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Report to Congressional Requesters

August 2006

STRATEGIC PETROLEUM RESERVE

Available Oil Can Provide Significant Benefits, but Many Factors Should Influence Future Decisions about Fill, Use, and Expansion

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Highlights

Highlights of GAO-06-872, a report to congressional requesters

August 2006

STRATEGIC PETROLEUM RESERVE

Available Oil Can Provide Significant Benefits, but Many Factors Should Influence Future Decisions about Fill, Use, and Expansion

Why GAO Did This Study

Congress authorized the Strategic Petroleum Reserve (SPR), operated by the Department of Energy (DOE), to release oil to the market during supply disruptions and protect the U.S. economy from damage. The reserve can store up to 727 million barrels of crude oil, and currently contains enough oil to offset 59 days of U.S. oil imports. GAO answered the following questions: (1) What factors do experts recommend be considered when filling and using the SPR? (2) To what extent can the SPR protect the U.S. economy from damage during oil supply disruptions? (3) Under what circumstances would an SPR larger than its current size be warranted? As part of this study, GAO developed oil supply disruption scenarios, used models to estimate potential economic harm, and convened 13 experts in conjunction with the National Academy of Sciences.

What GAO Recommends

GAO is recommending that the Secretary of Energy (1) assess the effectiveness of experts' proposals to use dollar cost averaging when filling the SPR and allow delays in SPR fill; (2) to better serve users, store some heavy sour oil in the SPR; (3) clarify the difference in assumptions and purposes of two models DOE uses to estimate the impact of using the SPR; and (4) periodically reassess the ideal size of the SPR in light of changing oil market conditions. DOE generally agreed with the report and recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-06-872.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at (202) 512-6877 or wellsj@gao.gov.

What GAO Found

The group of experts recommended a number of factors to be considered when filling and using the SPR. They generally agreed that filling the reserve by acquiring a steady dollar value of oil over time, rather than a steady volume of oil over time as has occurred in recent years, would ensure that more oil will be acquired when prices are low and less when prices are high. Experts also suggested allowing oil producers to defer delivery of oil to the reserve at times when supply and demand are in tight balance, with oil producers providing additional oil to the SPR to pay for the delay. Regarding use of the SPR, experts described several factors to consider when making future use decisions, including using the reserve without delay when it is needed to minimize economic damage.

During oil supply disruptions, releasing oil from the SPR could greatly reduce damage to the U.S. economy, based on our analyses and expert opinions. Particularly when used in conjunction with reserves in other countries, the SPR can replace the oil lost in all but the most catastrophic oil disruption scenarios we considered, lasting from 3 months to 2 years. DOE uses one model to estimate the optimal size of the SPR and another to estimate the economic effects of oil supply disruptions. Both models predict positive effects from using the SPR, but the magnitude of such benefits differ. The substantial differences between the results of these two models could lead DOE to provide inconsistent advice about expanding and using the reserve. Furthermore, factors beyond the SPR's ability to replace oil affect the extent to which the SPR can protect the U.S. economy from damage. For example, SPR crude is not compatible with all U.S. refineries. During a disruption of heavy sour crude oil, refineries configured to use this type of oil would have to reduce production of some petroleum products when refining the lighter oil in the SPR, decreasing the reserve's effectiveness at preventing economic damage.

If demand for oil increases as expected, a larger SPR would be necessary to maintain the existing level of protection for the U.S. economy. The Energy Information Administration recently projected increases in U.S. demand for petroleum of approximately 12 percent by 2015 and 24 percent by 2025, compared with the 2005 level. In this regard, a 2005 study prepared for DOE found that the benefits of expanding the reserve to 1.5 billion barrels exceed the costs over a range of future conditions. However, many factors that influence the SPR's ideal size are likely to change over time. For example, although projections show increasing oil demand, the level of demand depends on many factors, including rates of economic growth, the price of oil, policy choices related to alternatives to oil, and technology changes. Consequently, periodic reassessments of the SPR's size in light of new information could be helpful as part of the nation's energy security planning.

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Abbreviations

CAFE	Corporate Average Fuel Economy
DOE	Department of Energy
EIA	Energy Information Administration
GDP	gross domestic product
ORNL	Oak Ridge National Laboratory
SPR	Strategic Petroleum Reserve

United States Government Accountability Office
Washington, D.C. 20548

August 24, 2006

The Honorable Susan M. Collins
Chairman
Committee on Homeland Security and Governmental Affairs
United States Senate

The Honorable Carl Levin
Ranking Minority Member
Permanent Subcommittee on Investigations
Committee on Homeland Security and Governmental Affairs
United States Senate

Oil is the world's most important energy resource. The world consumes approximately 83 million barrels of oil per day, accounting for nearly 40 percent of world energy consumption. In 2004, the most recent year for which data are available, 40 percent of the energy used in the United States and 96 percent of the energy used in the U.S. transportation sector were derived from oil, the majority of which was imported. In 2004, the United States imported 65 percent of its crude oil supply, or approximately 10 million barrels per day. Supply and demand for oil are in tight balance today, with only about 1 million barrels per day of spare oil production capacity, meaning that even small disruptions in supply can cause large increases in prices. Unusually high prices for petroleum products due to a strike at Venezuela's national oil company in 2002 to 2003 and Hurricanes Katrina and Rita in 2005 demonstrated this effect.

Because of the central role that oil plays in the U.S. economy, sudden increases in its price can cause economic damage. Increases in crude oil price are reflected in the prices of products made from crude oil, such as gasoline, diesel, home heating oil, and petrochemicals such as fertilizer. Furthermore, because petroleum products are an important part of the production of many goods and services, the prices of these goods and services also increase. These price increases can reduce the total amount of goods and services that consumers can afford, thus reducing economic activity. Past studies have shown that oil price shocks can cause hundreds of billions of dollars of damage to the U.S. economy.

To help protect the U.S. economy from damage caused by oil supply disruptions, Congress authorized the Strategic Petroleum Reserve (SPR) in 1975, following the Arab oil embargo of 1973 to 1974. The SPR is owned by the federal government and operated by the Department of Energy (DOE).

It can store up to 727 million barrels of crude oil in salt caverns located at sites in Texas and Louisiana. Since 1976, the United States has spent about $45.2 billion in 2005 dollars to build, maintain, fill, and manage the SPR. In addition, the United States and 25 other nations that are members of the International Energy Agency have agreed to maintain reserves of oil or petroleum products equaling 90 days of net imports and to release these reserves and reduce demand during oil supply disruptions.[1] In June 2006, the SPR contained about 689 million barrels, equal to 59 days of U.S. oil imports. In addition to government reserves, private industry inventory varies over time, but DOE estimates that private inventory contains an amount equal to an additional 59 days of U.S. oil imports. Thus, at the current level of oil demand, the SPR combined with private industry holdings contains enough oil to exceed the United States' 90-day reserve requirement.

Under conditions prescribed by the Energy Policy and Conservation Act, as amended, the President and the Secretary of Energy have discretion to authorize release of the oil in the SPR to minimize significant supply disruptions.[2] In the event of an oil supply disruption, the SPR can provide supply to the market—by selling stored crude oil or trading this oil in exchange for a larger amount of oil to be returned later. When oil is released from the SPR, it flows through commercial pipelines or on waterborne vessels to refineries, where it is converted into gasoline and other petroleum products, then transported to distribution centers for sale to the public.

Refineries are configured to refine specific types of crude oil. Crude oil is generally classified according to two parameters: density and sulfur content. Less dense crudes are known as "light," while denser crudes are known as "heavy."[3] Crudes with relatively low sulfur content are known as

[1]The 26 member countries of the International Energy Agency are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[2]Pub. L. No. 94-163 (1975), as amended.

[3]The density of crude oil is commonly described in terms of API gravity. Higher API gravity indicates less dense oil.

"sweet," while crudes with higher sulfur content are known as "sour."[4] In general, heavier and more sour crudes require more complex and expensive refineries to process the oil into usable products, but are less expensive to purchase than light sweet crudes. Many refiners in the United States have upgraded their facilities in recent years to process heavy sour crude. The SPR contains about 40 percent sweet crude and 60 percent sour crude, stored in separate caverns. Both crude types in the SPR are considered "light."

Oil markets have changed substantially in the 31 years since the establishment of the SPR. At the time of the Arab oil embargo, price controls in the United States prevented the prices of oil and petroleum products from increasing as much as they otherwise might have, contributing to a physical oil shortage that caused long lines at gasoline stations throughout the United States. Now that the oil market is global, the price of oil is determined in the world market primarily on the basis of supply and demand. In the absence of price controls, scarcity is generally expressed in the form of higher prices, as purchasers are free to bid as high as they want to secure oil supply. In a global market, an oil supply disruption anywhere in the world raises prices everywhere. Releasing oil reserves during a disruption provides a global benefit by reducing oil prices in the world market.

Use of the SPR during an oil supply disruption mitigates damage to the economy by replacing the oil lost, thereby reducing the price spike and the resulting economic damage. Such damage is typically reflected in a temporary reduction in gross domestic product (GDP), the total market value of all goods and services produced in the U.S. economy in a given year, compared with what it would have been without the disruption. The reduction in GDP caused by an oil supply disruption and the resulting price increases depends on several factors, including the size and duration of the disruption; the availability of oil market "cushions," such as excess oil production capacity and private inventories; and the importance of oil to economic activities. Severe oil supply disruptions in the past, such as the Arab oil embargo, caused sudden spikes in oil prices accompanied by economic losses of billions of dollars in the United States and other major oil-consuming economies. More recent disruptions, such as the Venezuelan strike in 2002 to 2003, have involved smaller quantities of oil for shorter

[4]The sweet oil in the SPR contains less than 0.5 percent sulfur, while the sour oil in the SPR contains approximately 1.4 percent sulfur.

durations and caused less economic damage. Two offices within DOE—the Office of Petroleum Reserves and the Energy Information Administration (EIA)—use models to analyze the effects of oil supply disruptions and SPR use on the economy. The Office of Petroleum Reserves is in charge of the day-to-day operations of the SPR, and it uses a model to calculate the effects of oil supply disruptions and SPR use as part of a study of the net benefits of expanding the reserve. EIA is a statistical agency that uses a separate model to estimate the impact of oil supply disruptions and to advise officials about their potential consequences.

From 1977 to 1992, Congress appropriated money to purchase oil from the market to fill the SPR. Since 1999, oil for the SPR has been obtained through the royalty-in-kind program. Through this program, the government receives oil instead of cash for payment of royalties on leases of federal land in the Gulf of Mexico. Because oil produced in the Gulf generally does not meet the specifications to be stored in the SPR, DOE trades this oil with contractors who provide oil that can be stored in the SPR. Recently, the Energy Policy Act of 2005 directed DOE to increase the SPR inventory to 1 billion barrels and required DOE to select sites for the expansion to accommodate the inventory no later than 1 year after enactment, or by August 2006.

Historically, DOE has added oil to the SPR in response to specific concerns about oil supply security. For example, when DOE acquired oil for the SPR after the Arab oil embargo of 1973 to 1974 and the Iranian revolution in 1979, the goal was to rapidly create a reserve large enough to be useful in case of a severe oil supply disruption. During the mid- to late-1990s when oil prices were relatively low, there were no significant oil security concerns and little oil was added to the SPR. In contrast, following the terrorist attacks of September 11, 2001, the President directed that oil be added to the SPR, even though it already contained enough oil to meet potential near-term supply disruptions. The stated goal was to maximize long-term protection against oil supply disruptions. Some have criticized filling the SPR at that time because they believe doing so increased the price of oil.

The President has the primary authority to decide when to use the SPR. Additionally, the Secretary of Energy is authorized to carry out exchanges from the SPR and test drawdowns to evaluate SPR procedures. Presidents have twice ordered that oil be sold from the SPR in response to oil supply disruptions: that is, in response to the 1990-1991 Persian Gulf War and Hurricane Katrina in 2005. Additionally, the SPR has sold or exchanged oil on several other occasions, including providing small quantities of oil to refiners to help them through short-term localized oil shortages.

In conducting our review, we answered the following questions: (1) Based on past experience, what factors do experts recommend be considered when filling and using the SPR? (2) To what extent can the SPR protect the U.S. economy from damage during oil supply disruptions? (3) Under what circumstances would an SPR larger than its current size be warranted?

In addressing these questions, we developed six hypothetical oil supply disruption scenarios. These scenarios are set in today's oil market, with global crude oil demand of approximately 83 million barrels per day and U.S. demand of approximately 21 million barrels per day. The scenarios are as follows:

- A hurricane in the U.S. Gulf Coast disrupts oil supplies by up to 1.5 million barrels per day for 6 months, similar to the disruptions caused by Hurricanes Katrina and Rita in 2005.

- A strike among oil workers in Venezuela disrupts oil production by up to 2.2 million barrels per day over 5 months, similar to a strike that occurred in 2002 to 2003.[5] Production then remains 0.2 million barrels per day below its prestrike level for an additional 19 months.

- Iran stops exporting oil for 18 months, removing 2.7 million barrels per day from the market.

- A terrorism event at an oil facility in Saudi Arabia disrupts up to 6 million barrels per day over 8 months.

- Closure of the Strait of Hormuz, which is a vital oil shipping lane located at the entrance to the Persian Gulf, disrupts 17 million barrels per day for 1 month. Supply then recovers over the next 2 months.

[5]Although the strike among oil workers in Venezuela in 2002 to 2003 lasted only 63 days, the resulting oil supply disruption lasted for approximately 5 months. See GAO, *Energy Security: Issues Related to Potential Reductions in Venezuelan Oil Production*, GAO-06-668 (Washington D.C.: June 27, 2006).

- Saudi Arabia stops oil production, removing 10 million barrels per day from the market for 18 months. Production then recovers over the following 6 months.

We selected these hypothetical scenarios to illustrate the potential benefits of strategic reserves in a wide range of different situations, not because we consider these scenarios likely.

To collect expert opinions on the impacts of past SPR fill and use and recommendations for the future, we convened a group of experts in conjunction with the National Academy of Sciences[6] and interviewed experts from industry and academia. We convened the group to allow the experts to exchange and challenge ideas, but the group was not designed to reach consensus on the issues discussed. We also reviewed records and reports from DOE and the International Energy Agency and interviewed officials from these agencies and other oil industry experts.

To analyze the ability of the SPR to reduce economic damage caused by oil supply disruptions, we reviewed the economic literature on the impact of oil supply disruptions and used two DOE simulation models to estimate the reduction of harm to U.S. GDP that would result from releasing oil from the SPR and international reserves during our oil supply disruption scenarios. These two models estimate the increase in oil prices and the reduction in GDP that are likely to occur during an oil supply disruption of a given size. Although the models provide useful information, they make assumptions and do not include some factors that could influence the reserve's operation, such as the compatibility of SPR oil with U.S. refineries. Therefore, we interviewed oil industry experts, members of our group of experts, and representatives from companies that comprise 76 percent of the refining capacity of the United States to learn about issues with SPR operation not included in the models that affect the extent to which the SPR can protect the economy.

To learn about the circumstances under which a larger SPR would be warranted, we reviewed U.S. stockholding obligations to the International Energy Agency, estimates of future U.S. oil demand, and a 2005 study performed by a contractor for DOE that analyzed the expected costs and

[6]Four organizations comprise the National Academies: the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council.

benefits of expanding the SPR.[7] We also reviewed studies and interviewed members of our National Academy of Science group of experts and other oil market experts about factors that influence the ideal size of the SPR. Our intent was to present useful information and discussion of key considerations about expanding the SPR, not to make recommendations about whether the SPR should be expanded.

We did not independently verify information about security, drawdown rates, or other operational factors reported by the Office of Petroleum Reserves, nor did we analyze or verify strategic reserves held by other countries that belong to the International Energy Agency. A more detailed description of our scope and methodology is included in appendix I. We performed our work between March 2005 and July 2006 in accordance with generally accepted government auditing standards.

Results in Brief

The group of experts with whom we consulted recommended a number of factors to be considered for filling and using the SPR. With regard to filling the SPR, although recent fill activity during a time of tight supply and demand conditions raised some concerns that filling the SPR was increasing world oil prices, experts generally agreed that the nearly steady acquisitions of oil for the SPR from late 2001 through 2005 caused minimal increase in world oil prices. To reduce the cost of filling the reserve, experts in our group and others recommended acquiring a steady dollar value of oil over time—that is, a dollar-cost-averaging approach—to ensure that more oil is acquired when prices are low and less oil is acquired when prices are high. We estimated that if DOE had followed a dollar-cost-averaging approach when filling the SPR from October 2001 through August 2005, it could have saved approximately $590 million while acquiring the same amount of oil. Simulations we performed of this approach under various potential oil market conditions, including scenarios of rising and falling prices and periods of smaller and larger price volatility, showed that this approach would likely save money in the future as well. Some experts also suggested that DOE should allow oil producers to delay oil delivery to the SPR when supply and demand are in tight balance. Producers could provide additional oil to the SPR to pay for the privilege of delaying delivery. With regard to using the SPR, experts

[7] Leiby, Paul and David Bowman, *Economic Benefits of Expanded Strategic Petroleum Reserve Size or Drawdown Capability*, Oak Ridge National Laboratory (Oak Ridge, TN: Dec. 31, 2005).

generally supported providing broad discretion about when to use the reserve, although they questioned some past presidential decisions about SPR use. Experts also described several key factors to consider when making future decisions about using the SPR, including using the SPR without delay when it is needed to minimize economic damage.

The SPR is an extremely valuable asset, and releasing oil from the reserve during oil supply disruptions could greatly reduce the damage to the U.S. economy, as measured by losses in GDP. According to DOE, the SPR can currently release up to 4.4 million barrels of oil per day—about 44 percent of U.S. daily oil imports—for 90 days, and can release a diminishing amount of oil for an additional 90 days. This level alone is sufficient to completely replace oil lost in the Gulf Coast hurricane and Venezuelan strike scenarios we evaluated and, when combined with international reserves, can completely replace the losses from our Iranian embargo and Saudi terrorism scenarios. However, world reserves are inadequate to fully replace the oil lost in our most catastrophic scenarios: that is, the closure of the Strait of Hormuz and the loss of Saudi oil production. DOE uses one model to estimate the net benefits of expanding the SPR and another model to estimate the economic effect of oil supply disruptions. These models rely on different assumptions, particularly about the effect of oil price increases on GDP. Both models show a positive effect from using SPR, although the results are very different in magnitude. For example, for our Gulf Coast hurricane scenario, the Office of Petroleum Reserves and EIA models estimate avoided GDP damage of $7 billion and up to $400 million, respectively; in our Saudi shutdown scenario, the models estimate avoided GDP damage of $170 billion and up to $66 billion, respectively. The substantial differences between the results of these two models could lead offices within DOE to provide inconsistent advice about expanding and using the SPR. Additionally, several factors beyond the SPR's ability to replace oil could decrease or increase the economic benefit of the reserve. For example, the crude oil in the SPR is not compatible with all U.S. refineries. During a disruption of heavy crude oil supply, refineries configured to use this type of crude oil would have to reduce production of some petroleum products if they processed the lighter oil stored in the SPR. This decrease in production could raise prices for these products and decrease the SPR's effectiveness in reducing economic damage.

If demand for oil in the United States increases as expected, a larger SPR would be necessary and desirable to maintain the economy's existing level of protection. EIA recently projected increases in U.S. demand for petroleum products of approximately 12 percent by 2015 and 24 percent by

2025, compared with the 2005 level. Using these demand projections, DOE estimates that the United States will drop below its stockholding obligation to the International Energy Agency by 2025. Additionally, a 2005 study prepared for DOE finds that the benefits of expanding the SPR to 1.5 billion barrels exceed the costs over a range of future conditions. However, factors that influence the SPR's ideal size are likely to change over time. For example, although projections show increasing oil demand in the United States and world, the level of oil demand depends on many factors, including rates of economic growth, the price of oil, future policy choices related to increasing conservation and availability of alternative energy sources, and technology changes. As the world oil market changes over time, periodic reassessments by DOE of the appropriate size of the SPR could be helpful as part of the nation's long-term energy security planning.

We are making four recommendations to the Secretary of Energy to improve the operation of the SPR and to improve decisions surrounding the SPR's use and expansion. Specifically, we are recommending that the Secretary should (1) study how to best implement experts' suggestions to fill the SPR more cost-effectively, including acquiring a steady dollar value of oil for the SPR over the long term and providing industry with more flexibility in the royalty-in-kind program to delay oil delivery to the SPR; (2) conduct a new review to examine the maximum amount of heavy oil that should be held in the SPR and ensure that DOE implements its own recommendation to hold at least 10 percent heavy oil in the SPR; (3) clarify the differences in structure and assumptions between the models used by the Office of Petroleum Reserves and EIA and clarify to policymakers how the models are used; and (4) periodically reassess the appropriate size of the SPR in light of changing oil supply and demand in the United States and the world. In commenting on a draft of this report, DOE generally agreed with the report and recommendations.

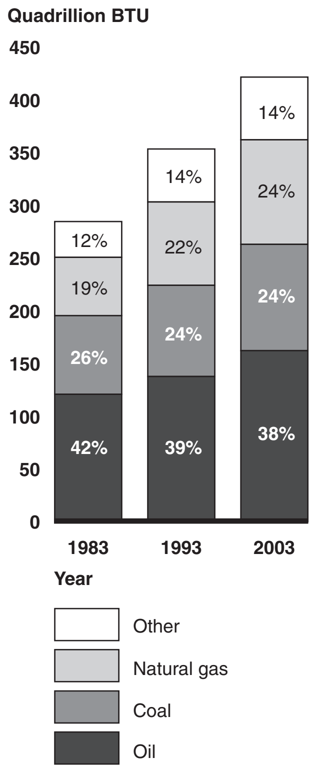
Background

Oil is vitally important to the world and U.S. economy, accounting for nearly 40 percent of world primary energy consumption.[8] As shown in figure 1, although world oil consumption has increased significantly over the past 20 years, oil's share of primary energy consumption has remained fairly constant. EIA projects similar trends for the next 20 years, with total

[8]Primary energy is all energy consumed by end-users—excluding electricity, but including the energy consumed at electric utilities to generate electricity.

world energy consumption increasing 2 percent annually through 2025 and oil comprising about 38 percent of all energy consumption in 2025.[9]

Figure 1: World Primary Energy Consumption



Source: GAO analysis of EIA data.

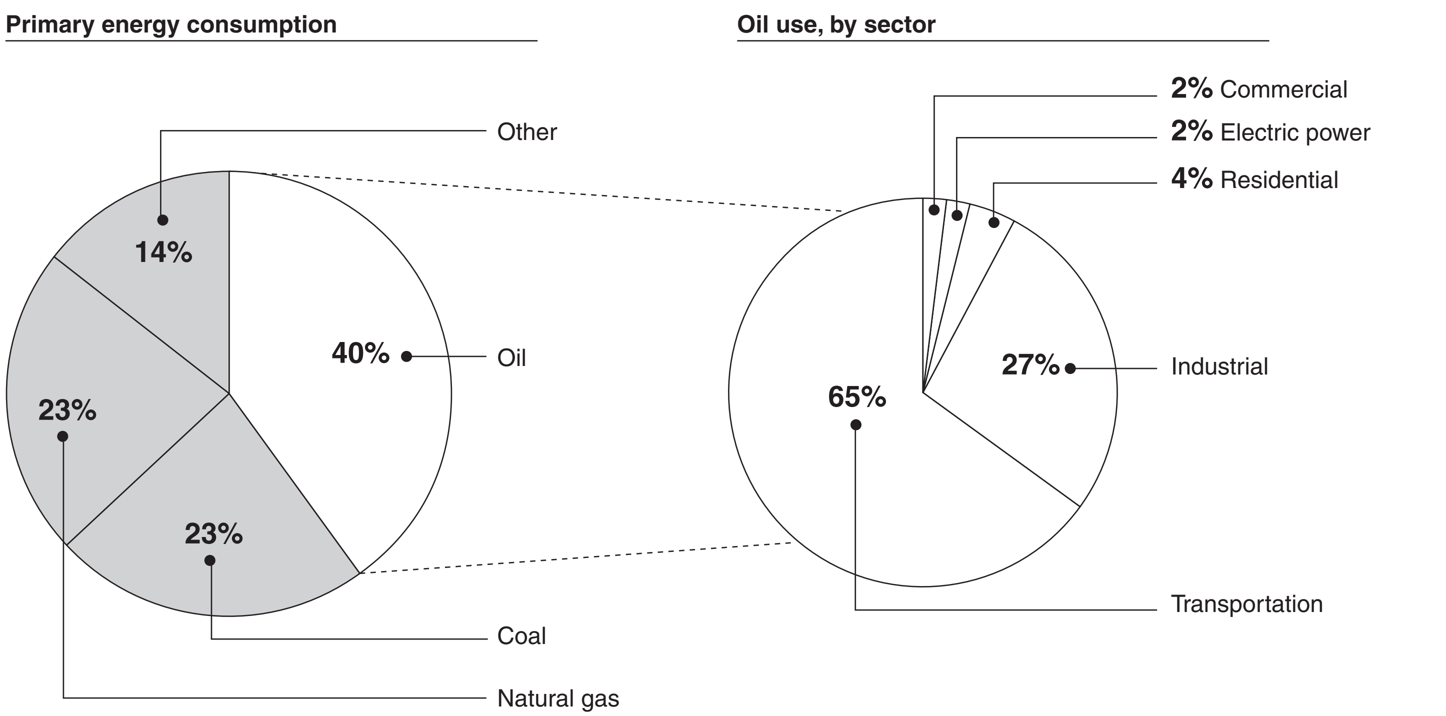
Note: Percentage shares may not add to 100 percent due to rounding.

Oil is also the largest primary source of energy in the United States, accounting for about 40 percent of all energy consumed in 2004. As shown in figure 2, two-thirds of the oil consumed in the United States is used for transportation. About 96 percent of energy used for transportation in the United States comes from oil. The transportation sector is almost exclusively dependent on oil because there are no significant competitive alternatives. EIA projects that transportation will comprise an even larger part of U.S. oil use in the future, about 72 percent in 2030, because it

[9]DOE, EIA, *International Energy Outlook 2005*, DOE/EIA-0484(2005) (July 2005).

expects the growth in demand for transportation to far exceed increases in fuel efficiency.[10]

Figure 2: U.S. Oil Consumption, by Sector, 2004

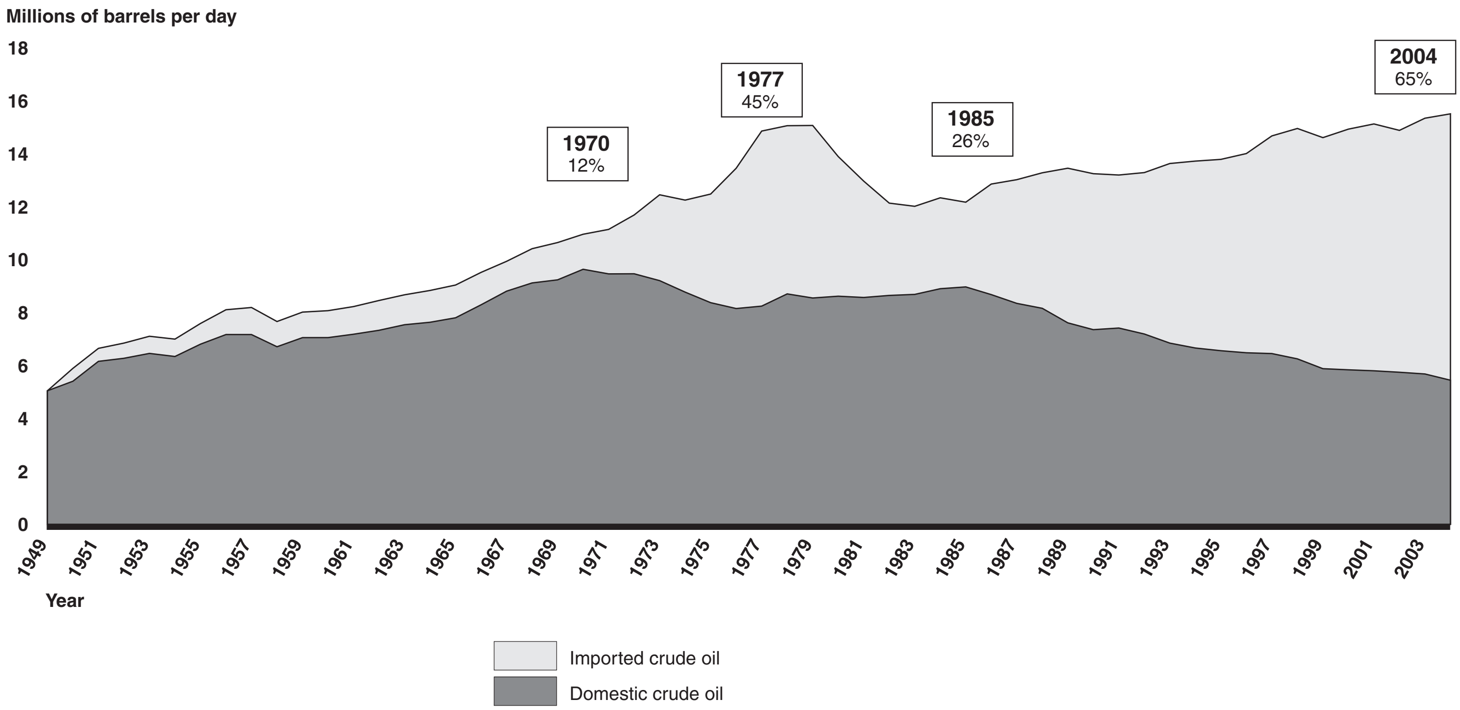


Source: GAO analysis of EIA data.

As shown in figure 3, the United States' demand for imported crude oil increased rapidly after 1970, when domestic crude oil production peaked. Although the percentage of imported crude oil decreased from about 45 percent in 1977 to about 26 percent in 1985 due to a reduction in demand for oil, imported crude oil increased again to 65 percent by 2004 due to a combination of increases in consumption and decreases in domestic production.

[10]DOE, EIA, *Annual Energy Outlook 2006*, DOE/EIA-0383(2006) (February 2006).

Figure 3: United States' Use of Domestic and Imported Crude Oil



Source: GAO analysis of EIA data.

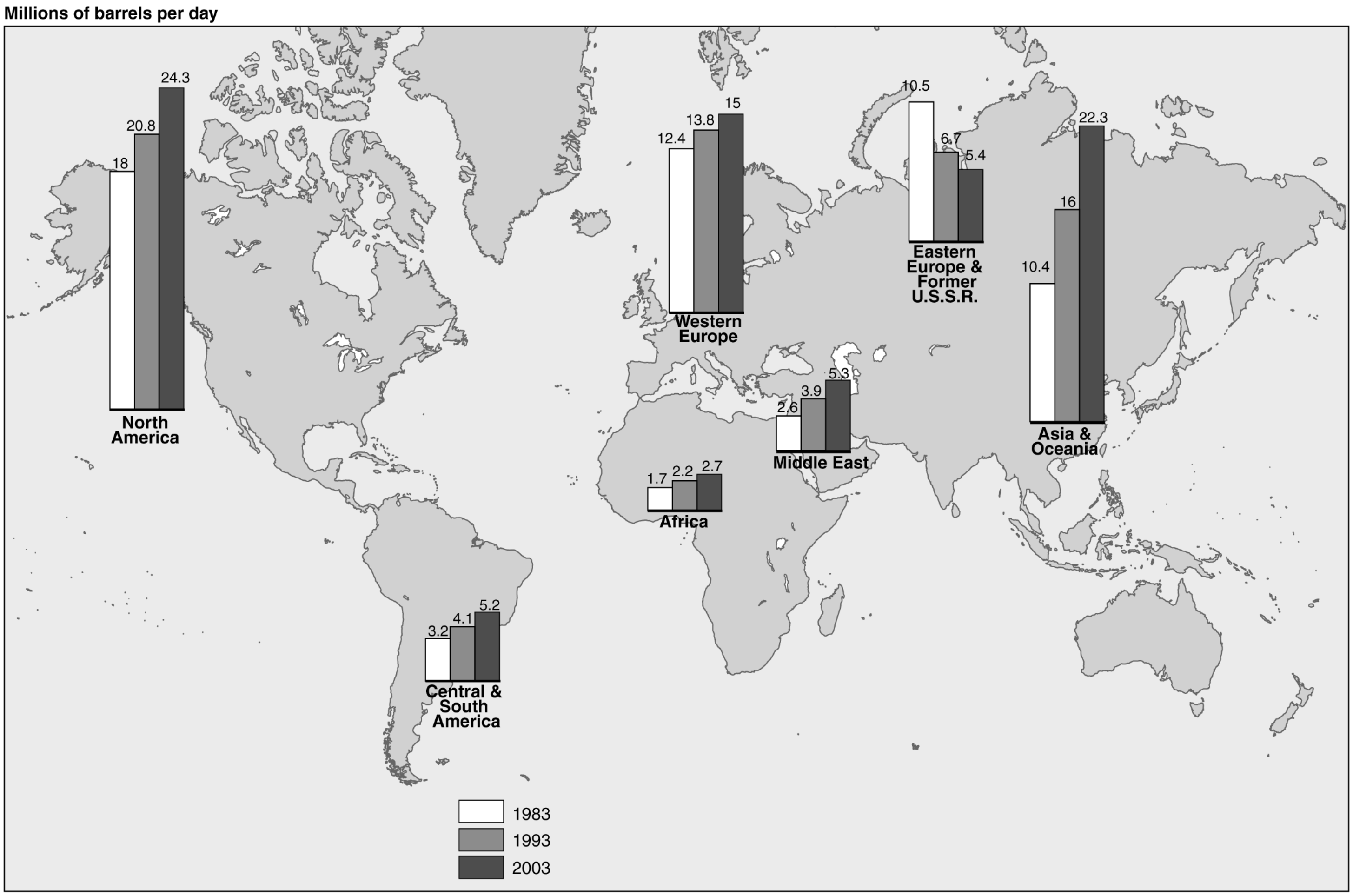
The United States created the SPR because the country's reliance on oil imports makes it vulnerable to disruptions in oil supply. Strategic oil reserves like the SPR are particularly important now because oil market cushions, such as excess oil production capacity and private inventories, have decreased in recent years. Although estimates of spare production capacity are uncertain, experts believe that spare production capacity dropped to around 1 million barrels per day in 2004, close to a 20-year low. Additionally, private inventories of oil and oil products have been on a long-term declining trend, in part because of a trend toward just-in-time inventory. The absence of these market cushions means that less oil is available in the market to mitigate price spikes during oil supply disruptions. Thus, a supply disruption that takes even a small amount of oil off the market could cause the price of oil to rise dramatically.

One factor limiting excess oil production capacity is recent steep increases in world consumption of oil. Together, the United States and Western Europe accounted for 44 percent of the 80 million barrels of oil per day of world oil consumption in 2003.[11] The United States is the world's largest oil consumer, accounting for about 25 percent of the world's oil consumption, despite having only 5 percent of the world's population. In addition to the high levels of consumption in the United States and Western Europe, oil consumption has also been rising rapidly in Asia and Oceania, as shown in figure 4. For example, according to a recent study by the International Monetary Fund, China and India accounted for 35 percent of incremental oil consumption between 1993 and 2003, even though they accounted for only 15 percent of world economic output over the period.[12] China has overtaken Japan as the second largest oil consumer in the world, second to the United States.

[11]The countries included in Western Europe are as follows: Austria, Belgium, Bosnia and Herzegovina, Croatia, Denmark, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Iceland, Ireland, Italy, Luxembourg, Macedonia, Malta, the Netherlands, Norway, Portugal, Serbia and Montenegro, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

[12]International Monetary Fund, *World Economic Outlook, Globalization and External Imbalances* (April 2005).

Figure 4: World Oil Consumption, by Region



Source: GAO analysis of EIA data.

Since 1976, the United States has spent about $26.3 billion—$45.2 billion when valued in year 2005 dollars—to build, maintain, fill, and manage the SPR. The largest cost has been the cost of filling the reserve. Since filling began in 1977, $20.0 billion has been spent to obtain oil ($35.1 billion in 2005 dollars).[13] This amount includes $15.7 billion of oil purchased with

[13]Our cost estimate for obtaining oil is the cost of filling the reserve to its current level. Funds appropriated for purchasing oil that were later rescinded are not included, nor are funds used to purchase oil that has since been withdrawn from the SPR and sold.

funds appropriated from 1977 through 1992, and $4.3 billion of oil received in lieu of government royalty payments since 1999.

Since 1999, oil for the SPR has been obtained through the royalty-in-kind transfer program, in which royalties from government oil leases in the Gulf of Mexico are taken in the form of oil, rather than in cash. The Department of the Interior's Minerals Management Service, which collects the royalties, contracts for delivery of the royalty oil to designated market centers. Because the oil delivered to these market centers often does not meet SPR quality specifications and is distant from the SPR storage sites, DOE awards complementary contracts to exchange royalty oil at the market center for SPR-quality oil delivered to the SPR facilities. However, the logistics of Gulf of Mexico oil production from federal leases limits the rate at which royalty oil can be economically delivered to the SPR sites.

The SPR oil is stored in salt caverns at the following four facilities: Bayou Choctaw and West Hackberry in Louisiana, and Big Hill and Bryan Mound in Texas. These caverns range in size from 6 million to 35 million barrels and were created by solution mining, in which water injected into an underground salt formation dissolves the salt and creates a cavern. According to DOE, salt caverns offer the lowest cost, most environmentally secure way to store crude oil for long periods of time. Storing oil in aboveground tanks generally costs 5 to 10 times as much. Also, because the salt caverns are 2,000 to 4,000 feet below the surface, geologic pressure will seal any crack that develops in the salt formation, ensuring that no crude oil leaks from the cavern. An additional benefit is the natural temperature difference between the top of the caverns and the bottom, which keeps the crude oil continuously circulating in the caverns, ensuring that the oil in the cavern is of consistent quality.

Areas near the Gulf of Mexico were a logical choice for locating the SPR. In addition to the more than 500 salt domes concentrated along the Gulf Coast, many U.S. refineries and distribution points for tankers, barges, and pipelines are available. The four SPR storage areas are connected via pipelines to the Gulf Coast and the Midwest refining regions. Oil can be transferred via tanker to the Louisiana Offshore Oil Port, which is a major facility in the Gulf of Mexico that is connected via pipeline to over 50 percent of the United States refining capacity. The location of the SPR is less advantageous for distributing oil to or receiving it from the western United States.

Past drawdowns of the SPR have occurred for a wide variety of reasons. The SPR has sold oil twice under emergency conditions, 17.3 million barrels in 1991 at the beginning of Operation Desert Storm and 11.0 million barrels in 2005 after Hurricane Katrina. In response to problems ranging from a blocked pipeline to a potential shortage of commercial heating oil stocks, exchanges of crude oil from the SPR with private companies have occurred eight times, ranging in size from 500,000 barrels to 30 million barrels. The largest exchange occurred in the fall of 2000 in response to concerns about low inventories of heating oil in the Northeast. In these exchanges, the borrowing parties returned the amount of oil borrowed plus additional volumes of oil as interest. In two cases, conducted for operational reasons, the SPR exchanged 11.0 million barrels of lower quality oil for 8.5 million barrels of higher quality oil and 2.7 million barrels of crude oil for 2.0 million barrels of heating oil. DOE has also conducted two test sales to demonstrate the readiness of the SPR, in 1985 and 1990. In addition, sales to reduce the federal deficit occurred mainly in 1996.

Based on Historical Experience, Experts Suggested Alternative Practices for SPR Fill and Points to Consider for Use

Recent concerns about filling the SPR and long-standing concerns about its use can be addressed in ways that improve SPR effectiveness, according to numerous energy and oil market experts. A number of persons have raised questions because they believe that recent efforts to fill the SPR during tight oil supply conditions put upward pressure on oil prices. Others have expressed concerns that the SPR has not been used in disruptions where its use was warranted and, when used, has not been used early enough after a disruption has occurred. In addressing these concerns, experts with whom we spoke suggested alternative practices to consider when filling the SPR to reduce fill costs, as well as various points to consider when deciding whether to use the SPR.

Experts Suggested Practices to Reduce the Cost of Filling the SPR

While early SPR fill activity focused on establishing an oil reserve large enough to be useful during a supply disruption, more recent fill activity has focused on maximizing long-term protection against disruptions. Although several oil analysts and experts believe that filling the SPR from late 2001 through 2005 during a time of tight supply and demand conditions caused the price of oil to increase by several dollars per barrel, most of the experts with whom we spoke believe that filling the SPR at that time had minimal impact on oil prices because the volume was so small compared with world oil demand. Experts suggested SPR fill practices that could reduce the cost of filling the SPR. They recommended that DOE acquire a fixed dollar value of oil per time period, rather than a fixed volume of oil per time period, and allow industry more flexibility in the timing of oil deliveries to the SPR.

Early Fill Activity Was Generally Focused on Making the SPR Large Enough to Respond to Disruptions

Prior to 1984, several pieces of legislation set forth minimum fill rates for the SPR, in an effort to increase the volume of the reserve to a level large enough to be useful during an oil supply disruption. However, the actual rate of fill often fell short of these goals. Several studies completed around this time reported that, given the SPR's small size, it should be reserved for severe disruptions since it is a one-time source of crude oil, which must be replenished after a drawdown. They advised that only after the SPR contained a minimum of 250 million to 500 million barrels of oil would it be advisable to use it. In a September 1981 report, we echoed this concern, believing that DOE should not suspend SPR fill, except during severe disruptions, until the SPR reached a minimum threshold size.[14] Furthermore, we stated that, given the importance of the SPR, filling it should be considered a part of U.S. base demand and should not be cut back under tight market conditions.

Figure 5 shows the progress in filling the SPR since its inception in 1975. Fill was suspended from September 1979 to September 1980 when oil supplies were disrupted following the Iranian Revolution. The SPR reached a volume of about 500 million barrels in 1985, and filling the reserve slowed considerably after that time. SPR fill was again suspended in 1990 after the Iraqi invasion of Kuwait. The size of the SPR did not significantly increase again until after the September 11 terrorist attacks, when the President ordered DOE to fill the SPR to its 700 million barrel capacity to maximize the long-term protection against potential oil supply disruptions.[15] The President's statement accompanying the fill order indicated that, although current strategic inventories in the United States and other countries were sufficient to meet any potential near-term supply disruption, filling the SPR to capacity would strengthen the long-term energy security of the United States. The President directed that the SPR be filled in a deliberate and cost-effective manner, principally through royalty-in-kind transfers. From April 2002 to August 2005, DOE added 138 million barrels to the SPR at a

[14]GAO, *The United States Remains Unprepared For Oil Import Disruptions*, Volumes I and II, GAO/EMD-81-117 (Washington, D.C.: Sept. 29, 1981).

[15]Since 2003, due to physical changes in the caverns and the recertification of a previously out-of-service cavern, SPR's capacity has increased to 727 million barrels.

cost of $4.3 billion.[16] The SPR received oil from the royalty-in-kind program at average rates varying from about 60,000 to 116,000 barrels per day, although fill was suspended twice during this period, including January to April 2003 in response to the disruption of crude oil supplies from Venezuela.

Figure 5: SPR Inventory Over Time

Source: GAO analysis of EIA data.

Note: Congress authorized the SPR in 1975, but filling the reserve did not begin until 1977.

Experts Generally Agreed That Recent SPR Acquisitions Caused Minimal Increase in Oil Prices, and Suggested Practices to Reduce the Future Cost of SPR Fill

The President's directive to fill SPR in 2001 became controversial. Several oil analysts and experts believe that filling the reserve at that time caused the world price of oil to increase by several dollars per barrel. Most of the oil experts with whom we spoke, however, believe that filling the SPR had minimal impact on oil prices, because the volume of oil going to the SPR was very small, less than one-quarter of 1 percent of total world demand.

[16] Because oil was added to the SPR at that time using the royalty-in-kind program, the $4.3 billion cost represents forgone revenue to the U.S. government, rather than federal funds spent.

To decrease the cost of filling the SPR, many experts recommend changes in SPR practices, including more flexible timing of oil acquisition. Generally, all fill options must balance the cost of adding oil to the SPR now against the benefits that the additional oil will provide in the future. During the initial filling of the SPR, it was clear that the benefits of adding oil outweighed the immediate costs of doing so. However, now that the SPR holds nearly 700 million barrels of oil, there is a greater interest in finding ways to reduce the acquisition costs.

Several experts suggested that DOE should use a predictable, transparent long-term process to acquire oil for the SPR. For example, some experts suggested a dollar-cost-averaging approach, where DOE would acquire a steady dollar value of oil per time period (e.g., day or month) instead of a relatively steady volume, as has generally been the case in recent years. A dollar-cost-averaging approach would take advantage of fluctuations in oil prices, since the same dollar amount will purchase more oil when prices are low than when prices are high. To evaluate the effect of a dollar-cost-averaging approach on SPR fill cost, we estimated the potential savings of this approach had it been used from October 2001 through August 2005. Our results showed that if DOE had followed a dollar-cost-averaging approach when filling the SPR during that time, it could have saved approximately $590 million while acquiring the same amount of oil. We also ran simulations to estimate potential future cost savings from using a dollar-cost-averaging approach over 5 years. The simulations showed that dollar cost averaging is likely to save money over a range of plausible paths of future oil prices, whether prices are rising or falling and whether price volatility is small or large. The savings due to dollar cost averaging were generally greater when oil prices were more volatile.

As an additional measure, some experts suggested that DOE exercise flexibility and react to market conditions when filling the SPR. They said that DOE should not fill the SPR when the oil market is tight or when doing so would significantly tighten the market. DOE officials told us that the department has approved some delivery deferrals that contractors have requested, in particular after the oil workers' strike in Venezuela, but DOE has also turned down some requests. In return for these deferrals, DOE received additional barrels of oil as a premium. From October 2001 through August 2005, payment for deferrals added 4.6 million barrels of oil to the SPR, with a value of approximately $110 million. Some experts suggested that DOE could expand the use of deferrals by allowing oil producers to delay oil delivery to the SPR when they believe that supply and demand are in tight balance and current prices are higher than expected future prices.[17] Under these conditions, it is financially advantageous for oil producers to delay delivery, and producers could provide additional oil to the SPR to pay for the privilege of delaying delivery. Experts noted that there may be considerations beyond the oil market, such as national security concerns, that would necessitate the delivery of oil to the SPR at a particular time, therefore, DOE would want to exercise its authority to disallow deferrals at times when it is in the national interest that oil deliveries not be delayed.

Experts Suggested Several Points to Consider When Deciding on SPR Use

The law allows broad presidential discretion and provides only general guidance for the SPR's use, making use of the SPR a matter of judgment by the President. SPR use decisions are largely a matter of judgment, and members of our group of experts disagreed about the appropriateness of past use decisions. Past drawdowns have been for widely varying purposes, including emergency responses, test sales, and deficit reduction. In addressing use-related issues, experts suggested several points to consider when deciding whether to use the SPR.

SPR Legislation Allows Broad Presidential Discretion

The President has the primary authority to decide when to use the SPR. The Energy Policy and Conservation Act authorizes the President to use the SPR in the event of a severe energy supply disruption or when required to meet the obligations of the United States to the International Energy Agency.[18] Amendments to this act in 1990 gave the President additional authority to use the SPR in reaction to a circumstance that constitutes or is likely to become a significant shortage, and where action taken would assist in preventing or reducing the adverse impact and would not impair national security. These amendments allow for only limited use of the SPR—no more than 30 million barrels may be sold over 60 days, and no sales may be made if the SPR is below 500 million barrels.

In addition to presidential authority, the Secretary of Energy is authorized to carry out test drawdowns and sales or exchanges from the SPR to evaluate the drawdown and sale procedures. The Secretary may not release more than 5 million barrels of oil during such a test. DOE officials pointed

[17]Expected future oil prices are reflected in the futures market, where oil is traded for delivery at a specified place, price, and time in the future.

[18]Pub. L. No. 94-163 (1975).

out that they follow a series of progressive steps in responding to a disruption. They can (1) identify relevant inventories and evaluate market impacts (with the help of EIA); (2) defer any ongoing deliveries to the SPR, thereby making this oil available to the market; (3) make exchanges in response to requests from individual companies facing problems; and (4) arrange for competitive exchanges, whereby companies bid for oil from the SPR by promising to replace it with a greater volume of oil at a specified date in the future. DOE officials believe that this graduated approach allows them a flexible and measured response appropriate to the size of the disruption.

While the President's discretion over the release of oil introduces some uncertainty into the market, it also has certain advantages. Members of our group of experts told us that uncertainty around SPR use can be valuable. For example, the President can use the SPR as a bargaining tool in diplomatic negotiations during energy crises, enabling him to encourage behavior by oil-producing nations that could be beneficial to the United States.

Members of our Expert Group Disagreed about Past SPR Use Decisions

Members of our group of experts disagreed about the appropriateness of past SPR use decisions. Since the decision about whether the SPR should be used to ameliorate a situation is generally a matter of judgment, experts tend to view past decisions from the perspective of hindsight. For example, several members of our group told us that they believed the oil workers' strike in Venezuela in 2002 to 2003 was a clear case in which SPR use was appropriate, although the reserve was not used in response to the strike. However, DOE officials stated that oil from the SPR was not needed during the strike. They noted that other oil-producing nations had agreed to increase production, and that the U.S. government allowed oil companies to delay delivery of oil to the SPR—which together added significant quantities of oil to the market.

Members of our group of experts held a range of views about the timeliness of past use, including the SPR's first emergency use during the Gulf War in 1991. While some said that reserve use in this instance was timely and showed the market that supply would be available, others contended that the United States did not use the SPR soon enough, when it could have dampened oil price increases and prevented the U.S. economy from slipping into a recession. However, these experts acknowledged the difficulty of disentangling the effects of the war from the effects of the SPR release on oil prices.

Group members were generally supportive of SPR use in response to Hurricane Katrina in 2005. Several experts agreed that this use of SPR demonstrated that the government understood its role as one of complementing rather than competing with the market.

Experts Suggested Several Points to Consider When Making Decisions about SPR Use

Despite the lack of clear consensus regarding previous decisions to use the SPR, experts in our group suggested several points that policymakers should consider when deciding whether to use the SPR: (1) that recent increases in the size of the SPR should result in a greater willingness to use it during a disruption, (2) that more extensive experience with the SPR during oil supply disruptions may enable better understanding of the features of each disruption that determine whether SPR use is warranted, and (3) that using the SPR without delay when it is needed will minimize economic damage. DOE officials told us that, while they do not have a formal checklist, they consider all relevant features when considering SPR use during a disruption, including the features noted by our group of experts.

First, experts in our group and in interviews noted that the SPR is much larger today than in the past, and that this change allows the SPR to be used with less concern about keeping enough oil in the reserve for future disruptions. Members of our expert group pointed out that today's larger reserve diminishes the value of holding oil back during a disruption as a hedge against possible future disruptions, and they noted greater willingness to use reserves in response to disruptions now than in the past.

Second, more extensive experience with the SPR during past disruptions may enable better understanding of the unique features of future oil disruptions that warrant a release of oil from the SPR. In a 1993 report,[19] we stated that U.S. policy emphasized initially relying on free market forces in oil supply disruptions. However, the report observed that this policy provides little specific guidance on how long market forces should be allowed to operate before the SPR is used or what conditions should dictate its use. Experts in our group agreed that the SPR should be used to supply oil during disruptions where the market cannot make up for lost supply. Experts also identified a variety of specific features of disruptions that could help determine when SPR use is warranted. These features included the volume of oil disrupted, the type of oil disrupted, the

[19]GAO, *Energy Security and Policy: Analysis of the Pricing of Crude Oil and Petroleum Products*, GAO/RCED-93-17 (Washington, D.C.: Mar. 19, 1993).

availability of spare oil production capacity, the source of the disruption and its distance from the United States, and the time of year that the disruption occurs (with implications for gasoline supplies in the summer and heating oil in the winter).

Economic experts have described additional points to consider when making decisions about using the SPR during a disruption.

- Experts noted that not all oil price increases are equally damaging to the economy. Economic research shows that rapid oil price increases, or price shocks, are much more harmful to the economy than oil price increases along a steady upward path. For example, one expert noted that although average world crude oil prices increased by more than $30 per barrel between 2001 and 2005, there was no price shock, and the U.S. economy remained strong, growing at about 3.5 percent annually during this period.

- Under some conditions, decision makers could use monetary policy to partially offset economic damage from an oil price shock. The Federal Reserve might be able to prevent some economic damage by allowing a one-time increase in the money supply to stimulate spending and spur GDP growth. However, not all economists agree that monetary policy would be effective, or that monetary policy could offset the impacts of a disruption without having other negative impacts on the economy.

Third, avoiding delay in using the SPR when its use is warranted will minimize economic damage. Expert group members encouraged early use of the SPR as a first line of defense against oil supply disruptions, noting that recent changes in the oil industry—including diminished spare crude oil production capacity, refining capacity, and product inventories—have removed sources of supply security that have covered short-term supply losses in the past. Additionally, some experts believe that much of the harm to the U.S. economy occurs in the early phases of a disruption, before the economy has a chance to adjust to higher prices.

Avoiding delay in SPR use is also important because even when spare production capacity is available in the world to take the place of disrupted oil supply, this oil will take time to reach the United States. EIA estimates that the majority of the world's spare oil production capacity is located in Saudi Arabia and takes about 30 to 40 days to reach the United States. For this reason, experts told us that spare capacity would be unlikely to mitigate the early stages of a domestic disruption or a disruption affecting a nearby oil supplier, such as Venezuela, whose oil takes about 5 to 7 days to reach the Gulf Coast of the United States.

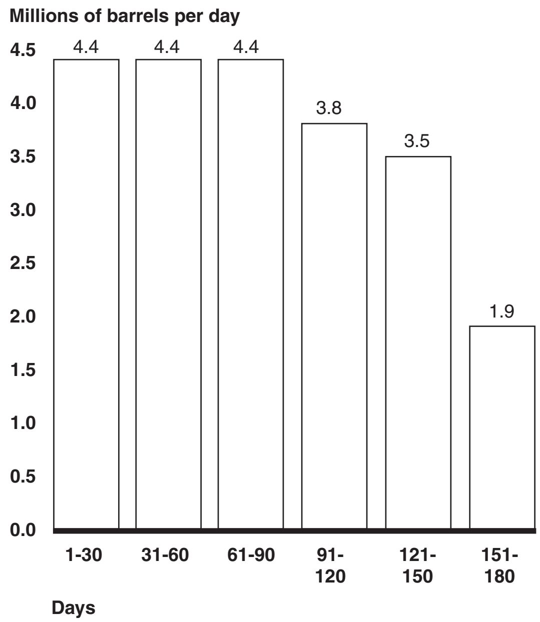
SPR Use during Disruptions Can Provide Substantial Benefits, but the Magnitude of These Benefits Is Uncertain

At their current capacities, the SPR and international reserves can replace the oil lost in all but the most catastrophic disruptions. Doing so protects the economy from significant damage, according to the results of two DOE models, although these models disagree about the magnitude of the avoided damage. Additionally, several factors beyond the SPR's ability to replace oil could decrease or increase the economic benefit of the reserve, such as the compatibility of SPR oil with some U.S. refineries.

SPR and International Reserves at Their Current Size Can Replace the Oil Lost in All but the Most Catastrophic Disruptions

In June 2006, the SPR contained 689 million barrels of oil that can be released at a maximum initial rate of 4.4 million barrels a day, a rate that can replace about 44 percent of U.S. oil imports. As shown in figure 6, the maximum drawdown rate gradually decreases after 90 days as the storage caverns are emptied. If the SPR is drawn down more slowly, it could release a million barrels of oil per day for nearly 1½ years, or at smaller rates for an even longer period.

Figure 6: SPR Maximum Drawdown Capability



Source: DOE's Office of Petroleum Reserves.

In addition to the reserves in the United States, members of the International Energy Agency have about 2.7 billion barrels of public and industry reserves, of which about 700 million barrels are government-controlled for emergency purposes.[20] These government-controlled reserves can release a maximum of about 8.5 million barrels of oil and petroleum products per day, diminishing quickly to about 4.5 million barrels per day after 30 days, about 3.5 million barrels per day after 60 days, and slightly more than 1 million barrels per day after 90 days. Reserves of refined petroleum products, such as gasoline or diesel, can be useful during oil supply disruptions, but they are more expensive to store than crude

[20]Our definition of "emergency stocks" held by member countries of the International Energy Agency includes those stocks completely financed by governments and agency stocks. Agency stocks are generally held under a cost-sharing agreement between private entities and government.

oil.[21] We did not independently verify the potential drawdown rates of international reserves.

The SPR, either alone or in combination with these international reserves, can replace the oil lost in four of the six hypothetical disruption scenarios that we developed for this review. The six scenarios are (1) a hurricane in the U.S. Gulf Coast, (2) a strike among oil workers in Venezuela, (3) an embargo of Iranian oil supply, (4) a terrorism event at an oil facility in Saudi Arabia, (5) closure of the Strait of Hormuz, and (6) a shutdown of Saudi Arabian oil production. For each scenario, we assume that world excess crude oil production capacity and world fuel-switching capabilities, which together total 850,000 barrels per day, are available immediately to help offset a disruption.[22] We also assume that private inventories of crude oil are neutral during a disruption—holders of private inventory neither draw down their inventories nor hoard oil. (See app. II for a more detailed description of our scenarios.)

As shown in table 1, the SPR is large enough and has enough drawdown capacity to completely replace the oil lost during our Gulf Coast hurricane and Venezuelan strike scenarios, which reduce world oil supply by 155 million barrels over 6 months and 307 million barrels of oil over 24 months, respectively. The SPR could eliminate these hypothetical disruptions by releasing 24 million and 87 million barrels of oil, respectively, and world spare capacity and fuel switching would make up the remaining 131 million and 220 million barrels.

[21]The Northeast Home Heating Oil reserve, located in Connecticut, Rhode Island, and New Jersey, contains 2 million barrels of heating oil that can be used during supply disruptions. This reserve is not considered in the following analysis.

[22]Since the majority of excess oil production capacity is currently located in Saudi Arabia, assuming that this capacity would be available for our Saudi disruption scenarios produces a conservative estimate of the economic damage that could result from such a disruption.

Table 1: Ability of the SPR and International Reserves to Replace Oil

Barrels in millions

Hypothetical oil supply disruption scenario	Disruption length (months)	Disruption size	Excess capacity and fuel switching	Release from the SPR alone: Can replace oil?	Release from the SPR alone: Volume of release	Release from the SPR and international reserves: Can replace oil?	Release from the SPR and international reserves: Volume of release
Gulf Coast hurricane	6	155	131	Yes	24	Yes	24
Venezuelan strike	5	307	220	Yes	87	Yes	87
Iran embargo	18	1,478	465	No	684	Yes	1,013
Saudi terrorism	8	882	207	No	650	Yes	675
Strait of Hormuz closure	3	882	78	No	344	No	688
Saudi shutdown	24	6,205	620	No	684	No	1,461

Source: GAO assumptions and analysis of data from Leiby, Paul N. and David W. Bowman, "Disruption Scenarios and the Avoided Costs Due to SPR Use," *Oak Ridge National Laboratory Working Paper* (Jan. 19, 2006).

The SPR alone is not large enough to replace all of the oil lost in our Iranian embargo scenario, and it does not have enough drawdown capacity to completely replace the oil lost during our Saudi terrorism scenario. Our Iranian embargo scenario assumes a disruption of almost 1.5 billion barrels of oil over 18 months. Even if the United States were to release all of the oil in the SPR and if excess production capacity and fuel switching were available in the amount assumed here, there would still be a net disruption of slightly more than 300 million barrels. In our Saudi terrorism scenario, the drawdown capacity of the SPR would be insufficient to replace the oil lost during the 1st month of the disruption. For the SPR to replace the oil during the 1st month with no assistance from international reserves, maximum SPR drawdown capacity would need to be increased by almost 1 million barrels per day, to a total drawdown capacity of approximately 5.2 million barrels per day. In both of these cases, however, a coordinated international response could replace all of the disrupted oil.

Even with a coordinated response, the SPR and international oil reserves are not adequate to replace the disrupted oil from our catastrophic Strait of Hormuz closure and Saudi shutdown scenarios. The drawdown capacity of international reserves is inadequate to replace the very large amount of oil that could be disrupted if the Strait of Hormuz were closed. We assume that a closure of the Strait of Hormuz could disrupt 17 million barrels of oil per day during the 1st month—more than 12 million barrels per day beyond what the SPR could release on its own and more than 4 million barrels per day beyond what could be released during a coordinated international response. In contrast, the volume of oil in international reserves is inadequate to replace the oil lost during our Saudi shutdown scenario. Even if all of the oil in the SPR were used in a unilateral response, the net disruption would still be more than 4.9 billion barrels over 2 years, an amount equal to about 16 percent of the crude oil consumed in the world in 2004. Assuming a coordinated international response, the net disruption would still be over 4.1 billion barrels over 2 years, an amount equal to more than 13 percent of the crude oil consumed in the world in 2004.

SPR Use during Disruptions Can Prevent Substantial Economic Damage

The SPR can reduce economic damage during oil supply disruptions by replacing some or all of the disrupted oil, moderating the resulting oil price increase and its negative effect on U.S. economic activity, as measured by GDP. As previously noted, DOE uses two different economic models to estimate the impact of oil supply disruptions on oil prices and GDP: one used by the Office of Petroleum Reserves and one used by EIA. We used both of these models to estimate the reduction in economic damage (avoided damage) that could result from releasing oil from the SPR and international reserves during our six hypothetical disruption scenarios. (See app. II for additional description of these models and the assumptions used in our analysis.)

Table 2 shows the oil price increases that the Office of Petroleum Reserves' model estimates for our six disruption scenarios if reserves were not used, if the SPR were used alone, and if the SPR were used as part of a coordinated international response. This model estimates oil prices each month during a disruption and assumes that completely replacing the oil lost in a disruption eliminates the resulting price increase. Thus, this model predicts no price increase in situations where the SPR or international reserves can completely replace the disrupted oil, although experts told us that a price increase would likely occur in this instance due to market psychology. For those scenarios where some, but not all, of the oil can be replaced, the model estimates smaller oil price increases than if reserves were not used. For example, the model estimates that oil prices could rise by up to $47 per barrel during our Saudi terrorism scenario if reserves were not used.[23] However, if SPR oil were released into the market, the estimated maximum price increase would be only $7 per barrel. If oil from

[23]For all price estimates, the models assume a base oil price of $55 per barrel.

international reserves were also released into the market, the model estimates there would be no price increase, because the reserve oil would completely replace the disrupted oil.

Table 2: Maximum Monthly Increases in Oil Price, According to the Office of Petroleum Reserves' Model

Dollars per barrel

	Maximum monthly oil price increase		
Hypothetical oil supply disruption scenarios	**No release**	**SPR release**	**SPR and international release**
Gulf Coast hurricane	$5	$0	$0
Venezuelan strike	11	0	0
Iranian embargo	16	5	0
Saudi terrorism	47	7	0
Strait of Hormuz closure[a]	175	121	34
Saudi shutdown	89	77	63

Source: GAO analysis of data from Leiby, Paul N. and David W. Bowman, "Disruption Scenarios and the Avoided Costs Due to SPR Use," *Oak Ridge National Laboratory Working Paper* (Jan. 19, 2006).

Note: For each scenario, we assume that world excess crude oil production capacity and world fuel-switching capabilities, which together total 850,000 barrels per day, are available immediately to help offset a disruption.

[a]This model shows a very large maximum oil price increase in the 1st month of the Strait of Hormuz closure because the disruption volume in this month is the largest of any of the scenarios, even though the volume of the disruption as a whole is smaller.

To estimate how much economic damage could be avoided by using the SPR and international reserves during our oil supply disruption scenarios, we first estimated the damage that would occur if no reserves were used. We then estimated the damage to GDP, if any, from the disruptions if the SPR were used, either alone or in conjunction with international reserves. The difference between the estimates with and without reserve use is the avoided damage to GDP resulting from use of the reserve. As shown in table 3, the Office of Petroleum Reserves' model estimates that the ability of the SPR alone to curb rising oil prices reduces damage to GDP by a range of $7 billion for our 6-month Gulf Coast hurricane scenario to $142 billion for our 8-month Saudi terrorism scenario. In all but the two smallest scenarios, the model shows that a coordinated international response can provide a greater reduction in damage, ranging from $118 billion for the 3-month closure of the Strait of Hormuz to $201 billion for our 18-month Iranian embargo scenario. In our 24-month Saudi shutdown scenario, the model shows that economic damage of approximately

$662 billion occurs even if international reserves were used in response to the disruption.

The damage caused by each disruption and the portion of that damage that can be avoided by releasing reserves depend on the nature of the disruption. For example, the SPR and international reserves cannot eliminate all of the economic damage that could be caused by our Strait of Hormuz closure scenario because, even though the duration is short, it involves a disruption of a very large quantity of oil that the reserves cannot replace. Additionally, the models show that replacement of a portion of the oil lost in the Saudi Arabian shutdown scenario results in less benefit to the economy than completely replacing the oil lost in the smaller Iranian embargo scenario.

Table 3: Ability of the SPR and International Reserves to Reduce Damage to GDP, According to the Office of Petroleum Reserves' Model

Dollars in billions

		GDP damage that can be eliminated by reserves	
Hypothetical oil supply disruption scenarios	**GDP damage caused by disruption**	**SPR alone**	**SPR and international reserves**
Gulf Coast hurricane	$7	$7	$7
Venezuelan strike	23	23	23
Iranian embargo	201	132	201
Saudi terrorism	149	142	149
Strait of Hormuz closure	146	56	118
Saudi shutdown	832	77	170

Source: GAO analysis of data from Leiby, Paul N. and David W. Bowman, "Disruption Scenarios and the Avoided Costs Due to SPR Use," *Oak Ridge National Laboratory Working Paper* (Jan. 19, 2006).

Note: For each scenario, we assume that world excess crude oil production capacity and world fuel-switching capabilities, which together total 850,000 barrels per day, are available immediately to help offset a disruption.

The way in which oil is released from the reserves also impacts how effective the reserves are in preventing damage to GDP. In each scenario, the results previously described include the assumption that release begins immediately and occurs at a steady rate for the entire length of the disruption. The results also include the assumption that the rate of release either completely replaces the oil lost or is the maximum sustainable rate for the entire disruption. Delaying the release of reserves in response to a disruption is harmful in every scenario, and the harm is greater the longer release is delayed. This effect is particularly large in scenarios where more oil is lost at the beginning of the disruption, such as the closure of the Strait of Hormuz or the Saudi terrorism scenarios. Replacing the oil lost during the disruption at the maximum rate possible instead of a steady rate gives a different result only in our largest disruption scenario, the Saudi shutdown. The maximum release strategy is advantageous in this scenario because the model assumes that the economic damage from the disruption is worse at the beginning, before the economy has had a chance to adjust. Since international reserves are emptied to respond to this scenario, releasing more oil at the beginning provides more benefit than releasing at a steady rate.

Table 4 shows the oil price increases that the EIA model estimates for our six oil supply disruption scenarios for the same three circumstances described for the Office of Petroleum Reserves' model: if reserves were not used, if the SPR were used alone, and if the SPR were used as part of a coordinated international response. The EIA model estimates a range of price impacts for each quarter of the disruption, rather than a single value for each month as in the Office of Petroleum Reserves' model. Both models consider the amount of oil disrupted when calculating oil price increases, but the EIA model also estimates the impact of the disruption on market psychology. For example, an EIA official stated that disruptions caused by violent events would have larger price impacts than disruptions caused by peaceful events, such as a strike or natural disaster. Furthermore, the EIA model assumes that even if reserves can replace all of the oil lost in a disruption, oil prices may still increase because of' market psychology. For these reasons, in some cases, the EIA model predicts larger price increases when reserves are used than the Office of Petroleum Reserves' model. For example, for the Saudi terrorism scenario, the EIA model predicts a price increase of $18 to $39 if the SPR were used alone (see table 4), while the Office of Petroleum Reserves' model predicts a maximum price increase of only $7 (see table 2).

Table 4: Maximum Quarterly Increases in Oil Price, According to the EIA Model

Dollars per barrel

	Maximum quarterly oil price increase		
Hypothetical oil supply disruption scenarios	No release	SPR release	SPR and international release
Gulf Coast hurricane	$1 - $2	$0	$0
Venezuelan strike	9 - 13	0 - 2	0 - 2
Iranian embargo	19 - 28	11 - 17	6 - 11
Saudi terrorism	39 - 67	18 - 39	15 - 35
Strait of Hormuz closure	54 - 82	32 - 52	11 - 24
Saudi shutdown	66 - 104	60 - 96	54 - 87

Source: GAO analysis using the EIA model.

Note: For each scenario, we assume that world excess crude oil production capacity and world fuel-switching capabilities, which together total 850,000 barrels per day, are available immediately to help offset a disruption. Oil price increases are modeled for each quarter of the disruption, rather than each month as in the previous model, meaning that the price increases are not directly comparable.

As shown in table 5, the EIA model estimates that the ability of the SPR alone to mitigate increases in oil prices reduces damage to GDP by $0.4 billion to $1.0 billion for our Gulf Coast hurricane scenario up to $15 billion to $38 billion for our Iranian embargo scenario. As with the Office of Petroleum Reserves' model, the EIA model also shows that a coordinated international response reduces more economic harm in each scenario, except those where the SPR can replace the oil alone. As it does with oil price increases, the EIA model estimates a range of GDP damage for each scenario, rather than the single value that the Office of Petroleum Reserves' model produces.

Table 5: Ability of the SPR and International Reserves to Reduce Damage to GDP, According to the EIA Model

Dollars in billions

Hypothetical oil supply disruption scenarios	GDP damage caused by disruption	Damage that can be eliminated by reserves: SPR alone	Damage that can be eliminated by reserves: SPR and international reserves
Gulf Coast hurricane	$0.4 - $1.0	$0.4 - $1.0	$0.4 - $1.0
Venezuelan strike	2.6 - 7.5	2.6 - 6.3	2.6 - 6.3
Iranian embargo	34 - 99	15 - 38	23 - 60
Saudi terrorism	21 - 71	13 - 34	15 - 38
Strait of Hormuz closure	16 - 48	6.9 - 17	13 - 34
Saudi shutdown	137 - 442	11 - 31	24 - 66

Source: GAO analysis using the EIA model.

Note: For each scenario, we assume that world excess crude oil production capacity and world fuel-switching capabilities, which together total 850,000 barrels per day, are available immediately to help offset a disruption.

DOE Models Yield Significantly Different Estimates of the Economic Damage Avoided by Using the SPR

Under every scenario, the EIA model predicts much smaller avoided harm to GDP than the Office of Petroleum Reserves' model. For example, in the Iranian embargo scenario, the Office of Petroleum Reserves' model estimates that using international reserves could prevent $201 billion in economic harm, while the EIA Model predicts $23 billion to $60 billion in avoided harm. This difference occurs primarily because the EIA model assumes that oil price increases cause less harm to GDP, meaning that there is less economic harm for the SPR and other reserves to mitigate. The estimates of the effect of oil price spikes on GDP from the Office of Petroleum Reserves and EIA models are, respectively, near the high end and low end of the spectrum of such estimates in the economic literature. Officials from the Office of Petroleum Reserves and EIA acknowledged that they hold different views about how oil supply disruptions impact the economy. An EIA official also told us that EIA is currently updating its model, although the assumptions about how oil price changes impact GDP have not changed substantially.[24]

[24]The EIA model's update had not been publicly released as of May 25, 2006.

This discrepancy in results between the two models is potentially problematic because the results of the two models are used to support different decisions about the SPR. The Office of Petroleum Reserves' model has been used to estimate the net benefits of expanding the SPR, as described in the following section of this report. The larger economic impacts predicted by the Office of Petroleum Reserves' model would justify a larger SPR than if the model predicted smaller economic impacts. The EIA model is used to estimate the impact of oil supply disruptions and to advise officials about their potential consequences. The smaller economic impacts predicted by the EIA model could lead to recommendations that the SPR not be used as often or for as many oil supply disruptions as would be the case if the model found larger economic impacts. The results of these two models pull decision makers in opposite directions, making it important to clarify the differences between the two models and to ensure that policymakers are aware of the different views within DOE.

Other Factors, in Addition to the SPR's Ability to Replace Oil, May Affect the Extent to Which the SPR Can Protect the U.S. Economy from Damage

The purpose of the SPR is to protect the economy from harm during oil supply disruptions by replacing the disrupted oil. However, factors beyond the amount of oil that SPR can replace affect the extent to which SPR can protect the U.S. economy from damage. For example, during some situations, such as a hurricane, typical transportation routes for oil could be blocked, reducing the benefits of releasing SPR oil. Also, the benefits of releasing SPR oil could also diminish if the type of oil in the SPR is not a good substitute for the disrupted oil, or if refining capacity is damaged. On the other hand, the SPR can provide economic benefits to the United States when it is used as a tool for diplomacy and as a deterrent against intentional disruptions, even when no oil is released.

Transport of Oil to Refineries May Be Difficult during Some Disruptions

During a drawdown, SPR oil is shipped through marine terminals or pipelines. Shipping time from the SPR to different parts of the country varies, as shown in table 6. The oil pipeline network and marine shipping allow SPR oil to reach every region of the United States, except for the Rocky Mountains. Canada provides the only imported oil to the Rocky Mountain region, and DOE believes that a disruption of Canadian oil is unlikely.[25]

[25]Although DOE considers a disruption of Canadian oil unlikely, oil supply disruptions can occur from any supplier, including domestic suppliers.

Table 6: Consumption of Imported Oil and Shipping Time for SPR Oil to Various Regions

Region[a]	2004 crude oil imports (millions of barrels per day)[b]	Days to reach region
1 - East Coast	1,370	6 - 8
2 - Midwest	519	5 - 9
3 - Gulf Coast	5,445	<1
4 - Rocky Mountain	0	N/A
5 - West Coast	864	16 - 18

Source: GAO analysis of DOE data.

[a]DOE divides the United States into five Petroleum Administration for Defense Districts for planning purposes. The result is a geographic aggregation of the 50 states and the District of Columbia into five districts.

[b]This table does not include data on imports from Canada.

The ability of the SPR to reduce economic damage may be impaired if transport of oil to refineries is delayed. For example, the SPR was large enough to replace the oil lost from recent Hurricanes Katrina and Rita, but petroleum product prices still increased dramatically following the hurricanes, in part because power outages shut down pipelines that refineries depend upon to supply their crude oil and to transport their refined petroleum products to consumers. For example, Colonial Pipeline, which transports petroleum products to the Southeast and much of the East Coast, was not fully operational for a week after Hurricane Katrina. Consequently, short-term gasoline shortages occurred in some places, and the media reported gasoline prices greater than $5 per gallon in Georgia.

SPR Oil Is Not Fully Compatible with Some Refineries

The crude oils stored in the SPR are compatible with many refineries in the United States. However, some U.S. refineries process crude oils heavier than those stored in the SPR. Of the 8.3 million barrels of non-Canadian oil imported into the United States per day in 2004, 3.5 million barrels, or about 40 percent, were heavy oil.[26] Refineries that process heavy oil may have difficulty operating at normal capacity if their supply of heavy oil is disrupted. A December 2005 DOE report identified 74 refineries that are connected to the SPR that receive non-Canadian imports of oil, and the

[26]As defined by the Office of Petroleum Reserves in the *Strategic Petroleum Reserve Crude Compatibility Study*, heavy sweet oil has an API gravity less than 26 degrees and heavy sour oil has an API gravity less than 30 degrees.

report found that the types of oil currently stored in the SPR would not be fully compatible with 36 of those refineries, or slightly less than 50 percent.[27, 28] DOE estimated that if these refineries had to use SPR oil, U.S. refining throughput would decrease by 735,000 barrels per day, or 5 percent. DOE estimated that production of distillate fuels, such as diesel and jet fuel, would decrease substantially from heavy oil refineries, but DOE estimated that production of gasoline would increase.

To improve the compatibility of SPR oil with refineries in the United States, the DOE study concluded that the SPR should contain about 10 percent heavy oil. However, DOE may have underestimated how much heavy oil should be in the SPR to maximize compatibility with refiners and minimize oil acquisition cost. First, DOE determined the least amount of heavy oil that could be added to improve the compatibility of the SPR oil inventory with U.S. refineries. However, because heavy oil is less expensive to purchase than the lighter oils currently stored in the SPR, a cost-benefit analysis may show that a larger amount of heavy oil is beneficial, while still maintaining compatibility with U.S. refining capacity.[29] Second, the DOE report may have underestimated the potential impact of heavy oil disruptions on gasoline production. Several refiners who process heavy oil told us that they would be unable to maintain normal levels of gasoline production if they used only SPR oil. For example, an official from one refinery stated that if it used solely SPR oil in its heavy crude unit, it would produce 11 percent less gasoline and 35 percent less diesel. Representatives from other refineries said that they might need to shut down portions of their facilities if they could not obtain heavy oil. A refining industry expert explained that a reduction in gasoline production would likely occur when some heavy oil refineries processed light oil, because the light oil would not provide enough feed to units designed to convert heavier products into gasoline.

[27]DOE, Office of the Deputy Assistant Secretary for Petroleum Reserves, *Strategic Petroleum Reserve Crude Compatibility Study* (December 2005).

[28]Our summary of DOE conclusions does not include asphalt plants, which also would be harmed by a disruption of heavy oil supply.

[29]The price differential between light and heavy crude oils varies over time and depends on the types of crude oil involved. For example, the differential between Brent, a light European crude oil, and Maya, a heavy Mexican crude oil, varied from about $9 to nearly $18 during the last year.

Releasing Oil from the SPR Is Less Helpful If U.S. Refining Capacity Is Damaged

In addition to disrupting crude oil supplies, disasters such as hurricanes and terrorist acts can disrupt supplies of petroleum products by damaging refineries. Crude oil must be processed in refineries to be useful. Following Hurricanes Katrina and Rita, nearly 30 percent of the refining capacity in the United States was shut down, disrupting supplies of gasoline and other products. Because the SPR contains only crude oil, it cannot replace petroleum products if a disruption in refining occurs. However, some countries in the International Energy Agency hold petroleum products in their reserves, and they released these products after Hurricanes Katrina and Rita. DOE reported that these releases of petroleum products helped reduce prices for gasoline and diesel after the hurricanes.

SPR Can Provide Benefits to the U.S. Economy Without Releasing Oil

Several members of our group of experts and other experts noted that the SPR has value to the United States economy in addition to physically replacing oil during supply disruptions. First, the ability of the SPR to replace supply during disruptions may deter adverse behavior on the part of oil-producing nations. Since the SPR can replace a large amount of disrupted oil, cutting off supply would not have the intended negative economic consequence. Second, the SPR could be used as a negotiation tool to encourage producers to increase oil production when needed. Third, experts told us that they believe the SPR may reduce oil prices by lowering the risk premium sometimes included in the price of oil. Oil prices can increase because of fear of a disruption, and some experts told us that the existence of the SPR may quell this fear.

A Larger SPR Is Warranted If Demand for Oil Grows as Expected

If demand for oil in the United States increases as expected, a larger SPR will be necessary to maintain the economy's present level of protection from oil supply disruptions. Expansion of the SPR could also be required under the U.S. agreement with the International Energy Agency. In addition, a recent study prepared for DOE shows that the benefits of expanding the SPR to as much as 1.5 billion barrels would exceed the costs over a range of future conditions, although expanding the reserve to this size would take approximately 18 years. However, factors influencing the SPR's ideal size are likely to change over time, including factors such as oil demand and the likelihood of oil supply disruptions.

Oil Demand Projections Support a Larger SPR

Future oil demand in the United States has an important impact on the benefits of expanding the SPR, and current projections support the interest in a larger SPR. Under the base case in the EIA's most recent *Annual*

Energy Outlook, published in February 2006, U.S. demand for petroleum will rise from 21.1 million barrels per day in 2005 to 23.6 million barrels per day in 2015 and 26.1 million barrels per day in 2025, increases of 12 percent and 24 percent, respectively.[30] As a result, the volume of imported oil and petroleum products is projected to increase over time to meet this demand, from 12.5 million barrels per day in 2005 to 13.2 million barrels per day in 2015 and 15.7 million barrels per day in 2025.

The amount of protection that the SPR provides to the U.S. economy is generally measured in days of net import protection. The SPR contained enough crude oil in 2005 to offset about 58 days of imports. Using the most recent EIA forecast, we calculate that the net import protection that the SPR provides at its current size will decrease to 53 days in 2015 and 45 days in 2025.

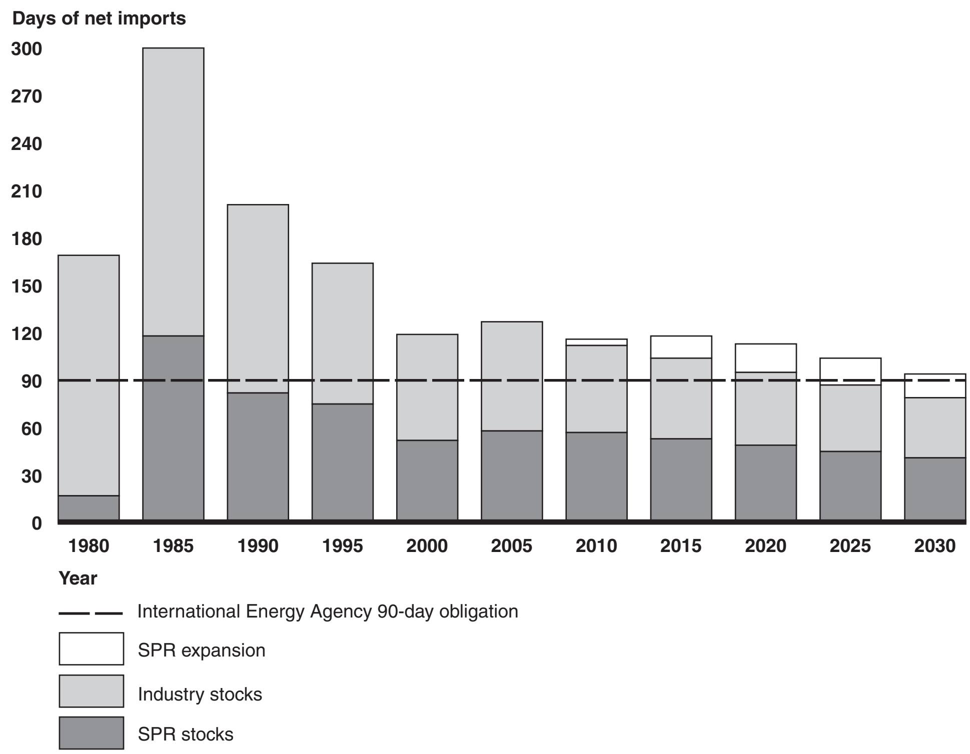
The United States' agreement with the International Energy Agency could also require an expanded SPR as imports of oil and oil products increase, if private inventories do not increase enough to cover the difference in demand. As we previously mentioned, the United States agrees to hold inventories of oil and petroleum products totaling 90 days of net imports as part of its obligation to the International Energy Agency, and the United States meets its obligation with a combination of public and private inventories. Privately held inventories of oil and petroleum products vary, but in 2005 DOE assumed these inventories could offset 58 days of imports. In total, the SPR and private inventories could offset 127 days of imports in 2005. As shown in figure 7, DOE estimates that without SPR or private inventory expansion, the United States will drop below its 90-day stockholding obligation in 2025. With the expansion of the SPR to 1 billion barrels included in the Energy Policy Act of 2005, DOE estimates that the United States will remain in compliance with its 90-day obligation through 2030.[31] As figure 7 shows, the number of days of net import protection provided by private inventory of oil and petroleum products has generally decreased since the mid-1980s, and DOE officials expect this trend to

[30]EIA publishes an *Annual Energy Outlook* each year that forecasts future prices and demand for oil and other energy sources. The 2006 edition includes a base-case forecast, a higher-price forecast, and a lower-price forecast.

[31]This analysis assumes that the volume of private inventory remains constant in the future, meaning that the days of import coverage from private inventory decrease as demand increases.

continue. Holding inventory is costly to private companies, so they have an incentive to keep their inventory as low as possible.

Figure 7: United States' Current and Estimated Compliance with International Energy Agency Obligation to Hold Reserves



Source: DOE's Office of Petroleum Reserves.

DOE Estimates That Long-term Benefits of SPR Expansion to 1.5 Billion Barrels Exceed Costs

To evaluate the costs and benefits of expanding the SPR to a capacity of up to 1.5 billion barrels, DOE's Oak Ridge National Laboratory (ORNL) prepared a study for DOE in late 2005.[32] This study relies on the same model that the Office of Petroleum Reserves used, as discussed in the previous section, to estimate the reduction in economic damage from using the SPR during oil supply disruptions. The study shows that the benefits of expanding the reserve to 1.5 billion barrels exceed the costs over a 45-year horizon. The study estimates the costs and benefits of SPR expansion through 2050 because of the long construction time for additional SPR capacity and the large up-front investment required. The costs of constructing and filling the additional capacity dominate the analysis until 2020, while benefits of the additional capacity accrue from 2021 through the end of the analysis in 2050. The study uses EIA forecasts of oil price and demand through 2025, and a linear extrapolation of these forecasts from 2025 through 2050. Any analysis of costs and benefits so far in the future is inherently uncertain. However, this study is the only one of its kind to analyze the future net benefits of SPR expansion.

The costs of expanding the SPR to 1.5 billion barrels consist of capital costs to acquire and construct the facilities, the cost of crude oil to fill the new capacity, and ongoing maintenance and security costs for the additional facilities. DOE estimates that expanding the physical structure of the SPR to 1.5 billion barrels would take approximately 18 years and cost approximately $5.4 billion, in 2004 dollars. DOE assumed that expanding the reserve to this size would involve purchasing or constructing additional storage capacity at three existing SPR sites: West Hackberry and Bayou Choctaw in Louisiana, and Big Hill in Texas. The remaining expansion would be accomplished by constructing new storage sites at three sites selected from five potential sites in Texas, Louisiana, and Mississippi. The ORNL study's authors estimate the cost of filling the additional SPR capacity at $23.0 billion, in 2004 dollars. This estimate is based on the base-case oil price forecast from the 2005 *Annual Energy Outlook* because the 2006 volume was not yet published when the ORNL study was completed. The 2006 *Outlook* forecasts higher crude oil prices than the 2005 *Outlook*. Using the most recent base-case forecast, the ORNL authors estimated a fill cost of $36.2 billion in 2004 dollars. These calculations assume that the new SPR capacity is filled as it is completed at a maximum fill rate of 100,000 barrels per day, a fill rate achievable using the royalty-in-kind program.

[32] All benefits assessed in the ORNL study were economic benefits.

The ORNL study does not separately consider the costs and benefits of the expansion to 1 billion barrels authorized in the Energy Policy Act of 2005. DOE estimates that expanding to this size would take approximately 15 years and cost at least $1.3 billion, in 2004 dollars, based on selection of the lowest-cost expansion options. This cost includes, as we previously described, purchasing or constructing additional capacity at three existing SPR sites and constructing a new storage site at one of the five potential locations. We estimate that filling the additional capacity would cost approximately $13.4 billion in 2004 dollars, using the base-case cost estimate in the 2006 *Annual Energy Outlook*.

The ORNL study estimates that the benefits of expanding the reserve to 1.5 billion barrels exceed the costs over a range of assumptions about future demand and oil prices. Expanding the SPR to 1.5 billion barrels is estimated to be cost-beneficial for each of the demand and world oil price forecasts in EIA's 2005 *Annual Energy Outlook*. The 2005 *Outlook* contains four forecasts of the world oil market: a base-case forecast, a lower-price forecast, and two higher-price forecasts.[33] A different level of oil demand is associated with each of these price forecasts. The estimated net benefits of expanding the SPR are greatest in the EIA forecast when oil demand is highest and oil prices are lowest, and least when oil demand is lowest and prices are highest. The ORNL study used the 2005 forecasts because, as we previously mentioned, it was completed before the 2006 *Outlook* was published. The 2005 *Outlook* forecasts higher oil demand and lower oil prices than the 2006 edition, but the author of the ORNL study noted that the highest-price case included in the 2005 report closely resembles the 2006 base case. Thus, SPR expansion appears to be cost-beneficial for the 2006 base-case forecast, but the study does not include oil prices as high as those in the 2006 high-price forecast, which would tend to decrease the benefits of a larger reserve.

Beyond assumptions about future oil demand and price, the ORNL study makes a number of additional assumptions, including important assumptions about the probability of disruptions and the impact of oil price increases on GDP.

[33]The 2005 *Annual Energy Outlook* contained an additional high-price case, called the October futures price case. The results of this case are similar to the base case over the long term, and the ORNL study did not include this case.

- The likelihood of oil supply disruptions in the future is uncertain and difficult to assess. The ORNL study considers two different estimates of the probability of oil supply disruptions: one that DOE created in 1990 and a second that the Stanford Energy Modeling Forum created in 2005.[34] The benefits of expanding the SPR to 1.5 million barrels exceed the costs for both disruption probability estimates, but the benefits are larger for the 2005 Stanford Energy Modeling Forum estimate because this estimate (1) considers longer disruptions than those considered in the 1990 estimate and (2) recognizes that excess capacity will not be available from a part of the world where supply is disrupted.

- The measure of how much a given increase in oil price reduces GDP is known as the GDP elasticity of oil price. GDP loss avoided when the SPR is used during oil supply disruptions is a measure of the benefit of the SPR. The ORNL study used a range of GDP elasticity estimates and the results of the model runs indicate that, over that range, expanding the SPR is cost-beneficial. Some economists, however, believe that the GDP elasticity is lower than the bottom of the range of elasticity estimates used by the ORNL study. For example, the model we described in the previous section that EIA uses to estimate the impacts of oil supply disruptions uses values for this GDP elasticity derived from the Global Insight Macroeconomic Model that are one-quarter to one-half the size of the smallest value considered in the ORNL study. A smaller value for the GDP elasticity would reduce the calculated benefits of expanding the SPR.

Factors Influencing the SPR's Ideal Size Are Likely to Change Over Time

Many factors influence the ideal size of the SPR, including world demand for oil and the probability and potential size of oil supply disruptions. Although current projections anticipate increasing future demand for oil in the United States and world, future oil demand conditions are uncertain. Predicting future demand is difficult because it depends on many factors, including the rates of economic growth, the price of oil, policy choices, and technology changes.

[34]The Stanford Energy Modeling Forum is a structured forum for discussing important energy and environmental issues. Participants are leading energy experts and advisors from government, industry, universities, and other research organizations. DOE sponsored an expert panel study by the Stanford Energy Modeling Forum to quantify oil disruption risk.

The rate of world economic growth strongly influences oil demand. Strong economic growth in China has increased its demand for oil and petroleum products, contributing to rising world oil prices since 2004. In that year, China became the world's second largest consumer of oil, behind the United States, and its demand for oil grew at an annual rate of 15 percent. Conversely, the financial crisis in Asia in mid-1997 dramatically slowed the rate of oil demand growth in the region at that time, and oil demand even decreased between 1997 and 1998 in some countries. This change in demand contributed to lower oil prices in 1998 and early 1999, according to some experts.

Future demand for oil will also depend on its price. As we previously described, crude oil prices are set in the world marketplace, and are largely outside the control of U.S. policymakers. High oil prices can encourage conservation and investment in fuel-efficient technologies and alternative fuels, reducing demand, while low oil prices can have the opposite effect.

Members of our group of experts suggested several policy choices that might diminish growth in U.S. demand for oil. First, they suggested that research and investment in alternative fuels might reduce the growth of future U.S. oil demand. Vehicles that use alternative fuels, including ethanol, biodiesel, liquefied coal, and fuels made from natural gas, are now generally more expensive or less convenient to own than conventional vehicles, because of higher vehicle and fuel costs and a lack of refueling infrastructure. Alternative-fuel vehicles could become more viable in the marketplace if their costs and fuel delivery infrastructure become more comparable to vehicles fueled by petroleum products. Second, expert group members suggested that greater use of advanced fuel-efficient vehicles, such as hybrid electric and advanced diesel cars and trucks, could reduce U.S. oil demand. The Energy Policy Act of 2005 directs the Secretary of Energy to establish a program that includes grants to automobile manufacturers to encourage domestic production of these vehicles. Third, several members of our group of experts suggested improving the Corporate Average Fuel Economy (CAFE) standards to curb demand for petroleum fuels in the United States. After these standards were established in 1975, the average fuel economy of new light-duty vehicles improved from 13.1 miles per gallon in 1975 to a peak of 22.1 miles per gallon in 1987.[35] More recently, the fuel economy of new vehicles in the United States has stagnated at approximately 21 miles per gallon. New CAFE standards for light trucks, including minivans and sport-utility vehicles, were announced by the administration in March 2006, which include larger vehicles that were not regulated under past standards. Other experts have questioned the need for enhanced CAFE standards, noting that today's higher gasoline prices will bring about more efficient use of gasoline. Additionally, studies from the Congressional Budget Office suggest that a tax on gasoline could reduce demand at lower cost to the economy than enhanced CAFE standards.[36]

The size of the SPR needed to protect the U.S. economy also depends on the likelihood of oil supply disruptions. A number of factors in today's energy market cause particular concern, including a reduction in global surplus oil production capacity in recent years, the fact that much of the world's supply of oil is produced in relatively unstable regions, and rapid growth in world oil demand that has led to a tight balance between demand and supply. However, factors influencing disruption probability are likely to change over time.

As we described in the previous section, international reserves augment the SPR's ability to replace oil during supply disruptions. Since a release of oil anywhere in the world during a disruption can lower oil prices everywhere, strategic reserves in other countries are beneficial to the United States and influence the SPR's ideal size. Along these lines, some members of our group of experts stressed the importance of international reserves to U.S. oil security and suggested that the United States and the International Energy Agency should encourage construction of strategic reserves abroad to be used during oil supply disruptions and should offer technical assistance to countries that want to construct such reserves. Officials from DOE and the International Energy Agency described efforts to support construction of reserves in other countries, including sponsoring workshops and providing other assistance. Experts pointed out that encouraging the construction of strategic reserves is particularly

[35]According to the Environmental Protection Agency, these fuel economy numbers are based on "real world" estimates that the federal government provides to consumers and are about 15 percent lower than the values used for compliance with the CAFE program.

[36]Congressional Budget Office, *The Economic Costs of Fuel Economy Standards Versus a Gasoline Tax* (December 2003); and *Reducing Gasoline Consumption: Three Policy Options* (November 2002).

important in developing countries that are significant oil consumers and that are not currently members of the International Energy Agency, such as China. EIA forecasts that through 2025, demand in China will increase at a much faster rate than demand in more developed countries.

Projections of future oil demand and oil market conditions are inherently uncertain, but these projections are key to any estimate of the optimal or necessary size of the SPR. If demand for oil grows as projected, keeping the SPR at its current size may put the economy at greater risk from the negative effects of oil supply disruptions. However, the estimates of world oil demand used in current studies could be too high or too low, resulting in high or low estimates of the SPR's optimal size. Therefore, as time passes and oil markets change, periodic reassessments by DOE of the appropriate size of the SPR could be helpful as part of the nation's long-term energy security planning.

Conclusions

The SPR is a valuable asset for protecting the U.S. economy, providing benefits as a source of oil during supply disruptions and as a tool of diplomacy in foreign policy discussions. Our work shows that the SPR, particularly in conjunction with reserves held by the other countries of the International Energy Agency, can replace the oil lost during all but the most catastrophic disruption scenarios and, thus, can reduce the negative consequences of oil supply disruptions on the U.S. economy. However, our work also describes issues that could impact the cost and effectiveness of the SPR, including the conditions under which the reserve is filled, how DOE estimates the economic impacts of using the reserve, and the type of crude oil in the reserve. Expanding the reserve makes sense and will be necessary to maintain the economy's present level of protection if demand for oil in the United States increases as expected. However, factors that influence the ideal size of the SPR are likely to change over time and will warrant periodic reassessments.

Since the SPR's inception, it has been filled and used in response to world events and changing conditions. Although some experts claimed that acquiring oil for the SPR after the terrorism events of September 2001 caused substantial increases in oil prices, the majority of experts we talked with believe that this increase was minimal because the volume of oil going to the SPR was very small relative to world oil demand. Experts believe that changes in SPR practices—including following a "dollar-cost-averaging" approach, where the government acquires a fixed dollar value of oil for the SPR over a specified time period, and allowing oil producers more flexibility in the timing of delivery for oil acquired for the SPR—could reduce the future cost of filling the SPR.

Different parts of DOE have very different opinions on the amount of economic harm oil supply disruptions can cause and, thus, implicitly about the ideal size and use of the SPR. The estimates of the effect of price spikes on GDP that these different parts of DOE use are, respectively, near the high end and low end of the spectrum of such estimates in the economic literature. The two models have been used to support different kinds of decisions—the Office of Petroleum Reserves' model has been used to support decisions about whether to expand the SPR, while the EIA model has been used to advise policymakers about the potential economic consequences of oil supply disruptions. Clarifying the differences between these models and how the models are used to provide policy advice would help ensure that DOE provides consistent transparent advice about the size and use of the SPR.

The SPR protects the economy during oil supply disruptions by replacing the oil lost. For the SPR to be most effective, refiners need to be able to efficiently use the oil in the reserve in the absence of other sources of supply. The two types of crude oil currently stored in the SPR can be effectively used by most refineries during a supply disruption, but the lack of heavy sour oil in the SPR poses problems to refiners who use this type of oil. Adding some heavy sour oil to the SPR could provide a source of supply to these refiners during a disruption, while still leaving enough oil of other types for other refiners. A 2005 DOE study supports this finding, concluding that separately storing approximately 10 percent heavy sour crude in the SPR could provide oil supply to refiners who process heavy sour oil during a disruption and better protect the economy. Additionally, adding some heavy sour oil to the SPR could decrease the cost of filling the SPR, since this oil is generally less expensive than the lighter grades currently stored in the reserve.

Although another 2005 study for DOE shows that expanding the SPR could be warranted, factors influencing the ideal size of the SPR are likely to change over time. Many factors influence the ideal size of the SPR, including oil demand levels and the likelihood of oil supply disruptions. Because these factors are very dynamic, decisions about expanding the SPR will always be made under uncertainty. Nonetheless, as the world changes, periodically revisiting decisions about SPR size would allow policymakers to use new information to refine their views on the SPR's proper size.

Recommendations for Executive Action

The Secretary of Energy should take the following four steps to improve the operation of the current SPR and to improve decisions surrounding the SPR's use and expansion. Specifically, the Secretary should:

- Study how to best implement experts' suggestions to fill the SPR more cost-effectively, including
    - acquiring a steady dollar value of oil for the SPR over the long term, rather than a steady volume, to ensure a greater volume of fill when prices are low and a lesser volume of fill when prices are high and
    - providing industry with more flexibility in the royalty-in-kind program to delay oil delivery to the SPR during times when supply and demand are in tight balance and current prices are higher than expected future prices.
- Conduct a new review about the optimal oil mix in the SPR that would examine the maximum amount of heavy sour oil that should be held in the SPR, in addition to the minimum amount determined in DOE's prior report. The Secretary should ensure that DOE, at a minimum, implements its own recommendation to have at least 10 percent heavy sour oil in the SPR.
- Clarify the differences in structure and assumptions between the models used by the Office of Petroleum Reserves and EIA and clarify to policymakers how the models are used when providing advice to Congress and the executive branch.
- Periodically reassess the appropriate size of the SPR in light of changing oil supply and demand in the United States and the world.

Agency Comments and Our Evaluation

We provided a draft of this report to DOE for review and comment. DOE generally agreed with the conclusions and recommendations presented in the draft report, but provided additional information regarding the implementation of two of our recommendations. Additionally, DOE explained EIA's efforts to update its model of the economic impacts of oil supply disruptions. In reviewing our draft report, DOE also provided technical and clarifying comments, which we incorporated as appropriate. DOE's written comments are reproduced in appendix III.

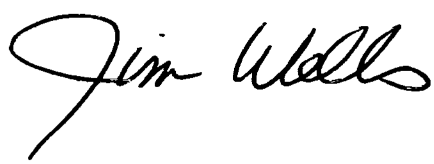
In response to our recommendation to study how to implement experts' suggestions to fill the SPR more cost effectively, DOE noted that decisions on when to acquire oil are extremely complex and subject to many strategic and tactical considerations in addition to cost. We agree that SPR oil acquisition decisions must consider cost, market conditions, national security concerns, and other issues. DOE also stated that dollar cost averaging as a means to improve the cost-effectiveness of SPR fill could be employed only when DOE is purchasing oil, and noted that recent oil acquisition has been accomplished by the transfer of royalty oil from the Interior Department. However, we believe that dollar cost averaging when acquiring oil through the royalty-in-kind program is possible, although it would require that DOE vary the amount of oil it accepts from royalties and perhaps purchase some oil at times of low prices. Because of the potential for cost savings, we continue to believe that DOE should study such an approach. Finally, regarding this recommendation, DOE stated that it believes that the value of deferring oil deliveries to the SPR during the period of 2002 to 2004 would have been less than $590 million. To clarify, we did not attempt to value deferrals that DOE might have approved during this time period. Instead, the $590 million of potential savings referred to in the report reflects the potential savings from applying a dollar-cost-averaging approach from October 2001 through August 2005, not to the savings that could have occurred from deferring oil delivery.

In response to our recommendation to consider storing heavy sour oil in the SPR, DOE stated that it does not believe the advantages of holding a heavier crude stream would justify replacing any of the current inventory. Instead, it believes that studying and implementing this recommendation should wait until the SPR is expanded. Neither our work nor DOE's recent study explored the costs and benefits of adding heavy sour oil to the SPR. We believe that DOE should study the costs and benefits of adding heavy sour oil with and without SPR expansion. Without such analysis, DOE does not have data to determine whether replacing of any of the current inventory with heavy sour oil is economically justified.

Regarding the last two recommendations, DOE agreed that officials will work together to better articulate the different approaches and perspectives contained in their modeling of the effects of oil supply disruptions on the economy, and committed to periodic reassessments of the SPR's ideal size. DOE also described an ongoing update of the EIA model for assessing the impacts of supply disruptions. The new model is more complex than the older model, but according to EIA, its estimates of the GDP impacts of supply disruptions will remain smaller than those estimated by the Office of Petroleum Reserves' model.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution of it until 21 days from the report date. At that time, we will send copies of this report to interested congressional committees, the Secretary of Energy, and other 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) 512-6877 or wellsj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who have made major contributions to this report are listed in appendix IV.



Jim Wells
Director, Natural Resources and Environment

Scope and Methodology

We addressed the following questions during our review: (1) Based on past experience, what factors do experts recommend be considered when filling and using the Strategic Petroleum Reserve (SPR)? (2) To what extent can the SPR protect the U.S. economy from damage during oil supply disruptions? (3) Under what circumstances would an SPR larger than its current size be warranted?

In addressing these objectives, we conducted a comprehensive literature review of economic and public policy material relevant to the SPR's fill and use, and to its ability to provide energy security for the U.S. economy. To identify articles for our literature review, we searched databases using key terms. We also obtained recommended reading lists of studies from several experts on issues related to the questions we addressed. We considered the methodological soundness of the articles and studies included in our literature review and determined that the findings of these studies were sufficiently reliable for our purposes. In addition, we conducted interviews with academics and experts, as well as industry representatives and officials from several offices within the Department of Energy (DOE), including the Energy Information Administration (EIA) and the Office of Petroleum Reserves. We also conducted interviews with academics and experts at institutes that study energy security issues. We selected these individuals on the basis of their expertise in energy security and SPR policy as represented by their presentations or publications. We present data and forecasts from EIA that have been deemed sufficiently reliable for our purposes.

Additionally, we contracted with the National Academy of Sciences[1] to convene a group of experts to collect opinions on the impacts of past SPR fill and use and on recommendations for the future, as well as on the benefit of the SPR in reducing economic losses in the event of oil supply disruptions. We worked closely with the National Academies to identify and select 13 group members (see table 7) who could adequately respond to our general and specific questions about current practices for filling and using the SPR and about the economic benefit the SPR could provide at its current size and at a larger size. In keeping with National Academies' policy, the group members were invited to provide their individual views, and the group was not designed to reach a consensus on the issues that we

[1]Four organizations comprise the National Academies: the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council.

asked them to discuss. The group members convened at the National Academies in Washington, D.C., on December 1, 2005. The views expressed by the group members do not necessarily represent the views of GAO or the National Academies. After the group of experts met, we analyzed a transcript of the discussion to identify principal themes and group members' views. Although we were able to secure the participation of a balanced, highly qualified group of experts, the group was not representative of all potential views. Nevertheless, it provided a rich dialogue on current practices for filling and using the SPR and on what considerations are pertinent to identifying the best fill and use policies, as well as on how the SPR, at its current size and at a larger size, can protect the economy from significant losses in the event of oil supply disruptions.

Table 7: Members of the Group of Experts Compiled by GAO and the National Academies

Name	Affiliation
Robert Hirsch (moderator)	Senior Energy Program Advisor, SAIC
Joseph E. Aldy	Fellow, Resources for the Future
Kyle M. Cooper	Vice President, Futures/Fixed Income, Citigroup Global Markets, Inc.
Leonidas Drollas	Deputy Executive Director and Chief Economist, Centre for Global Energy Studies
Robert Ebel	Chairman, Energy Program, Center for Strategic and International Studies
Lawrence J. Goldstein	President, PIRA Energy Group
David L. Goldwyn	President, Goldwyn International Strategies, LLC
Les Harding	Senior Manager, Trading, Valero Energy Corp.
Hillard G. Huntington	Executive Director, Stanford Energy Modeling Forum, Stanford University
Klaus Jacoby	Head, Emergency Planning and Preparations Division, International Energy Agency
Paul Leiby	Science and Technology Policy Group, Environmental Sciences Division, Oak Ridge National Laboratory
John A. (Jack) Riggs	Executive Director, Program on Energy, the Environment and the Economy, The Aspen Institute
John Shages	Deputy Assistant Secretary, Petroleum Reserves, Department of Energy

Source: GAO.

To learn what factors experts recommend be considered when making decisions about SPR fill and use, we reviewed records and reports from DOE and the International Energy Agency. We also reviewed available literature on the political and economic implications of various ways of filling and using the SPR, and interviewed experts from government, academia, and private industry on issues of SPR fill and use.

To estimate the potential savings of using a dollar-cost-averaging approach to fill the SPR, we calculated the cost of using this approach for SPR oil acquisitions between October 2001 and August 2005. In addition, we ran simulations to project potential savings from a dollar-cost-averaging approach going forward over 5 years. Specifically, we evaluated 12 possible paths that future oil prices may take. First, starting from an initial price of $70 per barrel, we allowed prices to increase or decrease on average by varying degrees—the price paths increased or decreased at average rates of 1, 5, and 10 percent per year. Second, for each of these 6 possible price paths, we allowed prices to fluctuate to account for potential price volatility—for each of the 6 possible price paths, we allowed for a low- and high-price volatility case. Specifically, prices for each month were drawn randomly from a normal distribution, with standard deviations of $15 for the low volatility case and $50 for the high case. For each of these 12 scenarios, we then simulated future prices for 60 months and compared the average price per barrel under dollar cost averaging versus acquiring oil at a steady rate. We ran 1,000 simulations for each of the 12 scenarios and found that in all but 10 of the resulting 12,000 simulations, dollar cost averaging saved money. These simulations are not intended to measure the magnitude of savings. To do so would require using actual projections of oil prices and price volatility, something that was beyond the scope of this report.

We did not independently verify information about security, drawdown rates, or other operational factors of the SPR or other strategic reserves held by countries that belong to the International Energy Agency.

To analyze the ability of the SPR to reduce economic damage caused by oil supply disruptions, we present the results of two DOE models used to estimate the reduction of harm to U.S. gross domestic product (GDP) that would result from releasing oil from the SPR and international reserves during six hypothetical oil supply disruption scenarios. Oak Ridge National Laboratory (ORNL) produced one of these models under contract with DOE's Office of Petroleum Reserves. ORNL officials produced model results for us. EIA produced the second model. We produced model results using the EIA model, and then verified these results with EIA officials. (See app. II for a more detailed discussion of the hypothetical oil supply disruption scenarios and the economic modeling effort.) Additionally, we conducted semistructured interviews with representatives from the refining industry. We spoke with representatives from companies that comprise 76 percent of the refining capacity of the United States to learn about their views on SPR operations. We also reviewed studies of the potential for oil supply disruptions to occur and to reduce U.S. GDP.

To learn about the circumstances under which an SPR larger than its current size could provide additional energy security benefits, we reviewed an ORNL study that analyzed the expected costs and benefits of expanding the SPR, U.S. stockholding obligations to the International Energy Agency, and estimates of future U.S. oil demand. Finally, we also reviewed studies and interviewed expert group members and other oil market experts about factors that influence future demand for oil in the United States and alternatives for reducing U.S. economic losses in the event of oil supply disruptions.

Economic Modeling of Oil Supply Disruptions

We present in this appendix the results of models that economists at ORNL and EIA created to simulate the effects of six hypothetical oil disruption scenarios. These scenarios illustrate the impacts of a variety of oil supply disruptions and the extent to which the SPR and international reserves could replace oil and protect the economy from losses. Both models make a number of assumptions in simulating the effects of disruptions on the economy, and some of these assumptions differ between models.

Oil Supply Disruption Scenarios

To study the capabilities of the SPR and international reserves to replace oil and prevent economic damage during oil supply disruptions, we developed six hypothetical oil supply disruption scenarios. The six scenarios are as follows:

- A hurricane along the United States Gulf Coast decreases domestic oil production. This scenario is closely based on Hurricanes Katrina and Rita, which struck the U.S. Gulf Coast in August and September, 2005, and temporarily stopped a large percentage of the offshore crude oil production in the Gulf of Mexico. The disruption in production continued for several months as damaged offshore production platforms, pipelines, and onshore facilities were repaired.

- A strike occurs among oil workers in Venezuela. This scenario is based on the oil worker strike that occurred in Venezuela in 2002 to 2003. Although that strike lasted only 63 days, oil production was well below normal for several months and did not recover to its prestrike level.

- Iran stops exporting oil for 18 months. Although none of Iran's 2.7 million barrels per day of exported crude oil go directly to the United States, removing this oil from the market would raise prices everywhere, thus impacting the U.S. economy.

- Terrorists attack the Abqaiq oil-processing facility in Saudi Arabia, which handles more than half of Saudi Arabia's 10.4 million barrels per day of oil output. This facility is the largest oil-processing plant in the world, removing water, gas, sulfur, and other impurities before the oil is exported. This scenario assumes that a terrorist attack cripples the facility for 1 month, and then production recovers over 7 additional months as the facility is repaired. Terrorists attempted to attack this facility in February 2006, but security forces turned back the attack.

- Terrorist or military action closes the Strait of Hormuz, which connects the Persian Gulf with the Arabian Sea. Our scenario assumes that military action closes the Strait completely for 1 month, removing 17 million barrels per day of crude oil from the market. Oil supply then recovers over 2 months as the Strait is cleared and oil reaches the market through alternate routes.

- A catastrophic loss of oil production in Saudi Arabia occurs, eliminating exports of oil for 18 months. Oil production then recovers over the next 6 months. Since Saudi Arabia is the world's largest exporter of crude oil, this is nearly a worst-case scenario for world oil supplies.

For each scenario, table 8 shows the amount of crude oil disrupted during each month over a 2-year period.

Table 8: Amount of Crude Oil Disrupted over a 2-Year Period, by Hypothetical Scenario

Barrels in millions

	Oil supply disrupted per day, by hypothetical scenario					
Month of disruption	**Gulf Coast hurricane**	**Venezuelan strike**	**Iranian embargo**	**Saudi terrorism**	**Strait of Hormuz closure**	**Saudi shutdown**
1st	1.5	1.8	2.7	6.0	17.0	10.0
2nd	1.0	2.2	2.7	4.0	8.0	10.0
3rd	0.8	1.4	2.7	4.0	4.0	10.0
4th	0.8	0.5	2.7	4.0	0	10.0
5th	0.5	0.4	2.7	4.0	0	10.0
6th	0.5	0.2	2.7	4.0	0	10.0
7th	0	0.2	2.7	2.0	0	10.0
8th	0	0.2	2.7	1.0	0	10.0
9th	0	0.2	2.7	0	0	10.0
10th	0	0.2	2.7	0	0	10.0
11th	0	0.2	2.7	0	0	10.0
12th	0	0.2	2.7	0	0	10.0
13th	0	0.2	2.7	0	0	10.0
14th	0	0.2	2.7	0	0	10.0
15th	0	0.2	2.7	0	0	10.0
16th	0	0.2	2.7	0	0	10.0
17th	0	0.2	2.7	0	0	10.0
18th	0	0.2	2.7	0	0	10.0
19th	0	0.2	0	0	0	8.0
20th	0	0.2	0	0	0	6.0
21st	0	0.2	0	0	0	4.0
22nd	0	0.2	0	0	0	2.0
23rd	0	0.2	0	0	0	2.0
24th	0	0.2	0	0	0	1.0

Source: GAO.

We selected these scenarios to illustrate the potential benefits of strategic reserves in disruptions of different size and duration, not because they are likely to occur. These scenarios are set in today's oil market, with global crude oil demand of approximately 83 million barrels per day and U.S. demand of approximately 21 million barrels per day.

Modeling of Economic Impacts

We used two DOE models to estimate the economic effects of our six disruption scenarios. EIA developed one model and economists at ORNL developed the other, under contract to DOE's Office of Petroleum Reserves. Both models estimate U.S. GDP loss from oil supply disruptions by linking disruptions to oil price spikes and linking price spikes to GDP losses. We used both models to estimate the economic effects of our hypothetical disruptions under three conditions: that is, no reserves are used in response to the disruption, the SPR is used alone, and the SPR is used in conjunction with international reserves.

In both models, we assumed that world excess crude oil production capacity and world fuel-switching capabilities, together totaling 850,000 barrels per day, are available immediately to help offset a disruption. We also assumed that private inventories of crude oil are neutral during a disruption—holders of private inventory neither draw down their inventories nor hoard oil. Finally, we assumed that SPR and international reserves are used immediately at their maximum sustainable rate or at a rate large enough to replace disrupted oil supply.

EIA Model

EIA's Division of Energy Markets and Contingency Information has developed "rules of thumb" for estimating the oil price and U.S. macroeconomic impacts of oil supply disruptions, based on simulations from the Global Insight Macroeconomic Model of the U.S economy. The assumptions relating disruptions to oil price spikes are summarized in the "price rules of thumb" and the assumptions relating price spikes to GDP losses are summarized in the "economic rules of thumb."

EIA measures the response of world oil prices to a hypothetical supply disruption as the projected quarterly average increase in the price of West Texas Intermediate oil. EIA's oil market analysis is based on competitive forces producing a market price on the basis of market fundamentals and market psychology during an oil supply disruption. The "price rules of thumb" are based on net disruption sizes and the current and expected future oil price level before the disruption. These rules of thumb provide a range of oil prices around an average price, and do not try to quantify the size of price spikes that could occur during disruptions. EIA estimates that a supply disruption when the price of oil is around $40 per barrel results in an oil price increase of between $4 and $6 per barrel for each 1 million barrels per day of oil that is disrupted. However, if the price of oil is about $50 per barrel, EIA estimates a price increase of between $5 and $7 per barrel for each 1 million barrels per day of oil that is disrupted. For a disruption of a given size, the higher the predisruption oil price, the bigger the price increase needed to balance supply and demand after the disruption. Additionally, EIA adds a “market psychology price premium” to the price calculated using the rules of thumb in situations where it believes market psychology will further increase the price.

To translate oil price increases into GDP losses, EIA uses “economic rules of thumb,” based on simulations from the Global Insight Macroeconomic Model of the U.S. economy. These rules estimate that a sustained increase of 10 percent in the price of oil could result in a 0.05 to 0.1 percent reduction in real U.S. GDP relative to its baseline value (the forecasted GDP without an oil disruption). EIA states that, for price increases greater than 10 percent, the GDP impacts would increase linearly with the price impacts, so that a doubling of the price impacts would result in a doubling of the GDP impacts. The EIA model’s GDP responsiveness estimates are derived from the Global Insight model that EIA uses for its long-run forecasts of energy market and overall economic activity. EIA notes that additional factors, such as the effect of high oil prices on the rest of the world’s economy, the reaction of the Federal Reserve to ameliorate the economic damage of high oil prices, and the change in the value of the dollar against foreign currencies, may also influence the economic impact of an oil price spike.

Office of Petroleum Reserves’ Model

Economists at ORNL, under contract to DOE’s Office of Petroleum Reserves, developed a model to estimate the costs and benefits of expanding the size and drawdown capability of the SPR. Economists at ORNL used a portion of this model to estimate the GDP impacts of our oil supply disruption scenarios. The model estimates the economic impacts of oil supply disruptions by first calculating the remaining oil shortfall after world excess oil production capacity has been utilized. Then the model assumes that world oil price increases sufficiently for world oil demand to contract enough to equal the now-reduced supply. On the basis of a review of the literature, the modelers assume a short-run price elasticity of demand for oil between -0.10 to -0.25. The elasticity gets larger as the duration of the supply shock gets larger and longer.[1] The short-run oil demand elasticities then are used to determine the increase in the world price of oil. The GDP elasticity of oil price is then used to infer the losses in economic output that would follow a sudden, unanticipated oil price shock. The modelers draw on results from econometric studies of the sensitivity of the U.S. economy to oil price spikes to select a GDP elasticity, expressed in percentage terms, of -5.4 percent for a 100 percent spike in oil price.

To estimate the benefits of expanding the size and drawdown capability of the SPR, the model simulates the impact of oil supply disruptions against DOE's baseline paths for oil prices, world oil demands, U.S oil demands, and U.S. oil supplies. The primary benefit from the SPR is the GDP loss avoided when it is used to prevent or lessen the effects of oil price spikes. Their cost-benefit approach uses a simple model of the oil market and the U.S. economy to (1) assess the potential causes and likelihood that oil supply disruptions will occur, (2) account for the size of existing strategic oil stocks and expected degree of international cooperation on their use, (3) estimate the cost to the U.S. economy of oil supply disruptions and the incremental ability of additional SPR stocks and drawdown capability to reduce these costs, (4) estimate the costs of buying and storing oil in the SPR, and (5) determine the net benefit and efficient size of the SPR. The model uses a Monte Carlo simulation of the world oil market over the next several decades to model the likelihood of future oil supply disruptions.[2]

Similarities and Differences between the EIA Model and Office of Petroleum Reserves' Model

In assessing the economic costs of disruptions, the Office of Petroleum Reserves' model makes a number of assumptions similar to those made by EIA, in particular, assumptions about the responsiveness of oil price to supply disruptions. However, the Office of Petroleum Reserves' model assumes a considerably greater degree of responsiveness of the

[1]Elasticity refers to the responsiveness of one variable to a change in another. For example, the price elasticity of demand for oil refers to the responsiveness of the quantity of oil demanded to a change in its price and the GDP elasticity of oil price refers to the responsiveness of GDP to a change in oil price.

[2]A Monte Carlo simulation is a form of estimation that uses random numbers to measure the effects of uncertainty, such as the uncertainty associated with a future oil supply disruption. A simulation is composed of thousands of events, each event being a randomly selected projection of the world oil market through the year 2050. Some of these projections include supply disruptions, others do not. The thousands of sampled outcomes are recorded and averaged to produce an estimate of the average benefit from the SPR in the presence of uncertainty about the likelihood and duration of future supply disruptions.

macroeconomy to oil price spikes than the EIA model. The Office of Petroleum Reserves' model assumes for its base case that a sudden doubling in the price of oil could reduce GDP in the following year by about 5.4 percentage points below what it otherwise would have been. This contrasts with the EIA model result that a sudden doubling of the price of oil would cause about a 0.5 to 1.0 percent reduction in the level of real GDP relative to its value if an oil price increase did not occur.

Some experts have suggested that the EIA model and Office of Petroleum Reserves' model have assumptions that could be responsible for differences in their estimates of the responsiveness of GDP to disruptions. In the Office of Petroleum Reserves' model, the responsiveness of GDP to an oil price shock incorporates a controversial assumption, that U.S. monetary authorities would not intervene and increase the money supply to accommodate the price shock. Some experts have suggested that, by increasing the money supply, monetary authorities could restore consumers' purchasing power to its predisruption level and eliminate or moderate the GDP loss. Experts have also suggested deficiencies in the model that EIA uses for its estimates of the responsiveness of GDP to oil price shocks. A number of experts believe that large-scale macroeconomic models, such as the EIA model, underestimate the effects of oil price shocks on the economy. They question whether these models can distinguish between a price shock and a more gradual price increase. In contrast, the econometrically based estimates used by Office of Petroleum Reserves' model and others are derived from models of oil price shocks.

Comments from the Department of Energy

Department of Energy
Washington, DC 20585

August 4, 2006

Mr. Jim Wells
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Wells:

The Department of Energy appreciates the extensive efforts made by the staff of the GAO in researching and preparing the study of the Strategic Petroleum Reserve (SPR) resulting in the August 2006 draft report, Strategic Petroleum Reserve: Available Oil Can Provide Significant Benefits, but Decisions about Fill, Use, and Expansion Are Difficult.

Employees of the Department have worked closely with GAO to make available all analyses and opinions that would allow the best possible study and report. Generally, the Department agrees with most of the analysis. The Department, excluding the Energy Information Administration, which does not take positions on policy matters, is very much in agreement with the conclusion that, "Expanding the Reserve makes sense and is necessary to maintain the economy's current level of protections if demand for oil in the United States increases as expected."

We offer the enclosed comments on the Recommendations for Executive Action and other related portions of the draft report as discussed therein.

While the Department generally agrees with the recommendations presented in the report, we believe incorporation of the enclosed comments would help ensure the report's accuracy and clarity. If you have any questions, please contact John Shages, Deputy Assistant Secretary, Office of Petroleum Reserves at (202) 586-4410.

Sincerely,

Thomas D. Shope
for Jeffrey D. Jarrett
Assistant Secretary
Office of Fossil Energy

Enclosure

Printed with soy ink on recycled paper

Comments on August 2006 Draft Report GAO-06-872
Strategic Petroleum Reserve: Available Oil Can Provide Significant Benefits, but Decisions about Fill, Use, and Expansion Are Difficult

Recommendation: The Secretary should study how to best implement experts' suggestions to fill the SPR more cost-effectively, including:

- Acquiring a steady dollar value of oil for the SPR over the long term, rather than a steady volume to ensure a greater volume of fill when prices are low and a lesser volume of fill when prices are high.
- Providing industry more flexibility in the royalty-in-kind program to delay oil delivery to the SPR during times when supply and demand are in tight balance and current prices are higher than expected future prices.

Response: The Department agrees that it should study experts' recommendations that could help reduce costs. However, the Department notes that decisions on whether to acquire oil or to delay acquisition are extremely complex and subject to many strategic and tactical considerations in addition to cost. The history of the SPR is replete with changes in priorities that led to either acceleration or deceleration of the fill program. For example, following the oil crisis of the late 1970s, despite the fact that oil prices were at an all time high in nominal and real terms, President Reagan characterized the SPR as a national security asset and ordered that it be filled. Congress accommodated that decision during the five fiscal years from 1981-1985 by appropriating over $12 billion for oil acquisition, and during those years almost 400 million barrels of oil were added to the SPR.

Similarly, in November 2001, President Bush directed that the SPR be filled to its then capacity of 700 million barrels at a deliberate pace. That decision followed the terrorism events of September 11, 2001. Both of these decisions were motivated by energy and national security considerations and priorities. At the time of those decisions, price was an important, but secondary, issue.

The Energy Policy Act of 2005, section 301 requires the Secretary of Energy to develop procedures for oil acquisition that take into account the need to:

(1) maximize overall domestic supply of crude oil (including quantities stored in private sector inventories);
(2) avoid incurring excessive cost or appreciably affecting the price of petroleum products to consumers;
(3) minimize the costs to the Department of the Interior and the Department of Energy in acquiring such petroleum products (including foregone revenues to the Treasury when petroleum products for the Reserve are obtained through the royalty-in-kind program);
(4) protect national security;

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(5) avoid adversely affecting current and futures prices, supplies, and inventories of oil; and
(6) address other factors that the Secretary determines to be appropriate.

This direction is in addition to the direction contained in subsection 160(b)(1) of the Energy Policy and Conservation Act which directs the Secretary to the greatest extent practicable to acquire oil for the Reserve with the objective of, "minimization of the cost of the Reserve;" among others.

The Department, in drafting the required procedures, made clear that the acquisition of oil is subject to many different objectives and that the priority of those objectives may be rearranged depending upon the circumstances at the time acquisition is contemplated. When the procedures are finalized in August 2006, it will be clear that the Department must have flexibility to consider a wide array of factors in deciding at what rate to acquire oil.

In conformance with both the law and good management procedures, the Department will always favor minimizing the cost of the SPR's petroleum acquisition. However, it does not mean that DOE will always choose to delay or defer acquisition in order to achieve the lowest possible costs.

Similarly, when the Department is using the transfer of royalty oil from the Department of the Interior to acquire oil for the SPR, opportunities to defer deliveries will be limited by perceptions of future market prices. Consequently the ability to defer deliveries may not coincide with other public interests. For example, during 2002, 2003, and 2004, spot and future market prices were such that oil companies willingly offered to defer deliveries of oil owed to the SPR. However, at that time, the Office of Fossil Energy was focused on the requirements of energy security and did not generally agree to deferrals. In the current market, futures prices are generally higher than spot prices and consequently companies are not eager to defer deliveries, and there is no opportunity for the Department to significantly reduce acquisition costs.

Finally, the report states that the Department could have saved $590 million over the period 2001-2005 by utilizing dollar cost averaging. As a technical matter, dollar cost averaging is a technique that could be employed only when the Department is purchasing oil, and during the period 2001-2005, all oil acquisition was accomplished by the transfer of royalty oil from the Interior Department; there were no cash purchases. While the Department agrees that costs to the Treasury could have been reduced by deferring deliveries during the period 2002-2004, we believe that the value of the deferrals would have been less than $590 million. We also note that if the deferrals had been agreed to, the Department would have deferred deliveries during the time when oil prices were in the range of $30-50 per barrel, and would have been taking oil from the commercial markets at today's prices.

3

Recommendation: Conduct a new review about the optimal oil mix in the SPR that would examine the maximum amount of heavy sour oil that should be held in the SPR, in addition to the minimum amount determined in its prior report. DOE should also, at a minimum, implement its own recommendation to have at least 10 percent heavy sour oil in the SPR.

Response: The issue of appropriate mix is extremely dynamic and will change with time. The Office of Fossil Energy shares the opinion that some of the oil in the SPR can be heavier than either the current sweet or sour streams. However, we do not subscribe to a specific percentage, and we do not believe the advantages of a heavier crude stream would justify replacement of any of the current inventory. We do envision that as expansion of the SPR progresses toward one billion barrels, the extra capacity would make inclusion of a third quality stream viable. Minimizing oil movements would contribute to cost control, and we would very much prefer to avoid trading away oil already acquired simply to reduce the quality.

While we agree that additional study is in order, we believe that both the study and implementation of this recommendation should wait until commission of a sizeable increment of new capacity is anticipated. This would be prudent because the schedule for expansion of the SPR is several years long, and fill necessarily will follow expansion.

Recommendation: Clarify the differences in assumptions between the models used by the Office of Petroleum Reserves and the Energy Information Administration and clarify for policy makers how the models are used when providing advice to Congress and the Executive Branch.

Response: The Department agrees with the recommendation that all model assumptions and results should be clearly stated and displayed. This applies to both the model created by the Oak Ridge National Lab used by the Office of Fossil Energy and to the work of the Energy Information Administration. The Office of Fossil Energy and the Energy Information Administration will work together to better understand and articulate their approaches and perspectives on the economic effects of oil supply disruptions and the potential efficacy of the SPR in suppressing the effects of disruptions. They will also clarify model assumptions and results when providing advice to Congress and the Executive Branch. In addition, the Office of Fossil Energy and the Energy Information Administration will engage with other government agencies and outside researchers on issues relating to oil supply disruptions and price shocks.

Recommendation: Periodically reassess the appropriate size of the SPR in light of changing oil supply and demand in the United States and the world.

The Department of Energy agrees with this recommendation. Historically, size reviews occur only at obvious break points in the size of the SPR, or when required by legislation. In light of the large shifts that have occurred in world economic growth, oil supply and demand, and energy prices during the last ten years, and the likelihood that further dramatic changes will occur as time passes, the Office of Fossil Energy will commit to periodic reassessments of the optimal SPR size.

Other Comments:

The draft report noted that the Energy Information Administration is updating its model for assessing the impacts of supply disruptions. The Energy Information Administration's "rules of thumb" (ROT) are being replaced with the Disruption Impact Simulation (DIS) model, which is a spreadsheet-based tool used to estimate the impact of world oil supply disruptions on world oil prices and on the U.S. economy. DIS is more complex than the ROT and relies on more recent economic literature about how prices and the economy respond to oil market disruptions. The Energy Information Administration believes that the development of DIS is a major improvement over the ROT.

Were the disruption scenarios specified in the GAO report assessed using the DIS, the results would be different than those obtained from using the ROT. In general, DIS would provide similar market price impacts to those calculated by the Oak Ridge model because both models employ similar estimates of the price elasticity of world oil demand. However, estimated GDP impacts of a supply disruption in DIS remain smaller than those in the Oak Ridge model because the estimated GDP elasticities are lower than those used by Oak Ridge (although the GDP elasticities in DIS are greater than in the ROT). As with assessments based on the ROT, assessments made using DIS forecast less damage to the GDP than the Oak Ridge model. Hence the ameliorative effect of offsetting the disruption by releasing strategic reserves is less because the target of opportunity is less.

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