United States General Accounting Office

GAO

Report to the Chairman, Committee on the Budget, House of Representatives

December 1996

ENERGY SECURITY

Evaluating U.S. Vulnerability to Oil Supply Disruptions and Options for Mitigating Their Effects

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GAO/RCED-97-6

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-273024

December 12, 1996

The Honorable John R. Kasich
Chairman, Committee on the Budget
House of Representatives

Dear Mr. Chairman:

This report responds to your request that we assess the effectiveness of the administration's 1995 National Energy Policy Plan in reducing the vulnerability of the U.S. economy to oil supply disruptions and price shocks (oil shocks). The report estimates the economic benefits of importing oil and compares these benefits with the economic costs of past disruptions. The report also provides measures of the economy's vulnerability to oil shocks and forecasts the likely impact of the administration's initiatives and other factors on these measures through the year 2015. Finally, the report provides the views of oil experts and industry analysts on the most effective strategies for dealing with the economy's vulnerability to oil shocks.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Energy, and other interested parties. We will also make copies available to others upon request.

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

Sincerely yours,

Victor S. Rezendes
Director, Energy, Resources,
and Science Issues

Executive Summary

Purpose

Since the early 1970s, the world oil market has experienced three major supply disruptions that harmed the U.S. economy. All three originated in the Persian Gulf. Concerned that growing dependence on low-priced imported oil, especially from the Persian Gulf, increases the economy's vulnerability to oil supply disruptions and price shocks (oil shocks), the current administration, through its 1995 National Energy Policy Plan, has adopted policies and programs intended to reduce that vulnerability and its associated economic costs.

As requested by the Chairman, House Committee on the Budget, this report assesses (1) the economic benefits of importing oil compared with the potential economic costs of vulnerability to oil shocks, (2) the extent to which the U.S. economy's vulnerability to oil shocks will likely change over time given the programs and policies contained in the administration's 1995 National Energy Policy Plan and other relevant factors, and (3) options for reducing the economy's vulnerability to oil shocks. To accomplish these objectives, GAO asked the Department of Energy's Energy Information Administration to estimate the economic benefits of importing oil using its modeling capabilities and assessed existing studies on the historical and projected costs of oil shocks.[1] GAO also used projections of domestic oil savings and production resulting from the Department of Energy's programs and the Energy Information Administration's long-range forecasts of vulnerability measures. Finally, GAO consulted with 19 recognized oil industry, oil market, or oilsecurity experts representing a wide range of views on energy policy issues.

Background

The current administration issued its biennial National Energy Policy Plan in July 1995, as required by title VIII of the Department of Energy Organization Act, enacted in 1977. Partly to reduce the nation's vulnerability to oil supply disruptions, the plan includes programs for increasing energy efficiency, substituting alternative energy sources for oil, and increasing domestic oil production. It also states as a policy that the administration will seek to dampen the effects of an oil supply disruption by drawing down the nation's Strategic Petroleum Reserve in coordination with related actions by other countries. Besides reducing the economy's vulnerability to oil shocks, the plan has two other goals—maximizing energy productivity and preventing pollution. GAO's review focused on reducing the economy's vulnerability to oil shocks. Such vulnerability depends largely on the likelihood or probability of a

[1]The results of the Energy Information Administration's modeling should not be construed as advocating or reflecting any policy position of the Department of Energy.

disruption, the extent to which the economy depends on oil, and the nation's ability to respond; GAO's review focused primarily on the latter two areas.

Oil accounts for about 40 percent of all U.S. energy consumption. Declining domestic oil production and relatively low world oil prices have increased the nation's reliance on foreign sources. If prices remain low, oil imports are projected to rise from about 50 percent of the nation's oil consumption in 1995 to over 60 percent over the next 20 years.

Results in Brief

GAO estimates that the U.S. economy realizes hundreds of billions of dollars in benefits annually by using relatively low cost imported oil rather than relying on more expensive domestic sources of energy. By comparison, oil shocks impose large but infrequent economic costs that, when annualized, are estimated to cost the U.S. economy tens of billions of dollars per year. More importantly, substituting more costly domestic production for oil imports without lowering overall oil consumption would be unlikely to substantially lower the costs of oil supply disruptions. In essence, the economic costs of oil price shocks depend largely upon the rise in the price of oil coupled with the nation's level of oil consumption, rather than the level of imports. As long as market forces prevail, the price of domestic and world oil will be the same and will rise and fall with changes in world oil market conditions. Under these conditions, an incremental decrease in oil imports would reduce the benefits of such imports without substantially lowering the costs of oil price shocks. Nevertheless, oil supply disruptions impose significant economic costs, and reliance on imported oil imposes military and other costs that are not easily measured.

While adopting the National Energy Policy Plan's initiatives may keep the economy's vulnerability to oil supply disruptions below what it otherwise would be, the Energy Information Administration's forecasts indicate that by most measures the economy will not likely be significantly less vulnerable through 2015, primarily because the demand for oil is projected to increase. Only over a longer period do energy analysts anticipate significant improvement—and that depends on technological advances in such areas as energy efficiency and alterative fuels.

While their views varied, almost all of the experts GAO consulted about options for reducing the economy's vulnerability to oil supply disruptions said that, in the short run, the United States should rely on rapid and large

releases of oil from the Strategic Petroleum Reserve to blunt price increases at the onset of an oil supply disruption. Many experts also said that the United States might be able to limit the economic damage through the effective use of monetary policy by adjusting interest rates and the money supply. In the long run, the experts generally favored research to develop cost-competitive alternatives to petroleum, particularly in the transportation sector, which is responsible for most of the nation's oil consumption. While some experts suggested raising taxes on domestic gasoline consumption to increase the price, lower the demand, and make alternatives more cost competitive, they also recognized the existence of opposing views on this option and the potential for public opposition to it.

GAO's Analysis

Estimated Benefits of Imports Exceed Likely Costs of Disruptions

Estimates of the day-to-day economic benefits of using low-priced imported oil exceed the estimated economic cost of occasional oil supply disruptions. Moreover, to the extent that imports were replaced with higher-cost domestic oil, the benefits from such imports would decline, but the cost of oil shocks would remain largely unchanged. The large benefits accrue from not having to rely on more expensive domestic sources of energy for the share of the nation's energy needs that is supplied by imported oil. The analysis done for GAO by the Energy Information Administration (EIA) estimated the annual cost to the U.S. economy of reducing imports. On the basis of this analysis, GAO estimates, for example, that reducing the expected growth of future U.S. oil imports by between 2.0 million barrels per day (mmbd) and 3.2 mmbd below the forecast level of 11.4 mmbd in 10 years would cost the United States between $50 billion and $100 billion per year in 1994 dollars in lost gross domestic product (GDP). This hypothetical reduction represents only a portion of the nation's actual oil imports, and the cost would increase if imports were further reduced. Thus, the nation's current level of oil imports provides hundreds of billions of dollars in economic benefits per year. These estimates are based on the expected pace of technological development and future oil prices. If the pace of technological development is faster than expected, then the estimated benefits of oil imports would be lower than reported here. Moreover, the United States could lower its imports without reducing economic growth.

In comparison, the estimated annualized costs of occasional oil supply disruptions are considerably smaller. Such costs are concentrated in the periods following disruptions, but when averaged over time, estimates of past and potential future costs ranged from $22 billion to $73 billion per year. Furthermore, substituting increased domestic oil production for imported oil would reduce the benefits from imports but would not substantially lower the costs of future disruptions. As long as oil prices are set in the marketplace and the United States is a part of the world oil market, U.S. consumers and businesses would pay the same higher world oil price for both domestically produced and imported oil during a disruption, with likely similar economic consequences. Under these conditions, the costs of a disruption depend on the level of oil consumption rather than the level of oil imports.

Reducing oil imports by increasing more costly domestic production would increase output and employment in the domestic oil industry, but this benefit would be more than offset by losses in other sectors of the economy. EIA's analysis found, for example, that reducing oil imports by 4.7 mmbd in 2015 would increase output in the mining sector (which includes the drilling and production of oil) by about $16 billion per year. Increases in employment would accompany such increases in output. However, reducing imports would also reduce output and employment in most other sectors, and the total estimated net decline in GDP would be about $100 billion per year. Furthermore, reductions in oil imports would be unlikely to affect the net trade deficit. That deficit is largely determined by the gap between savings and investment and by the government budget deficit, which are unlikely to be substantially affected by changes in the level of oil imports.

The economic benefits of importing low-priced oil are at least partially offset by the human and financial costs of military and national security operations in the Persian Gulf, where many of the world's low-cost reserves are located. According to different studies, the costs of preserving the stability of oil supplies range from as little as a few billion dollars per year to as much as $65 billion per year. However, it is unclear how military or security costs would change if the United States imported less oil. In addition, reliance on low-cost oil from the Persian Gulf may entail other unmeasurable costs, such as a reduction in the number of options available to U.S. foreign policy decisionmakers. The environmental costs of oil consumption are excluded from this analysis because they derive largely from the consumption, not from the source, of the oil.

U.S. Vulnerability to Oil Shocks Is Unlikely to Decline Substantially Over the Next 20 Years

The 1995 National Energy Policy Plan (NEPP) contains many policies and programs aimed at reducing the economy's vulnerability to oil shocks. These generally include (1) energy efficiency programs to reduce the consumption of oil or develop alternative energy sources, (2) fossil energy programs to increase the production of domestic oil and other fossil fuels, and (3) policies to draw down the Strategic Petroleum Reserve and other oil stocks during an oil supply disruption and facilitate the diversification of international oil supplies. However, it is difficult to assess the impact of these programs and policies on the economy's vulnerability because the NEPP does not offer ways to measure this vulnerability or quantify the initiatives' long-term effects on it.

GAO and Department of Energy (DOE) officials agreed on several measures of the economy's vulnerability to oil shocks—the concentration of world oil production, the excess world oil production capacity, the oil intensity of the U.S. economy, the oil dependence of the U.S. transportation sector, and the level of world oil stocks. Although DOE officials believed that the level of oil imports should also be included, they agreed that it is a weak measure because, as discussed, the economic effects of disruptions are largely the same regardless of the level of imports. DOE officials projected that, if other factors remained constant, their energy efficiency programs could collectively reduce the nation's oil consumption by about 2.1 mmbd by 2010 and by up to 3.5 mmbd by 2020. In addition, they projected that their fossil energy programs could collectively increase U.S. oil production by about 0.8 mmbd by 2010 and by up to 1.4 mmbd by 2020.

While adopting the NEPP's initiatives may keep the economy's vulnerability lower than it otherwise would be, EIA's projections indicate that increases in the demand for oil may offset many of the gains. EIA's forecasts that assume a continuation of DOE's existing policies and programs show improvement by 2015 in only one measure of vulnerability—the oil intensity of the U.S. economy. The other measures are expected to remain nearly the same or worsen during the forecast period. EIA's forecasts that assume greater technological advances indicate improved trends for the applicable measures, but by 2015 these measures are still at nearly their current level except for the oil intensity of the economy, which shows greater improvement. DOE officials point out that the measures would be worse without the NEPP's initiatives and that the initiatives result in other benefits, such as reduced pollution and greater domestic economic activity and employment. Despite these potential benefits, only over a longer term do energy analysts see the potential for a significant reduction in the economy's vulnerability to oil shocks.

Experts Identified Options for Mitigating Vulnerability

While their views varied on the advantages and disadvantages of individual options, oil experts and industry analysts offered several near- and long-term ways to reduce the nation's vulnerability to oil shocks, some of which also appear in the NEPP, but with some important differences. For the near term, they generally agreed that early use of the Strategic Petroleum Reserve (SPR) during an oil supply disruption is the most effective tool available to mitigate a disruption's adverse economic effects. Many also believed that a market-oriented trigger, such as the sale of options to purchase SPR oil, is needed to avoid time-consuming governmental decision-making and ensure a rapid and sufficient drawdown of the SPR at the onset of an oil crisis. The NEPP calls for using the SPR early during a disruption but does not call for a market-oriented trigger.

While not directly related to oil markets, monetary policy was cited by some experts as potentially effective in offsetting the short-term economic costs of an oil supply disruption. Although most of these experts believed that monetary policy is an important tool for offsetting the effects of an oil shock, some said that the relationship between the two is complex and requires more detailed study. The plan does not indicate what the nation's monetary policy should be during a disruption, but DOE is currently studying this issue, with input from Federal Reserve officials and others, and plans to release the results by the end of 1996.

Over the long term, the experts generally favored research to develop cost-competitive alternatives to petroleum, especially in the transportation sector. They also generally believed that the federal government should participate in energy research, particularly basic research, but did not favor federal mandates or subsidies to promote the use of alternative fuels. In addition, while acknowledging potential political and public opposition, some experts nevertheless suggested raising the domestic gasoline sales tax in order to increase the price and thus both lower the demand for gasoline and increase the cost-competitiveness of alternative fuels. Other experts pointed out that higher gasoline taxes would increase consumers' costs. The NEPP contains research initiatives related to alternative fuels and calls for the continued implementation of current mandates and subsidies for their use. The plan does not suggest raising gasoline tax rates.

Recommendations

GAO is not making any recommendations in this report.

Agency and Other Comments and GAO's Evaluation

GAO provided a draft of this report for review and comment to DOE and the energy or modeling experts consulted during GAO's study. DOE was critical of the report, while the experts who responded overwhelmingly agreed with the report's overall message.

In summary, DOE said that GAO's approach to analyzing the economic benefits of importing oil is seriously flawed and yields no insight into the overall consequences of oil imports. GAO estimated the economic benefits of importing oil by assessing the costs to the economy of lowering imports through hypothetically increased oil prices and an oil import fee. GAO validated this approach extensively with the 14 economic or modeling experts listed in appendix II of this report, as well as others. GAO believes that information on the extent of the economic benefits, coupled with information on the extent and source of the costs of oil supply disruptions, provides an important perspective for policymakers considering the implications of the nation's expected growing reliance on oil imports. DOE also said that GAO did not perform an adequate analysis of the expected changes in the economy's vulnerability to oil shocks largely because the report does not show the results both with and without the effects of DOE's programs. GAO's objective, which has been clarified, was to assess the extent to which the U.S. economy's vulnerability to oil shocks would change over time given the effects not only of DOE's programs but also of projected increases in the demand for oil and other important changes in the economy. To respond to this objective, GAO relied on EIA's published or readily available energy forecasts, which consider all of these factors but do not present the incremental effect of each one. Such an analysis might demonstrate DOE's view that the report's measures of vulnerability would be worse without DOE's programs—a view that GAO emphasized in both its draft and final report. Appendix VI contains the complete text of DOE's comments, along with GAO's detailed responses. In addition, chapters 2 through 4 conclude with summaries of DOE's applicable comments and GAO's responses.

The energy or modeling experts listed in appendixes I and II of this report who commented on a draft overwhelmingly agreed with the overall message, and several said that the report will make an important contribution to the continuing debate on energy security issues. Their detailed oral or written comments are technical in nature or address the emphasis given to various issues in the report. These comments are not included in the final report but are summarized at the end of chapters 2 through 4.

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Abbreviations

Btu	British thermal unit
CBO	Congressional Budget Office
CFCC	Continuous Fiber Ceramic Composites
DOD	Department of Defense
DOE	Department of Energy
EIA	Energy Information Administration
EMF	Energy Modeling Forum
FEMP	Federal Energy Management Program
FY	fiscal year
GAO	General Accounting Office
GDP	Gross Domestic Product
GNP	Gross National Product
IAC	Industrial assessment centers
IEA	International Energy Agency
IHEM	In-House Energy Management
MIT	Massachusetts Institute of Technology
mmbd	million barrels per day
mmby	million barrels per year
NAFTA	North American Free Trade Agreement
NEMS	National Energy Modeling System
NEPP	National Energy Policy Plan
NICE-3	National Industrial Competitiveness through Energy, Environment, Economics
OECD	Organization for Economic Cooperation and Development
OPEC	Organization of Petroleum Exporting Countries
ORNL	Oak Ridge National Laboratory
PNGV	Partnership for a New Generation of Vehicles
R&D	research and development
SPR	Strategic Petroleum Reserve

Introduction

Oil is an important source of energy used to fuel the world's economic activities. It currently accounts for about 40 percent of the energy consumed in the United States. In 1995, the United States consumed nearly 18 million barrels of oil per day (mmbd), or over one-fourth of the oil consumed in the world that year. Although the U.S. share of the world's oil consumption is projected to decline to just above 22 percent in 2015, largely because consumption is projected to increase in developing countries, the share of the nation's energy consumption met by oil is expected to remain the same in 2015. This high level of oil consumption, coupled with declining domestic oil production, has resulted in a growing reliance on imported oil. Compared with alternative domestic sources of energy, imported oil represents a relatively low-cost source of fuel to the U.S. economy. Imports supplied about 50 percent of the nation's oil consumption in 1995 and could supply over 60 percent by 2015 if oil prices remain low.

Because the world's lowest-cost oil reserves are currently concentrated in the Middle East, especially in the Persian Gulf, the United States and other oil-importing countries will rely more on this historically unstable region to supply a rising share of their oil imports. The current administration has expressed concern that the rising U.S. reliance on low-cost imported oil, especially from unstable sources, threatens national security by increasing the economy's vulnerability to world oil supply disruptions and price shocks (oil shocks). The extent of the economy's vulnerability depends on the likelihood or probability of a disruption, the economy's dependence on oil, and the nation's ability to respond to a disruption.[1] To reduce this vulnerability, the administration has proposed several programs and policies in its 1995 National Energy Policy Plan (NEPP).

The National Energy Policy Plan

Title VIII of the Department of Energy Organization Act, enacted in 1977, requires the President to submit a comprehensive biennial national energy policy plan that includes information on a number of energy issues. Title VIII sets broad provisions for the preparation of the NEPP, requiring administrations to set national energy objectives; identify the strategies to achieve the objectives; project energy supply, demand, and prices; provide the data and analysis to support goals and strategies, and invite public input. Since the requirement for a national energy policy plan was enacted, successive administrations have used the NEPP as a vehicle to define their visions of the nation's energy future and to set forth specific objectives

[1]This study focuses primarily on the potential economic effects of an oil shock and the nation's ability to respond. We do not attempt to assess the likelihood or probability of an oil shock.

and methods for achieving those objectives, but conformity with the provisions of title VIII has varied among the plans. In reviewing the six plans submitted between 1979 and 1991, we found that each plan developed its own approach to setting objectives instead of following the provisions of title VIII.[2] Besides reducing the nation's vulnerability to oil shocks, the administration's plan has two other goals—maximizing energy productivity and preventing pollution. Our review focused only on reducing the nation's economic vulnerability.

U.S. Concerns About Vulnerability to Oil Shocks

The United States has long been concerned, as a nation, about its vulnerability to oil shocks. Occasionally, the U.S. government, as well as the public, has equated this vulnerability with dependence on "oil imports," implying that curbing oil imports would solve the vulnerability issue.[3] For example, the first major energy policy initiative taken by the U.S. government after the Arab oil embargo in 1973 was Project Independence. Three weeks after the embargo, President Nixon announced that by the end of the 1970s, the United States would have developed the potential to meet its own energy needs without depending on any foreign energy sources. Project Independence sought to achieve this goal by increasing domestic oil supplies, primarily through higher prices, and by rapidly expanding the development of nuclear energy.[4]

Several other studies performed by federal agencies since the 1980s have linked the nation's oil-shock vulnerability to oil imports. In 1980, DOE issued a report stating that "our dependence on imported oil makes us vulnerable."[5] The study recommended several policy options, including "adjusting the price of imported oil to make it clear that continued imports include a tangible cost to the nation which must be compensated for in some way." A study by the Congressional Research Service in 1983 measured the economic vulnerability of the United States and its Western allies caused by hypothetical disruptions in supplies of imported oil from

[2]Excluding the current administration three administrations have prepared six energy plans in response to title VIII since 1979. See Energy Policy: Changes Needed to Make National Energy Planning More Useful (GAO/RCED-93-29, Apr. 27, 1993) for a review of the first six plans' conformity with title VIII's provisions.

[3]For reasons discussed in chs. 2 and 3 of this report, we believe that the U.S. economy's vulnerability to oil shocks is linked more to the nation's dependence on oil and participation in the world oil market than to the level of oil imports.

[4]Robert Stobaugh and Daniel Yergin, Energy Future: Report of the Energy Project at the Harvard Business School (1979), p. 277.

[5]Reducing U.S. Oil Vulnerability: Energy Policy for the 1980s (Nov. 1980).

the Persian Gulf.[6] This study emphasized building up governmental and private stocks as a way for the United States and its allies to address their vulnerability. The final Reagan Administration plan, issued in 1987, stated that "higher [oil] import dependence would increase the risk of major supply disruptions that are damaging to our economic well-being and energy security."[7] This plan examined the pros and cons of different policy options but did not recommend any specific policies.

More recently, in response to a petition filed by the Independent Petroleum Association of America to investigate the impact of imported oil on the nation's security, the Department of Commerce issued a study concluding that the nation's growing reliance on low-cost crude from unstable foreign sources threatens national security by increasing U.S. economic vulnerability to oil supply disruptions.[8] Following this study's recommendation, the Clinton administration proposed continuing its present efforts to improve U.S. energy security rather than adopting a specific import-adjustment mechanism. These efforts are contained in the most recent plan.

Objectives, Scope, and Methodology

As requested by the Chairman, House Committee on the Budget, this report assesses

- the economic benefits of importing oil compared with the potential economic costs of vulnerability to oil shocks,
- the extent to which the U.S. economy's vulnerability to oil shocks will likely change over time given the programs and policies contained in the administration's 1995 National Energy Policy Plan and other relevant factors, and
- options for reducing the economy's vulnerability to oil shocks.

To assess the economic benefits of importing oil relative to the potential costs of vulnerability to oil shocks, we asked DOE's Energy Information Administration (EIA)[9] to use its National Energy Modeling System (NEMS) to estimate the potential losses in the nation's aggregate economic output, or gross domestic product (GDP), that would be caused by reducing oil

[6]Western Vulnerability to a Disruption of Persian Gulf Oil Supplies: U.S. Interest and Options (Mar. 24, 1983).

[7]DOE, Energy Security, A Report to the President of the United States (Mar. 1987).

[8]Department of Commerce, The Effect of Imports of Crude Oil and Refined Petroleum Products on the National Security (Dec. 1994).

[9]EIA is an independent statistical and analytical agency within DOE.

imports by different amounts.[10] The reductions are induced by higher oil prices attained through hypothetical alternative scenarios, including a decline in oil production by the Organization of Petroleum Exporting Countries (OPEC) and the imposition of an oil-import fee.[11] We also searched the available literature and obtained estimates of the historic and future economic costs associated with past and potential future oil shocks. Appendix II discusses our efforts to measure the benefits of importing oil.

To assess the extent to which the U.S. economy's vulnerability to oil shocks will likely change over time, we reviewed the plan and other applicable documents, interviewed DOE and EIA officials, and, in consultation with DOE, developed measures of vulnerability. We obtained DOE's projections for how much its energy efficiency and fossil energy programs are expected to decrease the demand for oil or increase the supply. We did not, however, analyze these programs' prospects for success in achieving the projected results. We also used EIA's forecasts to assess potential future changes in the measures of vulnerability.

To identify options for reducing the economy's vulnerability to oil shocks, we selected and interviewed a cross section of oil-industry, oil-market, and oil-security experts representing a wide range of views on energy policy issues. These experts came from academia, the energy industry, and government. We also reviewed the literature on economic and energy policy, including studies by most of the experts we contacted. We also reviewed previous GAO reports. Appendix I lists the people we contacted in responding to this objective.

Our evaluation was limited in several respects. Estimates of the economic benefits of oil imports or the costs of oil supply disruptions may not be calculated with complete accuracy. For example, our estimated results do not include certain hard-to-quantify costs and benefits, including such costs as the military expenditures that are made with multiple objectives in mind and the potential loss of human life that may be associated with ensuring the security of oil from foreign sources. In addition, future market developments, technological advances, and changing international relationships make precise forecasts of future events difficult.

[10]NEMS is a scientific, policy-neutral methodology designed by EIA to assist policymakers and the public in assessing the impact of various policy initiatives. See app. II for more information about NEMS and its use in this report.

[11]OPEC was created in 1960. Its current members are Algeria, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela. The Persian Gulf members of OPEC are Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates.

Although our evaluation of the 1995 NEPP's programs and policies focused on the impact of reducing the economy's vulnerability to oil shocks, many of the programs and policies address multiple goals, such as environmental improvement and economic development. Finally, although we solicited views from a cross section of experts on the most effective options for reducing the economy's vulnerability, the options presented in this report may not be representative of all experts' views on this topic.

We discussed our analysis of the data on measures of vulnerability and the effects of the plan's programs with the EIA and DOE officials who provided the data. We also discussed the modeling results in chapter 2 with the Director and staff of EIA's Office of Integrated Analysis and Forecasting. We provided copies of a draft of this report to DOE, which led the administration's effort to develop the 1995 NEPP, and to the experts in energy or modeling listed in appendix I or appendix II of this report. The comments we received and our responses are summarized at the end of the applicable chapters. Appendix VI contains the complete text of DOE's comments, along with GAO's detailed responses.

We conducted our review from August 1995 through November 1996 in accordance with generally accepted government auditing standards.

Importing Low-Cost Oil Provides Large Economic Benefits and May Not Substantially Increase the Economic Cost of Oil Supply Disruptions

GAO estimates that U.S. consumers and businesses gain hundreds of billions of dollars in benefits annually from access to relatively low-cost foreign oil. These benefits accrue from avoiding the expenses of relying more extensively on higher-cost domestic energy. By most estimates, the day-to-day benefits for the United States of relying on low-cost foreign oil substantially exceed the occasional, but severe, costs of disruptions to the world oil supply. More importantly, reducing the nation's reliance on foreign oil by increasing domestic production would probably do little to decrease the economic cost of such disruptions because it would not substantially reduce their likelihood or cost. Dependence on oil itself—as distinct from dependence on oil imports—coupled with participation in the world oil market, causes the U.S. economy to bear the consequences of disruptions. Regardless of the level of imports, the U.S. economy could suffer economic harm from a disruption, particularly if the disruption were severe or long-lasting.

During Normal Markets, the Economic Benefits of Importing Low-Cost Oil Are Large

Both a recent study by the Department of Commerce and the 1995 NEPP recognize the benefits to the U.S. economy of access to relatively low-cost foreign oil, but these studies do not quantify the benefits. On the basis of the analysis that EIA performed at our request, we estimate that U.S. consumers and businesses gain hundreds of billions of dollars per year by avoiding purchases of costlier domestic energy.[1] While these estimates should be interpreted as a rough guide to the magnitude of the economic benefits, they are broadly consistent with the results of past studies. These benefits accrue without substantially affecting the nation's long-term trade deficit or harming overall domestic employment, but they may also impose military and diplomatic costs that are difficult to identify or measure. The environmental costs of oil consumption are excluded from this analysis because they depend largely on the level of oil consumption, not the source of the oil.

Benefits of Importing Low-Cost Oil Come From Avoiding Costlier Alternatives

U.S. consumers and businesses benefit from importing low-cost oil because they pay less for energy than they would if they were to rely more extensively on higher-cost domestic oil or alternative fuels. In addition, with the money they save by buying cheaper oil, they can increase their consumption of energy and other goods and services. Hence, the economic benefits of importing oil can be approximated by calculating the expenses that Americans avoid by not relying more extensively on comparatively expensive domestic oil or alternative fuels and the

[1]This analysis should not be construed as advocating or reflecting any policy position of DOE or EIA.

increased opportunities for consumption that arise from lower energy prices. Similarly, businesses benefit because their products can be more competitive with those of other countries that also have low energy prices. Because oil is an important commodity that is widely used in the United States, the benefits of importing oil accrue continuously to most American consumers and businesses. According to a study of oil production published by DOE's Oak Ridge National Laboratory (ORNL), some Persian Gulf countries can discover, pump, and ship oil very cheaply—in some locations for perhaps as little as $1 to $5 per barrel.[2] In contrast, the cost of discovering, pumping, and shipping oil or producing alternative fuels is much higher in the United States. The costs at currently producing sites could approach the current world oil price, which has fluctuated between $17 and $26 per barrel during the past year. Other sources of energy could be developed at prices that exceed the current world oil price. If the United States were to rely more extensively on domestic production, domestic oil prices would rise to reflect the higher production costs. The prices of gasoline and home heating oil would also rise, as would the prices of goods and services that require large amounts of energy in their production, such as plastics and air travel. Correspondingly, imports of these goods and services would rise to supplant domestic production. Even the prices of alternative energy sources, such as natural gas, would rise as the demand for these fuels rose. Our analysis of the benefits of importing oil depends on the pace of technological change assumed in EIA's reference case. If, however, technology advanced more quickly than EIA assumed in its reference case, then the cost of domestic oil or its alternatives could fall to a level that would be more competitive with the cost of imported oil. With a decline in the gap between the costs of domestic and imported oil, our estimates of the benefits of imports would correspondingly decline. More importantly, the United States could simultaneously improve its energy security and maintain domestic economic growth.

Importing Low-Cost Oil Produces Substantial Net Economic Benefits

From EIA's analysis, we conclude that U.S. consumers and businesses benefit by hundreds of billions of dollars each year from importing oil.[3] We obtained these estimates by asking EIA to model two approaches for decreasing U.S. oil imports and to compare the estimated GDP under these approaches with the reference case reported by EIA in its Annual Energy

[2]David L. Greene, Donald W. Jones, and Paul N. Leiby, The Outlook for U.S. Oil Dependence (ORNL-6873, May 11, 1995).

[3]The Impacts on U.S. Energy Markets and the Economy of Reducing Oil Imports, DOE, EIA, SR/OIAF(96-04), (Sept. 1996).

Outlook 1996. The reference case, discussed at greater length in chapter 3, reflects EIA's projection of the most likely future trends in energy markets and the U.S. economy. Because the benefits from importing oil cannot be measured directly, we estimate them indirectly by measuring the harm that would be caused by reducing imports from their current level. The differences between GDP in the reference case and GDP in the reduced-import cases represent the economic benefits of importing oil because these differences measure the savings realized by using imported oil instead of relying on relatively more expensive domestic sources of energy. Under one approach, as foreign production gradually declines, the world oil price rises, causing domestic prices to rise. Alternatively, under the other approach, the domestic oil price rises above the world oil price through the imposition of an oil import fee.[4] Both approaches use market mechanisms to reduce oil imports by raising the price of imported oil, thereby discouraging consumption and encouraging domestic production. In general, compared with regulatory approaches, market mechanisms have the advantage of reducing imports at the lowest possible cost to the U.S. economy. Furthermore, most experts agree that if policymakers wish to lower oil imports, an oil import fee is an effective and comparatively low-cost method to do so. (App. II describes in greater detail the methodologies and results of measuring the benefits of oil imports.) Both approaches provide an estimate of the benefits to the U.S. economy of importing oil and are useful for illustrating the large gains attributable to buying oil from the cheapest source, rather than imposing restrictions to enhance domestic energy production. Because of the many uncertainties in estimating the benefits of imports, the estimates are best interpreted as rough guides to the magnitude of the benefits of oil imports, rather than as precise estimates.

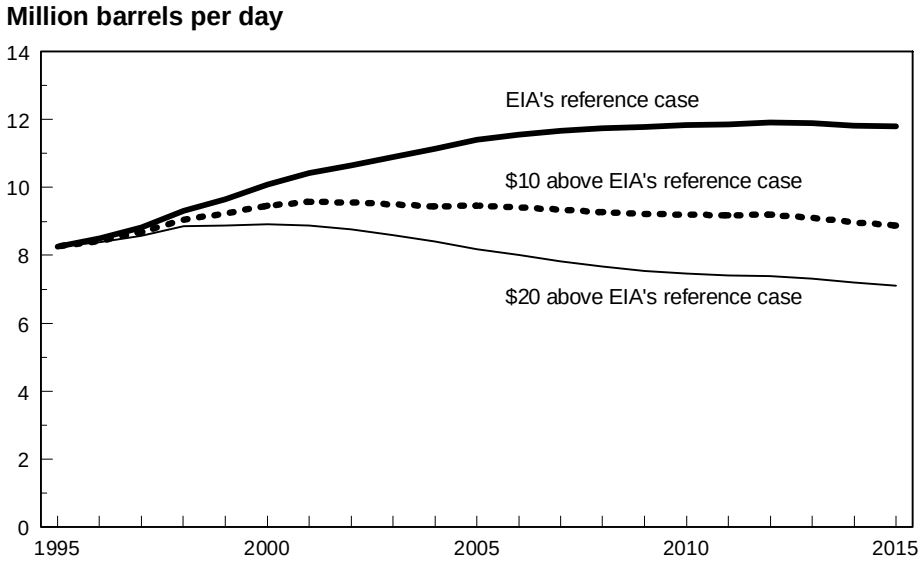
Using one approach, EIA analyzed the effect of an increase in the world oil price resulting not from a policy change but, for instance, from a gradual decrease in foreign oil production. According to EIA's reference case forecasts, the United States will import 11.4 mmbd of oil at a price of $22 per barrel in 2005, measured in 1994 dollars.[5] Figure 2.1 shows that if the price of crude oil were to rise to $32 per barrel in 2005—$10 per barrel higher than expected—U.S. oil imports would be about 9.5 mmbd, or

[4]GAO does not endorse an oil import fee or any particular energy program or policy goal. We selected an oil import fee rather than other alternatives, such as domestic production subsidies or import quotas, for illustrative purposes only. Most experts believe that an oil import fee would be among the most cost-effective methods for reducing imports. Using other methods for illustrative purposes would, therefore, provide even larger estimates of the benefits of buying oil from its cheapest source.

[5]Oil imports refer to crude oil and refined products made from crude oil, such as gasoline. Of the current import level of 8.3 mmbd, 7.4 mmbd are in the form of crude oil and 0.9 mmbd are in the form of refined products.

about 2 mmbd lower than currently projected. Nevertheless, the higher price would only slow the growth of oil imports because they would still exceed their current level of 8.3 mmbd. According to EIA's analysis, slowing the growth of imports by 2 mmbd would decrease GDP by an estimated $50 billion per year in 2005. A larger reduction in U.S. oil imports would impose a greater-than-proportional cost on the U.S. economy. For example, a $20-per-barrel increase in the price of oil by 2005 would reduce oil imports by 3.2 mmbd rather than 2 mmbd—a 60-percent larger decline in oil imports—and would double the annual economic cost from about $50 billion to about $100 billion by 2005. Figure 2.2 shows the effect on GDP of raising the price of oil $20 per barrel above the price projected in EIA's reference case for 2005.

Figure 2.1: U.S. Oil Import Levels Under Various Future Oil Price Scenarios



Note: Oil prices in 1994 dollars.

Source: EIA.

Using the other approach, EIA also estimated the benefits of oil imports by examining the economic consequences of reducing imports through the imposition of a hypothetical oil import fee. The import fee level was selected to reduce oil imports by approximately the same amount (3.2

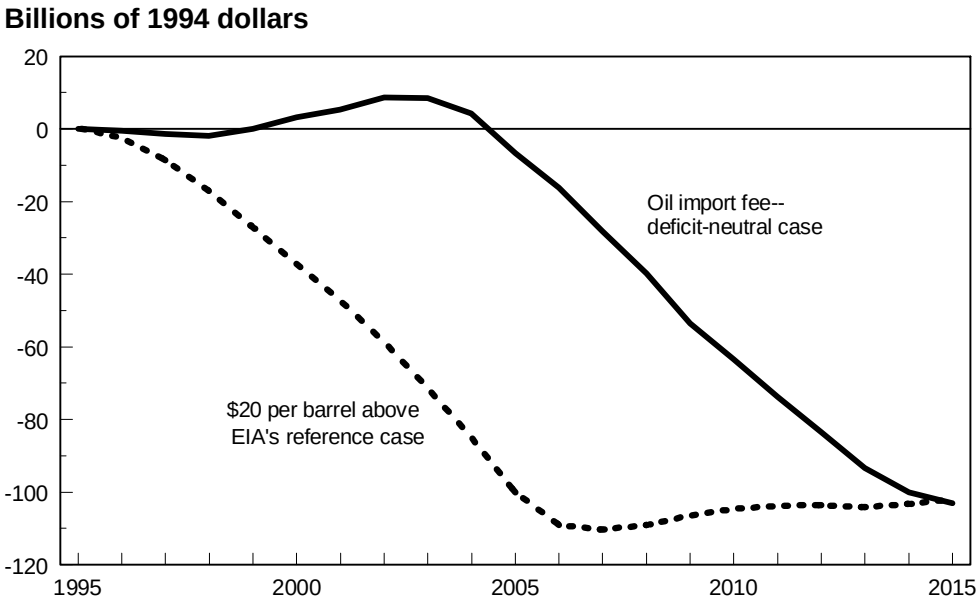
mmbd) as an increase of $20 per barrel in the price that EIA currently projects for oil in 2005. Unlike the previous approach, an oil import fee would raise the domestic oil price above the world oil price and would increase the manufacturing costs of domestically produced goods relative to those of imported goods. To bring about such a reduction in oil imports, EIA estimated that the import fee would need to be about $22 per barrel in 2005.[6] Unlike higher world oil prices, an oil import fee would raise substantial revenue for the government. The economic effect of reducing imports by imposing an oil import fee on the U.S. economy depends critically on how the fee revenues are used. EIA estimated two scenarios for the fee revenues. In one scenario—the deficit-neutral scenario—the fee revenues would be rebated to American workers and businesses through a reduction in the Social Security payroll tax, and the federal deficit at full employment would remain unchanged from EIA's reference case. In the other scenario—the deficit-reducing scenario—the fee revenues would be used to reduce the federal deficit below the level in EIA's reference case. We believe that the deficit-neutral scenario provides a more accurate representation of the long-term economic effects of reducing oil imports because, under the deficit-reducing scenario, the beneficial effects of reducing the federal budget deficit are combined with the harmful effects of reducing oil imports and relying on relatively more expensive domestic alternatives.

As figure 2.2 shows, the deficit-neutral oil import fee would have only small effects on the U.S. economy during the first 10 years. However, after 2005, reducing imports would impose large economic costs. By 2015, the fee, which by then would reduce imports by 4.7 mmbd, would reduce GDP by more than $100 billion per year. The cost of reducing imports would be hidden temporarily because rebating the fee would temporarily encourage spending. However, the long-term cost of reducing imports would eventually overwhelm the short-term benefits accruing from the fee rebate. In contrast, under the deficit-reducing scenario, which is not shown here, GDP would fall immediately when the oil import fee was introduced. By 2015, however, GDP would return almost to its baseline level. However, we believe that the increase in GDP would result from the

[6]The oil import fee is applied to all oil imports except those from Canada and Mexico, which are trading partners of the United States under the North American Free Trade Agreement (NAFTA). We assumed that these countries would meet their domestic demand with their domestic production and export their excess production to the United States.

beneficial effects, particularly a decline in interest rates, of reducing the federal deficit rather than from reducing the nation's oil import level.[7]

Figure 2.2: Changes in GDP From High World Oil Prices and a Deficit-Neutral Oil Import Fee



Note: Changes are relative to EIA's reference case.

Source: EIA.

The results of these two scenarios allow us to estimate the benefits of importing oil by measuring the costs of reducing imports by approximately 2 mmbd to 3.2 mmbd. We chose these particular reductions because estimating the full benefits of the nation's current level of imports—8.3 mmbd—is beyond the model's technical capability. Nevertheless, these relatively modest reductions in imports would impose costs on U.S. consumers and businesses ranging from $50 billion to $100 billion per year. More substantial reductions in imports would impose more than proportionately larger costs. As a result, we conclude that given today's

[7]The results of the two oil import fee cases may depend on whether foreign exchange rates are allowed to adjust to changes in imports or whether they remain fixed at their baseline levels, as the analysis assumes. Discussions with EIA analysts suggest that allowing exchange rates to change when an oil import fee is imposed could temporarily increase projected GDP, especially between 2005 and 2015. By 2015, however, the long-term effects would be similar under either assumption. See app. II for additional details.

technology and prices, relatively low-cost oil imports provide hundreds of billions of dollars in benefits annually to U.S. consumers and businesses.

Results of Other Studies Are Consistent With This Analysis

The results of EIA's analysis are broadly consistent with those of earlier studies of the benefits of oil imports. In 1986, we reported that a $10-per-barrel tariff on imports of refined crude oil products coupled with a $5-per-barrel tariff on crude imports would cost consumers about $73 billion annually.[8] In addition, a similar $5-per-barrel tariff on crude oil and refined products would reduce GDP by between 0.5 and 1.0 percent, or between $38 billion and $77 billion, given the current size of the economy.[9] Similarly, in 1987, DOE reported that a $10-per-barrel oil import fee would cost the economy $253 billion over 8 years, or about $32 billion per year.[10] A more recent study based upon projections of supply and demand from six different world oil models estimates the costs of reducing oil imports.[11] This analysis estimates that doubling the price of oil would not necessarily reduce the level of imports in the future. However, such a policy would reduce GDP by between $122 billion and $366 billion between 1989 and 2010, or between $6 billion and $17 billion per year. The differences among the results of these studies reflect differences in their assumptions and goals, as well as uncertainties in estimating the benefits of oil imports. For example, the study based on six world oil models includes only the direct effects of reducing oil imports on businesses and consumers; it does not, like EIA's analysis, include the indirect effects on the U.S. economy. This study also estimates the reductions in wealth transfers out of the United States that would occur at different import levels if an oil shock were to occur. Nevertheless, the studies arrive at the same basic conclusion: Comparatively low-cost oil imports provide large benefits to U.S. consumers and businesses.

[8]The results from other studies were adjusted for inflation that has occurred since the studies were published. These results are stated in 1994 dollars for consistency with EIA's analysis.

[9]Petroleum Products: Effects of Imports on U.S. Oil Refineries and U.S. Energy Security (GAO/RCED-86-85, Apr. 15, 1986).

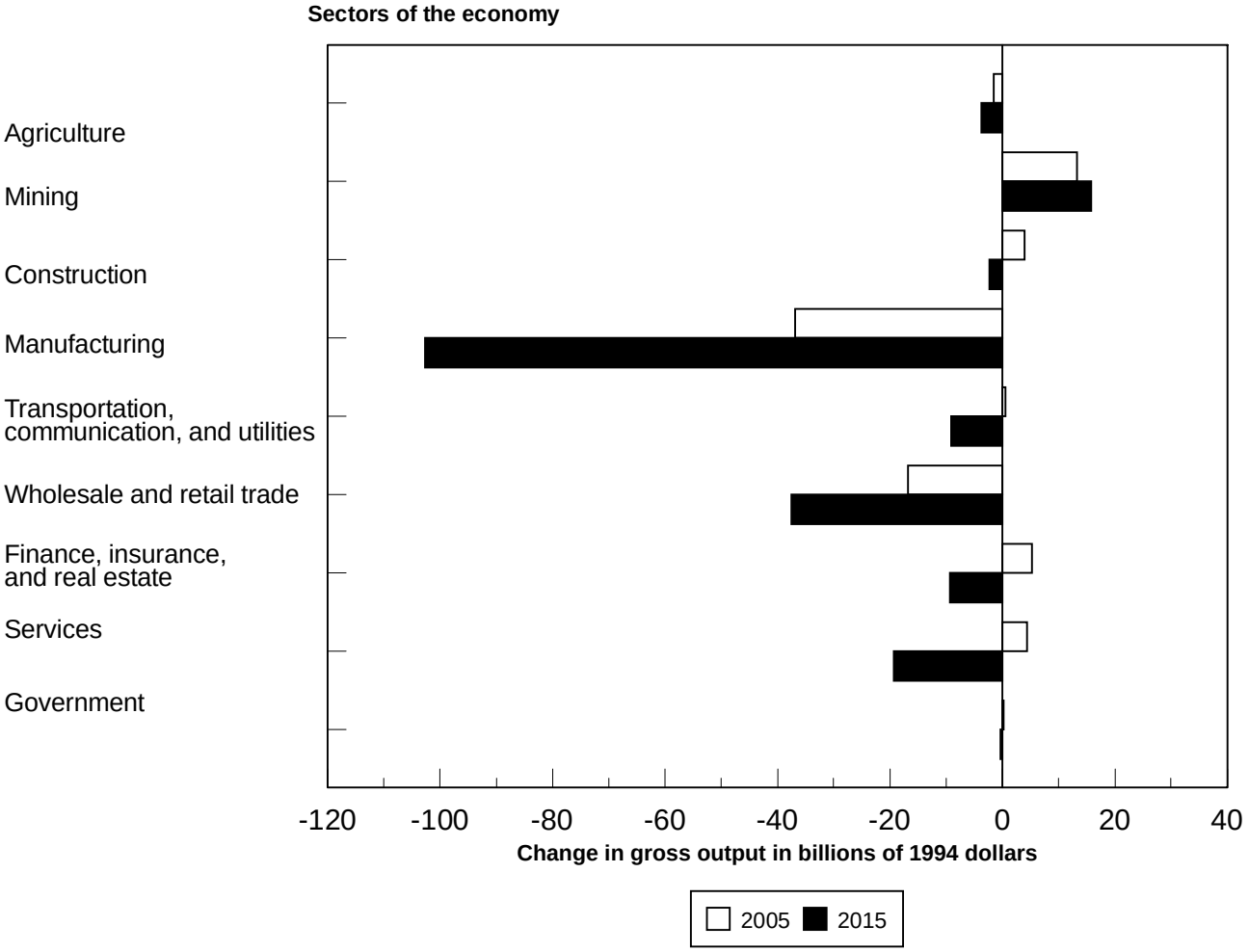
[10]Energy Security: A Report to the President of the United States (DOE/S-0057, Mar. 1987).

[11]Hillard G. Huntington, "Limiting U.S. Oil Imports: Cost Estimates," Contemporary Policy Issues, Vol. XI (1993).

Reducing Oil Imports Is Unlikely to Increase Total Domestic Employment or Reduce the Trade Deficit

Reducing oil imports would provide obvious benefits to the domestic oil industry and would increase employment in the domestic energy sector. However, the benefits to the domestic oil sector would be more than offset by the harm to other sectors of the economy. As part of its analysis, EIA assessed the effect of an oil import fee on different sectors of the economy. As figure 2.3 shows, by 2015 production would rise in the mining sector, which includes oil production, by about $16 billion per year if the deficit-neutral oil import fee were imposed as described earlier. However, higher oil prices would then decrease output in other sectors of the economy, and the net effect on the economy would be negative. According to EIA, changes in employment by sector would accompany changes in output in each sector—broadly speaking, industries suffering relatively large decreases in output would be the most likely to suffer relatively large decreases in employment.

Figure 2.3: Changes in Economic Output Caused by Imposing a Deficit-Neutral Oil Import Fee



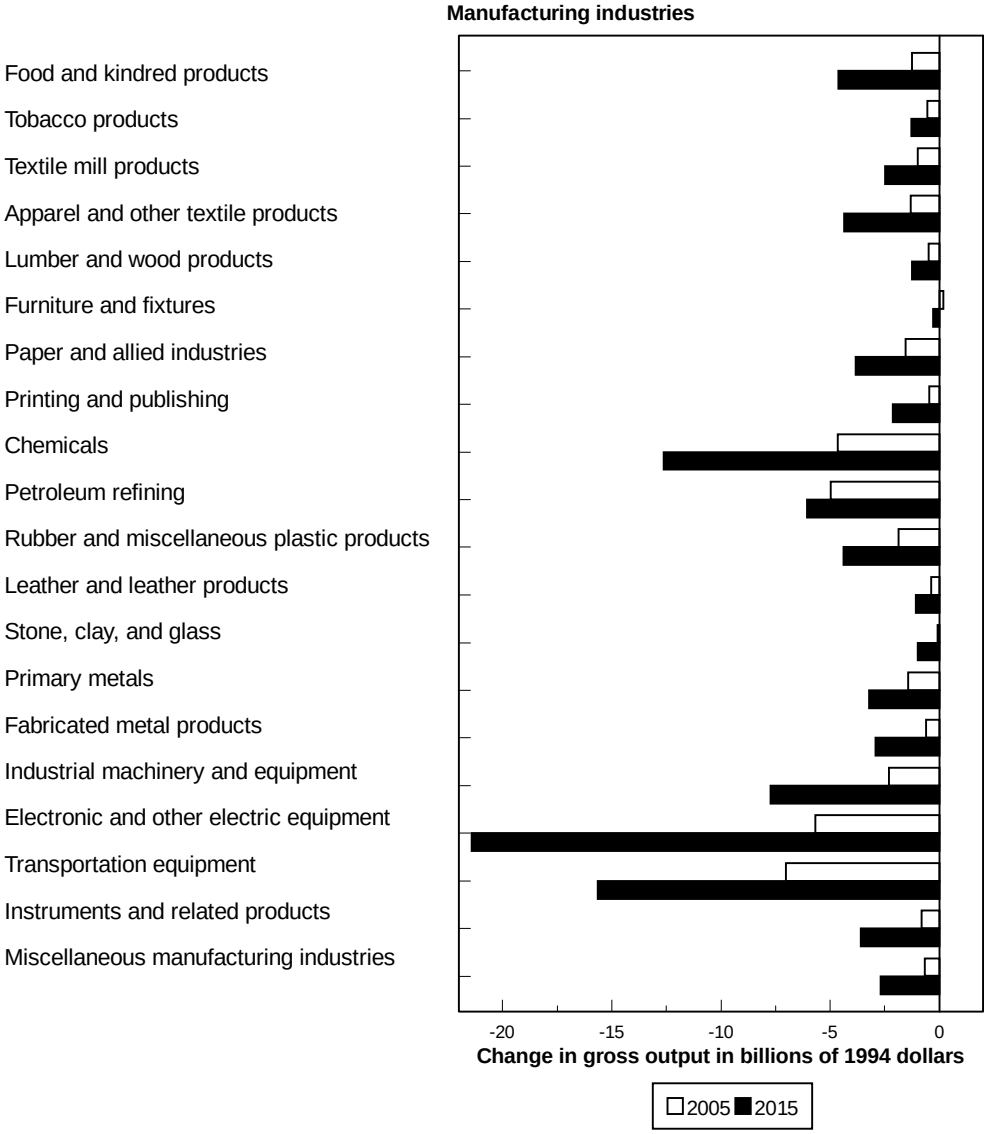
Note: Changes are relative to EIA's reference case.

Source: EIA.

EIA further divided the manufacturing sector of the economy, which would experience the greatest losses, into its components. As figure 2.4 shows, with a deficit-neutral oil import fee, output would decline relative to EIA's reference case in all manufacturing industries by 2015. As discussed in appendix II, the effects of the deficit-reducing oil import fee would be

qualitatively similar but quantitatively smaller because the effects of paying higher prices to reduce oil imports would be offset by the benefits of reducing the federal budget deficit.

Figure 2.4: Changes in Manufacturing Output Caused by Imposing a Deficit-Neutral Oil Import Fee



Note: Changes are relative to EIA's reference case.

Source: EIA.

Reducing oil imports would probably not substantially reduce the long-term U.S. trade deficit.[12] Although crude oil and natural gas are the fifth largest category of imports—following transportation equipment, electronic and electrical machinery, nonelectrical machinery, and textiles and apparel—they accounted for only 6.8 percent of the nation's total imports as of 1994. Moreover, the trade deficit is ultimately determined by factors such as the aggregate level of savings and investment, including the federal government's budget deficit, that are unrelated to oil imports. In the short term—such as during the months following an oil supply disruption—increases in oil prices or reductions in oil imports could affect the U.S. trade deficit. However, in the long term, if oil imports decreased, then total U.S. exports would eventually decrease or other U.S. imports would increase in order to keep the trade deficit near its initial level. According to most of the experts we contacted, the U.S. trade deficit is determined by the difference between the nation's total savings and total investment needs. When domestic investment needs exceed savings, the shortfall attracts foreign investment in the United States to meet such needs. The inflow of foreign funds, created by the savings shortage, eventually returns to foreign countries because the United States imports more goods and services than it exports. Thus, according to these experts, the trade deficit stems from saving too little rather than from importing too much oil.[13]

Reliance on Imported Oil Imposes Military Costs and May Reduce Foreign Policy Flexibility

The benefits of importing oil are at least partially offset by the financial costs and risk to human life of military and national security operations and the continued U.S. presence in the Persian Gulf. These costs, however, are hard to compare with the incremental costs of reducing oil imports. Even if we could identify the share of total military spending resulting from the need to secure oil imports, it would be difficult to forecast how military costs would change if the United States imported less oil but still imported a sizeable amount. Nevertheless, in 1991 we reported that the Department of Defense (DOD) spent $27.2 billion during fiscal years 1980-90 for military programs and other activities directly related to missions in Southwest Asia, which includes the Persian Gulf area. In addition, DOD invested $272.6 billion in programs that were motivated by requirements outside the Persian Gulf but have proved useful in that region. These figures exclude the incremental costs of Operations Desert

[12]The term "trade deficit" sometimes refers only to the merchandise trade deficit; however, our use of the term refers to the entire current account deficit.

[13]For a simple but more complete discussion of this relationship, see Charles L. Schultze, Memos to the President (Washington, D.C.: Brookings Institution, 1992), p. 117.

Shield and Desert Storm, which were estimated to be about $61 billion but were mostly covered by U.S. allies.[14] The military or security costs of importing oil depend on the portion of these spending totals that can be attributed to oil imports. Various research projects used different assumptions to estimate the cost of preserving the stability of oil supplies. Such estimates range from a few billion dollars per year to as much as $65 billion per year.

Depending on potentially less stable sources of petroleum may also reduce the nation's flexibility in foreign policy. The United States and its allies may be constrained from pursuing foreign policy actions for fear of alienating oil producing nations and provoking them into actions that would increase world oil prices. With lower import levels, the United States might be less inclined to commit troops or more willing to call upon its allies to defend oil supply lines. Moreover, the lack of flexibility could interfere with cooperative efforts by oil importing nations to avoid bidding up world oil prices after an oil supply disruption. Finally, the lack of flexibility might make international conflicts more difficult to resolve peacefully. While the magnitude of such human and financial costs is not known precisely, the costs are no less real. Whatever costs are attributable to preserving the stability of oil supplies directly offset the benefits of importing oil from the regions affected by U.S. military actions. Some experts argue for an oil import fee—ranging from $1 per barrel to $10 per barrel—to pay for these costs.

Some experts, as discussed in chapter 4, also argue for a tax on the consumption of all oil, whether domestic or imported, to address the environmental costs of oil consumption. Estimating these environmental costs is beyond the scope of this report because the costs generally arise from the consumption rather than the importation of oil.[15] Moreover, concerns about the environmental impact of oil consumption do not reduce the benefits of obtaining oil from its cheapest source.

[14]Southwest Asia: Cost of Protecting U.S. Interests (GAO/NSIAD-91-250, Aug. 14, 1991).

[15]In some cases, imported oil may impose greater environmental costs than domestically produced oil because imported oil often arrives by tanker rather than oil pipelines and some oil exporting countries may have lower environmental standards than the United States.

The Economic Costs of Market Disruptions Are Large but Mainly Unrelated to the Level of Oil Imports

Oil supply disruptions impose large costs on the U.S. economy because they increase the costs of consuming oil and cause consumers and businesses to make costly adjustments in their routines. While these costs can be significant and can impose hardships on American consumers and businesses, they are not likely to exceed the day-to-day benefits of obtaining oil from its cheapest source. More importantly, even if imports were lower, the economic impact of oil supply disruptions would not be substantially reduced given the same level of oil consumption. U.S. participation in the world market causes the effects of oil supply disruptions on the U.S. economy to be felt regardless of the level of oil imports.

Oil Supply Disruptions Impose Large Costs on the U.S. Economy

When oil supply disruptions occur, rapidly rising energy prices impose hardships on American consumers and increase operating costs for U.S. businesses by imposing two types of costs on the U.S. economy.[16] First, higher oil prices harm the economy by reducing the economy's potential GDP, which is the amount that the U.S. can produce when all resources are fully employed. Potential GDP is determined by the nation's resource base, which consists of its labor force, natural resources, and capital stock and the productivity of these resources. In response to the high energy prices, firms may use less energy, which reduces the amount of output that can be produced with a given amount of capital and labor. Second, because market disruptions occur suddenly rather than gradually, they impose additional costs, known as adjustment costs, on consumers and businesses; that is, until adjustments can be made, the economy's total output will be even less than it could be, given the new lower potential output level. For example, most individuals cannot quickly change from heating oil to, say, natural gas if oil prices rise unexpectedly. However, if price increases are anticipated, individual homeowners can make long-term decisions, such as whether to heat with oil or natural gas.

The impact of oil supply disruptions on the U.S. economy depends more on how much oil the nation consumes than on what fraction of that consumption is imported. Nevertheless, estimates of the costs of oil supply disruptions provide a useful context for evaluating the gains from importing oil.[17]

[16]We focus on the economic costs because, according to DOD, the military requirements for petroleum fuels could be satisfied under current planning scenarios.

[17]The results from other studies were adjusted for inflation that has occurred since the studies were published. These results are stated in 1994 dollars for consistency with EIA's analysis.

- Studies of the costs of past shocks show that they can impose large costs on the economy. For example, a 1980 study of countries in the Organization for Economic Cooperation and Development (OECD)[18] estimated that the 1973-74 oil shock cost these countries 2.9 percent of their national incomes. In today's domestic economy, if this shock had the same impact on the United States as it did on the other members of OECD, it would cost about $209 billion during a shock year.[19] Because shocks do not occur every year, the annual cost, averaged over time, would be smaller. Another study, published by the Oak Ridge National Laboratory, estimated that oil shocks may have cost the U.S. economy as much as $73 billion per year, on average, between 1972 and 1991.[20]

- In 1990, DOE simulated the cost of potential future oil supply disruptions. According to its forecast, the estimated net present value of three hypothetical oil supply disruptions between 1990 and 2020 is $650 billion, or about $22 billion per year. In addition, a study by the Oak Ridge National Laboratory reports that the estimated net present value of losses in gross national product (GNP)[21] and of economic adjustment costs from hypothetical oil supply disruptions between 1993 and 2010 could be $400 billion, or about $22 billion per year.[22]

Like estimates of the benefits of importing oil, estimates of the costs of oil supply disruptions should be viewed as rough estimates that provide a general guide to the magnitude of such costs. Both types of estimates are subject to the same uncertainties and difficulties.

[18]OECD is an intergovernmental organization established to stimulate economic growth in its member countries. OECD consists of countries with developed, market-based economies, including the United States.

[19]William D. Nordhaus, "Oil and Economic Performance in Industrial Countries," Brookings Papers on Economic Activity 2 (1980), pp. 341-388.

[20]David L. Greene and Paul N. Leiby, The Social Cost to the U.S. of Monopolization of the World Oil Market, 1972-1991 (ORNL-6744, Mar. 1993).

[21]Until recently, "GNP" was used instead of "GDP" to measure U.S. economic performance. GDP is now preferred, but the two terms are essentially interchangeable.

[22]David L. Greene, Donald W. Jones, and Paul N. Leiby, The Outlook for U.S. Oil Dependence (ORNL-6873, May 11, 1995).

Replacing Oil Imports With Domestic Oil Production May Not Substantially Lower Oil Supply Disruption Costs

Reducing oil imports by purchasing currently noncompetitive domestic oil would not substantially reduce the U.S. economy's vulnerability to the effects of sudden increases in oil prices. Experience has shown that such increases can cause economic disruptions, regardless of how much oil is imported or produced domestically. Oil supply disruptions anywhere in the world would cause the price of oil to rise in the United States, and the economy would bear the consequences even if oil imports were much lower. Import fees, regulatory actions, domestic production subsidies, or other programs aimed at artificially increasing the production of domestic oil or alternative fuels and, thus, reducing oil imports below the level determined by world oil prices, as discussed above, would substantially decrease GDP but would do little to decrease the impact of oil supply disruptions.[23]

Integrated World Markets Cause Oil Supply Disruption Costs to Be Felt Globally Regardless of Import Levels

The integration of the U.S. oil market into the world oil market means that the United States cannot isolate itself from the effects of oil supply disruptions. As long as oil prices are set in the marketplace, oil price changes in one part of the world affect oil prices everywhere, including the United States. Reducing oil imports would not reduce the negative effects of oil price increases on U.S. consumers, most businesses, or the economy as a whole, although it would, as discussed later in this chapter, benefit a segment of the economy—domestic oil producers and their stockholders. Rising prices would increase domestic production and transfer wealth from consumers to domestic rather than foreign producers. However, unless the United States were to shift fundamentally away from a market-based economy and ban all oil imports and exports, reducing oil imports could not substantially reduce the effects of oil supply disruptions on the U.S. economy.

Experience demonstrates that countries cannot insulate themselves from the effects of oil supply disruptions. For example, following the Iraqi invasion of Iran in 1979, the world oil price rose to $76 per barrel (in 1994 dollars). At that time, Great Britain was rapidly approaching independence from oil imports because its production from the North Sea oil fields was sufficient to supply most of its domestic demand for oil. Nevertheless, according to some experts, this oil supply disruption precipitated one of Great Britain's worst economic recessions. At the same time, Japan experienced virtually no economic downturn, even though Japan depends almost entirely on oil imports. Some analysts argue that Japan's monetary policy was better able than that of other industrialized nations to accommodate the rise in oil prices, suggesting that monetary policy could

[23]Ch. 4 of this report discusses options for reducing the negative effects of oil shocks.

play an important role in determining the level of economic harm caused by an oil price shock. (The potential effect of monetary policy is discussed further in ch. 4.) Similarly, in 1986, neither the United States nor the other industrialized nations experienced an economic boom when oil prices declined sharply around the world. Taken together, these experiences suggest that import levels, by themselves, do not determine a nation's vulnerability to oil supply disruptions: Low import levels do not shield a country from such disruptions any more than high import levels pose a threat to its economy.

Even if the United States were to undertake the expensive task of reducing its oil imports, it could not insulate itself from the effects of oil supply disruptions. For one thing, its economy is so closely tied to the economies of its major trading partners that it could not help but feel the effects of disruptions on them. For another thing, the United States has committed itself, through an agreement signed with the International Energy Agency (IEA), to share the burden of energy market disruptions when they occur. Under this agreement, the United States is responsible for maintaining strategic petroleum reserves and using these reserves in concert with other members of IEA to mitigate the effects of oil supply disruptions. (Ch. 4 contains a more complete discussion of the use of strategic petroleum reserves.)

Replacing Oil Imports With Domestic Oil Production Would Help U.S. Producers During Disruptions, but the Overall Economic Effect Is Uncertain

Reducing U.S. oil imports would benefit domestic oil producers and their stockholders as prices rose during oil supply disruptions. If the United States were to rely more heavily on domestic producers, then during oil supply disruptions the higher prices would accrue to domestic, rather than foreign, producers of oil.[24] Transfers of wealth from consumers to producers can be substantial during oil supply disruptions and depend on the magnitude, frequency, and length of the disruptions, the quantity of oil consumed, and the responsiveness of oil consumption to oil price changes. While such transfers would benefit U.S. producers, they would come at a price to the U.S. economy as a whole because, as discussed earlier, oil imports provide large net benefits to American consumers and businesses. Reducing imports would ensure that, during oil shocks, more wealth would be transferred to domestic than to foreign oil producers. However, reducing imports would also decrease the economywide benefits of obtaining oil from its cheapest source.

[24]To the extent that domestically produced oil is owned by foreigners, these wealth transfers would not be reduced.

Observations

The U.S. economy derives large net economic benefits from obtaining oil from its cheapest source. Such benefits accrue continually to a wide spectrum of the U.S. economy. The economic costs of oil supply disruptions are also large, but occasional, and historically they have been smaller than the cumulative benefits of oil imports. More importantly, replacing oil imports with domestically produced oil would only marginally lower the potential costs of disruptions because oil prices are set in the global marketplace and the price for all oil rises during disruptions. Even if the United States were to produce all of the oil it consumes, as long as the domestic economy is integrated into the world economy and oil prices are set in the marketplace, oil disruptions anywhere in the world will have substantial effects on the U.S. economy.

Agency and Other Comments and Our Evaluation

DOE said that our approach to analyzing the economic benefits of importing oil is seriously flawed, relies on unlikely scenarios, and yields no insight into the consequences or optimal level of oil imports. Although both DOE and the Department of Commerce have reported that there are benefits to importing relatively low-cost oil, neither has attempted to measure such benefits. Our approach does so by estimating the costs to the economy of lowering oil imports through hypothetically increased oil prices and an oil import fee. We validated this approach extensively with the 14 economic or modeling experts listed in appendix II of this report, as well as with others, and we stand by the results showing that the overall economic benefits are very large compared with past economic costs of occasional oil supply disruptions. We defined the modeling scenarios to reduce imports at the lowest possible cost and thus provide a conservative estimate of the benefits of such imports.

Calculating the optimal level of oil imports was outside the scope of GAO's review. Existing studies have already addressed this issue, although they have not conclusively determined whether the current level of imports is above or below the optimal level. In any event, as this report points out, it is not the level of oil imports that largely determines the economic costs attributable to rising prices during an oil supply disruption. Rather, it is the overall level of oil consumption. This distinction could have important implications for policymakers considering, for example, proposals designed to increase domestic oil production in order to increase the nation's energy security.

The experts who reviewed our draft report were nearly unanimous in supporting our methodology and the message of our report. One expert

did, however, say that we did not adequately include the environmental or military costs of oil imports in our analysis. We did not include the environmental consequences of oil imports in our report because such consequences depend largely on the nation's level of oil consumption, not on whether the oil was imported or produced domestically. Even if domestically produced alternative fuels supplant some oil consumption, the nation's economy continues to benefit from obtaining the oil that it does consume from its cheapest source. Although we agree that the military costs of oil imports are important, we state that these costs may not change if the nation's total oil imports change. The only other expert who specifically addressed this point agreed with our conclusion. In addition, several of the experts offered technical suggestions or suggestions about the emphasis given to various points in the report. For example, one expert thought we might have overstated the claim that lowering imports would leave the nation's trade deficit largely unchanged. Another expert, however, said this conclusion was correct and deserved more prominence in our report. Where appropriate, we have revised the report to reflect these suggestions.

The following chapters of this report explore in more detail the factors that most affect the U.S. economy's vulnerability to oil shocks, the extent to which current initiatives will likely lower such vulnerability, and the views of experts on what initiatives would be most effective.

Substantial Reductions in the U.S. Economy's Vulnerability to Oil Supply Disruptions Are Unlikely Over the Next 20 Years

The current National Energy Policy Plan (NEPP) seeks to reduce U.S. economic vulnerability to oil supply disruptions but does not provide a way to measure progress in achieving this goal. Several measures of the world's supply of and demand for oil, as well as the extent of the U.S. economy's reliance on oil, can be used to assess the nation's vulnerability. Changes in the world oil market since the 1970s have reduced that vulnerability, but oil market disruptions and their related economic effects remain a threat. Our analysis, based on EIA's forecasts, shows that the nation's vulnerability will grow by some measures and decline somewhat or stay the same by other measures. Overall, however, the U.S. economy will remain vulnerable to oil market disruptions for at least the next 20 years, even after accounting for many of the benefits anticipated from the NEPP's initiatives. Without these initiatives, the situation may even worsen, but only over longer periods do energy analysts see a potential for significant improvement—and that potential depends on overcoming technological barriers and on the price of alternatives becoming competitive with that of oil.

The NEPP Sets Reduced Vulnerability as a Goal but does Not Offer Ways to Measure Progress

A major goal of the NEPP is to reduce the U.S. economy's vulnerability to oil market disruptions, but the plan does not include measures for assessing progress over time.

The NEPP Sets Reduced Vulnerability as a Goal

The NEPP establishes a goal of keeping America secure, which it and DOE officials interpret, more or less, as "reducing the vulnerability of the U.S. economy to oil shocks." More specifically, the NEPP's goal is to

> "keep America secure by reducing our exposure to events beyond our control. The United States depends on reliable and competitively priced energy supplies to fuel stable economic growth. However, our economy relies on oil for 40 percent of our energy needs, which are being met increasingly by potentially unstable sources of world oil supply. While existing energy policy and improved macroeconomic policies can help reduce the economic harm from supply disruptions, our economy continues to be vulnerable to oil price shocks."

GAO Identified Measures of Vulnerability

The NEPP does not include ways to measure the extent of the economy's vulnerability or changes in that vulnerability over time. In discussing

appropriate measures with DOE officials responsible for preparing the NEPP, we agreed with these officials that the following measures are important. Later in this chapter we discuss the extent to which these measures have changed since 1975. We also discuss the changes in the measures that are indicated by EIA's forecasts through 2015.

- Concentration of world oil production. This measure can be expressed as the ratio of the Persian Gulf's oil production to the world's total oil production. The higher the ratio, the more production is concentrated in the historically unstable Persian Gulf and the higher the potential for significant disruptions.
- Excess world oil production capacity. This measure can be expressed at any given time as the difference in millions of barrels per day (mmbd) between the world's total oil production capacity and the world's total oil consumption. The greater the excess production capacity, the lower the vulnerability because, as excess production capacity increases, so does the ability to replace disrupted supplies with excess or surge production.
- Oil intensity of the U.S. economy. This measure can be expressed as the ratio of barrels of oil used in the U.S. economy to real gross domestic product (GDP). The lower the ratio, the lower the vulnerability because the oil price increases accompanying a disruption represent a smaller fraction of the economy and therefore have a smaller economic effect.
- Oil dependence of the U.S. transportation sector. This measure can be expressed as the percentage of the U.S. transportation sector's fuel consumption that is met using oil. The higher the percentage, the higher the vulnerability because vulnerability is directly linked to consumption. Some industries, such as the electricity-generating industry, have developed the ability to switch to other fuels during a disruption. The transportation sector, however, is almost 97-percent dependent on oil and accounts for nearly two-thirds of the nation's total oil consumption.
- World oil stocks. This measure, which includes strategic stocks such as the Strategic Petroleum Reserve, indicates, on the basis of daily world oil consumption, how many days world oil stocks or inventory will last if used to replace disrupted oil supplies. The measure can be expressed as the ratio of the total world crude oil and refined petroleum product inventories to the daily world oil consumption. The larger the ratio, the lower the vulnerability, reflecting the greater capacity to replace disrupted oil with oil stocks on hand.
- Dependence of the U.S. economy on oil imports. This measure can be expressed as the percentage of U.S. oil consumption met through imports. As we explain in chapter 2, we believe that this measure is a weak indicator of vulnerability because vulnerability is linked to dependence on

oil, not merely to dependence on imported oil. Nevertheless, as we also explain in chapter 2, domestic as well as foreign oil producers benefit from the higher prices that prevail during disruptions.[1] In addition, increasing domestic production could increase the nation's opportunities for mitigating the effects of a disruption. Tax policies, for example, could limit wealth transfers from U.S. consumers to U.S. producers. Also, increasing domestic production could increase the nation's policy options if, during a severe or catastrophic disruption, oil were not sufficiently or readily available in the world market at any price. For these reasons, we have included the percentage of U.S. oil needs met through imports as a measure of vulnerability.

Changes in the World Oil Market Have Lessened U.S. Vulnerability to Oil Shocks, but the Economy Is Still Vulnerable

Significant changes in the world oil market since the 1970s have decreased the risk of an intentional coordinated disruption of the world oil supply. Consequently, the U.S. economy is less vulnerable to oil shocks today than it was 20 years ago. Nevertheless, the effects of future shocks could still be great enough to warrant finding ways of mitigating the costs.

Changes in the World Oil Market Have Lessened Vulnerability to Oil Shocks

Several changes in the world oil market have, according to DOE and others, reduced the U.S. economy's vulnerability to oil market disruptions.

First, the deregulation of the domestic oil market and the development of a viable futures market and other oil trading markets has made the world oil market more efficient, allowing world oil prices to adjust quickly and fully to all available information about actual and potential changes in world oil supplies. Unregulated markets also make prices less subject to manipulation. Because prices adjust quickly during a disruption, the threat of potentially costlier physical supply shortages is greatly reduced. Furthermore, higher prices encourage consumers to conserve oil while rewarding producers for quickly increasing oil supplies. The development of a futures market allows producers and oil traders to mitigate the impact of future price changes by purchasing futures contracts that stipulate a quantity and price for oil to be delivered at a future date set in a contract.

[1]To the extent that the benefits from higher prices go to domestic producers instead of foreign producers—and the wealth transfers from other sectors of the economy to the oil industry remain within the United States instead of going to other countries—then the U.S. economy as a whole may benefit from increases in domestic production. As previously noted, however, the wealth transferred to domestic producers would come at the expense of the oil-consuming sectors of the economy.

Each of these features of a more complete market tends to reduce the economic impact of an oil market disruption.

Second, the United States and some of its allies have developed strategic petroleum reserves, enabling them to respond more effectively to an oil market disruption now than they could have done during the early 1970s. The United States currently has about 575 million barrels of oil stored in the Strategic Petroleum Reserve. This strategic reserve—along with others, largely in Germany and Japan—could increase world oil stocks as a percentage of world oil consumption. We should note that the level of private or industry stocks is also important and that both governmental and private stocks are included in the level of world oil stocks discussed earlier as a measure of vulnerability.

Third, although the transportation sector continues to rely heavily on oil, most other sectors of the U.S. economy, especially the electricity-generating industry, have reduced their dependence over the past 20 years. These other sectors have increased both their efficiency in using oil and their flexibility in using other fuels, such as natural gas. Thus, the effects of any given oil shock on the economy is likely to be less now than in the 1970s.

In addition to the above changes that tend to reduce the effects of a disruption, OPEC is less likely now to coordinate a disruption of the world oil supply than it was in the 1970s. OPEC has lost some of its market power because the divergent interests of its members have weakened its ability to act cohesively. Moreover, since the 1970s, world oil supplies have become more diversified as more countries have developed production capabilities. (This trend, however, is expected to reverse itself in the long run because the largest and least costly known reserves are concentrated in the Persian Gulf. Such concentration, as discussed above, is one of the measures of vulnerability to oil market disruptions.) In addition, the economic interests of the oil-importing and the oil-exporting countries have become interdependent. Members of OPEC, for example, have large investments in oil-importing countries, and damaging the economies of the oil-importing countries may not serve their interests. Additionally, the dissolution of the Soviet Union has lessened the competition for influence in the Persian Gulf between the East and the West. Finally, OPEC has increasingly recognized that higher oil prices can reduce the demand for its oil by making alternative energy supplies and energy technologies more viable.

The U.S. Economy Is Still Vulnerable to Potential Oil Shocks

Although changes in the world oil market over the past 20 years have reduced the U.S. economy's vulnerability to oil shocks, the risks of future shocks are still present and, as discussed in chapter 2, their costs to the economy could be large, particularly if the disruptions were large or long-lasting. Also, the demand for oil around the world is expected to rise, particularly in the developing world, pointing to new competition for available supplies. As discussed above, DOE and many of the energy market experts we spoke with believe that the risks of disruptions arise because many of the world's cheapest accessible reserves are concentrated in a few countries, some of which are in a politically unstable region of the world.

The NEPP does Not Indicate the Extent to Which Its Initiatives Will Reduce Vulnerability to Oil Shocks

The NEPP contains a number of initiatives aimed, directly or indirectly, at reducing the economy's vulnerability to oil shocks. These initiatives generally fall within one of the following three major areas: (1) energy efficiency programs aimed at decreasing the demand for oil or replacing oil with alternative fuels; (2) fossil energy programs aimed at increasing the production of oil or other fossil fuels; and (3) policies for drawing down the Strategic Petroleum Reserve (SPR) to reduce the effects of an oil shock and for facilitating the diversification of oil supplies in non-OPEC nations. For the most part, however, the NEPP does not indicate to what extent its initiatives will individually or collectively reduce the vulnerability of the economy as a whole, nor does it indicate how its initiatives will affect the specific measures of vulnerability discussed above.[2] To assess the effects of the NEPP's initiatives on the economy's vulnerability, we asked DOE to provide us with information on its programs and policies. DOE provided the following information on its energy efficiency and fossil energy programs. [3]

Energy Efficiency Programs

In presenting oil displacement benefits, DOE grouped its energy efficiency programs into "planning units." Table 3.1 presents DOE's estimates of how much oil will be displaced by the energy efficiency planning units with the greatest projected effects, as well as by all of the programs together. In addition to the initiatives for increasing energy efficiency, these programs include research and development (R&D) to promote the use of alternative motor fuels—such as natural gas, alcohol, and electricity—and renewable

[2]For a few—but not most—initiatives, the NEPP estimates how much energy will be saved or produced.

[3]We did not independently assess the likelihood that DOE would achieve its projected decreases in the demand for oil or increases in the domestic supply of oil.

energy technologies—such as technologies for deriving energy from wind, the sun (solar energy), and the earth (geothermal energy).

Table 3.1: Estimated Oil Savings Attributable to DOE's Energy Efficiency and Renewable Energy Programs

Projections in millions of barrels per year

Year	2000	2010	2020
Hybrid Vehicle Research R&D	0	180	300
Transportation Biofuels R&D	5	150	219
Electric Vehicle R&D	4	46	37
Fuel Cell R&D	0	13	140
Light Weight Vehicle Materials R&D	0	32	35
Light Duty Engine R&D	0	39	43
Heavy Duty Engine R&D	1	73	237
Chemical Related R&D	1	25	50
NICE-3[a]	6	12	13
Petroleum Related R&D	36	90	65
Total	**53**	**660**	**1,139**
Total for all energy efficiency programs	**88.6**	**767.6**	**1269.5**

[a]NICE-3 (National Industrial Competitiveness through Energy, Environment, Economics) provides seed funding to state and industry partnerships for projects that develop and demonstrate advances in energy efficiency and clean production technologies.

See appendix III for a complete list of the programs in each planning unit, including a brief description of each program and the amount recommended for it by the Congress for fiscal year 1996.

According to DOE, in addition to displacing oil, an objective of energy efficiency programs is to increase the ability of key industries to switch to other fuels if necessary during an oil supply disruption while continuing to use low-cost oil under normal market conditions.

Fossil Energy Programs

DOE believes that its fossil energy programs—including those for oil, natural gas, coal, and other fossil fuels—can reduce the economy's vulnerability to oil shocks by boosting domestic oil production or replacing oil with other fossil fuels. Table 3.2 summarizes the increases in domestic oil production that DOE anticipates from its Oil Technology Program. This program supports research on characterizing oil reservoirs, enhancing oil recovery techniques, and developing new oil exploration technologies. Appendix IV lists the Oil Technology Program's budget categories and subcategories and the amounts allocated to each in fiscal

year 1996. DOE did not provide us with estimates of how much oil its natural gas, coal, and other programs could, in total, replace. It did, however, estimate that the use of coal-derived liquid fuels could replace 2 million barrels of oil per day by 2030, but it had no earlier estimates for this program.

Table 3.2: Total Increase in Domestic Oil Production Attributable to DOE's Oil Technology Program

Millions of barrels per year

Year	2000	2010	2020
All oil programs	110	295	520

Strategic Petroleum Reserve and Diversification of Non-OPEC Oil Supplies

According to the NEPP, policies that effectively deal with potential disruptions in international oil markets can reduce the economy's vulnerability to the costs of such disruptions. The NEPP therefore affirms the administration's commitment to drawing down the SPR in coordination with other members of the International Energy Agency (IEA). (See ch. 4 for more information on the use of the SPR.) In addition, the administration says that it is facilitating efforts to increase oil and gas supplies in non-OPEC countries, such as Russia. For example, DOE officials said they are helping foreign governments to implement regulatory reforms and laws that can facilitate foreign investment in the oil sectors of their countries. DOE did not estimate the supply increases anticipated from these efforts.

Programs' Overall Effects Are Difficult to Assess

The information we received from DOE does not clearly assess the extent to which DOE's initiatives will reduce the economy's vulnerability to oil disruptions. First, the information does not reflect the extent to which the initiatives will result in changes to the measures of vulnerability discussed above. Second, the information does not take into account important factors such as anticipated increases in the demand for oil or other expected changes in the economy.

DOE estimates, for example, that if all of its energy efficiency programs are successful, oil consumption will decline by just over 1 billion barrels per year, or about 3 million barrels per day, by 2020. Currently, domestic consumption is about 6.6 billion barrels per year, or 18 million barrels per day. Decreased consumption could decrease vulnerability, as measured by several of the indicators of vulnerability discussed above. World oil stocks could increase, the economy could rely less intensively on oil, and the transportation sector could reduce its dependence on oil. Projected

reductions in consumption, however, could be offset by projected increases in the demand for oil. In its reference case, EIA forecasts that the economy's demand for oil will grow, increasing oil consumption by almost 3.5 million barrels per day from 1994 to 2015—or by slightly more than DOE expects to reduce consumption through its energy efficiency programs by 2020. Moreover, as we mentioned in chapter 2, the United States is part of the world oil market and, when viewed in the context of the world market, the projected decline of 3 million barrels per day represents only a small fraction of world oil demand, which EIA projects in its reference case to rise from about 68.5 mmbd in 1995 to about 98.9 mmbd in 2015. Also, as discussed later, EIA's reference case forecast recognizes, at least to some extent, the impact of many of the initiatives contained in the NEPP.

DOE projects that its fossil energy oil programs will increase domestic oil production by about 520 million barrels per year, or about 1.4 mmbd by 2020. As discussed earlier, however, increasing domestic production may not significantly reduce the economy's vulnerability to oil supply disruptions. In any event, the changes resulting from these programs, like the changes resulting from DOE's energy efficiency programs, need to be assessed in the context of the U.S. economy's as well as the world's increased demand for oil.

DOE officials correctly point out that projections of future consumption would be even higher if they were not offset by the reductions in oil consumption or increases in domestic oil production anticipated from the NEPP's initiatives. DOE officials also point out that energy efficiency programs have important objectives in addition to lowering the economy's vulnerability to oil disruptions, such as reducing energy costs to businesses and consumers, preventing pollution, cutting greenhouse gas emissions and urban air pollutants, and contributing to the nation's research and technology base. Similarly, DOE officials believe that the fossil energy oil program serves other goals and objectives, such as promoting the nation's leadership in basic and scientific research and technology, improving the stewardship of federal lands and the nation's oil and gas resources, protecting the environment, lowering the costs of domestic oil, and assisting the states in complying with energy mandates and managing their own resources. While the NEPP's initiatives, if successfully implemented, could produce these beneficial effects, our analysis did not assess the likelihood of their achieving such results.

To better assess the effects of the NEPP's initiatives on the economy's vulnerability, we used forecasts from EIA's Annual Energy Outlook 1996

and International Energy Outlook 1996, along with other information provided by EIA, to show the changes in the measures of vulnerability anticipated by 2015.[4] The results appear in the next section of this chapter.

EIA's Long-Range Forecasts Indicate Continued Vulnerability to Oil Supply Disruptions

EIA's projections indicate that the United States will remain vulnerable to oil supply disruptions in 2015, the last year of EIA's forecast, even after accounting for the effects of many of the NEPP's programs. Only over longer periods do energy analysts see the potential for significant reductions in vulnerability.

EIA's Forecasts Indicate Little Reduction in Most Measures of Vulnerability Over the Next 20 Years

In the figures that follow, the reference case combines historical data and EIA's reference or base case forecasts to show how current programs and policies are likely to affect the measures of vulnerability discussed above. For perspective, we have included historical information dating back to 1975. EIA's forecasts reflect a number of assumptions about anticipated economic growth, population increases, technology developments and other factors. Appendix V contains tables showing, where available, forecasted changes that differ from those in the reference case, assuming lower and higher economic growth in the United States or lower and higher world oil prices.

For its reference case forecasts, EIA assumed varying levels of technological improvements that could reduce oil consumption or increase domestic production. These levels are based primarily on EIA's examination of historical trends in technological advances but also reflect EIA's judgment about the likely impact of those NEPP initiatives that had been implemented at the time the forecasts were prepared. In incorporating the reductions in consumption or increases in production to be realized from DOE's energy efficiency and fossil energy programs, EIA was generally less optimistic under the reference case than DOE was in developing the estimates discussed above. In part, this difference occurred because EIA did not include credit, as DOE did, for research and development programs whose technologies are in the early stages.

EIA did, however, develop selected "high technology" forecasts of energy supply and demand, which we used to show the potentially greater effect of technological achievements on three of the measures of vulnerability

[4]Annual Energy Outlook 1996 With Projections to 2015 (DOE/EIA-0383(96), Jan. 1996) and International Energy Outlook 1996 With Projections to 2015 (DOE/EIA-0484(96), May 1996).

that we present in this report. The high technology forecasts are based on five of the "stand-alone" runs of the NEMS model that EIA prepared for the Annual Energy Outlook 1996 to illustrate the potential effect of higher technological success in reducing the U.S. demand for energy and/or increasing the U.S. oil supply. According to EIA, stand-alone runs represent the impact on a single sector of the energy markets, without considering the impact of interactions with other sources.[5] Four of these runs were used to forecast potential reductions in the demand for oil in the residential, commercial, industrial, and transportation sectors. These runs were made by assuming higher energy efficiency in buildings and energy-consuming equipment.[6] The fifth run, a high oil and gas technology run, was used to forecast potential increases in the supply of domestic oil. For this case, EIA assumed reductions in the costs of exploration and development and in refineries' consumption of fuel and increases in the amounts of recoverable oil and gas. According to EIA analysts, the high technology forecasts project at least as much—and sometimes more—technological success in decreasing oil consumption as DOE's energy efficiency programs predict, and about the same increase in oil production as DOE's fossil energy programs predict.

Even the high technology cases, however, do not reflect the effects of all of the NEPP's initiatives. For example, the forecasts do not attempt to estimate DOE's success in diversifying international oil production outside the Persian Gulf. Also, the high technology cases do not reflect all of the economic benefits that may accrue from deploying such technologies. Rather, the high technology cases attempt to recognize the gains that could be achieved from an energy perspective if new technologies were successfully developed and deployed in the marketplace more rapidly than EIA assumed in its reference case. For many of the NEPP's initiatives, success in reducing the economy's vulnerability to oil shocks hinges on developing and deploying technologies in the marketplace.

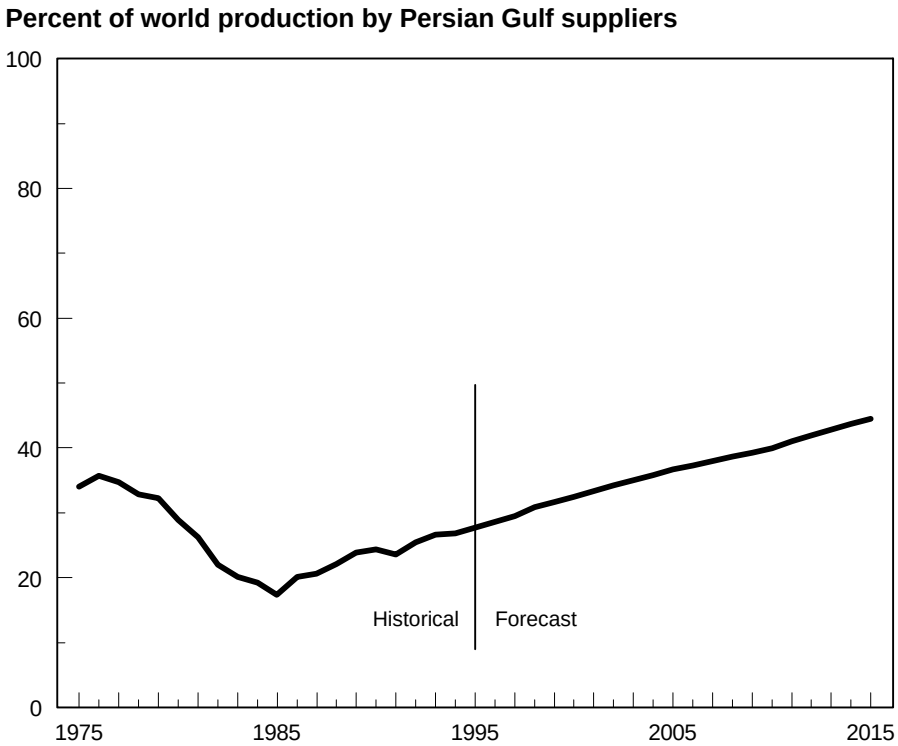
[5]We also analyzed these three vulnerability measures using EIA's high technology results from pilot integrated technology runs that consider some of the interrelated effects of supply and demand. The integrated runs result in even somewhat worse outcomes with respect to these vulnerability measures, due primarily to potentially lower world oil prices that could result from combined program impacts. However, the integrated runs also show that higher rates of technological progress could result in increased economic output over the period, again because of the potentially lower world oil prices. A complete analysis of the economic costs and benefits of higher rates of technological progress was not performed for these runs because their primary purpose was to examine energy markets. See Issues in Midterm Analysis and Forecasting 1996 (DOE/EIA-0607(96), Sept. 1996).

[6]In the residential and commercial sectors, EIA's high technology forecast assumes that consumers choose to replace their capital stock with the most energy efficient technologies available in each forecast year, regardless of cost. In the industrial and transportation sectors, the high technology forecast assumes that future gains in efficiency will equal those achieved since 1970.

Concentration of World Oil Production

Figure 3.1 indicates that the concentration of world oil production in the Persian Gulf declined from about 1976 to 1985 but has been rising since then and, under the reference case, is expected to continue rising. Table V.1 indicates that this trend is anticipated when low as well as high oil prices are assumed. This forecast reflects the fact that most of the world's low-cost oil reserves are located in the Persian Gulf. To the extent that the potential for instability in this region remains, so does the possibility of disruption for supplies that would be difficult to replace from other sources of production.

Figure 3.1: Concentration of World Oil Production, Reference Case



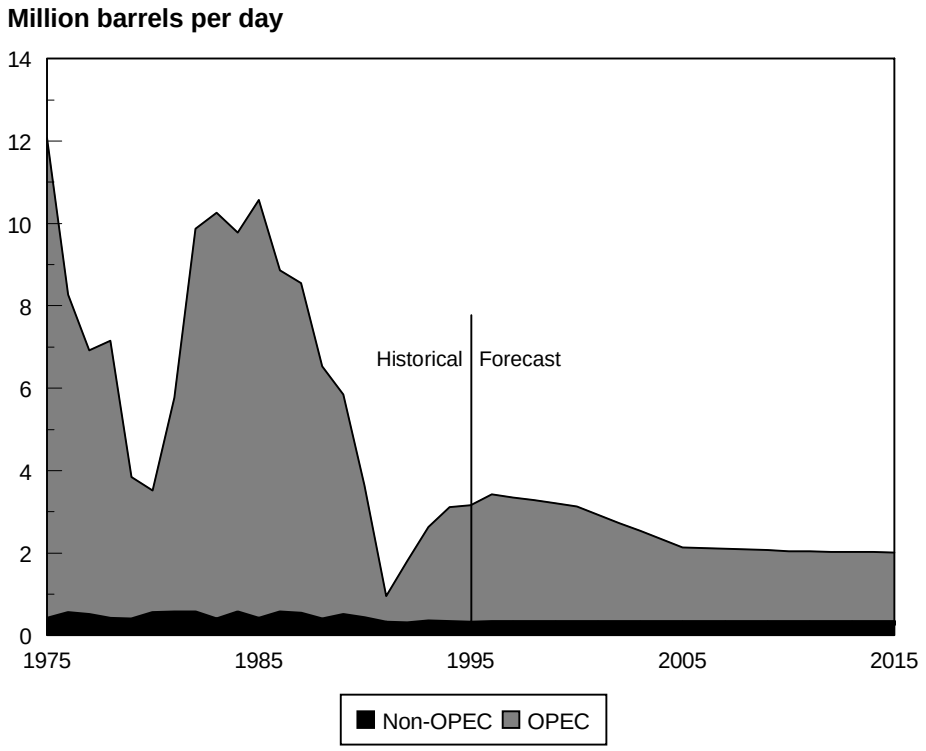
Source: EIA's Annual Energy Outlook 1996 and other EIA publications.

Excess World Oil Production Capacity

Figure 3.2 shows that excess world oil production capacity is expected to decline slowly from 1996 to 2015, making disrupted oil supplies more difficult to replace through this means. The figure also shows that most of the excess production capacity has resided and is forecast to continue

residing in OPEC's member states, including the Persian Gulf states, making it less useful during disruptions emanating from this region. The sharp rise beginning in about 1980 primarily reflects the decrease in oil consumption relative to production capacity brought about by the oil shocks and reactions to the high prices of the 1970s, according to EIA analysts. The drop beginning in about 1986 primarily reflects the increase in oil consumption brought about by sharply declining oil prices. Table V.2 indicates similar declines under lower and higher oil prices than the reference case assumes.

Figure 3.2: Excess World Oil Production Capacity, Reference Case



Source: EIA's Annual Energy Outlook 1996 and other EIA publications.

Oil Intensity of the U.S. Economy

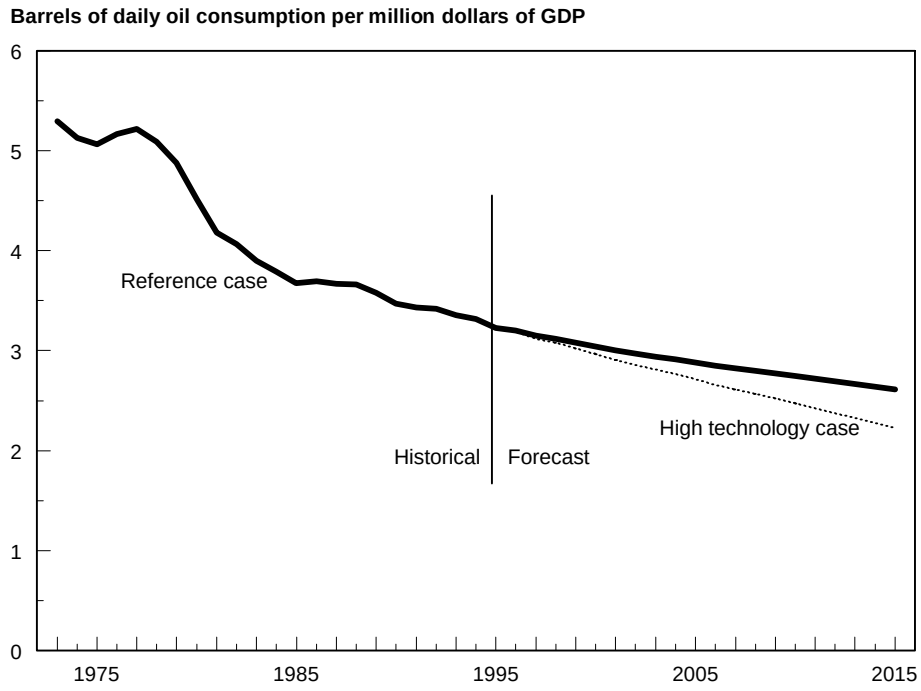
Figure 3.3 shows that oil consumption per million dollars of GDP will decline slowly under the reference case, indicating that even though oil consumption is expected to increase, GDP will increase somewhat faster. A reduction in oil intensity would lessen the economy's vulnerability to

disruptions because, all else being equal, oil disruptions of the same magnitude would have increasingly less effect on the economy. However, in terms of oil's share of the nation's total energy consumption—including energy from coal, gas, nuclear, and other sources—EIA's reference case projects little change over the forecast period from the 38.5 percent in 1995.

According to EIA's reference case, the domestic economy will be 19 percent less oil intensive in 2015 than it was in 1995, primarily because more efficient oil use is projected. The decline is projected to be greater for the high technology case, reflecting even more efficient energy use and some success in introducing alternative fuels. The high technology case should be considered an upper-bound estimate, though, because it includes reductions in the demand for oil achieved by increasing efficiency through technology and substituting alternative fuels, but it does not take into account the effects on price of lowering demand, which could lead to a partial rebound in consumption and a consequent increase in oil intensity. In addition, it does not include the costs of developing such technology. Also, the analysis does not assume any increases in the supply of oil that could result from technological advances. Such advances could result in lower prices and higher demand. Oil supply disruptions under either the reference or the high technology case would still likely impose large overall costs on the U.S. economy.

As figure 3.3 shows, the declines in oil intensity were greater between 1975 and 1985 than are projected for the future. This forecast reflects, in part, EIA's view that it was easier and less costly to gain energy efficiency and substitute other fuels for oil in the past than it is likely to be in the future. For example, according to EIA analysts, the electricity-generating industry has already largely switched from oil to other fuels. Table V.3 indicates that for both the high economic growth case and the high oil price case, the projected decline is slightly greater than for the reference case. For both the low economic growth case and the low oil price case, it is smaller than for the reference case. For all cases, however, the economy's oil intensity declines.

Figure 3.3: Oil Intensity of the U.S. Economy, Reference and High Technology Cases



Note: For the high technology case in this figure, EIA's four demand runs were combined to form a consolidated high technology case for demand. GDP is in 1987 constant dollars.

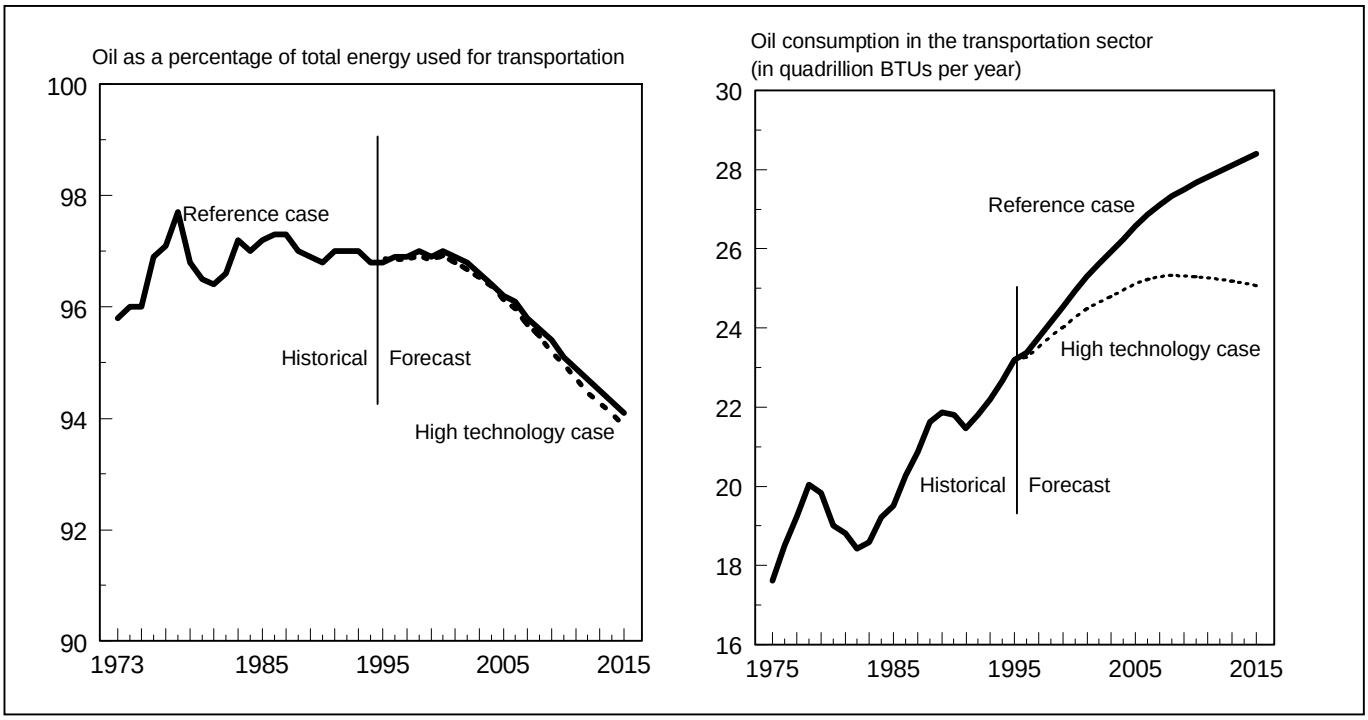
Source: EIA's Annual Energy Outlook 1996 and other EIA publications.

Oil Dependence of the U.S. Transportation Sector

As the left half of figure 3.4 indicates, the transportation sector's reliance on oil, measured as a percentage of the total energy used for transportation, will decline, but only very slightly over the forecast period, both for the reference and the high technology cases. It is important to note that the scale for this half of the figure starts with 90 percent to show the difference between the two cases. In either case, the transportation sector will remain more than 90-percent dependent on oil. Table V.4 indicates that the modest decline in oil dependence is projected to be the same under assumptions of low and high economic growth, as well as of low and high oil prices. This forecast reflects EIA's modeling results showing that alternative fuels will continue to have only limited success in displacing petroleum during the forecast period.

The right half of figure 3.4 indicates that oil consumption in the transportation sector will continue to rise under the reference case but will level off under the high technology case and even begin to decline somewhat before the forecast period ends compared with the reference case. According to EIA analysts, this decline is expected because greater efficiency gains are anticipated under the high technology case. However, for both the reference and the high technology cases, the level of oil consumption is projected to be higher throughout the forecast period than in 1995.

Figure 3.4 Oil Dependence of the U.S. Transportation Sector, Reference and High Technology Cases



Note: The high technology cases in this figure were based on EIA's transportation demand run.

Source: EIA's Annual Energy Outlook 1996 and other EIA publications.

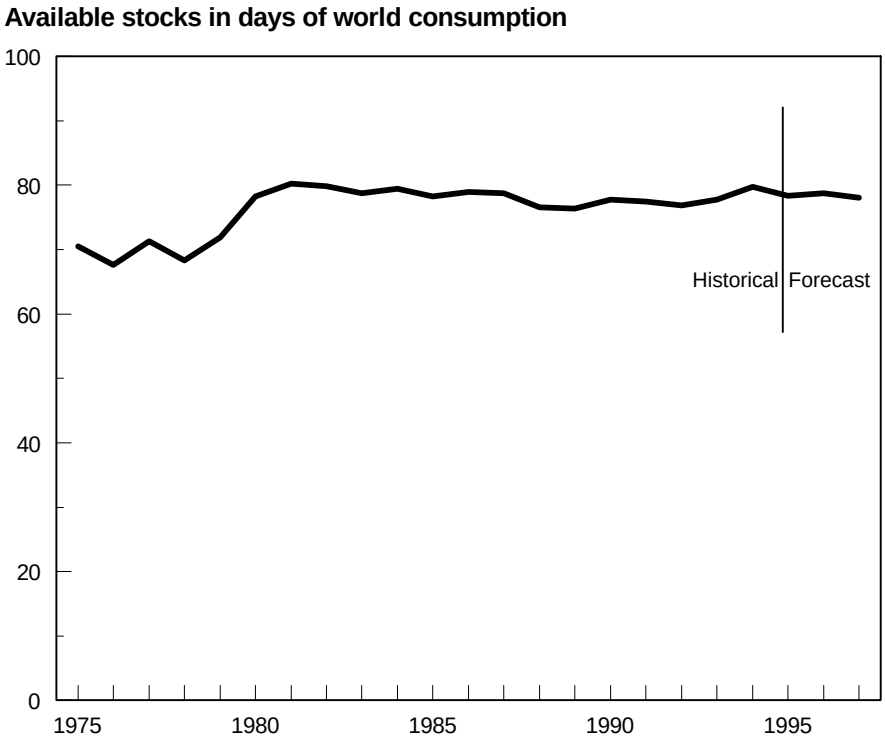
World Oil Stocks

Figure 3.5 indicates that the level of world oil stocks, as measured in days of consumption, has remained about the same since 1980 and is expected

to stay at this level at least through 1997. [7] Any decline in stocks increases the economy's vulnerability to disruptions because it reduces the nation's ability to replace disrupted oil supplies with stocks on hand. EIA did not forecast future stock levels beyond 1997 because stock levels are assumed to reflect short-term fluctuations, such as those caused by the effects of weather, which are not explicitly incorporated into the long-term projections. Although such levels are difficult to forecast, about 19 million barrels of oil in the SPR have been, or are currently being, sold to meet operational or budgetary needs, and additional sales are being considered to meet deficit-reduction goals and fund the reserve's future operations. Furthermore, as long as the oil industry remains committed to cutting costs, private oil stocks are not likely to rise over the long term. Some oil market experts told us that oil companies are trying to reduce their operating costs by adopting "just-in-time" inventory management techniques that keep inventories and related costs to a minimum but provide little buffer during oil shocks. According to one of these experts, such practices are already causing more volatility in oil prices and may result in even more pronounced price swings during oil supply disruptions.

[7]Many of the world oil stocks are located outside OPEC, largely in economically developed countries. Some of the oil included in stocks is needed for operations and therefore may not be available for use during supply disruptions.

Figure 3.5: World Oil Stocks



Source: EIA and the Organization for Economic Cooperation and Development.

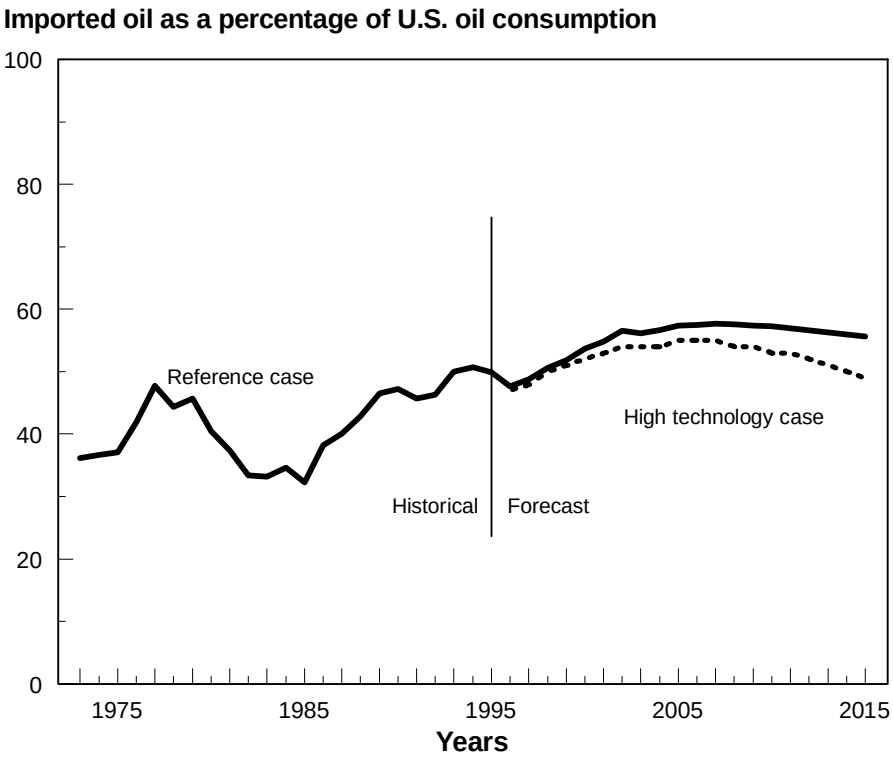
Dependence of the U.S. Economy on Oil Imports

Figure 3.6 indicates that the percentage of the nation's oil consumption met through imports rather than domestic production is expected to increase under the reference case until about 2005, when this percentage will begin to decline gradually. Under the high technology case, the percentage of imports is expected to peak and begin to decline earlier, in about 2000. This high technology projection should also be considered an upper-bound estimate because the analysis assumes that (1) decreases in oil consumption achieved through technological advances would displace only imported and not domestically produced oil and (2) both lower demand and higher supply would reduce prices, causing a partial increase in consumption and a reduction in domestic production, thus raising imports. In addition the effects of technological advances in oil production in other countries are not reflected in the analysis.

Table V.5 indicates that in the low oil price case, continuing increases in the percentage of imports are expected throughout the forecast period.

However, in either the high or the low economic growth case, or in a high oil price case, the percentages are expected to peak at some point. This expectation reflects EIA's assumption that technological advances lower domestic production costs and that oil prices will increase enough to stimulate increased domestic oil production in all but the low oil price case. In all but the high technology and high price cases, however, the percentage of imports is forecast to be higher in 2015 than in 1995. In the high technology and high price cases, the percentage of imports is expected to be slightly lower in 2015 than in 1995.

Figure 3.6: Dependence of the U.S. Economy on Oil Imports, Reference and High Technology Cases



Note: The high technology case in this figure combines the data from all five of EIA's stand-alone runs.

Source: EIA's Annual Energy Outlook 1996 and other EIA publications.

Substantial Reductions in Vulnerability Are Not Anticipated Until After 2015

Although the projected changes in the previously discussed measures of vulnerability do not show significant improvement over 1995 levels, particularly if low oil prices prevail, EIA's forecasts do indicate some positive trends. For example, the use of alternative motor fuels continues to increase, particularly in the later years of the forecast and, according to EIA, increasingly reflects consumers' choices rather than compliance with mandates. Efficiency gains, particularly in the high technology cases, produce significant oil savings. Finally oil imports peak and begin to decline at some point in all but the low oil price forecast. Also, as we reported in June 1996,[8] both DOE and EIA project greater use of biofuels, particularly beyond 2010, when such fuels are expected increasingly to replace gasoline. Moreover, in an April 1996 article that he co-authored, DOE's Deputy Secretary discussed the potential of the NEPP's initiatives to reduce the economy's vulnerability to oil shocks. In particular, he focused on research designed to increase energy efficiency and replace oil with alternative fuels.[9] According to the article, such research will not lead to energy independence in the next 15 years, but its results offer a chance in the years thereafter to blunt any foreign threat to raise oil prices dramatically and to limit the economic and geopolitical influence of Persian Gulf oil.

Observations

Many changes in the world oil market have lessened the U.S. economy's vulnerability to oil shocks, but, according to our analysis of EIA's projections, the economy is likely to remain vulnerable for the next 20 years, even when success is assumed for many of the initiatives in the most recent NEPP. While the economy's vulnerability might be even greater without such initiatives, the United States and the rest of the world are likely to continue depending on oil to meet a substantial portion of their energy needs, particularly for transportation, and to rely increasingly on potentially unstable supplies from the Persian Gulf. Only over longer periods do energy analysts see the potential for significant reductions in the economy's vulnerability through, for example, the use of alternative fuels. Given the persistence of this potential threat, limited financial resources, and the length of time required to determine the success of initiatives aimed at reducing the economy's vulnerability, it is important to make the right policy choices now. In chapter 4, we present the views of

[8]Motor Fuels: Issues Related to Reformulated Gasoline, Oxygenated Fuels, and Biofuels (GAO/RCED-96-121, June 27, 1996).

[9]Joseph J. Romm and Charles B. Curtis, "Mideast Oil Forever," The Atlantic Monthly (Apr. 1996), pp. 57-74.

oil experts and analysts we consulted on options for dealing with this threat.

Agency and Other Comments and Our Evaluation

DOE said that we did not adequately analyze the impact of the NEPP programs designed to reduce the economy's vulnerability to oil shocks, largely because we do not show changes in the measures of vulnerability both with and without DOE's programs. Our objective, which we have clarified, was to assess the extent to which the U.S. economy's vulnerability to oil shocks will change over time given the programs and policies contained in the NEPP, as well as other relevant factors, such as increases in the demand for oil and expected changes in the economy. Our approach for this objective was to use EIA's published or readily available energy forecasts that consider such factors, as well as the impact of DOE's programs, but do not indicate the incremental effect of each factor. An analysis of the measures of vulnerability with and without DOE's programs might support DOE's view that the economy would be more vulnerable without DOE's programs, and we stated this view prominently in both our draft and final reports. We also included in the draft and final reports measures of the programs' impact provided to us by DOE. These measures are expressed in terms of projected barrels per day of increased domestic oil production or decreased oil consumption. However, as we state in the report, these measures are not very useful for indicating how DOE's programs will affect the economy's vulnerability to oil supply disruptions because they are not expressed in terms that measure vulnerability. Neither do they consider projected increases in the demand for oil and other expected changes in the economy that could affect vulnerability. While EIA's forecasts do not isolate the impact of DOE's programs, we believe that they are more effective than DOE's measures for assessing vulnerability because they are expressed in terms that measure vulnerability and they take into account other important and relevant factors. As we stated in our report, EIA's forecasts do not consider all of the initiatives designed to reduce the U.S. economy's vulnerability to oil supply disruptions, but we believe that they are the most objective and comprehensive estimates available.

Two of the experts who reviewed our draft report suggested that oil companies now tend to keep inventories of crude oil to a minimum in order to cut costs. This practice can reduce the stocks available to respond to disruptions and increase the volatility of oil prices during both normal and disrupted markets. One expert also suggested that the probability of future disruptions is real, given the continued volatility

expected in the Persian Gulf region. Finally, one expert said that the unilateral oil trade sanctions imposed by the United States on other countries reduce the sources of oil available to the United States during a supply disruption.

Where appropriate, we have revised the report to reflect the comments we received from DOE and others.

Experts Have Identified Options for Mitigating the Economy's Vulnerability to Oil Supply Disruptions

Oil experts and industry analysts whom we interviewed suggested a number of options for reducing the economy's vulnerability to oil supply disruptions.[1] They cited four options most frequently: (1) an early release of SPR oil, (2) more effective use of monetary policy, (3) further research and development to make alternative fuels more competitive with gasoline, and (4) increases in gasoline taxes to discourage consumption and make alternative fuels more competitive. The first two are seen as ways to mitigate the impact of disruptions once they take place; the last two are seen as ways to reduce the economy's vulnerability to disruptions over the long term.[2]

The experts differed in their opinions on the desirability of individual options because they held different views on the role of government in markets, as well as on the potential impact of the options.[3] Almost all agreed that the SPR provides the best tool now available.

Experts Consider Early Use of the SPR the Best Available Tool for Mitigating Oil Shocks

Nearly all of the experts we spoke with and the studies we reviewed indicated that drawing down the SPR at the onset of an oil crisis is the best tool now available to mitigate the potential costs associated with short-term disruptions in oil supplies. According to the experts, the industry's expectations have such a significant effect on petroleum prices during a crisis that a drawdown of the SPR, or at least an announcement of a drawdown, is necessary early in a crisis to effectively dampen price increases. In theory, even with a release of SPR oil, prices would likely continue to rise, serving to reduce demand and provide incentive for increased oil production, but such increases would likely peak at lower levels than they would without a drawdown. Many of the experts criticized the government for releasing oil from the SPR too late during the Persian Gulf war. To guard against delays in the future, several suggested some kind of automatic "trigger" for releasing SPR oil.

[1]The oil experts and industry analysts we consulted and their organizational affiliations are listed in app. I. We hereafter refer to this group of people as the experts.

[2]Most experts who addressed the potential for increases in domestic oil production to lessen price increases during disruptions said that such increases would not help much because, as discussed in previous chapters, the price of all oil increases during disruptions. Several did note, however, that efforts to increase domestic oil production, particularly those directed at lowering related production costs, may be justified on other grounds, such as improving resource management or increasing economic activity and jobs in this industry.

[3]One expert believes that the government should not play any role in mitigating the economy's vulnerability to oil shocks because today's deregulated oil market has become increasingly flexible and self-correcting. He cited the existence of an active futures market as helping to provide such flexibility and to correct oil prices during oil shocks. We discussed some of these issues in ch. 3.

Experts Criticized Delay in Using the SPR During the Persian Gulf Crisis

Several experts criticized the decision to delay a release of oil from the SPR during the Persian Gulf war. During this crisis, the first major drawdown of the SPR ever was announced in January 1991, more than 5 months after Iraq invaded Kuwait and 3 months after oil prices peaked. These experts believe that the administration waited too long to release oil from the SPR.[4]

Shortly after Iraq's invasion of Kuwait, DOE explained that it intended to use the SPR only to offset physical supply shortages in the United States and that it had relied on market forces to encourage the production of additional supplies and discourage consumption during the early months of the crisis. However, the experts argued that basing the policy for drawing down the SPR on physical shortages during a crisis missed the point because such shortages are virtually impossible in a market environment. Rather, if supplies were disrupted, prices would rise with a potential detrimental effect on the economy. Rising prices, however, could also induce increased oil production and decreased consumption. One expert noted that production was sufficient to meet consumers' needs even during the more severe price shocks of the 1970s. This expert noted that the apparent shortages experienced then occurred because consumers and businesses increased their own private inventories out of fear that physical shortages would occur. In these cases, fear of physical shortages encouraged behavior that exacerbated the disruption. Thus, this expert believes that a release from the SPR can calm the market by ensuring a supplier of last resort. Many of the experts we contacted also believe, contrary to the administration's view in 1990, that the price increase during the early months of the crisis was large enough to justify using the SPR. Some of the experts described the SPR as an "insurance policy" that American taxpayers have purchased against oil shocks and their economic consequences. Therefore, an early drawdown to prevent a potential price run-up of the type observed during the Gulf crisis is the only way to obtain the reserve's benefits.

However, some also believe that the release of SPR oil during an oil supply disruption should depend upon the disruption's potential magnitude and duration. Hence, the higher the likelihood of a massive and sustained disruption, the greater the potential value of retaining SPR oil for future use. For example, in a report issued in December 1994, the Congressional Budget Office (CBO) stated that the administration's decision not to release SPR oil during the Persian Gulf war might have been justified on the

[4]While the world price of crude oil dropped by about $10 per barrel after DOE announced that oil would be released from the SPR, DOE acknowledged that the true effect of the drawdown could not be separated from other factors, including, most significantly, the early success of the air war against Iraq at that time.

grounds that potential additional losses in oil supplies as the war progressed might have caused a later release to yield even larger economic benefits.[5] Nevertheless, CBO recognized that the lack of a clear policy for releasing oil from the SPR and the government's early indecision about using the SPR could have added to the uncertainty about oil supplies already plaguing the oil markets.

The current administration's policy on drawing down the SPR, as stated in the NEPP, is to rely on market forces to allocate supplies in the event of a disruption and to supplement supplies through an early drawdown of the SPR in large volumes and in coordination with the nation's allies and trading partners. One stated purpose of the most recent announced drawdown of 12 million barrels from the SPR was to dampen the impact of gasoline price increases that occurred during the spring of 1996.[6] According to DOE, this sale was directed by the Congress before the price increases took place in order to raise $227 million for other programs in fiscal year 1996, but its timing was accelerated.

Experts Favor Automatic Trigger for SPR Release

To ensure more effective use of the SPR during an oil shock, many experts we consulted favored adopting a market-based trigger mechanism that would automatically release oil from the SPR at the appropriate time. The trigger mechanism cited most frequently is the sale of options.[7] Under this approach, the government would sell options to those wishing to guard against rising oil prices.[8] The sale could be in the form of a competitive bid, to buy SPR oil at a predetermined price called the "exercise" or "strike" price. In exchange, the government would receive a one-time up-front payment of a fee, called a premium, from the buyer. The strike price would, then, become the minimum price that would trigger an SPR drawdown during an oil crisis. In theory, the sale of options could serve two useful purposes. First, it could help to reassure the oil market during an oil crisis that a decision to use the SPR would not be held up by

[5]CBO's report, Rethinking Emergency Energy Policy (Dec. 1994), contains options for setting the price of SPR oil once a decision has been made to draw down the reserve so as to increase the impact of a release in the marketplace.

[6]DOE conducted a test sale in September 1990, selling 3 million barrels. More recently, DOE sold 5.1 million barrels of SPR oil to pay for the closure of the Weeks Island storage site, which has structural integrity problems.

[7]An option is a contract that gives the holder the right, but not the obligation, to purchase or sell oil at a predetermined price for a specified period of time in exchange for the payment of a one-time premium. The contract also obligates the seller, who receives the premium, to meet these terms.

[8]In testimony before the House Committee on Government Operations, we also noted that the use of options was a possible way to avoid delays in releasing SPR oil (GAO/T-RCED-90-105, Sept. 5, 1990).

governmental decision-making, but would instead be made by the oil market itself. Second, the payment of premiums from the sale of options would generate revenue for the government while the oil remained in storage.[9]

Another question about the SPR is its appropriate size. We did not discuss this issue in any detail with the experts, but those who expressed a view said that the SPR should be larger than it is currently because, among other things, the nation's consumption of oil is increasing. In addition, one expert suggested that the SPR is not large enough to play a significant role in large or long-term disruptions because such disruptions would greatly exceed the capacity of the reserve to affect the world oil market. As discussed in chapter 3, world oil consumption was about 70 million barrels per day in 1995. Nevertheless, as part of its fiscal year 1997 budget submission to the Congress, the administration indicated that in 2002 it plans to sell enough SPR oil to raise $1.5 billion to help achieve a balanced budget in that year. DOE also indicated that legislation may be required to authorize such a sale. More recently, DOE announced that it would carefully analyze the size of the SPR and other related issues before selling any oil in 2002.

Experts Believe Appropriate Monetary Policy Could Lessen the Economic Impact of Disruptions

Some of the experts whom we contacted believe that monetary policy could be effective in partially offsetting the economic harm caused by oil market shocks. Broadly speaking, oil market shocks harm the economy by reducing GDP in two different ways: They permanently reduce the economy's potential GDP, and they temporarily reduce GDP below the new lower potential. While monetary policy is set by the Federal Reserve and is outside the purview of energy policymakers, some experts believe that it could be effective in offsetting the temporary reduction in GDP.[10] Experience with past oil shocks shows, however, that choosing the best monetary policy is difficult and may depend on prevailing economic conditions. DOE is currently studying the role of monetary policy in offsetting the harmful effects of oil shocks.

[9]A potential drawback of the options approach is that the government could receive less money for the oil sold from the SPR if the prevailing market price during an oil shock exceeded the strike price by more than enough to offset the present value of the total revenue from the premium payments. However, one oil options expert suggested that this drawback could be mitigated by adopting a multitier price-setting release mechanism. Using this mechanism, the government would sell the options in tiers so that increasing volumes of oil would be sold at increasing prices.

[10]The Federal Reserve, through its Federal Open Market Committee, is independently responsible for setting monetary policy for the United States. In general, monetary policy may be used to pursue the broad objectives of stabilizing prices and employment while fostering economic growth. The Federal Reserve can pursue these objectives by influencing interest rates and the availability of credit.

Oil shocks harm the economy by reducing the economy's potential GDP, which is the amount that the United States can produce when all resources are fully employed. Potential GDP is determined by the nation's resource base, which consists of its labor force, natural resources, and capital stock and the productivity of these resources. In response to the high energy prices, firms may use less energy, reducing the amount of output that can be produced with a given amount of capital and labor. Hence, the productivity of labor and capital declines. In addition, a rise in oil prices may render older, more energy-using capital prematurely obsolete. Firms may retire some of their machines and factories that are heavily dependent on fuel, thus effectively reducing the nation's capital stock and potential GDP. The Federal Reserve cannot offset this damage to the nation's potential economic output unless the price of oil falls to its previous level. Moreover, the increase in oil prices would cause a one-time increase in the economy's overall price level.

Oil shocks can also harm the economy because the economic costs of adjusting to them can cause the nation's GDP to fall temporarily below the new lower potential. In a severe form, this reduction in GDP could be sufficient to cause a recession. Monetary policy may be effective in offsetting this source of economic harm. For example, according to one of the experts we consulted, effective monetary policy could help the economy achieve its new lower potential GDP without causing a sustained increase in inflation. The Federal Reserve might be able to accomplish this result by allowing a one-time increase in the money supply. The increased money supply would lower real (inflation-adjusted) interest rates, which would stimulate investment and spur GDP growth. The challenge for the Federal Reserve would be to ensure that the one-time increase in the money supply did not signal a sustained expansion of the money supply that would produce a sustained increase in inflation. However, this view is not universally held by all experts. Others argue that the Federal Reserve would probably have little or no success in offsetting a drop in GDP caused by an oil shock.

Monetary policy decisions during oil supply shocks could also have adverse economic consequences. According to some of the experts that we contacted, decisions made during past shocks may have exacerbated economic problems caused by the shocks. One expert stated that the recession in the United States and Europe that followed the 1979 oil shock was caused, in part, by government actions to fight inflation by reducing the money supply and increasing interest rates. The NEPP also points out that shortcomings in previous economic policy reactions have amplified

the negative effects of oil price increases and helped trigger economic recessions.

While some of the experts we contacted said that monetary policy can help to mitigate the potential adverse economic impact of oil shocks, they also said that the relationship among monetary policy, oil shocks, and economic performance is only partially understood. Moreover, as stated above, monetary policy choices would depend on the economic conditions at the time of the shock and policy decision about which economic goals receive the highest priority. According to the experts, more research is needed to understand the complexities of these economic relationships. DOE is currently conducting a study, with input from Federal Reserve officials and others, that includes an analysis of the effect of monetary policy choices on economic performance during oil shocks. This study is expected to be released by the end of 1996.

Experts See Research and Development on Alternative Transportation Fuels as the Most Promising Long-Term Solution

Most of the experts we consulted said that in the long term, sustained research and development on alternative transportation fuels and vehicles may hold the key to significantly reducing the economy's vulnerability to oil shocks. Most of the experts also believe that the federal government should play a role in funding basic research in this area. A smaller number supported a federal role in applied research or demonstration programs, and almost none supported federal mandates or subsidies to encourage the use of alternative fuels or vehicles. Some of the experts said that the failure of the market and industry to place a high value on basic research in this area justifies a role for the federal government.

Experts Support Federal Research and Development for Alternative Fuels and Vehicles

Many of the experts we consulted believe that the economy's long-term vulnerability to oil shocks may be greatly reduced through research on alternative fuels and vehicles whose use could curb the demand for oil in the transportation sector. Alternative fuels include natural gas, ethanol, methanol, propane, and electricity. As discussed in chapter 3, the transportation sector is the largest user of oil, accounting for almost two-thirds of all oil consumed in the United States. According to DOE, in 1994, oil supplied about 97 percent of the energy consumed in the transportation sector. This sector's consumption exceeded the nation's total domestic oil production by 38 percent. Therefore, the development of alternative fuels and vehicles that can cost-effectively decrease the transportation sector's use of oil could substantially reduce the economy's dependence on oil.

Advances in U.S. research on alternative fuels and vehicles could have worldwide implications. Such advances could reduce not only the nation's, but also the world's, dependence on oil and vulnerability to oil supply disruptions.

Although many experts supported federal funding for research on alternative transportation fuels and vehicles, many indicated that the federal role should be limited to funding research to develop technological options. Several of the experts, including oil company representatives, said that the market should ultimately determine the market penetration rate and the use of such fuels and vehicles. They cautioned against federal involvement in mandating the use of alternative fuels or vehicles or subsidizing the commercialization of alternative fuels. One expert expressed the view, however, that subsidies and mandates may be needed to offset the advantage that petroleum-based fuels derive from an existing infrastructure for refueling. [11]

Governmental subsidies can be costly, as we found in a 1992 report on the lessons learned from other countries' experiences with alternative fuels.[12] Furthermore, any wavering in financial or other commitments may lead to a negative response from consumers and industry. Among other important lessons, we learned that consumers want (1) the prices of alternative fuels and alternative-fueled vehicles to be competitive with the price of gasoline, (2) alternative fuels to be conveniently available, and (3) alternative fuels and vehicles to perform as well as gasoline fuels and vehicles.

Some Experts See Externalities as Justifying a Federal Role in Research

Some of the experts we consulted believe that the existence of external costs not included in the price of oil, or externalities, justifies federal involvement in research on alternative fuels and vehicles to reduce the economy's dependence on oil. The experts cited several externalities, including OPEC's power to influence the world price of oil and to cause a world oil crisis and associated economic disruptions.[13] The environmental

[11]DOE and other federal agencies are currently implementing several programs that selectively mandate the use of alternative fuels or provide subsidies for their use.

[12]Alternative Fuels: Experiences of Brazil, Canada, and New Zealand in Using Alternative Motor Fuels (GAO/RCED-92-119, May 7, 1992).

[13]Some experts believe that because of the economic interdependence between OPEC and the oil-importing nations, OPEC is not likely to deliberately precipitate an oil crisis through embargoes similar, for example, to the 1973-74 crisis. However, as discussed previously, many fear that the risk of an oil supply disruption has not been eliminated because the Middle East remains politically volatile and internal conflicts affect the stability of some core members of OPEC.

cost of using oil, especially the air pollution caused by the transportation sector, is another external cost that might decrease if alternative fuels were used in place of oil.

In addition, some experts argued that the federal government should take the lead in funding basic research for alternative fuels and vehicles because such research, if successful, would confer more benefits on society than a private party who undertook such research would be able to recoup. Furthermore, it may take a long time—perhaps several decades—for research to make alternative fuel prices competitive with oil. For these reasons, the private sector may be unwilling to invest in such research and a federal role may be justified.

Although many experts supported the government's participation in energy research, there was no consensus on the optimal level of federal funding for such research. A leading energy expert told us that the optimal level of federal funding for alternative energy research should be determined by the estimated cost of the externalities associated with oil consumption.[14]

While most experts we consulted favored federal research for alternative fuels and vehicles, a few did not believe that such research was a cost-effective way to mitigate the economy's vulnerability to oil shocks. These experts questioned whether much has been gained from federal investments in such research over the past two decades, arguing that despite these expenditures, oil consumption, especially in the transportation sector, has not decreased. They believe that uncertainties associated with the cost and convenience of alternative fuels and vehicles reduce the likelihood of their being able to compete with conventional fuels and vehicles within any reasonable period of time.

Very few of the experts mentioned research to improve fuel efficiency in the transportation sector or in other sectors as an option to reduce the economy's vulnerability. One who did address the subject believes that increases in fuel efficiency may be overtaken by increases in demand, as has occurred historically. In a recent report the Office of Technology Assessment stated that in predicting the eventual outcome of research to improve fuel efficiency, a key unknown is whether the demand for travel

[14]There is no consensus among the experts we consulted on the estimated amount of the external costs associated with oil consumption, or even on their components. Some included factors such as OPEC's market power, environmental pollution, the macroeconomic adjustment costs associated with oil price spikes, the military costs attributable to protecting oil imports, and even the costs of developing and maintaining the SPR.

will keep on growing and overwhelm the effects of efficiency gains or whether it will instead reach a plateau or grow very slowly so that rising efficiency will reduce total energy use.[15] We note, however, that according to proponents of energy efficiency measures, a large amount of oil could be saved at a reasonable cost through greater energy efficiency.

Experts See a Higher Gasoline Tax as a Way to Decrease Oil Consumption

Many of the experts suggested that a higher federal gasoline tax could reduce the economy's dependence on oil and vulnerability to oil shocks by lowering the consumption of oil. At the same time, they were aware of the potential political and public opposition to such a tax, as well as the widespread public support for recent proposals to lower existing gasoline taxes. While there was no consensus among the experts on what the optimal tax rate should be, most of those supporting a higher gasoline tax believe that it must be high enough to bring about an appreciable reduction in oil consumption. Gasoline taxes in Western Europe and Japan are already much higher than in the United States. Higher gasoline taxes may have adverse effects on the economy, but these effects could be lessened through offsetting changes in fiscal or monetary policy.

Experts Believe a Higher Gasoline Tax Could Help Reduce U.S. Oil Consumption

Many of the experts we interviewed believe that substantially increasing the federal gasoline tax rate would help to decrease the demand for motor gasoline, thereby reducing oil consumption and vulnerability to oil shocks. As discussed, the transportation sector is fueled almost entirely by oil, and this sector alone accounts for about two-thirds of the nation's oil consumption. Furthermore, EIA forecasts under its reference case that the transportation sector's demand for oil will grow by about 25 percent between 1994 and 2015. Many of the experts we consulted attributed much of the transportation sector's high and rising demand for oil to the relatively low price of gasoline in the United States—a price many believe does not fully reflect all of the external costs of using gasoline discussed above. In a 1992 study, we found that U.S. gasoline prices did not reflect all of the external costs associated with gasoline use.[16] Our study identified "vulnerability to oil supply disruption and price shocks" as one of the external costs of the transportation sector's heavy reliance on petroleum. It also found that a higher tax on gasoline was an option that could be used to reduce the nation's dependence on oil and ultimately help secure the U.S. economy against oil price shocks.

[15]Office of Technology Assessment, Saving Energy in U.S. Transportation (July 1994).

[16]Energy Policy: Options to Reduce Environmental and Other Costs of Gasoline Consumption (GAO/RCED-92-260, Sept. 17, 1992).

Other studies have also found that reducing the economy's vulnerability to oil shocks would justify higher gasoline tax rates.[17] According to several of the experts we consulted, such a tax must be sufficiently high to bring about a sizable and sustainable reduction in the demand for oil because, overall, the demand for gasoline in the United States does not respond very much to small increases in price, particularly in the short term. In addition, some experts believe that by boosting the price of gasoline, a higher gasoline tax could, over time, stimulate and facilitate the development of alternative fuels, making their price more competitive in the marketplace.

The Average Retail Gasoline Price Is Much Lower in the United States Than in Western Europe

On average, the retail price of gasoline is much lower in the United States than in Western Europe or Japan. For example, as of June 1996, the average price of gasoline at the pump was about $1.29 per gallon in the United States, compared with a combined average of about $4.11 per gallon in Germany, the United Kingdom, France, and Italy. This wide difference between the average retail price of gasoline in the United States and in these countries is almost entirely explained by the prevailing differences in gasoline taxes. As of June 1996, the gasoline tax averaged around $0.38 per gallon in the United States,[18] compared with a combined average of $3.22 per gallon in Germany, the United Kingdom, France, and Italy.

According to the Office of Technology Assessment's report cited above, European automobile fleets are more efficient than U.S. fleets, partly because Americans purchase large numbers of light trucks for personal use and partly because American automobiles are larger than their European counterparts. The report also noted that per-person travel and energy consumption in Europe, while growing, should remain significantly below U.S. levels for several reasons, including differences in geography and the wide disparity between European and U.S. gasoline prices. The NEPP also notes that gasoline prices in the United States are lower than in other industrialized nations, contributing to high rates of motor vehicle use.

[17]See, for example, Jonathan Haughton and Soumodip Sarkar, "Gasoline Tax as a Corrective Tax: Estimates for the United States, 1970-1991," The Energy Journal, Vol. 17, No. 2 (1996), pp. 103-126. See also Sanjeev Gupta and Walter Mahler, "Taxation of Petroleum Products: Theory and Empirical Evidence," Energy Economics, Vol. 17, No. 2 (1995), pp. 101-116.

[18]This consists of 18.3 cents for federal tax and an average of 19.77 cents for all the states and the District of Columbia.

A substantially higher gasoline tax could, however, negatively affect the U.S. economy in the short term unless it were offset by other changes to fiscal or monetary policies. A higher gasoline tax could slow economic growth by reducing consumers' disposable income and raising costs for businesses using gasoline-powered light-duty vehicles.

Observations

The options most often recommended by the experts we consulted are generally included in the NEPP, but there are some important differences. For example, both the experts and the plan propose early use of the Strategic Petroleum Reserve and the appropriate use of monetary policy to mitigate the impact of oil supply disruptions once they take place. The plan, however, does not adopt the automatic market-based trigger recommended by many of the experts to avoid delays in releasing oil from the reserve. The plan cites the importance of monetary policy but stops short of stipulating a role for such policy during oil supply disruptions. DOE is currently studying the role of monetary policy in more detail.

Both the plan and the experts see further research and development on alternative transportation fuels and vehicles as a way to reduce the economy's vulnerability to oil supply disruptions, particularly in the long run. The plan, however, calls for continuing existing mandates and subsides for the use of alternative fuels, which the experts generally do not favor. Although the higher gasoline taxes recommended by many of the experts are not part of the plan, even the experts who favor this option are aware of the potential political and public opposition to it.

The plan contains a number of initiatives aimed at increasing domestic oil production, but most of the experts who addressed this issue said that while such efforts may be justified on other grounds, such as increased domestic economic activity and employment, such initiatives would not significantly reduce the nation's economic vulnerability to oil supply disruptions for the reasons discussed in chapter 2.

Agency and Other Comments and Our Evaluation

DOE said that the experts we consulted essentially endorsed the NEPP's core programs. Yet despite some similarities, important differences separate the NEPP's proposals from the views of these experts. We outlined these differences in the preceding observations section in both the draft and final report.

One expert commenting on our draft report said that during prior disruptions, oil production capacity exceeded consumption, but precautionary and speculative buying still drove up oil prices. This expert believes that using the SPR is the most effective strategy to prevent such price rises. Another expert said that the size of the SPR should be increased and opposed the recent sale of SPR oil to pay for other federal programs. Finally, one expert said that higher gasoline taxes in this country would raise the cost of doing business and adversely affect the nation's international competitiveness. Where appropriate, we have revised the report to take these comments into consideration.

Experts and Industry Analysts GAO Consulted on Options for Dealing With U.S. Vulnerability to Oil Supply Disruptions

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Richard Brown, Thomas Hogarty, Edward Porter, American Petroleum Institute.

Peter C. Fusaro, President, Global Change Associates.

Lawrence J. Goldstein, President, Petroleum Industry Research Foundation, Inc.

William W. Hogan, Professor, Harvard University.

J. Daniel Khazzoom, Professor, San Jose State University.

Edward N. Krapels, Director, Energy Security Analysis, Inc.

W. C. Lonquist, President, Memorial Exploration Company.

Michael C. Lynch, Research Affiliate, Massachusetts Institute of Technology.

John R. Moroney, Professor, Texas A&M University.

Edwin S. Rothschild, Energy Policy Director, Citizen Action.

Michael R. Ryan, Manager, Regulatory Affairs, Texaco, Inc.

John Saucer, Senior Energy Analyst, Smith Barney, Inc.

Irwin M. Stelzer, Director, Regulatory Policy Studies, American Enterprise Institute for Public Policy Research.

Vito Stagliano, Visiting Scholar, Resources for the Future.

Philip Verleger, Jr., Vice President, Charles River Associates, Inc.

Robert J. Weiner, Associate Professor, George Washington University.

Roy Willis, Senior Vice President, Independent Petroleum Association of America.

Estimating the Benefits of Low-Cost Oil Imports

This appendix describes the Energy Information Administration's (EIA) methodology for estimating the benefits to the U.S. economy of access to low-cost oil imports.[1] It also expands chapter 2's brief description of the results of EIA's analysis.[2]

Two Approaches Illustrate Benefits

At our request, EIA used its National Energy Modeling System (NEMS) to evaluate the impact of higher oil prices on U.S. oil import levels and subsequently on U.S. macroeconomic performance. EIA developed and maintains NEMS to forecast the effects of energy policies or programs and changing world energy market conditions on the U.S. and world energy markets. NEMS can also be used to forecast the effects of changing energy markets on the U.S. economy.[3]

To estimate the benefits of oil imports to U.S. consumers and businesses, we asked EIA to pursue two different approaches. The benefits of oil imports cannot be measured directly, so economists estimate them indirectly by measuring the harm that would be caused by reducing imports from their current level. Hence, we designed these approaches to illustrate the cost to the U.S. economy of reducing oil imports by relying on more expensive domestic sources of energy. Similarly, the well-being of consumers and businesses cannot be measured directly, so we use Gross Domestic Product (GDP) as a proxy measure of their well-being. We compared GDP under these reduced oil import cases with GDP under the reference case in EIA's Annual Energy Outlook 1996. This reference case, discussed at greater length in chapter 3, reflects EIA's projection of the most likely future trends in energy markets and the U.S. economy. The difference between GDP under the reference case and GDP under the reduced import cases represents an estimate of the cost of reducing oil

[1]We would like to thank EIA's Office of Integrated Analysis and Forecasting for their assistance in the modeling and analysis phases of our study. However, this analysis should not be construed as advocating or reflecting any policy position of the U.S. Department of Energy or the Energy Information Administration. We would also like to thank M. A. Adelman, Massachusetts Institute of Technology; Douglas Bohi, Resources for the Future; Stephen Brown, Federal Reserve Bank of Dallas; Richard Farmer, Congressional Budget Office; Bert Hickman, Stanford University; William Hogan, Harvard University; Hillard Huntington, Stanford University; Daniel Khazzoom, San Jose State University; Edward Krapels, Energy Security Analysis, Inc.; Alan Manne, Stanford University; Bradley McDonald, World Trade Organization; James Sweeney, Stanford University; Sidney Winter, The Wharton School of the University of Pennsylvania; and Mine Yücel, Federal Reserve Bank of Dallas, for their assistance in designing our study. Nevertheless, the views expressed in this report do not necessarily reflect their views.

[2]The Impacts on U.S. Energy Markets and the Economy of Reducing Oil Imports, DOE, EIA, SR/OIAF(96-04), (Sept. 1996).

[3]More information on NEMS is available in The National Energy Modeling System: An Overview (DOE/EIA-0581(96), Mar. 1996).

imports or, alternatively, the benefits of importing oil at the current level. Under one approach, higher world oil prices, caused by a gradual decline in foreign production, gradually reduce imports. Under the other approach, a hypothetical oil import fee raises the prices of imports, reducing their levels. We chose an oil import fee for two reasons. First, unlike higher world oil prices, an oil import fee is an option that U.S. policymakers could choose. Second, many of the experts we consulted agree that if policymakers wish to lower oil imports, an oil import fee is an effective and comparatively low-cost method of doing so. Other options for reducing oil imports, such as implementing regulations to limit imports or subsidizing domestic production, impose costs at least as high as these two approaches. Thus, the choice of an import fee was entirely for illustrative purposes; we do not endorse any particular energy program or policy goal. In order to isolate the economic effects of reducing oil imports from those of other possible concurrent changes, such as changes in the money supply, we generally assumed that other economic policy instruments would remain unchanged from EIA's reference case.[4] Both approaches provide an estimate of the benefits to the U.S. economy of importing oil, and both are useful for illustrating the large gains derived from buying oil from the lowest-cost source, rather than imposing restrictions that would enhance noncompetitive domestic energy production. Because of the many uncertainties in estimating the benefits of imports, the results of applying the two approaches are best interpreted as rough guides to the magnitude of the benefits of oil imports, rather than as precise estimates.

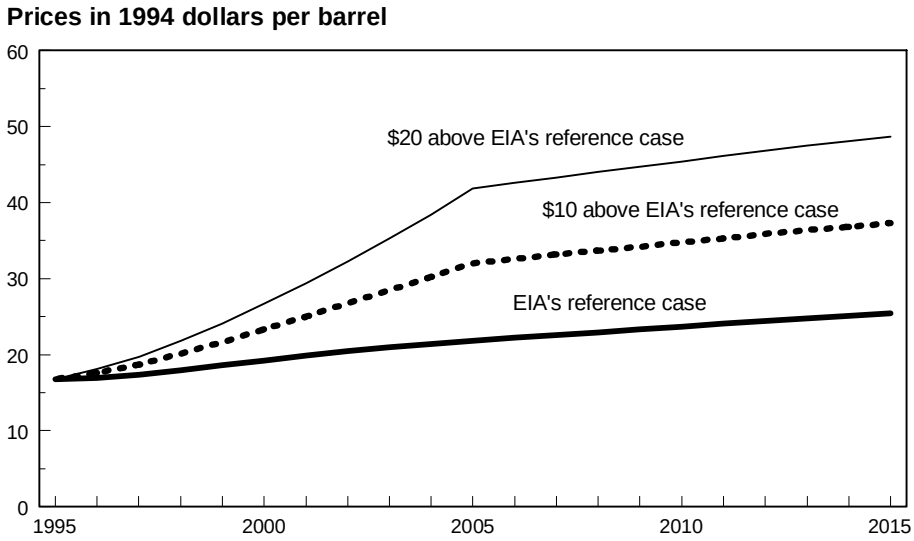
Higher World Oil Prices

EIA modeled four cases to measure the effects of higher world oil prices on U.S. oil imports and macroeconomic performance. In these cases, the world oil price was assumed to rise gradually, by 2005, to $5, $10, $15, and $20 per barrel above the forecast price in EIA's reference case ($22 per barrel in 2005), in 1994 dollars. Figure II.1 compares the price paths for two of the higher-price cases—the $10 and $20 cases—with the path for EIA's reference case. As the figure shows, oil prices rise more quickly for the higher-price cases than for the reference case. For the $10 case, the world oil price is about $32 per barrel in 2005, or about $10 per barrel higher than for the reference case. The differences in price between the higher-price cases and the reference case are assumed to result from a gradual decline in world oil production, not from a deliberate policy choice by the U.S. government. The higher prices are assumed to be

[4]While the Congress or the Federal Reserve could change fiscal or monetary policy to minimize the effects of reducing imports on GDP or other economic indicators, such changes could confound the measurement of the gains from trade.

phased in over a 10-year period to minimize the adjustment costs created by price changes. After 2005, the prices in the four higher-price cases are assumed to grow at the same rate as the price in the reference case.

Figure II.1: World Oil Prices Under Three Scenarios



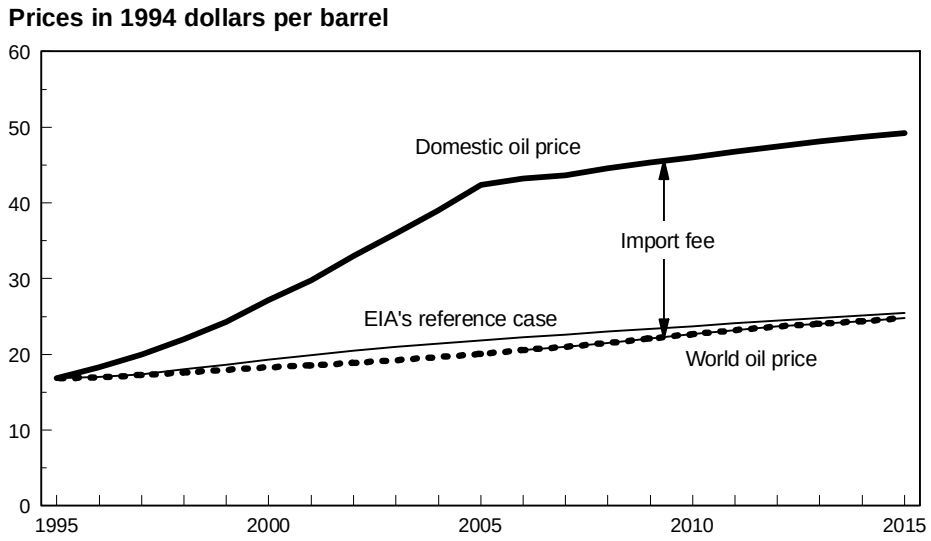
Source: EIA.

Import Fee

Imposing an oil import fee would raise the domestic oil price above the world oil price. This result contrasts with the results of higher world oil prices, which apply equally to all markets, foreign and domestic. As figure II.2 shows, the world oil price would decline slightly relative to EIA's reference case if the United States were to impose an oil import fee. This decline would occur because lower oil consumption in the United States would lower the world's total demand for oil. Figure II.2 shows the relationship that would exist between the world oil price and the domestic oil price if the United States were to impose an import tariff sufficient to reduce imports by the same amount as the $20 price increase in the case described above. For any given year, the vertical distance between the domestic oil price and the world oil price is the import fee. Although the oil import fee would be imposed only on imported oil, the price of domestically produced oil would rise to the same level, creating an increase in revenue for domestic oil producers. In this case, the hypothetical fee, like the price increases in the higher-price cases, is

implemented over a 10-year period to minimize the adjustment costs that it would impose.

Figure II.2: U.S. and World Oil Prices With an Oil Import Fee



Source: EIA.

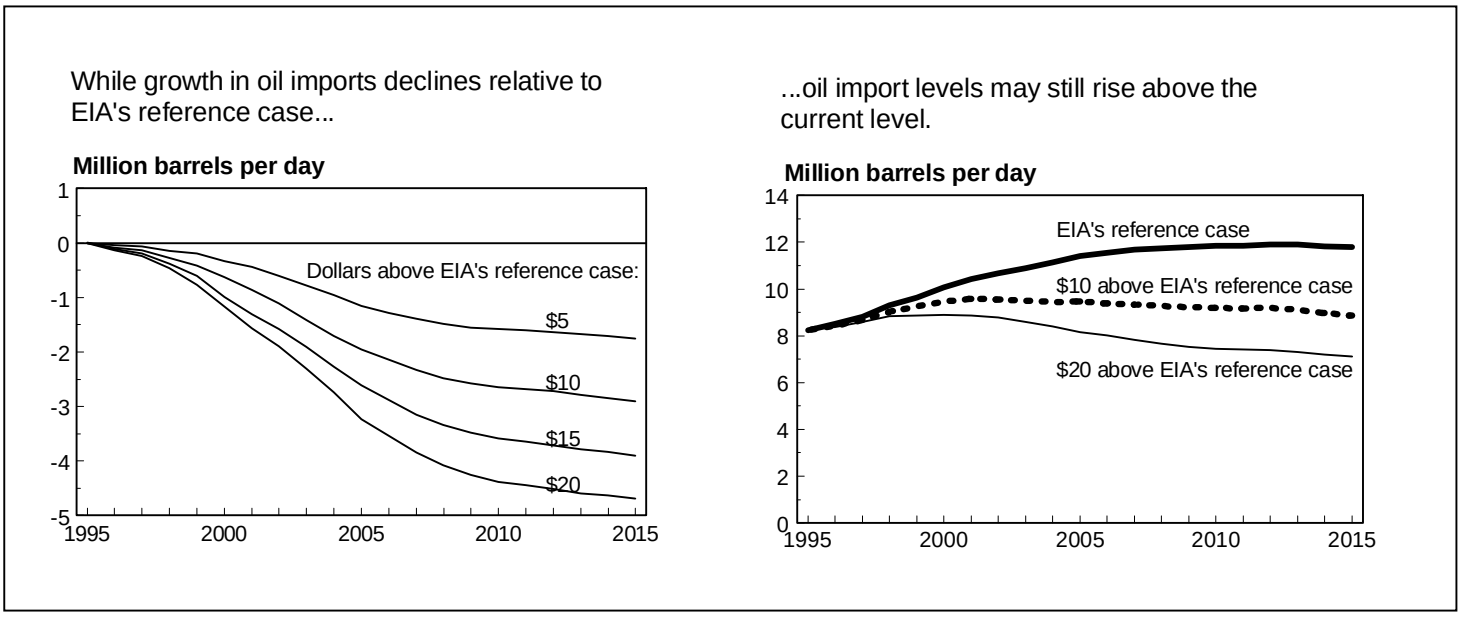
For the import fee case, it was assumed that crude oil and refined crude oil products imported from the United States' North American Free Trade Agreement (NAFTA) partners—Canada and Mexico—would not be subject to the oil import fee. It was also assumed that the volumes available from Canada and Mexico would be limited to the volumes available for export from Canada and Mexico after these countries met their domestic consumption needs with their domestic production. For all of the import fee cases, all excess production was imported into the United States. The import fee was applied uniformly to all other foreign production.

Higher Oil Prices Reduce Oil Imports

Under both of the approaches that we asked EIA to model, the price of domestic oil increases; in the one case, the domestic price rises with the higher world price, while in the other case, the oil import fee raises the price. Higher domestic oil prices increase domestic production and

decrease domestic consumption; as a result, oil imports decline. Figure II.3 shows that in the four higher-price cases, imports fall relative to EIA's reference case. For example, if the world oil price is $10 higher than expected by 2005, imports will be about 2.0 million barrels per day (mmbd) below EIA's current projection. Similarly, if the world oil price is $20 higher than expected, imports will be about 3.2 mmbd below EIA's current projection. By 2015, imports will continue to decrease by a total of 2.9 mmbd and 4.7 mmbd, respectively. Nevertheless, figure II.3 also shows that oil imports will continue to rise relative to their current level, at least initially. In its reference case, EIA projects that imports will rise from the current level of about 8.3 mmbd to a peak of about 11.9 mmbd in 2012 before declining slightly. In other cases, imports will continue to rise above the current level initially. In the $5- and $10-higher-price cases, imports in 2015 remain above the current level. Only in the $15- and $20-higher-price cases do imports fall below the current level. Because the oil import fee was designed to produce the same effects on imports as the $20-higher-price case, the fees effects on imports are not shown separately.

Figure II.3: U.S. Oil Import Levels Under Various Future Oil Price Scenarios



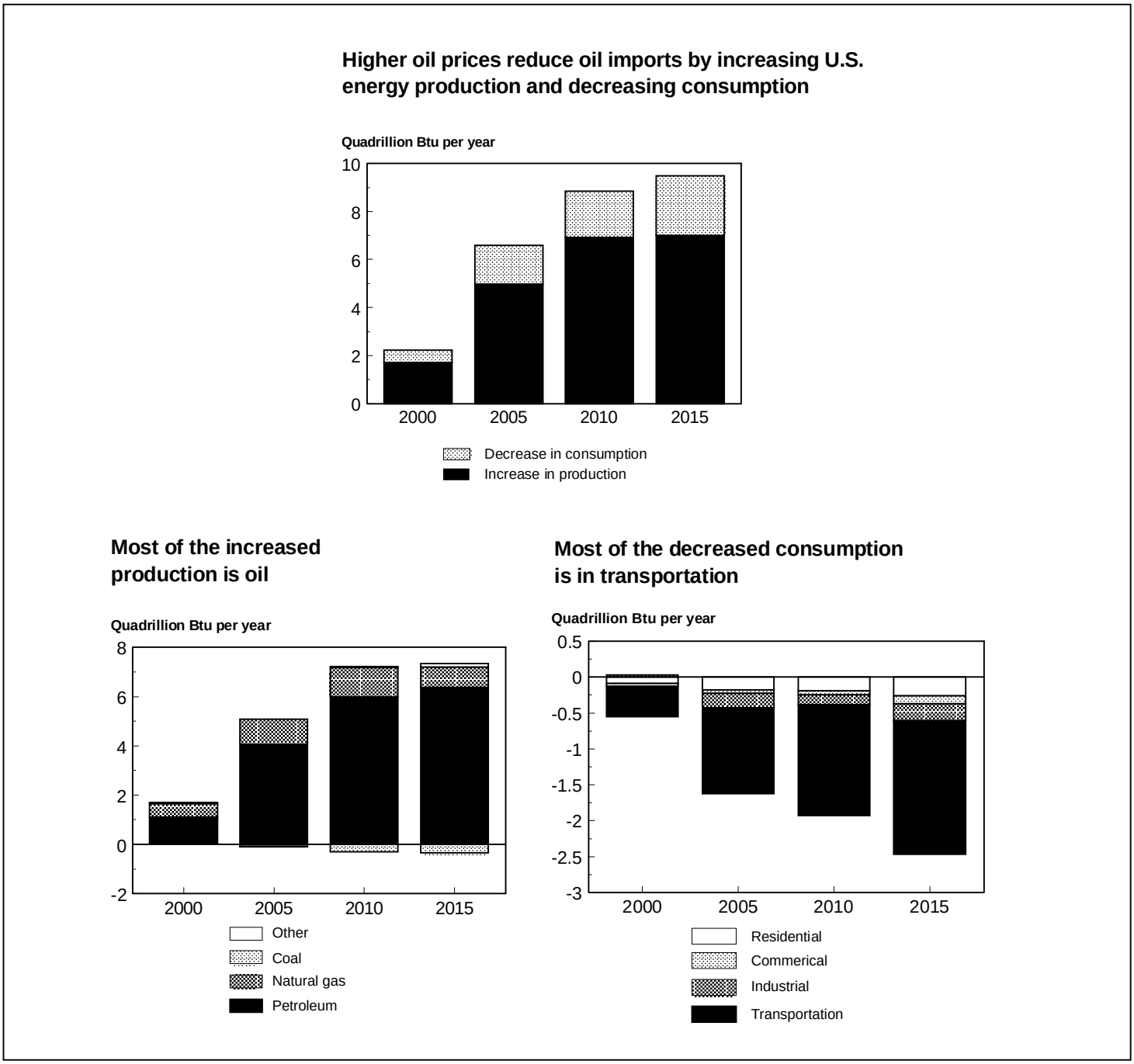
Notes: Changes shown in left half of figure are relative to EIA's reference case. Prices are in 1994 dollars.

Source: EIA.

Increased crude oil prices have predictable effects on the U.S. energy sector: Domestic oil production increases while the transportation sector's demand for fuel declines. Increased crude oil prices have indirect effects on the production of natural gas and coal and other aspects of the energy market, but these effects are modest relative to the direct effects on oil production and the transportation sector's demand for oil.

When domestic oil prices rise, either because world oil prices increase or because an oil import fee is imposed, oil imports fall. They fall because domestic production increases and domestic consumption decreases. Figure II.4, which refers to the $20-per-barrel-higher-price case shows that the increases in domestic production exceed the decreases in domestic consumption, but both contribute significantly to reducing imports. For example, in 2005 under the $20-higher-price case, increased domestic production represents 73 percent of the reduction in imports while decreased consumption accounts for 24 percent. The import reductions in figure II.4 arise from the $20 increase in the world oil price but would be similar if the import fee were imposed. The primary difference would be a decline in oil imports coupled with a rise in refined product imports. In the tariff cases, refined products imports would rise relative to oil imports because inexpensive imports become available under NAFTA. Figure II.4 also demonstrates that the majority of the increased domestic production is in the form of oil. (Because increases in domestic production arise from changes in several sources of energy, not just oil, EIA measures the contribution of each form of energy in quadrillions of British thermal units (Btu) rather than barrels of oil.) Decreases in domestic consumption come largely from the transportation sector, as figure II.4 also shows.

Figure II.4: Impact of $20-Per-Barrel-Higher Oil Prices on U.S. Energy Production and Consumption



Note: Changes are relative to EIA's reference case.

Source: EIA.

Reducing Oil Imports Imposes Large Economic Costs

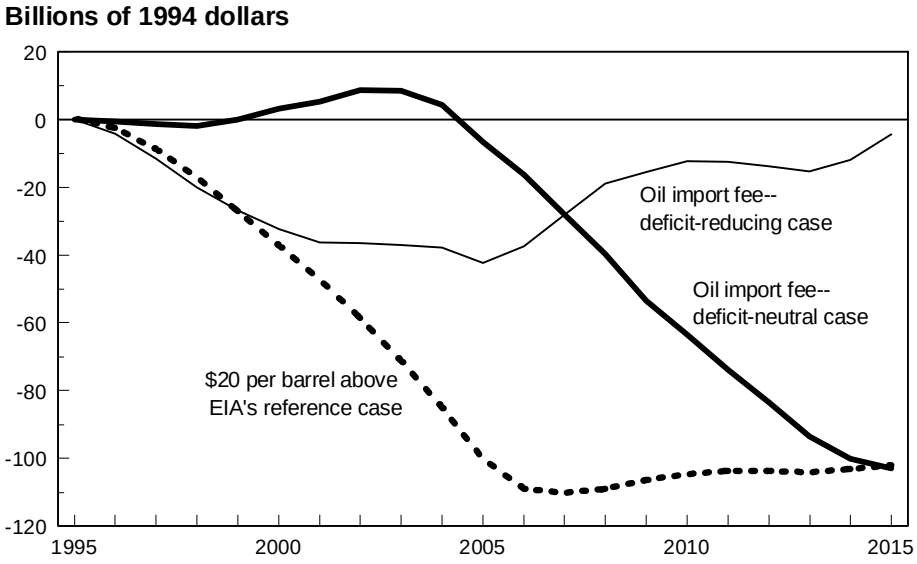
Higher prices for oil would impose large costs on the economy. As discussed earlier, these costs, or macroeconomic losses, represent the gains realized from the nation's current level of oil imports. In the higher-price cases, such as the $20-higher-price case shown in figure II.5, GDP declines relative to EIA's reference case as oil prices rise and imports decline. Specifically, in the $20-higher-price case, by 2005 GDP has declined by about $100 billion annually. It continues to decline for another year, to about $110 billion, before improving slowly to about $100 billion per year below the reference case in 2015. The smaller higher-price cases show proportionately smaller effects on GDP—the $10-higher-price case reduces GDP by about $50 billion per year in 2005 and GDP remains approximately constant thereafter.[5]

The macroeconomic consequences of the oil import fee are more complex. Unlike higher world oil prices, the oil import fee generates substantial revenues for the government. These revenues alter the economic consequences of reducing oil imports. Although many alternatives exist for using these revenues, we asked EIA to focus on two cases: In one case, the revenues are rebated equally to consumers and businesses through reductions in the Social Security payroll tax and the total federal budget deficit at full employment remains unchanged from EIA's reference case, while in the other case, the revenues are used to reduce the federal budget deficit. How these funds are used makes a large difference. As figure II.5 shows, when the fee revenues are used to reduce the federal budget deficit, the economy is adversely affected through 2005, but GDP begins to return to the reference case, nearly reaching that level by 2015. In the early years, the economy is adversely affected by higher energy prices and lower import levels, while in the later years, interest rates decline in response to the reductions in the federal budget deficit, stimulating investment. We believe that GDP returns to the reference-case level because of the benefits of reducing the federal budget deficit. In contrast, when the fees are rebated to consumers and businesses, the economy stays at or slightly above EIA's reference case through 2005 but declines sharply thereafter. In this deficit-neutral case, the early results stem from the rebate, which

[5]According to EIA, the costs of reducing imports would be roughly the same even if the current estimates of future prices prove to be too high or too low. In other words, the economic costs of deviation from the expected future prices depend on the amount of the deviation rather than the level of the future prices.

encourages consumption and ameliorates the near-term effects of the oil import fee. However, investment declines as interest rates rise, and GDP begins to decline rapidly relative to the reference case after 2005.

Figure II.5: Changes in GDP From High World Oil Prices and Oil Import Fee

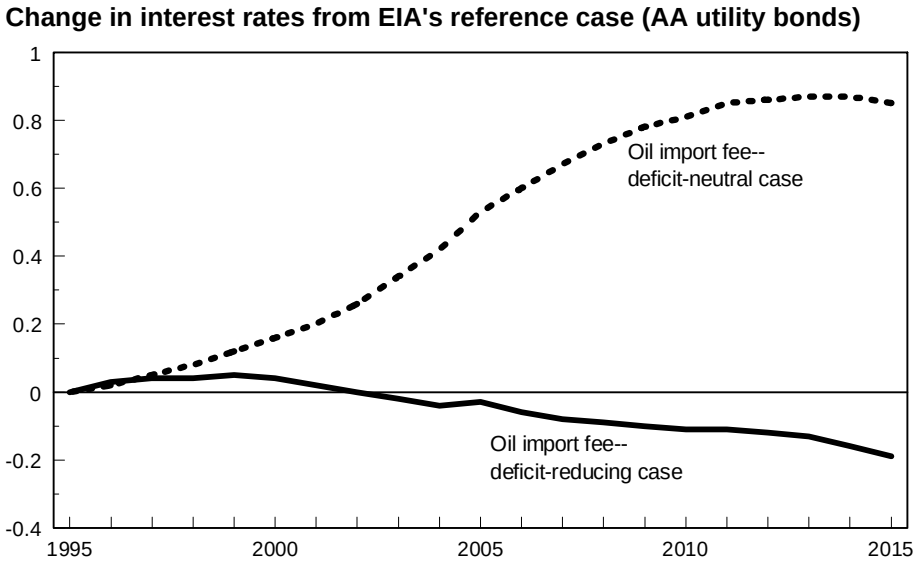


Note: Changes are relative to EIA's reference case.

Source: EIA.

The effect of an oil import fee on interest rates depends on how the fee revenues are used. Figure II.6 shows changes in interest rates from EIA's reference case under the deficit-reducing and deficit-neutral cases. In the deficit-reducing case, the rise in energy prices increases inflation and temporarily increases nominal interest rates. This increase temporarily discourages investment and interest-sensitive components of consumers' expenditures, such as automobiles and housing. However, over a longer time period, as the temporary increase in inflation subsides, the continued reduction in federal borrowing lowers interest rates slightly, encouraging investment and long-term economic growth. In contrast, in the deficit-neutral case, nominal interest rates rise throughout the period. This rise discourages economic investment and limits long-term economic growth, thereby reducing GDP in the long term.

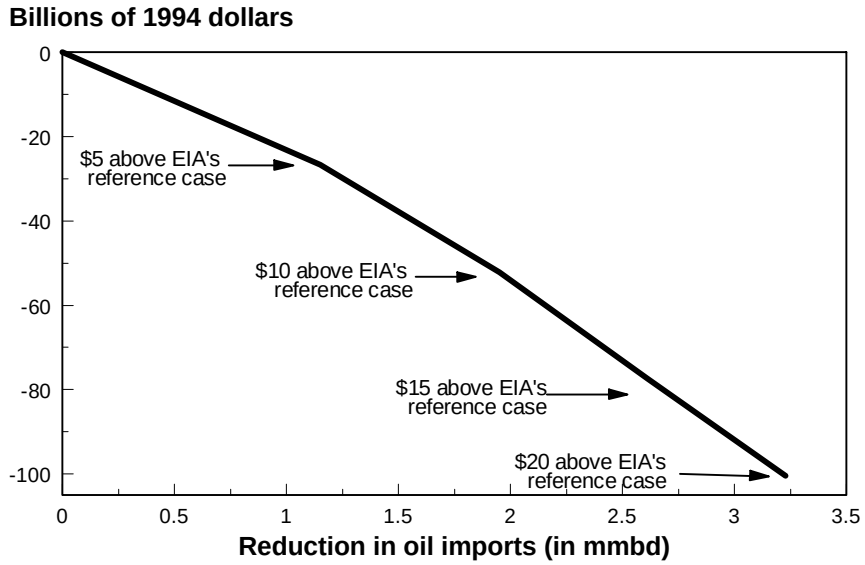
Figure II.6: Bond Rates



Source: EIA.

Figure II.7 shows that each successive reduction of 1 million barrels per day can be achieved only at a higher cost: The cost of reducing imports rises more rapidly than the rate of reduction in imports themselves. For example, the first $10 price increase reduces oil imports by 2.0 mmbd by 2005, while the next $10 increase reduces them by only an additional 1.2 mmbd. Thus, doubling the price increase, and the subsequent effect on GDP, is only 60 percent as effective in reducing imports as implementing the original price increase.

Figure II.7 GDP Losses as a Function of Import Reductions



Source: EIA.

Economic Changes Are Reflected in Various Sectors of the Economy

As discussed, higher world oil prices would reduce GDP. This reduction takes two different forms. First, higher oil prices harm the economy by reducing the economy's potential GDP, which is the amount that the U.S. can produce when all resources are fully employed. Potential GDP is determined by the nation's resource base, which consists of its labor force, natural resources, and capital stock and the productivity of these resources. In response to the high energy prices, firms may use less energy, which reduces the amount of output that can be produced with a given amount of capital and labor. Hence, the productivity of labor and capital declines. In addition, a rise in oil prices may render older, more energy-using capital prematurely obsolete. Firms may retire some of their machines and factories that are heavily dependent on fuel, thus effectively reducing the nation's capital stock and potential GDP.

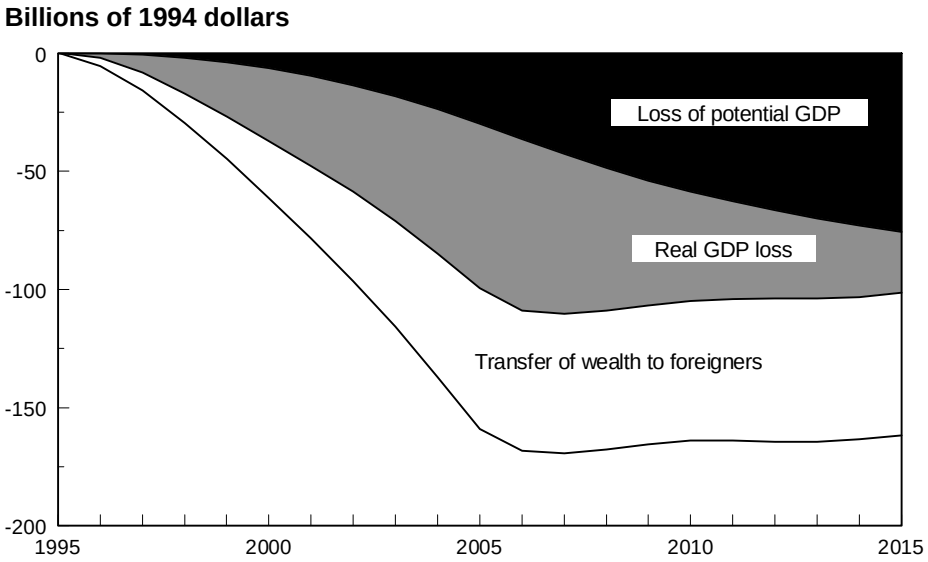
Second, changing prices imposes adjustment costs on the economy because individual businesses and consumers cannot adjust their behavior instantaneously as prices change. Figure II.8 shows the reduction in potential and real GDP (including the adjustment costs) under the $20-higher-price case. By 2005, and for the remainder of the 20 years covered by this study, real GDP fell by about $100 billion per year under this case. Some of these costs are temporary, and over a longer period, the

losses in potential and real GDP would tend to converge. Besides reducing potential and real GDP, higher energy prices transfer wealth from oil consumers to oil producers. Figure II.8 shows the additional wealth that would be transferred to foreign oil producing nations if the world price of oil were to increase.

The oil import fee cases, not shown here, also reduce potential and real GDP and transfer wealth. The two cases affect the magnitude of the potential and real GDP differently because the different uses of the fee revenues have different effects on the economy as a whole. In particular, real and potential GDP losses would be substantially less in the deficit-reducing case because, as described earlier, reducing the federal budget deficit would decrease interest rates and boost investment. While an oil import fee, like higher world oil prices, would transfer wealth from oil consumers, it would transfer the wealth to domestic rather than foreign oil producers.

Changes in GDP can be measured for its components—consumption, investment, government spending, and net exports. Figure II.9 focuses on changes in these components under the $20-higher-price case. In this case, consumption and investment fall by $85 billion and $36 billion, respectively, by 2005. They remain substantially reduced throughout the study period.

Figure II.8: Loss in Real and Potential GDP, and Wealth Transfer



Notes: Changes are relative to EIA's reference case.

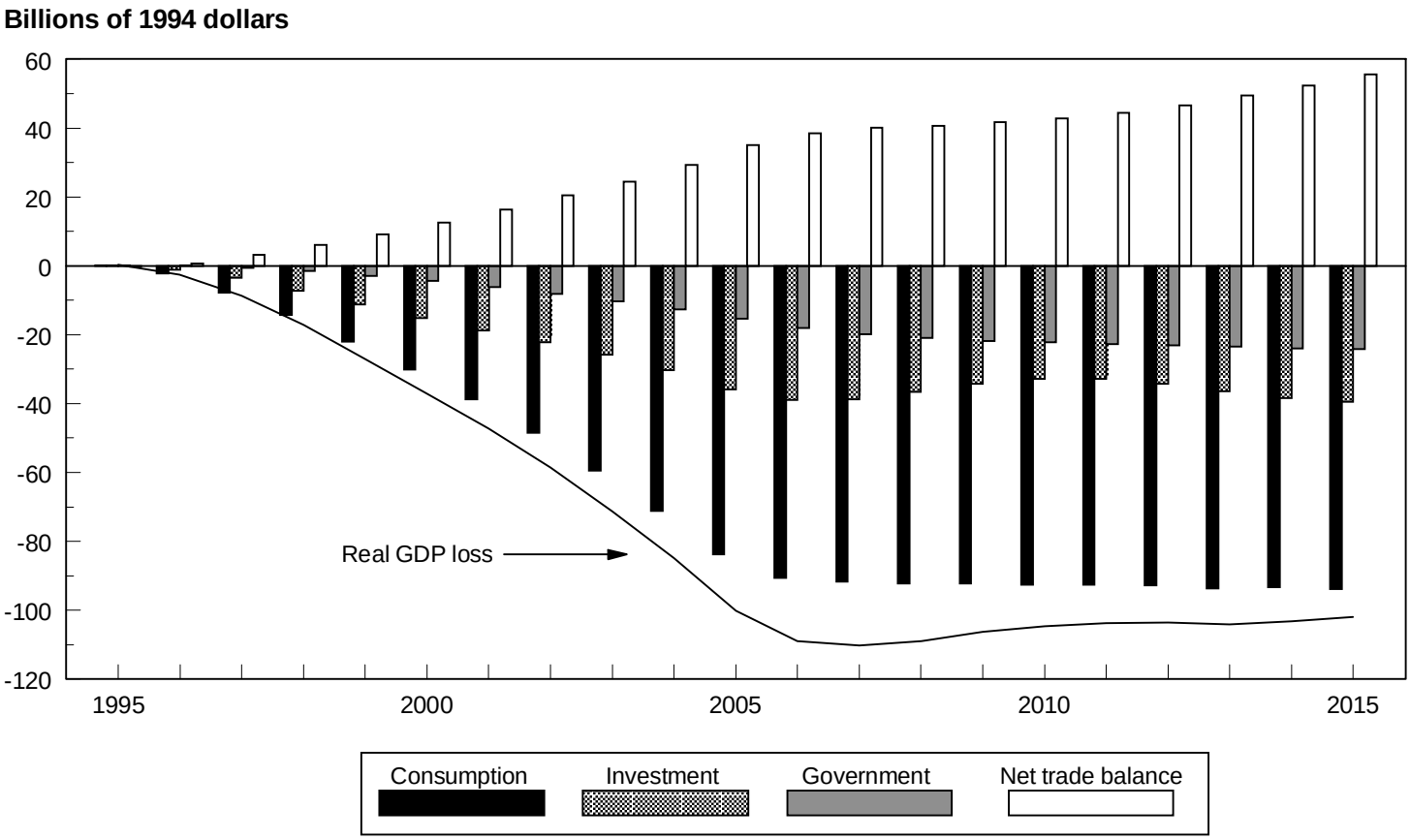
$20-per-barrel-higher-world-oil-price case.

Source: EIA.

In chapter 2, we said that the trade balance—the current account—would be likely to remain largely unchanged if oil imports declined. Little change would occur because, if oil imports fell, total U.S. exports would also fall or other U.S. imports would rise to retain the balance between total savings and investment needs. As discussed in chapter 2, the current trade deficit is caused by the shortfall between domestic savings and investment needs and does not depend on the level of oil or of any other commodity imported into the United States. If imports were to change, foreign exchange rates would change to retain the balance between total savings and investment needs. The NEMS results, however, are based on the assumption that exchange rates will remain at their baseline level—they will not change as U.S. imports change. This assumption was made because NEMS focuses primarily on domestic macroeconomic effects, and its ability to incorporate international flows of funds is limited. In discussions with EIA, we agreed that raising the domestic oil price above the world oil price would decrease oil imports. Depending on the effect of higher oil prices on the competitiveness of U.S. goods and services, NEMS'

results could show a change in the trade deficit because of this restriction on exchange rates. Nevertheless, we continue to believe, and EIA does not disagree, that a more complete international model might show that the net trade balance would remain essentially unchanged.

Figure II.9 Components of Real GDP Loss



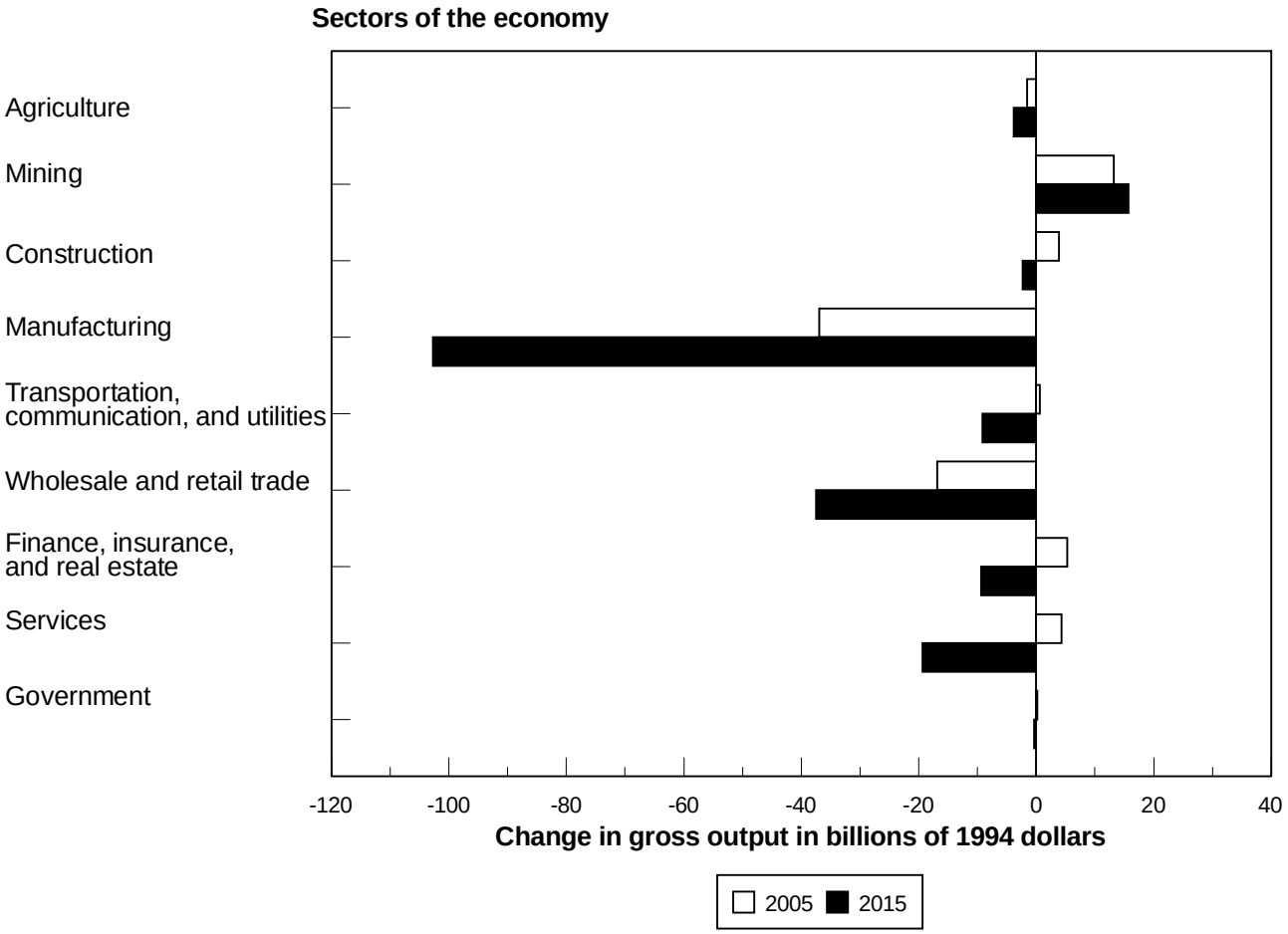
Notes: Changes are relative to EIA's reference case.

$20-per-barrel-higher-world-oil-price case.

Source: EIA.

The imposition of an oil import fee, like higher world oil prices, would likely bring benefits to domestic oil producers, who are included in the mining sector of the economy. However, these benefits would be more than offset by reductions in other sectors of the economy, and the net effect of reducing oil imports would be negative. Figures II.10 and II.11 show the economic impact of an oil import fee on different sectors of the economy. Figure II.10 reflects the assumptions of the deficit-neutral case, while figure II.11 reflects those of the deficit-reducing case. Differences between the two cases can be traced to differences in the impact of interest rates and prices, as well as of the total change in GDP. Interest-sensitive industries would feel fewer effects under the deficit-reducing case because, as described earlier, interest rates would fall slightly in this case but rise in the deficit-neutral case.

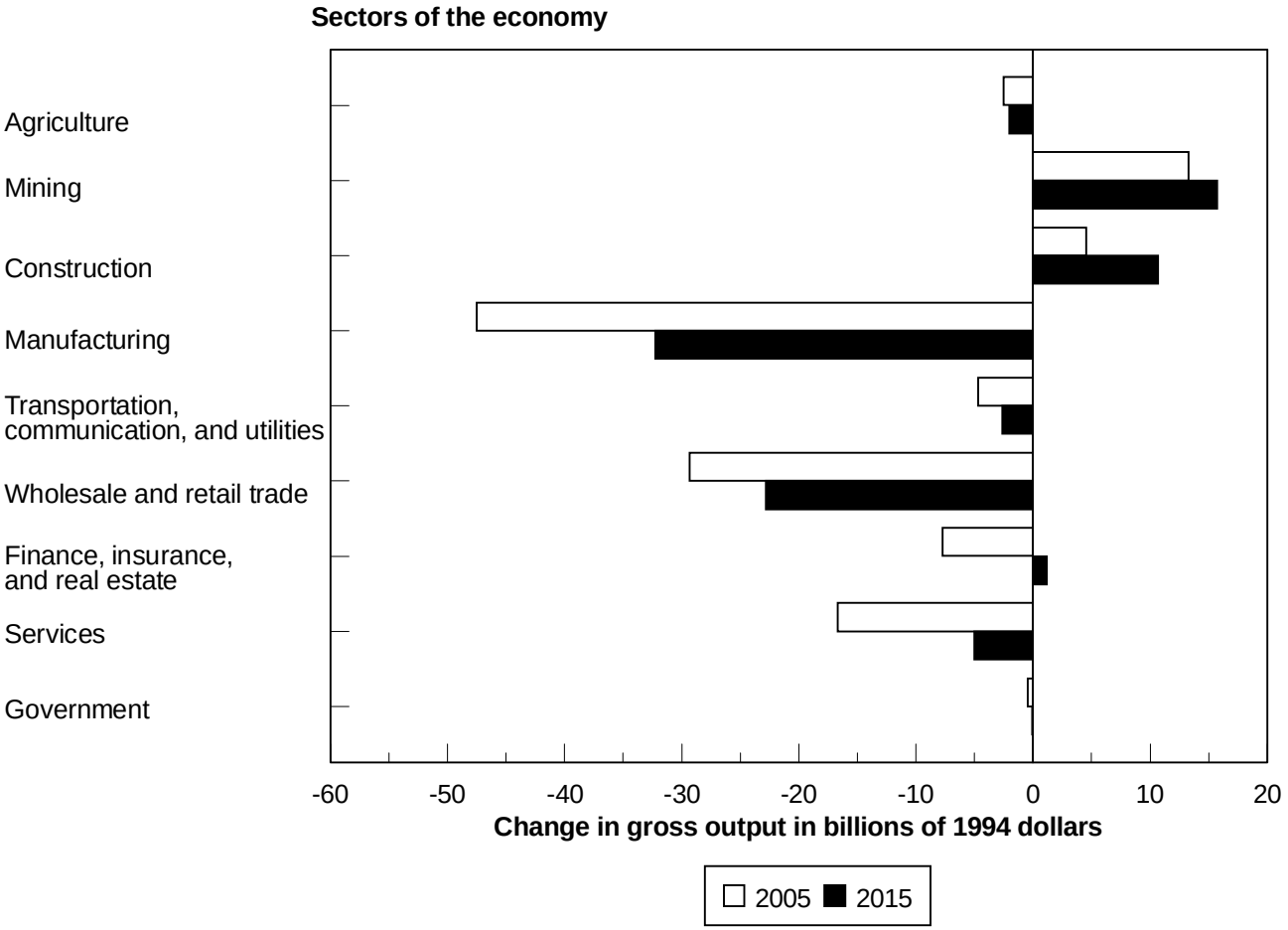
Figure II.10: Changes in Economic Output Caused by Imposing a Deficit-Neutral Oil Import Fee



Note: Changes are relative to EIA's reference case.

Source: EIA.

Figure II.11: Changes in Economic Output Caused by Imposing a Deficit-Reducing Oil Import Fee

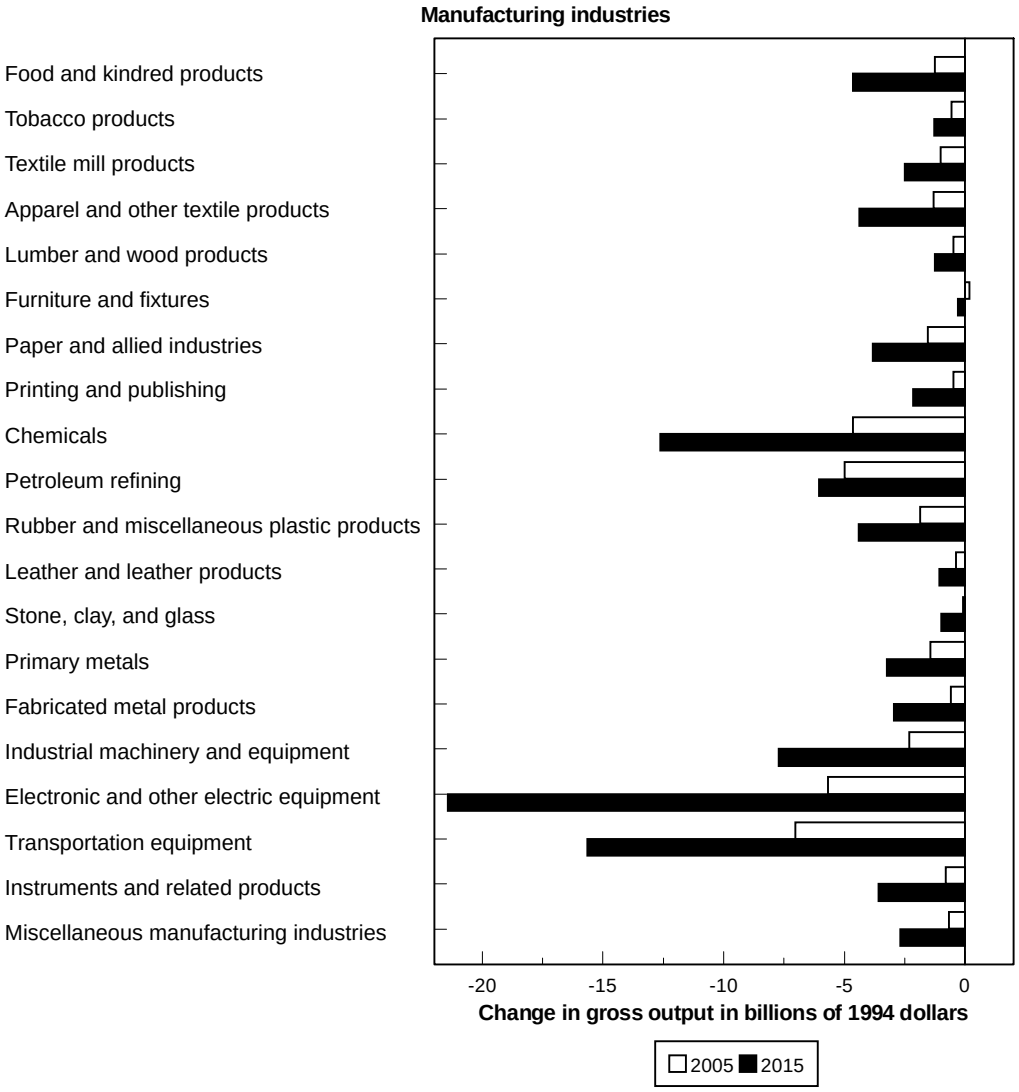


Note: Changes are relative to EIA's reference case.

Source: EIA.

The manufacturing sector of the economy is further subdivided into its components for both oil import fee cases. Figure II.12 and figure II.13 show the impact on output for the deficit-neutral and deficit-reducing cases, respectively. For both cases, the impact on most manufacturing industries, including petroleum refining, would be negative.

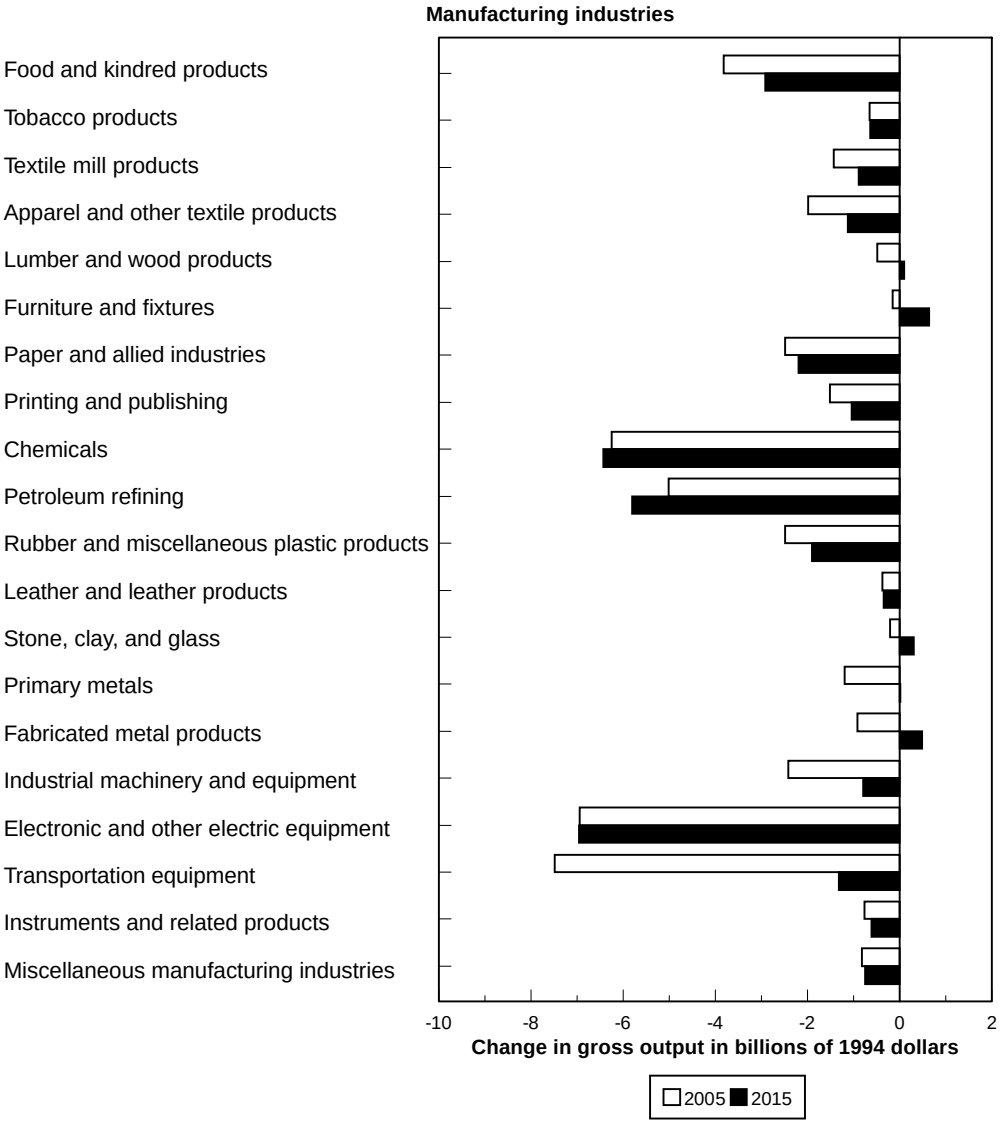
Figure II.12: Changes in Manufacturing Output Caused by Imposing a Deficit-Neutral Oil Import Fee



Note: Changes are relative to EIA's reference case.

Source: EIA.

Figure II.13: Changes in Manufacturing Output Caused by Imposing a Deficit-Reducing Oil Import Fee



Note: Changes are relative to EIA's reference case.

Source: EIA.

Oil Savings by Energy Efficiency Planning Unit

Descriptions of DOE's Energy Efficiency Programs

GAO requested that the Department of Energy provide detailed information on the energy efficiency programs designed to reduce oil consumption. The Division of Applied Analysis, in the Office of the Assistant Secretary for Energy Efficiency and Renewable Energy, furnished the following descriptions, together with the data and projections presented in table III.1.

In-House Energy Management (IHEM)

This program aims to reduce energy consumption and utility costs for DOE's facilities.

Federal Energy Management Program (FEMP)

This program leads an interagency and public private partnership to provide cost-effective financial options and technologies for reducing the cost of energy used in the federal government. In 1994, the government spent approximately $9 billion on energy supplies for its buildings, fleets, operations, and industrial processes. The programs in FEMP seek to reduce the cost of energy for the federal government by 30 percent.

Building Equipment and Materials

The programs within this planning unit conduct research and development (R&D) activities to provide the building industry with the advanced technology base needed for high-efficiency globally competitive building components (equipment, envelope subsystems, and materials) and to accelerate the adoption and use of these advanced components. Some of these technologies are advanced roofs, walls, and foundations; heat pumps and chillers; advanced lighting and appliances; and advanced glazing and electrochromic windows.

Buildings Systems Design

The programs within this planning unit conduct research and development to improve the overall efficiency of the nation's commercial and residential buildings by improving the performance and integration of energy systems in buildings. This goal is pursued through the development and deployment of integrated systems and controls to link heating, cooling, lighting, and other building energy services in the most efficient manner possible; support of infrastructure changes that accelerate the deployment of energy efficient technologies for commercial and residential buildings; and facilitation of the design and construction of buildings in the most efficient and productive manner possible through the development and deployment of tools and methods known as best practices. Some of these technologies are energy design tools, advanced commercial buildings, and advanced residential housing.

Codes and Standards

This program implements legislatively mandated energy efficiency standards, codes, and guidelines for buildings, building equipment, and appliances to improve energy efficiency in the nation's buildings. Setting efficiency standards can improve the average energy performance of buildings and equipment.

Industries of the Future

The programs within this planning unit are developing, jointly with industry, visions of the future and technology "roadmaps," and conducting research and development of advanced energy and material efficient technologies to respond to industry needs. Seven industries, producing over $700 billion in annual shipments, are partners. These industries are chemicals, forest and paper products, glass, metals casting, petroleum refining, steel, and aluminum. A large number of diverse technologies are under development. A few of these technologies are auto shredding and recycling, chemical bioprocessing systems, wood pulp black liquor gasification, advanced glass melting and process heating, aluminum casting, petroleum refining separations and membranes, and steel plant waste oxide recycling and aluminum melting, aluminum cell cathodes/inert anodes.

Cogeneration

This planning unit is developing technologies to both improve conventional turbines and develop an advanced gas turbine for the production of electricity and steam in industrial applications. This advanced turbine system is designed to be 15 percent more efficient than new conventional turbines. Specific technologies in this program include, in addition to the advanced turbine system, a ceramic retrofit gas turbine, a high-performance steam turbine, and a retrofit to lower emissions of nitrous oxides.

Advanced Materials and Continuous Fiber Ceramic Composites (CFCC)

The programs within this planning unit develop new alloys, composites, and ceramics for a wide variety of industrial applications. Examples of these technologies include materials for recovery boilers, nickel iron aluminides for steel mill rolls, organic polymers, selective inorganic thin films, CFCC diesel engine components, CFCC gas turbine components, and hot gas filters. The market for the advanced materials and CFCCs includes a large array of manufacturing applications—including chemical production, plastics, high-temperature processes, boilers, etc.

Industrial Technology Assessment

These programs disseminate information about energy efficiency techniques and technologies to potential users in industry and manage various programs to stimulate their adoption. Climate Wise is a voluntary program in which industry adopts energy efficiency and pollution prevention technologies to reduce greenhouse gas emissions. Industrial assessment centers (IAC) provide energy and waste assessments to small and medium-sized manufacturers at no cost through university-based programs that provide hands-on training for students. The Motor Challenge program works in partnership with industry to help capture over $13 billion in estimated energy savings by the year 2010 through the greater use of energy efficient motor-driven systems. The National Industrial Competitiveness through Energy, Environment, Economics (NICE-3) program provides seed funding to state and industry partnerships for projects to develop and demonstrate advances in energy efficiency and clean production technologies.

Inventions and Innovations

This program develops innovative energy technologies and increases the nation's intellectual property base by supporting research, development, and deployment by independent inventors of innovative energy technologies and concepts.

State and Local Partnerships

These programs facilitate the adoption of energy efficiency and renewable energy technologies among states, municipalities, institutions, and private citizens.

Technology Access

These programs assist in moving renewable energy and energy efficient technologies into domestic and international markets. They address market barriers that slow the acceptance of new and existing technologies.

Biofuels Research and Development

This program seeks to develop low-cost biomass energy feedstocks and cost-effective conversion technologies for liquid fuel markets. The technologies include biochemical conversion and the development of woody and herbaceous crops for fuel feedstocks. Cost-competitive biofuels from waste are expected by 2000 and from energy crops by 2010.

Alternative Fuel Vehicles

The programs within this research and development planning unit reduce oil consumption and environmental emissions in the transportation sector in the near and mid-term through the introduction and commercialization of economical alternative transportation vehicles and fuels. This goal is pursued through the establishment of sustainable alternative fuel and vehicle production industries, vehicle engine optimization, vehicle testing, acquisition and dissemination of fleet performance data, coordination of fleet purchases, and sponsorship of student competitions.

Partnership for a New Generation of Vehicles (PNGV)

The programs within this planning group seek to produce a commercial prototype light-duty vehicle with at least triple the efficiency of conventional vehicles by 2004. Specific technologies that contribute to this goal include advanced batteries, hybrid vehicle propulsion systems and components, fuel cell propulsion systems, advanced alloys and composites for vehicle bodies and components, and ceramic materials for propulsion systems.

Conventional Vehicles

The programs within this research and development planning unit develop technologies to improve the energy conversion efficiency of conventional combustion engines in vehicles, including both light-duty vehicles and trucks, while simultaneously reducing emissions. This work includes incremental improvements to gasoline engines as well as the development of a “clean diesel” with a potential for a 20- to 50-percent efficiency improvement.

Solar Technologies

The programs within this research and development planning unit develop and facilitate the commercialization of a range of solar electric technologies to meet the nation’s need for inexpensive, reliable, and environmentally benign electric power. These technologies include photovoltaics (concentrators, flat plate modules, single crystal silicon, and thin-film technologies), solar thermal (dish/engine systems, parabolic troughs, and power towers) and biomass power (advanced direct combustion, cofiring, direct-fired, and gasification). In addition to their other environmental benefits, these technologies will cut greenhouse gas emissions. In addition, these technologies will help to maintain or establish competitive industries that produce high-value technologies for domestic consumption and export—particularly to developing nations—contributing to long-term economic growth.

Wind Energy

This research and development program seeks to further develop and facilitate the commercialization of wind energy technology to meet the nation's need for inexpensive, reliable, and environmentally benign electric power. The principal technology is a utility-scale horizontal axis wind turbine. Additional work focuses on providing design tools and supporting infrastructure development.

Geothermal Energy

This program is to reduce the cost of producing electricity with geothermal resources and to facilitate the deployment of geothermal heat pumps in commercial and residential markets. These goals are being accomplished through geothermal reservoir characterizations, development of advanced drilling technology, development of small-scale binary technology power plant prototypes, and geothermal heat pump infrastructure support.

Hydrogen Research

This planning unit supports the development of practical and cost-competitive hydrogen energy technologies and systems. This is done through research and development of mid-to long-term technologies to produce, store, transport and use hydrogen. Technology work focuses on electrochemical, photochemical, and thermochemical production; physical storage; and solid-state storage.

Electric Energy Systems

The programs in this planning unit develop advanced power delivery technologies that improve power quality, improve reliability, and increase the efficiency of electric power distribution systems; improve the value and effectiveness of renewable energy technologies within conventional utility systems; and support systems analyses to increase the use of renewable energy technologies. In addition to other contributions, this planning unit group includes high-temperature superconductivity research and development, which has potential applications in a wide range of electric and industrial technologies, including generators, transformers, transmission cables, motors and other electric end-use technologies.

Utility Technology Access

The Integrated Resource Planning program develops tools and methods to assist utilities, regulatory commissions, and consumer groups to make more economic and flexible resource decisions. Climate Challenge is a joint initiative of DOE and the utility industry to reduce greenhouse gas emissions through voluntary actions that make economic sense.

Savings in Consumption Expected From Energy Efficiency Programs

These estimates were aggregated by "planning units" that contain similar programs. The initial funding year is the first fiscal year the program was operating. The budget for each unit is for fiscal year 1996. Estimates of reduced oil consumption are in millions of barrels per year (mmby), in 10-year increments. Estimates of total reductions in consumption are presented in both mmby and millions of barrels per day (mmbd).

Table III.1: Oil Savings by Energy Efficiency Planning Unit

Dollars in thousands

Planning unit group/planning unit name	Initial funding year	Funds available FY 1996	2000 (mmby)	2010 (mmby)	2020 (mmby)
IHEM/FEMP[a]					
IHEM	1977	$0	0	0.1	0.2
FEMP	1978	$17,100	0.8	2.5	4.2
Building Equipment and Materials					
Materials and Structures R&D	1977	$3,260	1.6	3.1	4.5
Space Conditioning R&D	1977	$15,257	1.0	3.1	6.0
Windows and Glazing R&D	1986	$6,106	0	0	0
Lighting and Appliance R&D	1980	$4,360	0.2	0.5	0.9
Building Systems Design					
Best Practices	1978	$4,571	0.7	2.4	5.2
Commercial Buildings	1985	$11,026	1.4	4.7	8.5
Residential Buildings	1989	$6,865	0	0.3	1.6
Codes and Standards					
Lighting and Appliance Codes and Standards	1979	$5,738	0.2	2.0	3.0
Building Codes and Standards	1984	$8,901	0.4	1.4	1.6
Industries of the Future					
Forest and Paper Products Vision	1995	$11,553	0	0.3	2.6
Glass Vision	1995	$1,414	0.2	0.5	1.2
Aluminum Vision	1985	$1,449	0.1	0.9	2.3
Chemicals Vision	1995	$13,840	1.0	24.8	50.1
Petroleum Refining Vision	1995	$6,726	35.7	89.7	64.9
Steel Vision	1986	$6,780	0	0.2	0.2
Metals Casting Vision	1990	$1,992	0	0	0
Cogeneration					
Cogeneration	1992	$22,125	4.3	4.3	0.1
Advanced Materials and CFCCs					

(continued)

Dollars in thousands

Planning unit group/planning unit name	Initial funding year	Funds available FY 1996	2000 (mmby)	2010 (mmby)	2020 (mmby)
Advanced Materials and CFCCs	1992	$17,476	0.1	1.1	3.5
Industrial Technology Assessment					
Climate Wise	1995	$2,000	5.9	0	0
IACs	1976	$8,679	0.1	0.1	0.1
Combustion Technologies	1977	$70	0	0.1	0.1
Motor Challenge	1995	$5,332	0	0	0
NICE-3	1991	$6,000	2.1	11.6	14.7
Inventions and Innovations					
Inventions and Innovations	1975	$5,504	0.6	2.1	0
Grants					
Weatherization Assistance Program	1977	$114,196	0.2	0.6	0.9
State Block Grants	1976	$26,500	5.9	13.8	14.1
Municipal Energy Management Program	1978	$1,843	0	0	0
Regional Biomass Program	1983	$3,940	0	0	0
Technology Access					
Commercialization Ventures	1994	$3,000	3.0	10.9	22.3
Information and Communications	1981	$2,940	0	0	0
International Market Development	1990	$2,907	0	0	0
Solar International	1990	$4,000	0	0	0
Biofuels					
Biofuels	1974	$27,200	5.0	150.0	219.0
Alternative Fuel Vehicles					
Alternative Fuel Vehicles R&D	1976	$29,303	12.1	46.6	24.1
PNGV					
Electric Vehicle R&D	1976	$17,692	4.0	46.0	37.0
Fuel Cell R&D	1987	$22,250	0	13.0	140.0
Hybrid Vehicle R&D	1993	$57,690	0	180.0	300.0
Lightweight Vehicle Materials R&D	1993	$13,360	0	32.0	35.0
Propulsion System Materials (Ceramics)	1983	$22,125	0	0	0
Conventional Vehicles					
Heavy Duty Engine R&D	1976	$5,454	1.0	73.0	237.0
Light Duty Engine R&D	1976	$4,649	0	39.0	43.0
Solar Technologies					
Biomass Power R&D	1992	$21,200	0.1	3.2	10.0
Photovoltaic Systems R&D	1974	$65,000	0	0.2	1.4
Solar Thermal Electric R&D	1976	$25,000	0	0.2	0.6

(continued)

Dollars in thousands

Planning unit group/planning unit name	Initial funding year	Funds available FY 1996	2000 (mmby)	2010 (mmby)	2020 (mmby)
Wind Energy					
Wind Energy R&D	1974	$32,500	0.7	2.1	7.7
Geothermal Energy					
Geothermal Energy R&D	1973	$31,447	0.1	0.8	0.7
Hydrogen Research					
Hydrogen Research R&D	1979	$14,500	0	0	0
Electric Energy Systems					
Electric and Magnetic Fields R&D	1978	$9,924	0	0	0
Energy Storage R&D	1990	$2,000	0.1	0.3	0.3
High Temperature Superconductivity R&D	1989	$19,000	0	0.1	0.9
Utility Technology Access					
Climate Challenge	1995	$0	0	0	0
Total (mmby)			**88.6**	**767.6**	**1,269.5**
Total (mmbd)			**0.2**	**2.1**	**3.5**

Note: Oil savings are direct oil savings as reported and assumed to be 5 percent of electricity savings.

[a]The FEMP numbers in this table represent incremental oil savings resulting from fiscal year 1996 efforts in federal facilities only; they assume 20 percent energy savings in the year 2000 and 30 percent energy savings in the year 2005 (EPACT, Ex. Orders 12759 and 12902 goals).

Increased Oil Production Resulting From DOE's Oil Technology Program

DOE projects that its Oil Technology Program will increase domestic oil production over the next decades, as shown in table IV.1:

Table IV.1: Projected Increases in Domestic Oil Production

Increases in millions of barrels of oil per day

	Fiscal year		
	2000	**2010**	**2020**
Increase	0.30	0.81	1.42

Source: DOE.

Funding for the Oil Technology Program has varied significantly in the last few years, as shown in table IV.2:

Table IV.2: Funding for Oil Technology Program, Fiscal Years 1993-96

Dollars in millions

Fiscal year	Appropriated funds available
1993	56.1
1994	74.3
1995	75.2
1996	55.7

Source: DOE.

The funding for fiscal year 1996 is allocated to four subprograms, as shown in table IV.3:

Table IV.3: Funding for Fiscal Year 1996 Oil Technology Subprograms

Dollars in millions

Subprogram	Funding	Activities
Supporting research	$33.5	Includes reservoir characterization, drilling completion and stimulation, production, and exploration.
Demonstrations	11.1	Includes cost-shared projects with industry for reservoir characterization, drilling techniques, and enhanced oil recovery.
Environmental research	5.5	Includes risk assessment and work on reducing water produced during oil production.
Oil-refining programs	5.7	Includes pollution prevention (e.g., to curb airborne emissions produced during refining), environmental compliance, and upgrading of refining technologies.

Source: DOE.

Measures of Vulnerability Under Alternative Scenarios

The tables in this appendix show how the measures of vulnerability discussed in chapter 3 would be affected under scenarios incorporating different assumptions about oil prices and/or economic growth.[1]

In each of the tables, we used EIA's forecasts to produce the values for the measures. EIA's reference case reflects EIA's views about the effects of current policies and programs on oil demand and supply and on other factors. EIA's forecasts are based on assumptions about trends in economic growth, demographics, and technological developments. For comparison, we also include, when available, values for EIA's alternative scenarios, which differ from the reference case with respect to EIA's assumptions about world oil prices and/or U.S. economic growth.

For the low-world-oil-price case, EIA assumes that world oil prices drop below current prices for the next few years and then gradually return to current levels, where they remain throughout the forecast period. For the high-world-oil-price case, EIA assumes that world oil prices increase to $32.61 per barrel in 2010 and continue rising to $33.89 in 2015. All prices are in 1994 constant dollars.

For the low-economic-growth case, EIA assumes lower rates of growth for population, labor force, and labor productivity than the reference case, resulting in higher prices, higher interest rates, and lower growth in industrial output. Under this case, economic output increases by 1.5 percent a year over the forecast period. For the high-economic-growth case, EIA assumes higher rates of growth for population, labor force, and productivity than the reference case. Because productivity gains are higher, inflation and interest rates are lower than in the reference case. Under this case, economic output increases by 2.5 percent a year between 1994 and 2015.

Table V.1: Concentration of World Oil Production

Percentage of world oil produced by Persian Gulf suppliers

Case	1994	2000	2005	2010	2015
Reference case	26.8	30.6	35.3	39.2	44.3
Low oil price	[a]	32.7	38.7	44.7	50.1
High oil price	[a]	28.1	31.0	35.0	40.7

[a]Not applicable.

Source: EIA, International Energy Outlook 1996.

[1]The level of world oil stocks is not included in this appendix because EIA has not projected this measure beyond 1997.

Table V.2: Excess World Oil Production Capacity

Production capacity in millions of barrels per day					
Case	**1995**	**2000**	**2005**	**2010**	**2015**
Reference case	3.16	3.13	2.14	2.05	2.02
Low oil price	[a]	4.04	3.26	3.09	2.99
High oil price	[a]	3.04	2.17	1.79	1.71

[a]Not applicable.

Source: EIA, Annual Energy Outlook 1996 and other EIA publications.

Table V.3: Oil Intensity of the U.S. Economy

Intensity in barrels of daily oil consumption per million dollars of GDP					
Case	**1995**	**2000**	**2005**	**2010**	**2015**
Reference case	3.23	3.04	2.88	2.75	2.61
Low economic growth	[a]	3.07	2.93	2.81	2.70
High economic growth	[a]	3.01	2.84	2.69	2.54
Low oil price	[a]	3.09	2.95	2.84	2.73
High oil price	[a]	2.98	2.79	2.66	2.53

Note: GDP in 1987 constant dollars.

[a]Not applicable.

Source: EIA, Annual Energy Outlook 1996 and other EIA publications.

Table V.4: Oil Dependence of the U.S. Transportation Sector

Oil as a percentage of total energy used for transportation					
Case	**1995**	**2000**	**2005**	**2010**	**2015**
Reference case	97.0	97.0	96.2	95.0	94.1
Low economic growth	[a]	97.0	96.2	95.1	94.0
High economic growth	[a]	97.0	96.2	95.1	94.2
Low oil price	[a]	97.0	96.3	95.1	96.2
High oil price	[a]	97.0	96.0	95.0	94.0

[a]Not applicable.

Source: EIA, Annual Energy Outlook 1996, and other EIA publications.

Table V.5: Dependence of the U.S. Economy on Oil Imports

Imported oil as a percentage of total U.S. oil consumption					
Case	**1995**	**2000**	**2005**	**2010**	**2015**
Reference case	49.9	53.7	57.4	57.3	55.7
Low economic growth	[a]	53.2	57.2	57.0	55.0
High economic growth	[a]	53.9	57.4	57.5	56.5
Low oil price	[a]	58.2	64.3	67.2	68.4
High oil price	[a]	48.0	47.1	46.4	45.4

[a]Not applicable.

Source: EIA, Annual Energy Outlook 1996 and other EIA publications.

Comments From the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

Department of Energy
Washington, DC 20585

October 18, 1996

Victor S. Rezendes
Director
Energy, Resources, and Science Issues
General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Rezendes:

See comment 1.

See comment 2.

Thank you for the opportunity to review the draft report *Energy Security and Policy: Evaluating U.S. Vulnerability to Oil Supply Disruptions and Options for Mitigating the Effects.* In our view, the analysis that motivates your conclusion regarding the benefits of imported oil is seriously flawed. Nevertheless, the expert panel that GAO engaged to evaluate energy security options essentially endorsed the programs described in the most recent National Energy Policy Plan entitled *Sustainable Energy Strategy: Clean and Secure Energy for a Competitive Economy.*

Regarding the GAO analysis, the attempted comparison between the economic benefits of imported oil and the potential economic costs of vulnerability to oil shocks yields no insight into the overall consequences of oil imports. Moreover, the GAO did not perform an adequate analysis of the benefits of DOE programs designed to reduce vulnerability to oil shocks. The attachment provides detailed comments on the GAO analysis presented in the report.

The report ends with a brief list of policies recommended by a group of experts that the GAO consulted. The experts asserted that the Strategic Petroleum Reserve (SPR) should be used early in an oil price shock; appropriate monetary policy could accommodate the shock; alternative transportation fuels are a promising long-term solution; and higher gasoline taxes could reduce oil consumption. The Department of Energy strongly advocates the early release of SPR oil in the event of an oil emergency and is the major source of policy innovations and research and development funding for alternative fuels. The Department has no role in setting monetary policy, and higher gasoline taxes, whatever their overall economic merits, lack political support necessary for adoption. Overall, the GAO expert panel essentially endorses the core policies advocated in the *Sustainable Energy Strategy.*

See comment 3.

We agree with many of the expert panel's conclusions, but we strongly disagree with the GAO analysis and observations GAO draws from it. We believe that the Congress and the public would be better served if the GAO rethought its approach to this issue. This report would only cloud an important subject that already suffers from a lack of analytical consensus. Finally, in this and future uses of Energy Information Administration (EIA) modelling capability, it is important to separate the modeling that EIA does from the ownership of the assumptions imposed on EIA models. The report should clearly restate the disclaimer, which EIA includes in its service report, to preserve the neutrality of EIA when it provides analytical services.

Sincerely,

Marc W. Chupka
Acting Assistant Secretary for Policy
and International Affairs

Attachment

2

Attachment

The GAO sets itself three tasks in this study:

(1) comparing the economic benefits of importing oil with the potential economic costs of vulnerability to oil shocks;

(2) determining the extent to which the programs and policies in the Administration's 1995 National Energy Policy Plan are likely to reduce the economy's vulnerability to oil shocks; and

(3) assessing options for reducing the economy's vulnerability to oil shocks.

The analysis undertaken to address Tasks (1) and (2) exhibits significant flaws in both the assumptions used and the interpretation of the results. These are discussed below.

Task 1

See comment 4.

Task (1) seems to require comparing the consumer surplus from current levels of oil import consumption with the discounted, probability-weighted costs of oil supply disruptions. While those quantities could be theoretically computed, such calculations do not shed light on whether the net benefit or cost was the minimum, maximum, or another point in the range of possible net benefits or costs. Consequently, the calculation would not indicate any clear policy direction. For Task (1), GAO asked the Energy Information Administration (EIA) to model a very high price oil scenario and an oil import fee case. GAO then compared the paths of GDP in each scenario with the EIA's reference case and finds very large differences that the GAO asserts are the benefits of oil imports. They are not. The GAO has produced a comparison between two unlikely scenarios and the baseline, but these results cannot be extended to answer other questions, particularly the central question of whether DOE programs reduce the U.S. economy's vulnerability to oil price shocks.

See comment 5.

A relatively low oil price environment, such as the present, confers both benefits and costs. Clearly much of the United States economy is better off with low oil prices, but important domestic industries are threatened by these lower prices. Moreover, as consumption responds to these prices, it becomes more difficult to offset increases in vulnerability to oil price shocks. Nevertheless, the DOE program outlined in the National Energy Policy Plan is configured to be successful

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in just such an environment.

Task 2

See comment 6.

Chairman Kasich's request is addressed most directly by Task (2). The core of our criticism is not the EIA modeling, which was performed with its usual professionalism, but rather with the way GAO set up the analysis. Typically, decision makers are interested in the difference between a baseline that does not include new programs and the alternatives that include proposed programs. The GAO did not perform such an analysis.

See comment 7.

EIA does not explicitly model DOE programs, particularly those that are planned and not yet enacted. Hence the outyear effects of the programs of DOE's Office of Fossil Energy (FE) and the Office of Energy Efficiency and Renewable Energy (EE) were provided by the offices themselves. In terms of oil imports being displaced, these estimates were largely accepted by the GAO. The analysis that the GAO did undertake, however, was to compare the millions of barrels of oil imports per day backed out by FE and EE programs with the baseline rise in U.S. oil consumption over the life of the EIA forecast period. GAO finds that baseline consumption growth is slightly above the reductions in oil import demand from FE and EE programs. Such comparisons of physical oil trade are not relevant, however. GAO itself set up GDP as the proxy for measuring welfare changes in Task (1). Implicit in GAO's comparison is that U.S. oil consumption should be held at 1996 levels. This is not a goal of the Department nor the Administration and shows a weak understanding of energy programs.

See comment 8.

The Department's approach to oil price shock vulnerability is different from the GAO's attempt to assess its effects. The Department's goals are to increase domestic supply through technology-driven exploration and production cost reductions and technology transfer; to decrease domestic demand for oil-based fuels through increased energy efficiency and greater utilization of alternative fuels; and to hold sufficient oil stocks in the Strategic Petroleum Reserve to cushion the effects of a severe oil price shock. When fully implemented, these programs will help decrease world oil prices, stimulate the U.S. economy, and decrease U.S. vulnerability to oil price shocks. The GAO does not fully analyze DOE programs, so these effects are not reflected in the GAO report. Further, a major objective of EE programs that goes unremarked by the GAO is to increase the elasticity of demand for oil in key markets, which provides the country a way to increase the use of oil services without increasing vulnerability to potential shocks.

See comment 9.

Forecasts that show the energy market and macroeconomic outcomes for the U.S. economy, with and without DOE programs, are needed to answer Chairman Kasich's main question. GAO did mention EIA's Oil and Gas High Technology

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forecast cases that resemble the effects of EE and FE programs but chose not to have the EIA make integrated energy and economic model runs using these cases. Had they requested these runs, they might have had a analytically firmer and more defensible response to Chairman Kasich's inquiry.

See comment 10.

While the indices of vulnerability cited in the report provide useful gross indicators, there is no agreed-upon correlation between changes in an index and the resulting changes in vulnerability. GAO claims that directionally-correct movements caused by DOE programs are not sufficient to reduce vulnerability. This claim is not based on any empirical work but rather represents a GAO conjecture. More to the point, because the GAO has focused on total imports rather than the more economically relevant marginal changes, there is no sense in the GAO work as to what the optimal or ideal level of imports might be. The voluminous oil premium literature and the Department's own work show that reductions in oil imports bring benefits at the margin.

See comment 11.

In sum, the GAO did not fully appreciate the rationale behind the DOE programs referenced in the *Sustainable Energy Strategy*, did not construct an analytically sound methodology, did not ask EIA to make the proper modeling runs, and did not interpret correctly the EIA runs it did request.

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The following are GAO's comments on the Department of Energy's letter dated October 18, 1996.

1. Our comments on the general points made in DOE's cover letter appear in the executive summary and in the applicable chapters of this report. In the remainder of this appendix, we address each of the detailed comments made in DOE's letter and attachment.

2. According to DOE, the experts we consulted essentially endorsed the programs in the National Energy Policy Plan (NEPP). We stated in the draft report that the options most often recommended by the experts we consulted are generally included in the NEPP. However, we noted in chapter 4 that there are important differences between the plan and the experts' views. For example, many of the experts favor the use of an automatic market-based trigger to release oil from the Strategic Petroleum Reserve, while the plan does not adopt such a strategy. Also, the experts do not generally favor the continuation of mandates and subsidies for alternative transportation fuels such as are called for in the plan. In addition, most of the experts do not believe that the plan's initiatives for increasing domestic oil production would significantly reduce the nation's vulnerability to oil shocks, although some said such initiatives could be justified on other grounds.

3. GAO's ownership of the assumptions used in the analyses performed by EIA at GAO's request was clearly stated in chapter 2 and appendix II of the draft report, where EIA's modeling was discussed in detail. As the draft report indicated, the approaches used in the modeling were GAO's and the views expressed in the report do not necessarily reflect EIA's views. We revised the final report in several places to make this distinction even clearer. However, in chapter 3 and appendix V of both the draft and the final report, where we present EIA's forecasts of the vulnerability measures, we relied on EIA's assumptions, which are summarized in the report where appropriate.

4. We believe that our study provides very useful information to policymakers. The NEPP and a study by the Commerce Department recognize that oil imports provide economic benefits, but they do not quantify such benefits. We attempted to measure the magnitude of these benefits by estimating the incremental (marginal) cost of reducing the nation's imports below the current level. We found that such costs increase with the size of the reduction in imports and that the total benefits of importing relatively low-cost oil—expressed as the costs of

eliminating all oil imports—are very large. We also found that the economic costs of oil shocks are large but depend primarily on the nation's level of oil consumption, not on the level of oil imports. Thus, an incremental decrease in imports would yield an incremental reduction in the benefits derived from imports but would leave the costs of oil shocks largely unchanged. This finding could have important implications for policymakers considering, for example, proposals designed to increase energy security by increasing domestic oil production.

We agree that this report does not identify the optimal level of oil imports. Such an analysis, which was outside the scope of our review, would depend, in part, on the external costs of oil imports. Existing studies have already addressed this issue, though they are somewhat inconclusive about whether the current level of imports is above or below the optimal level.

We disagree with DOE's claim that our methodology does not measure the benefits of oil imports. We validated our modeling approach by discussing it with the 14 experts listed in appendix II. While analysts may differ on the technical details of the model's formulation or the use of GDP as a measure of economic well-being, the basic approach is broadly accepted.

As discussed in chapter 2 and appendix II, we chose scenarios that reduced imports at the lowest possible cost and thus provide a conservative estimate of the benefits of oil imports. These scenarios are useful because they illustrate the benefits that would be forgone if imported oil were replaced with more costly domestic oil.

We agree with DOE that our analysis, which was designed to estimate the benefits of oil imports, does not address the role of DOE's programs in reducing the economy's vulnerability to oil shocks. This issue is addressed in chapter 3 of our report.

5. We agree that today's relatively low oil prices have both benefits and costs, and our report indicates that low oil prices, while benefiting many sectors of the economy, may harm certain other sectors, especially domestic oil producers. In our view, our analysis is particularly useful for demonstrating the relative magnitude of the benefits and costs of low prices, showing, as it does, that the overall benefits to the economy exceed the costs to individual sectors.

We also agree that low oil prices can increase the nation's oil consumption and, in turn, the economy's vulnerability to oil price shocks. EIA's low-oil-price forecasts of the vulnerability measures discussed in appendix V of our report clearly demonstrate this point. To the extent that DOE can successfully and cost-effectively implement programs such as alternative fuel and energy efficiency initiatives that decrease oil consumption, even when low oil prices prevail, the economy's vulnerability could be lowered. However, EIA's forecasts for the vulnerability measures discussed in chapter 3 of our report indicate that the projected increase in demand for oil may offset much of the decrease in consumption resulting from such programs. This is particularly so under forecasts that assume continued low oil prices.

6. A baseline analysis that would show the incremental or separate impact of DOE's programs on our measures of vulnerability was outside the scope of our review and not necessary to meet our objective. Our objective was to assess the extent to which the U.S. economy's vulnerability to oil shocks would change over time given such programs and policies, as well as other relevant factors, such as increases in the demand for oil and expected changes in the economy. We clarified our objective and made other corresponding changes in the final report to make it clear that we did not intend to measure the separate impact of DOE's programs. Because the NEPP did not contain measures of vulnerability, we developed them in concert with DOE officials. We then used EIA's published or readily available energy forecasts that consider all of these factors, including, as discussed under comment 7, the potential impact of DOE's programs. A separate analysis of the vulnerability measures with and without DOE's programs might support DOE's view that the measures we used would be worse without such programs, and we stated this view prominently in both our draft and our final reports. We also included in the report the measures of the programs' expected incremental impact that DOE provided to us. These measures are expressed in terms of projected barrels per day of increased domestic oil production or decreased oil consumption. DOE's measures are not very useful, however, in showing how the programs will affect the economy's vulnerability to oil shocks because they are not expressed in terms that measure vulnerability. Neither do they take into consideration projected increases in the demand for oil and other changes expected to take place in the economy that could ultimately affect its vulnerability. We think our approach significantly enhances DOE's measures of program impact with respect to assessing expected changes in vulnerability because it does take these factors into consideration. Although, as stated in the report, EIA's forecasts do not consider all of the

initiatives designed to reduce the economy's vulnerability to oil supply disruptions, we believe that they are the most objective and comprehensive estimates currently available.

7. EIA's reference case forecasts for the measures of vulnerability presented in our report take into account EIA's views on the likely success of DOE's current policies, programs, and technology development programs in meeting their objectives. The high technology forecasts assume even greater technological success for current and planned programs. Technological advances are a cornerstone of DOE's efforts to reduce the economy's vulnerability to oil supply disruptions. According to EIA officials, the high technology forecasts provide at least as much and, in some cases, more credit for increased oil production or decreased oil consumption than DOE claims for its programs. It is these forecasts, not the information provided by DOE's Fossil Energy and Energy Efficiency Programs, that we used to assess potential changes in the measures of vulnerability.

We believe that the extent to which the impact of DOE's programs will be offset by increases in the overall demand for oil is very relevant, particularly in evaluating the extent to which the economy's vulnerability to oil shocks may change. The expected increases in oil consumption have a dramatic impact on the vulnerability measures presented in our report.

Our analysis neither assumes nor implies that the nation's oil consumption should be held at 1996 levels. Rather, we point out that one of the NEPP's three major goals is to reduce the economy's vulnerability to oil supply disruptions. Our approach was to develop measures that could be used to objectively assess progress in achieving this goal over time.

8. According to DOE, the potential results of its programs are not reflected in our report. We agree that DOE's programs may have economic and other benefits in addition to their contribution to reducing the economy's vulnerability to oil disruptions, and we provided examples in the draft and final reports of such benefits that were provided to us by DOE. Assessing the extent of these benefits, however, was outside the scope of our review. With respect to reducing the economy's vulnerability to oil shocks, we state in chapter 3 that DOE's programs are designed to increase the domestic oil supply, decrease the demand for oil, and maintain strategic oil stocks. As discussed above, we also included data provided by DOE that show the potential for such programs to increase domestic oil production and decrease consumption.

However, as we also discuss in these comments and in the report, we believe that programs aimed at increasing the domestic oil supply may not substantially decrease the nation's economic vulnerability to oil disruptions over the next 20 years. We also agree and state in the report that successfully decreasing the demand for oil could lessen the economy's vulnerability and might have other economic benefits as well. As discussed above, however, while the forecast reductions in consumption attributable to DOE's programs may keep the measures of vulnerability from becoming worse than they otherwise would be, such reductions may be more than offset by the increases in oil demand projected in EIA's forecasts. We also agree that maintaining and appropriately using strategic stocks can help cushion the effects of oil shocks; however, we note in the report that such stocks have been declining and may continue to do so in the future, even though oil consumption is expected to rise. We believe that an objective gauge of the economy's vulnerability to oil shocks that considers these and other relevant factors in the world oil market is needed and that our measures of vulnerability provide such a gauge.

We have clarified chapter 3 of our report to indicate that an objective of DOE's programs is to increase the ability of key industries to switch to other fuels if necessary during disrupted markets while continuing to use low-cost oil during normal markets (or increase the elasticity of demand). Our draft report pointed out that some industries, such as the electricity-generating industry, currently have such capabilities. However, the transportation sector depends on oil for 97 percent of its energy and accounts for about two-thirds of the nation's oil consumption. In this area, EIA's forecasts do not indicate any significant change over the next 20 years. While oil shocks and accompanying increases in oil prices might make alternative transportation fuels more attractive, a significant amount of time would be required to make the transition to such fuels, while the economic effects of shocks are felt almost immediately. In addition, the cost of producing vehicles with a standby ability to operate on alternative fuels and of developing the infrastructure for standby alternative fueling could be very high in this key industry.

9. As discussed under comment 6, we disagree that energy market and macroeconomic forecasts with and without DOE's energy efficiency and fossil energy programs are necessary to assess the extent to which the economy's vulnerability to oil shocks will change over time given these programs and other relevant factors. Also, as discussed under comment 8, an integrated analysis of the macroeconomic and other benefits of DOE's

programs was outside the scope of our review, but we included DOE's views on such benefits in both the draft and final report.

10. We agree with DOE that the measures of vulnerability in our report provide useful indicators of the economy's vulnerability to oil shocks. Taking that as a given, we also believe that projected changes in such measures that consider the effects of programs designed to reduce the economy's vulnerability are useful indicators of how well such programs may work. We used EIA's forecasts of such measures, which are the most comprehensive empirical evidence available. We believe that the results show how persistent the economy's vulnerability to oil shocks may be.

See comment 4 for our response to DOE's statement about reducing oil imports at the margin.

11. We strongly disagree with DOE's summary comment. As discussed above, we believe that we have constructed a sound methodology to answer our objective and that we have interpreted the results correctly. More importantly, we believe that we have gone beyond the information provided in the NEPP and in related documents supplied by the administration by developing useful measures of the economy's vulnerability to oil shocks and by assessing potential future changes in such measures given the potential impact of the administration's programs, potential increases in the demand for oil, and other relevant factors. We agree with the many experts who commented on this report and said, overwhelmingly, that it would make an important contribution to the continuing debate on energy security.

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