increasing the costs of production, changing engines to be able to meet performance and emissions standards using a wide mix of biofuel blends would also entail potential losses in fuel efficiency.

  From refineries, petroleum products are distributed through an extensive supply infrastructure composed of pipelines, barges, tanker vessels, marine terminals, rail roads, trucks, and storage tanks. Pipelines are generally the cheapest domestic mode for transporting crude oil and petroleum products. Crude oil and petroleum products are transported in separate pipelines, and while different types and specifications of petroleum products are shipped in the same pipelines, they must be kept separate during transport and storage in order to maintain the specific desirable performance and emissions characteristics of these different fuels. Crude oil pipelines connect several large refining centers to crude oil sources, and petroleum product pipelines connect these refineries to population centers all over the country. Trucks and rail have generally distributed only a small fraction of petroleum products to wholesale terminals. However, they are being increasingly utilized to move ethanol to locations near final demand centers where the ethanol is blended with gasoline. This is because existing pipelines cannot currently accommodate ethanol due to an insufficient collector pipeline network linking ethanol refineries with major pipelines, and because ethanol has corrosive and other properties that complicate its transport in pipelines that also carry petroleum products.

Refiners, distributors, and marketers of petroleum products maintain inventories of crude oil and petroleum products to facilitate smooth supply operations and mitigate the effects of supply disruptions. Crude oil and petroleum product inventories consist of three levels. Primary inventories comprise the crude oil or petroleum products held at production sites, refineries, and storage terminals, and in pipelines, tankers, barges, and other transportation centers. Secondary inventories consist of retail outlets and small storage facilities—those with less than 50,000 barrels of total capacity—that exist between the primary distribution system and the end user. Tertiary inventories are the petroleum products in the hands of end users, for example, in drivers' gasoline tanks. The federal government also maintains strategic stocks of crude oil and, in the Northeast, heating oil to be released in the event of a major supply shortage. The Energy Information Administration (EIA) collects inventory data for the primary system. Information about changes in inventory levels can inform market participants about underlying demand or supply conditions that will influence prices.

A number of federal agencies have programs and activities related to the oversight or monitoring of the refining, distribution, or importing of petroleum and petroleum products. For example, the Department of Transportation (DOT) oversees crude oil and petroleum product pipelines and monitors their operations to ensure public safety. The Federal Energy Regulatory Commission (FERC) regulates the "tariffs"—or rates and conditions—under which interstate crude oil and petroleum product pipelines operate, while individual states have oversight over intrastate pipelines within their borders. EIA collects data from refiners and others about shipments of crude oil and petroleum products by pipeline and barge between regions of the United States. In addition, a number of federal and state agencies and other local and private entities become involved in approving new supply infrastructure projects. For example, the approval to build or repair a pipeline could involve DOT's Pipeline and Hazardous Materials Safety Administration, the Environmental Protection Agency, Bureau of Land Management (if pipelines cross federal lands), Army Corps of Engineers, U.S. Fish and Wildlife Service, as well as other federal agencies, and state and local stakeholders. Legislation in 2002 mandated the formation of an interagency committee to help expedite pipeline review and permitting processes for pipeline repairs. That committee is composed of 11 federal entities. For construction of interstate natural gas pipelines, the Federal Energy Regulatory Commission takes a lead role in coordinating the permitting process across the relevant federal agencies and can convey the right of eminent domain to builders of natural gas pipelines to resolve disputes with

owners of land needed to build a pipeline.[2] However, no such federal coordinating authority or power of eminent domain exists for construction and expansion of new interstate petroleum product or crude oil pipelines.

To better understand changes in domestic and international markets for petroleum products and the implications of these changes for recent price increases, you asked us to evaluate trends and effects on petroleum product prices in (1) international trade of petroleum products; (2) refining capacity and intensity of refining capacity use internationally and in the United States; (3) international and domestic crude oil and petroleum product inventories; and (4) domestic crude oil and petroleum product supply infrastructure, particularly pipelines and marine transportation.

To evaluate trends in the international trade of crude oil and petroleum products, we analyzed data from EIA and the International Energy Association (IEA) and spoke with numerous government agency and oil company officials and industry experts. To assess trends in refining capacity, we evaluated IEA, EIA, and *Oil and Gas Journal* data, and spoke with numerous industry experts. To evaluate trends in inventories of crude oil and petroleum products, we reviewed data from EIA and IEA on inventories and demand to analyze international, U.S. national, and regional inventories. We analyzed New York Mercantile Exchange (NYMEX) and other futures market data, as well as EIA data, and asked experts about the effects of these futures prices for crude oil on inventory holding decisions. To evaluate trends in supply infrastructure for crude oil and petroleum products, we collected and analyzed available data on the pipeline and marine infrastructure system, capacity, throughputs, and constraints. We examined reports and data from supply disruption case studies to examine those cases' impact on prices and price volatility. We spoke with numerous government agency and pipeline company officials and industry experts. This report focuses on long-term trends in the industry, rather than recent events that have influenced prices of gasoline and other petroleum products. GAO currently has ongoing work looking at such recent trends as refinery outages through the spring of 2007 and mergers in the industry since 2000.

[2]FERC also serves as the lead agency in coordinating the permitting process across federal agencies and can similarly convey the right of eminent domain for electricity transmission lines.

This report uses data from domestic and international wholesale petroleum products and crude oil markets and domestic retail markets. In contrast to retail prices, wholesale prices do not include taxes, distribution and marketing expenses, and profits. In every case for the data used in this report, we assessed and determined that the data were sufficiently reliable for our purposes. A more detailed description of the scope and methodology of our review is presented in appendix I. We performed our work from August 2006 through September 2007 in accordance with generally accepted government auditing standards.

Results in Brief

International trade in petroleum products has expanded significantly over the past two decades, making markets for gasoline and other petroleum products increasingly global in nature. This trend has been particularly important for the United States; while in 1970 the United States was largely self-sufficient in gasoline, we now import over 10 percent of our annual gasoline consumption. Having access to more sources of supply can benefit the United States in the event of domestic supply disruptions. For example, the benefit of such flexibility in sources of supply helped U.S. marketers and retail sellers obtain gasoline and other petroleum products in the aftermath of Hurricanes Katrina and Rita, when imports of gasoline to the United States increased to fill the void left by damaged or shut-down domestic refineries and pipelines. However, the fact that petroleum product markets are international means that supply disruptions or unexpected increases in demand anywhere in the world can influence U.S. prices. Our analysis of wholesale prices in the United States, Europe, and Asia shows that prices in geographically dispersed markets rose significantly following Hurricanes Katrina and Rita, indicating that prices in these markets are linked to some extent. We also evaluated petroleum product import data and found that products came from a wider range of countries during this period, again indicating that products move in response to price signals globally. Recent plans and mandates in the United States and other countries to greatly expand the use of biofuels blended with petroleum products—for example, ethanol blended with gasoline and biodiesel blended with petroleum diesel—may have the unintended effect of reducing opportunities for trade because blending different levels of biofuels with petroleum blending stocks will require changes to these blending stocks and thereby reduce their fungibility. For example, if European countries adopt widely different blending levels biofuels in gasoline and diesel products as current plans call for, the refineries serving these countries will have to alter petroleum blending stocks for those blending levels, and this could make the blending stocks themselves less tradable across countries.

For most of the past 25 years, there has been excess refining capacity globally, but this excess capacity has shrunk considerably in recent years as demand has increased faster than capacity growth, causing refineries to run closer to their production capacity, and, along with rising crude oil prices, contributing to recent increases in petroleum product prices and price volatility. Demand for petroleum products has grown more quickly than has refinery capacity for much of the past 25 years, in large part because excess refining capacity historically caused profitability of the refining sector to be low compared to that of many other industries. More recently, this tightening of the balance between supply and demand for petroleum products has, along with higher crude oil prices and other factors, contributed to increased petroleum product prices and higher oil industry profits, and could contribute to greater price volatility. Recently high petroleum product prices and increased profits over those seen during the 1990s in the refining industry have spurred new refinery capacity investments in the United States and internationally. However, experts say it is unclear whether or for how long the current market tightness will continue, in part because of uncertainties about how much additional refining capacity will actually be built in the face of rising construction costs, and initiatives that may reduce future demand for petroleum products such as through the blending of large volumes of biofuels into the transportation fuels markets in many countries. The absence of national standards for blending biofuels with gasoline and diesel could also increase the number of gasoline and diesel blending stocks refiners have to make, which could require additional refining investment to make those blends that could crowd out investment in refining capacity expansions.

When measured as average days of consumption, long-term trends in inventories of petroleum products and crude oil in the United States indicate a general decline over the past 20 years. Similarly, gasoline and crude oil inventories in the Organisation for Economic Co-operation and Development (OECD) countries, excluding the United States, have also generally fallen over the same period.[3] Inventories, as measured by EIA

[3]The Organisation for Economic Co-operation and Development is a group of 30 countries committed to democracy and the market economy to support sustainable economic growth, maintain financial stability, and assist other countries' economic development. These countries are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States. However, we consider the United States separately for the purposes of this report.

IEA, and others, have some limitations as a measure of what is available to meet demand in the event of a supply shortfall, in part because the United States has imported an increasing share of its gasoline over the period during which inventories have fallen, and as such, the domestic inventory data do not account for large volumes of these products on the water or in tankers from foreign sources that are destined for the U.S. market or in storage terminals at foreign ports serving this trade in gasoline. A number of factors have contributed to the long-term decrease in inventory holdings in the United States, including reductions in both domestic crude oil production and the number of refineries. Advances in technology and changes in management processes also may have contributed to reduced inventories by enabling refiners to more closely time the production of supplies to meet expected demand. Lower operating costs associated with lower inventories may have translated into lower consumer prices during normal periods. However, in the short term, because inventories provide a smoothing effect against temporary demand and supply fluctuations, lower than normal inventories can lead to higher or more volatile prices in the event of supply disruptions or surges in demand.

The nation's petroleum product supply infrastructure is constrained in key areas and is likely to become increasingly constrained, unless timely investments are made. Industry and federal agency officials report a systemic lack of pipeline capacity in the supply infrastructure system in key states including Arizona, California, Colorado, and Nevada, and note the existing supply infrastructure is insufficient to carry the commensurate volumes of petroleum products and crude oil needed to meet growing demand there. A constrained supply infrastructure can exacerbate price effects and price volatility due to a supply disruption. For example, during a pipeline outage in 2003 that affected pipeline supplies to Arizona, retail prices of gasoline rose by about 45 cents per gallon. However, we were unable to assess the full extent of supply infrastructure constraints or the impacts of these constraints on prices and price volatility, in large part because there is no central source of data that tracks system bottlenecks. In 2006, DOT put forth a legislative proposal and Congress passed legislation that mandated the Secretaries of Energy and Transportation to conduct periodic analyses of (1) where unplanned petroleum product pipeline outages or insufficient pipeline capacity increase prices and (2) whether or not regulation is adequate to minimize the potential for unplanned losses of pipeline capacity. While there is widespread recognition that such a study is needed to fully identify the extent of infrastructure inadequacy and the impact on prices, to date, no such analysis has been undertaken. DOT and Department of Energy (DOE) officials told us that they were not allocated funds specifically to do the

mandated analyses and that the agencies have not re-allocated other funds for this, although DOE told us it has met with DOT to discuss how this work could be approached. However, given that the study has not begun, it seems highly unlikely that agencies will be able to meet their June 2008 deadline for reporting to Congress. There are many private sector plans to expand the supply infrastructure, and if implemented in a timely fashion, these plans could significantly alleviate the stresses on the system. However, a complex permitting and siting process involving as many as 11 federal agencies and numerous state and local stakeholders has slowed or impeded the expansion and construction of new pipelines. The permitting process for building natural gas pipeline infrastructure has been made easier by the designation of FERC as a lead federal agency to streamline permitting for interstate natural gas pipeline expansion, but no such lead federal agency exists to facilitate permitting of crude oil or petroleum product pipeline construction or upgrading.

GAO is making recommendations aimed at improving the functioning of petroleum product markets, including that the Secretaries of Transportation and Energy coordinate with other relevant agencies to (1) encourage uniform biofuel and petroleum product blending practices, (2) conduct a study of infrastructure system adequacy, and (3) evaluate the feasibility of assigning a lead federal agency to coordinate the permitting of infrastructure construction. In commenting on the report, the Federal Energy Regulatory Commission generally agreed with the report's findings and recommendations, while the Departments of Energy and Transportation neither fully agreed nor disagreed.

Background

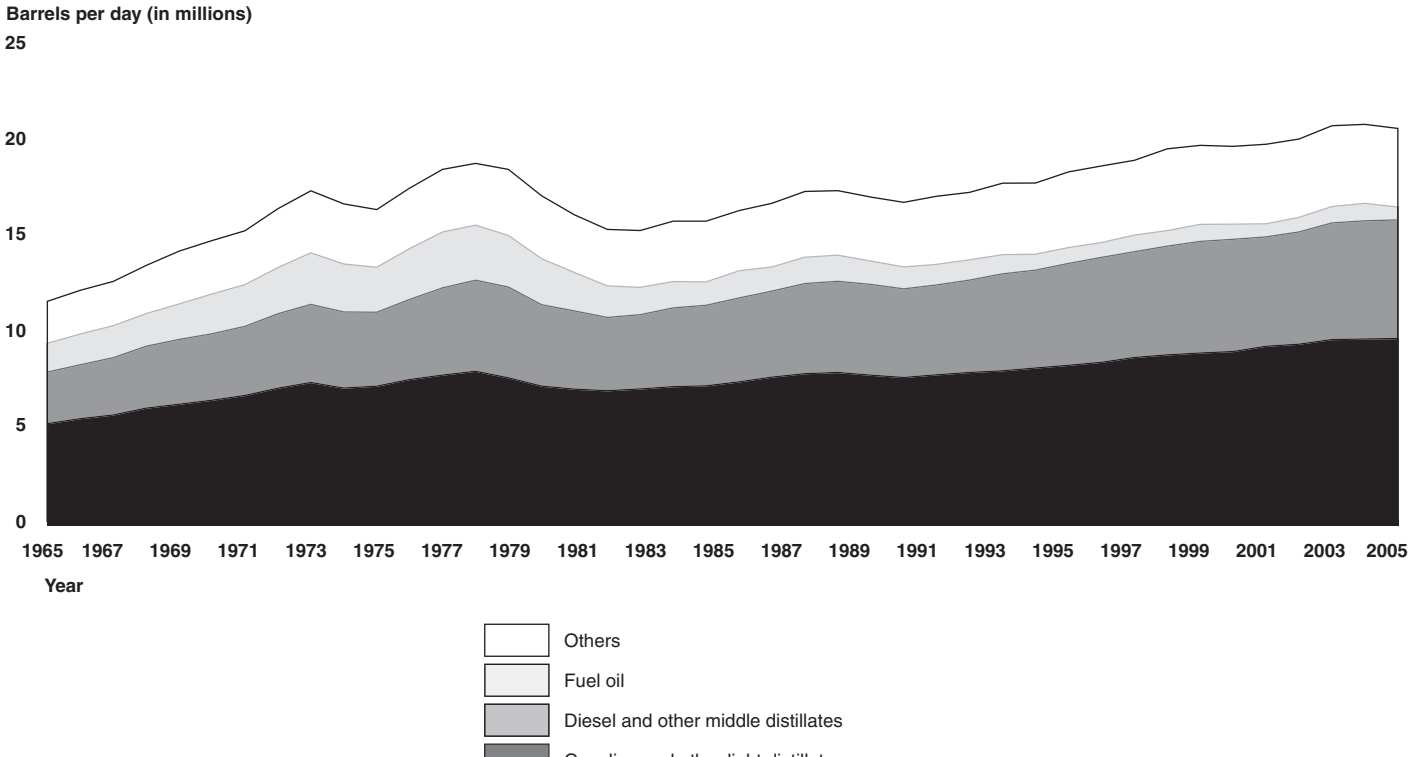
The United States is the largest consumer of crude oil and petroleum products of all nations, though demand for crude oil is growing faster globally, led by growth in developing countries such as China and India. When processed, crude oil is refined to produce petroleum products such as gasoline, diesel, and jet fuel, which have been instrumental in providing the nation with affordable fuel for automobiles, trucks, airplanes, and other forms of transportation and heating in some parts of the country. The petroleum industry consists of three main segments: the exploration and production segment (upstream); the refining and marketing segment (downstream); and a third segment typically referred to as the midstream, which consists of the infrastructure used to transport crude oil and petroleum products. Several U.S. agencies regulate and monitor the downstream and midstream oil industry and petroleum product markets.

The United States Is the Largest Consumer of Crude Oil and Petroleum Products, but Global Demand Has Grown Significantly in Recent Years

While the United States is the largest consumer of crude oil and petroleum products, global demand for crude oil and petroleum products is growing at a faster pace than U.S. demand, driven by growing consumption of crude oil and certain petroleum products in developing countries such as China and India. In 2006, the United States' share of world oil consumption was approximately 25 percent. The EIA projects in its reference, or "baseline," scenario that world oil consumption will continue to grow and will reach 118 million barrels per day in 2030. About 43 percent of this growth will come from non-OECD countries, particularly China and India, but the United States will remain the world's largest consumer. Under the assumptions of EIA's reference case scenario, U.S. demand for oil is projected to increase by 30 percent between 2005 and 2030—from about 21 million barrels per day in 2005 to about 27 million barrels per day in 2030—compared to 39 percent for the entire world. Meanwhile, domestic production of oil has generally been in decline for decades, leading to greater reliance on imported oil. In 2006, the United States imported about 66 percent of its crude oil.

When processed, crude oil produces petroleum products such as gasoline, diesel, and jet fuel, which have been instrumental in providing the nation with affordable fuel for automobiles, trucks, airplanes, and other forms of transportation, and—in some parts of the country—heating. Overall, demand for petroleum products in the United States has generally increased over the last 25 years, as shown in figure 2.

Figure 2: U.S. Consumption of Petroleum Products, 1965-2006



Source: GAO analysis of BP Statistical Review of World Energy June 2007.

Notes:

Other light distillates consists of aviation gasoline and light distillate feedstock (LDF)

Other middle distillates consists of jet and heating kerosene, and gas and diesel oils (including marine bunkers)

Fuel oil includes marine bunkers and crude oil used directly as fuel

Others consists of refinery gas, liquid petroleum gas, solvents, petroleum coke, lubricants, bitumen, wax, and other petroleum products and refinery fuel and loss

Key Aspects of the Petroleum Product Markets: Refining, Inventories, and Infrastructure

The petroleum industry consists of three main segments: the exploration and production segment (upstream); the refining and marketing segment (downstream); and a third segment typically referred to as the midstream, which consists of the infrastructure used to transport crude oil and petroleum products. This report is mainly concerned with certain aspects of the downstream and midstream segments, namely refining, inventories, and the pipeline and marine supply infrastructure.

Refining

Refineries change crude oil into petroleum products primarily through a distillation process that separates the crude oil into different fractions based on boiling point ranges. One barrel of crude oil produces a varying amount of gasoline, diesel, jet fuel, and other petroleum products depending on the configuration–or complexity–of the refinery and the type of crude oil that is being refined. Through the addition of specialized equipment, refineries can be optimized—or "upgraded"—to produce greater proportions of specific types of products or to use different grades of crude oil. For example, hydrocracking units enable refiners to increase the production of lighter fuels including gasoline, diesel fuel, and jet fuel; catalytic cracking units increase the production of gasoline; and hydrotreating units enable refiners to produce lower-sulfur fuels required by the European Union, United States, and many other countries. Changes in product specifications, shifts in demand, and environmental regulations all have important implications for refineries. For example, the regulated shift to unleaded gasoline that began in 1974 caused refineries to install equipment to produce high-octane components to replace the lost lead. Similarly, in response to environmental regulations such as limits on the emissions of certain air pollutants refineries have invested in equipment and processes to control such emissions. The proliferation of some special gasoline blends, or "boutique fuels," has made it more complicated to supply gasoline and raised costs, significantly affecting operations at refineries.[4] Last, to the extent that varying amounts of biofuels blended with gasoline and diesel require changes to the gasoline and fuel blendstocks, further refinery changes may be required to accommodate these blends. Shifting demand for petroleum products, such as Europe's declining demand for gasoline and growing consumption of diesel, can also cause refiners to invest in different processes to produce the mix of products desired by the market.

In general, the United States' refineries are among the most sophisticated in the world, and domestic refineries have generally been optimized to produce large proportions of cleaner-burning gasoline to meet the huge transportation demand subject to various environmental constraints. Historically, U.S. and international refining capacity has broadly grown

[4]GAO, *Gasoline Markets: Special Gasoline Blends Reduce Emissions and Improve Air Quality, but Complicate Supply and Contribute to Higher Prices*, GAO-05-421 (Washington, D.C.: June 2005).

and fallen in response to shifts in demand for petroleum products. For example, U.S. and international refining capacity fell sharply during the early 1980s in response to falling demand for petroleum products, caused in part by high prices of these products and worldwide recession. By 1983, demand had fallen so much that almost 30 percent of U.S. refinery capacity was not being used. Many refineries were shut down or idled and refining capacity thus fell. Demand began growing again in the United States and internationally around 1982.

Inventories

Inventories of petroleum products and crude oil are maintained by refiners, distributors, marketers, and others to mitigate the effects of disruptions, and to ensure a continuity of supply to their customers. Companies build inventories in preparation for planned maintenance and production, refining, and logistical systems. The primary inventory system comprises the crude oil or petroleum products held at production sites, refineries, and storage sites, and in pipelines, tankers, barges, and other transportation centers. Secondary inventories exist between the primary distribution system and the end user, and consist of retail outlets and small tank farms, which have less than 50,000 barrels of total capacity. Tertiary inventories are inventories held by consumers, for example, in automobile tanks. EIA collects inventory data for the primary system. EIA collects inventory data for crude oil and petroleum products held in storage at refineries, pipelines, and tank farms, and bulk terminals that can store at least 50,000 barrels of petroleum products. EIA also collects inventory data for Alaskan crude oil in transit by tanker from the terminus of the Alaskan pipeline in Valdez, Alaska, to other U.S. ports, as well as oil in the Strategic Petroleum Reserve.[5]

Pipeline and Marine Supply Infrastructure System

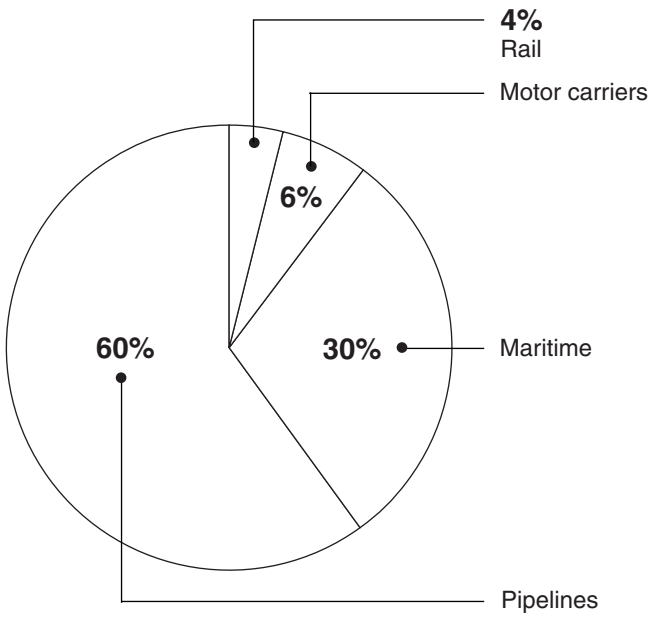
The supply infrastructure is composed of petroleum product and crude oil pipelines, barges, vessels, marine terminals, and storage tanks. Trucks and rail also distribute a small fraction of the products—about 6 and 4 percent respectively—but are being increasingly utilized with the rise of biofuels such as ethanol, which existing pipelines cannot currently accommodate.[6]

[5]The Strategic Petroleum Reserve (SPR) is a federally maintained stockpile of about 700 million barrels of light crude oil for use in the case of a major disruption of oil supplies.

[6]Access to the rail market is limited and tanker trucks' expenses depend on distances traveled.

As displayed in figure 3, about 90 percent of all petroleum products currently travel by either pipeline or marine transport. Because of these two modes dominance, our analysis of the nation's supply infrastructure system will be limited to the pipeline and the marine transport system.

Figure 3: Transport Mode of Petroleum Products in the United States, 2004



Source: GAO analysis of Bureau of Transportation Statistics data.

Pipelines are generally the least expensive mode for transporting oil and most petroleum products.[7] Most of the United States pipeline infrastructure—approximately 166,000 miles of crude oil and petroleum product pipeline—was constructed in the 1950s, 1960s and 1970s to accommodate the needs of the refining sector and demand centers at that time. These main pipelines were built to transport petroleum products from the Gulf Coast and Midwestern oil fields—where many of the nation's refineries were—to the East Coast, the United States' largest consuming region. The first large transmission pipelines for petroleum products were constructed during World War II, and ran primarily from

[7]By petroleum products, we refer to primarily gasoline, diesel, jet fuel, heating oil. Most petroleum products and crude oil are shipped primarily by pipeline within the United States. Imports of petroleum products and crude oil, however, travel to the United States mainly over sea by vessel.

the Gulf Coast to the Mid-Atlantic states; the network expanded significantly until the 1970s. Pipelines feed refinery centers and market hubs because the regions with the most supply are not the regions with the most demand. Most pipelines are common carriers, offering transportation services to anyone who wants them, but subject to some regulations. While crude oil and petroleum products generally do not travel on the same pipelines, numerous different petroleum products are shipped back to back in batches through the same pipelines. During this process, some blending of any two adjacent batches of petroleum products occurs where the two batches interface. This blended material may be simply mixed with the lower-valued product—for example, the mix of high- and low-octane gasoline at the interface between batches of these commodities would be downgraded, or mixed with the low-octane fuel—or, if the blended material is incompatible with either of the two petroleum products that interfaced, it must be removed and reprocessed into something that can be used. To access space on a pipeline, a shipper must ask for the right to use capacity by nominating amounts of liquid for service to be received, delivered or stored by the pipeline company. Different shippers' nominations of common products are often combined by the pipeline in order to reduce the number of batches and therefore the amount of downgrading or reprocessing of blended products.

Marine transportation of crude oil and petroleum products accounts for nearly one-third of domestic shipments. The marine transport system consists primarily of waterways; ports and vessels, including crude oil tankers; and product tankers and tank barges. Built to accommodate smaller vessels, many of the major ports have had to expand in response to increasing marine transport and trade and to accommodate larger tanker vessels.

Several U.S. Agencies Regulate and Monitor the Downstream and Midstream Oil Industry and Petroleum Product Markets

Several U.S. agencies have jurisdiction over or monitor the U.S. downstream oil industry and petroleum product markets:

- Within DOE, EIA collects and analyzes data on the supply, consumption, and prices of crude oil and petroleum products, including inventory levels, refining capacity and utilization rates, and product movements into and within the United States. DOE's Office of Fossil Energy manages the U.S. Strategic Petroleum Reserve (SPR), which is a federally maintained stockpile of about 700 million barrels of crude for use in the case of a major disruption of oil supplies, as well as the Northeast Home Heating Oil Reserve, a component of the SPR that has 2 million barrels of emergency fuel oil for homes and businesses in the Northeast that could be released

during heating oil supply interruptions or high periods of demand caused by severe winter weather.

- FERC is an independent agency that regulates the transmission of oil through interstate pipelines by setting and enforcing pipeline "tariffs"—the prices and terms under which shippers send their products through the pipelines and the rules governing access to these pipelines.[8]

- The Federal Trade Commission (FTC) enforces antitrust and consumer protection statutes. For example, in the petroleum industry, the FTC generally reviews proposed mergers and approves such mergers only if they are deemed not to have anticompetitive effects.

- DOT's Pipeline and Hazardous Materials Safety Administration regulates safety for oil pipelines that transport oil and petroleum products. Among other things, it oversees oil pipelines' design, maintenance, and operating procedures. DOT's Maritime Administration (MARAD) reports to Congress on the status of public ports' supply infrastructure needs.

- The Environmental Protection Agency (EPA) develops and enforces regulations that implement environmental laws including the Clean Air Act, the Clean Water Act, and the Oil Pollution Act, which aim to control the discharge of pollutants into the environment by refiners and other industries. EPA also administers the National Environmental Policy Act, which requires federal agencies to consider environmental impacts of proposed actions.

In addition, individual foreign countries play regulatory roles and can affect trade conditions for products through their individual or collective actions. The IEA is an organization established by treaty of 26 mainly net oil-importing OECD countries to cope with oil supply disruptions and coordinate an international response in the case of a disruption to the global oil supply. Member countries agree to keep significant strategic stocks of crude oil and/or petroleum products to be available in the event of a severe supply disruption. IEA also maintains a database that provides information on IEA member crude oil and petroleum product inventory levels, refining capacity, and utilization rates.

[8]FERC also collects administrative, financial, and operational information on crude oil and petroleum product pipeline companies.

Petroleum Products Markets Have Become Increasingly Global with Greater Trade and Prices Increasingly Linked across Countries

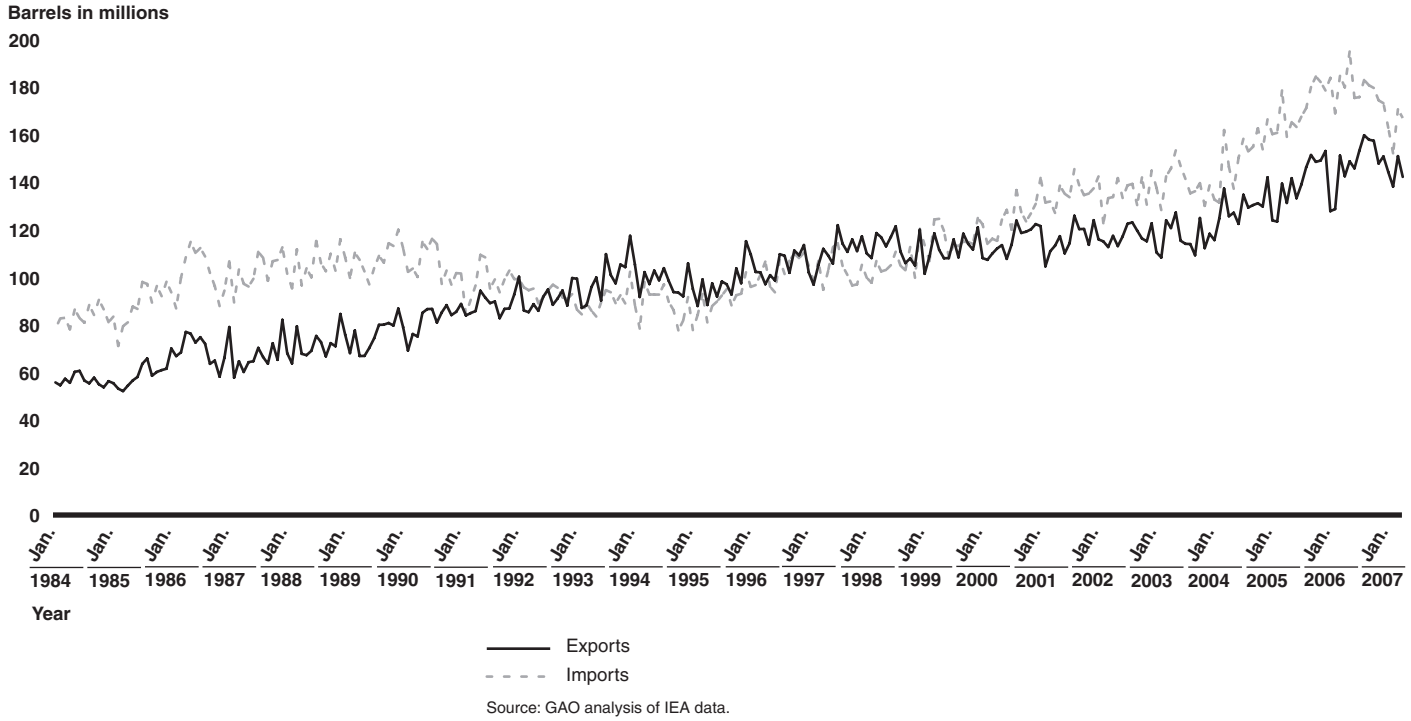
International trade in petroleum products has expanded significantly over the past 20 years, making the markets for gasoline, diesel, and jet fuel increasingly global in nature, and providing additional gasoline supply options for the United States. This trend has been particularly important for the United States, which has seen large increases in the volume of imported gasoline. A key impetus for global trade in petroleum products has been a structural surplus in production of gasoline and deficit in production of diesel in Europe as a result of a systematic switch in European countries to diesel-burning automobiles. While many experts we spoke with believe that growth in international trade of petroleum products will likely continue, they identified several factors that may limit or change the patterns of trade, including plans and mandates to introduce significant volumes of biofuels and the potential expansion of differing fuel specifications that a proliferation of biofuel blends would entail.

International Trade in Petroleum Products Has Expanded Significantly

International trade in petroleum products has expanded significantly over the past 20 years, making the markets for gasoline, diesel, and jet fuel increasingly global in nature. Specifically, our analysis of IEA data shows that OECD imports of gasoline, diesel, and jet fuel more than doubled between 1984 and 2006, from about 80 million barrels per month to over 160 million barrels per month. Similarly, OECD exports increased from about 55 million to over 140 million barrels per month over the same time period. While OECD exports and imports in these products have more than doubled, OECD demand for these products rose by less than 40 percent during the same time period. Figure 4 shows the increase in OECD imports and exports of gasoline, kerosene-type jet fuel, and diesel fuel.[9]

[9]Figures represent trade originating or ending in OECD member nations, including trade between OECD nations, from OECD nations to non-OECD nations, and from non-OECD nations to OECD nations. Because figures include some trade from OECD nations to other OECD nations, such trade is counted as both an import and an export and therefore includes some duplication of counting. Furthermore, figures do not account for trade between non-OECD nations and therefore understate the total global trade of these products.

Figure 4: Imports and Exports of Gasoline, Kerosene-type Jet Fuel, and Diesel Fuel for All OECD Countries, 1984 - 2007



Source: GAO analysis of IEA data.

Trade in gasoline has been particularly important for the United States, which has seen large increases in the volume of imported gasoline. While in 1970 the United States was largely self-sufficient in gasoline, we now import over 10 percent of our annual consumption of gasoline and smaller percentages of jet fuel and some other products.[10] U.S. imports of gasoline and gasoline blending components, which accounted for about 31 percent of our imports of refined petroleum products in 2005, averaged about 1.1 million barrels per day, or more than 10 percent of U.S. daily consumption. According to DOE, imports have supplied about half of U.S. gasoline demand growth from 1993 to 2005.[11] These "total gasoline" imports include finished gasoline, which can be sold directly to retail markets, as well as gasoline blending components that are combined in the United States to

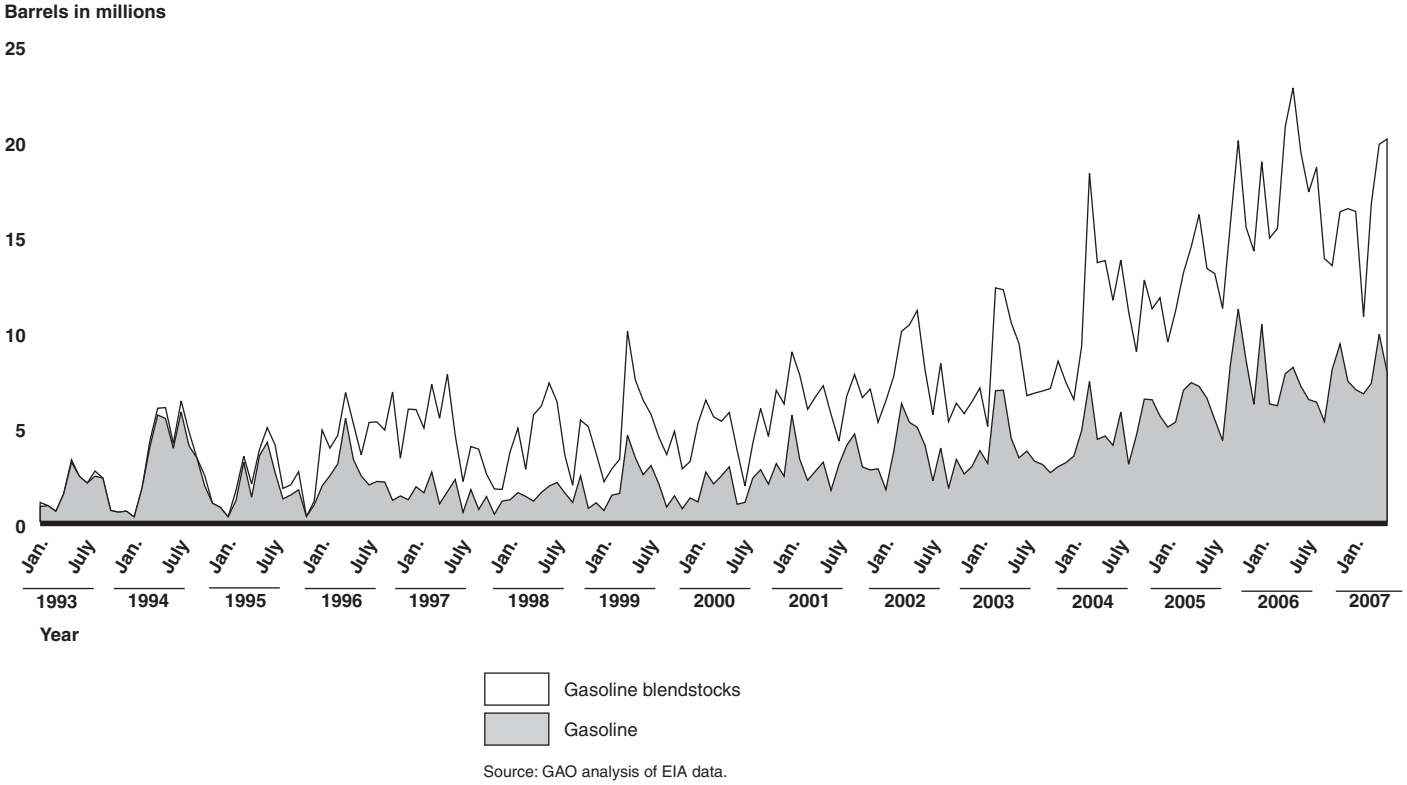
[10]Total gasoline includes both finished motor gasoline and motor gasoline blending components.

[11]Imports of distillate fuels and jet fuel have also risen in the last 20 years, while imports of residual fuel oil have declined.

make finished gasoline to serve various markets, some of which use special, cleaner-burning gasoline blends as part of their plans to meet federal air quality requirements.

A key impetus for global trade in petroleum products has been a structural surplus in production of gasoline and a deficit in production of diesel in Europe. This surplus of gasoline is largely the result of a systematic switch in European countries toward automobiles with diesel-powered engines, which are more efficient than gasoline-powered engines. European regulators promoted diesel fuel use in Europe by taxing diesel at a lower rate, and European demand for diesel fuel-powered vehicles rose. The European refining and marketing sector responded to this change in demand by importing increasing amounts of diesel, and exporting a growing surplus of gasoline to the United States. The United States has purchased increasing amounts of gasoline, including gasoline blendstocks, from Europe in recent years, as shown in figure 5. These imports have generally had a strong seasonal component, with higher levels of imports during the peak summer driving months and lower imports during the fall and winter. The major exception to this seasonality came in the months October 2005 through January 2006, when imports surged in response to U.S. shortfalls as a result of damage to and shutdowns of refineries and pipelines following Hurricanes Katrina and Rita in August and September 2005, respectively.

Figure 5, U.S. Imports of European Gasoline and Gasoline Blendstocks, 1993 - 2007



Source: GAO analysis of EIA data.

Experts and company representatives told us they believe this structural imbalance within the European Union will continue for the foreseeable future, and perhaps widen, resulting in more exports of European gasoline and blending components to the United States. Specifically, company representatives and industry experts told us that European refiners are unlikely to significantly expand their refining capacity in the near future or reconfigure to produce less gasoline for a number of reasons, including the following:

- The profitability of the U.S. gasoline market acts as a draw for surplus gasoline worldwide. Many company representatives told us that the United States' continued appetite for gasoline—combined with many countries' declining demand—has resulted in most surplus gasoline being exported to the United States, and that this trend would likely continue in the future. For example, some refining interests in Europe told us they had configured their refinery operations to be essentially a U.S. "gasoline machine."

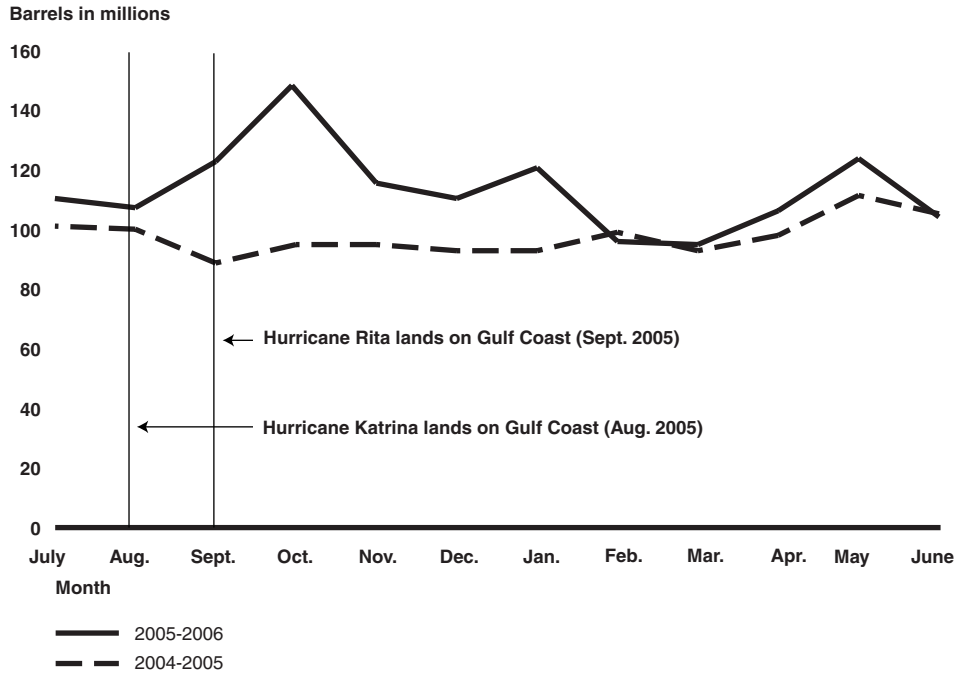
- Construction costs have increased significantly, raising the cost of investments in refining capacity or upgrades. For example, some refining interests in Europe and elsewhere told us that some planned conversion and upgrading of refinery capacity in Europe was on hold, because of increased construction costs worldwide. Some of these upgrade plans called for enhanced diesel fuel production mainly for the European market, as well as surplus gasoline exported to the United States.

- European refiners told us that they are reluctant to make large investments necessary to produce significantly more diesel because doing so will increase their greenhouse gas emissions. Their concern is that as greenhouse gas emissions caps are lowered, companies will be required to pay to reduce emissions or buy costly emissions credits.

  EIA and other experts have stated that, at times, imports from Europe could be provided more competitively than gasoline from the U.S. Gulf Coast and other domestic refineries. In addition, more sources of supply can also benefit the United States in the event of domestic supply disruptions. For example, the flexibility in sources of supply helped U.S. marketers and retail sellers obtain gasoline and other petroleum products in the aftermath of Hurricanes Katrina and Rita in August and September of 2005, respectively, when a large fraction of the nation's refineries and pipelines were temporarily shut down. During the 3 months following the hurricanes, imports of gasoline to the United States increased by about 30 percent compared to what they were during the same months in the previous year, and imports came from a number of countries that do not typically sell to the U.S, market. Imports of other petroleum products into different regions of the country also rose. As illustrated by figure 6, U.S. imports of petroleum products surged in response to Hurricanes Katrina and Rita compared to levels during the same months of the previous year.[12]

[12]The graphic shows that imports remained significantly higher than in the same months during the previous year at least through January 2006. This was likely the result of lasting damage to U.S. refining production caused by the hurricanes.

Figure 6: Petroleum Product Imports into the United States, 2004-2006



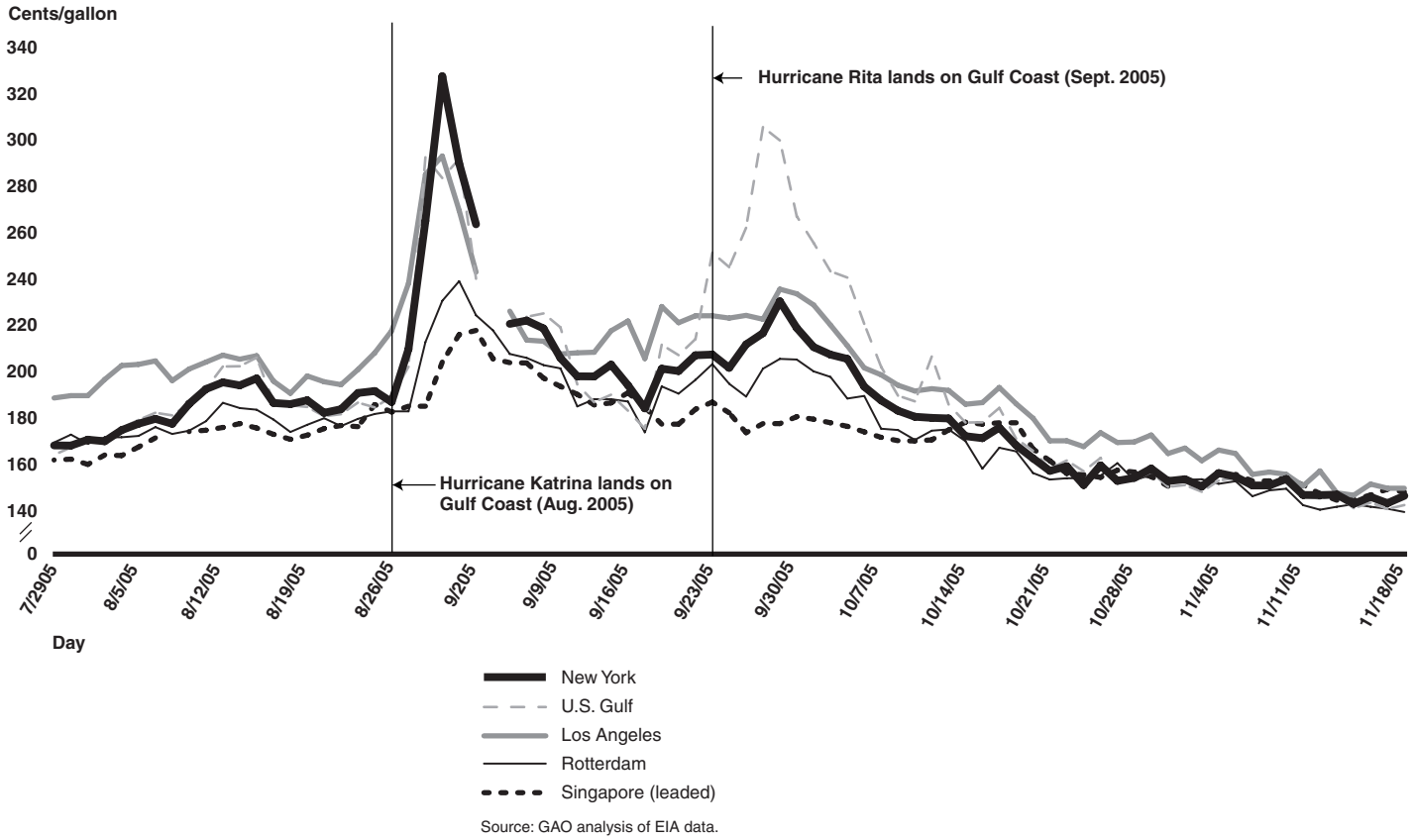
Source: GAO analysis of EIA data.

In addition to gasoline, kerosene-type jet fuel imports into the Gulf Coast surged to about 3.3 million barrels in October of 2005, compared to just 20,000 barrels in October 2004. Some countries that did not export significant quantities of this fuel in 2004 exported significant quantities following the hurricanes to the United States in 2005. For example, France exported 580,000 barrels of kerosene-type jet fuel to the United States in October 2005, but nothing in October 2004 or October 2006.

Our analysis of wholesale prices in the United States, Europe, and Asia shows that prices in geographically dispersed markets rose significantly following Hurricanes Katrina and Rita, indicating that prices in these markets are linked to some extent. Because imports surged from many countries in response to the resulting supply disruptions in the United States, gasoline prices around the world rose along with prices in the United States before prices eventually returned to pre-hurricane levels. Figure 7 illustrates the price spikes that occurred in late August and late September 2005 as a result of the severe damage to oil and gas production facilities in the Gulf of Mexico and to refineries and pipelines onshore from Hurricanes Katrina and Rita. The figure clearly shows that European

and, to a lesser extent, Asian spot gasoline prices—wholesale prices for gasoline traded on a daily basis at major market centers—responded to the resulting petroleum product supply disruptions in the United States. The additional supplies to U.S. markets from Europe and elsewhere reduced prices in the United States, and spot prices everywhere declined to pre-hurricane levels before the middle of October.

Figure 7: Wholesale Gasoline Prices during the 2005 Hurricanes, 2005 - 2006



Source: GAO analysis of EIA data.

Note: Breaks in lines represent days for which no data were recorded.

While experts have stated that the availability of additional sources of petroleum product supplies has benefited the United States through lower and less volatile prices, and foreign gasoline supplies clearly helped reduce prices following Hurricanes Katrina and Rita, the fact that petroleum product markets are international means the United States will be exposed to supply disruptions or unexpected increases in demand anywhere in the world. Further, because some foreign suppliers are

further away from the U.S. demand centers they serve than the relevant domestic supply center, the length of time it takes to get additional product to a demand center experiencing a supply shortfall may be longer than had the United States had more refining capacity. For example, imports of gasoline to the West Coast may come from as far away as Asia or the Middle East, and the transport time and therefore cost is greater. To the extent that imported gasoline or other petroleum products come from far away, the lengthening of the supply chain has implications for the ability to respond rapidly to domestic supply shortfalls. Specifically, if supplies to relieve a domestic regional supply shortfall must come from further away, the price increases associated with such shortfalls may be greater and/or last longer. In this sense, the West Coast is more vulnerable to price increases or volatility than is the Northeast, which can receive shipments of gasoline into New York Harbor or elsewhere in the U.S. Northeast from Europe, often on voyages of less than a week.

Growth in International Trade of Petroleum Products Is Expected to Continue but Growth in Biofuel use May Limit or Change the Patterns of Trade

With demand for petroleum products growing globally, experts we spoke with believe the trade in petroleum products will continue to increase for a number of reasons. For example, global trends toward lower-sulfur fuels have resulted in more uniform sulfur specifications, creating more trade opportunities. Strong global demand for certain petroleum products—especially distillates such as diesel and jet fuel—will increase competition for, and facilitate global trade of, these petroleum products. For example, since 2005, diesel wholesale prices have generally been at a premium compared to the price of gasoline, in response to sharp consumer demand, and in the United States, diesel demand grew 6.9 percent in 2005, compared to 2.5 percent for gasoline. Demand for jet fuel is growing with the increase in air transportation, and given that jet fuel has uniform global specifications, jet fuel will continue to trade relatively freely based on global price signals.

While many experts we spoke with believe that growth in international trade of petroleum products will likely continue, the planned expansion of the use of biofuels, such as ethanol made from corn or other crops, and biodiesel made from soybeans or other crops, in the United States and many other countries could reduce the growth of demand for petroleum products and thereby reduce the opportunity for trade.

At the U.S. federal level, the EPA administers the Renewable Fuel Standard Program, which went into effect in 2007 and requires most U.S. gasoline refiners, importers and blenders to sell a minimum portion of biofuels each year. Refiners can meet the standard by blending biofuels

with conventional gasoline or diesel in various proportions. Plans and mandates in a number of countries and regions, including the United States to introduce larger volumes of biofuels, primarily as additives to gasoline or diesel, could displace demand for and trade in petroleum products. In addition and as discussed previously in this report, some of these biofuel policies mandate that all gasoline or diesel sold in an area be blended in specific proportions with biofuels, with differences across states in the timing and level of such blending. Still other states specify a certain proportion of biofuels to be blended but allow flexibility in how they are blended, thereby creating the potential for widely different biofuel blended fuels within even a single state—for example, the mandated biofuel requirement could be met by a uniform proportion of ethanol blended into every gallon of gasoline used in the state, or by using a small amount of E85 (fuel composed of 85 percent ethanol and 15 percent gasoline components) with ethanol blended into the rest of the gasoline, and any combination of blends and volumes that meets the overall requirements would also satisfy the mandate. States and localities have pursued such policies for a variety of reasons, including viewing biofuels as a means to boost farm economies by increasing demand for feedstock crops while also contributing to a cleaner environment.[13] However, the current absence of uniform standards for biofuels and varying plans by various countries and regions to blend different volumes of biofuels with petroleum-based gasoline and diesel could reduce the fungibility of these fuels and thereby reduce opportunities for trade.

[13]States are subject to some federal requirements in setting biofuel policies. Currently, EPA has determined that only blends of up to 10 percent ethanol are allowed in conventional gasoline vehicles and blends of up to 85 percent ethanol are permitted in flexible fuel vehicles. However, the state of Minnesota and the Renewable Fuels Association, as well as DOE are developing research and tests to gather the data required to facilitate EPA certification of fuel blends up to E15 or E20.

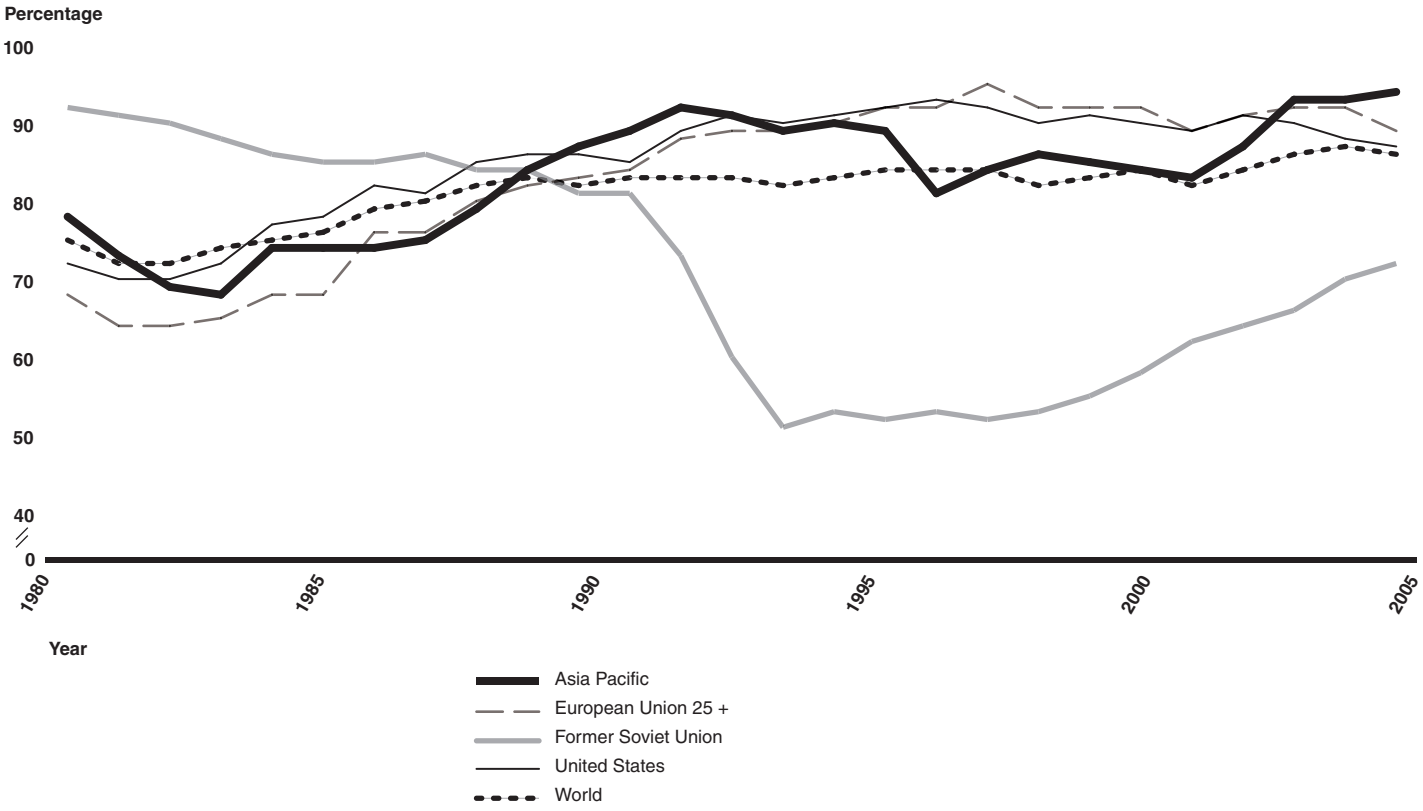
Global and Domestic Refining Capacity Have Not Kept Pace with Demand, Leading to Tight Demand and Supply Balance and Recently Contributing to Higher Petroleum Product Prices

For most of the past 25 years, there has been excess refining capacity globally, but this excess capacity has been reduced over time as demand has increased faster than capacity has grown. Capacity growth has lagged behind demand for a number of reasons, including low profitability in the refining sector and demands on industry to meet changing fuel specifications and reduce emissions of environmental pollutants. More recently, unexpectedly rapid growth in demand for petroleum products caused refineries to run closer to their production capacity. Current market tightness has contributed to higher and more volatile prices and increased profits in the refining industry. While these higher profits have encouraged increased investments in refining capacity, it is unclear whether or for how long the current market tightness will continue. This uncertainty is, in part, because rising construction costs and uncertain future demand make it difficult to estimate how many of the planned refining projects will actually be completed and because biofuel initiatives in many countries could reduce demand for petroleum products while potentially requiring further refining investment to make and keep separate different gasoline and diesel specifications to be blended with ethanol and biodiesel.

Demand for Petroleum Products Has Grown More Quickly than Has Refinery Capacity, Tightening the Supply and Demand Balance Worldwide

For much of the past 25 years, demand for petroleum products in the United States and internationally has outpaced growth in refining capacity. Demand for petroleum products fell dramatically from 1978 to 1982, creating significant excess capacity—by 1983, almost 30 percent of U.S. and world refining capacity was idle. Demand for petroleum products began growing again around 1982, and this demand growth, along with the shutting down of some idle refining capacity, began to narrow the gap between capacity and demand. Since that time, growth in demand for petroleum products has generally exceeded growth in refinery capacity, causing refineries to run more intensively to meet demand. Figure 8 shows how refinery utilization in the United States and internationally, with a few exceptions, including the countries of the former Soviet Union, has increased significantly since the early 1980s.

Figure 8: Refinery Utilization in the World and Selected Countries, 1980-2006

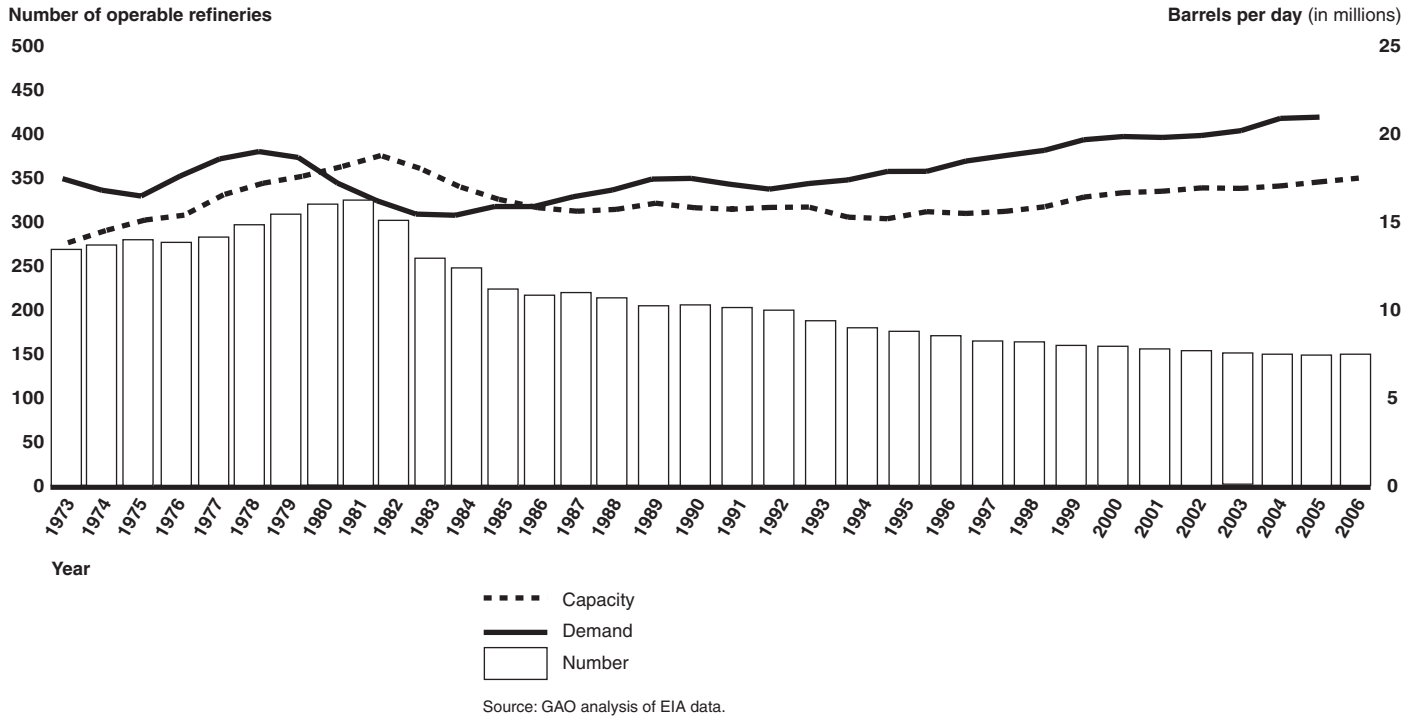


Source: GAO analysis of BP Statistical Review of World Energy June 2007.

Refining capacity in the United States has been growing since 1994 through expansions at existing refineries. The last major complex refinery on a new, or "green field" site in the United States was built in the 1970s, and many, mostly smaller, refineries were shut down starting in the early 1980s. However, as figure 9 shows, even as the number of refineries in the United States fell since 1981, refiners have since 1994 generally expanded total capacity at remaining facilities. Capacity expanded by an annual average of 192,000 barrels per day between 1994 and 2006—more than the average-sized refinery in 2006, which had a capacity of 116,000 barrels per day. For example, ExxonMobil's Baytown refinery grew by about 166,000 barrels per day in capacity between 1994 and 2006, more than equivalent to adding a new refinery. In this sense, it is potentially misleading to say that no new refineries have been built in the United States since the 1970s. Instead, experts have said that expansion in the United States has centered

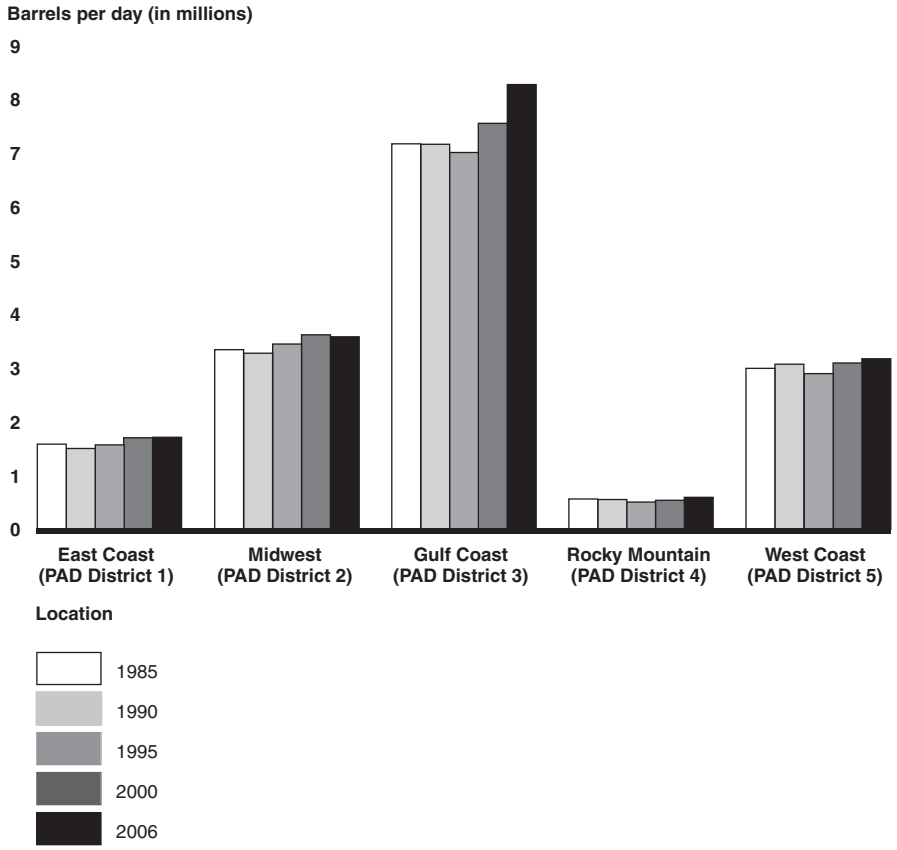
at existing facilities because such expansion is less expensive than building an entirely new refinery at a new, "green field" site because of lower construction, permitting, and land acquisition costs. Some industry officials we spoke with said that construction at a green field site can be about two to three times more expensive than expanding capacity at existing sites on a per barrel basis.

Figure 9: U.S. Crude Oil and Petroleum Product Consumption and Number and Capacity of Operable Refineries, 1973 - 2006



Source: GAO analysis of EIA data.

Figure 10: Refinery Capacity by U.S. Region, 1985-2006



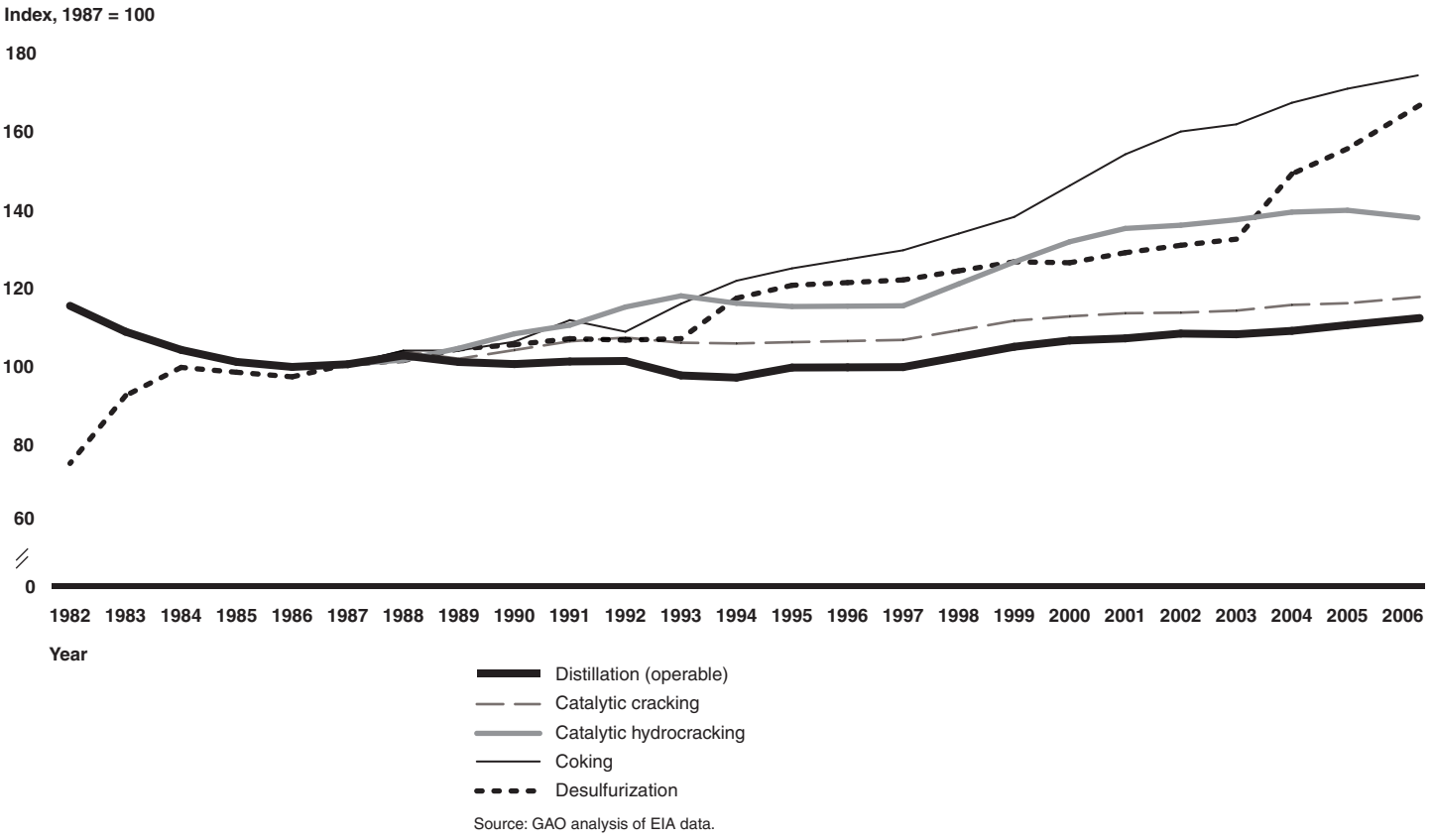
Source: GAO analysis of EIA data.

Figure 10 shows how much of the recent growth in refining capacity in the United States has been concentrated in the Gulf Coast. This growth in capacity in the Gulf Coast is consistent with the view of many industry experts we spoke with that the Gulf Coast provides one of the most competitive environments for U.S. refiners. Experts cited several factors, including ready access to imported crude oil supplies, numerous options for shipping product to the rest of the United States by pipeline and waterways, and a concentration of highly skilled workers.

U.S. refineries also have invested in equipment to upgrade their refineries to be able to produce more high-value products from a wider variety of raw inputs. For example, hydrocracking equipment enables refiners to adjust the yields of various products, and coking capacity allows refiners to process heavier crude oils. Figure 11 shows how the capacity of such

downstream units, particularly hydrocracking and coking, has grown faster than distillation capacity overall. The addition of such downstream units does not increase the distillation capacity of refineries—the traditional measure of capacity—but enables refineries to produce a greater portion of products in high demand (such as gasoline, diesel, and jet fuel) and also to process more heavy and sour crude inputs. In fact, the proportion of gasoline, diesel fuel and jet fuel produced per barrel of crude input in the United States has increased from 77 percent in 1993 to 81 percent in 2005 even as the quality of crude oil inputs used has deteriorated.

Figure 11: U.S. Refinery Distillation Capacity and Capacity of Selected Downstream Units, 1982-2006

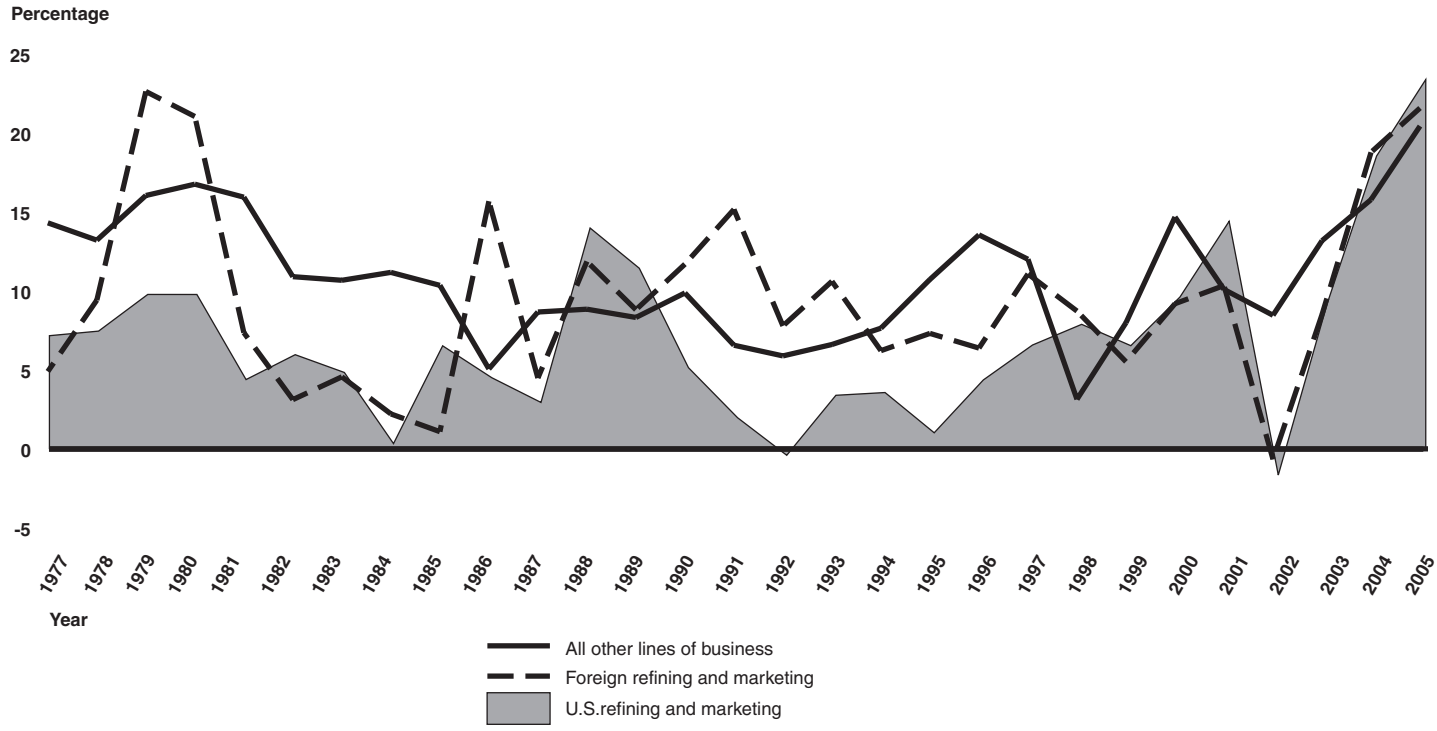


Source: GAO analysis of EIA data.

Industry officials and experts we spoke with said that several factors have caused refinery capacity to grow more slowly than demand in the United States. First, industry officials and experts said that refining has been a low-, even negative-return business for much of the past two decades, with

profits too low to encourage significant expansion. Companies in the oil industry overall, which includes upstream oil exploration and production activities as well as downstream refining and retail marketing, have in general performed better than some industries and worse than others. However, according to an analysis by Deutsche Bank, cash returns on investment for oil companies in the Standard and Poor's 500 index were less than the cost of capital from 1986 to 2000. In other words, it cost companies more to raise the money to invest than those investments earned. Within the oil industry, the refining segment has been less profitable than other lines of business in the petroleum industry, according to EIA data, as illustrated in figure 12. Except for a few years since 1977, returns for U.S. refining and marketing operations have been lower than returns in foreign refining and marketing and lower than exploration and production. Specifically, during the entire period 1977-2005, average return on investment for the U.S. refining industry was 7 percent, compared to 9 percent for foreign refining and slightly over 10 percent for all other lines of business. For the integrated oil companies that still control a major portion of the nation's refining capacity, U.S. refining must compete with foreign refining and upstream investment options for capital. The lower returns for U.S. refining can make it harder for companies to justify expanding U.S. refining capacity.

Figure 12: Return on Investment in U.S. and Foreign Refining Compared to Other Lines of Business for Major Energy Producers, 1997 - 2005



Source: GAO analysis of EIA data.

Note: This graphic is based on the performance of major energy producers covered by EIA's Financial Reporting System (FRS). These companies represented about 81 percent of U.S. refining capacity in 2005.

Another indication that the refinery industry has long had low expectations of profitability is that existing refinery capacity has sold very cheaply. U.S. refineries have often sold for significantly less than what it would cost to build a new similar refinery. According to an analysis by the National Petroleum Council of the value of existing refinery purchases between 1998 and 2004, refineries sold for about one-fourth to one-third the cost of equivalent new construction. The cost of buying an existing refinery was also less than the general cost of expanding capacity on an existing refining site, which experts indicated could be less than one-half the cost of new construction. This suggests that refiners have had low expectations of future returns in the U.S. refining market. This also indicates that until recently, a refiner looking to expand capacity in the United States may have been able to do so more affordably by purchasing an existing refinery. This would add to that refiner's capacity, but would not expand domestic refinery capacity overall.

A second reason experts cited for slow domestic refinery capacity growth is that more rigorous product specifications; the proliferation of special gasoline blends, or "boutique fuels" around the country; and environmental controls have all required refineries to invest in additional processes in order to meet the specifications and regulations, and these investments did not typically add to base capacity. Officials we spoke with said that the large investments required to reduce harmful air emissions at refineries and meet more stringent product specifications drew from the capital that may otherwise have been available to invest in expanding capacity.

A third reason for slow domestic refinery growth, according to some industry representatives, is that permitting difficulties have discouraged refinery expansions. Refineries are required to obtain permits from relevant state and local authorities in order to build or expand refinery capacity. These are often difficult to obtain owing to regulatory hurdles and public opposition. Other experts suggested that permitting adds to the difficulty of expanding capacity but has been a less important factor than overall low expectations of returns. DOE officials told us that resistance to refinery expansions by nearby communities could be a more important factor in discouraging new domestic refinery construction or expansions.

Finally, EIA officials and others pointed to the surplus production of gasoline in Europe as a major, more recent, reason domestic refinery capacity has not kept up with domestic demand. They stated that Europe could at times provide gasoline to the Northeast more competitively than some Gulf Coast refiners, and therefore gasoline imported from Europe has displaced domestic supplies and discouraged domestic refinery expansions.

More recently, global demand for gasoline, diesel, and jet fuel grew particularly quickly around 2004, partly as a result of rapid growth in China, where demand surged by over 15 percent. In order to increase production and meet this recent surge in demand for petroleum products, refiners have had to run their refineries even more intensively—capacity cannot be added quickly because of the long lead times involved in designing and constructing a refinery or an expansion project. Since 2004, world refinery utilization rates have risen to around 86 percent, the highest levels since 1980, when data first became available. Experts told us that many refineries have been running near their production capacity in order to meet demand. This is particularly true in the United States and Europe, where refineries have been running at or near 90 percent utilization since the 1990s, even though spare capacity still existed worldwide, particularly

in the countries of the former Soviet Union and to a lesser extent in the Asia Pacific region.

Current Market Tightness Has Contributed to Higher Petroleum Product Prices, Higher Price Volatility, and Higher Industry Profits

The recent tightening of the balance between supply and demand for petroleum products has, along with higher crude oil prices and other factors, contributed to increased petroleum product prices and higher industry profits, and has contributed to greater price volatility. In addition, a tight demand and supply balance means less flexibility in industry's response to unanticipated events. For example, at times of excess capacity, if a particular refinery were to unexpectedly shut down for emergency maintenance, capacity that wasn't being used could be brought on line to meet demand. However, when refineries are generally running near capacity, there is less excess capacity to call on, and what available capacity there is tends to be located farther away from demand because the lower-cost and nearer refining capacity tends to be used up first.

An analysis by the FTC illustrated the effects of tight refining capacity at the regional level. This analysis compared the impact on gasoline prices of two refinery outages in the upper Midwest in the spring and summer of 2001 with a major refinery outage in Oklahoma in July 2003. Each of the Midwest refinery failures was associated with wholesale gasoline price increases of between 30 and 40 cents.[14] By contrast, the Oklahoma refinery failure was found to have little effect on gasoline prices in that state. The FTC attributed the difference in the price responses to the fact that the upper Midwest region lacks sufficient refinery capacity to meet the region's demand, while Oklahoma produces significantly more petroleum products than the state needs. Therefore, when a major disruption occurs, the upper Midwest must rely on supplies from distant refineries, while Oklahoma simply exports fewer petroleum products to other states.

Further, as we have previously reported, the West Coast of the United States generally has higher gasoline prices than much of the rest of the country.[15] Among the reasons for these consistently higher gasoline prices are a tight supply and demand balance for gasoline, the fact that the region is isolated from other major domestic and foreign refining regions, and the

[14]The price increases were measured in gasoline prices in Chicago relative to Houston prices.

[15]See, for example, GAO's *Motor Fuels: Gasoline Prices in the West Coast Market*, GAO-01-608T, (Washington, D.C.: Apr. 25, 2001).

adoption in California of a unique blend of gasoline that is more costly to make than many other blends and that is not routinely produced by many refineries outside the West Coast. Prices in the West Coast can rise rapidly in response to supply disruptions as a result of these factors.

Profits in the refining industry have increased significantly since 2002, in part as a result of sustained market tightness and, in the United States, owing to wide price differentials between heavy and light crude oils. For example, the difference between crude oil input prices and petroleum product prices, a strong indicator of refining profits, has increased worldwide, though particularly in the United States. In the United States, these wide price spreads have caused returns on investments in the refining and marketing segment of the petroleum industry to reach record levels in 2004 and 2005, the latest data we were able to obtain. In the United States, these higher margins are, in part, the result of the ability of U.S. refineries to take advantage of low-price, low-quality crude oil inputs. Sophisticated U.S. refineries are able to convert large quantities of low-quality crude oil inputs into higher-valued products, while refineries in the rest of the world do not have such capacity to the same extent. Shifts in global crude oil production and demand have contributed to a glut of such low-quality oils, lowering their price relative to higher-quality crude oils and improving the position of U.S. refineries relative to that of their international competitors.

Increased Profit Margins Have Led to More Investment, but Future Market Tightness Will Depend on Several Factors

Currently high petroleum product prices and high profits in the refining industry have spurred new refinery capacity investments in the United States and internationally. Global investment in refining has increased in recent years. According to IEA data, capital spending grew from $34 billion in 2000 to $51 billion in 2005 and is expected to average $60 billion per year between 2006 and 2010. Analysis by IEA of plans and projects currently underway worldwide suggest that almost 10.5 million barrels per day of capacity may be added through 2011. This rate of refinery capacity growth is somewhat higher than expected demand growth, which is projected to grow by about 9.2 million barrels per day by 2011. The majority of this capacity expansion is expected to take place overseas, especially in China, India, and the Middle East. In the United States, EIA officials have said that announced investments through 2011 could add an additional 1 million barrels per day to domestic refinery distillation capacity, along with significant additions to downstream processing capacity. If realized, these domestic and international investments could help alleviate the tight balance between refining supply and demand. However, since tight refining capacity is just one of a number of factors

affecting prices, the biggest factor being crude oil prices, even a less tight refining market may not bring much price relief at the gasoline pump.

While recent profits and prices have renewed interest in expanding refining capacity, experts said it is unclear whether or for how long current refining market tightness will continue. Future refining market tightness depends on changes in refining capacity and on changes in the demand for petroleum products. Industry officials and experts we spoke with said future conditions are highly uncertain for several reasons:

- It has become much more costly to expand refinery capacity in recent years due to rapidly rising construction costs. Various construction materials such as iron, steel, and concrete are important in energy projects, and their costs have increased significantly. For example, while prices for iron and steel fell in the decades prior to 2002, prices increased by 9 percent annually between 2002 and 2004, and by 31 percent from 2004 to 2005. Similarly, industry officials said that many decades of low investment levels have led to a small pool of qualified project engineers to design and oversee construction and expansion projects, causing labor prices to soar. Moreover, the Nelson-Farrar refinery construction cost index, which tracks prices for materials such as iron and steel, equipment and skilled and unskilled labor, shows that costs for refinery investment rose by 17 percent from 2002 to 2005 in real terms. Industry officials indicated that these cost estimates did not capture the full extent to which refinery expansion costs have increased. Officials also said that the waiting lists to purchase key refinery equipment are getting longer. In the United States and in Europe, some planned refining expansions have been delayed or canceled, in part because of these rising costs and delays in acquiring equipment and skilled labor.

- Uncertainty about future demand makes refinery investments risky and may inhibit investments. The United States is considered a mature market, with demand for motor gasoline forecast by EIA to grow by 1.2 percent annually between 2005 and 2030. Meanwhile, refinery capacity has on average expanded by almost 1 percent annually since 1999. Some industry officials we spoke with believe that U.S. demand for petroleum products will peak in the next decade and then begin to decline, implying only a temporary need for additional refining capacity. Company representatives told us that various proposals under consideration dampen the U.S. refining investment climate. For example, the Administration has proposed to reduce U.S. petroleum gasoline consumption by 20 percent by 2017 through increased use of biofuels and more stringent automobile fuel economy standards. If achieved, this could turn the United States from a gasoline importer to a net exporter within 10 years; and current refining

capacity could meet future demand even without expansions that are currently planned.

- Similar initiatives to blend large volumes of biofuels into the transportation fuels markets in other countries could similarly displace demand for petroleum products. It is unclear whether such initiatives could ease the demand and supply tightness that currently exists. On the one hand, reducing demand growth can reduce pressure on refinery capacity. On the other hand, reduced expectations of future demand can alter the attractiveness of refinery investments, and some refiners may respond by cutting back refinery expansion plans.

- New initiatives to blend biofuels in varying proportions into transportation fuels could potentially add to the need for further refining investments both to refine and to keep separate new blending stocks, possibly absorbing resources that could have been used to expand capacity. Automobile industry experts we spoke with agreed that each different ethanol blend requires a specific gasoline or diesel blend stock in order for the resulting blended fuel to meet performance and emissions standards. In other words, the gasoline that is blended with ethanol to make E10 (10 percent ethanol) is different than the gasoline used to make E85 (85 percent ethanol). The absence of national standards for blending biofuels with gasoline and diesel could also increase the number of gasoline and diesel blending stocks refiners have to make, and could lead to a proliferation of new blendstocks. Further, to the extent that new equipment is needed at refineries in order to produce, handle, or keep separate these various blendstocks, refineries will need to invest in this equipment in order to meet various federal, state, and local biofuel mandates and standards. These added investments could crowd out resources that could otherwise have gone to expanding refinery capacity.

Domestic and OECD Inventories of Petroleum Products and Crude Oil Have Declined Relative to Demand, with Mixed Effects on Prices and Price Volatility

When measured as average days of consumption, long-term trends in inventories of petroleum products and crude oil in the United States indicate a general decline over the past 20 years. Similarly, gasoline and crude oil inventories in OECD countries excluding the United States have also generally fallen over the same period. However, there are limitations to inventory data as measured by EIA and IEA, in part because these data do not fully match stocks with their intended markets; in general petroleum product exporting regions will typically have large stocks of these products relative to that region's demand, while inventories held in net importing regions will typically be lower relative to demand. For example, petroleum products stocks of gasoline in Canada, Europe, and the Caribbean that are destined for the United States are counted as

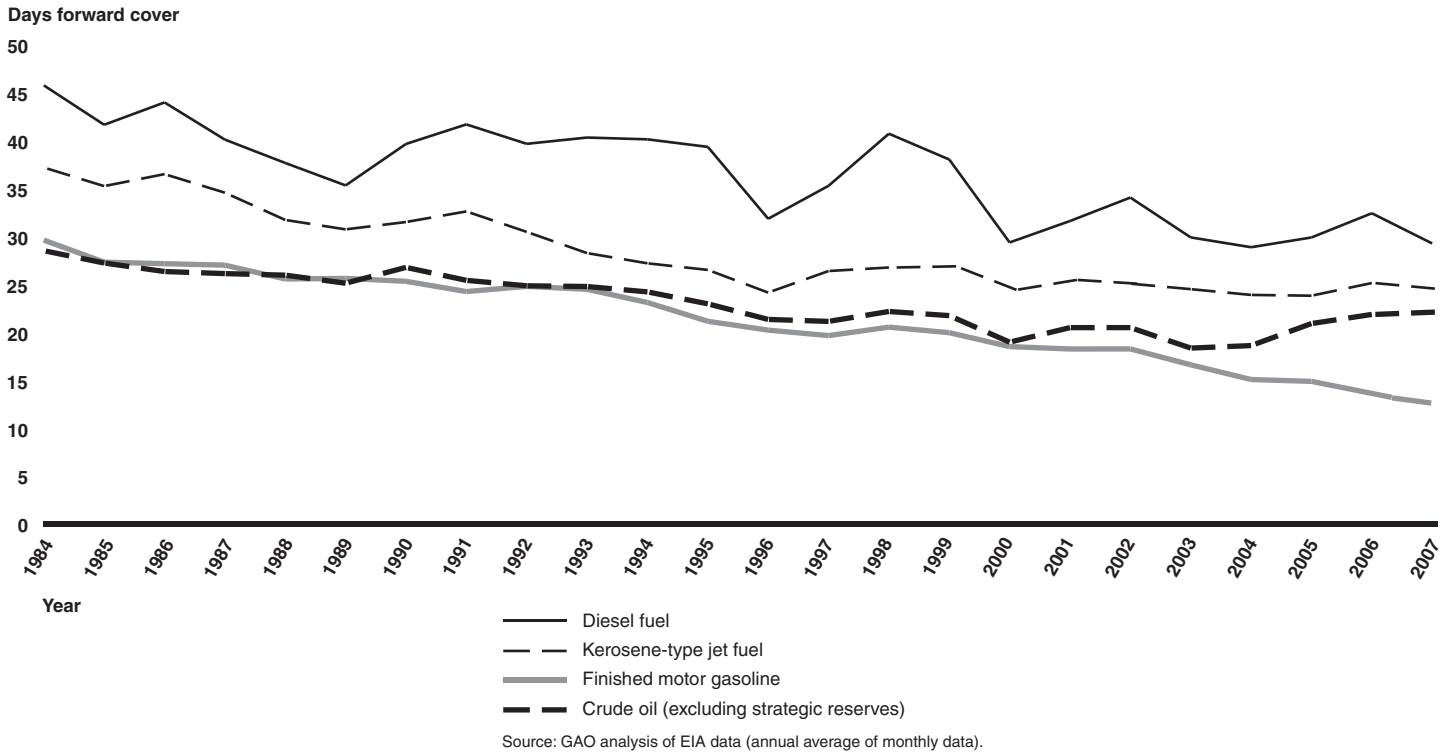
inventories in those countries but not as inventories in the United States. A number of factors have contributed to the long-term decrease in inventory holdings in the United States, including reductions in domestic crude oil production and in the number of refineries as well as advances in technology and management processes that allowed for reduced inventories and a concomitant reduction in operating costs. Lower operating costs associated with lower inventories may have translated into lower consumer prices during normal periods. However, in the short term, inventory levels tend to fluctuate within a "normal" range, and—since inventories provide a smoothing effect against temporary demand and supply fluctuations—lower than normal inventories can lead to higher prices in the event of supply disruptions or surges in demand.

Inventory Levels of Petroleum Products in the United States and Other OECD Countries have Generally Fallen over the Past Two Decades

Privately held inventories of petroleum products and crude oil in the United States have generally fallen over the past two decades, in terms of average number of days worth of supply, or "days forward cover."[16] Specifically, as illustrated in figure 13, days forward cover for gasoline in the United States averaged about 30 days in 1984 but fell to an average of about 12 days for the first 5 months of 2007. Similarly, crude oil days forward cover fell from about 29 to about 22 days, and jet fuel and diesel fuel days forward cover also fell over the same period.

[16]In the United States, inventory data reported in this report refer only to privately held stocks, not the federally held crude oil and heating oil strategic reserves. As will be discussed later in this report, this is not true of some other OECD member inventory data.

Figure 13: Crude Oil (Excluding Strategic Reserves), Finished Motor Gasoline, Kerosene-type Jet Fuel and Diesel Fuel Days Forward Cover in the United States, 1984 - 2007



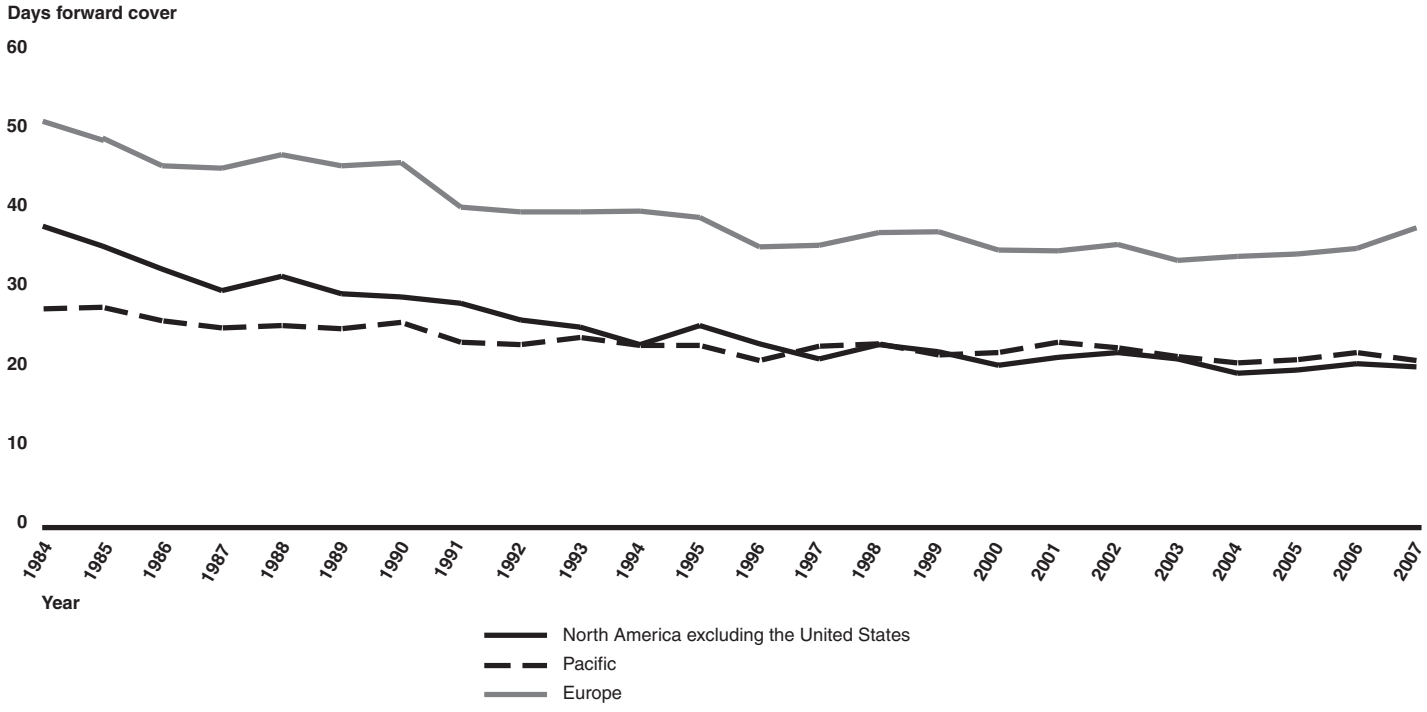
Source: GAO analysis of EIA data (annual average of monthly data).

Other OECD countries have also generally seen a reduction in days forward cover for motor gasoline. Figure 14 shows the general downward trends in gasoline days forward cover for the OECD regions of Europe, Pacific, and North America excluding the United States. Specifically, European stocks declined from about 50 days in 1984 to about 40 days in 2001, before increasing to almost 46 days on average for the first 5 months of 2007. The much larger inventory figure for Europe compared to that for the United States reflects the fact that the inventory data include strategic stocks of gasoline held by some private companies.[17] The recent increase in European stocks of gasoline coincides with a period in which demand for gasoline fell in Europe relative to supply, and exports of gasoline to the

[17]Unlike in the United States, where the federal government holds strategic stocks of primarily crude oil—but also a relatively small stock of fuel oil in the U.S. Northeast Home Heating Oil Reserve—European countries hold a large fraction of their strategic stocks in petroleum products, including gasoline and certain distillate fuels. Some European countries require private companies to maintain these stocks.

United States increased a great deal. Figure 14 also shows large reductions in gasoline stocks in North America, excluding the United States, from about 44 to 18 days forward cover over the same time period, while stocks in Pacific OECD countries fell more modestly from 20 to almost 16 days.

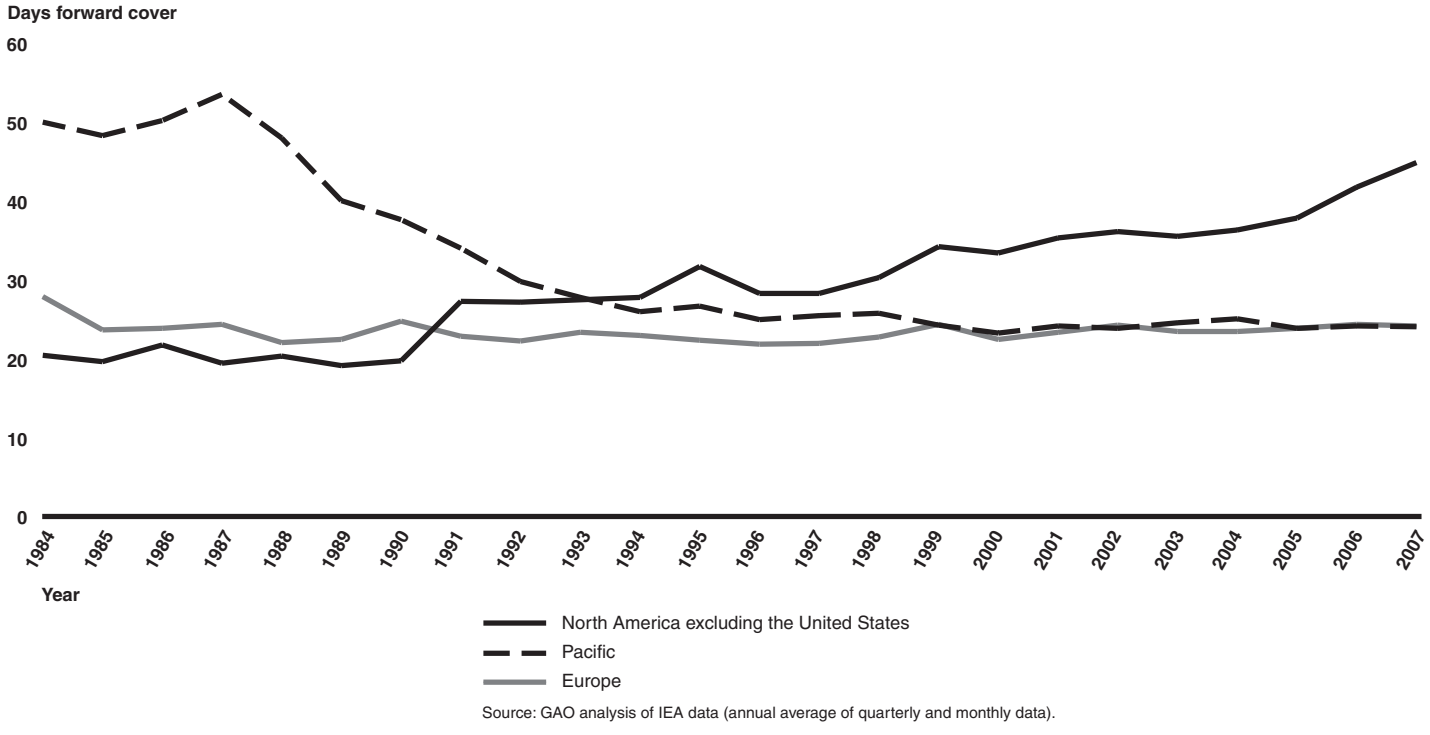
Figure 14: Motor Gasoline Days Forward Cover, by OECD Region, 1984-2007



Source: GAO analysis of IEA data (annual average of quarterly and monthly data).

Crude oil stocks in two of the three other OECD regions, Europe and Pacific, decreased over the period, while stocks in North America excluding the United States rose significantly, driven in part by increases in Canadian oil sands production and the storage and delivery infrastructure associated with this increased production. Figure 15 illustrates these changes in crude oil inventories in days forward cover. We do not have inventory data for non-OECD countries. However, as with petroleum products, net crude oil exporting countries would be expected to have much higher levels of days forward cover for crude oil than net importing countries, especially if strategic stocks are excluded.

Figure 15: Crude Oil Days Forward Cover, by OECD Region, 1984 - 2007



Source: GAO analysis of IEA data (annual average of quarterly and monthly data).

Inventories, as measured by IEA, EIA, and others, have some limitations as a measure of what is available to meet demand in the event of a supply shortfall. For example, as discussed above, the United States has imported an increasing share of its gasoline over the period during which inventories have fallen, and as such, the domestic inventory data do not account for large volumes of these products on the water in tankers from foreign sources that are destined for the U.S. market or in storage terminals at foreign ports serving this trade in gasoline. Our analysis indicates that about 16 million barrels of gasoline and gasoline-blending components were en route to the United States on the average day during 2006, representing about an additional 2 days of forward cover, and an unknown additional amount is held in storage terminals that would be available for shipment in the event of a supply shortfall in the United States. Data on U.S. gasoline inventories may further under-represent available inventories if we ignore the part of inventories held at foreign refineries that are intended to serve the U.S. petroleum products market. The inventories represented in these refineries' storage systems and in the tanker and pipeline system supporting the flow of products to the United States, or at least some portion, could be considered part of U.S.

inventories for the purpose of evaluating our days forward cover of products in the event of a supply disruption. However, it would be difficult to estimate the precise volumes of these foreign inventories as we do not collect such data from offshore suppliers and because many of these inventories are at varying distances from U.S. markets and would have to be evaluated differently, depending on how long they would take to reach the United States in the event of a domestic supply shortfall.[18] Another limitation in interpreting inventory data arises because much of the measured volumes of petroleum products in pipelines cannot be effectively removed from the pipelines in the event of a supply shortfall because they are needed to keep the pressure in the pipelines at operable levels. Similarly, some inventories are in so-called "tank bottoms," or the part of storage tanks that cannot effectively be retrieved in the event of a supply shortfall. As a result of these and other limitations, we do not have an accurate measure of precisely how much is in the full supply chain to the United States, or the actual number of days' worth of usable supply we could rely on in the event of a supply disruption.

Looking forward, the refining expansions discussed previously in this report may lead to increases in the days forward cover measure as pipelines and storage facilities associated with the new refining capacity add to inventory holdings. However, any increase in days forward cover is likely to be modest overall because demand is also projected to grow, and companies continue to strive to develop more efficient inventory holding practices and reduce costs associated with holding any excess inventory.

A Number of Factors Have Contributed to the Long-Term Decrease in Inventory Levels Since 1980

A number of factors have contributed to the long-term decrease in U.S. days forward cover. These factors include (1) a reduction in the number of refineries and falling domestic crude oil production, (2) the fact that demand has been rising faster than refining capacity for much of the past 20 years, (3) gains in technological and management efficiency that have allowed companies to reduce the level of operating inventories, and (4) the rise of futures markets for crude oil and gasoline that have enabled oil

[18]It is also not clear that the benefits of collecting and maintaining such data outweigh the costs. Evaluating these trade-offs was beyond the scope of this report, but such an evaluation would have to be made before making a decision to collect a broader range of inventory data.

companies and others to reduce exposure to market risk by holding financial as well as physical stocks of these commodities.[19]

In the United States the decline in U.S. crude oil production resulted in decreased inventory in gathering pipelines and storage infrastructure, as pipelines and storage tanks were decommissioned. This decline in production-related inventories could be quite significant, although we do not have data to measure it directly. Oil production in the United States peaked in 1970 at around 10 million barrels per day, but by 2005 had fallen to less than 6 million barrels per day. This decline in production has left a number of abandoned crude oil pipelines and therefore represents a reduction in measured inventories. Similarly, the closure of many small refineries and the decommissioning of these refineries' storage and pipeline connections to the greater supply infrastructure also reduced inventories held at these facilities and in the pipeline connections. As discussed previously in this report, this reduction in the number of refineries was significant. For example, in 1980, there were well over 300 refineries in the United States, while in 2006 the number was about 150. This sheer drop in numbers probably overstates the drop in associated inventories because, while the number of refineries fell, the average size of refineries rose, both because it was smaller refineries that tended to be shut down and because many of the remaining refineries expanded their capacity significantly. Nonetheless, EIA has stated that refinery closures had an important impact on petroleum stocks prior to 1995.

A related cause of the reduction in days forward cover for petroleum products has been the fact that for much of the past 20 years, demand for these products has risen faster than domestic refining capacity. Because days forward cover is measured as the number of days' worth of demand that is in the domestic supply chain, any increase in demand that is not met by a commensurate increase in domestic supply will lead to a reduction in days forward cover. However, as discussed previously in this report, this is potentially misleading because the supply chain between foreign refiners and the United States is relevant for measuring actual days forward cover and the U.S. imports of gasoline have been increasing dramatically over the past decade, and imports of crude oil have been increasing for much longer than that.

[19]Assessing the relative importance of these factors with any precision would be very difficult and we did not undertake this task in this report, so the list of factors should not be seen as a ranking of those factors in any way.

According to company representatives and industry experts we spoke with, as well as the National Petroleum Council, delivery system efficiency improvements have also resulted in reduced crude oil inventory levels. Company representatives told us improved information technology has given managers better tools needed to optimize stock levels, and that this was mirrored in many other industries over this same period, as improved logistics and management practices enabled companies to more closely track production and delivery. By reducing inventories, refiners were able to reduce their operating costs, providing incentives to invest in efficiency-improving measures. Some officials told us that low refining profit margins were a major driver in getting companies to reduce their inventory holdings.

Finally, the relationship between the future price of crude oil and petroleum products and the amount of inventory stored has, at times, contributed to changes in overall inventory levels. For example, according to a 1997 EIA report, during the period between 1995 and 1996, the prevalence of instances where the current trading price of crude oil or petroleum products was higher than the future expected price appeared to be an important factor behind the reduction in stocks.[20] In such a price environment, oil companies and others could sell currently held inventories and buy futures contracts to meet their future expected needs. In recent years, the future price of crude oil has most frequently been higher than the current price, and industry officials told us that this has been a factor in explaining why absolute inventory levels increased between December 2004 and early 2007. For example, total U.S. crude oil stocks, excluding strategic stocks, were about 355 million barrels in June 2007, or about 31 percent higher than in January 2004, according to EIA data.

[20]Energy Information Administration, Petroleum 1996: Issues and Trends, (Washington D.C., September 1997).

Long-Term Inventory Cost Reductions have Likely Reduced Prices of Gasoline and Other Petroleum Products, but, In the Short Term, Reductions in Inventory Levels below Normal Ranges Can Lead to Higher Prices during Supply Shortfalls

To the extent that improved technology and inventory management over the long term have resulted in lower operating costs, some of the savings may have been passed on to consumers in the form of lower prices. We found no consensus among industry experts about the extent of such price reductions, nor any empirical analyses that would quantify the savings to consumers from lower inventory holding costs. However, because refineries compete with one another to sell their products, they would likely be forced to pass on some savings in operating costs in order to remain in operation, especially during that portion of the last three decades in which there was unused refining capacity as well as during recent years when surplus gasoline production in Europe has increasingly found its way to U.S. markets.

However, because inventories provide a smoothing effect against temporary demand and supply fluctuations, lower than normal inventories can signal underlying changes in supply and demand conditions that will cause prices to rise. For example, if a large refinery in the United States were to suffer an unexpected outage, the resulting reduction in domestic supplies would likely result in a drawdown of that refinery's inventories to meet its demand, and if that is insufficient, the refinery would buy from other refiners. If inventories were on the high end of the normal range, such a disruption would likely have little effect on petroleum product prices, all else remaining the same. On the other hand, if inventories were on the low side of or below the normal range—the result of other supply shortfalls or unexpectedly high demand—the additional refinery outage would be more likely to cause significant price increases. The size of the supply disruption relative to available inventories, as well as to the size of the refining sector, can also influence how prices respond. For example, if a large refinery outage were to occur in the Gulf Coast refining region, the large volume of inventories and the large number and capacity of other refiners relative to that refinery's production would likely mean that the effect on prices of petroleum products would be small. Similarly, the availability of large stocks of gasoline in Europe, often less than 1 week away by tanker to the U.S. East Coast market, probably insulates the latter market from extreme price fluctuations in the event of a domestic supply shortfall. On the other hand, if the refinery outage were to occur in the West Coast, where one refinery's production would be significantly larger relative to available inventories and total sector capacity, a significant price response is more likely. For these reasons, lower than normal inventories are frequently cited as a factor in price run-ups of petroleum products. For example, the Northeast diesel price spike of January 2000 was preceded by lower than normal inventory buildup, and the California

Energy Commission cited relatively low inventory levels as one of several contributing factors to the gasoline price spike in the spring of 2006.

U.S. Supply Infrastructure Is Constrained in Key Areas and Likely to Become Increasingly Constrained, Thereby Increasing Prices and Price Volatility unless Timely Investments Are Made

The nation's crude oil and petroleum product supply infrastructure is constrained in key areas and may become inadequate to handle future volumes of petroleum products and biofuels unless sufficient investment is undertaken. Inadequate supply infrastructure can lead to higher prices and price volatility during supply disruptions or unexpected increases in demand because the supply infrastructure cannot handle the changed or increased delivery of fuels. However, the extent of the problem and the prospect for the future of the supply infrastructure is uncertain, in part because there has been no comprehensive study done to assess infrastructure adequacy. There are many planned infrastructure expansions that could alleviate the stress on the system to some extent. However, a complex approval process—involving numerous federal, state, and private entities—and other factors increase the time and cost of building and maintaining infrastructure.

The Nation's Supply Infrastructure Is Constrained in Key Areas and Likely to Become More Constrained

Industry and agency officials report that key crude and petroleum product pipelines are constrained and operating at or near capacity. As the Secretary of Energy noted in a December 4, 2007 discussion with industry media, the U.S. energy infrastructure system—including oil pipelines—is "pressed," and it is important that pipeline and other energy infrastructure owners maintain their assets effectively, to maintain adequate supplies. Both DOT and industry officials report a systemic lack of pipeline capacity in the supply infrastructure system in key states including Arizona, California, Colorado, and Nevada, and note existing pipeline supply infrastructure is insufficient to carry the commensurate volumes of petroleum products and crude oil needed to meet growing demand. Industry officials told us that pipelines in the Southwestern region, such as Arizona and Las Vegas, have reached maximum utilization, or become "constrained." For example, industry experts told us that a new petroleum product pipeline from the Gulf of Mexico to El Paso is already approaching full capacity. Denver's petroleum product pipelines have also become generally constrained and unable to meet increased gasoline demand for summer travel. This raises the cost of delivering petroleum products to Denver; in instances when pipelines are full, shippers must make alternate shipping arrangements by more costly rail or truck. Further, a key petroleum product line from the U.S. Gulf Coast to North Carolina is reportedly constrained, thereby increasing delivery costs for

petroleum products in that region, and key petroleum product pipelines radiating outward from the major refining center of Houston are also reportedly constrained. Finally, in certain areas, pipeline infrastructure to support certain demand or production centers' needs does not exist. For example, there are no petroleum product pipelines into Florida. Additionally, despite strong demand in California, the existing petroleum product pipelines support the flow of product from California to other Southwestern states, but no petroleum pipelines flow into California from other regions.

Industry representatives and federal studies also report that many of the nation's port facilities are operating at or near capacity. For example, one-fourth of the ports in a U.S. Maritime Administration (MARAD) survey described their infrastructure impediments as "severe." Officials from the interagency U. S. Committee on the Maritime Transportation System, which includes MARAD, the National Oceanic and Atmospheric Administration, and the U.S. Army Corps of Engineers told us that U.S. ports and waterways are constrained in capacity and utilization, and anticipate marine supply infrastructure will become more constrained in the future. The Ports of Los Angeles, Long Beach, Oakland, Houston, Savannah, and Charleston reported congestion and emphasized in a 2005 report that they are experiencing higher than projected growth levels.

The capacity of the supply infrastructure not keeping pace with increasing demand in certain areas has raised concerns about the adequacy of the infrastructure to accommodate expected increasing volumes of crude oil and petroleum products. Population increases in the West and South are expected to increase the need for pipelines, marine transportation, and capacity utilization there. DOT reports that already high pipeline capacity utilization levels may not meet growing demands unless significant expansion occurs. The situation is similar for the U.S. marine infrastructure. In a 2005 report, MARAD evaluated the status of U.S. ports and waterways and concluded that domestic marine transport supply infrastructure will become more constrained in the future. As imports of petroleum products are projected to increase by over 80 percent by volume between 2004 and 2030, according to EIA, this anticipated demand growth will challenge a marine transport system that is already operating, in some instances, at the limits of its capacity.

The introduction of biofuels will also increase the strain on the existing supply infrastructure. For example, ethanol-producing plants tend to be relatively small near the sources of biofeedstocks—currently mostly corn—used to make ethanol. At present, the ethanol produced by these

plants, unless they are located next to rail facilities, are typically trucked to central rail loading facilities and then shipped to demand regions on unit trains—trains whose cars are entirely made up of a single product and typically going to a single destination. Trucking biofuels to these central locations is costly and also uses petroleum products, thereby reducing the volumes of these latter fuels the ethanol can displace. Experts we spoke with generally agreed that eventually a more efficient collection system will likely be built—probably consisting of feeder pipelines—to connect the relatively small ethanol plants to major rail or supply and demand centers. Nonetheless, according to DOE, the existing petroleum product pipelines are currently not configured to transport ethanol from regions where it is currently produced to regions where it is consumed. Because pipelines are ultimately the cheapest form of domestic shipment of petroleum products and crude oil, it may make sense to ultimately ship ethanol through the pipeline system, and existing or new petroleum pipelines could be used in certain areas to transport ethanol if ongoing efforts by operators to identify ways to modify their systems to make them compatible with ethanol or ethanol-blended gasoline are successful.

In addition, as discussed previously in this report, a proliferation of biofuel blends in this country will require additional variations in the blends of petroleum products that are mixed with these biofuels. Pipeline companies report that varying fuel specifications complicate petroleum product delivery and supply infrastructure systems by requiring separate storage and increasing the complexity of the distribution system. Also, pipeline operators told us that sending more and smaller batches of these special blends has slowed the flow of fuels through pipelines because pulling off more and smaller batches of fuels requires a slower speed to not miss significant parts of these batches. However, when we asked, these pipeline operators did not offer any quantification of the extent to which effective tank capacity reduction or pipeline slowness has occurred.

Infrastructure Disruptions Lead to Increases in Prices and Price Volatility and Constraints in Supply Infrastructure Could Exacerbate Price Effects

A constrained supply infrastructure can be a major factor influencing prices of petroleum products during supply disruptions. For example, during the rupture in the Kinder Morgan pipeline in Arizona in August 2003, Arizona's gasoline prices rose by about 45 cents during the 3-week period ending on August 25, 2003. Due to the connectivity of the pipeline network among California, Arizona, and Nevada, the disruption not only caused prices to spike in Arizona itself, but the extra burden from Arizona's demand also contributed to higher prices elsewhere in the West; during the disruption, California's prices rose by 40 cents to peak at $2.10, and Washington, Nevada and Oregon all experienced price increases of

over 30 cents per gallon.[21] Any constraint in the supply infrastructure can reduce supply reliability by making it more difficult to reallocate supplies in response to even relatively minor disruptions in the supply and distribution system. In this way, a constrained supply infrastructure could increase price volatility and exacerbate price effects due to disruptions.

When certain localities are inadequately served by pipelines or reasonably priced marine supply infrastructure, alternative transport modes tend to be more costly, leading to higher prices for consumers. For example, since relatively few pipelines connect the West Coast with other regions, some supplies of petroleum products and crude oil must be shipped by truck or barge from other domestic regions or by tanker from foreign countries; such modes of transport are slower and more costly than via pipelines. For example, it can take around 2 weeks for a vessel to travel from the Gulf Coast to Los Angeles port—including transit time through the Panama Canal. This can increase recovery time from an unplanned refinery outage, other supply disruption, or an unanticipated surge in demand, thereby leading to higher or longer-lasting price spikes.

Federal agency officials and industry experts told us that the slow permitting process and corresponding delays in infrastructure development could lead to higher and more volatile petroleum product prices in the future. For example, while the recent expansion of pipeline capacity from the Gulf Coast to El Paso, following the opening of the Longhorn pipeline in June 2004, has been expected to ease the infrastructure constraint on Arizona's petroleum product supplies, permitting impediments continue to perpetuate the lag between the growth of demand for petroleum products on the West Coast on the one hand and the growth of the pipeline capacity to move products to the region on the other. The California Energy Commission has recently stated that similar constraints on marine infrastructure expansions to accommodate future growth in demand for imports of petroleum products will be a major challenge for the West Coast. Such failure of the region's supply infrastructure to handle the requisite volumes of petroleum products to meet rising demand will continue to contribute to the persistence of higher and more volatile prices in the West Coast compared to other regions.

[21]Note that there may have been additional factors influencing prices during this period, so we are not asserting that the pipeline outage was responsible for the entire change in prices.

We were unable to assess the extent of supply infrastructure constraints or the impacts of these constraints on prices and price volatility, in large part because there is no central source of data that tracks system bottlenecks. Information that would indicate whether a pipeline is operating at or near capacity is also not collected in a central location by federal agencies or industry trade groups. These data would include pipeline throughputs, measured by the amount of product flowing into a pipeline and the volume of output received at key market locations. Companies are not required to report such information. By contrast, FERC requires natural gas pipelines to report, via their web sites, throughput information that allows regulatory, public, and private entities to track bottlenecks and identify where shortages in supply, or system constraints, affect regional prices. A number of studies and analyses of constraints in natural gas pipelines have quantified the effects on natural gas prices. For example, EIA routinely uses natural gas pipeline capacity and outages in making projections about natural gas prices. These data on natural gas pipeline capacity and the flow of natural gas are collected and evaluated to determine the reliability of the infrastructure to meet demand, and it is well understood that constrained pipelines lead to higher natural gas prices and can even lead to disruptions of service in severely constrained cases.[22]

We recognize there are differences between the natural gas industry on one hand and the petroleum industry on the other, particularly because of the fact that the former industry evolved under a rate-regulated utility framework, while the petroleum industry did not. Specifically, under rate regulation, the former requirement that utilities meet all demand at their regulated prices at any point in time necessitated the monitoring of supply and infrastructure constraints that could cause a failure of service. By contrast, petroleum product prices have largely not been regulated, and prices have generally been allowed to adjust to equilibrate supply with demand at any point in time. Further, we are not suggesting in this report that petroleum product markets should be regulated like natural gas or any other markets. However, these historical regulatory differences notwithstanding, we believe that it is important to understand the extent to which constraints on the current petroleum product supply infrastructure affect prices as well as the adequacy of the infrastructure to

[22]It should be noted that whether or not the benefits of collecting and maintaining such data outweigh the costs is unknown. Evaluating these trade-offs was beyond the scope of this report, but such an evaluation would have to be made before making any decision to collect a broader range of pipeline or other infrastructure data.

meet growing demand. Federal agencies, industry experts, and Congress have all recognized this as a priority. For example, industry consultants and agency officials have acknowledged the importance of a system-wide study of pipeline capacity constraints and regulatory impediments to future investment. In addition, DOT officials have stated that the extent of capacity restrictions in the nation's pipeline infrastructure is becoming more apparent, that the current regulatory mechanisms may not lead to appropriate reinvestment in the industry. In June 2006, DOT put forth a proposal and in December 2006 Congress passed legislation that mandated the Secretaries of Energy and Transportation to conduct periodic analyses of the adequacy of the nation's pipeline supply infrastructure. The first report to Congress of the results of such an analysis is required by June 2008.[23] The language for the mandate stated that "such analyses should identify areas of the United States where unplanned loss of individual pipeline facilities may cause shortages of petroleum products or price disruptions and where shortages of pipeline capacity and reliability concerns may have or are anticipated to contribute to shortages of petroleum products or price disruptions. Upon identifying such areas, the Secretaries may determine if the current level of regulation is sufficient to minimize the potential for unplanned losses of pipeline capacity." Despite widespread recognition that such a study is needed to fully identify the extent of infrastructure inadequacy and the impact on prices, to date, no such analysis has been undertaken. DOT and DOE officials told us that they were not appropriated funds specifically to do the mandated analyses and that the agencies have not re-allocated other funds for this, although DOE told us in its comments that DOE and DOT staff have met to discuss how this work could be approached. Given that the study has not begun, it seems highly unlikely that the agencies will be able to meet their June 2008 deadline for reporting to Congress.

[23]Pub. L. No. 109-468, §8.

Expansions in Supply Infrastructure Are Planned, but High Construction Costs, Investment Risk, and a Complex Regulatory Environment Can Deter or Delay These Needed Infrastructure Investments

There are many private sector plans to expand the supply infrastructure, and if implemented in timely fashion, these plans could significantly alleviate the stresses on the system. For example, there is a long-anticipated project for a 500-mile petroleum product pipeline expansion from Louisiana to Georgia, several plans for new crude pipelines to accommodate the expected increased flows of Canadian oil sands, as well as other crude and refined product pipeline plans to meet more localized needs. However, many such plans are in a conceptual stage and/or subject to permitting approval and other possible complications. Thus, industry representatives told us, it is difficult to determine how many of the industry plans for new construction or expansion of existing pipelines will be realized.

However, the high cost of construction, uncertain investment climate, and complex regulatory environment increase the time it takes to build this supply infrastructure and raises risk and investment costs. With regard to construction costs, a shortage of skilled labor and specialized equipment to perform the work, and high prices of steel and concrete have increased construction costs and the time it takes to expand the nation's supply infrastructure system. For example, pipeline companies and other industry experts we spoke with said that major pipeline expansion and construction projects take anywhere from 2 to 15 years to complete and currently cost about $1 million per mile to build. With regard to the uncertain investment climate, pipeline companies and industry experts told us that uncertainty about petroleum product demand, biofuel development and shipping, and future changes to fuel specifications complicate the decisions about where and when to build new or expand existing infrastructure. Regulations governing pipeline and other infrastructure expansions, including regulations governing water and air pollution, endangered species protection, and public safety, have evolved to protect the environment and ensure public safety. However, there can be tension between these goals and the goals of ensuring adequate energy supplies and keeping prices down. For example, in order to build a new pipeline or significantly expand capacity or upgrade an existing pipeline, companies must first navigate a mixed and sometimes complex jurisdiction of federal, state, and local regulators, as well as secure right of way approval from the necessary landowners whose lands will be crossed by the pipeline. At the federal level alone, as many as 11 agencies may be involved in granting approval to build new pipeline projects. In addition, industry experts told us that some potential market entrants have had difficulty meeting permitting requirements and are often unable or unwilling to wait out lengthy delays in obtaining permits, such as when two companies in southern California reportedly recently backed out of

plans to build storage terminals there after trying to complete the federal, state and local approval processes. A study conducted for Association of Oil Pipe Lines, an FTC report on gasoline prices, and industry officials told us that building or expanding pipelines has become increasingly difficult in certain situations. For example, a major pipeline operator encountered federal and local legal and regulatory issues that delayed for 10 years the development of a key pipeline from the Gulf Coast to El Paso, Texas. As a result of such delays and impediments to investment, regional demand that could support new pipeline capacity must be served by more costly transportation modes for years, as has been the case in parts of the Rocky Mountains and Southwest and West Coast regions. Finally, an uneven balance of costs and benefits of expansion for various entities can also contribute to declining investment in supply infrastructure by certain entities. For example, DOT reports that common carrier pipelines achieve only modest returns from relieving constrained pipeline capacity. However, it reports consumers would benefit proportionately greater through the enhanced competition resulting from the increased capacity of new pipeline investments. Pipeline companies, on the other hand, report they will expand when sufficient demand is secured, particularly through the "presale" of capacity in the proposed pipeline.

Ideally, the permitting and approval process should be streamlined without sacrificing the important protections provided by regulatory oversight. Industry and federal agency officials have pointed out that a federal model exists for this in the permitting process for interstate natural gas pipelines. Specifically, FERC facilitates expansions and construction of natural gas pipelines by serving as the lead agency to process company permit applications, conduct the required environmental impact study, and coordinate the timing of other necessary permits that fall under the purview of various federal agencies. In addition, FERC authorizations convey the right of eminent domain to pipeline builders to resolve specific right of way issues in the event an agreement cannot be reached between a landowner and a project sponsor. FERC officials told us that although its authorizations convey the right of eminent domain, pipeline companies rarely have to exercise it because its existence is usually sufficient to get landowners to negotiate a solution with pipeline builders. Streamlining the federal regulatory process with regard to crude oil and petroleum product pipeline repairs has already begun in response to a federal statute passed in 2002 to coordinate environmental reviews and permitting needed for pipeline repairs and more clearly define federal roles in the pipeline repair

process.[24] However, this streamlined federal process has not been applied to constructing new crude oil or petroleum product pipelines or significantly upgrading or increasing capacity of existing pipelines.[25]

Conclusions

The choices the United States and other countries make about how to ensure sufficient supplies and stable prices of petroleum products and other fuels such as ethanol and biofuels will greatly influence energy prices in the United States. For biofuels in particular, cost and availability will depend in part on how well international, federal, state, and local governments coordinate their biofuel standards and methods of integrating them with petroleum products. Harmonizing fuel specifications worldwide, while continuing to allow for regional differences in fuels specifications that are there to meet specific environmental or vehicle performance goals, would make it easier to refine and transport common blends, streamline delivery, increase opportunities for trade, provide additional sources of supply, and potentially reduce prices and price volatility. However, if the world and the United States end up with numerous different biofuel blends—as appears to be happening under existing plans and mandates—this could expand the array of incompatible gasoline and diesel blending stocks and final blended products that cannot be interchanged at the retail level, reducing opportunities for trade. In addition, these products will have to be segregated during shipment, further straining the supply infrastructure. Unless the supply infrastructure catches up and keeps up with these changes, the domestic energy supply will be less secure and prices will tend to be higher or more volatile.

[24]Pub. L. No. 107-355, § 16

[25]In 2006, DOT identified the need for additional Congressional authority to reduce the regulatory burden on companies trying to construct new pipelines or repair existing ones. Specifically, DOT proposed legislation that, according to DOT, would among other things provide "minimal authority" to assist pipeline operators in overcoming state and local-level impediments to constructing new pipelines and would further streamline the permitting process for pipeline repairs. At this time, Congress has not provided this additional authorization. DOT's proposal did not call for a federal agency to have the authority to convey the power of eminent domain in cases where conflicts over infrastructure placement cannot be resolved but it would have authorized the Secretary of DOT to "designate an ombudsman to assist resolving disagreements between Federal, State, and local agencies and pipeline operators arising during agency review of pipeline repairs and hazardous liquids pipeline construction projects…"

Even without these changes, rising demand for crude oil and petroleum products over the last 25 years has challenged the supply infrastructure for these commodities in certain areas, leading to higher prices during supply disruptions or during periods when pipelines or ports lack sufficient capacity to transport the products suppliers wish to ship. As noted by the Secretary of Energy in December 2007, the U.S. energy infrastructure system—including oil pipelines—is "pressed," and it is important that pipeline and other energy infrastructure owners maintain their assets effectively, in order to maintain adequate supplies of energy. In the absence of a comprehensive analysis of the likely weaknesses in our infrastructure, policy makers and regulatory agencies involved in overseeing the safety and adequacy of supply infrastructure remain in the dark about the extent of these problems and their effects on prices of petroleum products. Further, as demand for petroleum products and biofuels grows, the existing system may become increasingly constrained and need to be upgraded and expanded to handle greater and different product flows. Because federal and state agencies and other entities will be involved in approving such upgrades and expansions, it is essential that they be well informed as to the current state of the supply infrastructure and the areas in most critical need of further investment. Furthermore, the lack of a lead agency to streamline the complex and costly permitting process for U.S. supply infrastructure construction or expansion projects and the lack of ability of federal agencies to convey the power of eminent domain in cases where conflicts over infrastructure placement cannot be resolved may deter potential market entrants from investing in much-needed upgrades in a timely fashion. As a result, we could end up with less security of supply and higher and more volatile prices in the future.

Recommendations for Executive Action

To better monitor and evaluate the development of our nation's supply infrastructure systems, as well as to facilitate the continued tradability of products across domestic and global markets and to ensure that gasoline supplies from Europe and elsewhere remain compatible with U.S. gasoline specifications, we are making a number of recommendations that, if adopted, should improve prospects for the future security of petroleum product supplies and price stability.

- To avoid additional proliferation of differing fuel specifications that would further burden the existing supply infrastructure and create impediments to trade, we recommend that the Secretary of Energy coordinate with EPA and other relevant federal agencies, states, IEA, the European Union, and other foreign entities to encourage development of biofuels and petroleum products standards and blending practices that maximize the fungibility of

these fuels and minimize the spread of differing fuel types that would further strain the supply infrastructure, while recognizing that some fuel differences to reflect local environmental requirements, engine performance, or other factors are likely beneficial.

- To comprehensively analyze the U.S. supply infrastructure's capacity to accept, handle, and transport the increasing volumes and types of petroleum products and biofuels expected to traverse its system, we recommend the Secretaries of Energy and Transportation undertake the comprehensive study of existing and projected increases to the infrastructure system—including terminal capacity and pipeline throughputs—to evaluate whether future demand is likely to be met by existing infrastructure and planned increases as mandated by Congress in 2006. To the extent that the data to comprehensively conduct such analyses may at present not be collected, the Secretaries should consider evaluating the merits of enhancing the reporting of utilization and throughputs, perhaps using natural gas pipeline and storage reporting requirements as a model.

- In conjunction with the completion of the first comprehensive study of the supply infrastructure, we recommend the Secretary of Transportation work with DOE, FERC, EPA, and other federal agencies to evaluate the feasibility and desirability of designating a lead federal agency, with authority to convey the power of eminent domain, to coordinate across agencies and streamline the permitting and siting process for crude oil and petroleum product interstate pipeline expansions, upgrades, and new construction, using FERC's role with natural gas pipelines as a model. If this is found to be feasible and desirable, we recommend the aforementioned agencies work together to determine which agency should take the lead role and to prepare a legislative proposal for Congress to provide any additional authority needed to implement this recommendation.

Agency Comments and Our Evaluation

We provided the Departments of Energy and Transportation and the Federal Energy Regulatory Commission with a draft of this report for their review and comment.

DOE neither agreed nor disagreed with our report and primarily provided technical comments, which we incorporated as appropriate. However, we do note that the Secretary of Energy recently commented that the U.S. energy infrastructure system—including oil pipelines—is "pressed," and that it is important that infrastructure assets are maintained effectively, which appears to be in accord with our recommendations. Specifically,

with regard to our recommendation that the Secretaries of Energy and Transportation undertake the comprehensive study of existing and projected increases to the infrastructure system, it would seem that such a study would be critical in determining the level of maintenance and development needed to maintain adequate supplies of crude and refined products, a matter of national interest, as stated by the Secretary of Energy. Further, in light of the Secretary's comments, it would seem prudent that DOE also implement our recommendation to work with other federal agencies to evaluate the feasibility and desirability of designating a lead federal agency, with authority to convey the power of eminent domain, to coordinate across agencies and streamline the permitting process for crude oil and petroleum product interstate pipeline expansions, upgrades, and new construction. DOE's letter is printed in appendix II of this report.

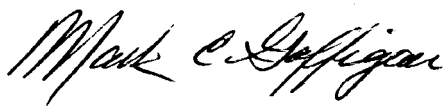
DOT gave us oral comments on the report. With regard to our second recommendation, DOT commented that the agency supports the idea of conducting the comprehensive infrastructure study, as mandated by Congress in December 2006—in fact, a DOT 2006 legislative proposal also included language about the need for such a study—although agency officials added that they need funding to accomplish this task. In its comments, DOT said it believed our report unfairly portrayed DOT's inaction with regard to starting this mandated study as a failure. Specifically, it said this was not fair because the agency was not appropriated the funding to do the study. In response to these comments, we added language to the report that points out that DOT had proposed such a study to Congress. We already had language in the report acknowledging that DOT and DOE had said that they were not appropriated funding for the study. Still, our recommendation is in accordance with DOT's 2006 legislative proposal to perform this study, and we believe DOT and DOE should take steps to begin this study, either by reallocating their current budget or, if this is not possible, to request additional funding from Congress. With regard to the third recommendation, to study the streamlining of the petroleum product pipeline permitting and siting process, DOT commented that the agency supported streamlining the process for expanding petroleum product pipelines and had already proposed legislative language to Congress in 2006 that would have done so and also would have made DOT the lead federal agency in coordinating this process. Therefore, DOT commented that it had already done what we are asking in our third recommendation: namely, to evaluate the feasibility and desirability of designating a lead federal agency to coordinate the federal permitting process for crude oil and petroleum product interstate pipeline expansions, upgrades, and new

construction. In reviewing DOT's legislative proposal, it does not call for the lead agency to have the ability to convey the power of eminent domain, as we also recommend be considered. Further, we cannot, on the basis of our work, endorse a specific agency to take the lead. Finally, we think that a coordinated effort among DOT, DOE, and other relevant agencies is needed to evaluate this issue and advise Congress on the best way to proceed. For these reasons, our recommendation is still appropriately addressed to the Secretary of DOT and the other named agencies.

FERC generally agreed with our findings and recommendations in the draft report, and provided technical comments, which we addressed in the body of the report as appropriate. Appendix III contains a reproduction of FERC's letter, which underscores FERC's agreement with GAO's recommendations and points out that FERC's role as the lead agency for siting natural gas pipelines could serve as a good model to use in interagency discussions about how this could be accomplished in the case of petroleum product pipelines.

As agreed with your offices, unless you publicly announce the contents of the report earlier, we plan no further distribution of it until 30 days from the report date. At that time, we will send copies of this report to interested congressional committees; the Administrator, Environmental Protection Agency; the Secretaries of Energy and Transportation; the Chairman, Federal Energy Regulatory Commission; and other interested parties. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staffs have any questions about this report or need additional information, please contact me at (202) 512-3841 or gaffiganm@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Major contributors to this report are included in appendix IV.



Mark Gaffigan
Acting Director
Natural Resources and Environment

Appendix I: Scope and Methodology

The Chairman and a member of the Senate Commerce, Science, and Transportation Committee asked GAO to evaluate trends and effects on petroleum product prices in (1) international trade of petroleum products; (2) refining capacity and intensity of refining capacity use internationally and in the United States; (3) international and domestic crude oil and petroleum product inventories; and (4) domestic crude oil and petroleum product supply infrastructure, particularly pipelines and marine transportation.

To address the first objective, we examined data from the Department of Energy's (DOE) Energy Information Administration (EIA) and the International Energy Association (IEA) to evaluate trends in the international trade flows for crude oil and petroleum products and their price correlations over time at international trading hubs. In addition, IEA data were used to calculate total global imports and exports of crude oil and petroleum products as well as for key global regions including Europe, Asia and the United States. We met with more than 20 oil industry companies—including refiners and pipeline companies—a number of financial and investment corporations, more than 25 industry groups, and more than 15 domestic and international government agencies to corroborate trend analyses, reports, and data. We conducted audit work in various locations in Texas, California, New York, and Washington, D.C., as well as Belgium, France, Germany, and the United Kingdom to obtain industry's perspective on recent trends in the international trade of petroleum product as well as prospective trends going forward. In addition, we analyzed EIA and New York Mercantile Exchange, (NYMEX) data on historical spot and futures prices for crude oil and petroleum products at international and domestic trading hubs to see how price volatility has changed over time.

To address the second objective, we assessed trends in refining capacity, refining capacity additions, utilization, complexity, and planned investments using IEA, EIA, and *Oil and Gas Journal* data, and determined the data were sufficiently reliable for our purposes. We met with more than 20 oil-industry companies—including refiners and pipeline companies—a number of financial and investment corporations, more than 25 industry groups, and numerous staff and officials of more than 15 domestic and international government agencies in California, Texas, New York, Washington D.C. ,as well as Belgium, France, Germany and the United Kingdom to corroborate trend analyses, reports and data. We also reviewed and analyzed trends in refinery investment, operating costs, and profitability in the U.S. and internationally, using literature and data on

U.S. and international refining practices, trends and forecasts, and interviewed experts on these trends.

To address the third objective, we used data from EIA and IEA on crude oil and petroleum product inventories and projected demand to conduct international, U.S. total domestic, and U.S. Petroleum Administration for Defense District (PADD) inventory trend analysis on inventories in absolute terms and in "days forward cover" terms. We analyzed NYMEX and other futures market data, as well as EIA data, to observe the effects of the expected future price for crude oil on inventory holding decisions. To collect these data, we conducted a site visit to meet with industry and government representatives in Belgium, France, Germany, and the United Kingdom to gain information about the European Union's policy of maintaining strategic petroleum product reserves and their effects on price levels and price volatility.

To address the fourth objective, we interviewed federal and state agencies that oversee the economic, safety, and environmental impacts of pipelines and marine transportation on current and future utilization capacity of the petroleum product infrastructure. Where possible, we collected and analyzed data on the age of the pipeline and marine infrastructure system, capacity, throughputs, and constraints. We compared data reporting requirements for petroleum products with reporting requirements for liquefied natural gas, and identified differences in such reporting requirements. We spoke with common carrier pipeline operators, port authorities, government entities, and trade association and consumer advocate groups to gain their perspectives on supply infrastructure investment, capacity utilization levels, and potential system constraints. We also reviewed previous relevant GAO reports and testimonies, and Department of Energy and Department of Transportation reports. In addition, we examined reports and data from supply disruption case studies to examine those cases' impact on infrastructure, prices, and price volatility.

During our audit work we consulted with the following entities:

- We met with the following oil industry companies, including refiners, supply infrastructure and oil service companies: BP; Buckeye Partners; Chevron Corporation; ConocoPhillips Company; ExxonMobil Corporation; Fluor Corporation; Frontier Oil Corporation; Hess Corporation; Holly Corporation; Kinder Morgan Energy Partners; Longhorn Partners Pipeline; Magellan Midstream Partners; Marathon Oil Company; Mid-continent Express Pipeline; Oiltanking GmbH; Paramount Petroleum Corporation;

Plains All American Pipeline L.P.; RaceTrac Petroleum, Inc.; Sunoco, Inc.; TEPPCO Partners L.P.; Tesoro Corporation; UOP LLC; Valero Energy Corporation.

- We met with the following financial organizations: Deutsche Bank; Goldman, Sachs & Co; JP Morgan Chase Bank; Morgan Stanley; New York Mercantile Exchange, Inc. (NYMEX).

- We met with the following industry groups and expert institutions: Allegro Energy Consulting; American Association of Port Authorities; American Petroleum Institute (API); Association of Oil Pipe Lines (AOPL); Conservation of Clean Air and Water in Europe (CONCAWE); Consumer Federation of America; Energy Analysts International, Inc.; European Petroleum Industry Association (EUROPIA); Global Insight, Inc.; Institut Francais du Petrole (IFP); Muse Stancil & Co.; National Association of Regulatory Utility Commissioners; National Petrochemical & Refiners Association; *Oil & Gas Journal*; Petroleum Marketers Association of America; Pipeline Safety Trust; PIRA Energy Group; Purvin & Gertz, Inc.; Stillwater Associates LLC; Turner, Mason & Company; the Rabinow Consortium, LLC; UK Petroleum Industry Association; Union of European Petroleum Independents (UPEI); University of California Energy Institute; Western States Petroleum Association; Wood Mackenzie Research and Consulting.

- With regard to government and agency sources, we met with the following U.S. agencies and governmental institutions: Department of Defense, including the Army Corps of Engineers; Department of Energy, including the Energy Information Administration; Department of State; Department of Transportation, including Pipeline and Hazardous Materials Safety Administration (PHMSA); Department of Homeland Security; Federal Energy Regulatory Commission; Federal Trade Commission; Interagency Committee on Marine Transportation; Oak Ridge National Laboratory. We met with the following state and local governmental agencies: California Energy Commission (CEC); California Environmental Protection Agency Air Resources Board (CARB); Hawaii Energy Planning and Policy Branch; Port of Houston Authority. We met with the following international government and multilateral organizations: European Commission Directorate-General for Energy and Transport; EBV (German Stockholding Agency); French General Directorate for Energy and Raw Materials; International Energy Agency (IEA); International Monetary Fund (IMF).

  The report primarily uses data from the domestic and international wholesale petroleum product and crude oil markets. In contrast to retail markets, wholesale prices do not generally include extra costs such as

federal and state taxes, distribution and marketing expenses and profits. In every case for the data used in this report, we assessed and determined that the data were sufficiently reliable for our purposes. We performed our work from August 2006 through September 2007 in accordance with generally accepted government auditing standards.

Appendix II: Comments from the Department of Energy

Department of Energy
Washington, DC 20585

November 28, 2007

Mark Gaffigan
Acting Director
Natural Resources and Environment
Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Gaffigan:

Thank you for the opportunity to review GAO's report entitled *ENERGY MARKETS: Increasing Globalization of Petroleum Products Markets, Tightening Refining Supply and Demand Balance, and Other Trends Have Implications for U.S. Energy Supply, Prices and Price Volatility*. The breadth and complexity of the topic made this a challenging report. We, along with the DOE Office of Policy and International Affairs and the Office of Fossil Energy previously provided GAO with technical comments. A few additional comments are enclosed for your consideration.

If you have further questions, please contact Joanne Shore (202-586-4677).

Sincerely,

Guy F. Caruso
Administrator
Energy Information Administration

Enclosure -

Appendix III: Comments from the Federal Energy Regulatory Commission

FEDERAL ENERGY REGULATORY COMMISSION
Washington, D.C. 20426

November 13, 2007

OFFICE OF THE CHAIRMAN

Mr. Mark Gaffigan
Acting Director, National Resources and Environment
United States Government Accountability Office
Room 2T47
441 G Street, NW
Washington, DC 20548

Dear Mr. Gaffigan:

Thank you for the opportunity to comment on your report entitled *Increasing Globalization of Petroleum Products Markets, Tightening Refining Demand and Supply Balance, and Other Trends Have Implications for U.S. Energy Supply, Prices and Price Volatility.* In general, I agree with the recommendations of the report relevant to the Commission's responsibilities. The Federal Energy Regulatory Commission's (Commission) role in regulating crude oil and petroleum products pipelines is defined by the Interstate Commerce Act (ICA). The ICA gives the Commission authority to regulate only the transportation rates, and terms and conditions of service on these pipelines. The Commission does not have authority to regulate the siting of, construction of, or the abandonment of service by, crude oil or refined petroleum product pipelines.

Although the Commission does not have siting authority for petroleum pipeline construction, the Commission has encouraged and supported the building of new and expanded crude and petroleum product lines through its issuances of orders on pipeline petitions for declaratory orders. The Commission has approved certain rate methodologies and granted other rate assurances prior to construction in order to reduce the uncertainty and risk inherent with these large infrastructure projects. Specifically, the Commission provided pre-construction assurances in the following orders: Express Pipeline Partnership issued September 11, 1996, in Docket Nos. OR96-11-000 and 001; Enbridge Energy Company, Inc. issued March 3, 2005, in Docket No. OR05-1-000; Colonial Pipeline Company issued May 23, 2007, in Docket No. No. OR06-8-001; and Calnev Pipe Line LLC issued July 20, 2007, in Docket No. OR07-10-000.

As noted in the report, the Commission is responsible for the siting of interstate natural gas transportation pipelines in the United States. In this capacity, the Commission has gained extensive experience in issues surrounding pipeline construction and operation and has used this knowledge in its assistance to other agencies. Of recent note, the Commission was asked to assist the State Department in its environmental review as lead agency of the proposed TransCanada Keystone Pipeline, L.P. (Keystone) project, an oil pipeline crossing from Canada into the United States. Specifically, the Commission supplied the State Department with information on our environmental review process and examples of environmental documentation. Commission staff also provided assistance in the selection of the third party contractor, guidance on how the Commission facilitates interagency cooperation and public scoping meetings, technical assistance in the preparation of the draft environmental impact statement, and guidance on how the Commission builds the public record for a project. I believe our assistance with this project ultimately will help provide for an expeditious, but thorough, review and facilitate needed infrastructure to the oil industry.

Finally, the report recommends that several agencies, including the Commission, work together to evaluate the feasibility and desirability of designating a lead agency with eminent domain authority in order to streamline the process for siting oil and product pipelines. The suggested use of the Commission's role in the siting of gas pipelines as a model will help to expedite the deliberations of the agencies. Further, the active participation of the Commission will help facilitate a decision on the lead agency designation.

Sincerely,

Joseph T. Kelliher
Chairman

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Mark Gaffigan (202) 512-3841 or gaffiganm@gao.gov

Staff Acknowledgments

In addition to the individual named above, Frank Rusco (Acting Director), Kimberly Cutright, Philip Farah, Craig Fischer, Quindi Franco, Samantha Gross, Carol Kolarik, Michelle Munn, Daniel Novillo, Alison O'Neil, and Barbara Timmerman made key contributions to this report.

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