Chapter 1

Introduction and Summary

Contents

	Page
BACKGROUND	3
WHAT HAS CHANGED?	3
Patterns of Oil Supply and Demand	4
Major Changes	4
OVERVIEW OF U.S. OIL REPLACEMENT POTENTIAL	7
Methodology and Assumptions	8
Technical Replacement Capability	8
IMPLICATIONS OF GROWING OIL IMPORT DEPENDENCE AND ERODING OIL REPLACEMENT CAPABILITY	12
MAJOR OPPORTUNITIES FOR REDUCING OIL IMPORT DEPENDENCE,	13
Automotive Fuel Economy	14
Alternative Transportation Fuels	15
Increased Domestic Production	16
Diversity in Oil Supply	18
LOOKING TOWARD THE FUTURE-SCENARIOS FOR REDUCING OIL DEPENDENCE	18
POLICY CONSIDERATIONS	20
Replacing Oil Use in a Severe Import Disruption	21
Reducing Oil Import Vulnerability as Part of Long-Term National Energy Policy	25
CONCLUSION	26

Figures

Figure		*Puge*
1-1.	World Oil Consumption 1983 and 1989	4
1-2.	Total U.S. Oil Imports and Imports From the Middle East, 1989	5
1-3.	U.S. Petroleum Products Supplied by Type	5
1-4.	U.S. Energy and Oil Consumption, 1989	6
1-5.	U.S. Energy and Oil Intensity	7
1-6.	Oil Replacement Potential by Sector, 1984	10
1-7.	US. Oil Replacement Potential Technical Capability by Sector, 1991	10
1-8.	Estimated Car and Light-Truck New Fuel Economy and Gasoline Prices, 1978-90	15
1-9.	US. Oil Supply and Demand Futures Baseline Projection: Current Trends in Domestic Oil Production, Net Imports, and 1989 New Car Fuel Economy	19
1-1o.	U.S. Oil Supply and Demand Futures: Impacts of Increased Domestic Oil Supply and Improved Fuel Economy	19
1-11.	U.S. Oil Supply and Demand Futures, Impacts of Improved Domestic Oil Supply and Fuel Economy, and Oil Backout	20

Tables

Table		*Page*
1-1.	Estimated Oil Replacement Potential, 1984	9
1-2.	Summary of Estimated Oil Replacement Potential, 1991	9
1-3.	OTA Estimates of Potential Short-Term Fuel Economy Gains	15

Chapter 1

Introduction and Summary

BACKGROUND

The 1991 war in the Middle East has once again focused world attention on the geopolitics of that region. In the United States, energy security has returned to the national policy agenda after nearly a decade of absence. In response to renewed concerns, OTA has been asked to reexamine the U.S. technical capability for coping with a sustained disruption in oil supply.

Seven years ago, at the request of the Senate Committee on Foreign Relations, OTA published the report ***U.S. Vulnerability to an Oil Import Curtailment: The Oil Replacement Capability***[1] which analyzed the supply and demand technologies that could replace a shortfall of 3 million barrels per day (MMB/D) in U.S. oil supply over a 5-year period. In August 1990, following the Iraqi invasion of Kuwait, the Senate Committee on Energy and Natural Resources asked OTA to revisit the findings of its 1984 report to examine how changes in world oil markets and in the geopolitical setting have affected the technical potential for oil replacement and, consequently, the candidate policy options. Early in 1991, the Energy and Power Subcommittee of the House Committee on Energy and Commerce endorsed the Senate request. This report responds to that request.

WHAT HAS CHANGED?

In our 1984 assessment, we assumed a scenario of an immediate loss of imported oil of 3 MMB/D, beginning in mid-1985 and continuing for at least 5 years.[2] The scenario was equivalent to a curtailment of 70 percent of U.S. net imports and a loss of 20 percent of U.S. oil supplies, Our analysis concluded that the United States had the technical capability to replace 3.6 MMB/D of oil over the projected period. Thus, U.S. oil replacement capability in 1984 exceeded the assumed serious oil import curtailment by the considerably comfortable margin of 600,000 barrels per day (B/D).

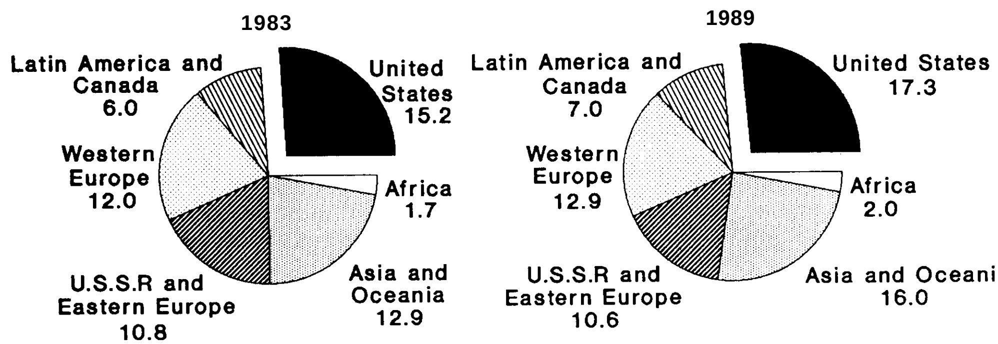
By 1990, the picture had clouded. U.S. petroleum consumption had risen from 15 to 17 MMB/D, while domestic production slipped from 10.3 to 9.2 MMB/D. Oil imports had risen from 5 to 8 MMB/D, and the share of U.S. oil needs supplied by imports had increased from 33 to over 40 percent. If we faced an oil disruption today comparable in magnitude to the scenario assumed in our 1984 report (i.e., a curtailment of all 15 MMB/D of Persian Gulf exports), the impacts could be devastating. The short–fall in U.S. oil imports could be as high as 5 MMB/D, still 70 percent of net imports, however, it would represent 30 percent of U.S. oil supplies. Moreover, reliance on technical means alone to replace lost oil imports would prove insufficient. OTA estimates that currently available oil replacement technologies could displace only about 2.9 MMB/D of 1989 oil use within 5 years. This replacement potential must be offset by the expected continuing decline in domestic oil production, yielding an effective import replacement capability of from 1.7 to 2.8 MMB/D. Thus the present U.S. potential to respond to a serious and prolonged oil shortage is less than it was in 1984 and would fall several million barrels short of the 5 MMB/D cutoff assumed in our 1991 disruption scenario.

Fortunately, many experts believe that the probability of a serious and prolonged disruption of the magnitude assumed in our analysis is very low. Surge production capacity, voluntary conservation measures, and private and government stockpiles were sufficient to allow oil consumers to weather the most recent oil disruption. However, our analysis suggests that as the current world surplus in oil production capacity is reduced the U.S. could face serious difficulties in responding to major oil supply disruptions that persist for more than a few months.

[1] U.S. Congress, Office of Technology Assessment, U.S. *Vulnerability to an* Oil *Import Curtailment: The Oil Replacement Capability,* OTA-E-243 (Washington, DC: U.S. Government PrintingOffice, September 1984), available from the National Technical Information Service, Springfield, VA22161, NTIS order #PB 85-127 785/AS. Hereinafter referred to as ***The Oil Replacement Capability.***

[2] The *United* States has never faced a supply disruption of such magnitude and duration. Most studies have assumed that an oil cutoff would last 1 or 2 years, but an indefinite shortfall is not implausible. Political upheavals, war, and natural or manmade disasters in the Middle East oil regions could have such a result. Indeed, the long-lasting oil price increases resulting from the 1970s disruptions were the economic equivalent of a lasting supply shortfall. Between 1978 and 1983, the real price of oil increased 60 percent, and there was an unadjusted decline in oil demand of nearly 4 MMB/D. Ibid., p. 9.

Figure 1-1—World Oil Consumption 1983 and 1989
(million barrels per day)



Total: 58.7 MMB/D   Total: 65.8 MMB/D

SOURCE: Office of Technology Assessment, 1991, based on data from U.S. Department of Energy, Energy Information Administration, International Energy Annual 1991, DOE/EIA-0219 (89) (Washington, DC: U.S. Government Printing Office, February 1991), table 8.

In the following, we note the more significant changes in U.S. oil supply and use since 1984 and explore the implications for our current concern over U.S. import dependence.

Patterns of Oil Supply and Demand

Today, the world consumes about 65 MMB/D of oil, up 12 percent from 58.7 MMB/D in 1983 when the 1984 0TA assessment was completed. The United States consumes about 17 MMB/D, which continues to be over 25 percent of the total world consumption. U.S. oil consumption has risen by about 14 percent since 1983; however, U.S. domestic production is down sharply, with the result that net imports have risen from about one-third of total U.S. consumption in 1983 to over 40 percent in 1990.[3] Moreover, the fraction of total oil imports coming from Persian Gulf nations has increased from about 4 percent of total U.S. oil consumption (10 percent of total U.S. oil imports) to over 11 percent (25 percent of gross U.S. oil imports in 1990). (See figures 1-1 and 1-2.)

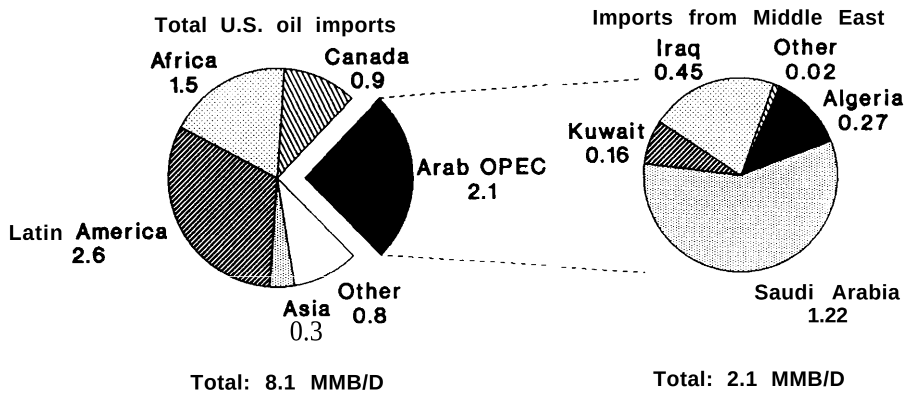
Present patterns of U.S. oil consumption in the aggregate are very similar to those of 1983. The relative proportions of consumption by product category (e.g., gasoline, middle distillates, fuel oil) are quite similar to those of 1983, with about 42 percent of oil consumed as gasoline (see figure 1-3). Industrial and transportation use of oil have both grown about 13 percent since 1983, residential and commercial use has grown only 9 percent, and electric utility use has remained almost unchanged. However, since industrial and transportation applications together approach 90 percent of U.S. oil use, the relative proportions of oil use across end-use sectors remain about the same as in 1983-transportation (63 percent), industrial (25 percent), residential and commercial (8 percent), and electric utilities (5 percent). (See figure 1-4.) The various oil products and their uses are described in more detail in chapter 2.

Major Changes

Advances in technology and resource discovery, price trends, changes in U.S. and world economic structure, and policy shifts have all altered—in some cases, dramatically—the context within which decisions about U.S. oil use and supply are made by industry, government, and consumers. The following are the major changes that have occurred in the last two decades:

[3]Two OTA reports have examined the pressures on the domestic oil industry and the factors that will influence future production. See U.S. Congress, Office of Technology Assessment, ***Oil Production in the Arctic National Wildlife Refuge: The Technology and the Alaskan Oil Context, OTA-E-394*** (Washington, DC: U.S. Government Printing Office, February 1989); and U.S. Congress, Office of Technology Assessment, ***U.S. Oil Production: The Effect of Low Oil Prices,*** Special Report, OTA-E-348 (Washington, DC: U.S. Government Printing Office, September 1987), available from the National Technical Information Service, Springfield, VA 22161, NTIS order #PB 88-243548.

Figure 1-2—Total U.S. Oil Imports and Imports From the Middle East, 1989 (millions of barrels per day)



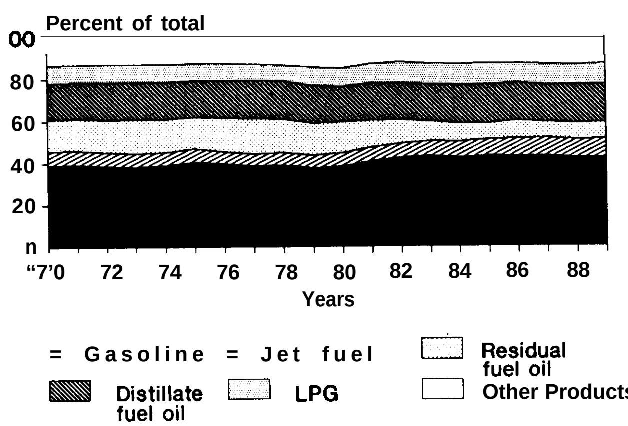
SOURCE: Office of Technology Assessment, 1991, based on data from U.S. Department of Energy, Energy Information Administration, Petroleum Supply Anual 1989, DOE/EIA-0340(89) vol. 1 (Washington, DC: U.S. Government Printing Office, May 1990), table 21.

Improved U.S. Energy Efficiency-Energy efficiency has increased considerably in all sectors of the economy and has entailed many permanent structural changes, including improvements in both the efficiency and flexibility of energy-using technologies.[4] For example, automotive fuel economy, industrial boiler and electric power plant fuel efficiency have all improved substantially. Nonetheless, many opportunities to improve efficiency remain, although they may be more difficult to secure without raising energy prices.[5]

Decreased Oil Intensity—The considerable shift from oil use by industry and electric utilities in the 1970s and 1980s resulted in a decline in oil intensity (oil used per dollar of gross national product (GNP); see figure 1-5). Improvements in energy efficiency and the shift to other fuels (especially natural gas, coal, and nuclear energy) contributed to the decline.

Increased Strategic Petroleum Reserve (SPR)—The United States now has an SPR of approximately 568 million barrels of crude oil, the equivalent of about 90 days of net crude oil imports for the first half of 1991. Similarly, Europe and Japan have added to their strategic storage, although not to the same extent as the United States. The SPR was tapped for the first time during the Persian Gulf Crisis, initially in a congressionally approved test drawdown, and later as

Figure 1-3-U.S. Petroleum Products Supplied by Type* (percent of total 1970-1989)



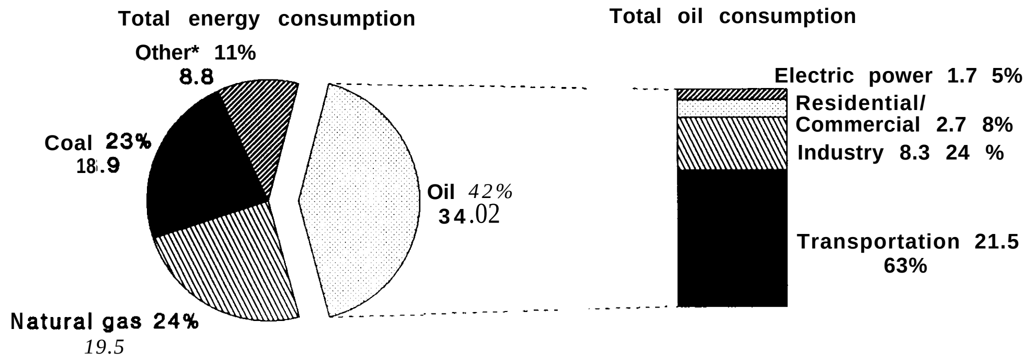
*Petroleum products supplied is an approximation of petroleum consumption.

SOURCE: Office of Technology Assessment, 1991, based on data from U.S. Department of Energy, Energy Information Administration, Annual Energy Review 1989, DOE/EIA-0384(89) (Washington, DC: U.S. Government Printing Office, May 1990), table 60.

[4] See U.S. Congress, Office *of Technology Assessment, Technology and the American Economic Transition: Choices for the Future,* OTA-TET-283 (Washington, DC: U.S. Government Printing Office, May 1988), available from the National Technical Information Service, Springfield, VA 22161, NTIS order #PB 88-214 127/AS.

[5] OTA is examining this in more depth in its ongoing assessment, ***U.S. Energy Efficiency****: Past Trends* ***and Future*** *Opportunities.*

Figure 1-4-U.S. Energy and Oil Consumption, 1989
(quadrillion Btus (Quads))



Total: 81.2 quads

Total: 34.02 quads (17.3 MMB/D)

• Other includes hydroelectric, nuclear, geothermal, and wind power generation and other renewable energy sources.

SOURCE: Office of Technology Assessment, 1991, based on data from U.S. Department of Energy, Energy Information Administration, *Annual Energy Review* 7989. DOE/EIA-0384(89) (Washington, DC: U.S. Government Printing Office, May 1990).

part of an internationally coordinated release of reserves to cushion possible supply impacts from the launching of Operation Desert Storm.

Diversified World Oil Production—Sources of world oil production have become substantially more diversified since the 1970s, with the Organization of Petroleum Exporting Countries' (OPEC) share of the world oil market declining from 60 percent in 1979 to approximately 35 percent today. For the next several years, at least, no single country or cohesive group of countries can control as large a share of the world market as was previously possible.

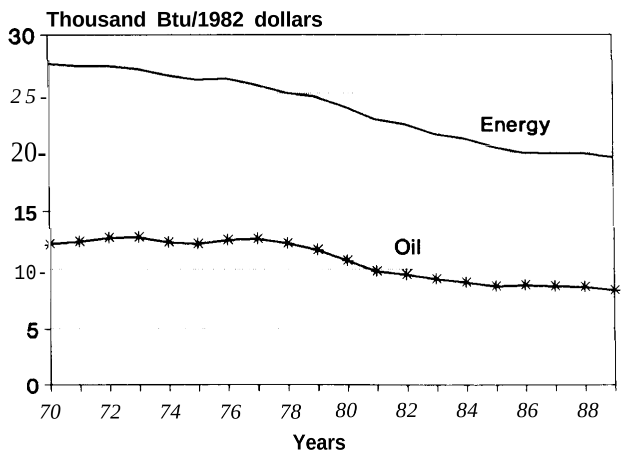
Concentrated World Oil Reserves—Despite diversified world oil production, nearly all recent reserve additions have been in the Middle East. Moreover, the costs of exploration, field development, and production in the Middle East remain considerably below that of other oil-producing regions, and are likely to remain so. As the Soviet Union, the United States, and other non-OPEC nations deplete their oil reserves, the geopolitical importance of Middle Eastern oil will grow.

Increased Flexibility of Oil Use-A significant fraction of any increase in oil consumption, both in the United States and in the remainder of the free world, is reversible. For example, much of the increase in U.S. oil use in transportation over the last decade involves changes in consumer behavior, such as increased driving or purchases of larger cars. Some of these changes could be modified in case of an oil shortage or large price increase. In the industrial and electric utility sectors there has been a shift away from oil to other fuels. At the same time, the fuel switching capability among remaining oil users has grown substantially since the 1970s—allowing many of the existing oil-fired units to burn alternate fuels, primarily natural gas, when price or availability concerns dictate.

New International Oil Trading **Mechanisms**—Most of the world's oil trade now operates on the spot market, in contrast to the long-term contracts of the 1970s. Coupled with an active futures market, this new oil trading situation makes single-country embargoes, which could never be airtight, even in the past, still less of a threat. Because most contract prices are tied to posted prices on the oil trading exchanges, rapid changes in futures or spot market prices in response to real or perceived threats to oil supplies are almost instantly reflected in the world price of oil.

Increased Availability of Natural Gas—In the 1970s there was widespread concern about the future availability of natural gas. For much of the 1980s the

Figure 1-5-U.S. Energy and Oil Intensity (thousand Btus per 1982 dollar of Gross National Product)



SOURCE: Office of Technology Assessment, 1991, based on data from U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1989, DOE/EIA-0384(89)* (Washington, DC: U.S. Government Printing Office, May 1990).

U.S. natural gas industry has faced surplus capacity and depressed prices. Nonetheless, long-term concerns about future natural gas deliverability and price still exist.

International Agreements on Oil Sharing—The International Energy Agency (IEA) was created in the 1970s in part to coordinate maintenance of strategic stocks of petroleum as well as to coordinate plans for demand reduction for use during an emergency. Since the 1970s the IEA's coordination plans have developed substantially. Additional countries (i.e., Finland and France) are currently seeking IEA membership. In early 1991, the IEA governing board voted to draw on 900 million barrels of crude oil reserves (including the SPR) to avert any shortages caused by the war in the Middle East, but little oil was actually withdrawn because supplies proved adequate and prices remained low.

Changed Energy Regulation—U.S. oil prices are no longer regulated like they were during the 1970s. Given a new price increase, the market forces that act to reduce demand and increase supply will be felt in full. In addition, restrictions on the use of oil and natural gas in electric utility boilers and other industrial applications have largely been repealed.

Changed Economic Structure-Over the last decade, the decline in energy intensity (energy consumed per unit of gross domestic product produced) accelerated in response not only to the influence of improvements in energy efficiency, as noted above, but also to the changing patterns of consumer demand, a shifting balance of imports and exports of both energy and nonenergy goods, and the changing market basket of goods produced in the United States. These changes have, as a consequence, reduced the future oil replacement potential in the U.S. economy.[6] Demographic changes, such as the population migration to the Southwest from the Northeast and Midwestern States, have contributed to reduced overall oil intensity. The use of electricity and natural gas to fuel new residential, commercial, and industrial growth in the Southwest is possibly replacing oil used in the Northeast.

Changed Policy Environment—The policy environment within which regulatory and administrative decisions affecting U.S. oil use are made has changed considerably since the mid-1980s. Concerns over physical shortages of oil have given way to concerns over price trends and volatility, the functioning of international markets, and other public policy goals, such as energy security, environmental quality, and international competitiveness.

OVERVIEW OF U.S. OIL REPLACEMENT POTENTIAL

The Persian Gulf crisis, while one of the largest supply disruptions ever, does not match the scale of the disruption assumed in our 1984 and 1991 scenarios. The reduction in crude oil production capacity from Kuwaiti and Iraqi oilfields at the onset of hostilities was about 4.3 MMB/D. But, because of existing underutilized capacity, the loss was quickly and fully offset by surge production in Saudi Arabia and elsewhere. By early 1991, Saudi crude output increased to 8 MMB/D (up from about 5.5 MMB/D before the war).[7] On the other hand, oil production in the Soviet

[6] OTA addressed this changing structure in detail in U.S. Congress, Office of Technology Assessment, *Energy Use and the U.S. Economy*, OTA-BP-E-57 (Washington, DC: U.S. Government Printing Office, June 1990).

[7] U.S. Department of Energy, Energy Information Administration, *Petroleum Supply Monthly: February 2991*, DOE/EIA-0109(91/02), (Washington, DC: U.S. Government Printing Office, February 1991), p. xix.

Union, the world's largest oil producer, was down 1 MMB/D from a year earlier, and Soviet ability to sustain historical levels of production is now questionable.

On balance, sustained shortfalls in world oil production due to the war or other disruptions are considered by most analysts to be much less likely then they were in the 1970s. Nonetheless, substantial shortfalls are still possible and recent experience has given some indication of the potentially devastating human and economic costs of a major and prolonged oil cutoff. Given the high concentration of the world's oil reserves in the politically unstable Middle East, the growing dependence of the U.S. economy on oil imports, declining domestic production, and the likelihood that the easiest options for reducing U.S. reliance on foreign oil have already been exercised, it is not surprising that there is now a renewed interest in potential benefits and costs of a strategic policy decision to reduce the risks of oil dependence.

Methodology and Assumptions

For this report OTA examined the oil replacement potential from deploying various technologies that are technically and economically feasible for use within the next 5 years. Technical feasibility requires technologies that are commercially available either now or by 1992 that can be manufactured insufficient quantity and installed within 5 years, and that require no significant changes in industrial mix or consumer lifestyles. Some technologies even offer additional benefits to environmental quality, economic growth, and international competitiveness. To be economically feasible, the technology must be cost-competitive at today's oil prices or at the significantly higher prices expected to prevail in an oil shortage and/or be among the least costly alternatives for replacing oil use in the relevant sector. The technologies that met these criteria were largely the same ones identified in 1984.

The assumptions used in our updated oil disruption scenario, except for the size and onset of the shortfall, are virtually identical to those used in the 1984 report. The major assumptions for the 1991 reassessment are:

1. A cutoff of Persian Gulf exports to world markets and international oil-sharing agreements result in an immediate loss of 5 MMB/D in U.S. oil imports. The disruption begins in 1991 and is expected to last at least 5 years.
2. The SPR and private oil stocks plus other emergency, voluntary, and mandatory conservation efforts cushion the initial impacts of the shortfall. Eventually, however, the oil reserves are drawn down to zero.
3. Oil replacement technologies that meet the criteria of technical and economic feasibility are deployed over 5 years.
4. Investment capital, materials, and technical personnel are available in adequate quantity to support an aggressive oil replacement strategy. Necessary environmental and other permits and licenses are processed expeditiously, but without any lowering of environmental standards.
5. There are no major structural changes in the output mix or behavior of the U.S. economy that could deter the 5-year deployment objective.
6. There are no new special tax or other government financial incentives that favor or inhibit deployment of specific technologies.

Technical Replacement Capability

In the 1984 assessment OTA found that the potential to replace lost oil imports through conservation, efficiency, and fuel switching was about 1 MMB/D in each of the transportation, industry, and residential/commercial sectors and about 0.6 MMB/D in electric utilities, for a total of about 3.6 MMB/D. Table 1-1 shows the oil replacement technologies and potential savings identified in our 1984 report; figure 1-6 shows the rate of deployment of these oil saving technologies. The drawdown of government and private oil reserves and deployment of oil replacement technologies were more than adequate to respond to a major oil import curtailment of 3 MMB/D within 5 years.

In just 7 years, our oil replacement capability has eroded significantly. We found that the effective U.S. technical oil replacement capability has been reduced to about 1.7 to 2.8 MMB/D, owing to a number of changes over the past decade. This finding has important implications for future strategies to reduce oil consumption. Table 1-2 shows the estimated current oil replacement potential of various technologies under the updated oil disruption scenario. Figure 1-7 shows the rate of oil replacement by sector.

Table 1 -l—Estimated Oil Replacement Potential, 1984

Sector	Millions of barrels per day after 5 years[a]
Electric utilities:	
Switching to coal and completing new powerplants currently under construction	0.5
Increased use of natural gas	0.1
Subtotal	0.6
Industry:	
Switch to natural gas	0.45
Switch to coal	0.2
Increased efficiency	0.15
Reduced refinery throughput	0.2
Subtotal	1.0
Residential and commercial (heat and hot water in buildings):	
Switch to natural gas	0.45
Switch to electricity	0.4
Increased efficiency and switch to other fuels	0.15
Subtotal	1.0
Transportation:	
Increased efficiency of cars and light trucks	0.7
Increased efficiency in other transportation modes	0.1
Increased production and use of ethanol	0.1
Switch to other alternative transportation modes	0.1
Subtotal	1.0
Total	3.6

[a]Numbers rounded to nearest 0.05 MMB/D.

SOURCE: Office of Technology Assessment, 1991, from U.S. Office of Technology Assessment *U.S. Vulnerabilify to an Oil import Curtailment The Oil Replacement Capability, OTA-E-243* (Springfield, VA: National Technical information Service, September 1984), p.11.

Table 1-2-Summary of Estimated Oil Replacement Potential, 1991

Sector	Millions of barrels per day after 5 years
Electric utilities:	
Convert/switch to coal	0.36
Switch to natural gas	0.09
Renewable fuels	0.10
Newly completed nuclear plants	0.04
Other new capacityand demand management	0.02
Subtotal	0.60
Industry:	
Switch to natural gas	0.30
Convert/switch to coal, electricity, renewables	0.05
Process changes and increased efficiency	0.10
Reduced refinery throughput	0.36
Subtotal	0.80
Residential and commercial:	
Convert to natural gas	0.50
Convert to coal	0.06
Convert to electricity	0.40
Renewable fuels and efficiency improvements	
Subtotal	1.00
Transportation:	
Increased fuel economy in light-duty vehicles	0.30[a]
Alternativevehiclefuels	
natural gas	0.13
biomass fuels (ethanol)	0.03
Improved traffic management	0.10
Subtotal	0.60
Total replacement potential (all sectors)	2.95
Domestic petroleum supply (decline)	(0.1 - 1.2)
Effective technical replacement potential	1.7 - 2.8

[a]Range Of oil savings scenarios 67,000 to 545,000 B/D in 5 years.

SOURCE: Office of Technology Assessment ,1991, based on Renova Engineering, P.C., "Oil Replacement Analysis-Evaluation of Technologies," OTA contractor report, February 1991.

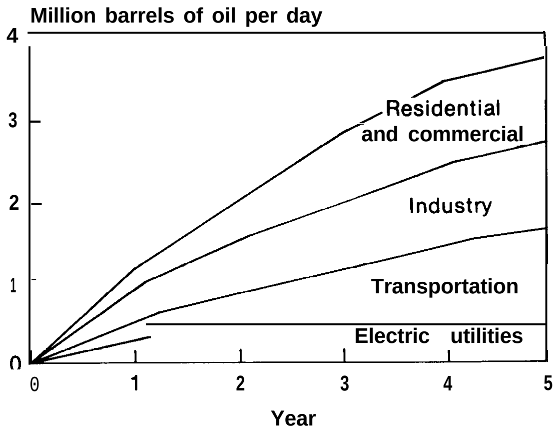
Residential and Commercial Sectors

A vigorous effort to reduce oil use in the residential and commercial sectors by switching to natural gas, electricity, coal, and renewable fuels and by speeding the adoption of efficiency improvement measures could replace almost 1 MMB/D, or about 72 percent of 1989 consumption, within 5 years. This would entail converting over 13.5 million homes and commercial buildings to natural gas or electric heat and hot water systems and converting 88,000 of the larger remaining commercial and residential heat systems to burn coal slurry fuels. Weatherization improvement, and installation or retrofitting of oil furnaces and boilers with more efficient units in the remaining oioil dependent buildings would also contribute to total Potential oil savings.

Electric Utility Sector

Electric utilities accounted for less than 5 percent of total oil consumption in 1989. 0TA estimates that it is technically feasible to replace about 600,000 B/D, or over 80 percent of 1989 utility oil use within 5 years by fuel switching in existing dual-fuel units, shifting generating loads to non-oil units where capacity permits, completing planned capacity now under construction, converting existing units to natural gas or coal, and installing new non-oil generating capacity, including renewable energy facilities. Power purchases from independent generators and qualified facilities would also contribute to this strategy. These efforts could be facilitated by and additional savings could be gained through demand-side efforts.

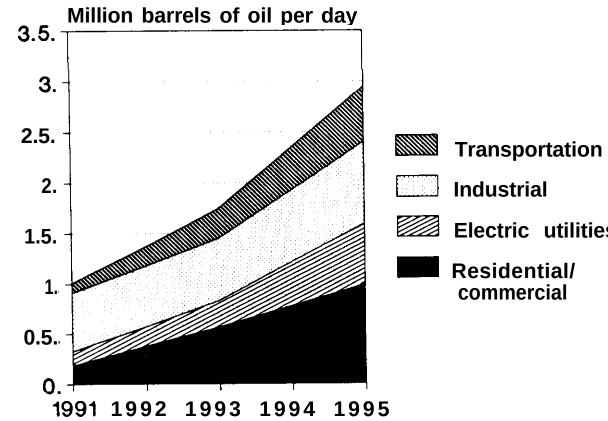
Figure 1-6-Oil Replacement Potential by Sector, 1984



Potential Replacement of Oil Through Fuel Switching and Increased Efficiency.

SOURCE: US. Congress, Office of Technology Assessment, U.S. *Vulnerability to an Oil Import Curtailment: The Oil Replacement Capability, OTA-E-243* (Springfield, VA: National Technical Information Service, September 1984), p. 10.

Figure 1-7—U.S. Oil Replacement Potential Technical Capability by Sector, 1991



SOURCE: Office of Technology Assessment 1991.

Industrial Sector

OTA estimates that the industrial sector could technically displace about 800,000 B/D of petroleum products, or about 20 percent of its 1989 consumption. The oil replacement options in the industrial sector include credit for oil savings from reduced refinery throughput (360,000 B/D) and the savings that would result from switching to natural gas and other fuels for process heat, steam, and power generation, and from intensifying the adoption of a myriad of more energy-efficient process changes in manufacturing (including increased recycling, waste reduction, and use of alternative feedstocks). The major oil replacement potential in the industrial sector is in manufacturing. There still remains only limited capability for replacing oil used in industrial feedstocks and in nonmanufacturing applications in agriculture, forestry, fishing, mining, construction, and oil and gas production.

Our analysis suggests that U.S. flexibility in replacing oil in the industrial sector has declined by about 340,000 B/I) since 1984 (exclusive of net savings from reduced refinery throughput). This decline partly reflects a greater reliance on natural gas, electricity, and waste/byproduct fuels and already achieved efficiencies in oil use. However, these savings are offset by rising oil demand for refinery operations and for feedstocks.

Transportation Sector

The transportation sector is the U.S. economy's largest oil user, accounting for almost 63 percent of the Nation's total oil consumption, or about 10.8 MMB/D of petroleum products in 1989-more than domestic oil production.[8] The transportation system is virtually locked into petroleum use for all but the long-term, and efforts to shift to alternate energy sources face significant hurdles. Transportation's share of total oil use has increased from 54 percent in 1979 to 63 percent in 1989, and transportation demand is growing. As transportation uses make up an even larger share of domestic energy use, U.S. flexibility to respond to oil supply and price disruptions will diminish.

The most promising opportunities for fuel savings in both the short- and long-term in this sector involve oil replacement options for automobiles and light trucks, which together account for well over half of transport oil use. Although we can expect continued incremental improvements in fuel efficiency in other

[8] U.S. Department of Energy, Energy Information Administration, *Annual Energy Review* 2989, DOE/EIA-0384(89) (Washington, DC: U.S. Government Printing Office, May 1990), table 62.

motor vehicles and other modes of transportation, the short-term technical potential for reducing petroleum consumption there is relatively small, and no net savings are included in our estimates.

The major oil displacement opportunities for light-duty vehicles (LDVs) for most of the 1990s are improved fuel efficiency, conversion of some fleet vehicles to natural gas and other alternate fuels, and better traffic management. OTA estimates that it is possible to displace about 555,000 B/D of petroleum products in the transportation sector within 5 years, or about 5 percent of 1989 consumption. This would be accomplished using existing technologies and with only minor shifts in customer preference or new-vehicle fleet mix. Additional savings are possible with considerable effort, but would require changes in vehicle manufacturers' product plans, and consumer preference and behavior.[9]

The estimated savings are highly contingent on assumptions about the characteristics of the existing fleet and future changes. For purposes of this report, we have assumed that, under the pressure of a prolonged world oil shortfall, it is technically feasible with available technology to achieve a new LDV fuel economy average of 30 to 33 miles per gallon (mpg) by 1995. This further assumes changes in customer purchase behavior equivalent to the 1987 new fleet size and performance mix. The total oil savings potential after 5 years range from 67,000 to 545,000 B/D, depending on other assumptions about the speed of technology adoption, new car sales, fleet replacement rates, and miles driven. We have adopted a mid-range estimate of 300,000 B/D as a reasonable estimate of potential savings.

The potential saving of about 300,000 B/D from improved LDV fuel economy is significantly less than the 1984 OTA estimate of 700,000 to 800,000 B/D.[10] The 1984 study assumed that in a crisis, the new-car fuel efficiency could be increased from 27.5 to 36 mpg, or a gain of about 31 percent and that these newer vehicles would replace 10-year-old cars that averaged about 14 mpg. Today, the older cars being replaced are more fuel-efficient, and new car fuel-efficiency gains have lagged.

Other measures adopted in response to an oil supply crisis would supply the remaining 250,000 B/D in oil replacement potential, including:

1. converting 1.2 million existing fleet vehicles (about 10 percent of the fleet LDVs) to run on natural gas. (about 130,000 B/D of oil);
2. increasing use of ethanol and expanding production capacity to displace an additiona1 25,000 B/D of gasoline; and
3. adopting various measures to improve traffic management to promote more efficient vehicle travel, cut vehicle miles traveled, and increase car pooling and reliance on public transportation —together, saving a minimum of 100,000 B/D.

Domestic Oil and Gas Production

Declining domestic crude oil production threatens to exacerbate any oil import shortfall. While crisis-driven increased oil prices and demand for natural gas are expected to spur domestic oil and gas exploration, development, and production, it is uncertain whether, over a 5-year period, these efforts would be able to reverse the rate of decline that could cause domestic oil production to fall to 8 to 9 MMB/D by 1995 from 1989 levels of 9.2 MMB/D. There is some potential for stemming this trend. Production from already discovered onshore and offshore fields, including increased infill drilling, delaying abandonment of existing wells, reopening shutin production, and accelerating enhanced oil recovery, could contribute, by our conservative estimates, from about 170,000 to 510,000 B/D of additional crude oil supply. Expanded natural gas production could also add 100,000 to 200,000 B/D of natural gas plant liquids. But the expected decline in U.S. crude oil production could mean a loss of 400,000 to 1 million B/D resulting in an internal shortfall of 0.1 to 1.2 MMB/D in addition to a 5 MMB/D loss of imports.

[9] According to a 1988 OTA contractor analysis, a new car fleet average of 38 to 39 mpg would be attainable by 1995, if there were a shift in consumer preferences toward smaller, more efficient models, and if manufacturers accelerated the use of available fuel-saving technologies to more models. With little improvement in fuel economy of the fleet since then, achieving these levels by 1995 would be extremely difficult even under crisis conditions. OTA ha.. examined the potential contributions of various fuel economy standards as part of a separate report, ***Improving Automobile Fuel Economy: New Standards, New Approaches***, expected to be published in October 1991.

[10] *The Oil Replacement Capability*, supra note 1.

IMPLICATIONS OF GROWING OIL IMPORT DEPENDENCE AND ERODING OIL REPLACEMENT CAPABILITY

As the United States faces the 1990s and the dawning of a new century, it is more dependent on oil imports and less prepared to respond to a severe oil supply disruption than it was just 7 years ago. Part of this change is the byproduct of our success at replacing many uses of oil and improving our efficiency of use in all sectors. This shift has reduced our easier opportunities for switching from oil in the event of a crisis. And, it has focused attention on two sectors where oil replacement poses significant technical challenges—transportation and industry. Nevertheless, OTA believes that opportunities remain to reduce oil import vulnerability.

It is important to distinguish between ***oil import dependence*** and ***import vulnerability.*** Import dependence is measured as the percent of domestic consumption that is met by foreign oil. In 1990 the United States obtained about 42 percent of its oil needs from foreign sources. This was still lower than the high of 46 percent in 1977.[11] A growing level of imports contributes to import vulnerability, but import dependence alone does not translate into a serious threat to energy security. Import vulnerability arises out of the degree and nature of import dependence, the potential harm to the economic and social welfare from a severe disruption in physical supplies or prices, its duration, and the likelihood of such a disruption occurring. Understanding the components of import vulnerability allows the targeting of effective countermeasures.

Because oil use is pervasive and deeply rooted in America's economy and way of life, U.S. dependence on oil imports is of increasing concern. For many, oil is a vital necessity. It heats homes, offices, and schools, provides electricity, and fuels the automobiles, trucks, and buses that move people and things within and among communities. Major and prolonged supply (or price) disruptions would bring hardship and deprivation. Historically, even small supply disruptions have triggered disproportionate economic impacts.

The National Petroleum Council estimated that the 1973 Arab Oil Embargo resulted in a reduction in real GNP of 2.7 percent and that the 1979 Iranian Revolution triggered a 3.6 percent drop in real GNP.[12] Some analysts have estimated that the price impacts of the Iraqi invasion accelerated the recession and added billions to the U.S. oil bill. These disruptions were far smaller than the scenario used in this report.

Future oil disruptions will continue to pose a serious threat to U.S. economic activity even though U.S. reliance upon oil to power its economy and the portion of GNP needed to pay for oil have declined over the last two decades. The growing dependence on imported oil, especially from the politically unsettled Persian Gulf is more cause for concern for several reasons:

1. Greater reliance on oil from foreign sources magnifies the potential impacts of import curtailments on U.S. oil supplies and the economy.
2. Oil imports contribute to U.S. balance of payments deficits and as oil imports (and/or prices) rise, more U.S. export earnings must be allocated to paying for oil rather than devoted to domestic consumption. In 1990 the bill for oil imports amounted to $65 billion, more than half of our $101 billion balance of payments deficit.
3. The threat of potential economic and social dislocations that could accompany major oil supply or price disruptions could constrain U.S. policymakers in foreign affairs, national security and military matters where oil supplies might be affected.
4. The ready availability of cheap imported oil in the United States is a powerful financial disincentive for oil-saving investments inefficiency and alternative energy sources or the development of higher cost domestic oil. Unlike Japan and most Western European countries that are highly dependent on oil imports and where oil is heavily taxed, U.S. oil prices are comparatively low and do not fully reflect many of the external costs of oil use. Among the most notable of these externalities are, for example, the environmental damage from production, oil spills, and emissions from refining and combustion, and the costs of maintaining and

[11] U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review: July 1991,* DOE/EIA-0035(91/07) *(Washington,* DC: U.S. Government Printing Office, July 1991), tables 3.1a and 3.1b.

[12] National petroleum Council, ***Factors Affecting U.S. Oil and Gas Outlook 1987,*** Washington, DC, 1987.

deploying military forces to protect supplies). The defense costs in particular have applied disproportionately to the United States relative to European countries and Japan.

Some argue forcefully that increased import dependence should not be viewed as a threat as long as the net domestic economic benefits are positive. Low oil prices have been advantageous for many American businesses and consumers, but have undercut domestic oil ventures, energy efficiency initiatives, and competing alternative energy sources. An honest appraisal of the costs and benefits must take account of all the social, economic, environmental, and political costs of increased import reliance and of the availability of measures to counter the risk it entails.

Of course, if it is less expensive (as measured in total indirect and direct costs) to import oil than to offset that need domestically, then it makes sense to import. But there is strong reason to believe that the reverse is true, and that our national economic well-being would be improved by shifting investment to limit imports under a long-term least-cost strategy.

MAJOR OPPORTUNITIES FOR REDUCING OIL IMPORT DEPENDENCE

Historically, since the early 1970s, the biggest oil savings in the U.S. economy have come from fuel switching in electric utilities, industry, and the residential and commercial sectors and from efficiency improvements in all sectors. The transportation sector still offers attractive options for oil savings by improving the fuel economy of automobiles and trucks, reducing total driving in the United States, and switching to alternative transportation fuels. In addition, increasing the diversity in world oil production reduces the vulnerability of U.S. oil use to political instability in specific oil supply regions, notably the Middle East.

Because transportation accounts for 63 percent of total U.S. oil use (about 10.8 MMB/D, up 17.6 percent from 1983), it offers the largest potential opportunities for oil savings. And some progress has been made: average automobile fuel efficiency is up-from about 17 mpg in 1983 to about 20 mpg in 1988. (Average new car efficiency has increased, from2 6 to 28 mpg.) However, the average number of miles driven per car and the number of cars are also up sharply. The net result is that motor gasoline consumption has been gradually increasing since 1983, from 6.6 to 7.3 MMB/D in 1989. Substantial opportunities thus remain for improving the fuel efficiency of U.S. cars and trucks.[13]

In addition to cutting oil use, improved automotive fuel economy has other recognized benefits. Since 1983 the policy initiatives for pursuing improved auto fuel economy have expanded beyond the traditional (and now resurgent) concern over energy security to include local and global environmental concerns as well (urban ozone, acid rain, and global warming issues). The environmental dimension strengthens but complicates the likely policy options, since the persistent controversies over the technical potential of improved fuel economy and the relationship between fuel economy and pollution emissions continue. Environmental concerns have, however, improved the longer term prospects considerably for shifting from gasoline to alternative transportation fuels-alcohol-based fuels, natural gas, electricity, or hydrogen.[14]

The situation is further complicated by recent market demands for increased performance at the expense of fuel economy, probably brought about by low real fuel prices (gasoline prices today in 1991 are lower in real terms, i.e., adjusted for inflation, than in the 1970s). Moreover, average new car prices in real terms increased almost 50 percent in the decade 1978 to 1988, contributing to the trend of a longer average age of cars on the road (up from 6 to 7.6 years during that same decade). As a result, an important opportunity may lie in providing incentives to get older, less efficient vehicles off the road.[15]

[13]OTA examined U.S. automotive fuel economy improvements as part of a related OTA report, *Improving Automobile Fuel Economy: New Standards, New Approaches,* to republished in October 1991. Interim results were offered in Steven E. Plotkin, Senior Associate, U.S. Congress, Office of Technology Assessment, "Legislative Proposals to Increase Automotive Fuel Economy and Promote Alternative Transportation Fuels," testimony before the Subcommittee on Energy and Power of the House Committee on Energy and Commerce, Apr. 17, 1991.

14See us. Congress, Office of Technolog, Assessment, *Replacing Gasoline: Alternative Fuels For Light-Duty Vehicles,* OTA-E-364 *(Washington,* DC: U.S. Government Printing Office, September 1990).

15OTA is investigating the costs and benefits of retirin, older vehicles in it ongoing project, *Retirement of Older Vehicles: Fuel Efficiency and Emissions Reduction Benefits.*

In U.S. industry, many of the energy efficiency investments of the 1970s, the fuel switching to natural gas and electricity, and the changing market basket of goods and services produced in the United States have contributed to the declining oil intensity since 1983 (see figure 1-5).[16] Much of the fuel switching has resulted from the large increase in the use of dual-fuel boilers (oil and natural gas) since the early 1980s. Many of these boilers now burn natural gas because of the favorably low prices of natural gas relative to oil that existed even before the current oil price rise.[17]

By 1983 many of the opportunities to reduce oil consumption in the electric power sector had already been exploited in response to the 1973 and 1979 oil price shocks, and so today few utilities are very dependent on oil (although until the recent crisis, a number of them were reconsidering oil as an option, given the 1986 price drop). Nonetheless, the United States still consumes slightly more oil today in electric power generation than it did in 1983—740,000 B/I) in 1989 versus 673,000 B/Din 1983. The bulk of this generation is located in New England, New York, the Middle Atlantic States, California, and Hawaii. However, many utilities now use oil primarily to generate electricity only at peak times, rather than as abase or intermediate generating option. In addition, utilities have many other generating options (including natural gas), more aggressive demand-side management, and purchases from nonutility generators (either independent power producers or qualifying facilities under the Public Utilities Regulatory Policies Act, Public Law 95-615).

Finally, residential and commercial use of heating oil is currently about 1.4 MMB/D, although it has been increasing since 1983 (about 9 percent). Twelve percent of U.S. households use heating oil as the primary fuel, down very slightly from 1983. Much of this consumption is in New England and the Middle Atlantic States where electricity rates are high and natural gas availability limited. Most areas do have alternatives available to shift from oil to natural gas or electricity. More concerted oil conservation measures such as improving building weatherization and furnace efficiency improvements can shave oil use in this sector.

The portfolio of technical options that might be used to implement strategic decisions to reduce oil import dependence are largely the same as those in a disruption scenario, minus the emergency measures for reducing oil use such as rationing or other mandatory restrictions on oil use. The relative long-term effectiveness, and hence the priority of alternative options, may be different in a strategic scenario. For example, over a 5-year period, alternative transportation fuels would likely play a minor role, in the longer term they will be essential.

Automotive Fuel Economy

Automobiles and light trucks account for 40 percent of U.S. oil consumption. The efficiency of the new vehicle fleet increased sharply in the 1970s with the advent of higher mileage standards and fuel prices. But gains have ceased in the face of government apathy and consumer preference for increased vehicle acceleration, size, and other characteristics that conflict with improved fuel economy (see figure 1-8).

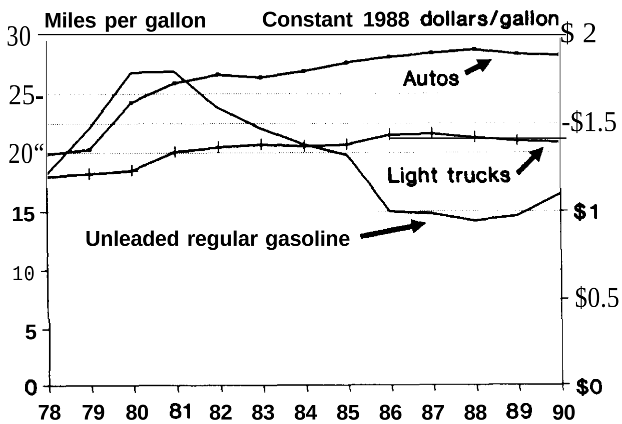
OTA believes that there is a substantial potential for further fuel economy increases through purely technological means (i.e., without diminishing consumer choice), but the magnitude of this potential within the next decade is not what we would like it to be. Even without the push provided by a severe supply disruption or dramatic increases in gasoline prices, technology is available that would allow a new car fleet fuel economy of about 30 mpg by 1995 and 37 mpg by 2001 (both values measured according to the Environmental Protection Agency's test procedure).[18] Longer term progress, beyond the year 2000, could be much larger if strong, continual incentives for fuel economy are brought to bear on the industry. Regulatory or other measures that produce a basic shift in the size and performance of the fleet could stimulate even

[16] See U.S. Congress, *Office of Technology Assessment, Energy Use and the U.S. Economy,* OTA-BP-E-57 (Washington, DC: U.S. Government Printing Office, June 1990).

[17] The efficiency of energy use in industry is being explored in OTA ongoing assessment, *U.S. Energy Efficiency: Past Trends and Future Opportunities.*

[18] These values assume that each manufacturer is required to meet a company-specific standard that reflects its particular technological capability. BY using all technologies identifiable today as likely to be achievable for 2001 model year regardless of cost, and assuming a rollback to 1987 size and performance, we believe that the entire U.S. fleet could achieve 38 to 39 mpg. OTA is currently completing an analysis of automotive fuel economy at the request of the Senate Energy and Natural Resources Committee.

Figure 1-8-Estimated Car and Light-Truck New Fuel Economy and Gasoline Prices, 1978-90



SOURCE: Office of Technology Assessment, 1991, based on data from U.S. Department of Energy, Energy Information Administration, *Anual Energy Review 1989, DOE/EIA-0384(89)* (Washington, DC: May 1990); and Stacy C. Davis and Patricia S. Hu, *Transportation Energy Data* Book: *Edition 11,* ORNL-6649 (Edition 11 of ORNL-5198) (Oak Ridge, TN: Oak Ridge National Laboratory, January 1991), tables 2.19 and 3.33.

greater gains in overall fuel economy than what can be achieved with strictly technical fixes. For example, the options for improving automotive fuel economy in OTA's study on global climate change,[19] included scenarios that permitted altering the mix of vehicle size and weight for the U.S. fleet as well as introducing technical improvements aggressively, including a shift to diesel engines. Under such assumptions, new car fleet efficiencies of 42 mpg by 2000 and 58 mpg by 2010 might be achievable.

Today's light-duty passenger vehicles include automobiles, minivans, vans, and light trucks. Vans and light trucks have lower fuel economy standards than passenger cars and are a large and increasing portion of the U.S. fleet. To achieve higher fuel economy goals all passenger vehicles will have to be targeted. Table 1-3 shows a summary of OTA's analysis of the various conditions under which improved automotive fuel economy would be possible in the short term.

Table 1-3-OTA Estimates of Potential Short-Term Fuel Economy Gains
(EPA miles per gallon)

1995 Product plan

Assumptions:

- Manufacturers' currently planned product line with fuel economy technologies "cost effective" at low oil prices
- Continuation of current trends in size and performance mix of new cars
- No new policy initiatives

Potential automotive fuel economy:

28,3 miles per gallon (mpg) domestic
31.1 mpg imports
29,2 mpg fleet

1995 Product Plan - Short-Term Fuel Economy Gain

Assumptions:

- Manufacturers' current and planned product line with a return to overall relative size, weight, and performance mix of 1987 new cars
- Existing (low oil price) cost effective fuel economy technology
- Customer preference for more fuel efficient version of each model

Potential automotive fuel economy:

31.2 mpg domestic
34.6 mpg imports
32,3 mpg fleet

SOURCE: Office of Technology Assessment 1991.

Alternative Transportation Fuels

The growth of non-oil based liquid fuels is an important adjunct to increased fuel economy and increased domestic oil production (in reducing U.S. dependence on imported oil). A recent OTA analysis of several alternatives to gasoline[20] found that alternative fuels present a key opportunity to reduce U.S. oil dependence. Over the next few decades, alternative fuels derived from natural gas—methanol and compressed natural gas (CNG)--and from biomass, including truly renewable fuels from sustainable production of biomass, should be capable of substituting for a significant fraction of transportation petroleum use.

Electric vehicles, perhaps employing not only batteries, but fuel cells or small engines, could also be important possibilities in some regions of the United

[19]U.S. *Congress,* Office of Technology Assessment, *Changing by Degrees: Steps To Reduce Greenhouse Gases, OTA-O-482* (Washington, DC: U.S. Government Printing Office, February 1991).

[20]U.S. Congress, Office of Technology Assessment, *Replacing Gasoline: Alternatives for Light-Duty Vehicles, OTA-E-364* (U.S. *Government printing* Office, October 1990).

States in the later 1990s. This, of course, depends on the pace of research and technology development in energy storage technology and the constraints on other options. For example, last year California passed legislation requiring deployment of some "ultra-low polluting" vehicles to promote air quality, and other States are considering following California's lead.

Currently, coal-based liquid fuels are considerably more expensive than natural gas-based fuels. However, continued development of the fuel production processes have lowered costs and, in the future, may lower costs sufficiently that this source could compete economically with fuels from natural gas. Large U.S. coal reserves make coal-based liquid fuels attractive from an energy security perspective. But, even with emerging "clean coal" technologies, coal use presents serious environmental challenges (especially carbon dioxide emissions), that the Nation cannot afford to ignore in evaluating which potential liquid fuel strategies to pursue.

As an even longer term option, the transportation sector might free itself from fossil fuel dependence by tapping electricity and hydrogen, both obtainable from nuclear and solar sources. But both have serious cost, engineering, and other constraints and will require a major development effort. Over the next century, however, they could greatly diminish greenhouse gas emissions by progressively replacing fossil-based transportation fuels.

Increased Domestic Production

The recent decline in U.S. oil production could be slowed somewhat if rising oil prices stimulate increased production from existing fields and accelerated use of enhanced oil recovery technologies.[21] Compared to other oil-producing regions, the United States has been extensively explored. Experts estimate that 80 percent of the oil and gas eventually to be found in the United States lies in fields that have already been discovered.[22] The remaining exploratory potential is still substantial. But much of this undiscovered oil and gas will come from smaller fields than in the past.

This maturity does not mean that the future for the U.S. oil industry is a rapid and inevitable decline in production from increasingly high-cost deposits. Many in the oil industry hold to a belief that domestic production can be stabilized or slightly increased. In support they note the continuing strength in U.S. reserves additions and a more sophisticated understanding of the nature of U.S. oil and gas resources.

Even as drilling activity has slowed, reserve additions since 1986 have averaged 90 percent of those in the high oil price-high activity years 1978 to 1985. An estimated 86 percent of these reserve additions are attributable to reserve growth in existing fields-i. e., increases in the estimates of conventionally recoverable oil resulting from extensive and intensive drilling within existing fields, improved recovery, and identification of new pools.[23]

The past decade has brought recognition that sizable quantities of conventionally mobile oil remain to be recovered in existing fields. The greatest potential recovery is contained in complex reservoirs that will require improved geologic models to make infield drilling and enhanced oil recovery more effective in tapping these deposits. Enhanced oil recovery techniques are evolving that eventually could allow production of the immobile, residual oil in existing reservoirs.

Tapping these resources is contingent on the economic attractiveness of the prospects at present and anticipated world oil prices, and continued technology development. The higher oil prices and sense of urgency accompanying a severe oil import disruption would likely provide some impetus for expanded exploration and development.

Oil exploration activities are a primary key to maintaining reserve additions to sustain production. Exploration activities surged in the late 1970s because of high oil prices and the expectation that even higher world oil prices would prevail. In 1981, as a result of this rapid industry expansion, the main indicators of exploratory activity reached record peaks-a weekly average of 3,970 rotary rigs operating, a monthly average of 681 seismic crews active,

[21] See *U.S. Oil Production: The Effect of Low Prices*, supra note 3.

[22] W.L. Fisher, "Factors in Realizing Future Supply Potential of Domestic Oil and Natural Gas," paper presented to the Aspen Institute Energy Policy Forum, July 10-14, 1991, Aspen Colorado.

[23] Ibid.

and an annual total of over 17,500 exploratory wells completed.[24] When world oil prices began to slide, domestic exploration activities fell too. The free fall in world oil prices in 1986 further devastated domestic exploration and development. That year the number of wells drilled plunged to 201, and rotary rigs active totaled only 964-less than half the number operating a year before.[25] Exploratory wells completed dropped to 7,150. As oil prices began to firm up in the later 1980s, albeit at much lower real levels than previously, there was a modest rise in domestic exploration and development investment. However, key indicators still hit a 40-year low in 1989—869 rotary rigs in operation, 132 seismic crews active, and about 5,220 exploratory wells completed.

This sustained drop in exploration and production activity resulted in a shrinking in the infrastructure of the domestic oil industry. The reduction in the availability of equipment, skilled workers, and supporting manufacturing and maintenance services capability could slow any future expansion of domestic exploration.

The higher oil prices in 1990 brought about a brief upswing in exploration indicators, but by late spring 1991, these critical indicators were again trending downward as lower world oil prices returned and domestic natural gas prices all but collapsed.[26] Even so, for the first time since 1985 domestic crude oil production increased—up 0.6 percent over the first 6 months of 1990. The rise was attributed to better economic conditions for producers, the expanded exploration and development activities in 1990, and improved technology.[27]

The scarcity of new opportunities for finding large new oil fields within the mature oil regions of the lower 48 States has created pressure for the Federal Government to open to exploratory drilling and development a number of promising areas currently off-limits to such activities, such as the Arctic National Wildlife Refuge (ANWR), offshore California, and other frontier areas.

The debate over ANWR development is a classic battle between conservation and resource development interests.[28] The oil industry considers the coastal plain of the ANWR to be the United States' most promising remaining prospect for finding giant oil fields, and they have made it the central focus of the debate for opening new areas for commercial exploitation. There is considerable disagreement, even among proponents, about how much commercially recoverable oil might be present in the refuge, if any.[29] Earlier in 1991, the Department of the Interior released a revised estimate that ANWR has a 46-percent chance of containing economically recoverable oil, with a mean estimated oil volume of 3.6 billion barrels—a potential resource equivalent to the third largest discovery in U.S. territory and one that, for a few decades, could deliver several hundred thousand barrels of crude oil per day to the lower 48 States.[30]

---

24 *Annual Energy Review 1989,* supra note 8, tables 41 and 42.

25 For further discussion of the impacts on the domestic petroleum industry, see *U.S. Oil Production: The Effect of Low Oil prices,* supra note 3.

26 U.S. Department of Energy, Energy Information Administration, *Monthly Energy Review: June 1991,* DOE/EIA-0035(91/06) (Washington, DC: U.S. Government Printing Office, June 1991); and Institute of Gas Technology, *International Gas Technology Highlights,* vol. 21, July 15, 1991.

27 See "Oil Demand Fails t. Lowest Level Since 1983," *The Energy Daily,* July 15 1991, p. 4.

28 See *Oil Production in The Arctic National Wildlife Refuge: The Technology and the Alaskan Oil Context,* supra note 3.

29 See the discussion of the factors and assumptions that drive various estimates of ANWR potential in *Oil Production in the Arctic National Wildlife Refuge,* supra note 3, ch.3

30 OTA has reviewed the Department's previously published estimates of a 19 percent chance of at least one field with commercially recoverable quantities of oil with an estimated mean of 3.2 billion barrels of recoverable oil. We found that this estimate was highly sensitive to their assumptions about the minimum economic field size—i.e., the smallest oilfield that could support the oil pipelines and other facilities needed to produce and move the oil. This minimum field size is, in turn, dependent on oil price. DOI had assumed a world oil price in the year *2000* of $35/bbl oil price in 1984 dollars, which has been criticized as to high. Lowering the assumed price would increase the minimum economic field size required and reduce the estimated probability of finding commercial quantities of oil in the ANWR, and affect estimates of the volume of recoverable oil. OTA's review found that DOI's minimum economic field size was probably too large, because smaller fields could likely be developed at the assumed price, or larger fields at a lower price. Overall, because DOI's estimates were based on assessments of both geologic and economic factors, OTA could not conclude that DOI's estimate of total recoverable oil resources in ANWR coastal plain were either conservative or optimistic. Some factors tend to understate estimates of ANWR potential, while others could overstate it. OTA did conclude, however, that DOI's estimate of a 19 percent probability of finding economically recoverable oil in the refuge was probably overly pessimistic. Ibid., pp. 103-105, According to reports, the 1991 revised DOI estimate reflects some additional geologic data, and modifications in some of the economic assumptions, but specific details were not published.

Groups opposing development view the coastal plain as a unique and invaluable Arctic ecosystem and wilderness area, and are convinced that exploration Poses unacceptable risks, and that development would destroy the plain's wilderness character and seriously damage its wildlife and other environmental values. They also point out that relatively modest investments in energy efficiency could save a similar amount of oil over the same period of time.

Even if Congress were to act swiftly to authorize exploration of the coastal plain of the refuge with an accelerated leasing schedule, and if the industry were to discover oil and move as rapidly as possible to develop the field, oil could not start flowing from the plain for many years. The industry's own estimates of the time from actual leasing of the plain (which itself will take a few years) to production startup is about 12 years, and peak production would not be reached for a number of years after that. Estimates for new production leadtimes from frontier offshore areas are similar. Given the long periods involved, such prospects are more important as potential components of longer-term energy plans than as part of any near term response to an actual or threatened loss of oil imports-and as longer-term options they can be evaluated according to overall goals of energy security, environmental quality, and prosperity.

For the nearer term, the best hopes for maintaining domestic production lie in the same nonglamorous sources that have continued to supply most of the reserve additions in recent years. These include sustaining exploratory and developmental drilling activity in known fields, horizontal drilling, accelerating enhanced oil recovery, bringing shutin or marginal oil fields back into production, and limiting the premature abandonment of existing wells.

Diversity in Oil Supply

The world's recoverable world oil resource is huge, but much of it is in the Middle East. Moreover, as demand for oil grows in rapidly industrializing nations, it is not safe to presume that in the future the United States can count indefinitely on 8 to 10 MMB/D in oil imports at an attractive price. The United States could ease pressure on world oil supplies by encouraging oil exploration and development in areas outside of the Middle East. For example, helping the Soviets expand oil production in return for a share of it could have several benefits to the United States. Because the region has major sedimentary basins with limited exploration and poor production to date, success in developing this region and in increasing Soviet oil exports would not only diversify the U.S. import base but also provide the Soviets with the hard currency so badly needed to maintain peaceful progress toward a viable market economy. A second example is the opportunity (again with joint ventures in research, exploration, and production) to assist sister nations in the Western Hemisphere in petroleum development. Massive reserves, for example, exist in Venezuela, some of which (e.g., the heavy oils in the Orinoco Basin) can benefit from further research.

LOOKING TOWARD THE FUTURE-SCENARIOS FOR REDUCING OIL DEPENDENCE

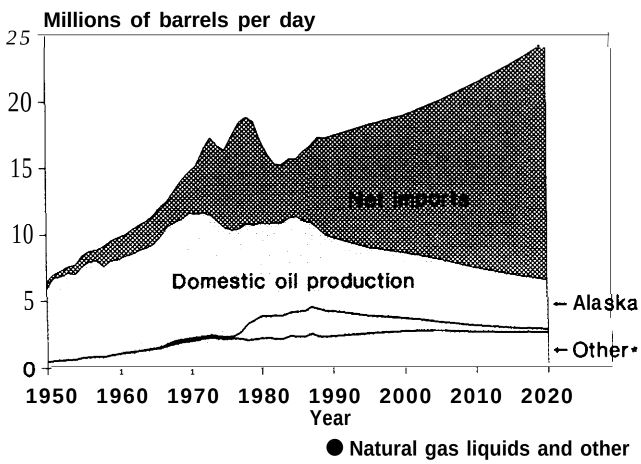
What would be the relative contribution of these various options in possible future scenarios for reducing U.S. oil import dependence? Figures 1-9 through 1-11 summarize the impacts of several aggressive strategies for reducing U.S. oil import dependence. The scenarios focus on the options of increased supply, efficiency, and fuel switching. The major strategies include improving automotive fuel economy, increasing domestic oil production, expanding use of alternative fuels in transportation, and switching away from oil and enhancing end-use efficiency in the industrial, residential, and commercial sectors.

The three alternative future scenarios were derived by OTA from the Energy Information Administration's (EIA) ***Annual Energy Outlook 1990*** Base Case.[31] As the figures clearly indicate, vigorous and sustained efforts would be required to hold down oil import dependence over the next several decades—even to a level of 50 percent of total consumption.

Scenario I: Baseline-Figure 1-9 is a baseline adapted by OTA from the EIA ***Annual Energy Outlook 1990*** Base Case. With some adjustments, the Baseline represents a continuation of current trends

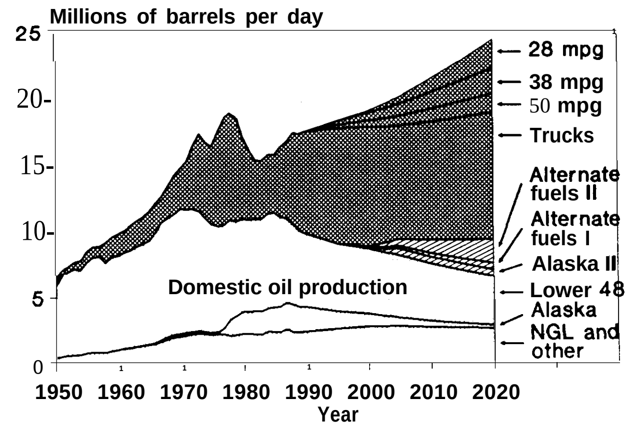
31 U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 1990 With Projections to 2010,* DOE/EIA-0383 (Washington, DC: U.S. Government Printing Office, January 1990).

Figure 1-9—U.S. Oil Supply and Demand Futures Baseline Projection: Current Trends in Domestic Oil Production, Net Imports, and 1989 New Car Fuel Economy



SOURCE: Office of Technology Assessment 1991

Figure 1-10-U.S. Oil Supply and Demand Futures: Impacts of Increased Domestic Oil Supply and Improved Fuel Economy



SOURCE: Office of Technology Assessment 1991.

without additional energy efficiency and oil import displacement initiatives. The Baseline values for oil production from Alaska and the lower 48 States extend the 2005 to 2010 trend projected by the EIA to 2020. Natural gas liquids (NGL) production was similarly left at the EIA projected levels to 2010, and then extended to 2020 following the same trend as 2005 to 2010. The category "Other" (e.g., miscellaneous refinery products) was frozen at the EIA 1995 level of 0.8 MMB/D; levels in the EIA projection above 0.8 MMB/D were separated under the category "Alternative Fuels I" and were added in separately in scenarios II and III.

The EIA projection assumes U.S. new vehicle fuel economy reaches 38 mpg for new cars and 24.4 mpg for new light trucks in 2010. Our base case (figure 1-9) adjusted the EIA projection to reflect a continuation of the current level for new cars of 28 mpg and for new light trucks of about 21 mpg.[32]

Scenario II: New Supply and Efficiency Improvements—Figure 1-10 illustrates the impacts of three new sources of liquid fuel supplies and three levels of transportation efficiency improvements phased in gradually.

The line labeled "Alternative Fuels I" assumes that fuels such as methanol, ethanol, and the like are added beginning in 2000 and reach a consumption level of 500,000 B/I) by 2020, with production capacity increasing by 100,000 B/I) every 5 years,[33] The line labeled "Alternative Fuels II" reflects the accelerated development of alternative biomass-derived liquid fuels resulting from intensive investment in renewable energy research, development and demonstra-
mpg activities.[34] The line labeled "Alaska II" assumes that a large new oil field is found in Alaska and an accelerated development effort is results in production beginning in 2000 and rising to 500,000 B/l) by the year 2005.

[32]This adjustment resulted in a change in weighted (cars and light trucks) fleet average mileage from EIA projected levels of 23.5 mpg in 2010 to 20.5 mpg in 2000, which was then kept at this level till 2020 (on-the-road mileage is assumed to be 80 percent of that measured by a CAFE-type standard). Corresponding annual percentage changes in mileage (on-road fuel economy of the total fleet) are 1.18 percent in the EIAprojection (38 mpg case) carried through to 2020, and 1.0 percent in the 28 mpg case until 2000 and then left unchanged from 2000 to 2020. This assumed increase in light-duty vehicle fuel economy is counterbalanced, however, by EIA projections of an increase in vehicle miles traveled (VMT) of 1.82 percent per year from 1988 levels through 2010. We assumed that VMT continue to increase at this rate through 2020 driven by such factors as population growth of 0.8 percent/year (246 million in 1988 to 307 million in 2025) and real GNP growth of 2.4 percent per year overall, or about 1.6 percent per year per capita.

[33]These estimates are derived from the EIA Bas. Case, Ibid., and are comparable to the estimates used in the development of the President's National Energy Strategy. See the "Business as Usual" case in "The Potential of Renewable Energy: An Interlaboratory White Paper," SERVI'P-260-3674 (Golden, CO: Solar Energy Research Institute, March 1990).

[34]The accelerated development case listed in the Interlaboratory White Paper, Ibid., foresees alternative biomass derived liquid fuels reaching 1.8 MMB/D more than in the base case by 2020 if additional RD&D funding is made available.

Figure 1-10 also depicts three different transportation efficiency improvement strategies that are assumed to be phased in gradually through the year 2020. These are shown as "28 mpg" (base case), "38 mpg," "50 mpg," and "Trucks." The 28 mpg case is a continuation of the current new car fleet fuel economy average. The 38 mpg case reflects the fuel economy gains assumed in the EIABase Case. The 50 mpg case assumes that by 2020 both new cars and new light trucks have an overall weighted average fuel efficiency of 50 mpg, resulting in an average on-the-road total fleet fuel efficiency of 36 mpg by 2020 (allowing for turnover of the fleet stock and for the 20-percent reduction in actual on-the-road efficiencies from CAFE-type standards). The case "Trucks" assumes that the use of compressed natural gas and increased efficiency could reduce by half the projected 2020 diesel fuel consumption by heavy trucks, buses, and others heavy vehicles (based on continuing the EIA projection to 2010 at the same growth rate to 2020) could be reduced by year 2020.

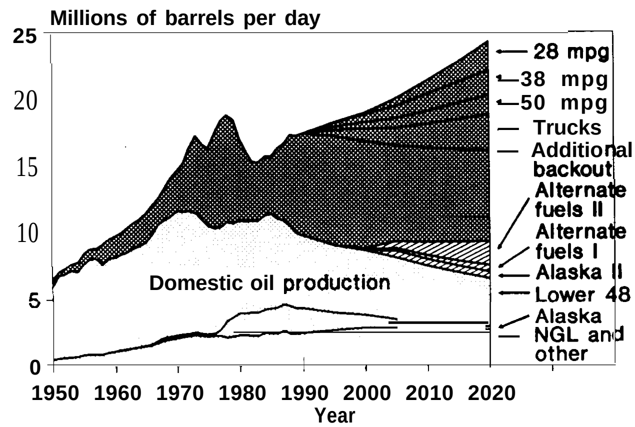
Scenario III: Aggressive Oil Backout—Figure 1-11 includes further oil replacement and conservation initiatives in industry and electric utilities. It assumes (in addition to the 50 mpg light-duty vehicle fuel economy and "Trucks" adopted in Scenario II) that one-half of the remaining nontransport uses of oil will be reduced (backed out) in an aggressive oil conservation and fuel conversion program. This results in a savings of 2.7 MMB/D by 2020, phased in linearly.[35] Compared with current rates of use, this would suggest oil savings in the EIA Base Case of about one-half in the residential and commercial sectors, and one-third in the industrial and utility sectors from what it would be in 2010 if energy use were to grow linearly with economic activity and population.

The lesson from these scenarios is that much can be done to countervails against the ominous projected growth of oil import dependence, but that even with relatively heroic measures we face a future of high dependence on imports.

POLICY CONSIDERATIONS

The United States has already taken a number of steps to offset import vulnerability y, such as establishing (and using) the SPR, adopting CAFE standards, and supporting oil replacement and efficiency technology research development, and demonstration (RD&D). Should Congress decide to take further action targeted at reducing oil vulnerability, there are a number of potentially effective measures available. No single technology will eliminate oil import dependence and there are no quick fixes to the oil import vulnerability dilemma. Any significant shift away from oil products cannot be accomplished quickly and may entail substantial capital investment and adjustments in consumer preferences and lifestyles. An effective approach will require a combination of oil replacement initiatives, perhaps combined with other energy and environmental policy measures. But no strategy will be successful unless it has the continuing support of government, business, and consumers.

Figure 1-11—U.S. Oil Supply and Demand Futures, Impacts of Improved Domestic Oil Supply and Fuel Economy, and Oil Backout



SOURCE: Office of Technology Assessment 1991

This report presents two strategies for promoting the adoption of oil replacement technologies:

1. replacing oil use in a severe import disruption, and
2. reducing oil import vulnerability as part of long-term national energy policy objectives.

Chapter 5 discusses various policy options that might be utilized under each strategy. Both strategies

[35] The EIA Base Case Scenario already envisages annual residential and commercial consumption of oil decreasing at 2.6 percent and 1.8 percent respectively, between 1990 and 2010), while population grows at 0.6 percent and total real GNP grows at 2.4 percent annually. Oil use in the utility and industrial sectors is assumed to increase at about 0.7 percent per year each, while electricity generation and manufacturing output are assumed to increase 3 percent and 2.8 percent, respectively, per year.

rely on many of the same oil replacement technologies and policy initiatives. One critical difference is that some policy options and technologies have fewer implementation problems and offer greater oil savings if adopted as part of a long-term oil replacement strategy rather than as part of a crisis-driven strategy.

Replacing Oil Use in a Severe Import Disruption

The major Federal goals in responding to a severe oil import crisis would be cutting oil use in all sectors, speeding the adoption of oil replacement technologies, encouraging domestic oil and gas production, and easing the negative social and economic impacts of reduced oil supplies. Attaining the maximum technical oil replacement potential will require concerted efforts, large amounts of capital, broad public support, and government leadership. There is a wide range of possible legislative options that could enhance oil replacement in each sector. But because oil replacement technologies alone will not be sufficient to makeup the shortfall, it is also relevant to consider the adequacy of Federal energy emergency authorities and plans.

Residential and Commercial Sectors

In an oil emergency, getting residential and commercial building owners to accelerate oil conversions and efficiency improvements in existing buildings will require a mix of information, exhortation, direct financial incentives, and voluntary and mandatory efficiency standards. Successful implementation of an oil replacement strategy will require the cooperation of millions. Legislative options to foster oil savings include: taxes or surcharges on oil products and equipment, measures to reduce front-end-costs and cash flow barriers, financing assistance, efficiency standards, labeling and certification programs, public information, and technology R&D programs. Measures to improve local availability of natural gas would also help oil-to-gas conversions.

Electric Utility Sector

Most oil dependent utilities now appear well situated to respond to an oil supply emergency. Nevertheless, there are several legislative actions that could further enhance oil displacement capability and oversight. Most of these measures would be most beneficial if they were put in place before any oil import emergency. Following the precedent of PURPA, Congress might, for example, require States to consider adopting regulatory policies that favor oil replacement technologies and efficiency improvements in planning, licensing, and rate matters and to prepare oil emergency contingency plans. Congress might also direct the Federal Energy Regulatory Commission (FERC) to defer to State-approved oil replacement plans in passing on the rates, terms and conditions for wholesale electricity transactions. Measures that improve interstate transmission system capability and transmission access for emergency power transfers to displace oil generation or that enhance regional availability of natural gas, would also improve oil replacement capability.

Industrial Sector

Because of the diversity of oil use in the industrial sector and the limited oil replacement alternatives available, targeting of incentives and technical standards is difficult. This sector is highly sensitive to price signals. In an oil emergency, higher oil prices, coupled with concerns over the availability of oil products at any price, would probably trigger a high degree of oil replacement without any additional financial incentives, Targeting financial incentives to spur incremental oil savings and efficiency improvements without creating a windfall for those who would make the investments anyway has proven difficult in the past. OTA previously found that, in general, policies that encourage investment in new plant and equipment also tend to improve energy efficiency, including efficiency of oil use.[36] Programs that improve the availability of information to industrial consumers about potential energy and oil savings have also proved helpful.

Areas for possible legislative action to improve oil replacement capability in this sector include technical assistance, information, and R&D programs to identify and disseminate oil saving industrial technologies and financial incentives such as tax deductions, credits, or loan guarantees specifically targeted at incremental oil savings. Additional RD&D efforts

[36] U.S. Congress, Office of Technology Assessment, *Industrial Energy Use,* OTA-E-198 (Washington, DC: U.S. Government Printing Office, June 1983), available through the National Technical Information Service, Springfield, VA 22161, NTIS order #PB 83-240-606.

might be directed at developing effective oil replacement technologies for oil-derived feedstocks and for oil products used in nonmanufacturing applications. There also appear to be opportunities for indirect oil savings through actions directed at increased recycling and reduction of hazardous and solid wastes (e.g., recycled plastics, tire-derived fuels). Attention might also be give to the adequacy of Federal emergency authority to restrict oil use or require conversions, private oil stockpiles, and the availability of natural gas supplies and storage for industrial users. With the limited exception of revised and expanded Federal oil emergency authority, all of these measures would work best if put in place in advance of any import crisis.

Transportation Sector

Cutting oil use by cars and light trucks offers the most significant opportunity for short-term oil savings in transportation. An aggressive oil replacement strategy would include four goals:

1. improving light-duty vehicle (LDV) fuel efficiency;
2. accelerating the adoption of alternative non-oil transportation fuels and vehicles;
3. limiting the increase in or cuttingvehicle miles traveled; and
4. improving the efficiency of traffic movement.

Achieving the full savings potential will require action by Federal, State, and local governments, cooperation by manufacturers, and a high degree of public acceptance.

Improvements in new LDV fuel efficiency would offer oil savings over 5 years even without changes in fleet mix and consumer preference. Forcing incremental efficiency gains is difficult because of the challenges in modifying manufacturers production plans and consumer purchasing patterns. Policy options for improving LDV fuel efficiency include:

- ***Amending Federal vehicle fuel efficiency standards to require new cars and light trucks to attain maximum fuel economy levels under available technology. The*** choice of an appropriate standard will require a balancing of many interests and is the subject of a separate OTA study.[37] The level of savings that could be achieved is also dependent on other factors such as the level of new car sales, fleet turnover rates, and consumer preferences.

- ***Using various market-oriented mechanisms to affect the front-end and life cycle costs of LDVs, based on the assumption that consumers will choose more efficient vehicles in response to such price signals.*** Examples of mechanisms that could be used alone or in combination include imposing significantly higher gasoline taxes, raising the gas guzzler tax on the purchase of inefficient new vehicles, offering gas sipper rebates for highly efficient new vehicles, and imposing fuel efficiency-based annual vehicle registration fees. Past studies on the effects of higher prices on vehicle preferences and discretionary driving are mixed, so that the effectiveness of these measures alone is uncertain. At the very least, they appear to be more effective as longer term, rather than rapid response, measures in affecting overall fleet efficiency.[38]

- ***Requiring fleet operators (including Federal agencies) to purchase more fuel-effiient vehicles.*** Fleet vehicles on average are driven more than private vehicles, so that efficiency improvements here offer significant savings. Imposing purchase requirements also would tend to create a market-pull for more fuel-efficient vehicles and would prompt manufacturers to supply them. The Federal Government alone is the largest purchaser of LDVS in the country.

Shifting a portion of the LDV fleet to vehicles that run on fuels not derived from oil could offer attractive oil savings within 5 years and even greater savings beyond then. The successful commercialization of alternative fueled vehicles requires:

- manufacture or retrofit of alternative fuel vehicles in sufficient quantity,

---

[37] OTA is currently completing an analysis of automotive fuel economy standards. Results have been presented in testimony before congressional committees. See references in note 12 supra.

[38] See *Changing by Degrees: Steps To Reduce Greenhouse Gases,* supra note 18, pp. 165-166 and cited references.

- the development of an adequate refueling and service support infrastructure, and
- consumer acceptance.[39]

Among policy measures suggested to create a market-pull for alternative fueled vehicles are: 1) giving rebates or tax incentives to purchasers of such vehicles or fuels; 2) requiring private and government fleet operators to purchase or retrofit a minimum number of alternative fueled vehicles; and 3) promoting industry and industry-government joint ventures to accelerate vehicle technology RD&D and commercialization. Development of an adequate refueling and servicing network could be aided by resolving any existing regulatory impediments for commercial distribution of natural gas vehicle fuels, requirements that refiners and large gasoline retailers offer a certain percentage of alternative vehicle fuels, and expanding alternative vehicle fuel subsidies, such as those now offered for ethanol production. Consumer acceptance could be enhanced by government information on the reliability and potential cost savings from alternative fuel vehicles and requiring manufacturers and retrofitters to warrant the performance and reliability of their vehicles and to back it up with effective customer service. At the same time, the Federal Government could support continued RD&D on improving alternative vehicle technologies, including those that would not be commercially ready or cost effective within 5 years, but might be within an additional 5 to 10 years, for example, electric and hydrogen vehicles.

Traffic management and control technologies can reduce vehicle miles traveled and improve the efficiency of traffic movement and save oil. In general, these measures have the advantage of short lead-times and low capital costs. They work best when they have a high degree of local involvement and community support, There has been only limited analysis of the potential oil savings of these technologies, but available studies suggest that while individual measures offer small savings, when grouped together they offer a significant opportunity for both short- and long-term contributions. Congress could fund additional Federal support for the further development and support of traffic management and efficiency improvements through the Departments of Energy and Transportation. Congress could require States and localities to develop or improve local plans and programs for implementation in an emergency or as part of a longer term effort to increase oil displacement capability.

Domestic Oil and Gas Production

Oil replacement technologies can counter the effects of an oil import disruption, but will achieve their maximum replacement potential only if domestic production of oil is maintained at or near current levels and domestic natural gas production increases to meet new demand. Policy options that maintain domestic production and encourage oil and gas exploration and development are thus part of any oil replacement strategy.

The best hopes for maintaining and even slightly increasing domestic oil production in the near term lie in unrecovered oil in already discovered fields rather than in prospects for new large discoveries in frontier areas. Drilling thousands and thousands of wells in existing fields provided fully 70 percent of total U.S. reserves additions from 1979 to 1984.

Legislative options intended to encourage domestic exploration, development and production can be grouped as follows:

1. targeted tax incentives for exploration or production such as tax deductions, credits, depletion allowances;
2. measures that raise the price of oil or natural gas at the wellhead such as import fees or price floors;
3. technical assistance and technology transfer programs;
4. changes in the SPR program to favor certain classes of domestic producers or to include preservation of domestic production potential;
5. opening more Federal onshore and offshore lands to leasing or adopting more favorable lease terms or royalties; and
6. resolving specific regulatory or environmental controversies that are delaying exploration, development, or production.[40]

[39] For a more extensive discussion see the OTA's recent report, *Replacing Gasoline,* supra note 14.

[40] For an extensive treatment of the pros and cons of policy options to aid the domestic oil industry, see National petroleum Council, ***Factors Affecting U.S. Oil and Gas Outlook,*** February 1987.

All of these measures are politically controversial because they often conflict with other public policy goals such as increasing Federal revenues, reducing the deficit, restoring fairness in tax laws, eliminating energy subsidies, protecting the environment, protecting the international competitiveness of U.S. manufacturers, or promoting greater competition among energy sources and suppliers. All approaches raise questions of whether they would actually be effective at spurring incremental production.

Our technical review found that the most attractive opportunities for maintaining domestic production over the near term were continuing development in existing fields, accelerating enhanced oil recovery, bringing shutin or marginal oil wells back into production, and limiting premature well abandonment. All of the policy options listed above could, in some way, affect these prospects. Further study of the relative effectiveness, cost, and incremental oil yields from these options would be needed to determine which would offer the greatest benefits for reducing oil import vulnerability in the near term.

Enhancing Natural Gas Availability

Concerns over natural gas availability include not only the adequacy of domestic production, but also the ability to move gas from the wellhead to the burner tip. Natural gas use in some regions has been constrained because interstate pipeline capacity and storage facilities are insufficient to meet incremental demand. Planned capacity additions, new pipelines, and Canadian gas imports are reported to have faced delays in obtaining needed regulatory approvals. Measures, such as changing FERC procedures for approving new interstate pipelines to expedite regulatory review, while assuring that environmental and competitive issues are satisfactorily resolved, might enhance natural gas availability,

In addition to increasing interstate pipeline capacity, improvements to local distribution systems and gas storage facilities would also be needed to support greater use of natural gas instead of oil. Some local distribution companies, electric utilities, and large industrial users are considering expansion of natural gas storage capacity, including natural gas liquefaction and storage facilities, as a means to overcome seasonal availability problems. Congress may wish to consider requiring the Department of Energy to review technical, environmental, and regulatory issues associated with improving local deliverability and expanding gas storage capacity and to identify any appropriate legislative changes.

In our 1984 report, we found that an aggressive program of natural gas efficiency improvements could result in significant gas savings—sufficient to meet most of the new natural gas demand from deployment of oil replacement technologies. Congress may consider requiring the Department of Energy, in cooperation with State regulatory commissions, to examine the potential for increasing local availability of natural gas through improved conservation and demand side management by gas utilities and to recommend any appropriate legislative changes.

Oil Import Disruption Contingency Planning and Emergency Response

Because technical means alone would be insufficient to offset the loss of oil imports in a major and prolonged supply disruption, the availability of strategic and private stocks and oil emergency contingency plans and authorities assume a greater importance than before. As imports rise, the amount of oil needed for the SPR will also need to increase. Congress recently approved a l-billion-barrel SPR, but this level will not be reached until the late 1990s. Congress also approved the creation of oil product reserves. Congress may wish to reexamine the adequacy of existing law for responding to prolonged oil import disruptions and to assure that oil emergency plans are kept up to date.

In light of recent experience, Congress may wish to review the structure and operations of the SPR. Among the possible changes that might be considered are clarifying provisions for release of SPR oil to include sharp, panic-driven oil price increases as well as physical shortages, accelerating the SPR fill rate, and providing for automatic adjustment of the SPR fill target to maintain adequate levels of reserves. Other suggestions include adding provisions to accelerate purchases to take advantage of low oil prices or to maintain stripper well production.

OTA's 1984 report noted that the Federal Government was ill-prepared to respond to an oil supply crisis, or even to monitor actual technical capability to deploy oil replacement technologies and the rate of oil replacement. Among options that could be taken in advance of a crisis to redress these shortcomings are collecting and maintaining accurate information on investments in oil replacement technologies and establishing standby oil replacement incentives and taxes. In an oil supply shortfall, the government could rely on the investment monitoring system to determine whether oil replacement was proceeding effectively. If investments were occurring too slowly and market intervention seemed desirable, standby taxes and financial incentives could be activated and increased or modified, as needed, to be sufficiently effective.[41] The advantage of such a strategy is that it allows a flexible and well-defined government response that can be adjusted, depending on the market behavior and response to various levels of incentives. Since our 1984 report, government information collection and reporting have improved only slightly, but are not specifically directed at providing the kinds of timely information and analysis that would be needed in a crisis.

Reducing Oil Import Vulnerability as Part of Long-Term National Energy Policy

Energy security can be viewed not only in terms of a short-term contingency plan, but also from a long-term perspective embracing the three broader and more fundamental national goals of economic health, environmental quality, and national security. As the United States approaches the task of developing a national energy strategy, it makes sense to do so in ways that support these and other related goals. Such a strategy will require a delicate balancing of energy with other objectives. Some energy options advance all three national goals. Others, particularly those that improve efficiency of production and use, may support one goal but run counter to the others. For example, increased reliance on coal and methanol transportation fuels from coal could cut oil import dependence, but exacerbate problems of air pollution and global climate change.

There are no quick and easy technical "fixes" to America's oil import dependence. Major changes in energy systems—and major changes are what would be needed—require decades and unwavering commitment from citizens, political leaders, and industry. Given time, energy is a flexible component of a modern economy, but a long time will be needed to effect a major turnover of the capital stock of energy supply and consumption technology. In the absence of a supply crisis, short-term strategies-either to spur production or to curb consumption-could prove inefficient and traumatic.

The same oil replacement technologies and policies that could prove critical in an oil import crisis also can contribute to achieving a long term goal of reducing import vulnerability. Indeed, many of these technologies offer larger savings over the longer-term than they do as short-term replacement options—improvements in total automobile fleet fuel efficiency and a transition to alternative vehicle fuels both are more effective as long-term rather than short-term options. The additional time for technology development and institutional change under a long-term oil replacement strategy would also enhance the effectiveness and reliability of other technologies. For example, new technologies, such as electric vehicles and fuel cells, could reach commercial viability. In short, a long-term oil replacement strategy offers more robust technology options than does a crisis scenario.

Establishing National Energy Goals

The United States can succeed in easing oil import vulnerability, but only if we establish long-term energy goals and stick to them through periods of both crisis and calm and through high and low oil prices. Certainly, a sensible, comprehensive energy policy must be responsive to sudden changes of events, but it must be fundamental y grounded in long-term strategies.

In many ways, Congress acts as a supreme board of directors for our national enterprise, setting broad policy goals, approving plans to reach these targets, and periodically measuring progress and recharting direction. A similar structured approach could be adopted in establishing a comprehensive national energy strategy. Congress would set broad long-term energy policy goals and approve the implementation program submitted by the President and the Secretary of Energy. (This implementation program would likely include many of the oil replacement options previously discussed under the oil disruption response strategy.) To aid in oversight, Congress could direct the Secretary to develop quantitative indicators

[41] See OTA supra note 1, pp. 26-35.

of our progress in attaining our targets and report on them periodically. The Secretary might also be required to include in any legislative requests a statement of how new energy programs or appropriations would advance the national energy goals. Congress would review the goals every 5 years and make any necessary modifications or additions.

Candidate goals for limiting oil import vulnerability, increasing energy efficiency, and beginning a long-term transition to a post-fossil economy by the year 2010 might include, for example:

1. limiting U.S. net oil imports to not more than 50 percent of annual oil consumption;
2. promoting efforts to diversify sources of world oil production in regions outside the Middle East when such assistance can be aligned with other U.S. policy interests;
3. increasing U.S. energy efficiency (i.e., energy per unit of domestic output) by 20 percent per decade or an average of 2 percent per year;
4. initiating a move towards a post-fossil economy in the long term by reducing carbon intensity by 10 percent in each of the next two decades (equivalent to an average of 1 percent per year average over 10 years);
5. improving the efficiency of the U.S. transportation sector by increasing light-duty fuel efficiency by an average of 2 percent per year; and
6. reducing oil's share of U.S. transportation energy use by 10 percent by 2010.

Having adopted a comprehensive set of national energy goals and an implementation plan for achieving them, other policy initiatives and legislation could then be evaluated based on how they contributed to achieving those goals. For example, an underlying objective for federally supported technology RD&D, and commercialization would be to identify and advance promising technologies to achieve these national energy goals.

CONCLUSION

In facing the prospects of continuing oil import vulnerability and lessened technical capability to respond to severe and prolonged oil disruptions, the United States has three choices:

1. We can continue on the current path and wait until the next disruption occurs before deciding on an appropriate response.
2. We can anticipate that such disruptions will occur and set in place effective measures that enhance our ability to replace oil in response to the disruption.
3. Or, we can begin now to craft a more comprehensive national energy strategy that embraces along-term goal of reducing our reliance on oil and other fossil fuels and beginning a transition to the eventual post-fossil era, and that does so consistent with other national policy objectives.

Whichever path we choose, success in reducing our oil import vulnerability will require a strong Federal example and the sustained support and cooperation of citizens, business, and government.