United States General Accounting Office

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Report to the Chairman, Subcommittee on Energy and Power, Committee on Energy and Commerce, House of Representatives

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ENERGY POLICY

Ranking Options to Improve the Readiness of and Expand the Strategic Petroleum Reserve

GAO

United States
General Accounting Office
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Resources, Community, and Economic Development Division

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The Honorable Philip R. Sharp
Chairman, Subcommittee on Energy and Power
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

On May 25, 1994, we testified before the Subcommittee on the results of the work we performed at your request on several near- and long-term options for improving the readiness of and expanding the Strategic Petroleum Reserve (SPR).[1] Specifically, you asked our position on the relative priority that should be given to the options of (1) eliminating problems related to the buildup of the heat and gas content of some crude oil in the SPR; (2) replacing existing facilities and systems to extend the useful life of the reserve; (3) filling the SPR to the current 750-million-barrel capacity or expanding and filling the SPR to 1 billion barrels; and (4) increasing the daily drawdown rate from 4.5 million to 6 million barrels for the SPR's current size, as well as for a 1-billion-barrel reserve.

In conducting our analyses, we used a Department of Energy (DOE) model that is designed to examine the costs and benefits associated with a variety of size and drawdown issues. The benefits come largely from replacing with SPR oil imported oil whose supply has been disrupted, thereby dampening oil price increases and their resulting impact on the nation's economy. The model allows us to make different assumptions about the probability and length of disruptions, oil prices and the quantities of oil available in the marketplace, market price elasticities, the impact of oil price increases on the gross national product, discount rates, and other parameters. As agreed with your office, this report presents the results of our analyses concerning the relative priority that should be given to four near- and long-term options presented above for improving the readiness and expansion of the SPR, as well as a detailed description of the model and the related analyses of its methodology and sensitivity that we performed. (For more details about the model, our assumptions, and the results of our analyses, see app. I.)

[1]Energy Policy and Conservation Act Reauthorization (GAO/T-RCED-94-214, May 25, 1994).

Results in Brief

We found that resolving problems that affect the SPR's readiness, such as the buildup of geothermal heat and gas in stored crude oil, and replacing equipment that is at the end of its design life would correct or prevent the significantly degraded ability of the SPR to respond to oil disruptions. Because of this, we ranked these options as high priorities. Continuing to fill the reserve to its current capacity of 750 million barrels or expanding the reserve to hold 1 billion barrels would both entail much higher costs. Considering the limited potential benefits and the higher costs of filling or expanding the SPR, we gave this option a relatively low priority. The benefits of increasing the SPR's daily drawdown capability are less clear; however, implementing this option would increase the nation's ability to respond more flexibly to oil disruptions and would likely entail more moderate costs. We ranked this option as a medium priority.

Background

The SPR, which is authorized by the Energy Policy and Conservation Act to store up to 1 billion barrels of crude oil for use during a disruption in the oil supply, provides insurance against oil market shocks and their potentially significant effects on the economy. In October 1991, DOE, which manages the SPR, completed the development of facilities for storing 750 million barrels of crude oil in underground Gulf Coast salt domes in Louisiana and Texas and in a marine terminal on the Mississippi River at St. James, Louisiana. DOE is working toward achieving a maximum design drawdown rate of 4.5 million barrels a day. Currently, SPR facilities are designed to draw down crude oil at a rate of about 4.3 million barrels a day. Since fiscal year 1976, the Congress has appropriated about $21 billion (or about $33 billion when adjusted for inflation to 1994 dollars) for SPR programs and activities. As a result, almost 600 million barrels of crude oil has been stored.

After developing a storage capacity of 750 million barrels, DOE shifted its attention to improving the readiness of the reserve for a drawdown of the existing inventory. In 1992, the agency established as top priorities ensuring this readiness and extending the useful life of the SPR's present systems beyond the end of this decade. DOE has also conducted studies, analyses, and public hearings to produce the reports mandated under the Energy Policy and Conservation Act Amendments of 1990 (P.L. 101-383) to pick sites and complete an SPR Plan Amendment to expand the reserve to 1 billion barrels.

The SPR's Program Office in Washington, D.C., is responsible for managing the overall program and planning activities to achieve the program's goals and objectives. The Assistant Secretary for Fossil Energy has overall programmatic responsibility for achieving these goals and objectives. The Project Management Office, located in New Orleans, Louisiana, carries out day-to-day project activities, including the management and operation of five underground storage sites and the one marine terminal.

Correcting Problems of Heat and Gas Buildup Should Be Assigned High Priority

In the SPR, both the amount of oil available for drawdown and the total daily drawdown rates have been lessened because the temperature of the stored crude oil has been elevated by geothermal heating, and gas, primarily methane, from the surrounding salt formations has mixed with some of the oil. Both the elevated temperatures and the high gas content diminish DOE's ability to draw down the oil because they have raised the vapor pressure of the oil above safety and air pollution limits. The vapor pressure must be reduced to ensure that crude oil from the SPR can be delivered at the proper specifications for commercial transportation and refining.

As early as 1984, DOE had indications that crude oil stored in the SPR had elevated temperatures and excessive gas content. However, the results of early tests to determine the scope and impact of the problems were inconclusive. After becoming convinced in 1993 that the problems were significant and widespread, DOE established a Vapor Pressure Task Force—consisting of SPR personnel, various contractors, and representatives of DOE's national laboratories—to define the full extent of the problems and develop corrective actions. While tests continue, DOE now estimates that about 400 million barrels, or two-thirds of the oil, is affected. DOE further estimates that by blending affected and unaffected oil and observing certain operating restrictions, it could draw about 520 million barrels out of the reserve without further corrective actions, but only at a maximum daily rate of about 2 million barrels per day, or less than one-half the maximum design rate for the reserve. Without blending affected and unaffected oil and observing the operating restrictions, only about 800,000 barrels could be drawn down per day, according to DOE's estimates.

DOE plans to permanently install heat exchangers to dissipate the excess heat as the reserve is drawn down. DOE intends to complete this work by April 1995 at a cost of about $19 million. To reduce the gas content of the oil to acceptable levels, DOE will bring about 144 million barrels to the surface, degas it, and then return and blend it with other oil in the caverns.

DOE plans to complete this work by November 1997 at a cost of about $45 million.

Using a DOE model, we estimated that the benefits of reducing the heat and gas content could be substantial. The net present value of the benefits ranges from about $2.9 billion to $16.7 billion, depending on the extent to which the reserve's drawdown capability is restricted and which disruption scenario is evaluated. The benefits are substantial because the heat and gas significantly impair the SPR's drawdown capability and therefore limit the SPR's ability to dampen oil price increases and their economic impact. Because of the large potential benefits and relatively low total cost of this action—about $64 million—we would assign it a high priority.

Replacing Aging Facilities Could Avert Future Loss in the SPR's Capability

The SPR's drawdown rate is also threatened by major problems in the mechanical, civil, and electrical systems—problems that DOE believes will become progressively worse. The United States has spent over $3.9 billion (or about $6 billion when adjusted for inflation) for SPR storage sites and related distribution systems. These systems were installed in the late 1970s and early 1980s, with a designed life span of 20 years. DOE plans to replace and upgrade the drawdown and distribution systems through its Life Extension Program and at the same time simplify and standardize equipment to reduce future maintenance costs. These changes will also enhance DOE's ability to test equipment under maximum usage rates.

Using DOE's evaluation of the SPR system's availability without a Life Extension Program, we estimated that the daily drawdown rate could drop to about 3 million barrels per day, or about 67 percent of the system's design capability, within 10 years. The most severe drop would occur at the SPR's two largest sites, the Bryan Mound, Texas, and West Hackberry, Louisiana, sites, where over 420 million barrels of SPR oil are stored. DOE estimates that the Life Extension Program will take 7 years to complete and cost about $375 million (or about $315 million in present value terms). The program will extend the useful life of the reserve to the year 2025.

Our analysis shows that if the drawdown rate is lessened to about 3 million barrels per day, the net benefits of carrying out the Life Extension Program could be as high as $1.6 billion across the various disruption scenarios under which the reserve would be needed. These results do not include the additional maintenance costs of keeping the present SPR facilities and systems operational if the life extension projects are not done. Given the extent to which the SPR's capability could be degraded without the Life Extension Program and the potential net benefits of preserving the large investment in equipment and capability to date, we would also assign this activity a high priority.

Filling the SPR to Its Current Capacity or Expanding the Capacity Would Be Costly

Because of budget constraints, DOE is not requesting any funds in fiscal year 1995 to continue to fill the reserve from its current level of about 600 million barrels to its capacity of 750 million barrels. DOE estimates that filling the reserve to capacity would cost a total of about $4.2 billion (or $3.7 billion in present value terms). Also, DOE has informed the Congress that because of extreme demands on the federal budget, the administration does not foresee that the reserve can be expanded to the authorized 1 billion barrels within a meaningful planning horizon.[2] DOE estimates that expanding and filling the reserve to 1 billion barrels would cost between $10 billion and $11 billion (or between $6.4 billion and $7.1 billion in present value terms), depending on the price of oil and the sites selected for the expansion. Any expansion of the reserve would also have to address the potential for heat and gas to build up in the expanded portion of the reserve.

Our analysis shows that filling the reserve to its 750-million-barrel capacity could produce net benefits of as much as $3.3 billion, which occurs under the severe disruption scenario, in which large, longer-lasting disruptions are more likely. However, under a milder disruption scenario, in which disruptions are shorter, the costs would exceed the benefits by as much as $1.3 billion. Because the costs of expanding and filling the reserve to 1 billion barrels would be very high, our analysis shows that the costs would exceed the expected benefits under all but the most severe disruption scenario. Such costs would exceed the benefits by as much as $2.8 billion. Given the high costs of purchasing additional oil and expanding the reserve's capacity and the relatively few disruption scenarios under which a larger reserve would produce benefits, we would assign these options a relatively low priority.

Some SPR staff believe that cost savings might be possible if the size of the SPR were officially capped at its current size of about 600 million barrels. This cap could enable DOE to consolidate and take out of operation unneeded sites and limit life extension projects to only those sites

[2]DOE has conducted studies, analyses, and public hearings to select expansion sites. However, the agency has forwarded to the Congress a bill to amend the Energy Policy and Conservation Act, as amended, that will require continued planning to expand the SPR to 1 billion barrels only when a pattern of appropriations develops that would provide for filling the existing facilities within 5 years.

remaining. SPR staff are examining this issue but have not yet reached any conclusions.

Increasing the Daily Drawdown Capability Could Increase Flexibility

Increasing the daily drawdown capability, either while increasing the total amount of oil in the reserve or separately, would increase the nation's ability to replace disrupted crude oil supplies and dampen oil price increases and their impact on the economy. DOE has estimated the cost of increasing the maximum daily drawdown capability from the existing 4.5 million barrels per day to 6 million barrels per day as the reserve is expanded to 1 billion barrels. These estimates range from $2 million to $196 million, depending on which sites DOE selects to expand. DOE has not estimated the cost of increasing the daily drawdown capability for the existing reserve without an expansion. SPR program officials we spoke with said, however, that such capability could be added, and, if required, could logically be included in the Life Extension Program. Any increase in drawdown capability also assumes that the problems of heat and gas buildup are resolved.

Our analysis shows that increasing the SPR's drawdown capability to 6 million barrels per day, for the current or an expanded reserve, produces net benefits under most scenarios only for the expanded reserve. However, we cannot fully evaluate the potential advantages of increasing the drawdown capability because of constraints in the model that limit the amount of SPR oil that can be released at any given time. For example, the model will not readily allow the user to increase, or "surge," the initial drawdown and then lower it if a disruption seems likely to last longer than originally anticipated. Such a surge capability could help to meet DOE's stated intention of quickly injecting large amounts of oil into disrupted markets to dampen oil price increases. The model does show that if disruptions are relatively short, increasing the daily drawdown capability provides more net benefits than increasing the current size of the reserve. Also, increasing the daily drawdown capability would likely cost less than purchasing large quantities of additional oil or expanding the reserve, and it would give DOE more flexibility to respond to a wider range of disruption scenarios. Consequently, we would assign this option as applied to the reserve's current size a medium priority.

Agency Comments

We discussed the facts of this report with the Associate Deputy Assistant Secretary Strategic Petroleum Reserves and his staff and with officials of the Oak Ridge National Laboratory who developed DOE's DIS-RISK model.

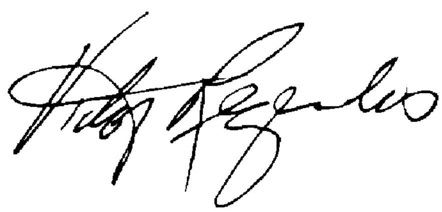
They agreed with the facts presented and suggested minor changes that were incorporated where appropriate. However, as requested, we did not obtain written agency comments on a draft of this report.

In conducting our work, we held extensive interviews at DOE headquarters and the SPR project office and reviewed numerous related studies and evaluations. In the project office, we reviewed DOE's Vapor Pressure Task Force and its contractors' records in order to analyze short-term and long-term corrective actions, as well as estimates of the cost, time, and impact of DOE's proposed actions to correct the SPR's problems of heat and gas buildup. For the life extension and expansion programs, we reviewed cost projections prepared by contractors for the work DOE is proposing to undertake. As noted earlier, appendix I describes the DOE model we used in our analyses to determine the relative priority of the various options for improving the readiness of and expanding the SPR. We performed our work between May 1993 and May 1994 in accordance with generally accepted government auditing standards.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days after the date of this letter. At that time, we will send copies to the Secretary of Energy. We will also make copies available to others upon request.

Please call me at (202) 512-3841 if you or your staff have any questions. Major contributors to this report are listed in appendix II.

Sincerely yours,



Victor S. Rezendes
Director, Energy and
Science Issues

Contents

Abbreviations

DOE	Department of Energy
EIA	Energy Information Administration
GAO	General Accounting Office
GNP	gross national product
SPR	Strategic Petroleum Reserve

Description of DOE's Model and Our Evaluation of SPR Readiness and Expansion Issues

This appendix discusses the results of risk analyses that we performed, using a model developed and provided to us by the Department of Energy (DOE) to evaluate the Strategic Petroleum Reserve's (SPR) readiness and expansion issues. The first section provides an overview of DOE's "DIS-RISK" model. The second section contains a detailed technical examination of the model's structure, tracing the model's logic from the generation of a random oil supply disruption to the calculation of SPR costs and benefits, given the simplifying assumptions underlying the model. The third section contains our comments on some of the underlying assumptions made in the model. The fourth section briefly describes the SPR readiness and expansion issues we examined. In the fifth section, we describe five scenarios—collections of assumptions about the nature of oil supply disruptions and oil market responses—that we used to examine each of these SPR issues. The sixth section contains estimates of the net benefits under each scenario for each readiness or expansion issue. In the last section, we compare the benefits and costs of enhancing the SPR's drawdown capabilities with those of filling the SPR.

Overview of the DIS-RISK Model

As the basis for examining SPR issues, we used a model developed for this purpose by DOE. DOE provided us with a model known as DIS-RISK, a risk-analysis version of the DIS-SPR model first developed during an interagency study evaluating SPR expansion issues.[1] DIS-RISK is designed to evaluate the incremental benefits of changes to the SPR in an uncertain environment. Given that the future course of oil market disruptions is uncertain, this modeling approach is useful because it generates a range of possible outcomes that can be expected under various scenarios. The model incorporates important simplifying assumptions about the oil market's and policymakers' responses, and alternative assumptions can be chosen and the results can be examined to determine their sensitivity.

Many uncertainties surround SPR issues, and they must be addressed in evaluating the benefits of expanding the SPR's size and capabilities. These uncertainties include whether the oil supply will be disrupted, when and how severely it will be disrupted, and how long it will be disrupted. Further uncertainty surrounds the oil market's response to a supply disruption—how high oil prices will rise, for example, and how quickly

[1]Participants in the interagency study, which was chaired by DOE, included the Departments of State, the Treasury, Defense, the Interior, and Commerce; the Office of Management and Budget; the Central Intelligence Agency; the National Security Council; the Economic Policy Council; the Council of Economic Advisers; the Federal Emergency Management Agency; and the Energy Information Administration. The study, the 1990 Interagency SPR Size Study, examined the costs and benefits of expanding the SPR.

they will return to more normal levels. In addition, the effects of higher-than-anticipated oil prices on the economy as a whole are uncertain, as are the government's policies for drawing down the SPR and for adding oil to the reserve to meet specified targets.

The DIS-RISK model addressed these uncertainties explicitly by requiring assumptions about the following:

- the nature of supply disruptions, characterized by (1) the length of disruptions in calendar quarters, assumed to be known in advance, and (2) the underlying probability distribution describing the likelihood that a disruption of a given size will occur;
- the condition of the oil market in the future, including (1) oil prices and quantities, (2) measures of the price elasticity of demand, (3) measures of alternative oil supplies, including available foreign stocks, and (4) the rate at which oil prices will return to expected levels after a shock;
- the impact of an unanticipated oil price increase on the gross national product (GNP), expressed in elasticity form as the percentage decrease in GNP resulting from a 1-percent increase in the price of oil; and
- the policies governing the use of the SPR.

DIS-RISK compares one potential SPR configuration, specified in terms of target size, drawdown and distribution capability, and fill rates, with an alternative SPR configuration. For instance, one SPR configuration may be based on the SPR's current size of approximately 600 million barrels, and the alternative may represent an expanded SPR of 750 million barrels. Both SPR configurations are subjected to the same set of oil market disruptions, as well as the same set of assumptions about the condition of the oil market, the effects of oil-prices on the economy, and SPR drawdown rules.

For each year through year 2020—the end of the analysis period—the model generates a gross oil market disruption as a random value derived from the specified probability distribution. In conjunction with the assumptions about SPR policies reacting to oil disruptions, oil market conditions and responses, and economic impacts, it is possible to define SPR costs and benefits for both of the SPR configurations. In most years, large disruptions do not occur, but the government, as owner of the reserve, bears the costs of adding oil to the SPR (at least if the SPR is less than its target size). In years in which large disruptions do occur and the SPR is drawn down, the government will receive revenues from selling SPR oil. If the SPR oil cannot fully offset the disruption, however, disruption costs will be incurred.

The model calculates these disruption costs as the sum of lost GNP costs, incremental oil import costs, and deadweight losses of oil consumers.[2] By calculating the costs of the two SPR configurations, as well as comparing their responses to the same set of disruptions, the DIS-RISK model estimates the net benefits of increases in the SPR's size or capability. In most years, a larger or an enhanced SPR will provide little or no incremental benefits because the SPR will not be drawn down, even though the expansion or enhancement was costly in terms of additional facilities, oil acquisition, or both. However, in some years, perhaps a very small number of years, a larger or enhanced SPR will better mitigate a supply disruption than a smaller SPR. The benefits of a larger SPR can be expressed in terms of smaller GNP disruption costs, incremental oil import costs, and deadweight losses. The net benefits of SPR expansion are the present value of these benefits, less the present value of incremental oil acquisition costs, capital costs, and operating costs. More specifically, net benefits are defined as the average of the net benefit values obtained for each of the large number—1,000—of iterations we performed for each readiness or expansion issue under each scenario.

Structure of the DIS-RISK Model

One way to highlight the structure of DIS-RISK is to trace the model's linkages in the event of an oil supply disruption. In general, these linkages reflect the basic set of assumptions derived from the 1990 Interagency SPR Size Study.[3] We take this underlying structure as given. These core assumptions include, for example, the uncertainty characterizing supply disruptions, the basic structure of the oil market, the rule defining SPR usage, and the definition of benefit categories. Within this framework, however, the DIS-RISK model permits great flexibility in terms of specific parameterization. For instance, disruptions can be characterized by a variety of underlying statistical distributions.

Each iteration of the model produces for each year through 2020 a gross disruption, expressed in terms of barrels per day. Specifically, each iteration produces for each year a value from a specified Weibull

[2]Deadweight losses are those losses in welfare by oil consumers that are not offset by gains to oil producers. The deadweight loss and incremental oil import cost categories reflect disruption costs in the oil market. GNP losses reflect the frictional and cyclical costs incurred as other sectors of the economy adjust to an oil price shock.

[3]A complete description of the DIS-RISK model and the model's relationship to the 1990 Interagency SPR Size Study is provided in Paul N. Leiby and Donald W. Jones, "DIS-RISK Model for SPR Analysis, Model Documentation and Benchmarking Results," Oak Ridge National Laboratory (Dec. 1993).

distribution,[4] although other distributions could be used. This random value represents a percentage of the volume of the world's oil market in that year, translated into barrels per day. The model limits the size of the gross disruption in two ways. First, the gross disruption cannot exceed 50 percent of the world's oil market, and, second, the gross disruption cannot exceed 20.25 million barrels per day. Disruptions are assumed to be of known duration and are expressed in terms of quarters, so a given disruption that lasts for 2 quarters is more severe than a disruption of equal magnitude that lasts for 1 quarter.

In the DIS-RISK model, attempts are made to offset the gross disruption. Major sources of offsets include fuel switching capability, slack capacity, and foreign and private oil stockpiles. Reference paths specify amounts for these offsets for each year through 2020. If the disruption is larger than the available offsets, then the SPR is drawn upon.

A key assumption of the DIS-RISK model is that the SPR will be drawn down in an attempt to offset fully any remaining oil shortfall, subject to two important constraints.[5] One constraint is the exhaustion rate, defined as the amount of oil in the SPR in a given year divided by the number of days in the disruption. Because disruptions are assumed to be of known duration, any given random disruption represents a known amount of oil. If this amount of oil exceeds the amount of oil stored in the SPR, then the SPR cannot fully offset the disruption even if the reserve is emptied. Thus, the exhaustion rate can be viewed as a size-based limit on the SPR's ability to mitigate disruptions—the SPR cannot release more oil than is stored, and the exhaustion rate is simply the daily drawdown amount that would, by the end of the disruption, drain the SPR. The second constraint is the distribution and drawdown constraint. The amount of oil released to the market is further limited by the SPR's drawdown capabilities—the SPR cannot release more oil than can be accommodated by its system of pipelines, pumps, and terminals.

If a net disruption does not exceed the exhaustion and drawdown limits, the SPR is drawn down by the amount of the disruption. An oil price increase is thus averted because the SPR oil is substituted for the oil whose supply is disrupted. The government, as owner of the reserve, receives payment for the oil it sells from the SPR. However, if a net disruption exceeds either the exhaustion or the drawdown limits, the SPR does not

[4]The Weibull distribution is a continuous, two-parameter distribution that is often used, for example, to study the reliability of systems.

[5]Actually, the model requires a fixed response rule, such as "attempt to offset fully."

fully offset the disruption even if it is drawn down as much as possible. In this event, the price of oil increases to induce decreases in the quantity of oil demanded by oil users.

The estimated costs of disruptions depend on various conditions in the oil market, as well as on relationships between the oil market and the production of goods and services more generally. One key factor is, of course, the magnitude of an oil price increase, which depends on the size of the net oil shortfall and the price elasticity of the demand for oil.[6] Another important issue is the extent to which a given increase in the price of oil negatively affects the production of goods and services. Another key factor is how quickly oil prices return to normal—that is, to the reference oil path.[7]

The precise amount by which oil prices rise depends on oil market conditions, specifically on oil market demand elasticities. The DIS-RISK model estimates the world price elasticity of demand, which in turn depends on an estimate of the U.S. price elasticity and the U.S. share of world oil demand. A more inelastic oil demand means that any given supply disruption will lead to a larger increase in the price of oil.[8]

One major category of SPR benefits is measured in terms of losses in the GNP that are avoided. To the extent that SPR oil is substituted for oil whose supply has been disrupted, the economic costs of reallocating resources among sectors of the economy are avoided. In the 1990 Interagency SPR Size Study, GNP losses resulting from an unanticipated oil price increase are represented by a simple elasticity relationship between the oil price increase and the GNP losses. This relationship simplifies the effects of many linkages from the oil sector to other parts of the economy, including the potential reactions of the monetary authorities. In the DIS-RISK model, GNP losses are incurred only for the duration of the disruption.

Two other categories of SPR benefits also involve disruption costs avoided. These are incremental oil import costs and deadweight losses of oil consumers. During a drawdown of the SPR, oil released from the reserve is

[6]The size of the shortfall depends in turn on the severity of the disruption, the condition of the supply side of the oil market in terms of available offsets, and the size and drawdown capability of the SPR.

[7]Reference path refers to the oil price and quantity values that are specified for each year through 2020.

[8]The price elasticity of demand is assumed to change over time. Throughout the period of the analysis, elasticity values are assumed to fall in the inelastic range of the demand schedule; less inelastic values are assumed to obtain later in the period being analyzed.

substituted for imported oil. However, if the disruption is large enough to cause an increase in oil prices, a higher price is paid for the oil that is still imported. Likewise, a higher price is required to induce consumers of oil to reduce the quantity of oil they use. Some expenditures for oil are transferred to oil producers and are already accounted for as a disruption cost to the extent that these expenditures flow to foreign suppliers of oil. However, the price increase also creates a deadweight loss. These disruption costs can linger beyond the duration of the disruption because these costs are relevant as long as oil prices exceed the anticipated oil price—that is, the reference price assumed to hold in the absence of a disruption. Hence, assumptions made about the rate at which oil prices return to the reference price path after a disruption affect the calculation of disruption costs avoided.

Table I.1 presents values for some of the key parameters developed during the 1990 Interagency SPR Size Study.

Table I.1: Values for Key Parameters Developed in the 1990 Interagency SPR Size Study

Parameter	Low case	Mid case	High case
Discount rate	8 percent	10 percent	12 percent
Offsets[a]	2.9 million barrels per day	6.2 million barrels per day	7.5 million barrels per day
Disruption probabilities	32.5 percent probability of disruption of greater than 1 percent of world market and 0.52 percent probability of disruption of greater than 15 percent of world market	32.5 percent probability of disruption of greater than 1 percent of world market and 1.0 percent probability of disruption of greater than 15 percent of world market	32.5 percent probability of disruption of greater than 1 percent of world market and 1.44 percent probability of disruption of greater than 15 percent of world market
Maximum disruption	[b]		[b]
Percent of market		50 percent	
Barrels per day		20.25 million	
Oil price adjustment (per quarter after disruption)	[b]	38.2 percent of difference between actual price and reference price	[b]
Demand elasticity[a]	-0.10	-0.14	-0.17
GNP elasticity	-.020	-.025	-.040

[a]Average of values over the years 1994 through 2020.

[b]Low-case and high-case parameter values are the same as in the mid case.

Derlying Assumptions Made in the DIS-RISK Model

The DIS-RISK model calculates economic benefits associated with the SPR, focusing on the fundamental uncertainties surrounding disruptions in oil supply. Many of the assumptions made in this model are designed to simplify the complicated linkages among sectors of the economy and to permit analytical tractability. Additionally, the assumptions are not intended to describe fully the complicated policy choices about the rates for filling and drawing down the SPR. In this section, we discuss three key aspects of the DIS-RISK model's structure: the role of price signals, the government's SPR policy, and the model's treatment of drawdown issues.

The model assumes that the SPR is drawn down whenever a gross disruption cannot be offset by other sources of energy, including foreign stocks and fuel switching. Furthermore, if the SPR successfully offsets the disruption, even if it is drained of oil in the most extreme case, the price of oil will not increase. These are important assumptions. For one thing, oil price increases would likely be necessary to signal fuel switching and to bring slack production on line. Additionally, it is quite unlikely that oil prices would not increase, at least temporarily, during a disruption that was large enough to engage the SPR.

SPR policy assumptions in the DIS-RISK model include the automatic drawdown rule, as well as fill and refill rates. Drawdown that is automatic does not describe the actual conditions under which the SPR could be drawn down. The Energy Policy and Conservation Act provides that SPR drawdown may not occur unless the President determines such action is necessary due to a severe energy supply disruption. Furthermore, recent fill rates have been far smaller than those assumed in the 1990 Interagency SPR Size Study. Fill rates are particularly important in examining SPR expansion issues.

Other important assumptions come into play in examining drawdown issues. The smallest unit of time that is relevant is 1 quarter (3 months), so that any variation in economic or policy variables that would occur within a 3-month period during a real disruption is not reflected in the model. As mentioned earlier, the drawdown constraint may not effectively limit the SPR's performance during a disruption. In particular, if disruptions are assumed to be longer or SPR's size is assumed to be smaller, the exhaustion rate rather than the drawdown rate constrains the SPR's performance. Within the constraints of the DIS-RISK model, it may not be possible to examine, for example, the effects of surge drawdown that would be possible if the SPR's drawdown capability were expanded.

SPR Readiness and Expansion Issues That We Examined

We examined four issues relevant to investments in the SPR.

Elevated Temperatures and Gas Content

- First, we examined the effect of elevated temperatures and gas content on the availability for use of some crude oil stored in the SPR. We obtained information from DOE about the implications for the SPR's size and drawdown capabilities if these impairments are not addressed. DOE estimates that, by blending the affected and unaffected oil and observing certain operating restrictions, it could draw about 520 million barrels out of the reserve without further corrective actions. However, it could draw out only about 2 million barrels per day. DOE further estimates that if it did not blend the affected and unaffected oil and observe the operating restrictions, it would have all of the oil available, but it could draw down only about 800,000 barrels per day. For the purposes of estimating net benefits, we defined the impairment in two ways on the basis of these alternative descriptions.

Life Extension

- Second, we obtained information from DOE about the size and drawdown implications of DOE's proposed Life Extension Program. According to DOE, without the proposed life extension projects, the drawdown and distribution capabilities at some of the SPR sites will be impaired and some sites will fall well below 70 percent of their design capabilities.

SPR Size Issues: Fill to Current 750-Million-Barrel Capacity and Expand to 1 Billion Barrels

- Third, we examined the issue of filling the SPR to a target size of 750 million barrels and then expanding the SPR's capacity from 750 million barrels to 1 billion barrels. Since DOE has already developed the capacity to store 750 million barrels of oil, the remaining costs of filling to this capacity would largely be for additional purchases of oil. To expand the reserve to 1 billion barrels, additional sites and caverns would have to be developed and additional oil would have to be purchased.

Drawdown Enhancements

- Fourth, we examined two aspects related to increasing the SPR's drawdown capability. We examined increasing drawdown and distribution from the current 4.5 million barrels per day to 6 million barrels per day, assuming, first, that the SPR would remain at its current size and, second, that it would be expanded to a target size of 1 billion barrels.

Specific Scenarios Used in Our Analyses

To provide a range of estimates of SPR net benefits and show how investments are sensitive to the major uncertainties, we defined five scenarios, or collections of assumptions about oil supply disruptions and oil market conditions, to use in examining each of the four SPR expansion and drawdown issues. Key aspects of these scenarios are presented in table I.2.

We characterize the five scenarios as (1) the base case, (2) severe disruptions, (3) mild disruptions, (4) responsive oil markets, and (5) low oil prices. In general, we relied heavily on the assumptions made in the 1990 Interagency SPR Size Study and maintained in the DIS-RISK model. Importantly, we relied on the interagency study's assumptions about disruption probabilities and oil market conditions. We used 1993 DOE forecasts of future oil prices and quantities that are incorporated in the DIS-RISK model.

Our base case includes assumptions similar to those used in the interagency study with one notable exception. We use a 4-percent real discount rate rather than a 10-percent real rate selected by DOE. The 4-percent real discount rate better reflects the government's current borrowing costs over the period of the analysis. We believe, in general, that this represents the appropriate discount rate to use in analyzing government investments. The 4-percent discount rate, which we use in all of our scenarios, places a higher present value on net benefits received in the future than a 10-percent discount rate would do.

The severe disruption scenario differs from the base case in its assumptions about the probability and duration of disruptions. In particular, disruptions are assumed to last for 9 months and there is a greater chance that a very large disruption will happen. In other respects, this case is similar to the base case.

The mild disruption scenario also differs from the base case only in its assumptions about the probability and duration of disruptions. In this scenario, disruptions are assumed to last for 3 months. The severe and mild disruption scenarios demonstrate that beliefs about the likelihood and severity of disruptions are important in examining SPR issues.

The fourth scenario—responsive oil markets—incorporates a different set of assumptions about how oil markets respond to a disruption. This scenario makes the same assumptions about the probability and duration of disruptions as the base case, but it posits more elastic demand relationships, quicker oil price adjustments, and smaller impacts on GNP from an oil price shock. This scenario examines the possible effects on the role of the SPR if innovations in the oil market, such as the development of futures markets, tend to reduce the impacts of oil shocks.

Finally, actual world oil prices have been lower than those forecasted by DOE and used in the base case scenario. The low oil price scenario, also developed by DOE, demonstrates the importance of low oil prices on SPR investments, particularly on oil acquisition costs.

Table I.2: Five GAO Scenarios

	Scenario:				
Parameter	**Base**	**Severe**	**Mild**	**Responsive**	**Low oil price**
Disruption length (in quarters)	2	3	1	2	2
Disruption probability	DOE mid case	DOE high case	DOE low case	DOE mid case	DOE mid case
Oil price adjustment	38.2 percent	38.2 percent	38.2 percent	66.7 percent	38.2 percent
GNP elasticity	-.025	-.025	-.025	-.015	-.025
Offsets	DOE mid case	DOE mid case	DOE mid case	DOE high case	DOE mid case
Elasticity	DOE mid case	DOE mid case	DOE mid case	DOE high case	DOE mid case
Oil prices	EIA[a] mid case	EIA mid case	EIA mid case	EIA mid case	EIA low case
Real discount rate	4 percent	4 percent	4 percent	4 percent	4 percent

[a]Energy Information Administration.

Benefits of Near- and Long-Term SPR Readiness and Expansion Issues

For some readiness and expansion issues, our estimates of net benefits are not particularly sensitive to the choice of scenario, while for other issues, our estimates of net benefits may be positive under only one scenario. In general, the benefits of filling and expanding are larger if disruptions are assumed to be long-lasting, as in the severe disruption scenario, while the costs exceed the benefits if disruptions are assumed to be short, as in the mild disruption scenario. Conversely, the benefits of drawdown enhancements are more likely to be larger if disruptions are assumed to be shorter, as in the mild scenario. Across the expansion and readiness issues, the responsive scenario generally produces lower net benefits than the base case because the responsive scenario assumes that oil markets are better able to adjust to disruptions and that the economic effects of a price shock are smaller. Conversely, the low oil price scenario generally produces higher net benefits than the base case because the low oil price scenario assumes that the costs of filling (and refilling) the SPR are lower.

Elevated Temperature and Gas Content

The benefits of reducing the SPR's elevated temperature and gas problems are substantial. Our results, summarized in table I.3, suggest that, under all scenarios examined, the present value of net benefits exceeds $2.9 billion, and in some scenarios incorporating the more extreme definition of impairment, this value exceeds $15 billion.[9]

Table I.3: Benefits of Reducing Heat and Gas Problems With SPR Crude Oil

Dollars in billions

	Net benefits[a]	
Scenario	**Case 1[b]**	**Case 2[c]**
Base case	$6.4	$14.7
Severe	2.9	15.6
Mild	4.6	7.5
Responsive	3.0	5.9
Low oil price	6.9	16.7

[a]Analysis evaluates net benefits of increasing actual SPR capabilities from impaired state, as defined, to design capabilities.

[b]Impaired SPR defined as 520 million barrels of oil available and drawdown rate of about 2 million barrels per day.

[c]Impaired SPR defined as all stockpiled oil available and drawdown rate of 800,000 barrels per day.

Life Extension

The benefits derived from SPR life extension are less clear, that is, whether the benefits exceed the costs depend on the scenario. DOE officials characterize the Life Extension Program as correcting impairments in the SPR's drawdown capabilities that are likely to become more pronounced over time without the program. The design drawdown capability of 4.5 million barrels per day is the sum of the design drawdown capabilities at the five SPR sites. Given assessments by DOE of the extent of the impairment in drawdown capability likely to be experienced at each site at different times in the future, we developed an impaired drawdown

[9]Dollar figures are expressed in constant 1994 dollars.

capability schedule.[10] DOE estimated that the actual capability at three of the five sites would be less than 70 percent of the design capability. On the basis of further discussions with SPR staff, we interpreted this open-ended assessment to mean an overall reduction of 50 percent of the design capability at these sites, which resulted in a systemwide daily drawdown capability of approximately 3 million barrels.

The net benefit estimates presented in table I.4 reflect Life Extension Program costs of about $300 million. Any additional operating costs that would be incurred in the absence of the Life Extension Program have not been quantified. Modest net benefits are estimated under four of the five scenarios. Only under the severe disruption scenario, in which disruptions are assumed to last for 3 quarters, do the costs exceed the benefits. This result is due in part to the way in which the DIS-RISK model constrains the release of oil from the SPR in the event of a disruption. For a 3-quarter disruption, the exhaustion rate constraint rather than the drawdown constraint is binding, and no measurable incremental benefits accrue from being able to draw down 4.5 million barrels per day rather than approximately 3 million barrels per day.

Table I.4: Benefits of Replacing SPR Facilities and Systems Through a Life Extension Program

Dollars in billions

Scenario	Net benefits[a]
Base case	$0.9
Severe	–0.3
Mild	1.6
Responsive	0.2
Low oil price	1.0

[a]Net benefits assume that the present value of the Life Extension Program's costs is about $300 million. The benefits are derived by improving daily drawdown capabilities from 2.9 million barrels (after 10 years) to the design capability (4.5 million barrels). The SPR is assumed to have about 600 million barrels of crude oil in storage.

Fill and Expansion Issues

The net benefits of filling the SPR from its current size to 750 million barrels are positive under some scenarios, including the base case, but not under others. Net benefits are largest under the severe disruption scenario, in which disruptions are more likely and, importantly for SPR size issues, longer. Under the responsive oil markets scenario, net benefits are

[10]We did not attempt to assess the improvement in daily drawdown that could be obtained if oil from sites whose drawdown capability was relatively impaired were reallocated to sites whose actual capability was closer to their design capability. While costs would be associated with transferring oil between sites, such transfers could mitigate the drawdown impairment.

negative. The net benefits of expanding the SPR from 750 million barrels to 1 billion barrels are generally negative. Unlike filling to 750 million barrels, expanding beyond this size requires additional capital costs to prepare additional cavern capacity. These additional costs could be expected to range from $300 million to over $1.5 billion, depending on site-specific characteristics. The net benefit figures presented in table I.5 assume that the capital costs are $1 billion.

Table I.5: Benefits of Filling the SPR to Its Current Capacity or Expanding and Filling Additional Capacity

Dollars in billions

Scenario	Net benefits	
	Fill to 750 million barrels	Expand to 1 billion barrels[a]
Base case	$1.5	$-1.5
Severe	3.3	1.7
Mild	–1.3	–2.8
Responsive	–0.2	–2.4
Low oil price	2.3	–0.4

[a]Assumes that the present value of the capital costs of expanding the SPR is $1 billion.

Drawdown Enhancements

The costs of increasing drawdown capabilities are modest compared with the capital and oil acquisition costs of significant SPR expansions. Increasing the distribution and drawdown capability would allow more SPR oil to be extracted in a given period and would afford operational flexibility by permitting a quicker initial response. However, in the DIS-RISK model, the potential advantages of increasing drawdown capabilities may not be fully realized because the exhaustion rate constraint rather than the drawdown constraint may limit the amount of SPR oil that can be released. If the amount of oil assumed to be stored in the SPR is large and if disruptions are assumed to be short, increases in the SPR's drawdown capability are more likely to result in net benefits, as shown in table I.6.

Table I.6: Benefits of Enhancing Daily Drawdown Rate to 6 Million Barrels Per Day

Dollars in billions

Scenario	Net benefits[a]	
	600-million-barrel SPR	1-billion-barrel SPR
Base case	$-0.1	$1.3
Severe	–0.1	–0.1
Mild	0.9	1.0
Responsive	–0.1	0.5
Low oil price	–0.1	1.5

[a]Net benefits assume that the present value of the incremental costs of enhancing the daily drawdown rate is $100 million.

Comparing the Benefits and Costs of Drawdown and Fill Options

Table I.7 compares the benefits and costs of filling the SPR with the benefits and costs of adding drawdown enhancements. Clearly, assumptions about the duration of any disruptions are important in choosing among these alternatives. For this analysis, we changed slightly our scenario definitions to emphasize the importance of a disruption's duration. We did this by defining the length of the disruption in all five scenarios first as 1 quarter and then as 2 quarters.[11] All other assumptions about oil prices, oil markets' responsiveness, and disruption probabilities are the same as in our previous analyses. In general, if disruptions are short, drawdown enhancements are valuable, and if disruptions are longer, increased oil stocks are more valuable.

Table I.7: Comparing Benefits of Enhancing Daily Drawdown With Filling the SPR

Dollars in billions

Scenario	Net benefits			
	Enhanced drawdown[a]		Fill to 750	
	1-quarter disruption	2-quarter disruption	1-quarter disruption	2-quarter disruption
Base case	$2.1	$-0.1	$-1.2	$1.5
Severe	3.0	–0.1	–1.1	2.7
Mild	1.0	–0.1	–1.3	0.2
Responsive	0.6	–0.1	–1.3	–0.2
Low oil price	2.5	–0.1	–1.0	2.3

[a]Net benefits assume that the present value of the incremental costs of enhancing the daily drawdown rate is $100 million.

[11]In our other analyses, disruption lengths were assumed to be 2 quarters in the base, responsive markets, and low oil scenarios; 3 quarters in the severe scenario; and 1 quarter in the mild scenario.

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Related GAO Products

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

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