Chapter 5

U.S. Energy Policy and Technologies for Replacing Imported Oil

Contents

	Page
INTRODUCTION	115
Policy Considerations	115
POLICY OPTIONS FOR REPLACING OIL IN AN OIL SUPPLY DISRUPTION	117
Residential and Commercial Sectors	117
Electric Utility Sector	120
Industrial Sector	122
Transportation Sector	123
Encouraging Domestic Oil and Gas Production	126
Enhancing Natural Gas Availability	127
Reexamining Oil Import Disruption Planning and Emergency Response	127
POLICY OPTIONS FOR REDUCING OIL IMPORT VULNERABILITY AS PART OF OTHER NATIONAL POLICY OBJECTIVES	128
Setting National Energy Policy Goals	128
CONCLUSION	131

Chapter 5

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INTRODUCTION

The United States faces a future of growing dependence on imported oil and an ever-increasing vulnerability to oil supply and price disruptions on world markets unless effective countervailing measures are taken to reduce these risks. Technologies available today can lessen our vulnerability: some are cost-competitive with oil now; others would be so at higher oil prices. However, with demand for oil growing and domestic production declining, it is no longer possible to rely on technical means alone to replace a significant share of lost oil imports in a prolonged supply disruption. Moreover, in addition to enhancing our energy security, acceptable oil replacement technologies will have to be compatible with other policy goals such as environmental protection and international competitiveness.

This chapter examines policies and strategies for countering increased oil import vulnerability. It begins with a discussion of key policy considerations in crafting effective legislative options and follows with a brief discussion of some policy options for promoting the adoption of oil replacement technologies: 1) in response to or in the event of a major oil supply disruption and 2) as part of a more general national energy strategy.

This report does not examine any of these policy options in depth, or evaluate the best methods of implementation, or quantify the potential costs and benefits. If Congress decides to pursue these measures, it might use the legislative process to elicit this information from the Department of Energy (DOE), energy industries, States, and academic and other experts; or, as part of a phased implementation strategy, Congress could require DOE **to** investigate and report on optimum policies, and expected costs and benefits.

Policy Considerations

In developing appropriate legislative responses to the problems posed by growing oil imports, it is important to distinguish between oil ***import dependence*** and ***oil import vulnerability.*** Import dependence is measured as the percent of domestic consumption that is met by foreign oil. In 1990 about 42 percent of our oil needs came from foreign sources.[1] Arising 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 of a severe disruption in physical supplies or prices, its duration, and the likelihood of such a disruption occurring. An increase in oil import dependence does not by itself generate an equal increase in oil import vulnerability.

Understanding the components of import vulnerability allows the targeting of effective countermeasures. For example, oil is now a fungible and freely traded commodity on world markets. Crude oil prices will continue to be set in world markets regardless of the extent of U.S. oil import dependence. Unlike the situation prevailing in the 1970s, oil prices in the United States are virtually unregulated. They move freely with changes in world market prices. With the rapid growth of oil spot and futures markets, and the changes in the terms of oil contracts to set delivered prices based on these posted prices, oil prices can be very volatile. Changes in supply (or rumors of changes in supply) are reflected almost instantly in world prices. The consequences of this structural change in the oil industry were brought painfully home to consuming nations in the aftermath of Iraq's invasion of Kuwait.

[1] U.S Department of Energy, Energy Information Administration, ***Monthly Energy Review:*** *February 1991*, DOE/EIA-0035(91/02) (Washington, DC: U.S. Government Printing Office, February 1991), tables 3.1a & 3.1b.

Growth in oil import dependence has its costs; for example, higher import levels can make it more difficult for the United States to adjust to price or supply disruptions and require increased U.S. exports or changes in the international value of the U.S. dollar to pay for the imports.[2] On the other hand, oil imports have some positive aspects. First, they may provide a ready supply of cheap oil, benefiting U.S. consumers and oil-intensive industries. Second, U.S. oil companies are actively involved in oil exploration and production in foreign countries and derive a significant share of their revenues and profits from foreign operations, which in turn depend on exports to the United States and other consuming nations. Third, U.S. oil equipment manufacturers and oil service companies are also active in foreign countries. Fourth, U.S. imports offer a potential outlet for alternative supply sources outside of the politically volatile Middle East. Diversification of world oil production reduces that region's control of world supplies and, thus, enhances U.S. energy security. Fifth, the growth of oil and gas industries in many developing countries has spurred economic development and provides an important source of foreign exchange that allows those countries to import goods and services to improve the lives of their citizens. The United States has supported their development efforts through foreign assistance programs and international organizations. Sixth, many of the our major oil suppliers are nations with whom we have developed important and strategic relationships that go well beyond reliance on oil (Canada, Mexico, Venezuela, Saudi Arabia, the United Kingdom, and Norway, for example). Efforts targeted at cutting oil imports could damage these relationships with usually stable suppliers.

One way of reducing oil import vulnerability would be to cut the level of imports, but reducing imports alone poses questions of practicality and effectiveness. No one has seriously suggested that in the near term, by 2010, or later that the United States could or is willing to pay the costs of fully replacing imports with a combination of domestic production, fuel switching, alternative fuels, demand reduction, and efficiency improvements. President Bush's National Energy Strategy projects that the United States will become even more dependent on Middle Eastern oil imports in the future even if all of the strategy's proposals are implemented.[3] Moreover, even if we succeeded in replacing imports, we would still remain vulnerable to oil price disruptions as long as oil prices continue to be set in potentially volatile world markets (although the extent of vulnerability may be reduced because oil might lose some of its importance in the overall economy). Clearly, this is an area where a delicate balancing act is called for.

The United States has already taken a number of steps to offset import vulnerability. Chief among these, and the first line of defense for supply disruptions, is the Strategic Petroleum Reserve (SPR), the government-held stockpile of crude oil intended to supply at least 90 days worth of U.S. oil imports in the event of an oil emergency. The United States is also party to International Energy Agency (IEA) agreements on international oil supply emergencies that commit members to maintain strategic stockpiles, develop standby demand reduction plans, and to share oil supplies in a shortage. In early 1991, Operation Desert Storm triggered an IEA-coordinated release of government-held strategic stocks to counter possible market impacts of allied action against Iraq.

Other government actions, such as corporate average fuel economy (CAFE) standards for automobiles and light trucks, fuel use restrictions, purchase and interconnection requirements for qualifying cogeneration and small power producers under the Public Utilities Regulatory Policies Act (PURPA), and federally funded energy technology research, development, and demonstration (RD&D) programs, have combined with price signals to help the United States make great progress in reducing the oil intensity of the economy and in using oil more efficiently. Independently of government programs, businesses, utilities, and individuals have significantly reduced their own vulnerability to the consequences of oil supply or price disruptions through, for example, dual fuel capability and efficiency improvements. One consequence of this success, however, is that the easy steps have already been taken and replacing the remaining uses of oil has become increasingly more difficult.

If Congress decides to reduce oil import vulnerability by displacing oil use or enhancing our technical readiness for replacing imports, there are a number of

[2] National petroleum Council, *Factors* Affecting *U.S. Oil and Gas Outlook*, February 1987, p. 7.

[3] *National Energy Strategy: Powerful Ideas for America, First Edition* **1991/1992** (Washington, DC: U.S. Government printing Office, February 1991).

potentially effective measures available. No single technology will eliminate oil import dependence and no quick fixes will eliminate oil import vulnerability. An effective strategy will require a combination of oil replacement initiatives, perhaps combined with other energy and environmental policy measures.

To illustrate how oil replacement technologies might contribute to the goal of reduced oil import vulnerability, we present two strategies:

- promoting the adoption of oil replacement technologies in an oil supply disruption, and
- reducing oil import vulnerability as part of long-term national energy policy objectives.

Both strategies 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.

POLICY OPTIONS FOR REPLACING OIL IN AN OIL SUPPLY DISRUPTION

A variety of policy measures could reduce oil use either by improving energy efficiency or by encouraging conversions to other fuels. This section presents such policy options for each energy sector. In addition, options for improving the domestic supply of oil and for enhancing emergency response measures are explored.

Residential and Commercial Sectors

Replacement of most oil use in the residential and commercial sectors is technically feasible; however, the success of such a strategy will depend on individual decisions by millions of consumers. It is already abundantly apparent that price alone is insufficient to achieve reductions because many oil savings technologies are already cost-effective. A number of institutional and technical constraints have discouraged oil replacement and energy efficiency improvements in these sectors.[4] There are, however, policy initiatives than can be targeted to overcome these financial, informational, cost, and institutional constraints.

Several financial disincentives are at work. First, residential and commercial oil demand is highly inelastic. (Price elasticity measures the change in energy demand in response to the change in the price of energy. Inelastic demand is insensitive to price changes-i. e., it does not change much or quickly when prices go up or down.)[5] Thus, oil prices would have to rise dramatically over the costs of competing fuels to trigger enough replacements or retrofits to have significant oil savings. Analyses vary about what level of price increase would suffice.[6]

Second, residential and commercial customers are generally highly sensitive to front-end costs. High front-end costs and cash flow considerations can deter them from making conversions and efficiency improvements that offer lower life cycle costs. This is true even for measures with relatively short payback periods of 4 years or less.

Third, this preference for low front-end costs is amplified for equipment and efficiency decisions for new construction, rehabilitation, and rental properties where those making initial purchase decisions are often not the ones who will be paying the fuel and operating costs.

Finally, the structure of the residential-commercial fuel supply network does not encourage fuel suppliers to promote efficiency, except out of fear of loss of market share to competing fuels.[7] Their revenues, after all, depend on the volume of sales. This is in marked contrast to the many regulated electric and

[4] OTA has an Ongoing project investigating overall energy efficienc, in the residential and commercial sectors which examines both institutional and technological issues in more detail. The institutional aspects of promoting energy efficiency and reduced emissions of pollutants in the buildings sector and related policy options are also examined in another OTA report: 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), ch. 4. Hereinafter referred to as ***Changing by Degrees.***

[5] See ch. *4* of this report for a discussion of the response of the U.S. economy to oil price changes.

[6] *Changing by Degrees*, supra note 4 at pp. 135-137, and cited references.

[7] For example during the fall and early winter of 1990-91, fuel oil distributors mounted an aggressive advertising camPaign citing 'he 'igh costs ‹' converting to natural gas and the perceived relative safety of fuel oil, even at higher costs.

gas utilities that have aggressive conservation programs as part of demand-side management strategies or in response to State regulatory program directives or financial incentives. Despite these disincentives, it should be noted that the energy efficiency of new homes and commercial buildings is much higher than that of older stock.

Many building owners have already made some improvements in energy efficiency. However, while DOE survey data suggest that still more incremental savings are possible,[8] it is not clear how many of these measures are attractive at today's energy prices. Some analysts have attributed the lag in savings in part to a lack of information about the potential from building efficiency improvements and better equipment.

A key uncertainty in converting existing oil furnaces, boilers, and water heaters to natural gas is the limited availability of natural gas in some areas. This constraint is due to: the extent of local gas distribution companies' service infrastructure, the seasonal availability of gas supplies, and insufficient interstate natural gas pipeline capacity and gas storage facilities to meet potential demand.

Under normal conditions, the pace of energy conservation and oil conversions in the residential and commercial sectors is slow because so much is determined by the characteristics of the existing buildings and equipment. To get residential and commercial building owners to accelerate oil conversions and efficiency improvements in an oil emergency will require a mix of information, exhortation, direct financial incentives, and voluntary and mandatory efficiency standards. Legislative options to foster oil savings in the residential and commercial sectors include: options affecting fuel prices and availability, measures to reduce front-end costs and cash flow barriers, financing assistance, efficiency standards, public information (labeling and certification programs), and technology RD&D programs. There is not extensive experience with most of these measures under normal conditions, and little conclusive analysis of their effectiveness. Some of these measures may provide only marginal oil savings over the short term, but may be more effective over a longer period of time.

Making Oil Use More Expensive

Discouraging oil use by making it more expensive through the imposition of oil surcharges, fees, or taxes has frequently been advocated. The relatively higher oil taxes paid by European and Japanese consumers and their, presumably more efficient, lower per capita oil use are often cited as support for this approach. Other purposes for imposing such surcharges include: conserving oil, reducing oil imports, raising Federal revenues to pay for specific programs or to cut the deficit, and correcting market failures that keep oil prices low by excluding the full cost of various externalities in oil use.

In addition to the financial disincentives previously discussed, this approach has several drawbacks as an effective option for encouraging near-term oil replacement in response to an import crisis. First, such surcharges tend to be regressive, burdening lower income families more than affluent households. Second, higher oil prices would frustrate other energy assistance programs by reducing the impact of already limited Federal, State, and local resources for helping the poor pay their energy bills. Third, and perhaps most significantly, raising fuel costs even higher than the levels already triggered by an oil shortage could exacerbate the economic effects of the crisis. These results could be politically unacceptable. While it is possible to include mechanisms to offset the regressive features of a surcharge, such as tax credits or rebates, the overall economic impacts of higher oil prices would remain controversial.

Reducing Front-End Costs and Cash Barriers

Rebates, tax credits, tax deductions and other mechanisms for cutting up-front costs of oil conversions or efficiency improvements would appear to be attractive ways of countering financial disincentives. However, experience with these as measures for displacing oil use is limited.

Rebates on the purchase and installation of oil-saving measures might be comparable to customer rebates in utility demand-side management programs. Some have suggested that the rebates be coupled with

[8] For additional insight into th complicated nature of determining the cost-effectiveness of SOme available building efficiency retrofits> see 'he discussion in U.S. Congress, Office of Technology Assessment, ***Energy Efficiency of Buildings in Cities, OTA-E-168*** (Springfield, VA: National Technical Information Service, March 1982).

and financed by an initial purchase tax on inefficient equipment, or even on buildings.[9] It is not clear whether such a program would be adequately self-financing if directed only at oil use, or if it would actually be effective in shifting purchase decisions to more efficient products or structures. Also uncertain is who would administer an oil-savings rebate program-utilities, fuel oil suppliers, State agencies, or the Federal Government.

Congress could consider allowing property owners (and tenants, in some instances) to deduct or credit against their income taxes some or all of the costs of installing oil replacement equipment or qualified efficiency improvements such as increased insulation, storm windows, and flame retention burners. However, studies of the effectiveness of the residential energy and solar tax credits were inconclusive about its success in spurring incremental investments that would not otherwise have been made.[10] Some analysts argue that the tax credits had little or no incremental benefit and amounted to a windfall for certain taxpayers; others suggest that the credit was too low to be effective, or that the increase in energy prices dwarfed the effects of the tax incentive. To be effective, great care would have to be taken in creating appropriate tax incentives to trigger incremental investments in oil savings.

Financing Energy Savings

Congress might also consider enacting or expanding mechanisms, such as grants, loans, loan guarantees, and shared energy savings programs, to aid the financing of conversions and efficiency improvements. Federal law already provides a variety of mechanisms that might be useful.[11] OTA has not investigated how much additional oil savings they might provide and at what cost.

Setting Energy Efficiency Standards

Congress could encourage measures affecting the availability of efficient equipment and the energy efficiency of buildings, such as voluntary and mandatory equipment standards, energy rating systems, product certifications, and building codes. Coupled with other incentives to trigger oil conversions and efficiency improvements, these measures could help assure that investments in these technologies achieve optimum oil savings by providing pertinent information to consumers and keeping inefficient products out of the marketplace. The Federal Government has cooperated in developing model building codes that promote energy-efficient construction and is committed to encouraging States to adopt these requirements. Efficiency standards for furnaces and water heaters are mandated under the National Appliance Energy Conservation Act of 1987 (Public Law 100-12). For example, the annual fuel utilization efficiency (AFUE) standard for oil boilers effective in 1992 is 78 percent, yet there are many models commercially available today approaching 90 percent AFUE.[12] Such minimum efficiency standards and codes could be made more stringent or accelerated in an oil emergency.

In response to a crisis, Congress could either restrict oil use in or require replacement of oil-burning equipment in large residential and commercial buildings or complexes after a specified transition period. Mandating equipment replacement in private homes and small commercial buildings, however, would be more difficult and controversial, and oil savings might better be achieved through a combination of incentives and other measures. For example, Congress might require that new or existing homes must either replace oil-burning equipment or achieve a prescribed building efficiency rating to qualify for federally backed mortgages or as a condition of sale. Congress could direct States to consider additional measures to cut residential oil use.

Improving Public Information

Other measures that enhance the availability and quality of consumer information on oil savings technologies, such as appliance labeling, energy rating

[9]For more on such proposals, see ***Changing*** *by Degrees,* supra note 4, ch. 4.

[10]Eric Hirst, Richard Goeltz, Hyldee Manning, "Household Retrofit Expenditures and the Federal Residential Energy Conservation Tax Credit," ORNL/CON-95 (Oak Ridge, TN: Oak Ridge National Laboratory, July 1982). Salvatore Lazzari, "Are the Residential Energy Tax Credits an Effective Tool of Energy Conservation," *Congressional Research* ***Service Review, vol. 4,*** March 1983, pp. 11-13.

[11]***Changing by Degrees,*** supra note 4, ch. 4.

[12]American Council for an Energy Efficient Economy, ''Handbook on Energy Efficient Appliances," at pp. 24-25.

systems for buildings, energy audits, and energy conservation assistance programs, could help building owners and tenants learn about potential cost-effective oil savings. Such promotional efforts could improve the effectiveness of voluntary conservation.

Improving the Availability of Natural Gas

A critical uncertainty in achieving a high degree of residential and commercial oil replacement is the availability and deliverability y of natural gas for space and water heating systems. While there appears to be sufficient production capacity to meet increased residential and commercial demand, local gas systems in some areas would not be able to accommodate the flood of new customers without significant investments in additional infrastructure for distribution and storage and commitments of expanded delivery capability from interstate pipelines. Without a more detailed examination of the natural gas supply system, we cannot suggest specific legislative actions that could remedy this situation. Congress may wish to consider directing the Secretary of Energy, in consultation with State regulatory authorities, to study the matter further and to report on the capability of gas distribution companies to expand their services as a means of replacing oil, and to delineate any needed Federal actions to enhance this capability. Additional measures to improve gas availability are discussed later in this chapter.

Providing Federal Assistance for Technology Development

The Federal Government could assist in RD&D and commercialization of technologies that hold promise for rapid oil savings in the residential and commercial sectors either by redirecting or by adding to existing Federal energy and housing research programs. For example, further investigation of technical and institutional matters associated with converting oil boilers to burn coal slurry fuel during an oil emergency would seem fruitful. Improvement of cost-effective and quickly installed devices for retrofitting oil burning hydronic heating systems to accommodate other fuels or to enhance efficiency would also seem particularly attractive, given the large number of residential units that would benefit.

Electric Utility Sector

Although it is technically feasible to back out virtually all use of residual oil in the electric utility sector, it is not clear whether an aggressive backout would be necessary or desirable, even in a major oil import disruption. High oil prices, new capacity, demand management programs, State regulatory policies, and Federal programs under PURPA and the Powerplant and Industrial Fuel Use Act (PIFUA) already have cut oil use by electric utilities.[13] Most oil-dependent utilities now appear well situated to respond to an oil supply emergency. Nevertheless, several legislative actions could further enhance oil displacement capability and oversight in this sector if Congress wanted to speed a shift away from oil-fired generation and promote greater flexibility in responding to supply disruptions.

Electric Utility Regulation

State regulatory agencies have the primary responsibility for overseeing electric utility generation and transmission capacity planning, operations, and retail rate matters. Nevertheless, Congress has, under PURPA for example, enacted legislation influencing how States exercise their regulatory authority. Congress might consider further legislative actions now to reduce vulnerability of electric utilities in a future oil import crisis. Possible actions include the following:

- State public utility commissions (and unregulated utilities) could be required to consider oil-supply emergency responses in their contingency and capacity planning, if they do not already do so, and to consider giving preferences to oil displacement technologies (including demand and supply-side management) in the selection of new generating capacity or power supplies.

[13] The ~] ectric utility industry is highly regulated with jurisdiction over utilit y activities split between the Federal Energy Regulatory Commission and State public utility commissions. States generally have exercised supervision over capacity planning, siting, and acquisition of new generating and transmission facilities, and demand-side management programs. FERC has passed on wholesale electricity transactions, transmission agreements and fees, and set general policy guidance for State implementation of PURPA.

- The Federal Power Act could be amended to direct the Federal Energy Regulatory Commission (FERC) to accept State approved preferences for oil replacement technologies in passing on the rates, terms, and conditions of bulk power sales.
- PURPA could be modified to direct FERC to authorize States to approve a bonus payment above avoided cost for power sales by qualifying facilities (QFs) using certain State-approved oil replacement technologies.
- State public utility commissions could be required to consider amending their transmission line certification or licensing approval criteria to include improving the capability of the regional transmission system to move power to displace oil in a supply crisis, if they do not already do so.

Federal Programs and Policies

In matters of national energy policy, energy security, and Federal jurisdiction over interstate power sales, the Federal Government has a continuing role in the oversight of electric utilities. In this area, too, there are several legislative actions that might be considered to improve emergency preparedness in advance of an oil import shortfall.

- Congress might require the Secretary of Energy, in cooperation with State regulatory authorities and other appropriate Federal agencies, to study and report back on the capability of regional electric transmission systems to increase power transfers to displace oil in an import crisis and suggested measures for necessary improvements. Even though, over the past decade, there has been a clear trend away from oil use in new generating units, some analysts project that in the late 1990s electric utilities will increasingly turn to oil-fired generation if electricity demand grows and natural-gas supplies tighten.[14]
- Congress may wish to consider reimposing Federal requirements that utilities, independent power producers, and industrial facilities demonstrate that any new oil-burning units (over a certain size) be capable of modification or replacement to burn an alternate fuel within 6 to 12 months.
- Federal efforts to increase the seasonal availability of natural gas could allow greater use of gas-fired generating capacity by utilities.
- Congress could direct that federally sponsored fossil energy and clean coal programs include RD&D projects for cost-effective and short-leadtime technologies to convert oil-fired units to burn coal slurry fuels or other fuels.

Congress could review the adequacy of Federal emergency authority for responding to an oil import crisis. Among possible amendments are:

- Granting additional authority to the Secretary of Energy or the President to restrict nonessential utility oil use during oil supply emergencies.
- Requiring utilities to prepare regional transmission sharing plans to facilitate voluntary bulk power transfers to displace oil-fired generation in an oil supply emergency.
- Authorizing the FERC to order utilities to provide transmission access for oil-saving bulk power transfers for other utilities in an oil supply emergency if sufficient transmission capacity is then available, including requiring any facility upgrades or operational changes necessary to carry out the transfers.[15]
- Directing the Environmental Protection Agency (EPA) to examine applicable permit review and approval procedures for conversions of oil-burning facilities to natural gas or coal and to recommend any changes that might be needed to expedite the processing of such requests in an emergency.

[14]This could be especially true if peak load grows faster than base load. The low capital costs and short lead-times of new oil-fired units could make them attractive if adequate supplies of natural gas are not available. It is not clear, given recent experience, that any utility would build such a single-fuel plant now unless it were redundant capacity.

[15]For a discussion of the technical and policy issues involved, see U.S. Congress, Office of Technology Assessment, *Electric Power Wheeling and Dealing: Technological Considerations for Improving Competition, OTA-E-409* (Washington, DC: U.S. Government Printing Office, May 1989), chs. 5 and 7.

Industrial Sector

Much of industrial sector oil demand is for feedstocks and nonmanufacturing applications that currently have few replacements available. Consequently, most of the near-term oil replacement potential in this sector is in manufacturing. We believe that with additional research, oil replacement options for other industrial products and applications could be expanded.

Oil product use in manufacturing is diverse, and detailed analysis of the full extent of oil replacement potential is not possible based on the limited information available. OTA, like others, focused on opportunities in the most oil-intensive industries and found the major technical opportunities for oil savings to be fuel switching, converting industrial boilers to non-oil fuels, efficiency improvements and process changes, alternative feedstocks, and industrial and end-use consumer recycling and waste reduction.

The industrial sector is highly responsive to price. Over the past two decades, higher oil prices plus uncertainty about the availability of oil supplies led U.S. manufacturers to cut oil use and to enhance their capability for fuel switching. We believe additional opportunities for oil savings and efficiency gains still remain.[16] policy options that maybe most effective in this sector include those that would speed the adoption of more energy-efficient technologies. These include oil taxes or surcharges, tax incentives, and technology transfer efforts. Policies that advance other goals, such as waste reduction, can also create a market pull for oil replacement technologies. Given the extent of nonreplaceable oil use in this sector, attention should also be given to emergency fuel use authorities, the adequacy of government and private stockpiles, and RD&D efforts.

Creating Financial Disincentives for Oil Use

Imposition of fees, surcharges, or taxes on oil products to make them more expensive to use would probably trigger some additional conservation efforts in this sector. We have not investigated how much incremental oil replacement would occur or at what price. But a tax would also have negative effects. As noted previously, if the tax were imposed during a supply crisis, it could magnify the economic impacts of any shortage. Price is not the sole determinant in industrial oil use. Considerations of cost, fuel availability, process compatibility, equipment, and product quality may dictate continued use of oil. The added costs would particularly burden manufacturers who have limited replacement alternatives and would erode their international competitiveness if similar costs were not imposed on their foreign counterparts.

Creating Investment Incentives

OTA's report, Industrial Energy *Use,* found that, in general, policies that encouraged investment in new plant and equipment also tended to improve energy efficiency.[17] However, OTA also found that legislation directed specifically at improving energy efficiency in industry had little influence on investment decisions. Thus, for example, the targeted 10-percent energy investment tax credit in the Energy Tax Act of 1978 (Public Law 95-618, now expired) was found to have had minimal effect on the industrial sector, as did the accelerated cost recovery provisions of the Economic Recovery Tax Act of 1981 (Public Law 97-34) under then prevailing conditions of high interest rates and low demand growth. The most significant shifts in energy efficiency were found to have arisen from the availability of low-cost capital that made investment in capital-intensive technologies, such as cogeneration and heat recovery devices, more attractive. It is conceivable that in an emergency, high energy costs would make investments so attractive for major industrial oil users, that additional financial incentives would have only marginal impacts.

As in the utility sector, there are several oil replacement policies that if adopted in advance of an oil supply crisis could enhance industry flexibility in responding to an oil shortfall. In an actual oil shortage there may be few effective policy options, other than emergency oil use restrictions and allocations, that could achieve significant near-term oil savings over those triggered by higher oil prices.

[16] OTA has a currently ongoing project on industrial energy efficiency which will include more detailed policy options.

[17] U.S. Congress, Office of Technology Assessment, *Industrial Energy Use,* OTA-E-198, June 1983, available from the National Technical Information Service, Springfield, VA 22161 (order #PB 83-240 606), chs. 1 and 3.

Promoting Technology Development

The major oil-intensive industries have a vested interest in and a commitment to improving the availability of oil replacement options and their efficiency of oil use. Smaller companies and specialized manufacturers may not have the same resources for technology development. DOE's active Industrial Energy Conservation Program supports R&D, technology transfer, energy audits, and industrial energy education and outreach programs. Congress may wish to use the oversight and appropriations process to assure that DOE's programs give sufficient attention to oil-saving technologies. Congress could also encourage the inclusion of oil-saving and energy-efficient technologies in the RD&D and outreach activities of other agencies that support energy-related research of particular importance to the industrial sector, including the Department of the Interior (Bureau of Mines), the Department of Transportation (Federal Highway Administration), the Department of Commerce, and the Department of Agriculture.

Reducing Waste

Potential savings from process changes and alternative feedstocks include the recycling of plastics, used oil, and old tires. All of these have some potential oil and energy savings, although we have not examined them in detail. Recycling efforts have largely been driven by waste disposal concerns. Congress could require manufacturers of these products to establish programs to recycle a portion of their output either as a replacement for virgin material or as waste-derived products.[18] This might be coupled with restrictions on landfilling, incinerating such waste, or waste-end taxes. Because of the myriad of technical and implementation hurdles that must be overcome for significant savings to occur, this may not be a particularly effective near-term oil replacement option, and may be better suited to a long-term strategy; however, the added urgency of an oil crisis might provide the necessary impetus for government, industry, and consumer cooperation to overcome these obstacles.

Transportation Sector

The U.S. transportation sector is virtually locked into oil as its dominant fuel for all but the very very long term and faces significant challenges in cutting oil demand. Nevertheless, given the large amount of oil used (60 percent of total demand), even small improvements can make important contributions to more efficient oil use. Improving motor vehicle fuel economy and shifting from gasoline to other fuels also offer the prospect of reduced emissions of harmful pollutants.[19] The transportation sector has already made some efficiency improvements, spurred by higher prices, voluntary conservation, and government programs, but progress has not been as great as some, including, OTA, once hoped.

With aggressive conservation measures, and the cooperation of government, industry, and consumers, it is technically feasible to cut oil use in the transportation sector by over half a million barrels per day (B/D) within 5 years in response to an import crisis. 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. cutting or limiting the increase in vehicle 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. Because no single policy will provide the full savings, a combination of options seems warranted.

The possible policy options for implementing this strategy are varied, and many are controversial. Some of the most commonly suggested alternatives for each goal are discussed briefly below. A detailed analysis of each of these options is beyond the scope of this report; however, as noted, several of them are examined in other OTA studies.[20]

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[18] See ch. 3 of this report and U.S. Congress, Office of Technology Assessment, ***Facing America's Trash: What Next for Municipal Solid Waste?*** ***OTA-E-424*** (Washington, DC: U.S. Government Printing Office, October 1989).

[19] U.S. Congress, Office of Technology Assessment, ***Replacing Gasoline: Alternatives for Light-Duty Vehicles, OTA-E-354 (Washington,*** DC: U.S. Government Printing Office, June 1990).

[20] See Rep/acing *Gasoline,* ibid., and *Changing by Degrees,* supra note 4, ch. 5. The potential for additional improvements in auto fuel economy being examined ina separate OTA report, ***Improving Automobile Fuel Economy: New Standards, New Approaches,*** scheduled for publication in October 1991.

Improving Light-Duty Vehicle Fuel Efficiency

Among the competing options for increasing LDV fuel efficiency are the following: relying on a combination of higher (shortage-induced) market prices, taxes, and rebates to create price signals that influence consumer choice; strengthening Federal fuel economy standards; and requiring fleet operators (including Federal agencies) to purchase more fuel-efficient vehicles. There is considerable debate about the relative effectiveness, political viability, and appropriate balance of these approaches.

Influencing Consumer Choice Through Price Signals—A market-oriented approach using various mechanisms to affect the front-end and life-cycle costs of cars and light trucks is based on the assumption that consumers will choose more efficient vehicles in response to such price signals. In addition to allowing gasoline prices to rise freely in response to a supply shortage, possible mechanisms 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. (Congress raised gas guzzler taxes at the end of the 101st Congress.) 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.[21] Tax-based measures pose the problem of setting a rate high enough to be effective while still being acceptable and nonregressive. Rebates raise questions of funding sources and potential windfalls for consumers who would have purchased efficient vehicles anyway.

Strengthening Federal Vehicle Fuel Economy Standards--Amending Federal vehicle fuel efficiency standards to require new cars and light trucks to attain maximum fuel economy levels under available technology would offer some oil savings even without substantial changes in fleet mix and consumer preference. These savings would begin to be apparent within 5 years as manufacturers accelerated the application of fuel-efficient technologies. More aggressive standards could achieve greater savings, but would entail greater uncertainties, changes in fleet mix, and more disruption of manufacturers' product plans.

Some, including OTA, have suggested that the form of the fuel economy standard can be technology forcing. For example, changing the standard from an industry-wide corporate average fuel economy standard to a volume-averaged fuel economy standard would require manufacturers to increase the efficiency of all vehicles in their product lines.[22] Requiring across-the-board increases in fuel economy has been criticized as unfairly penalizing manufacturers who have already made significant gains and who face more difficult technical hurdles than those manufacturers who have lagged in adoption of fuel-efficient technology. Revised standards might favor fuel-efficient imports over domestically made models (although the addition of imported models by domestic manufacturers to their product lines and the location of foreign-owned manufacturing plants here have considerably muddied this problem). Finally, Congress faees the choice of whether to allow fuel economy credits to manufacturers for vehicles that incorporate stringent emissions controls, dual-fuel capability, or additional safety features. (Some of these issues have been addressed in OTA testimony and are included in a separate OTA report on automotive fuel economy.)

Requiring More Fuel Efficient Replacement Vehicles—Other methods of creating a market pull for more efficient vehicles would be to require fleet owners (including Federal agencies) to purchase replacement vehicles from the most efficient in the applicable size class, with stiff penalties for failure to comply and waivers for appropriate circumstances. This would be similar to provisions for alternatively fueled fleet vehicles in nonattainment areas included in the Clean Air Act Amendments of 1990. This is one area where Federal procurement policies could affect oil use, since the Federal Government is perhaps the largest purchaser of new vehicles.[23]

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[21] See *Changing by Degrees*, supra note 4, pp. 165-166, and references cited therein.

[22] 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.

[23] See u s Congress, Office of Technology Assessment, Energy *Efficiency in the Federal Government: Government by GoodExample?* OTA-E-492 (Washington', DC: U.S. Government Printing Office, May 1991).

Promoting Alternative Transportation Fuels and Vehicles

The successful commercial penetration of alternatively fueled vehicles requires:

- the manufacture or retrofit of alternative fuel vehicles in sufficient quantity,
- the development of an adequate refueling and service support infrastructure, and
- consumer acceptance.[24]

Among policy measures suggested to create a market-pull for alternatively fueled vehicles are the following: giving rebates or tax incentives to reduce the front-end costs of these vehicles compared to those of gasoline models; requiring private and government fleet operators to purchase or retrofit a minimum number of alternative fueled vehicles; and promoting industry and industry-government joint ventures to accelerate vehicle technology RD&D and commercialization. Under existing programs, the Federal Government could support continued RD&D unpromising alternative vehicle technologies, such as electric vehicles and hydrogen vehicles, that would not be commercially ready or cost-effective within 5 years, but might be within an additional 5 to 10 years.

Development of an adequate refueling and servicing network could be aided by requiring refiners and large gasoline retailers to offer a certain percentage of alternative vehicle fuels through their existing networks; and increasing alternative vehicle fuel subsidies, such as those now offered for ethanol production, and revising, as appropriate, inadvertent regu–latory impediments for commercial distribution of natural-gas vehicle fuels.

Consumer acceptance could be enhanced by better information and minimum product standards for alternatively fueled vehicles. Commercial fleet operators are highly sensitive to fuel costs and overall vehicle life-cycle costs because their fleets tend to be driven more than private vehicles. An informational program for fleet operators that set out the reliability and potential cost savings from alternatively fueled vehicles could also encourage commercial interest. Manufacturers and retrofitters could be required to warrant the performance and reliability of their vehicles and to back it up with effective customer service.

Reducing Vehicle Miles Traveled

Measures that discourage discretionary driving and encourage increased car pooling and use of available public transportation can save fuel by cutting vehicle miles traveled. Higher fuel costs (either from higher market prices or increased taxes) are believed to have some immediate impact on discretionary driving and mode choice, but the extent of such savings is unknown. Ways to reduce vehicle miles traveled include: car and van pool matching services, parking restrictions, higher parking fees, employer-based transportation, flexible or staggered work weeks, telecommuting, high occupancy vehicle (HOV) lanes, and bikeways.[25] In general, these measures require comprehensive, locally designed approaches and public and employer acceptance to be successful. Federal assistance or requirements that localities or regions develop contingency plans to reduce vehicle miles traveled might speed implementation in an oil import crisis. Through the Departments of Energy or Transportation, the Federal Government could fund additional studies of the effectiveness of such measures at cutting vehicle miles traveled and share the results with local governments.

Improving the Efficiency of Traffic Movement

Traffic management and control technologies can promote efficiency by keeping traffic running smoothly and at more fuel-efficient speeds. Measures to improving the flow of traffic include highway and street improvements to reduce congestion, such as the installation of sophisticated traffic signals, ramp meters, and redesigned intersections, as well as measures aimed at cutting the number of vehicles on the road, such as HOV lanes and staggered work hours. Strictly enforcing speed limits would also boost fuel savings. Congress could require State and local governments to give consideration to the oil savings potential of additional traffic efficiency measures in preparing transportation plans and might provide financial assistance for such planning or system improvements.

[24]For a more extensive discussion see, ***Replacing Gasoline,*** supra note 19.

[25]See ch 3 of this report. See also, ***Changing by Degrees,*** supra note 4, ch. 5.

Encouraging 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 if 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 import replacement strategy.

Increases in the market price of crude oil, and perhaps of natural gas, can be expected to accompany an oil import shortfall. These, in turn, will generally increase the level of domestic exploration and development activity. Under the expectation of a prolonged supply disruption (and presumably higher prices) the response might be greater than that seen under previous intermittent oil price disruptions.

Because of the lead times of 10 years or more involved in developing frontier production, remote areas such as the Alaska National Wildlife Refuge (ANWR) and frontier offshore areas, even if they were opened to exploration and commercial quantities of oil or gas were found, would be of little relevance in responding to a significant oil import disruption within the next decade. The best hopes for maintaining and even slightly increasing domestic oil production in the near term lie in unrecovered oil in existing fields. In a previous OTA report, ***U.S. Oil Production: The Effect of Low Oil Prices, we*** noted that:

> The great majority of oil reserves added to the U.S. inventory during recent times has come from nonglamourous sources. Fully 70 percent of the total U.S. reserves additions during 1979 to 1984 came from drilling thousands and thousands of extension and infield wells in the United States' large inventory of discovered oilfields. The potential for continuing high rates of reserve growth in discovered oil fields at relatively low cost is one key to the future of U.S. domestic oil production in a low price environment.[26]

A wide range of legislative options has been proposed to encourage domestic exploration, development, and production. In general, they 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 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 delay exploration, development, or production.[27]

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 among suppliers. All approaches raise questions about whether they would actually spur incremental production, whether they would merely provide a general windfall, and whether any increased oil profits would be plowed back into exploration.

Our technical review found that the most attractive opportunities for maintaining domestic production over the near term were sustaining exploratory and developmental drilling activity in known fields, accelerating enhanced oil recovery, bringing shut-in or marginal oil fields back into production, and limiting the premature abandonment of existing wells. 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.

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[26] U.S. Congress, Office of *Technology Assessment, U.S. Oil production: The Effect of Low Oil Prices, OTA-E-348 (Washington,* U.S. Government Printing Office, September 1987), p. 75.

[27] 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.

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. Changes in the FERC's 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.

As an alternative to increasing pipeline capacity, 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. Congress could require the DOE to review the technical, environmental, and regulatory issues associated with expanding gas storage capacity and to identify any appropriate legislative changes that may be needed.

Some areas also lack adequate local natural gas delivery systems, effectively foreclosing the gas conversion option for many potential customers. Congress might consider measures to encourage local natural gas distribution utilities and State regulatory authorities to review the adequacy of natural gas service and to seek ways to enhance the capability to add new customers. This would increase the potential for rapid gas-to-oil conversions in the event of a crisis.

Natural gas transportation fuels raise the related, but separate, issue of natural gas refueling stations for alternatively fueled vehicles and natural gas purchases by industrial and large fleet owners and service station operators. Congress and local regulatory authorities could create a special category for such operations exempting them from regulation as public utilities. In addition, Congress could ask DOE to examine whether additional incentives or Federal requirements are needed to encourage the rapid development of a natural gas transportation refueling and service infrastructure to meet the needs of private and government fleet owners.

Reexamining Oil Import Disruption Planning and Emergency Response

Because technical means alone would not be sufficient 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. As imports rise, the amount of oil needed for the SPR will also have to increase. Congress recently approved a 1 billion barrel fill level for the SPR, but this will not be reached until the late 1990s. Congress also approved the creation of oil product reserves.

In light of the recent experience with the Iraqi invasion of Kuwait, Congress may wish to consider additional refinements of the SPR system. For example, provisions authorizing the release of oil from the SPR might be clarified to allow SPR sales to respond to sharp, panic-driven increases in the price of oil, in the absence of any physical shortage. A mechanism might be added to accelerate the SPR fill rate and to raise the SPR maximum to maintain adequate levels of reserves. Additional purchases might be authorized to take advantage of low oil prices, for example. Alternative SPR financing mechanisms might also be considered.

Under the Defense Production Act and energy emergency legislation passed in the late 1970s, the President and the Secretary of Energy were given extensive authority to respond to an oil supply crisis by instituting rationing, driving restrictions, and other emergency conservation and allocation measures. Some of these authorities have lapsed, and many contingency plans were never developed fully. 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.

OTA's 1984 report noted that the Federal Government was ill-prepared to respond to an oil supply crisis, or even to monitor our 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 the event of an oil supply shortfall, the government could

rely on the investment monitoring system to determine whether the rate of oil replacement was proceeding effectively. If investments were occurring too slowly, and market intervention seemed desirable, then standby taxes and financial incentives could be activated and increased or modified, as needed, to be sufficiently effective. 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 the 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.

POLICY OPTIONS FOR REDUCING OIL IMPORT VULNERABILITY AS PART OF OTHER NATIONAL POLICY OBJECTIVES

The prospect of a prolonged and severe oil import crisis, as assumed in our technical analysis, may be remote, but not implausible—and the impacts on the economy and our way of life could be devastating. OTA has previously addressed the issue of reducing oil import vulnerability in testimony on national energy goals and in a related report on energy technologies for the future.[29] We stressed that energy security can be viewed not only in terms of a short-term contingency plan, but also from a long-term perspective embracing broader and more fundamental national goals of economic health, environmental quality, and national security. Developing a national energy strategy requires a delicate balancing of energy security with these other objectives. Some energy options advance all three national goals. Others, particularly those that improve efficiency of production and use, 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 solutions 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. A major turnover of the existing capital stock of energy supply and consuming equipment will take a longtime. 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 more significant savings over the longer term than they do as short-term replacement options. For example, improving 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. Over the longer term, new technologies, such as electric vehicles and fuel cells, could reach commercial viability. In short, a long-term oil replacement strategy offers more technology options than a crisis scenario.

Setting National Energy Policy Goals

We can ease oil import vulnerability 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. A sensible, comprehensive energy policy must, of course, be responsive to sudden changes of events, but it must be fundamentally grounded in long-term strategies.

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[28] 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 Printing Office, September 1984) available from the National Technical Information Service, Springfield, VA22161, (order #PB 85-127 785/AS), pp. 26-35, p. 29.

"'Energy Policy Context for the 1990's: Considerations fora National Energy Strategy," testimony of John H. Gibbons, Director, U.S. Congress, Office of Technology Assessment, Before the House Committee on Energy and Commerce, Subcommittee on Energy and Power, Feb. 20, 1991. "On Energy Perspectives," testimony of John H. Gibbons, Director, U.S. Congress, Office of Technology Assessment, Before the House Committee on the Budget, Oct. 24, 1990; and testimony of John H. Gibbons, Director, U.S. Congress, Office of Technology Assessment, Before the Senate Committee on Energy and Natural Resources, Oct. 2, 1990. U.S. Congress, Office of Technology Assessment, *Energy Technology Choices: Shaping Our Future, OTA-E-493* (Washington, DC: U.S. Government Printing Office, July 1991), chs. 1 and 5.

The time may have come to make an explicit commitment to a smooth, multidecade transition to the post-fossil fuel age while constantly advancing our energy efficiency. Doing so at minimum cost will require several decades to stabilize our dependence on imported oil, and possibly a century, to get beyond fossil fuels. Our long-term economic, environmental, and national security future could well depend on the success of these transitions, and the specter of global warming could greatly foreshorten the time in which we once thought we could depend on fossil fuels. The relationships among the long-term goals of economy, environment, and security provide some important guiding principles—principles from which a systematic, integrated, and comprehensive energy strategy that is responsive to all three goals can logically follow.

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. To establish a comprehensive national energy strategy, Congress could set broad, long-term energy policy goals and approve the implementation plans and programs submitted by the President and the Secretary of Energy (these implementation programs 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 of our progress in attaining our targets and to 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. diversifying 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 (energy per unit of domestic output) by 20 percent per decade or an average of 2 percent per year;
4. initiating along-term transition to a post-fossil economy by reducing carbon intensity by 10 percent in each of the next two decades (equivalent to an average reduction of 1 percent per year);
5. improving the efficiency of the U.S. transportation sector by increasing light-duty vehicle 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 comprehensive national energy policy 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 programs would be to identify and advance promising technologies to achieve these national energy goals.

Capping Oil Imports

Dramatic and sustained efforts would be required to hold down oil import dependence over the next several decades-even to a level of 50 percent. There are major opportunities to improve efficiency in all sectors and to shift industrial, residential, and commercial oil use to other sources such as natural gas or electricity. Capitalizing on these opportunities can provide good jobs and boost domestic economic activity. To the extent that we improve efficiency, supplies will last longer, economic competitiveness will improve, environmental problems will be eased, and international tensions will be lessened. Supply--side mechanisms to limit import dependence include sustained domestic oil and gas production and the development and production of alternative transportation fuels.

Diversifying World Oil Production

The growth of oil production outside of the Organization of Petroleum Exporting Countries and the Middle East has lessened the ability of single nations to cut off world oil supplies and tempered the pros-

pects for prolonged price disruptions. Surge production in areas outside of the Persian Gulf helped offset the loss of Iraqi and Kuwaiti oil, for example. Because oil is a globally traded commodity, the United States can encourage, to a certain extent, the oil development efforts of other nations, thus easing pressures on world markets and prices. This can often coincide with other policy objectives. For example, helping the Soviet Union expand its oil production could have several benefits. First, the Soviet Union contains major sedimentary basins that offer great potential for exploration and development Second, success in increasing Soviet oil exports would not only diversify world production (and possibly U.S. imports) but also would provide the Soviets with the hard currency so badly needed to maintain peaceful progress toward a viable market economy. The Soviets are already significant oil exporters, but economic difficulties in that nation have threatened continued production. One prominent energy analyst has even suggested that the next oil shock might originate not in the Mideast, but in the loss of Soviet exports.[30] There are also opportunities to assist petroleum development in sister nations in the Western Hemisphere through technology transfer and joint ventures in research, exploration, and production. Massive reserves, for example, exist in Venezuela, some of which (e.g., the heavy oils in the Orinoco Basin) can benefit from further research.

Improving Energy Efficiency

OTA's studies over the past decade have consistently shown that energy efficiency is an essential cornerstone to a comprehensive energy policy framework. Overall energy intensity of the U.S. economy fell 2.5 percent per year over the last decade, most of which was due to improved efficiency. The growth in electricity use, historically greater than that of the economy, has fallen back to the same rate of change as the GNP. Moreover, these efficiency gains have generally come about with net cost savings. Considerable gains in future energy efficiency are still possible in all sectors of the economy using existing technology. Even greater savings in cost and efficiency will be possible with technologies under current R&D. A goal of sustained energy-efficiency improvement of 2 percent per year for the next two decades is realistic for the United States. With more vigorous research on energy efficiency, coupled with leadership and investment, this goal can be met or exceeded—and with options that are no more costly than pursuing the supply-side path. Moreover, pursuing such a goal appeals to all three policy interests of economic health, environmental quality, and national security.

Long-Term Transition to a Post-Fossil Economy

For decades we assumed that fossil fuels could supply our energy needs for several more centuries. Thus our major commitment to a nonfossil future has been our work on harnessing nuclear power-fission and fusion. While nuclear fusion remains a frustrating and elusive goal, nuclear fission now accounts for 20 percent of U.S. electricity generation, or about 8 percent of our total primary energy budget. Other nonfossil sources (mostly hydroelectric power) add another 4 percent, so our present nonfossil energy production is about 12 percent. But the nuclear fission enterprise, for several reasons, is in deep trouble—so deep that rescuing it could well be more difficult than the original task of creating it. And our long-term efforts to harness solar energy-directly or indirectly through wind, biomass, hydropower or other means have been very limited.

The rising specters of air pollution and climate change casts an ominous shadow over the fossil era, accelerating its possible demise to within a century or less. This means that unless we ignore, at our peril, global climate change we must consider solar and nuclear power (both fission and fusion) as new, potentially globally dominant energy sources, perhaps within 50 years. Developing and preserving nuclear and solar options will entail long-term commitments of research, development, and investment that requires us to begin that odyssey now.

With this imperative, a candidate goal for U.S. energy policy is to reduce the carbon intensity of our energy use on average 1 percent per year for the next two decades. The number we choose for this goal is less important than the will to pick a number and vigorously pursue it with a multipronged commitment to technology research, development, demonstration, and commercialization across all energy sectors. Energy efficiency improvements would domi-

[30] Daniel Yergin, "The Next Oil Surprise," *The New York Times Magazine*, part 2, Dec. 2, 1990, pp. 8,26.

nate the first decade, securing time to allow alternative transportation fuels and alternative, nonfossil sources for electric power generation to develop systematically and efficiently.

Improving Energy Efficiency in Transportation

OTA believes that there is a substantial potential for further fuel economy in transportation through purely technological means (i.e., without major changes in consumer choice), but the magnitude of this potential within the next decade is less than we would like. Our best estimate for this potential is for a new car fleet fuel economy in the absence of a crisis of about 30 miles per gallon (mpg) by 1995 and 37 mpg by 2001, both values measured according to the EPA's test procedure.[31] Longer term progress, beyond the year 2000, could be much greater if strong continual incentives for fuel economy are brought to bear on the industry. If Congress believes that even larger gains in fuel economy are necessary beyond that which can be achieved with strictly technical fixes, it could mandate a basic shift in the size and performance of the fleet either through regulatory or economic means.

Cutting Oil Dependence in Transportation

Non-oil-based liquid fuels are 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 gasolines shows 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—and from biomass should be capable of substituting for a significant fraction of transportation petroleum use. The worldwide resource base for natural gas is very large, and considerable volumes of undeveloped gas resources exist outside of the Middle East, including large volumes in the Soviet Union. Electric vehicles, perhaps employing not only batteries but fuel cells or other hybrid engines, could also be important possibilities in some regions of the United States. This, of course, depends on the pace of R&D and the constraints on other options. The pace of progress is promising. For example, California has passed legislation requiring deployment of some "ultra-low polluting" vehicles, which should force commercialization of alternatively fueled vehicles.

In the long term, we must chart a course beyond fossil fuel dependence in transportation-that means electricity and hydrogen, both obtainable from nuclear and solar sources. But both have serious cost, engineering, and political constraints and will require a major development effort. Over the next several decades, however, these options could greatly diminish greenhouse gas emissions by progressively replacing fossil-based transportation fuels. Developing the technology, the support infrastructure, and consumer acceptance of nonfossil vehicles will be a formidable challenge.

CONCLUSION

In confronting the prospects of continuing oil import vulnerability, the United States has three choices. We can continue on the current path and wait until the next disruption occurs before deciding on further action. 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. Or, we can begin now to craft a more comprehensive national energy strategy that embraces a long-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 goals. 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.

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[31] Steven E. Plotkin, Senior Associate, U.S. Congress, Office of Technology Assessment, "Estimating Levels of Corporate Average Fuel Economy," testimony before the Senate Committee on Energy and Natural Resources, Mar. 20, 1991.

32 *Replacing Gasoline*, supra note 19.