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ENERGY SECURITY

A REPORT TO THE PRESIDENT
OF THE UNITED STATES

UNITED STATES DEPARTMENT OF ENERGY
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FOREWORD

President Ronald Reagan's concern for and commitment to U.S. energy security has been unswerving since his first day in office. Only a week after becoming the Nation's chief executive, President Reagan eliminated the Federal price and allocation controls on oil, which were discouraging exploration and development of petroleum. Since then the President has acted to strengthen the domestic energy industry, to rebuild international energy alliances, and to build the Strategic Petroleum Reserve as a safeguard against an oil supply interruption.

The following Department of Energy review of our energy-related national security interests, *"Energy Security," was conducted at the request of President* Reagan in response to his concern over declining domestic oil production and rising oil imports. It reviews and projects the nature and scope of our energy security concerns. The domestic and international dimensions of energy security are examined, and all of the Nation's principal energy resources are evaluated. Finally, this report weighs the costs and benefits of a full range of policy options for meeting our energy security objectives.

The Nation faces new challenges today to its energy security—and new choices. Under the President's leadership, the Nation has made great progress in building a stronger foundation of energy security in response to the energy crises of the 1970's. However, despite many gains, America is at another equally critical juncture in the state of its energy security. The crisis in the domestic petroleum industry, an industry that is critical to our energy security, is taking an enormous toll and is creating serious problems for the future.

Energy security considerations carry tremendous weight and are cause for deep concern for every American. We cannot afford to be complacent. Energy security is a vital part of the foundation on which our foreign and domestic policies—and our economy—rest. As a Nation, we must recognize the warning signs and take thoughtful and prudent action that meets our responsibility to consumers, industry, and the Nation alike. I strongly commend this report to members of the Administration and Congress, and to the American people, as a focal point for serious discussion. This study provides a solid, technical data base and options for further action by the Administration and Congress to preserve energy security.

John S. Herrington

John S. Herrington
Secretary of Energy

ENERGY SECURITY

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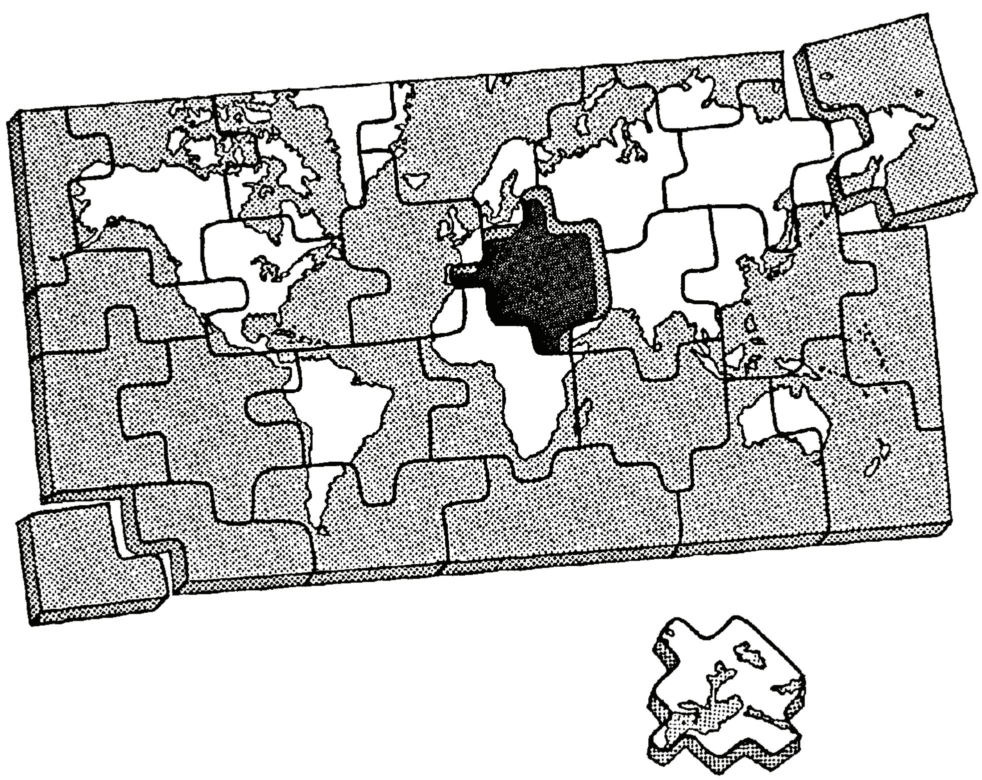
WORLD ENERGY OUTLOOK: ECONOMIC AND SECURITY IMPLICATIONS



THE SITUATION IN BRIEF

Supplies of energy are abundant in the world today, and prices are relatively low; but trends are emerging that raise serious concerns.

When oil prices fell precipitously during 1986, this brought good economic news to oil consumers—and, in fact, to users of *all* forms of energy. Partly as a consequence of lower oil prices, however, the world as a whole will turn once again toward countries in the historically unstable Persian Gulf region—where most low-cost oil reserves and currently unused production capacity are located—to fulfill vital requirements for oil. Growing dependence on Persian Gulf suppliers has important implications for the economic, foreign policy, and national security interests of the United States.

The world still gets nearly half of all its energy from oil, and this fuel accounts for well over 40 percent of U.S. energy use. Thus, it is understandable that oil is the most important component in this world energy outlook. Oil prices and oil supply—as these stand now and as they might develop—are clearly related to the way people use and plan to use any kind of energy.

By 1985, a buyers' market had emerged for oil and other energy resources. Prices for oil and competing fuels had dropped substantially from the heights attained in 1981. Oil consumption in the industrialized countries was falling, even while their economies expanded. In 1986, consumers reaped more advantages from this market shift. Oil prices plummeted from about $25 per barrel in January to about $11 in July and then partially recovered—to over $17—by early 1987.

As a direct result of this price drop, inflation was lower than expected (reaching the lowest point in 25 years in the United States), and this led to lower interest rates worldwide. These developments were welcomed by those less developed countries that are oil importers and already heavily in debt. In all countries, businesses and consumers were able to use more oil at lower prices. As they spend and invest the resultant savings, the world economy should expand further—providing more jobs and higher incomes. On the other hand, petroleum is a depletable resource with a record of price volatility. There are good reasons to anticipate a return to higher fuel costs at some point.

More important, not everyone benefited from falling oil prices. In particular, oil producers in the United States and other countries saw their revenues and profits sharply reduced. The industry responded by a drastic retrenchment, laying off thousands of skilled people and cutting back on exploration for and development of new oil reserves. Various other business sectors—including the firms that build drilling rigs and numerous kinds of oil-field service companies, as well as many banks, industries, and supporting community enterprises in oil-producing areas—faced bitter financial difficulties. The debt problems of Mexico, Nigeria, Venezuela, and other oil-producing countries loomed even larger than before.

The most pressing question raised by the oil price collapse is what will happen if the United States and its principal allies and trading partners become much more dependent on oil supplies from the Persian Gulf region and from other countries that are members of the Organization of Petroleum Exporting Countries (OPEC), which has consistently tried to control prices by mutual agreement among major suppliers.

In conducting this study, the Department of Energy (DOE) developed a range of projections for energy markets over the next decade. The key projections show U.S. oil imports increasing from 5.2 million barrels per day (about one-third of the Nation's oil consumption) in 1986 to between 8 and 10 million barrels per day (about one-half of projected consumption) in the 1990's. Other countries' oil imports are projected to rise as well. At present, almost two-thirds of the free world's oil reserves are in just five countries: Saudi Arabia, Kuwait, Iran, Iraq, and the United Arab Emirates. Furthermore, more than two-thirds of the 10 million barrels per day of oil production capacity that is currently unused lies in the Persian Gulf region. As countries increasingly choose to import oil from these obvious sources (which can afford to sell it at comparatively low prices and still make a good profit), this region's share of the world oil market is projected to rise from less than 25 percent now to between 30 and 45 percent by 1995. The market share for all OPEC countries is projected to rise from 40 percent to between 45 and 60 percent. This is comparable to the percentage shares controlled by OPEC in the 1970's.

Although dependence on insecure oil supplies is thus projected to grow, energy security depends in part on the ability of importing nations to respond to oil supply disruptions; and this is improving. The decontrol of oil prices in the United States, as well as similar moves in other countries, has made economies more adaptable to changing situations. Furthermore, the large strategic oil reserves that have been established in the United States (and, to a lesser extent, in other major oil-importing nations) will make it possible to respond far more effectively to any future disruptions than has been the case in the past.

The current world energy situation and the outlook for the future include both opportunities and risks. The oil price drop of 1986 showed how consumers can be helped by a more competitive oil market. If adequate supplies of oil and other energy resources continue to be available at reasonable prices, this will provide a boost to the world economy. At the same time, the projected increase in reliance on relatively few oil suppliers implies certain risks for the United States and the free world. These risks can be summarized as follows:

- If a small group of leading oil producers can dominate the world's energy markets, this could result in artificially high prices (or just sharp upward and downward price swings), which would necessitate difficult economic adjustments and cause hardships to all consumers.

- Revolutions, regional wars, or aggression from outside powers could disrupt a large volume of oil supplies from the Persian Gulf, inflicting severe damage on the economies of the United States and allied nations. Oil price increases precipitated by the 1978-79 Iranian revolution contributed to the largest economic recession since the 1930's. Similar or larger events in the future could have far-reaching economic, geopolitical, or even military implications.

The challenge for policymakers is to find the proper balance between relying on free and competitive markets, where they can exist, and taking appropriate, cost-effective action to ensure the Nation's economic health and national security. This is a sensitive and difficult task, but it *can* be accomplished.

LOWER OIL PRICES BRING ECONOMIC BENEFITS BUT ALSO RAISE SECURITY QUESTIONS

INFLATION AND INTEREST RATES FALL WHILE NEW JOB OPPORTUNITIES COME WITH EXPANDED OUTPUT

In general, the lower world oil prices that have prevailed since early 1986 have had a positive effect on the economies of the developed countries, which use substantial amounts of petroleum in transportation, industry, businesses, and homes.

- Having ample supplies of energy available at lower cost provides more fuel and feedstock for numerous industries—resulting in more products for final consumption.
- As automobile owners, households, and businesses spend and invest the money they save through lower fuel costs, the economy should grow overall. This generates more jobs and higher incomes.
- Lower prices for oil products (as well as for competing fuels, such as natural gas and coal) dampen inflation. This, in turn, helps to keep interest rates down.
- In many countries, taxes on oil consumption have reduced the benefits consumers actually receive from lower oil prices; but this has not been the case in the United States, where it has been the Administration's policy to pass such benefits along fully to consumers. The average American car owner spent about $165 less to fuel his or her automobile in 1986 than in 1985.

Not everybody is affected in the same way by lower oil prices, however, because substantial income is being transferred from oil and gas producers to consumers whenever prices decline. This transfer occurs both within countries and between countries. Certain countries (such as Norway) and some regions within countries (such as the oil-producing States in the United States) have suffered as a result of the recent drop in world oil prices.

In the United States, lower oil prices have particularly helped certain energy-intensive industries:

- **The chemical industry** is one of the most energy-intensive. Oil and natural gas (both as fuel and feedstocks) account for 50 to 70 percent of the total manufacturing costs for some basic chemicals.
- **The airline industry** is highly sensitive to oil prices. Even at current low prices, fuel accounts for a quarter of this industry's costs.
- **The trucking industry** also uses large quantities of oil. Ups and downs in the price of oil easily make trucking less or more competitive, as compared with alternative forms of transport.

Lower oil prices also benefit less developed countries (LDC's) in general, although in this case the effects are less uniform:

- All LDC's stand to gain from faster world economic growth, from lower inflation, and from lower interest rates.
- For oil-*importing* LDC's (such as the Philippines and South Korea) lower oil prices also have improved the terms of trade and freed up foreign exchange for additional debt service, new investment, and consumption.
- Many oil-*exporting* LDC's have suffered, however. This is particularly the case for some oil-producing countries that are deeply in debt—such as Egypt, Mexico, Nigeria, and Venezuela.

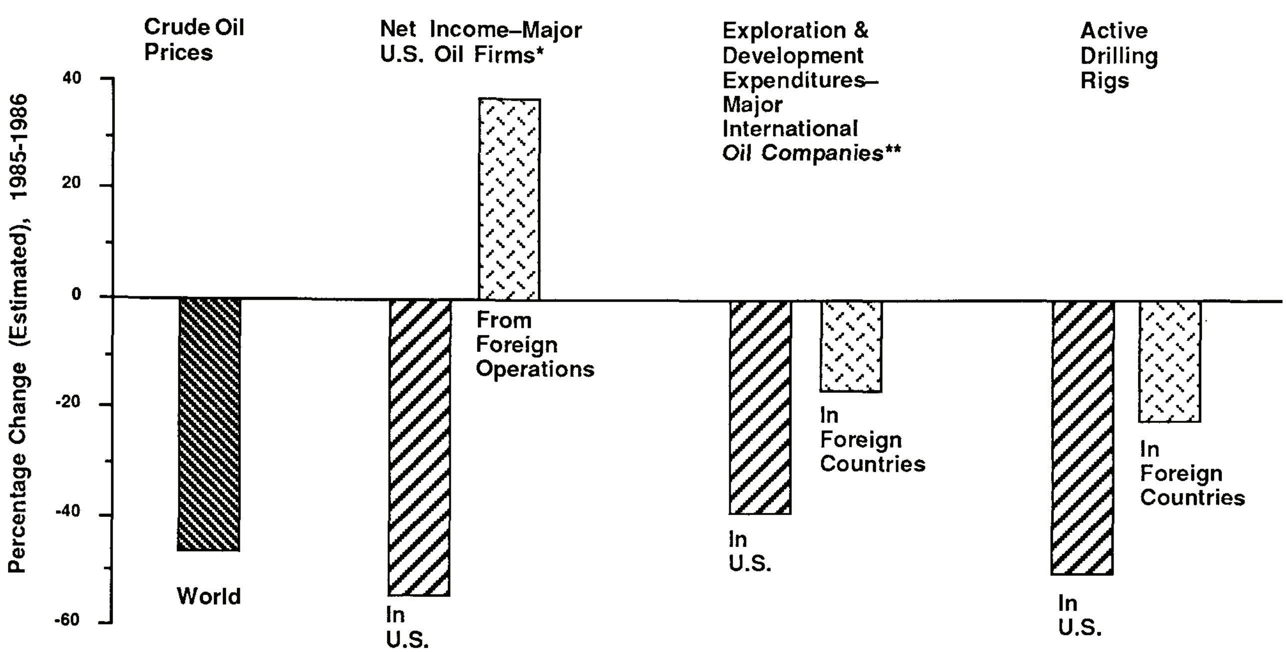
THE COLLAPSE IN OIL PRICES BRINGS PAINFUL ADJUSTMENTS TO THE WORLD OIL INDUSTRY

The world oil industry has been subject to boom-and-bust cycles thoughout its history; but it suffered one of its most severe setbacks in 1986, when the prices for its products plummeted.

The worldwide net income of the 22 largest U.S. oil companies was 54 percent lower for the first three quarters of 1986 than it had been during the first three quarters of 1985. This decline has been concentrated in the companies' domestic oil and gas production activities. Independent oil and gas producers in the United States experienced especially large net income losses in 1986, and many companies failed. Improved profit margins in the refining part of the business offset some of the net losses for integrated oil companies, and independent refiner/marketers even saw an opportunity to make significant profits. However, worldwide exploration and development expenditures by large oil companies in 1986 were about 30 percent lower than in 1985. This decline was largest in the United States (almost 40 percent), while it was almost 20 percent elsewhere in the world. A further decline is expected for 1987, although it should be smaller.

Reduced spending by oil companies has particularly affected oil service industries such as drilling-rig construction firms and oil-field services companies, which showed large losses in net income for 1986. U.S. drilling contractors experienced a 37-percent decline in revenues during the first three quarters of 1986, compared to the same period in 1985, while drilling equipment and service companies suffered a 22-percent decline.

Price Drop of 1986 Hit Oil Business



* January through September data
** Estimated

Sources: Energy Information Administration, Oil and Gas Journal, Salomon Brothers, Inc.

Related industries, such as the manufacturers of tubular steel, also have been harmed.

Competitive price-cutting by the companies that service the oil industry has combined with lower interest rates to reduce the costs of new exploration and development, but so far this has not been enough to offset the cutbacks by oil companies in the fresh capital expenditures they were willing to commit as their oil-price outlook dimmed. Thus, less exploration and development are being pursued. It was estimated that about 2,200 oil drilling rigs were in active service throughout the world at the end of 1986; this was about 40 percent lower than the 3,500 operating rigs at the end of 1985, and 65 percent lower than the 6,200 rigs that had been operating at the end of 1981. The falloff in the rig count since late 1985 has been largest in the United States (about 50 percent) and smaller in other countries (about 20 percent). A small additional drop in the rig count is expected for 1987 in the United States. Drilling in the United States has fallen to pre-World War II levels.

Less near-term exploration and development worldwide means that there will be fewer additions to reserves over the next 10 years or more. It also implies less non-OPEC production during this period. Yet some factors should moderate this trend:

- Companies will tend to abandon or reduce exploration and development activities in areas where costs are high and prospects are least attractive, but such activities should continue in the most economic areas. Thus, each dollar spent or foot drilled ought to yield more oil than it might have otherwise. Also, if and when oil prices increase in the future, companies will become more active again in areas where potential is known to be high.

- This means that, in general, high-cost oil reserves have not been lost as a result of lower oil prices; they have merely been conserved until such time that lower cost reserves are no longer available and it once again becomes attractive to develop the higher cost resources. In the distant future, this could mean more non-OPEC production.

- Many governments, both in developed and less developed countries, have changed or are considering changing the level of taxes or royalties charged to companies producing oil on their territory. These and other regulatory changes can reduce costs and provide a more attractive environment for investment.

- Intensified competition among oil companies and the pressure of smaller budgets may encourage innovations that will reduce costs. The net result could be a smaller but more efficient world oil industry.

Despite these moderating factors, the industry as a whole has suffered appreciable damage. Many skilled workers have been laid off, and large quantities of specialized equipment have been mothballed. It is unclear how this leaner worldwide industry will be able to respond if and when oil prices rise sharply again.

- On the positive side, history shows that the oil industry responded very rapidly to the price increases of the 1970's, even though it had experienced a sustained decline in activity from 1956 until 1971; and there are several factors that could make a future response even faster. Future price increases are likely to occur in an environment of a larger overall economy and in the absence of oil price controls. Furthermore, geological work and technological developments completed during the previous industry expansion will still be available for use.

- On the negative side, the precipitous price decline in 1986 has caused more structural damage than the 1956-71 slump (for example, the disappearance this time of many independent operators), and the recent experience of price volatility—and particularly a sudden 50-percent collapse in prices—may significantly deter investment decisions that ordinarily might follow a future price rebound.

Regardless of how quickly the industry responds in the future, 5 to 10 years are likely to elapse between each new investment decision and any actual production resulting from it.

THE PROSPECT OF RISING OIL IMPORTS WORLDWIDE HAS ECONOMIC AND TRADE IMPLICATIONS

Oil is a vital resource for fueling the U.S. and other countries' economies. Oil prices and the level of oil imports have important implications for each individual economy and for international trade.

Lower oil prices bring many immediate economic benefits for the U.S. economy, but are expected to encourage higher imports in the future. Eventually, this may pave the way for a reversal of the price decline that occurred in 1986. Excess capacity in OPEC countries will be reduced as the United States and other countries import more oil. This sharpens the possibility of a steep price increase at some point, resulting either from a supply disruption or from major producers' exercise of their market power.

In case of a new oil supply disruption, U.S. gross national product (GNP) could be expected to decline somewhat as a result of the short-run increase in prices; but the blow would be softened by the fact that this country and its trading partners are better prepared now for such a possibility. In the unlikely event of an extremely large, temporary disruption in supplies occurring in the mid-1990's, the GNP loss is estimated at 1 to 2 percent for a year—about the same magnitude as the recession experienced in 1981-82. In addition to the GNP loss, there would be a temporary effect on terms-of-trade, because of higher import bills during the disruption plus economic-efficiency losses. These two effects (GNP and terms-of-trade) represent different kinds of economic losses, so they are not simply additive.

As energy demand and oil imports increase, so do the potential economic losses that could result from any future disruptions in oil supply. However, higher energy demand and imports could also be associated with a higher average rate of economic growth over the next decade; and the prospective benefits might counterweigh the risks. Even if one or two major supply disruptions should take place, cumulative real income would be higher if there also had been high economic growth, high energy demand, and high oil imports than it would have been in an environment of lower economic growth, energy demand, and imports—even without any supply disruptions in the latter instance.

The price of oil and the volume of oil imports are both now projected to increase over the next decade. In the case of the United States, the bill for oil imports fell from more than $70 billion (in 1986 dollars) for 1981 to $28 billion in 1986, but now it is turning upward again. By 1995, U.S. oil imports may cost the equivalent of about $80 billion, and a similar pattern could be expected for other oil-consuming countries.

With higher revenues from petroleum sales, however, oil-producing countries might step up their demand for American-made and other foreign goods; and they might also increase their foreign investments. These actions would offset part of the balance-of-payments effects of the higher oil import bills.

GROWING RELIANCE ON INSECURE OIL AFFECTS CONDUCT OF FOREIGN POLICY

The United States and many of its allies and trading partners are likely to become more dependent in the future on imports, particularly from low-cost suppliers in the Persian Gulf. Higher import dependence would increase the risk of major supply disruptions that are damaging to our economic well-being and energy security.

This risk affects national security and the conduct of U.S. foreign policy to the extent that (1) the foreign policy actions of our allies are affected as they respond to perceived vulnerabilities and rivalries for "scarce" supplies undermine allied solidarity; (2) the

U.S. loses some flexibility in responding to disruptions, so that it becomes more difficult to reach peaceful resolutions of disputes; or (3) oil supply disruptions coincide with a major defense emergency, complicating an already troublesome situation.

A politically inspired oil embargo similar to the one organized among suppliers in 1973-74 is not considered a significant threat at present, but it could become one as oil imports increase and excess production capacity declines. However, it should also be noted that the extent of a new embargo's damage to the United States would depend on how far total oil production was cut back worldwide at the same time. Unless there were a general production cutback, an embargo directed against selected countries would have little effect.

It is because the United States seeks to limit the concerted market power of any group of producers that this country avoids multilateral producer/consumer discussions, or any other actions that might strengthen the solidarity of collaborating suppliers or otherwise improve their opportunities to control supplies or prices. At the same time, the United States tries to maintain good bilateral relations with friendly producing countries and to provide them with appropriate security assistance. All recent U.S. administrations have viewed the strategic Persian Gulf region as an area of vital security interest. This is evidenced by the creation of the U.S. Central Command (a unified command assigned to deter or oppose Soviet aggression in the Southwest Asia and Middle East region), and by the regular presence of U.S. Navy vessels in that part of the world.

Because of the integrated nature of the world oil market, U.S. energy security is inseparable from that of our allies and trading partners. Even if supply was disrupted in a producing country that did not export oil to the United States, the oil market would redirect some supplies of nondisrupted oil from the United States to countries that previously had imported oil from the sources that were now cut off or cut back. Furthermore, oil prices would rise generally all over the world, affecting oil consumers everywhere. Thus, so long as other countries in the free world are vulnerable to supply disruptions, the United States also is at risk. The United States can reduce but cannot eliminate vulnerability by reducing its own imports.

Energy security can be achieved only on a collective basis. In the event of a supply disruption, measures aimed at ensuring this country's access to oil supplies at the expense of others not only will fail, but also will encourage others to bid up the price of oil—thereby further damaging U.S. economic and security interests.

In contrast, cooperative efforts to reduce collective vulnerability give the United States greater flexibility in foreign policy and add to its national security. Efforts along these lines can include measures to reduce any country's dependence on imports and also measures that will bolster their responses to any disruptions to oil supply that might occur.

If the United States, as the world's largest user of oil, responds effectively itself, this can reduce pressure on the world market considerably and thus assist all countries. Similarly, effective measures by other consuming countries should benefit the United States. By working with its partners in the International Energy Agency (IEA) to discourage price controls and to coordinate programs for drawing down stocks and making other appropriate responses in the event of future supply disruptions, the United States is helping to minimize some sources of international tension and to maximize economic and security benefits to everyone.

VULNERABILITY TO OIL SUPPLY DISRUPTIONS HAS IMPLICATIONS FOR MILITARY PREPAREDNESS

An integral part of U.S. energy policy has always been to ensure adequate energy supplies for defense and broader national security purposes under all circumstances, both emergency and nonemergency.

During peacetime, the U.S. military establishment uses between 2 and 3 percent of the petroleum products consumed by this country. More than two-thirds of this military demand involves jet fuels, and most military requirements for energy are satisfied by procurement in the United States—although some buying is done overseas.

In a major conventional military conflict, direct military consumption would likely be two or three times the current level of just under half a million barrels per day. Nevertheless, this would still represent a relatively small proportion of total U.S. oil consumption—although the percentage share would increase if nondefense demand were constrained simultaneously by a supply disruption, which might easily be the case. Most of the incremental military demand would be overseas.

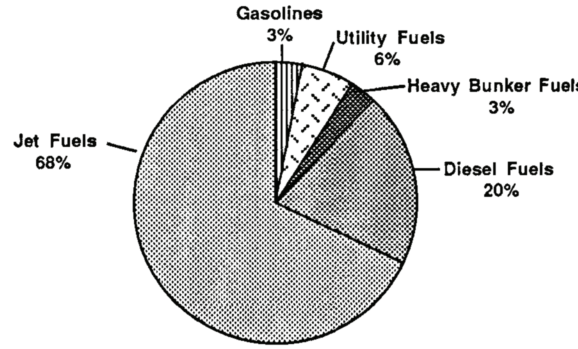
Besides direct military needs, defense requirements for petroleum in a major conventional war would include whatever was needed to mobilize the U.S. economy in producing goods and services for the war effort. The size of such indirect needs is difficult to pin down, because they would depend on the length, scope, and character of the conflict. In the event that significant defense needs could not be met fully through purchases on the open market, direct defense requirements would be met first; and, if necessary, indirect military needs would also be given priority over nondefense needs. To the extent that oil supplies were disrupted during a war, more discretionary nondefense demands would have to yield to vital defense needs.

THE CHALLENGE IS TO REAP MAXIMUM BENEFITS FROM FREE MARKETS WHILE MAINTAINING NATIONAL SECURITY

A primary purpose of this study has been to consider the national security implications of growing reliance on imports from a small group of supplying countries. Maintaining national security, which is a key role of the Federal Government, depends on three factors: a

Defense Department Demand for Petroleum, 1985

These types of fuels . . .



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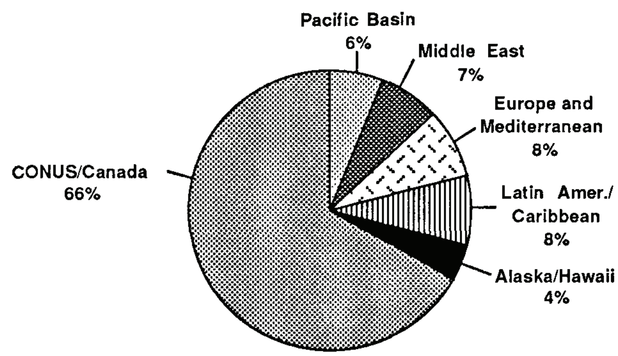


healthy domestic economy, an effective foreign policy designed to prevent aggression against our vital interests abroad or our own national territory, and a strong defense against aggression if it does occur.

Fundamentally, a healthy economy in the United States rests upon the operation of free and competitive markets. There are situations, however, where free and competitive markets do not exist . . . and other instances in which national security is particularly threatened. In considering specific governmental actions to meet such conditions, it must be recognized that a strong economy and national security are complementary goals.

Developments over the past 5 years have demonstrated that freer operation of energy markets can invigorate the economy. Oil price decontrol in the United States and the loosening of OPEC's pricing grip internationally both helped to lower fuel costs to consumers throughout the world. To summarize some of what has already been said, however, the oil market is subject to two threats that undercut the usual ground rules and thus raise special government concerns:

- **Oil Supply Disruptions:** Revolutions, regional wars, or conflicts instigated by outside powers in the Middle East could disrupt oil supplies again and cause economic hardship for the United States and other countries. In the most severe cases, our military preparedness could be affected. Furthermore, politically inspired production cutbacks by major oil producers could also hurt the U.S. economy or at least limit its geopolitical options. If dependence on certain oil producers carries with it these dangers, the government has a responsibility to take defensive action of some sort.

- **Manipulation of the Market:** Within the United States, the Federal Government tries to ensure that markets for all goods and services are competitive. There are laws that prohibit market-share agreements, price-fixing, and other forms of trade-restraining collusion among companies. There are various ways of preventing a single selling company (a monopoly) or a small group of selling companies (an oligopoly) from being powerful enough to manipulate most markets. Where such situations cannot be avoided, the Government generally regulates the activities sufficiently to protect consumers. Outside U.S. borders, however, the reach of this country's laws is limited, and their application is more problematical. In many oil-producing countries, in fact, the oil industry is controlled by the national government itself rather than by competing companies. Furthermore, the 13 national governments that are members of OPEC meet frequently to try—often with success—to coordinate their oil production and pricing policies so as to wield maximum power. Here again, to the extent that OPEC actions pose a potential threat to this Nation's economic health, the U.S. Government has a legitimate role to defend the interests of U.S. oil producers, refiners, and consumers.

It is important to remember that market competition and national security—the two central concepts here—are relative, not absolute. Pure competition and perfect security are rare conditions. In recognition of this fact, the government typically looks for policy courses that will *enhance* competition and national security rather than actions to *achieve* either one.

The best way to weigh the advisability of taking any specific government action is to compare the likely benefits (in terms of the country's economic health *and* its national security) against the costs from it that can be foreseen. A cost in one case might take the form of government expenditures that must be financed by taxes, while in another it might assume the form of regulations that clearly would distort the operation of market forces. Thus, proposed government actions cannot be judged merely on the basis of whether or not they prevent exercise of market power or make the Nation more secure. Instead, all the benefits of these actions must be weighed against all their costs—both in economics and security. Some government energy policies in the past have been far more costly than beneficial. For example, oil price controls and allocation systems enhanced neither national security nor competition, yet they inflicted large net costs on the economy and they shortchanged most individual citizens.

One basic principle of government action is to defend against harmful situations that can be avoided (such as foreign manipulation of markets) but to let the economy itself adjust to unavoidable situations (such as depletion of the Earth's resource base). Attempts to insulate a national economy from long-term, inevitable changes in the world economy generally only postpone adaptations that must take place eventually. Such attempts make the adjustment harsher when it does occur.

Once the world energy outlook is defined as clearly as possible and its implications for economic and national security have been analyzed, the challenge will be to focus on policies that allow the economy to benefit from the operation of free and competitive markets, where they can exist—and that also ensure adequate economic and national security—at minimum cost to the Nation.

OIL PRICE INCREASES IN THE 1970's CAUSED MAJOR CHANGES IN WORLD ENERGY MARKETS

ENERGY USE IS INCREASING, BUT FUEL PREFERENCES AND APPLICATIONS CHANGE

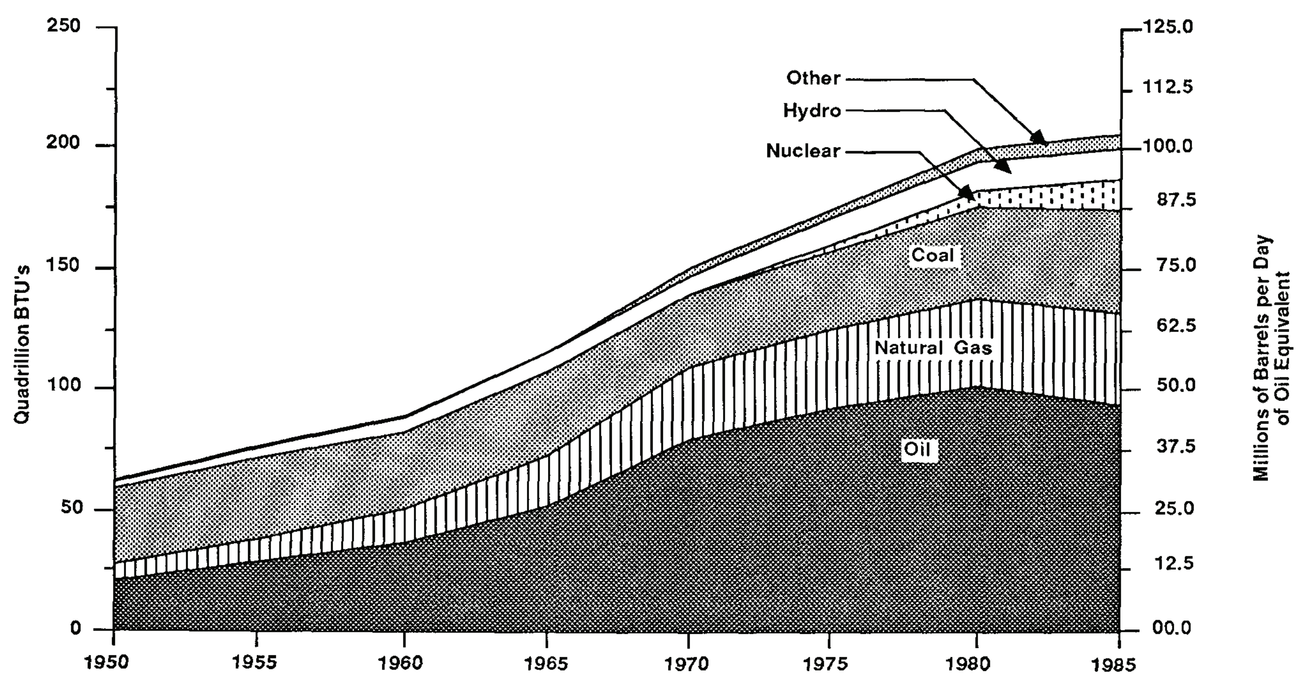
It is difficult to understand the economic and security implications of today's shifting energy markets in their global context—much less venture any projections of what might happen to them over the next decade or more—without reviewing some of the trends to date.

Free-world energy use (excluding use of traditional fuels such as wood) has more than tripled since 1950, growing at a compound annual rate of more than 3 percent. Significantly, however, energy consumption per unit of economic output has fallen sharply since 1973.

Oil has fueled most of the increase in world energy consumption since World War II. In 1950, oil accounted for less than one-third of world energy use. By 1980, oil use had grown fivefold (at a compound annual rate of more than 5 percent). In response to price increases, structural changes in the economy, and reduced economic activity in the early 1980's, however, the consumption of oil fell off sharply. Nevertheless, oil remains the world's most important energy resource. It now accounts for almost half of the energy resources being used each year throughout the world.

Coal use declined during the 1960's, but it has increased substantially since 1975. Although coal accounted for more than half of the energy used in the world in 1950, it now

Global Energy Use, 1950-1985*



***Excludes centrally planned economies**

Source: U.S. Energy Information Administration, United Nations, Shell Briefing Service accounts for only one-fifth. Coal supplies are plentiful, but demand is constrained by high capital costs and environmental concerns.

Natural gas consumption also has grown strongly over the past three-and-a-half decades. Gas use is now almost as high as coal use in the free world.

Use of hydroelectric power has increased substantially, increasing its share of total energy consumption from 6 percent in 1950 to about 8 percent today.

Nuclear powerplants began to contribute significantly to meeting the world's energy needs in the early 1970's, and by 1985 they provided about 6 percent of total energy consumption—15 percent of all electricity generated. In some countries without large reserves of fossil fuels, such as France and Belgium, nuclear energy now provides about two-thirds of all electricity production.

Technologies for using energy more efficiently have helped to reduce the need for oil and other fuels, particularly over the past 10 years. Small applications of renewable resource technologies (primarily the continued use of firewood and other traditional fuels) also have slowed growth in the use of oil, gas, and other fuels. The contributions of energy-efficiency gains are not shown explicitly in the graph on the opposite page, but their effects are reflected implicitly in the consumption levels of the resources that are shown.

In 1985, the United States used about 74 quads[1] of energy, of which about 42 percent was oil. This amounted to more than one-third of total free-world energy use. Many factors will affect future energy demand in the United States and the world, including some that remain uncertain. Projections for this study (which concentrated on U.S. energy security in its global context) considered: (1) general economic growth; (2) the changing composition and efficiency of energy-using U.S. capital stock; (3) the changing structure of the national economy; and (4) responses by energy users to changing prices of various forms of energy. Low oil prices and good economic growth are obviously both factors that usually lead to higher end-use energy demand.

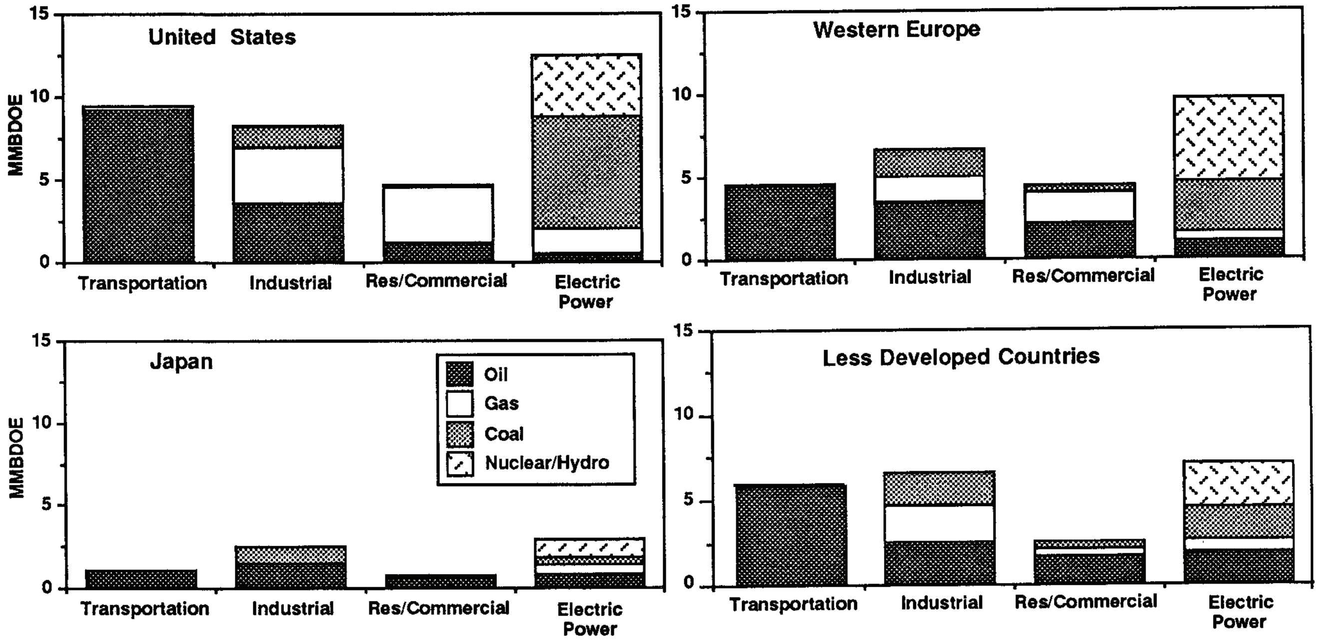
OIL PLAYS AN IMPORTANT ROLE IN ALL COUNTRIES' ECONOMIES, BUT ITS USES VARY

In the **United States**, oil use is concentrated in the large transportation sector. Industry is the second-largest oil-consuming sector. Oil use in the electric utility and residential/commercial sectors has declined in recent years to relatively low levels. Natural gas is the second-ranked fuel in the United States. The industrial and residential/commercial sectors are the most important consumers, but electric utilities also use considerable quantities of gas. Coal consumption is almost as large as gas use. Electric utilities account for more than 80 percent of U.S. coal use, and most of the remaining demand is in the industrial sector. Nuclear and hydroelectric power provide an important contribution to electric power production. (Much more detail on all aspects of U.S. energy use is given in other parts of this report.)

In **Western Europe**, oil use is more evenly divided among sectors than in the United States. The transportation sector accounts for less than half of oil use, while the industrial sector accounts for almost one-third. The residential/commercial and electric utility sectors consume more oil than in the United States. Natural gas use in Western Europe is less than one-third as large as oil use. The industrial and residential/commercial sectors account for most gas consumption. Coal use is larger than gas use in Western Europe, and it is concentrated in the electric utility and industrial sectors. Nuclear and hydroelectric

[1] "Quad" is a short term for a unit of measurement that is useful in quantifying very large amounts of any form of energy. It means 1 quadrillion (a million billion) British thermal units (BTU's). Using 1 quad of oil in a year averages out to nearly 500,000 barrels of oil per day; but "quad" can also refer to the energy content of coal, gas, or any other fuel.

1985 Consumption of Primary Energy
(Millions of Barrels per Day of Oil Equivalent)



Sources: U.S. Energy Information Administration; Lawrence Berkeley Laboratory

power combined contribute as much energy as coal, and these two supply about half of all electrical power.

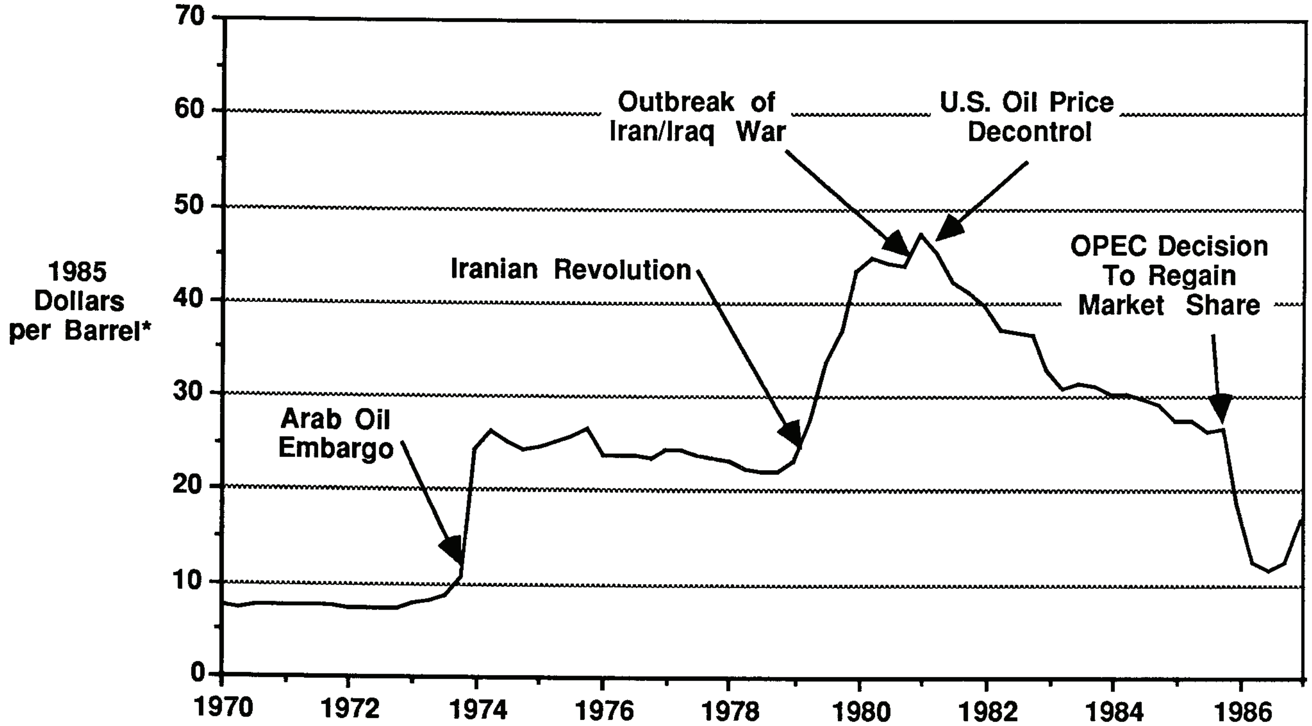
In **Japan**, the industrial sector uses more oil than the transportation sector. Oil continues to be an important fuel in the Japanese electric utility and residential/commercial sectors. Gas use is relatively small in Japan because of the lack of indigenous resources. The use of coal in Japan is concentrated in the industrial rather than the electric power sector. Nuclear and hydroelectric power account for a large part of electric power production.

In the **less developed countries**, oil accounts for more than half of all energy consumption. Sectoral details are sketchy, but the transportation and industrial sectors are estimated to be the most important. Gas consumption is fairly small in most LDC's, but it is quite important in those that are oil producers (because gas production and reserves often are associated with oil production and reserves). Coal, nuclear, and hydroelectric power account for a fairly small but growing part of LDC energy consumption, particularly in those that lack oil resources.

1970's OIL PRICE INCREASES ENCOURAGED ENERGY PRODUCTION AND MODIFIED CONSUMPTION

The real price of petroleum declined modestly during the 1950's and 1960's, and this encouraged a rapid increase in the use of oil—and of energy in general. During this period, the big integrated oil companies effectively controlled most of the oil they were producing around the world. Throughout the early 1970's, producing countries pushed with increasing vigor for higher prices; and they insisted on more direct participation in oil operations. Because it was widely expected that oil reserves in countries that were not members of the Organization of Petroleum Exporting Countries would not be able to meet the rising demand for oil, these demands carried increasing weight. The entrance of small oil companies into international

Oil Prices Reflect International Events



* Average quarterly cost of crude oil imported by U.S. refiners.

Source: U.S. Energy Information Administration

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production operations further strengthened OPEC countries' position.

As OPEC countries increased their market share further in the early 1970's, they began to set prices for their oil exports and to take control over their oil resources away from foreign companies. Finally, several events in the 1970's and early 1980's precipitated a series of sudden oil price increases, and these tended to remain in effect long after the various situations changed. These oil price increases (along with associated increases in the price of other fuels, such as natural gas) slowed the growth in energy demand and spurred energy production outside OPEC.

- At the outbreak of the Arab-Israeli War in October 1973, member countries of the Organization of Arab Petroleum Exporting Countries (OAPEC) imposed an oil embargo against selected Western countries—including the United States—and cut back their total production. The selective embargo itself had little effect, but the overall production cutbacks reduced worldwide supply briefly by as much as 3 to 4 million barrels per day. Gradually, OAPEC production rose again; but the result was a net supply disruption over a 6-month period that averaged about one-and-a-half million barrels per day. (These figures may understate the effects to some extent because they ignore the fact that demand had been projected to continue rising during this period. Taking this into account, the effective net shortfall because of reduced output from the OAPEC countries may have been as high as 4 million barrels per day.) Prices on the world market tripled—from around $4 per barrel to more than $12 per barrel. When adjusted for inflation, this price increase represents a jump in 1985 dollars from about $7.50 to about $25.00 per barrel.

- From November 1978 through April 1979, unrest in Iran eliminated up to 6 million barrels of that country's average daily production. Stepped-up production in other countries substituted for part of this disruption, but there was still a net supply loss for the world market of about two or two-and-a-half million barrels per day during those 6 months. Furthermore, the effects of this disruption lingered because of the way companies handled their inventories of oil, based on the widely held view that supplies would continue to fall short of demand and that prices would keep going up. The cancellation of long-term contracts by some companies and, in the United States, the maintenance of a system of government price controls and allocations elicited panicky reactions from smaller oil companies and from consumers. By mid-1980, prices had more than doubled—from around $14 to well over $30 per barrel. In 1985 dollars, the increase was from about $22 to more than $44 per barrel.

- The outbreak of war between Iraq and Iran in the fall of 1980 again removed 2 to 3 million barrels per day of oil from the market. Prices increased by about $4 per barrel, but in this case they soon returned to previous levels because of worldwide surplus production capacity and high inventory levels. (By January 1981, of course, the United States had ended its price controls on oil entirely.)

Each in its own way, all of these price increases spurred major efforts to reduce energy consumption, to use energy more efficiently, and to develop high-cost oil reserves and alternative energy sources. The response of the oil industry in the United States was remarkable. The number of oil wells completed each year in the United States grew at a compound annual rate of 13.1 percent, from 26,300 in 1971 to 90,000 in 1981. Employment in oil and gas production and oil-field service activities more than doubled over this period.

The decline in U.S. production was even halted. This was largely because of the completion of the Alaskan pipeline, which made available oil from the Prudhoe Bay field (discovered in 1967), but also because of a multitude of minor discoveries. For a while, thanks to drilling at all-time record rates, U.S. domestic production actually increased slightly.

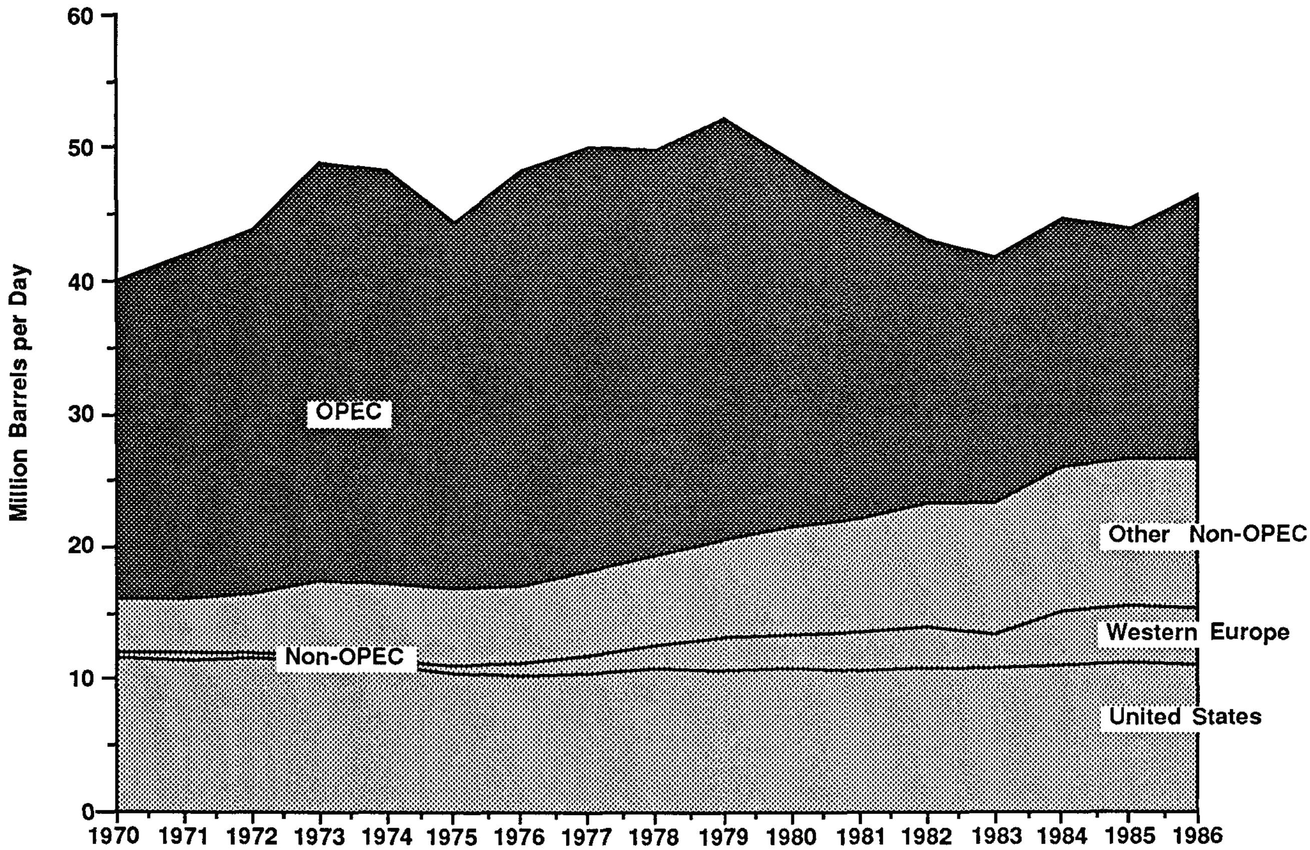
Response to high oil prices was obviously bolstered by President Reagan's action to achieve immediate decontrol of U.S. oil prices in 1981. As a result of the market response to oil prices, world dependence on OPEC oil declined from about 28 million barrels per day in 1980 to about 17 million barrels per day in 1985. Despite efforts by OPEC to sustain prices, in fact, oil prices have fallen continuously since 1981. Adjusted for inflation, average prices in 1986 were only about $5 a barrel higher than the average prices for 1973—when the whole "energy crisis" cycle began.

NON-OPEC PRODUCERS GAINED MARKET SHARE AND INFLUENCE

In response to the higher prices that OPEC was charging for its oil during the early 1980's, other sources of new oil production increasingly became available. OPEC's output dropped from more than 31 million barrels per day in 1979 to about 17 million barrels per day in 1985. By contrast, non-OPEC oil production rose from about 21.5 million barrels per day in 1980 to its current rate of close to 27 million barrels per day.

Production in the North Sea grew most rapidly, accounting for about one-third of the whole increase; and Mexico accounted for another 15 percent of the production rise outside OPEC. The price increases that had piled up during the 1970's also encouraged production from countries such as Egypt, Oman, Angola, Cameroon, Brazil, Colombia, China, India, and Malaysia. The U.S. import mix shifted dramatically during the early 1980's; imports from Mexico, the United Kingdom, and Canada each surpassed the level of imports from Saudi Arabia. But in 1986 this trend halted. OPEC countries regained part of their earlier market share—by cutting prices.

Free-World Oil Production



OPEC - Organization of Petroleum Exporting Countries

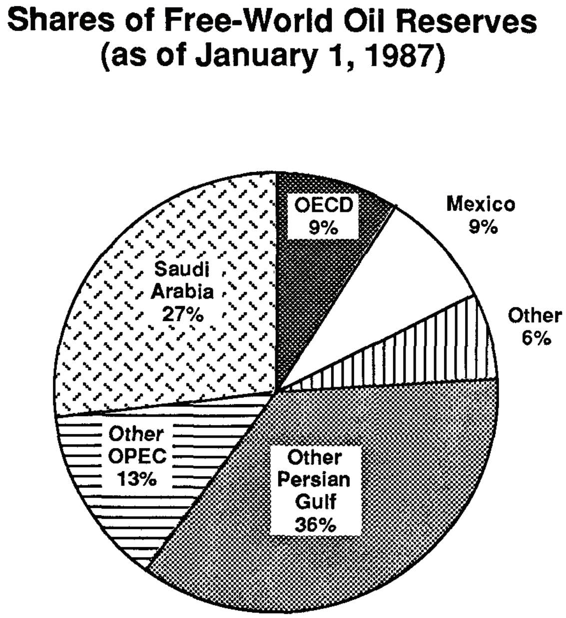
Note: Production includes natural gas liquids, other liquids, and refinery gains

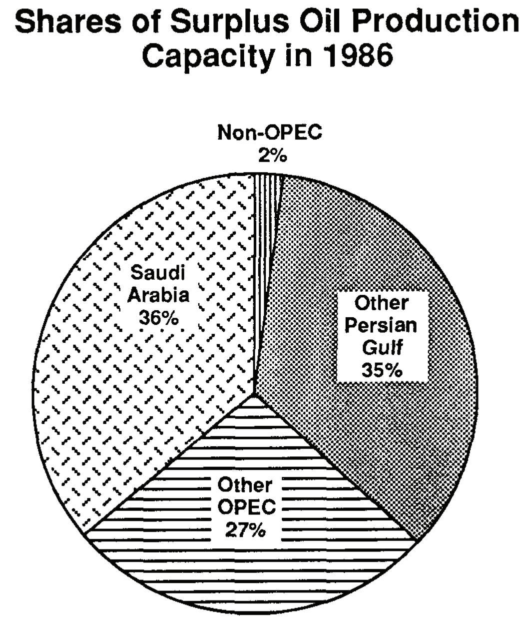
Source: U.S. Energy Information Administration

Oil producers inside and outside OPEC will continue to compete. The size of the worldwide market will be determined to a considerable extent by where the price of oil is and where it appears to be heading. Shares of any new growth in this market will gravitate normally to those areas where additional production is most readily available—considering whatever the price happens to be.

MOST OIL RESERVES AND SURPLUS OIL PRODUCTION CAPACITY ARE IN THE PERSIAN GULF

Of all the known oil reserves that can be recovered economically with current technology at today's prices, some 63 percent are in the region surrounding the Persian Gulf. Saudi Arabia has the largest reserves, comprising 27 percent of the free-world total. The most important of the other countries in the same area are Kuwait (15 percent of world reserves), Iran (8 percent), and Iraq (8 percent).





Source: Energy Information Administration

Other OPEC countries—*outside* the Persian Gulf region—hold another 13 percent of free-world reserves. Venezuela and Libya have the largest reserves in this group.

This leaves only 24 percent of world reserves in non-OPEC countries. Although the United States is the largest consumer of oil and is still the second-largest single producer, it holds just 5 percent of world reserves—only slightly more than the 4 percent share in Western Europe. Mexico, with 9 percent, has the largest oil reserves outside OPEC. The remaining 6 percent of world reserves are split up among a large, diverse group of other countries.

During the entire time OPEC was being forced to reduce production because of sales lost to others, non-OPEC oil producers generally held their own production close to the maximum levels they could sustain. As a result, most of the world's surplus oil production capacity today is in OPEC countries. OPEC is best prepared to expand output quickly now if demand grows.

Currently, the Department of Energy estimates that there are about 10 million barrels per day of surplus oil production capacity outside the centrally planned economies; and Persian Gulf countries account for about two-thirds of this. Most of the remaining one-third is in other OPEC countries—principally Libya, Nigeria, and Venezuela.

The current distribution of oil reserves and production capacity is not expected to change significantly over the next decade, although the way *surplus* production capacity is distributed could change completely as the production levels in various countries go up or down.

The Soviet Union and China hold large oil reserves that are not included in these free-world percentages. The combined recoverable reserves of oil in these two huge and populous countries account for about 10 percent of the Earth's total today. There is little surplus production capacity in either the U.S.S.R. or China, however, because both tend to produce as much oil as they can at any given time.

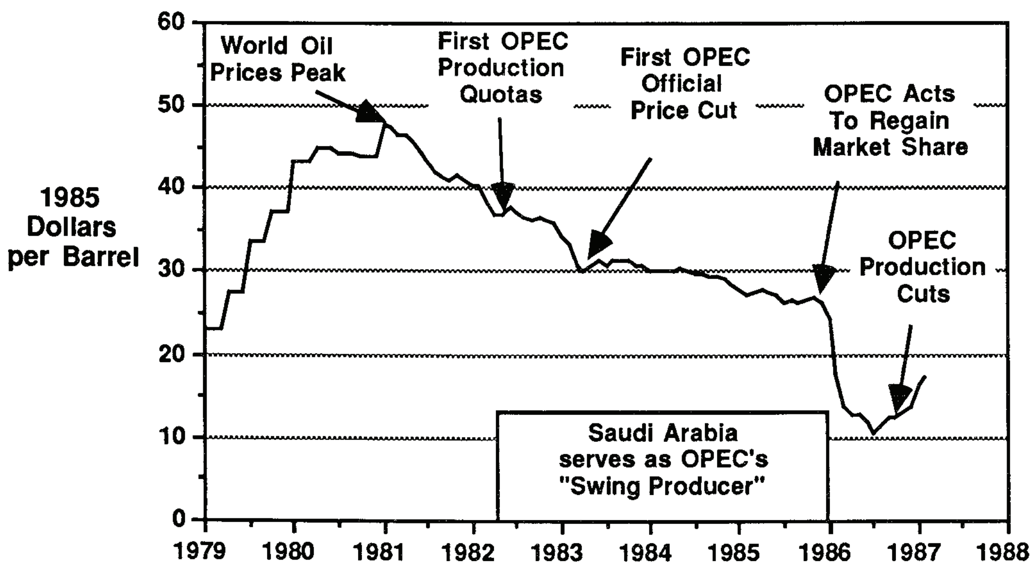
THE U.S. AND OTHER COUNTRIES ARE TRENDING AGAIN TOWARD OPEC (SPECIFICALLY PERSIAN GULF) SUPPLIERS

OIL PRICES HAVE FALLEN SINCE 1981, AND THEY DROPPED PRECIPITOUSLY IN 1986

In the early 1980's, the response of the worldwide energy market to high oil prices was to find ways of getting along with less oil and to develop new sources of this particular fuel from outside OPEC. The decision in the United States to follow a policy of reliance on market forces—epitomized by the instantaneous decontrol of oil prices in 1981—undoubtedly had global repercussions. OPEC's market share deteriorated, much of its production capacity had to be shut in for lack of buyers, and oil prices began to decline in 1981. OPEC tried to regain control of the situation by having its members observe national quotas on oil production and thus stem the price decline, but ultimately these efforts failed and prices dropped precipitously in 1986.

For about 5 years, most of the burden of cutbacks in OPEC production had been shouldered by Saudi Arabia, whose crude oil output (excluding natural gas liquids) fell from about 10 million barrels per day in 1980 to less than 2 million barrels per day in the summer of 1985. This was well below Saudi Arabia's implied OPEC quota, but Saudi Arabia was willing for a long while to serve the role of "swing" producer—voluntarily abstaining from output (and world sales) to whatever extent the rest of OPEC went beyond the production that had been agreed upon. However, the Saudis finally abandoned this role. Between August and December of that year, Saudi Arabia adopted a market-based pricing system and doubled its crude oil production from about 2.3 to about 4.7 million barrels per day. By the third quarter of 1986, the rate of Saudi Arabian production had returned to almost 6 MMBD.

Average Monthly Cost of Crude Oil Imported by U.S. Refiners



Source: U.S. Energy Information Administration

In December 1985, other OPEC nations decided to join Saudi Arabia and defend OPEC's market share through price cuts, thus directly challenging non-OPEC producers. Following that meeting, world oil prices collapsed; from about $25 per barrel in January 1986, they fell to about $10 per barrel in July. OPEC's sales could not increase enough to offset a price decline of this magnitude, however, and OPEC countries' oil revenues fell dramatically. Some OPEC members began to call for renewed production cuts and a return to somewhat higher prices—so that their total revenues could rise again.

In August 1986, OPEC reached a temporary agreement to reduce production by several million barrels per day through October 1986. Oil prices increased to $13-$15 per barrel, and they remained fairly stable as OPEC extended the agreement until the end of 1986.

In December 1986, OPEC reached a new agreement to restrict production further and to try to reestablish fixed prices at about $18 per barrel. Early in 1987, prices were indeed higher; but whether this agreement will continue to work depends on many factors—including whether oil companies retain or release their substantial inventories, whether Iraq (which did not agree to abide by the agreement) exercises production restraint, and whether all OPEC producers abide by their respective production quotas and official prices, particularly as demand slackens in the spring. As in the past, the behavior of OPEC countries may be strongly influenced by various political factors.

With about 10 million barrels per day of excess oil production capacity existing worldwide, and with demand for oil projected to rise only slightly in the near term, world oil prices could remain in the $15- to $20-per-barrel range for some time. Nevertheless, the large price fluctuations experienced during 1986 have led many people in the oil industry to expect additional short-term swings.

It should be recognized that the world oil market is not a completely free and competitive market. The adoption of free-market policies in the United States and some other countries helped to reduce OPEC's market power and stimulate competition; but some of the world's major producing countries have nationalized oil industries, and these often do not operate according to the normal rules and methods of an unfettered marketplace. Furthermore, 13 of these producing-country governments meet frequently within OPEC to engage in coordinated production restraints and in price-fixing—moves that are sometimes supported by some producing countries outside that organization. Even though OPEC is less powerful today than it was 6 years ago, its policies continue to influence current market developments.

THIS STUDY HAS FOCUSED ON SEVERAL SCENARIOS, WITH GENERALLY LOW OIL PRICES

Outright prophecy about this country's and the world's energy future is too shaky a base on which to try to construct (or even evaluate) energy policy. For that reason, in conducting this study, the Department of Energy did not content itself with flat, simplistic predictions. Instead, DOE worked with a number of Federal Government agencies to develop several alternative energy-market scenarios through 1995. The two most important scenarios, as described below, present the upper and lower boundaries in an admitted range of uncertainty, thus offering at least some generalized projections about future U.S. oil imports and OPEC production that might be considered reasonable.

- The **"Lower Oil Price Case"** assumed that oil prices of about $15 per barrel would continue until 1990, after which the world oil price would increase gradually to about $22 per barrel in 1995. As factors that might vary on their own—aside from their relation to oil prices—this "case" also made a conservative estimate of how much oil non-OPEC reserves actually contain, assumed that gross domestic product (GDP) in this country would grow at an average annual rate of 2.7 percent, and estimated that the ratio between growth in energy demand and

Projections Zeroed In on Two Feasible "Energy Futures"

KEY ASSUMPTIONS (FACTORED INDEPENDENTLY)	CASE INVOLVING HIGHER OIL PRICES	CASE INVOLVING LOWER OIL PRICES
World Oil Price (1985 dollars/barrel)		
1985	$27	$27
1986	$14	$14
1990	$23	$15
1995	$28	$22
Annual U.S. Economic Growth (1985-1995)	2.5%	2.7%
Degree of Energy Efficiency	Higher	Lower
Non-OPEC Oil Resource Base	Higher	Lower

the increase in GDP would be about 0.6. All of these distinct assumptions would tend to encourage U.S. oil imports, and this case projected ultimately that the Nation would be buying about 10 million barrels of foreign oil per day by 1995 under these conditions.

- The **"Higher Oil Price Case"** assumed that the world oil price would rise to about $23 per barrel in 1990 and to about $28 per barrel in 1995. It also assumed an average annual GDP growth rate in the United States of about 2.5 percent and an energy/GDP growth ratio of about 0.5. On this basis, it projected U.S. oil imports in 1995 of 8 million barrels per day.

On the basis of these two oil market scenarios, the Department of Energy prepared scenarios for the energy market as a whole, which underlie this study. Variations in GDP growth and in assumptions of how large oil reserves will actually turn out to be reflect uncertainties about economic, technological, and physical factors. The oil prices assumed for both main scenarios are relatively low compared to prices experienced in the early 1980's.

The use of these two scenarios was intended to show a range of possible outcomes—beginning with reasonable assumptions about economic growth, the resource base, OPEC production and pricing policies, consumer reactions to oil prices changes, interfuel competition, and other factors. Although they bracket a range of U.S. oil imports and OPEC production, they are subject to substantial uncertainty, particularly in the later years. Furthermore, even if such projections turn out to be generally accurate, it is likely that there will be significant short-term deviations from the smooth paths they show.

In addition to the two principal scenarios, two variations of the lower price scenario were also examined:

- a "**Price-Ratchet Case**," in which prices would increase rapidly during the 1990's as a result of major producing countries' exerting their renewed market power; and

- a "**Price-Collapse Case,**" in which oil prices would fall again to $10 per barrel by mid-1987.

These two variations of the lower price scenarios, as well as several scenarios for oil-supply disruptions, are discussed in more detail in other sections of this report.

LOWER OIL PRICES ACCELERATE DECLINE IN OIL PRODUCTION FROM HIGH-COST SOURCES

High oil prices in the 1970's and early 1980's encouraged investment in exploration and development of high-cost resources outside OPEC—for example, in Alaska and in the smaller North Sea fields. This trend was contrary to normal economic behavior, which would be to exploit low-cost reserves first and high-cost reserves only later. Because OPEC prices were artificially high, in fact, high-cost reserves were being produced at maximum rates, while some large reserves of low-cost oil were being produced at rates much lower than their potential.

Even before the 1986 price collapse, it had been expected that non-OPEC production would decrease over the next decade, because existing fields would be depleted more rapidly than new fields were likely to be discovered. Lower oil prices will accentuate the short-term decline in oil production from high-cost sources, but this result is totally consistent with normal economic behavior.

- Many marginal production wells in the United States were shut in during 1986. (For the most part, these were "stripper" wells—defined as wells producing 10 barrels per day or less each.)

Projected Free-World Oil Production*

(Millions of Barrels per Day)

	1985		1990	1995
U.S.	11.2	Higher Price Case	10.1	8.9
		Lower Price Case	9.2	7.6
Europe	4.3	Higher Price Case	4.5	3.7
		Lower Price Case	3.7	3.2
Persian Gulf	10.2	Higher Price Case	12.7	14.6
		Lower Price Case	18.3	23.2
Other OPEC	7.0	Higher Price Case	7.3	7.4
		Lower Price Case	7.0	6.8
All Other**	13.0	Higher Price Case	13.4	14.2
		Lower Price Case	12.6	12.5
TOTALS	45.7	Higher Price Case	48.0	48.8
		Lower Price Case	50.9	53.3

* Includes crude oil, natural gas liquids (NGL's), and refinery gains.

** Includes Australia, Canada, Non-OPEC LDC's, and net exports from centrally planned economies.

- Development of some high-cost reserves and the application of "enhanced recovery " techniques to some old projects (for example, the injection of chemicals or an inert gas to stimulate the flow of petroleum) are being postponed.

- Exploration has slowed in "frontier areas" (including remote Arctic regions and deep sea beds), as well as in locations that have been producing oil for so long that they are considered "mature," offering little hope of very large new finds.

For the most part, high-cost reserves will not be lost as a result of reduced exploration and development activities; these high-cost reserves will merely be used at a later date. Only some quantities of stripper well production may be lost indefinitely.

The cost of finding and producing oil in the United States is higher than in any other major producing country. According to data from the Financial Reporting System of the Energy Information Administration (EIA), companies' average 1982-85 costs to find oil and gas reserves in the United States were about $8.50 per barrel, and their marginal direct costs to extract oil and gas in 1985 totaled almost another $5 per barrel. (These costs exclude taxes; the tax policies of producing countries can profoundly affect the attractiveness of investments in oil and gas exploration and development.) U.S. oil production is projected to decline from more than 11 MMBD in 1985 to the range of 8 to 9 MMBD in 1995.

Production costs in Europe are significantly lower: about $4 per barrel to find oil and an additional $3.50 per barrel to produce it. European (mainly North Sea) production is projected to decline from about 4.4 MMBD in 1986 to less than 4 MMBD in 1995.

In the Middle East, finding costs are almost irrelevant at present because so much excess production capacity is already available in the form of oil that has already been pinpointed. At this point it costs less than $2.50 per barrel to bring such oil to the surface and prepare it for shipment to market. This explains why Persian Gulf production can be projected to increase from 10.2 MMBD in 1985 to between 15 and 23 MMBD by 1995.

Production costs in other OPEC and non-OPEC countries generally are lower than those in the United States and Western Europe but higher than those in the Persian Gulf. Significant production increases are possible in some countries outside the Middle East, such as Norway and Venezuela; but relatively stable production is projected in Canada, Indonesia, and most other countries of the free world. Net exports from the centrally planned economies are expected to decline over the next decade.

LOWER OIL PRICES ALSO STIMULATE MORE CONSUMPTION OF PETROLEUM PRODUCTS

Lower oil prices encourage consumption of petroleum products in three ways:

- The higher economic growth that results from lower oil prices stimulates consumption of all goods and services, including oil.

- In some applications, lower oil prices will encourage consumers to use oil instead of other fuels . . . or to postpone any plans consumers might have had to substitute other fuels for oil. Of course, many electric utilities and industrial companies that switch back to oil from other fuels will be able to return to other fuels if and when oil prices rise.

- Lower oil prices provide less incentive to invest in energy-efficient equipment, and they encourage such oil-consuming behavior as driving more and heating homes to higher temperatures. Recent structural changes in the economy from industries that are energy-intensive to less-energy-intensive industries and services are unlikely to be reversed by lower oil prices.

Total free-world oil consumption is projected to grow at an average annual rate of 0.6 to 1.3 percent between 1985 and 1995. Consumption is projected to increase from 46.4 MMBD in 1985 to 49.1 MMBD in the higher oil price case and to 53.0 MMBD in the lower price case.

- In the United States, oil consumption is projected to grow at a rate between 0.4 and 1.2 percent annually—rising from 15.7 MMBD in 1985 to between 16.4 and 17.7 MMBD in 1995. Most of this rather modest growth is expected in the transportation sector, but growth also is expected in industry and among electric utilities—particularly in the mid-1990's, after most of the coal and nuclear powerplants under construction now have been completed.

- A similar pattern is expected in other developed countries. Other OECD countries' consumption is expected to expand from 18.5 MMBD in 1985 to between 19 and 21 MMBD in 1995. This growth is also expected to be strongest in the transportation sector, followed by the industrial and residential/commercial sectors. Outside the United States, current plans for additional coal and nuclear powerplants extend farther into the future than they do in this country, and this should help to curb growth in the use of oil by the electric power sector in the mid-1990's.

- Less developed countries outside OPEC have added to their use of oil quite rapidly over the past 15 years—increasing consumption of this fuel at an overall average rate of 4.2 percent. Although this trend is expected to moderate during the next decade, their consumption growth will continue to be higher than in OECD countries, especially if the LDC economies resume rapid real growth. Non-OPEC LDC consumption of oil is now projected to rise between 1985 and 1995 at a rate of somewhere between 0.8 and 1.5 percent per year, but this projection is highly uncertain.

- The OPEC countries are projected to grow fastest of all in consumption of oil—boosting their own domestic use by about 2 percent per year, despite their current economic difficulties. The principal reason is the artificially low prices for oil products that have been maintained in these countries.

Projected Free-World Oil Consumption
(Millions of Barrels per Day)

	1985		1990	1995
U.S.	15.7	Higher Price Case	15.7	16.4
		Lower Price Case	16.7	17.7
Other OECD	18.5	Higher Price Case	19.3	19.1
		Lower Price Case	20.4	21.0
OPEC	3.4	Higher Price Case	3.7	4.2
		Lower Price Case	3.7	4.2
LDC's	8.8	Higher Price Case	9.2	9.5
		Lower Price Case	9.7	10.2
TOTALS	46.4	Higher Price Case	47.9	49.1
		Lower Price Case	50.4	53.0

U.S. OIL IMPORTS WILL PROBABLY INCREASE SUBSTANTIALLY BY 1995

If the U.S. produces less oil in the future and uses more, its imports of this energy source will clearly go up. In the past, some observers have used import level for oil as something like a shorthand indicator of "oil vulnerability" (presumably the antithesis of "energy security"); but it is worthwhile to note that this is an oversimplification. Certainly, the level of vulnerability depends on the likelihood of supply disruptions and on the ability to respond to such events as well as on the level of dependence on imports. Using import levels as the only criterion for a successful energy policy overlooks the obvious economic fact that the availability of lower cost oil imports brings down the effective domestic price of oil—which benefits all consumers.

Even before the price collapse of 1986, U.S. oil imports were expected to rise during the late 1980's and early 1990's. Now it is likely that the recent decline in oil prices will lead to somewhat faster and larger growth in imports. The size of the increase is highly uncertain; but it will depend in particular on how low oil prices go, how long they stay low, and how large the resulting demand and supply responses are.

Net U.S. imports of crude oil and petroleum products had been cut in half between 1977 and 1985—falling from a high of 8.6 MMBD to only 4.3 MMBD. During 1986, partly in response to lower prices of the fuel, oil imports climbed by about one million barrels per day above the 1985 level. However, about one-third of these increased imports can be explained by expansions of U.S. inventories for oil and oil products.

Over the longer term, U.S. oil imports could exceed the range they reached in the mid-1970's. In the lower oil price scenario (which also assumes a smaller domestic oil resource base than is usually estimated), U.S. oil production could decline further and U.S. oil consumption could rise slightly (even though "built-in" gains in energy efficiency are likely to continue despite the appeal of lower oil costs). In the higher price case, U.S. oil consumption would hold fairly steady and domestic oil production would ease down more gradually; but the need to increase imports would still exist. The projections in this study show U.S. net oil imports in the range of 8 to 10 million barrels per day in the mid-1990's—about one-half or more of total projected U.S. oil consumption.

OTHER COUNTRIES' IMPORTS OF OIL ARE LIKELY TO INCREASE AS WELL

Non-U.S. OECD Countries

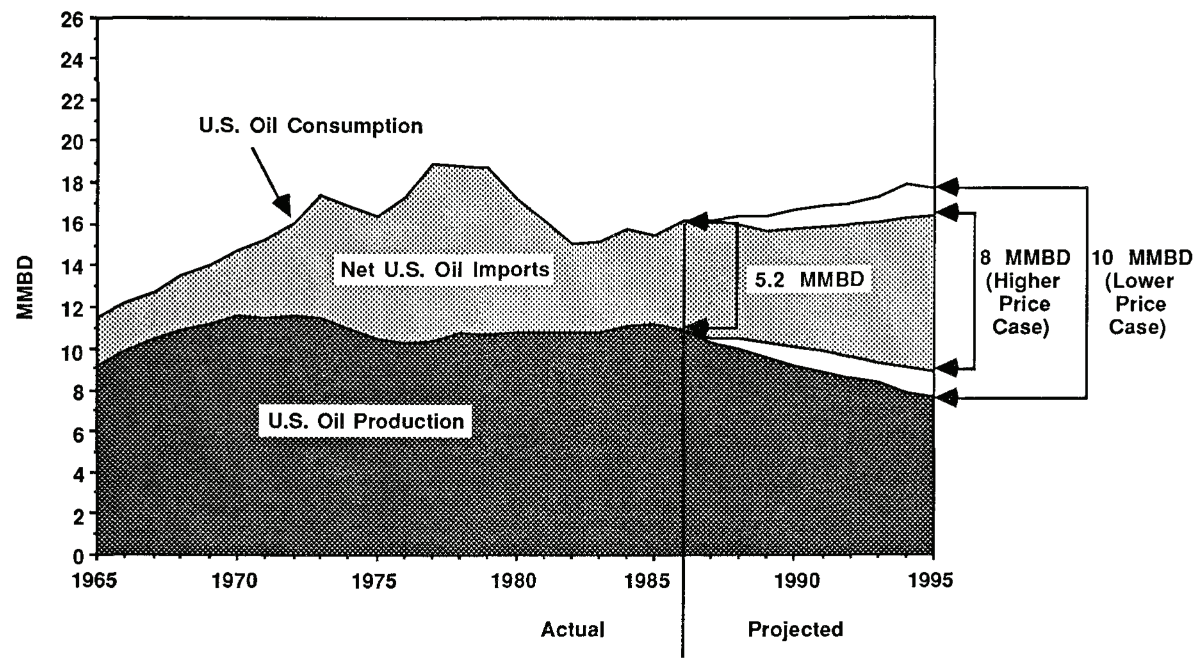
The United States' partners in the Organization for Economic Cooperation and Development (OECD) depend substantially as a group on importing oil to keep their economies operating normally. In 1985, about 64 percent of their oil requirements were satisfied by imports. Japan is almost totally dependent on foreign oil, and Western Europe bought more than 60 percent of its oil from non-European suppliers. At the same time, Canada, Norway, and Great Britain export considerable amounts of the oil they produce.

If prices stay low over the long term, non-U.S. OECD oil production is likely to decline while consumption increases (despite continuing conservation gains). The projections in this study show this group's oil imports rising from 11.6 million barrels per day in 1985 to about 12 to 15 million barrels per day in 1995. This level of imports in 1995 would represent 65 to 75 percent of total consumption—considerably higher than the import share projected for the United States.

Less Developed Countries

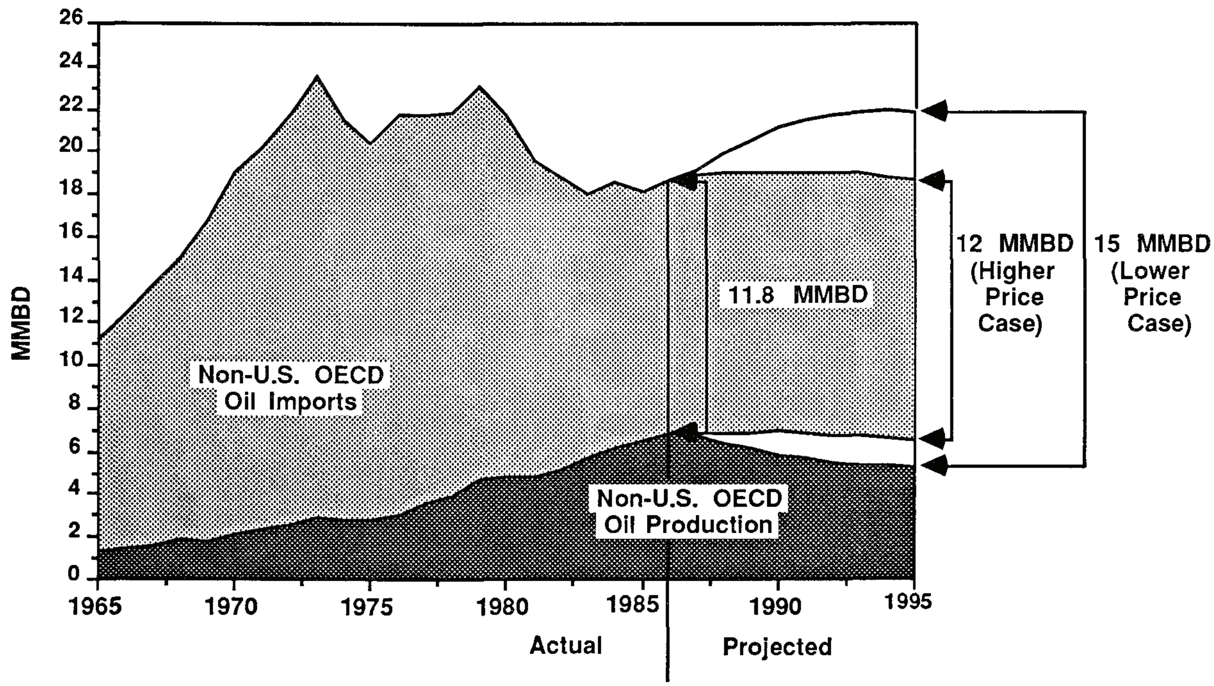
Oil consumption in the less developed countries (including those LDC's that are members of OPEC) is projected to grow faster than in the industrialized nations. These countries' populations are growing rather

History and Outlook for the U.S. . . .



Source: U.S. Energy Information Administration

. . . and for other OCED Countries



Source: U.S. Energy Information Administration rapidly, and their economies are expanding. Oil consumption also tends to increase as populations migrate from rural to urban locations. Finally, many LDC's subsidize the prices of oil products.

Because of the huge disparity in economic, population, financial-resource, and other factors in countries as divergent as South Korea, India, Egypt, and Brazil, there will be large variations in future patterns of oil imports. Despite this lack of homogeneity, it seems fairly clear that growth in oil consumption will outweigh the increase in oil production between now and 1995 in those LDC's that are not part of OPEC. On balance, their net oil imports are expected to increase.

RISING IMPORTS IMPLY GROWING RELIANCE ON OPEC OIL, ESPECIALLY FROM THE PERSIAN GULF

As the United States and other countries import more oil between now and 1995, production is virtually sure to rise in OPEC—and in particular around the Persian Gulf. This is because—as was pointed out earlier—almost 100 percent of the world's current excess production capacity is in OPEC countries; and nearly 70 percent is in the Persian Gulf states of Saudi Arabia, Iran, Iraq, Kuwait, and the United Arab Emirates alone. This dependence can be expected to extend into the longer term as well, because about three-fourths of the world's currently known oil reserves are in OPEC countries, and about two-thirds of the world's reserves are in countries surrounding the Persian Gulf.

The OPEC share of free-world oil production rose from 50 percent in 1960 to more than 60 percent in the 1970's before falling below 40 percent in 1985. OPEC's production share is projected to increase again by 1995, although it might range anywhere from 45 to 60 percent by that time.

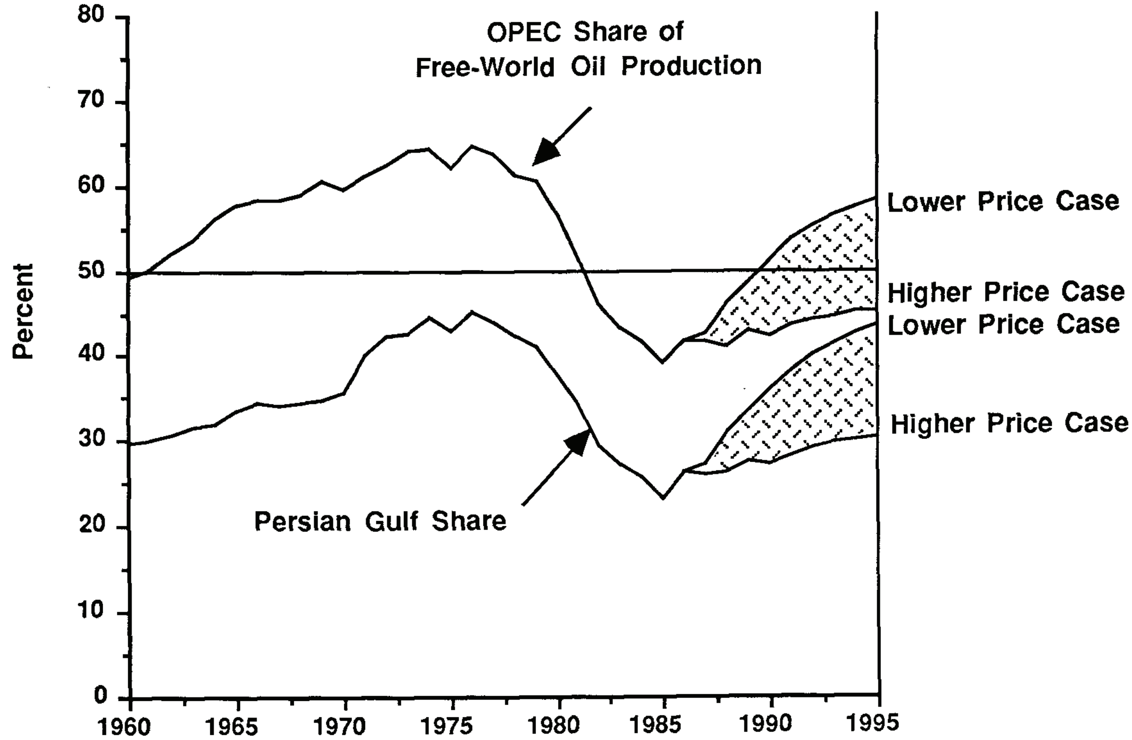
The Persian Gulf's production share has followed a similar pattern, growing from 30 percent in 1960 to more than 45 percent in 1976 before falling to 23 percent in 1985. Its share of world production in 1995 is projected to be between about 30 and 45 percent—depending on the various assumptions that characterize the higher price and lower price cases, respectively.

The Persian Gulf region is strategically sensitive because of its location and its vast oil reserves. The area is potentially vulnerable to external threats, and it also is subject to the turmoil of internal conflicts. Recent Middle Eastern history shows that oil supplies from there can be interrupted. One need only cite the oil embargo and production cuts of 1973-74, the Iranian Revolution, and the Iran-Iraq war—which continues today after more than 6 years of fighting.

Furthermore, many elements contribute to continuing instability in the Middle East:

- The war between Iran and Iraq not only affects oil production in both countries, but also oil transportation in the Gulf. And it is always possible that other oil-producing countries in the area could become involved in this conflict.
- The longstanding Arab-Israeli dispute is a continuing threat to the whole region. Miscalculations could lead once again to a wider conflict at almost any time.
- The civil war in Lebanon has involved other countries in the area, and it tends to influence many political decisions by those nations.
- The influence in this part of the world of radical ideologies contrary to U.S. interests cannot be denied.
- Attempts by the Soviet Union to undermine U.S. influence and interests in the area must always be considered.

For approximately a decade following the 1973-74 Arab Oil Embargo, OPEC countries maintained oil prices at artificially high levels.



Source: U.S. Energy Information Administration

Over the past few years, OPEC has agreed several times on specific production quotas for its members and has sought complementary cutbacks in production from nonmember countries. OPEC's shrinking share of the world oil market in recent years prevented the organization from keeping oil prices as high, but it remains uncertain whether OPEC will try (or will be able) to exert the same degree of upward price pressure as it did in the past when its market share rises in the future.

There are considerable economic benefits to be derived by the United States and other oil-importing countries by getting low-cost oil from Persian Gulf suppliers. Often there may be no alternative supplies available at equivalent prices. The question is one of balancing these benefits against risk—the risk that the imports may be subject to supply interruptions, or that the suppliers could restrict output intentionally in order to push prices back up to artificially high levels once again.

PRICES COULD BE RAISED AGAIN AS OPEC USES MORE OF ITS PRODUCTION CAPACITY

In the past, OPEC has raised its oil prices at times when it was employing 80 percent or more of its production capacity. In 1970, OPEC's output of 24 MMBD of oil represented only about 70 percent of its production capacity; but by 1974, production had increased to 31 MMBD—more than 80 percent of capacity—and that was when the world got its first serious oil-price shock. In 1979, at the time of the second great shock, OPEC's production of nearly 32 MMBD represented some 90 percent of its capacity.

Of course, many other factors (such as political and military events) also have influenced oil pricing in the past. It is not inevitable that prices will rise as OPEC's surplus production capacity declines, but it does stand to reason that price increases will become more likely.

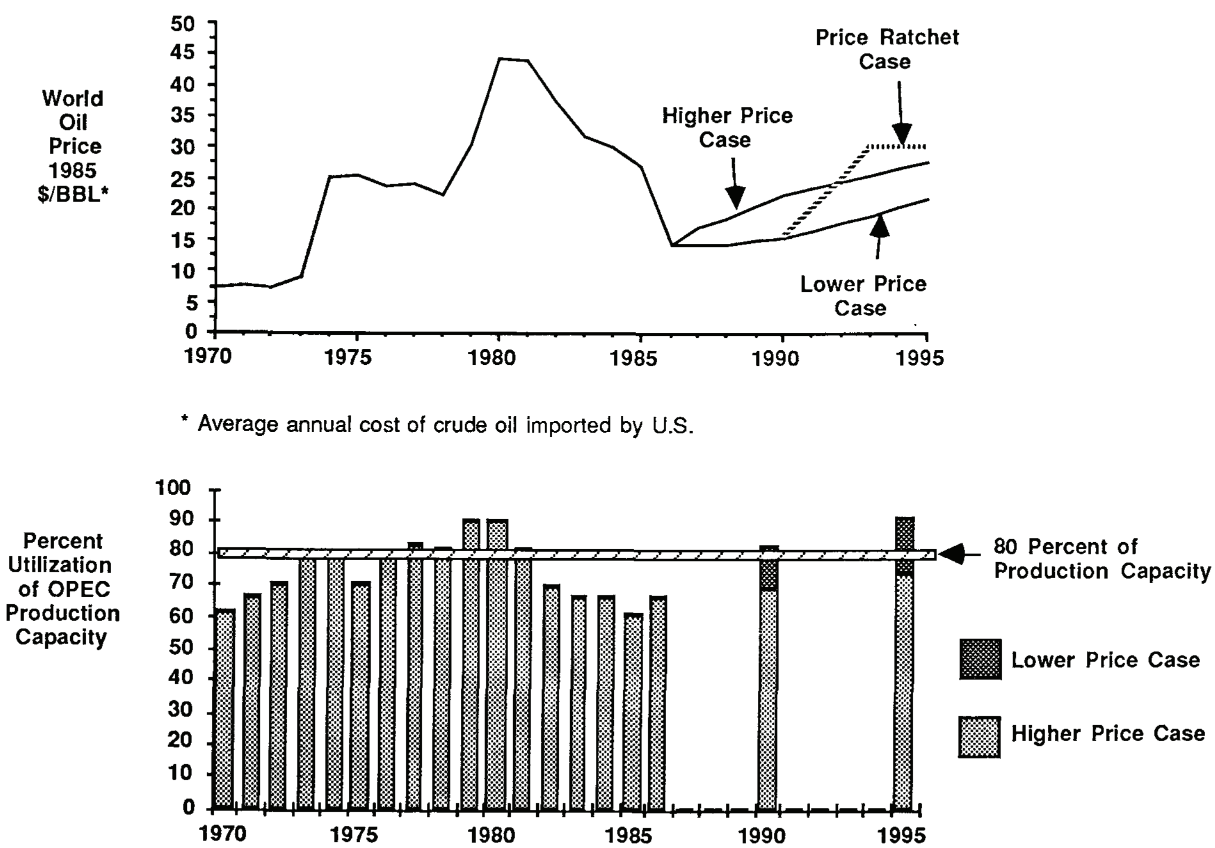
Under the lower price case, OPEC production would increase from about 17 MMBD in 1985 (approximately 60 percent of capacity) to about 25 MMBD in 1990 (about 80 percent of projected capacity), and to about 30 MMBD in 1995 (up to 90 percent of projected capacity at that time). The setting would be similar to what it had been during previous periods of rapid price increases.

In.the basic lower price case, oil prices were assumed to increase moderately—from an average of about $14 per barrel in 1986 to about $15 per barrel in 1990 and about $23 in 1995. Given the high production levels assumed for OPEC under such conditions, however, prices could go up at a considerably faster rate—particularly if certain external events (such as some small supply disruptions) brought about price increases that persisted after the end of these events. In this price-ratchet scenario, it was projected that oil prices would rise from $15 per barrel in 1990 to $30 in 1995.

Such rapid price increases would result in temporarily higher inflation, lower GNP, and higher oil import bills for the United States and other importing countries. Higher prices would, of course, also encourage more non-OPEC production and tend to lower consumption. These responses would bring prices back down eventually, but they would take several years to take effect. Meanwhile, there would be some costs to the economy during the transition.

Under circumstances of the higher price case OPEC production would be lower, making this

Oil Prices Could Ratchet Up in the 1990's As OPEC's Market Power Increases



sort of rapid price increase less likely. On the other hand, the gradual price increase assumed under the higher price scenario would result in an oil price in 1995 of almost $28—only about $2 below the $30 price projected in the price-ratchet case. However, the higher price case would have involved a price level above that of the price-ratchet case during the 1987 to 1991 period.

PRICES COULD ALSO COLLAPSE, BUT $10 OIL PROBABLY COULD NOT BE SUSTAINED

Another oil market scenario was also examined, in which prices collapsed in mid-1987 and remained at very low levels through 1988. The conclusion from this examination was that a $10 per barrel price could not be sustained for long. There would be little excess oil production capacity worldwide at this price level, so oil would probably go back above $15 per barrel by 1990, winding up in almost the same place as in the basic lower price case.

Under this scenario of a price collapse, total free-world oil consumption would be almost 1 million barrels per day higher in 1990 than it would be under the lower price scenario. Non-OPEC production, on the other hand, would be almost 1 million barrels per day lower. The consequence of higher world oil consumption and lower non-OPEC production thus would be higher dependence on OPEC—with Persian Gulf suppliers being responsible for virtually all of the production growth and actually gaining market-share beyond that.

Under the price-collapse scenario, OPEC production would be 27 million barrels per day in 1990, about 1.5 million barrels per day higher than under the lower price scenario. This production would represent more than 85 percent of OPEC's projected production capacity (compared to 82 percent projected in 1990 for the lower price case and only 66 percent actual capacity utilization by OPEC in 1986). Thus, even if prices did not recover by 1990, they could surely be expected to rise soon thereafter.

By 1995, world oil prices, free-world oil consumption, and the OPEC and non-OPEC production levels would all return to roughly the same levels under the price-collapse scenario as they would have reached if prices had followed a steadier trajectory as assumed for the lower price case.

MANY "WHAT IF" MARKET SCENARIOS ARE POSSIBLE

Energy forecasting is always difficult, and "surprises" should be no surprise. Many diverse scenarios for oil and energy markets are possible, each with at least slightly different implications for the future of oil prices, U.S. oil imports, free-world dependence on imports from OPEC, and energy security. Here are some of the key unknowns that could cause the actual energy future to diverge from this study's projections:

Oil Prices: Apart from fundamental supply and demand factors, prices could be influenced by unpredictable supply disruptions and political events. If prices continue to be very volatile over the next few years, this could also have an important effect on the ability of the oil industry to secure financing for its exploration and development investments.

Oil Industry's Ability to Snap Back: After the price shocks of the 1970's the worldwide oil industry grew very rapidly, but this spurt produced some inefficiencies and (temporarily at least) inflated industry costs. There is no way to be certain how the industry might respond to a prolonged period of lower oil prices now—or to potential price increases.

Oil Demand: A critical uncertainty for the oil market both in the near and the longer term is how consumers will react to lower oil prices. This analysis assumed that oil demand would increase, but not dramatically. If demand for oil were to grow much more rapidly, oil imports would be higher than projected here; and low oil prices would be harder to sustain. Most forecasters failed to predict that the use of petroleum would fall as abruptly as it did in response to higher prices in the early 1980's, and forecasters now may be underestimating (or overestimating) the collective consumption response to the generally lower prices expected over the next few years.

Iran-Iraq War: Another factor complicating the oil market is the ongoing Iran-Iraq war, which still has the potential to disrupt oil flows from the Persian Gulf. If an end to the war should lead to higher production from the region, OPEC might fall into a squabble about how to apportion the added production. Alternatively, an end to the war could create conditions under which OPEC would be able to limit output more efficiently. Depending on how the war ends, this entire region could become either more or less stable.

Substitutes for Oil: Greater use of oil substitutes than has been assumed would reduce oil demand. For example, this study assumes that virtually no practical replacements for oil-based fuels will make a dent in the transportation market over the next ten years, and that the use of oil will increase marginally in the electric power sector during the 1990's when the rate of completion of new nuclear and coal-fired powerplants is expected to slow. Both assumptions seem sound, but both could turn out to be wrong.

PROSPECTS BEYOND 1995 ARE EVEN MORE DIFFICULT TO PREDICT CONFIDENTLY

If any projection of market trends between now and 1995 must admit to a range of uncertainty, prospects beyond that time horizon are far vaguer. Nevertheless, it is important for planning purposes to explore some longer term developments, at least in general terms. The lead times for the discovery and development of oil reserves in frontier areas and for the construction of new coal-fired or nuclear power electricity generating plants is such that projects that are not under way yet cannot be counted on before 1995. For renewable fuels, the lead times are even longer.

Although future oil prices and the rate at which this country uses oil will affect the exact amounts, U.S. oil imports are likely to go on rising for some time beyond 1995. In part this is because there is little promise of slowing the expected rapid rate of decline for conventional oil production in the United States.

Conventional production of natural gas in the "Lower 48" is also likely to diminish beyond 1995. The alternative sources of natural gas to meet domestic demand include: gas from North Alaska; increased imports of Canadian gas; LNG imports; possible gas imports from Mexico; and higher cost domestic gas produced by unconventional techniques.

The only coal-fired and nuclear plants that will be generating U.S. electricity in 1995 will be those that are either already built or at least under construction. Beyond that date, the amount of electricity coal and nuclear generation can contribute to U.S. and world energy consumption will depend on how the attractiveness of investment in new plants with these fuels compares with such alternatives as oil- or gas-fired plants, renewables, and various utility approaches to load-management and higher efficiency. If coal or nuclear generation capacity proves less attractive in the future because of regulatory, financial, or any other sort of costs, the world is likely to consume more oil, face higher oil prices, and become more dependent on insecure oil from the Persian Gulf than otherwise.

The long-term contribution from solar power, geothermal systems, wind turbines, and all the other forms of renewable energy will depend chiefly on how the total cost of using these renewables compares with continued use of available fuels. Technological developments could slash the cost of deriving energy from renewable resources, or higher oil prices might make renewable energy more competitive even in the absence of significant technological advances. On the other hand, lower oil prices reduce the incentive to invest in renewable resources.

Despite the uncertainties surrounding energy markets beyond 1995, it is likely that the United States and other countries will continue to be highly dependent on potentially insecure oil supplies. These countries therefore will want to have available to them the maximum possible number of economically viable energy resources that can substitute for oil and reduce their dependence.

OIL SUPPLY DISRUPTIONS ARE STILL POSSIBLE, BUT THE ABILITY TO HANDLE THEM HAS IMPROVED

DEPENDENCE, RISK, AND RESPONSE CAPABILITIES ARE ALL "VULNERABILITY" FACTORS

Vulnerability to economic and/or national security damage from disruptions in oil supply depends on three main factors:

- Dependence of the United States and other countries on imports potentially subject to disruption.
- The risk that net disruptions of various sizes and durations will actually occur—taking into account possible production increases from other sources.
- Capabilities to respond to such import disruptions (for example, by drawing on strategic reserves of oil or substituting other energy sources promptly).

As has already been explained in regard to the first point, imports of oil by the United States and other OECD countries are projected to rise significantly over the next decade. Furthermore, most of the imports will come from the currently excess production capacity in the Persian Gulf and other segments of OPEC.

Based on history, there is a significant risk of disruptions to some supplies from the Persian Gulf and other OPEC countries. The highly important Gulf nations are highly dependent on revenues from oil exports, however, and they have demonstrated their intention to keep up their export capacity. For example, two of these countries have built export pipelines to provide the flexibility of alternate transportation routes. Saudi Arabia has constructed and is enlarging a pipeline from its Persian Gulf oil fields to Yanbu on the Red Sea. Iraq has added a spur to the Yanbu line, is building a separate pipeline through Saudi Arabia to the Red Sea, and is expanding still another pipeline through Turkey to the Mediterranean.

The combined effect of all these activities will be to lift the capacity of operable pipelines bypassing the Persian Gulf shipping routes to more than 6 MMBD by the early 1990's—compared with less than 1 MMBD a decade earlier. Admittedly, pipelines do not make these countries' exports invulnerable to disruption, but they do reduce risks.

Ordinarily, one might expect the large excess production capacity existing in the world today to be another significant hedge against risk—on the grounds that it would allow some countries to increase their production and compensate for oil supply disruptions. Because most of this excess capacity is in the Persian Gulf region, however, it would itself quite possibly be subject to interruption at the same time. Furthermore, some of this excess production capacity is projected to disappear in the future as world oil consumption rises and non-OPEC production declines.

The major factor limiting the free world's energy vulnerability currently lies in the policies and response capabilities of the United States, Japan, West Germany, and some other OECD countries. These have improved substantially since the 1970's.

The adoption of market-based policies by the United States and some other countries ensures that these economies should be able to respond quickly and efficiently to future oil supply disruptions. Furthermore, the levels of emergency stocks under government control have increased considerably. Many countries have made and are making progress toward developing sound strategies for using their stocks in a supply disruption. The International Energy Agency has agreed on a program for coordinated response to supply disruptions, and IEA member countries are working to prepare procedures to implement this program.

Although increasing dependence on imports will tend to make most countries more subject to supply disruptions, a variety of other factors must thus be considered in estimating true vulnerability.

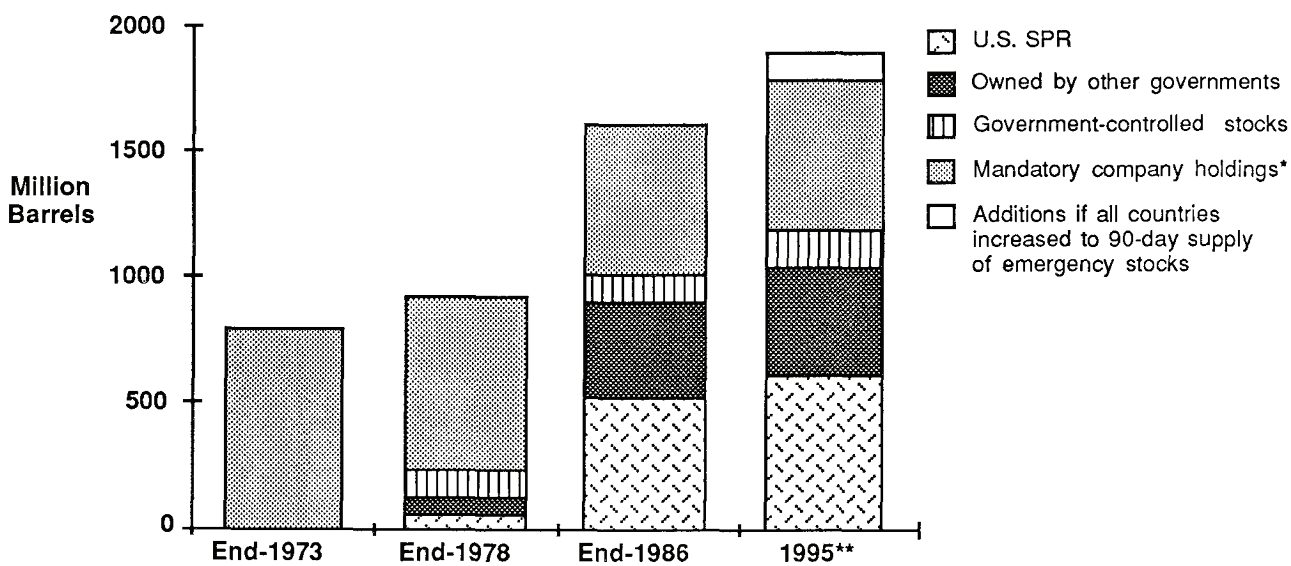
STOCK LEVELS FOR OECD AS A GROUP ARE SUBSTANTIAL AND IMPROVING

During previous supply disruptions, emergency petroleum stocks in OECD countries were low. They consisted mainly of stocks that private companies held, in excess of normal operating requirements, to fulfill government regulations in Europe and Japan. There were virtually no stocks of oil then that governments themselves owned and controlled. Today, government-owned and -controlled stockpiles are substantial and many countries are planning to further expand their stockpiles.

- The U.S. Strategic Petroleum Reserve (SPR), which has been built and is owned by the Federal Government, now contains more than 515 million barrels of oil. It is stored principally in underground caverns, and tests have shown that its contents can be pumped back to the surface as needed. In August 1986, the President reaffirmed the commitment to fill the SPR toward a goal of 750 million barrels. The Reserve now is being filled at a rate of 75,000 barrels per day, but in view of budgetary constraints, the Administration has proposed a 35,000 barrel per day fill-rate for fiscal year 1988. The Department of Energy believes that the 750 million barrel goal should be achieved by the mid-1990's if oil imports continue rising rapidly.

- Several other OECD countries also have established government-owned stockpiles. These reserves currently contain about 225

OECD Emergency Stocks of Oil



* Private stocks in excess of operational requirements, but required by government regulations.

** Assumes a fill rate of 35,000 barrels per day in 1988-1995, which results in a SPR level of 635 million barrels by the end of FY 1995. To achieve a 750 million barrel SPR by 1995, a 75,000 barrel per day fill rate would be required. Also assumes completion of other countries' announced programs to increase stocks, and no change in mandatory company holdings.

Sources: Department of Energy; International Energy Agency million barrels, of which 140 million barrels are in Japan and 55 million barrels are in Germany. The Japanese Government plans to increase its reserve to almost 190 million barrels by early 1989.

- Four European countries within the OECD have established special organizations to hold emergency stocks of oil; and these organizations currently hold about 125 million barrels. The largest of these, in Germany, is scheduled to increase from its current total of almost 100 million barrels to about 135 million barrels by the end of 1988. The Netherlands also intends to raise the level of its emergency stocks.

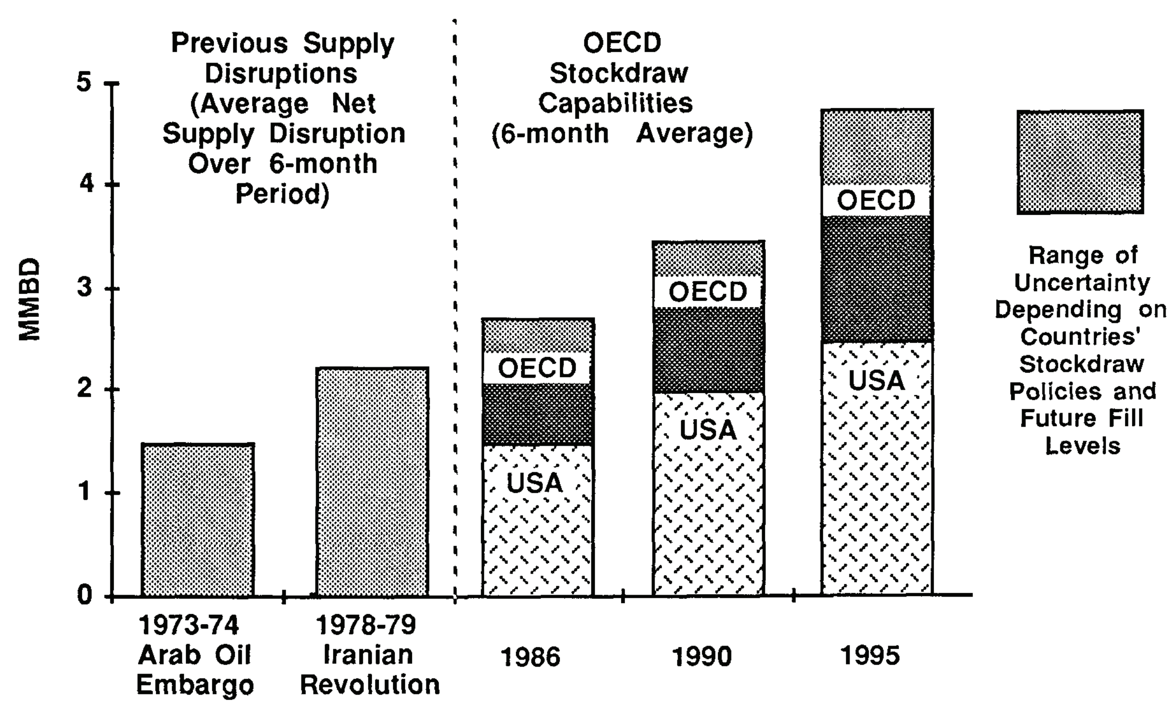
- Japan and most European OECD countries require by law that oil companies maintain stocks equivalent to 90 days or more of each company's sales. Approximately half of these stocks are necessary for the companies' operational needs, but the other half (about 600 million barrels) are potentially available for use in an emergency situation.

Given the prospect of higher dependence on imports in the 1990's, and given current low oil prices and readily available supplies, this is an opportune time for some countries (especially those where emergency stocks remain quite low) to boost stock levels. The United States has persisted in encouraging its partners in the International Energy Agency to expand their strategic reserves.

OECD COUNTRIES CAN RESPOND WELL TO THE SORTS OF DISRUPTIONS THAT OCCURRED IN THE 1970's

Oil-consuming countries will be in far better shape to respond to any supply disruptions that might confront them in the 1990's than they were in the 1970's. Emergency stocks alone will be sufficient to offset the net reductions in supply that occurred during the 1970's, or even somewhat larger ones. Increased reliance on market forces to set prices and to allocate supplies in the event of a disruption should do much to prevent the gasoline lines, regional inequities, and general confusion that prevailed before.

Large hikes in oil prices during the 1970's were precipitated by relatively small supply disruptions. The average net reductions in oil production during the 1973-74 and 1978-79 oil shocks (after taking into account the offsetting



increases in production from some countries) were less than 5 percent of total free-world oil supplies.

It was ineffective and inappropriate government policies in responding to the disruptions in the 1970's that exacerbated the price situation and created physical shortages. Price controls in the United States sent false market signals to both oil consumers and oil producers. When domestic oil prices were suppressed in spite of changes in the world market, this encouraged too much consumption, too little production, and too little fuel-switching in this country. An oil supply allocation program forced motorists in some parts of the country to waste many hours (and a great deal of fuel) in lines at filling stations while there were oversupplies of gasoline in other areas. Government-owned and -controlled oil stockpiles were relatively small during these disruptions, but no attempt was made to draw down even those modest stockpiles.

When supply disruptions occurred in the1970's, the world had relatively little oil production capacity that was not being used. The 10 million barrels per day of excess production capacity available now sharply reduces the probability that large net supply disruptions could take place. (This comfortable situation is expected to change in the 1990's, however, as demand for oil rises.)

Preparations for dealing with potential supply disruptions in the 1990's are getting better:

- The United States has dismantled its programs for price control and allocation of oil so the market will be free to operate in response to future supply disruptions. Many other developed countries, such as Germany and the United Kingdom, also have adopted market-based policies for dealing with supply disruptions.

- Emergency stocks provide the best means to offset short-term interruptions in supply and thereby limit the resulting price increases and associated economic dislocations. By 1995, the U.S. Strategic Petroleum Reserve will be capable of pumping out and distributing an average of at least 2.5 million barrels per day over a 6-month period. The stated policy of the United States is ordinarily to draw down the SPR early in response to supply disruptions and to do so at a rapid rate. Many other OECD countries would be able to do the same with their emergency stocks; but in some cases their present inclination is to use demand-restraint measures (such as restrictions on driving) as the first line of defense. Nevertheless, other OECD countries could be expected to draw upon as much as 1.5 million barrels per day in the event of a supply disruption such as the ones experienced during the 1970's. In addition, many of the steps contemplated to curb OECD demand would be expected to dampen the price effects of the disruptions.

Having adequate emergency stocks and being prepared with other response measures can do more than just promise to reduce damage from future disruptions. The fact that such steps are feasible also should deter producing countries to some extent from taking deliberate actions to reduce production in an attempt to influence U.S. or allied countries' foreign policy. Thus response capabilities provide certain benefits even if they are never used.

A LARGER DISRUPTION MIGHT CAUSE CONSIDERABLE DAMAGE, BUT IT IS UNLIKELY

A *very* large disruption in oil supply (for example, 10 million barrels per day) in today's oil market environment is highly unlikely. With about 10 million barrels per day of under-utilized production capacity readily available, at least some areas that had not been affected by the disruption would probably be able to step into the breach quickly with a resumption of production. Even as this excess capacity shrinks in the 1990's, disruptions of comparable size will remain improbable. Only a catastrophic event, such as a major widespread war in the Middle East, or a rapid series of smaller events affecting a number of producing countries could result in such a large disruption.

It is important to keep in mind that a disruption of these dimensions over a 6-month period would be several times larger than any experienced to date. Even though such a possibility is considered quite remote, DOE has examined the economic impact that might result from such a catastrophe occurring in the mid-1990's—at a time when imports are assumed to be higher and dependence on OPEC is substantial.

The United States and other consuming countries could contain about half of the effects from such a large supply disruption merely by drawing down emergency stocks. Some electric utilities and industrial users would be able to switch from oil to other fuels. Demand-restraint programs in some countries could further reduce oil demand, although this would probably inflict some damage on their domestic economies.

All this would still mean that the supply of perhaps 5 million barrels per day would be disrupted. Clearly such a blow would impose heavy costs on the world economy—presumably through a large increase in the price of oil. The analysis done for this study has estimated that in this situation prices might rise by $18 to $50 per barrel during the period of the disruption and that it could take at least 6 months after it ended for prices to decline back to pre-disruption levels. This range of prices reflects such uncertainties as the amount of excess production capacity worldwide and the level of prices before the disruption. As a result of such a 12-month period of high prices, U.S. GNP would drop 1 to 2 percent below where it would have been during the period if no disruption had taken place. There also would be a transfer of wealth from the United States to oil-producing countries amounting to 1 to 2 percent of GNP, and similar effects would be felt by other consuming countries.

Although the economic damage resulting from a hypothetical disruption of this size would be large, this should be weighed against the relatively low probability that such an event could occur. Also, it should be noted that this economic damage would be felt over a relatively short time. It would thus have a relatively low cumulative effect as compared with other situations (such as higher prices and lower import dependence) whose smaller instantaneous effects would last for many years.

INDIGENOUS OIL, ENERGY EFFICIENCY, AND FUEL SUBSTITUTION ALL LIMIT DEPENDENCE ON OIL IMPORTS

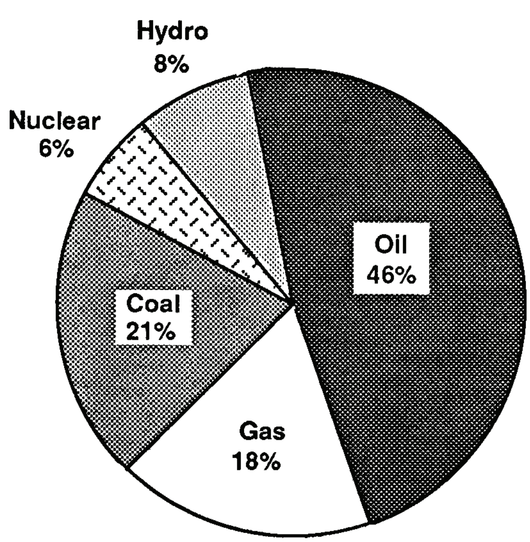
PETROLEUM WILL REMAIN A CRITICAL FUEL FOR THE WORLD EVEN BEYOND 1995

Using oil—even imported oil—is not necessarily bad in itself. So long as adequate supplies are available at reasonable prices, the world will continue to use this fuel. It has advantages over other energy sources in many applications, of which the most pivotal is transportation. The continued use of oil can contribute to sustained economic growth throughout the world.

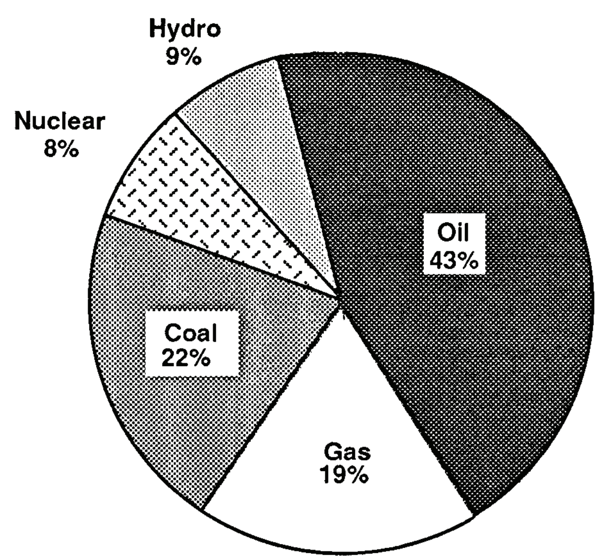
Nevertheless, oil's share of the energy consumed throughout the free world has declined in recent years, and this pattern is expected to continue in the near to medium term—even with lower world oil prices being projected. In 1979, the world got 54 percent of its energy from oil. By 1985, this share has fallen to 46 percent; and it is projected to drop to about 43 percent in 1995.

This is not to say that the world will be using less oil in absolute terms, however. In response to high prices, the absolute level of world oil consumption did decline from about 52.0 MMBD in 1979 to 46.4 MMBD in 1985. But the lower price paths projected for the future now imply that oil consumption will rise by 1995—to somewhere between 49 and 53 MMBD.

World Energy Requirements by Fuel Type



1985
211 Quadrillion BTU's



1995 Mid-Case
253 Quadrillion BTU's

Source: U.S. Energy Information Adminstration

Oil will remain the largest single energy source in the world, leading its closest competitor (coal) by a wide margin. In the developed countries of the OECD, oil use is expected to evolve as follows:

- In the transportation sector, oil will retain its dominant role, providing well over 90 percent of the energy used in this sector. Within the next decade, no substitute transportation fuels are expected to get very far in replacing gasoline, diesel, and jet fuel.

- Industry is expected to use a bit more oil in the future, but oil's share of total industrial energy consumption is expected to go down slightly—from 29 percent in 1985 to between 26 and 28 percent in 1995. Increased industrial energy demand will be met primarily by electricity; industrial use of gas and coal may grow marginally.

- Oil now supplies about 16 percent of the residential and commercial energy used by OECD countries. Oil's share in these two sectors combined is expected to decline to 14 or 15 percent by 1995, as electricity's use continues to increase.

- The volume of oil used in the electric power industry is expected to grow slightly over the next decade, particularly if oil prices remain low. Electric power generation is expected to grow considerably over the next decade; and, although gas, coal, and particularly nuclear power are expected to fuel most of this growth, oil will still play a significant role. Oil's share of energy consumption in this sector is expected to be between 8 and 10 percent in 1995, compared to 10 percent in 1985.

Oil produced in the United States and in other secure areas will continue to be available as an alternative to less secure oil supplies. Even though oil companies have searched for oil extensively in the United States and have produced some 100 billion barrels here during the past century, large quantities of oil remain to be produced from known domestic resources.

Many of these resources may not be recoverable at current prices with today's technology, but new technological developments or higher oil prices in the future could make them available. In particular, certain techniques for enhanced oil recovery hold great promise.

Many areas of the world have barely been explored by the oil industry. Even with lower oil prices, oil companies are continuing to seek new oil reserves all over the world. To the extent that these efforts are successful, secure new oil supplies may be obtainable at reasonable prices.

NATURAL GAS IS THE FUEL THAT IS MOST READILY SUBSTITUTABLE FOR OIL

Natural gas is an abundant resource. Proven world gas reserves represent almost as much energy as proven oil reserves, even though companies have looked for oil far more intensively than they have for gas. World gas consumption, on the other hand, is only about one-half as much as oil consumption.

Natural gas can be superior to oil in some applications—notably electric power generation, certain industrial uses, and home heating. For an equivalent energy output, burning gas results in lower emissions of sulphur oxides, carbon dioxide, nitrogen oxides, and particulate matter compared to burning residual fuel oil or middle-distillate fuels. Natural gas also can serve as an industrial feedstock in lieu of certain petroleum products. Natural gas cannot now substitute for oil on a large scale in the transportation sector; but compressed natural gas, use of methanol (based on natural gas) as a transport fuel, and other technologies may improve the potential for such substitution in the future.

Expansion of natural gas use is limited by several factors:

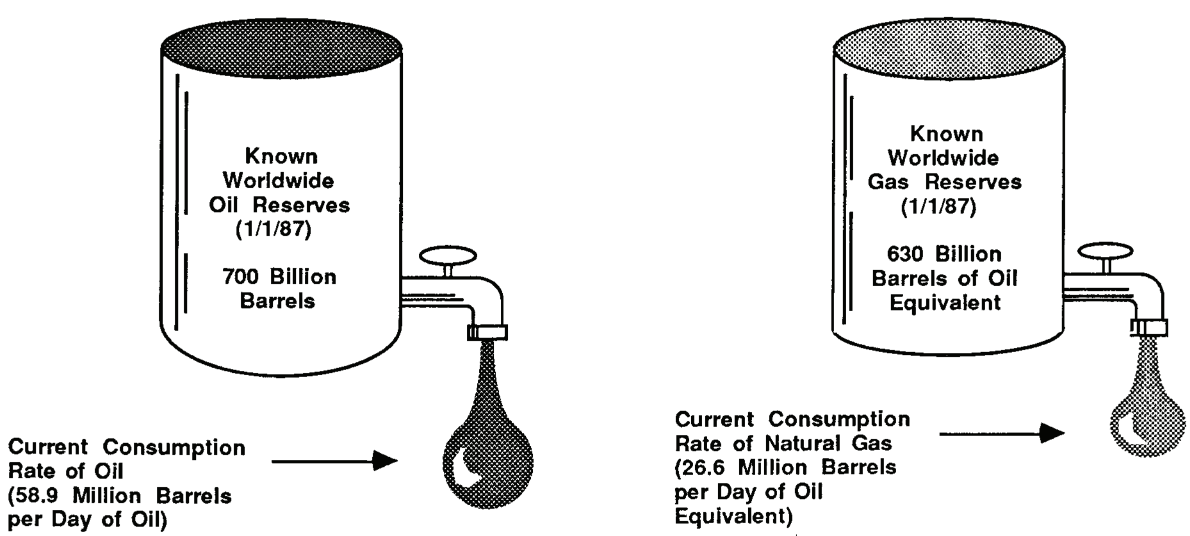
- **Delivery costs**: Transportation of natural gas from producing areas in the Middle East, Africa, and the Far East to major consuming regions requires costly pipelines or liquefaction facilities. Many developing countries have the potential of producing gas for their own internal use, but this potential often is not realized because of the lack of adequate internal distribution systems and uncertainties about the profitability of producing gas for the domestic market in an LDC.

- **Security concerns**: The largest portion of world gas reserves (43 percent) is in the U.S.S.R. Many West European countries are purchasing significant quantities of gas from the Soviet Union under long-term contracts. Ministers of IEA countries agreed in July 1985 to avoid undue dependence on any single source of gas imports, to press development of indigenous resources, and to strengthen their ability to deal with possible disruptions in gas supply. Development of Norwegian offshore gas will help these countries to fulfill their commitment.

- **Non-market-responsive pricing:** Regulatory controls in the United States continue to inhibit the production, transportation, and use of natural gas. Several groups estimate that additional supplies of about 30 trillion cubic feet or more would be made available as a result of regulatory changes allowing freer operations of U.S. natural gas markets. Elsewhere in the world, disagreements between exporting and importing countries have occurred, particularly when sellers tried to set prices independent of market forces. For example, Canada's gas exports to the U.S. declined sharply from 1980 to 1984, until the Government of Canada adopted a more market-responsive pricing policy.

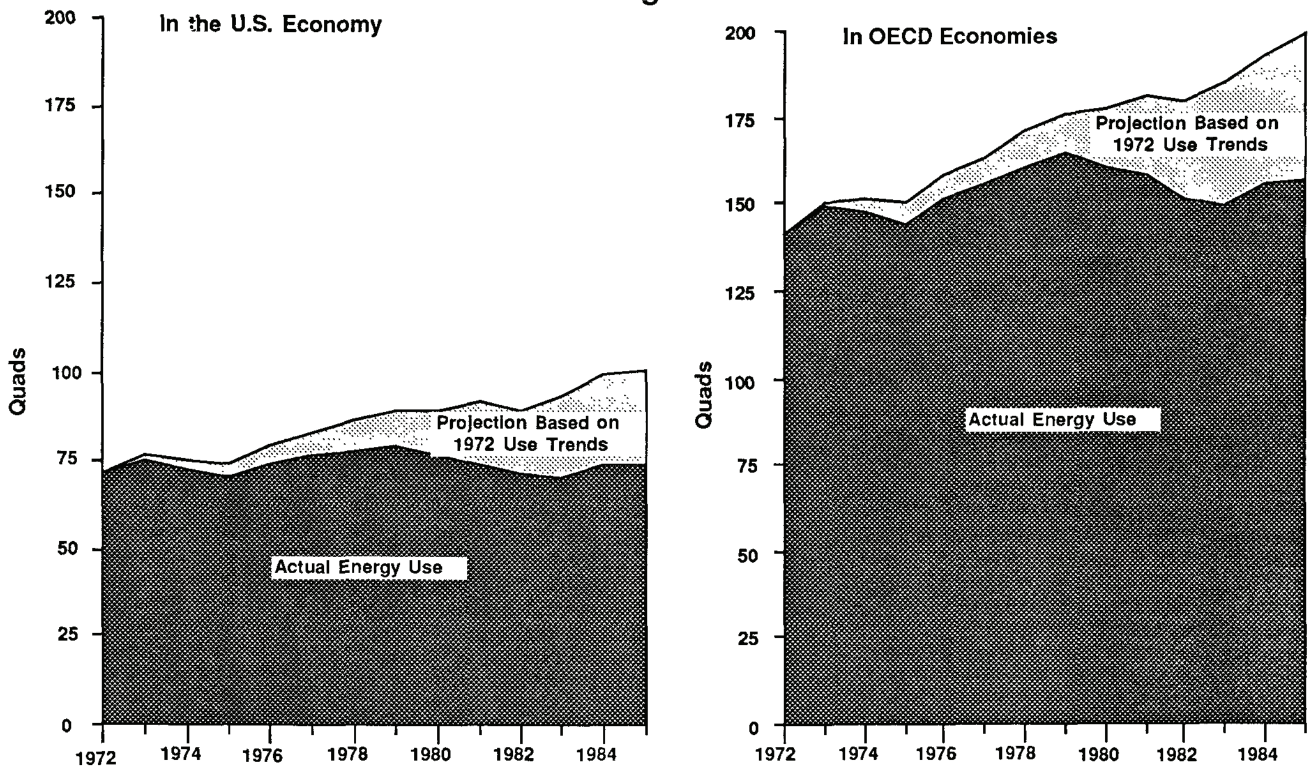
Using more natural gas from secure sources could effectively reduce the demand for oil and thereby reduce vulnerability to oil supply disruptions. Increased gas production and use will depend on long-term investments in transportation and distribution facilities, as well as free trade in gas based on reasonable economic criteria.

Gas Reserves Rival Those of Oil
. . . But Gas Production Is Much Smaller



(Statistics include centrally planned economies)

Conservation Savings Have Been Dramatic



ENERGY EFFICIENCY REDUCES NEED FOR OIL AND OTHER RESOURCES

When a barrel of oil is "saved" by a consumer anywhere in the world, this implies that an additional barrel of oil is available for other consumers. The unprecedented oil price increases and market dislocations of the 1970's spurred major efforts to increase energy-use efficiency; and the results in the United States and other industrialized countries have been dramatic:

- The United States currently uses about 29 quads less energy in a year than it would have if our economic growth since 1972 had been accompanied by the less-efficient trends in energy use we were following just before then. Part of the change in the intensity and pattern of U.S. energy use is due to shifts in the mix of its industrial products and to changes in consumer behavior. But most of it is due to technological improvements in vehicles, buildings, and equipment.

- In 1985, countries of the Organization for Economic Cooperation and Development consumed virtually the same amount of oil as in 1970 despite GDP growth of 29 percent during the intervening years. This was achieved through increased efficiency, fuel substitution, and the accelerated development of nuclear power generation.

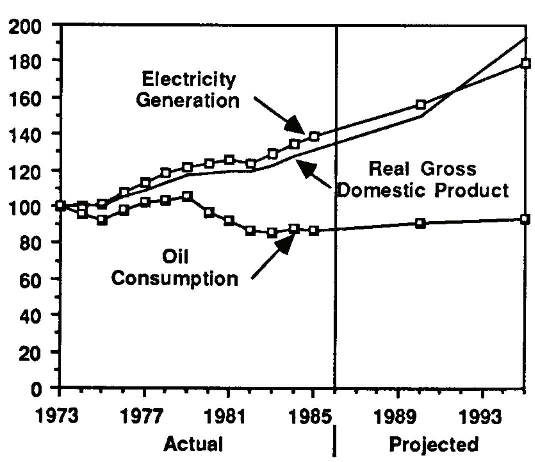
However, in less developed countries, where such efforts have lagged, energy demand has paralleled GDP. By 1985, LDC's were using nearly twice as much oil as they had used in 1973. This demand was driven by rapid industrialization, price controls on oil products, exceptionally high growth rates in population and urbanization, and the replacement of such traditional fuels as wood and agricultural residues with commercial fuels. LDC oil consumption has grown by almost 2 percent per year over the past 5 years, and similar growth is expected over the next 10 years.

As a result of lower oil prices, the pattern of general improvement in global energy efficiency could be slowed, and consumption could increase moderately over the next 5 to 10 years. Furthermore, serious impacts on energy efficiency could be felt in the year 2000 and beyond. Lower oil prices will undoubtedly postpone some investments in currently available and new energy-efficiency technologies and will reduce incentives for market penetration by alternative fuels. Nevertheless, the potential exists for more progress in cost-effective application of advanced technology to reduce dependence on oil.

DEMAND FOR ELECTRICITY EXPANDS, IN STEP WITH ECONOMIC GROWTH

Electricity is pivotal in the world outlook, because it is both a major consumer of primary energy and a major supplier of energy for end-uses. More primary energy goes into generating electricity than is consumed directly by any of the three basic end-use sectors—transportation, industry, or residential/commercial. This is true in the United States, Western Europe, Japan, and even the less developed countries around the world. Electricity also continues to account for a larger percentage of end-use energy in the world each year. This is true for industry, homes, and businesses (though not in transportation).

OECD Electricity Use Relative to GDP Growth and Oil Use



Index: 1973=100

Source: Energy Information Administration

In industrialized countries, the growing demand for electricity has kept its close statistical link to the ups and downs of GNP. Furthermore, electrification of the industrial economy is still not complete—even in the United States; and many cost-effective techniques for boosting productivity depend on further applications of electricity (for example, in steel "mini-mills," various drying processes, and computer-controlled manufacturing).

In LDC's, additional electrification would appear to be an inevitable accompaniment to future industrialization and improved living standards, as well as simple population growth.

Electricity provides several advantages over other forms of energy:

- Some applications (for example, lighting, motors, and electronics) require electricity as the only practical energy input.
- Electricity's end-use efficiency is often extremely high.
- Electricity can be produced from a multitude of primary energy sources (including renewable energy), so its use is comparatively independent of fuels on the world market that are vulnerable to supply disruptions and price volatility.

The use of oil to generate electricity around the world has dropped sharply since the early 1970's, but it is likely to rise again if world oil prices stay low. Besides, generating electricity with fuels other than oil is not without its problems:

- Coal plants are often opposed on environmental grounds, but some pollution-control systems threaten their economics.
- Nuclear power has been challenged on grounds of economics, public health, and long-term safety.

- High costs of transporting natural gas over long distances make gas uncompetitive in some parts of the world.

- Except for hydroelectric dams and some geothermal facilities, deriving electricity from renewable sources on a large scale is apt to be marginally economic at best (or limited to few sites, as in the case of windpower) through the end of this century.

FREE-WORLD CONSUMPTION OF COAL IS EXPECTED TO INCREASE

Coal is by far the most abundant fossil fuel. The Earth's recoverable coal reserves hold about three times as much energy as the proven oil and gas reserves combined. Coal reserves are widely distributed throughout the world. The United States has the largest recoverable reserves, followed by the U.S.S.R., China, Australia, Germany, South Africa, and Poland. The coal market is very competitive and is relatively well insulated against potential international price manipulation.

Worldwide use of coal is likely to increase by more than one-third between now and 1995, with international trade expanding by almost 50 percent to accommodate this growth.

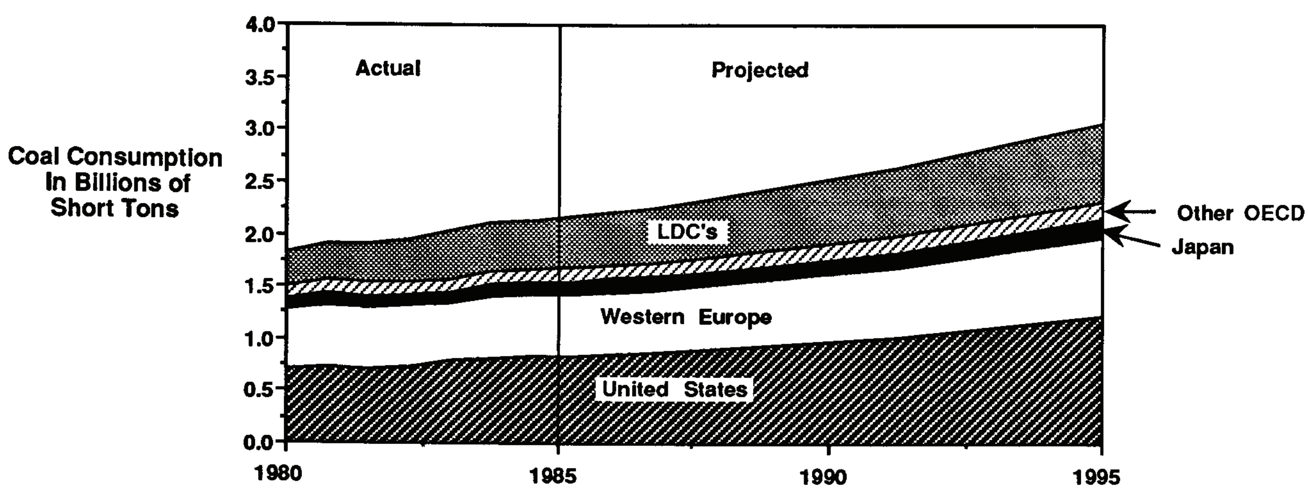
- In the United States, coal use is expected to increase by 25 percent between 1985 and 1995. Virtually all of this expected increase will be in the electric utility sector. Similar growth is expected in other OECD countries.

- The less developed countries are projected to increase their coal use by 30 to 60 percent over the next 10 years. This increase is based on projections of a faster rate of economic growth than that in the developed countries, and on considerably expanded use of electricity in LDC's.

It is possible for coal to do more than is now projected in reducing future dependence on oil. Several factors could encourage this to come about:

- Development of new technologies for burning coal in a more environmentally acceptable manner and in smaller applications (permitting its use in more industrial processes).

Consumption of Coal in the Free World, 1980-1995



Source: U.S. Energy Infomation Administration

- Prudent environmental regulations, which balance energy and environmental concerns and which minimize regulatory delays and barriers to new coal technologies.

- Expansion of world coal trade—through reductions in domestic subsidies by some countries, and through more efficient technologies for production and transportation.

Existing demand for coal is relatively insensitive to lower oil prices because coal is clearly the least expensive fuel in its most common application—generating electricity. A variation between $23 and $28 in 1995 oil prices would have little net effect on total demand for coal, because at the lower end of this range coal's use would be spurred by higher economic growth while at the higher end coal would be more favored as a substitute for oil. Only if oil prices are sustained at very low levels (below $15 per barrel) would substitution of oil for existing coal use begin to become an important factor.

On the other hand, *uncertainties* about future economic growth, electricity demand, environmental regulations, and oil prices might discourage capital investments in coal-using equipment that could further expand the role of this secure and plentiful fuel. The challenge will be to maximize coal's potential in the United States and other countries in the face of these uncertainties.

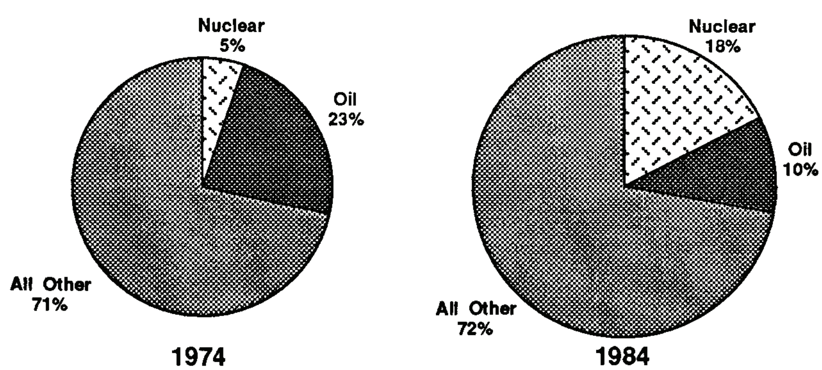
NUCLEAR POWER REPLACES MUCH OIL WORLDWIDE, BUT FACES AN UNCERTAIN FUTURE

In generating electricity, the respective contributions of nuclear energy and oil have essentially been reversed during about the past decade. More than one-fifth of the world's electricity now comes from reactor-based powerplants.

Nuclear energy today does the job of fossil fuel equivalent to more than 7 million barrels per day of oil (some 13 percent of the total worldwide daily consumption of approximately 55 million barrels). If it were not for the nuclear plants' output, the demand for oil or other substitutes would be all the higher. Today's uncertain prospects for operating nuclear plants, for those being built, and for others that might be ordered thus pose a troublesome economic and security problem.

Many nations have turned to nuclear energy, both for the expected long-term economic savings nuclear plants have offered and for the relative independence they provide from possible future disruptions in imported fuel supplies. The United States has the world's largest peaceful nuclear power program—with considerably more than twice the output of the second-ranking nation, France; however, about a dozen nations obtain higher

Fuel Use for Electricity Generation in OECD Countries



Source: Organization for Economic Cooperation and Development percentages of their electricity from nuclear plants than the 15-percent share in this country.

France and Belgium get roughly two-thirds of their electricity from nuclear power. West Germany and several other European countries rely on nuclear power for 30 percent or more of their electricity. The current figures for Taiwan and Japan are 52 and 27 percent respectively; and in the U.S.S.R. (with the world's third-largest program), nuclear power produces 11 percent of all electricity.

Nuclear power will continue to be the fastest growing supplier of electricity worldwide between 1985 and 1990, but the expansion experienced since 1970 will soon begin to slow. In the United States, 117 nuclear plant orders have been canceled since 1974, and no new orders made since 1973 still stand. Nuclear powerplant construction times have more than doubled since the early 1970's, and initial plant costs have increased by a factor of almost 10. Naturally, the long-term economic competitiveness of nuclear power has decreased.

The post-Chernobyl safety debate has affected many other countries' nuclear programs. Some countries are pressing forward, but others are reconsidering previously planned expansions, and Sweden is considering a speedup for its planned phaseout of nuclear power.

A complex of problems clouds the future of nuclear power. Uncertainty will persist—particularly in the United States—unless three conditions are met:

- Nuclear power must be economically competitive.
- Its safety must continue to be demonstrated, in order to ensure public acceptance.
- There must be a clear path leading to permanent disposal of high-level waste.

RENEWABLE RESOURCES PROVIDE LIMITED INPUT NOW, BUT LARGE POTENTIAL OVER TIME

Renewable resources, by definition, are almost infinitely abundant. Some renewable resources, such as hydroelectric power and firewood, are in widespread use throughout the world today. Other renewable resources, such as solar, wind, and geothermal energy, are in limited use today but may be used extensively in the future.

Hydroelectric powerplants now provide about 8 percent of free-world energy—about 20 percent of all electricity generation in the world. Most of the world's rivers with the highest hydroelectric potential already are being exploited, but construction of small-scale hydroelectric facilities will contribute to some limited growth over the next 10 years.

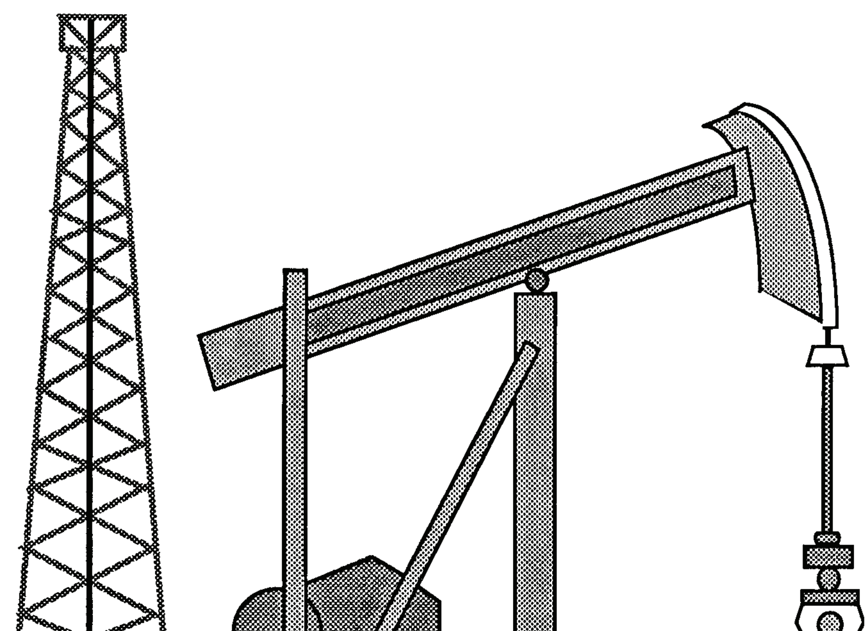
Wood and agricultural waste are the second most important form of renewable energy in use today. Wood is used for heating and cooking to a limited extent in the United States and other industrialized countries, but to a larger extent in less developed countries. Worldwide use of wood and agricultural wastes for energy purposes is expected to grow only slightly over the next decade—largely because of increased use of commercial fuels (oil, gas, and electricity) in LDC's.

Energy derived from solar, geothermal, wind, and biomass (other than firewood and agricultural waste) plays a relatively small role today compared to the principal commercial energy resources: fossil fuels, nuclear power, and hydroelectric power. Although renewable resources are vast, current technology does not enable them to compete on a large scale. Major technological strides have been made over the past decade, however, and future progress may make one or more of these resources economically competitive. Higher prices in the future for depletable resources also could improve the competitive position of renewables.

Because renewable resources are widely distributed throughout the world, increased use of these resources would tend to enhance energy security for all consuming nations. This benefit will not be realized to a very large degree over the next 10 years, but continued research conducted by private industry and by the United States and other governments should bring a variety of cost-effective technologies onto the market after the year 2000.

2

U.S. OIL: CRITICAL RESOURCE AT RISK



THE SITUATION IN BRIEF

The United States—an industrial giant with a large population, land area, and transportation system—uses more oil than any other nation. Although it is the world's second-largest petroleum producer, this country has high oil-production costs, and its currently recoverable oil reserves are relatively modest. Since oil is the country's principal energy source, the health of the domestic oil industry is critical to the Nation's energy security.

For the greater part of this century, the U.S. oil industry has been the backbone of America's energy and economic strength. Throughout a history of boom-and-bust cycles, the industry has shown a capacity to respond rapidly to rising prices when it was allowed to do so. Recently, however, the industry has undergone major consolidation as a principal result of the oil price collapse in 1986. Next time prices spiral upward, a battered oil industry may have trouble responding as quickly.

Recent declines in energy prices benefit the U.S. economy and U.S. consumers by cutting production costs and the cost of living, while also reducing the Federal deficit. However, low oil prices simultaneously undercut the U.S. oil industry as a whole. Low prices erode its profits and its cash-flow, and they jeopardize oil-industry loans—thus sharply reducing fresh capital expenditures, drilling, and employment.

The oil-service industry is especially hard-hit. A few elements of U.S. oil, such as the refining sector, have done reasonably well in spite of the recent price collapse; but, for most companies, 1986 and early 1987 have been a time of trauma and dislocation.

National energy policy today aims at maintaining adequate energy security at the lowest reasonable costs—primarily by letting consumers choose for themselves the precise balance among economic and other important objectives, rather than by pursuing government-dictated solutions. One crucial ingredient of U.S. energy security is a more competitive domestic oil industry that will continue to explore for and develop U.S. oil reserves. Under current low prices, exploration and production have fallen as the oil industry has retrenched. The industry needs to become more competitive, but there is no consensus yet—even within the industry—as to how this might best be achieved.

There are several cost-effective and environmentally acceptable ways in which this country can encourage higher output here as it becomes needed and also expand its crude oil reserves more vigorously.

This study has examined a representative sample of proposals. Each one is evaluated in terms of its benefits as weighed against its costs—including significant impacts on consumers, the environment, the Federal budget, the macroeconomy, and trade.

Providing Incentives: The Administration supported tax reform legislation that retained oil exploration and production incentives, and it supports repeal of the windfall profit tax. A variety of other incentives to increase U.S. oil exploration and production have been suggested as means of enhancing U.S. energy security.

- Different types of import fees have been urged, but analysis indicates that their economic costs are invariably excessive in comparison with the energy security and other benefits they might offer.
- A variety of tax incentives are being considered, including increased depletion allowances for new and enhanced oil recovery, tax credits for expenditures on exploration and development, and faster tax recovery of geological and geophysical costs. Such tax proposals can increase domestic oil production without imposing the economic and trade costs associated with import fees. However, such tax incentives have Federal revenue and other economic costs that have to be taken into account.
- Also under review are changing lease terms and royalty fees to provide incentives for domestic oil and gas exploration and development. While the cost of these proposals is relatively low, it is unclear that they could result in much additional activity.

Removing Impediments and Targeting R&D: Last year the Administration supported the Oil and Gas Revitalization Act of 1986, which attempted to remove several impediments to domestic oil and gas production. Removing barriers to production, providing better access to Federal lands, and targeting R&D will enhance energy security by making the U.S. oil industry more competitive. Examples of existing impediments include these:

- Environmental regulations can be improved in various ways to reduce uncertainty, reduce delays in obtaining required permits, and reduce compliance costs while maintaining appropriate environmental protection. For example, establishing a clearinghouse to test drilling muds could reduce the industry's costs without compromising environmental quality.
- More reasonable access to Federal lands, including the Arctic National Wildlife Refuge (ANWR) and the Outer Continental Shelf, could add significantly to U.S. oil reserves—even though careful consideration must be given to environmental concerns.
- Leasing policies are also under review by the Department of the Interior to permit more flexibility in terms as oil prices change; and this could encourage further exploration and development while protecting an adequate return to the public.
- Allowing U.S. producers to export crude oil (particularly from North Alaska) would increase economic efficiency by allowing oil (from both here and abroad) to flow to its natural markets. Removal of export restrictions, however, would adversely affect the domestic maritime industry and could reduce the availability of militarily useful tankers.

Targeting a higher percentage of Federal R&D funding toward cooperative ventures with industry and the universities can lower the costs of U.S. oil exploration and production. Focusing on enhanced oil recovery (EOR) and petroleum geosciences could reduce EOR costs, making enormous amounts of otherwise uneconomic oil available in the country.

THE U.S. HAS HIGH OIL CONSUMPTION, LARGE OUTPUT, BUT MODEST RESERVES

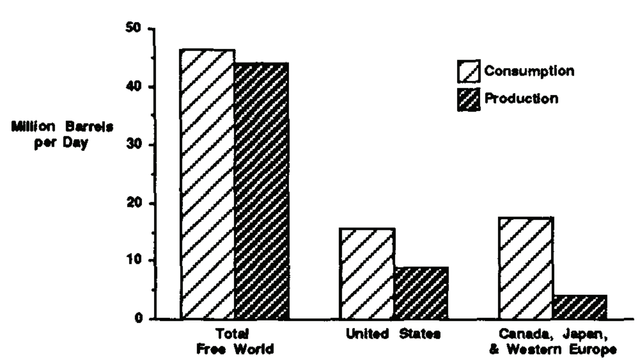
AMERICA'S SIZE AND VIGOR MAKE IT WORLD'S TOP USER, AND IT IS SECOND IN PRODUCTION

Primarily because of its large population and industrial base, the U.S. consumes more oil than any other country. In 1985, the United States accounted for about one-third of total free-world oil consumption.

This country also produces a large amount of oil. In 1985, the United States provided about one-fourth of total free-world oil production—more than any nation on Earth except the Soviet Union. Saudi Arabia has the capability to produce more oil than the United States; but recently that country produced at less than half its capacity, in an attempt to sustain higher world oil prices.

There are many reasons why oil is so crucial to the Nation. The United States is a geographically dispersed country, with an exceptionally well-developed road system that contributes to high demand for gasoline and diesel fuel for cars and trucks. The agricultural sector in this country is very productive, but it requires large amounts of petroleum products to operate machines for planting, harvesting, and moving agricultural products to markets. Finally, U.S. citizens require a large amount of energy to maintain their high standard of living, which includes both a large and varied housing stock and the means to travel to and from their homes.

Oil Consumption and Production, 1985

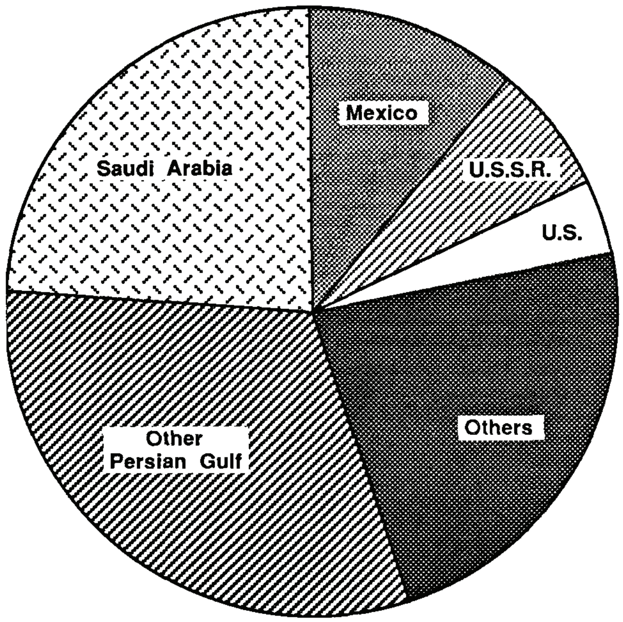


U.S. OIL RESERVES ARE LIMITED IN COMPARISON WITH OTHER LARGE PRODUCERS

Despite being the second-largest oil producer, the United States contains only about 4 percent of the world's known oil reserves. U.S. oil reserves of about 28 billion barrels equal only about 9 years of its current production. By comparison, Saudi Arabia, the country with the world's largest oil reserves, has a reserve-to-production ratio of more than 90 years (assuming production of about 5 million barrels per day). Undiscovered oil resources will probably follow a geographic pattern similar to that for known reserves. Thus, new discoveries of crude oil are unlikely to alter the present situation—in which most of the world's crude oil lies in the Persian Gulf region.

Although the reserve-to-production ratio is a reasonable indicator of reserve adequacy among countries, it does not necessarily tell how long a country or region can sustain its production. Each year the United States and most other oil-producing regions add to their reserves through "extensions" (enlargements in the *area* of proved reserves), "revisions" (changes in reserve estimates based on new information, such as the demonstrated economic feasibility of advanced production equipment and techniques), and totally new discoveries (either new fields or unpredicted reservoirs in existing fields). In fact, because of all such reserve additions each year, the U.S. reserve-to-production ratio of 9 years has remained at about that level or greater for more than 35 years. The United States will continue to produce crude oil for many years to come, but the oil price collapse and prevailing conditions in the industry raise concerns as to the adequacy of future reserve additions and production.

World Crude Oil Reserves
(700 Billion Barrels)



Concern about "running out of oil" because of a low reserve-to-production ratio is often misplaced. As far back as the 1920's, fears were raised that the United States might soon run out of oil. Rather than straightforward exhaustion of oil resources, the genuine concern for the next several decades should be that most of the world's cheapest oil reserves and potential resources are located in the unstable Persian Gulf. Increasing U.S. dependence on Persian Gulf oil combined with the principal reliance on that oil region by U.S. allies poses risks to U.S. energy security. A disruption in supplies from that region or rapid price increases through exertion of market power *are* major causes for concern.

There are many current and potential substitutes for conventional oil as that resource is depleted. Oil prices will rise in response to depletion and eventually bring more of these substitutes into the market. In addition to increased efficiency in the use of oil and the use of alternative fuels (such as natural gas, coal, nuclear power, and renewable energy), other direct substitutes for conventional oil include these:

- **Enhanced oil recovery:** Only about one-third of the oil known to be in place is recovered now through conventional techniques. As a result, about 300 billion barrels of U.S. oil remain in the ground from past production—more than ten times current conventional reserves. By increasing the recovery rate, advanced techniques can tap into the large potential of oil that otherwise would be left in the ground.

- **Heavy oil and tar sands:** Several regions have large quantities of these unconventional oil resources. They are uneconomic to produce at current oil prices, but would be economic at significantly higher price levels. For example, Canada and Venezuela contain about 600 billion barrels of such unconventional oils.

- **Shale oil:** The United States has tremendous potential for oil shale development. Estimates place U.S. oil shale resources at about 4 trillion barrels of oil equivalent. About 10 percent (some 400 billion barrels) could be produced with current technology, but it would be economic to do so only if oil prices were significantly higher. Development of this resource also faces serious environmental difficulties in regard to water and land use.

- **Conversion of solid or gas fuels to liquids:** If oil prices rise sufficiently, it may become economic to convert natural gas, coal, or biomass into liquid forms that can be used as transport or other fuels. For example, Brazil currently uses about 200 thousand barrels per day of liquid fuels derived from biomass. South Africa produces about 190 thousand barrels per day of coal liquids. Other countries are exploring the conversion of natural gas to methanol—or directly to gasoline—as a way to improve the value and use of excess gas in those regions.

The problem with most of these substitutes is that they are uneconomic under current conditions, and therefore they will not be available in the near future to reduce foreign import dependence and vulnerability to supply disruptions and economic shocks. Long lead-times are involved in developing and applying significant quantities of any of these longer-term substitutes. Thus, short-term problems remain the most important energy security threat caused by world reliance on oil from the unstable Persian Gulf region.

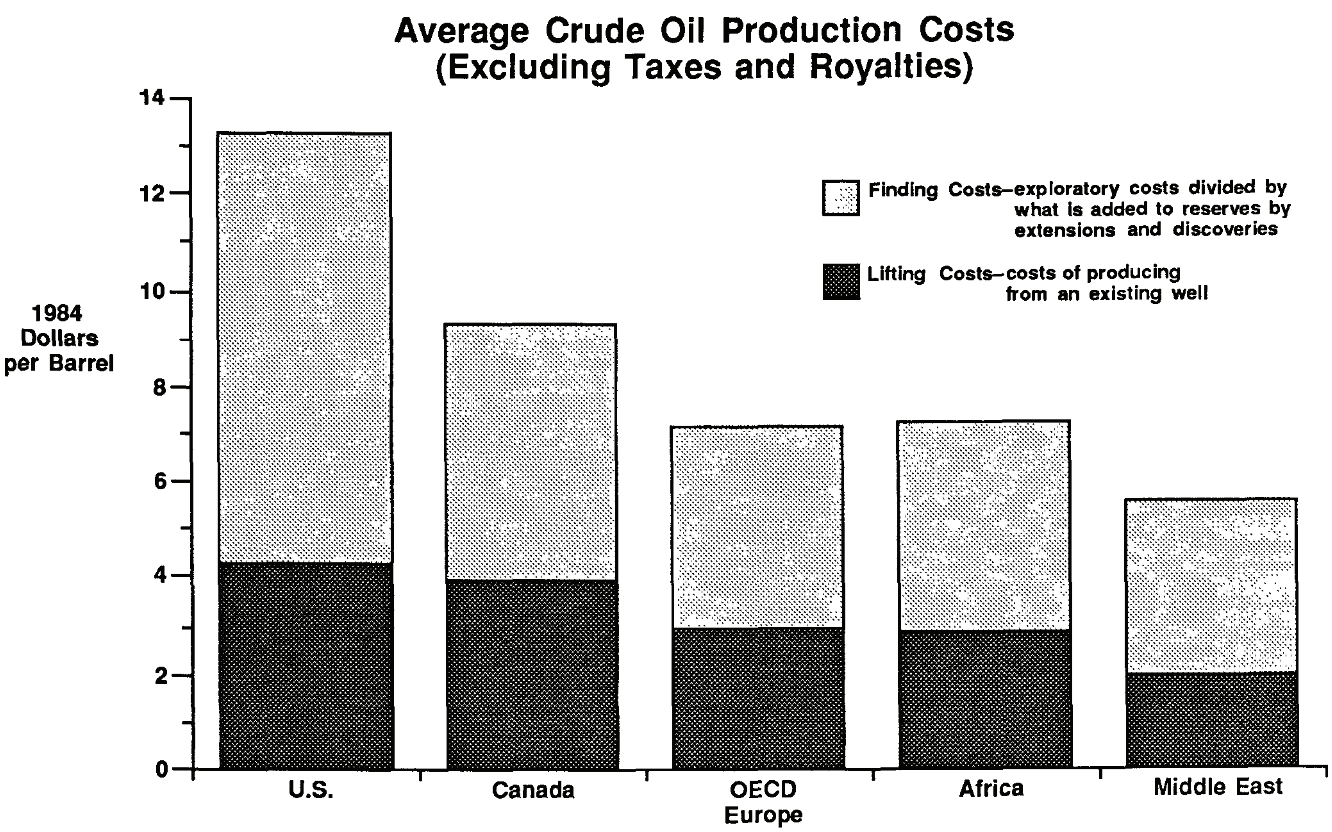
FINDING AND PRODUCING OIL IS MUCH MORE EXPENSIVE HERE THAN IN MOST OTHER COUNTRIES

U.S. oil costs much more to find and to produce than petroleum in other countries. In recent years, finding costs alone have averaged about $8 to $10 per barrel across the United States (excluding development costs, taxes, and royalty payments). In the harsh regions of North Alaska or in deep water offshore, these costs may be more than twice that. In the Middle East, by contrast, such costs are less than half the U.S. average.

"Finding costs" are calculated by defining the total annual exploration expenditures—both capitalized and expensed—by the amount of oil and gas reserves added by extensions and discoveries. "Lifting costs," on the other hand, are the short-term costs of producing each additional barrel from an oil well. For the United States, lifting costs are estimated to average about $4 to $5, excluding royalties and taxes; however, this average is deceptive because marginal costs vary considerably. For example, lifting costs can approach $20 per barrel for some low-production U.S. wells, while these costs in large oil fields may be less than $4 per barrel.

Recent data indicate that lifting costs in most developed oil fields around the world are less than those in the United States. In Canada, they are only slightly lower—also in the range of $4 to $5 per barrel; and lifting costs in Europe and northern Africa range from $3 to $4 per barrel. In the Middle East, however, marginal production costs are just about half what they are in the United States.

In addition to direct production costs, firms also pay taxes and royalties. When these payments



Source: EIA, "Impact of Lower World Oil Prices and Alternative Energy Tax Proposals on the U.S. Economy," 1986 are taken into account, the short-term marginal production costs in the United States are roughly the same as in most other countries outside the Middle East—a total of about $10 per barrel. Obviously, then, if world oil prices stayed at $10 to $12 per barrel, production from most known reserves would decline, although this would not have to occur in an area such as the Persian Gulf. Any oil producer is likely to keep up output from an existing well only so long as the price received for each new barrel is at least sufficient to cover the expense of lifting it from the underground reservoir. As demand for oil increased under such conditions, however, prices would presumably increase again; and, in response some oil production would eventually be restored. Any such reduction in production, coupled with a likely increase in oil demand, would eventually cause oil prices to return to a level that made more production economic.

Finding and lifting costs for U.S. oil production average about $13 per barrel. Development costs add an additional $1 per barrel. However, this does not include royalty payments and production taxes, which raise total production costs considerably. As crude oil prices approach or drop below the average cost of U.S. oil production, an increasing amount of U.S. oil production capacity becomes uneconomic. Marginal or "stripper" wells that produce small quantities of oil but represent approximately 15 percent of U.S. production are shut in and eventually plugged and abandoned. This production is essentially lost forever. With average total costs substantially exceeding $13 per barrel, there is little incentive to invest and explore for new oil. Lower prices retard capital formation and result in fewer reserve additions. The lack of drilling activity then increases import dependence and weakens the domestic industry.

DESPITE INTENSIVE U.S. DRILLING, DISCOVERIES OF NEW CRUDE OIL RESERVES REMAIN LOW

No region in the world has been explored more intensively for crude oil and natural gas than has the United States. As of 1986, about 80 percent of all the wells ever drilled worldwide—2.9 million—had been drilled in this country.

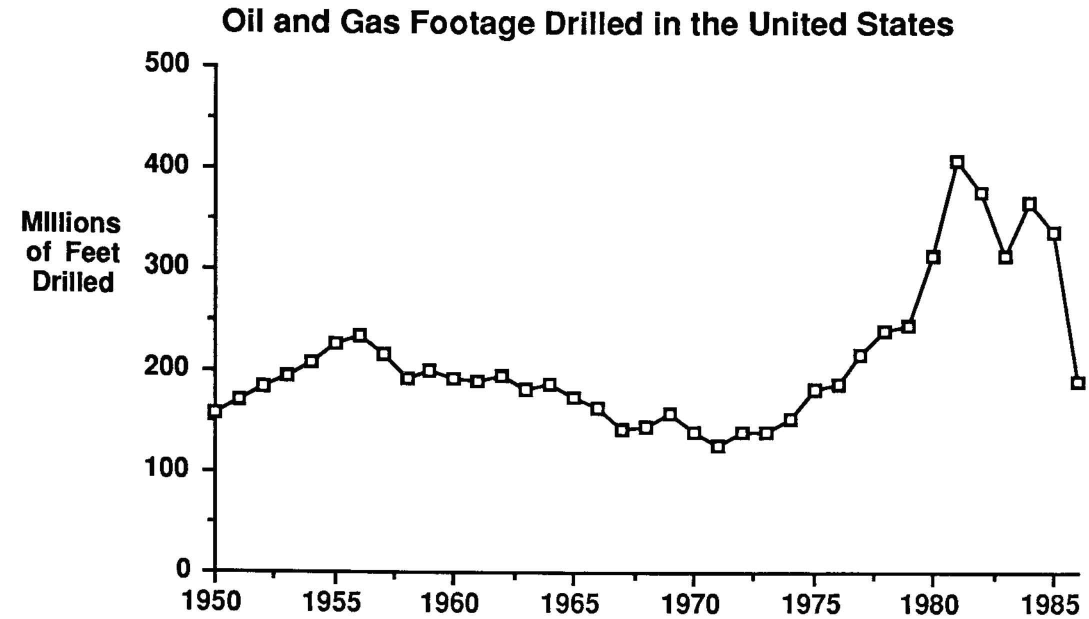
Because the United States has been explored so extensively already, most of the very large oil fields here have probably been discovered. This is especially true for the "Lower 48," where most U.S. drilling has occurred. As a result, the finding rate in the United States (the amount of crude oil found per foot of well drilled) has been declining.

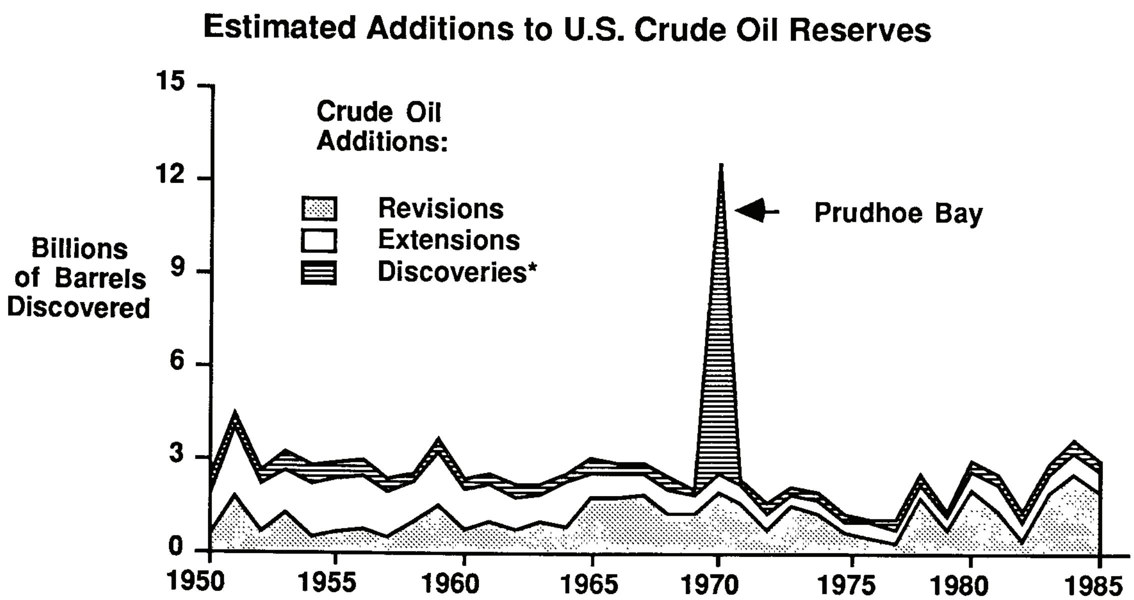
In the 1950's, an average of about 16 barrels of crude oil was discovered for each foot of drilling in this country. That amount increased slightly in the 1970's, averaging about 17 barrels per foot drilled. But during the 1980-to-1985 period, the discovery rate for crude oil averaged only about 8 barrels per foot drilled.

Unless very large U.S. oil fields are discovered offshore or in North Alaska (where there has been much less exploration than in the Lower 48) a considerable amount of drilling activity will be required just to keep the Nation's oil reserves at current levels. U.S. crude oil production over the last 5 years has averaged about 8.7 million barrels per day, which means that about 3.2 billion barrels of crude are being taken out of the ground—removed from reserves—each year. With a discovery rate close to 8 barrels per foot drilled, about 375 million feet of drilling are required to keep the reserve total from slipping.

The declining finding rate for U.S. oil in terms of barrels discovered per foot drilled also means that more and more drilling activity is required to sustain the country's oil output capability. During the 1970's, U.S. drilling activity increased dramatically, rising from 140 million feet in 1970 to 410 million feet in 1981; yet the additions to reserves remained fairly constant at about 2.5 billion barrels per year.

In the future, the U.S. oil industry will have to work hard just to maintain its present production capability, let alone increase production. The recent decline in oil prices has made much drilling unprofitable, so additions to crude oil reserves and oil production are dropping off sharply. Fortunately, there are still two areas of promise for future U.S. oil exploration and development —recovery of oil from known reservoirs (enhanced oil recovery) and discovery of new large oil fields offshore and in North Alaska.





* "Discoveries" include new reservoirs in old fields as well as totally new fields.

ENHANCED OIL RECOVERY HAS LARGE POTENTIAL IN "LOWER 48"— BUT EOR COSTS ARE HIGH

Despite the popular image, petroleum is not found in huge, convenient underground pools. It is a difficult and expensive task to extract crude oil from natural "reservoirs." In fact, only about one-third of the oil estimated to be in place is recovered. The remaining oil is known to be in the ground, but it is too expensive to produce with conventional techniques. "Enhanced oil recovery" refers to more sophisticated (and presently more expensive) techniques that can remove a larger fraction of the oil from a particular reservoir. One example of EOR is the injection of steam into a heavy oil reservoir—making the crude oil less viscous, so that it flows more easily into "recovery wells."

EOR potential may be further enhanced by the utilization of newly developed geologic data bases and engineering characterizations which facilitate precise targeting of specific locations where the most economical secondary and tertiary recovery may be accomplished.

Detailed information about the special characteristics of individual crude oil reservoirs is essential to apply enhanced oil recovery techniques successfully. For example, proper injection of steam or chemicals requires that the driller know about the existence and location of impermeable layers or other geologic conditions that could prevent injectants from being fully effective.

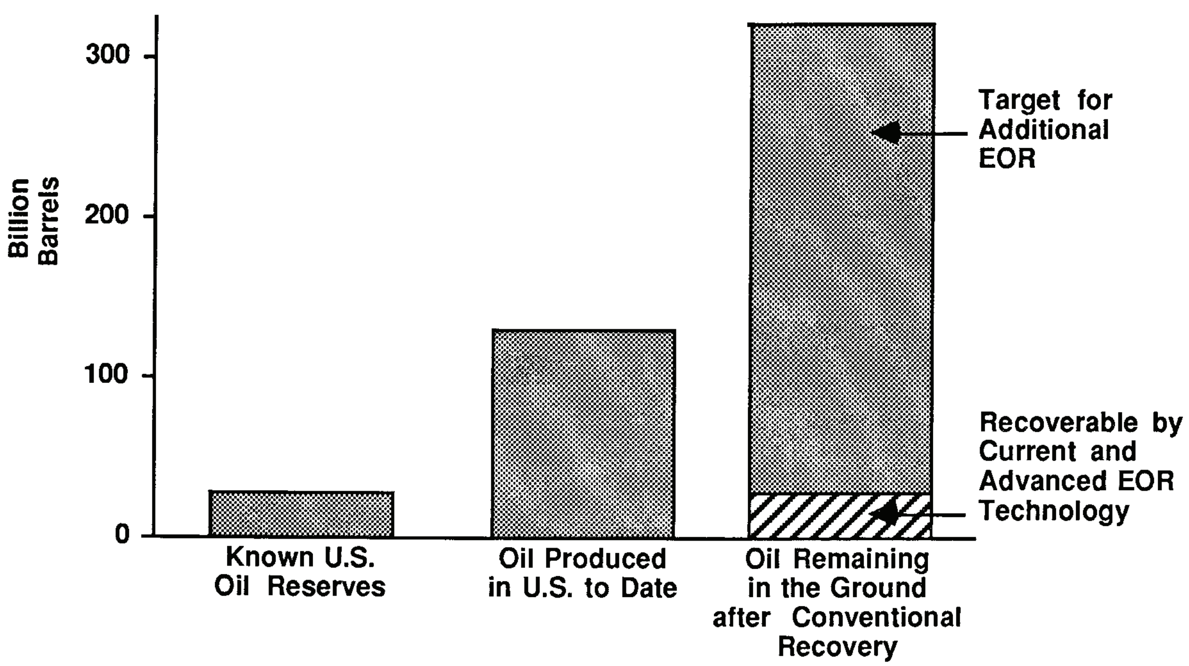
Conventional recovery of the oil discovered to date in the United States has left about 300 billion barrels of oil remaining in the ground. Potentially about 30 billion barrels of this crude oil could be recovered by employing EOR techniques that are already being used or tested by the industry. The remaining 270 billion barrels is an inviting target for new enhanced oil recovery techniques that might be developed. As oil prices increase, more and more of the oil remaining in the ground will become economic for advanced enhanced oil recovery techniques.

If the costs of enhanced oil recovery could be reduced, especially as world oil prices rise in the future, enhanced oil recovery could become a critical source of U.S. oil production. Lower prices, however, have discouraged research and development expenditures by the oil industry and progress in this area has slowed significantly. Under present economic conditions, a joint effort by the industry and universities fostered by government may be the only way to achieve significant progress in the near future.

OFFSHORE AND NORTH ALASKA OFFER THE BEST PROSPECTS FOR FINDING BIG NEW U.S. OIL FIELDS

The onshore region of the lower 48 States has been so completely explored that there is very little likelihood of discovering any more big oil fields, equal to even half the size of Prudhoe Bay, in North Alaska. Prudhoe Bay—the

U.S. Oil Already Produced, Current Crude Oil Reserves, and Potential for Enhanced Oil Recovery (EOR)



largest crude oil field ever discovered in the United States—added 10 billion barrels to U.S. oil reserves and achieved a maximum daily output of about 1.5 million barrels per day. The next largest U.S. oil field, East Texas (discovered in 1930), added 6 billion barrels to domestic reserves.

Offshore regions and North Alaska now offer the highest likelihood of finding really large new oil fields. The coastal plain of the Arctic National Wildlife Refuge in North Alaska, for example, is probably the most promising region of the United States in terms of having the potential for oil reserves the size of Prudhoe Bay. In addition, about 4 billion barrels of recoverable undiscovered oil resources are estimated to be off the California coast.

DESPITE OVERALL BENEFITS TO THE ECONOMY, THE U.S. OIL INDUSTRY HAS BEEN HURT

LOWER OIL PRICES AUGMENT CONSUMERS' PURCHASING POWER AND FAVOR GENERAL EXPANSION

The drop in oil prices of nearly 50 percent in the spring of 1986 brought some substantial benefits to the U.S. economy and to consumers:

- The purchasing power of consumers rose as they began to pay lower prices for gasoline, home heating oil, heavy fuel oil, and other petroleum products, as well as for competing fuels such as natural gas and coal. Gasoline prices in 1986 were lower in constant dollars than they have been at any time since 1949.

- The drop in oil prices has lowered inflation. In 1986, consumer prices increased by only 1.3 percent, the smallest increase in more than two decades. Wholesale prices declined by 2.3 percent—the largest decrease in U.S. history.

- Lower inflation has, in turn, contributed to lower interest rates. Three-month Treasury bills and the prime rate charged by banks dropped by about two percentage points during 1986, and home mortgage rates dropped a full percentage point. Lower energy costs, lower inflation, and lower interest rates have also helped to reduce Federal expenditures (including interest on the national debt) and thus have served to control the Federal deficit.

- The combined result of all these factors is that the current economic recovery remains strong and is the second longest economic expansion of the past 50 years.

Unemployment is at its lowest level in seven years. The economy continues to grow and to create new jobs at the rate of more than 2 million per year.

Here are a few ways in which lower oil prices have favored individual energy-users and petroleum-consuming industries:

- **Car Owners:** The average car owner has saved more than 25 cents on each gallon of gasoline. That meant paying out about $165 less per car in 1986 than in 1985. The average household saved approximately $300 on gasoline bills last year.

- **Airlines:** A 1-cent-per-gallon decline in fuel prices results in about $120 million of savings to the industry. Total savings in 1986 were estimated at $3.2 billion.

- **Petrochemicals:** Costs of certain feedstocks declined roughly 50 percent in 1986. Feedstocks and fuel use make up about 50 to 70 percent of the costs for some petrochemicals.

- **Trucking:** Approximately $7 billion in savings on trucking costs were realized in 1986. The savings on a single heavy truck averaged nearly $2,500.

- **Government:** About $100 million in direct purchases for petroleum products is saved each year for each penny a gallon in lower fuel prices. Lower oil prices also cut government expenditures indirectly by lowering the inflation rate, because this reduces transfer payments on programs that are indexed.

Internationally, low oil prices benefit the economies of the oil-dependent industrial countries; and they are especially helpful to oil-dependent less developed countries that are already burdened with high debts. The impact of lower oil prices on the U.S. trade deficit is more complex. An immediate effect is to narrow the deficit by reducing the cost of imported crude oil. Over time, however, crude oil imports will likely increase in response to lower oil prices; and this would increase the future import bill for crude oil. Changes in the oil import bill create pressures that affect exchange rates and trade flows of other commodities too—so the long-term implications on the trade deficit are still not clear.

Just as lower oil prices benefit the U.S. economy and consumers, however, it should be kept in mind that the reverse is also true. Rapid oil price increases in 1974 and 1979 resulted in very large economic losses to the U.S. and other oil-consuming nations. The U.S. recessions following the 1974 and 1981 oil price shocks were the most severe in terms of depth and duration since the Great Depression. Inflation throughout the 1970's was higher in part because of higher oil prices. Admittedly, the economic losses of that period were made worse by government policies, including price controls, allocations, and an expansive monetary policy. Nevertheless, while the current benefits of lower oil prices are in many ways good for the economy and consumers, justifiable concern remains that new oil price shocks in the future might again threaten U.S. economic prosperity.

OIL-PRODUCING STATES SUFFER REVENUE LOSSES AS PRICES FALL; SOME ACT TO AID INDUSTRY

Although lower oil prices have broad economic benefits for oil consumers, they have a serious negative impact on the major oil-producing States, such as Texas, Alaska, Louisiana, and Oklahoma. By the same token, these oil-producing States were much better off during the oil price increases of the 1970's, when the rest of the country was suffering economic loss.

Governments of oil-producing States have long relied on income from oil taxes and royalties as a primary source of revenue—a source that ebbs when oil prices plummet and oil production falls off. In the case of Alaska, 85 percent of all revenues come from oil and gas taxes. In New Mexico, the share is 41 percent; in Oklahoma, 25 percent; in Texas, 20 percent; and in Louisiana, 18 percent.

For every dollar decline in oil prices, Alaska loses about $150 million and Texas loses about $100 million in combined revenue for production taxes and royalty payments.

Employment cutbacks in petroleum and petroleum service industries have led to higher-than-average unemployment in oil-producing regions. Texas, Louisiana, Alaska, and Oklahoma, which account for about 10 percent of national employment, are experiencing unemployment rates well beyond the national average. Unemployment nationally averaged about 7 percent in 1986, compared to about 14 percent in Louisiana, 11 percent in Texas and Alaska, and 9 percent in Oklahoma.

Several States have acted to give the oil industry some relief during this period of lower oil prices. By reducing the operating costs for production, they have restored some part of the incentive for and profitability of sustaining production despite lower oil prices, but more can be done:

- Alabama, Louisiana, Mississippi, and Montana have reduced production taxes, State severance taxes, and/or taxes on special types of production (such as enhanced oil recovery).
- Regulatory agencies in Oklahoma and Kansas have reduced electricity rates for operators of oil and gas leases, thereby reducing operating costs and postponing the shut-in time for marginal production.
- Oklahoma and Texas have extended the deadline for plugging inactive wells beyond the 90-day period they had allowed, so that such wells may now remain unplugged for 1 year or longer.

U.S. DRILLING IS OFF SHARPLY AS INDEPENDENTS CUT BACK EFFORT THAT HAS MADE MOST NEW FINDS

Lower oil prices are forcing an extremely painful adjustment upon the U.S. oil industry, especially on independent producers who do not have refineries or other profitable operations to offset losses. Last year's financial results for oil drillers reflected the sharp decline in oil prices. From the third quarter of 1985 to the third quarter of 1986, oil drillers' revenues fell by 49 percent (for sampled forms). After a profitable year in 1985, the drilling industry suffered enormous losses in 1986.

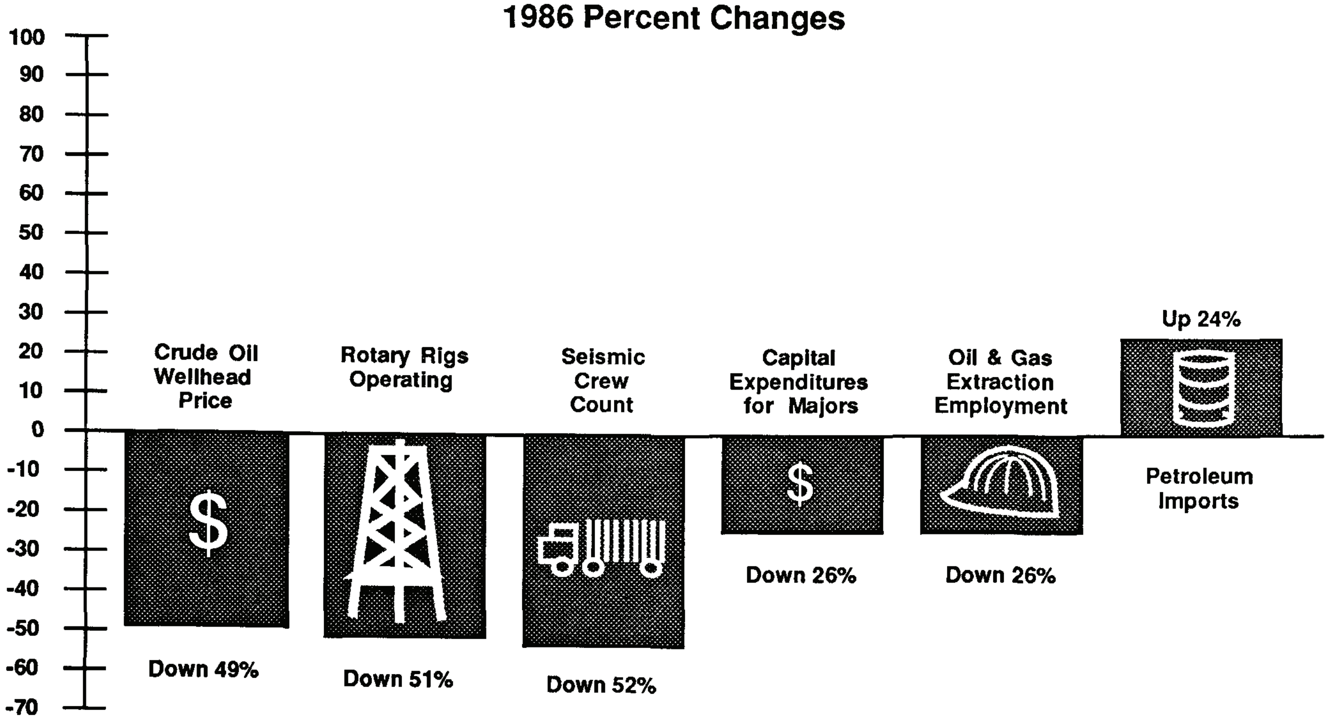
Capital expenditures for oil exploration and development have dropped by nearly 50 percent since the record high year of 1981, and such spending by major oil companies was off about 26 percent in 1986 alone. Major oil companies' net profits remain positive, but their earnings in 1986 were down considerably. Most of these companies reported drops of between 20 and 80 percent in fourth-quarter earnings.

Independents, who have less cash flow and must rely heavily on external financing for investment, slashed their capital programs by 50 percent or more in 1986. The severity of the impact on independents is especially significant, since independents in the past have discovered the majority of new oil and natural gas in the lower 48 States.

Data from the Bureau of Labor Statistics show that by the end of 1986, 150,000 oil industry jobs had been lost—representing close to 30 percent of the total work force devoted to oil and gas exploration and oil field services. Current oil industry employment of about 424,000 is at about the same level as in 1977, before the industry expansion that resulted from the 1979/80 oil price increase. Unemployment among petroleum geologists is about 26 percent.

Reduced expenditures and exploration activities in the United States will mean fewer additions to reserves and lower future production levels, although some factors are moderating the negative impacts of lower oil prices. In particular, exploration costs are

1986 Percent Changes



Source: Visual Concept, IPAA; Numbers, Department of Energy lower now because of a surplus of drilling rigs and other available equipment. Also, companies are focusing on areas with the highest prospects for success, so the percentage of dry holes should decline. Although lower oil prices are reducing the size of the U.S. oil industry and causing considerable hardship and difficulties, the overall efficiency of the industry should increase.

THE OIL SERVICE INDUSTRY HAS BEEN PARTICULARLY HARD HIT BY LOWER OIL PRICES

The oil service industry includes specialized manufacturers of supplies as well as field-service groups that are contracted to perform special work for petroleum companies in relation to exploration, development, well completion, reworking, or well maintenance. Although low oil prices have affected all sectors of the petroleum industry, they have been particularly damaging for the service sector. Large petroleum corporations with diversified holdings retain their earnings from activities other than exploration, development, and production when oil prices are low. The service industries, however, are wholly dependent upon oil and gas exploration and development. When oil prices are low and exploration and development work declines, heavy losses are inevitable for oil service businesses.

In 1986, drilling activity (as measured by rigs in use) reached a 46-year low. In July, the rig count was below 700, compared to a 1981 peak of 3,970 rigs in use. Since July, the rig count has increased; and it recently averaged above 800. The number of crews engaged in seismic exploration has declined steadily since 1985. The number of seismic crews employed in mid-1986 was 60 percent below the 1985 count.

For the first time in recent history, the net profitability of the entire oil service sector was negative in the third quarter of 1986. No U.S. oil service company is likely to show a profit for 1986.

The reduction in a skilled labor pool for oil service could produce substantial delays and higher costs for the U.S. petroleum industry whenever oil prices increase and a faster pace of drilling is resumed.

FINANCING OIL EXPLORATION IS MORE DIFFICULT WITH LOWER OIL PRICE EXPECTATIONS

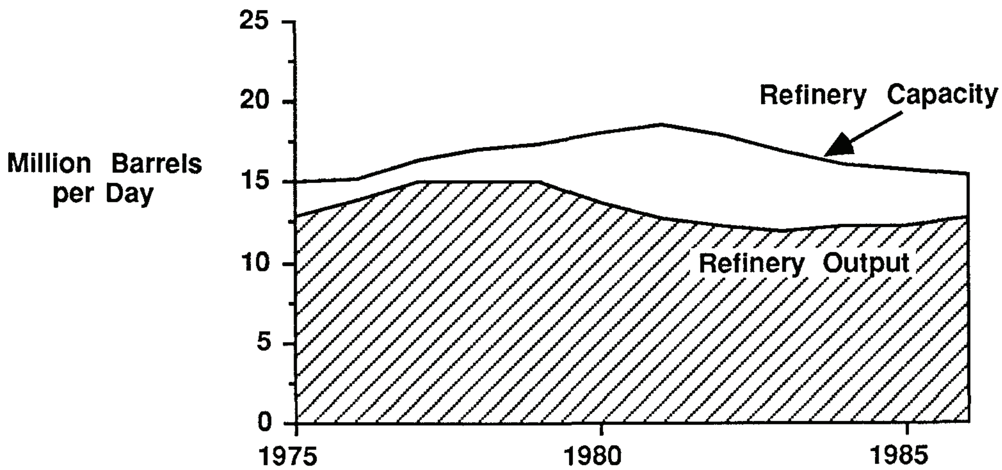
The oil price decline since 1981 and the price collapse in 1986 have fundamentally changed oil price expectations. During the 1970's, there was also uncertainty about oil prices, but it was almost entirely on the upward side. The oil price then looked like a reasonable floor for investment planning. By 1981, however, investment planners began to worry about a possible price drop. Prices had gotten high enough so that—if anything—the uncertainty was switched to the down side.

In January 1986, oil prices were above $25 per barrel, in June they had dropped below $10, and by the end of the year they had bounced back to about $18. Although the collapse to less than $10 per barrel was apparently temporary, the fact that it had even occurred means that investment planners and creditors now must take such a future price scenario into consideration. Even if prices stabilize now above $15 per barrel for a year or two, many financial institutions will use lower oil price scenarios in evaluating loans for oil exploration and development. Several banks have reported using $5 and $8 per barrel price cases in evaluating credit lines.

Cautious lenders in the future are bound to remember that many banks went under during the past few years because of bad energy loans. Many loan officers lost their jobs. For the next few years, financial analysts will tend to be very conservative about oil-price projections. They will recall government and private-sector projections that proved much too high.

In addition, the collapse of regional banks in Texas, Oklahoma, Louisiana, and other oil-producing States diminishes the funds

U.S. Oil-Refining Capacity and Output



available to local independent oil producers, who rely to a heavy extent on such institutions. They were especially hard hit by low oil prices because many such banks also had precarious loans to farmers and real-estate developers.

The caution of financial institutions is causing particular difficulties for independent oil producers, who rely largely on external funds to support their exploration and development. Major oil companies fund much of their activity of this type from internal cash flow, but a period of caution by lending institutions could make it far more difficult for independent producers to get the capital they need to go after what they consider economic prospects.

INCREASED PRODUCT DEMAND AT LOWER OIL PRICES BOOSTS U.S. REFINERY OUTPUT

Refiners process crude oil into various products, such as gasoline, diesel, heating oil, and residual fuel oil. While lower oil prices hurt the domestic exploration and production segments of the U.S oil industry, the impact of lower oil prices on U.S. refiners is less severe, and may in fact be positive.

Lower oil prices increase demand for refined petroleum products, so sales increase and domestic refiners get to operate closer to capacity. In 1984 and 1985, U.S. refiners raised concerns about the quantity of product imports that might come into this country from refiners in the Middle East, Europe, Indonesia, and elsewhere because so many U.S. refineries had been closed since 1981. These concerns led to questions of whether the U.S. refining industry would be able to meet future national security requirements. The U.S. Department of Energy has published a report addressing these questions, entitled *Product Imports, Energy Security and the Domestic Refining Industry* (DOE/PE-0075, June 1986).

The analysis in the report indicates that total U.S. refining capacity and the expected level of product imports pose no energy security threat to the United States. Total U.S. refining capacity is expected to remain fairly constant in the near term, and enough excess refining capacity is available (in the United States and in other major petroleum-refining centers) to carry out necessary refining operations in the event of a disruption of product supply from the Middle East and North Africa, provided domestic crude oil inventories are adequate.

The closures of U.S. refining capacity since the end of crude oil price controls in 1981 closely paralleled reductions in national demand for petroleum products. Oil price decontrol forced U.S. refiners to compete in the world products market without subsidies on the crude oil input; and many small refineries were no longer profitable without what was called the "small refiner bias" of the entitlements program.

Through significant restructuring and upgrading, however, the U.S. refining industry is now adjusting successfully to increased competition in the domestic market. Lower crude oil prices have reduced feedstock costs, and refiners' margins in 1986 edged back toward earlier levels. Analysis indicates that the U.S. refining industry will continue to cope successfully with tough market conditions into the 1990's.

THE U.S., A HIGH-COST OIL PRODUCER, FACES LOWER OIL OUTPUT IF LOW PRICES PERSIST

STRIPPER-WELL PRODUCTION IS ESPECIALLY VULNERABLE AT CURRENT PRICE LEVEL

Chapter 1 of this report and Appendices A and B describe several scenarios used in this study to examine a range of possible energy futures. The scenarios cover oil price cases that range between a "price collapse" case of $10 per barrel in the near term, to 1990 oil prices in the $15 to $20 per barrel range, and 1995 prices in the $20 to $30 per barrel range (1985 dollars).

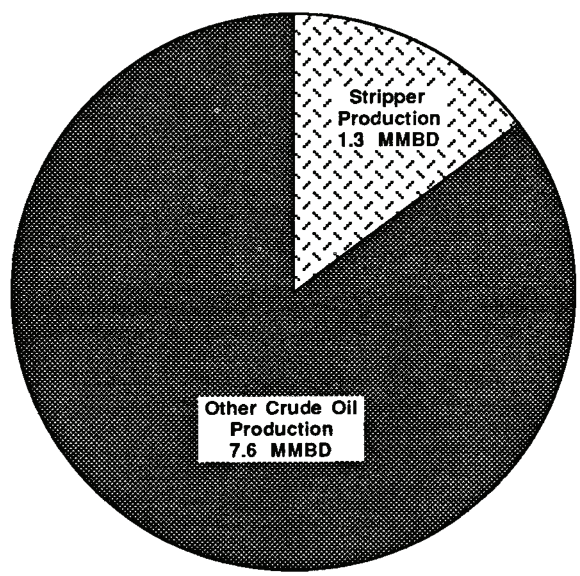
Lower prices have adverse effects on this country's domestic output of crude oil—especially its higher cost production. High-cost U.S. oil production includes oil from stripper wells, from enhanced oil recovery projects, and other marginal oil supplies with operating costs in the $10 to $20 per barrel range. Most high-cost domestic oil production is from stripper wells.

Any oil well that produces 10 barrels per day or less is called a stripper well. Average daily production of the 450,000 U.S. stripper wells is less than 3 barrels per day per well. Low volume wells tend to have high production costs, and these have lifting costs ranging from $8 to $24 per barrel. At current low oil prices, many owners and operators find stripper wells uneconomic to operate and have temporarily shut-in production—or, in some cases, are having the wells plugged and abandoned.

Average production of domestic nonstripper wells is 45 barrels per day, but even this is low by comparison with oil fields around the Persian Gulf. In the Middle East, an average well produces more than 2,500 barrels per day.

Although each one is responsible for only a modest amount, U.S. stripper wells produce in aggregate a total of 1.3 million barrels per day (about 15 percent of all U.S. oil production). More than half of all U.S. stripper wells are in three States—Texas, Oklahoma, and Kansas. One-third of all stripper well production comes from Texas, and one-fifth comes from Oklahoma. Nearly half of all stripper-well oil reserves (2 billion barrels) is in Texas.

Stripper Wells' Share of Total U.S. Oil Production, 1985



Estimated Stripper-Well Production Losses at Various Prices

Oil Price ($ per Barrel)	Barrels per Day
$10	638,000
$15	277,000
$20	107,000

Source: IOCC, March, 1986

If a stripper well is permanently abandoned, the well must be sealed with concrete—primarily for safety and environmental reasons. Once a stripper well is plugged and abandoned, the well is rarely reopened because of the high expense. Current regulations of Federal and most State lands have recently been changed to allow stripper wells to be temporarily shut in for up to 1 year without having to be plugged.

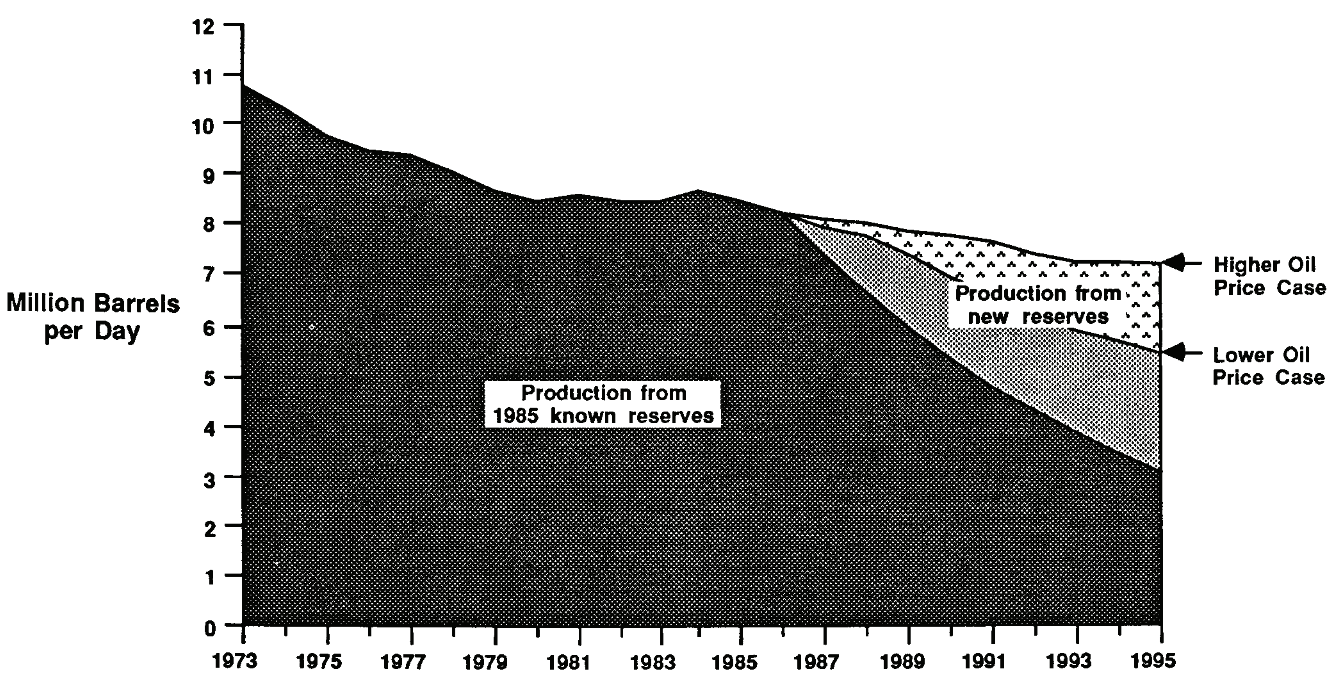
Data are not yet available on how much stripper production has been lost permanently because of lower oil prices. Part of the problem lies in distinguishing between temporarily shut-in production and permanently lost production. It has been estimated that sustained oil prices of $15 per barrel would cause a loss of about 280,000 barrels per day of stripper production and that if oil prices stayed at $10 per barrel for an extended period this would result in about 650,000 barrels per day of lost stripper production in the United States.

CONVENTIONAL CRUDE OIL OUTPUT FROM THE "LOWER 48" IS DROPPING SHARPLY

Current low oil prices discourage investment in both exploration and development. U.S. production fell substantially in 1986, and additions to U.S. reserves and U.S. oil production will be further reduced if the expectation of low prices continues to discourage such investment. Oil exploration and production requires a long lead time from the initial investment for preliminary surveys to significant levels of production. In known onshore oil regions, the lead time can be on the order of 3 to 5 years. In offshore areas and in harsher climates, the lead times can exceed 10 years. Current oil production still benefits from the high prices that prevailed in the late 1970's and the first half of the 1980's. Those prices and price expectations encouraged investment in exploration and development in properties that are still producing.

Crude Oil Production From the "Lower 48"

(Includes Natural Gas Liquids)



Primarily because of the collapse in oil prices during 1986, U.S. crude oil production declined last year by close to 800,000 barrels per day. Some of that decline represents temporary shut-in of production that could return with higher oil prices.

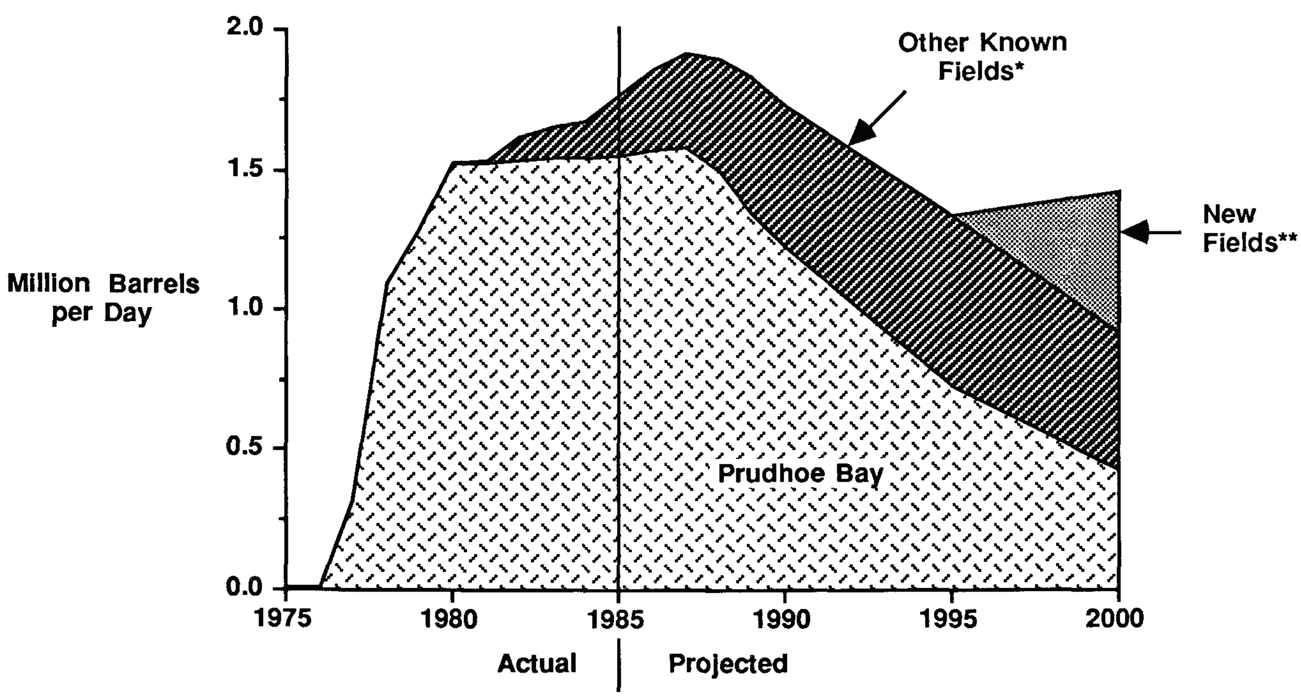
"Lower 48" oil production in 1985 was about 7.2 million barrels per day, or about 80 percent of all domestic production (this excludes natural gas liquids). Production in the "Lower 48" could decline to between 5.3 and 6.0 million barrels per day in 1990, and it could drop to between 4.1 and 5.3 million barrels per day in 1995, if oil prices remain in the $15 to $22 per barrel range. This translates into requirements for 1.2 to 1.9 million barrels per day of additional U.S. oil imports in 1990 and 2.0 to 3 million barrels per day of additional requirements in 1995. If oil prices drop much below $15 per barrel for an extended period, lower 48 production would decline even faster.

OFFSETTING THE DECLINE IN NORTH ALASKAN PRODUCTION AT PRUDHOE WILL BE DIFFICULT

The decline in oil production from the Lower 48 that began in 1970 was offset by the development of the Prudhoe Bay oil field in North Alaska, the largest oil field ever discovered in the United States. Production from the Alaska North Slope averages about 1.8 million barrels per day. This accounts for about 20 percent of total U.S. oil production. About 85 percent of North Alaska oil production comes from Prudhoe Bay, whose peak production has been about 1.5 million barrels per day.

Production from Alaska's North Slope is expensive because of high transportation costs and the harsh environmental conditions

Alaskan North Slope Oil Production



*Includes Kuparuk, Lisburne, Milne Point, NGL Project, Gwydyr Bay, Point Thompson, Seal Island, and West Sak.

**Includes potential development of the Arctic National Wildlife Refuge (ANWR).

that prevail there, but especially because of unusual regulations on exploration and production. In addition to the extreme cold, the winter months are always dark; yet most of the exploration and development there must take place during the winter because of the need to mitigate impacts on the migration of bowhead whales, the calving season of caribou, and the permafrost in the region.

Because of the harsh environment and the seasonal constraints on exploration and development, it takes between 10 and 15 years to move from discovery of an oil field in this area to the first production of oil. Prudhoe Bay itself, with about 75 percent of proven North Alaskan reserves, was discovered in 1968; but it was not until 1978 that significant production began.

The level of North Slope production can significantly affect U.S. production totals. Under higher price paths and more optimistic assessments of the resource base, Alaska could sustain production at about 1.5 million barrels per day through 1995. Under low prices and more pessimistic assessments of the resource base, North Slope production could be reduced to about 1.1 million barrels per day or less by 1995. This would be based largely on an expected decline of 10 percent per year in Prudhoe Bay production—primarily because secondary and tertiary recovery techniques (which increase the amounts of oil that can be recovered from Prudhoe Bay and other large fields) would not be profitable.

The Arctic National Wildlife Refuge (ANWR) near Prudhoe Bay may have recoverable oil resources that range somewhere between 0.6 billion and 9 billion barrels (making it potentially comparable to Prudhoe Bay). Allowing development of ANWR could provide a significant addition to Alaskan North Slope production, and it could help replace the eventual depletion of Prudhoe Bay.

A COMPETITIVE U.S. OIL INDUSTRY IS VITAL TO ENERGY SECURITY

REDUCED U.S. OIL EXPLORATION AND PRODUCTION INCREASES RELIANCE ON INSECURE SUPPLIES

A trend of rising oil imports is apparent. In 1986, net U.S. oil imports increased to about 5.3 million barrels per day, accounting for about 32 percent of U.S. oil consumption. This represents an increase of about 1 million barrels per day over 1985 net oil imports. With low oil prices (averaging about $15 per barrel in 1985 dollars by 1990), U.S. net oil imports could approach 8 million barrels per day—or about 50 percent of consumption—as early as 1990. If oil prices are higher (about $20 per barrel in 1990), oil imports will not likely reach 8 million barrels per day until the mid-1990's. In either case, however, under a reasonable range of world oil price scenarios, net U.S. oil imports are likely to be in the 8 to 10 million barrel per day range by 1995.

These U.S. oil import projections are representative of many recent studies. For example, the National Petroleum Council study of the U.S. oil and gas outlook, material from which was used in this report, shows U.S. oil imports growing to 50 percent of U.S. oil consumption as early as 1990. The National Petroleum Council report also identifies many of the serious difficulties faced by the domestic oil industry.

Lower oil prices are causing similar trends in other parts of the world, leading to increased reliance on oil supplies from the historically unstable Persian Gulf. It is important to reiterate that it is this global reliance on the Persian Gulf that matters, not just the level of U.S. oil imports. In an oil supply disruption, all nations that use oil will absorb the costs. U.S. oil supplies will be affected during a disruption, even if this country doesn't import oil from the disrupted region.

It is important to try to improve the stability of the Persian Gulf region. If a supply disruption should occur, however, this country's ability to cope with it will be conditioned by certain measures of international cooperation and emergency preparedness that are already being taken:

- Maintenance of strategic oil stockpiles and other oil emergency preparedness measures by U.S. and foreign governments, including plans to use market pricing to allocate supplies efficiently during a disruption.

- Coordination with the International Energy Agency, which shares information and helps to develop cooperative strategies and which will implement the Emergency Sharing System in the event of a significant disruption.

- Encouragement of a flexible energy system which will be capable of switching away from oil use in an emergency.

Although all of these steps are necessary, they do not in themselves reduce reliance on insecure oil supplies, but merely bolster the ability to respond to temporary disruptions once they have occurred. Another more direct method of coping with the energy security concerns raised by reliance on insecure oil supplies is actually to reduce dependence on Persian Gulf oil. There are at least three ways of doing this:

- Increasing oil production in more secure world regions such as the U.S., Canada, Norway, Great Britain, Mexico, Venezuela, and other countries outside the Persian Gulf.

- Increasing energy efficiency.

- Increasing production of oil substitutes like natural gas, coal, nuclear, and renewable energy.

This section of this report only addresses the first of these—specifically, how increased U.S.

oil exploration and production can contribute to enhanced energy security. Other chapters will address energy efficiency and alternative fuels. Separate chapters are also devoted to emergency preparedness and international cooperation.

The decline in U.S. oil exploration and development brought about by lower world oil prices will continue to reduce U.S. oil production for several years to come. Lower U.S. oil production and lower reserves in the future have several adverse effects on U.S. energy and economic security:

- Lower U.S. oil production increases U.S. oil imports. It raises demand for OPEC oil, and Persian Gulf oil in particular. That reduces excess production capacity worldwide, creates upward price pressure, and increases the likelihood and potential severity of future disruptions in oil supply.

- Increased dependence on insecure oil supplies reduces flexibility in the conduct of U.S. foreign policy.

- With lower U.S. oil production capacity, the costs of any new disruption to the U.S. economy will be greater.

- Finally, the U.S. oil industry will be weakened further by a lower level of exploration and production over the next few years.

The final sections of this chapter deal with policy options intended to increase domestic oil exploration and production. In discussing domestic oil exploration and production, it is useful to distinguish between exploration activities and actual production in terms of energy security.

- Once identified, crude oil resources represent a long-term reserve stockpile, from which U.S. oil production can draw. However, it takes a long time to move from discovery of crude oil to actual production; and there also may be constraints on the rate of production. Nevertheless, larger U.S. crude oil reserves add to U.S. energy and economic security. They provide a secure source of potential oil supplies for the long term.

- Current production reduces current U.S. oil imports, so it has immediate energy security benefits. On the other hand, those near-term benefits have to be weighed against the depletion effect of oil production. Every barrel of crude oil that is produced depletes U.S. oil reserves—leaving less in the ground for future production.

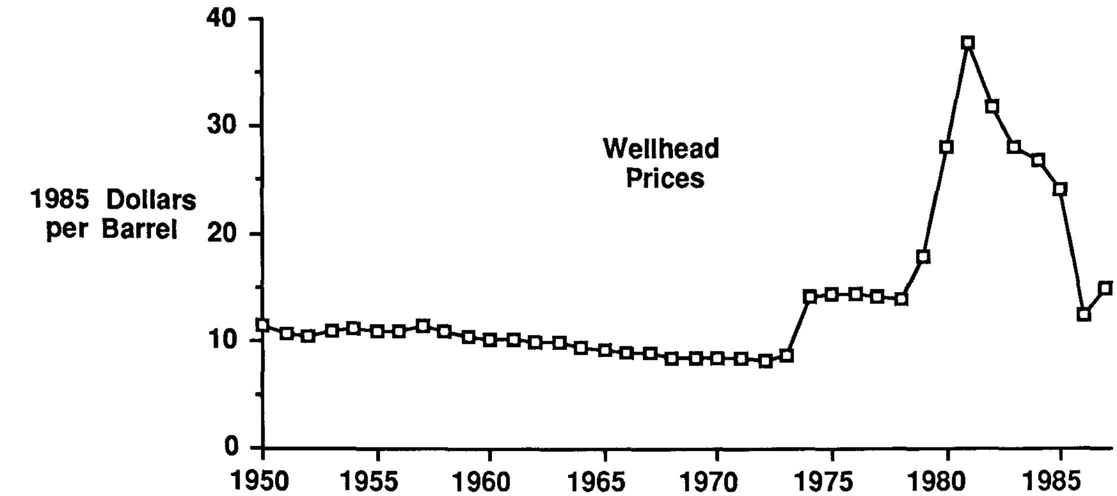
U.S. OIL INDUSTRY HAS A HISTORY OF BOOM-AND-BUST CYCLES

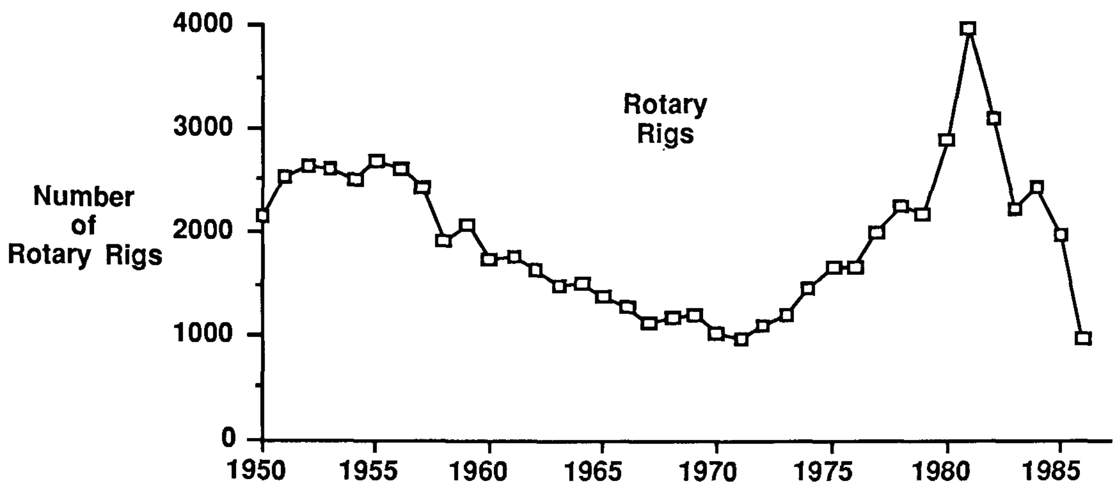
Given the contribution that the U.S. oil industry makes to energy security, it is important to ask how the industry might respond to the rapidly changing market conditions that it has faced in 1986 and is likely to see in the next few years. The way this industry has reacted to rapid market shifts in the past gives some clues (but no guarantees) about its possible future vitality.

The exploration and development segment of the U.S. oil industry has gone through several boom-and-bust cycles. The industry swelled in the 1940's and 1950's, peaking in 1956. Then, between 1956 and 1971 the domestic industry contracted. Several major U.S. oil companies increased operations overseas, primarily in the low-cost Persian Gulf region. The active domestic drilling rig count dropped from 2,620 in 1956 to 976 in 1971. Over the same period, employment in the domestic oil industry declined by about 22 percent (from about 340,000 to about 264,000). In 1971 domestic oil industry activity was at its lowest level since the 1940's.

From 1971 to 1981, the U.S. oil industry demonstrated a remarkable ability to respond to changing market conditions. World oil prices rose by 1,000 percent during that period, and the high cash flow and high profitability from them financed a rapid expansion in domestic drilling activity. The rig count increased from 976 to 3,970 and employment in the industry went from 264,000

Relationship of Oil Prices and Drilling





to about 708,000. The level of drilling activity (in millions of feet drilled) more than tripled—a considerable achievement for a 10-year period.

The rapid buildup between 1971 and 1981 inflated costs in the industry, however; and operations became less efficient. Nevertheless, the U.S. oil industry was able to respond quickly to radically higher prices.

The decline in oil prices from 1981 to 1986 resulted in a major contraction of the U.S. oil industry. Active drilling rigs in the United States dropped from close to 4,000 in 1981 to fewer than 1,000—about the same number as in 1971. Employment in the industry, including field services, shrank by 34 percent. The United States in 1986 was at a level of domestic oil activity not far from where it was 15 years ago—before the succession of sharp price increases. However, in 1971 the industry had not experienced the same degree of turmoil and dislocation as it has today. In the 1970's, the industry showed that it could respond very well to rising oil prices. But the question turns to whether or not it will be willing and able to respond to changing market conditions again for the final decade of this century.

LOWER OIL PRICES RAISE CONCERNS ABOUT THE VITALITY OF THE U.S. OIL INDUSTRY

Lower oil prices and uncertainty about future prices have substantially reduced exploration and development for oil and gas in the United States. Exploration yields the additional reserves from which future crude oil production comes, and it is invariably a period of years between initial exploration and large-scale production. The length of time varies with the harshness of the environment and numerous other factors. As mentioned previously, the time delay for onshore fields in the "Lower 48" may be only a few years; however, it may take a decade or longer to develop and produce oil from a large new field in North Alaska.

Long lead times mean that the current dropoff in drilling activity will probably affect U.S. oil production after 1990. Greater investment in the creation of additional reserves during the next 5 years would increase this country's capability to produce oil in the 1990's, a period when the United States is expected to become increasingly dependent on imported oil.

Data on oil industry employment, drilling levels, and reserve additions indicate that the industry responded vigorously to the oil price increases that took place in 1973-74 and 1979-80. However, the economic environment of the 1970's and the condition of the oil industry at that time were very different than they are now. In the event of a substantial future rise in oil prices, it is uncertain whether the industry could respond rapidly.

- **Lower Oil Prices and Price Expectations:** In the 1970's, despite oil price controls, U.S. oil prices increased sufficiently to give strong incentives to explore and produce oil. There was little, if any, concern about price collapses. If oil prices are low (in the $10-to-$15 range) for the next several years, the U.S. oil industry might decline to a lower base level of activity than in 1971, and this would inhibit its ability to expand as rapidly as it did during the 1970's. Even if oil prices start to increase, the oil price collapse of 1986 has now lowered oil price expectations. Some dampening of investment seems likely.

- **Financing:** Independents will continue to have difficulty finding the funds to support drilling activity. Changes in tax law have reduced the after-tax profitability of certain oil exploration activities. Lending institutions, faced with many nonperforming loans, will be more cautious about approving new loans. Also, many oil firms now have a heavy debt burden—which may require higher oil prices than otherwise would be the case to justify new loans.

- **Skilled Workers:** With the very large layoffs of oil industry personnel in 1986, a skilled cadre of drilling rig workers, petroleum engineers, and geologists have retired ahead of schedule or taken other types of employment. Having just lost their jobs, some of these workers may be reluctant to return to the oil industry. This and other reasons may create delays (or a requirement for higher-than-normal wages) in bringing some of them back—or in educating and training replacement workers.

- **Inventory of Economic Prospects:** A backlog of economic oil prospects was built up in the wake of U.S. oil price controls during the 1970's. That backlog was eliminated during the intense drilling of the late 1970's and early 1980's, but currently few new prospects are being developed. If prices increase, reserve additions (especially in the form of revisions and extensions of known reserves) may not develop as quickly as they did in the past, because fewer promising areas have been identified.

Given all the potential delays between the industry's perception of new economic incentives to expand drilling activity and the resulting increase in U.S. oil production, there are legitimate concerns about the ability of the U.S. oil industry to make its full contribution to the energy security of the United States in the 1990's. These concerns will grow if exploration and development activity remain at low levels for the next several years.

GOAL IS ADEQUATE ENERGY AT LOWEST COSTS—BALANCING A NUMBER OF DIVERSE AIMS

POLICY CHOICES SHOULD REFLECT ASSESSMENT OF IMPACTS: SECURITY, ECONOMY, ENVIRONMENT

Whenever possible, public policies should be chosen on the basis of a thorough evaluation—in advance—of the various direct and indirect effects those policies are likely to produce. For example, a proposal that aims at enhancing energy security by making the U.S. oil industry more competitive is worth pursuing only if it stands a good chance of achieving its primary goal and objective at an acceptable cost overall, considering such matters as the following:

- **Consumer Effects:** Consumers are affected by higher or lower oil prices and by the costs of programs to bolster domestic energy efficiency and production. Consumers suffer if there are oil supply disruptions or rapid oil price increases. Consumers benefit from lower prices. Incentives to boost U.S. oil exploration and production generally allow higher prices to producers. Higher prices will be passed on to consumers, including energy-intensive industries.

- **Oil Industry Effects:** Regulations and other policies may clearly affect the exploration and production costs of domestic oil. They may also affect the time that is likely to elapse between identifying oil resources and bringing those resources to market. Lease terms, royalty fees, taxes, and import fees on crude oil affect the cash flow and profitability of the oil industry.

- **Environmental Effects:** The environmental impacts of policies to increase U.S. oil exploration and development need to be estimated and taken into proper account.

- **Federal Budget Effects:** Increased Government expenditures—or revenues lost in taxes or royalties—increase the already large Federal deficit.

- **Macroeconomic Effects:** A strong economy contributes to general prosperity and to national security. Efforts to increase U.S. oil production by raising U.S. prices or by restricting imports could stunt economic growth, reduce employment, and create inflationary pressures.

- **Trade Effects:** Importing more oil can contribute to large balance-of-trade deficits in the future. But higher prices in the United States for oil and gas can harm energy-intensive industries and hinder U.S. efforts to compete with goods produced by other nations.

Various competing objectives must be balanced against one another in evaluating policy options and the Administration's overall energy goal offers a context for achieving such a balance. The fundamental energy policy goal continues to be that Americans should have an adequate supply of energy, available at a reasonable cost. The basic strategies for holding to this goal are to rely on the free decisions of the entire populace to the greatest practical extent, while maintaining public health and safety and environmental quality, and to promote a balanced and mixed energy-resource system.

DIRECT INCENTIVES TO BOOST U.S. OIL ACTIVITY ALSO CARRY SUBSTANTIAL COSTS TO BE WEIGHED

VARIETY OF OPTIONS GIVEN IN THREE CATEGORIES TO ASSIST PUBLIC POLICY DEBATE

This section summarizes a variety of suggested policy options that involve government incentives to promote U.S. oil exploration and production. It should be pointed out that such government programs in the past, though often well intentioned, have usually cost the Nation a great deal, without much perceptible improvement to energy security. It is also worth noting that the recent tax reform legislation was intended to eliminate many of the special incentives that had become part of the tax code over the years. Any direct incentives should show high energy security benefits to compensate for costs to consumers and to other sectors of the economy.

The intent here is not to promote or to dismiss specific incentives; it is to provide a balanced discussion of various options—laying out important advantages, disadvantages, and impacts. No recommendations are made. The purpose is to offer readers a better basis for reaching their own informed judgments about specifics.

The options described in this section constitute a balanced list of proposals. They range from modest to large in the extent of the incentives they propose for exploration and production. Still, the policies they cover present only a representative sample of the major options within the public policy debate rather than a comprehensive list. Many other policy suggestions will continue to be reviewed, both within and outside the government. The inclusion or omission of any particular suggestion does not imply support or disfavor for that option.

Incentives for exploration and production can be provided in a variety of ways. They may reduce the costs of exploration, and/or they may increase the revenues firms can expect from producing new reserves. The options cited here are divided into three categories:

- **Oil Import Fees/Price Floors**
- **Tax and Financial Options**
- **Lease Terms and Royalty Fees**

OIL IMPORT FEES/PRICE FLOORS

Statistical models were used to evaluate both the macroeconomic and oil market impacts of oil import fees. Fixed fees of $5 and $10 per barrel and a variable fee pegged to a price of $22 per barrel were examined. Complete world and U.S. oil market scenarios were developed with and without the fees to estimate the impacts of the fees on world oil prices, and on U.S. oil consumption, production, and imports. Oil supply disruption cases were developed and evaluated to measure the energy security and other economic effects of an oil import fee. Finally, macroeconomic analysis was performed to measure the impacts of the fees on the U.S. economic output, inflation, and employment. Appendix D provides a more complete description of the oil import fee analysis.

A $5 To $10 Fixed Oil Import Fee—

Many individuals have suggested a tariff or fee on crude oil and petroleum products as an efficient means of improving energy security. By raising domestic oil prices, an import fee would increase U.S. oil production, inhibit oil consumption, and reduce U.S. oil imports. With lower import demand, the United States would be less vulnerable to future OPEC market manipulation. An import fee would also stimulate U.S. oil exploration and development by improving oil industry profitability. A $10 import fee, for example, could raise 1995 U.S. oil production by 500,000 barrels per day compared to what would otherwise occur.

An oil import fee benefits the oil industry and oil regions by raising the price of domestic crude oil to the landed cost of imports (burdened by the fee). A $10 fee could reduce 1995 U.S. oil imports by up to 1.5 million barrels per day. About one-third of this reduction would result from increased domestic production and the other two-thirds would come from lower consumption of oil in this country.

An oil import fee could raise some Federal revenues (although the revenue gain would be offset by its impact on other tax collections and government expenditures). A $10 fee could add about 120,000 jobs in the oil industry; but it could reduce employment in other sectors by about 400,000. Finally, an oil import fee might also contribute to lower oil prices in the future by limiting the ability of OPEC to raise prices and by limiting the rise of oil prices in a future disruption. For a $10 fee, the value of these benefits to energy security and in reduced world oil prices is estimated at about $46 billion (net present value in 1985 dollars).

There are, however, significant costs to an oil import fee as well. An oil import fee would raise the cost of oil and oil substitutes in the United States (not just oil). Raising energy prices for U.S. consumers above the levels paid in other countries would seriously reduce the Nation's economic growth, increase inflation, and reduce U.S. competitiveness in both foreign and domestic markets. A $10 fee would have a major economic impact, reducing U.S. GNP by about $30 to $45 billion per year and causing a one-time inflationary effect of 2 or 3 percentage points. The cumulative costs of a $10 fee over the next decade could reach $200 billion (net present value in 1985 dollars).

An import fee transfers income from consumers to oil producers and the Federal Government. Each $1 per barrel of fee would take more than $4 billion per year from consumers of petroleum products (gasoline, heating oil, jet fuel, diesel, and other products). Not all the additional revenue provided to the domestic oil industry would be re-invested in oil projects. Restrictions to require re-investment in oil would be complex and probably inefficient.

Fee exemptions or refunds of the fee would undoubtedly be requested by U.S. petrochemical companies and other energy-intensive export industries, as well as by close trading partners (such as Canada, Mexico, Venezuela, and the U.K.) and others—perhaps including users of heating oil. Granting exemptions or refunds would increase the administrative burden and complexity of implementing a fee.

An import fee is essentially a "drain America first" program. A fee raises the U.S. crude oil price and encourages accelerated production of U.S. reserves, leaving smaller reserves here for future production and impairing long-term energy security.

An import fee would also discourage production from secure foreign sources by lowering world oil prices. The profits from operating low cost reserves in the Middle East would be threatened less severely than the profits on higher cost reserves in Canada, Mexico, and the North Sea. Since secure regions generally hold higher cost reserves than the Middle East, the consequences of a U.S. import fee would disproportionately reduce the profitability of production from secure areas and could discourage the expansion of production outside the Middle East.

In summary, fixed oil import fees have large economic costs—associated with raising domestic oil prices above world levels; and they offer some energy security benefits.

Variable Fee/Domestic Price Floor—

A fixed import fee would raise oil and other energy prices in U.S. markets at any given world oil price. A variable import fee would raise U.S. oil prices only to the extent that world oil prices fall below some designated price. A variable fee could be set above current prices (pegged to maintain oil investment at higher levels) or set at a price below current prices to act as a price floor. Proponents of a fee to maintain investment suggest a level of at least $20 to $22 per barrel. Some favor a price floor at a lower level (perhaps $10 to $12).

A variable fee would give producers additional price assurances that would reduce the risks of new oil investments. A higher price floor would increase the profitability of oil investments. Even if oil prices never reached a price floor below current prices, such a floor would remove the possibility of very low prices—and thus make investors more willing to make oil investments.

A variable fee is harder to administer than a fixed fee, since the amount of the fee varies over time and must be calculated from the prevailing price at the time of each transaction. For administrative feasibility, a variable fee would probably be administered as a fixed fee within a particular time period. The fee would be recalculated periodically to correspond to prevailing oil prices.

A variable oil import fee benefits the domestic oil industry by supporting U.S. oil prices, industry profits, and employment in the industry. A variable fee also provides energy security benefits by reducing dependence on foreign oil. Unlike a fixed fee, a variable fee would raise U.S. prices only to the legislated level and would prevent foreign suppliers from offsetting part of the fee to preserve their U.S. sales.

The economic costs listed for fixed import fees extend to any variable fee that actually affects prices. Just as with a fixed fee, a variable fee that raised oil prices would reduce GNP, reduce U.S. employment, and contribute to inflation. The size of those losses would depend on the amount by which the variable fee raised prices. If oil prices stayed above the legislated level, the variable fee would not add to the direct economic costs of rising oil prices.

In addition to producing losses in economic efficiency, any import fee that was actually collected would transfer large sums from oil consumers to oil producers. Import fees rely on government regulation (instead of the marketplace) to determine the economic balance between various economic sectors and geographic regions. The costs and unintended consequences of government involvement in oil markets during the 1970's are well known.

TAX AND FINANCIAL OPTIONS

A variety of tax and financial options have been suggested to improve U.S. energy security by increasing domestic oil and gas production. These tax incentives carry economic costs, especially in terms of reduced Federal revenues; but because they generally leave domestic oil prices unchanged, the tax and financial measures do not have the severely negative macroeconomic and trade costs associated with import fees.

As an example, consider a tax incentive, or combination of incentives, that increased U.S. oil production by 200,000 barrels per day. This increase could improve energy security by reducing U.S. oil imports and world reliance on oil from unstable regions. The likelihood and costs of future oil supply disruptions would thus be lowered.

In terms of economic effects, such an increase in oil production could reduce the world oil price by up to 25 cents per barrel—which could increase U.S. economic activity by $1.3 billion per year. Producing domestic oil rather than purchasing imported oil creates capital investment and jobs in the United States. Reduced oil imports and lower oil prices would also reduce the U.S. oil import bill by $2.0 billion per year. However, tax incentives that would increase oil production by as much as 200,000 barrels per day would also carry significant costs—in terms of lower Federal revenues and transfers of economic resources from more productive to less productive uses. The costs of achieving higher oil production must be weighed against the energy security and other benefits.

The following sections define a variety of specific tax incentive proposals and provide oil production and revenue estimates for each of the options.

Repeal of Windfall Profit Tax—

The windfall profit tax (WPT) was enacted in 1980 to capture some of the profits that were expected to result from the decontrol of domestic oil prices at a time when world oil prices were higher than the controlled price. The WPT is imposed on the excess (if any) of the wellhead price of the oil produced over an adjusted base price (subject to further adjustment for State severance taxes). Both the tax rate and the adjusted base price vary with the nature of the oil produced (a lesser tax is imposed on newly discovered oil) and the nature of the producer (independent producers are taxed at lower rates than integrated companies). The WPT was enacted with a sunset provision that provides for its phasedown and ultimate elimination, beginning in 1991. Virtually no WPT would be levied in 1987 on old oil sold at prices less than $18 per barrel, or on newly discovered oil sold at prices less than $28 per barrel.

At prices below $18 per barrel, the WPT contributes virtually nothing to Federal tax receipts. Repeal of the WPT before its scheduled phasedown in 1991, however, would give oil producers the prospect of higher profits if oil prices were to rebound sharply before then. WPT repeal would also eliminate the burden of continued recordkeeping requirements.

Taking the midpoints of high and low oil price scenarios shows that the WPT would raise about $50 million from 1987 to 1991. However, if prices remained low, almost no revenue would be collected.

Consumer interests may want to retain the WPT as a potential revenue raiser in the event that oil prices rise sharply before 1991, and because the WPT was considered part of the bargain that led to oil price decontrol. However, oil producers complain that it is unfair to take a part of their revenues with a special tax when prices are high, yet offer no special assistance when prices are low. Furthermore, imposition of a special tax on a single industry is contrary to the objectives of the Tax Reform Act of 1986.

Repeal of the "Transfer Rule"—

"Percentage depletion" allows oil producers to deduct a percentage of oil and gas gross revenues from taxable income, in place of more restrictive "cost depletion," (which limits total depletion deductions to the unrecovered investment). Integrated oil companies (the "majors") cannot claim percentage depletion at all. Further, under current law, the percentage depletion allowance may not be used after proven oil properties have changed ownership. This means that otherwise eligible producers cannot use the allowance for production from proven properties that they have purchased. This option would repeal the ownership transfer restriction.

Such a change would permit independent producers to use percentage depletion on properties they had bought from majors. Often, majors discontinue marginally profitable operations because of overhead costs. This proposal would encourage small independents with lower overhead to buy such properties and continue to operate them. By keeping marginal wells in production, U.S. oil production is maintained without additional drilling costs. Economic efficiency would be increased.

The cost of this option in lost tax revenues is estimated to average about $23.4 million per year over the 1987-91 fiscal years. The resulting increase in oil and gas production from marginal properties is estimated at about 55,000 barrels per day of crude oil equivalents, including about 30,000 barrels per day in oil production.

To limit the transfer of more profitable properties from a cost-depletion basis to percentage depletion, this option could be restricted to stripper wells, whose operating costs are often high and which are most threatened with shut-in under low prices; but this could introduce a regulatory cost to ensure compliance.

Rise in Net-Income Limitation—

The percentage depletion allowance for oil and gas is computed as 15 percent of the gross income from the property, but it is also limited to 50 percent of the net income from the property (with certain other restrictions). This option would increase the amount allowed to 100 percent of the income from the property.

Independent oil producers with high operating costs would thus be able to claim greater depletion deductions. This would increase their after-tax income and encourage the continued operation of some marginal properties whose operation would otherwise be discontinued. It could also encourage some added investment in new oil projects. By keeping marginal wells in production, U.S. oil production is maintained without additional drilling costs. Economic efficiency would be increased.

Repealing the net income limitation *completely* (instead of simply raising it) would permit oil and gas producers to use percentage depletion from one property to shelter income from other properties—or even to shelter non-oil and gas production income. Increasing the net income limit to 100 percent allows only the production income from the property in question to be offset by the percentage depletion allowance applicable to its production.

It is estimated that adopting this option would reduce tax receipts by an average of $47.2 million per year over the 1987-91 fiscal years. The corresponding increase in domestic oil and gas production is estimated to be 58,000 barrels per day by 1990, including about 32,000 barrels per day in oil production. This additional production would arise primarily from delayed abandonment of marginal wells, together with some production from new investment by independent producers.

Faster Recovery of G&G Costs—

Geological and geophysical (G&G) costs are those incurred for the purpose of identifying and locating productive oil and gas properties. They include geological mapping, gathering seismic data, and other work that precedes exploratory drilling. In 1984, G&G expenditures of $2.7 billion constituted 12 percent of oil industry investment for exploration. At present G&G costs must be capitalized and recovered through depletion deductions. This option would allow domestic G&G costs to be expensed in the same manner as intangible drilling costs (IDC's). This would encourage greater G&G expenditures, and thus should lead to discovery of additional domestic oil and gas reserves.

Under current law, independent producers using percentage depletion (which is not based on the incurred costs) get no tax benefit for G&G expenditures. They now spend a relatively smaller amount on G&G investment than other producers, but this option might encourage them to use more G&G work productively.

This option directly encourages exploration activity leading to development of new reserves; it does not encourage production from known reserves.

Its revenue cost is estimated at a total of $260 million per year, on average, over the 1987-91 fiscal years. Its adoption would increase domestic oil and gas production by an estimated 200,000 barrels per day by 1992, and add 700 million barrels to U.S. oil and gas reserves. Of this total, about 110,000 barrels per day is increased oil production.

Exploration-Development Tax Credit—

Under current law, with but few exceptions, tax credits are not provided for any investments—including those related to oil and gas. This option would allow a tax credit equal to a specified percentage of eligible investment. Two versions are considered here: a comprehensive tax credit that would allow a 5-percent credit for all exploration and drilling expenditures, and a more restricted credit that would allow a 5-percent credit only for geological and geophysical (G&G) expenditures.

This option would reduce the cost of finding and producing oil, and thus directly encourage increased oil and gas exploration and development. But enacting a special (nonneutral) oil industry tax incentive would be contrary to the objectives of the 1986 Tax Reform Act, which already provides favorable tax treatment for drilling over other investments.

The more comprehensive provision is estimated to reduce tax revenues by $740 million per year over 5 years, and raise domestic oil and gas production by the equivalent of 325,000 barrels per day by l992. Of the total, about 180,000 barrels per day would be increased oil production. The more sharply focused credit of 5 percent for G&G expenditures is estimated to reduce 1987-91 fiscal year tax revenues by $65 million per year, and increase long-term oil and gas production by the equivalent of 80,000 barrels per day (about 44,000 of which is oil).

Higher Depletion for Independents—

Under current law, independent producers and royalty owners may claim percentage depletion on the first 1,000 barrels per day of their oil and gas production. The percentage depletion allowance is equal to 15 percent of their gross income from the property (subject to certain income limitations). This option would increase the rate to 27.5 percent.

This option would increase the after-tax profitability of eligible oil- and gas-producing properties. This would encourage increased drilling and production by eligible producers. Because of the passive role of royalty holders in the oil production process, it is unlikely that reduced taxes for royalty recipients would contribute significantly to increased oil production.

This option is a direct subsidy for production and an indirect subsidy for investment in reserve additions. It would reward all production by eligible producers, not just their new production. Most of the benefits of this proposal would accrue as a windfall to royalty owners and operators of the more prolific oil and gas wells. Encouraging increased production from existing reserves could reduce the availability of lower cost supplies in later years.

The total 1987-91 fiscal year revenue cost of this option is estimated to be $680 million per year, resulting in an estimated increase in oil and gas production of 280,000 barrels per day of oil equivalent by 1992. Of this total, about 154,000 barrels per day is increased oil production.

Higher Depletion on New Production—

Under current law, integrated companies cannot claim percentage depletion for their oil or gas production. Independent producers and royalty owners may claim percentage depletion (equal to 15 percent of gross income from eligible properties subject to certain limitations) on only the first 1,000 barrels per day of production. This option would allow all taxpayers to claim percentage depletion on an unlimited amount of domestic production of new oil and gas at a rate of 27.5 percent.

This option would increase the after-tax profitability from producing new oil and gas. This would lead to an increase in exploration and development of new oil and gas as well as an increase in revenue to the hard-hit oil services industry.

Like the preceding option, this one would provide greater benefits to producers as oil prices rose and reduced benefits at lower oil prices. To mitigate this, either of these two programs might contain a sunset provision that would restore existing rules on depletion allowances if oil prices exceeded some specified price for a 12-month period.

Expanded percentage depletion for new oil and gas production would require a clear definition of "new". Attempting to distinguish new oil and gas from all other oil and gas would lead to some compliance difficulties.

If the depletion allowance were raised immediately to 27.5 percent, tax revenues would be reduced by $460 million per year from 1987 to 1991. This average for 5 years is somewhat misleading, however. There would be virtually no revenue loss at first, but in later years (as new oil production increased), the loss in revenue would exceed the average considerably. Furthermore, the revenue cost would increase rapidly thereafter, increasing to almost $2 billion per year by 1995, as new oil and gas begin to represent an ever-increasing fraction of total domestic production. This tax incentive would result in an increase of about 370,000 barrels per day of domestic oil and gas production by 1992. About 55 percent, or 200,000 barrels per day of the total, is increased oil production.

Raising the percentage depletion allowance for new oil would provide an incentive for increasing drilling and production. It was estimated that oil industry employment would rise by as much as 50,000—spurring growth in oil-producing States. In particular, an increase in percentage depletion of new oil could bring an additional 500 drilling rigs back into use. In addition, the number of seismic crews could almost double—thus adding to the discovery of new oil and gas fields, which further improves domestic energy security.

Financial Loan-Price Guarantees—

New domestic oil investment could be protected against the risk of low oil prices by government financial guarantees. Private lenders and investors are reluctant to commit funds to produce $18 oil when there is some chance that prices could fall to $10 or less. A loan guarantee would protect lenders by a guarantee of repayment in the event a borrower defaulted on his loan. A loan guarantee would protect lenders against the failure of borrowers to produce oil as well as defaults because of low oil prices.

Loan guarantees would, in fact, offer lenders too much protection; and they would remove private incentives to limit loans to worthwhile projects. A loan guarantee would indemnify losses from the failure to find oil. By contrast, a price guarantee would protect oil investors only against the risk of low oil prices—while still requiring the investors to cover the risk that no oil would be found.

Price guarantees could prove costly to the government and to the U.S. economy. If world prices fell $5 per barrel below the guaranteed price, the guarantee for all U.S. oil production could cost $15 billion per year. A price guarantee limited to new oil could cost $5 billion per year by 1991 under the same price conditions. Limiting price guarantees to new oil produced by independents would further limit the revenue loss. In addition, U.S. energy costs would exceed those of other nations, causing macroeconomic losses. Just as in the farm support programs, a price guarantee could encourage overproduction and allocation of resources to oil production that could be used more profitably elsewhere in the economy.

The direct costs of a price guarantee program depend on how far market prices fall, and for how long. Indirect costs include (1) the economic costs of using resources to produce oil that could be purchased in the world market more cheaply, (2) larger Federal deficits, and (3) a less efficient domestic energy industry (because producers receiving guaranteed prices would have less incentive to hold costs down).

An oil price guarantee could be implemented in various ways. It could come in the form of tax credits for oil producers, or as direct payments to producers whose oil failed to receive the legislated price. In each instance the impact of guaranteed prices on the economy depends less on the method used than on the domestic oil prices that result.

A Tax on Gasoline—

Many individuals have suggested an increase in gasoline taxes (usually taken to mean taxes on gasoline and diesel fuel used on highways) as an efficient means of improving energy security. By raising the cost of motor fuel (gasoline and diesel oil), such a tax increase would reduce U.S. petroleum demand and oil imports.

The primary benefit to energy security from a higher gasoline tax is that U.S. oil imports should decrease because less motor fuel would be consumed. An increase in gasoline taxes would send a signal to consumers that oil remains a longer term problem. A gasoline tax of 25 cents per gallon, for example, is estimated to reduce U.S. oil imports by up to 490,000 barrels per day in 1990 and up to 630,000 barrels per day in 1995. With oil prices at current levels, that import reduction could reduce the U.S. oil import bill in 1990 by about $3 billion per year.

Reduced U.S. oil demand could lower world oil prices. A 25-cent-per-gallon gasoline tax could reduce world oil prices by as much as $1.00 per barrel.

Implementation of a tax on gasoline would be administratively simple since the Federal collection mechanism is in place. A gasoline tax of 25 cents per gallon would raise about $28 billion (in nominal dollars) through direct tax receipts in 1990. However, net Federal revenue gains would be significantly smaller because of the effect of business tax deductions and reduced economic activity caused by the tax. In addition, the inflation generated by the tax would increase Federal expenditures, thus diluting the contribution of increased tax revenues to deficit reduction.

Imposition of an increase in motor fuel taxes carries significant costs:

- As mentioned, a 25-cent-per-gallon gasoline tax would transfer about $28 billion per year from consumers of gasoline to the government in the form of gross tax receipts. This amounts to about $150 per car per year.

- A gasoline tax would reduce gross national product in the first year after its enactment by about 1 percent of total GNP ($23 billion). This would result from a reduction in the disposable income available to consumers. Unemployment would rise as a direct consequence of the large GNP decrease.

- Taxes on gasoline and diesel oil would increase the price level in the year of enactment. The extent of the inflationary effect would depend in part on Federal monetary policies.

- A motor fuel tax would have particularly negative impacts on several industries. The automobile industry, the trucking industry, and all travel-related businesses would suffer negative impacts. Automobile travel would become more costly.

- An increased motor fuel tax is regressive, since low-income users of automobiles spend a much higher percentage of their income on gasoline than do higher income users.

For a more detailed analysis of a gasoline tax, see Appendix E of this report.

LEASE TERMS AND ROYALTY FEES

Lower Minimum on OCS Bids—

One way to increase the industry's interest in bidding on and exploring Federal Outer Continental Shelf (OCS) acreage might be to reduce the minimum bid requirements. Accepting lower bids would increase the number of tracts that firms acquire and explore—at least to the extent that acreage not considered to be worth the present minimum has any bid value at all.

Since 1983, the minimum bid required for OCS leases has been $150 per acre; but previously, the Department of the Interior had set a minimum bid value of $25 per acre. At the present minimum, a bidder must offer at least $864,000 for the typical 5,760-acre tract. At $25 per acre, the minimum bid for a standard tract was only $144,000.

Analyses by the Minerals Management Service show that, in today's oil price environment, returning the minimum bid to its old level of $25 per acre could increase the number of leases bid on and awarded by as much as 40 percent for lease sales in the Gulf of Mexico. Bonus receipts, however, would be about $50 million less in FY 1988. Using the $25 per acre minimum during FY 1988 and FY 1989, while oil prices are relatively low, would reduce receipts by a total of about $100 million for the FY 1988 to FY 1992 period. Assuming that some of the additionally leased acreages eventually became productive, of course, total Federal royalties would increase by some amount in the long run.

Applying a $75 per acre minimum to deep water tracts only would reduce receipts in FY 1988 by about $10 million and, in FY 1988 to FY 1992 by about $20 million. It is estimated that about 10 percent more acreage would be leased as a result.

The success of this option in increasing exploration and the creation of new reserves will depend on such factors as these:

- **The ability of firms to finance additional activity.** If firms remain severely cash-constrained because of low oil prices, a reduction in the minimum bid might encourage little additional exploration.

- **Whether firms will explore the acreage acquired through lower bids.** A strategy frequently followed in the past was for firms (often smaller firms) to acquire marginally attractive acreage at low (that is, near-minimum) bid values. Such acreage might lie adjacent to more promising acreage that would typically be leased at much higher bid levels. Subsequently, the lessees that acquired the marginally economic acreage would only drill this acreage if drilling on the more promising acreage (usually by other firms) proved successful. In this light, drilling might not take place on the less promising acreage (leased for less) any sooner than it would have if it had been leased at a later date (following successful activity nearby) at the present higher minimum bid price.

Defer OCS Bonus Payments—

Under existing legislative authority, the Secretary of the Interior may permit winners of oil and gas leases to pay bonuses over a delayed payment schedule for up to five years.

Exercising this authority might encourage more acquisition of OCS leases and more exploration activity. Bonuses could be paid by making a 20-percent payment at the time of the sale and five annual installments (including interest).

The principal value to the industry of such a deferral would be to reduce the short-term cash flow problems that firms may experience as they bid for and subsequently explore oil and gas leases during periods when oil prices are relatively low. Stretching out the bonus payment over a longer period does not, in itself, greatly improve the economic attractiveness of lease acquisition or of exploration activity on a specific tract—because the lessee is still obligated to pay the bonus, with interest.

Whether deferring bonus payments would increase lease acquisition and exploration activity depends on the severity of the cash-flow problems being experienced by some oil firms and whether firms are willing and able to assume the additional liability for the extended lease payment. For financially strong firms, the extended payment option might not be important; and, at the other extreme, financially weak firms might not be able to assume the liability because of credit limitations. As a result, the bonus payment deferral option does not promise to increase leasing and exploration by much more than about 10 percent.

One possible problem with this option is that it might encourage financially weak firms to gamble on successful discoveries with a lease—so subsequent proceeds from an assignment or farm-out could meet the schedule of bonus payments. Considering the odds of exploration failures, the Government might be left holding "bad debts" on unpaid lease payments rather frequently.

Over the long run, the effects of bonus deferrals on the Federal Treasury could be neutral if interest were charged at market rates. However, it would reduce receipts significantly in the near term, resulting in higher deficits. For example, if bonus deferral were elected by bidders on half the bonuses in FY 1988, and firms deferring bonuses bought 10 percent more acreage, receipts in FY 1988 would be about $100 million less than estimated. Assuming a 10-percent interest rate, the total receipts for the FY 1988 to FY 1992 period would decrease by about $18 million if such bonus deferrals were allowed only for FY 1988 and FY 1989.

If the bonus deferrals continued in a similar fashion on lease sales through FY 1991 (as a result of continued low oil prices), the FY 1988 to FY 1992 receipts would be reduced by $106 million. Receipts in the FY 1993 to FY 1996 period, however would be increased by about $300 million as bonus installment and interest payments were made. Of course, there is also the possibility that a bonus deferral system—once in operation—could become permanent.

Responses to a recent *Federal Register* notice by 14 companies show 9 generally against bonus deferral, and 5 neutral.

Partial Credit for Exploration Costs—

In specified areas that would not otherwise be drilled, the Department of the Interior could permit firms to credit a fraction of their exploration outlays against bonus and royalty payments due on Federal oil and gas leases. This lease payment credit mechanism would be likely to encourage additional exploration and leasing activity, because it reduces the cost to the successful bidder of exploring such tracts. As a result, marginally economic tracts become more attractive to acquire and explore.

Exploration credits could be limited to a specified number of exploratory wells in offshore frontier areas that otherwise would be unlikely to receive exploratory drilling during periods of lower oil prices. This would permit targeting the Federal incentive on areas in which it might add most effectively to discovery of future reserves. The period in which credits would apply could be limited to times when oil prices are below the $25 to $30 per barrel range, within which such areas become more attractive to explore.

The fractional amount of a credit could be varied by geographic location and by the character of the exploration activity. For example, a higher credit might be used in high-risk, high-cost, frontier areas off Alaska to encourage firms to continue activity in such areas—where exploration has virtually stopped. For example, providing credits equal to 50 percent of exploration costs for the first wells in selected offshore Alaska areas might result in moving forward by 5 to 10 years the leasing, exploration, and potential discovery of approximately 1 billion to 3 billion barrels of oil.

Credits equal to 50 percent of drilling costs in selected Alaska offshore areas would reduce receipts by perhaps $50 million in FY 1988 and by a total of $200 to $250 million during the FY 1988 to FY 1992 period. The cost to the Treasury of such an exploration credits program would tend to be somewhat less than the total in credits, because competitive bidding would return a portion of the prospective exploration credit to the Government in the bonuses paid. In addition, bonuses would be received earlier because of the credit, and royalties would be realized sooner if production took place on an earlier timetable.

Holiday on Royalty Fees—

A royalty fee holiday is a temporary waiver of the requirement that firms producing oil and gas on Federal leases pay royalties to the Federal government. While a variety of royalty schedules are in effect on different leases, the typical royalty rates are 16.67 percent for offshore production and 12.5 percent for onshore production. A royalty holiday is thus equivalent to an oil price increase of about $3 per barrel.

Royalty holidays could be restricted to "new" production (that is, from existing leases that were not producing in FY 1986), to production from newly granted leases, or to all production on Federal leases. If a royalty holiday were restricted to "new" production or new leases during a period of relatively low prices, it would give some incentive to invest in exploration and development to bring new reserves into production sooner and maximize output before the royalty holiday expired; but a gain of $3 per barrel is not likely to result in significant reserve additions or production in the 1990's from either existing or new leases. If a royalty holiday were applied to all production, a stronger cash flow effect would be created. Cash flow to producers would increase substantially (even though the incremental profits would be taxable) and production from "new" wells or fields would become even more attractive. However, an average of only about 18 percent of additional earnings would be spent on exploratory drilling, unless the royalty holiday required that the resulting savings be "plowed back."

One advantage of a royalty holiday on all production is its administrative simplicity. It could be implemented without any new administrative mechanism; producers would not have to submit any new forms to determine their eligibility; and no Federal agency would need to distribute funds. A program limited to new production could be more complicated if it involved a highly technical determination of what production was to be regarded as new.

A royalty holiday has three key disadvantages. First, the reduction in cash flow to the Federal government reduces receipts and increases the deficit (States that share in Federal royalties would also be cut back in revenue). Second, the benefits of the royalty holiday would be distributed unevenly across firms in the oil industry. Those that held Federal leases would receive a gain that holders of other leases did not. Third, it would tend to deplete U.S. resources somewhat more rapidly, leaving less oil to be produced in future decades when prices may be higher.

A royalty holiday on new oil and gas production on the Outer Continental Shelf would reduce receipts by about $160 million in FY 1988 and $450 million over the FY 1988 to FY 1992 period, assuming that prices would be high enough by FY 1990 to end the holiday. Receipts would be affected much less during this period if the royalty holiday applied only to new leases. In either case, the oil industry would pay taxes on the increased profits, if any, that resulted from a royalty holiday, and this would reduce its net cost to the Treasury. A holiday on all royalties could reduce Federal receipts by $2.8 billion in FY 1988 and by $17.5 billion if it continued throughout the FY 1988 to FY 1992 period.

Linking Royalty Scale to Oil Prices—

A sliding-scale royalty is a royalty schedule that varies the rate paid on oil and gas production from a particular lease tract according to a specified parameter. The parameter could be selected so that financial risk from the possibility of low oil prices was transferred from the lessee to the Federal Government. Sliding-scale royalties on Federal leases to date have been based on production per well or production value per tract. It would be possible to develop a sliding scale that yielded substantially lower royalty rates during periods when oil prices are lower. Such a royalty adjustment might enable the Federal Government to establish somewhat higher royalty rates for periods in which oil prices are higher.

There are three advantages from using a sliding-scale royalty in future leasing. First, it would improve the incentive to invest in exploratory drilling despite some uncertainty as to how high oil prices will be in the future. Second, it would increase industry cash flow (relative to a fixed royalty) during periods when oil prices were low—thereby making cash available for exploration and other investments. Third, it would give producers an economic incentive to continue producing oil from marginal wells that might be shut down on the basis of fixed royalty rates.

Because productivity and cost vary significantly, a sliding-scale royalty rate could actually discourage production from less productive, high-cost leases. A sliding scale for these could make their royalty rates higher than the regular fixed rate would be. Thus, any use of the sliding-scale royalty should be targeted on appropriate properties.

A sliding-scale royalty has three key disadvantages. First, the reduction in royalty revenue (when oil prices are low) would reduce Federal receipts by up to $3 per barrel on production occurring under such lease terms. Second, this program (like a royalty holiday) would create a gain for holders of Federal oil and gas leases when oil prices are lower, relative to holders of other leases. Third, it might encourage firms to make changes in production rates that are not economically efficient.

Application of a sliding-scale royalty to new Federal leases would have little overall affect on the Treasury because firms would tend to adjust their bonus bids to reflect any differences in royalty payments they might anticipate. Furthermore, the sliding scales could yield higher royalty rates (and thus greater revenues) during periods when oil prices were high.

If simple sliding-scale formulae are used, such royalties could be implemented at a modest administrative cost. The program would be under the control of the Department of the Interior. No new method of revenue collection or revenue disbursement would be required.

CLEARING AWAY IMPEDIMENTS AND TARGETING R&D COULD MAKE U.S. OIL MORE COMPETITIVE

BARRIERS TO PRODUCTION, AREAS OF POTENTIAL BREAKTHROUGH ARE SUMMARIZED

It is consistent with the Administration's market-oriented approach to try to remove a variety of existing impediments to more efficient operation of the U.S. oil industry. This could enhance energy security by making this industry more competitive internationally while maintaining environmental and other important societal objectives:

- **Environmental Policies:** National environmental regulations can be improved to reduce uncertainty, to reduce permitting delays, and to reduce compliance costs in a way that maintains environmental protection. Actions can be taken to develop more balanced environmental policies that continue to protect the environment, but that do not impose unnecessary regulatory costs by: amendment of major environmental laws; administrative and rulemaking changes; and special studies supporting development of environmental policies and rulemaking. For example, the Administration supported the Oil and Gas Production Revitalization Act of 1986, which included five environmental initiatives affecting the storage and disposal of oil and gas related wastes.

- **Access to Federal Land:** The Department of the Interior continually examines the impact of existing programs and regulations and the potential advantages of alternative approaches. To some degree, the Department itself has the authority to adjust the pattern of access to Federal lands of mineral leasing, or of other policies to help ensure that domestic exploration and development activities are consistent with national interests. For example, the Secretary of the Interior is developing a new 5-year leasing program for the Outer Continental Shelf (OCS), which will be approved in mid-1987. In other areas, however, congressional action is needed. For instance, congressional action is necessary if oil and gas exploration and development are to occur in the coastal plain of the Arctic National Wildlife Refuge (ANWR), which appears to be the most promising region for large discoveries of oil and natural gas in the United States. Access to ANWR has the potential to increase domestic oil production by a significant amount, and it may be that exploration and production can take place in a way that involves minimal environmental impacts.

- **Oil Export Restrictions:** Removal of restrictions on crude oil exports, particularly the ban on exports from North Alaska and restrictions on exports from California, would remove economic inefficiencies in the transport and use of that crude oil. This would raise oil prices at the wellhead in North Alaska and California, and thus stimulate additional production. Increased production would reduce net U.S. oil imports and contribute to energy security. Removal of the restrictions, however, would adversely affect the domestic maritime industry and reduce the availability of militarily useful tankers.

- **Research and Development:** There is some long-term R&D that seems to be of initial interest for the Nation's future that is not being pursued at the moment to the extent it might be. Successful petroleum R&D can appreciably increase the amount of domestic oil that will be found and recovered at any given price. Both the private sector and government support a variety of research activities in this area, but private-sector funding has been significantly reduced in the past year as a result of lower cash flow in the industry. Private sector/government cooperative ventures represent a promising strategy for effectively leveraging Federal R&D support. Enhanced oil recovery (EOR) and R&D on petroleum geoscience are two examples of targeted basic research areas where breakthroughs could make billions of barrels of otherwise uneconomic U.S. oil available.

ENVIRONMENTAL LAW REVISION, ADMINISTRATIVE AND REGULATORY CHANGES DESERVE STUDY

When Congress reauthorizes various major environmental laws within the near future, there will be opportunities to make some amendments that will provide a better balance among national goals while continuing to ensure adequate environmental protection.

For example, the Clean Air Act is likely to be reauthorized in this Congress; and there are several areas of possible change—some procedural, and others substantive—that deserve further study because of what they could accomplish to improve energy security.

- The program to prevent significant deterioration (PSD program) in areas where air quality is now acceptable has proved to be very complex and time consuming. Simpler procedures may reduce costs while providing equivalent protection.

- The provision on New Source Performance Standards (NSPS) sets rates for emissions from steam generators and other new emission sources, as well as a requirement for percentage reductions in emissions. Changes to the percentage reduction requirement might be considered that would retain existing emissions rates and protect the environment, but would broaden the range of choices in ways to meet the emission limits.

- The act authorizes waivers for innovative technology, but under conditions that are inappropriate for most new energy installations. A waiver is allowed for a maximum of 7 years, and standards revert to the original if the promise of the innovative proposal is not realized fully. A longer period should be considered for construction and testing new technologies and a more forgiving formula for tests that are not totally successful should be analyzed.

The Solid Waste Disposal Act is scheduled for reauthorization in 1988. In several areas, amendments that would better support energy security should be studied.

- The 1984 amendments to this act prohibited land disposal for hazardous wastes. Land treatment is the spreading or injection of wastes on soil or into the ground. Some wastes—including certain oil production wastes—degrade and become nonhazardous through such land-treatment processes, while other disposal alternatives for these wastes are much more expensive. An amendment to permit environmentally sound land treatment should be considered.

- It is not clear whether underground storage tank provisions apply to a variety of small and/or temporary collection devices. These devices include oil sumps, hydraulic lift reservoirs, drip-collection devices, oil/water separation, and well cellars. All of these generally contain small amounts of wastes, but are associated with production rather than with storage processes. If these devices are included in regulations, then risk to the environment could actually increase if developers chose consequently to avoid using them for this reason. Clarification by Congress would be appropriate.

Generally, administrative decisions should be made to clarify uncertainties, whenever possible—before any formal clarification in legislation is needed. For example, policies to provide greater use of emissions "trading" and "bubbles" can and should be emphasized in this way. Both of these techniques for managing emissions within a given area provide additional opportunities for both environmental protection and economic growth.

Environmental rulemaking is presently a process for eliciting public views on proposed rules, including impacts on the economy and on energy use. The regulatory agencies should direct public discussion and inquiries in such a way as to stimulate increased comment on how available options interact with energy security.

There should also be greater use of interagency working groups in preparing proposed rules that can affect nonenvironmental national goals in a significant way. Furthermore, the more general use of consultation in setting regulations can give all affected interest groups an opportunity to cooperate with regulators in developing proposed regulations in such a way that multiple desirable goals—including energy security—will receive adequate consideration.

Special studies of procedures and regulations that can support energy security and environmental protection simultaneously will be undertaken, to better meld economic efficiency with protection. An interagency study should be launched to look at ways that regulatory waivers and special permit processes might be used to encourage demonstrations of innovative "clean" processes and improved controls. Finally, more efficient procedures for granting the necessary permits to various types of facilities need to be identified and implemented.

In connection with an area that is exclusively associated with the oil industry, consideration should be given to establishing a clearinghouse to test drilling muds. This could standardize which muds and discharge practices are acceptable, under which environmental situations. Drilling muds are the circulating fluids used in rotary drilling of a well to clean and lubricate the hole and to counterbalance geologic pressure. Muds consist of fluid media (usually water, but sometimes oil) and suspended solids (such as clay and chemical additives). Materials of concern in drilling muds may come from impurities in the makeup clays, from chemical additives, or from geological strata through which the well is drilled. A clearinghouse for definitive information on permissible usages would reduce costs, uncertainties, and storage needs for the entire industry while maintaining environmental quality.

Congress has already recognized the need to carry out special studies to characterize environmental conditions and available control options prior to rulemaking. Some of these could profit from making greater use of interagency capabilities.

- An interagency workgroup will help to characterize industry practices and analytical assumptions in connection with the congressionally mandated study of oil and gas production wastes. This study will determine whether or not these wastes should be regulated as hazardous or special wastes.

- A series of interagency workgroups will be used in preparing legislative amendment proposals that might stimulate greater consideration of other national goals in environmental management.

- Optional strategies for groundwater protection should be developed through interagency study efforts too, and the relative impacts on energy and the economy could be examined by the same group.

Access to Federal Lands:

THE ARCTIC NATIONAL WILDLIFE REFUGE

The Arctic National Wildlife Refuge is located in North Alaska between Prudhoe Bay and the Canadian border. It contains about 17 million acres. In April 1987 the Secretary of the Interior is due to submit to Congress a report providing an assessment of the wildlife and oil and gas resources of ANWR's coastal plain (1002 area), along with his recommendations about future management of that plain. Congressional action would be required to provide the authority to allow exploration and development of the coastal plain of ANWR. According to a draft report, the coastal plain of ANWR— consisting of about 1.5 million acres—is one of the regions of highest oil and gas resource potential. The coastal plain is also the breeding ground of the Porcupine Caribou herd. For this and other reasons development of the region raises environmental concerns. Fortunately, ANWR is located close to an existing oil pipeline which takes oil from Prudhoe Bay to Valdez in southern Alaska. No additional trans-Alaska pipeline would be required to move ANWR oil to South Alaska.

The draft report estimates that the coastal plain of ANWR has an oil and gas potential of up to 9 billion barrels of recoverable oil. This suggests the possibility of Prudhoe Bay-size reserves in ANWR. If 9 billion barrels of oil are found, production after the year 2000 could exceed 1.5 million barrels per day. ANWR appears to be the only U.S. frontier region which currently has the potential to yield a discovery of this magnitude. At current oil price levels, that production would reduce the U.S. trade deficit by about $11 billion per year.

The long lead times for exploration and development of North Alaskan oil resources mean that ANWR oil would not be available in large quantities until the turn of the century. However, the identification of large ANWR reserves through exploration, if authorized by Congress, could occur earlier. Such information would affect world oil market expectations in a positive way—even prior to development; and it would also help the United States better plan its energy security future.

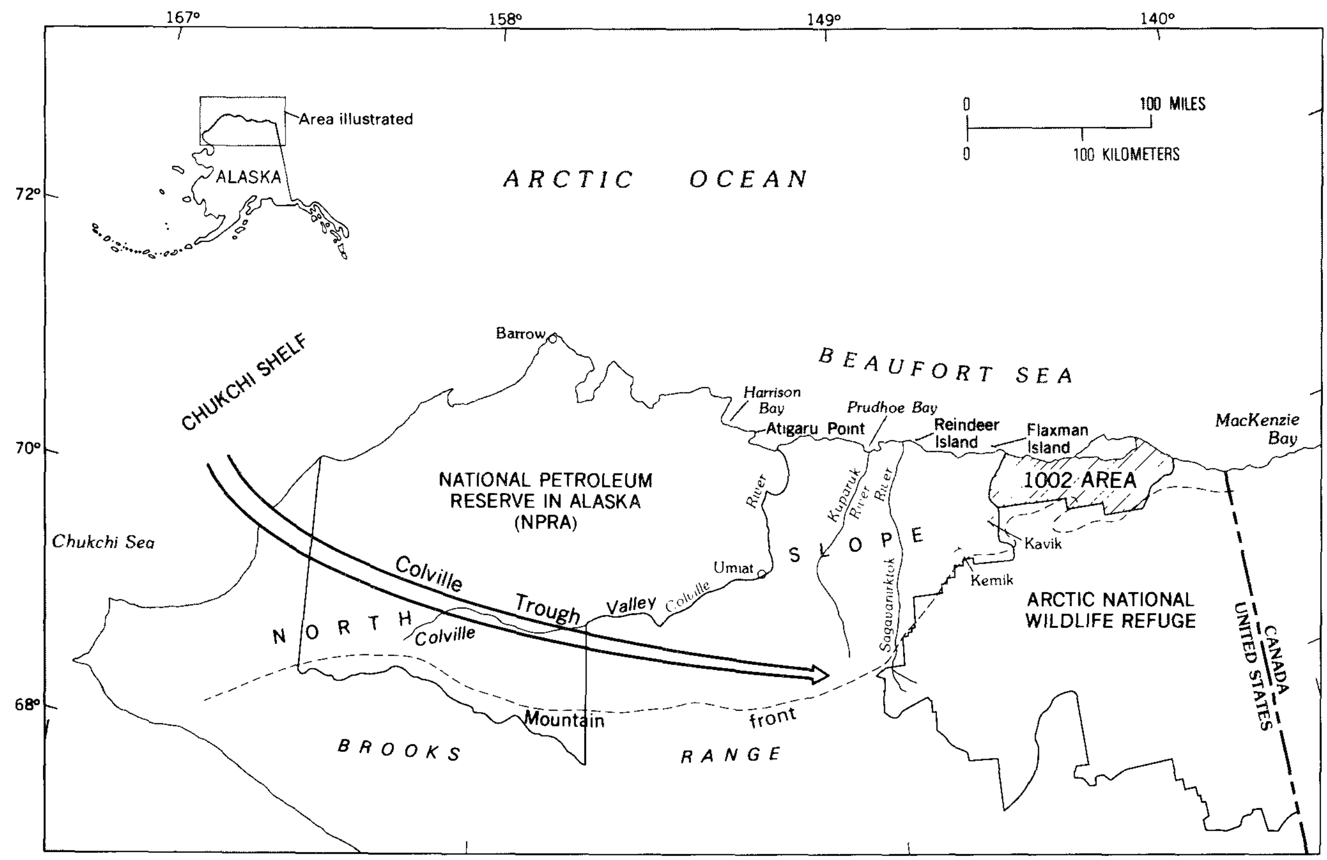
Access to Federal Lands:

THE OUTER CONTINENTAL SHELF AND PUBLIC-LAND LEASING

Outer Continental Shelf (OCS)

The Outer Continental Shelf of the United States contains more than 800 million acres, of which only 39 million acres have been leased.

A mean estimate of the undiscovered, recoverable oil underlying the OCS is more than 12 billion barrels—in addition to more than 90 trillion cubic feet of natural gas. This equals



about 30 billion barrels in oil and gas equivalent terms. Substantially greater amounts of oil and gas may exist beneath the OCS, but its existence could only be verified by drilling.

The OCS Lands Act (as amended) governs the availability of Federal OCS acreage for oil and gas exploration by requiring a 5-year leasing program that specifies the size, timing, and location of lease sales. The Secretary of the Interior is expected to approve a new 5-year leasing program in mid-1987. A special exception to the 5-year process has been formulated for offshore California, and this was submitted recently to Congress for comment. The California proposal is an attempt to avoid the imposition of moratoria on leasing activity off California, which have tied up an estimated 2 to 5 billion barrels of oil-equivalent in potential reserves across some 37 million acres.

Moratoria and/or litigation efforts have also impeded access to the OCS off Alaska, the Atlantic, and the eastern Gulf of Mexico since 1982.

New amendments to the OCSLA could be considered to provide incentives and opportunities for exploration and development of petroleum resources. This would give that Act the flexibility needed to respond to significant changes in market conditions (as have been witnessed in the past few years) and to wide regional variations in industry interest and risk.

Oil and Gas Leasing on Public Lands

Oil and gas leasing on public lands has been hindered by several weaknesses in the existing statutory authorities. The previous Congress came close to passing a satisfactory reform of the leasing authorities, and the Administration supports such a move.

The proposed reform would, first of all, subject all onshore Federal lands to competitive leasing for oil and gas. If any part of these lands did not receive a bonus bid at or above the level per acre set by the Secretary of the Interior, however, those parts would become available for noncompetitive leasing. Second, the revised authorization would set the royalty rate at a flat 12-1/2 percent for all leases. Third, it would establish civil and criminal penalties for knowingly and willfully misrepresenting to the public the provisions of the act and its implementing regulations.

Under this proposed reform, the onshore oil and gas leasing program would encourage exploration and development while ensuring an adequate return to the public. It would be relatively inexpensive to administer, and it would be less vulnerable to fraudulent schemes than the existing program. At a time when the future of the domestic oil and gas industry is uncertain, this bill would strengthen the domestic petroleum capability of the U.S. by bringing stability and predictability to the Federal program of onshore leasing for oil and gas and by making Federal lands accessible in a timely manner.

"DILIGENCE REQUIREMENTS" ON PRODUCTION OF OIL AND GAS LIMIT LESSEES' FLEXIBILITY

Currently, Federal oil and gas leases are subject to "diligence requirements"—which specify that exploration and production must begin within a certain time period. Removing the requirement for production according to a fixed schedule would allow lessees, if they so desired, to delay production from discoveries in the expectation of higher prices. Such delays in production could be advantageous at times—because firms could build a larger oil and gas reserve base, allowing a more rapid increase in production in response to future increases in oil price.

According to this proposal, however, lessees would remain subject to diligence requirements for exploration. Failure to conduct exploration activities in a timely manner would expose them to the possibility that their Federal oil and gas leases would be forfeited.

Diligence requirements for production from Federal oil and gas leases prevent firms from delaying or slowing down production activity in response to private market pricing information. It might be argued that such requirements eliminate problems in production timing that might result if the public-sector discount rate ever exceeded the private-sector cost of capital or the investment hurdle rate, or that they offset other differences in social and private costs. Lacking any evidence that such situations actually exist, however, there is no basis in economic efficiency for continuing the requirements at this time. To the contrary, there is a clear loss in economic efficiency associated with diligent production requirements. They may prevent firms from responding individually to diverse expectations of how scarce resources will be in the future and what path the associated energy prices might follow. Firms that are more pessimistic about future energy resources might thus be prevented from conserving oil and gas reserves so that they can be produced during a time of greater demand (relative to supply). Hedging against future scarcity of resources is ruled out.

Diligent production requirements may also inhibit exploration in frontier areas, since they leave firms less flexibility to increase the returns on their exploration investments by timing the production from discoveries that result most appropriately. In the current market, some firms with adequate financial resources might choose to explore now for oil and gas to take advantage of low exploration costs (such as low costs of acquiring acreage and low day-rates for drilling rigs). Such firms would expect generally higher oil prices in the future; however, if they discover oil and gas on Federal leases, they would have to start production by a certain date—even though their return from development and production could be greater later on (even considering the time-value of money). The production diligence requirement would cause the firms to produce "now" (when the additional production has less incremental value to society) and prevent them from delaying production until a time—perhaps only a few years away—when the marginal benefit to society from the production could be substantially greater. In the worst case, firms might decide to pass up the opportunity for exploration and discovery on Federal lands entirely at this point.

Removing production diligence requirements now would cost the public little and would probably bring benefits—especially in frontier areas. Admittedly, firms must have rather strong expectations about future increases in oil prices to explore now with the expectation of delaying production. However, simulation analyses of decisions about the timing of development and production under alternative price paths show that holding newly discovered reserves for later development/production would make economic sense under reasonably plausible price expections.

The principal concerns regarding this measure are that: (1) it might have only a small effect in encouraging additional reserve formation; and (2) it could be seen as encouraging speculation with public resources, which many regard as inappropriate.

PARADOXICALLY, ENDING BARS TO EXPORT OF U.S. OIL COULD HELP U.S. ENERGY SECURITY

At present there is effectively a ban on exporting crude oil from North Alaska. Because of this, about half of the 1.8 million barrels per day of North Alaskan crude oil is shipped to California, while roughly the other half goes all the way down and across Panama to refiners along the Caribbean and Gulf Coasts. Removal of the export restrictions would permit some Alaskan oil to be shipped a shorter sea distance to markets in the Pacific Rim, especially to Japan. With lower transportation costs, the "netback" to Alaskan producers would be higher. They would be encouraged to produce more oil and to look for more.

Section 27 of the Merchant Marine Act of 1920 (Jones Act) requires carriage of Alaskan crude by U.S. flag tankers between U.S. ports. Approximately 40 percent of the U.S. domestic tanker fleet is currently employed in the Alaskan crude trade.

Restrictions on the export of Alaskan crude distort the market and interfere with efficient allocation of domestic resources. The inflow of

Alaskan oil to California has created a crude oil excess there that has depressed wellhead prices and will reduce long-term California production over what might otherwise occur. Thus, lifting the restrictions would increase the wellhead value of *both* Alaskan *and* Californian crude oil. Increased cash flow and profitability would stimulate additional exploration and production in both States. Dropping the effective ban would also head off a possible misallocation of resources in the future, such as construction of additional pipelines to transport crude oil from California.

Producing more crude in Alaska and California would enhance U.S. energy security, because it would reduce net U.S. oil imports—and thus reduce world dependence on insecure oil supplies. Greater security and diversification of oil supplies for U.S. trade partners in the Pacific would also reduce the likelihood of their bidding up world oil prices in a supply disruption. And Federal and State tax revenues would both be increased—because the value of this U.S. crude oil at the wellhead had risen.

There are several reasons why the ban on Alaska crude oil remains in place. Some believe that exporting any American crude to foreign countries would make this country less secure. In fact, however—given the integrated nature of the world oil market—it is net U.S. oil imports, not the amount of crude oil exports, that are important to our energy security. If net oil imports actually decline somewhat by allowing crude oil exports (through higher production in Alaska and California), then U.S. energy security has been improved.

A more contentious argument against allowing exports from northern Alaska is that it would likely result in the idling of a large number of U.S. tankers and a loss of jobs in the U.S. maritime industry. This loss of tankers would reduce the availability of militarily useful tankers for defense purposes in case of an emergency that required them.

California consumers of petroleum products (both industrial and residential) are concerned about removal of the export ban for another reason. They fear a potential price increase in petroleum products that might occur in California as the excess crude in that region was shipped elsewhere. Also, large investments in pipelines to move excess California crude to other U.S. markets would be jeopardized if the export restrictions vanished.

Exports of oil produced in South Alaska—which do not go through the trans-Alaska pipeline—are less restricted than are exports of oil from North Alaska. In 1985, the President exercised his authority to allow export of crude oil from Cook Inlet in South Alaska.

Targeting R&D:

GOVERNMENT-PRIVATE COOPERATION ADDRESSES NEEDS ECONOMICALLY

Cooperative research and development ventures can create government/industry partnerships to finance fossil fuel research and technology development that will augment the Department of Energy's traditional core R&D program. This approach for promoting the development of new technology can use government/taxpayer resources more effectively. Many new technologies that might benefit from broader use of this approach would increase future domestic production of liquid fuels and fuel substitutes.

Cooperative ventures give companies the opportunity to share resources and risks, and they are becoming increasingly important to companies as they seek to remain competitive in a global economy. DOE first proposed the cooperative venture approach in its FY 1987 budget request. Under this proposal, DOE would be a minority funding partner, involving itself principally in matters of policy and investment decisions, while the other participants would determine the project's scope, technical activities, and form of management.

Congress, however, indicated that it needed additional details on how cooperative R&D ventures would be applied to fossil energy projects before funds could be appropriated specifically for a cooperative venture pool. A public conference held by DOE in December 1986 elicited significant interest in the concept, and three regional meetings are now scheduled to discuss the idea further with the public. DOE intends to structure a cooperative R&D venture program in fossil energy, the details of which will be included in a FY 1988 budget amendment.

Based on interactions to date with the private sector, there appear to be promising opportunities for cooperation in extraction (for example, unconventional gas recovery, enhanced oil recovery, underground coal gasification) and in various coal technologies.

Government-private sector cooperation in R&D ventures, in comparison with ongoing programs, can add leverage to tax dollars, government talent, and other resources. They should also increase the likelihood that technologies will be commercialized, because more companies will be financially involved. Benefits from the increased sharing of risks and resources are especially important to the energy industry at this time, when many segments are in a depressed state. Nevertheless, most U.S. companies—including those in the energy industry—have a historical bias against cooperative R&D ventures because of a lack of experience and because of concerns over the application of the anti-trust laws, which the Justice Department has attempted to clarify. Aggressive government action will probably be needed to help catalyze some useful ventures that otherwise may not materialize.

DOE also participates in R&D agreements and studies with States and with foreign countries. Potential areas for such activities in the future include cooperative R&D on petroleum characterization and recovery, studies on actions States can take to increase production from marginal reservoirs, and providing technology and expertise to small field operators.

Targeting R&D:

HUGE UNTAPPED RESERVOIRS AWAIT ENHANCED OIL RECOVERY SYSTEMS

Encouraging the development of innovative enhanced oil recovery (EOR) technologies through long-term, high risk R&D (including cooperative research with industry and States) can help make available some of the 300 billion barrels of oil in existing reservoirs that will remain unrecovered even after currently known technologies have been applied.

As explained above, EOR includes the development of sophisticated technologies to recover more oil from a given reservoir—and ultimately to permit recovery of a significant amount of oil that would remain in the ground after all "conventional" techniques had been applied. Besides using natural forces, conventional techniques include the injection of water or natural gas into a reservoir to push the oil out. EOR techniques go beyond this to include the injection of heat and/or fluids and gases into the reservoir that cause physical or chemical changes within it, facilitating further oil recovery.

DOE's FY 1988 budget request for EOR includes these areas:

- Detailed characterization of heterogeneities in reservoirs.
- Research on novel EOR techniques, such as microbial EOR.
- Fundamental studies of rock and fluid properties and interactions.
- Small cooperative industry field tests.
- Cooperative research with oil-producing States.
- International agreements for cooperative research on petroleum characterization and recovery.

This program represents long-term/high-risk research that oil companies have tended to give low priority, favoring (particularly in periods of low oil prices and cash flow) prospects with more near-term payoffs.

Included in the FY 1988 budget request is an initiative that begins or expands work in all of the domestic EOR areas mentioned.

Targeting R&D:

PETROLEUM GEOSCIENCE RESEARCH MIGHT LOCATE ADDITIONAL OIL

There is a natural interaction between EOR research and geoscientific studies of the oil that remains untapped in existing reservoirs. Applying the two together can maximize recovery from U.S. oil fields.

Fundamental petroleum geoscience can help lead to the recovery of oil (and natural gas, to a lesser degree) in existing reservoirs that have been bypassed by current production techniques because of reservoir heterogeneities. Such oil is referred to as "mobile" oil, because it could flow to a producing well if a path were available. Oil and gas could be recovered through infill drilling, enhanced oil recovery (EOR), and unconventional gas recovery (UGR). Cooperative government-industry research could help develop a fundamental understanding of reservoir properties, recovery processes, and the interactions between the two. It would increase the predictability of innovative EOR and UGR technologies and of targeted infill drilling.

Very preliminary estimates suggest that in Texas alone there may be 35 billion barrels of mobile oil in existing reservoirs, and this is not even counted in existing reserves or in estimates of undiscovered/recoverable resources. The target on a national level may exceed 100 billion barrels. Similar estimates for gas are simply unavailable. In fact, very little research is being conducted in industry because of the speculative nature of the resource.

In order to realize the benefits of this resource at some point in the future, industry must be able to:

- Define the target oil—by determining its location and distribution, and the conditions controlling its movement.
- Determine how EOR processes interact with reservoir rocks and fluids to mobilize and displace the oil (for that portion of the target oil amenable to EOR).
- Consolidate this knowledge into reliable quantitative predictions.

The payoff from this research might be significantly increased domestic production during the rest of this century and beyond. Potentially much of the oil and gas that results would cost less than that to be found in high-cost, frontier areas where most of the country's undiscovered oil and gas is now assumed to be. This resource could also be developed and brought into production with much shorter lead times. Merely defining this resource would make national energy projections more reliable, because these rely heavily on forecasts of oil production. Thus, it would provide a better basis for future policy decisions.

Funding for such a program is problematical, however. Industry-government cost-sharing or a joint venture arrangement might hold the key.

Recently, several prominent groups from the private sector have proposed major initiatives in petroleum geoscience research, and the Department of Energy is examining their positions. Additionally, at the request of Congress, the Department has developed a "Geosciences Research Plan for Oil and Gas Discovery and Recovery."

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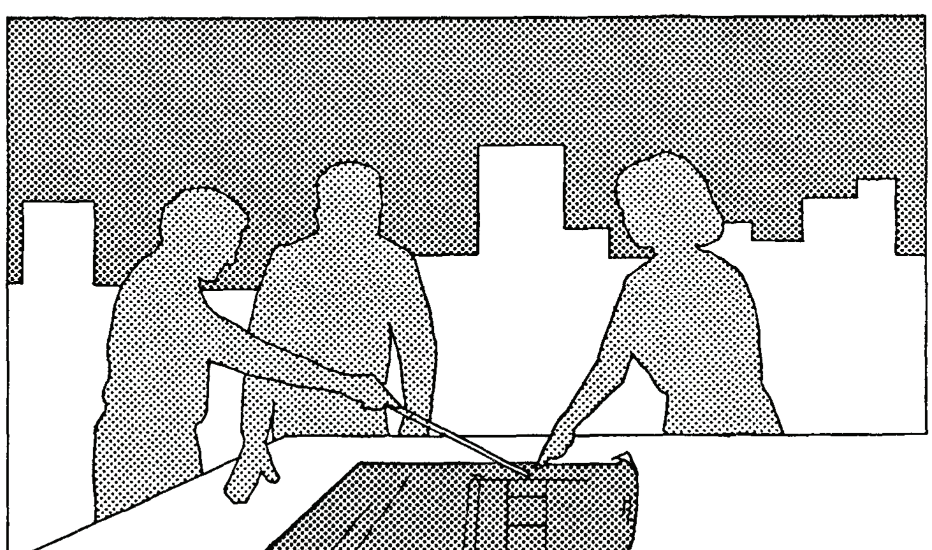
ENERGY EFFICIENCY: GETTING THE MOST FROM THE ENERGY WE HAVE



THE SITUATION IN BRIEF

"Energy efficiency" is a key ingredient in this country's energy mix.

Today, the United States uses virtually no more energy (and less oil) than it did in 1973—although its population is still expanding and the Nation steadily continues to turn out more in products and services. The U.S. economy has demonstrated an impressive ability over the past decade to use energy efficiently and flexibly. Energy efficiency has also improved during this same period in other countries of the Organization for Economic Cooperation and Development (OECD). In less developed countries (LDC's), on the other hand, energy demand has increased at about the same rate as gross domestic product (GDP); and growth in the use of energy (especially oil) is expected to continue at high rates in many LDC's over the next decade.

Higher energy prices have stimulated the use and development of energy technologies that are more efficient. This has taken place primarily through market forces, with energy consumers making their own fuel choices or investing in various methods of using energy more efficiently. Improvements in average energy efficiency can be expected to continue, despite the decline in world oil prices—but perhaps at a slower rate. The memory of high prices in the past will continue to influence additional investments by consumers toward efficiency, and expectation of a return to higher prices at some future date will also be a factor. Some of the improvements that have already taken place involved long-term or permanent changes to capital stock (such as more efficient cars, better insulated homes, and more efficient industrial processes); and others represent behavioral changes (for example, more timely maintenance of industrial equipment).

Without the improvements in energy productivity that have taken place since 1973, the United States would now hypothetically require 29 additional quads more of energy each year—the avoided equivalent of about 14 million barrels of oil every day. In response to market forces, the American people have found new and better ways of using energy—to a degree that surprised even the optimists.

Advances in technology have accounted for two-thirds of the recent energy-productivity improvements in U.S. industry and three-fourths of those in transportation—resulting in more product output per energy unit and more miles per gallon. Continuing changes in the structure of the U.S. economy also affect the kinds and amounts of energy we use. Many of the most obvious and least expensive energy-conservation steps have been taken in all types of U.S. energy uses, including residential and commercial buildings. However, the potential for energy conservation has by no means been exhausted. Further economic gains in energy efficiency should continue through the eventual turnover of almost all less-efficient capital stock (for example, autos) with new, more energy-efficient products and devices. This country can save between 10 and 25 quads of energy (the energy equivalent of 5-12 million barrels per day of oil) annually by the year 2000—in addition to savings from steps that have already been taken—if existing cost-effective technologies and those anticipated from future R&D are applied fully to improve energy efficiency. So long as they are cost-effective, gains in energy efficiency can help U.S. products stay competitive in domestic and international markets (particularly in the production of such commodities as chemicals, metals, and wood and paper products, as well as factory-built housing, appliances, and manufacturing equipment).

Oil will be a critical U.S. fuel for the next decade and longer, largely because American transportation and industry continue to depend heavily on petroleum products. The most promising strategies for the Nation are to continue to encourage the application of energy-efficient technologies wherever and whenever they are cost-effective, and also to develop the potential for fuel flexibility in motor vehicles.

OUR ENERGY OUTLOOK IS INFLUENCED BY HOW (AND HOW EFFICIENTLY) ENERGY IS USED

EFFICIENCY MEETS DEMANDS OF ECONOMIC GROWTH, AND THINGS CAN IMPROVE

The unprecedented oil price increases and market dislocations of the 1970's spurred major efforts to reduce energy consumption, to increase energy-use efficiency, and to develop alternative energy sources in the industrialized world.

Improvements in the efficiency with which energy is being used by the United States and other developed countries have been dramatic:

- The United States currently uses about 29 quads less energy in a year than it would have if the Nation's economic growth since 1972 had been accompanied by the less-efficient trends in energy use that prevailed then.

- Part of the change in the intensity and pattern of U.S. energy use is due to shifts in the mix of industrial products and to changes in consumer awareness and behavior. But most of it is due to technological improvements in vehicles, buildings, and equipment—motivated largely by higher prices.

- In 1985, countries of the OECD (Organization for Economic Cooperation and Development) consumed slightly less oil than in 1970 despite GDP growth of 29 percent during the intervening years. This achievement was the result of increased efficiency, fuel substitution, and the accelerated development of nuclear power generation.

In less developed countries, however—where conservation efforts have been less evident—energy demand has grown at the same rate as GDP. By 1985, LDC's were using nearly twice as much oil as they had used in 1973. This demand was driven by rapid industrialization, exceptionally high growth rates in population and urbanization, and the replacement of such traditional fuels as wood and agricultural residues with commercial fuels. In many cases, also, oil prices in LDC's are subsidized. This encourages oil use and discourages any resort to technology that could replace it or make energy use more efficient.

The technological potential exists for more progress, and that can mean a great deal. Each 1-percent gain in world energy efficiency through advanced technology can displace about 1 million barrels per day of oil equivalent. Among LDC's, the potential for increased energy-use efficiency in the residential, commercial, and industrial sectors remains largely untapped.

The projections used in this study assume that efficiency trends will continue from the application of existing cost-effective technologies and from the results of new research and development that can be foreseen. Annual energy savings could amount to 10 quads in the United States by 1995—the energy equivalent of about 5 million barrels per day of oil (14 percent of total current annual energy consumption).

Worldwide energy consumption is projected to grow only moderately in the short term, but it is more difficult to estimate what will take place by the year 2000 and beyond. Lower oil prices could discourage or postpone some investments in new technologies for energy-efficiency that are already available. On the other hand, lower interest rates and higher economic growth (both of which result in part from lower oil prices) might encourage investments and speed up the turnover of capital equipment. In the long run, if cost-competitive alternatives become available to substitute for fuels in U.S. motor vehicles, this could lead to the displacement of a significant portion of all the petroleum used in the United States.

ENERGY CONSUMPTION AND U.S. ECONOMIC GROWTH ARE NO LONGER LINKED ONE-TO-ONE

From 1960 to 1973—a period of relatively stable energy prices—U.S. energy consumption grew at roughly the same rate as GNP (about 4 percent per year). However, rapid increases in energy prices during the 1970's encouraged all sectors of the U.S. economy to find ways of satisfying end-use requirements without consuming more energy—and especially without using more oil.

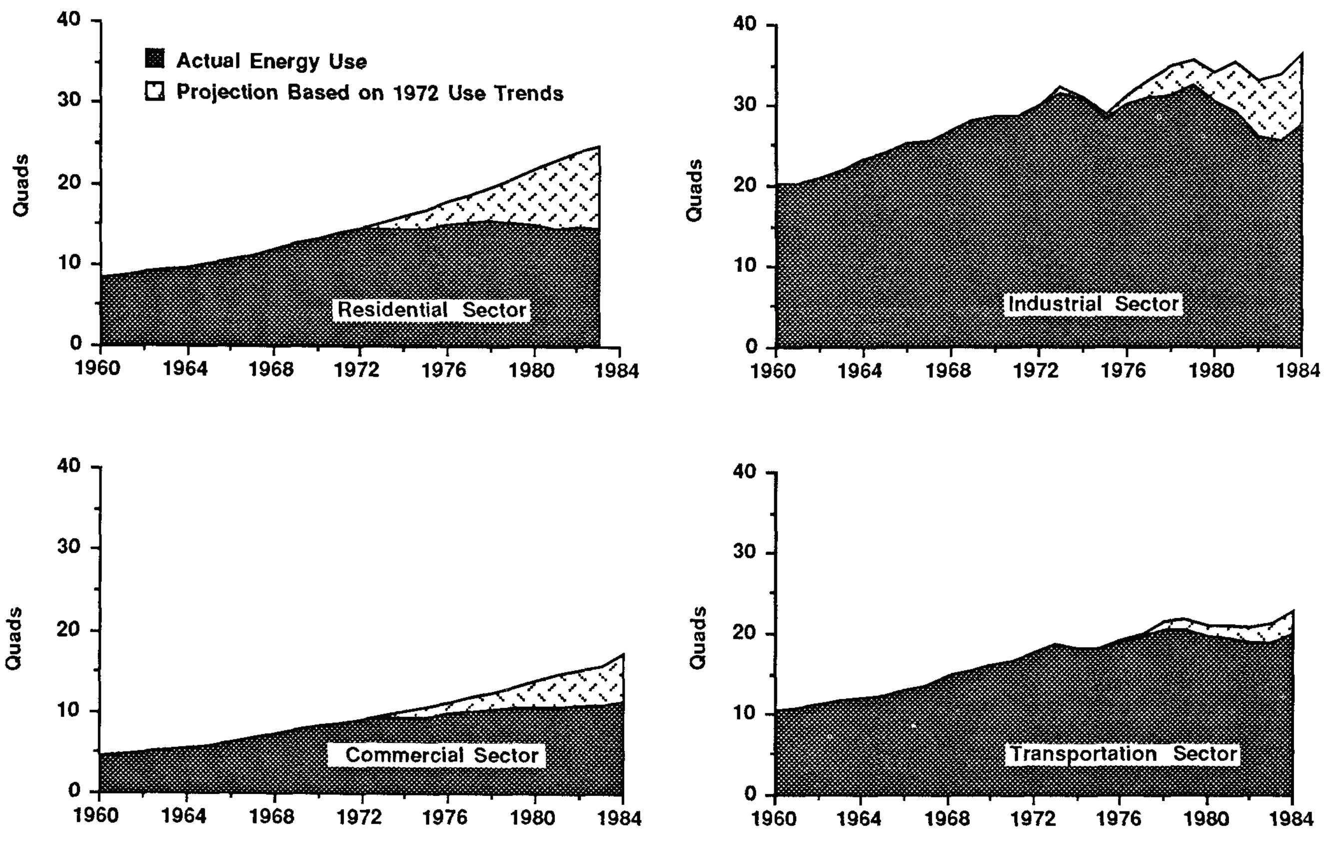
The United States used no more energy in 1985 than it did in 1973, even though economic output has continued growing at an average rate of about 2.5 percent per year. Had pre-1972 energy-use trends continued, by 1984 the United States would have been consuming almost 40 percent more energy than it actually did. Part of the explanation lies in price-induced savings from increased energy efficiency (using less energy per unit of economic output); part can be ascribed to changes in consumer behavior (such as better equipment maintenance and different habits in thermostat settings). In addition, changes in the mix of industrial products (for example, more computers and less steel) also reduced the amount of energy this country consumes.

All sectors of the economy have been involved:

- **Transportation.** The fuel efficiency of new cars has increased by about 10 mpg—to more than 26 mpg. Aircraft operating efficiency increased about 90 percent too, as a result of more efficient aircraft and engines, and higher load factors. (The transportation sector depends on oil for about 97 percent of its energy needs.)

- **Residential.** Improved building-shell designs and materials, more efficient appliances, and some behavioral changes reduced total energy use by the residential

All Sectors of U.S. Economy Now Use Energy More Efficiently



sector by about 10 percent during this period despite a 23-percent increase in the number of households. Consumption per household decreased by 26 percent, as more than 75 percent of all houses put conservation to work in some form.

- **Commercial**. More efficient building designs and energy-efficient retrofits contributed to a 31-percent decrease in the use of oil. Overall energy consumption per square foot of floor space decreased by 35 percent.

- **Industrial**. More efficient equipment, better operating procedures, and a shift away from production of energy-intensive goods cut energy use by 7.5 percent.

Between 1985 and 1995, energy-use intensity (the amount of energy consumed per unit of economic output) is expected to drop by an additional 11 percent in the United States.

TECHNOLOGIES THAT USE ENERGY MORE EFFICIENTLY BROADEN MARKET CHOICES

Choices of energy supply in the world now rest chiefly on the relative availability and prices of commodities, such as oil and gas. These commodities are subject to price fluctuations. They face supply constraints in some cases. They may come from insecure sources.

Markets can work only with the choices available, but the technologies that apply energy more efficiently give energy users a *new* set of choices in the free market. Energy-efficient technologies are comparable in a way to new energy supply options. Thus, "a barrel saved is equal to a barrel found."

Higher energy prices have been a major encouragement to the use of improved, more energy-efficient technologies. In combination with conventional commodity-based supply options, the new technologies can help to promote stable, secure, and adequate energy supplies—and more predictable energy costs—in the future.

ANALYZING U.S. ENERGY USE SHOWS WHERE TECHNOLOGICAL INPUT CAN HELP MOST

IMPROVING EFFICIENCY BEGINS WITH UNDERSTANDING IN SOME DETAIL HOW ENERGY IS USED

More than one-quarter of all the energy used in the United States goes into transportation, with personal transportation accounting for most of that. About 97 percent of transportation energy comes from oil.

Americans use as much energy in their houses (mostly for heating and cooling) as they do in their autos; but a relatively small amount of that is oil. Electricity use for appliances, heating, and cooling is growing, and it now represents almost 30 percent of residential energy. About 60 percent of all U.S. homes now have air-conditioning.

Commercial-sector energy use in the United States is growing as the service sector grows. The heating and cooling of buildings account for the majority of this energy use, but lighting and hot water are also quite important in some specific types of commercial buildings (for example, hospitals and hotels). Office buildings and retail stores are not very energy-intensive compared to hospitals, college facilities, or hotels that are used 24 hours per day. Electricity and natural gas are the main fuels in this sector.

The industrial sector, which includes mining, manufacturing, construction, and agriculture, is the largest direct energy user in the economy, accounting for 21 quads. Oil and gas together make up three-fourths of this total.

In agriculture, mining, and construction, the motor fuels for engines (such as in tractors and construction equipment) and heat for processing are both important uses. In manufacturing, process heat (for example, for steel and glass making), space conditioning, and electric motors are large users.

Feedstocks (for example, oil used to make plastics or asphalt, natural gas for producing ammonia, and coal used as a base for some chemicals) are also a large and important use of energy resources, with natural gas and oil contributing the largest shares. Use as feedstocks amounts to about 20 percent of total oil and gas consumption.

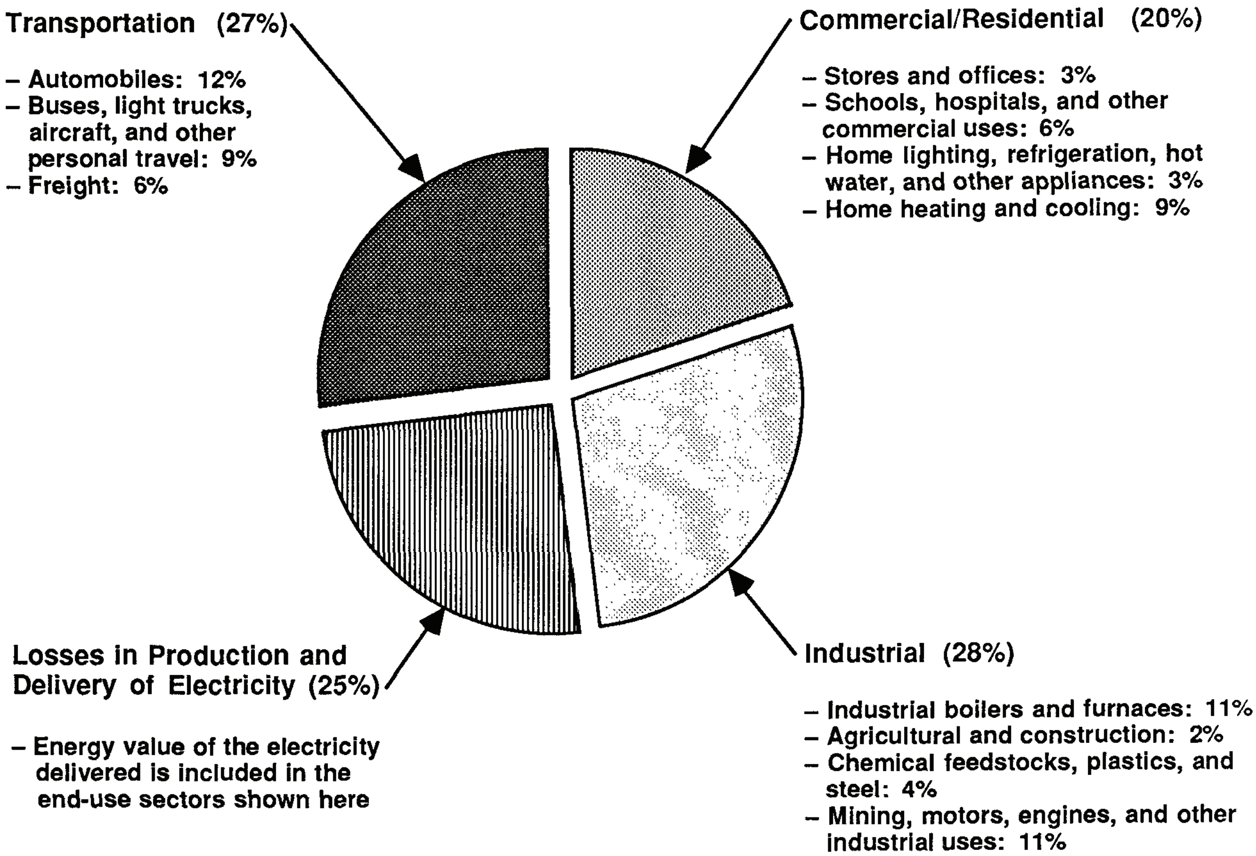
The electric utility sector is an intermediary between primary energy supplies and many end-uses. In supplying electricity, the sector consumes about 3 quads of input energy for every quad of electricity delivered to end-users. The transformation and distribution losses for electricity account for about one-fourth of all the energy used in the United States. (Although electric utilities increased their consumption of petroleum fuels in 1986, they still used only about 650,000 barrels per day of oil—well under 4 percent of total oil consumption).

Imports, such as steel and autos, are an indirect means of consuming energy that is embodied in products and services. In 1985, nearly $300 billion in various goods this country imported (excluding crude oil, petroleum products, and other direct energy imports) would have required the use of 7 quads of U.S. energy if they had been produced domestically.

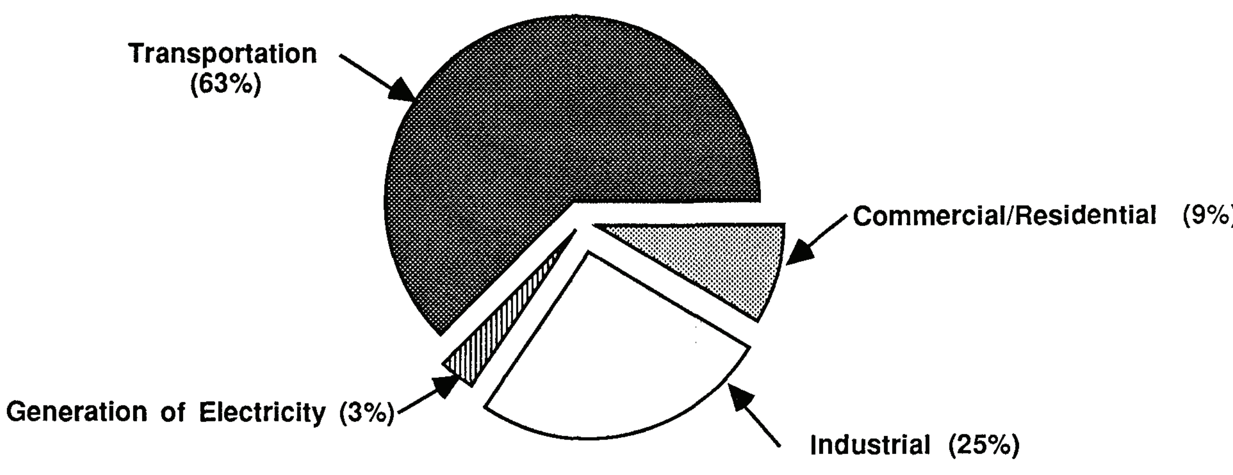
TRANSPORTATION AND INDUSTRY ARE THE LARGEST CONSUMERS OF PETROLEUM IN THE U.S.

Oil use in the U.S. economy is now concentrated in the transportation and industrial sectors. Combined, these two sectors account for about 90 percent of the approximately 16 million barrels per day (MMBD) of oil consumed daily for various end-uses. Transportation and other uses of motor fuels (for example, agriculture and construction equipment, pumps, generators) alone account

Consumption of all U.S. primary energy broke down like this in 1985:



. . . and this is how oil consumption was divided among the major sectors:



for 10.5 MMBD. In industry, process heat and feedstocks account for 11 percent of total U.S. oil use.

Analysis of available data suggests that short-term fuel switching under present circumstances could reduce this Nation's net use of oil by about a million barrels per day in response to an oil supply disruption or in the face of rapidly increasing oil prices (assuming that the level of goods and services was to be maintained). The transportation sector would remain heavily oil-dependent in such a situation, because roughly 92 percent of transportation's energy needs still would be met by oil. There might be some additional short-term reductions in oil demand in the transportation sector simply because driving habits would adjust to higher prices.

Dual-fired capacity in many industrial boilers (typically the ability to burn either residual oil or natural gas) and secondary heat sources also allow some reduction in the use of oil.

In the long term, U.S. oil consumption will be influenced by many factors, including these:

- The availability of alternative transportation and motor fuels . . . and their cost.
- Greater efficiency in gasoline use.
- Increased availability of economically competitive natural gas.
- Development of more efficient energy-using and energy-transforming technologies.
- Demand management techniques and new generating capacity for electricity that are not based on oil.

U.S. TRANSPORTATION ALONE USES MORE OIL EACH YEAR THAN THE NATION PRODUCES

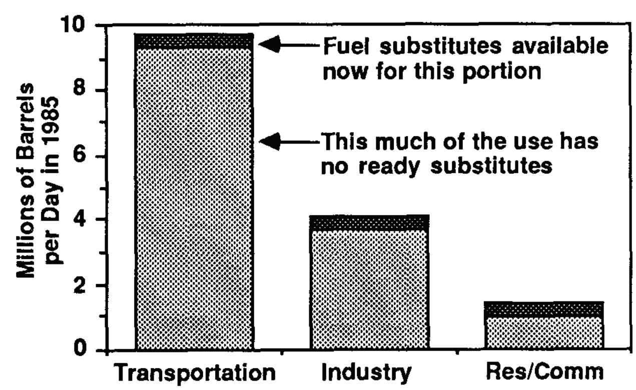
Transportation accounts for more than 62 percent of all U.S. oil use. Fifty-nine percent of the oil use for U.S. transportation is concentrated in autos and light trucks.

- Heavy trucks use 17 percent.
- Marine transport and rail together use 9 percent. Stimulated somewhat by deregulation, they haul more with less fuel than do other transport modes.
- Aircraft have shown the largest percentage improvements in fuel economy, and they account for only 8 percent of the sector's oil use now.
- Military and other users account for 7 percent of U.S. oil consumption.

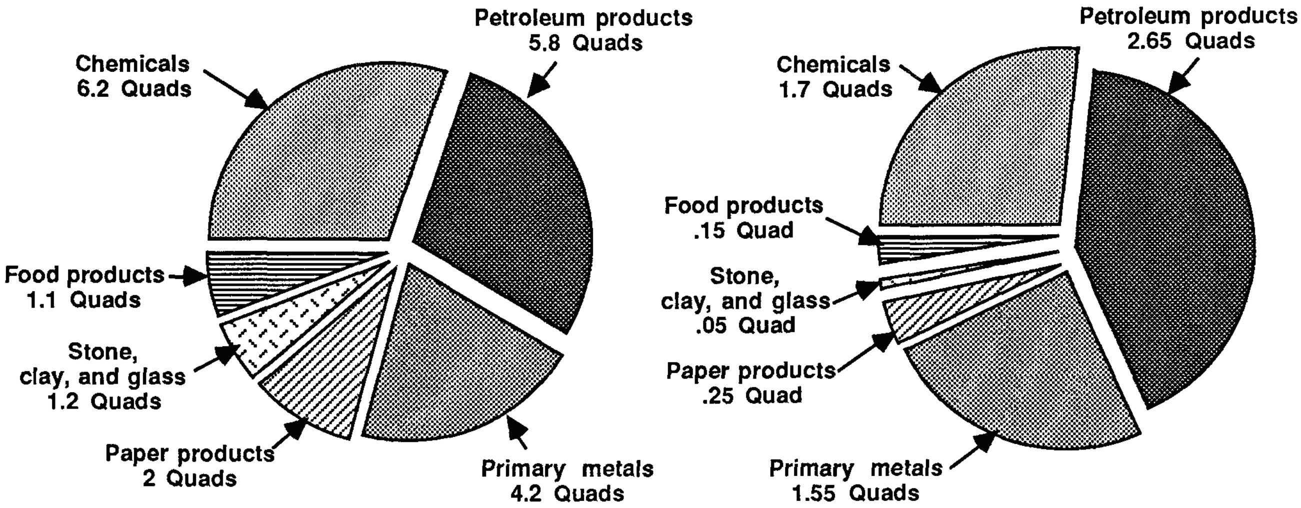
There is clearly great potential to reduce this country's oil use by market-driven fuel switching that is economically cost-effective, and by the introduction of new efficiency improvements in the transportation sector.

Significant improvements will continue to occur in autos and light trucks from turnover in the

Current U.S. Use of Oil by Sector



Breakdown of How Energy Is Used by Six Key Industrial Groupings (1984)



vehicle fleet. These energy-efficiency improvements will be larger in the next 5 years than those resulting from new technology.

Alternative fuels have huge potential to displace oil use in transportation if they are cost competitive.

INDUSTRY'S USE OF ENERGY (AND OIL) IS CONCENTRATED IN A FEW AREAS

Six areas of energy-intensive production (chemicals, petroleum, primary metals, paper, stone-clay-glass, and food) account for about two-thirds of all industrial energy use.

The industrial processes that use the most energy are combustion for process steam and self-generated electricity, electrolytic processes, chemical reactors, combustion for direct heat in furnaces and kilns, and direct motor-drive. Approximately 800,000 barrels of crude oil each day, about 4 percent of total U.S. consumption, are used as petrochemical feedstocks (including LPG, naphthas, waxes, and lubricants). But economic forces are changing industrial patterns of energy use.

Industrial energy efficiency has improved by an average of more than 25 percent since 1972 in the United States, resulting in savings estimated now at 7 quads annually. The decline in primary metals production (which is very energy-intensive) accounts for much of the domestic reduction in industrial energy use since 1973, and particularly for the reduced use of coal. Environmental costs and constraints have also tended to discourage coal use. However, industry is continuing to increase its use of electricity, and coal is the Nation's principal electric-generation fuel. The low current prices for oil are encouraging greater industrial use of this fuel, and it may be that they have discouraged some fuel-switching investments.

New energy-efficient technologies should change the amounts and types of fuel used by U.S. industry in several ways. Just to cite a few examples:

- Generating systems (such as cogeneration) that can switch readily from one fuel to another could help cushion future energy shocks.
- New high-temperature equipment that can recover what might otherwise be "waste heat" gets its job done while using less initial energy input.

- End-use energy consumption per constant dollar of industrial output declined by 28 percent between 1974 and 1984—reflecting substantial improvements in energy efficiency as well as the relative decline in output from energy-intensive industries in this country.

RESIDENTIAL AND COMMERCIAL BUILDINGS WILL USE MORE ENERGY, BUT NOT MUCH MORE OIL

During 1985, more than 35 percent of all the primary energy consumed in the U.S. went into satisfying the requirements of the residential and commercial sectors combined. (These two often are counted as one in statistical breakdowns.) However, only a small part of this (about a million barrels per day of oil, or 7 percent of total oil consumption) was in the form of petroleum products for direct use—such as home heating oil. The chief end-use energy sources for the homes, offices, stores, and other buildings that comprise the residential and commercial sectors were electricity (63 percent) and natural gas (26 percent).

More than half of the energy used in buildings goes into temperature-conditioning of the space within them (heating in cold weather and ventilation or air conditioning during warm periods). But the relative importance of space heating as a fuel user is declining, and the use of air conditioning is on the increase. The increasing use of electricity to heat U.S. buildings (especially via heat pumps) has been based on population shifts to the Sun Belt, simple convenience, and the growing ability to afford that convenience.

Water heating uses a significant share of residential energy (17 percent), but it accounts for only 6 percent of the energy use in commercial buildings. Lighting is quite important in the commercial sector's use of energy (24 percent), but it consumes only 7 percent of the energy used in homes. Household refrigerators and freezers consume 11 percent of residential energy–about the same as all small appliances put together.

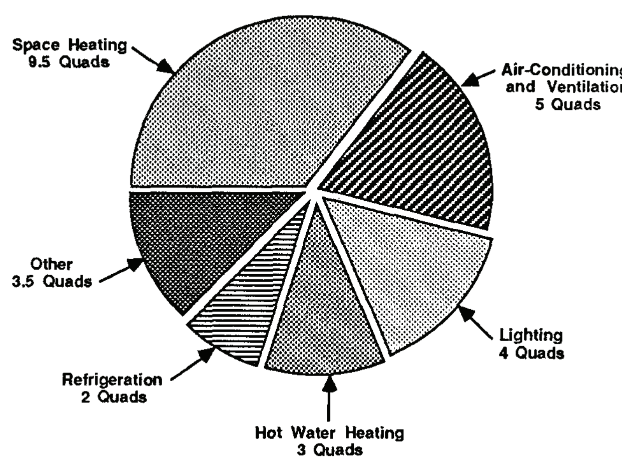
With the incentive of higher energy prices during the past decade, residential consumers increased their total use of energy by only 4 percent—even though the number of households was rising by 22 percent. Part of this apparent improvement in effective energy use can be traced to smaller households, population shifts to more moderate climates, and changes in lifestyles; but about one-third of it is due to building-shell improvements and the popularization of more energy-efficient appliances.

While commercial floor space increased by 29 percent during the same decade, energy consumption in the sector rose just 24 percent. About half of this improvement in energy-use intensity resulted from retrofits of existing buildings. Existing techniques can make new commercial buildings twice as energy-efficient as those of the early 1970's, but turnover in building stock is fairly low.

A variety of factors and technologies can affect future energy use:

- A growing population and a rising standard of living in the United States can lead to increasing energy consumption in the residential and commercial sectors between now and the end of this century; but oil makes up relatively little of the demand in these sectors now (because of shifts in use patterns over the past decade).

Energy Use in U.S. Buildings*



*Expressed as consumption of primary energy, rather than end-use.

- Oil and gas will be conserved by improvements in combustion systems and ever-broader use of advanced heat pumps.

- All forms of energy can be saved by improving the thermal integrity of buildings through better window glazing, better insulation materials, improved wall and roof components, optimized systems integration, and new ways of retrofitting.

- District heating systems provide fuel flexibility as well as energy savings.

- Innovative fluorescent lighting technology uses one-fourth less energy than conventional fluorescents, at only about half the life-cycle cost.

EFFICIENCY IN ELECTRICITY SECTOR HELPS ACROSS THE BOARD AND STEMS OIL CONSUMPTION

The use of oil as a fuel to generate electricity in the United States was cut sharply as oil prices rose. However, with oil prices lower now—and with many utilities hesitating to invest in large new coal and nuclear powerplants for a variety of reasons—the shares of both oil and gas as primary inputs for generation are likely to rise.

"Load management" is a widely favored method of using the generation facilities on hand more efficiently. By using a variety of techniques to smooth out some of the customary ups and downs in demand for electricity, it becomes possible to concentrate more of any utility's output in the units that operate at the lowest cost. In most cases, this also means that oil-burning units will be kept on line less.

About 9 percent of all electricity that is generated is lost now in the process of transmitting it over long distances and distributing it among end-users. Once again, there are many different technologies that promise to reduce such losses—ranging from superconducting cables (in the more distant future) to new lower-loss materials in electric equipment such as transformers or motors.

Small improvements in actual conversion efficiency would have an even greater multiplier effect, but it will take a long time for their value to be felt because of the enormous number of generating plants already in operation and the extremely slow turnover in such expensive capital stock.

The contribution of Federal research and development in this case has focused on basic research in materials and development of a broader understanding of fundamental principles. While these are not easily linked in the public mind to the more dramatic breakthroughs that are more likely to come from extensive applied research and development by the utility industry itself, they are important as a scientific foundation on which new technologies can be constructed.

ENERGY EFFICIENCY IS LINKED TO PRODUCTIVITY AND COMPETITIVENESS, AS WELL AS TO SECURITY

U.S. INDUSTRY HAS PROVED IT CAN TURN OUT PRODUCTS WITH LOWER ENERGY INPUT

Economic efficiency is normally increased when less energy is used, in response to price and other market forces, to produce a given product or service. This, in turn, helps to make the United States more competitive in international markets.

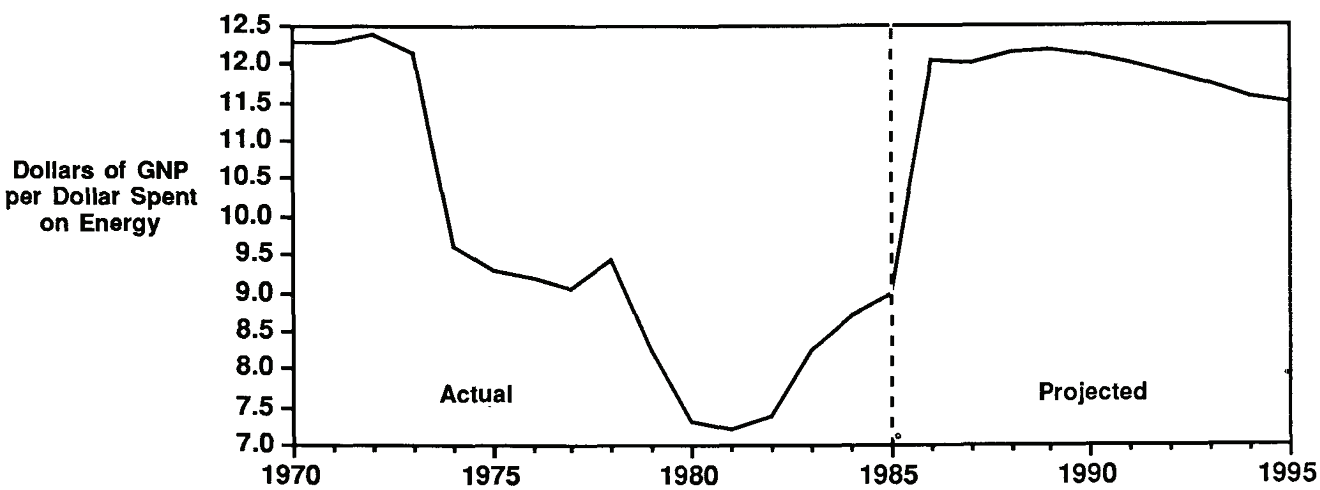
Industrial energy efficiency has improved by an average of more than 25 percent since 1972, resulting in savings estimated at 7 quads annually. Some industries (such as chemical products, paper products, lumber and wood products, electronic equipment, and transportation equipment) have improved by 30 percent or more. Yet additional improvements in energy efficiency and productivity will be necessary for U.S. industry to remain competitive worldwide.

The "bottom line" in national energy productivity depends on how much the United States can produce in goods and services for each dollar the Nation spends on end-use energy. The oil price shocks of the 1970's increased energy's cost as a factor of production, while—as the graph on this page reveals—price controls at first discouraged normal market adjustments. With more realistic market pricing in the 1980's, the productivity of the energy dollar increased.

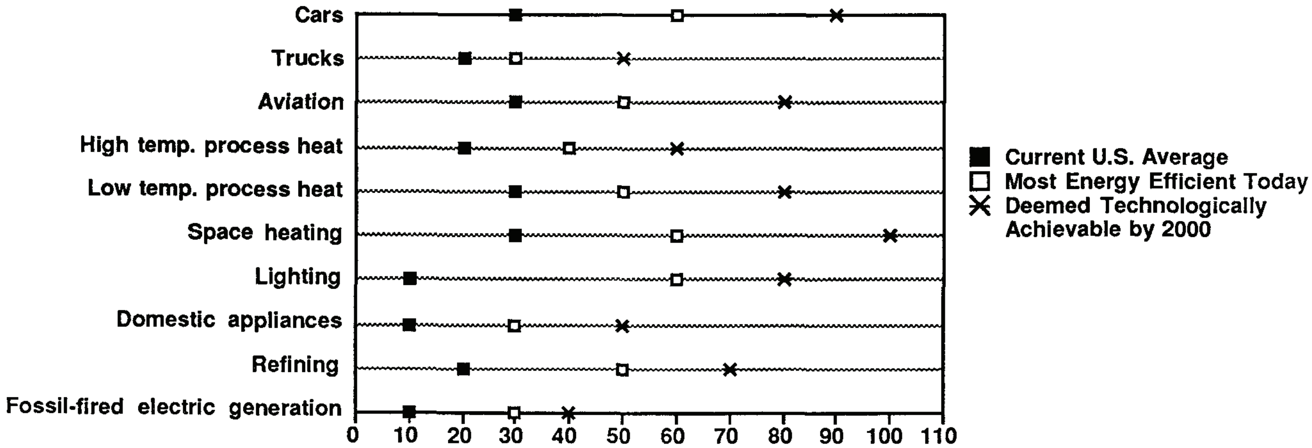
Now that many low-cost steps toward improving energy-use efficiency have been taken, however, this "dollar productivity" ratio is projected to decline again slowly in the mid-term. The lower oil prices currently projected could change the economics of investment in energy-using equipment, although other factors are also involved that might offset this. (For example, lower interest rates could speed capital stock turnover and thus improve technology efficiency.)

The latest industrial equipment (including such items as boilers, pumps, and motors) is much improved over what was available 10 years ago. As a result, the American economy is becoming increasingly energy-efficient as new equipment replaces old. This sort of momentum is not thrown off much by a short-term reduction in energy prices.

Nation's Output (Real GNP) per Dollar Spent on Energy



Percentage Improvement in End-Use Efficiencies (Beyond 1973 Averages)*



* Based on data supplied by Cambridge Energy Research Associates in 1986.

ALREADY AVAILABLE TECHNOLOGY CAN IMPROVE ECONOMIC AND ENERGY EFFICIENCY

As the chart above shows, dramatic gains have been made in U.S. energy efficiency since the early 1970's. Much more could be done, in a cost-effective way, simply by applying technology that is already available.

The chart shows the percentage of improvement since 1973 in units of the pertinent activity (such as the number of miles driven by a vehicle, the building volume that can be heated, or the amount of finished goods produced) by using a given amount of energy. In many cases, today's most efficient energy systems offer at least twice as much improvement over what was being done in 1973 as the average item that is actually in use now across the country. The best technology that can reasonably be projected for the turn of the century invariably offers another substantial jump in getting the same jobs done.

Industrial improvements in energy efficiency show ingenuity, flexibility, and adaptability to a remarkable degree. Twenty-two technologies developed with Federal R&D support and cost-shared by private industry are already saving U.S. industry and its customers energy expenditures that were valued at $150 million in 1986. But this is a modest amount compared with what will be done through wider application of existing technologies as industry continues to make changes that serve their needs and make economic sense.

The rising efficiency of U.S. cars, particularly of large- and medium-sized vehicles, has helped U.S. manufacturers to protect their market share. On the other hand, in energy-intensive basic materials (for example, steel, aluminum, phosphates), U.S. industry has been moving offshore. But the U.S. firms that stayed in this country have shifted toward higher efficiency, higher productivity processes—such as steel mini-mills.

REMOVING BARRIERS TO MARKET FORCES IMPROVES LIKELIHOOD OF ENERGY EFFICIENCY

FACTORS IN CONSUMER CHOICES MAY SLOW THE PACE AT WHICH ADVANCED TECHNOLOGY FITS IN

Energy users often are blocked from reaching decisions that could lead to greater energy efficiency by the structural barriers of tradition, regulation, and vested interests. For instance, changes in the building sector often are slowed by the fact that the first purchaser (or contractor) of energy-consuming equipment is usually not the ultimate owner and may be more concerned with minimizing initial costs. Renters frequently do not pay their individual energy costs either. And State and local building codes and guidelines may inhibit the implementation of new, energy-efficient construction practices.

There is also considerable competition for capital. Distortions in the market caused by government intervention can cause capital to be allocated inefficiently. Consumers often lack the capital to purchase (or retrofit) more efficient equipment or buildings, even where such efforts are cost-effective. The immediate need to reduce Federal deficits discourages some moves to reduce energy use in Federal facilities and operations. In fact, large budget deficits themselves compete for capital—which could otherwise be used for other purposes, including energy-efficiency investments. And, if lower oil prices persuade industry to cut back privately funded R&D in energy efficiency now, less new conservation technology will be available 5 to 10 years from now.

The question of whether to choose near-term or long-term benefits also affects the pace of improvement in energy efficiency. Consumers typically look for short payback periods—6 months to 2 years—for energy-conserving investments. Yet many such investments will produce energy savings for years, as in the case of an efficient furnace with a useful life of 20 years.

The potential value of alternative fuels for motor vehicles has already been cited. Yet most alternative fuels are not economical in today's circumstances except where subsidies or small limited markets exist. The resulting absence of a distribution infrastructure for such fuels discourages their introduction.

Finally, both buyers and sellers must have good timely information if markets are to function properly; but this is sometimes lacking.

What should the Government do about all this? Although markets may be imperfect, government intervention is also imperfect. In fact, it can be counterproductive. It is unrealistic to expect a full government "fix" for each and every imperfection in the marketplace. Clearly, what is called for is a balanced approach that takes full advantage of whatever markets can accomplish without picking up the disadvantages of blatant government intervention.

THE GOVERNMENT'S ROLE IN "THE EFFICIENCY OPTION" IS LARGELY INDIRECT

Aside from making sure that the Government itself uses energy in a cost-effective fashion, the Federal role in energy efficiency is one of partnership with the private sector rather than direction. The Federal establishment carries on basic research, serves as a sounding board for new ideas, tries to avoid or remove unjustified impediments to relevant new technology that otherwise would be economically viable, and continues to do its utmost to let fuel prices reflect their correct relative levels—which encourages prudent nationwide use of energy.

Recent declines in interest rates make it easier to take advantage of long-term savings opportunities, even with lower current oil prices. In calculating "payback" periods for fresh investments in more efficient methods of applying energy, the key number is not what the energy that might be saved in the future would cost at today's prices, but what one might have to pay for it over the useful life of the new equipment or process (while fuel prices may well be rising).

Numerous conservation programs were put into place during the 1970's. These programs, including the 55-mile-per-hour national speed limit and auto fuel economy standards (CAFE), were aimed at conserving energy. These programs were useful in saving energy and helped to raise consumer awareness when energy prices were held low during the period of controlled petroleum prices. In today's market, however, when many of the most cost-effective opportunities for increasing energy efficiency have already been taken and consumers are free to respond to decontrolled petroleum prices, these programs have outlived their usefulness.

The Federal Government's role in promoting energy efficiency within the U.S. economy is fundamentally an indirect one—as a catalyst or market facilitator; but government activity can still be targeted selectively. Federal research and scientific programs are designed to provide useful knowledge at key points in the continuum of advanced technology development. Federal energy information activities, including the labeling of appliances and motor vehicles, are designed to help consumers in all sectors to make well-informed and efficient choices—thus spurring free-market competition among energy-using devices, measures, products, and technologies.

The Federal role in R&D focuses on the earlier phases of the process. It is willing to undertake precommercial stages of "higher risk" projects that show potential for large long-term benefits, but which would not be cost-effective for private organizations. The reason why individual companies or industrial groups are reluctant to tackle such projects on their own might be their inability to count on reaping the benefits from them. Or perhaps it is because of a project's high cost, uncertainty, or likely slow payoff. Still, maximum cost-sharing and participation by the private sector is encouraged, because this adds leverage to limited Federal resources.

The success of the energy-efficiency improvements seen thus far came primarily from individual actions, rather than government-mandated programs. Should prices rise, the record shows that energy users will adjust their energy use appropriately. Even in research and development, the great bulk of R&D expenditures relating to specific energy production, distribution, and use will still come—as they traditionally have—from private-sector entrepreneurs competing with each other in order to make a profit. It is their job to sell their products (including cost-effective tools of energy efficiency) in the marketplace, and for the public to choose among the wares offered.

Ultimately, success in energy efficiency will depend literally on actions by tens of millions of individuals and organizations, whose actions are inherently decentralized. Small actions by a multitude of people result in large cumulative effects.

FIVE AREAS OF ACTIVITY FOR FUTURE ENERGY EFFICIENCY DRAW SPECIAL ATTENTION

Energy-efficiency improvements and the use of alternative fuels for transportation offer great potential for stemming the trend towards increasing dependence on insecure supplies of petroleum. In particular, the potential should be carefully explored for alternative fuel systems—including such possibilities as methanol, compressed natural gas, electricity, ethanol, gasoline-alcohol mixtures, synthetic oil products, and hydrogen.

Energy efficiency has improved significantly in response to market forces, but it may have slowed recently as a result of price declines. In order to promote further progress in increasing energy security and cost-effective efficiency in energy use—while still relying basically on market forces—five specific areas of activity are outlined in the pages that follow.

Five Areas of Activity

ASSESS COSTS AND BENEFITS OF A MOTOR VEHICLE SYSTEM WITH FUEL FLEXIBILITY

Even the widespread use of more fuel-efficient vehicles will leave the U.S. heavily dependent on oil for transportation in the foreseeable future. The most promising technological opportunities for further reductions in oil consumption rest in the development of alternative fuel systems.

Having the ability to respond to fluctuations in petroleum price and supply through the use of indigenous fuels complements improvements in energy security to be gained from greater energy efficiency.

The Department of Energy will conduct a technical analysis of the costs and benefits of developing a flexible-fuel transportation system. It will share its analytical work with the major players in the public and private sectors, using a task force that includes representatives of other Federal agencies, State agencies, and the private sector to review and comment on the study. The Government recognizes that the private sector must narrow the choices ultimately on its own.

Five Areas of Activity

TARGET RESEARCH TO PROVIDE ENERGY-EFFICIENT TECHNOLOGIES FOR AMERICA'S FUTURE

Industry and business—the people who actually use most U.S. energy and who produce and market the devices that apply it—will continue to be primarily responsible for investing in energy-efficiency R&D. However, they will also be closely involved in Federal research and program planning. Everybody should benefit, because fresh successes in energy efficiency often are associated with product improvements, substitutions of material, new industrial processes, and even completely new products. All of these can improve U.S. ability to compete in world markets.

This involves more than just a means of encouraging cost-sharing by industry on Federal research—although its demonstrable benefits to the private sector justify a continuation of this approach, and cost-sharing is also an effective method of ensuring that the best resources are applied conscientiously to potentially useful projects. Federal budget limitations make it impractical to try to satisfy an R&D "wish list" from the private sector. Planners of future Federal research in the field of energy-efficient technology will seek, accept, and try to apply advice from competent nongovernment organizations that are likely to take a significant part in commercializing research results.

Federal energy research will continue to stress the fundamental, underlying "building blocks" of technological understanding, so additional "spinoffs" can be expected as our national knowledge base expands. One recent breakthrough by a national laboratory holds promise of a low-cost way to eliminate nitrogen-oxide pollution from auto emissions as well as from fossil-fuel-fired boilers. Clearly, this has potential value in general efforts to keep the environment clean and healthful, as well as in broadening the use of coal to limit dependence on imported oil. The practical payoff from research often depends less on how much it costs than on how wisely it is targeted. The Federal effort will steer clear of demonstrations of "off the shelf" technology and concentrate instead on truly innovative project areas to lessen U.S. oil dependence or improve efficiency. One of these encompasses the use of alternative fuels in motor vehicles. Another would include equipment of all sorts (ranging from turbine generators to industrial boilers) that can switch readily and efficiently from one fuel to another.

Five Areas of Activity

CONTINUE GETTING KNOW-HOW ABOUT EFFICIENCY TO THOSE WHO CAN PUT IT TO PRACTICE

The government laboratories and other facilities where Federal research goes on are not responsible for manufacturing or marketing the products that actually apply the technological fruits of their work. Results of Federal research are provided to the marketplace in many ways: through trade associations, State and local governments, scholarly publications, seminars and conferences, and through direct involvement of private industry in the actual R&D work.

The goal of formal "technology transfer" programs within government is to make know-how about energy efficiency available to a diverse clientele in the commercial and industrial sectors—thus increasing the likelihood that all cost-effective ideas and developments will be used. Such programs are being emphasized and given a sharper focus—along the lines already described in relation to the research itself. The awards program of the Department of Energy is one method that even reaches individual consumers, through publicity in local communities.

Finally, recent changes in patent policy and antitrust legislation encourage cooperative R&D involving both private industry and government. The intent is not only to speed the development of new technologies, but also to encourage their prompt and full introduction to end-users.

Five Areas of Activity

LET GOVERNMENT LEADERSHIP SPUR FUTURE PROGRESS IN ENERGY EFFICIENCY

The Federal Government should lead by example in testing and adopting cost-effective technologies that use energy more efficiently, especially those that minimize future reliance on insecure supplies of oil.

Federal law has been changed recently to let agencies share the savings from investments in energy conservation and efficiency with the companies that supply the necessary equipment or services in lieu of making large "up-front" capital investments. This makes it easier for the Government to take steps that might otherwise be "budget busters" because of being capital-intensive. Success in this program can encourage the private sector to adopt the same approach more generally.

Continued support for energy-related inventors and inventions is helping to stimulate creativity. This Federal program and its results should lead to new energy-efficient technologies and products that will compete with those being developed in other nations. The National Awards for Energy Innovation are providing inspirational models for industry, individual members of the public, and all levels of government for what has been and can be accomplished.

The voluntary guidelines of the BEPS (Building Energy Performance Standards) will give State and local governments a model for improving local codes. This can encourage construction contractors and developers to incorporate space-heat efficiencies and other well-known technologies that reduce oil-dependence and long-run costs for both commercial and residential buildings. Furthermore, the Federal National Mortgage Association now increases mortgage allowances on the basis of potential savings from improvements in energy efficiency that have been financed by private lending.

Householders with especially low incomes have been offered a combination of Federal, State, local government, and private help in making energy-efficiency investments—principally through weatherization assistance and low-interest loan programs. Information programs carried out by utilities and rebate incentives on the sale of high-efficiency appliances have helped raise public awareness. Recently, nearly $3 billion from the escrow funds arising from petroleum price-law violation cases have been made available to the States for certain energy conservation activities. And DOE is helping States (through technical assistance and information) to use petroleum-overcharge funds they are receiving most effectively.

EXPAND INTERNATIONAL ENERGY COLLABORATION TO IMPROVE EFFICIENCY IN USE

The use of oil in less-developed countries (LDC's) is growing more rapidly than elsewhere. Part of the problem stems from energy policies that subsidize energy costs and constrain consumer choices. Part of the problem lies in lack of technical know-how and experience to improve energy-use efficiency and creative fuel substitution. Part of the problem is due to an unfavorable investment climate in many countries.

Overcoming all of these barriers to energy efficiency will require changes in economic and energy policies that may be encouraged through international collaboration. This can be promoted through both bilateral and multilateral cooperation, and it is in the interest of the United States to be a leader in both types of initiative.

The United States can help LDC's to assess their respective conservation opportunities by means of energy-demand analysis. DOE laboratories can help stimulate effective policies of oil-conservation and energy-efficiency by providing training to individuals who represent energy ministries or major consumers from LDC's. Individual consultations may encourage LDC policies that acknowledge the mutual benefit of welcoming sound foreign investment opportunities that are directed toward improving energy efficiency.

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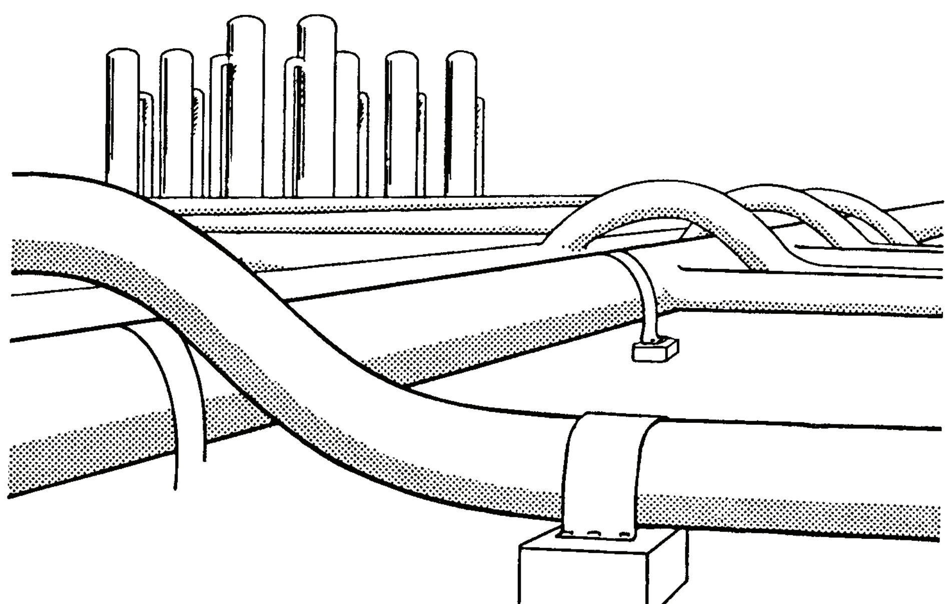
NATURAL GAS: TIME FOR A COMPREHENSIVE SOLUTION



THE SITUATION IN BRIEF

The recent collapse in world oil prices has led to a significant reduction in levels of drilling activity and a decrease in U.S. oil production. These developments have encouraged rising oil imports, which at current trends could reach 50 percent of total U.S. consumption. Growing import dependence places our national security at serious potential risk through possible disruptions of supplies.

It is imperative that the United States take full advantage of those energy sources that can economically displace imported oil.

Natural gas is a clean-burning, widely used, and domestically abundant fuel that currently accounts for about one-quarter of all U.S. energy consumption. In many applications, natural gas can be substituted economically and easily for oil, thus reducing dependence on imports. However, natural gas cannot make its full contribution to U.S. energy security goals unless existing impediments are removed. The time for comprehensive legislative reform on natural gas is now, so that additional reserves will be available in the 1990's when their contributions to energy security goals will be most critical.

Three components contribute to the essential elements of reform legislation. Working together, these elements could ensure the fullest production of available natural gas supplies. First, decontrolling all gas prices at the wellhead would increase the proportion of old (lowest cost) gas in the market and lower average prices; second, eliminating restrictions on gas use would allow gas to compete with other fuels and allow freedom of fuel choices; and third, opening up pipeline transportation would let buyers shop for least-cost gas supplies and encourage increased competition. These three components together would provide the full benefits of a competitive market. Deregulated prices with open transportation and with no restrictions on gas use will lead to lower consumer prices, increased production, and greater pipeline throughput.

This chapter presents the history of natural gas industry distortions, the potential for new uses of natural gas, and a fuller treatment of the components of a comprehensive solution.

The natural gas market has a history of regulation. Wellhead price controls on interstate production led to gas shortages in the interstate market in the 1970's. The Natural Gas Policy Act of 1978 (NGPA) was enacted during a time of rising fuel prices and perceived scarcity, but those conditions have clearly changed.

The NGPA was intended to end shortages in the interstate market through the decontrol of "new gas" prices, but it left in place a myriad of gas categories with different price ceilings. The price of "old gas" was to be controlled at a low level forever under the NPGA—in part because it was assumed that production from existing fields would increase little, if any, in response to higher gas prices. Recent studies indicate, however, that there will be a significant response in the supply of old gas at market-based prices.

The price controls and demand restrictions imposed by the NGPA and the Powerplant and Industrial Fuel Use Act encourage inefficiencies in the production and use of natural gas. Lack of open access to pipeline transportation exacerbates distortions in natural gas production and use. In the current market, gas prices are higher than they ought to be, and there is a gas surplus. These conditions encourage the Nation to depend on oil imports more than it needs to.

A comprehensive solution to the problems of natural gas could allow this fuel to achieve its full potential in substituting for oil. In addition, it would provide these benefits:

- The U.S. economy would realize a net gain of $16 billion to $24 billion between 1988 and 1995 because the production, transportation, and use of natural gas would be carried out with greater economic efficiency.

- Residential consumers could look forward to saving $25 to $45 on each annual gas bill, starting the first year.

- The United States would require 300,000 to 350,000 barrels per day less foreign oil between 1988 and 1995.

- At least 30 trillion cubic feet (tcf) of low-cost gas reserves (about 2 years' national supply at current consumption rates) would be produced instead of being lost forever. A recent decision by the Federal Energy Regulatory Commission (FERC Order 451) should make about one-third of that amount economical to produce almost immediately.

NATURAL GAS IS A SECURE, CLEAN, ABUNDANT FUEL THAT CAN LESSEN NEED FOR IMPORTED OIL

U.S. NATURAL GAS RESOURCES COMPARE FAVORABLY TO DOMESTIC OIL RESOURCES

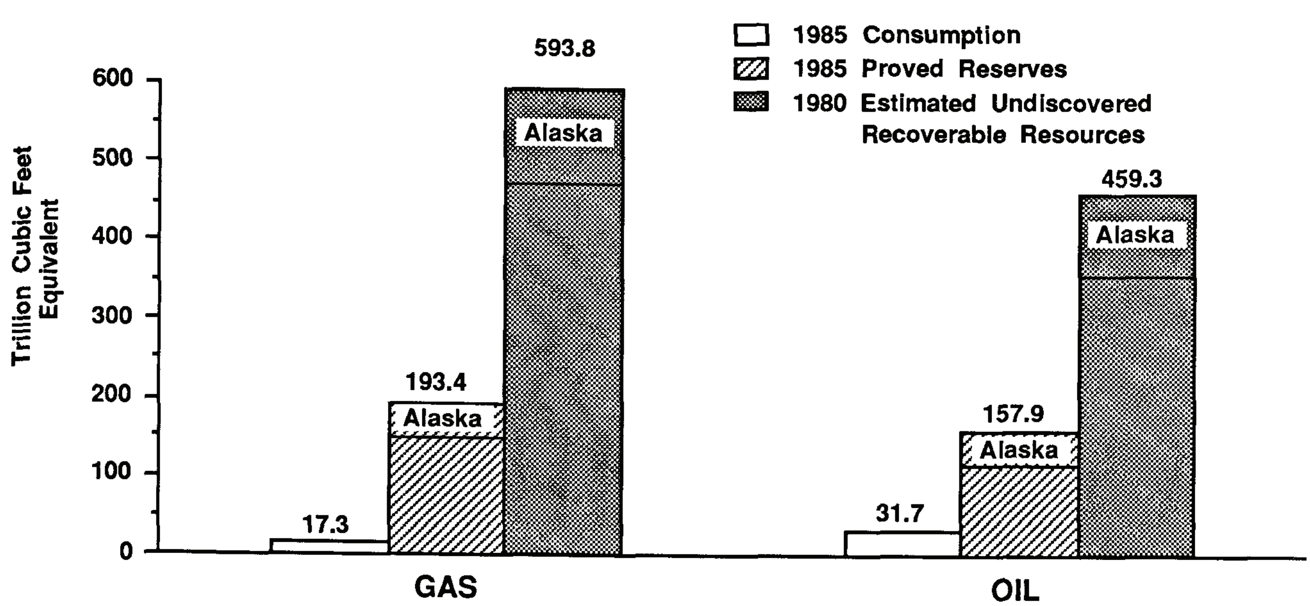
U.S. natural gas resources are large when compared to current domestic gas consumption. At the end of 1985, the United States had 193 trillion cubic feet of estimated proved reserves, compared to consumption in 1985 of 17.3 tcf. In addition, it was estimated in 1980 that there were 593 tcf of recoverable natural gas resources remaining to be discovered; this amount would support approximately 35 years of consumption at current rates. Sixty-three percent of this country's proved reserves—and 66 percent of the estimated undiscovered recoverable resources—lie onshore in the lower 48 States. If unconventional gas supplies (such as gas shales, tight gas sands, and gas hydrates) are included in the total, the Nation's supplies of natural gas may support 200 years of consumption at current rates.

Alaskan natural gas resources are substantial. Under appropriate market conditions, Alaskan gas could serve the lower 48 domestic market directly, or through exports to the Pacific Rim countries, thus permitting the economic redirection of other energy sources to the domestic market. The Arctic National Wildlife Refuge may also have significant natural gas resources.

Other North American reserves of natural gas are abundant relative to current production rates. Canada had 100 tcf of proved reserves at the end of 1986 (and a 1985 production rate of 2.8 tcf), while Mexico had 77 tcf of proved reserves at the end of 1986 (with a 1985 production rate of 1.0 tcf).

Worldwide reserves of natural gas, at 3,626 tcf, are abundant compared to the current production rate of approximately 60 tcf, but most are concentrated in less secure regions.

U.S. Natural Gas Resources Are Comparable to Oil Resources



Source: Energy Information Administration

At the end of 1986, more than 40 percent the Earth's proved gas reserves were in the Soviet Union, and about one-fourth were in the Middle East. The 1986 figures were as follows:

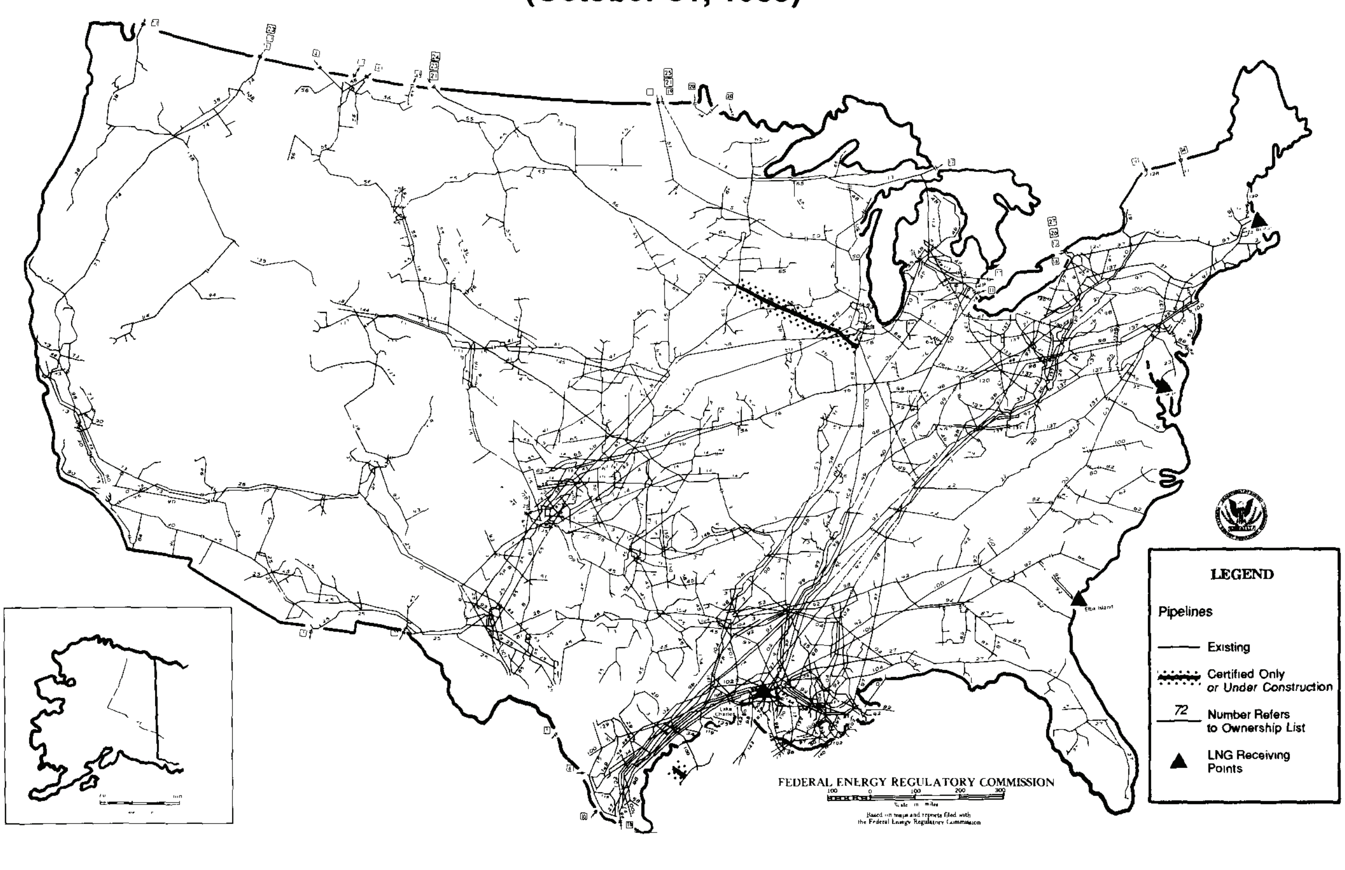
Soviet Union:	1,550 tcf
Middle East:	925 tcf
North America:	361 tcf
All other areas:	790 tcf
Total:	3,626 tcf

Natural gas burns much more cleanly than other fossil fuels. For an equivalent energy output, burning gas results in lower emissions of sulfur dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, and particulates than those that come from burning residual fuel oil or middle distillate fuels. In addition, natural gas combustion produces almost no solid waste, sludge, or water pollution. Boiler combustion emissions of sulfur dioxide (a precursor of acid rain) are less than 1 pound per billion BTU's for natural gas, compared with as much as several tons per billion BTU's for oil and coal—depending on the kind of oil or coal.

THE GAS DISTRIBUTION NETWORK LINKS DISPERSED SOURCES TO ALL MAJOR U.S. MARKETS

Natural gas wells are widely dispersed throughout the Nation. In addition, the U.S. has extensive underground storage capacity for natural gas. As of March 1986, the United States had 396 active underground storage reservoirs across 26 States, with an estimated combined capacity of 8.1 tcf. About half that capacity is filled with gas actually available for

Major Natural Gas Pipelines (October 31, 1985)



withdrawal. About 80 percent of this storage capacity is from gas reservoirs that were emptied by production; about 20 percent is from aquifer pools, which are natural geologic structures. Unlike refined petroleum products, natural gas does not deteriorate under prolonged storage. Unlike oil, which requires centralized refineries that could be vulnerable to disruption, natural gas requires little treatment before use.

From the well to the burnertip, U.S. gas supplies flow through a decentralized network. This distribution network consists of more than a million miles of pipeline, mostly underground. Included in this figure are 90,000 miles of field and gathering pipeline, which gathers gas from the fields and funnels it into main transmission lines; 270,000 miles of transmission pipeline, which is wide-diameter pipe used to move large volumes of gas over long distances; and 750,000 miles of distribution pipeline, which is smaller diameter, lower pressure pipe used to deliver gas to ultimate customers. Most of this distribution network has the capacity to deliver much higher volumes of natural gas than are being handled now; during the early 1970's, this network delivered more than 22 tcf of natural gas per year, which was about 25 percent more gas than was consumed domestically in 1985. Certain transmission segments, however, now operate at full capacity during peak delivery periods.

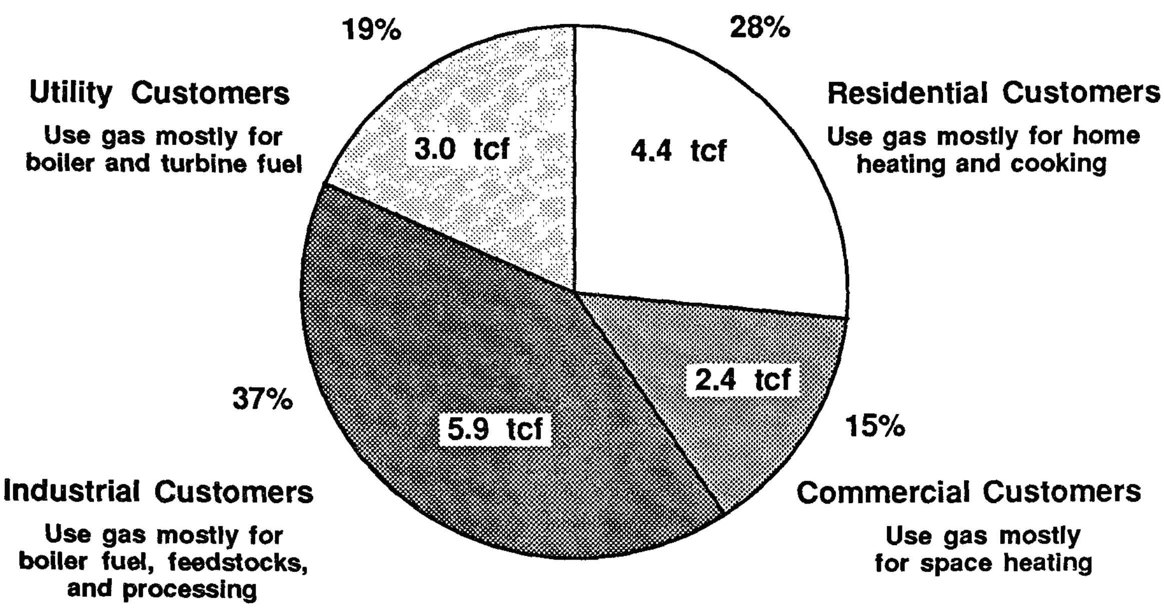
Canadian and Mexican pipelines interconnect directly with U.S. pipeline facilities across friendly borders. Imports from Canada comprise 5 percent of U.S. gas consumption, but in recent years the United States has not imported gas from Mexico.

ALREADY WIDELY USED, NATURAL GAS HAS POTENTIAL FOR FURTHER MARKET PENETRATION

Gas is a widely used fuel, currently accounting for about one-fourth of the total energy consumed in this country:

- **Residential:** 55 million customers use gas, mostly for home heating and cooking.

Natural Gas Consumption by End-Use Sector, 1985



- **Commercial:** 3.8 million customers use gas, mostly for space heating.

- **Industrial:** 189 thousand customers use gas, mostly for boiler fuel, feedstocks and processing.

- **Utilities:** 1,800 customers use gas, mostly for boiler and turbine fuels.

The extent to which natural gas increases its penetration in traditional markets depends on gas prices, the prices of substitute fuels, technological developments, and general economic conditions. Areas where existing technology might expand current uses include the following:

- **Power generation:** The use of natural gas for power generation by electric utilities can be increased. New combined-cycle gas-burning technology provides more efficient electricity generation than the old boiler technology.

- **Cogeneration:** Some industrial cogeneration facilities use a single natural gas energy system to produce heat for certain industrial processes and also to generate electricity.

- **Boiler fuel:** Natural gas is used as a boiler fuel for driving industrial processes.

- **Space heating:** Gas now heats 55 percent of the homes in the United States.

Natural gas may also have potential in new markets:

- **Cooling:** Gas-fired cooling technology has existed for decades, but was put to very limited use for a long time due to problems with equipment quality, equipment cost, and high maintenance costs. However, the recent introduction into the U.S. market of the more efficient double-absorption cooling

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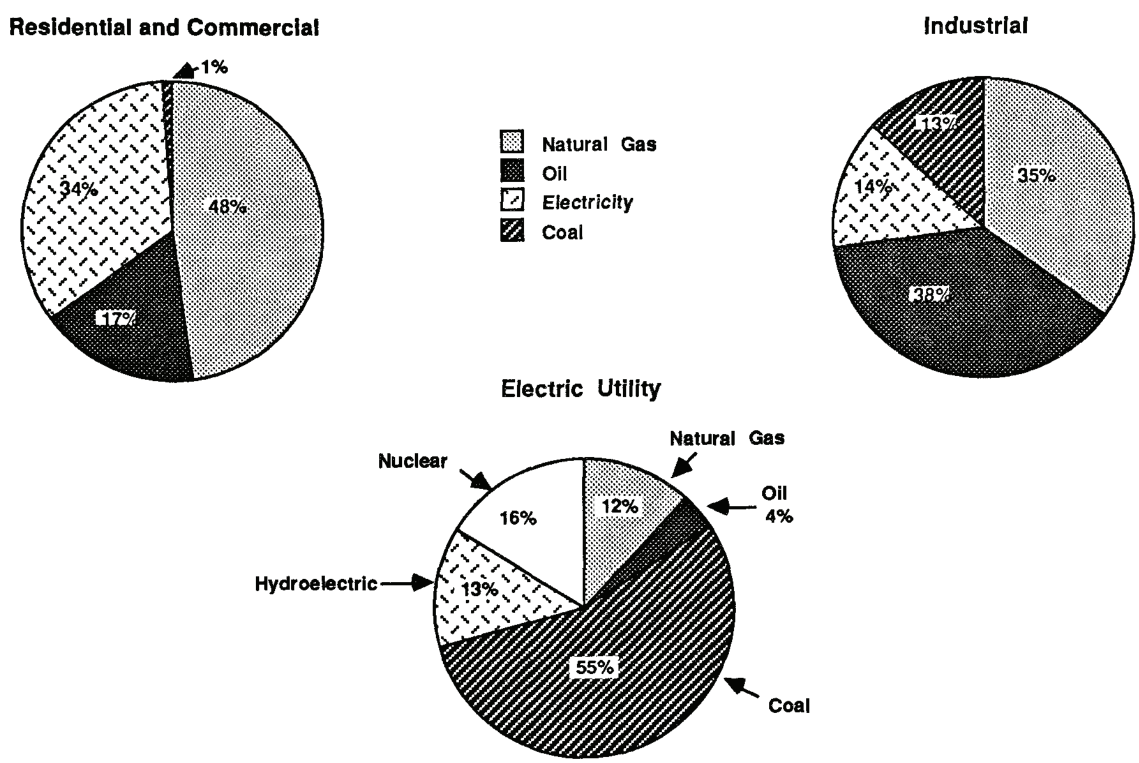
Proportionate Consumption of Energy by Source and Sector, 1985



Source: Energy Information Administration technology has rekindled interest in natural gas-fired space cooling.

- **Natural gas vehicles (NGV's):** The powering of NGV's by compressed natural gas has been demonstrated to be economic in certain applications; 30,000 operate in the U.S., and 375,000 worldwide. The cost of making NGV's is about the same as that of conventional vehicles; and existing diesel trucks can be economically converted to powering by compressed natural gas. Because NGV's require large storage tanks and special refueling facilities, the greatest potential for NGV's is in long-haul trucking, bus transportation, and fleet vehicles.

- **Methanol-powered vehicles:** The technologies exist to manufacture methanol-compatible vehicles, to convert gasoline-powered vehicles to use methanol, and to manufacture the methanol fuel from natural gas. Because of the cost to transport gas, the methanol must be produced near gas fields large enough to supply natural gas for the life of the methanol plant. At current gasoline and natural gas prices, however, the use of methanol to power vehicles is not economic.

- **Gasoline from natural gas:** Natural gas can be converted to high-quality gasoline, with methanol as an intermediate step. Although additional investment and energy costs are associated with the gasoline production, these may be offset in certain markets by the advantage of being able to use the fuel in existing vehicles. One commercial-scale natural gas-to-gasoline plant is now operating in New Zealand.

NATURAL GAS CAN SUBSTITUTE READILY FOR IMPORTED OIL IN MANY APPLICATIONS

In an emergency, secure supplies of natural gas can replace oil in many applications, thereby freeing up available oil supplies for those uses in which other fuels cannot substitute. Gas can substitute for oil in a variety of applications: fuel-switchable industrial users can switch from oil to gas almost immediately; existing electric utility boilers can switch easily from oil to gas; new electric powerplants can use gas-fueled combined-cycle technology; and natural gas can serve as an industrial feedstock in lieu of certain petroleum products. Finally, compressed natural gas or methanol vehicles could allow gas to substitute for oil in transportation.

Economic factors affect the ability of natural gas to substitute for oil. In particular, gas and oil compete based on their relative prices. Industrial decisionmakers opt to use natural gas for fuel-switchable functions when its price is lower. Because of the time necessary to make equipment changes, this substitution of natural gas for oil increases with the duration of any rise in oil prices. For the next 2 or 3 years, the surplus deliverability of natural gas is likely to keep the price of gas low.

OVERREGULATION OF NATURAL GAS HAS STIFLED EFFICIENT PRODUCTION, TRANSPORT, AND USE

PARTICIPANTS IN GAS MARKET HAVE VARYING OBJECTIVES THAT DON'T ALWAYS MESH

The U.S. natural gas market is an interconnected network of thousands of producing wells, hundreds of pipeline and distribution companies, and millions of consumers. Government regulation at both the Federal and State level is superimposed on this network from wellhead to burnertip.

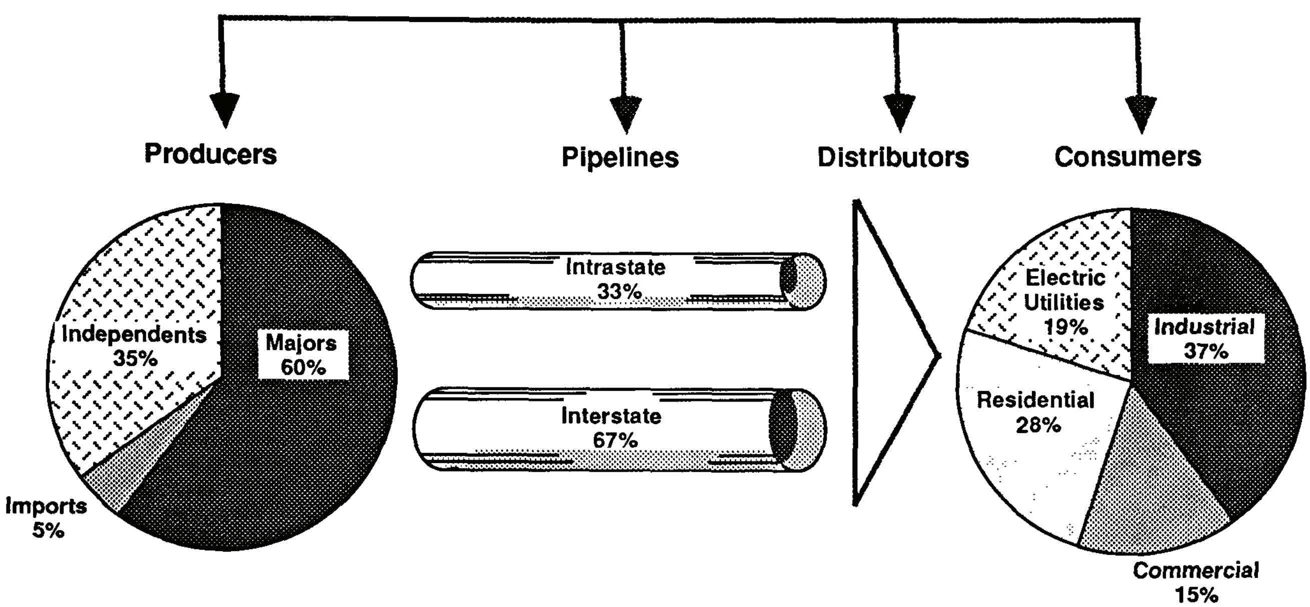
- **Producers** want access to markets and a fair price for their commodity. Gas produced for the U.S. market comes from three sources: majors (large, integrated oil and gas companies); independents (smaller, nondiversified companies); and imports. Currently, almost all imports of gas into the United States come from Canada.

- **Pipelines** want to fulfill service obligations, remain competitive, and provide a reasonable return to investors. Pipelines buy gas from producers and sell it to distributors and consumers. Pipelines also transport gas owned by others. Pipeline profits depend on the quantity of gas transported rather than the price of gas. Interstate pipelines (which use trunklines of the national network) and intrastate pipelines (which operate within only one State each) may be governed by quite different sets of regulations.

- **Distributors** want access to the lowest cost supplies, reliable service from pipelines, and an adequate share of the market they serve.

- **Consumers** are concerned with both price and reliability of service. In particular, residential/commercial customers, who use gas primarily for space heating, and

Federal and State Regulation of Natural Gas



Note: Some pipelines deliver gas directly to industrial and electric utility customers without going through distributors.

industrial customers using gas as chemical feedstocks and in processing, want uninterrupted delivery at reasonable prices. Industrial customers who use gas in boilers with fuel-switching capability want the lowest possible price and may accept interruptible service in return for lower gas or transport rates. Electric utilities, which use gas in boilers and turbines, want lowest cost supplies and may also accept interruptible service.

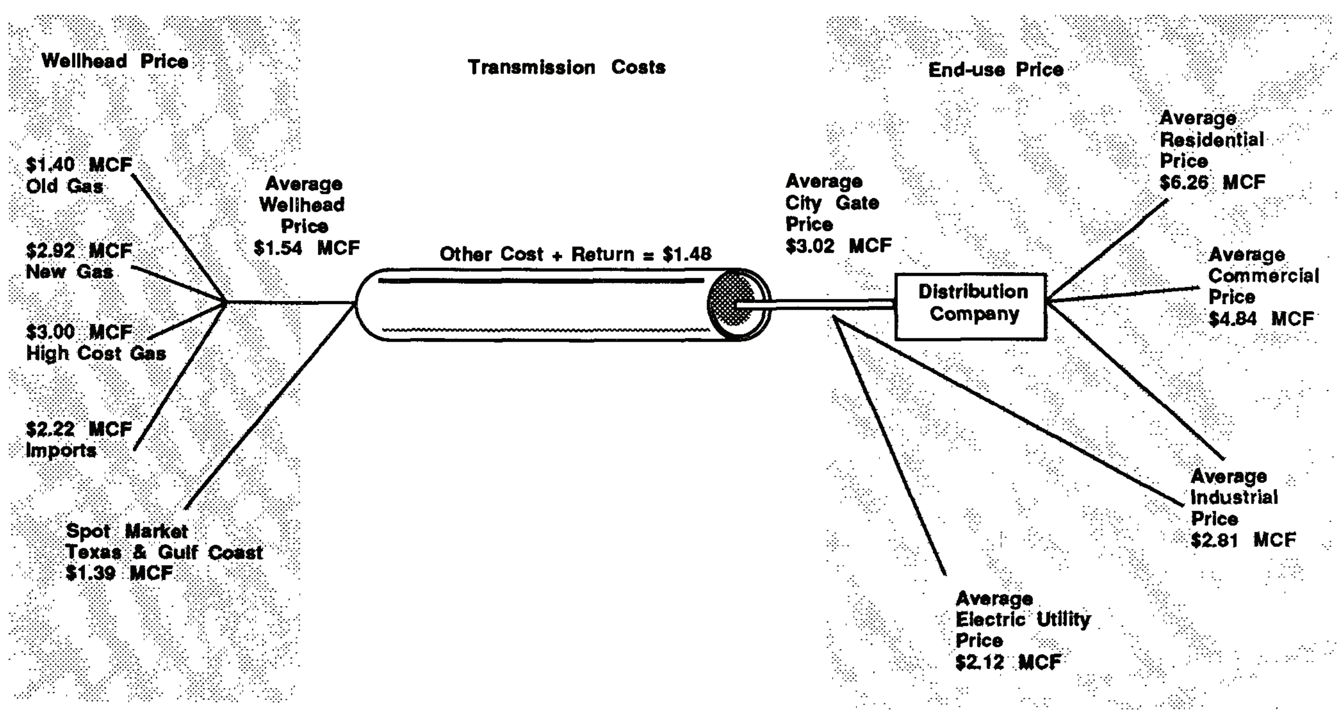
- **Regulators** control each level of the natural gas market, subject to a complex set of regulations. The two main regulatory bodies are the Federal Energy Regulatory Commission (which regulates wellhead prices of old gas, as well as transportation and sales of gas by interstate pipelines); and the relevant State regulatory commission (which regulates intrastate pipelines and local distribution companies).

REGULATORY INTERVENTIONS HAVE LONG PERVADED THE NATURAL GAS MARKET

The Federal Government has long been responsible for regulating natural gas pipelines that cross State borders. Since the 1950's, however, the Federal role expanded greatly. The resulting complex web of regulations contributed to numerous problems, including supply shortages and unnecessarily high consumer prices. Now the swing is in the other direction, with progress being made in untangling this web and moving toward a more competitive and efficient natural gas market. But important changes still need to be made.

Consumer Gas Prices Are Based on Many Factors

(Prices Are From Fall 1986 Period)



Phase I— Regulation Leads to Shortages

The Natural Gas Act of 1938 imposed Federal regulation on interstate pipelines. The Supreme Court's 1954 decision in the *Phillips Petroleum Co.* v. *Wisconsin* case extended Federal regulatory control to wellhead prices for natural gas sold to the interstate market. Gas sold into the intrastate market remained unregulated.

Because regulated prices did not keep pace with increasing production costs, shortages and curtailments of deliveries to customers developed by the winter of 1976-77.

Phase II—Partial Solutions

These shortages, together with forecasts of future scarcity, led to passage of the Natural Gas Policy Act and the Powerplant and Industrial Fuel Use Act (FUA). The NGPA extended wellhead price controls to old gas sold in the intrastate market while allowing for phased partial decontrol of new and high-cost gas.

The NGPA thus created incentives to produce high-cost gas, but it created disincentives for full production of low-cost gas by continuing to hold old-gas prices below market levels. Furthermore, the NGPA and the Fuel Use Act restricted the use of gas by large-volume industrial users and electric utilities.

In 1986, FERC issued Order 451, which "devintaged" old gas ceiling prices. Order 451 did not decontrol old gas; rather, it provided a means for producers and purchasers to negotiate the contract price of gas—new gas as well as old—to try to bring prices more into line with market reality. Order 451 created a single new ceiling price for old gas of approximately $2.50 per thousand feet (subject to monthly adjustment). Receipt of this ceiling price is subject to a good-faith negotiation procedure involving producers and purchasers. This action provided economic incentives to increase production of low-cost supplies of what had been capped in price as "old gas."

Phase III—The Growth of Competition

By lifting price controls partially during a period of regulation-induced shortages, the NGPA allowed gas prices to rise significantly as pipelines sought to replenish long term supplies and resume deliveries to curtailed customers. Many of the contracts made during this period contained non-market-responsive price terms and required that purchasing pipelines pay for the contracted volumes of gas whether or not these volumes were actually taken ("take or pay"). The 1979 oil price shock also contributed to higher market prices for natural gas.

By 1982, in part because of falling oil prices and customer fuel-switching from gas to oil, many pipelines were unable to sell all of the gas they had committed to take at the contract prices. Pipeline sales volumes fell, and most pipelines began to incur take-or-pay penalties as they cut back the amounts of gas they took. Pipelines often reduced their purchases of low-priced, old gas to minimize the total effect of these take-or-pay penalties. Consequently, substantial supplies of low-priced old gas were shut in. A surplus of deliverable supplies developed, and it remained at approximately 2 tcf at the end of 1986.

Producers sought customers for low-priced shut-in gas, while customers and local distribution companies sought transportation services from pipelines so they could buy lower priced gas directly from sources that were independent of the pipeline. Pipelines were reluctant to offer transportation services for customer-owned gas that would displace the pipelines' own gas sales and worsen take-or-pay liabilities.

Because the pipeline gas under contract at relatively high prices was essentially unmarketable, some pipeline-producer contracts were renegotiated. As a result, the average cost of pipeline gas began to decline, but not to levels low enough to eliminate the surplus. Competition of gas against oil, as well as gas against gas, led to the growth of a "spot," or relatively short-term market, for nontraditional sales of gas directly involving producers and customers. Such sales often took place through brokers, with the pipelines providing only transportation.

FERC issued Order 436 in 1985 to provide interstate pipelines with blanket authority to transport shipper-owned gas at flexible, nondiscriminatory rates. The intent of Order 436 is to provide consumers greater access to competitively priced gas, but participation by pipeline companies in the Order 436 program is voluntary.

By the end of 1986, almost half of all gas coming to market was merely being transported by interstate pipelines for distributors and end-users, rather than being sold to them by the pipelines. This portion had been only 3 percent as recently as 1982. In general, the "bundled" pipeline services traditionally offered by pipelines (gas purchasing, transportation, and storage) were gradually complemented by an array of "unbundled" services—with transportation becoming the predominant service offering. Despite these changes, many customers and producers are still unable to gain access to the transportation system to purchase gas directly.

CURRENT REGULATIONS ENCOURAGE INEFFICIENCIES THROUGHOUT THE GAS INDUSTRY

Government regulations have skewed the natural gas market in such a way that both consumers and the gas industry are being ill-served.

Production Inefficiencies

In 1985, it was estimated that NGPA price ceilings then in effect prevented the economic production of 30 trillion to 34 trillion cubic feet of old, low-cost gas. An estimated 11 to 14 tcf of that total was made economic by FERC Order 451, which permitted producers to seek the highest ceiling price allowed for any old gas by the NGPA—regardless of which year the field from which the gas came had gone into production initially.

Pipelines buy a mix of low-cost and high-cost gas and sell this to their customers at an average price. Thus, below-market price ceilings on old gas allow pipelines to pay above-market prices for new gas, so there is less pressure on new-gas prices to fall to market levels. Average prices remain high, however, and not all the deliverable gas is consumed; this is what creates the surplus. As a result, gas loses some of its market share to imported oil.

Transportation Inefficiencies

Willing buyers and sellers cannot always deal directly with each other, since pipelines generally control access to the transportation system. Pipelines can shut in low-cost gas to alleviate take-or-pay liabilities. Lack of open access to transportation prevents producers from selling these supplies to consumers. FERC's Order 436 is only a transitional mechanism that subjects natural gas industry participants to increased market discipline. The growing experience under Order 436 underscores the need for completing the transition to open access transportation.

End-Use Inefficiencies

The incremental pricing provisions of the NGPA and the demand restrictions in the Fuel Use Act prevent potential large-volume gas consumers from choosing freely among possible energy sources.

Regulatory Inefficiencies

The industry is evolving toward providing an array of bundled and unbundled services. Regulatory policies should reflect this new market reality. Regulatory policies at FERC may result in price signals that reflect past purchasing and investment decisions rather than current, market-responsive price signals. Delays and a heavy paperwork burden at FERC could impede the ability of pipelines to price and market their services aggressively in an increasingly competitive environment.

Although gas is a homogeneous, fungible commodity that should be delivered at a single price, current FERC rate designs could foster artificial price and tariff distinctions based on the relative costs of producing, gathering, storing, and transporting gas from different geographical areas.

FREER GAS MARKET WOULD BENEFIT CONSUMERS, THE ENERGY INDUSTRY, AND THE NATION

A COMPETITIVE GAS INDUSTRY CAN ENSURE RELIABLE SUPPLIES AT REASONABLE PRICES

Despite its shortcomings, the NGPA established as national energy policy the movement toward a workably competitive natural gas market in the United States. Through the operation of a competitive market, natural gas will flow to its most highly valued uses as determined in the marketplace, ensuring that natural gas will be available to substitute for imported oil when such substitution is economical.

This Administration has extended the policy goal of gas market competition to imports that can supply natural gas to U.S. consumers at competitive prices and be responsive to changes in the markets served. Imports from reliable sources can provide a stable and secure addition to domestic resources. Although imports make up only about 5 percent of U.S. consumption, they have contributed to a decline in the average prices U.S. consumers pay for natural gas. Eliminating the remaining barriers to trade will ensure that the lowest cost supplies of natural gas are brought to consumers.

Four institutional prerequisites should be satisfied to achieve these benefits:

- Wellhead gas prices, like the production prices of all other traditional fuels in the United States, should be set exclusively by market forces and must be free of all regulatory controls.

- Effective natural gas competition requires that the greatest possible number of buyers and sellers have access to a national market. Although not all buyers and sellers are currently interconnected by the U.S. natural gas delivery network, open access to the existing transportation system would significantly increase access to such a national market. In addition to increasing the size—and thus the efficiency—of the market, open-access transportation would make it far easier for the essential price signals to be flashed back and forth between buyers and sellers—quickly and accurately.

- Consumers should be free to choose among competing fuel types on the basis of economic, environmental, and other considerations. Artificial restrictions on the use of natural gas in certain applications prevent its efficient use and impair its ability to substitute for imported oil.

- Because the interstate pipeline network exhibits natural monopoly characteristics in some of the markets it serves, FERC regulation under the Natural Gas Act will discourage traditional monopoly abuses. Many FERC policies and regulations, however, were promulgated to accommodate an industry regulated "from wellhead to burnertip." A revised regulatory framework must be provided that encourages and rationalizes the competitive forces untethered by the NGPA. Regulatory burdens should be eliminated or reduced to the maximum extent practicable.

DECONTROLLED PRICES WILL INCREASE PRODUCTION OF LOWER COST GAS RESERVES

Decontrol of gas prices makes the increased recovery of existing low-cost old-gas supplies more economic. Greater production of low-cost old-gas will result in the displacement of some high-cost gas and renegotiation of some high-cost contracts. Thus, this move in itself should lower average prices for natural gas. The gas surplus will dissipate under total decontrol, because gas will be priced more competitively. Production will be more efficient, as the United States gets the chance to use its lowest cost gas supplies first.

Additional low-cost supplies of about 30 to 34 tcf in all will come from three sources:

- **Delayed Abandonment:** Market prices for old gas will increase revenues from old gas wells and allow them to continue operating. Recovery of gas from existing wells will increase by about 12 to 14 tcf.

- **Infill Drilling:** Market prices will encourage the drilling of additional wells in existing fields. Recovery of gas in this fashion from existing fields will increase by about 15.5 tcf.

- **Production Enhancement:** Market prices for old gas will spur investments in techniques to increase the volumes of gas ultimately recovered from existing old-gas wells. Use of these techniques will increase recovery from existing wells by about 2.5 to 4.5 tcf.

DOE's 1985 estimate that 30 to 34 trillion cubic feet of additional lower cost reserves will be produced if old gas prices are allowed to reach market levels is supported by other studies:

- The Energy Information Administration estimates reserve additions of 28 tcf (1986 study).

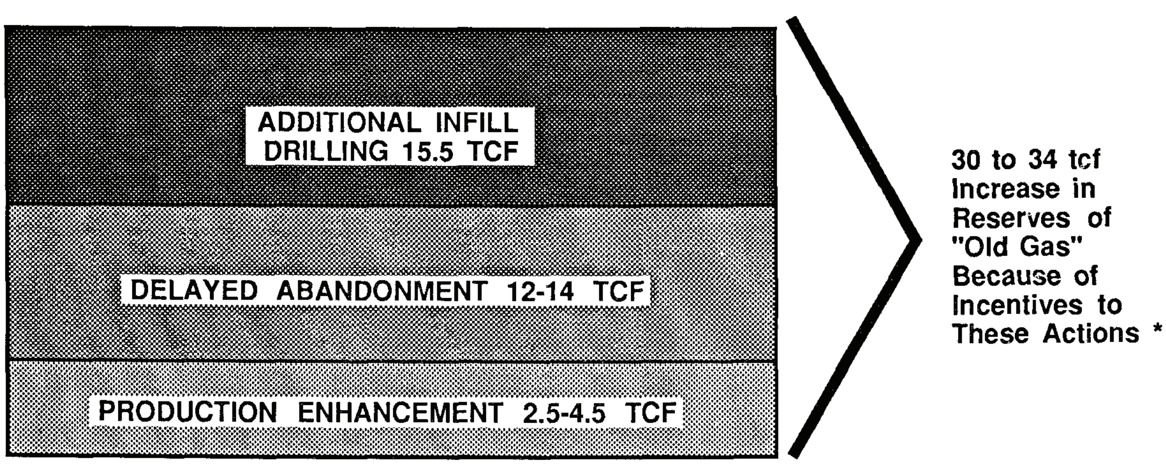
- The Office of Technology Assessment estimates reserve additions of 19 to 38 tcf (1984 study).

- Shell Oil estimates reserve additions of 42.5 tcf (1986 estimate).

OPEN ACCESS TO PIPELINES WILL LOWER GAS PRICES THROUGH DIRECT DEALINGS

Allowing producers and consumers nondiscriminatory access to available pipeline capacity will allow willing buyers and sellers to deal directly. This will facilitate the development of an orderly, competitive natural gas market in which producers have access to a large number of consumers, and consumers in turn have access to a large number of producers. In the current market, this access will permit low-priced gas to flow to consumers from wells that have been shut in by pipelines.

Price Decontrol Would Increase U.S. Gas Reserves About 15 Percent



* DOE estimates that about one-third of this 30 to 34 tcf has been added to reserves by FERC Order 451.

Although FERC Order 436 made a good start, further reforms are needed. Whether a particular transaction takes place is often influenced by factors other than the desire of willing buyers and sellers to make transactions.

Open access also will avoid further delays in fully implementing FERC Order 436 by requiring a pipeline to carry gas unless it is incapable of rendering service. It will increase the pressure on producers and pipelines to renegotiate those gas contracts that currently keep gas prices from falling.

REMOVING END-USE RESTRICTIONS WILL INCREASE COMPETITION AMONG ALTERNATIVE FUELS

The Fuel Use Act prohibits construction of gas- and oil-fired industrial and electric utility boilers. But the reason for such a prohibition is no longer valid—if it ever was at all. As a consequence of the phased decontrol of wellhead prices for natural gas under the NGPA, the threat of disruptive shortages to residential gas customers has been effectively eliminated.

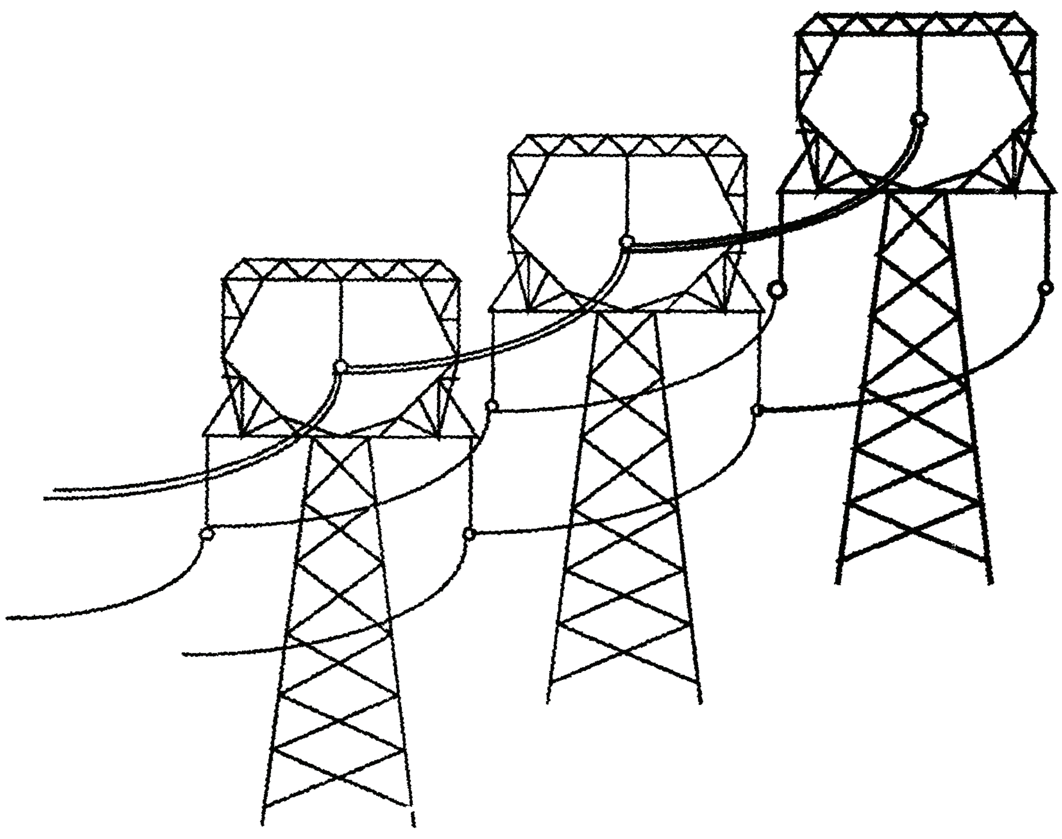
In recent years, the development of new and efficient combined-cycle technologies has made the use of natural gas highly competitive in electric generation. The more efficient use of natural gas in applications where it is cost-effective could lead to the economical displacement of oil, thus decreasing demand for oil imports. Currently, prospective users of natural gas for industrial boilers and electric utility power generation may obtain formal exemptions from the Fuel Use Act prohibitions; however, this process introduces delay and uncertainty into the user's fuel technology decision.

In addition to the explicit end-use restrictions in the Fuel Use Act, Title II of the NGPA established incremental pricing to preserve scarce supplies of natural gas for residential customers. The effect of Title II incremental pricing, if fully implemented, would be to discourage industrial uses of natural gas through a price surcharge.

Elimination of both the end-use restrictions on natural gas in the Fuel Use Act and the incremental pricing provision in the NGPA would enable natural gas to compete freely with alternative fuels.

5

ELECTRICITY'S FUTURE IN THE U.S.



THE SITUATION IN BRIEF

As an energy form, electricity is inherently flexible. It can be generated from many resources, and it is extremely adaptable to user requirements. In some cases it substitutes directly for oil. These characteristics have made electricity a critical commodity in this Nation's economy and an important factor in limiting its dependence on imported oil.

Electricity's share of total energy use in the United States is increasing. Demand for electricity is still rising in tandem with gross national product (GNP). Even with the current surplus of generating capacity and continued improvements in the efficiency of electricity's distribution and use, it is likely that substantial new generating capacity will be needed nationwide during the1990's to ensure an adequate, efficient, secure, and reliable supply.

U.S. electricity can come from a variety of sources apart from oil: cogeneration, renewables, Canadian imports, coal, nuclear powerplants, gas-fired combustion turbines, and—in a sense—demand management. However, many regulatory and technological uncertainties make it difficult to determine which combination of options is most likely to result in a reliable, economical mix.

Despite this wealth of options, under today's regulatory framework the electric power industry may evolve in a way that is economically inefficient and unduly reliant on oil (and gas) as generation fuels. This problem has several roots:

- The industry is experiencing a period of excess capacity, rising costs and "rate shocks" from high-cost plants coming on line. In many cases, commitments to build these plants were made before the impact on demand of the OPEC fuel-cost shocks; and their construction costs rose dramatically because of regulatory changes and delays, inflation, and problems in construction management. Regulators are now under intense pressures to allocate some of the enormous costs of these plants between ratepayers and investors. Regulators have shown a reluctance to pass through the costs of new plants to customers even if these same regulatory bodies had initially approved the plants' construction and the plants were prudently built.

- Today's regulatory environment prompts electric utilities to focus on short-term economics . . . and to avoid new capital investment, because they no longer trust regulators to allow them to recover their costs on capital-intensive projects with long lead times. Coal, nuclear, and even most renewable generating technologies (for example, wind, solar, and geothermal) are capital-intensive. Despite the possible long-term economic advantages of such options, utilities are avoiding them in most current plans for new generating capacity.

- Most options with lower capital costs (demand management, cogeneration, Canadian imports, and refurbishment of existing plants) are attractive, but their economic potential appears limited. Accordingly, many utilities are looking primarily to gas-fired combustion turbines to satisfy remaining supply needs. Planning decisions that will be made over the next few years could cause a rapid rise in the use of natural gas, even though it may not be the best economic choice for the long term.

- Generation of electricity by nonutility sources under the Public Utility Regulatory Policies Act of 1978 (PURPA) is up dramatically, but PURPA as now structured fails to maximize potential benefits that could reduce all customers' rates over the long term. Generation is also increasing in sectors of the industry that receive low-cost Federal financing.

Natural gas is expected to remain an attractive option as a generating fuel, at least for the near term, because of its relatively low cost and abundant supplies. If the electric power industry remains averse to capital investment, however, and is unable to make timely selections of other options, it could overcommit itself to new gas- or oil-fired generation.

This potential problem of rising gas or oil consumption for electricity generation cannot be resolved efficiently through regulations or statutes which constrain the industry's technology or fuel choices. A better approach is to restructure the Nation's regulatory processes to enable the industry to respond more readily to changing market conditions.

Decisions to build substantial amounts of new oil- or gas-fired generating capacity will affect national and international fuel markets significantly in the 1990's. A major increase in the electric power industry's use of oil and gas after 1995 likely would put upward pressure on oil and gas consumption, prices, and imports.

Competitive pressures in the electricity sector are increasing, because of (1) growth in nonutility electricity suppliers, chiefly cogenerators, (2) electricity price differentials that cause municipalities and large industrial customers to wish to "shop" for cheaper power via the transmission grid, and (3) recent reductions in the price of natural gas and petroleum products.

Vigorous competition among all generation sources and technologies to meet the needs for new capacity could reduce long-term costs to all customers. Expanding access to electricity transmission networks could be a means of facilitating the competitive process. However, any policy to expand access by nonowners to the power lines should be reviewed carefully to ensure that it would improve economic efficiency without degrading service reliability.

Fundamental regulatory changes may be required to ensure reliable and economical electricity supplies in the 1990's and beyond. A sustained effort is needed to evaluate and promote reforms that are likely to:

- Increase the efficiency of the electric power industry, thus strengthening the U.S. economy and enhancing national energy security.
- Increase the industry's reliance on market forces to guide its choices among competing technologies and its basic investment decisions.
- Improve the regulation of matters that cannot be handled exclusively by the market.
- Maintain an appropriate balance between Federal and State responsibilities for regulating electricity rates.
- Provide a basis for nondisruptive, evolutionary change in this industry.

ELECTRICITY IS CRITICAL TO ECONOMIC HEALTH AND ENERGY SECURITY OF THE UNITED STATES

IN A HIGH-TECHNOLOGY ERA, ITS VERSATILITY MAKES IT AN ESSENTIAL COMMODITY

Electricity's reliability, precision in application, convenience, and inherent flexibility have rendered it especially suitable to many of the energy needs of a high-technology economy. Today, electricity provides virtually 100 percent of many common but economically critical requirements, such as lighting, space cooling, refrigeration, electronic communications, and stationary motor-drives.

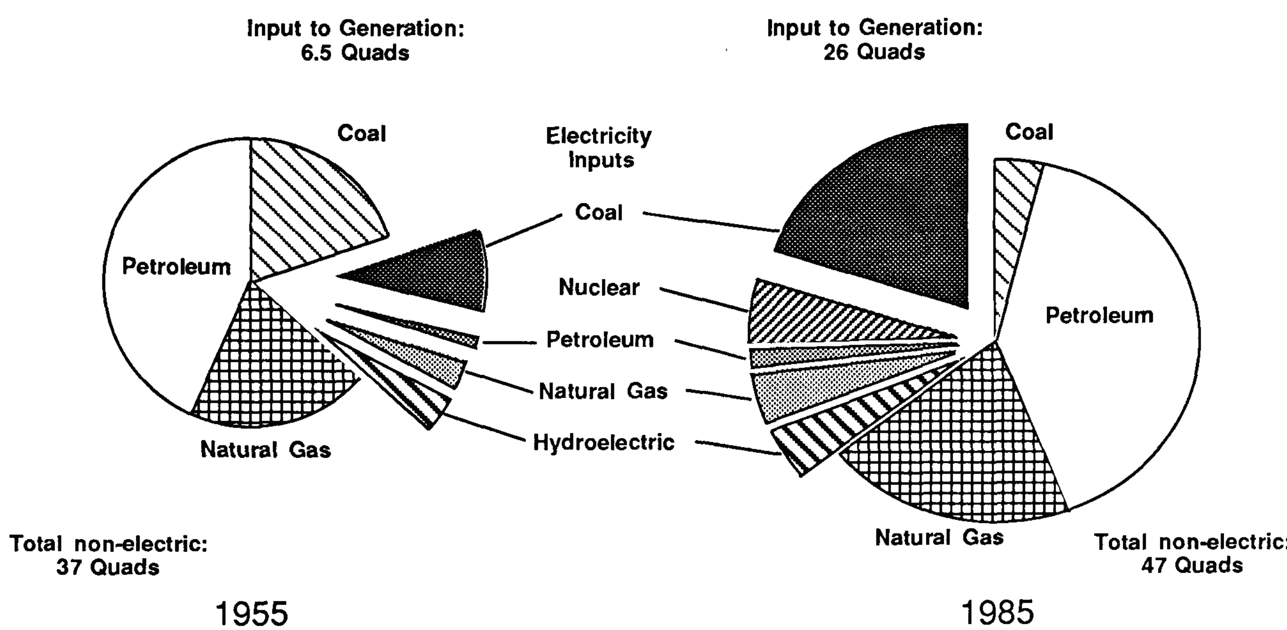
Electricity's flexibility makes it very useful for maintaining long-term energy security and stability in an unstable world. Because electricity can be generated from a wide range of energy resources (such as coal, oil, gas, uranium, and biomass), a diversified electricity supply system can adjust to swings in the prices or availability of different energy resources with a minimum of disruption to consumers. In fact, electricity is the primary mechanism for transforming coal, uranium and renewables into an energy form that is clean, safe, and widely applicable in its end uses. In this respect, increased use of electricity can reduce dependence on fluid fuels and contribute to this Nation's energy security.

Electricity's economic importance and its contribution to the Nation's long-term energy security make it essential that a healthy, economically efficient electricity supply system be maintained.

It seems clear that:

- Electricity supply requirements are likely to continue to grow.
- Under the present framework for electricity

Use of U.S. Energy to Generate Electricity Has Quadrupled Since 1955



rate regulation, the electricity supply system is evolving in a direction that is likely to be economically inefficient and unduly dependent on scarce or depletable oil and gas for generation.

- Regulatory reforms are needed to ensure that electricity supplies will continue to be reliable, secure, and economically efficient.

ELECTRICITY COSTS MOST HOMES LESS PER KWH THAN IN 1960, AND PRICES ARE STABILIZING

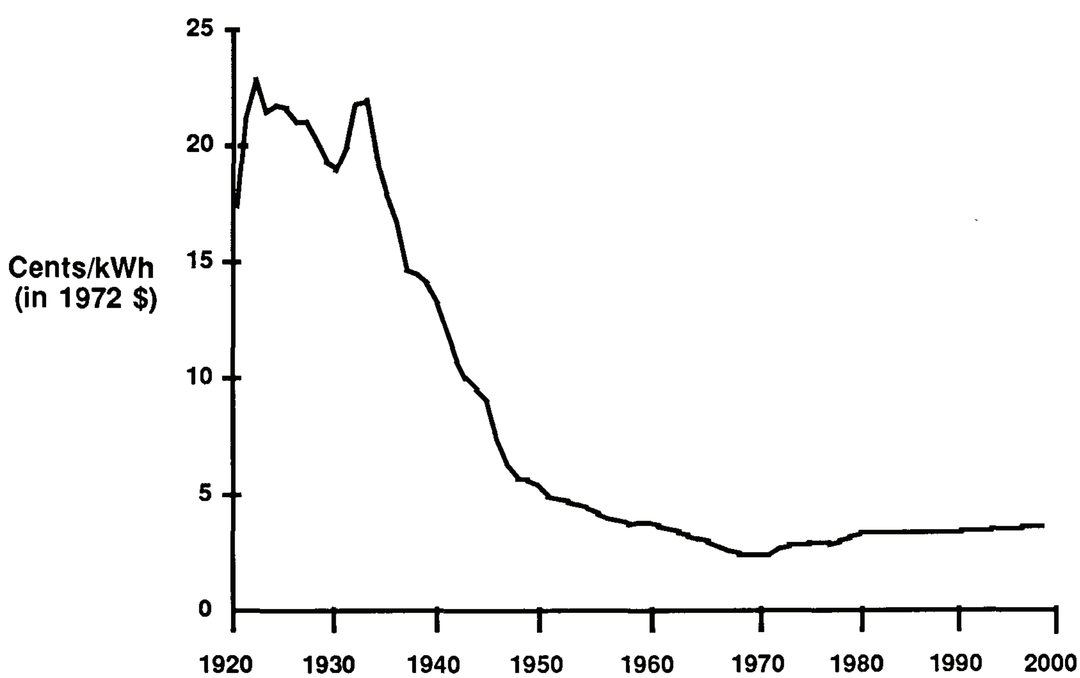
Projections of electricity prices through 2000 show stable prices until the mid-1990's, because during this period it is expected that fuel prices will remain low and relatively little new capacity will be added. Thereafter, rising oil and gas prices and the probable addition of new generating capacity likely will cause modest price increases.

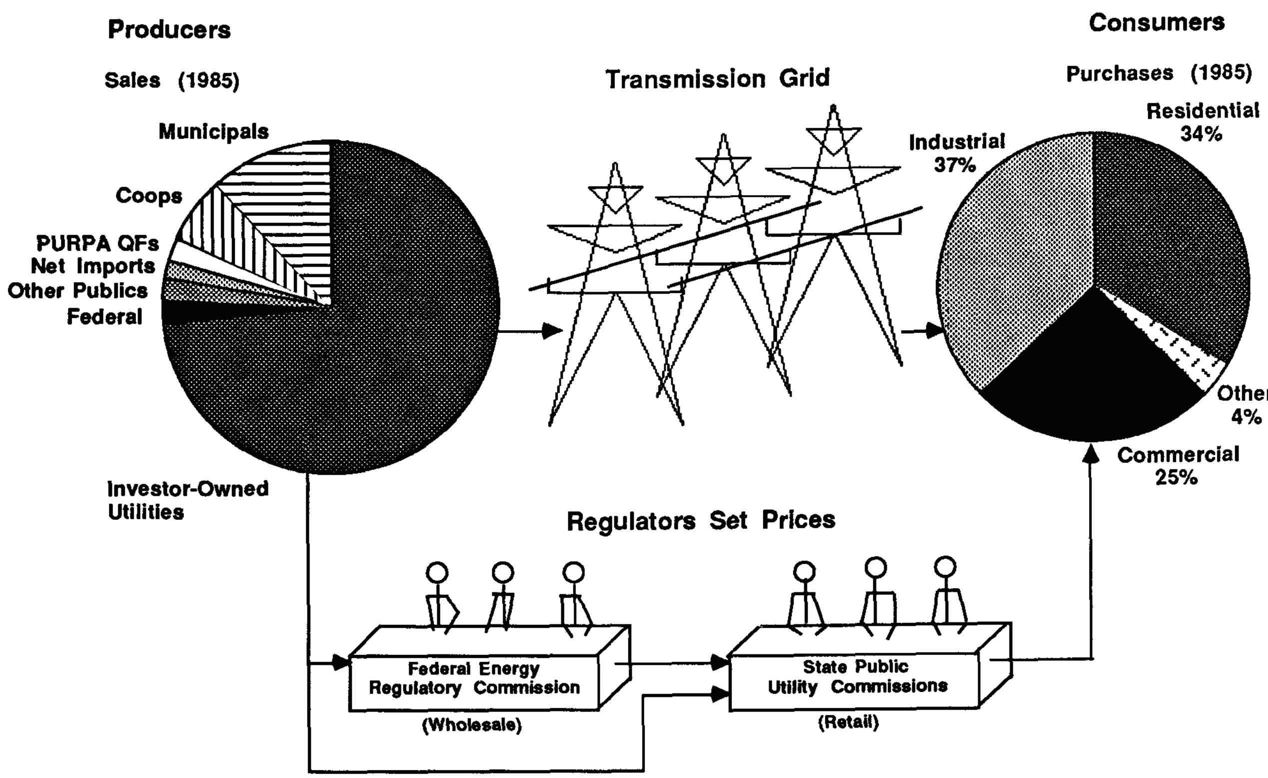
During the period from about 1935 through about 1970, electricity prices moved steadily downward. The main reason for this decline was that utilities were consistently adding new generating capacity, and the new units were generally larger and more efficient than their predecessors. Declining prices and technological innovations in end-use applications caused electricity demand to grow very rapidly during this period.

From about 1970 through 1982, electricity prices rose. This upward trend was caused by higher fuel costs and interest rates, construction delays, the cost of environmental controls, and the fact that new plants were no longer typically more efficient than their predecessors. This turnaround in the electricity price trend caused electricity price regulation to change from a relatively benign administrative matter into a politically contentious one.

Since about 1982, average prices have been stable or declining, as the amount of new capacity being added has slowed and fuel prices have stabilized. However, in areas where new plants have been added, politically contentious rate increases have continued.

Average Real Residential Prices for Electricity





REGULATORS' DECISIONS AFFECT ALL PARTICIPANTS IN ELECTRICITY MARKETS

There are three primary groups of participants in electricity markets:

- **Electricity producers:** There are several types, but investor-owned utilities are the predominant subgroup.

- **Electricity consumers:** In terms of national totals, the residential, commercial, and industrial sectors each use about a third of total electricity consumption, but there is a lot of variation among individual utilities.

- **The regulators:** Rates for retail electricity sales are typically set by State or municipal authorities. Rates for wholesale electricity transactions are set by the Federal Energy Regulatory Commission (FERC).

In addition, three other participant groups are important, but less visible:

- **Stockholders** who literally own (but do not manage) the investor-owned utilities.

- **Corporations** comprising the Nation's financial community, whose members assist utilities in raising capital by marketing their securities. Analysts for these firms compare the risks and rewards inherent in new utility investments with the risks and rewards presented by alternative investments. Their judgments affect utility stock prices and bond ratings.

- **The U.S. Treasury**, which provides below-market-rate financing to many publicly owned utilities.

The electric utility industry is the most heavily regulated of the energy industries, and it is one of the most heavily regulated sectors of the U.S. economy. FERC and State public utility commissions (PUC's) each exercise authorities granted to them by Federal or State statutes.

Virtually all aspects of electric utility activities are influenced by regulation:

- Decisions on new investments are influenced by the rate of return authorized on past investments and by the regulatory treatment of recently completed projects.

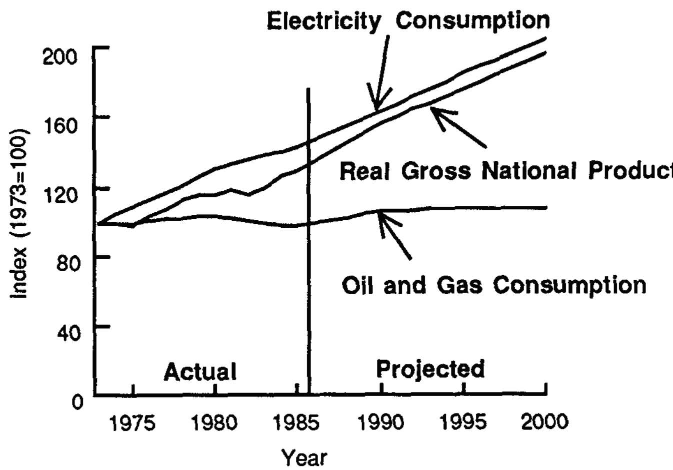
- The rates utilities charge their customers are set by regulators. In a typical rate proceeding, the utility's "revenue requirement" for a given future period is determined by summing the funds needed by the utility to repay its investors for past investments plus a reasonable rate of return, and to pay its operating costs. The regulators are also responsible for determining the relative rates to be paid by a utility's different customer classes.

- The facilities used to produce and distribute electric power are also subject to environmental and safety regulation at both the State and Federal level.

ADDITIONAL ELECTRICITY SUPPLY IS LIKELY TO BE NEEDED IN THE 1990's

UNLIKE OIL AND GAS, ITS DEMAND IS EXPECTED TO GROW WITH THE ECONOMY

For many years, there has been a strong link between growth in sales of electricity (kWh) and overall economic growth (GNP). Since the mid-70's, growth in U.S. consumption of oil and gas has been largely "decoupled" from GNP, but electricity demand has continued to grow at about the same pace as the economy.



"Electricity use and gross national product have been, and probably will continue to be, strongly correlated."[1] The relationship between electricity demand and economic growth is expected to continue for several reasons:

- Electricity is the means consumers prefer for meeting many basic energy requirements in an increasingly high-technology, service-oriented economy.
- When electricity prices were rising steadily in the 1970's and 80's, demand continued to grow, although at a slower pace than in earlier years. Now, electricity prices are expected to be fairly stable through the mid-90's, placing no inhibitions on demand growth.
- If low prices for oil and gas were to persist, electricity could lose some of its market share to these fuels. However, oil and gas prices are expected to increase again in the 1990's, favoring continued growth in electricity demand.
- Over the past decade, U.S. electricity demand has grown somewhat less rapidly, reflecting slower national economic growth. But the rise in demand has even survived many years of migration to other countries by some electricity-intensive industries (such as aluminum, steel, and some chemicals).
- Electricity now is used more efficiently than it was a decade ago. Without such increased efficiency, demand growth would have been even higher. This trend of increased efficiency in the use of electricity is expected to continue.[2]

For the years 1982-85, the ratio of weather-adjusted electricity demand growth to economic growth has been 0.9 on a national basis. On a regional basis, however, this ratio has varied substantially, ranging from 0.5 (Mountain Census Region) to 1.7 (East North Central Census Region).[3]

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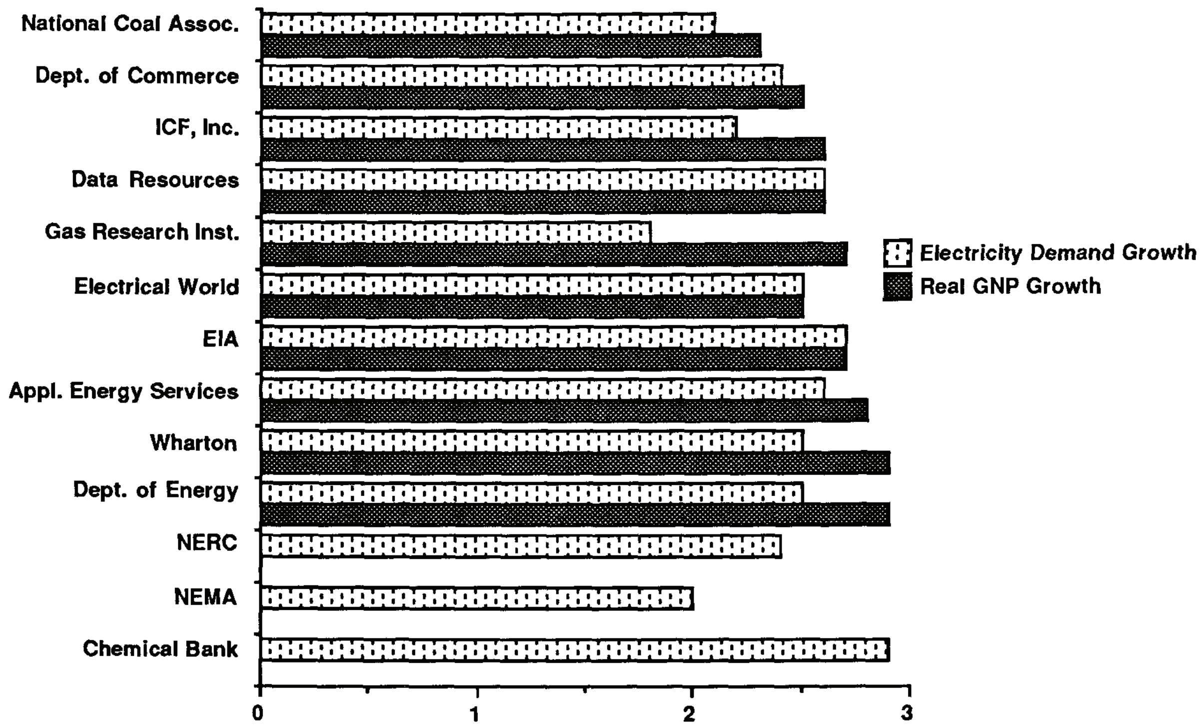
[1] *Electricity in Economic Growth*, National Research Council (National Academy Press, 1986). p. xvii.

[2] *Electricity-Conserving Technologies in the NEPP Projections*, prepared for the U.S. Department of Energy by Applied Energy Services, Inc., 1986; *The Electric Energy Savings From New Technologies*, prepared for the U.S. Department of Energy by Pacific Northwest Laboratories, 1986.

[3] Calculations based on weekly electric output figures published by Edison Electric Institute and degree day data provided by the National Oceanic and Atmospheric Administration (NOAA).

Projections of U.S. Economic and Electricity Demand Growth Rates (Average Annnual Growth, in percent, 1985–2000)



Sources: National Coal Association, "Coal 2000," March 1986; U.S. Department of Commerce, Joseph F. Gustaferro, "U.S. Energy for the Rest of the Century," July 1985; ICF, Inc., from Edison Electric Institute, "Electric Perspectives," Spring 1986; Data Resources, Inc., "U.S. Long-Term Review," Spring 1986; Gas Research Institute, "1985 GRI Baseline Projection of U.S. Energy Supply and Demand to 2010," November 1985; Electrical World, "37th Annual Electric Utility Industry Forecast," September 1986; U.S. Energy Information Administration, "Annual Energy Outlook 1985," February 1986; Applied Energy Services, Inc., "U.S. Electricity Markets in the 1990's," Testimony prepared for the Committee on Energy and Natural Resources, U.S. Senate, July 25, 1985; Wharton Econometric Forecasting Associates, "Long Term Forecast," December 1985, and conversation with Jeffrey Shapiro, U.S. Services Division; U.S. Department of Energy, "National Energy Policy Plan Projections to 2010," Preliminary 1987 Reference Case, September 1986; National Electrical Manufacturers Association, "Tenth Biennial Survey of Power Equipment Requirements of the U.S. Electric Utility Industry 1985-1994," March 1986; Chemical Bank, "U.S. Electric Utility Industry Outlook to the Year 2000," February 1984.

MANY SEE 2 TO 3 PERCENT LONG-TERM ANNUAL GROWTH FOR BOTH GNP AND ELECTRICITY

Most of today's midrange estimates of long-term growth are between 2 and 3 percent per year for *both* the economy and electricity demand.

These are only projections, of course, and they are therefore subject to considerable uncertainty. Higher or lower growth projections are possible, but in general they require alternative assumptions (about such factors as the rate of population growth, the rate of household formation, and the rate of technological change) which experts believe to be less likely.

ALL SECTORS ARE EXPECTED TO USE SIGNIFICANTLY MORE ELECTRICITY BY THE YEAR 2000

Current midrange projections for electricity demand during the 1985-2000 period show consumption in all sectors (except transportation) rising at average annual rates around 2 to 3 percent.

Residential Sector

- Electricity for space heating is expected to grow relatively rapidly (about 3 percent per year), reflecting continued penetration of this market nationally by electric heat pumps and the expected return of higher oil and gas prices in the 1990's.

- On the other hand, use of electricity for space cooling, refrigerators, and freezers, as well as lighting and small appliances, is expected to grow more slowly (1.5 percent per year). This is due in part to increasing saturation of the markets for air-conditioning, freezers, and refrigerators, and in part to efficiency improvements in these appliances and in lighting.

Commercial Sector

- Electricity use for heating purposes (space, water, cooking, and drying) is expected to increase rather rapidly (about 3 percent per year). Because heating uses in the commercial sector are relatively small, however, their effect on total sectoral growth is limited.

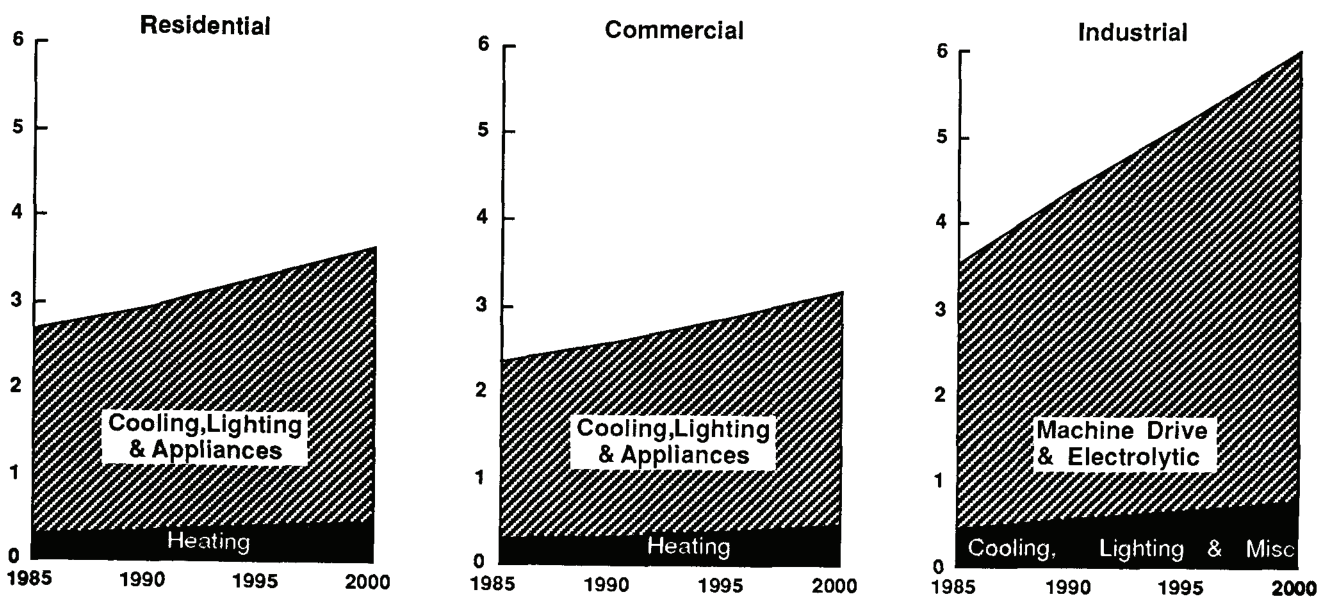
- Electricity use for commercial space cooling, lighting, and miscellaneous appliances is projected to grow at about 2 percent per year. This figure is somewhat lower than the expected rate of growth in commercial floor space because it reflects expected efficiency improvements in lighting and space cooling.

Industrial Sector

- The use of electricity for machine drive and for electricity-dependent manufacturing processes accounts for the bulk of electricity use in U.S. industry. Such use is expected to grow at about 3 percent or more per year—because of overall economic expansion and penetration of new process applications for electricity (such as microwave drying, induction heating, and laser cutting). Some of these requirements will be met by industry through self-generation or cogeneration, so that growth in sales by the electric utility industry would be somewhat lower. (Cogeneration is the simultaneous production of electricity and some other useful form of energy—usually steam—from the same fuel.)

- Electricity use for air-conditioning, lighting, and miscellaneous purposes is expected to grow more rapidly (close to 4 percent), reflecting a trend toward lighter industry.

Sectoral Use of Electricity in the U.S., 1985–2000 (Quads)



Transportation Sector

- Currently, electricity plays a very minor role as a fuel in the transportation sector. However, advances in battery technology could make electricity competitive as a transport fuel in the post-2000 period. Such a development would have a major impact on long-term electricity demand growth.

MORE ELECTRICITY SUPPLIES NEEDED TO MEET GROWTH AND OFFSET PLANT RETIREMENTS

Future requirements for new sources of electricity supply[4] are determined mainly by two factors:

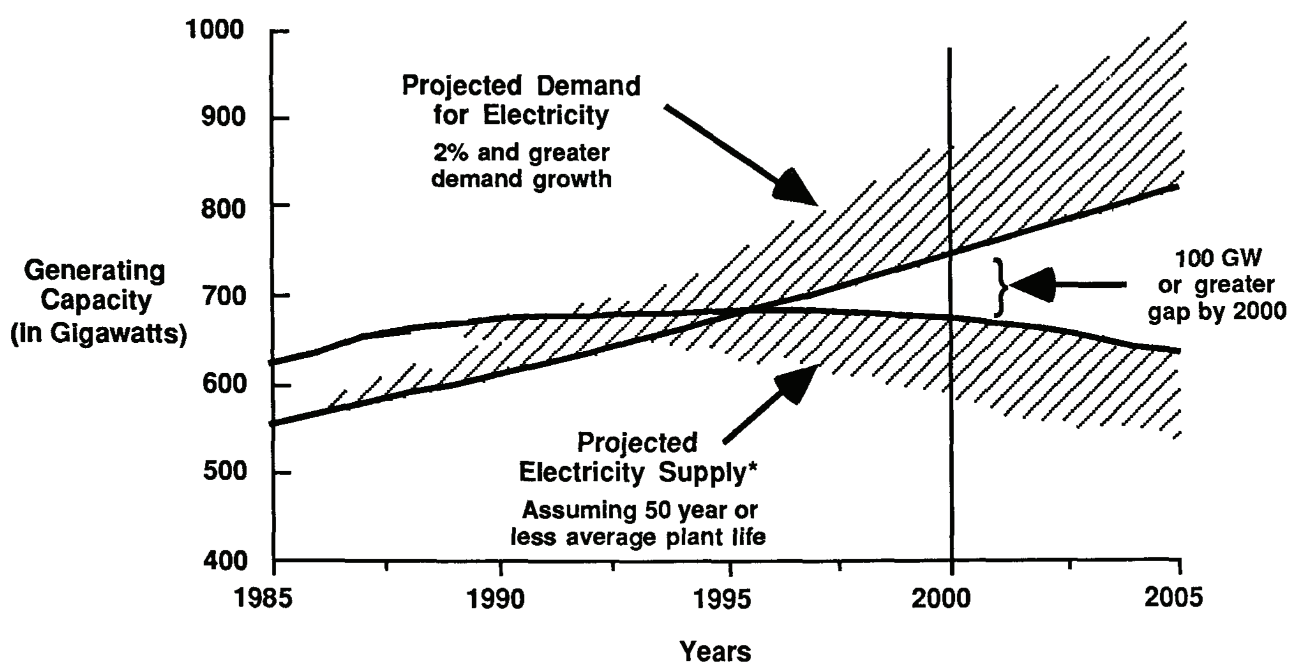
- Growth in demand.
- The need to retire and replace aging or uneconomic plants.

Under cautious assumptions (2 percent demand growth and 50-year average plant lifetimes), in the year 2000 the Nation will need approximately 100 gigawatts of new electric generating capacity (beyond plants now under construction) to maintain adequate electricity supplies. If higher demand growth or shorter plant lives are assumed, the projected amount of new capacity needed would be substantially larger.

A significant portion of this requirement can be met through additional utility programs for efficiency improvement and load management, though the size of these contributions is still difficult to assess. Nevertheless, substantial amounts of new generating capacity of some type also will be needed.

[4] *A thoughtful treatment of the issues related to new supply requirements is presented in the 1986 Reliability Review*, published by the North American Electric Reliability Council (NERC) in October 1986.

Need for New Capacity Expected To Grow Rapidly After 1995



*Existing plants plus plants under construction minus retirements.

As a practical matter, a literal shortage of electricity is unlikely. If necessary, utilities could turn to various short-term expedients to "keep the lights on," such as increased use of oil-fired generation, voltage reductions, and interruptions of service to selected customers, but these measures would be undesirable for the long term. In addition to reducing the quality of service, such measures would tend to drive rates and costs up, which would inhibit economic growth and reduce our international competitiveness. Further, a lack of confidence in the future availability of reliable and economic electricity could itself inhibit economic growth and cause consumers to rely more heavily on other energy sources, particularly oil and gas.

As electric power markets move from the current period of excess supply to a period when additional capacity is required, the nature of the regulatory process will be radically changed. With the current excess capacity, the regulatory process generally is focused on the contentious equity issues of deciding who will shoulder the costs of past mistakes. Through time, as the need for new capacity becomes more apparent, the process will have to refocus on how to encourage producers to make efficient decisions to ensure future supply adequacy. This transition may be difficult.

DESPITE REGIONAL VARIATIONS, ALL AREAS OF U.S. ARE LIKELY TO NEED MORE CAPACITY IN 1990's

To maintain reliable and economic service, additional electric generation capacity (beyond expansions now in process) will be needed in every region of the Nation before the turn of the century. This is the case under a broad range of demand-and-supply scenarios.

With 3 percent annual growth in demand and 40-year powerplant lifetimes, every region will need new supply by the early 1990's. Assuming only 2 percent yearly demand growth and 50-year powerplant lifetimes, new supply will still be needed in every region by the late 1990's. If technologies requiring long lead times for construction are to meet some of these expected regional needs, decisions to proceed with them must be made soon.

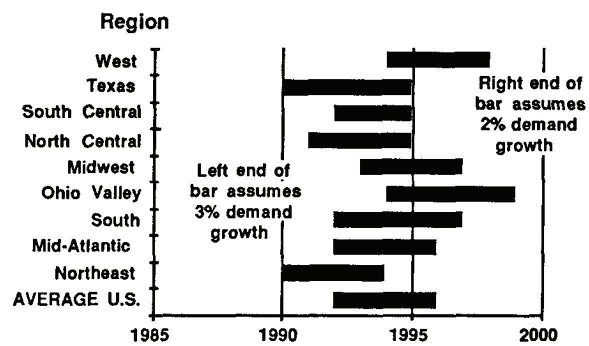
Regional Highlights

- **West:** The recent surge of cogeneration development in California—in some cases at prices higher than actual "avoided utility costs"—has postponed incremental supply needs. If fluid-fuel prices rise again, an enlarged transmission network may be needed to enable additional hydroelectric power from the Pacific Northwest and Canada, as well as coal-fired and nuclear power from the Southwest, to displace the use of natural gas (and potentially oil) for electricity generation on the heavily populated West Coast.

- **Southwest:** Recent cutbacks in the domestic oil and gas industries have dampened this region's economic growth and its demand for electricity. However, recovery in these markets could put pressure on electricity supplies by the late 1980's in Texas and early 1990's elsewhere. A rebound in natural gas prices in the early 1990's would restore the desirability of displacing natural gas as a baseload generation fuel in this region.

- **Central Industrial Regions:** Weakness in industrial demand has resulted in significant excess supply, but current demand projections indicate that the surplus is likely to be eroded by the mid- to late-1990's. Meanwhile, there is interest in selling

Period During Which More Electricity Supply (Beyond Current Construction) Will Be Needed



electricity to the East—to displace oil and meet faster growing demand for electricity in that region.

- **East:** Demand growth has been stronger than in other regions. Further demand growth, coupled with substantial use of oil as a generation fuel in Florida, the mid-Atlantic states, New York, and New England, is expected to cause the eastern United States to require new power supplies sooner than other areas. Canada shows increasing interest in exporting power to this region.

Despite Many Options To Choose From, Numerous Uncertainties Exist

Electricity Supply Options	Potential Economical Input to New Supply By the Year 2000	Reservations and Other Comments
Conservation and Load Management	EPRI's midrange estimate is 45 GW.[a]	Economic efficiency of utility programs subject to debate, and consumer behavior is uncertain.
Cogeneration	20-50 GW.[b]	Frequently oil- or gas-fired; under current regulation may displace more economic generation if all technologies are not allowed to compete fairly.
Renewables and Fuel Cells	Uncertain, but technical and economic viability are improving.	Some options unproven in commercial applications and have real and perceived market risks.
Canadian Imports	5-10 GW.[c]	Economically competitive, but overreliance as a result of constrained domestic alternatives could lead to an excessive dependency in certain regions.
Enhanced Transmission	Unknown, but probably not large.[d]	Siting of new lines controversial. Option will be less important as excess generation capacity now available for interregional transfers is eroded by demand growth. However, transmission needs could increase substantially depending on trends in generation technologies.
Plant-Life Extensions	Uncertain, but probably significant.	Total potential uncertain—defers, but does not eliminate, future supply needs.
Nuclear	Additional capacity (beyond 21 GW under construction) very uncertain.	Simpler, certified/standardized light-water reactor designs could be developed in the early 1990's. Designs for advanced systems may become competitive after 2000.
Conventional Coal	As needed, if requirements are not met by more economic options.	Coal is currently the mainstay of the industry. Cleaner coal-using technologies are under development and are likely to make a major contribution.
Gas-fired Combustion Turbines/Combined Cycle (w/potential conversion to coal/synfuels)	Depends on future oil/gas prices. Virtually unlimited capacity additions possible independent of economic considerations.	Increasingly a preferred option in utility supply plans due to short lead times and low capital requirements. However, future operating costs may be high and may raise oil/gas use for electricity generation, unless coal/synfuel conversion proves economically feasible.

[a] *Impact of Demand-Side Management on Future Customer Electric Demand,* EPRI report EM-4815-SR (October 1986).

[b] *Electricity Outlook,* EPRI, December 1985; forthcoming study from AES, *Industrial Cogeneration: Boom or Bust; New Electric Power Technologies,* Office of Technology Assessment, July 1985; *Industrial Cogeneration Potential (1980-2000),* Dun and Bradstreet (August, 1984); *Industrial and Commercial Cogeneration,* Office of Technology Assessment, (February 1983).

[c] Estimates derived from projections in *Canadian Power Imports,* General Accounting Office, April 1986; *U.S. - International Electricity Trade,* Energy Information Administration, September 1986; *Canadian Energy Supply and Demand 1985-2005,* National Energy Board, October 1986.

[d] *ECAR/MAAC Interregional Power Transfer Analyses,* ECAR/MAAC Coordinating Group, June 1985.

TO ENSURE RELIABLE AND EFFICIENT SUPPLY, ALL ELECTRICITY OPTIONS MUST BE CONSIDERED

PLANNING AN OPTIMAL "MIX" REQUIRES WEIGHING AVAILABILITY AND COST AGAINST RISKS

Selecting a reliable, economically efficient mix of options to meet electricity supply requirements is difficult. Many of today's newer options appear economically attractive, but they have yet to be tested by broad commercial use or are likely to be of limited availability.

Developing a successful mix will require new capital investments and will entail substantial investment risks. Efficiency will suffer if the regulatory environment biases the technological and fuel choices by not encouraging fair and vigorous competition among all options.

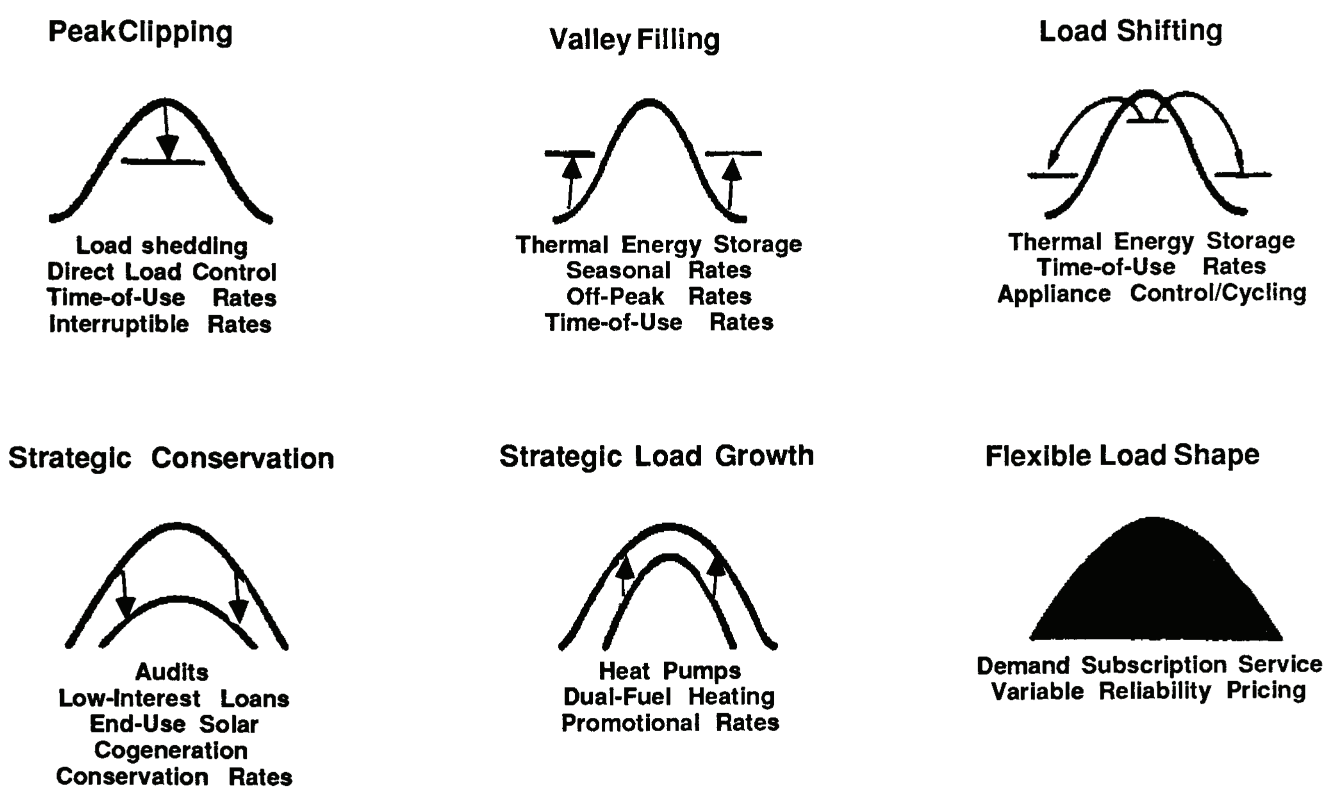
Utilities and other companies, not governments, will make the decisions that will shape the future generation mix. If energy security goals are to be achieved in the electricity sector, the regulatory environment must give appropriate incentives to all players.

SOME DEMAND MANAGEMENT SHOWS ECONOMIC PROMISE, BUT POTENTIAL REMAINS UNCERTAIN

Many new electricity-saving technologies exist today that, if implemented, could reduce new capacity requirements. For example:

- **Residential:** Advanced heat pumps (electric and gas); high-efficiency insulation and anti-

Demand Management Programs Must Be Tailored to Local Needs



Source: Electric Power Research Institute infiltration devices; high-efficiency appliances; and daylighting.

- **Commercial:** High-efficiency lighting; high-efficiency films and glass for windows; heat and cool storage systems; and daylighting.

- **Industrial:** High-efficiency motors; adjustable-speed motor controls; and new electricity-using manufacturing processes (for example, laser cutting, microwave drying).

However, most such technologies are likely to penetrate their respective markets slowly because they require significant front-end investments, their economics are uncertain, or consumers simply do not know enough about them.

Utilities may find it economically beneficial to encourage consumer acceptance of these technologies, because this could delay somewhat the need to build new generating capacity.

- For example, many utilities now offer substantial rebates to purchasers of high-efficiency air-conditioners—not to accelerate air-conditioner sales, but to induce customers to select relatively efficient models. However, such programs must be designed carefully if they are to be of net benefit to all customers and not just those who get rebates.

- The design of economically efficient programs of this type will vary greatly from one utility to another—depending on the climate, the nature of the local economy, projected electricity consumption patterns, the characteristics of the utility's existing generation capacity, and the regulatory environment in the State.

Thus it still is unclear how much demand management programs can contribute to the Nation's long-term electricity needs.

- Careful planning and research by individual utilities are needed to develop and implement cost-effective programs. It is particularly important to distinguish between the amount of market-generated conservation that would occur independent of utility programs and the incremental amount attainable through such programs. Without this distinction, the amount of conservation attributable to utility efforts is almost certain to be overestimated, and its costs underestimated.

- Cost projections for reductions in electricity use (kWh) and peak demand (kW) that might reliably result from optimal demand management in each service area are subject to honest debate.

- Demand management programs frequently involve the equity issue of achieving an appropriate balance between the direct benefits (in lower bills) to customers who participate in the program and the program's net impact on nonparticipating customers.

SOME COGENERATION ECONOMIC NOW; BUT RENEWABLES NEED ADDITIONAL R&D

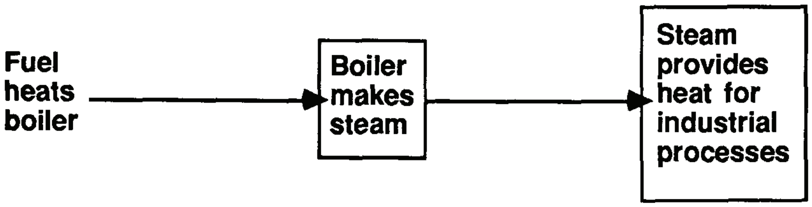
Cogeneration of Electricity and Steam

The long-term economics of some cogeneration applications are uncertain, but the theoretical potential is significant (20 to 50 GW). Despite their higher thermodynamic efficiencies, oil and gas cogeneration units may be less economical than standard utility coal plants in the long run if oil and gas prices return to previous high levels.

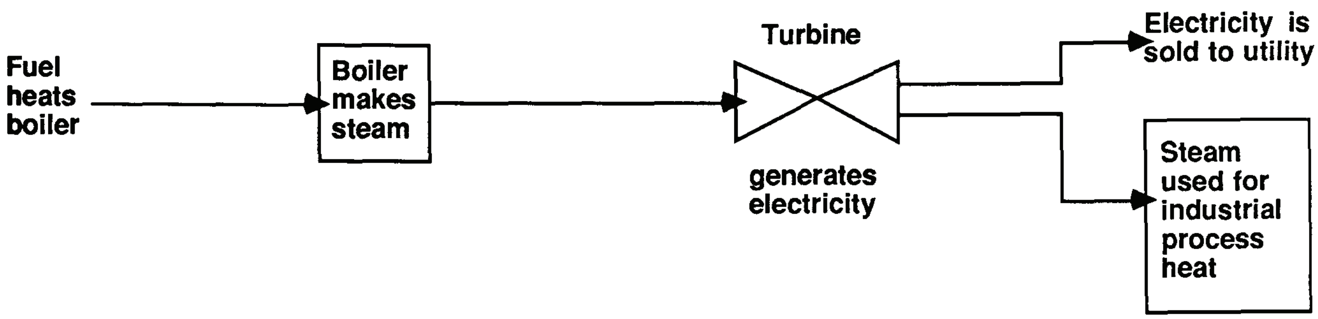
To the extent that cogeneration units using oil or gas displace either renewables or solid-fuel technologies, they heighten the long-term vulnerability of the United States to oil supply disruptions.

Cogeneration's impact on overall pollution depends largely on which types of cogenerators displace which kinds of utility resources. Broadly speaking, cogeneration generally reduces pollution because so much of it is gas-fired. The higher fuel-efficiency of cogeneration plants also tends to make them

This Is How a Conventional Industrial Steam Facility . . .



. . . Compares With a Cogeneration Plant, Producing Electricity and Steam



inherently less polluting than conventional plants of the same type—with the important exception of small coal-fired cogenerators, which are not required to have scrubbers or to meet the same pollution limits that new utility coal plants must meet. This issue also is complicated by the location of certain cogeneration units. Although cogenerators produce less pollution, the emissions may take place in some cases within more sensitive areas (such as cities).

Electricity from "Renewables"

There are several types of renewable generation sources, most of which are capital-intensive. In general, they do not use imported or scarce fuels, and some are less harmful environmentally than most conventional options. However, it will take time (and additional research and development) to improve their economics adequately and to resolve some other problems.

- **Wind systems:** Probably not economic at present without subsidies, but technical and economic performance is improving. An intermittent source of power; no air or water pollution.

- **Small hydro:** Limited potential, due to lack of suitable sites. Produces no air pollution, but remains controversial in many cases because of environmental effects on rivers.

- **Biomass:** Many applications are economic today because fuels used are low-cost (with collection and transportation the key factors). Produces most conventional air pollutants.

- **Solar:** Actually includes many different technologies. Photovoltaics believed to have greatest potential, but these are not yet economic except in special applications (such as remote locations not connected to the grid).

- **Geothermal:** A small resource, in terms of economic potential proven to date. The only economic dry steam resource known in the United States is already largely developed, and other geothermal resources (such as hot brine and lower temperature heat sources), though large, have not yet been proven economically practical for generating electricity. Some water pollution problems, associated with disposal of brine contaminants.

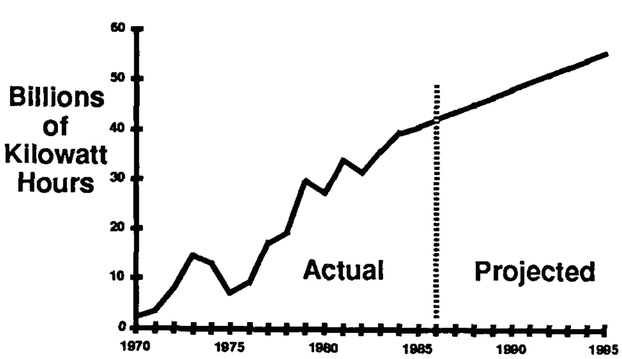
- **Municipal solid waste:** Generally considered a renewable resource because additional waste is constantly being produced as new fuel. Economics are improving, in part because of "disposal credits" based on scarcity of landfill sites. Produces conventional air pollutants.

ELECTRICITY IMPORTS FROM CANADA ARE SMALL, BUT EXPECTED TO GROW OVER NEXT DECADE

Imported Canadian power, although it represents less than 2 percent of electricity sold nationwide in the United States, is an important and growing source of electricity in several regions:

- **Northeast:** Hydroelectric power from Quebec and Labrador, along with nuclear power from New Brunswick and Ontario and some coal-fired power from Ontario, already supplies a sixth of the electricity used in New York State and is likely to supply a similar fraction of New England's power by the early 1990's.

Net Imports of Electricity From Canada



Quebec is expected to develop roughly 15 gigawatts of new hydro resources over the next 20 years, and some of this power should be available for export.

- **Plains:** Manitoba hydropower supplies roughly 7 percent of electricity used in the Dakotas, Nebraska, Iowa, and Minnesota. Manitoba is planning to develop some 3 gigawatts more hydropower by 2005.

- **West:** British Columbia sends hydropower to California via the Pacific Northwest-Southwest Intertie. Roughly 2 to 4 gigawatts of additional hydro resources are slated for development after 1990.

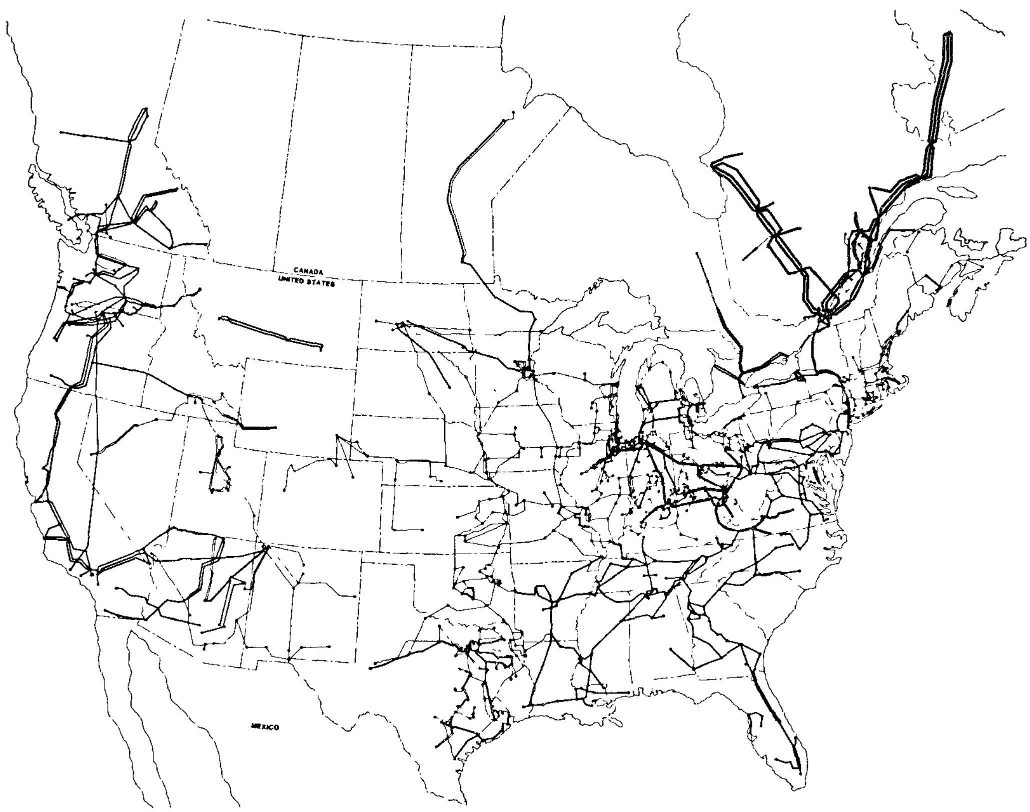
So long as adequate provision is made to enhance transmission capacity as power imports expand, imports should not affect the reliability of electric service. However, the enhancements required could prove extensive.

Many current long-term contracts link the price of imported electricity to the average cost of generation from fossil fuels in the importing region. Where generation is largely fueled by oil, as in the Northeast, an increase in oil prices would make Canadian power more costly.

Most Canadian power is generated by "crown corporations" that are exempt from Canadian income taxes. This has led to assertions that Canadian electricity exports are subsidized. However, the price of Canadian power to U.S. buyers is freely negotiated; while the sellers make a profit, the buyers realize savings relative to other supply sources. Current negotiations for a free trade agreement with Canada may further ensure that long-term supply contracts do not discriminate between U.S. and Canadian buyers.

Power imports can enhance U.S. security by displacing imported oil used in electricity generation. However, current projections indicate that demand growth in Canada is expected to eventually outstrip new Canadian supply. Therefore, if U.S. utilities are unable or unwilling to build their own powerplants, certain regions could be left with inadequate supplies as existing import contracts expire.

North American Electric Transmission Grid



ACCESS TO TRANSMISSION GRID FOR NONUTILITY PARTIES IS A CONTROVERSIAL TOPIC

Many regard transmission access for customers as the principal issue today in electric power markets, for two reasons:

- In some areas, the prospective introduction of large new generating facilities into the rate base points to potential rate increases as high as 50 percent or more. Industrial users for whom electricity is a large component of costs face tough international competition and sometimes cannot compete in the event of such large rate increases. Rural and municipal utilities who buy all or most of their power from other utilities also have difficulty absorbing these price shocks. These two utility customer groups have a powerful incentive to "shop" on the electric power grid for lower cost power from elsewhere.
- Some regions have substantial excess generating capacity, while others anticipate near-term shortages. This creates the possibility of efficiency gains through increased interregional electricity trade, if adequate transmission capacity is available.

Under current law, wholesale customers have very limited access to the electric power grid. The Federal Power Act allows the Federal Energy Regulatory Commission to mandate a utility to transmit power from another source to a wholesale customer only after it has been demonstrated that such "wheeling" (transmission across one or more utilities) does not materially affect the competitive relationship among all parties. Under this provision, mandatory wheeling is in effect prohibited. Further, FERC has no authority to order wheeling of power to a retail customer.

Mandating electric power transmission access for retail customers could be destabilizing and could reduce rather than increase efficiency. Any reforms in transmission access policy should be designed to ensure that they serve to improve economic efficiency without degrading service reliability.

- Differences in electric power rates are causing customers to seek ways to "shop" on the grid; but regulated rates are based on embedded average costs and do not reflect true market prices. Since the incentives to shop are not based on true economic costs, trade resulting from more open access would not necessarily increase efficiency.

- Overall efficiency improvements would occur only if low-cost electricity sources could be used more and if higher cost sources could be used less. However, utility systems today are relatively interconnected and coordinated, and through a practice called economic dispatch, sources that are cheaper are already heavily utilized.

- Open access could strain operation of the Nation's electric power grid systems. The technical constraints and capacity limitations of the electric power grid are significantly more complex than natural gas and telephone systems. Past electricity failures, such as the Northeast blackouts, indicate the difficulties in managing the grid system, whose continued reliability is invaluable.

- The utility industry is already allowing considerable access to the power grid in some circumstances. Many utilities also are offering reduced rates to industrial customers who might otherwise turn to cogeneration. However, unlimited customer access to the grid could have serious negative impacts. As a consequence of their obligation to provide reliable service, utilities have made major investments to serve projected demand within their respective territories; the loss of major customers would shift more of a utility's fixed costs to its remaining customers and would create many difficult issues of fairness between customers. Moreover, the utilities that had recently brought new plants on line would be the ones most severely affected, thus exacerbating the industry's current tendency to avoid new capital investment.

TYPICAL POWERPLANTS ARE AGING, SO NEED TO REFURBISH OR REPLACE THEM WILL INCREASE

The age of the typical U.S. generating unit will increase from about 15 years in 1985 to between 25 and 30 years in the year 2000. This prospective shift has several implications:

- As facilities age, they are eventually likely to run less efficiently and less reliably and to require more expensive maintenance.

- One way to meet incremental supply needs is to keep existing fossil-fueled steam plants in service beyond their typical design life of 30 to 40 years, through refurbishment.

- Plant-life extension may be an important source of additional capacity after 2000, when its potential application will be quite large.

The life-extension option involves many uncertainties.

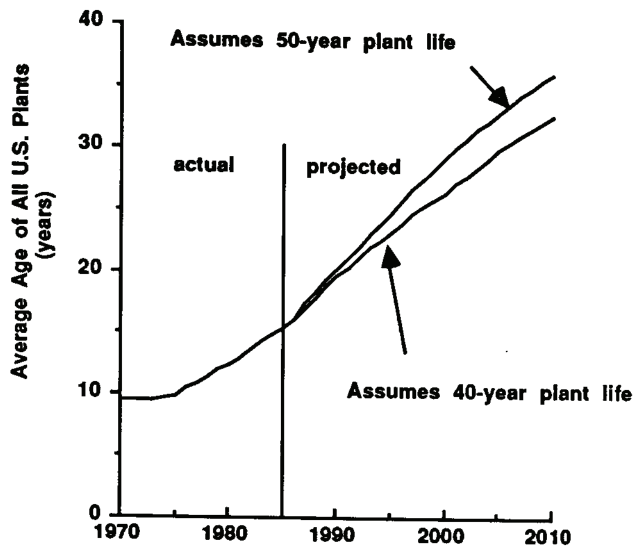
- Because of only limited experience to date with extending plant life, it is unclear how well refurbished plants would operate, how long an extension might be effective, and what fraction of existing capacity actually is suited economically to this procedure.

- Plants built during the past 20 years may be less suited physically to life extension than older ones, because many newer plants were built to closer engineering tolerances than their predecessors.

An option known as "repowering" may be pursued in combination with plant-life extension. Repowering involves replacing the boiler and perhaps other critical parts of the plant. In some cases, this can increase electricity output; in others, it can reduce the emission of pollutants. A few repowering efforts are under way, some using new fluidized-bed technologies. Repowering is unproven on a broad commercial basis and therefore is subject to the same general uncertainties as life extension.

COAL HAS BEEN AND WILL REMAIN A VITAL SOURCE OF THE NATION'S ELECTRICITY

Average Age of Electric Capacity



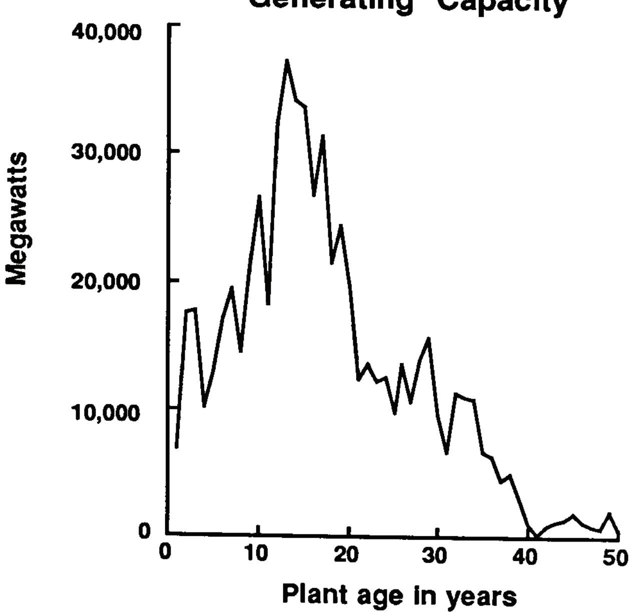
In recent decades, the U.S. coal and electric utility industries have become very interdependent.

- In 1950, only about 20 percent of U.S. coal production was consumed in generating electricity. By 1985, this figure had risen to about 80 percent.

- In 1985, 57 percent of the electricity used in the United States was generated from coal; and in many areas of the country, existing coal-fired plants are the cheapest sources of electricity.

- Over the past decade, increased generation from coal (and nuclear fission) has displaced large quantities of oil, as new plants have come into service and "coal by wire" from existing plants has been delivered to distant markets.

Age Profile of Today's Generating Capacity



Nevertheless, a major increase in the use of coal by utilities is potentially problematic. (A more detailed discussion of these issues is provided in the chapter of this report that deals with coal.)

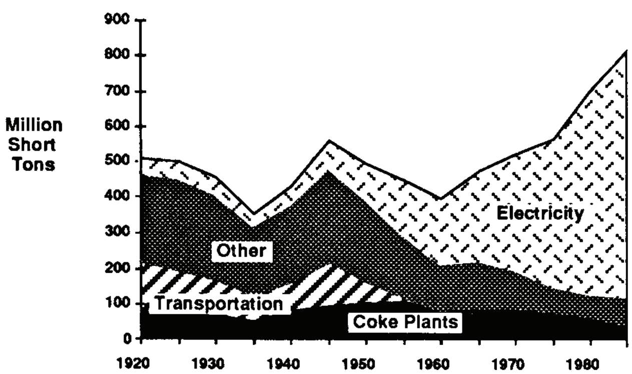
- Most coal-based generating technologies are capital-intensive. Under today's regulatory practices, many utilities systematically avoid capital-intensive investments, regardless of their potential long-term economic benefits.

- There is growing concern over acid rain, but new coal-based generation technologies are under development that emit low levels of sulfur and nitrogen oxides. Several of these technologies are soon to be tested commercially and will contribute potential technological solutions to the control of acid rain.

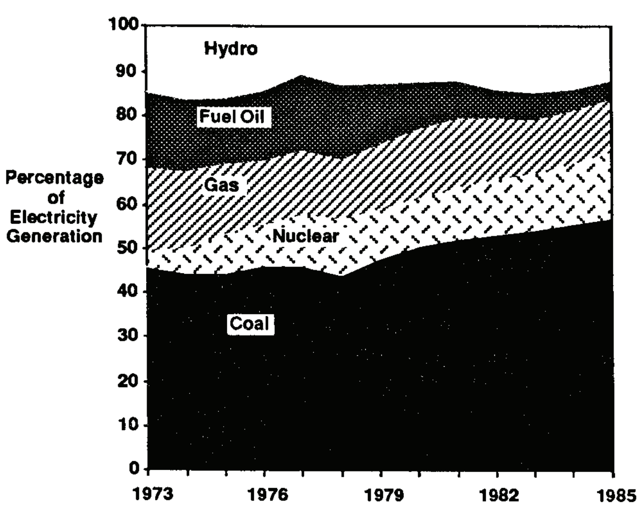
- All fossil-fuel combustion generates carbon dioxide, which some analysts believe will lead to worldwide temperature increases through the "greenhouse effect." Research on the greenhouse effect is continuing, but conclusive results may not be available for many years.

Coal is likely to remain the mainstay of the Nation's electric power system for decades to come. The United States has proven reserves of coal sufficient to supply our expanding energy needs for several centuries. With advances in clean-coal technologies, coal will be a strong competitor for meeting new generation needs. However, long-term environmental concerns are a reminder of the importance of having a diversity of sources for new electric power generation.

Coal Consumption by Sector



Electric Generation by Fuel Type



NUCLEAR POWER IS A LARGE, SECURE DOMESTIC RESOURCE— WITH AN UNCERTAIN FUTURE

Nuclear power is a major source of U.S. electricity. In 1986, it provided 16 percent of our total generation. The United States has more than 100 operable nuclear generating units, and an additional 18 are under construction.

Nuclear energy is a secure resource, unaffected by international oil supply or price disruptions. Since 1974, nuclear power has been responsible for one-third of the total generating capacity added to meet growing demand for electricity, and it has been pivotal in reducing the use of oil and gas for electric generation.

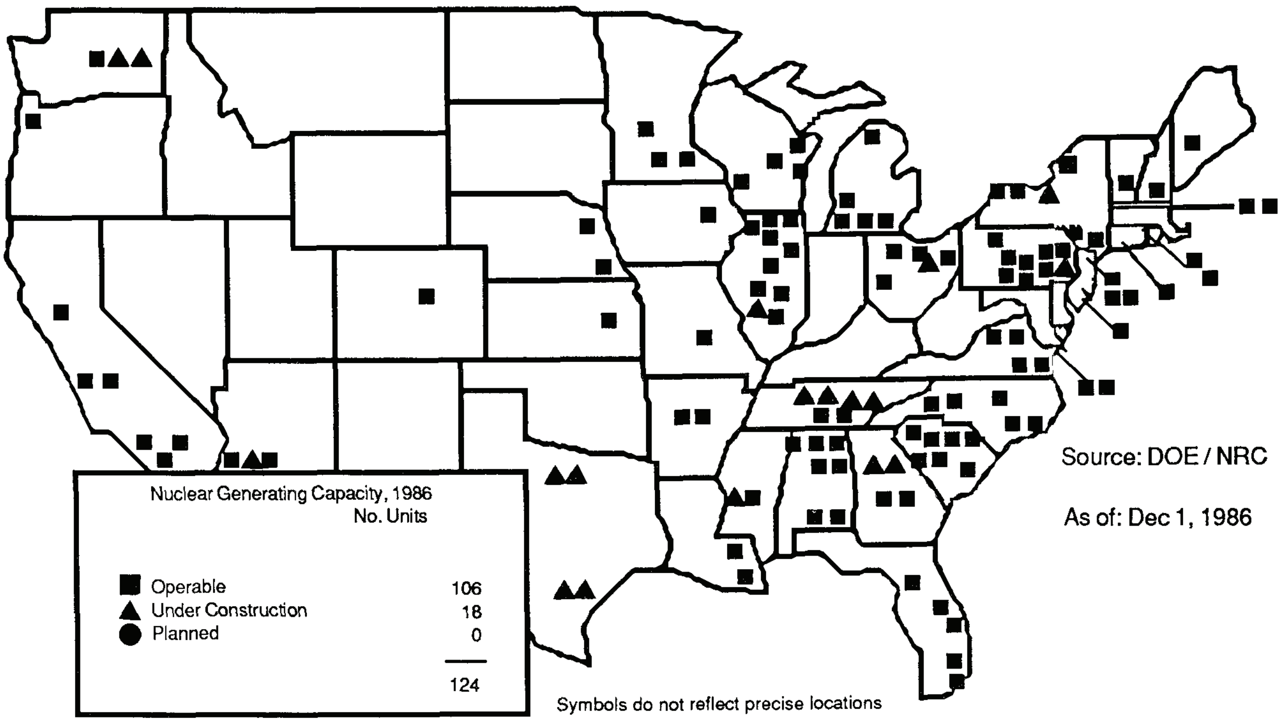
Nuclear energy currently produces electric power which, if it were generated from oil, would consume 2.4 million barrels per day of oil (MMBD). Plants under construction will increase this figure by an additional 0.6 MMBD.

Still, a variety of factors make nuclear energy's contribution to meeting the future demand for electricity uncertain.

- The Chernobyl accident heightened public concern about the safety of nuclear power, and nuclear programs worldwide have been affected adversely. However, any link between Chernobyl and the U.S. nuclear power program is limited and indirect. The safety record of nuclear power in the United States is enviable by worldwide industry standards, and in comparison with other large-scale generating technologies. Nevertheless, public perceptions and apprehensions are important and should not be overlooked.

- Standardized plant designs and nuclear licensing reform legislation are both needed to make new nuclear plants more competitive economically.

Nuclear Powerplants in the United States



- The regulatory process for licensing and operating nuclear plants has become unduly prolonged and unpredictable. As a result, utilities are unwilling to commit to new nuclear construction projects in part because they believe that the potential risks of such investments greatly outweigh potential benefits.

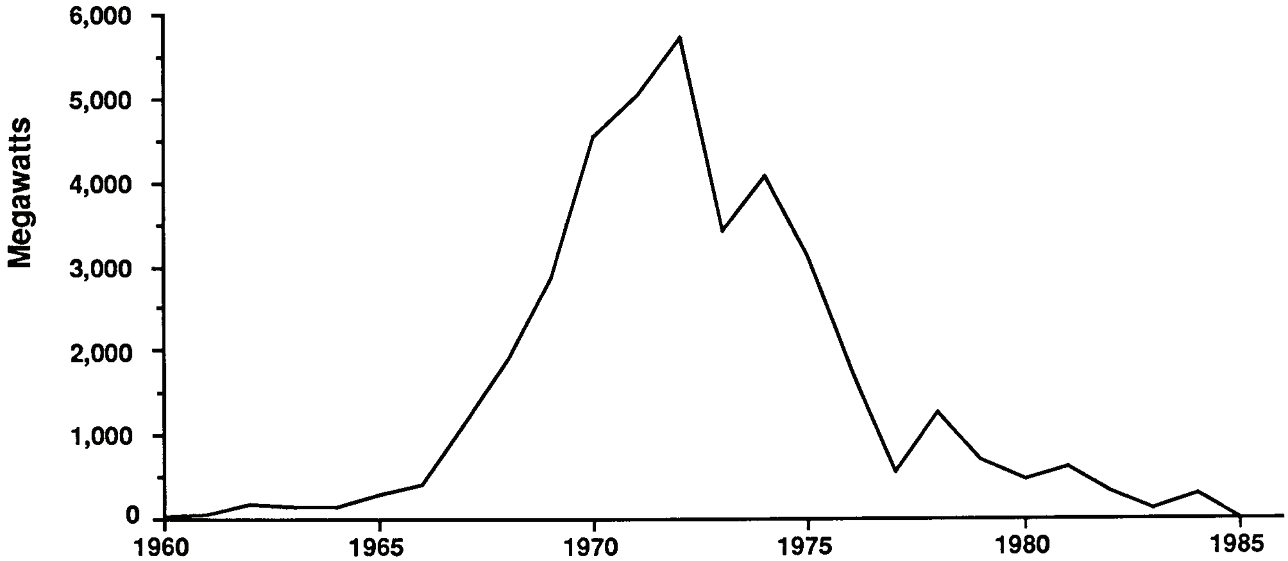
- Waste management issues also could impede the further development of nuclear power. States have been slow to respond to the development of additional low-level waste sites in compliance with the Low-Level Radioactive Waste Policy Amendments Act of 1985. In addition, the candidate States have expressed strong opposition to the repository for high-level radioactive waste mandated by the Nuclear Waste Policy Act of 1982.

IN THE PAST, UTILITIES USED COMBUSTION TURBINES TO COPE WITH SUPPLY SHORTAGES

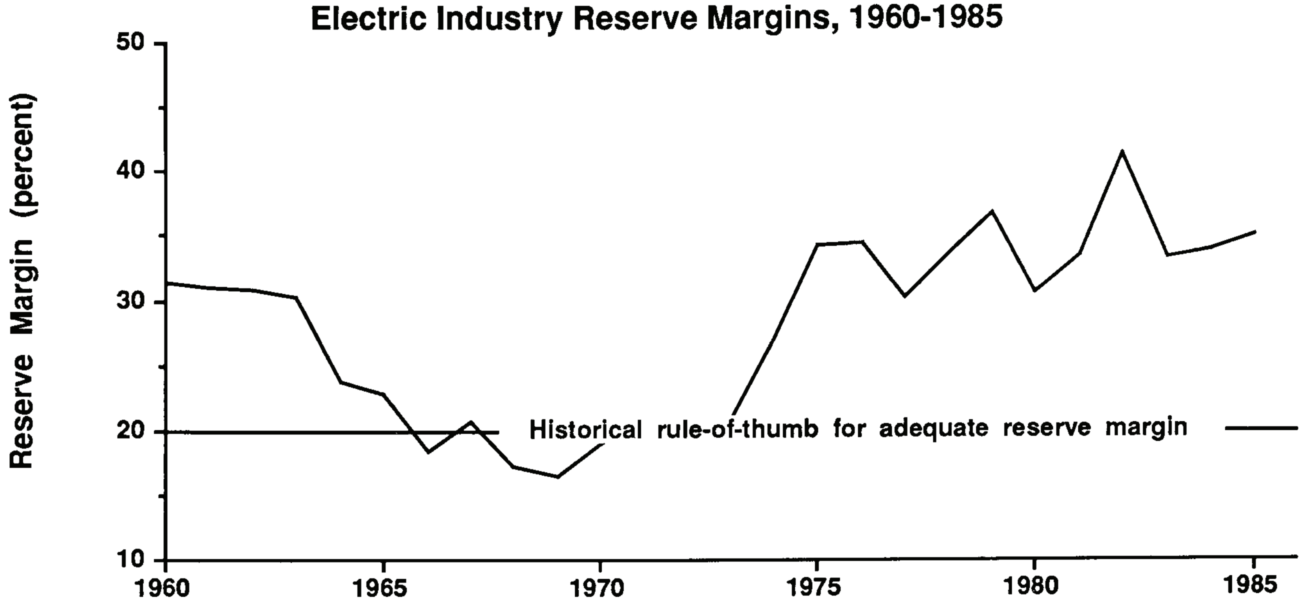
Historically, when utilities have been hard-pressed to meet short-term peaks in demand for electricity because of dwindling "reserve margins" in generating capacity, they have responded by ordering oil- or gas-fired combustion turbines. Combustion turbines are cheap and easy to build, though they are more expensive to operate than coal-fired, nuclear, or hydroelectric facilities.

Reserve margins (the excess of reliably available supply over peak demand) are the most common gauge for measuring the adequacy of electric supply. A reserve is necessary because electricity cannot be stored efficiently and some powerplants are always out of service because of scheduled maintenance or unplanned equipment failures. By rule of thumb, a reserve margin of about 20 percent has been considered necessary to ensure reliable service.

Installation of Gas Turbines, 1960-1985



Electric Industry Reserve Margins, 1960-1985



In the late 1960's and early 1970's, reserve margins nationwide fell to an average of about 20 percent—precipitating an increase in orders for combustion turbines. Just before the 1973 oil embargo, delivery of oil- and gas-fired combustion turbines exceeded 5 gigawatts per year. Nearly 40 gigawatts of combustion turbines remain in service today.

Construction of new powerplants by the electric utility industry has dropped sharply. At the same time, continued growth in electricity demand is expected to shrink reserve margins once again, so they could approach 20 percent by the mid-1990's. Without adequate advance planning, utilities or others may once again have to rely on combustion turbines for extended periods to maintain reliable service. This could lead to an uneconomic use of gas that otherwise could be substituted for oil in many applications throughout the economy. Such uneconomic use of gas could contribute to higher oil prices or higher oil imports.

Today, many utilities are plannning to build gas-fired combustion-turbine/combined-cycle plants. Some intend to construct these plants so as to allow substitution of synthetic gas from coal at a later date. Although this combination of technologies has many attractive attributes (including the ability to restrict emissions of most pollutants) and has performed well on a demonstration basis, it is not yet fully developed commercially and is significantly more capital-intensive than a conventional combustion turbine.

The use of natural gas as a fuel for electricity production has been, and may continue to be, economically appropriate. In peaking applications, combustion turbines burning natural gas or oil are making an economic contribution to power production. The public policy concern is whether the electric power industry faces substantial regulatory biases that could cause it to rely in the future on oil- and natural gas-fired facilities to an extent that would not be economically justified.

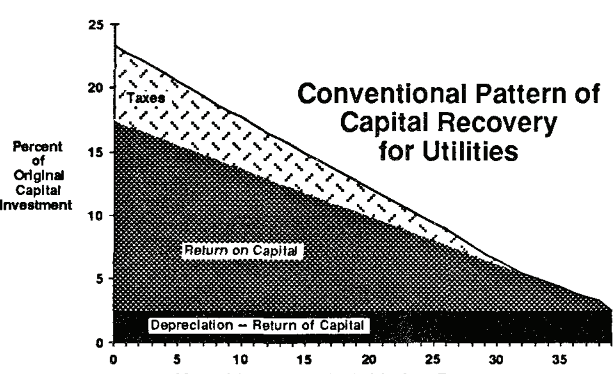
INSTITUTIONAL PROBLEMS DEMONSTRATE THE NEED FOR REGULATORY REFORM

"RATE SHOCK" RESULTS PARTLY FROM REGULATORY PRACTICES GOVERNING CAPITAL RECOVERY

After decades of continuously falling generation costs and prices for electricity, the industry began to experience cost increases in the early 1970's. Electricity prices increased by about 60 percent in real terms on a national average basis from 1973 to 1982. Since then, electricity prices (measured nationally) have held almost constant in real terms; and they are projected to change little through the mid-1990's.

In some regions and localities, on the other hand, serious "rate shocks" have occurred and are continuing. If a new facility represents a major addition to a utility's asset base (and sometimes a single new plant may cost as much as the residual value of all prior installations combined), it can cause rates (which are based on the utility's past investments) to increase sharply. This frustrates consumers and threatens the commercial viability of industries in the utility's service territory.

Rate shock has several component causes, but the most fundamental cause is the pattern of cost recovery for capital assets that is inherent in traditional rate-of-return regulation as practiced in this country. As the chart on this page shows, when a new asset is introduced into a utility company's rate base, the pattern of cost recovery is heavily loaded toward the near term:



- Even though the asset may have a 40- to 60-year life, customers are charged almost 25 percent of the original cost of the facility in its first year of operation (unless a special "phase-in" scheme is used) to recover capital, earn a return on the capital, and pay Federal and State taxes.
- These charges are then reduced year by year as the facility is depreciated. Thus, although a new plant can cause a sharp increase in rates during its early years of operation, it may serve to reduce rates through most of its operating life.

This front-end loading of cost recovery creates problems for consumers, regulators, and utility investors. However, the regulatory practices that underlie it have developed over several decades and are not easy to change.

This front-loaded pattern of cost recovery does not occur in unregulated markets, where prices are set by competitive forces.

UTILITIES' "CAPITAL AVERSION" INHIBITS SELECTION OF CAPITAL-INTENSIVE OPTIONS

The present climate of utility regulation in many States discourages new capital investment, and this restricts the range of new supply options that might otherwise be considered.

A fundamental responsibility of a utility regulator is to balance customers' welfare with that of company stockholders; but in recent years the traditional compact in such regulation (which balanced limited risks with limited rewards) has been broken.

Sources: Energy Daily and Boston Globe

- In cases where utilities made investment decisions that seemed sound when approved but later appeared wrong, regulators have frequently ruled that utilities must forego recovery of a substantial portion of their sunk costs.

- When utility investment decisions have proven to be sound, on the other hand, regulators have routinely allocated most of the benefits to the utilities' customers. Utilities' returns on such beneficial investments often have been unduly limited.

This asymmetry in risks and rewards to utilities is caused in large part by pressure on regulators to hold down electricity rates in the near term. This pressure comes from various sources:

- Many consumers who regard electricity as a basic necessity, to which they are entitled at a cheap price; and the regulatory process is sensitive to these political forces.

- Changes in utility industry economics, which have frequently caused new plants to cost more in real terms than previous plants.

- The "front-end loading" of the capital costs of new plants in rates, which frequently causes significant short-term local or regional rate increases ("rate shocks"), even when the lower operating costs of these plants should reduce rates over the long term.

- High costs related to long-delayed nuclear plants, which have become easy political targets.

Some States have recently enacted legislation or regulations putting the risks associated with new plants entirely on utilities, thereby codifying an imbalance between risks and rewards.

Utility managers see the present regulatory situation as "Heads we may break even, tails we lose." The result has been a wave of plant cancellations and an aversion to new investments, especially those involving substantial capital costs, long construction periods, and regulatory uncertainties.

WITHOUT REGULATORY REFORMS, UTILITY USE OF OIL AND GAS MAY HIT INEFFICIENT LEVELS

Under current regulation, utilities will be reluctant to make the major investments necessary for capital-intensive coal, nuclear, and renewables capacity.

This aversion to capital investment is leading many utilities to prefer gas-fired, combined-cycle combustion turbines in adding capacity. Furthermore, about 40 percent of the capacity for which applications have been filed under the Public Utility Regulatory Policies Act by potential nonutility suppliers is gas- or oil-fired.

If these trends continue, consumption of oil and gas for the generation of electricity could more than double in the next 20 years—a period in which oil and gas prices are expected to rise, world oil supplies are likely to tighten, and gas is likely to be in demand as an alternative to oil.

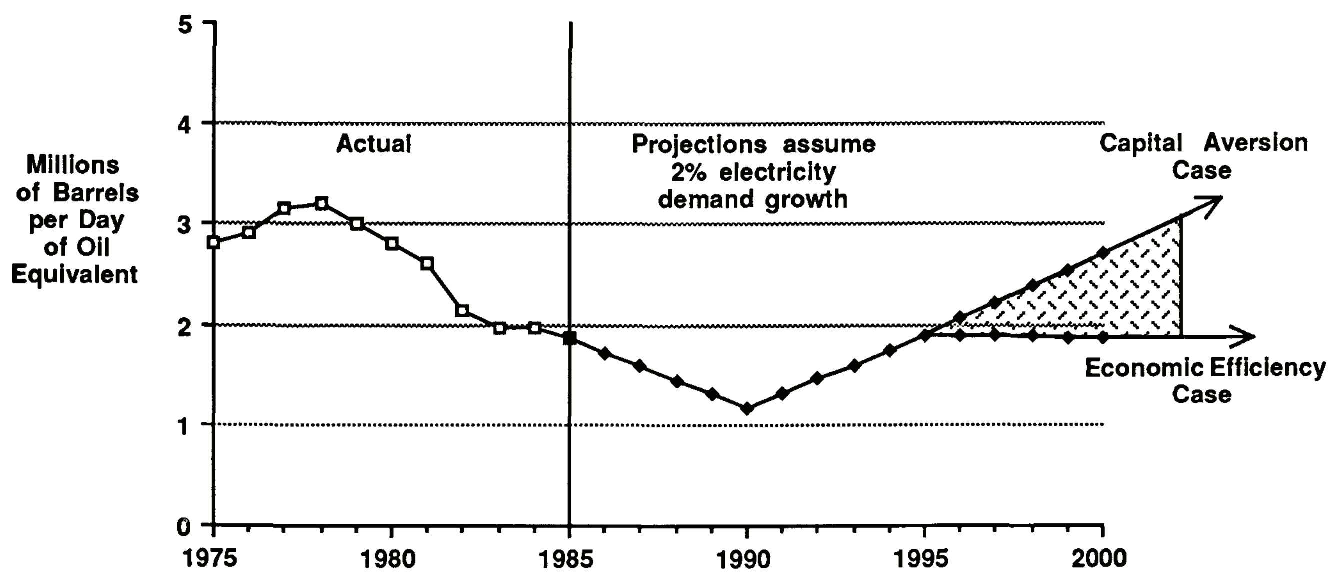
As shown in the accompanying chart, the strategy of "no new capital-intensive investments" announced by many utilities could cause the industry's oil and gas use to rise sharply after 1995. By contrast, regulatory reforms designed to facilitate appropriate responses to market forces could lead to significantly lower use of these fuels, as well as lower electricity prices.

The chart assumes oil prices (in 1985 dollars) of $19 in 1990, $26 in 1995, $35 in 2000, and $44 in 2005. If prices take a lower path, oil and gas use for electric generation could be significantly higher in both scenarios. If prices are higher, consumption could be lower.

Consumption in both scenarios is essentially identical until about 1995, because most of the decisions to order capital-intensive facilities that could be in place by that date have already been made. As the chart shows, however, consumption of oil and gas by electric utilities could increase significantly after 1995. This rise in consumption could cause problems:

- Demand for such large quantities of oil and gas for electricity generation would help to drive up oil and gas prices.
- Total U.S oil imports could increase, with attendant impacts on national energy security.

Oil and Gas Consumption by Electric Utilities May Increase Beyond Economic Levels



The problem of rising consumption of oil or gas for electricity generation cannot be resolved efficiently through regulations or statutes that constrain the industry's technology or fuel choices. The current low cost and abundant supplies of natural gas make it an attractive option, at least in the near term. The problem is that if the industry is unable to make timely capital-intensive investments in other options, it may overcommit to new gas-fired generation, which in the longer term would unnecessarily increase power costs. Thus, the solution is to ensure that future regulatory practices allow market forces to guide the industry's technology choices and investment decisions.

COGENERATION AND SMALL POWER PROVIDE MOST NEW CAPACITY, USING "PURPA" PROVISIONS

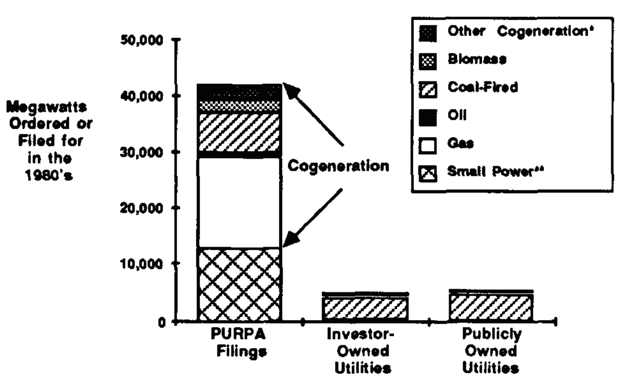
Experience under the Public Utility Regulatory Policies Act of 1978 has demonstrated the feasibility of developing nonutility-owned capacity on a basis other than traditional rate-of-return regulation, but its application has been limited to a few generating technologies (cogeneration and the use of renewable resources such as wind, solar, biomass, and small hydro).

- To benefit from the pricing arrangements established through PURPA, power suppliers must establish that their projects are "qualifying facilities" by filing applications for such status with FERC. Since 1980, applications for more than 43,500 megawatts of generating capacity have been filed. (An estimated 10 percent of this capacity was already in existence when PURPA was enacted.) Gas- and oil-fueled cogenerators make up 40 percent of the total capacity filed under PURPA through June 1986.

- Roughly 10,000 to 11,000 megawatts of this capacity is operating now, and an additional 3,000 to 4,000 megawatts is being built.

- By contrast, only 9,500 megawatts of conventional boilers have been ordered in the 1980's under traditional regulation (4,500 by investor-owned utilities and 5,000 by publicly owned utilities). Actual construction by an investor-owned utility has begun on only one 720-megawatt plant under traditional regulation. All nuclear plants now in operation or still under construction were ordered before 1974.

Electric Capacity Filed for or Ordered in the 1980's



* Waste, solar, and nuclear.
** Small hydro, wind, geothermal, etc.

One reason for PURPA's attractiveness to entrepreneurs is that regulation under it differs fundamentally from traditional electric utility regulation:

- Under PURPA, prices to be paid to developers are set before funds are committed to a project, and profits are not directly regulated. PURPA power suppliers face only the risks associated with controlling construction costs and operating efficiencies. Superior performance yields higher returns.

- Under traditional regulation, overall investment returns are regulated and electricity prices are adjusted after each major project is completed. Increasingly, full recovery of sunk investments is being challenged and disallowed. Utility investors assume much of the risk associated with regulatory changes, uncertain demand growth, construction costs, and operating costs—but without much hope of higher returns for better performance.

However, the benefits of PURPA are now open to only a few supply options.

PURPA is functioning increasingly as a mechanism for developing new supply; but its technical, fuel, size, and ownership restrictions limit the range of facilities that can be developed under it. Thus, fair competition among *all* of the available supply technologies is being inhibited.

NEW CAPACITY REACHES RETAIL MARKETS NOW VIA FOUR REGULATORY PATHS

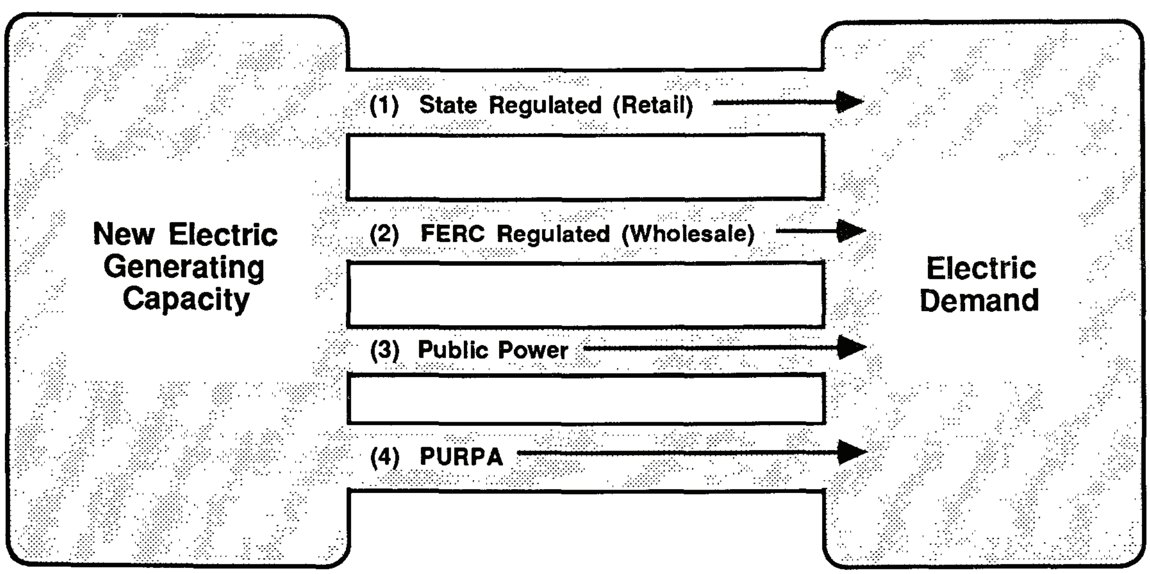
Within the current regulatory framework, new electric supplies that will be needed by the United States in the 1990's and beyond can be delivered to the retail market through the four institutional "paths" illustrated below.

- **Path 1:** The State-regulated path is the traditional one through which investor-owned utilities have built most of the Nation's existing capacity. However, a growing imbalance between the risks and rewards associated with new investments in most States has made utilities wary of using this path for new capital-intensive investments. Only options that have relatively small capital requirements—such as gas-fired, combined-cycle combustion turbines—are likely to reach the market through this path in the future.

- **Path 2:** The Federal Energy Regulatory Commission regulates sales of electric energy (firm and nonfirm) at wholesale in interstate commerce. This includes transactions between investor-owned utilities and wholesale sales to municipals and cooperatives. Increased use of this path (and the possible growth of wholesale-only utilities) raises concerns about the appropriate balance between Federal and State regulation.

- **Path 3:** Publicly owned utilities use below-market interest rate loans to build new generating capacity, in most instances without either State or Federal regulatory oversight of the potential effect on rates.

- **Path 4:** Under the Public Utility Regulatory Policies Act of 1978, nonutility developers of cogeneration and small power production capacity are guaranteed prices for their electricity output based on the local utility's "avoided costs."



Capital aversion is leading utilities away from the State-regulated (retail) path, which is resulting in more reliance on the other three paths. This is leading to:

- More regulation at the Federal level (Path 2). Wholesale power transactions have grown by 40 percent and wheeling by 150 percent over the past 10 years, while retail sales have only grown by 30 percent. This trend toward regional bulk power markets is a result of many forces, but it could be accelerated if utilities continue to avoid the use of Path 1.

- More public power (Path 3). For example, the installed generating capacity of cooperatives borrowing from the Rural Electrification Administration (REA) has grown on average more than 10 percent for the past 10 years. Total U.S. installed generating capacity has grown on average less than 5 percent over the same period. Other publicly owned utilities include Federal power marketing agencies, municipals, and TVA. The capital expansion by the public power sector has been made possible by subsidized, tax-free capital. Although some argue that the existence of a mixed public and private electric system offers a form of "yardstick" competition, the expansion of competition in the electric power industry is likely to cause an increasing focus on the subsidies offered to public power through tax-free securities and access to Federal funds at less than market rates.

- More third-party cogenerated power (Path 4). The chart on page 157 demonstrates the dramatic growth of nonutility generation under PURPA relative to investor- and publicly owned utilities.

None of the current regulatory paths (whether singly or in combination) facilitates fair competition among all potential generation sources and ensures that those which are most economic over the long term will be developed as needed to meet new supply requirements.

PROPOSALS FOR REFORM SHOULD BE GAUGED BY FIVE BASIC CRITERIA

As a matter of national economic policy and energy security, any reform proposal should have the objective of ensuring that future U.S. electricity supplies will be adequate, efficient, and reliable for the long term. In particular, such reforms should be designed to ensure that appropriate investments are made in both conservation and electric generating capacity.

Each supply option should have an equal chance to compete for its appropriate role in the capacity mix. To encourage free choice of the most efficient options, there must be some means of balancing risks and rewards for future supply investments. It is also fundamentally important that the playing field for this competition be kept as level as possible. No fuel, technology, or ownership structure (for example, public versus private) should have an inherent advantage administered by governments. Each should compete on the basis of its own merits.

Evolutionary change in regulation is more appropriate and feasible than revolutionary change. Reform should respect existing "property rights." Proposals that challenge existing rights or benefits will meet stiff resistance from the interests affected.

Preservation of an appropriate balance between Federal and State responsibilities in electricity rate regulation is essential because each has critical functions to perform. Retail sales could not be regulated efficiently at the Federal level—the industry and its service areas are simply too diverse and heterogeneous. On the other hand, wholesale transactions between utilities are an increasingly important element of interstate commerce and thus require Federal regulation.

Reform proposals must be consistent with public goals for protection of health, safety, and the environment. Reform in the economic regulation of electricity should be carefully insulated from other regulatory policies that deal with the health, safety, and environmental attributes of the various options.

IT IS TIME TO DEVELOP A CONSENSUS ON ELECTRIC REGULATORY REFORM

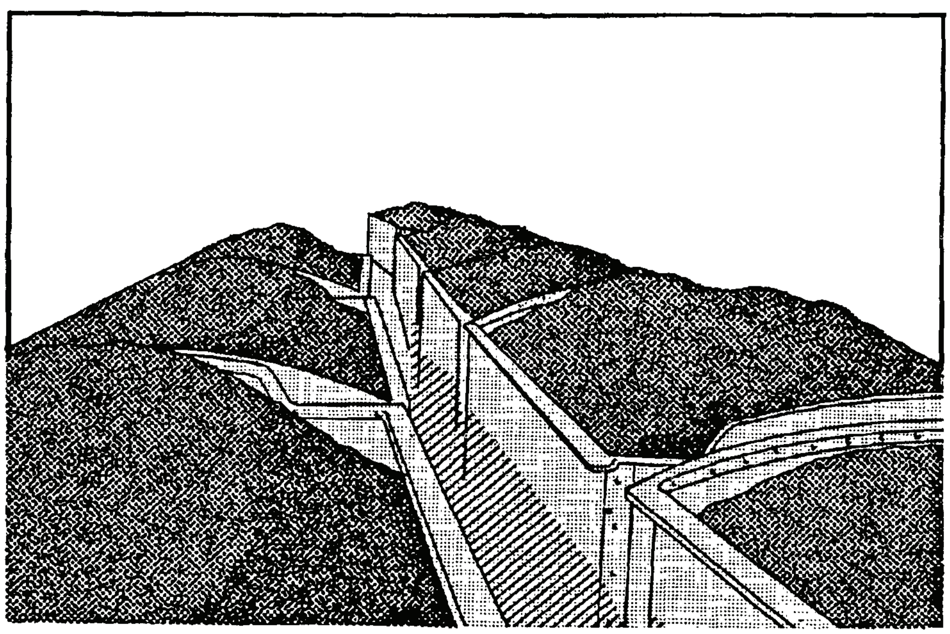
Any effort to develop a consensus for reform of the electric power industry must be based on a careful and deliberate process. The technical and political complexity of the issues involved, as well as the diversity of the industry from region to region, demands that all affected players get the chance to participate fully in any reform effort. The industry (both public and private), consumers, and regulators must all be closely involved in any effort to set a new course for the industry.

Because there is excess generating capacity now in most regions of the country, this is a period during which these difficult issues can be addressed without the pressures of an imminent crisis; but continuing growth in electricity demand is eroding this buffer. A few regions are already starting to grapple with difficult choices in meeting new supply needs. It is fundamentally important to energy and economic policy at both the national and local level that these choices be made in an environment that minimizes biases against market-based solutions.

It is essential to national energy security, as well as to national economic policy, that the electric power infrastructure of this country continue to be the model for the world. But maintaining the high standards of the past will require a careful and thoughtful policy reponse to a changing environment. The Department of Energy will bring increasing attention to these important issues of electricity policy. It will try to bring these important issues into proper focus and encourage the various players to work together in identifying and implementing timely and efficient reforms.

6

REALIZING COAL'S POTENTIAL



THE SITUATION IN BRIEF

By using more coal since the early 1970's, the United States and the free world have made themselves less dependent on oil without giving up economic growth. In the future, coal can do more to help this country grow economically while becoming more secure from an energy standpoint—if technical and regulatory difficulties at each stage of the "coal supply cycle" (production, shipping, and end-use) can be resolved prudently.

This Nation has more coal than any other fossil fuel resource; and for many decades of U.S. history, coal was king. It fueled the industrial revolution, powered the railroads, and heated many homes and businesses. But, in the face of increased oil and gas supplies and their convenience of use, and with the advent of nuclear power, coal's role diminished rapidly in the first two-thirds of the twentieth century.

The 1970's and early 80's brought a new coal age. Higher oil and gas prices (plus utilities' reluctance to make additional nuclear commitments) resulted in the Nation's using about a quarter of a billion tons more coal in 1985 than it did in 1974. And, although the use of coal has increased, air quality has improved at the same time.

Within the United States, the electricity sector has stepped up its use of coal by almost 70 percent in the past decade, while cutting its use of oil by more than two-thirds. Even broader acceptance of coal can boost employment and improve the U.S. balance of payments. Future patterns of coal consumption hinge in part, however, on still-unresolved questions—including the desirability of further reducing emissions related to the formation of acidic compounds and ozone, and longer term concerns about the potential effect of an increased buildup of carbon dioxide in the atmosphere.

To many in the industry, the recent history of U.S. coal has seemed like a series of brief ups and disheartening downs. Short upward spurts in demand have attracted new investment and sparked new hopes, but the sustained boom that was predicted confidently by euphoric planners in the mid-1970's never materialized. Many mines that were opened in anticipation of ever higher demand are now either shut down or producing much less than they could because of the failure of coal use to grow as rapidly as once expected. There is simply no market at present for the additional coal the United States is capable of mining.

The recent fall in oil prices that reversed the fortunes of the oil and gas industry has also chipped away at the already poor financial condition of coal producers. Profits and new investments are down, unemployment in the coal fields is high, and the survival of many marginal producers is in doubt.

To achieve coal's full potential, its costs must remain reasonable, and unnecessary barriers to its use in a competitive market should be removed. The policy guidelines to reach these goals boil down to these:

- Continued development and commercial demonstration of "clean coal" technologies can increase world and U.S. coal use while reducing combustion emissions.

- An efficient coal supply chain (production, processing, and transportation) can reduce the costs of using coal.

- Balanced environmental programs can reduce the costs of using coal, while actually improving environmental quality.

- Reducing barriers to investment in new, upgraded, environmentally clean coal-use facilities will make coal more competitive in the marketplace.

- A vigorous trade policy can expand U.S. exports of coal and coal technology.

- Close consultation with industry advisory groups, such as the National Coal Council and the Energy Research Advisory Board, can reinforce government initiatives.

COAL HAS SUBSTANTIAL POTENTIAL TO LIMIT DEPENDENCE ON IMPORTED OIL

LOW OIL PRICES HAVE CONFLICTING EFFECTS ON RISING COAL DEMAND

Coal furnishes about one-fifth of all the primary energy used in the free world and nearly one-fourth of what the United States uses.

Faster-than-average worldwide growth in the use of coal, nuclear, and hydropower between 1973 and 1985 (largely in generating electricity) all helped free-world energy consumption to increase by more than 17 percent while the demand for oil showed no net increase.

For the next decade, coal is at least likely to maintain its present share of world energy consumption, and U.S. coal use should grow appreciably. When oil prices are lower, economies are stimulated; more electricity is consumed, industry flourishes, and demand for coal should rise. However, something of a paradox also exists. When oil prices are lower, that fuel may compete directly with coal to a greater extent—thus *limiting* coal demand at the same time.

At any rate, free-world use of coal has increased by more than 35 percent in the past 10 years. Estimates prepared for this study suggest that the demand will increase by another 20 to 35 percent over the next decade.

Although overall prospects for greater use of coal are thus good, uncertainty about future oil prices and economic growth reduces the incentives for prospective coal users to *invest* in using coal. Unless prospective coal users have positive incentives to choose coal, it may frequently be more convenient and less risky to turn to oil or gas. The challenge is to maximize coal's use and thereby curb demand for oil imports in the United States and the free world without overlooking economic efficiency.

FREE-WORLD CONSUMPTION OF COAL IS EXPECTED TO KEEP GOING UP

The two principal oil price scenarios used in this analysis ($23 and $28 per barrel in 1995, respectively) suggest that world consumption of coal is likely to continue rising. Within this oil-price range, in fact, there is only moderate fluctuation in world demand for coal.

Worldwide coal consumption is expected to show substantial additional growth before the end of the century, primarily because of increasing coal-fired electric generating capacity. World coal trade is expected to expand by almost 50 percent by 2000.

- The United States will continue to consume at least half the coal used within the Organization for Economic Cooperation and Development (OECD), possibly increasing its own consumption by almost 50 percent by 2000.
- Japan's consumption of coal is also expected to increase almost 50 percent by the end of the century, based entirely on growing demand for steam coal.
- European demand for coal is expected to increase by another 30 percent, with the largest tonnage increases in Germany and Italy.
- The increase in coal demand in other OECD nations is likely to approach 35 percent by the end of the century.
- Less developed countries (LDC's) are expected to have the greatest rate of increase in coal consumption, almost 60 percent between now and the year 2000.

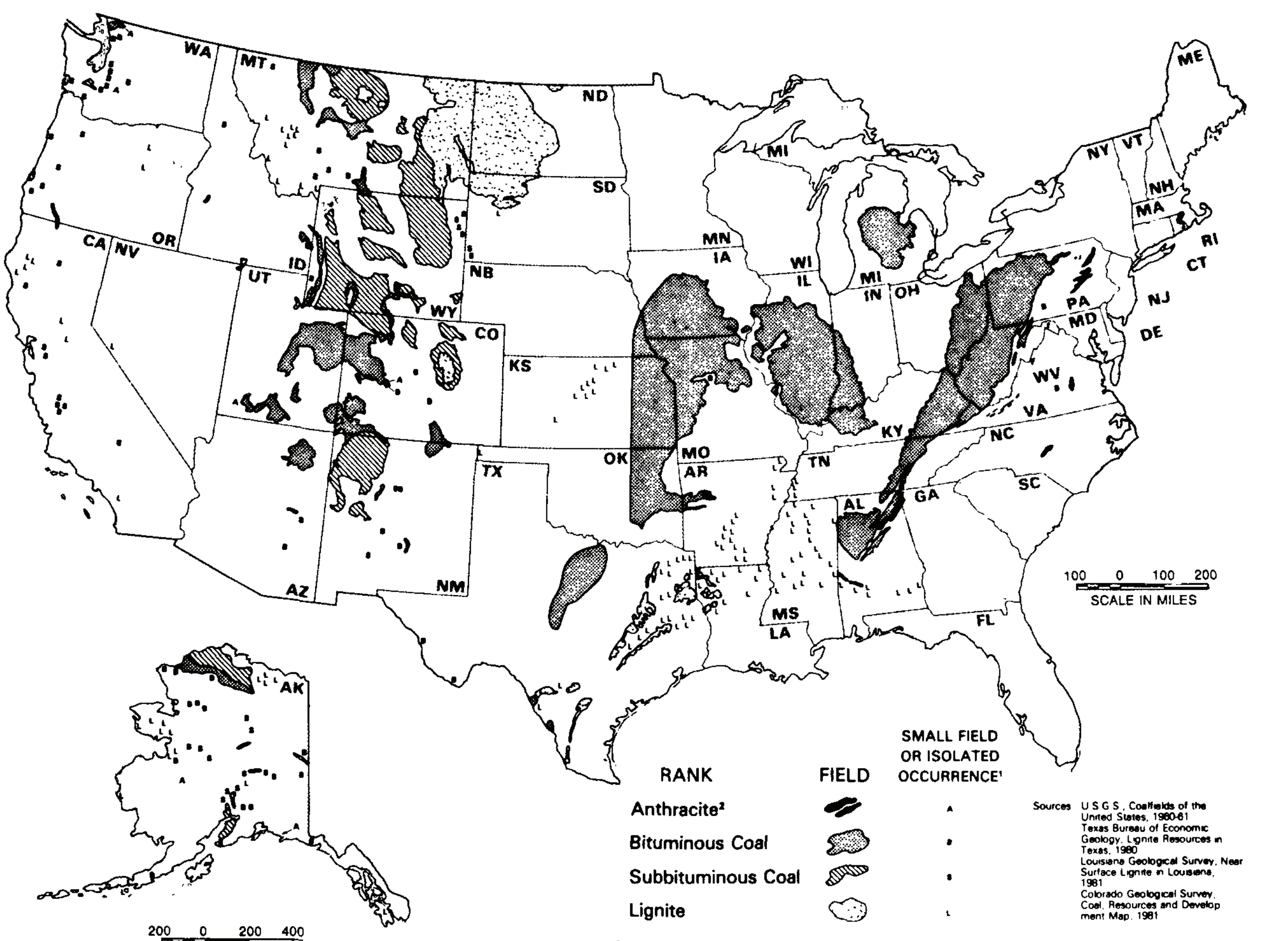
Total OECD coal demand in 1995 varies less than 10 percent under the two key price projections. This is because the effects of economic growth and fuel substitution offset one another as prices vary. If oil prices are in the higher portion of the range, coal will be substituted for oil more often. If oil prices are in the lower portion of the range, greater economic growth will spur new world demand for coal.

Existing demand for coal is relatively insensitive to lower oil prices in today's market, because coal is clearly the cheapest fuel in its most common application—electricity generation. Only if oil prices are sustained at unexpectedly low levels (below $15 per barrel) does substitution for existing coal use begin to become a factor. Demand for coal could, of course, decline if oil prices fell further.

Coal can and should play a leading role in enhancing free-world energy security:

- Coal supplies are abundant in many countries, this fuel is subject to widespread competition, and its availability is relatively insulated from foreign political manipulation.
- Demonstrated coal reserves in the United States alone are almost 500 billion tons, amounting to several hundred years of domestic supply at current levels of consumption.
- Total coal resources are many times the level of coal reserves, and some of these resources will be turned into proven reserves as more exploration is completed.

Coal-Bearing Areas of the United States



1 Symbolic representation; these small areas or data points cannot be shown to scale.
2 Principal anthracite deposits are in Pennsylvania. Small deposits occur in Alaska, Arkansas, Colorado, Massachusetts-Rhode Island, New Mexico, Utah, Virginia, Washington, and West Virginia.

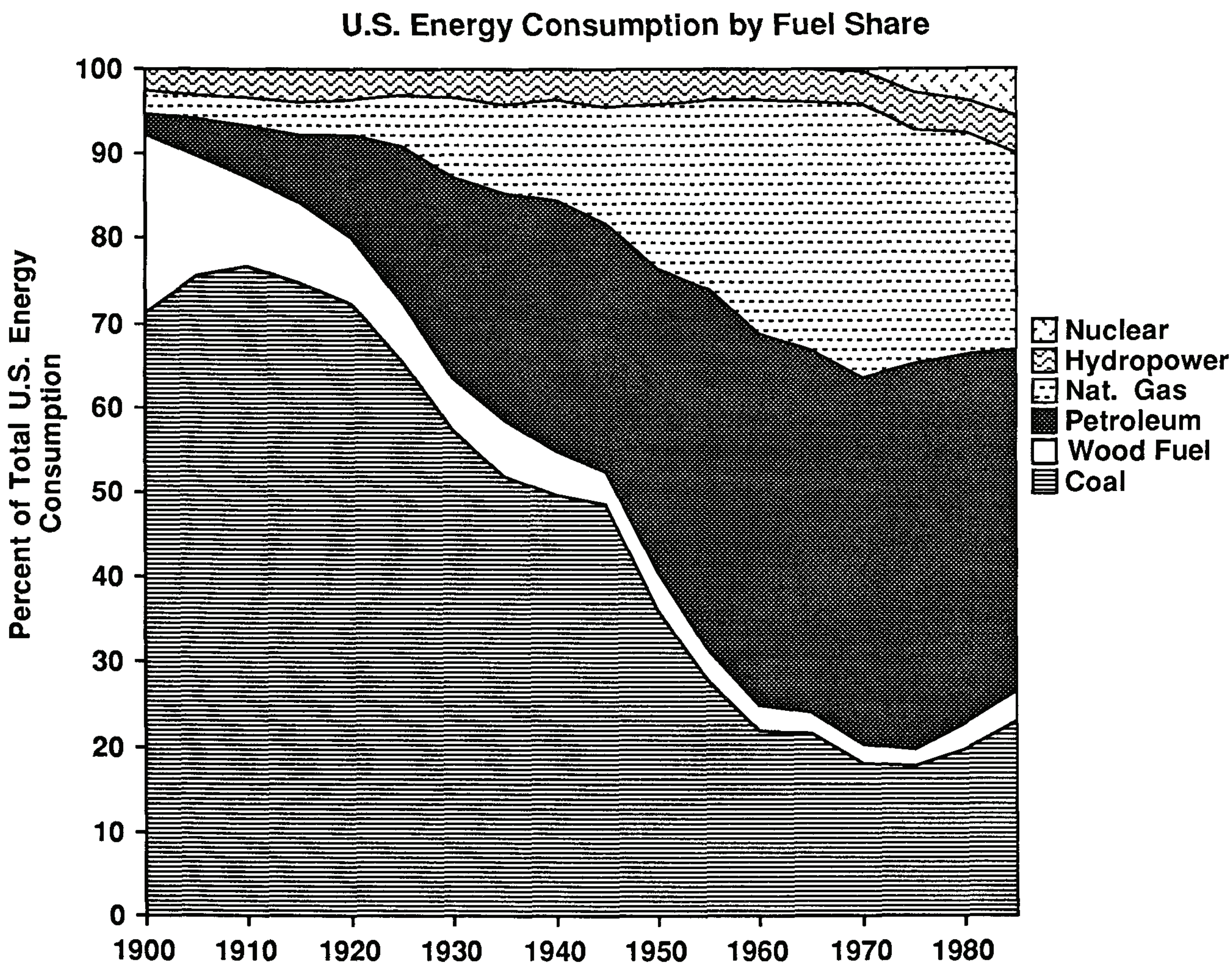
COAL, ONCE THE TOP U.S. FUEL, FELL BUT HAS REBOUNDED SINCE THE OIL PRICE SHOCKS

For much of U.S. history, coal was this country's primary fuel source. It has been mined here commercially for more than 240 years. And it was the Nation's major fuel during the industrial expansion of the late 19th century, providing nearly 90 percent of all U.S. energy from mineral fuels in 1910.

Early in this century, coal began to lose its dominance as an energy source. Coal lost markets through the early 1970's for many reasons:

- U.S. gas and oil production and pipelines expanded.
- Coal-fired locomotives converted to diesel fuel.
- Packaged industrial boilers were developed, using oil and gas as fuel.
- Use of coal as a residential and commercial heating source decreased.
- Inexpensive Middle East oil became available.
- Oil, gas, and nuclear fuels increased as electricity-generating sources.
- Concerns about air pollution emerged, adding to the costs of using coal.

By the early 1970's, coal markets were reduced essentially to two:



- U.S. electric utilities in or near coalfields (steam coal).
- Domestic and foreign steelmaking (metallurgical coal).

But the oil price shocks of the 1970's gave coal new growth opportunities:

- Conversion of some coal-capable powerplants back to coal.
- Increased use of existing coal-fired powerplants, via dispatching and interregional transmission.
- Increased use of coal in new electric generating capacity.
- Replacement of oil and gas in cement and lime kilns.
- Reversal of coal's decline as an industrial boiler fuel.
- Development of a vigorous market in the international steam coal trade.

Since 1974, domestic coal consumption has increased by almost 50 percent, or the energy equivalent of almost 2.3 million barrels per day of oil.

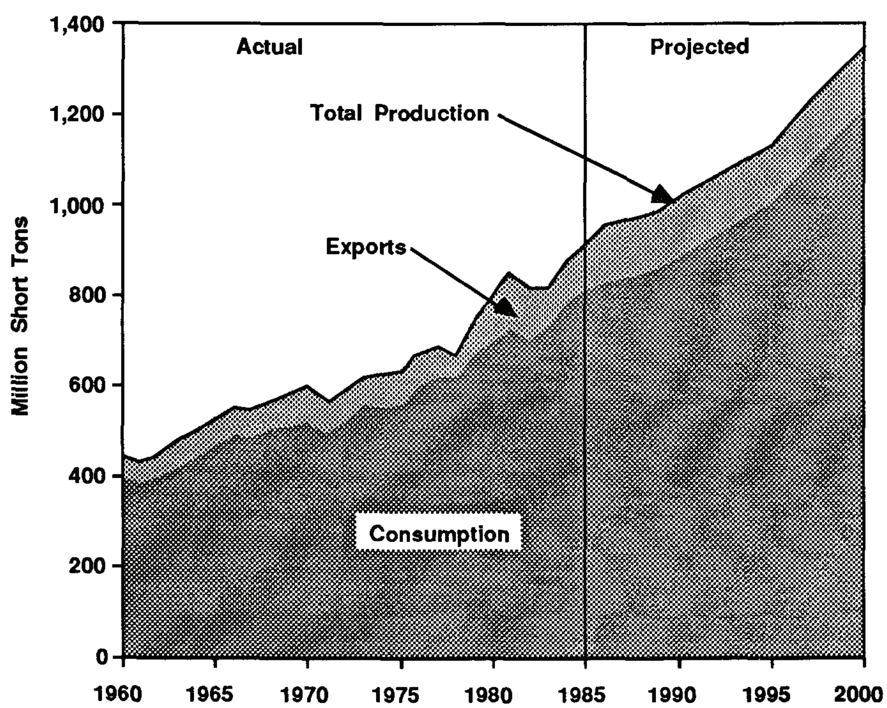
CONSUMPTION AND PRODUCTION OF COAL IN THE U.S. SHOULD CONTINUE TO GROW

U.S. coal consumption is expected to continue expanding, possibly increasing by one-fourth between 1985 and 1995.

This growth is primarily the result of increasing electric utility demand for coal. Electric utilities will continue to consume more than 80 percent of the coal used in the United States, with electric utility demand for coal growing almost 30 percent by 1995.

Coal use in the industrial sector currently comprises about 15 percent of domestic coal consumption. Industrial demand for coal is expected to increase slightly by 1995, despite continuing declines projected in domestic demand for metallurgical coals.

Actual and Projected U.S. Coal Production



U.S. demand for coal is even less sensitive to variations in oil prices than is world coal demand. This is attributable in part to the differences in types of electric generating capacity. Compared with other OECD countries, a higher proportion of U.S. generating capacity is coal-based, and fuel-switching capability is less. In addition, oil prices must be lower if oil is to substitute for coal in the United States, because the domestic cost of coal is typically less than the cost of coal traded in the world market.

U.S. coal production is also expected to increase, but the rate of increase is uncertain—primarily because there is considerable uncertainty about the volume of U.S. coal exports. Estimates of U.S. coal exports in 1995 range from 80 to 120 million tons per year, compared with 91 million tons during 1985. The wide range in these projections is attributable mainly to two factors:

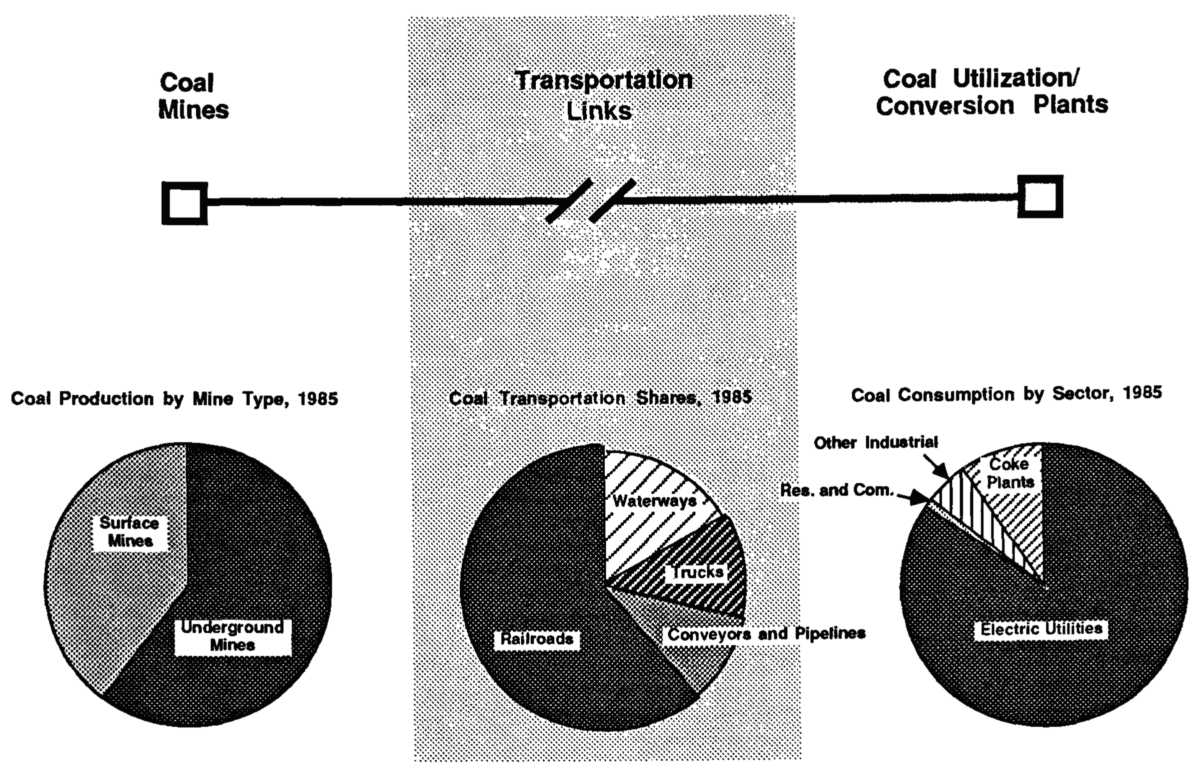
- Worldwide demand for coal is somewhat more sensitive to oil prices than U.S. demand.
- It is uncertain how competitive other coal-exporting countries will be, in terms both of costs and reliability.

Coal production in the Western United States is expected to continue to increase more rapidly than production in the East. The principal reason for this difference is faster-growing demand in the West for coal to meet growth in electricity demand.

EXTENT OF COAL'S CONTRIBUTION DEPENDS ON EFFICIENCY OF ITS FUEL-SUPPLY CHAIN

This is a fuel whose use is not constrained by its supply. The United States and the world have large recoverable coal reserves and unused mine capacity, which can respond rapidly to additional demand. As a result, the delivered price of coal is generally lower and likely to remain more stable than the prices of oil and gas. Nevertheless, coal faces stiff competition in some marginal applications from

The Coal Supply Chain



both oil and gas—especially whenever the prices of the latter fuels drop.

Coal is a demand-constrained commodity. The only likelihood that its use might increase much beyond projected levels would involve increasing demand. Lower coal prices would promote some increase in consumption, but more substantial demand increases are hindered currently by various technological and regulatory obstacles. To some extent, they affect each step in the coal-supply chain—production, delivery, and use.

Coal has a number of characteristics that currently reduce its competitiveness:

- Coal is bulky. It is relatively expensive to move, requires substantial storage space at the site of its use, and produces significant amounts of waste products that must be disposed of.

- Coal-burning equipment is generally more expensive than that which uses fluid fuels. High capital costs tend to limit coal to applications where large capacities and high utilization rates can compensate for larger initial capital costs.

- Emission-control devices for coal-burning plants are expensive to install and maintain.

For coal to fulfill its potential, artificial barriers to its ability to compete with oil and gas in a free market must be removed. The challenge is to ensure that the use of coal be made as inexpensive, clean, and convenient as possible.

Government regulations affect coal at all stages of coal development, production, and use. To the extent that they are poorly conceived or inefficiently implemented, regulations can add unnecessarily to coal's costs.

OBSTACLES EXIST TO INCREASED USE OF COAL, AND ALL DESERVE TO BE ANALYZED FAIRLY

HIGHER MINE PRODUCTIVITY HAS CUT COAL PRICES, BUT POLICIES NEED FRESH STUDY

Overcapacity has forced producers to look for new ways to sell more coal, and price competition with other energy sources has spurred them to gains in mine productivity. The resulting cost cuts per ton of output often have outpaced the cost increases attributable to mining and reclamation regulations. As a result, real coal prices have fallen in the United States.

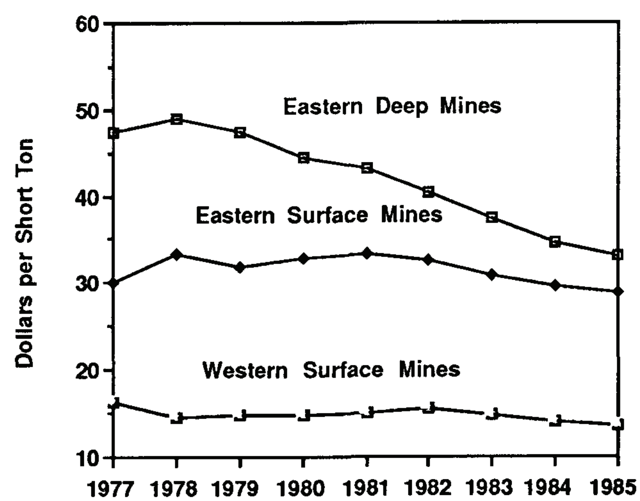
Some of the costs added by coal production regulations appear to be unnecessary, however, because they go beyond what is essential in meeting environmental and health and safety standards. Some areas in which re-examining current policies might uncover more effective solutions include these:

- Surface mining reclamation requirements and fees.
- Restrictions on subsidence from underground mines, which hinder the use of more productive extraction techniques and reduce minable reserves.
- Mine safety and health regulations in general.
- Long-pending regulatory actions, such as issuance of standards for waste disposal and "fugitive dust."

The Federal Government also influences coal markets substantially through its leasing programs. In the West, the Federal Government owns about 60 percent of all coal and indirectly controls another 20 percent. Yet Federal coal leasing has been under a moratorium for 12 of the past 15 years—due not only to environmental concern, but also to uncertainties about methods for assigning values to lease tracts and for bidding. This has made it difficult to match supply with potential markets and has hindered the orderly development of a sound transportation infrastructure.

- Federal royalties on leases granted since 1976 generally have been 8 percent for underground mines and 12.5 percent for surface mines. When first imposed in 1976, these rates were far above prevailing levels; and if royalties on Federal coal are excessive, the Government may lose revenues in the long run—while at the same time consumers pay higher-than-efficient prices for coal. In addition, pre-1976 lease royalties are typically paid on a cents-per-ton basis rather than being computed as a percentage. This situation may distort production away from the lowest cost coal supplies.
- Still another problem concerns Federal "diligence requirements." Under current law, these bar holders of undeveloped pre-1976 leases from bidding for new coal, oil, or gas leases. If they "turn back" such leases to comply with these requirements, however,

F.O.B. Mine Values (1985 Dollars)



owners stand to lose the development costs they have already incurred. Furthermore, new lessees might have to incur those same costs again.

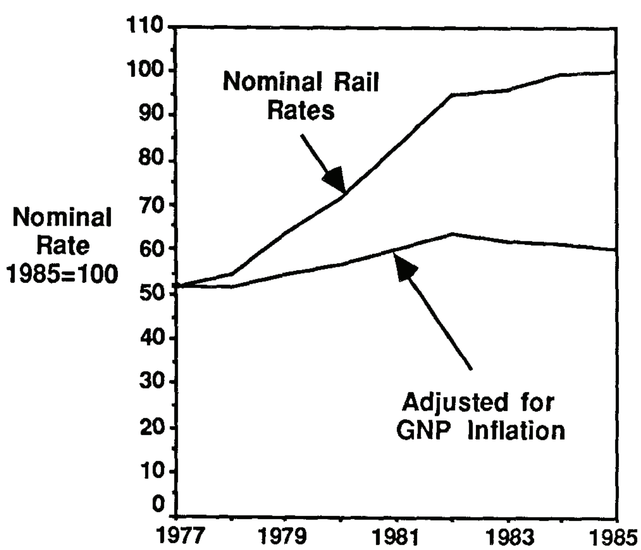
RAIL DEREGULATION IS HELPING MOVE COAL MORE EFFICIENTLY; COMPETITIVE TRANSPORT STRESSED

Transportation expenses typically represent about 30 percent of the delivered cost of coal, and they can be more than 70 percent. Coal mines often are located hundreds of miles from the consumer; and coal—as a bulky commodity—is not easy to haul.

Coal moves by several modes, but more than 60 percent of it is delivered by rail. Trucks and conveyors typically are used for short distances, and barge and rail transportation typically haul coal longer distances. Seventeen percent moves by water, 12 percent by truck, and 10 percent by conveyor and pipeline.

The Staggers Rail Act of 1980 has helped railroads to improve their own operating efficiency and to reduce costs. Lower costs have contributed to the improved financial performance of railroads and have helped to keep increases in rail rates relatively small. Because many individual coal shippers are served by a single railroad for all or portions of the distance between mines and the point of use, the Staggers Act was designed to offer protection for such shippers against unreasonable rates.

Index of U.S. Rail Rates



The Administration supported recently enacted legislation that will enable coal to be moved more efficiently by water, too, if critical port and inland waterway projects identified in this legislation can be completed expeditiously. Higher user fees in the form of increased fuel taxes on waterborne traffic will help to defray the costs of these improvements. Coal transportation also can be made more efficient by deepening some ports so that larger colliers have access to U.S. coals. Local-Federal cost-sharing will help to make decisions about such port improvements sensitive to market realities.

Coal slurry pipelines might also make coal transportation in the United States more efficient and more competitive. However, their development has been hindered by difficulties in securing rights-of-way across property controlled by the railroads, by environmental concerns, and by problems in obtaining water to operate such pipelines.

ELECTRICITY USES MOST COAL, BUT REGULATORY PRACTICES DISCOURAGE A GREATER ROLE

Electric utilities consume more than 80 percent of the coal produced in this country. More than 55 percent of the electricity generated in the United States is coal-fired. Coal is still an economic fuel choice for most baseload electric utility capacity. Its lower fuel costs (relative to oil and gas) can more than offset its higher capital costs.

As noted earlier, growth in demand for electricity will probably continue to be closely related to economic growth; and even relatively conservative assumptions about demand growth and retirements of existing facilities indicate a need for at least

100 gigawatts of additional capacity (beyond units already announced) by the year 2000. Meeting new demand primarily with fluid fuels would increase consumption of oil and gas by 2.5 million barrels per day of oil equivalent.

For coal to share in this market, however—and to provide an efficient source of electricity for the long term—its potential users must be confident that:

- Coal prices are predictable.
- Coal burning and the pollution-control equipment associated with it are cost-effective and reliable.
- There are adequate financial incentives for taking the risk of making higher capital investment.

Low oil and gas prices, combined with the lower capital investments required to burn these fuels, could tempt utilities to avoid new commitments to coal. Some regulatory practices exacerbate this effect. Utilities are increasingly being required to absorb the risks of new capital investments, while the benefits of profitable investments continue to flow through to consumers. This growing imbalance between the risks and rewards in new capital investment has reduced the willingness of utilities to pursue the more capital-intensive options, including coal-based generation. If pollution-control standards are revised and stricter regulation is imposed on emissions, this would increase the cost of using coal further; and the Nation's most substantial market for this abundant domestic fuel would become less attractive.

MANY QUESTIONS REMAIN ABOUT "ACID RAIN" AS RESEARCH EFFORTS CONTINUE

Acidic deposition ("acid rain") is a major environmental concern, even though scientists are still uncertain about the extent of its effects and how much specific pollutants contribute to them. Emissions in the air that lead to acidic deposition are sulfur dioxide, nitrogen oxide, and hydrocarbons. Coal-fired boilers are the principal source of sulfur dioxide emissions in the United States and a major source of nitrogen oxide emissions.

The principal potential consequences of acid deposition are effects on aquatic life in headwater lakes and streams, damage to forests, and a speedup in the "weathering" of some manmade materials. Historically, acid deposition has been associated with damaged aquatic resources in the Northeast.

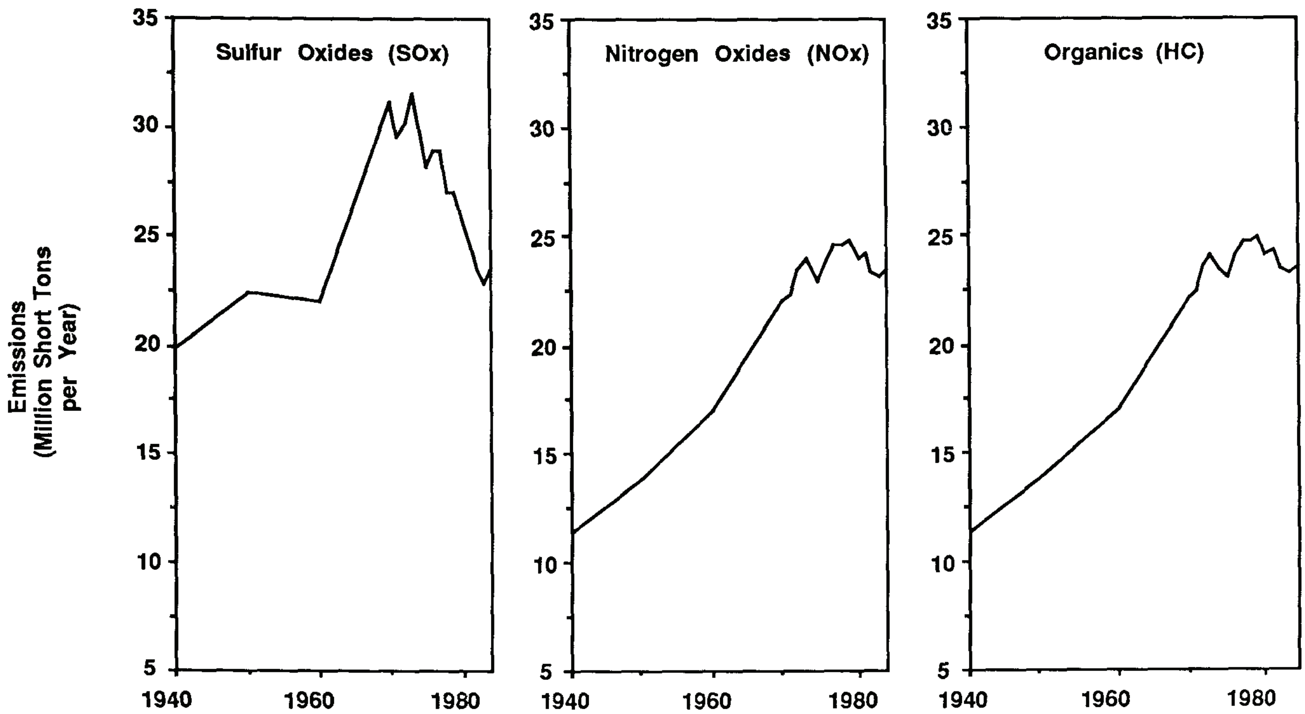
The types, causes, locations, and severity of damage are still highly uncertain because the pollutants that cause harm and their exact relationship either to specific emissions or to apparent effects are so difficult to pinpoint. For example:

- Ozone is sometimes involved in forest damage, but it is not yet known whether acid rain is also a contributor.
- Research results have now ruled out acid deposition as a substantial cause of crop damage.
- Available data are unclear as to whether the aquatic effects that have been observed are declining, stabilized, or increasing.
- There are many uncertainties about the deterioration of exposed materials. It is still not known which pollutants are most important, whether the problem is primarily urban or regional, or whether it would be more cost-effective to reduce emissions further or to take mitigative measures.

A comprehensive Federal program of research, monitoring, and analysis is entering its sixth year in a 10-year plan. This program serves two related purposes:

- Increasing general understanding of the causes and effects of acid deposition.
- Confirming or refuting specific hypotheses that relate acid deposition to widespread or increasing damage.

U.S. Emission Levels of Major Air Pollutants



If it is determined that the effects from acid deposition are sufficient to justify ordering additional reductions in sulfur dioxide and nitrogen oxide emissions from facilities that are already operating, it could cost a great deal more to continue using coal in existing boilers. Prices for electricity would surely go up, and there could even be some noticeable changes in the generating fuel mix nationwide.

Whatever the effects of acidic deposition are determined to be, it will not be possible to select the most appropriate measures for addressing them without understanding how any proposed controls might affect them. It may be that major additional reductions in emissions are worthwhile, but it is also possible that current emission limits and authorities are sufficient. Thus, adding controls prematurely could turn out to be ineffective, inefficient, or even unnecessary.

NONUTILITY SECTORS OFFER OTHER OPPORTUNITIES FOR COAL TO DISPLACE OIL

About 80 percent of recoverable U.S. fossil energy reserves are coal, compared with less than 3 percent for oil and 4 percent for gas. Despite these vast coal reserves and the extensive use of coal in the electric utility industry, however, the United States still gets less than half as much energy from coal as it does from oil. Broader substitution of coal for oil is not a simple matter.

Even though transportation is the largest consumer of oil, the near-term potential for coal to displace oil in this sector is limited, because the transportation sector has been developed around other fuel specifications and forms.

- Use of coal-fired heat engines for locomotives is one near-term possibility.

- In the long term, liquids derived from coal might be used as fuel by motor vehicles.

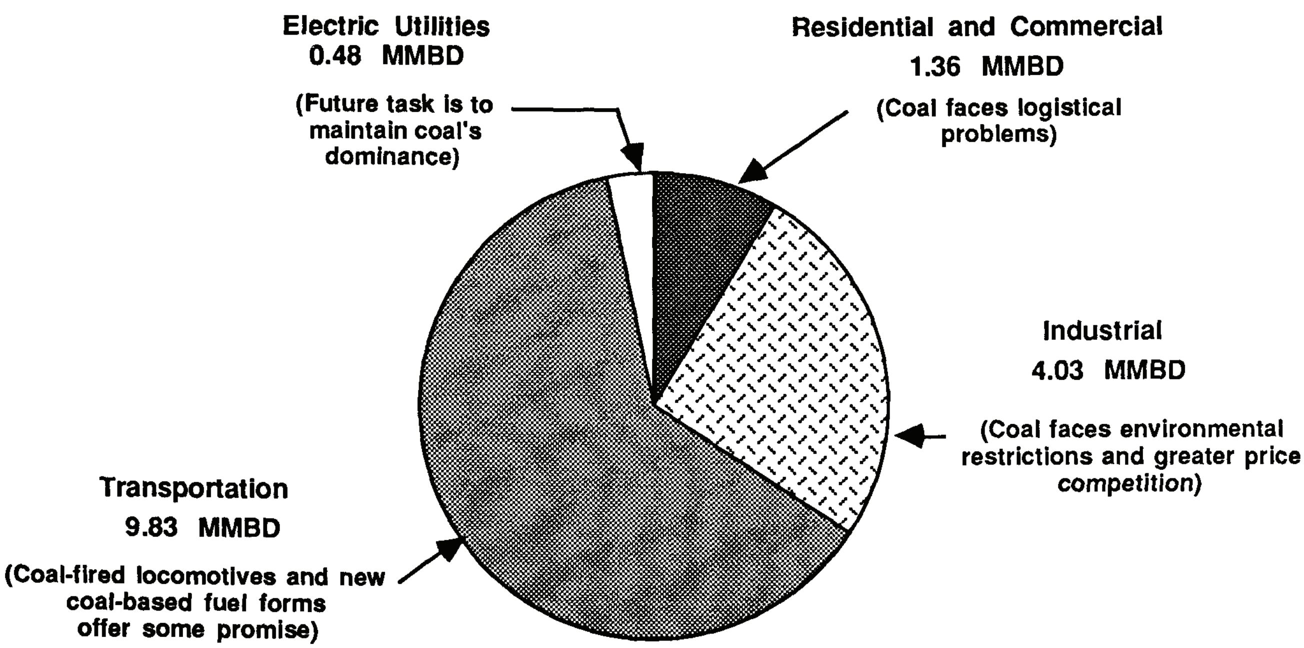
Despite the fact that coal is being used more now than it was some years ago in industrial boilers and in cement and lime kilns, the hope that coal would displace large portions of industrial oil and gas consumption has not materialized. Oil still provides more than one-third of all end-use energy used in the industrial sector. Construction of new plants that would be more likely to use coal has been cramped by the fact that the useful lives of older plants have been extended, while energy conservation and declining heavy industry production in recent years have reduced the U.S. industrial need for energy overall.

New Source Performance Standards for Industrial Boilers are currently under review. DOE has filed its comments on these proposed standards with EPA. Unless some artificial barriers to industrial coal use are removed, there is little prospect that such use will expand to any great extent any time soon:

- The use of coal in cement and lime kilns is close to saturation, while declining steel production in this country continues to limit the demand for metallurgical coal.
- With oil prices below $20 per barrel, coal sees its advantage over oil in new industrial boilers begin to slip away. Further declines in oil prices could also cause some shifts from coal to oil in kilns and coke ovens.
- Any additional environmental regulations would add to capital and operating costs of coal-fired boilers relative to other fuels.
- Many logistical problems remain if coal is to be used in smaller scale applications. Small shipment sizes involve additional preparation requirements, and there are often diseconomies of scale in equipment.

The U.S. residential and commercial sectors comprise a potential market for more than 100 million tons of coal, but direct coal use in these sectors is minor now and it continues to decline. While the vast majority of the oil and gas consumed in this sector goes into space and water heating (applications to which coal is amenable in large-scale applications), the costs and logistical problems of small-scale use have prevented the revival of these markets for coal thus far.

U.S. Oil Consumption, 1985



WORLD COAL TRADE EXPANDS, CREATING NEW POTENTIAL MARKETS FOR U.S. COAL

World coal trade is expected to continue growing in the long term. Most of the increase is expected in steam coal, while demand for metallurgical coal is likely to remain relatively flat.

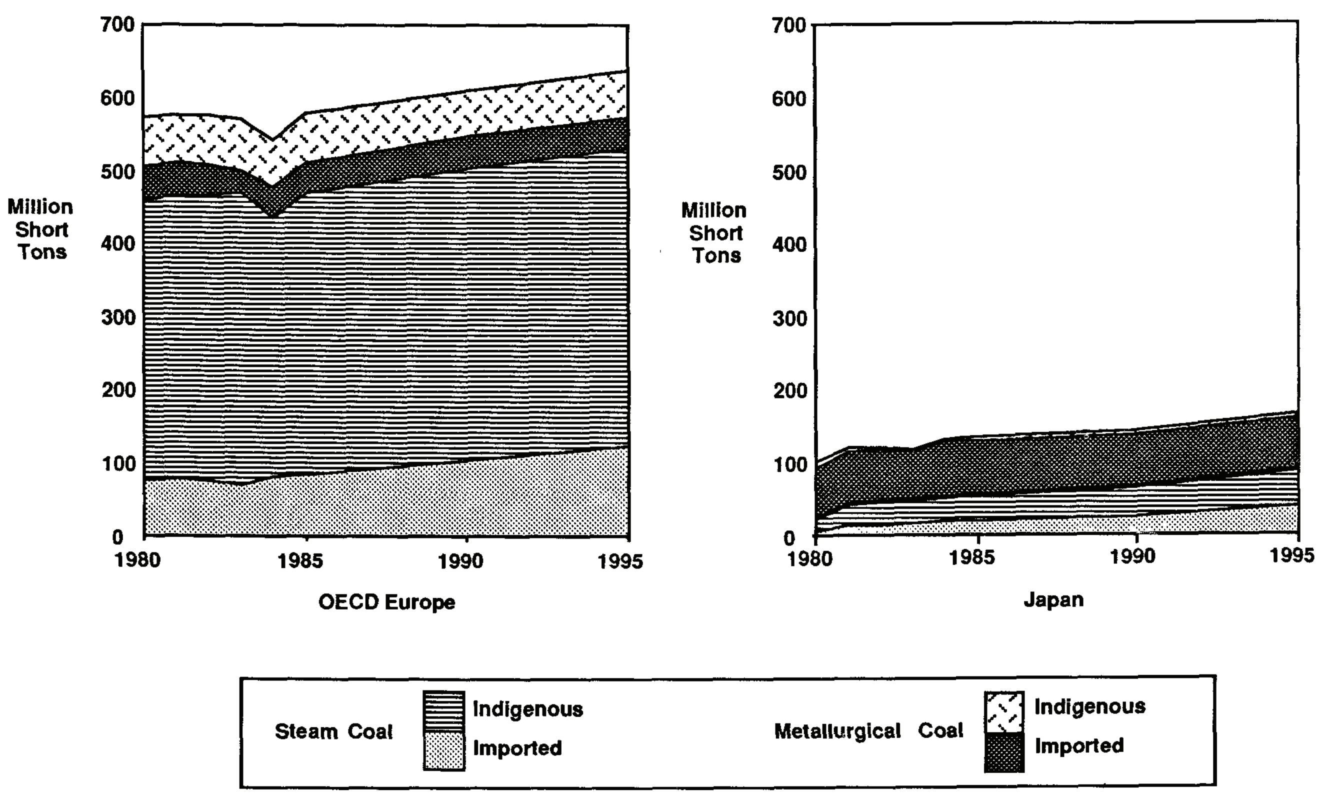
In Europe, steam-coal imports are expected to grow 79 percent between 1985 and 1995, but metallurgical coal demand is seen as stagnant. Asian steam-coal imports totaled 38.3 million short tons in 1984 and are expected to grow moderately as new coal capacity comes on line. The fastest growing steam-coal import markets in Asia are South Korea and Taiwan. South Korea also is increasing imports of metallurgical coal. Japanese coal imports have been weighted toward metallurgical grades, but this segment of Japanese demand has leveled off.

Reductions in foreign governments' subsidies of their domestic coal production could increase the amount of U.S. coal some of those countries import. The United States clearly has the capacity to supply the world with more coal.

To complement its large reserve base, the United States has excess production, transportation, and port capacity. Much of this infrastructure has been completed over the past 5 years. U.S. coal producers continue to increase their productivity and to reduce costs. Moreover, a large and stable labor force ensures that the United States is able to meet its commitments.

Despite these strengths, the United States recently has lost market share to its competitors. The U.S. share of international coal sales dropped from 32 percent to 25 percent between 1980 and 1984. In the past

Coal Consumption and Import Projections for Major U.S. Markets



decade, South Africa has entered the steam-coal market, Australia's role has escalated substantially, Colombia is beginning to export coal, and China will enter the world market soon.

U.S. hopes for higher coal exports face several obstacles. Among them are the higher sulfur content of many low-priced Eastern U.S. coals, longer inland distances from mines to ports and to coal's growing markets, and greater socioeconomic costs. High-quality U.S. metallurgical coal has little competition in world markets, but these markets are expected to grow slowly. In the steam-coal market, where demand is growing more rapidly, U.S. coals face stiff price competition from other exporters. Moreover, excess production capacity in the United States of about 100 million tons—plus another 40 million tons in the rest of the world—has driven international prices down.

COAL'S ABILITY TO COMPETE WITH OIL AND GAS CAN BE IMPROVED

PRIVATE AND PUBLIC ACTIONS CAN HELP IN FIVE AREAS

This Nation and the world have abundant fossil-fuel resources in the form of coal, and substantial progress has been made in increasing reliance on coal as an alternative to dependence on imported oil. Continuing this progress in the future, however, will require that various obstacles to expanded coal use be overcome. In seeking to achieve this, it is important always to measure benefits against costs before taking action. The impacts on consumers, the environment, the Federal budget, the economy at large, and U.S. trade should all be taken into account.

Drawing on the counsel of the Energy Research Advisory Board and the National Coal Council, the U.S. Department of Energy has pinpointed five principal areas in which actions are needed:

- Developing "clean coal" technologies.
- Removing barriers to an efficient coal-supply chain.
- Ensuring balanced environmental programs.
- Broadening the opportunities to choose coal as a fuel.
- Expanding U.S. coal exports.

Coal can play a major role in enhancing domestic and international energy security. By using more coal, the United States can reduce its dependence on oil imports. Selling U.S. coal and coal technology to other countries will enable allies to reduce their import dependence too, at the same time it helps the United States reduce its trade deficits. Finally, expanded use of coal—both here and abroad—will reduce unemployment and stimulate growth in coal-producing regions. Following is a more specific outline of what actions might be incorporated in each of the five areas.

Five Areas of Activity

CONTINUE TO CONTRIBUTE TO TECHNOLOGICAL BASE FOR "CLEAN COAL" USES

Continue basic research on scientific principles. Research on scientific principles improves the knowledge base on which new technology can be developed for the future. Ultimately, this can further improve the economic and environmental performance of coal.

Expand technology options by pursuing research to the proof-of-concept stage. A variety of new technologies now in the conceptual stage could be applied to major existing coal markets and also to the light industrial, commercial, and residential markets. The objective should be to help bring such new technologies to the point of proof-of-concept, and to facilitate subsequent applied research—where results justify it—via a balanced program of industry-government cost-sharing.

Encourage process development via demonstrations of emerging "clean coal" technologies. The Energy Department's current Clean Coal Technology Program is responding to a diverse set of environmental, economic, and energy security goals, many of which are consistent with recommendations of the *Joint Report of the Special Envoys on Acid Rain*. Future appropriations will be sought to satisfy the Joint Envoys' criteria, as established by the Department and Congress.

Enhance government investment by encouraging industry to undertake cooperative R&D ventures. Recent legislation reduced the constraints to jointly funded research by firms within a single industry. The Administration is now seeking other means by which to encourage cooperative industrial R&D ventures, including those with international partnerships.

Improve efficiency of technological development by complementing State and private R&D initiatives. The Department of Energy should ensure that Federal efforts in regard to clean-coal technology complement and supplement ongoing State and private-sector programs. DOE also has the lead in coordinating technological research, development, and demonstrations relating to acid rain, whether it is being pursued at the Federal level or within the business-industrial sector, States, or other public and private groups.

Five Areas of Activity

REMOVE UNNEEDED BARRIERS TO EFFECTIVE EFFICIENCY ALONG THE SUPPLY CHAIN

Adjust Federal laws and leasing regulations to reflect changes in coal markets. Because of the long time required to open a Western coal mine and to develop markets for its production, some coal mine operators run a great risk of losing the investment they have made in coal leases. Adjustments to look at include:

- Consider submitting legislation to amend the Federal Coal Lands Act by increasing the "diligent development" period from 10 years to 15 years and by allowing the payment of an advance royalty in lieu of production—making this payment creditable against future production.

- Appraise the effects of changing the leasing system to allow potential lessees to acquire options on a given tract before entering into a long-term lease. The potential lessee would use the option period to assess the quality of the reserves and the cost of production, and to judge whether or not the coal can be marketed.

- Evaluate whether current royalty rates are constraining the efficient development of coal on Federal lands.

Enhance coal's competitiveness and its ability to respond quickly to demand surges. Coal's position as a bulwark of energy security depends on its availability as an economic substitute for less secure energy sources. Thus, it seems appropriate to:

- Consider incentives that might encourage continued gains in productivity.

- Streamline the permitting process to reduce the time it takes to open a new mine.

Encourage greater efficiencies in coal transportation to lower consumers' costs. As total coal prices have fallen, the delivery of this fuel in some cases represents a major portion of its cost. Progress in holding transportation costs to fair but reasonable levels can be made in at least two ways:

- Recently enacted legislation will improve the Nation's ports and waterways. In addition, partial rail deregulation has helped restore the railroads to financial health. However, many coal shippers still have access to only one transportation link or mode; thus, regulatory practices need to be monitored constantly to ensure that "captive shippers" are receiving the protection set forth in the Staggers Act.

- Competitive transportation systems are essential to ensure competitive coal prices in all markets. The national interest can be served by government actions to encourage the construction of coal slurry pipelines in a way that adequately protects the water rights of the individual States.

Five Areas of Activity

ENSURE BETTER BALANCE AMONG LEGITIMATE GOALS IN ENVIRONMENTAL PROGRAMS

Pursue aggressive research on acidic deposition. Untimely or misdirected legislation or regulation related to "acid rain" could increase energy costs without conferring comparable benefits. Ongoing programs to reduce uncertainties include:

- The National Acid Precipitation Assessment Program, which is identifying the causes and effects of acid deposition.
- Coordination with Canadian and other international research counterparts in clarifying the entire problem.

Assess the need for legislative changes to lift constraints on choosing fuels efficiently. Major environmental laws and regulations should be reviewed periodically to address ambiguities and inefficiencies that have been identified, and to ensure regulatory options that allow efficient fuel choices. For example, the EPA administrator could be given discretion to select lower cost regulatory options in regard to fossil-fuel use if they provide equivalent environmental protection.

Enhance the quality of regulations by improving the procedures for formulation and review. Procedural improvements that can reduce adverse impacts on energy objectives—and enhance environmental protection—include greater use or introduction of the following:

- Interagency consultation to improve the understanding of affected industries and to develop more effective regulatory analyses and options.
- Consultative approaches (which have been tested recently) to permit resolution of differences among interested parties early in the development of a regulation.
- Provisions for the Domestic Policy Council to resolve conflicts among energy, economic, and environmental goals.

Five Areas of Activity

BROADEN THE OPPORTUNITIES ENERGY USERS HAVE TO CHOOSE COAL

Expand the R&D focus on existing and emerging technologies. Some coal technologies, such as coal gasification units linked to combined-cycle turbines, are commercially available today but are not economically attractive now in light of the current low oil and gas prices. The Department of Energy should investigate ways to improve the designs for smaller modules of these technologies that could be built faster in the event of another sudden advance in oil prices. Additional long-term insurance can be provided by encouraging:

- New technologies (already in the developmental stage) that will be able to use coal directly in traditionally oil-fired applications, including combustion turbines and diesel engines.
- Fuel flexibility in new boiler designs, which would make it possible for them to burn coal when other fossil fuels are in short supply.

Reduce barriers to commercialization of innovative technologies by revising regulations. Current implementation of the Clean Air Act's New Source Performance Standards represents one of several barriers to the introduction of new technologies. Regulatory changes are needed to:

- Provide effective waivers on innovative control techniques that would allow proposers more time for construction and would provide a more forgiving solution if a technology falls short of its intended performance.

- Provide special regulatory alternatives for any innovative technologies that reduce total effluents and waste-management problems.

Reduce investment barriers for coal-using equipment to generate electricity. A discussion in the chapter of this report that deals with electricity has already described the importance of improving the balance between risks and rewards for utilities in adding electricity-generation capacity.

Reduce uncertainties that inhibit investments in coal via more timely rulemakings. Some environmental studies and rulemakings are years behind congressional schedules, causing unnecessary uncertainty for developers and investors. New schedules and study plans are especially needed for studies of coal ash and waste disposal.

Five Areas of Activity

CONTINUE WHERE POSSIBLE TO MATCH U.S. EXPORTS OF COAL WITH WORLD NEEDS

Remove barriers to international coal trade to improve global energy security. Institutional, economic, and other barriers (such as the lack of familiarity among potential users with coal and coal technology) constrain the free trade of coal worldwide. The Administration will continue to:

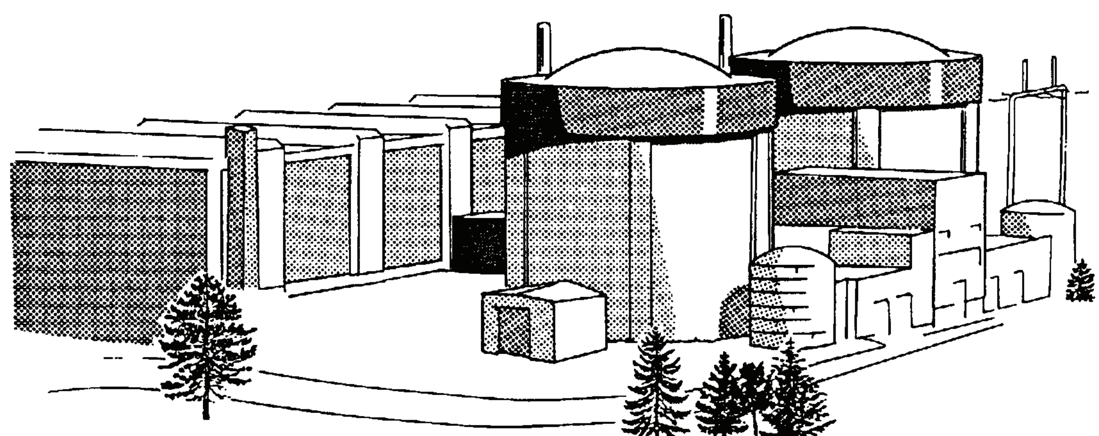
- Work through international bodies (such as the International Energy Agency) to ensure coordinated international review of coal production, consumption, and trade issues.
- Encourage foreign coal-producing nations to eliminate subsidies to their domestic production and other barriers to freer coal trade.
- Draw on independent analysis (such as the current National Coal Council study of the international competitiveness of U.S. coal and coal technologies) to identify specific opportunites for additional coal and technology exports.

Take some specific steps to encourage exports of U.S. coal and coal technology. In a free-market environment, U.S. coal and coal-use technology can be competitive. This would increase U.S. employment, reduce the country's trade deficit, and contribute to increased energy security. The following steps are important:

- Work to increase the use and flexibility of existing Federal export-financing programs within current budget constraints.
- Highlight the importance of coal trade in key bilateral energy discussions, and push for maintenance and expansion of purchases of competitive American coal as one way of contributing positively to trading relationships.
- Continue to press vigorously for implementation of the 1983 Reagan-Nakasone *Joint Statement on Energy Cooperation*, which sought to expand U.S. fuel exports to Japan.
- Expand technology-sharing bilateral agreements to improve the knowledge and use of American coal. Coal combustion studies with Italy, the United Kingdom, and Japan are current examples of such agreements.
- Promote America's coal-burning technology through international forums, seminars, fairs, and testing agreements.

7

THE NEED FOR NUCLEAR POWER



THE SITUATION IN BRIEF

Nuclear power has helped over the past decade to relieve the world's thirst for petroleum. Although it is a secure domestic energy resource whose importance in this country is still growing, nuclear power's future contribution is clouded by a variety of problems that the U.S. Government and industry each could help solve.

The hundreds of nuclear powerplants supplying electricity right now in more than a score of countries supply the equivalent of more than 7 million barrels per day of oil—at a time when only 55 million barrels of oil are being produced each day in all. Roughly two-thirds of what now is surplus production capacity for free-world oil could effectively vanish if oil were required to generate the electricity currently coming from nuclear powerplants; and the United States (which counts on nuclear power for one-sixth of all its electricity, reaching all the lower 48 States) would be using more oil, paying more for each barrel of it, and feeling much less secure about its energy outlook.

Although several countries that lack any appreciable domestic resources of fossil fuel already rely on civilian nuclear power for more than 50 percent of their electricity, the nuclear safety debate (particularly since the Chernobyl accident) has slowed down some national programs. Others are pushing ahead, for both economic and security reasons.

In the United States, continued growth in the use of electricity (regardless of source) seems to be tied inextricably to the hoped-for rise in national productivity, competitiveness in world trade, and living standards. A diversified mix of sources for electricity is essential for this country into the 21st century if energy demands are to be met satisfactorily. However, nuclear power's future contribution to this mix is uncertain. No additional orders for nuclear powerplants are likely in this country until the conditions of the past few years are changed enough to permit a renewal of nuclear energy's earlier economic edge, public acceptance of its demonstrated safety, and a clear path for the cautious long-term program that has already been legislated to dispose of radioactive waste permanently.

The Federal Government's basic policy goal here is to help ensure that existing nuclear powerplants can continue to operate safely and efficiently, that those in the construction pipeline can be completed in a timely fashion to permit the additional contribution to the national energy economy they need to make, and that nuclear energy remains a choice for the long-term future that can be judged on its own merits. Some legislative and administrative reforms to accomplish this are already in place, but others have met persistent opposition. This chapter explains how a four-part Federal initiative can help to resolve matters by:

- Pursuing a program that meshes with industry efforts looking to the future.
- Taking certain legislative, licensing, and regulatory actions.
- Stimulating reform in the rate regulation of utilities.
- Deploying waste-management systems.

WORLDWIDE USE OF NUCLEAR ENERGY FOR ELECTRICITY IS LARGE AND EXPANDING

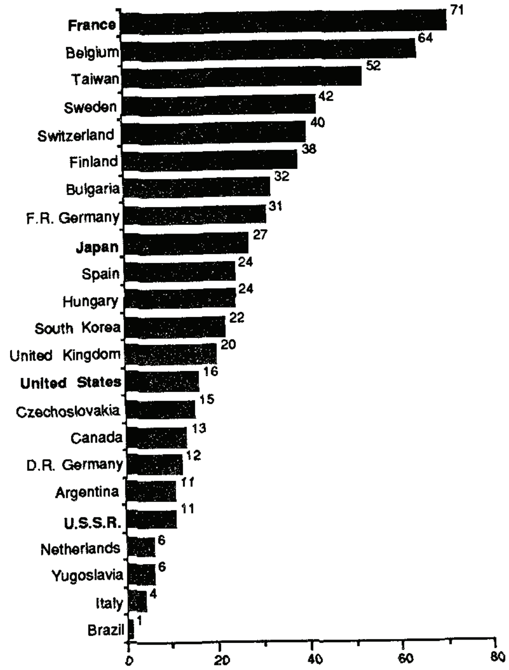
NUCLEAR PLANTS SUBSTITUTE WIDELY FOR OIL AND GAS, STRETCHING GLOBAL ENERGY RESOURCES

For more than 20 years, nuclear-power reactor systems have been a substantial and increasingly important means of producing electricity and diversifying energy supplies worldwide. If it were not for nuclear energy, the demand for oil or other substitutes would be far higher. Reducing oil demand in this way has lessened upward price pressures and limited OPEC's ability to influence the global oil market. If oil alone had to replace existing nuclear capacity, a majority of the world's excess oil production capacity would vanish.

By the early 1990's, the countries that have been trying to displace oil in electricity generation with nuclear energy will have completed most of this job. The primary purposes for further nuclear powerplant construction will be to meet increased electricity demand and replace obsolete capacity; and it would be natural to expect the use of nuclear energy to grow as worldwide use of electricity increases.

- Electricity is the largest consumer of primary fuel of all energy uses in the Western World.
- Worldwide production of electricity by nuclear energy increased 14 percent from 1984 to 1985, following a 19-percent increase from 1983 to 1984.
- Nuclear energy will be the fastest growing supplier of electricity worldwide between 1985 and 1990. More than 100 nuclear powerplants have been ordered worldwide since the last U.S. order in 1978. More than 370 nuclear powerplants are currently in operation, and approximately 500 are expected to be operating by 1990.

Percentage of Electricity Supplied by Nuclear Power



BOTH ECONOMIC AND SECURITY REASONS UNDERLIE THE TURN TO NUCLEAR POWERPLANTS

Nations without adequate supplies of fossil-fuel resources have turned to nuclear powerplants as the only proven large-scale energy technology that does not rely on fossil fuels:

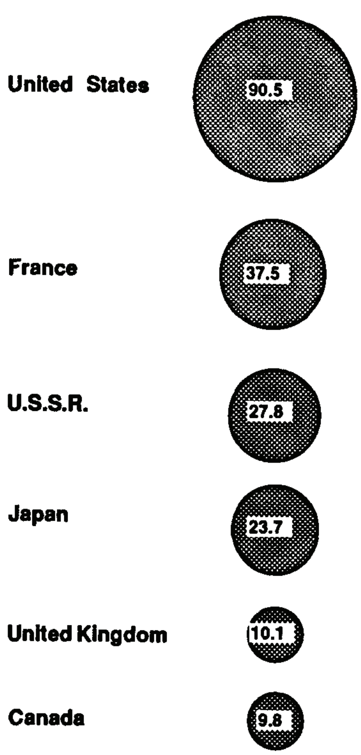
- More than 70 percent of France's electricity is produced by nuclear energy. Belgium, Taiwan, Sweden, and Switzerland get 40 percent or more of their total electricity from nuclear energy.
- More than a dozen nations obtain a larger share of their total electricity from nuclear energy than the United States.
- Japan is deploying nuclear powerplants at the highest rate in the world.

Even some nations with abundant fossil-fuel supplies are developing nuclear energy for economic and energy security reasons.

- The Soviet Union has abundant fossil-fuel supplies, but the U.S.S.R. cannot afford to devote 40 to 50 percent of its existing rail capacity to transporting the amount of coal that would be needed to meet its total electrical demand. The Soviet Union plans to increase the amount of electricity supplied by nuclear energy from 11 percent to 30 percent by the year 2000, and it appears that this goal may be achieved despite the accident at the Chernobyl plant in April 1986.

- By using nuclear energy, some countries intend to preserve their oil, coal, and gas for other uses. For example, Eastern bloc countries plan to increase their nuclear capacity fivefold by the year 2000—thus making more oil, gas, and coal available for export.

Installed Nuclear Capacity (Net Gigawatts Electric)



Nuclear energy also has given some countries an economic edge in export markets. For example, because of France's large nuclear capacity, its electricity prices are 20 percent lower than those in other European countries. This has helped to keep French manufacturing costs low.

Japan, on the other hand, has realized different sorts of advantages from its commitment to nuclear electricity. Because of its multibillion-dollar investment in light-water reactor technology over the past decade, Japan has enjoyed huge net savings through lower payments for oil. Now it is also in a position to be a major exporter of nuclear products and services in the Pacific Basin.

MOST BIG NATIONS MOVE AHEAD, BUT CHERNOBYL AGGRAVATED CONCERNS OF SOME

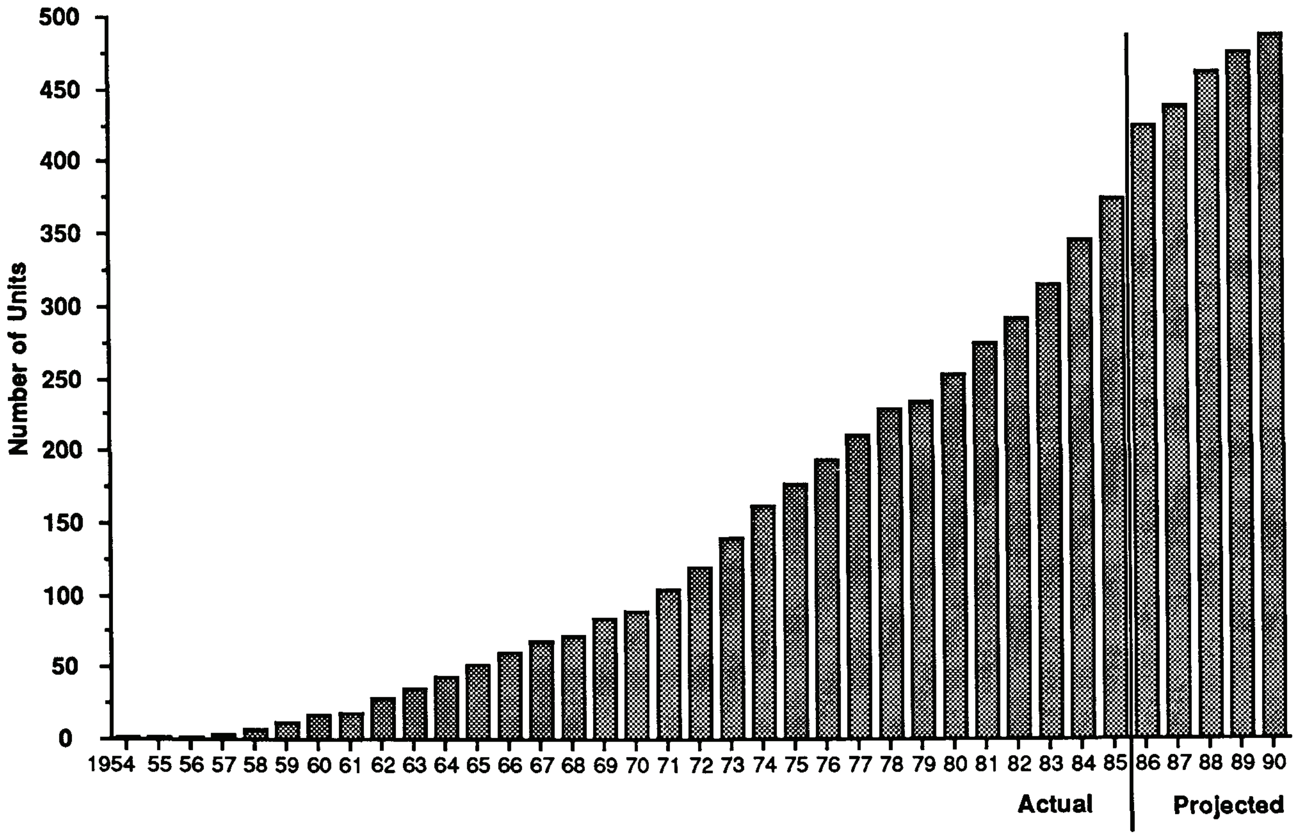
Since the Chernobyl accident, most countries with nuclear power programs have reevaluated them; but as a general rule the major efforts are continuing as planned:

- **Japan**: The nation is deploying nuclear powerplants at the highest rate in the world, and indications are that the growth of the industry will continue. The government predicts that 58 percent of Japan's electricity will be generated by nuclear energy by the year 2030, more than double the current level.

- **France**: The nation is moving forward aggressively with a program to demonstrate and deploy liquid-metal fast-breeder reactors in the future. In addition, France is selling nuclear fuel and fuel-cycle services such as reprocessing to other countries.

- **United Kingdom**: The nation's first commercial pressurized-water reactor (PWR) was recently endorsed by the Public Inquiry Inspector. There is utility and government interest in expanding nuclear power capacity by building PWR's.

Nuclear Powerplants in Operation Worldwide



Source: IAEA Power Reactor Information System

- **Federal Republic of Germany**: In light of the recent re-election of the Kohl government, there continues to be a strong commitment to nuclear power, but with a growing opposition led by the Green Party.

- **South Korea**: The nation plans to more than double the amount of installed nuclear-energy generating capacity by the year 2000 and is now negotiating to purchase two U.S.-designed nuclear powerplants.

- **U.S.S.R.**: Chernobyl Units 1 and 2 have been restarted, and Unit 3 is due to resume operation in spring 1987. The U.S.S.R. plans to triple the use of nuclear energy for electricity production by the year 2000, going from 11 percent to more than 30 percent.

At the same time, there have been several instances in which national nuclear plans were being questioned sharply for a variety of reasons even before the event at Chernobyl; and it may have been predictable that an accident with fatalities would heighten concerns and pressures against moving ahead:

- **Austria**: The Austrian cabinet has eliminated all possibility of completing the Zwentendorf nuclear plant.

- **Finland**: Previous plans for committing to a fifth nuclear plant have been shelved.

- **Sweden**: Consideration is being given to accelerating the phaseout of its operating plants, ironically focusing on the Baarseback plant, for which additional safety systems were recently installed in response to political pressures.

- **Netherlands**: Previous nuclear expansion plans will await the availability of additional information and analyses regarding Chernobyl.

- **Taiwan**: Work on Units 7 and 8 has been halted, and the restart of Maanshan-1 (damaged by a fire in its nonnuclear portion) has been postponed.

IN THE U.S., NUCLEAR ENERGY IS SECOND ONLY TO COAL IN SUPPLYING ELECTRICITY

ALL LOWER 48 STATES DEPEND ON EXISTING PLANTS TO AT LEAST SOME DEGREE

There are currently 105 commercial nuclear powerplants licensed to operate at power in the United States. In addition, 2 units are in the process of loading fuel and another 17 have construction permits. Nuclear energy is now the second-largest source of electricity in this country, providing about 17 percent of the total produced.

To put this in context, nuclear energy generates as much power today as was needed to meet the Nation's entire electricity demand in 1952. All the lower 48 States depend on nuclear energy now in varying degrees, because the entire Nation is interconnected, and even States that have no nuclear powerplants within their borders receive electricity from States that do. In fact, nuclear power provides more than 40 percent of all the electricity for 6 States, and there are 13 others that get more than 25 percent of their power from nuclear generation.

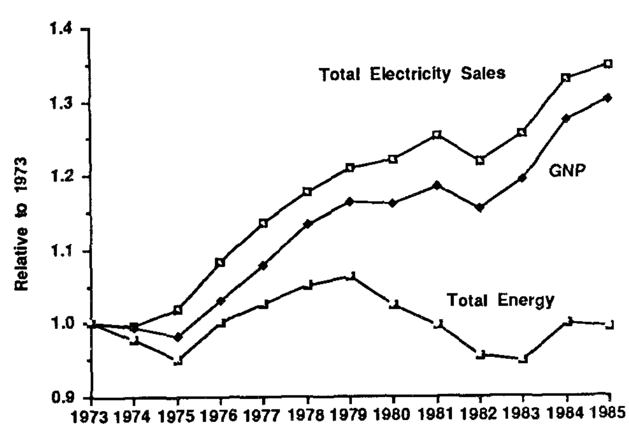
Since 1974, nuclear energy has been responsible for about one-third of the generating capacity that has been added in the United States to meet growing demand for electricity and to reduce the need to use oil and gas in producing it. Many utilities in the East and South built nuclear plants specifically to diversify their sources of electricity, reducing their dependence on oil and natural gas.

WITH ELECTRICITY USE GROWING, NUCLEAR ENERGY IS NEEDED TO DIVERSIFY U.S. SUPPLY

The United States must have an adequate and assured supply of electricity from domestic sources. Electricity demand, unlike total energy demand, has continued to increase—keeping pace with the growth in GNP. The use of electricity is up by 33 percent since 1973, although total energy consumption is about the same. GNP grew by 31 percent over the same time period.

Electricity accounts for 35 percent of the total energy consumed in the United States today; and this is expected to increase over time. Under these circumstances, nuclear energy has a key role to play in connection with U.S. energy security:

- The energy system of the United States is very complex, and its energy mix is difficult to project in the long term. Coal and nuclear energy are the only technically proven, large-scale sources of future electricity supply today that are viable alternatives to oil and natural gas.
- Given the difficulties in making accurate quantitative forecasts of electrical demand, but recognizing there is a high probability that significant additional electricity supply will be needed by the year 2000 and beyond, the United States should have all economic and environmentally acceptable



options available for energy diversification. One of these is nuclear power.

- Current economic and regulatory factors are increasing the likelihood that insufficient electricity supply in the next decade may impede economic growth.

  — Under cautious assumptions (a 2-percent demand growth and 50-year average plant lifetimes), by the year 2000, the Nation will need approximately 100 gigawatts of new generating capacity—beyond plants under construction—to maintain adequate electricity supply. (See graph on page 139 and the accompanying discussion.) Building additional supply on the order of 100 gigawatts or more will be challenging. Energy-efficiency programs may help curtail anticipated demand, and gas-fired plants will add some capacity. However, new large plants will still be needed.

  — The Nation's existing electricity-generating plants are aging, and many are approaching the end of their design lifetimes. More than 20 percent of the Nation's generating capacity, a total of about 140 gigawatts, is more than 25 years old and will have to be retired or extensively refurbished in the next decade. Life-extension projects are under way, but current plans affect only a fraction of plants.

  — Utilities, responding to a regulatory framework that distorts the electricity market, are making short-term decisions that are often at odds with long-term economic efficiency and energy diversification.

PROBLEMS CLOUDING THE FUTURE OF NUCLEAR POWER IN THE UNITED STATES DESERVE A CLOSER LOOK

DELAYS IN PLANT COMPLETION AND QUESTIONS ABOUT WASTE MAKE NEW ORDERS UNCERTAIN

No new U.S. orders for nuclear powerplants are expected until and unless current conditions change.

Since 1972, 117 nuclear plant orders have been canceled; and any project on which construction started after 1973 was eventually canceled. The economic recession of the 1970's and early 1980's slowed down the growth in demand for electricity, and it was accompanied by high inflation and high interest rates. All that caused a "stretch-out" of nuclear powerplant project times and sent costs spiraling upward. But this is still only part of the story:

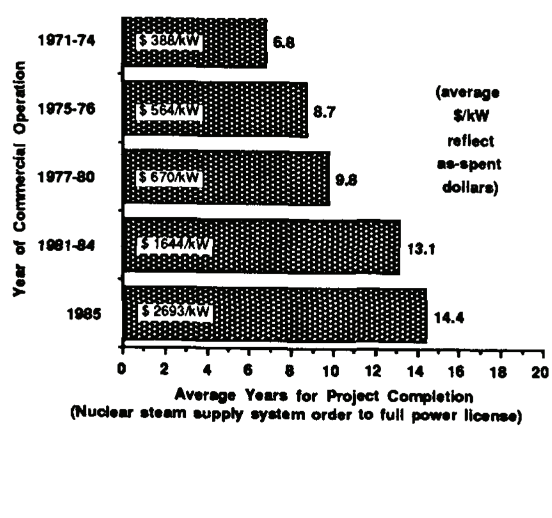
- The Federal regulatory environment for licensing and operating nuclear plants has been unpredictable.

- Current rate regulation is making it difficult for utilities to recover the full costs of nuclear plants. In some cases, this may be justified; in others, it may not be. If rate regulation is not rationalized, however, utilities are likely to look to nonnuclear sources, primarily oil- or gas-fired, to meet their future demand growth despite the potential for nuclear energy to compete effectively on an economic and environmental basis with other sources of electricity supply.

- The average time to complete nuclear powerplant projects has increased from 7 years for those plants that came on-line in the early 1970's to more than 14 years on the average for those entering commercial operation in 1985. Recent project times have ranged all the way from 9 to 20 years. However, U.S. plants in operation and comparable nuclear plants overseas have been completed routinely in as little as 6 years; but unless there is confidence that future projects can be carried out in a reasonable period of time in this country, it will be difficult to count on nuclear power for the United States beyond the plants that are already operating or nearing operation.

- The cost of recent U.S. plants has increased up to sevenfold, with obvious effects on the economic competitiveness of nuclear energy. This is in contrast to the cost of most U.S. plants already in operation and comparable ones overseas, which cost as much as 50 percent less than the projected completion costs for plants now being built in the United States. Besides inflation and "stretch-out," several other factors contributed in varying degrees to the soaring costs of plants coming on-line recently: The scope of work on plants has increased, especially since the Three Mile Island accident. New systems have been "retrofitted" into earlier plants, and regulatory uncertainty has slowed down most work. But there also have been instances of poor quality work, poor construction, and poor project management; and there have been some clear failures to comply with documentation requirements.

Events Over the Past 15 Years Have Resulted in Increased Completion Times and Costs



In addition to problems in deploying plants on an acceptable schedule and at reasonable costs, the nuclear power industry faces another public-acceptance problem in encouraging new orders: concerns about waste management.

- Pending the development of additional sites in compliance with the Low-level Radioactive Waste Policy Amendments Act, there are only three facilities for disposal of commercial low-level radioactive waste. These are located at Barnwell, SC; Richland, WA; and Beatty, NV. States have been slow to respond to the requirements of this Federal legislation.

- The high-level waste repository program needs to continue to move forward. Selecting a site for the Nation's first high-level radioactive waste repository, as mandated by the Nuclear Waste Policy Act of 1982, has become a major issue. The governors of each of the three candidate States and all three affected Indian tribes have expressed opposition.

THE PUBLIC SHOWS CONCERN WITH NUCLEAR POWER ECONOMICS, RADIATION, AND SAFETY

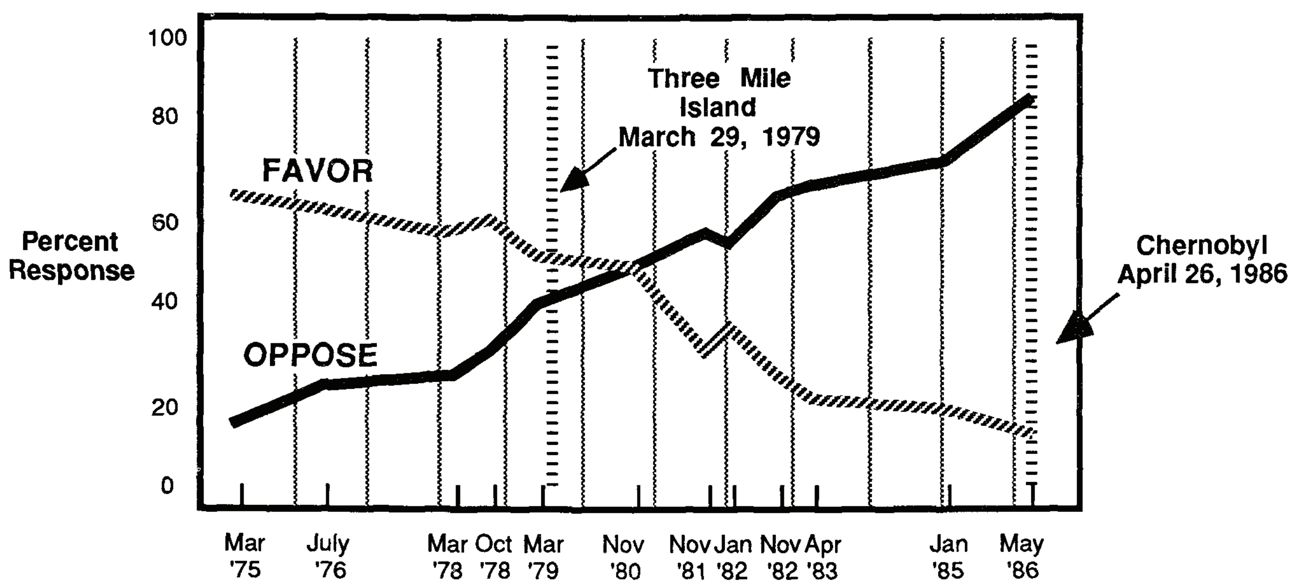
Three major factors appear to have increased public opposition to nuclear energy:

- The economic competitiveness of nuclear powerplants changed dramatically for the worse during the mid-1970's and early 1980's, resulting in widely reported "rate-shock."

- The accident at Three Mile Island in 1979, in addition to several widely reported events at other nuclear plants, significantly heightened concerns about nuclear safety.

- There has seemed to be an inability to dispose of high-level radioactive waste permanently, in a safe and environmentally acceptable manner.

Shift in Public Attitude Toward Nuclear Energy



Answers to the question: "In general, do you favor or oppose the building of more nuclear powerplants in the United States?"

SOURCES: 1975-1980 ABC News-Louis Harris and Associates, Inc., 1981-1982 NBC News, 1983-1986 ABC News-The Washington Post

- These factors, when combined, swayed the public's view of nuclear energy even before the Chernobyl accident in the Soviet Union in April 1986. All three probably contribute to the growing negative response various polling organizations have received over a period of more than a decade to the same basic question: "In general, do you favor or oppose the building of more nuclear powerplants in the United States?" Yet a Cambridge Report poll conducted in August 1986 revealed that 75 percent of the public believes that nuclear energy will be important in meeting future electricity needs.

Nuclear power apparently is viewed by many as a mixed blessing—whose economic and security advantages are evaluated differently by different observers, based on a variety of factors.

- A CBS News poll after Chernobyl asked if the need for nuclear energy outweighs the risks: 42 percent said yes, 45 percent said no.

- While the Center for Media and Public Affairs in Washington reported that 70 percent of the energy scientists and 82 percent of the engineers contacted in a recent poll support "rapid nuclear development," an August 1986 poll by the Roper Organization showed 55 percent of the U.S. public "very concerned" about radiation exposure from nuclear powerplants, with 67 percent "very concerned" about radiation exposure from nuclear waste disposal.

- When people were asked about construction of plants within 5 miles of their homes, the Gallup organization reported that opposition increased from 45 percent in 1976 to 60 percent in 1979 and to 70 percent in 1986.

It appears that a large segment of the public does recognize the need for nuclear energy; but their concerns must be addressed, both by industry and government. The scientific evidence clearly shows that these radiation risks are truly small. Nevertheless, safety evaluation reports, environmental impact statements, and public hearings have not succeeded in meeting these concerns.

POLICY FOCUSES ON WHAT IS NEEDED TO KEEP NUCLEAR ENERGY AS A CHOICE

THIS SOURCE'S FUTURE DEPENDS ON SATISFYING THREE CONDITIONS

Before new orders for nuclear plants can be expected in this country, the first condition that must be met is that nuclear energy should be able to compete with other sources of electricity supply in the marketplace on its own economic merits—as it did in the United States into the 1970's, and as it does in many other countries now.

Various economic and regulatory forces were at work in the 1970's that gradually precluded nuclear energy from being able to compete fairly as a future option. These forces point up some weaknesses in the U.S. regulatory structure for ratemaking and licensing; and actions to correct them will strengthen the overall framework within which future nuclear powerplants can be deployed, by enabling this source of electricity supply to compete fairly with others. However, private industry needs to improve further its management capabilities and its approaches to future nuclear powerplant deployment. Serious industry efforts along these lines, combined with a stable regulatory environment, should reduce the completion times for new nuclear projects to those of other countries, such as France and Japan; and this alone should reduce plant costs significantly.

A second condition is that the safety of existing and future U.S. nuclear powerplants must continue to be satisfactorily demonstrated—so that widespread public acceptance is restored.

The accidents at Three Mile Island and Chernobyl heightened public concern regarding the safety of nuclear powerplant operations. Furthermore, events at several U.S. nuclear powerplants illustrate that some installations have weaknesses in construction quality and operation that are not typical of most nuclear facilities. Industry and government must continue to insist on excellence in the construction, operation, management, and regulation of nuclear powerplants to regain the confidence of the majority of the public.

The third condition is that there must be evident progress toward siting and building high-level waste-management systems in a safe and publicly acceptable manner. A means must be established to dispose permanently of the high-level waste that has been generated by the operation of both defense and commercial nuclear facilities. Of course, this obligation exists regardless of the future of nuclear power. Commercial operating reactors have produced approximately 13,800 metric tons of spent uranium fuel. This is expected to increase to about 41,000 metric tons by the year 2000. In addition, the defense industry is expected to process for disposal the equivalent of about 4,000 metric tons by the year 2000 and about 8,000 metric tons by the year 2020.

GOVERNMENT AND INDUSTRY HAVE DISTINCT ROLES IN MEETING THESE CONDITIONS

Government and industry efforts will need to complement one another in satisfying the conditions that are prerequisites for nuclear power's future role as a viable energy choice for the United States. But the responsibilities of the public and private sectors are not the same.

Government has these roles and responsibilities:

- Propose and implement legislative, licensing, and regulatory reforms.
- Stimulate reforms in rate regulation of electricity-generating facilities.

- Perform research and development on advanced designs, and support cooperative design efforts.

- Deploy high-level waste-management systems.

It is industry's job, on the other hand, to take care of the following:

- Design and obtain licenses for nuclear powerplants.

- Undertake new approaches to deployment of nuclear powerplants that will ensure overall system quality, shorter construction times, and easier operation and maintenance.

- Ensure the reliability and overall safety of each commercial nuclear facility.

- Develop domestic and international markets.

- Carry on R&D to improve the reliability and safety of electricity-generating facilities.

Government actions, in combination with industry's actions, can meet the three conditions. To do its part, the Federal Government has formulated a four-part nuclear energy initiative.

GOVERNMENT'S RESPONSIBILITIES IN CIVILIAN NUCLEAR POWER INCLUDE A FOUR-PART INITIATIVE

Specifically, here is an outline of what the Federal Government has done, is doing, and proposes to do in order to safeguard the nuclear power option without violating the principle of public participation in a free-enterprise, democratic society concerning which forms of energy will be used and to what extent:

A Federal program in civilian nuclear energy that meshes with industry efforts looking to the 1990's and beyond: The Federal Government will conduct a civilian nuclear energy program that complements industry efforts to enhance and demonstrate the safety and economic competitiveness of future nuclear powerplants. In this context, the Federal Government will support the near-term certification of simpler advanced light-water reactors that do not require demonstration. It will also conduct research and development, in concert with industry, to develop more advanced designs, such as the liquid-metal reactor and the high-temperature gas-cooled reactor, for the longer term. In addition, the Federal Government will continue to conduct a stable and competitive business in enrichment of uranium. However, since this is the only portion of the "front-end" of the nuclear fuel cycle that is not privately owned, the Federal Government will continue to seek ways of privatizing uranium enrichment.

Legislative, licensing, regulatory, and related actions to eliminate weaknesses in the current system and justify public acceptance: The Federal licensing and regulatory process for nuclear powerplants has expanded broadly during the past 10 years. Making it more stable and predictable would enhance safety, rationalize costs and construction schedules, and allow a reasoned judgment of the benefits of nuclear-generated electricity. Efforts in this direction on the part of the Nuclear Regulatory Commission will continue, and proposed legislation to encourage standardization of nuclear powerplants also can help.

Stimulate reforms in rate regulation to improve economic efficiency: When the regulatory climate was stable, nuclear energy demonstrated its economic competitiveness. It should be able to compete again with other sources of electricity supply if current rate-regulation issues are addressed squarely.

Federal deployment of high-level waste-management systems: The Nuclear Waste Policy Act of 1982 mandated the creation of the Nation's first high-level waste repositories. Public confidence in the technical excellence and integrity of the Federal program to site and build them is essential to the success of this mandate. This confidence can be maintained if the public understands the Federal pledge that protection of the public health and safety is paramount, that technical solutions are available, and institutional questions can be resolved successfully.

Here are some additional details about each segment of the multipart initiative:

Four-Part Initiative

MESH FEDERAL PROGRAMS FOR FUTURE CIVILIAN NUCLEAR POWER WITH INDUSTRY EFFORTS

Advanced reactor certification: In support of the industry's programs to certify designs for simpler advanced light-water reactors, the Department of Energy will continue to sponsor the preparation of safety analyses to be used by industry in obtaining necessary NRC approvals. Working in cooperation with the Electric Power Research Institute and the vendors, the Federal Government will also try to resolve "severe accident" and "design criteria" issues for such reactors.

Longer term designs: Again in cooperation with industry, DOE also will pursue longer term development efforts for advanced reactors that can provide continued improvements in reliability, in modularized designs that ensure construction quality, and in reactor control. All of these aspects should contribute to improved safety, but the uncertainty of design research (and the fact that it "pays off" only in the very long term) precludes total reliance on private investments. Cooperation between the Federal Government and industry in such efforts will speed the day when advanced designs for the longer term are likely to become available. Beyond 1988, it is anticipated that one design will be pursued for future development.

Uranium enrichment: The enrichment of uranium is currently the only step in nuclear fuel preparation that has not been assumed by the private sector. The Federal Government operates this program as much like a competitive business as possible. It has stabilized the market and made its price more competitive. Steps will continue to reduce costs, increase this country's share of the world market, and pursue privatization.

Four-Part Initiative

STRIKE AT WEAKNESSES IN THE CURRENT SYSTEM TO JUSTIFY PUBLIC ACCEPTANCE

The Federal Government is endeavoring to undertake legislative, licensing, regulatory, and related actions to eliminate weakness in the current system. Here are the key proposals:

- **Enact "powerplant standardization" legislation:** Such legislation should provide authority to the Nuclear Regulatory Commission to:

  —**Approve standardized plant designs**: This can do much to clarify, simplify, and strengthen future regulation, in contrast with a situation in which every plant design undergoes an individual safety review.

  —**Approve plant sites in advance**: State and Federal approval for a "bank" of sites allows public participation in and resolution of siting issues *before* the need to build a plant arises.

  —**Issue combined licenses for construction and operation:** Utility, public, State, and Federal concerns need to be resolved before plant construction, to avoid the spiraling costs caused by delays—sometimes more than $1 million per day in interest costs alone.

  —**Establish a centralized review process and firm criteria for reviewing operation, maintainence, and testing procedures—as well as changes to plant designs**: The present process sometimes adds unnecessary costs to plants, and in some instances can even increase rather than decrease the risks resulting from plant operation.

- **Eliminate barriers to orderly licensing:** For example, the impasses that have sometimes arisen among utilities, State and local governments, and Federal regulatory agencies regarding the adequacy of emergency plans need to be resolved.

- **Reauthorize the Price-Anderson Act:** The Administration supports reauthorization of the Price-Anderson Act (which is scheduled to expire on August 1, 1987), providing prompt, uncontested compensation for any who might be injured in the event of a serious nuclear accident, but balancing this against a reasonable limitation on liability for nuclear accident claims.

Four-Part Initiative

STIMULATE REFORMS IN RATE REGULATION TO IMPROVE ECONOMIC EFFICIENCY

Trends in the regulation of public utilities during the past decade have badly skewed the balance between risks and rewards in regard to capital investments in electric power. Because nuclear generating plants are inherently capital-intensive, these trends have put them at a serious economic disadvantage. Reforms in electric power regulation, at both the State and Federal levels, will be required to ensure that nuclear energy can compete fairly with other electricity supply options.

If the United States is to have an adequate supply of electricity-generating capacity in the future—based on a secure and cost-effective mix of primary energy sources—regulatory practices that discourage prudent long-term investment need to be revamped. These issues are discussed more thoroughly in the chapter of this report that deals with electricity in general.

Four-Part Initiative

DEPLOY AN INTEGRATED SYSTEM FOR PERMANENT DISPOSAL OF HIGH-LEVEL WASTE

DOE will continue to implement the long-term Geologic Repository Program for the ultimate disposal of high-level waste from nuclear powerplant operations, and it also intends to move ahead in constructing a Monitored Retrievable Storage (MRS) Facility.

The Nuclear Waste Policy Act of 1982 mandated the creation of the Nation's first high-level waste repository, together with a related transportation system. It established a fund so that waste generators would pay for the program; and it pledged participation by States, affected Indian tribes, and the public to promote confidence.

The goal is to dispose of high-level radioactive waste permanently in a licensed repository in a manner that adequately protects public health, safety, and the environment. In keeping with this goal, the Federal Government will continue to implement its program for a first repository with the three sites selected for study. Redirection of the second repository program will be formally proposed to Congress by means of an amendment to the Mission Plan to comply with provisions of the act.

The Federal Government also is proposing a plan to Congress to build an MRS facility that can prepare spent fuel for its emplacement in a permanent repository. This facility would receive and package the spent fuel and it would be fully integrated into the nuclear waste-management system. Its anticipated storage capacity is 15,000 metric tons of uranium, but it will not begin to receive spent fuel until a construction authorization for a permanent repository has been received from the Nuclear Regulatory Commission.

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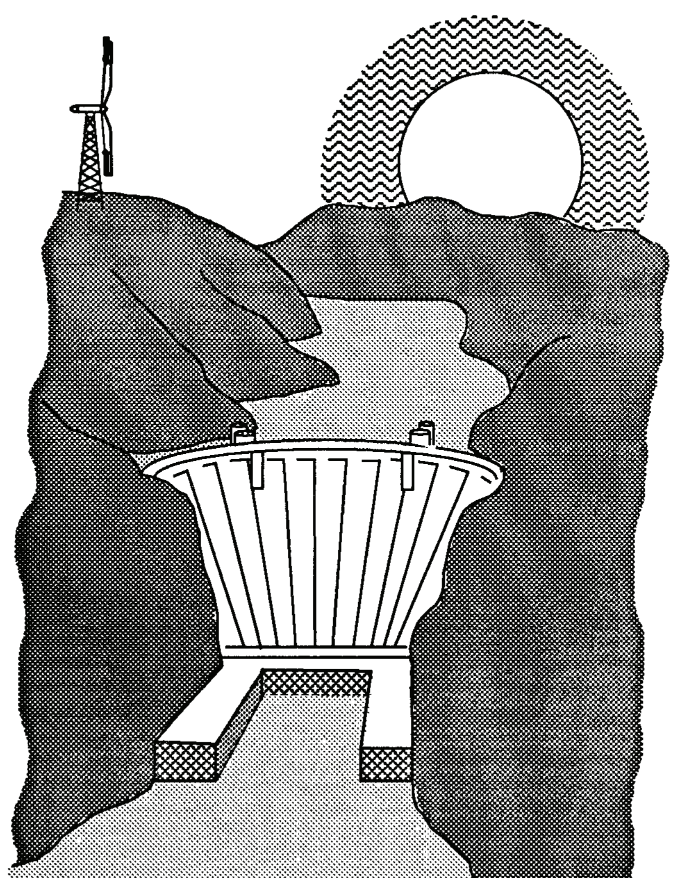
RENEWABLE ENERGY: AN EMERGING RESOURCE



THE SITUATION IN BRIEF

The United States and the world will, in time, come to rely largely on energy sources that are essentially inexhaustible, possibly including advanced nuclear fission reactors, fusion, and many diverse sources that are commonly lumped under the term "renewable energy."

The combination of solar, wind, geothermal, water, and biomass energy represents an extremely large resource base that, over the long term, could become a major new source of energy supply. The rate of technological progress and the forces of the energy market will determine the extent to which this resource potential can be developed. Even with the progress made to date, a number of years of research challenges remain.

The majority of the renewable energy used in the world now comes from conventional big hydroelectric plants and wood fuel—both of which have only slight future growth potential. There are other types of renewable energy that might grow almost explosively in the early part of the next century, but these are the ones based on much higher technology.

Perhaps the greatest advantage of these "new" renewables over the long haul is simply that they *are* based on technology—rather than on insecure resources. The resources that underlie them (including innovative ideas) are indigenous. They are not subject to politically induced disruptions. Their costs are likely to drop, rather than rise.

By its very definition, "renewable" energy can significantly reduce energy security problems—but only whenever and wherever it is available at a reasonable cost in sufficient quantities, and in the desired applications. Because the current cost of installing renewable energy systems is relatively high, however, the current prospect of low oil prices and certain deterrents to long-term investment are discouraging factors for renewable energy. The approach to achieving renewable energy's potential contribution is through a realistic, far-sighted effort to improve the technology base from which private enterprise can make development and investment decisions for the future. Competition with other energy supply sources, as well as among the various technological approaches for renewable energy, will determine how much of this country's energy needs each specific technology will ultimately satisfy.

Strategies to help the renewable *potential* emerge as *reality* include continued research, active international energy collaboration, and a continued Federal leadership role. The DOE's renewable energy research program is structured to provide the private sector with the technology base it will need to develop competitive technologies in the critical areas required to reduce system costs, improve performance, and lengthen the operating lives of systems. Based on discussions throughout this report, it is evident that one area of special interest will be fuels from renewable resources that in time could reduce the transportation sector's dependence on oil.

Renewable energy technologies provide "technological optimism" for global and national energy security in the more distant future.

VIEWING RENEWABLES IN WORLD OIL CONTEXT SHOWS MODEST INPUT NOW, VITAL POTENTIAL

MAJOR LONG-TERM GROWTH SHOULD COME FROM NEW TECHNOLOGIES RATHER THAN LARGE HYDRO

"Renewable" energy includes a family of technology options that span the entire range of the development process. Some technologies, such as hydroelectric power, are mature and have been adopted by the energy marketplace. Others, such as magma energy, are still in preliminary research phases. Several renewable energy sources involve different types of technology options at quite different stages of development.

Renewable energy's total supply contribution in the free world is projected to grow at a faster rate than any other energy source between now and 2005—increasing by 84 percent and thus climbing to 16.6 million barrels per day of oil equivalent. If this projection does hold true, the share of total energy supply coming from all forms of renewable energy combined will expand from 9 percent to 12 percent.

One reason why more of this growth cannot be counted on within the next decade, however—when it would be more directly applicable to the mid-term energy supply problems focused on in this report—is that the important increases will come from renewable energy technologies that still require additional research.

Roughly two-thirds of the renewable energy used in the world now comes from conventional big hydroelectric plants—a technology whose future growth potential is slight. Much of the remainder of today's renewable energy consists of the forest- and mill-wastes used directly as fuel by the U.S.

Matching Up Renewable Energy Sources With End-Uses

RESOURCE	TECHNOLOGY	ENERGY TYPE
SOLAR RADIATION	BUILDINGS: ACTIVE, PASSIVE	HEATING, LIGHTING, COOLING
	SOLAR THERMAL: CENTRAL RECEIVER, DISHES, TROUGHS	ELECTRICITY, HEAT
	PHOTOVOLTAICS: THIN FILM, CRYSTALLINE MULTI-JUNCTION, CONCENTRATORS	ELECTRICITY
BIOMASS:	DIRECT COMBUSTION, BIOCHEMICAL, THERMOCHEMICAL	HEAT, ELECTRICITY, FUELS
WIND	HORIZONTAL, AND VERTICAL AXIS TURBINES	ELECTRICITY
OCEAN	OCEAN THERMAL ENERGY CONVERSION (OPEN CYCLE) TIDAL, WAVE	ELECTRICITY
GEOTHERMAL	DIRECT DRY STEAM, SINGLE- AND MULTI-STAGE FLASH BINARY HYBRID BINARY	ELECTRICITY, HEAT GASEOUS FUELS

lumber and paper industries—another use without much chance for large expansion. Almost all the rest involve the simple burning of wood and other "biomass" in scattered locations. But these mature technologies are not expected to contribute more than 7.5 million barrels per day of oil equivalent after 1990.

The types of renewable energy that show great growth potential for the future are the more advanced technologies: highly efficient wind turbines, sophisticated systems of tapping temperature differentials in the sea and the earth, cost-effective devices to draw on heat and light from the Sun, and the manufacture of economically competitive liquid and gaseous fuels from new agricultural or forest crops.

As world energy use increases—with accompanying price increases (or the expectation of price increases) for conventional fuels—the opportunies to call upon nondepletable resources will expand as rapidly as their technical and market viability can be established. Local conditions, resource availability, and market competition will strongly influence the selection of the specific renewable technologies to meet the needs of each particular application.

AS RENEWABLES BEGIN TO COMPETE, THEY CAN CLEARLY HELP ACHIEVE FUTURE ENERGY SECURITY

Over the long term, there should be no doubt that technology-based applications of renewable energy can promote secure and adequate energy supplies at comparatively stable, predictable costs.

Renewable energy is based on abundant, diverse, nondepletable resources available in every region of the world. At the outset, high technology often involves high costs; but the experience so many U.S. consumers have had with items such as pocket calculators and home computers gives convincing evidence that prices for high-tech items quite often take breathtaking drops as the technology is improved and broad market acceptance takes place.

The very presence of additional, substitutable energy options in the marketplace will tend to moderate the size and frequency of swings in conventional fuel prices. Broader use of "new" renewable energy technologies—with their inherent long-term price stability—can be a special boon to economic development planning for developing countries. These technologies also represent a major potential U.S. export. Developing this export market will benefit U.S. trade and U.S. industry's ability to produce renewable technologies for the domestic market.

The diversity of renewable resources invites the development and application of a diverse family of technologies. Because the various resources are more widely dispersed than those associated with conventional fuels, the former are far less susceptible to suppliers' control, and to the sorts of supply manipulation that result in adverse economic and political consequences. Although not all resources are available everywhere, there are so many different kinds of abundant renewable energy sources that it should often be possible in the future to see that the most appropriate ones in each situation are matched directly with end-use energy requirements for heat, light, electricity, or motor fuels.

Furthermore, most renewable energy systems are flexible in system size and capacity. To the extent that renewable energy technologies become competitive, the fact that most can be assembled in relatively small "building blocks" or "modules" will permit additions to energy supply in smaller units than is common for conventional technologies. This could be a distinct advantage when energy demand projections are uncertain, and when growing financial risks are associated with the construction of large supply units such as more conventional generating plants. The shorter lead times required to add modular increments can reduce uncertainties in planning and allow incremental capital outlays over shorter periods—reducing the financial risk at any one time.

RENEWABLE ENERGY RESEARCH HAS HAD SPINOFFS THAT AID U.S. INDUSTRY'S COMPETITIVENESS

A flexible lightweight silver acrylic film, developed for solar concentrators, has been adapted as a reflector for fluorescent lights, and it shows promise in various other reflector applications. Potentially this acrylic film can reduce weight 75 percent by replacing heavier metal reflectors—reducing the costs of support structures by as much as 40 percent.

New drill bits developed for geothermal applications in harder rock than is typical for oil and gas drilling also have reduced the drilling costs of oil and gas wells by more than 10 percent—resulting in many millions of dollars in savings.

Electrical insulating materials for commercial ambient-temperature cables will allow the use of one-third less insulation. This makes it possible to expand capacity in existing rights-of-way and underground duct systems by replacing only the cables, rather than going through the costly and time-consuming operations usually required to dig up streets and replace ducts.

Improvements made in lead-acid batteries through the DOE program on deep-discharge batteries have improved their marketability in stationary applications. The Coast Guard has already installed 3,000 of these maintenance-free batteries in ocean buoys—decreasing maintenance costs and doubling battery life. Buoys offer a 14,000 unit market for battery installation over the next 2 to 3 years. In addition, the Coast Guard foresees the possibility of using 1kW photovoltaic recharging systems in conjunction with these batteries to decrease maintenance costs and extend battery life even more.

The silane process, a silicon purification method developed to reduce photovoltaic semiconductor-grade silicon costs, is being used to produce silicon for computer micro-chips. It will reduce costs from the current level of $45 per kilogram to less than $20 per kilogram.

A genetically improved hybrid cottonwood tree with superior productivity, greater drought resistance, and more resistance to disease has been developed in connection with the biomass feedstock program. Such trees grow as much as 10 feet per year; and, because of this rapid growth, they are being used in the forest products industry as a source of pulp for paper mills.

MARKETS WILL DICTATE RATE AT WHICH SOURCES FIT IN AS TECHNOLOGIES MATURE AND COSTS FALL

ADVANCES SUMMARIZED FOR VARIOUS TYPES OF RENEWABLE ENERGY

As illustrated in the two examples below, the development of renewable energy technologies has made significant progress. Many technical problems have been solved, uncertainties have been reduced, and a solid technical base for future R&D has been established. Although this research is very promising, it is accompanied by substantial scientific and technical risks.

Planned research has the potential to lead to competitive renewable energy technologies. Research performance objectives are based on technology-specific multi-year program plans.

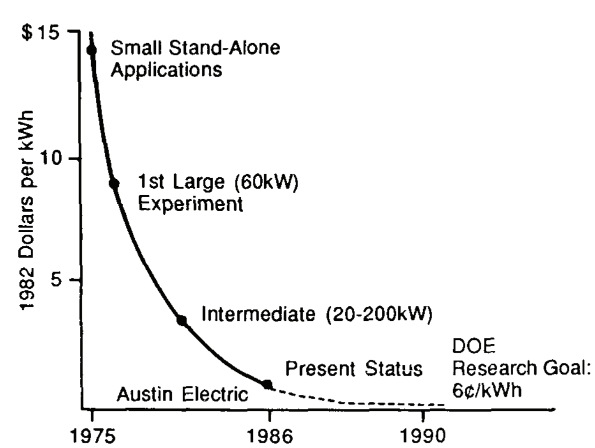
Photovoltaic technology research has focused on materials development and efficiency improvements. It has already resulted in significant cost reduction and the development of new research concepts. Continuing technical advances in materials and concentrator technology can lead to improvements in durability and efficiency—and eventually to costs that will compete with conventional electricity generation technologies.

Component costs for solar thermal systems have fallen dramatically, with significant reductions in heliostat costs. Research in mirror/glass technology has reduced weight, expanded size, and improved reflective coatings—leading to 80 percent reductions in costs. Silver/polymer and silver/steel stretched membrane technology bring into view the potential of realizing 6¢/kWh electricity costs from central receiver technology.

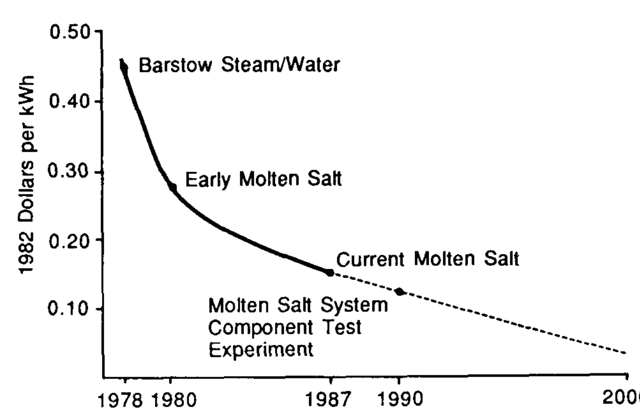
Additional advances have occurred in other renewable energy technologies:

- Wind technology research has improved turbine designs and materials, decreasing the delivered energy cost. Installed costs have dropped by more than 50 percent since 1981. New siting technologies and improved capacity factors have increased wind-turbine production of energy.
- Research in solar buildings technology has helped to improve flat-plate-collector efficiency and performance. Delivered

Photovoltaic Electricity Costs



Solar-Thermal Electricity Costs



energy costs dropped from an annualized cost of \$25/MMBTU in 1975 to present costs of less than \$10/MMBTU.

- Biofuels research in the area of woody feedstocks will capitalize on low-cost fuel. Tree cloning research has improved the yield of tree farms more than fivefold while cutting costs almost in half.

- Today's geothermal industry contributes more than 2000 MWe (about the same as two nuclear powerplants) to the Nation's energy supply at prices competitive with coal and nuclear power. Research in such areas as binary conversion, drilling technology, and the use of low-quality resources has produced growing amounts of electric energy at costs of 6.5 to 7¢/kWh.

Additional progress will require research over the long term. Renewable energy systems have not yet been proven in widespread large-scale use; and they will have to be integrated into a well-established and proven energy system of conventional fuels—just as other energy resources, such as oil or natural gas, have been in the past. The next few subsections are intended to indicate briefly how some of the major renewable technologies are beginning to fit in.

GEOTHERMAL ENERGY HELPS NOW, AND COULD MORE THAN DOUBLE ITS U.S. OUTPUT BY 1995

Geothermal technologies convert heat that is present naturally in the earth into useful energy (electricity and heat), tapping the geothermal resource in four forms: hydrothermal (steam and liquids), geopressured, hot dry rock, and magma.

Hydrothermal technology is today's source of geothermal energy. High-temperature fluids from the earth drive turbines to produce electricity. Lower-temperature liquids are utilized for direct heat applications. Hydrothermal steam technology produces baseload electricity at a cost that is competitive with coal and nuclear plants, and the average geothermal unit today is available on-line more than 95 percent of the time. New technology for electric generation from lower-temperature liquids is just starting to come on-line. The geopressured and hot-dry-rock technologies are in the research stage. Magma technology is still only a theoretical concept.

The U.S. geothermal industry consists of companies specializing in exploration, field development, or production. In addition to baseload electric energy from the 2,000 MW of existing capacity in the United States, geothermal plants in this country produced more than 2 trillion BTU's of heat energy for direct use last year. Based on announced industry plans, U.S. hydrothermal electric power capacity is projected to reach 4,700 MWe by 1995 (EPRI Survey of Utility Industry Estimated Capacity, 1986; GRC Bulletin, Sept./Oct. 1986).

Further reductions in the capital costs of geothermal wells and powerplants can improve the competitiveness of all these technologies. Research in reservoir analysis techniques can improve industry's ability to predict reservoir size, performance, and longevity. Improved conversion technologies should make it possible to use lower temperature liquids also for efficient electric generation, and to establish the viability of systems that will produce electricity from such potential energy resources as hot dry rock and magma.

SOLAR THERMAL TECHNOLOGY SEEMS CLOSE TO STANDING ON ITS OWN ECONOMICALLY

Solar thermal technology converts solar energy through high concentration and heat absorption into electricity or process heat. Applications for solar thermal cover a broad range of sizes and temperatures, and offer the advantage of *storable* energy—extending useful operation into nondaylight hours. Hybrid systems, which use fossil fuel combustion as a backup during periods of low insolation, can increase reliability and provide constant power output.

Technical feasibility and an extensive technology base for solar thermal systems have been established. However, the cost of solar-thermal-generated electricity must still be reduced by a factor of 1.5 to 2 to be competitive. This reduction can be achieved in part by replacing glass/metal concentrator technology with stretched membranes and utilizing either molten salt central receivers or dish Stirling engines.

The solar thermal industry has commercialized parabolic troughs. Such systems now are generating more than 100 MWe in the United States, with projected increases to 550 MWe in the next 5 years, based on announced industry plans.

The DOE projections for the prospective contribution from solar thermal (0.1 quads by the year 2005) are based on its being able to compete economically with fossil fuel and other renewables for electricity and process-heat generation by the mid-1990's.

PHOTOVOLTAICS MAY BE A $3 BILLION WORLDWIDE MARKET BY THE TURN OF THE CENTURY

Solar cells convert sunlight directly to electricity. Processing semiconductor materials to make them sensitive to light results in a photovoltaic (PV) solar cell. For greater power levels, cells are interconnected into modules, and finally into complete utility-sized systems.

Early technology had typical costs of $600/watt, and sunlight-to-electricity conversion efficiencies of 6 percent; and products carried 1-year warranties. Today's technology offers costs in the range of $5/watt, 13 percent efficiencies, and 10-year warranties. The largest operating PV system is currently 5 MW in size. More than 40 U.S. companies are selling PV systems, with 1986 sales approximating 10 MW. Japanese and German firms account for another 13 MW. Sales are mainly for remote power needs (telecommunications, water pumping, health clinics, and occasional household power).

The $200 million worldwide market is expected to grow to $500 million by 1990 and to $3 billion by 2000. According to a recently completed study by Strategies Unlimited, Inc. (private client data, February 1987), photovoltaics could contribute as much as 1300 to 1500 MW of capacity by the year 2005.

Research is keyed to material sciences in three major groups: amorphous silicon, high-efficiency silicon and gallium arsenide, and advanced polycrystalline "thin films." New deposition techniques for producing thin films can reduce costs through improved use of materials and continuous fabrication processes, rather than batch processing. Other materials research is directed at cost-effective cell coatings to enhance durability and cell efficiency and at resolution of material interface problems in multijunction devices. For market acceptance, industry also needs better data regarding long-term material stability and system reliability.

"PASSIVE" SOLAR CONTRIBUTES SUBSTANTIAL HEATING FOR BUILDINGS IN SOME AREAS

The area of solar buildings technology includes both passive and active systems to provide heating, cooling, and daylighting for buildings.

Passive systems control the transmission of solar radiation through glazing (to use it directly as lighting) and by storing heat within the building mass (for use in space heating). Passive space heating systems for residential buildings and passive space heating and perimeter daylighting systems for small nonresidential buildings are available commercially throughout the United States. In some regions they are competitive with conventional fuels. Passive solar technologies for medium to large nonresidential buildings are in the development stage. In some locations, passive systems can supply up to 40 percent of the heating requirements for residential and small nonresidential buildings.

Active solar domestic hot water (DHW) systems and solar space heating are also commercially available in the United States, but they are not yet able to compete broadly with conventional energy systems. Active solar cooling technologies are still in the development stage.

Research on solar buildings technology is directed at improved system efficiencies, advanced system design, reduced system costs, and improved system reliability. There are approximately 800,000 solar DHW systems, 100,000 active space heating systems, and 200,000 passive solar residences in the United States now. Utilization of solar buildings is expected to increase steadily, and energy contributions by 1995 will be very substantial, particularly from passive systems. By the year 2005, the use of solar energy in building systems can be expected to contribute 0.14 quads from active solar heating and cooling and 2.5 quads in all—including the energy *savings* provided by passive heating, cooling, and daylighting systems.

MODEST PRESENT ROLE FOR WIND TURBINES COULD RISE TENFOLD BY 1995

Wind energy systems convert the wind's kinetic energy into mechanical and then electrical energy. Wind turbines employ a variety of technical concepts and configurations to capture energy. Two to three airfoil-shaped blades, mounted on either a horizontal or a vertical axis, drive a gear box that is connected to a generator.

Wind turbines are being operated successfully in exceptionally high-wind-resource areas. However, major improvements are necessary and possible with continued research and technology development. Current systems typically have annual capacity factors of 20 and 40 percent peak wind-to-electricity efficiency. Production turbines are available in sizes from 1 kW to 600 kW, and experimental systems up to 4 MW have been tested. Energy production costs have been reduced from more than 30¢/kWh in 1980 to 10 to 15¢/kWh today at high-wind-potential sites.

More than 10 U.S. companies are currently producing turbines. More than 15,000 turbines totaling 1,400 MW of installed electric generation, primarily in wind farms, were in operation at the end of 1986. Worldwide use of wind energy is increasing. Following the U.S. lead, major European firms are competing with firms in this country.

Actual energy production from wind turbines in the United States in 1986 was more than 1 billion kWh. By 1995, annual energy production could exceed 10 billion kWh; and by 2005 it could reach 70 billion kWh.

Applying aerodynamics studies in ways that improve turbine airfoils could double the annual energy production from wind systems. Improved rotor blades and turbine structures should reduce weight and system complexity and could increase fatigue life by a factor of three or more. Being able to predict wind resources more accurately, especially in complex terrain, can also improve wind turbine design and performance efficiency.

MANY BIOFUELS APPROACHES LEAVE SOME UNCERTAINTY AS TO JUST WHAT THE FUTURE HOLDS

Biofuels resources include municipal solid waste (MSW) and dedicated feedstocks, such as short rotation wood, herbaceous crops, and aquatic plants grown specifically for conversion to energy. Besides direct combustion, conversion technologies include biochemical and thermochemical processes that produce gaseous or liquid fuels.

The family of biofuels technologies ranges from commercial systems (such as the direct combustion of wood and MSW) to technologies that are in preliminary research stages (such as alcohol from cellulosic materials or oil-bearing algae). Between these state-of-development extremes are technologies for producing gaseous and liquid fuels from dedicated feedstocks, the derivation of fuel alcohols from sugars and grains, low-BTU gasification of wood, and the anaerobic digestion of manures and sewage.

Today, the combustion of wood and MSW and the production of alcohol from sugar and grain provide approximately 3.5 percent of the Nation's energy needs. To date, however, grain alcohol and some MSW activities have been commercially attractive only because of tax incentives. DOE has projected that the combined contribution from currently available and newly developed biofuel technologies could increase about 30 percent by 2005—to 1.8 MMBDOE.

Future research on biofuels and municipal waste will emphasize the development of feedstocks with increased productivity, lower costs, and improved conversion characteristics. Research also includes efforts to further the understanding of the physical and chemical formation of liquid and gaseous fuels from biomass in order to improve fuel quality and output levels.

SMALL-SCALE HYDROPOWER CAN REACH HUNDREDS OF NEW ACCEPTABLE SITES

Small-scale (less than 30 MW) hydropower systems convert the kinetic energy of flowing water into electrical or mechanical energy. Small-scale hydropower systems employ a variety of technical concepts and configurations to capture energy from smaller flow volumes and lower hydraulic pressures.

Standard turbine types achieve efficiencies of from 70 to 95 percent. Technology is being developed by industry to retrofit existing dams for instream-flow and ultra-low-head operation, but efficiencies for these systems are still low.

Small hydropower supplied nearly 0.4 quads of energy in the United States in 1984. There were 1,460 small-scale plants on-line at the end of 1985, totalling 6800 MW of production capacity. As much as 10,000 additional MWe potential exists at approximately 1,400 environmentally and economically acceptable sites (National Hydropower Resource Study, U.S. Army Corps of Engineers, 1983). A number of the near-term targets of opportunity are current sites that would require only the retrofit of existing dam facilities.

OCEAN ENERGY PROMISES SPECIAL VALUE FOR ISLANDS AND SOME COASTAL AREAS

OTEC uses the temperature difference (approximately 20 ^{o}C) between ocean surface water and deep cold water to drive either an open- or a closed-cycle system to generate baseload electricity. Open-cycle and hybrid designs can also produce desalinated water as a byproduct, making them particularly attractive to island markets.

A 55-kWe OTEC power system was built and tested by a commercial consortium off Hawaii in 1980, and a 1-MWe (equivalent) OTEC subsystem experiment was tested there offshore by DOE in 1981-1982. A preliminary design for a 40-MWe closed-cycle OTEC system was completed by an industrial consortium under a DOE cost-shared contract in 1984, with a cost projection of $9,500/kWe.

No commercial OTEC units exist now or are under construction. Both domestic and foreign industrial consortia have completed conceptual and/or preliminary designs for OTEC plants at specific sites. OTEC is at an early stage of development; and system utilization by the year 1995 is expected to be quite low, based on the present status of technology. However, technological advances could result in significant interest in attempting OTEC technology at some locations. The Gulf Coast, Caribbean, Hawaii, and Pacific island areas are principal early markets.

The development of advanced heat exchangers in OTEC systems can improve the performance and life expectancy of materials and reduce system cost by reducing the flow per kilowatt of production. The development of improved cold water pipe materials and structures can improve deployment and installation. Development of a 165-kWe open-cycle OTEC net power producing experiment is expected to validate a technology level that presages the system-cost goal of $3200/kWe for such markets as Hawaii.

MANY FACTORS WILL AFFECT FUTURE U.S. INPUT, BUT 2005 LEVEL SEEN AS ALMOST TWICE TODAY'S

PRICE AND TECHNICAL ADVANCES BOTH AFFECT MARKET PENETRATION PACE

Research advances in renewable energy technologies are focused on developing a family of options that can effectively and competitively exploit an increasing fraction of the recoverable renewable resource.

While the total energy content of the solar, wind, geothermal, biomass, and ocean thermal resources present each year in the United States is many thousands of quads, only a very small fraction is potentially recoverable. Although any projection is subject to very large uncertainties in the long-term energy and economic outlook, it has been theorized that—with foreseeable technological advances—up to 80 quads of this base annually might be recovered eventually. Competitive market forces, land use, the cost of capital, and related factors will ultimately influence the extent to which this resource potential can be developed.

In 1985, of the total 76 quads of energy supplied to the U.S. economy, 6 quads of primary energy were produced from renewable energy resources, including 3 quads from hydroelectric power generation and 3 quads from the other five major renewable resources.

The pace of research-driven technological developments over the coming years will play a large part in determining the competitive status of renewable energy options in the marketplace and, therefore, the degree to which the resource potential can be realized. DOE has estimated that, even with limited technological progress and only moderate increases in conventional energy prices, the contribution from renewable energy resources will increase by more than 4 quads by the year 2005. Clearly, the rate of introduction will depend on many factors in the marketplace. Beyond the year 2005, projections become even more uncertain.

TOUGH GOALS FOR RENEWABLES SET BY CIRCUMSTANCES IN THE ENERGY FIELD NOW

Prices of conventional energy sources are projected to remain relatively stable in the short- to mid-term. While this situation provides adequate lead time for the research that is required for developing competitive renewable energy technologies, it also sets up challenging performance objectives and goals for delivered costs from renewable energy. This can prompt private sector deferrals of research and development investments that do not show large near-term payoffs.

Many of the private sector organizations involved in the development and marketing of renewable energy technologies are small- to medium-size companies that are new businesses or existing firms expanding into new fields.

Early Federal programs supported the creation of an industry and market for renewable energy technologies. Overemphasis on these incentive and subsidy program approaches, however, can hinder the long-term development and application of competitive renewable energy technologies. Firms that came into existence in response to regulatory incentives and tax credits have found that, in many cases, the current status of the technologies is not competitive with alternative energy supply options in the absence of incentives. This has led to business failures which, taken together with technical performance problems and failures, have created a skeptical, if not negative, perspective of renewable energy technologies' potential.

In order for renewable energy technologies to make significant contributions to the Nation's energy supply, they must be integrated into the Nation's electric network. This will require further research on electric system reliability, flexibility, dispatching responsiveness, and integrity during emergency conditions. Additionally, energy storage technology must be advanced to the point where those thermal and electric renewable energy systems that depend on intermittent resources can enhance energy supply in a cost-effective and safe manner.

RESEARCH HAS THE POTENTIAL TO LAY "KNOWLEDGE BASE" FOR NEEDED PROBLEM SOLVING

Renewable energy technologies represent a wide range of technological and economic maturity, ranging from commercially mature to theoretical. Estimates of economic competitiveness exhibit a similar range of precision (e.g., "current best practice" may represent actual costs of power from a commercial operating system or represent an extension of experimental data).

Economic performance is only one aspect of the research program, which addresses such other uncertainties as those related to environmental concerns.

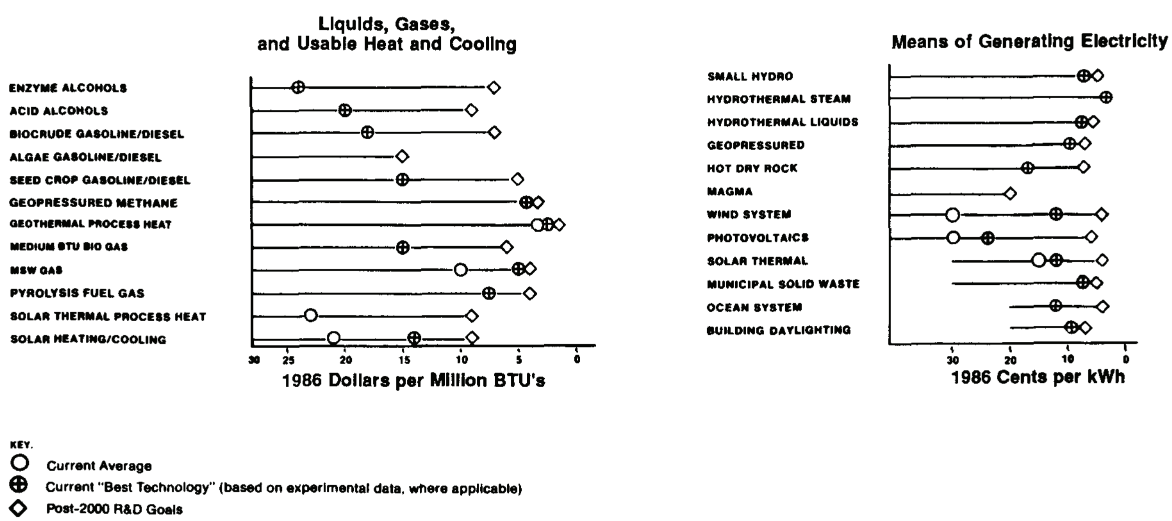
Renewable energy research is dedicated to producing the technical foundations required to realize cost-effective, competitive renewable energy technologies and to integrate them effectively into the Nation's energy supply networks.

Technical advances in materials and concepts provided by high-risk, high-potential-payoff investigations are the source of improvements in performance, durability, manufacturability, and material cost that underlie progress in achieving cost goals.

Continued technical advances in electric energy systems and energy storage research will help to improve system efficiency, shift peak loads, and enable integration of competitive renewable energy systems on the electricity network.

Renewable-energy technologies have excellent export potential in the developing countries. Penetrating these markets, and holding domestic markets in the face of rising foreign competition, depends on continuing technical progress driven by advanced research.

Projected Progress in Reducing Production Costs for Renewables



FOUR AREAS OF FOCUS DESERVE SPECIAL ATTENTION AT THE PRESENT TIME

The renewables field is enormous, and the Federal Government's proper role in energy development has already been defined as primarily a limited and indirect one. Nevertheless, it is possible to specify certain areas where DOE's attention should be—and is—focused:

NON-OIL-BASED TRANSPORTATION FUELS—

Transportation accounts for 65 percent of U.S. oil consumption. The extent of oil dependence in transportation is extreme, with 97 percent of energy consumption based on petroleum. Transportation alone consumes 107 percent of U.S. oil production.

By providing the market with additional options and flexibility, developing nonpetroleum transportation fuels could substantially reduce U.S. demand for oil and thus improve energy security. Even a 10-percent market penetration would displace about one million barrels per day of oil at current consumption levels.

For renewable resources to realize their potential contribution to national energy security, however, continued research will be required on effective, economic conversion technologies and on feedstocks for the production of methanol, ethanol, and other non-petroleum, renewable-based liquids and gases.

It will be important to encourage the transportation sector to develop the capability to use alternative fuels without government interference in the market. Having the ability to respond to petroleum fluctuations through the use of indigenous fuels can increase U.S. ability to respond to disruptions, and it complements the improvements in energy security to be gained from greater energy efficiency. Similarly, these research efforts complement the alternative-fuels study proposed in the chapter of this document devoted to energy efficiency.

LONG-TERM, HIGH-RISK R&D—

The development of a technology base upon which industry can build will involve a sustained research commitment well in advance of potential payoffs. The Federal research program will continue to emphasize collaboration with industry in long-term, high-risk areas of technology-base development. Continued research progress in key areas will speed the day when private sector initiatives make more renewable energy technologies competitive.

DOE research complements private sector research through cost sharing, the operation of test facilities, cooperative research ventures, and university exchange programs. The Federal Government should consider options for expanding innovative R&D programs and stimulating technology transfer, especially in areas of private sector risk-taking.

Dissemination of research results and patent licensing activity will help to transfer technical advances to the private sector, where they can be developed into competitive products. Innovative technology transfer programs could also be pursued to encourage broader industrial applications of cost-effective renewable energy. Renewable technologies will not be integrated into the energy markets as viable and competitive options unless and until private enterprise is ready to adopt them.

INTERNATIONAL ENERGY COLLABORATION—

Because U.S. national security is linked to global security, Federal efforts should continue and strengthen international cooperative efforts in renewable energy—to allow its advantages to be realized worldwide. The basic administrative apparatus is in place, and efforts will continue toward improving interagency coordination in this area. In addition to improving global and national security, these actions will provide the opportunity for the United States to improve its competitive position in world renewable-energy markets.

Economic growth worldwide and economically efficient markets will provide the greatest opportunities for growth in exports of renewable energy equipment and technologies.

Continued involvement in the International Energy Agency and bilateral/multilateral agreements can contribute to new U.S. technological innovations. Specifically, shared information and coordinated efforts will hasten the development and acceptance of renewable technology worldwide.

The Committee on Renewable Energy Commerce and Trade (CORECT) will provide the private sector with information and assistance in penetrating export markets. CORECT can also offer advice on efforts to bring assistance to developing countries in renewable energy activities, and the Committee can assist in determining the most appropriate areas of study.

The United States should continue to encourage developing countries to utilize renewable-energy technical information and products from this country, and to use foreign assistance to develop indigenous and renewable resources. For example, the Department of Energy and the World Bank are cosponsoring a wind energy resource assessment in developing countries. This two-phase effort, comprising resource data collection and feasibility analysis, will be critical to advancing this technology in the World Bank energy loan program. It may culminate in World Bank financing of five wind farm projects.

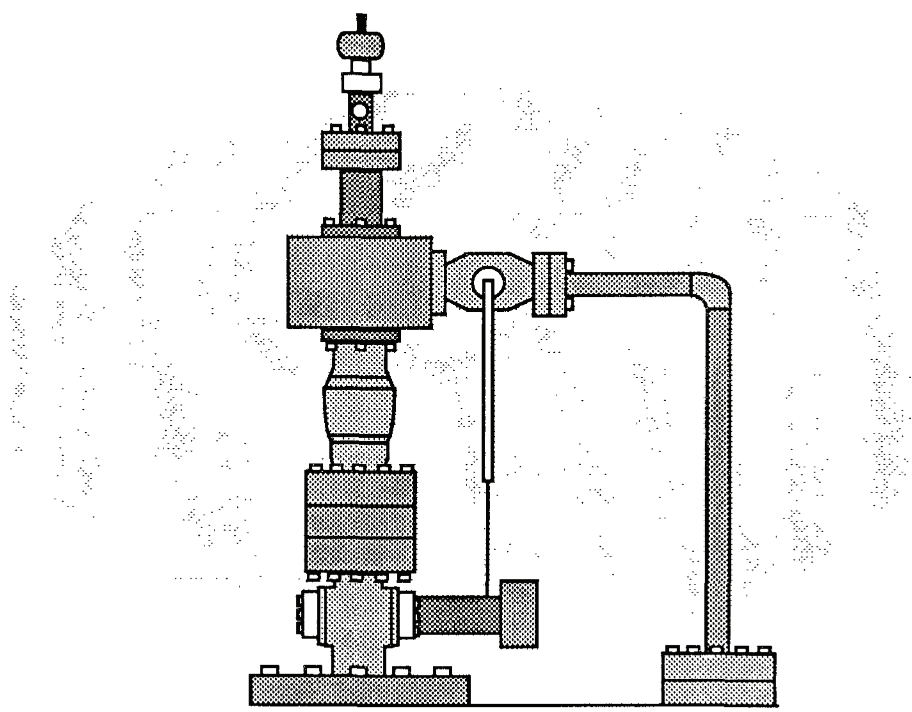
FEDERAL LEADERSHIP—

Energy market deregulation will encourage a free, competitive energy market in which both renewable and conventional energy can be developed and used efficiently and cost-effectively. Distortions in the market caused by government intrusion can cause capital to be allocated inefficiently. Such factors that inhibit renewable energy investments should be identified and evaluated.

Careful attention by top officials to viable renewable energy applications can help the renewable technologies gain the visibility and serious evaluation that could lead to their more extensive use in the government and private sectors. One way this can be accomplished is through expanded evaluation and use of renewable energy technologies in Federal installations or buildings where cost-effective.

9

STAYING PREPARED FOR EMERGENCIES



THE SITUATION IN BRIEF

The United States is better prepared than ever before to deter, as well as to respond to, any energy supply emergency arising from foreign oil disruptions or from domestic incidents involving our basic energy industries. Nevertheless, the Nation must not be complacent.

The Government has an important responsibility for promoting preparedness against potential energy emergencies, either foreign or domestic. The basic U.S. policy is to ensure adequate energy supplies for the United States and to cooperate in energy emergency planning with its partners in the Organization for Economic Cooperation and Development (OECD) and the North Atlantic Treaty Organization (NATO).

Past experience with energy supply disruptions has shown that government regulation of energy markets is a liability rather than an asset. Markets operate best when they are free of intrusive regulation, in emergencies as well as during normal periods. The cornerstone of U.S. energy emergency response policy is to rely on the free market, supported by the Strategic Petroleum Reserve (SPR) in an oil supply disruption. The SPR is being expanded to a 750-million-barrel capacity, and steps are being taken to make sure that oil can be taken from the reserve and distributed effectively if these procedures ever become necessary.

Globally, the United States continues to participate in the development of effective policy plans and programs of the International Energy Agency (IEA) for emergency response. It is also working with other IEA-member governments to build up strategic oil stocks further and to coordinate plans to draw on these government stocks promptly and rapidly during certain types of disruptions. The United States also joins in the planning and preparedness testing of IEA and the NATO Wartime Oil Organization.

Domestically, one feature of energy emergency preparedness involves ascertaining whether the Nation's energy production and distribution systems (for oil, natural gas, coal, and electric power) are amply protected from both domestic and international threats. This involves examining and monitoring each energy system component to determine where it is potentially vulnerable . . . working to reduce any recognized vulnerabilities through cooperative government-industry efforts . . . ensuring the strength of emergency responses through interagency, State, and local cooperation . . . and making sure at all times that the Nation has enough energy to meet defense and other vital needs.

The Government's emergency planners monitor the energy situation constantly, and they improve their emergency procedures periodically by conducting realistic tests and exercises.

STRIKES, WEATHER, ACCIDENTS, AS WELL AS FOREIGN ACTIONS, CAN CAUSE SHORTAGES

EMERGENCY PREPAREDNESS MUST SAFEGUARD NATIONAL INTERESTS IN WIDE RANGE OF CIRCUMSTANCES

Over the past 20 years, a number of major disruptions in energy supply have affected the United States. Some were the result of foreign oil supply disruptions—sparked by politically motivated acts, war damage, terrorism, and sabotage. Others were caused by such domestic factors as natural disasters (including weather), labor disputes, and electrical system failures. As used here, the term "energy disruption" or "energy emergency" refers to any nonroutine disturbance of U.S. energy supplies that might affect national security.

Foreign supply disruptions: As discussed previously in this report, foreign supply disruptions associated with the 1973-74 Arab oil embargo, the Iranian revolution in 1978-79, and the outbreak of the Iran-Iraq war in September 1980 reduced available oil supplies. Each of these events resulted in oil price increases and economic dislocations.

At the time of the embargo in 1973, an economic stabilization program was in effect in the United States. The U.S. Government responded to the embargo (and the other two disruptions mentioned) by maintaining its price control system on petroleum. It added an allocation system for crude oil and petroleum products in an attempt to stabilize prices and "share the burden" of oil shortages. However, the spot shortages that did develop were caused, in great part, by those very controls.

Domestic energy disruptions: There were also domestic energy disruptions in the 1960's and 1970's that resulted from electricity system problems, natural gas shortages, and labor disputes. Think back to these:

- **The electric power blackout** in the Northeast in 1965 and subsequent major outages in the mid-Atlantic region in 1967 and 1969. These outages occurred as a result of unforeseen equipment failures combined with unusually heavy demands on the system, and the particular configuration of the system at that time. Following the 1965 blackout, a joint Federal-industry report was published. In addition to technical recommendations, it recommended the establishment of strong regional organizations to promote the reliability of electric supply.

- **The natural gas shortages** during the winter of 1976-77. Because of price controls, the production of natural gas did not keep abreast of rising demand for that fuel. Unusually cold weather made the problem worse. Industries that could switch fuels went back to burning oil, but there were still major dislocations.

- **The lengthy coal strike of 1978.** Despite preparations by the electric power industry for a coal strike, many individual utilities were not fully prepared for a strike that lasted as long as this one did. Although the Taft-Hartley Act was invoked, union coal production fell short of what was called for. A major Federal effort was undertaken with industry groups to monitor coal supplies and electric power demand. Moving power in massive amounts from oil-burning regions to those where coal had been the mainstay was encouraged, and various other fuel-switching and conservation efforts were made.

FOREIGN AND DOMESTIC PROBLEMS MAY PROMPT DIFFERENT TYPES OF GOVERNMENT RESPONSE

Foreign Supply Disruptions

Central to this Administration's energy policy—both in periods of surplus and during supply emergencies—is a firm commitment to market principles. Past experience demonstrates that government regulation of energy markets lacks the flexibility to deal with all the complexities of the supply and demand system. During the 1970's, for example, here is what the price and allocation regulations on petroleum did:

- They wasted time and energy for motorists who had to wait in long gasoline lines.

- By dictating the distribution patterns and prices of crude oil and petroleum products—from producers down to local gasoline retailers—they eliminated competition at all levels of the supply chain. Ultimately this reduced the quantity of products to consumers and lowered the quality of the service they received.

- They were not flexible enough to match products that were available with the actual demand for those products at the time, because they used an arbitrary, historical base period that did not consider changes in the market.

- They created shortages, especially in metropolitan areas, by giving priority allocations to farmers and some others, despite the fact that there were excess supplies in rural and tourist areas.

- They discouraged domestic production by keeping the prices of petroleum below its market value, but stimulated consumption at the same time by exactly the same device. (In other words, they made things worse at both ends of the supply-and-demand chain.)

- They inspired thousands of official requests for interpretations, adjustments, assignments, and other relief. Many of these requests dragged on without being resolved for months or years—resulting in financial ruin for many small businesses, gasoline stations, and others. To top it all off, the enforcement efforts from that era are still going on.

Another important lesson from the earlier disruptions was that existing fuel stocks and excess production capacity can dampen the damaging effects. When the Iran-Iraq war broke out in September 1980, commercial stocks were at high levels. Oil prices increased somewhat, as about 2 to 3 million barrels per day of exports were lost from those two countries; however, increased production from other countries—coupled with the drawing down of commercial stocks—reduced panic buying and avoided the rapid price increases that had been experienced in the prior two disruptions of the 1970's.

President Reagan's deregulation of petroleum in January 1981, in the midst of the Iran-Iraq war, showed that market policies, in conjunction with sizable oil inventories, provide the most effective response to oil supply disruptions.

Domestic Energy Disruptions

The Nation's experience with other fuel or electric power emergencies has been quite different, principally because Government and industry have usually worked together to manage any short-term crisis. Impediments to an efficiently functioning market have been removed where necessary; and then steps were taken to find long-term solutions that could prevent or reduce the severity of similar problems in the future. For example:

- The electric power industry organized nine electric reliability councils regionally and formed a national representative body (the North American Electric Reliability Council). These regional councils now facilitate coordination among utilities in system planning and operating practices. Such coordination has resulted in better communication among utilities, and this has helped to prevent outages due to unusual occurrences or unexpected heavy loads on the system.

- During the coal strike, Government and industry exchanged information, recommended fuel-switching and conservation measures, and made sure that transfers of power among regions were carried out.

- During the natural gas emergency, the interstate movement of gas was facilitated by suspending certain regulatory requirements. Since then there have been no shortages—largely because of action to phase out price controls on new gas through passage of the Natural Gas Policy Act, and because of the Administration's continuing efforts to encourage greater competition and open access to transportation.

The Middle East continues to be volatile. Incidents of international sabotage and terrorism have increased. The situation in the world today emphasizes the need to assess international and domestic threats to U.S. energy supplies on a continuing basis—and to be ready to respond if any threat develops into an actual danger.

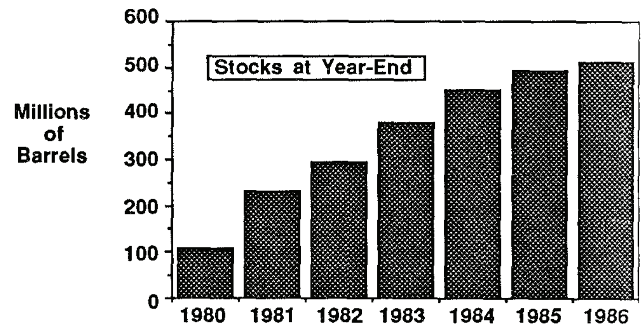
STRATEGIC OIL RESERVE HAS BEEN TESTED OPERATIONALLY AND IS READY WHEN NEEDED

The United States has supported efforts under the International Energy Program (IEP) to enhance the energy security of the 21 industrialized nations that are members of the International Energy Agency (IEA). Through the IEA, the United States has urged reliance on strategic stocks as the first line of defense in an oil supply disruption, and much has been accomplished.

Government-owned and -controlled oil stockpiles are considerably larger now than in the 1970's. The SPR in this country now contains more than 500 million barrels of oil, nearly five times the level on hand when this Administration took office. In August 1986, the President reaffirmed the commitment to a goal of 750 million barrels in the SPR. The Administration also has announced its basic policy to draw down the SPR early and in large volumes in response to a supply disruption.

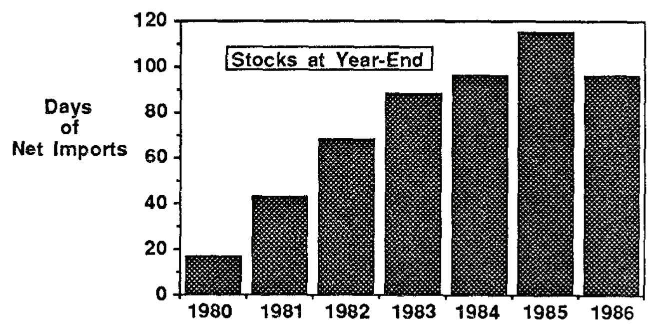
At this time, the SPR contains the equivalent of about 96 days of net imports at current import levels. Oil can be withdrawn and distributed from the SPR at a maximum rate of 2.3 million barrels per day for 120 days, and the entire Reserve can be drawn down over the course of a year. A test sale of oil from the SPR just over a year ago demonstrated the operational effectiveness of SPR sales and distribution procedures. This also gave the oil industry an opportunity to become more familiar with SPR procedures.

Contents of U.S. Strategic Petroleum Reserve



Source: EIA, Monthly Energy Review

Changes in Size of U.S. SPR, In Relation to Net Imports



Source: EIA, Monthly Energy Review

As discussed previously, other OECD countries also have established emergency oil stockpiles, which now account for about 350 million barrels of oil and are continuing to increase. Under the auspices of the IEA's Standing Group on Emergency Questions (SEQ), a consultative process has been established for drawing down such stocks in a coordinated manner. This agreement should maximize their value and avoid counterproductive measures.

The collective efforts of the OECD countries (including the United States) have taken significant strides in making industrialized nations less vulnerable to the perils of supply interruptions. In addition, the current excess production capacity of approximately 10 million barrels per day worldwide reduces overall vulnerability to a new disruption in oil supply.

In the domestic energy area, with the establishment of the Interagency Group on Energy Vulnerability, chaired by DOE, the Administration has institutionalized the process for assessing the vulnerability of U.S. energy systems and developing approaches to mitigate the effects of nonroutine disruptions to these systems from such causes as sabotage, terrorism, or natural disasters.

ONGOING EFFORTS ENSURE A MORE SECURE ENERGY FUTURE IN FACE OF ALL CHALLENGES

Here is an outline of what has been done—and what is still going on—to make sure that this Nation is adequately prepared for energy emergencies:

The Strategic Petroleum Reserve (SPR). The Administration will aggressively continue to fill the SPR until the goal of 750 million barrels is reached, subject to budget constraints. Not only is the SPR a powerful complement to the free market, but—in conjunction with strategic stocks in other oil-consuming nations—it also acts as a deterrent to deliberate attempts on the part of oil-producing countries to deny oil to consuming countries.

International Energy Program. The United States continues to work with its partners in the International Energy Agency (IEA) to maintain high emergency stock levels, establish procedures for early, coordinated stockdraw, and promote international energy policy goals to increase the common energy security of all IEA countries. The agreement on an International Energy Program signed in November 1974 established an emergency system for coordinating responses and sharing supplies in a major oil supply disruption. The United States stands firmly behind all its commitments to the IEP, although it is generally recognized that the emergency sharing system is likely to be cumbersome and that alternative measures should be tried first as long as practicable.

Monitoring the Energy Situation. Government energy planners monitor the energy market continuously and study intelligence information. Market studies and energy vulnerability assessments analyze the dynamics of changing technology, potential threats, and energy requirements. This effort draws on the best information available from various Federal agencies, private industry, and academia. It allows energy situations to be rapidly analyzed and brings potential and actual problems to the attention of officials responsible for implementing emergency procedures.

Improved Emergency Procedures. The Federal Government is continually improving its decisionmaking procedures and analytic tools (for example, the Energy Emergency Management System, data bases, computer models) by which appropriate response actions can be determined. The process for emergency response involves crisis identification and assessment, response decisionmaking, and response implementation. The systems and staffs to support this process are continually upgrading the ability to respond to an energy emergency.

Tests and Exercises. The Government tests its emergency response system in exercises such as these:

- Tests of the drawdown and distribution procedures for the Strategic Petroleum Reserve, as well as of the decisionmaking processes themselves.
- Tests of procedures for dealing with international oil emergencies.
- Tests of Federal emergency management systems and crisis management procedures for various energy and national security emergencies. DOE supports the Federal

Emergency Management Agency in these and other activities by providing analytical and response expertise in the energy sector.

Domestic Threats. As part of this effort to ensure a more secure energy future, the Federal Government will continue to work with the energy industries to make the Nation's energy systems more physically secure from sabotage and terrorism.

The objective of the energy system physical security program is to ensure adequate energy security at a reasonable cost. To accomplish this, the Government supports industry efforts by providing physical security planning assistance and information.

Government and industry operate jointly in evaluating potential threats to energy systems, assessing the vulnerability of these systems to such threats, and identifying programs to reduce vulnerability to an acceptable level.

Domestic energy emergency planners also support and participate in national counterterrorism efforts—such as the Vice President's Cabinet-level Task Force on Terrorism and the Interagency Group on Terrorism, which is chaired by the State Department.

FREE WORLD'S DEFENSE REQUIREMENTS MUST BE MET UNDER ALL CIRCUMSTANCES

RELATED FUEL NEEDS INVOLVE PEACETIME AND WARTIME USES AT HOME AND ABROAD

Administration policy is to ensure adequate energy supplies for defense and broader national security purposes under all circumstances, in both emergency and nonemergency periods.

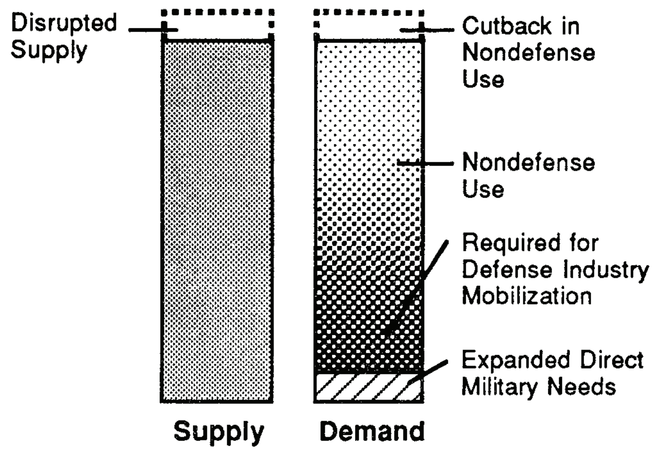
During peacetime, the U.S. military establishment uses between 2 and 3 percent of annual U.S. domestic petroleum product consumption. As noted in the "World Energy Outlook" chapter, military demand involves mostly jet fuel. During peacetime, purchases of military petroleum are made largely in the United States, but U.S. refiners also supply some overseas fuel needs.

In a major conventional military conflict, petroleum products such as jet fuels are critical; and direct military consumption would likely be double or triple peacetime levels. Nevertheless, even this substantial increase in direct military consumption would represent a relatively small proportion of normal U.S. oil consumption (a somewhat larger portion, if nondefense demand is constrained by a supply disruption), and most of the incremental demand would be overseas.

Ensuring that defense demands are met may mean that some other, more discretionary demands would yield to security requirements in an emergency.

During a major war, direct military needs would have top priority for available energy supplies. The next priority would be assigned to indirect defense needs, such as vital industrial use. (The exact extent of these could vary considerably, depending on circumstances.) Part of the remaining demand would be for essential civilian services.

Defense Demands Will Be Met in an Emergency



Under normal conditions, military fuels are bought competitively. Fuel contracts are also sought competitively, to the extent possible, under emergency conditions. Assured crude oil supplies, including supplies from the SPR, are important to the production of these fuels. In 1984, Congress granted the Department of Defense (DOD) authority to streamline the procurement process in, or in anticipation of, times of fuel shortage to improve procurement flexibility. The role of the Departments of Defense and Energy is to coordinate use of the Defense Production Act (DPA) when needed to ensure supplies for mobilization. The DPA has been needed only once since 1945—during the 1973 embargo, when 18 contracts were signed under allocations. In 1979 and 1980, when price and allocation controls were in place, DOD again experienced initial difficulty obtaining fuels, but successfully met fuel requirements, so that DPA did not have to be used.

Depending on the scenario, military fuel demand may increase quickly or slowly—in one or more regions. War reserve fuel stocks are placed strategically for that reason, to support initial requirements. Cooperative agreements with host nations can also help in obtaining supplies and moving the supplies to where they are needed.

Combat-based demand lies mostly overseas; and every effort would be made to obtain supplies within the affected region, for obvious logistical reasons. In a prolonged conflict, the United States would begin in time to ship larger amounts of fuel to its deployed forces.

Since even wartime demand is a small percentage of U.S. total demand, the primary limitations are logistics in the war zone, rather than supply availability.

GOVERNMENT AND INDUSTRY BOTH HAVE SIGNIFICANT ROLES IN GETTING THE JOB DONE

Federal preparedness efforts are oriented toward developing policies and programs that will ensure that energy requirements are met for the Department of Defense and the defense industrial base. Such policies and programs will be incremental, based on ascending levels of energy requirements and supply impacts.

The available capabilities for mobilization activities currently include the following:

- The Strategic Petroleum Reserve. Besides increasing oil supplies for general market distribution significantly, up to 10 percent of the daily drawdown may be directed to specific purchasers if deemed necessary.
- A system to implement authorities of the Defense Production Act as needed, to ensure that DOD and defense industrial base requirements are met.
- National Defense Executive Reserves, who could be activated to help manage programs for facilitating DOD access to energy markets, facilitating responses to other oil supply requirements, and working with industry to mitigate any temporary dislocations.

Efforts are under way to ensure that the energy required for mobilization and subsequent activities is available to operating forces, the U.S. industrial base, and the civilian sector:

- The recently chartered Interagency Group on National Mobilization carries out planning and analysis of mobilization requirements.
- DOE sponsors and fully participates with other agencies in tests and exercises oriented toward mobilization preparedness.
- The Federal Government also cooperates with industry in planning and program development efforts through a variety of channels. These include advisory committees and councils, as well as training of the National Defense Executive Reserves. The recent study by the National Petroleum Council on U.S. petroleum refining exemplifies the results of such efforts.

STRONG COMMITMENT TO NATO INVOLVES PLANS TO COORDINATE OIL INDUSTRY EXPERTISE

NATO's Petroleum Planning Commitee (PPC) is the focus of the U.S. Government 's interests regarding civil energy emergency preparedness. This group is responsible for coordinating NATO's civil petroleum planning to ensure that essential civil and military defense needs are met during crisis and wartime conditions. For example, the PPC has recently completed reports that highlight the role of strategic stocks in reducing Alliance vulnerability and highlight the need for increased planning to meet military fuel requirements. The U.S. energy emergency program with NATO ensures that:

- Mutual energy interests are being pursued with crucial U.S. allies.
- The U.S. National Oil Board (that is, the wartime DOE) will be operationally capable of performing its essential functions. These include adequate information systems to identify U.S. supplies and requirements to support NATO objectives. Systems are tested as part of regularly scheduled NATO

exercises and training sessions, for which the U.S. Government has provided a high level of staff support. Military requirements for both crisis and wartime conditions are developed by the Department of Defense.

- The NATO Wartime Oil Organization (NWOO)-West, which is based in the United States, is operationally ready. Key activities include the following: recruitment of oil industry experts who comprise the Joint Operational Staff; maintenance of a high state of readiness through training programs and periodic recruitment efforts to respond to the changing oil industry; development of detailed operational procedures and consultative mechanisms ready for use during a crisis or war; and predesignation of senior DOE officials to serve as U.S. representatives to NWOO-West and NWOO-East (headquartered in the United Kingdom). National representation is necessary for NWOO to perform its policy and executive functions, including establishment of oil supply policy for NATO.

In addition, DOE is undertaking a review of the NATO energy infrastructure, such as the NATO oil pipeline system. The results of the analysis will improve the U.S. Government's energy emergency plans and programs for supporting NATO. They will ultimately strengthen U.S. energy emergency response systems for the Alliance.

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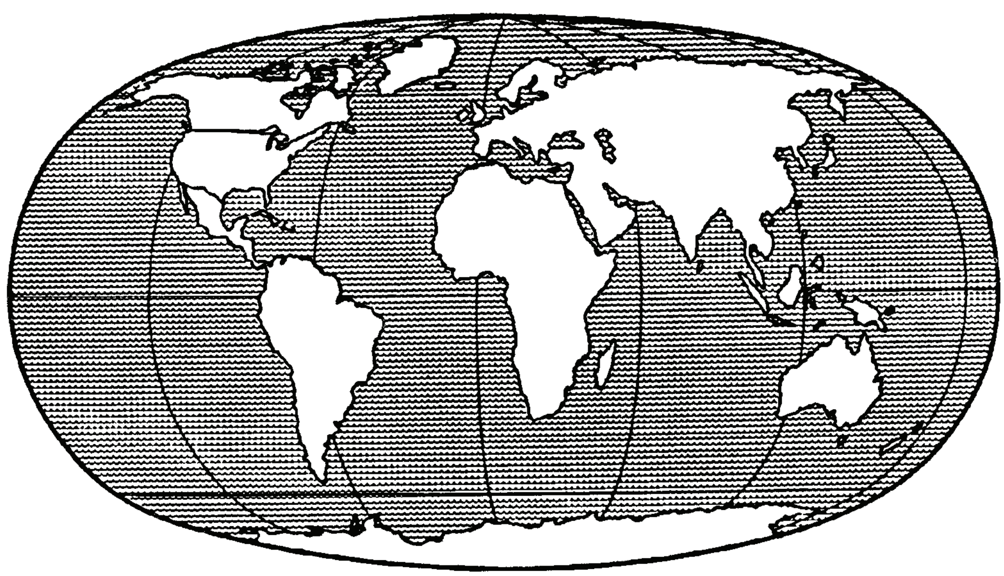
INTERNATIONAL ENERGY ACTIONS



THE SITUATION IN BRIEF

One of the key lessons learned from the 1970's was that world energy markets—especially international oil markets—are extremely interdependent. Individual nations cannot "go it alone"; they are inevitably affected by the decisions and reactions of all other major market participants—in both normal and abnormal times. A barrel of oil or any other unit of energy that is saved, stocked, or produced anywhere in the world can contribute to collective energy security. Similarly, a loss of supply anywhere can affect markets everywhere.

Much progress has been made since 1973. Energy is being applied more efficiently: real economic growth has been possible without any significant increase in overall energy consumption, and with an actual decline in the amount of oil used. Non-OPEC production potential has developed significantly; and this increase, combined with the expanded use of coal, nuclear power, and renewable energy has helped to limit dependence on less secure Persian Gulf oil.

There could still be some surprises in the way world energy markets respond to low oil prices. It seems only reasonable that monitoring of energy market developments should continue, that emerging trends need to be analyzed, and that the United States should continue to consult with its allies about developments in energy supply and demand. The free world should resist temptations toward either inaction or overaction.

U.S. international energy security policy is based on and is reflective of the domestic energy and economic policy strategies that have been outlined. The two-part international strategy has twin objectives:

- enhancing preparedness for any likely future energy emergency—improving the ability to mitigate harmful effects from short-term supply disruptions; and
- removing artificial barriers that make it difficult for free market forces to function, so that a mixed, balanced, and more flexible energy supply system can be developed efficiently—reducing the long-term problem of vulnerability related to rising dependence on potentially insecure supplies.

International cooperation and understanding represent the mechanisms for achieving this country's objectives; they should normally succeed in ensuring that complementary policies are developed, adopted, and pursued.

The United States and many of its allies are likely to become increasingly reliant on the Middle East's vast reserves of oil; and it is prudent to recall that this country shares many interests and objectives with the moderate Arab States of the Gulf. The United States can contribute much to the long-term security of energy supplies from this area by promoting those aspects of its bilateral relationships that will foster regional peace and stability.

INTERCONNECTED WORLD MARKETS DICTATE INTERNATIONAL APPROACH TO ENERGY SECURITY

DISRUPTION OF SUPPLIES ANYWHERE WILL AFFECT PRICES FOR ALL NATIONS

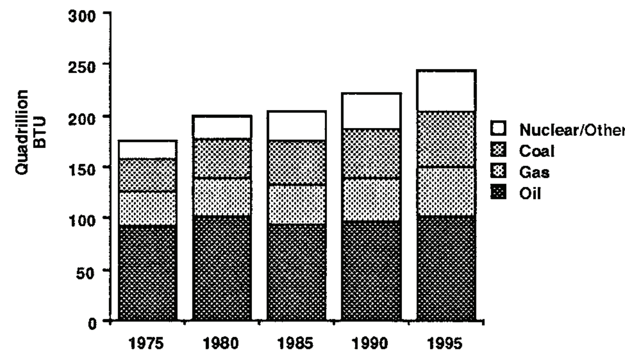
There is but one world oil market. A disruption of supplies anywhere will affect prices everywhere. Likewise, production from secure sources, or the addition of a barrel to emergency reserves anywhere, can contribute to the energy security of all consuming countries. Furthermore, all nations can contribute to international security through diversification of energy production and supply, through development of other fuels, through energy conservation, and by building strategic stocks of petroleum.

International cooperation is essential. One country cannot afford to go it alone.

Last year's decline in oil prices was the result of the collective response of all producers and consumers to the price increases of the 1970's. Likewise, the U.S. experience with domestic price controls during the 1970's shows that one country cannot insulate itself from conditions in the world petroleum market. Domestic price controls resulted in a rise in U.S. net oil imports that contributed to the overall tightening of the market precipitated by the outbreak of the Iranian revolution.

Many of the world's major oil suppliers have interests that coincide with those of the United States. It is in the national security interest to reinforce those commonalities and try to enhance the overall security and welfare of those producing countries—many of which are in unstable areas of the world.

Free-World Energy Consumption Trends



Source: U.S. DOE/EIA

A NUMBER OF FACTORS SUGGEST GLOBAL ENERGY CONSUMPTION WILL GROW ONLY MODERATELY

Reductions in oil demand because of conservation, efficiency gains, and substitution of alternative fuels, coupled with increased competition from non-OPEC oil suppliers, brought about the dramatic collapse of oil prices in early 1986. Oil prices have been volatile and are likely to remain so in the near term.

Lower oil prices, even if they persist for only a few years, will stimulate growth in total energy and oil demand, discourage oil production from high-cost reserves, slow down gains in efficiency and conservation, reduce the incentive to develop alternative fuels, and lead to rising dependence on imported oil. At the same time, lower oil prices promote economic growth, increase GNP, and have a net beneficial effect on the economies of the United States and other oil-importing countries.

As all these factors are projected to balance out, overall energy demand is seen growing only modestly over the next 10 years—by between 60 and 70 percent of the rate at which economic growth takes place. World oil consumption is expected to grow more slowly than total energy demand despite falling oil prices. Many nations, particularly those in Western Europe, have taxed away much of the price decline, so many world consumers continue to pay high prices right now.

Oil's share of the world energy market declined from more than 50 percent in 1973 to 46 percent in 1985, and is expected to fall further to 43 percent in 1995. Oil and natural gas together then may account for somewhat less than 60 percent of free-world energy supplies. Coal consumption will continue to grow in absolute terms, and nuclear power will continue to show the fastest growth as plants currently under construction are completed over the coming years. However, the uncertain long-term outlook for nuclear power could increase the demand for fossil fuels.

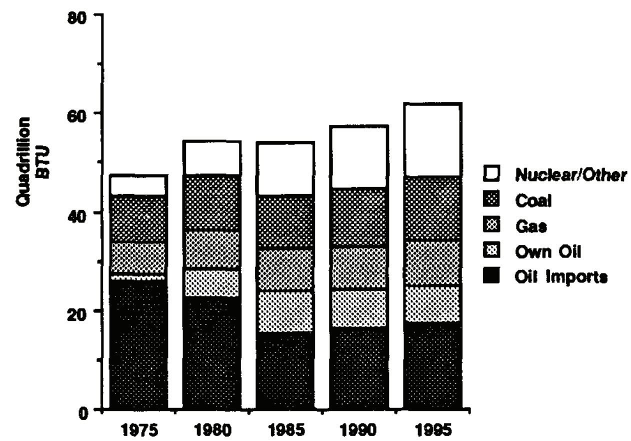
WEST EUROPEAN COUNTRIES EXPECTED TO INCREASE THEIR IMPORTS OF ENERGY

The growth of energy demand in Europe has been fairly modest, focused primarily in the industrial sector. High and rising fuel taxes are likely to dampen the growth of demand in some countries.

North Sea oil production will level off in the United Kingdom and will increase slightly in Norway, but overall European oil imports are on the rise. Gas imports from Algeria and the Soviet Union are increasing too, but over the longer term the extension of Dutch export contracts and the development of Norway's Troll and Sleipner fields will make a considerable contribution to energy security.

The potential exists for greater coal use. Presently, many countries subsidize domestic production of coal and constrain its importation. Coal could be more competitive—and in many cases cleaner—if European markets were opened fully to coal imports from all countries belonging to the OECD.

Western Europe Consumption Rate



Source: U.S. DOE/EIA

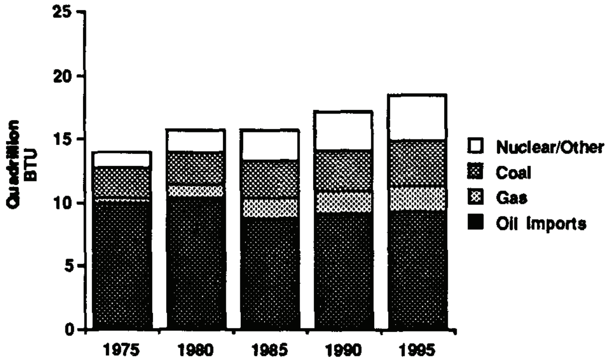
Several countries rely on nuclear power for more than 50 percent of their electricity needs. Most nuclear power in 1995 will have to come from plants that are already planned or under construction. Plants for the post-1995 period could be influenced by the debate surrounding nuclear power and safety.

If nuclear power development is stopped or delayed in Europe, electricity utilities there will have to turn to increased use of gas, oil, and coal. Increased coal generation may be constrained, however, by increasing concern in Europe about air pollution and "acid rain." Although European Community regulations generally prohibit oil- and gas-fired power-plants, there is substantial idle oil- and gas-fired electricity generation capacity; and—if nuclear power development is stopped or delayed—additional imports of oil and gas are the most readily available substitutes.

JAPAN WILL CONTINUE HIGH DEPENDENCE ON OIL IMPORTS DESPITE DIVERSIFICATION EFFORTS

Japan has very limited indigenous energy resources. It relies mostly on imports for its supplies. Energy demand in Japan is expected to continue rising; but the rate of increase will probably be less than it has been, because of a projected slowdown in economic growth there.

Japan's Energy Consumption Trends



Source U.S. DOE/EIA

Even though Japan has made progress in reducing its dependence on oil, oil is still the country's major source of primary energy. In fact, Japan is second only to the United States as the largest consumer of oil in the free world. Furthermore, Japan imports almost 100 percent of the oil it consumes; and more than three-fourths of this oil comes from the Middle East.

The demand for natural gas and imports of that fuel are growing rapidly in Japan because of the preference there for gas as a clean fuel. Japan has many diverse sources of liquefied natural gas (LNG) imports, and it is presently reviewing the possibility of expanded LNG imports from Alaska.

Japan is a major importer of metallurgical coal and steam coal. Steam coal imports are expected to rise, partly in response to Japan's recent policy decision to reduce subsidies to uneconomic domestic coal production between now and 1990.

Japan has undertaken an ambitious nuclear power program, and nuclear power generation exceeded oil-fired generation for the first time in 1985. Nuclear power is expected to continue to grow rapidly, and it should supply nearly 15 percent of Japan's primary energy needs by 1995.

Japan is trying to reduce its dependence on imported oil, and these ongoing efforts are expected to curb future increases in net oil imports somewhat. Oil imports are expected to rise from the 1985 level of 4.3 MMBD to a range between 4.4 and 4.6 MMBD in 1990 and from 4.4 to 4.8 MMBD in 1995.

LESS DEVELOPED NATIONS FACE RISING ENERGY DEMAND FOR A VARIETY OF REASONS

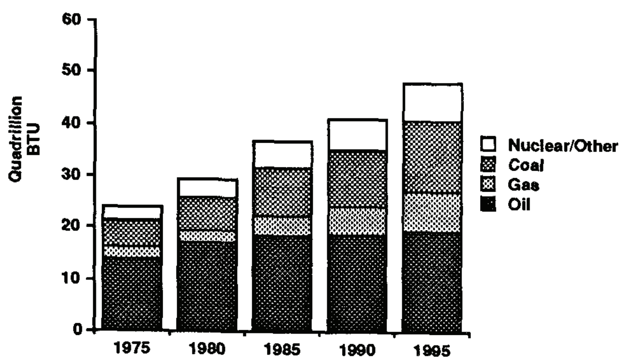
Energy demand in non-OPEC developing countries has grown rapidly in the past, and it is expected to continue to rise between now and 1995. In low-income developing countries, rising energy demand is the result of continued urbanization—which creates a shift from reliance on traditional fuels (such as wood) to greater reliance on commercial fuels (such as oil, gas, and coal). In the higher-income, newly industrializing countries, the relocation of some energy-intensive industries, such as steel, away from the OECD to these countries has caused energy demand to rise rapidly.

Rising incomes and an increase in the transportation sector's use of energy have caused the demand for oil to rise even faster than overall energy demand in many developing countries. However, higher oil prices slowed this demand growth in the early 1980's, and investments in alternatives to imported oil may hold the growth in oil demand to less than historical rates between now and 1995.

Many developing countries have considerable untapped potential for various types of energy production. Many obstacles to the economic development of energy resources need to be overcome, however, if this potential is to be developed at a pace that is rapid enough to meet rising demand.

Many of the obstacles to energy development in these countries are not technical in nature. They can be overcome with the adoption of sensible fiscal policies, deregulation, removal of barriers to foreign investment, and encouragement of a strong private sector.

Non-OPEC Developing Countries' Consumption Trends



Source: U.S. DOE/EIA

OPEC NATIONS NOT ALL ALIKE IN OIL RESOURCES THEY HAVE OR IN THEIR NEEDS FOR REVENUE

Following the 1973 oil embargo, OPEC countries coordinated their efforts to influence prices. Although the decline in OPEC's share of the world oil market has reduced its ability to influence the market considerably, OPEC's market power could revive to a considerable extent in the future.

About 70 percent of current world excess production capacity and 56 percent of the world's proven oil reserves are in Persian Gulf OPEC countries. Production by the Persian Gulf countries as a group varies more in response to swings in world oil supply and demand than does the production in other countries.

Saudi Arabia remains the single most important player in world energy markets. Despite its relatively small population, even Saudi Arabia cannot endlessly adjust its production level—and oil revenues—to accommodate a market glut; and this was evidenced by the Saudi decision in 1985 to abandon its role as OPEC's swing supplier. Nevertheless, Saudi Arabia retains the ability to influence oil prices at almost any time by withholding supplies from the market—or, alternatively, by using its substantial excess capacity to cause a further precipitous drop in prices. Because of its large reserve base, Saudi Arabia will remain a key factor in world oil supply security well into the next century.

Productive capacity in Iran and Iraq is still being limited by the continuing hostilities between those two oil producers. Once the war is over, capacity in that area could almost double. Because of their need to rebuild shattered economies and to restore depleted foreign exchange reserves, in fact, Iran and Iraq would be likely to try to increase their output if circumstances permitted this.

Other Persian Gulf OPEC countries have substantial oil reserves and small populations. Major changes in their oil production capacity are unlikely, although Qatar has world-class gas reserves.

More than 25 percent of the world's excess production capacity is in OPEC countries outside the Persian Gulf. Some of these countries are also among the organization's most populous, and as a result they have the greatest revenue requirements. This gives them a special incentive to maintain output to meet their revenue needs. Non-Persian Gulf OPEC countries, however, possess only about 15 percent of world reserves. Their capacity is not likely to increase dramatically in the future.

Because of the size of the Orinoco Heavy Oil Belt, Venezuela has potential oil reserves on a scale to match Persian Gulf producers. The vast majority of this oil, however, is uneconomic at today's prices.

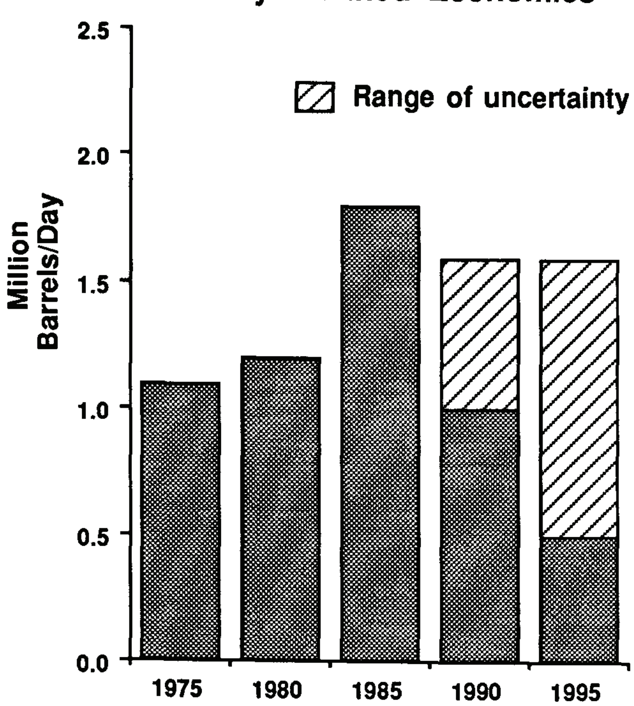
Because of steadily declining oil prices since 1981, the average rate of economic growth for all OPEC countries as a group has slowed. Nevertheless, OPEC's own oil consumption is increasing. It is expected to be about 4.2 MMBD by 1995, compared to an estimated 3.4 MMBD last year.

THE U.S.S.R. WILL TRY TO MAINTAIN ENERGY EXPORTS TO THE WEST TO EARN HARD CURRENCY

Among the centrally planned economies, the U.S.S.R. and China are responsible for almost all net oil exports. Although the U.S.S.R will probably remain the world's largest oil producer for the foreseeable future, total exports from the centrally planned economies are projected to drop from their 1985 level of 1.8 million barrels per day; and by 1995 they may be no more than half a million barrels per day.

The Soviet Union would almost certainly like to maintain hard currency earnings, so it will probably try to export more natural gas as its domestic oil production diminishes. During 1986, oil and gas exports accounted for about 40 percent of total Soviet hard-currency earnings. This was down from 55 percent in 1985, largely because of the decline in energy prices on the world market. The U.S.S.R.'s vast resources of both gas and coal—as well as its large-scale nuclear power program—give it considerable flexibility in substituting other energy sources for its domestic use of oil.

Net Oil Exports by Centrally Planned Economies



Source: U.S. DOE/EIA

China is widely believed to have considerable potential for oil and gas production, and its coal reserves and hydropower resources are well documented. Nevertheless, the rapid modernization and industrialization under way in China are likely to strain its existing and foreseeable capacity for energy production; and an inadequate energy supply is a heavy constraint on China's near-term economic development.

TWO-PART INTERNATIONAL STRATEGY CAN HELP TO ACHIEVE NATION'S ENERGY SECURITY OBJECTIVES

International coordination is highly desirable in emergency preparedness and in the development of adequate supplies of energy at reasonable costs. At the same time, this country is committed to relying on market forces rather than on government-imposed solutions, while maintaining a prudent concern for national security.

The United States has chosen a cooperative approach as the mechanism for implementing its international energy security strategy and ensuring the adoption of complementary policies. Through cooperation, the U.S. is attempting to maintain IEA solidarity on energy security issues and in opposition to collusion on prices and production between OPEC and IEA oil producers; and also to maintain friendly bilateral relations with key oil-producing countries—both within and outside OPEC.

The United States is pursuing the following two-part international program:

- **To improve international capability to respond to an energy emergency:**

  —The quality and quantity of strategic oil stocks held by OECD governments (including the U.S. Strategic Petroleum Reserve) should be raised and procedures for early, coordinated stockdraw should be established as the first line of defense for the OECD in an oil supply disruption.

- **To remove barriers to the economic development of alternative supplies and flexible energy-use systems:**

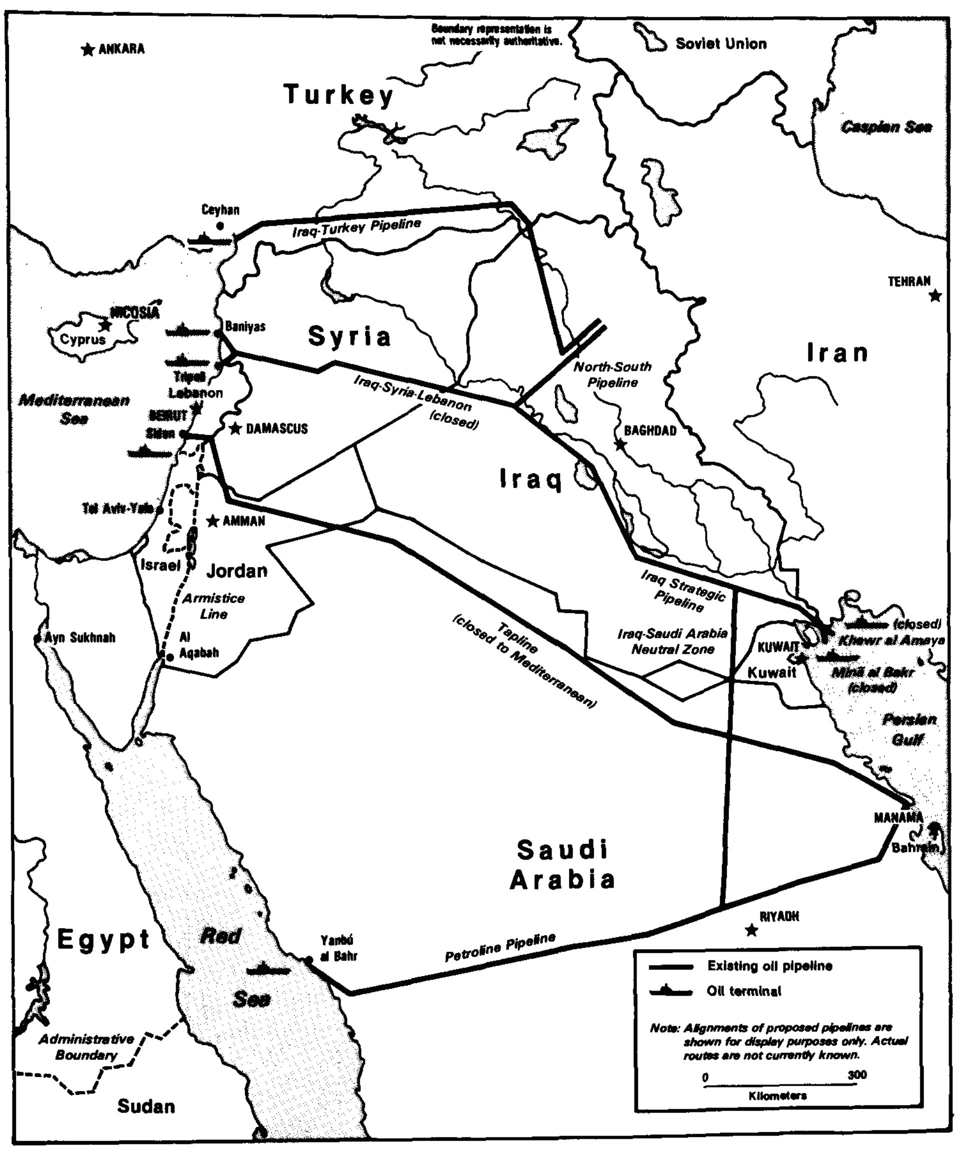
—Nuclear safety and safeguards must be promoted on a continuing basis, so nuclear power can remain a viable energy supply option in many countries.

—Market forces should continue to provide basic direction, even in an era of low oil prices. Both producer and consumer governments should be encouraged to let supply and demand determine prices and production levels.

—Western Europe should be discouraged from letting itself become unduly dependent on Soviet gas, but the expansion of intra-OECD gas trade should be encouraged.

—U.S. exports of energy and energy technology can be promoted by encouraging removal of barriers to trade—particularly in the EEC, Canada, and Japan—while resisting protectionist pressures within the United States.

Major Middle East Oil Pipelines



A COOPERATIVE APPROACH IS THE MECHANISM CHOSEN BY THE U.S. TO ACHIEVE ITS OBJECTIVES

STABILITY IN THE PERSIAN GULF IS OF VITAL IMPORTANCE TO ENERGY SECURITY

The U.S. interest in stability in the Gulf derives from the region's economic, strategic, and international political importance. A central interest is oil, of course, but the free world also needs unimpeded access to the transportation and communication routes of the Gulf. In addition, the independent, pro-western states of the region contribute positively to the world's economy, to economic development, and to political moderation.

Proven reserves of petroleum in Saudi Arabia alone amount to approximately 25 percent of the world total. The Gulf region as a whole (Iran included) accounts for more than half of the world's proven reserves.

U.S. trade with the countries of the Gulf totaled $9.95 billion in 1986. This country's exports to them totaled $5 billion, while imports (oil and refined products) were slightly less—$4.95 billion.

Saudi Arabia and some other Arab countries of the region have been supportive of efforts to promote peace and stability in the Middle East. Saudi Arabia, Kuwait, and the United Arab Emirates have contributed substantial portions of their oil revenues to bilateral and multilateral aid and to development organizations. The Gulf Cooperation Council (GCC) has sought to foster regional economic integration and collective defense in response to a growing Iranian threat. Saudi Arabia has provided generous financial and political support to the Afghan resistance.

To support its interests in the region and to bolster the security of its friends, the United States maintains a permanent naval presence in the Persian Gulf and the Gulf of Oman/Indian Ocean. In addition, this country has a large military training mission and an airborne warning and control (AWACS) detachment in Saudi Arabia. This military presence and the arms supply relationships with the GCC countries serve not only to deter Iran, but to demonstrate to the Soviet Union the U.S. commitment to protecting its regional interests.

BILATERAL COOPERATION WITH OIL-PRODUCING COUNTRIES FAVORS FREE-MARKET OBJECTIVES

Sound bilateral relationships with energy-producing countries are important to long-term U.S. energy security. In the long term, peace and stability in the oil-producing regions of the world—most notably the Middle East—are essential to ensuring energy security for the United States and the rest of the West.

Through these relationships the United States encourages the development of complementary energy policies and seeks to develop support for U.S. policy objectives—including the development of producer nations' policies along free market lines. These contacts have also proved useful in spotting and resolving potential disputes, and in the sharing of technical information and market outlooks.

Regular but informal dialogues have been established with Mexico, Venezuela, and Canada. All are important suppliers of energy to the United States and to key U.S. allies.

In the Middle East, bilateral discussions with the six-member Gulf Cooperation Council—all of whom are oil exporters—offer an important opportunity to project U.S. energy interests and concerns and to achieve a mutual understanding of long-term energy objectives.

Other efforts are under way to strengthen ties with energy-producing nations in the Pacific Basin, including China and the countries of Southeast Asia.

MULTILATERAL COOPERATION THROUGH IEA AND IAEA ADVANCES U.S. INTERESTS

Recognizing the interdependence as well as the independence of other nations, the United States seeks a stable and secure energy environment in which free markets and free people can determine price and production levels.

The United States participates actively in the International Energy Agency (IEA) of the OECD. The IEA is the principal international forum for industrialized country cooperation on energy security issues. It has proved its usefulness as a vehicle for sharing information and for coordinating policies in regard to oil stocks, free trade in energy, limiting dependence on Soviet gas, and joint R&D cooperation in emerging energy technologies.

In the future, the United States will work within the IEA to encourage the buildup of government-controlled strategic stocks, the removal of barriers to free energy trade, the maintenance of the nuclear energy option, and further advances in joint R&D cooperation.

The United States is also active in the Vienna-based International Atomic Energy Agency (IAEA). The IAEA has repeatedly proven its value to U.S. policy objectives, primarily through its system of nuclear nonproliferation safeguards. Those safeguards provide a necessary underpinning to the operation and development of commercial nuclear power worldwide.

Since its inception, the IAEA has assumed growing importance as a focal point for international efforts to assure the safe operation of nuclear power worldwide. Last September the international community—through the IAEA—adopted two key conventions, one on emergency notification of nuclear accidents and the other on emergency assistance in the case of nuclear accidents. This activity on the part of the IAEA embodies the commitment of the international community to the continued development of safe nuclear power. As such, it contributes to the maintenance of nuclear power as a key component in the energy mix of the West and thus to overall energy security.

Cooperation with LDC's is an important supplement to cooperative ties with IEA members. Through such cooperative activity, the U.S. seeks:

- To encourage the development of additional oil and gas supplies, and an environment in those nations which is conducive to the participation of the U.S. private sector;

- To work through AID, multilateral aid institutions, and technical exchange agreements to facilitate improved energy planning, conservation, and the development of cost-effective and market-based energy systems in the LDC's.

EMERGENCY PREPAREDNESS IS A GLOBAL JOB THAT CAN EASE STRESSES OF FUTURE DISRUPTION

WORLD OIL SUPPLIES HAVE BEEN INTERRUPTED NUMEROUS TIMES SINCE 1950

There have been about 15 oil supply interruptions since 1950. All of the major interruptions occurred as a result of political events in the Middle East. Because of prevailing market conditions, however, not all of these disruptions resulted in economic dislocations. For example, the Six Day War in 1967 removed approximately 2 MMBD from the market over two months without appreciable economic effects.

In 1956-57 the Suez Canal was closed at the outbreak of Arab-Israeli hostilities. West European dependence on this vital transportation corridor left it vulnerable. At that time there were not enough tankers to carry oil around the Cape of Good Hope, so market forces caused oil prices to rise significantly. Excess production capacity in the United States and Venezuela helped to limit the impact of that disruption; and after the Canal reopened prices fell.

At the outbreak of the October 1973 Arab-Israeli War, several Arab oil-producing countries declared an oil embargo against selected countries, including the United States; and they also cut back their overall production. Although this overall cutback was as high as 3 to 4 MMBD for a brief period, the average net supply disruption over a 6-month period was about 1.5 MMBD. For reasons that have already been discussed in this report, prices on the world market virtually tripled at that time. In response to the supply disruption the major oil-consuming countries formed the International Energy Agency and established an emergency oil-sharing system to try to cope with future embargoes and disruptions.

From November 1978 through April 1979, unrest in Iran resulted in another disruption of up to 6 MMBD. Production increases in other countries substituted for part of this disruption, holding the overall net supply loss to about 2.0 to 2.5 MMBD. Consuming countries responded with ineffectual measures centered on demand restraint and import ceilings. By mid-1980 prices had doubled.

The outbreak of the Iran-Iraq war in October 1980 removed 2.0 to 3.0 MMBD from the oil market. Prices increased briefly but soon returned to previous levels—thanks to increased production in other countries and to the utilization of company stocks as urged by the IEA.

In 1984, escalating hostilities between Iran and Iraq resulted in the beginning of attacks against oil tankers in the Persian Gulf. Significant excess production capacity existed then, and a coordinated international response included the widespread recognition of consumer countries' willingness to draw on oil stocks if necessary. This kept these attacks from having a noticeable impact on the world oil market.

Although there is only a small risk of a significant disruption that could cause another sharp increase in oil prices in the near term, many of the political, social, and military factors that led to past disruptions are likely to persist in the future. Disruptions in oil supply could trouble the world again.

EXPERIENCES HAVE SHOWN WHAT MIGHT HAPPEN AGAIN AND WHICH APPROACHES HELP

History has shown that relatively small changes in world oil supply and demand can produce dramatic swings in oil prices. The magnitude of the price change depends not only on the size of the initial disruption, but also on market expectations, inventory movements, the particular circumstances surrounding the disruption, and the responses of producing and consuming governments.

The risks of oil supply disruptions and the potential costs of energy price shocks will vary over time as market conditions change. The continuous evolution of oil and energy markets necessitates a flexible energy security policy that can incorporate the results of ongoing market monitoring and situation analysis.

In any case, however, the early use of stocks to reduce or to limit the economic damage of a supply disruption is preferable to response mechanisms aimed at redistributing the economic burdens of a shortage. International cooperation in the application of strategic oil stocks can maximize the benefits for all countries of building and using them. International cooperation is the key to reducing the risks of irresponsible behavior by governments. The fact that cooperative international emergency responses exist is in itself a deterrent to politically motivated supply manipulations.

In past crises, agreements by governments on short-term measures of demand restraint proved to be difficult to implement and to monitor. They were also highly ineffective. Likewise, government price and allocation controls exacerbated the effects of those supply disruptions. Reliance on market forces to allocate scarce supplies is evidently the most efficient alternative.

BUILDING UP STRATEGIC STOCKS INTERNATIONALLY HELPS OFFSET DANGER OF HIGHER DEPENDENCE

The United States has been encouraging its partners in the International Energy Agency to undertake a political commitment to increase emergency stocks and to establish a consultative process for drawing down such stocks in a coordinated fashion in the event of an oil supply disruption. Given the prospect of higher import dependence in the 1990's, and given current low oil prices and readily available supplies, this is an opportune time for IEA countries to improve their stock levels.

At the times of most previous supply disruptions, emergency stocks in OECD countries were low. These consisted mainly of stocks held by companies, in excess of their own requirements, as a result of government regulations in Europe and Japan. Government-owned and -controlled stocks were virtually nonexistent.

Most countries now hold total stocks that are equal to or greater than 90 days of net imports, in accordance with IEA requirements. These stocks are held by governments, stock-holding entities, and companies. However, a large part of these stocks are necessary for companies' minimum operating requirements, and thus are not accessible for use in an energy emergency. For example, IEA total stocks averaged about 179 days of net imports on October 1, 1986, but IEA accessible stocks averaged only about 124 days of net imports on the same date.

Government-owned and -controlled stockpiles now are considerably larger than in the 1970's, and some countries are planning to expand their stockpiles further.

The Strategic Petroleum Reserve owned by the United States Government now contains more than 500 million barrels of oil. In August 1986, the President reaffirmed the commitment to fill the reserve toward a goal of 750 million barrels. The President has called on other countries to shoulder their fair shares of the burden and to increase their strategic stocks accordingly.

Several other OECD countries also have established government-owned stockpiles. These reserves currently contain about 225 million barrels, of which 140 million barrels are in Japan and 55 million barrels are in Germany. The Japanese Government plans to increase its reserve to almost 190 million barrels by early 1989.

Four European OECD countries have established special semi-public organizations to hold emergency stocks. These organizations currently hold about 125 million barrels of oil. The largest of these, in Germany, is scheduled to increase its stocks from almost 100 million barrels to about 135 million barrels by the end of 1988. The Netherlands also intends to increase the level of its emergency stocks.

Many countries have improved their stock levels in recent years, but further efforts are called for in other countries to increase their emergency stocks and to bring these stocks under effective government control. International preparedness would be improved if other countries built their accessible stocks to levels comparable to or higher than that of the United States.

COORDINATED EARLY DRAWDOWNS FROM STRATEGIC OIL STOCKS SERVE TO ENHANCE EFFECTIVENESS

In an energy emergency, the United States and its allies have common risks and interests. The buildup and maintenance of large oil stockpiles represents a significant investment by the United States and its OECD partners. The economic benefits of using stocks in an emergency will be maximized if the drawdown of stocks is coordinated, and if stocks are drawn down in large volumes early.

The United States and its IEA allies are developing procedures to guarantee that such a coordinated stock drawdown can be implemented in the event of an oil supply disruption. These procedures involve:

- regular monitoring of the countries' legal authorities, administrative procedures, and logistic constraints with regard to engaging in a coordinated response;
- rapid exchange, in an emergency, of information regarding oil market developments;
- early consultation among IEA members to agree upon the details of a coordinated response; and
- monitoring of members' performance and the overall effectiveness of the coordinated effort.

To be used in a coordinated early drawdown, stocks will really have to be "available," (that is, not required for normal commercial operations), and they will probably have to be under government control.

ALTERNATIVE DELIVERY ROUTES, FUEL-SWITCHING CAPABILITIES ALSO CONTRIBUTE TO SECURITY

Security does not stop with strategic stocks and the development of alternative energy supplies. Additional measures to make the energy supply more flexible can also be important. The United States has pursued initiatives in this area bilaterally, with the IEA, and at NATO's Petroleum Planning Committee.

A critical bottleneck for international oil transport is the Strait of Hormuz in the Persian Gulf. The countries of the Gulf are developing a system of pipelines bypassing the Strait, and further additions to this network are being contemplated. This clearly demonstrates their intention and desire to maintain oil exports. As an immediate response to war-related threats to civilian shipping, the United States and others have increased the peace-keeping naval presence in the area. As a long term measure, developing alternate transportation routes makes supply lines less vulnerable.

Supplies of natural gas to Western Europe could be reduced critically now through the actions of a single supplier—the Soviet Union. Besides urging greater reliance on OECD sources, the United States has supported the examination of additional pipeline and LNG routes from Africa and the Middle East. This country also strongly supported an IEA analysis of natural gas supply security, which examined the flexibility of the Western European gas pipeline system.

Through market incentives and the removal of market impediments to the efficient use of alternative fuels, the ability to switch fuels (usually between oil and gas, but also between oil and coal) has improved. This ability demonstrated its value during the 1979-80 period in both the electric utility and industrial sectors. The existence of fuel-switching capacity also allows consumers to choose the most economical fuel source as relative energy prices change. Fuel-switching tends to promote greater price stability because it moderates the supply and demand swings that underlie large swings in fuel prices.

The United States has urged the IEA to examine its member countries' abilities to address oil and gas supply interruptions through fuel-switching. This country will continue to press for both a generic examination and country-by-country examinations, via the International Energy Agency's annual review and its emergency review processes.

A BALANCED AND MIXED ENERGY SUPPLY SYSTEM WILL ENHANCE LONG-TERM SECURITY

FREE AND FAIR TRADE LETS PRODUCERS AND CONSUMERS SEEK ROUTES OF LEAST COST

Free and fair trade and investment make it possible for economical alternatives to insecure energy supplies to be developed and used. But for this market-oriented approach to work, trade restrictions, production subsidies, and restrictions on foreign investment must be removed.

Progress is being made in this direction. For instance, the United States and Canada are engaged in constructive discussions to remove the remaining barriers to freer commerce in energy between these important trading partners.

The subsidies to domestic coal production used by several countries (including Germany, Japan, France, Belgium, Spain, and the United Kingdom), hamper free trade in coal. Progress has been made in reducing these subsidies through the IEA and bilaterally, but additional movement is necessary.

There has been significant progress in removing restrictions on trade in petroleum products. However, several countries (such as Greece and Spain) still maintain controls on oil trade. Japan, which has opened its market to an important extent, apparently still maintains administrative controls that affect the level of petroleum product imports. The United States is continuing to press these countries to remove their remaining restrictions.

Restrictions on investment and technology, imposed for domestic protectionism to limit foreign participation, also impair the efficient development of energy resources. The United States will continue to press countries that have such restrictions (for example, Canadian ownership requirements) to remove them.

The remaining bans on exports of oil from the lower 48 States and the Alaskan North Slope decrease this country's energy security and that of its allies—by reducing wellhead prices for Alaska and California producers, and by discouraging a much-needed inflow of foreign investment in exploration and development activity in the United States.

NATIONS WITH LESS OIL POTENTIAL THAN PERSIAN GULF COUNTRIES CAN MAXIMIZE WHAT THEY HAVE

There are many cases in secure non-OPEC countries where oil exploration and development could increase if regulatory and financial disincentives, including barriers to trade and international investment that now produce an unfavorable investment climate were only removed.

In the United States itself, oil production is expected to decline; but regulatory and fiscal reform could slow this process. Lifting the bans on oil exports would increase returns to Californian and Alaskan producers, and this would encourage additional investment in these promising areas.

Canada, with crude oil reserves of 6.5 billion barrels, was the largest single supplier of U.S. oil imports in the first half of 1986. Canada's crude oil production of 1.5 MMBD is expected to decline if low oil prices continue to retard exploration and development offshore, in frontier areas, and in syncrude development. But, Canada—to its credit—is continuing to reduce government involvement and to remove barriers to foreign investment.

Mexico, the third-largest supplier of U.S. oil imports is another example. This country currently produces 2.6 MMBD of crude oil from a reserve base now estimated at 49 billion barrels. Mexico is likely to be a significant supplier of oil to the world market for a number of years to come. However, domestic economic austerity and the need to service Mexico's foreign debt have retarded investment in oil production in recent years. Mexico's 10 percent cutback in exports (in support of OPEC) may affect PEMEX's ability to make necessary investments to sustain production and exports.

United Kingdom production from its sector of the North Sea reached a peak last year of 2.6 MMBD. Production is now expected to decline by about 0.1 MMBD per year over the next 5 years. The United Kingdom is currently reviewing the impact of low oil prices on investment in marginal fields, the tax treatment of incremental investment in existing fields, and the treatment of onshore exploration costs, with a view toward keeping the investment climate positive.

Norway's production from its sector of the North Sea, which rose steadily to its current level of just over 1.0 MMBD, is expected to continue to rise by about 0.1 MMBD per year for the next few years as a result of investment decisions that were made before the decline in oil prices. However, development costs of $15 to $20 per barrel in new Norwegian fields could slow development if low oil prices persist. Any production cutback imposed by Norway on producing companies in support of OPEC would be likely to damage the investment climate.

Other countries with oil production potential project small increases in output over the next few years. The removal of existing barriers to foreign investment in many of these countries could stimulate development.

USE OF MORE NATURAL GAS FROM SECURE AREAS CAN BE AN ATTRACTIVE ALTERNATIVE

Natural gas production and trade from secure areas can be an attractive and economically efficient substitute for oil in industrial facilities, in electric utility plants, and in residential and commercial applications. The development of indigenous OECD gas reserves, the promotion of free trade (which still prudently avoids undue reliance on insecure sources of supply) and the decontrol of natural gas in the United States can all help.

OECD countries (especially the United Kingdom, Germany, and Norway) have moved to develop flexible or modified tax and royalty regimes for their key gas projects (for example, Troll). Lower oil and gas prices call into question whether the present arrangements for gas production fit today's market situation. It would be beneficial for all current and potential gas producers to examine their tax and royalty regimes carefully, just to make sure that new investment barriers are not being created.

The most important single contribution to increasing the security of European gas supply was the recent Sleipner/Troll gas agreement to provide initially some 20 bcm per year to a European consortium. All of the consortium companies' governments have now approved the agreement.

The May 1983 IEA Ministerial meeting called on member countries to consider the economic implementation of options such as increased fuel switching, better integration of distribution grids, the establishment and maintenance of strategic gas stocks, and formalizing the coordination of an international emergency response in the event of a potential gas supply disruption. The country review process of the IEA will ensure that the Ministers' recommendation is being pursued.

Although the Sleipner/Troll contract will meet most of the currently forecast gas demand for Europe throughout this century, increased emphasis on the use of gas could raise demand. Demand for additional gas imports might also come from the United States and LDC's, and this would change the supply outlook. The U.S. Government continues to encourage the development of economic gas production worldwide.

Two areas of potential new demand for gas are as a transportation fuel and as an energy source for fuel cells. Given existing work on these two areas in a number of countries, they appear to be logical candidates for greater international R&D collaboration.

LARGER WORLD COAL TRADE WILL REDUCE RELIANCE ON OIL IF OBSTACLES CAN BE OVERCOME

Reducing barriers to world coal production, consumption, and trade can help to reduce reliance on oil, especially imported oil from insecure sources. Global demand prospects are currently constrained by environmental regulations on use, so improving the ability to burn coal cleanly is a key element in increasing coal consumption. Making the production and transportation of coal more efficient and eliminating barriers to coal trade, (such as subsidies to uneconomic production abroad) can step up coal's competitiveness even further.

As noted above, Germany, France, Japan, the United Kingdom, Belgium, and Spain continue to subsidize the production of high-cost domestic coal—thereby limiting economical world coal trade that should be taking place. Efforts to reduce uneconomic subsidies will improve coal's competitive position, expand coal trade, and speed the development of clean coal technologies.

Australia exports about 50 percent of its total coal production and is currently the world's largest coal exporter. Mining conditions are favorable there, and mines are typically located close to ports. Australia's low costs, combined with the excellent quality of its coal (typically low sulfur and high BTU content), make that country a strong competitor, particularly in the Pacific Rim.

South Africa has extensive mining operations and a dedicated transportation system—from mines to the ports. While the energy content of South African coals is low relative to other competitors, its low sulfur content is highly desirable. Recent trade sanctions against South Africa and internal political strife make its role in future world coal markets highly uncertain, however.

Poland supplied 39 million tons of coal to Soviet Bloc and Western European countries in 1983. Its mining costs are high, but having its major markets nearby helps to keep it competitive. Because its reserve base is small and investment capital is lacking, Poland is unlikely to expand its production capacity. If more Polish coal is forced to move to the U.S.S.R., less is likely to be shipped to the free world.

Canada primarily exports metallurgical coals, with steam coal as a by-product. It has an excellent infrastructure for export, including a government-supported, dedicated transportation system. Because Canada has more coal production capability than sales at present, and because its capital costs are high, no new Canadian coal mines are expected in the next five to ten years.

Colombia could become a major competitor in the world coal market. It has favorable mining conditions and low-sulfur, high-BTU coals. Moreover, Colombia's mines are close to ports and to European and Asian markets. Its long-term viability as a major producer, however, is dependent on its ability to attract foreign capital.

China is planning to expand its coal-export potential, using technical and financial assistance from other countries. Gaining the confidence of investors and importers will be critical to its success. Developing an adequate infrastructure to move the coal produced from its extensive reserves is also important.

NUCLEAR ENERGY CONTRIBUTES TO BALANCED ENERGY MIX IN MANY COUNTRIES

Using nuclear energy to produce electricity is one way of replacing oil-fired generating plants and slowing the return to dependence on oil. Retention of this option depends on maintaining high safety standards and public confidence. A major U.S. objective is to see that superior safety standards and design techniques are incorporated in plants around the world, with appropriate transfer of existing technology. Continued R&D on advanced reactor design can help too.

The United States has been in the forefront of promoting safety programs and enhanced international technical consensus within the IAEA and Nuclear Energy Agency (NEA). The IEA helps to let policymakers and the public know about the importance of nuclear power.

The U.S.S.R. and Eastern Europe are involved deeply in these multilateral activities. The United States is continuing to develop a comprehensive bilateral policy for cooperation related to the Chernobyl accident, including the enhancement of safety at operating Soviet plants, possible joint R&D on more passive designs for the future, and epidemiological studies on the radiological impacts of the accident.

Sweden, Denmark, and Austria have chosen to phase out nuclear power or not to develop it as an option. Their decisions will affect the environment (from burning fossil fuel alternatives), the prices of alternative fuels, and energy security (as reliance increases on insecure sources of alternatives).

Japan, France, the United Kingdom, Belgium, Canada, and Germany are continuing with their nuclear programs, which will contribute to international energy security. They are also sharing with other countries their own experiences relating to the costs and safety of nuclear power.

Korea and Taiwan show how low-cost, safe development of the nuclear power option can contribute to overall economic progress in developing countries that are not rich in indigenous energy resources.

COST-EFFECTIVE OPPORTUNITIES TO IMPROVE ENERGY EFFICIENCY ARE WORTH STRESSING

An analytical approach to understanding trends in energy efficiency and to evaluating the effectiveness of governments' conservation policies and programs provides the market with valuable information. This information can be disseminated through bilateral and multilateral channels.

Various means are being used to encourage developing countries to adopt market-based conservation programs: co-financing of conservation programs, provision of energy efficiency information via local AID missions and VOA, financing of fuel-switching and alternative fuel investments with AID and World Bank assistance, and the provision of energy conservation training to LDC technical personnel.

Tax policies have a major impact on energy consumption patterns. Some countries, particularly in Europe, have increased excise taxes because they fear rising energy demand as a consequence of lower oil prices. These taxes have also been based sometimes on environmental considerations, and/or they have been adopted simply as a means of raising government revenues. Whatever their genesis, however, excise taxes prevent consumers from realizing the full gains from lower oil prices.

In the United States, market-based energy pricing provides a sound foundation from which to promote efficient energy conservation. Economically, conservation investments are often less costly than supply-side investments; and the former generally avoid environmental consequences. They can and should be "sold" on their own merits. Conservation enhances international security because it acts as an energy resource and decreases the share of oil in importing countries' energy mix.

INTERNATIONAL R&D COOPERATION OFFERS VALUABLE SHORTCUTS AND ECONOMIES OF SCALE

International collaboration on research and development improves the efficiency of investment and maintains momentum for technology development. It helps the United States get the biggest return on its investment in the face of current budget realities.

Bilateral and IEA collaboration is expanding on existing achievements. Programs on clean coal technology, fusion, advanced techniques for tapping energy resources, and information systems related to energy technology are already planned or underway. Collaboration in other areas is under consideration. All of these activities stress early consultation and joint program planning by senior policy and program officials, as well as technology transfer.

In connection with the clean use of coal, the IEA held joint planning workshops during 1986 on Coal Liquefaction (in the United States), Pressurized Fluidized Bed Combustion (in Sweden), and Emissions Control (in Japan). Another is planned on Coal Water Mixtures (in Italy) for 1987. These workshops present an excellent opportunity for industry to increase its collaborative involvement in research and development. Workshops on End-Use Technology (Conservation), are being discussed by the IEA's Committee on Research and Development for 1987. They will cover not only technology, but also issues related to technology transfer for attractive new processes.

Canada and the United Kingdom have signed new memoranda of understanding with the United States that incorporate the joint-program-planning and task-sharing concepts. Australia is considering signing a similar memorandum. Promising collaborative programs should be expedited to hasten the benefits for each partner.

As government and industry R&D budgets face continued constraints, it becomes ever more important for IEA members to look to international collaboration as a means of assuring that the necessary technologies will be available when they are needed in the intermediate and longer term. In this light, the United States is proposing that a comprehensive R&D statement for presentation at the IEA Ministerial include the following elements:

- The extension of the international energy R&D collaboration process to transportation fuels, renewable energy, and end-use technology.

- The establishment of an international collaborative R&D effort on the implications of the increasing content of carbon dioxide in the atmosphere; and

- The improvement of industry-government collaboration in development and demonstration of energy supply and end-use technologies—both at the national and international levels.

CONTINUED MONITORING NEEDED TO GAUGE PROGRESS AND ASSIST FUTURE DECISIONS

Lower oil prices have not removed longer term concerns about the security of energy supply or the need for continuity in energy policy objectives. On the contrary, a prolonged period of relatively low oil prices might intensify these concerns and hasten the time when tighter energy markets can be expected.

Long-term energy policy objectives remain valid under today's circumstances. Short-term developments in world oil prices do not by themselves require or warrant major changes in basic energy policy.

Because of the uncertainties surrounding projections of future economic and energy-market conditions, the United States and its allies in the IEA have agreed to exercise continued vigilance by monitoring energy market conditions, analyzing developing trends, and continuously assessing progress in reducing their individual and collective vulnerability to energy supply disruptions. Active consultation between IEA member governments is a key part of the monitoring process.

No single indicator can be used as a measure of vulnerability to energy supply disruptions. By itself, dependence on imports of crude oil and petroleum products is definitely not such a measure. *Many* indicators of conditions in oil and other energy markets, of response capabilities, and of the real risks of disruption need to be considered—within a global perspective—in order to assess the overall outlook for energy security. That broad range of market indicators *is* being monitored continuously.

APPENDICES FOR SUPPORTING ANALYSIS

Introduction and Methodology

This appendix presents detailed information about the world oil and energy market projections made for use in the Department of Energy's study of oil and security. The appendix supplies historical energy information and describes two energy future scenarios. One scenario represents a world more dependent on oil as a source of energy (the lower price case); the other scenario represents a world less dependent on oil (the higher price case). Based on the assumptions made for these two scenarios the study estimates world energy consumption by fuel types, regions and sectors and projects future world dependency on oil supplies from Persian Gulf and other OPEC sources. The scenarios were developed from various opinions on the oil market outlook and on factors such as world economic growth, world oil prices, dependency on oil and use of non-oil energy resources.

A range of opinion on the market outlook for the 1990's was developed through a series of interagency discussions, involving analysts from the Department of Energy and other Federal Government agencies. The consensus view was that free world oil demand will increase from about 46 million barrels per day in 1985 to 49-53 million barrels per day by 1995. Oil demand in the U.S. (50 States) is expected to increase from 15.7 million barrels a day in 1985 to 16-18 million barrels per day by 1995. On the oil supply side, non-OPEC production (excluding Centrally Planned Economies) is believed to be particularly uncertain, ranging in 1995 from a low of 22 to a high of 26 million barrels per day. U.S. domestic oil production was projected to decline from more than 11 million barrels per day in 1985 to between 8 and 9 million barrels per day by 1995. The consensus oil price outlook associated with these projections foresees oil prices remaining relatively low for several years to come but average prices rising gradually again into the $20 to $30 per barrel range by the mid-1990s.

The oil market outlook alone was not sufficient to support the sensitivity analyses needed to address the various policy options being considered in the review of oil and security. For the purpose of these sensitivity analyses, the Energy Information Administration (EIA) was asked to simulate typical energy market scenarios that matched, as closely as possible, the full range of oil supply and demand projections obtained from the interagency consensus. This process confirmed the reasonableness of the consensus results relative to EIA's own projections as well as providing a range of more fully specified base cases for policy analysis.

The Energy Information Administration's Oil Market Simulation (OMS) model was used to estimate a range of oil prices that was consistent with both the oil demand projections (of 49-53 million barrels per day by 1995) and EIA's latest estimates of demand responsiveness to price changes. The Intermediate Future Forecasting System (IFFS) was then run at these oil prices and a reasonable range of uncertainty on economic growth, domestic oil finding rates, and other factors to derive a range of base cases for the U.S. energy market. Two base case scenarios have been specified as a result of this procedure. The higher price case assumes higher oil prices, higher non-OPEC production, lower oil demand, and consequently a lower demand for OPEC oil. The lower price case assumes continued lower oil prices, lower non-OPEC production, higher oil demand, and consequently a higher demand for OPEC oil. It must be emphasized that the initial oil price, economic growth and resource base assumptions were made independently. Thus the level of oil prices cannot be viewed as the only factor determining the economic growth and resource base assumptions, although it does influence these assumptions. The results of the higher and lower price cases are presented in Tables A1 and A2.

The OMS model also was used to examine two variations of the lower price scenario: one in which prices remained at about $15 per barrel until 1990 before increasing rapidly to $30 per barrel by 1993 (the price ratchet case) and one in which prices fell to $10 per barrel in mid-

1987 (the price collapse case). The results of these model runs are presented in Tables A3 and A4. Complete energy market projections were not made for these two cases, however, and these cases therefore are not discussed in detail in this appendix.

Key Economic and Energy Market Assumptions

The market for each major fuel (oil, gas, coal, nuclear, hydroelectric and renewables) will face key uncertainties of its own, but there are a number of key driving forces common to all energy markets. These are:

-- Free world economic growth is expected to average between 2.4 and 3.2 percent per year over the next 10 years. U.S. economic growth is expected to range between 2.5 and 2.7 percent per year. Higher economic growth rates of 3.3 to 4.0 percent per year are projected for the less developed countries.

-- The ratio of energy growth to real GNP growth (Energy/GNP ratio) is assumed to vary between .6 and .7, reflecting uncertainty concerning efficiency improvements. Rates are lower in developed countries, varying between .5 and .6, compared to rates of .7 to .9 for the less developed countries, and a rate of unity for OPEC countries. Alternative oil price projections also affect these rates.

Major assumptions for non-oil fuels are:

-- There is considerable uncertainty as to market penetration of natural gas in Europe due to both questions about gas prices and infrastructure development. Supply of gas to the world is demand driven; there are no major obstacles to supplying Europe or providing liquid natural gas to Japan. (Estimates of European gas supply prospects are provided below.)

-- Oil prices are not expected to remain low for a sufficient period of time to affect coal powered electricity generation. Uncertainty surrounding coal markets is due primarily to uncertainty about future electricity demand and nuclear generation. Coal supply is also demand driven.

Key Oil Market Assumptions

Assumptions underlying the oil market are:

-- Oil demand price elasticities are relatively small, but have significant lagged effects. Changes in price have little immediate effect on demand. However, sustained low or high prices have significant impacts over time.

-- Non-OPEC production is expected to remain near capacity, but capacity will be affected by oil prices. However, even with sustained high oil prices, non-OPEC production capacity is expected to decline in the1990's. The situation is exacerbated with sustained lower prices.

-- OPEC countries are not expected to expand their production capacity until current excess capacity is nearly used or is expected to be used. Low prices for several years will lead to capacity expansion; but due to reserve exhaustion in some OPEC countries, capacity expansion will not keep pace with ever increasing demand. If there is insufficient demand growth, OPEC production will continue to be limited and their capacity will not be expanded to the extent possible. In either event, there are limits to the amount of OPEC capacity that will be available in the 1990's, and OPEC production therefore is not expected to exceed 30 million barrels per day.

-- Oil prices are expected to rise to between $15 and $23 by 1990 and to between $22 and $28 by 1995.

For purposes of the review of oil and security, two key oil market scenarios were developed. These are referred to as *higher price* and *lower price cases*. These are business-as-usual cases utilizing the assumptions outlined above and are an attempt to summarize recent assessments made by government analysts.

-- The higher price case generally coincides with lower demand for oil, lower economic growth, lower energy demand, and greater expansion of substitutes for oil.

-- Conversely, the lower price case generally assumes higher oil demand, higher economic growth, higher energy growth, and less penetration of non-oil fuels.

Key Results

As with any forecast there is a great deal of uncertainty surrounding energy markets in the 1990's. The consensus view of the government analysts involved in this study can be summarized as follows:

-- Free world energy consumption is projected to grow by 1.5 to 2 percent per year, increasing from about 205 quadrillion Btu in 1985 to 239 to 250 quadrillion Btu by 1995.

-- World oil prices (expressed in 1985 U.S. dollars) are projected to rise from $14 per barrel in 1986 to between $22 and $28 per barrel by 1995.

-- Free world oil consumption is projected to rise from 46 million barrels per day in 1985 to between 49 and 53 million barrels per day by 1995.

-- Non-OPEC oil production is projected to decline in the 1990's, while OPEC production is projected to increase. OPEC production is projected to range between 22 and 30 million barrels per day by 1995, up from a level of 17 million barrels in 1985.

-- Even with the projected continuation of lower oil prices, all major energy sources except oil are projected to continue to increase their overall share of total energy consumption by 1995.

-- Oil's share of total free world energy consumption is expected to fall from its 1985 share of about 46 percent to between 42 and 43 percent by 1995. Even so, its contribution to total energy consumption, as the leading source of energy consumed in the free world, remains significant, particularly at low oil prices.

-- Electricity growth rates are projected to average from 2.3 to 2.9 percent per year in the OECD over the next 10 years, accounting for much of the end-use energy growth in these countries. Coal and nuclear-power generation are expected to play the major role in this growth.

Energy Demand by OECD Region and Fuel Type

Energy demand in the OECD is expected to increase by 1.2 to 1.6 percent per year between 1985 and 1995 to between 178 and 185 quadrillion Btu.

Higher growth rates of almost 2 percent per year are projected for Canada and Japan, due primarily to projected higher economic growth. Lower rates are expected in Western Europe (1.3 to 1.6 percent per year) and in the U.S. (1.2 to 1.5 percent per year).

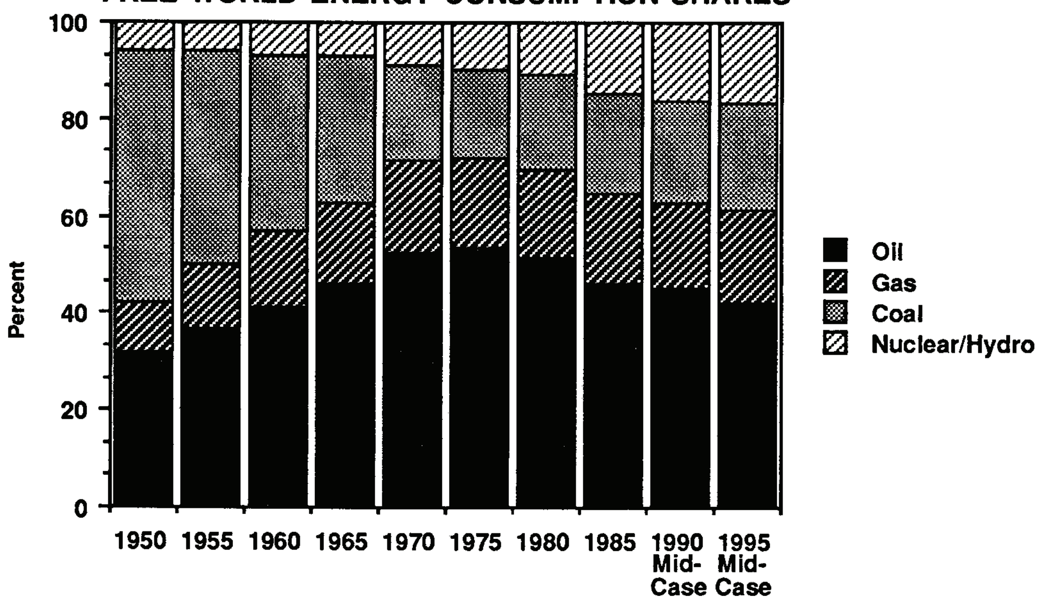
Within the OECD, consumption of coal, nuclear and hydroelectric energy sources is expected to grow the fastest. Between 1985 and 1995 coal consumption is projected to increase by 1.6 to 2.5 percent per year, nuclear is expected to grow by 3.7 to 4.7 percent per year, and hydroelectric power is expected to grow at a 1.6 percent annual rate.

Even with lower world oil prices the direction in the OECD countries is away from dependence on oil. Oil consumption is only forecast to grow by 0.2 to 1.1 percent per year by 1995. Oil's share of total energy consumption is expected to fall from 44 percent in 1985 to between 40-42 percent by 1995, however, oil remains the leading source of energy consumed.

The table below shows the OECD regions' changing shares of energy consumption. Europe is expected to move from oil to more nuclear and other energy sources. In the "other OECD countries," coal is expected to significantly increase its share of total energy consumption.

	Oil		Gas		Coal		Nuclear/Other	
	1985	1995	1985	1995	1985	1995	1985	1995
Region				(percent)				
U.S.	42	39-41	24	22-22	24	26-26	10	12-12
Canada	31	29-31	22	20-25	13	12-16	35	35-35
Japan	56	49-51	10	10-12	18	18-20	15	19-20
Europe	45	39-42	16	14-16	20	19-22	20	23-24
Other OECD	50	42-44	14	15-17	26	29-31	10	10-10
Total OECD	44	40-42	19	18-19	21	22-23	16	18-18

FREE WORLD ENERGY CONSUMPTION SHARES



Note: Midpoints for 1990 and 1995 were derived from range of uncertainty between lower and higher oil price cases.

OECD Energy Demand by Sector

Growth in the residential and commercial sector is expected to account for much of the increasing demand in the OECD. Consumption in this sector is expected to increase at an average annual rate of 1.5 to 2.2 percent – from 55 quadrillion Btu in 1985 to 63-68 in 1995. Industrial demand is expected to increase at about the same pace as total energy – from 67 quadrillion Btus in 1985 to 74-81 by 1995. In the transportation sector, demand is expected to increase by on average 1 percent per year – increasing from 36 quadrillion Btus in 1985 to 37-49 in 1990 and remaining at about the same level through 1995.

The residential/commercial sector is expected to account for a larger share of total energy demand by 1995, largely at the expense of a decreasing share for transportation. The industrial share is expected to remain about the same as in 1985.

Much of the increased consumption in the OECD countries is expected to be in the form of electricity. To meet these electricity demand increases, electric power generation is projected to grow at an average annual rate of 2.3 to 2.9 percent.

The mix of fuels consumed by electric utilities is expected to change somewhat between 1985 and 1995. Use of nuclear and hydroelectric power is projected to increase the fastest (2.7 to 3.3 percent per year), with the share of electricity generated by these fuels increasing from 41 percent in 1985 to 43 percent by 1995. Coal consumption by electric utilities is projected to continue to grow at a moderate pace, maintaining its current share of approximately 40 percent of power generation through 1995. Prospects for the use of oil by electric utilities vary widely between the lower and higher price cases. The natural gas outlook varies similarly since gas prices are closely related to oil prices. Oil and gas could maintain their share of electric utility consumption (about 10 percent for each fuel in 1985) in the lower price scenario, or lose some of their share of this market (1-2 percentage points each) in the higher price scenario.

Additional details on OECD countries' projected energy consumption by fuel and sector can be found in Tables A5 to A10. Table A11 shows projected worldwide energy consumption by fuel.

Free World Oil Consumption

The average annual growth rate for free world oil consumption is expected to range from 0.6 to 1.3 percent through 1995. Even though oil's share of total consumption is expected to decline through the forecast period in both the lower and higher price cases, oil is still expected to meet 42 to 43 percent of energy consumption, remaining the leading source of energy consumed. Free world oil consumption is forecast in millions of barrels per day as follows:

Region	1985	1990 Higher Price Case	1990 Lower Price Case	1995 Higher Price Case	1995 Lower Price Case
	(million barrels per day)				
U.S. (incl. terr.)	16.0	16.0	17.0	16.7	18.0
Canada	1.5	1.6	1.7	1.6	1.8
Japan	4.3	4.5	4.7	4.4	4.8
Europe	11.7	12.2	12.9	12.0	13.1
Other	9.6	10.0	10.6	10.3	11.0
OPEC	3.4	3.7	3.7	4.2	4.2
Free World	46.4	47.9	50.4	49.1	53.0

Growth in oil consumption in the OECD countries is slightly lower than for the rest of the free world at 0.2 to 1.1 percent per year. (Australia and New Zealand, though members of the OECD, have been included in the "Other" category. They represent from .8 t o 1 MMBD of the total). Higher growth in oil consumption is expected in OPEC and several other less developed countries (LDC's.)

Included in the "Other" category above is the very heterogeneous group of LDC's (less OPEC.) The rate of consumption growth among these countries varies greatly. Many of the more industrialized LDC's, particularly in the Far East, had increases in oil consumption of 4 to more than 6 percent in the early 1980s. High growth in oil consumption is expected to continue to occur in several of the LDC's.

Oil Consumption In Less Developed Countries

Developing countries (including OPEC) more than doubled their total oil consumption between 1970 and 1984 for an average annual growth rate of 5.3 percent per year.

Saudi Arabia's oil use grew by a factor of almost five as it rapidly developed its industry during this period.

Brazil and Mexico were the largest oil consuming countries among the developing countries in 1970 and actually increased their position by 1984. In 1970 Brazil and Mexico consumed one out of every six barrels of oil used by the group. By 1984 they consumed one out of every five barrels.

Oil demand growth in the less developed countries has been lower during the 1980's as a result of higher prices. Demand growth averaged 2.2 percent per year between 1980 and 1984.

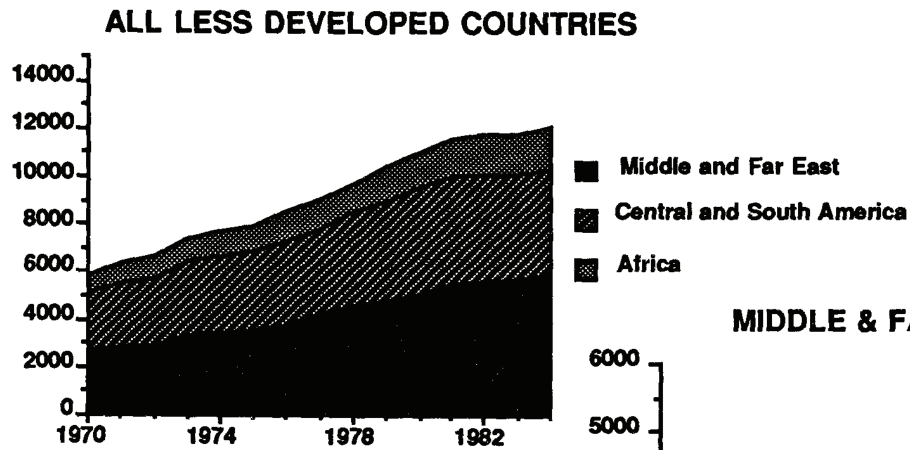
Oil demand growth in this area is expected to average an even lower 1.1-1.6 percent per year between now and 1995 for two reasons:

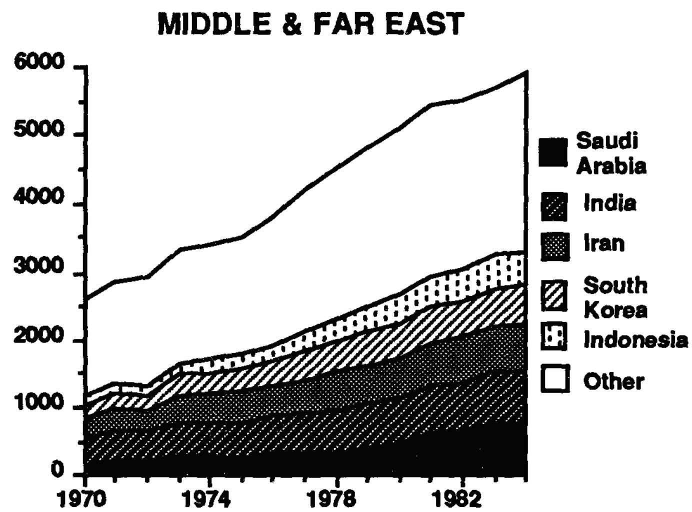
- Lower oil prices have slowed and even temporarily stopped oil demand growth in the oil exporting countries because of severely depressed economies.
- Capital investments have already been made in many of the less developed countries that will cause non-oil energy sources (primarily natural gas and nuclear) to be used more extensively in the future rather than imported oil.

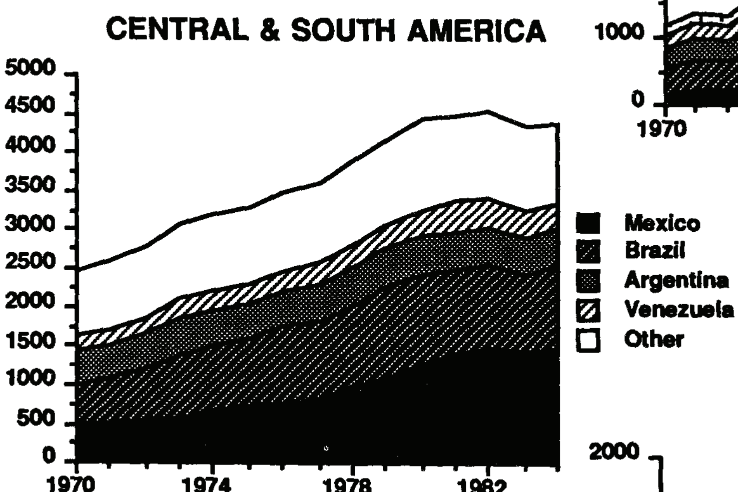
Even though LDC consumption is expected to grow more slowly than in the past, this growth rate will exceed the rate in the developed countries.

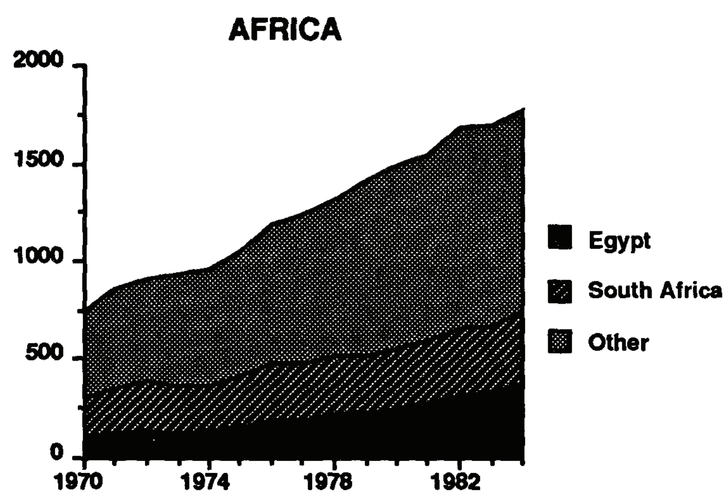
Oil Consumption in Less Developed Countries

(Thousand Barrels per Day)









Source: Energy Information Administration.

Free World Oil Supply

OPEC has been the marginal oil producer so that as oil demand increases, OPEC's market share becomes larger. As OPEC countries begin to utilize their low-cost excess capacity, their 1985 oil production share of 38 percent is projected to rise to between 42 percent (higher price case) and 50 percent (lower price case) by 1990. By 1995, with projected declines in non-OPEC oil production, OPEC's oil share could expand to as much as 56 percent (lower price case).

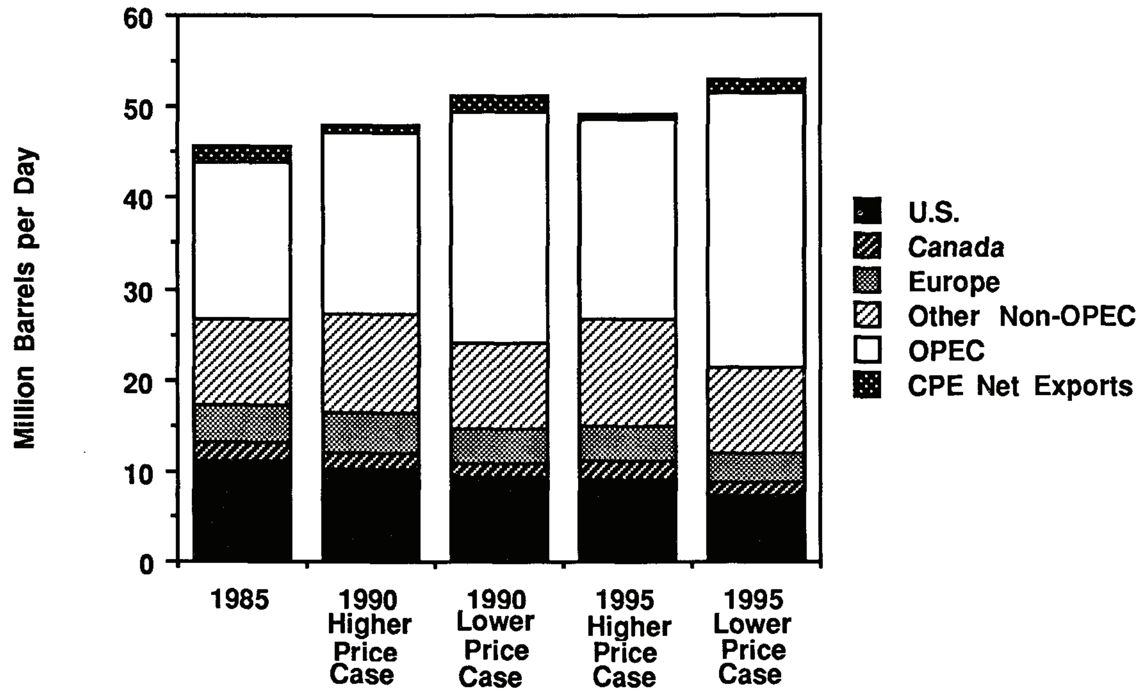
In 1985, non-OPEC countries (excluding net exports from Centrally Planned Economic's (CPE's)) provided 58 percent of world oil supplies. The non-OPEC share is expected to fall in the 1985 to 1990 period to between 47 percent (in the lower price case) to 56 percent (in the higher price case). In the 1985 to 1990 period with lower world oil prices and less incentive to produce, non-OPEC's oil supply growth is expected to be at most 0.3 percent per year. In the lower price case, non-OPEC production falls by 2 percent per year. After 1990, with non-OPEC reserves dwindling in both cases non-OPEC production is projected to fall further to represent between 41 and 54 percent of free world oil production by 1995.

Net oil exports from the CPE's also show a sharp difference between the lower and higher price cases. The lower price case, with high oil demand growth and reduced non-OPEC production, maintains demand for CPE exports at 1.6 MMBD. In the higher price case, projected CPE exports decline to 0.5 MMBD by 1995, due to less growth in free world oil demand.

Free world oil supply is forecast as follows:

	1985	1990	1990	1995	1995
		Higher Price Case	Lower Price Case	Higher Price Case	Lower Price Case
Region			(million barrels per day)		
U.S. (incl. terr.)	11.2	10.1	9.2	8.9	7.6
Canada	1.8	1.8	1.5	2.0	1.4
Europe	4.3	4.5	3.7	3.7	3.2
Other	9.4	10.6	9.5	11.7	9.5
Total Non-OPEC	26.7	27.0	24.0	26.3	21.7
OPEC	17.2	20.1	25.4	22.0	30.0
CPE Net Exports	1.8	1.0	1.6	0.5	1.6
Free World	45.7	48.0	50.9	48.8	53.3

FREE WORLD OIL PRODUCTION



World Oil Net Imports

In the United States, net imports are projected to increase from 4.3 MMBD in 1985 to about 5.7 to 7.5 MMBD in 1990 and 7.5 to 10.2 MMBD by 1995. Although net imports into the 50 States accounted for 27 percent of oil consumption in 1985, they are expected to represent 35 to 44 percent of 1990 consumption and 45 to 57 percent of 1995 consumption.

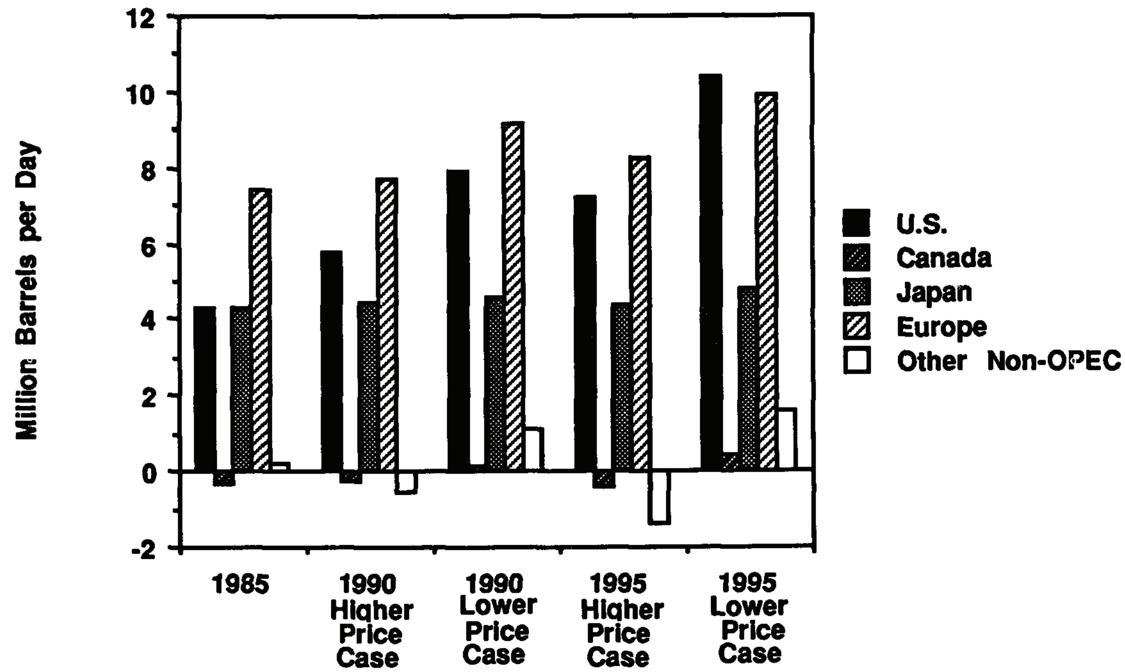
Western Europe already relies on imports for most of its petroleum requirements. In 1985, net imports of 7.4 MMBD provided 63 percent of the petroleum consumed in the region. Net imports are projected at 7.7 to 9.2 MMBD in 1990 (63 to 71 percent of consumption), increasing to 8.2 to 9.9 MMBD by 1995 (69 to 76 percent of consumption).

Japan imports virtually all the petroleum it consumes. Japan's ongoing efforts to reduce its dependence on imported oil are expected to constrain future increases in net imports from the 1985 level of 4.3 MMBD. The projected range of net imports is 4.4 to 4.6 MMBD in 1990 and 4.4 to 4.8 MMBD in 1995.

Canada is currently a net exporter of oil. Under the higher price assumptions, Canada's net exports are expected to decline from their 1985 level of 0.4 MMBD to 0.3 MMBD in 1990 before returning to their 1985 level by 1995. Under the lower price assumptions, however, Canada would become a net importer, with net imports projected to reach 0.2 MMBD in 1990 and 0.4 MMBD by 1995.

In the group of other non-OPEC countries most are net oil importers. Oil exports by Mexico and Egypt obscure the actual amount of oil imports for the group. Imports/exports of oil in the other non-OPEC countries vary widely between the lower and higher price cases. Other non-OPEC countries remain net oil importers in the lower price case, but in the higher price case oil exports by Mexico and Egypt exceed the oil imports of the remaining countries, making the group net oil exporters.

World Oil Net Imports



Western Europe's Natural Gas Supply Prospects

Natural gas demand in Western Europe–8.5 trillion cubic feet (tcf) in 1985–is currently supplied by indigenous production for local use (51 percent), intra-OECD trade (28 percent), and non-OECD trade (21 percent). The Netherlands, the United Kingdom, West Germany, and Italy are the largest producers for their own domestic requirements, the Netherlands and Norway are the principal West European exporters, and the Soviet Union and Algeria are the main suppliers from outside the OECD.

By 1995, demand is expected to reach 8.5 to 10.6 tcf, i.e. either to remain at about the same level as in 1985 or to increase by as much as 2.2 tcf. The main suppliers are expected to remain the same as in 1985, with a small shift in the relative importance of each source. As demand increases, the incremental requirements are likely to be met by supplies from outside the OECD, where the largest reserves are located. Nevertheless, Western Europe is expected to continue to rely on indigenous production and intra-OECD trade for about two-thirds of the region's projected 1995 requirements.

The prospects for future supplies are positive:

-- Reserves in Western Europe (estimated as of January 1, 1986) total 226.4 tcf, which is equivalent to 35 years production at 1984 rates. Reserves held by Western Europe's suppliers from outside the OECD are even greater–1628.5 tcf, equivalent to 73 years production at 1984 rates.

-- Algeria's liquefied natural gas (LNG) export facilities have spare capacity, and deliveries from Algeria and the Soviet Union have not yet reached their full contract volumes. Additional Soviet exports to Turkey are planned, and the capacity on Algeria's Trans-Mediterranean pipeline to Italy could be increased.

-- Deliveries from Norway's Troll and Sleipner fields are scheduled to begin in 1993. Nigeria and Qatar are considering proposals to begin exporting LNG, and Iran has been exploring pipeline exports to Europe.

Table A1. Oil Market Simulation Model Results: Higher Price Case

	1985	1986	1987	1988	1989	1990	1995
WORLD OIL PRICE							
1985 CIF $	27.03	14.23	17.00	18.51	20.51	22.51	27.51
CONSUMPTION (MMBD)							
UNITED STATES*	16.00	16.39	16.59	16.28	16.04	16.03	16.67
CANADA	1.48	1.53	1.55	1.56	1.56	1.55	1.58
JAPAN	4.34	4.42	4.46	4.48	4.48	4.48	4.44
WESTERN EUROPE	11.67	11.97	12.09	12.17	12.19	12.16	11.95
OPEC	3.40	3.40	3.46	3.53	3.59	3.66	4.16
OTHER COUNTRIES	9.56	9.81	9.92	9.99	10.00	9.98	10.26
TOTAL FREE WORLD	46.44	47.53	48.07	48.00	47.86	47.85	49.07
PRODUCTION (MMBD)**							
UNITED STATES	11.20	10.90	10.50	10.48	10.28	10.08	8.89
CANADA	1.84	1.82	1.81	1.78	1.78	1.80	2.00
WESTERN EUROPE	4.27	4.41	4.33	4.37	4.42	4.49	3.73
OPEC	17.21	19.35	19.44	20.08	20.20	20.06	22.00
OTHER COUNTRIES	9.37	9.44	9.91	10.10	10.33	10.59	11.70
CPE NET EXPORTS	1.80	1.70	1.60	1.40	1.20	1.00	0.50
TOTAL FREE WORLD	45.68	47.62	47.60	48.21	48.21	48.03	48.83
NET IMPORTS INTO UNITED STATES (MMBD)							
50 STATE AREA	4.29	5.23	5.69	5.51	5.45	5.66	7.54
U.S. TERRITORIES	0.27	0.29	0.30	0.31	0.31	0.32	0.29
TOTAL UNITED STATES	4.56	5.52	5.99	5.82	5.76	5.98	7.83
NET STOCK ADDITIONS AND STATISTICAL DISCREPANCY (MMBD)							
	-0.76	0.09	-0.47	0.21	0.35	0.18	-0.24

* Includes about 0.3 MMB/D of consumption in U.S. territories.
** Includes crude oil, natural gas liquids (NGLs) and refinery gains.

Table A2. Oil Market Simulation Model Results: Lower Price Case

	1985	1986	1987	1988	1989	1990	1995
WORLD OIL PRICE							
1985 CIF $	27.03	14.23	14.36	14.49	15.00	15.49	21.51
CONSUMPTION (MMBD)							
UNITED STATES*	16.00	16.39	16.62	16.57	16.68	16.97	18.01
CANADA	1.48	1.53	1.57	1.61	1.64	1.67	1.81
JAPAN	4.34	4.42	4.49	4.55	4.61	4.65	4.82
WESTERN EUROPE	11.67	11.97	12.21	12.45	12.66	12.85	13.14
OPEC	3.40	3.40	3.46	3.53	3.59	3.66	4.16
OTHER COUNTRIES	9.56	9.81	10.05	10.27	10.45	10.60	11.02
TOTAL FREE WORLD	46.44	47.53	48.40	48.98	49.63	50.40	52.97
PRODUCTION (MMBD)**							
UNITED STATES	11.20	10.90	10.29	9.99	9.60	9.22	7.57
CANADA	1.84	1.82	1.77	1.67	1.59	1.52	1.41
WESTERN EUROPE	4.27	4.41	4.30	4.08	3.88	3.70	3.22
OPEC	17.21	19.35	20.32	22.36	23.94	25.35	30.02
OTHER COUNTRIES	9.37	9.44	9.88	9.74	9.62	9.51	9.49
CPE NET EXPORTS	1.80	1.70	1.60	1.60	1.60	1.60	1.60
TOTAL FREE WORLD	45.68	47.62	48.16	49.44	50.22	50.90	53.30
NET IMPORTS INTO UNITED STATES (MMBD)							
50 STATE AREA	4.29	5.23	5.90	6.35	6.83	7.53	10.19
U.S. TERRITORIES	0.27	0.29	0.29	0.30	0.30	0.30	0.29
TOTAL UNITED STATES	4.56	5.52	6.19	6.65	7.13	7.83	10.48
NET STOCK ADDITIONS AND STATISTICAL DISCREPANCY (MMBD)							
	-0.76	0.09	-0.24	0.46	0.59	0.50	0.33

* Includes about 0.3 MMB/D of consumption in U.S. territories.
** Includes crude oil, natural gas liquids (NGLs) and refinery gains.

Table A3. Oil Market Simulation Model Results: Price Ratchet Case

	1985	1986	1987	1988	1989	1990	1995
WORLD OIL PRICE							
1985 CIF $	27.03	14.23	14.36	14.49	15.00	15.49	30.00
CONSUMPTION (MMBD)							
UNITED STATES*	16.00	16.39	16.62	16.57	16.68	16.97	16.29
CANADA	1.48	1.53	1.57	1.61	1.64	1.67	1.65
JAPAN	4.34	4.42	4.49	4.55	4.61	4.65	4.57
WESTERN EUROPE	11.67	11.97	12.21	12.45	12.66	12.85	12.22
OPEC	3.40	3.40	3.46	3.53	3.59	3.66	4.16
OTHER COUNTRIES	9.56	9.81	10.05	10.28	10.45	10.60	10.37
TOTAL FREE WORLD	46.44	47.53	48.40	48.98	49.63	50.40	49.29
PRODUCTION (MMBD)**							
UNITED STATES	11.20	10.90	10.29	9.99	9.60	9.22	7.99
CANADA	1.84	1.82	1.77	1.67	1.59	1.52	1.75
WESTERN EUROPE	4.27	4.41	4.30	4.08	3.88	3.70	3.47
OPEC	17.21	19.35	20.32	22.36	23.94	25.35	24.59
OTHER COUNTRIES	9.37	9.44	9.88	9.74	9.62	9.51	10.19
CPE NET EXPORTS	1.80	1.70	1.60	1.60	1.60	1.60	1.60
TOTAL FREE WORLD	45.68	47.62	48.16	49.44	50.22	50.90	49.59
NET IMPORTS INTO UNITED STATES (MMBD)							
50 STATE AREA	4.29	5.23	5.90	6.35	6.83	7.53	8.07
U.S. TERRITORIES	0.27	0.29	0.29	0.30	0.30	0.30	0.26
TOTAL UNITED STATES	4.56	5.52	6.19	6.65	7.13	7.83	8.33
NET STOCK ADDITIONS AND STATISTICAL DISCREPANCY (MMBD)							
	-0.76	0.09	-0.24	0.46	0.59	0.50	0.27

* Includes about 0.3 MMB/D of consumption in U.S. territories.
** Includes crude oil, natural gas liquids (NGLs) and refinery gains.

Table A4. Oil Market Simulation Model Results: Price Collapse Case

	1985	1986	1987	1988	1989	1990	1995
WORLD OIL PRICE							
1985 CIF $	27.03	14.23	12.00	10.00	12.90	15.22	22.91
CONSUMPTION (MMBD)							
UNITED STATES*	16.00	16.39	16.98	17.48	17.22	17.17	17.65
CANADA	1.48	1.53	1.60	1.68	1.71	1.73	1.81
JAPAN	4.34	4.42	4.53	4.66	4.72	4.75	4.83
WESTERN EUROPE	11.67	11.97	12.34	12.83	13.07	13.22	13.20
OPEC	3.40	3.40	3.46	3.53	3.59	3.66	4.16
OTHER COUNTRIES	9.56	9.81	10.19	10.64	10.78	10.82	10.91
TOTAL FREE WORLD	46.44	47.53	49.09	51.81	51.10	51.36	52.56
PRODUCTION (MMBD)**							
UNITED STATES	11.20	10.90	10.20	9.76	9.33	8.97	7.50
CANADA	1.84	1.82	1.73	1.55	1.45	1.39	1.38
WESTERN EUROPE	4.27	4.41	4.26	3.97	3.75	3.58	3.19
OPEC	17.21	19.35	21.21	24.79	26.11	26.98	29.70
OTHER COUNTRIES	9.37	9.44	9.84	9.60	9.44	9.34	9.51
CPE NET EXPORTS	1.80	1.70	1.60	1.60	1.60	1.60	1.60
TOTAL FREE WORLD	45.68	47.62	48.84	51.27	51.69	51.85	52.89
NET IMPORTS INTO UNITED STATES (MMBD)							
50 STATE AREA	4.29	5.23	6.34	7.48	7.63	7.98	9.91
U.S. TERRITORIES	0.27	0.29	0.30	0.32	0.31	0.31	0.28
TOTAL UNITED STATES	4.56	5.52	6.64	7.80	7.94	8.29	10.19
NET STOCK ADDITIONS AND STATISTICAL DISCREPANCY (MMBD)							
	-0.76	0.09	-0.17	0.46	0.59	0.49	0.33

* Includes about 0.3 MMB/D of consumption in U.S. territories.
** Includes crude oil, natural gas liquids (NGLs) and refinery gains.

Table A5. Energy Consumption by Fuel and Sector: United States

(Quadrillion Btu)

1985

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	7.7	7.1	2.8	-	9.5	27.1
Transportation	19.5	0.5	0.0	-	0.0	20.0
Residential/Commercial	2.6	7.1	0.2	-	17.0	26.9
Electric Utilities	1.1	3.2	14.5	7.7	-	-
Total	30.9	17.9	17.5	7.7	-	74.0

1990

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	7.9-8.3	7.2-7.3	2.9-2.9	-	10.6-10.6	28.8-29.2
Transportation	19.8-20.7	0.5-0.5	0.0	-	0.0	20.3-21.2
Residential/Commercial	2.7-2.8	7.3-7.4	0.2-0.2	-	18.8-19.0	28.9-29.1
Electric Utilities	0.5-1.1	2.9-3.2	16.0-16.0	9.6-9.6	-	-
Total	30.9-32.9	17.9-18.4	19.0-19.1	9.6-9.6	-	78.0-79.6

1995

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	8.2-8.5	6.9-7.1	2.9-3.0	-	12.5-12.6	30.4-31.3
Transportation	19.8-21.4	0.5-0.5	0.0	-	0.0	20.3-21.9
Residential/Commercial	2.6-2.8	7.5-7.5	0.2-0.2	-	21.8-22.1	32.2-32.4
Electric Utilities	1.7-2.4	3.4-4.0	18.5-18.7	10.2-10.2	-	-
Total	32.4-35.1	18.5-18.9	21.6-21.9	10.2-10.2	-	83.1-85.7

NOTE: Uncertainty ranges reflect the less and more dependent energy scenarios.

Table A6. Energy Consumption by Fuel and Sector: Canada

(Quadrillion Btu)

1985

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	0.9	1.2	0.3	-	2.2	4.6
Transportation	1.6	0.0	0.0	-	0.0	1.6
Residential/Commercial	0.4	0.8	0.0	-	2.3	3.5
Electric Utilities	0.1	0.1	0.9	3.4	-	-
Total	3.0	2.1	1.2	3.4	-	9.6

1990

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	1.0-1.0	1.1-1.3	0.1-0.3	-	2.5-2.6	4.7-5.2
Transportation	1.7-1.8	0.0	0.0	-	0.0	1.7-1.8
Residential/Commercial	0.4-0.4	0.8-0.9	0.0	-	2.6-2.7	3.8-4.0
Electric Utilities	0.1-0.1	0.2-0.2	1.1-1.3	3.6-3.7	-	-
Total	3.1-3.3	2.1-2.4	1.3-1.5	3.6-3.7	-	10.4-10.7

1995

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	1.0-1.1	1.1-1.3	0.1-0.3	-	2.7-2.9	4.9-5.6
Transportation	1.7-1.8	0.0	0.0	-	0.0	1.7-1.8
Residential/Commercial	0.4-0.5	0.9-1.0	0.0	-	2.8-3.1	4.1-4.6
Electric Utilities	0.1-0.2	0.5-0.6	1.0-1.4	3.8-4.0	-	-
Total	3.2-3.6	2.2-2.9	1.3-1.8	3.8-4.0	-	10.9-11.5

NOTE: Uncertainty ranges are calculated independently and do not sum to totals.

Table A7. Energy Consumption by Fuel and Sector: Japan

(Quadrillion Btu)

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
			1985			
Industrial	3.2	0.0	2.1	-	3.8	9.1
Transportation	2.4	0.0	0.0	-	0.2	2.6
Residential/Commercial	1.3	0.4	0.0	-	2.3	4.0
Electric Utilities	1.9	1.2	0.8	2.4	-	-
Total	8.8	1.6	2.9	2.4	-	15.7
			1990			
Industrial	3.2-3.2	0.0	2.1-2.3	-	4.2-4.4	9.5-9.9
Transportation	2.6-2.6	0.0	0.0	-	0.2-0.2	2.8-2.8
Residential/Commercial	1.3-1.4	0.6-0.7	0.0	-	2.6-2.7	4.5-4.8
Electric Utilities	1.9-2.1	1.2-1.3	0.9-1.0	2.8-3.1	-	-
Total	9.0-9.3	1.7-1.9	3.1-3.3	2.8-3.1	-	16.8-17.3
			1995			
Industrial	3.1-3.3	0.0	2.0-2.4	-	4.8-5.2	9.9-10.9
Transportation	2.6-2.7	0.0	0.0	-	0.2-0.3	2.8-3.0
Residential/Commercial	1.4-1.5	0.5-0.7	0.0	-	2.9-3.2	4.9-5.4
Electric Utilities	1.7-2.0	1.3-1.7	1.3-1.6	3.4-3.8	-	-
Total	8.9-9.6	1.9-2.3	3.3-3.8	3.4-3.8	-	18.1-19.0

NOTE: Uncertainty ranges are calculated independently and do not sum to totals.

Table A8. Energy Consumption by Fuel and Sector: Western Europe

(Quadrillion Btu)

1985

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	7.4	3.3	3.3	-	10.2	24.2
Transportation	9.8	0.0	0.0	-	0.5	10.3
Residential/Commercial	4.7	3.9	0.9	-	9.8	19.3
Electric Utilities	2.3	1.2	6.5	10.5	-	-
Total	24.2	8.4	10.7	10.5	-	53.7

1990

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	7.4-7.8	3.1-3.6	3.4-4.1	-	11.2-11.7	25.1-27.2
Transportation	10.3-10.8	0.0	0.0	-	0.5-0.6	10.8-11.4
Residential/Commercial	4.7-4.9	3.7-4.2	0.8-1.0	-	10.8-11.4	20.0-21.5
Electric Utilities	2.0-2.2	1.3-1.4	6.5-7.4	12.4-13.3	-	-
Total	24.3-25.7	8.0-9.2	10.9-12.0	12.4-13.3	-	57.4-59.0

1995

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	7.4-8.2	3.2-4.0	3.2-4.4	-	12.3-13.5	26.2-30.1
Transportation	9.9-10.8	0.0	0.0	-	0.6-0.6	10.5-11.4
Residential/Commercial	4.6-5.0	4.0-4.8	0.7-1.0	-	12.0-13.1	21.3-23.9
Electric Utilities	1.9-2.3	1.3-1.7	7.0-9.0	14.0-15.2	-	-
Total	23.9-26.3	8.3-10.4	11.5-13.7	14.0-15.2	-	60.9-63.2

NOTE: Uncertainty ranges are calculated independently and do not sum to totals.

Table A9. Energy Consumption by Fuel and Sector: Other OECD

(Quadrillion Btu)

1985

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	0.5	0.6	0.1	-	0.8	2.0
Transportation	1.3	0.0	0.0	-	0.0	1.3
Residential/Commercial	0.0	0.0	0.0	-	0.9	0.9
Electric Utilities	0.3	0.0	0.9	0.4	-	-
Total	2.1	0.6	1.1	0.4	-	4.2

1990

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	0.5-0.6	0.6-0.7	0.1-0.2	-	0.9-0.9	2.1-2.4
Transportation	1.3-1.5	0.0	0.0	-	0.0	1.3-1.5
Residential/Commercial	0.0	0.0	0.0	-	1.0-1.0	1.0-1.0
Electric Utilities	0.3-0.4	0.0	1.1-1.2	0.4-0.4	-	-
Total	2.1-2.4	0.6-0.7	1.2-1.3	0.4-0.4	-	4.5-4.8

1995

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	0.4-0.5	0.7-0.9	0.0-0.2	-	1.0-1.1	2.2-2.7
Transportation	1.2-1.5	0.0	0.0	-	0.0	1.2-1.5
Residential/Commercial	0.0	0.0	0.0	-	1.1-1.2	1.1-1.2
Electric Utilities	0.3-0.4	0.0	1.3-1.4	0.5-0.5	-	-
Total	2.0-2.3	0.7-0.9	1.4-1.6	0.5-0.5	-	4.8-5.2

NOTE: Uncertainty ranges are calculated independently and do not add to totals.

Table A10. Energy Consumption by Fuel and Sector: Total OECD

(Quadrillion Btu)

1985

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	19.7	12.1	8.6	-	26.5	66.9
Transportation	34.6	0.5	0.0	-	0.7	35.8
Residential/Commercial	9.0	12.2	1.1	-	32.3	54.6
Electric Utilities	5.7	5.7	23.7	24.4	-	-
Total	69.0	30.5	33.4	24.4	-	157.2

1990

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	20.0-20.9	12.0-12.9	8.6-9.8	-	29.4-30.2	70.2-72.4
Transportation	35.7-37.4	0.5-0.5	0.0	-	0.7-0.8	36.9-38.7
Residential/Commercial	9.1-9.5	12.4-13.2	1.0-1.2	-	35.8-36.8	58.2-60.4
Electric Utilities	4.8-5.9	5.6-6.1	25.6-26.9	28.8-30.1	-	-
Total	69.4-73.6	30.4-32.6	35.5-37.2	28.8-30.1	-	166.9-171.4

1995

Sector	Oil	Gas	Coal	Nuclear/Other	Electricity	Total
Industrial	20.1-21.6	11.9-13.3	8.2-10.3	-	33.3-35.3	73.6-80.6
Transportation	35.2-38.2	0.5-0.5	0.0	-	0.8-0.9	36.5-39.6
Residential/Commercial	9.0-9.8	12.8-13.9	0.9-1.2	-	40.6-42.7	63.6-67.5
Electric Utilities	5.7-7.3	6.5-8.0	29.1-32.1	31.8-33.6	-	-
Total	70.4-76.9	31.6-35.4	39.1-42.8	31.8-33.6	-	177.8-184.6

NOTE: Uncertainty ranges are calculated independently and do not add to totals.

Table A11. Energy Consumption by Fuel

(Quadrillion Btu)

Developing Countries

	Oil	Gas	Coal	Nuclear/ Other	Total
1985	18.5	4.0	9.2	5.1	36.8
1990	18.2-19.2	4.9-6.1	10.3-11.4	6.0-6.1	41.3-42.6
1995	18.7-20.2	6.3-9.3	12.1-14.9	7.0-7.5	46.8-49.9

OPEC

	Oil	Gas	Coal	Nuclear/ Other	Total
1985	7.2	3.3	0.0	0.4	10.9
1990	7.3-7.3	3.8-4.0	0.1-0.1	0.5-0.5	11.9-12.4
1995	8.3-8.3	4.9-5.4	0.1-0.2	0.6-0.6	14.0-15.2

Total Free World

	Oil	Gas	Coal	Nuclear/ Other	Total
1985	94.7	37.8	42.6	29.8	204.9
1990	97.6-104.0	39.0-42.7	45.9-48.7	35.3-36.7	220.3-226.4
1995	99.7-108.2	42.8-50.1	51.3-57.9	39.4-41.7	238.6-249.7

NOTE: Uncertainty ranges are calculated independently and do not add to totals.

Introduction

This appendix summarizes the EIA service report entitled Future Supply Capabilities of the United States Petroleum Industry, which is published separately and which should be considered part of this report. The projections of the U.S. energy outlook made for this report were made using the Energy Information Administration (EIA) Intermediate Future Forecasting System combined with the Gas Analysis Modeling System (IFFS/GAMS). All general model settings and assumptions were defined by those for the Annual Energy Outlook 1986 (AEO) forecasts published in February 1987. However, for the purposes of this study specific AEO assumptions were revised to make them consistent with the oil market outlook developed for the study of Energy and Security through a series of interagency discussions, involving analysts from the Department of Energy and other Federal Government agencies. Two scenarios were considered, a lower oil price case and a higher oil price case.

In the lower price case:

- Oil prices were assumed to follow a path from $14 in 1987 to $15 by 1990 and then rise smoothly to $22 by 1995 (1985 dollars).
- U.S. economic growth was assumed to average 2.7% per year over the period to 1995.
- EIA's standard assumptions on future oil finding rates were adjusted downwards by 10% to reflect a more pessimistic, but reasonable, lower bound on future reserves and production.
- Future estimates of reserve revisions, usually positive, were assumed to be zero.
- It was assumed that lower oil prices preclude further improvements in the average fuel efficiency of new cars, which are assumed to obtain 27.2 miles per gallon for the next 8 years.

In the higher price case:

- Oil prices were assumed to rise from $17 in 1987 to $28 by 1995 (1985 dollars).
- Economic growth was assumed to average 2.5% over the period to 1995.
- Oil finding rates and future reserve revisions were set at the standard AEO estimates.
- The new car fleet average fuel efficiency was assumed to rise to 32.8 mpg by 1995, which is the standard AEO assumption.

Methodology

The EIA models contain detailed representations of the U.S. energy market covering 10 regions as well as separate fuel supply and consumption sectors. For specific levels of world oil prices and economic growth, a detailed economic forecast is generated using the Data Resources Inc. annual model of the economy. This forecast in turn is used to derive estimates of residential housing and commercial building construction and a detailed representation of industrial growth. In addition, an independent assessment of new car sales and fleet mix is used to derive an estimate of future new car fleet average fuel efficiency, which together with other industrial transportation needs, sets the estimate for transportation demand.

On the production side the world oil price assumption is used in a detailed description of the U.S. petroleum and natural gas reserve base to assess the value of future drilling activity, reserve additions and potential U.S. production from these reserves for both oil and natural gas. Oil product pricing is calculated from the world oil price and from current estimates of refinery pricing for each fuel in each part of the Nation. Natural gas pricing is based upon an assessment of the role of current Federal Energy Regulatory Commission (FERC) initiatives, such as Orders 436 and 451, the current excess capacity of the market, the cost of new reserve additions, and the competition from imports. Electricity prices are calculated from a detailed model of utilities' revenue requirements adjusting for factors such as the cost of new capital additions, taxes, depreciation, and fuel changes.

The EIA models estimate the future consumption of energy by simulating the competition between oil, natural gas, coal and electricity in each of the end-use markets. A detailed characterization of the competition between oil and natural gas is employed for both electrical utility and industrial markets. The fuel capabilities of electric utilities over the 1986-1995 period are determined from firm utility construction plans and calculations of additional capacity requirements. Additionally, the potential for industrial cogeneration is considered, using reasonable estimates of the construction of currently PURPA-qualified facilities and additional potential for industrial cogeneration.

The AEO contains a more complete description of the base forecast outlook for a variety of world oil price and economic growth assumptions.

Summary Tables and Results

The main result of this analysis was a set of projections for U.S. energy production, imports, exports and consumption and a more detailed projection of oil supply and demand. The projections resulting from this analysis are presented in a series of tables printed at the end of this appendix. For the lower price case, Table B1 shows the yearly Supply and Disposition of Total Energy, and Table B2 shows the Petroleum Supply and Disposition Balance. Tables B3 and B4 show the corresponding results for the higher price case.

Using the assumptions of the lower and higher price cases, EIA made projections of future oil and gas exploration and production activities. These projections were built on the experience of the oil industry slump from 1956 to 1970, the surge in activity of the 1970's, and the recent downturn in industry activities. These projections indicate that oil industry employment and the number of feet drilled per year will increase in the 1990's compared to 1986 levels but will not attain the heights achieved in the early 1970's. The results of these projections are presented in Table B5.

EIA also examined the projected ability of U.S. refiners to meet the levels of consumption projected under the higher and lower price scenarios. This examination showed that the existing distillation capacity of U.S. refineries probably will be sufficient to meet the requirements of either case over the next 10 years, with utilization rates not exceeding 85-90 percent. Historically, the industry has sustained these levels and, in fact, much higher levels for long periods of time. If the existing U.S. refinery system is maintained at current levels of operable capacity, it should be able to meet the demand of consumers under the lower price case scenarios, and even a 10-percent surge requirement. The table on the next page shows the results from this examination of refining capacity.

Summary of Projected Refinery Distillation Capacity Utilization
(Million Barrels per Day)

	1986	1990		1995	
		Higher Price Case	Lower Price Case	Higher Price Case	Lower Price Case
(1) Inputs to Refineries	12.77	12.18	13.00	12.46	13.41
(2) Operable Capacity*	15.50	15.50	15.50	15.50	15.50
(3) Percentage Utilization**	.82	.79	.84	.80	.87

* Operable capacity is the maximum amount of input that can be processed by a crude oil distillation unit in a 24-hour period, making allowances for processing limitations due to types and grades of inputs, limitations on downstream facilities, scheduled and unscheduled downtimes and environmental constraints. It includes any shut-down refineries that could be placed in operation within 90 days.

** (3)=(1)/(2).

Downstream processing requirements reflect the mix of products required. While only modest changes in the total oil product supply are projected, significant changes are projected for individual products. In both the lower and higher oil price cases, demand for gasoline is projected to decline, while demand for distillate fuel, residual fuel, jet fuel and LPG's is projected to increase. While the projections in this study do not indicate a rising gasoline demand, even if gasoline demand should exceed these projections, existing refinery capacity would be able to handle up to a 10-percent increase for short periods of high product demand.

Table B1. Yearly Supply and Disposition Summary of Total Energy (Quadrillion Btu per Year)

Total Supply and Disposition	Lower Oil Price Case (More Import Dependent)[1]										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
World Oil Price[2]	27.03	14.23	14.36	14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
Production											
Crude Oil and Lease Condensate	19.0	18.3	17.0	16.3	15.4	14.6	13.9	13.1	12.6	11.8	11.1
Natural Gas Plant Liquids	2.2	2.2	2.2	2.4	2.3	2.3	2.3	2.4	2.3	2.2	2.3
Natural Gas[3]	17.1	17.0	16.9	17.6	17.3	17.3	17.3	17.5	17.4	16.6	17.3
Coal[4]	19.3	19.5	20.1	20.9	21.1	21.6	22.4	22.9	23.4	23.9	24.6
Nuclear Power	4.2	4.4	4.9	5.4	5.7	6.0	6.1	6.3	6.3	6.4	6.4
Hydropower/Other[5]	3.1	3.2	3.4	3.1	3.1	3.1	3.2	3.2	3.2	3.2	3.2
Total Production	64.9	64.7	64.6	65.6	65.0	65.0	65.2	65.3	65.3	64.2	64.9
Imports											
Crude Oil[6]	6.8	8.7	9.9	11.0	11.9	13.3	14.1	15.1	15.8	17.0	17.7
Petroleum Products[7]	3.8	3.8	4.1	4.0	4.1	4.1	4.3	4.5	4.7	5.7	5.3
Natural Gas[8]	.9	.7	.9	.7	1.0	1.1	1.2	1.3	1.4	1.5	1.8
Other Imports[9]	.5	.5	.5	.5	.6	.6	.6	.6	.6	.7	.7
Total Imports	12.0	13.8	15.3	16.2	17.5	19.1	20.3	21.5	22.6	24.8	25.5
Exports											
Coal	2.4	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.6	2.7	2.7
Crude Oil and Petroleum Products	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Total Exports	4.1	3.9	3.9	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3
Net Stock Withdrawals	1.0	-.1	.0	-.3	-.1	-.3	-.3	-.2	-.2	-.2	-.2
Adjustments[10]	.2	-.1	.1	-.1	-.2	-.2	-.2	-.2	-.2	.0	-.2
Consumption											
Petroleum Products[11]	30.9	31.8	32.2	32.2	32.3	32.9	33.3	33.6	34.1	35.4	35.1
Natural Gas	17.9	17.1	17.4	17.9	17.9	17.9	18.1	18.3	18.3	17.7	18.5
Coal	17.5	17.4	17.8	18.5	18.7	19.1	19.8	20.3	20.8	21.3	21.9
Nuclear Power	4.2	4.4	4.9	5.4	5.7	6.0	6.1	6.3	6.3	6.4	6.4
Hydroelectric Power/Other[12]	3.5	3.7	3.8	3.5	3.6	3.6	3.7	3.7	3.7	3.7	3.8
Total Consumption	73.9	74.3	76.1	77.5	78.2	79.6	81.0	82.2	83.3	84.5	85.7

[1] Assumptions include lower oil prices, higher economic growth, lower finding rate and lower energy efficiency.
[2] The cost of imported crude oil to U.S. refiners in 1985 dollars per barrel.
[3] Net dry marketed production after removal of nonhydrocarbon gases, plus supplemental natural gas.
[4] Historical coal production includes anthracite, bituminous, and lignite. Projected coal production (1986-1995) includes bituminous and lignite, with anthracite included in bituminous.
[5] Includes hydropower, geothermal power, and wood waste.
[6] Includes imports of crude oil for the Strategic Petroleum Reserve.
[7] Includes imports of unfinished oils and natural gas plant liquids.
[8] Includes dry natural gas imports from Canada and Mexico, and liquefied natural gas imports from Algeria. In both the historical and forecast periods, natural gas imports are net imports.
[9] Includes electricity, coal, and coal coke imports.
[10] Balancing item that includes stock changes, gains, losses, miscellaneous blending components, unaccounted for supply, anthracite shipped overseas to U.S. Armed Forces, and certain secondary stock withdrawals.
[11] Includes natural gas plant liquids and crude oil consumed as a fuel.
[12] Includes industrial generation of hydroelectric power, net electricity imports, and electricity produced from geothermal, wood, waste, wind, photovoltaic, solar thermal sources connected to electric utility distribution systems. Also includes net coke imports.

Note: Totals may not equal sum of components because of independent rounding.

Sources: Historical quantities are from the Energy Information Administration, *Annual Energy Review 1985*, DOE/EIA-0384(85) (Washington, DC, 1986), pp. 5-13, Tables 1, 2, 3, and 5. Historical quantities are through 1985. Projected values are outputs from the Intermediate Future Forecasting System.

Table B2. Petroleum Supply and Disposition Balance (Million Barrels per Day)

Supply and Disposition	Lower Oil Price Case (More Import Dependent)[1]										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
World Oil Price[2]	27.03	14.23	14.36	14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
Production											
Crude Oil[3]	8.97	8.67	8.05	7.65	7.29	6.90	6.58	6.17	5.96	5.59	5.24
Alaska	1.83	1.86	1.79	1.67	1.60	1.58	1.51	1.39	1.39	1.27	1.14
Lower 48	7.15	6.81	6.25	5.98	5.69	5.32	5.08	4.79	4.57	4.32	4.10
Natural Gas Plant Liquids	1.61	1.62	1.62	1.72	1.69	1.68	1.68	1.69	1.68	1.60	1.67
Other Domestic	.06	.05	.06	.05	.05	.05	.05	.05	.05	.05	.05
Processing Gain[4]	.56	.56	.56	.57	.57	.58	.59	.59	.60	.62	.62
Total Production	11.20	10.90	10.29	9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
Imports (including SPR)											
Crude Oil[5]	3.20	4.11	4.64	5.15	5.59	6.27	6.64	7.07	7.42	7.98	8.35
Refined Products	1.87	1.88	2.02	1.95	1.99	2.02	2.12	2.19	2.32	2.80	2.60
Total Imports	5.07	5.99	6.66	7.10	7.58	8.29	8.76	9.25	9.75	10.78	10.95
Exports											
Crude Oil	.20	.17	.19	.19	.19	.19	.19	.19	.19	.19	.19
Refined Products	.58	.59	.56	.56	.56	.56	.56	.56	.56	.56	.56
Total Exports	.78	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75
Net Imports (including SPR)	4.29	5.23	5.90	6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
Primary Stock Changes											
Net Withdrawals[6]	.22	-.14	.09	-.04	-.01	-.05	-.02	-.02	-.02	-.03	-.02
SPR Fill Rate Additions (-)[7]	-.12	-.05	-.06	-.04	-.04	-.04	-.04	-.04	-.04	-.04	-.04
Total Primary Supply[8]	15.60	15.94	16.22	16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
Refined Petroleum Products											
Motor Gasoline	6.83	7.04	7.02	6.97	6.93	6.96	6.92	6.88	6.91	6.93	6.96
Jet Fuel[9]	1.22	1.30	1.33	1.39	1.41	1.46	1.47	1.48	1.49	1.49	1.50
Distillate Fuel	2.87	2.88	3.01	3.05	3.10	3.15	3.22	3.27	3.33	3.39	3.42
Residual Fuel	1.20	1.42	1.29	1.17	1.22	1.34	1.46	1.53	1.68	2.17	1.97
Other Petroleum Products[10]	3.61	3.46	3.67	3.70	3.72	3.76	3.79	3.80	3.83	3.85	3.87
Total Product Supplied	15.73	16.10	16.33	16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
Refined Petroleum Products Supplied to Sectors											
Residential and Commercial	1.35	1.35	1.40	1.43	1.45	1.46	1.47	1.46	1.46	1.45	1.43
Industrial[11]	4.00	3.96	4.14	4.17	4.21	4.27	4.32	4.33	4.37	4.41	4.43
Transportation	9.88	10.12	10.27	10.31	10.34	10.45	10.48	10.49	10.60	10.69	10.78
Electric Utilities	.48	.64	.50	.34	.37	.46	.58	.66	.81	1.27	1.06
Total Consumption	15.71	16.08	16.31	16.26	16.37	16.65	16.85	16.95	17.24	17.82	17.70
Discrepancy[12]	-.12	-.14	-.10	.01	.02	.02	.01	.01	.00	.01	.01
Net Disposition[13]	15.59	15.94	16.22	16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72

[1] Assumptions include lower oil prices, higher economic growth, lower finding rate and lower energy efficiency.
[2] The cost of imported crude oil to U.S. refiners in 1985 dollars per barrel.
[3] Includes lease condensate.
[4] Represents volumetric gain in refinery distillation and cracking processes.
[5] In 1977 and later years, crude oil imports include crude oil imported for the Strategic Petroleum Reserve.
[6] Net stock withdrawals for a given year, t, are defined as the change in end-of-year stock levels from period t-1 minus the end-of-year stock level from the year t. A minus is treated as a deletion from total supply and a plus is treated as an addition to total supply.
[7] SPR is the Strategic Petroleum Reserve.
[8] Total primary supply is defined as total production plus net imports plus net stock withdrawals minus SPR additions.
[9] Includes naphtha and kerosene type.
[10] Includes aviation gasoline, kerosene, liquefied petroleum gas, petrochemical feedstocks, miscellaneous petroleum products, lubricants, waxes, unfractionated stream, plant condensate, natural gasoline, asphalt, road oil, still gas, special naphthas, and petroleum coke.
[11] Includes total industrial demand for petroleum.
[12] Represents the difference between total primary supply and total consumption.
[13] Net disposition is the sum of total consumption and discrepancy.

Note: Totals may not equal sum of components because of independent rounding.

Sources: Historical data are from the Energy Information Administration, *Annual Energy Review 1985*, DOE/EIA-0384(85) (Washington, DC, 1986), pp. 101-121, Tables 45, 46, 47, and 55. Historical quantities are through 1985. Projected values are outputs from the Intermediate Future Forecasting System.

Input data file: Historical = D1212861, Projected = HIDEPD.D0203871. Table printed on February 20, 1987.

Table B3. Yearly Supply and Disposition Summary of Total Energy (Quadrillion Btu per Year)

Total Supply and Disposition	Higher Oil Price Case (Less Import Dependent)[1]										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
World Oil Price[2]	27.03	14.23	17.00	18.51	20.51	22.51	23.51	24.51	25.51	26.51	27.51
Production											
Crude Oil and Lease Condensate	19.0	18.3	17.5	17.3	16.9	16.4	15.8	15.4	14.7	14.2	13.9
Natural Gas Plant Liquids	2.2	2.2	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Natural Gas[3]	17.1	17.0	16.9	17.5	17.5	17.7	17.8	17.7	17.8	17.6	17.6
Coal[4]	19.3	19.5	20.1	20.9	21.0	21.5	22.2	22.7	23.3	23.8	24.3
Nuclear Power	4.2	4.4	4.9	5.4	5.7	6.0	6.1	6.2	6.3	6.4	6.4
Hydropower/Other[5]	3.1	3.2	3.4	3.1	3.1	3.1	3.2	3.2	3.2	3.2	3.2
Total Production	64.9	64.7	65.1	66.6	66.6	67.1	67.5	67.7	67.7	67.4	67.8
Imports											
Crude Oil[6]	6.8	8.7	9.4	9.3	9.4	9.8	10.5	11.1	11.9	12.6	12.9
Petroleum Products[7]	3.8	3.8	4.1	3.9	3.7	3.7	3.9	4.0	4.0	4.3	4.5
Natural Gas[8]	.9	.7	.9	.8	1.1	1.2	1.3	1.4	1.5	1.7	1.8
Other Imports[9]	.5	.5	.5	.5	.6	.6	.6	.6	.6	.7	.7
Total Imports	12.0	13.8	14.9	14.5	14.6	15.2	16.2	17.1	18.1	19.2	19.9
Exports											
Coal	2.4	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.6	2.7	2.7
Crude Oil and Petroleum Products	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Total Exports	4.1	3.9	3.9	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3
Net Stock Withdrawals	1.0	-.1	.0	-.2	-.1	-.1	-.2	-.2	-.2	-.2	-.2
Adjustments[10]	.2	-.1	.1	-.1	-.1	-.1	-.2	-.2	-.2	-.1	-.1
Consumption											
Petroleum Products[11]	30.9	31.8	32.2	31.5	31.0	30.9	31.2	31.5	31.6	32.1	32.4
Natural Gas	17.9	17.1	17.4	17.9	18.2	18.4	18.6	18.6	18.8	18.8	18.9
Coal	17.5	17.4	17.8	18.5	18.6	19.0	19.6	20.2	20.7	21.1	21.6
Nuclear Power	4.2	4.4	4.9	5.4	5.7	6.0	6.1	6.2	6.3	6.4	6.4
Hydroelectric Power/Other[12]	3.5	3.7	3.8	3.5	3.6	3.6	3.7	3.7	3.7	3.7	3.8
Total Consumption	73.9	74.3	76.1	76.8	77.1	78.0	79.2	80.2	81.2	82.1	83.1

[1] Assumptions include higher oil prices, lower economic growth, higher finding rate and higher energy efficiency.
[2] The cost of imported crude oil to U.S. refiners in 1985 dollars per barrel.
[3] Net dry marketed production after removal of nonhydrocarbon gases, plus supplemental natural gas.
[4] Historical coal production includes anthracite, bituminous, and lignite. Projected coal production (1986-1995) includes bituminous and lignite, with anthracite included in bituminous.
[5] Includes hydropower, geothermal power, and wood waste.
[6] Includes imports of crude oil for the Strategic Petroleum Reserve.
[7] Includes imports of unfinished oils and natural gas plant liquids.
[8] Includes dry natural gas imports from Canada and Mexico, and liquefied natural gas imports from Algeria. In both the historical and forecast periods, natural gas imports are net imports.
[9] Includes electricity, coal, and coal coke imports.
[10] Balancing item that includes stock changes, gains, losses, miscellaneous blending components, unaccounted for supply, anthracite shipped overseas to U.S. Armed Forces, and certain secondary stock withdrawals.
[11] Includes natural gas plant liquids and crude oil consumed as a fuel.
[12] Includes industrial generation of hydroelectric power, net electricity imports, and electricity produced from geothermal, wood, waste, wind, photovoltaic, solar thermal sources connected to electric utility distribution systems. Also includes net coke imports.
Note: Totals may not equal sum of components because of independent rounding.
Sources: Historical quantities are from the Energy Information Administration, *Annual Energy Review 1985*, DOE/EIA-0384(85) (Washington, DC, 1986), pp. 5-13, Tables 1, 2, 3, and 5. Historical quantities are through 1985. Projected values are outputs from the Intermediate Future Forecasting System.

Table B4. Petroleum Supply and Disposition Balance (Million Barrels per Day)

Supply and Disposition	Higher Oil Price Case (Less Import Dependent)[1]										
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
World Oil Price[2]	27.03	14.23	17.00	18.51	20.51	22.51	23.51	24.51	25.51	26.51	27.51
Production											
Crude Oil[3]	8.97	8.67	8.26	8.16	7.97	7.75	7.49	7.26	6.96	6.69	6.57
Alaska	1.83	1.86	1.89	1.91	1.85	1.73	1.62	1.54	1.42	1.31	1.26
Lower 48	7.15	6.81	6.38	6.25	6.12	6.03	5.86	5.72	5.54	5.38	5.30
Natural Gas Plant Liquids	1.61	1.62	1.62	1.71	1.71	1.72	1.73	1.72	1.72	1.70	1.70
Other Domestic	.06	.05	.06	.05	.05	.05	.05	.05	.05	.05	.05
Processing Gain[4]	.56	.56	.56	.56	.55	.55	.55	.56	.56	.57	.57
Total Production	11.20	10.90	10.50	10.48	10.28	10.08	9.82	9.59	9.29	9.01	8.89
Imports (including SPR)											
Crude Oil[5]	3.20	4.11	4.42	4.37	4.41	4.60	4.93	5.19	5.58	5.92	6.08
Refined Products	1.87	1.88	2.02	1.89	1.80	1.82	1.90	1.95	1.98	2.12	2.22
Total Imports	5.07	5.99	6.44	6.26	6.21	6.42	6.83	7.14	7.56	8.04	8.29
Exports											
Crude Oil	.20	.17	.19	.19	.19	.19	.19	.19	.19	.19	.19
Refined Products	.58	.59	.56	.56	.56	.56	.56	.56	.56	.56	.56
Total Exports	.78	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75
Net Imports (including SPR)	4.29	5.23	5.69	5.51	5.45	5.66	6.08	6.39	6.81	7.29	7.54
Primary Stock Changes											
Net Withdrawals[6]	.22	-.14	.09	.01	.03	.00	-.02	-.01	-.01	-.02	-.01
SPR Fill Rate Additions (-) [7]	-.12	-.05	-.06	-.04	-.04	-.04	-.04	-.04	-.04	-.04	-.04
Total Primary Supply[8]	15.60	15.94	16.22	15.97	15.73	15.71	15.85	15.93	16.05	16.25	16.38
Refined Petroleum Products											
Motor Gasoline	6.83	7.04	7.00	6.84	6.67	6.57	6.51	6.45	6.41	6.36	6.32
Jet Fuel[9]	1.22	1.30	1.33	1.36	1.36	1.39	1.40	1.40	1.42	1.42	1.43
Distillate Fuel	2.87	2.88	3.01	3.01	3.03	3.04	3.09	3.12	3.18	3.24	3.30
Residual Fuel	1.20	1.42	1.29	1.11	1.03	1.06	1.17	1.27	1.32	1.49	1.59
Other Petroleum Products[10]	3.61	3.46	3.66	3.65	3.64	3.65	3.68	3.68	3.71	3.73	3.74
Total Product Supplied	15.73	16.10	16.29	15.97	15.73	15.71	15.85	15.93	16.05	16.25	16.38
Refined Petroleum Products Supplied to Sectors											
Residential and Commercial	1.35	1.35	1.40	1.41	1.42	1.41	1.41	1.39	1.38	1.37	1.36
Industrial[11]	4.00	3.96	4.13	4.10	4.08	4.08	4.13	4.16	4.20	4.25	4.30
Transportation	9.88	10.12	10.24	10.14	10.01	9.96	9.96	9.93	9.96	9.95	9.97
Electric Utilities	.48	.64	.50	.30	.22	.24	.34	.44	.49	.66	.75
Total Consumption	15.71	16.08	16.27	15.95	15.72	15.70	15.83	15.92	16.04	16.24	16.37
Discrepancy[12]	-.12	-.14	-.06	.01	.01	.01	.01	.01	.01	.01	.01
Net Disposition[13]	15.59	15.94	16.22	15.97	15.73	15.71	15.85	15.93	16.05	16.25	16.38

[1] Assumptions include higher oil prices, lower economic growth, higher finding rate and higher energy efficiency.
[2] The cost of imported crude oil to U.S. refiners in 1985 dollars per barrel.
[3] Includes lease condensate.
[4] Represents volumetric gain in refinery distillation and cracking processes.
[5] In 1977 and later years, crude oil imports include crude oil imported for the Strategic Petroleum Reserve.
[6] Net stock withdrawals for a given year, t, are defined as the change in end-of-year stock levels from period t-1 minus the end-of-year stock level from the year t. A minus is treated as a deletion from total supply and a plus is treated as an addition to total supply.
[7] SPR is the Strategic Petroleum Reserve.
[8] Total primary supply is defined as total production plus net imports plus net stock withdrawals minus SPR additions.
[9] Includes naphtha and kerosene type.
[10] Includes aviation gasoline, kerosene, liquefied petroleum gas, petrochemical feedstocks, miscellaneous petroleum products, lubricants, waxes, unfractionated stream, plant condensate, natural gasoline, asphalt, road oil, still gas, special naphthas, and petroleum coke.
[11] Includes total industrial demand for petroleum.
[12] Represents the difference between total primary supply and total consumption.
[13] Net disposition is the sum of total consumption and discrepancy.
Note: Totals may not equal sum of components because of independent rounding.
Sources: Historical data are from the Energy Information Administration, *Annual Energy Review 1985*, DOE/EIA-0384(85) (Washington, DC, 1986), pp. 101-121, Tables 45, 46, 47, and 55. Historical quantities are through 1985. Projected values are outputs from the Intermediate Future Forecasting System.
Input data file: Historical = D1212861, Projected = LODEPD.D0203871. Table printed on February 20, 1987.

Table B5. Oil and Gas Industry Exploration, Development and Production Activity Levels

	Historical						Projected*	
	1956	1971	1981	1982	1985	1986	1990	1995
Active rotary rigs (Hughes)	2,620	976	3,970	3,105	1,98	0964	NA	NA
Number of oil and gas wells completed (000)	57	26	90	83	69	37	NA	NA
Oil and gas feet drilled (millions)	233	127	409	374	307	164	153-275	216-346
Employment oil and gas production and field services (thousands)	340	264	692	708	585	464	404-532	464-602
Exploration, development and production expenditures (billion 1985 dollars)	-	22.4	116.8	102.2	70.8	42.1	NA	NA

*Range from higher and lower oil price cases.

APPENDIX C: ECONOMIC ANALYSIS OF OIL MARKET PROJECTIONS AND SUPPLY DISRUPTION SCENARIOS

INTRODUCTION

An interagency technical group consisting of staff from the Council of Economic Advisers, Office of Management and Budget, Department of Treasury and Department of Commerce were assigned two tasks in the energy security review: to evaluate the macroeconomic effects of the alternative oil price paths developed by the Department of Energy for the period 1987 to1995; and to analyze the effects on the oil market and the domestic economy of temporary supply disruptions.

The working group was provided with two scenarios for the world economy through 1995, a lower oil price case and a higher oil price case. Each scenario included a range of different assumptions about oil prices, economic growth, geology, oil production, capacity increases, and other economic variables in order to encompass reasonable extremes for the two possible states of the world oil market and the degree of dependency by oil-importing nations. Because of multiple differences in assumptions, it is not possible to attribute the contrasts in the two scenarios to differences in one particular variable alone, e.g., oil prices.

MACROECONOMIC CONSEQUENCES OF ALTERNATIVE OIL PRICE SCENARIOS

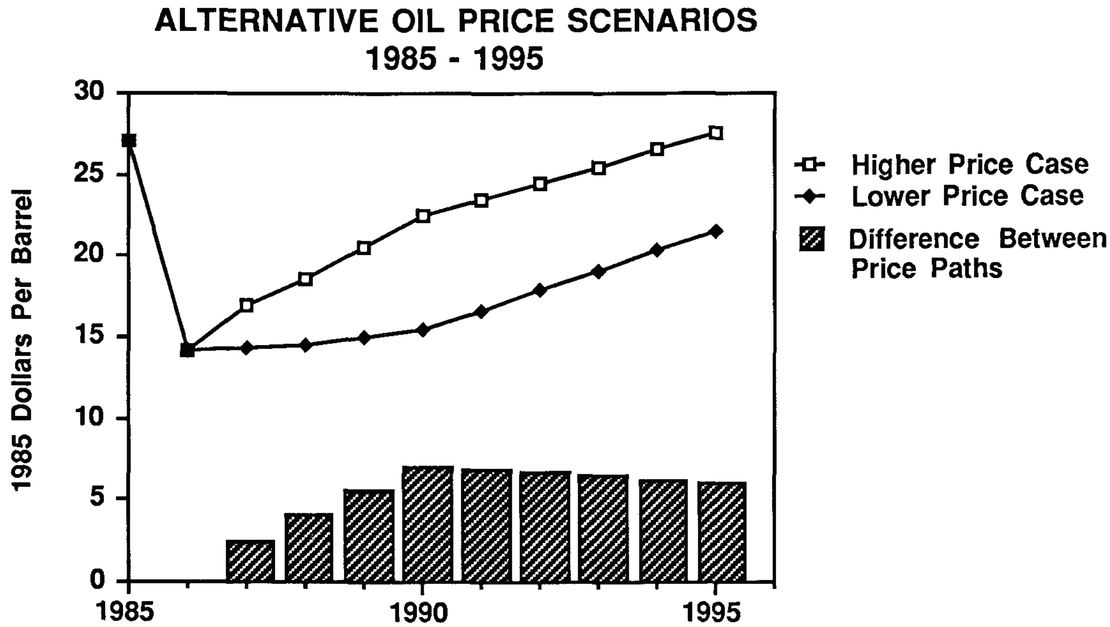
The working group was asked to evaluate the macroeconomic effects of two alternative oil price paths during the period 1987 through 1995. This analysis addresses the impact on the economy in terms of inflation, real GNP and its composition, and the terms of trade. The results were derived using a combination of econometric simulations and rules of thumb used by the forecasting group.

Characteristics of the Oil Price Scenarios

The two price paths differ in a number of respects, not only with respect to price. The lower price case envisions a world in which OPEC production policies result in lower oil prices. World oil demand responds strongly to the lower prices, eliminating most excess oil production capacity. In addition, problems develop with respect to supplies of alternate fuels so that their contribution to total energy supply is reduced in the 1990's. The higher price case assumes that OPEC succeeds in limiting production and maintaining higher prices, that excess capacity continues into the 1990's, and that other fuels continue to replace petroleum. In addition, the two cases differ with respect to economic growth. While all of these differences are important to some degree, the working group was asked to concentrate on the assessment of the economic impacts directly attributable to the alternative oil price paths.

The real price of oil, expressed in 1985 dollars, rises to $22 per barrel by 1995 in the lower price path, and to $28 per barrel in the higher price path. In the lower price case, the world oil price is little changed through 1990 at $15 per barrel, whereas, in the higher price case, prices begin rising immediately and reach $23 by 1990. The two price paths diverge rapidly in the early years, reaching a peak difference of over $7 per barrel by 1990. The price paths then converge slightly in the subsequent five years. As discussed below, the widening of the price differential in the early forecast years tends to exaggerate the real GNP and inflation effects of the higher oil price scenario relative to what they would have been if the differences between the two price paths diverged gradually to reach $6 per barrel by 1995.

One important assumption in both scenarios is that the volume of petroleum imports is expected to rise. Volume increases 25 percent from current levels in the higher price case and 100percent in the lower price case. The U.S. economy becomes more dependent on foreign oil in both scenarios. The oil price differential is not the only variable causing differences in the two scenarios. Many other factors are different as well. The $6 per barrel price differential is not, by itself, responsible for all of the oil market differences revealed under the higher price scenario.



Effects on Domestic Price Levels

The GNP deflator and the consumer price index employ different weighting schemes and definitions that result in substantially different impacts of higher oil prices on the two indexes. The GNP deflator is an index of prices for goods and services produced in the United States As such, it does not count the direct impact of higher prices of imported oil since that oil is produced in foreign countries. About two-thirds of the petroleum consumed in the U.S. today, however, is produced domestically. Higher prices for domestic oil will push up the GNP deflator.

The consumer price index measures prices for all goods and services purchased by households, regardless of where produced. Higher prices for imported oil directly affect the prices of gasoline and heating oil included in this index. Petroleum is also used to produce other non-energy goods and services. A higher petroleum price will not only raise consumer prices directly, but by raising business costs of production will indirectly affect prices of a wide range of consumer goods and services, providing the increase is accommodated by monetary policy.

The working group estimates that, by 1990, the overall consumer price index associated with the higher price assumption is roughly 2-1/2 percentage points higher than the lower price forecast, adding 1/2 percentage point to the inflation rate during that period (assuming no change in money supply growth). In comparison, the GNP deflator rises by 1-1/4 percentage points. After 1990, the combination of lagged effects and a narrowing oil price differential about offset each other so that the higher oil price path adds only 0.1 percentage point to the annual inflation rate.

Effects on Real GNP

An analysis of the effects of higher oil prices on real GNP needs to consider both supply and demand – the capacity to produce as well as the demand response. As will become clear, neither aggregate supply nor aggregate demand are likely to be changed in a major way because of the higher oil prices. The composition of GNP, however, is materially changed.

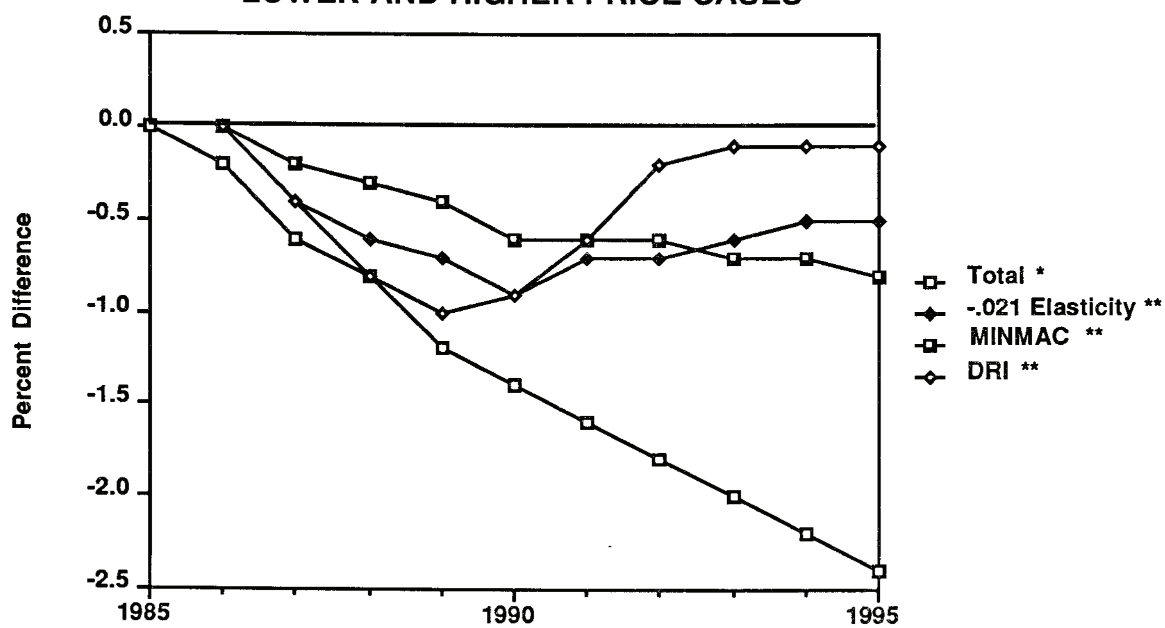
The capacity to produce – the supply side of the equation – is determined by growth in the labor force, changes in hours worked per week, and growth in productivity. The first two elements could be affected by higher oil prices, but it is not clear in which direction they would change. Higher prices tend to reduce real wages and make work less desirable; but they also reduce real income and could stimulate greater work effort in order to regain the lost income. The conflict of these two forces – in the context of a relatively small overall price change – is not likely to result in a measurable change in either direction.

Productivity growth is not likely to be perceptibly altered by higher oil prices. To the extent that energy and capital equipment are complementary inputs to production, higher energy prices should lead to a substitution of labor for both energy and capital. That would tend to dampen labor productivity, but the magnitude of this effect is very uncertain and is likely to be small.

For the two price scenarios under consideration, it seems best to consider the capacity to produce – the supply side – as essentially unaffected by the oil price differential.

The demand side of the economy is more heavily affected, at least in the early forecast period. Higher energy prices and a higher aggregate price level would reduce real incomes as well as aggregate demand until the economy adjusted to the higher prices. The level of real GNP, however, is most likely to be no more than one percentage point lower in 1990 in the higher price case than in the lower price case. This lower level of GNP is largely a consequence of the widening price differential over the 1987 to 1990 period.

GNP DIFFERENCES BETWEEN LOWER AND HIGHER PRICE CASES



* Total GNP difference due to all applicable factors.
** GNP differences due only to price paths.

As the differential between the two oil price paths narrows and then stabilizes, the economy adjusts to higher energy prices and the GNP losses are cut substantially. In 1995, the GNP loss is approximately one half percentage point. The economy does absorb a cumulative loss of real GNP of between $169 billion and $239 billion over the entire period through 1995 on an undiscounted basis. This represents an average yearly loss of 0.5 percent.

The working group used model simulation results from the Data Resources, Inc. (DRI) Annual Model of the U.S. economy and a DOE model (MINMAC) derived, in part, from an earlier version of the DRI model. In addition, the group compared the results of these simulations to the aggregate GNP/oil price elasticity (-0.021) used to evaluate short term oil supply disruptions (described below). The chart below shows the alternative results and compares them to the total GNP differential between the lower and higher price cases. On average, the model results indicate that about half of the assumed 1990 GNP differential can be attributed to the oil price differential, and less than one-third of the 1995 differential is attributable to oil prices. The working group concluded that variations in oil price assumptions of the magnitude considered ultimately will have only a small impact on the long-run level of aggregate production in the economy.

Effects on the Composition of Real GNP

Even though the total GNP effects are small, there are major differences in the composition of GNP between the two oil price paths.

- o Real personal consumption expenditures in the higher price case decline steadily relative to the lower price case. Oil consumption is unambiguously lower with higher prices, and spending on other goods and services is adversely affected by the loss of real income.

- o Much of the reduction in real personal consumption expenditures is absorbed by lower imports of various goods and services. Exports from the U.S. will be stimulated by the increased expenditures of oil exporters as they adjust to their higher real incomes in the regime with higher oil prices.

- o Real business fixed investment (including residential construction) is adversely affected in the short-run by higher oil prices. This occurs partly because of inflation-induced higher interest rates, especially in the early part of the forecast period. The long-term effects, however, are difficult to quantify. Higher oil prices may shift investments from energy-intensive sectors to those that are less intensive energy users. Some types of capital expenditures (oil rigs, energy-saving appliances) will be stimulated by higher oil prices, while other capital will be reduced as users shift to other types of capital and substitute labor intensive production.

Employment levels are closely tied to the level of real GNP. The real GNP losses translate into a one-quarter percentage point rise in the unemployment rate by 1990. Higher oil prices encourage a substitution of labor for capital, which acts to stimulate employment. By 1995, when the aggregate level of GNP is about the same in both scenarios, the unemployment rate should be back at the level attained in the lower oil price scenario.

Terms-of-Trade Effects

Real GNP measures the value of goods produced in the economy, not those consumed. Under conditions where the U.S. must pay a higher price for imported oil, this represents a transfer of wealth to foreign countries. Even if the aggregate output of the economy as measured by GNP remains unchanged, the U.S. must now exchange more goods per barrel of oil imports than before the increases in the world oil price. Thus, less of U.S. production is left for domestic consumption, and the real welfare of U.S. consumers has declined.

This terms-of-trade effect can be calculated approximately as the change in the oil import bill, holding imports at the level that would prevail either under the higher price or lower price scenario. Since these import levels differ substantially, the terms-of-trade loss is exaggerated when using the level in the lower price (high import level) case and understated in the higher price case. These cases present upper and lower bounds on the terms-of-trade loss. Averaging the two, we obtain a loss of $21 billion or 0.5 percent of GNP in both 1990 and 1995. Although imports are higher by 1995, the oil price differential between the two cases declines slightly. Consequently, the terms-of-trade loss is virtually unchanged.

The most likely long-run consequences of higher oil prices are that the Nation's imports and consumption of various goods and services would be lower, while its exports would be higher. In short, living standards will be somewhat lower, even though production (GNP) is not greatly affected. These wealth effects resulting from a deterioration in the terms of trade are not captured in the aggregate GNP measure, although they are reflected in shifts in the components of GNP.

ECONOMIC LOSSES FROM AN OIL SUPPLY DISRUPTION

The interagency working group also was asked to estimate the economic loss from potential oil supply disruptions occurring in the 1990's. The group examined both historical-size supply disruptions, involving net reductions in world oil supplies of about 2 million barrels per day, and major supply disruptions involving 10 million barrel per day net reductions in world oil supplies.

Historical-Size Supply Disruptions

In the event of a net reduction in world oil supplies of about 2 million barrels per day (after taking into account production increases from undisrupted areas) occurring in the 1990's, the Department of Energy estimated that drawdown of the U.S. Strategic Petroleum Reserve and some other countries' emergency stocks would be sufficient to offset the volumetric impact of the disruption over a six-month period. DOE therefore estimated that moderate supply disruptions would have little effect on world oil prices. Thus, the economic impacts of such supply disruptions were determined by the interagency working group to be negligible. This conclusion applies to moderate supply disruptions occurring under either the higher or lower oil price scenarios. In fact, countries' stockdraw capabilities would be large enough to offset temporary supply disruptions of up to 4 to 5 million barrels per day.

Although consuming countries' responses could prevent the occurrence of price increases caused by a fundamental supply/demand imbalance, it is possible that some short-term price increases would nevertheless take place, due to initial panic reactions and uncertainty about the extent of the disruption and of government responses to it. However, the market would be expected to adjust fairly quickly once the circumstances of the disruption became clearer and once consuming country governments began to implement their responses. These possible panic reactions and eventual market adjustments are difficult to model because they depend on such factors as the level of private stocks available at the time, the nature of the supply disruption and the speed and effectiveness of consumer country responses. The working group therefore did not attempt to estimate the economic impact of such short-lived price increases.

Major Supply Disruptions: Scenario and Background Assumptions

The "major disruption" scenarios examined here involve a six-month net reduction in free world oil supplies of about 10 million barrels per day. Levels of real oil prices (P_0), U.S. petroleum consumption (Q_0), imports (I_0), and GNP (GNP_0) prior to the disruption are shown in Table 1. Consumption and imports are measured in millions of barrels per day, and imports include refined products converted to a crude-equivalent basis.

Table 1

Initial Conditions before Supply Disruption

CASE	Oil Price (P_0) 1985 $ per Barrel	Consumption (Q_0) Million Bbls/day	Imports (I_0) Million Bbls/day	Economic Output (GNP_0) Billion 1985 $
1990				
Higher Price Case	22.51	15.84	5.64	4,515
Lower Price Case	15.49	16.66	7.32	4,577
1995				
Higher Price Case	27.51	16.49	7.71	5,106
Lower Price Case	21.59	17.65	10.13	5,228

Disruptions are expressed in terms of world price shocks. The price equivalents of the hypothesized supply disruptions have been computed by DOE, and are shown on a quarterly basis in Table 2. Although the supply disruption is only six months in duration, the price shock persists for a full year after the onset of the disruption, reflecting stickiness of the oil price in returning to its predisruption level.

Table 2

Oil Prices during Four Quarters
Following the Start of a Major Oil Supply Disruption

CASE	Quarter 1 (P_{11})	Quarter 2 (P_{12})	Quarter 3 (P_{13})	Quarter 4 (P_{14})
		(1985 dollars per barrel)		
1990				
Higher Price Case	39.00	39.00	33.00	29.00
Lower Price Case	58.00	59.00	42.00	32.00
1995				
Higher Price Case	45.00	45.00	39.00	35.00
Lower Price Case	71.00	72.00	53.00	41.00

Terms-of-Trade Effect of Major Supply Disruptions

The "terms-of-trade effect" and the "GNP effect" of the disruption must be calculated and reported separately. While both are important, they represent different kinds of economic losses. GNP is a measure of value added, calculated on the basis of the value of domestic production. As such, it does not measure the change in purchasing power or wealth that would be the result of a large increase in the world price of oil and the resulting increased expenditures for oil imports. Nevertheless, the transfer of wealth from oil consumers to oil producers would represent a real economic loss to the United States, since the United States is a net oil importer.

This terms-of-trade effect is relatively easy to compute. It is calculated as the component resulting from to the increase in the price paid for oil imports, plus the deadweight loss (measured by consumers' surplus) resulting from the price shock and subsequent reduction in oil consumption. In addition to the assumptions listed above, calculation of the terms-of-trade effect requires knowing the total U.S. price elasticity of demand for oil, as well as the domestic supply elasticity. Estimates of the demand elasticity in each quarter for each of the four cases are given in Table 3.

Table 3

U.S. Oil Demand Elasticities During the Four Quarters
Following the Start of a Major Oil Supply Disruption

CASE	Quarter 1 (e_1)	Quarter 2 (e_2)	Quarter 3 (e_3)	Quarter 4 (e_4)
<u>1990</u>				
Higher Price Case	-0.1065	-0.1125	-0.1395	-0.1440
Lower Price Case	-0.1000	-0.1060	-0.1420	-0.1465
<u>1995</u>				
Higher Price Case	-0.1270	-0.1330	-0.1725	-0.1765
Lower Price Case	-0.1300	-0.1360	-0.1820	-0.1860

These elasticities are arithmetic averages of the "high impact" and "low impact" elasticities for each case embedded in the DOE models. Since the disruption is a short-run phenomenon, the U.S. production elasticity is assumed to be zero. Stockdraw behavior (both private and SPR) is embodied in the price shock paths.

Since domestic production remains constant during the disruption, the entire reduction in consumption must come from a fall in imports. Thus, the change in imports can be calculated as the change in U.S. demand resulting from the price increase. Consumption in any quarter during the disruption is given by

$$(1)\quad Q_{1i} = Q_0(P_{1i}/P_0)^{e_i}$$

where Q_{1i} is consumption during quarter i, Q_0 is consumption before the disruption, P_{1i} is the oil price during quarter i of the disruption, P_0 is the predisruption oil price, and e_i is the elasticity of U.S. oil demand during quarter i.

Since there is no change in domestic production,

(2) $Q_{1i} - I_{1i} = Q_0 - I_0$,

where Q_{1i} and Q_0 are defined as before, and I_{1i} and I_0 are imports during and prior to the disruption, respectively. Thus, imports in quarter i of the disruption are given by

(3) $I_{1i} = I_0 - (Q_0 - Q_{1i})$.

The portion of the terms-of-trade loss due to the higher price of imports in quarter i, D_i, is

(4) $D_i = P_{1i} I_{1i} - P_0 I_{1i}$.

The total of this component of the loss is obtained by converting the daily rates into quarterly rates and summing over the four quarters affected by the disruption.

The next step is to calculate the loss of consumer surplus. This will be equal to the "triangle" under the total U.S. demand curve. Using the same specification of demand, the lost consumer surplus in quarter i, T_i, can be shown to be

(5) $T_i = [e_i/(1+e_i)]P_0Q_0 - [e_i/(1+e_i)]P_{1i} Q_{1i} - (Q_0 - Q_{1i})P_0$.

These losses are converted from daily to quarterly rates and summed to obtain an annual total. Note that there is no change in producers' surplus since the short-run domestic supply elasticity is assumed to be 0. The transfer from domestic consumers to domestic producers has no net wealth effect on the domestic economy.

Terms of trade effects for the four cases, in dollars and as a percent of GNP, are shown in Table 4. These losses are in every case less than a year's normal growth in GNP. Losses associated with less severe disruptions would, of course, be correspondingly smaller.

Table 4

Terms-of-Trade Losses, Major Oil Supply Disruption

CASE	Billions of 1985 $	% of GNP
1990		
Higher Price Case	-23.6	-0.5
Lower Price Case	-71.2	-1.6
1995		
Higher Price Case	-35.4	-0.7
Lower Price Case	-118.3	-2.3

GNP Effect of Major Supply Disruptions

The GNP effects of an oil supply disruption are different from the terms-of-trade effects. GNP effects occur because the unexpected change in relative prices creates the need for adjustments in factor allocations. These adjustments can take time and may be inhibited by structural or institutional rigidities. The result can be temporary unemployment of resources (including labor), with actual GNP falling short of potential GNP.

There are no empirically operational models that capture these rigidities and adjustment lags at the micro level. Lacking such models, the only guide to the estimation of GNP effects is historical experience. Historical experience, however, is an uncertain guide because (1) macroeconomic effects depend critically on the policy regime, which has not been stable over time and is difficult to predict, (2) many factors influence macroeconomic performance, so that the data do not contain enough information to permit precise identification of particular effects with specific causes, and (3) it is problematic to forecast outside the range of historical experience.

It is beyond the resources of the working group to develop a new model of the macroeconomic effects of oil price shocks. As a result, the group had to rely on existing models to develop its estimates. Most existing models are based on parameters estimated from a sample period that includes the 1970's, and therefore the oil price shock effects calculated from these models will include the effects of the policies that were followed during the disruptions of that decade. Since these policies of price and allocation controls exacerbated the adverse effects of the price shocks, macroeconomic effects calculated using the parameters of the existing models may be exaggerated. Furthermore, elasticity estimates based on price control era data will be too large (in absolute terms) because of the systematic data distortions associated with price controls. Lastly, the severe tight-monetary policy adopted in 1974 accentuated the decline in economic activity associated with the oil supply disruption. One somewhat countervailing advantage of using existing models is that the degree of U.S. dependence on imported oil during the 1970's was similar to that expected during the 1990's under the lower price scenario.

After considerable discussion, the group decided to estimate GNP effects by using the elasticity of GNP with respect to a permanent oil price change reported by Michael Darby in his 1982 AER paper*. The value of this elasticity is -0.021, so that GNP in the first year after an increase in oil prices would be given by

$$(6)\quad GNP_1 = GNP_0(P_1/P_0)^{-0.021}.$$

Darby's model includes some statistically significant short-run effects, but it is likely that these were "due to short-run movements which might be related to various panic policy responses, briefly adopted here and abroad, to the temporary OPEC embargo at the end of 1973." Thus, Darby's long-run elasticity was selected to separate, insofar as possible, the policy effects from the oil shock itself.

This elasticity of -0.021 is consistent with a recent survey of macroeconomic models conducted by the Stanford Energy Modeling Forum. The EMF in 1984 simulated the impact of a 50% oil price increase in 14 macroeconomic models. Most of these models allow separation of the effect of an oil shock into terms-of-trade losses and GNP losses. The GNP losses can be divided further into "cyclical" and "potential" GNP losses. There would be no significant loss in potential GNP from a temporary oil shock, and the simulations show that the median, cyclical loss is 68.4% of the median GNP loss. The first year's median GNP loss is 1.42% of GNP, so the cyclical component relevant to estimating the loss from a temporary oil shock is 0.97%. Since the simulated price increase was 50%, this translates into a first-year GNP elasticity of -0.024.

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* Darby, Michael R., "The Price of Oil and World Inflation and Recession," The American Economic Review, September 1982, pp.739-751.

Use of an elasticity, such as that reported by Darby, estimated for a permanent price shock is likely to overstate the effect of a temporary shock. A transitory increase in oil prices would only have a small effect on an individual's permanent income, lessening the effect of the shock on consumption. A disruption known to be of limited duration would lead to some rearrangement of activity over time, with a fairly rapid recoupment of earlier production losses when the disruption ended.

Estimates of GNP losses, in dollars and as a percent of GNP, are presented in Table 5. As before, the four quarterly impacts were summed to obtain the annual total.

Table 5

GNP Losses, Major Oil Supply Disruption

CASE	Billions of 1985 $	% of GNP
1990		
Higher Price Case	-40.9	-0.9
Lower Price Case	-104.0	-2.3
1995		
Higher Price Case	-42.0	-0.8
Lower Price Case	-106.8	-2.0

These estimates of the GNP loss associated with an oil price increase are much more uncertain than the terms-of-trade loss. In addition to the conceptual and data difficulties discussed previously, there are statistical uncertainties that affect the estimates. The standard error of one of the parameters Darby used to calculate the long-run elasticity is larger than the parameter estimate itself. If the EMF survey results are used, only five of the 13 U.S. models allow separate calculation of permanent and cyclical GNP effects. Of the five, two are small, reduced-form monetarist-type models in which changes in potential GNP dominate cyclical effects. These two cases were excluded by the EMF in calculating the median cyclical effect; if they had been included, the cyclical effect, and hence the implicit GNP elasticity, would have been smaller.

Finally, there have been important structural changes in the U.S. energy economy over the last several years that may not be fully reflected in these models, but which may mitigate the impact of supply disruptions. Lower overall oil intensity and increased fuel switching capability are probably the most important of these fundamental changes which may reduce the GNP impacts of rapid price increases.

Additional Points and Caveats

- It should be reiterated that this analysis calculates effects of price shocks that extend beyond our range of experience. Parameters may not extrapolate reliably for very different conditions. In particular, larger demand elasticities would reduce the change in the oil import bill resulting from the increase in oil prices, lessening the associated terms-of-trade loss. The GNP elasticity might be different for real oil price changes that are much larger than those observed historically. We do not have any direct estimates of the short-run elasticity of substitution between oil and other inputs at real oil prices in the $70/bbl range.

- The results are predicated on the absence of a panic reaction by the government, such as imposition of price and allocation controls. The experience of the 1970's suggests that such ill-conceived actions magnify the losses to the economy from a supply disruption. The estimates presented here also are based on a timely drawdown of the Strategic Petroleum Reserve in reaction to the disruption.

- Estimates of disruption impacts on the United States alone do not capture all the national security implications of such supply interruptions. The consequences of a disruption on the economies of Japan or EEC countries might be more severe.

- Although potential disruptions have greater impacts in the lower price case than in the higher price case, it does not follow that the higher price case is preferable on economic grounds. In fact, the opposite is true. GNP is higher in each year in the lower price scenario, because that case represents a future in which oil is more abundant worldwide than in the higher price scenario. The cumulative difference in GNP over the period 1986-1995 between the two cases is $667 billion in 1985 dollars, assuming no disruptions through 1995. If a disruption occurs in 1995, the lower price case would still be favorable, by $519 billion, to the higher price case: $667 - ($118.3 + $106. 8 - $35.4 - $42.0) = $519.3 billion, treating the total loss from the disruption as the sum of the terms-of-trade loss and the GNP loss. Even if the economy on the lower price path experienced major oil supply disruptions in both 1990 and 1995, cumulative real income would be greater than if the economy were on the higher oil price path with no disruptions through 1995: $667 - ($71.2 + $118.3 + $104.0 + $106.8) = $266.7 billion. These calculations are given for illustrative purposes only.

- Finally, it must be emphasized that the higher price and lower price scenarios are based on a variety of different assumptions regarding geology, oil production capacity, and economic growth. Although prices differ in the two cases, comparative analysis of a particular policy instrument such as an oil import fee can be conducted properly only under a single consistent set of scenario assumptions. DOE has estimated that the costs of a self-inflicted oil price shock (such as an import fee) are substantially greater than its benefits, even if a disruption eventually occurs in the lower price scenario.

INTRODUCTION

Imposing an import fee on foreign crude oil and refined petroleum products that enter the United States would raise the prices paid for all oil in this country, and this would permit domestic crude producers to operate more profitably. However, requiring everybody in this country to pay higher oil prices would raise costs for all energy and almost everything else throughout the nation's economy; and this would reduce the rates of growths in Gross National Product.

An import fee would increase U.S. oil production (by as much as 500,000 barrels per day for a fee of $10 per barrel); it would reduce the nation's oil imports; and it would stimulate employment in oil-producing regions. However, being forced to pay higher oil prices here would also inflate costs throughout the U.S. economy and—again, using the example of a $10 fee—this would reduce GNP between 1988 and 1995 by approximately $200 billion.

By stemming worldwide oil demand, an oil fee would make oil cost less in global markets—at the same time it was raising the prices U.S. energy buyers had to pay for it. Thus, higher oil prices in this country because of the fee would doubly handicap U.S. businesses in both foreign and domestic markets. Lower world oil prices would also reduce the incomes of oil-exporting allies and trading partners of the United States.

In short, an oil import fee would provide some clear energy security and sectoral or regional benefits, but at substantial economic cost. Between 1988 and 1995, a $10 per barrel fee would provide energy security benefits valued at $46 billion; but there would be a simultaneous reduction in GNP growth rates that would cost the nation more than four times that amount. By slowing down the economy through higher prices and inefficient allocation of resources, an oil import fee of $10 per barrel would eliminate more than three times as many jobs as it created.

A lower import fee and a variable fee produced similar results in the analyses, although the net losses would not be as great as in the case of a $10 levy.

METHODOLOGY

This cost-and-benefit analysis focused on the period from 1988 through 1995. Statistical models were based on the Energy Information Administration's Intermediate Future Forecasting System and other economic models noted in the EIA technical annex that follows this discussion.

The statistical models were used to evaluate the effects on oil markets and on the economy at large from assessing various fees on U.S. imports of oil. Fixed fees of $5 and $10 per barrel and a variable fee pegged to a market price of $22 per barrel were examined. Complete scenarios of the worldwide and U.S. oil markets were developed in accordance with a range of possible oil-price projections—with and without the fees—to estimate quantitatively how such fees would affect world oil prices, as well as the consumption, production, and importation of oil by this country. Disruptions in oil supply were also simulated, in order to measure the energy security and other economic effects of oil import fees under such circumstances. Finally, a macroeconomic analysis was performed to measure the overall effects of the fees on U.S. economic output, on inflation in this country, and on nationwide employment.

As might be expected, the analysis turned up a number of distinct—and generally measurable—benefits and costs:

Benefits:

- o Increased domestic oil production, exploration, and reserve additions.
- o Reduced U.S. oil imports.
- o Reduced payments for oil imports, and lower world oil prices.
- o Reduced economic penalties from a future disruption in oil supply.
- o Increased oil industry employment.
- o Import fee receipts.

In addition to these quantifiable economic benefits, an oil import fee could have less quantifiable advantages. Increased domestic oil production and reduced imports, particularly from the Persian Gulf region, would enhance U.S. Foreign policy flexibility. Increased domestic oil activity would slow erosion of U.S. oil field technology and competitiveness. It could also slow the deterioration in education and recruitment for petroleum engineering, geology and geoscience, which are crucial to the future of the U.S. oil industry.

Costs:

- o Increased energy costs for U.S. consumers, and an increase in the U.S. price level
- o Reduced U.S. economic activity.
- o Reduced efficiency in investment.
- o Lower local employment nationwide.
- o Lower general revenues and higher federal outlays.

In addition to these, there are some disadvantages and costs associated with import fees that cannot easily be quantified. For example, use of a fee would encourage faster depletion of U.S. oil reserves that would "drain America first." It would cause financial damage to friendly oil-exporting nations. It would reduce the relative competitiveness of U.S. industry. It would also invite possible retaliation by U.S. trade partners. Finally, it would probably produce demands from various quarters for fee exemptions that could bring a renewal of government regulation of oil markets domestically and generate tensions internationally.

The next two sections treat the economic benefit-and-cost factors, one-by-one.

ECONOMIC BENEFITS OF OIL IMPORT FEES

Increased Domestic Oil Production

Although oil import fees could be offset partially by the reductions in world oil prices domestic oil prices would rise after fee enactment. Higher oil prices in the U.S. would stimulate higher domestic oil production. By 1990, a $5 per barrel fee would increase U.S. oil production by 240,000 B/D and a $10 fee would increase U.S. production by about 500,000 B/D. To the extent that this added production came from newly discovered reserves, U.S. energy security would be enhanced. If increased production came from existing reserves and simply accelerated the production of already proven domestic reserves, however, no lasting energy security gains would be made.

Part of the increase in domestic production would undoubtedly come from increased workover of existing wells and delayed abandonment of marginal wells, while there would also be added investment in new wells of all types (including both in-fill and extension drilling) and renewed interest in enhanced oil recovery. Expenditures in search of new oil reserves would also be justified by the higher level of domestic prices following an oil import fee.

Reduced U.S. Oil Imports

The higher prices on all petroleum products resulting from an import fee would reduce U.S. demand for oil. With higher oil prices, some oil users could not afford to consume as much oil as before while others would simply choose to use less oil because of its higher price. In addition, over the long run, some oil users would make capital investments to reduce their demand for oil. Higher prices would encourage substitution away from oil consumption.

The anticipated price effect of a $10 oil import fee would reduce U.S. oil consumption, from the first year onward, by about 1 million B/D. By 1995, the combined effects of higher production and lower consumption of oil could reduce U.S. demand for imported oil by nearly 1.5 million B/D.

Reduced Payments for Imports

The United States would pay out less for oil imports following enactment of an import fee—for several reasons. First, increased U.S. oil production would mean that smaller volumes of imports could meet a given demand level. Second, the higher oil prices in the U.S. would restrict domestic oil consumption—so total demand would be lower. The decrease in GNP would also tend to lower all energy demand to some extent. Finally, the expected reduction in world oil prices following imposition of a U.S. oil import fee would reduce the cost-per-barrel paid to exporters of the reduced quantity of oil imports demanded in this country after a fee was imposed. An import fee of $10 per barrel would reduce U.S. payments for oil imports by small amounts immediately upon enactment, and by $10-12 billion per year beginning four years after enactment.

Reduced Economic Penalties from a Future Oil Disruption

The energy security benefit of an import fee is measured by the reduction in the potential economic cost of an oil supply disruption. This benefit has three parts. First, by increasing domestic oil production and reducing consumption, an import fee would cause the U.S. to enter a period of disruption from a lower base of imports. As a result, requirements for imports during the disruption would be lower than otherwise would have been the case. Aside from the fact that world prices—with or without a disruption—would be reduced somewhat by a U.S. import fee, the total cost of oil imports during a disruption would be lower—simply because their volume would be less. The size of the energy security benefit is in direct proportion to how large and how likely a disruption is believed to be. Under any reasonable assumptions, this benefit is very small.

With reduced oil dependency, prices would peak at a lower level during a disruption. Since economic losses come from price increases, enacting an import fee tends to reduce the potential economic losses if a disruption should occur. This takes effect in two ways: lower world prices would reduce the amount paid for whatever level of imports continued during the disruption, and lower prices would reduce the degree of macroeconomic shock and loss of GNP a disruption caused. However, if a U.S. import fee lowered world oil prices in the years prior to a disruption, oil imports in the rest of the world might rise as U.S. imports fell. Thus, higher oil imports outside the U.S. due to lower production and higher consumption would have partially offset the salutary effects lower U.S. imports could have had in mitigating the supply disruption's adverse effects. If world reliance on oil from unstable regions continued to grow, a U.S. oil import fee could leave the potential for price shocks in a disruption little changed, despite lower U.S. imports.

Increased Oil Industry Employment

The higher domestic prices that followed enactment of an oil import fee would stimulate oil industry employment. Higher oil prices would spur the demand for geologists, seismic crews, drillers, tool pushers and oil service crews for logging and workovers—increasing employment generally in the oil industry. In addition, demand for pipe and other equipment would increase employment by tool and pipe manufacturers and in related sales companies.

A $10 oil import fee could raise oil field employment by about 100,000 jobs, and employment in equipment manufacturing by an additional 20,000 jobs. (Although the import fee would increase employment in the oil industry, this gain is not the only employment effect, as explained above and below.)

Import Fee Receipts

An import fee would produce expanded government receipts from fee collections at relatively little additional administrative cost. A fee of $5 per barrel would produce receipts of $10 - $17 billion per year, and a fee of $10 per barrel would bring $17 - $32 billion per year at the estimated import volumes occurring through 1995 (assuming no exemptions).

However, the economic impact of an oil import fee would reduce federal tax receipts from other sources significantly—notably from income and payroll taxes. In addition, federal expenditures could rise because of the effects of higher energy prices on federal purchases and transfer programs (such as Social Security) that are indexed to inflation. Enactment of an oil import fee would not reduce the federal deficit, and it might actually increase it. This is just one of a number of economic costs that should be examined in considering this policy option.

ECONOMIC COSTS OF OIL IMPORT FEES

Increased Energy Costs for U.S. Consumers and a Permanent Inflationary Increase in the U.S. Price Level

An import fee translates directly into higher prices for petroleum. As energy markets respond to higher oil prices, prices for other fuels will increase. The prices of natural gas and other fuels increase if an oil import fee is enacted. A fee of $5 per barrel would raise the prices of gasoline, heating oil, and other petroleum products by 8 to 10 cents per gallon. The consumer price index would rise by between 1 and 2 percent. An import fee of $10 per barrel would raise product prices by 16 cents per gallon and would raise the CPI by 2 to 3 percent.

For each $1 per barrel of fee imposed, oil consumers would pay more than $4 billion per year extra for their purchases of energy. As already indicated, the cost of gasoline, diesel fuel, jet fuel and heating oil would all rise by nearly the full increase in crude oil prices. The price of natural gas would also rise somewhat, as consumers sought to substitute natural gas for oil that had become more expensive after imposition of the import fee.

The higher energy prices paid by U.S. consumers would constitute income to the industry. Some of these funds would be spent for new investment to find additional oil, some would go to workers for wages, some to land owners as higher royalties, and some to oil companies as increased profits. A $10 import fee would transfer $30 billion annually from consumers to oil producers, and an additional $10 billion annually would go to the federal government.

A fixed import fee would increase oil prices from any given level, regardless of the financial needs of the domestic oil industry. A variable fee has the possible advantage of raising oil prices only when the price is lower than the legislated price that serves as a price floor.

Reduced U.S. Economic Activity

Higher oil prices in the U.S. reduce GNP by:

- reducing real consumer incomes and domestic consumption spending,
- reducing the international competitiveness of goods produced in the U.S. with high-cost energy,
- reducing investment in the U.S. economy.

An import fee would reduce the standard of living of U.S. consumers by raising energy prices and by using resources to produce oil at costs higher than the prevailing prices on the world market. As a result, fewer U.S. resources would be available to produce other goods for domestic consumption or for export in exchange for still other goods.

Annual GNP losses following enactment of an oil import fee would range from $15 to $25 billion for a $5 per barrel fee and from $30 to 45 billion for a $10 fee. The reasons for these losses include the reduction in resources available for use in industries other than oil, the higher cost of oil to businesses and households, and the reduced competitiveness of the U.S. economy at home and in export markets where American goods would compete with products manufactured and shipped with energy purchased at prices that did not include import fees. Even if a U.S. import fee caused world oil prices to fall, U.S. energy buyers would still pay more than buyers elsewhere, effectively by the full amount of any fee imposed.

Reduced Efficiency in Investment

An import fee would reduce GNP because it diverts real resources from more profitable uses into oil production and induces consumers to incur added costs to reduce their use of energy. Labor and capital would be used to produce oil at prices equal to the new domestic oil price, even though oil could be purchased more cheaply from foreign sources. Expenditures on conservation would also be made as if the saving from reduced oil use were the domestic price, rather than the actual free-market cost of oil in world markets.

Lower Total Employment Nationwide

Higher domestic oil prices following an oil import fee would boost employment in the oil industry, but overall employment would decline.

Employment in the oil industry and related sectors could increase by 120,000 jobs. However, reduced GNP due to higher oil prices and less efficient investment could reduce nationwide employment by 400,000 jobs. On balance, an oil import fee and the resulting increases in energy prices would reduce U.S. employment.

Impact on the Federal Deficit

An oil import fee would raise substantial direct revenues based on anticipated import volumes through 1995. However, the impact of an oil import fee on the economy (through higher energy costs) reduces other federal revenues. Based on EIA analysis and DRI economic models of the U.S. economy, an oil import fee of $10 per barrel would raise direct federal revenues of $155 billion and reduce the deficit by $69 billion for the period 1988 to 1995. An import fee does not reduce the deficit by the full amount of fees collected, however, because—as mentioned earlier—the resulting energy price increases reduce other tax collections and increase federal expenditures indexed to prices.

The Problem of Requests for Fee Exemptions to Protect Some Oil Exporters, Consumers and Others from Import Fee Consequences

Imposition of an import fee would tend to lower world oil prices and reduce the incomes of friendly oil exporting nations.

Other nations are likely to argue that a U.S. oil import fee would violate the General Agreement on Tariffs and Trade (GATT). A defense to this argument might note the national security exception provisions of the GATT. Nevertheless, the imposition of new fees by the U.S. could lead to retaliatory fees on U.S. goods. More importantly, Canada, Venezuela and Mexico would be likely to demand exemptions. The U.K. and Norway, strong U.S. allies and partners in the International Energy Agency, would almost surely also demand exemptions from the fee. If fee exemptions were granted, this would encourage "exempt" suppliers to concentrate on sales to the U.S. market—unless complicated country-of-origin quotas were established. Depending on the supply capacity of exempt foreign suppliers, exemptions could sharply reduce or even eliminate both import fee income and price benefits to the domestic oil industry.

Consumers may also urge fee exemptions for certain products, such as heating fuel, to limit the impact of price increases. Small refiners might demand higher tariffs on product imports to protect them against competition from foreign refiners. U.S. manufacturers whose exported products incorporate energy, either imported or domestic, might also demand fee rebates to permit them to compete successfully in foreign markets against foreign producers who do not pay U.S. energy costs. Once begun, there is no clear end to exemptions for an import fee.

Any exemptions or special provisions could raise administrative costs and revive the bureaucratic apparatus of the 1970's. The cost of government administration of price controls and entitlements in the 1970's is well documented, as are their costly, unintended consequences.

COMPARISON OF BENEFITS AND COSTS FROM AN OIL IMPORT FEE

Evaluation of an import fee should consider all the economic costs and consequences of raising U.S. energy prices; it is not sufficient to look only at the benefits to one region or economic sector in isolation. Under the assumptions of the Lower Oil Price Case used in this study, an oil import fee of $10 per barrel could reduce world oil prices by about $3 per barrel under normal market conditions, and about $6 per barrel below prices that would otherwise occur in disrupted markets. The $10 fee would also raise prices in the U.S. market by about $7 per barrel. U.S. oil import costs would decline by about $40 billion (1987 present value) through 1995 as a result of lower world oil prices and reduced U.S. import demand. Of course, these benefits would be realized only if world oil prices were actually allowed to decline following enactment of an import fee.

Energy security benefits consist of lower oil import costs, plus reduced economic losses from any disruption that might occur as a result of lower U.S. energy consumption levels. The "energy security benefit" of a $10 oil import fee is less than $6 billion in potential reductions of import payments and $2 billion in reduced GNP losses, even if a very large disruption is assumed to occur sometime during the next 8 years. Under a variety of alternate assumptions, total import fee benefits range from $50 to $70 billion, compared to a range of estimated costs from $190 to $250 billion over 8 years. Thus, the net loss to the economy from enacting an oil import fee is between $150 and $200 billion over the 8 years ending in 1995.

The present value costs of a $10-per-barrel import fee through 1995 from reduced economic performance are estimated at $189 billion. The major impact of the fee is a reduction in energy use—reducing real GNP and raising prices generally. Reducing energy use throughout this economy and keeping oil prices in the U.S. higher than in other trading nations would reduce the efficiency of the U.S. economy. These efficiency losses would be felt through the entire economy, and they would greatly exceed the benefits concentrated in the oil industry.

Costs of Import Fees Substantially Exceed Benefits

- Macroeconomic losses from import fees over the long run far exceed energy security gains, given the likelihood of oil supply disruptions.
- Nationwide job losses considerably outnumber the employment gains in the oil industry. Higher oil prices increase activity in the oil industry, but they hurt the rest of the economy.
- Expenditures for oil imports would decline, but foreign purchases of U.S. goods might also fall. Foreign goods could gain larger market shares in domestic markets.
- Investment would be shifted to oil projects, even though capital productivity is higher in other sectors of the economy, and oil can be purchased more cheaply than it can be produced domestically.

Discussion of Variable Fees/Price Floors

The amount of a variable import fee actually levied would depend upon the level of world oil prices, so that it would decrease as a target level was approached and would be waived entirely if prices exceeded that level. A variable fee could avoid some of the economic costs of a fixed fee, but it is administratively more complicated, and the use of one could bring some unintended consequences. Because domestic oil prices would be raised only when the world price was below the stipulated price of oil for domestic markets, the oil industry would not receive price benefits under all conditions. However, setting a price target via the variable fee involves the government deeply in economic decisions that are better left to the marketplace. A variable fee also creates an incentive for foreign oil producers to raise oil prices to the target level, since they could do so without suffering any loss of demand from their U.S. markets. Once prices rose to the target level, there would be little incentive for producers to reduce prices. A variable fee would ratify higher prices up to the target, and it could contribute to a higher level of future world oil prices.

If a variable fee were set at a price below the current level, it would act as a price floor to protect domestic producers from the risk of very low market prices. Even if such very low prices ($10-12 per barrel) were never reached, such an emergency price floor could encourage higher levels of investment in the domestic oil industry—by giving lenders and investors greater protection from the risk of low oil prices. However, in the event such low prices were reached and the price protection became relevant, U.S. oil consumers would be denied some of the benefits they could normally expect from lower oil prices. In this case, the U.S. economy would suffer the same disadvantages that arise under any policy that raises U.S. energy prices above those paid in other nations with whom this country competes in international markets (including the U.S. domestic markets).

A variable fee could be administered as a fixed fee with frequent (monthly) recalculations of the amount in view of prevailing prices. A monthly fee calculation would simplify fee administration, but it might also impose serious costs on the economy. If importers delayed or accelerated their shipments in response to anticipated fee changes, U.S. oil buyers would pay significant additional costs.

TABLE 1: IMPACTS OF OIL IMPORT FEES

	1986	1990			1995		
	Actual	Base	$5 Fee	$10 Fee	Base	$5 Fee	$10 Fee
<u>Oil Market Impacts</u>							
World Oil Price (Dollars)	14.23	15.49	14.05	13.03	21.51	19.58	17.83
U.S. Oil Price (Dollars)	14.23	15.49	19.05	23.03	21.51	24.58	27.83
U.S. Oil Consumption (MMBD)	16.1	16.7	16.1	15.6	17.7	17.1	16.6
U.S. Oil Production (MMBD)	10.9	9.2	9.5	9.7	7.6	7.8	8.0
U.S. Oil Imports (MMBD)	5.2	7.5	6.7	6.0	10.2	9.4	8.6
Oil Import Bill ($ Billion)	27.2	46.9	38.2	28.5	80.0	67.0	56.4
<u>Economic Impacts</u>							
Employment Change (1000)	--	--	-230	-430	--	-170	-320
GNP Level (Billion 1982 $)	3688	4105	4092	4077	4688	4670	4650
Change in CPI (% points)	--	--	+1.8	+3.6	--	+1.3	+2.7

Background

Five scenarios are analyzed to examine the impact of an oil import fee on the economy. A $5 fee, a $10 fee, and a $22 floor are analyzed on the assumption that the U.S. will face a lower oil price on imported crude oil. A $5 fee, and a $10 fee are also analyzed on the assumption that the U.S. will face a higher price on imported crude oil.

In addition to these five scenarios, nine sensitivity analyses are also performed on the lower price $10 fee case to evaluate the change in costs and benefits in response to changes in exogenous variables such as OPEC retaliation to the U.S. import fee, different demand and supply elasticities, and alternate disruption probability distributions.

The major conclusion of this analysis is that an import fee will create an economic loss which is greater than the benefits from the fee. When a 10 percent discount rate is used to calculate the present value of the costs and benefits to 1987, the macroeconomic loss (loss in GNP) is consistently greater than the sum of all other benefits that could be obtained from an import fee. During a supply disruption, the magnitude of security benefit could be significant only in cases where OPEC retaliates to the import fee in the U.S. by reducing production and raising prices (to maintain their revenue stream) thus reducing the quantity of oil at risk of disruption. As a result, the crude oil price during a supply disruption would be lower and the effect on the overall economy is smaller. Even under such a scenario, the loss in GNP would outweigh the benefits of an import fee.

The quantitative cost and benefit results are as follows:

Welfare Loss

On the microeconomic level, an import fee affects both production efficiency and consumer welfare. Additional crude oil will be produced at higher cost. The cost of domestic oil exceeds the price of imported oil in the absence of a fee. This difference in the cost of imported oil and cost of production reflects an inefficiency that occurs as a result of the imposition of an import fee. A fee also causes oil consumption to be foregone, at a cost in consumer welfare compared to what could be achieved absent a fee. In this report, welfare loss includes the sum of the loss in production efficiency and consumer welfare.

Table ES-1 shows the welfare loss from 1988 through 1995 discounted at a 10 percent rate to the present value in 1987. The welfare loss for the lower price $10 fee case (11.29 billion 1985 dollars) is the largest; the welfare loss for the higher price $5 case (2.43 billion 1985 dollars) is the smallest. The magnitude and the pattern of the welfare loss for various fee cases reveal a clear relationship between the level of oil import fee and the welfare loss: a higher import fee creates a higher welfare loss.

In both the $5 and $10 fee cases, the welfare loss in the lower price scenarios is greater than in the corresponding higher price scenarios. This result reflects implicitly that the decrease in demand and increase in production in response to a higher oil price are stronger in the lower price scenarios.

Table ES-1. Present Value of Welfare Loss in 1987
(10% Discount Rate, Billion 1985 Dollars)

	Fee cases	Welfare Loss
	Lower Price	Higher Price
$5 fee	2.91	2.43
$10 fee	11.29	10.04
$22 floor	6.62	

Macroeconomic loss

The immediate effect of an import fee is to raise the price of crude oil. Costs of production in the manufacturing industry will rise and the demand for energy and other manufactured goods will decline. Productive resources will be transferred from the non-energy industries to the energy industry, and in the transition, some resources will lose value and become either unemployed or underemployed. Both the real disposable income and economic activity will decline as a result of an import fee. The oil shock in the 1970s provides an example of the impact of a sudden increase in the price of crude oil on the economy–a booming energy industry but a sluggish economy.

In general, a sudden rise in the price of crude oil will affect employment and economic activity. Not all of these effects can be measured in terms of economic values. In this study, the measure of the impact of an import fee on the economy is based upon gross national product (GNP).

Table ES-2 shows the value of macroeconomic loss in terms of the 1987 present value, expresed in constant 1985 dollars. The lower price $10 fee case shows a macroeconomic loss of 188.79 billion dollars, which is the largest among all cases. The higher price $5 fee case has the smallest macroeconomic loss. The lower price case shows a higher macroeconomic loss than the higher price case, and the $10 fee shows a larger macroeconomic loss than the $5 fee case.

Two important factors affect the results on the macroeconomic loss: the effect of prevailing oil prices on the oil consumption and economic activity and the effect of import fees on the world oil price. For a given level of price increase in crude oil, the higher the oil consumption in the base case, the greater the impact that an increase in oil price will have on the GNP. For a given level of import fee, the larger the impact on the world oil price, the smaller the increase in the price on domestic crude oil would be, and consequently, the smaller the effect on GNP.

The level of GNP is higher in the lower price base case because the world oil prices are lower. In the higher price base case, the level of GNP is lower because higher world oil prices restrain economic activity. As a result, the same level of price increase in the price of oil would have greater absolute impact on the lower price case than the higher price case.

The ability of an import fee to reduce the world oil price also plays an important role in determining the loss in GNP. In the lower price case, the effect of an import fee on the world oil price is smaller in the earlier years compared with the higher price case, but the effect of an import fee on the world oil price becomes larger in the latter years. This pattern of price changes in the world oil market indicates that in the long run oil import fees have a greater effect in the lower price case than in the higher price case. In the short run, however, the change in the world oil price is smaller in the lower price case. This is mainly due to the fact that in the earlier years the change in consumption and production in the lower price case is relatively small compared with the world demand and production capacity, but this relative change increases over time and thus exerts greater pressure on the world oil price in the 1990s. As a result of the difference in the world oil price profile between the lower price and higher price case, the present value of the macroeconomic loss becomes greater because the effect of an import fee on the reduction of world oil price is smaller in the lower price case.

Table ES-2. Present Value of Macroeconomic Loss in 1987
(10% Discount Rate, Billion 1985 Dollars)

Fee cases	Macroeconomic Loss	
	Lower Price	Higher Price
$5 fee	99.25	72.12
$10 fee	188.79	139.25
$22 floor	134.78	

Change in import cost

An import fee will reduce the total dollar outflow cost of imported oil. First, an import fee will reduce imports of oil. Second, an import fee will reduce the price of imported oil. The reduction in import cost, which is the product of the change in world oil price and the level of net imports, is a function of the impact of an import fee on world oil prices, the change in domestic oil production, and change in consumption. Table ES-3 reports the present value of import cost savings from the five import fee cases. The lower price $10 fee case shows the largest savings in the import cost and the higher price $5 fee case has the smallest saving in import costs. Greater savings in import costs for the lower price fee cases reflect the larger response in domestic oil production and consumption to higher crude oil prices in the lower price case.

Table ES-3. Present Value of Import Cost Savings in 1987
(10% Discount Rate, Billion 1985 Dollars)

Fee cases	Import Cost savings	
	Lower Price	Higher Price
$5 fee	22.49	17.55
$10 fee	36.92	28.21
$22 floor	27.63	

Security Benefits

An import fee will raise the price of energy products and consequently reduce consumption. Domestic production will also increase as a result of higher oil prices. Thus, in a normal business environment, an import fee will reduce imports and dependence on foreign oil. During a supply disruption, an import fee program would cause the U.S. to enter the disruption with a lower level of imports. In addition, there will also be a reduction in payments for imported oil during a disruption due to lower import level. If an import fee program actually reduces the oil price in a supply disruption, the additional benefit of an import fee would be to reduce the impact of an supply disruption on the domestic economy.

The benefits of an import fee to the economy can be summarized in three elements:

- o savings from lower disrupted oil prices
- o savings from lower imports
- o macroeconomic benefits

Table ES-4 reports the present value of security benefits in 1987.

Table ES-4. Present Value of Security Benefits in 1987
(10% Discount Rate, Billion 1985 Dollars)

Fee cases	Saving from Lower Disrupted Prices	Savings from Lower Imports	Macroeconomic Benefits
Lower Price			
$5 fee	0.85	3.34	2.32
$10 fee	0.79	6.19	2.32
$22 floor	0.98	0.30	1.07
Higher Price			
$5 fee	0.62	2.60	2.27
$10 fee	0.54	5.57	2.27

Savings from lower disrupted prices show a different pattern than the savings from lower imports. The $5 fee cases show bigger savings than the $10 fee cases. This is mainly due to the higher net imports in the $5 fee cases.

Savings from lower imports during a supply disruption appear to be the greatest among all three types of security benefits. The lower price $5 and $10 fee cases show bigger savings from lower imports than the corresponding higher price fee cases. This difference in savings is the result of the higher level of imports in the lower price base case.

The macroeconomic security benefit reported in Table ES-4 assumes that an import fee is waived during a supply disruption. Waiving the fee during a supply disruption could effectively reduce the price of oil facing the U.S. refiners and consumers, thereby reducing the economic impact of a supply disruption on the domestic economy.

A reduction in the domestic refinery acquisition cost of oil could be realized only if an import fee program caused the U.S. to enter the disruption with a lower level of imports and a relatively lower disruption price. As a result, the disrupted world oil price with a fee would be lower than the disrupted world oil price without a fee. Although the domestic refinery acquisition cost during a supply disruption could be higher than the disrupted world oil price if the fee is not waived, the oil price in the U.S. would be lower than the disrupted world oil price relative the pre-disruption pricing environment if the fee is waived during a supply disruption.

Waiving the fee will generate a macroeconomic security benefit, but in the meantime it would reduce savings from the other two components of the security benefit. The savings from lower disrupted prices will be reduced, if waiving the fee raises the demand and consequently the disrupted world oil price. The savings from lower imports would also decrease if the fee is waived as the relatively lower disrupted price induce demand and relatively higher imports. These reductions in the security benefits, however, are not considered in this report.

In Table ES-4, the $5 fee and $10 fee have the same macroeconomic benefits. The is due to the assumption that the disrupted prices are the same in the $5 fee and $10 fee case. The macroeconomic benefit for $5 fee case would be smaller if the disrupted price were larger for the $5 fee case.

The price increases assumed in the event of an oil supply disruption are for illustrative purposes only, and are very extreme values in order to determine whether extreme pessimism about the prospects for supply disruption would create a large security benefit. Such price increases would be possible only if extreme and highly unlikely decreases in wolrd oil supply and capacity were to occur.

DETAILED ANALYSIS

Introduction

Two price scenarios were studied. The first set assumes a situation of lower world oil price/higher imports. Three policies ($5 fee, $10 fee, and $22 floor) are examined. Results from the fee and price floor cases are analyzed in conjunction with the results generated for the lower price base case to compute values for economic variables such as welfare loss, macroeconomic loss, security benefit, present value of benefit, and revenue from an import fee.

The second price assumption reflects a situation of higher world oil price/lower imports . Two additional scenarios are generated using the higher price profile ($5 fee and $10 fee), and economic values for the same set of variables are computed and compared.

The second section of this report describes assumptions used in the generation of the world oil price and the solution of IFFS. The analysis methodology for computing economic values is also discussed.

Tables in the series A through C contain the quantitative results derived from the solution of IFFS. The focus of the comparisons results is on the welfare loss, macroeconomic loss, and security benefit.

Assumptions and Analysis Methodology

This section discusses the assumptions and analysis specifications that were provided by the requesting office and the assumptions that were incorporated in the analysis. In addition, the methodology used in the analysis of the costs and benefits of an import fee is also discussed.

This study analyses a $5 and $10 fee (1985 dollars) against high and low anticipated future oil prices.t In addition the study also examines a variable fee that provides a $22 floor for the lower price case. There are two cases for the OPEC response to an import fee. They are the reaction curve in the Oil Market Simulation (OMS) Model and a retaliation to maintain prices. The study incorporates the T-3 GNP elasticities of -0.021 to estimate the macroeconomic impacts of oil import fees. A 10 percent discount rate is used. No adjustment to domestic tax revenues are assumed to offset the fiscal impact of import fees.
The following assumptions were used in the IFFS runs:

1. The lower price case uses the Annual Energy Outlook, 1986 (AEO) high GNP version assumptions (high GNP growth rate). The transportation module assumes a lower vehicle fleet efficiency (lower MPG). In addition, a lower domestic finding rate is also assumed.

2. The higher price case uses the same assumptions as the AEO mid-macro case. The only difference between the higher price case and the AEO mid-macro case is the world oil price.

3. The fee cases use the same assumptions as the corresponding lower or higher price case, except that the price of crude oil (including fee) is different.

4. Domestic crude oil production levels for the fee cases are estimated using the elasticities derived from three AEO oil production and price profiles. The high level review runs also incorporate the revised EIA 1986 and 1987 crude oil production estimates while the AEO does not.

5. It is assumed that the crude oil and refined products exports will remain competitive in the world market due to a tariff rebate program. The administrative costs involved in monitoring the rebate program are assumed to have no effect on the IFFS model solution. Exports of crude oil and petroleum products are fixed at 19,000 barrels per day and 56,000 barrels per day respectively.

6. This analysis studies only the impact of fees imposed in the period 1988 through 1995.

7. Disruption impacts for the following three items are obtained from models associated with the Disruption Impact Simulator, which is a part of the OMS:
   - o Disruption price,
   - o Business as usual (BAU) GNP Elasticity,
   - o Disrupted GNP Elasticity.

Method of Analysis

An import fee affects both the petroleum market and the economy. The most direct benefit of an import fee is a reduction in the imports of crude oil and the dependence on imports. An import fee will lower world oil prices and reduce the amount paid for oil imports (excluding fee). It would also permit the U.S. to enter any potential oil supply disruption with a lower level of imports. An additional benefit would be the reduction in payments for imported oil during a disruption due to the lower import level.

The costs associated with an import fee include a loss in consumer welfare and a negative impact on macroeconomic conditions. It also causes additional expenditures to produce oil domestically, over and above what would be paid for imported oil in the absence of a fee.

To evaluate the costs and benefits of an import fee, four key variables are used to provide quantitative results:

- o change in import cost;
- o welfare loss;
- o macroeconomic loss; and
- o security benefit.

An import fee transfers wealth from U.S. consumers to the U.S. government in the amount collected directly. The fee also causes an increase in domestic oil prices, thus transferring additional wealth from U.S. oil consumers to U.S. oil producers. These transfers, all being within the U.S., are not included in calculation of the net economic costs and benefits of the fee.

In the following discussion, the four economic variables used in this study are defined and the computations described.

An import fee will lower the world oil price and reduce the amount paid for oil imports. This benefit is measured as the change in each year in the world oil price times the level of imports that will be purchased when the fee is in place.

In economic theory, a demand curve shows the relationship between price and quantity demanded. For example, Figure 1 shows the demand curve for imported oil. P_0 is the world equilibrium oil price without a fee, and Q_0 is the quantity of oil demanded at P_0. Any point on the demand curve reflects the price consumers are willing to pay for the corresponding quantity. The difference between the amount consumers are willing to pay and the actual amount consumers pay for the product is defined as consumer surplus. In Figure 1 the consumer surplus at the price P_0 is the triangle EP_0B.

For this study welfare loss is a measurement of the loss in consumer surplus as a result of the import fee, which causes oil consumption to be foregone. Figure 1 shows the demand curve for imported oil. P_0 is the world oil price without a fee, P_W is world oil price with a fee, and P_F is the crude oil price to U.S. consumers with a fee. The Q_0 and Q_F indicate the crude oil import levels without a fee and with a fee respectively. The effect of an import fee in the U.S. is to raise the oil price from P_0 to P_F and to reduce imports from Q_0 to Q_F. The reduction in consumer welfare in a given year is represented by the area ABQ_0Q_F. The savings from the reduction in imports is BQ_0Q_FC. This leaves a net loss of welfare, which is represented by the triangle ABC.

Figure 1: Costs and Benefits of an Import Fee
Undisrupted Markets

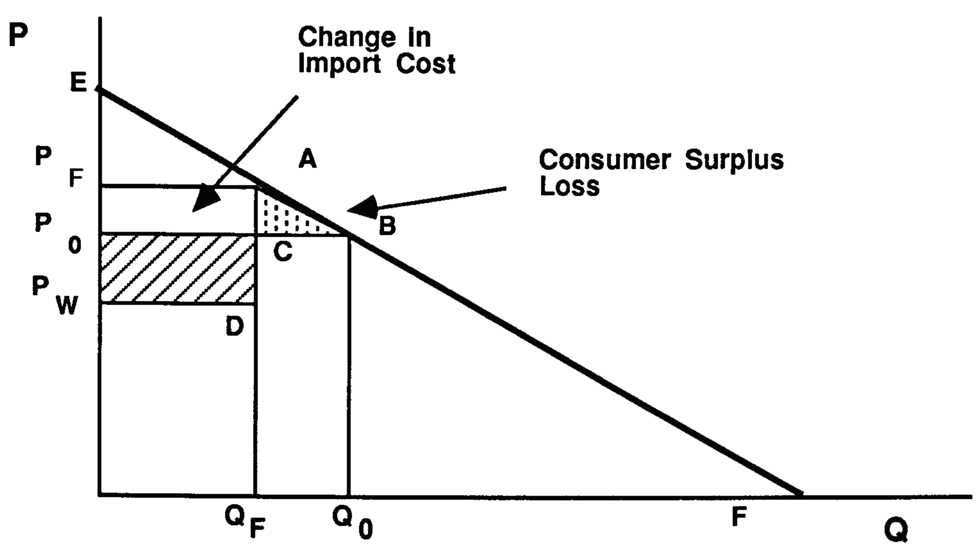
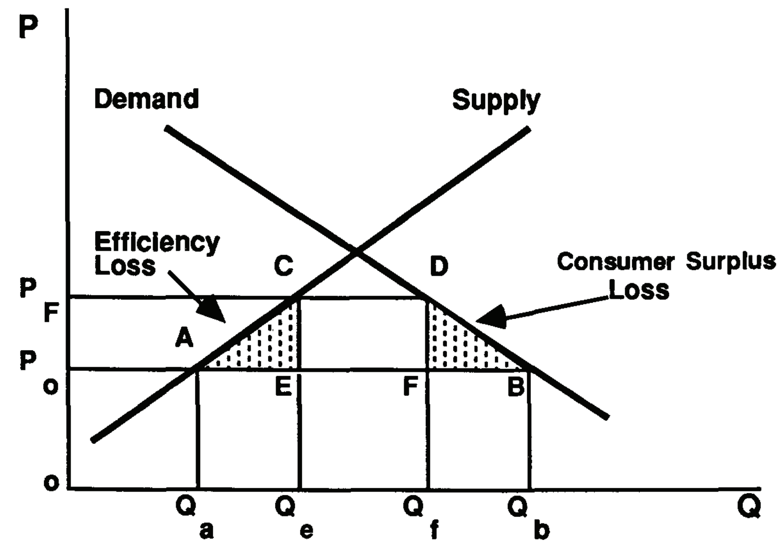


Figure 2: Loss in Consumer Surplus and Production Efficiency Caused by an Import Fee



In addition to a loss of consumer surplus, an import fee also reduces production efficiency. Figure 2 shows both the loss in consumer surplus and efficiency loss that result from an import fee. P_0 is the world oil price without a fee and PF is the crude oil price with a fee. At P_0 crude oil imports are measured by AB, and at PF crude oil imports are measured by CD. The difference in crude oil imports is AB minus CD, or AE plus FB. The change in imports as a result of an import fee, therefore, consists of two components: a reduction in consumption, FB, and an increase in production, AE. Both the reduction in consumption and the increase in production represent a loss to the market.

The triangle ACE represents a loss in production efficiency. The area ACQ_eQ_a represents the cost of producing the additional output, AE. The cost of importing AE was only AEQ_eQ_a before an import fee was imposed. The difference of these two areas, therefore, corresponds to a loss in the production efficiency; resources used in the production of additional output could have been used more efficiently in other sectors of the economy.

In this study, both the consumer welfare loss and the production efficiency loss are included as a welfare loss. The welfare loss is defined as the product of the change in net imports and the import fee times 0.5. (The area of the triangle ACB in Figure 1.)

An import fee raises the domestic price of oil above what it would be absent a fee, thus putting the U.S. economy on a permanently higher oil price path. A higher energy cost restrains domestic economic activity, and it changes the competitive position of the exporting industries relative to those in other countries that do not have a fee. In this study, the effect of an import fee on international trade is not addressed. A fee would make U.S. goods and service more expensive. Therefore, the impact of an import fee on the macroeconomy is likely to be underestimated.

The evaluation of the macroeconomic effect can be based on the GNP elasticity or on the model results for the EIA MINMAC. To evaluate the impact of an oil import fee on domestic economy, a constant GNP elasticity is used to estimate the response of GNP to changes in oil price. The specification of the elasticity equation is as follows:

Fee case GNP/base case GNP = (fee case oil price/base case oil price)** GNP elasticity .

Using the elasticity formula to solve for the change in GNP, we have:

Fee case GNP = base case GNP * (fee case price /base case price) ** GNP elasticity

Macroeconomic loss = Base case GNP - fee case real GNP.

Alternatively, the macroeconomic loss using results from MINMAC is calculated as follows:

Macroeconomic loss = Base case real GNP - fee case real GNP,

where the fee case GNP is estimated by MINMAC.

Security Benefit

The security benefit of an import fee during a supply disruption reflects three factors:

1. An import fee will cause the United States to enter an oil supply disruption with a lower level of imports, and consequently lower payments for imported oil during a disruption due to this lower import level.

2. If an import fee actually exerts an effect on the disrupted oil price, it would imply a lower disrupted world oil price with a fee than without a fee. If this situation occurs, an additional benefit will accrue due to this difference in disrupted price.

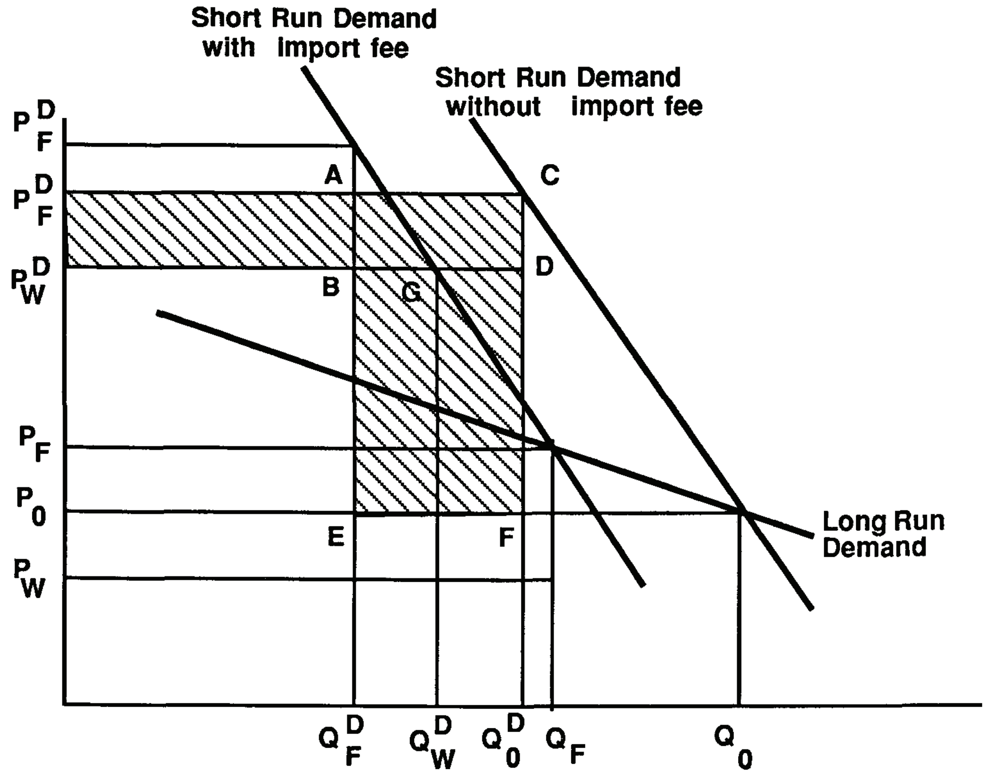
3. The impact of a supply disruption on the economy will be smaller because the oil import level before a supply disruption is smaller. In addition, if the import fee is waived during a supply disruption, the impact of disrupted price on GNP will be smaller.

The security benefit of an import fee is illustrated in Figure 3. The short run demand curve with a fee is located to the left of the short run demand curve without a fee. This result occurs because the demand for imported oil will be lower when the market is in equilibrium and the economy has absorbed the change in oil prices as a result of a fee. P_F, P_0, and P_W represent the price of oil with a fee, without a fee, and world oil price with a fee imposed on U.S. oil imports. Q_F and Q_0 represent the oil imports with and without a fee.

An oil supply disruption may have a different impact on the price of oil as shown in Figure 3. $P_W{}^D$ and $P_0{}^D$ correspond to world oil prices in a disruption with and without a fee and $P_F{}^D$ is the refinery acquisition cost during a supply disruption with a fee. The two shaded rectangles represent the security benefit of the import fee. The first rectangle ACFE shows the benefit of lower oil imports, which is the product of the difference between disrupted oil imports with and without an import fee and the increase in oil price as a result of a supply disruption. This difference in oil imports is measured by the length of AC, and the difference between the disrupted oil price and the undisrupted oil price is measured by AE. The security benefit of an import fee as a result of lower oil imports is calculated as the product of AE times AC.

The second rectangle, $P_0{}^DABP_W{}^D$, indicates the benefit of a lower disrupted price due to the effect of the fee initially. The difference in disrupted price with and without a fee is measured by AB. This difference in disrupted price times the disrupted oil imports with a fee, $OQ_F{}^D$, is the second component of the security benefit. There is no reason to believe that the second component of the security benefit will exist at all times. The price increase during a disruption could be the same with or without a fee, if an import fee lowered world oil price and induced higher consumption outside of U.S. and thereby maintained the same level of demand for the world.

Figure 3: Costs and Benefits of an Import Fee
Disrupted Markets



The computation of the three components for the security benefit uses an approach that is slightly different from the security benefit measured above. The difference between the oil imports with and without a fee is used to approximate the change in imports during a disruption. As shown in Figure 3, Q_0 -Q_F is the difference of the two import levels. The change in imports during a supply disruption is Q_0^D - Q_FD, which is clearly smaller than Q_0 - Q_F. The computation of the first component of the security benefit, therefore, overestimates the actual security benefit. This measurement error, however, is not likely to be significant, since the short run supply curve may be much less elastic than that shown in Figure 3.

The second component of the security benefit is savings from lower disrupted prices. This saving is computed as the product of the difference between the disrupted world oil price with and without a fee and the import level during a supply disruption. Both the difference in disrupted world oil price and the level of oil imports are based on data derived from the Disruption Impact Simulator of the EIA Oil Market Simulation Model (OMS). On the basis of the OMS model, the 35 percent of normal imports is used to estimate the level of imports during a supply disruption.

Computation of the security benefit for the macroeconomic effect is based on the percentage price change and the disrupted GNP elasticity. The sum of the above three components is the security benefit of an import fee.

Comparison of Results from \$5 and \$10 Fee and \$22 Floor Cases

Tables A1-A7 in this section present the quantitative results derived from the OMS runs and IFFS runs. The OMS model analyzes the effect of various import fees on the world oil market, and the IFFS model provides projections of key variables for the computation of the cost and benefit of an import fee. The results presented in this section assume that an oil import fee will reduce the price of oil by shifting the U.S. demand curve for oil imports so that the demand for OPEC oil equilibrates with 80 percent of OPEC capacity at a lower price.

The effects of oil import fees on world oil prices and OPEC revenues have been analyzed for the higher and lower price cases. Real world oil prices in 1995 in the no fee scenarios ranged from \$22 in the lower price case to \$28 in the higher price case (Table A1).

With the imposition of fees on U.S. oil imports, the higher domestic prices reduce U.S. consumption and increase domestic production. Since U.S. consumption constitutes such a large portion of free world demand (roughly one third in 1985), reductions in its consumption levels significantly affect the world's oil supply/demand balance and consequently, the world oil price as well. Also, U.S. domestic production constitutes more than one third of the non-OPEC free world production and the higher prices increase domestic supplies which would further reduce U.S. oil imports. It is estimated that a \$5 import fee could depress U.S. imports enough to lower world oil prices by \$1-\$2 per barrel by 1995, while a \$10 import fee could lower world oil prices by \$3-\$4 per barrel. Under the \$22 price floor scenario, there is little long range impact on world oil prices since pre-fee prices eventually rise above \$22 per barrel. Only in the lower price case would the \$22 floor still be in effect during the 1990's and would result in lower world oil prices by about \$1 by 1995.

The price changes in Table A1 indicate that oil import fees have a greater effect in the lower price case than in the higher price case. This is because a \$10 fee, for example, results in a bigger relative price change when prices are lower. The \$10 fee is equal to 46 percent of the pre-fee 1995 price in the lower price case but only 36 percent of the pre-fee 1995 price in the higher price case. The larger percentage price change in the lower price case results in its having larger demand effects and, consequently, greater changes in world oil prices.

The imposition of U.S. import fees tends to lower world oil prices, since there is a lower demand for OPEC oil. The rest of the consuming world could benefit from the lower price; however, OPEC revenues would be reduced. OPEC could retaliate by decreasing production, thus raising prices to cut its revenue losses. If OPEC retaliated by restricting production until prices returned to their pre-fee levels, the rest of the consuming world would return to their pre-fee position. The effect on OPEC revenues would be to roughly cut in half the losses that they would incur without retaliation.

Table A1 illustrates these OPEC revenue patterns by comparing the cumulative discounted OPEC revenue of the "without retaliation" to the "with retaliation" results. In the "without retaliation" scenarios, OPEC revenue losses range between \$76-103 billion with the \$5 import fee and between \$142-186 billion with the \$10 import fee. "With retaliation," OPEC revenue losses are reduced to \$53-54 billion with the \$5 import fee and to \$93-99 billion with the \$10 import fee. Short of increasing prices above pre-fee levels, OPEC revenues would be adversely affected by the imposition of a U.S. import fee.

The magnitude of the reduction in price will be lower if OPEC reduces production and capacity additions (e.g. those required to meet the call on OPEC in the low price case) because of the lower oil price. In this case, the fee need not reduce world oil prices.

Crude oil consumption in the U.S. will be lower if the world oil price does not decrease. Also domestic production may be higher, and net imports will be lower. There will be no change in import costs, which in any year is the product of change in world oil price and net imports. Welfare loss will be larger due to higher oil price and lower consumption. The macroeconomic loss will also be larger as the larger oil price increase exerts greater negative impact on the economy. The gain on security benefit will be greater due to a larger reduction in imports.

Based on the quantitative results, the effect of an OPEC retaliation on the U.S. import fee program is that the negative effect on GNP will outweigh any other gains from the higher oil prices.

Table A1 : IMPACT OF IMPORT FEES ON WORLD OIL PRICES

Scenario	Oil Prices[a] Without Retaliation ($/BBL)	Oil Prices[a] With Retaliation ($/BBL)
1995 High Price Case		
No Import Fee	$27.51	$27.51
$ 5 Import Fee	25.86	27.51
$10 Import Fee	24.33	27.51
$22 Floor Price	27.78	27.51
1995 Low Price Case		
No Import Fee	$21.51	$21.51
$5 Import Fee	19.58	21.51
$10 Import Fee	17.84	21.51
$22 Floor Price	20.29	21.51

[a]Oil prices are average delivered prices to U.S. refineries (excluding fees) expressed in 1985 dollars per barrel.

Table A2: COMPARISON OF CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)

	LOWER PRICE			HIGHER PRICE	
	$5 FEE	$10 FEE	$22 FLOOR	$5 FEE	$10 FEE
1988	1.01	1.43	1.34	1.24	1.81
1989	2.24	3.19	3.01	2.48	3.73
1990	3.52	5.38	4.81	3.42	5.30
1991	4.72	7.61	6.61	3.81	6.05
1992	5.89	9.76	8.15	4.18	6.79
1993	6.45	11.07	8.58	4.35	7.23
1994	6.76	11.70	7.51	4.37	7.47
1995	6.60	11.65	4.36	4.10	6.94

Change in Import Cost = Change in World Oil Price * Net Imports in the Fee cases.

Table A3: COMPARISON OF WELFARE LOSS
(BILLION 1985 DOLLARS)

	LOWER PRICE			HIGHER PRICE	
	$5 FEE	$10 FEE	$22 FLOOR	$5 FEE	$10 FEE
1988	-0.76	-3.02	-1.99	-0.67	-2.50
1989	-0.67	-2.77	-1.88	-0.43	-1.86
1990	-0.54	-2.12	-1.77	-0.37	-1.63
1991	-0.44	-1.67	-1.31	-0.43	-1.75
1992	-0.37	-1.46	-0.90	-0.44	-1.75
1993	-0.37	-1.36	-0.50	-0.37	-1.68
1994	-0.60	-2.01	-0.35	-0.40	-1.68
1995	-0.46	-1.75	-0.04	-0.45	-1.94

Table A4 : COMPARISON OF MACROECONOMIC LOSS
(BILLION 1985 DOLLARS)

	LOWER PRICE			HIGHER PRICE	
	$5 FEE	$10 FEE	$22 FLOOR	$5 FEE	$10 FEE
1988	-24.62	-44.50	-38.02	-18.79	-34.95
1989	-21.81	-40.72	-35.60	-14.83	-28.68
1990	-19.84	-37.96	-33.60	-12.33	-24.41
1991	-17.48	-34.14	-27.34	-11.83	-23.40
1992	-15.42	-30.62	-20.97	-11.36	-22.36
1993	-14.59	-28.85	-14.74	-11.58	-22.54
1994	-14.36	-28.04	- 8.55	-11.89	-23.98
1995	-14.62	-28.20	- 2.47	-12.31	-23.70

Table A5: SECURITY BENEFIT: SAVING FROM LOWER DISRUPTED PRICE
(BILLION 1985 DOLLARS)

	LOWER PRICE			HIGHER PRICE	
	$5 FEE	$10 FEE	$22 FLOOR	$5 FEE	$10 FEE
1988	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00
1995	1.83	1.69	0.63	1.33	1.17

Table A6 : SECURITY BENEFIT FROM LOWER IMPORTS
(BILLION 1985 DOLLARS)

	LOWER PRICE			HIGHER PRICE	
	$5 FEE	$10 FEE	$22 FLOOR	$5 FEE	$10 FEE
1988	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00
1995	7.16	13.27	2.10	5.58	11.93

[a] Disruption assumed to occur in 1995.

Table A7 : COMPARISON OF SECURITY BENEFIT: MACROECONOMIC BENEFITS
(BILLION 1985 DOLLARS)

	LOWER PRICE			HIGHER PRICE	
	$5 FEE	$10 FEE	$22 FLOOR	$5 FEE	$10 FEE
1988	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00
1995	4.97	4.97	2.29	4.86	4.86

[a] Disruption assumed to occur in 1995.

Quantitative Results Derived from Base Cases

Table B1, \$5 Fee VS Lower Price Case
Table B2, \$10 Fee VS Lower Price Case
Table B3, \$22 Floor VS Lower Price Case
Table B4, \$5 Fee VS Higher Price Case
Table B5, \$10 Fee VS Higher Price Case

Sensitivity Analysis Using \$10 Fee and Lower Price Case as Base

Table C1, An Import Fee Has No Effect on World Oil Price
Table C2, Double the Demand and Supply Elasticity
Table C3, Different Disruption Probabilities (1.0) and Prices without OPEC Retaliation
Table C4, Different Disruption Probabilities (1.0) and Price with OPEC Retaliation
Table C5, Macro Loss Derived from MINMAC Model Results

Table B1: $5 FEE VS LOWER PRICE CASE

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE									3.10
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FEE CASE WORLD OIL PRICE		13.98	13.96	14.05	14.91	15.83	16.97	18.23	19.58
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		18.98	18.96	19.05	19.91	20.83	21.97	23.23	24.58
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		4.49	3.96	3.56	3.22	2.93	2.87	2.92	3.07
2. CHANGE IN WOP (1985 DOLLARS)		-0.51	-1.04	-1.44	-1.78	-2.07	-2.13	-2.08	-1.93
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.30	0.36	0.24	0.18	0.17	0.13	0.24	0.23
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-0.54	-0.56	-0.59	-0.58	-0.53	-0.57	-0.87	-0.61
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-0.93	-0.93	-0.83	-0.75	-0.70	-0.70	-1.12	-0.82
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-1.01	-2.24	-3.52	-4.72	-5.89	-6.45	-6.76	-6.60
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-0.76	-0.67	-0.54	-0.44	-0.37	-0.37	-0.60	-0.46
8. MACRO LOSS (BILLION 1985 DOLLARS)		-24.62	-21.81	-19.84	-17.48	-15.42	-14.59	-14.36	-14.62
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.16
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.97
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		9.89	10.77	12.23	13.25	14.24	15.15	16.26	17.10
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	22.49	0.917212	1.850942	2.64577	3.221653	3.659269	3.642457	3.471244	3.079274
12. WELFARE LOSS	-2.91	-0.69279	-0.55546	-0.40515	-0.30103	-0.23242	-0.20696	-0.30628	-0.21433
13. MACRO LOSS	-99.25	-22.3795	-18.0267	-14.907	-11.9375	-9.57435	-8.23821	-7.36913	-6.8224
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.85	0	0	0	0	0	0	0	0.85369
B. SAVINGS FROM LOWER IMPORTS	3.34	0	0	0	0	0	0	0	3.338851
C. MACROECONOMIC BENEFITS	2.32	0	0	0	0	0	0	0	2.320648
15. GROSS REVENUE FROM FEE	69.84	8.992273	8.89876	9.186702	9.049587	8.838815	8.550369	8.344336	7.977393

Table B2: $10 FEE VS LOWER PRICE CASE

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE									3.10
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FEE CASE WORLD OIL PRICE		13.63	13.25	13.03	13.57	14.20	15.20	16.41	17.83
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		23.63	23.25	23.03	23.57	24.20	25.20	26.41	27.83
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		9.14	8.25	7.54	6.88	6.30	6.10	6.10	6.32
2. CHANGE IN WOP (1985 DOLLARS)		-0.86	-1.75	-2.46	-3.12	-3.70	-3.90	-3.90	-3.68
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.62	0.76	0.51	0.36	0.35	0.25	0.45	0.45
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-1.02	-1.07	-1.03	-0.99	-0.92	-0.97	-1.36	-1.08
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-1.81	-1.84	-1.54	-1.33	-1.27	-1.22	-1.81	-1.52
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-1.43	-3.19	-5.38	-7.61	-9.76	-11.07	-11.70	-11.65
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-3.02	-2.77	-2.12	-1.67	-1.46	-1.36	-2.01	-1.75
8. MACRO LOSS (BILLION 1985 DOLLARS)		-44.50	-40.72	-37.96	-34.14	-30.62	-28.85	-28.04	-28.20
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.27
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.97
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		16.57	18.21	21.86	24.38	26.39	28.40	30.00	31.65
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	36.92	1.295551	2.634184	4.040887	5.195809	6.062747	6.251453	6.00455	5.432732
12. WELFARE LOSS	-11.29	-2.7447	-2.28955	-1.59212	-1.1406	-0.90666	-0.76665	-1.034	-0.81787
13. MACRO LOSS	-188.79	-40.4544	-33.6493	-28.5219	-23.3153	-19.0155	-16.2868	-14.3879	-13.1555
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.79	0	0	0	0	0	0	0	0.789914
B. SAVINGS FROM LOWER IMPORTS	6.19	0	0	0	0	0	0	0	6.18909
C. MACROECONOMIC BENEFITS	2.32	0	0	0	0	0	0	0	2.320648
15. GROSS REVENUE FROM FEE	125.77	15.06455	15.05248	16.42637	16.65323	16.3858	16.02937	15.39628	14.76286

Table B3: $22 FLOOR VS LOWER PRICE CASE

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		30.00	35.00	40.00	42.00	44.00	46.00	48.00	50.00
CHANGE IN DISRUPTION PRICE		0.63	1.30	1.84	2.30	2.58	2.47	1.95	1.03
PRICE EXCLUDING TARIFF		13.74	13.46	13.31	13.97	14.84	16.18	18.00	20.29
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FLOOR CASR WORLD OIL PRICE		13.74	13.46	13.31	13.97	14.84	16.18	18.00	20.29
FLOOR CASE REFINERY ACQUISITION COST		22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
FLOOR CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		7.51	7.00	6.51	5.31	4.10	2.90	1.69	0.49
2. CHANGE IN WOP (1985 DOLLARS)		-0.75	-1.54	-2.18	-2.72	-3.06	-2.92	-2.31	-1.22
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.41	0.52	0.59	0.54	0.49	0.38	0.37	0.22
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-0.89	-0.94	-0.90	-0.82	-0.72	-0.59	-0.76	-0.24
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-1.45	-1.47	-1.49	-1.35	-1.20	-0.95	-1.12	-0.41
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-1.34	-3.01	-4.81	-6.61	-8.15	-8.58	-7.51	-4.36
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-1.99	-1.88	-1.77	-1.31	-0.90	-0.50	-0.35	-0.04
8. MACRO LOSS (BILLION 1985 DOLLARS)		-38.02	-35.60	-33.60	-27.34	-20.97	-14.74	-8.55	-2.47
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.10
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.29
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		14.77	16.71	19.16	19.52	19.08	17.10	13.01	6.10
PRESENT VALUE OF COST AND BENEFIT IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	27.63	1.219432	2.489964	3.61084	4.516118	5.062601	4.843011	3.855083	2.031656
12. WELFARE LOSS	-6.62	-1.80667	-1.552	-1.33	-0.89355	-0.55753	-0.28381	-0.17726	-0.0171
13. MACRO LOSS	-134.78	-34.568	-29.4233	-25.2435	-18.6725	-13.0184	-8.3184	-4.38725	-1.15317
14. SECURITY BENEFIT									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.98	0	0	0	0	0	0	0	0.980861
B. SAVINGS FROM LOWER IMPORTS	0.30	0	0	0	0	0	0	0	0.296206
C. MACROECONOMIC BENEFITS	1.07	0	0	0	0	0	0	0	1.066682
15. GROSS REVENUE FROM FEE	85.99	13.43001	13.80798	14.39367	13.33251	11.84583	9.652851	6.675469	2.847648

Table B4: $5 FEE VS HIGHER PRICE CASE

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE									3.10
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
HIGHER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		18.51	20.51	22.51	23.51	24.51	25.51	26.51	27.51
TOTAL PRODUCTION (MILLION BBL/DAY)		10.48	10.28	10.08	9.82	9.59	9.29	9.01	8.89
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		15.97	15.73	15.71	15.85	15.93	16.05	16.25	16.38
NET IMPORTS (MILLION BBL/DAY)		5.51	5.45	5.66	6.08	6.39	6.81	7.29	7.54
REAL GNP (BILLION 1982 DOLLARS)		3875	3943	4049	4172	4275	4372	4474	4581
FEE CASE WORLD OIL PRICE		17.78	19.09	20.64	21.54	22.46	23.57	24.70	25.86
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		22.78	24.09	25.64	26.54	27.46	28.57	29.70	30.86
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		4.27	3.58	3.13	3.03	2.95	3.06	3.19	3.35
2. CHANGE IN WOP (1985 DOLLARS)		-0.73	-1.42	-1.87	-1.97	-2.05	-1.94	-1.81	-1.65
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.31	0.35	0.35	0.41	0.42	0.37	0.35	0.43
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-0.48	-0.33	-0.31	-0.36	-0.39	-0.30	-0.34	-0.30
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-0.86	-0.66	-0.65	-0.78	-0.81	-0.67	-0.68	-0.73
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-1.24	-2.48	-3.42	-3.81	-4.18	-4.35	-4.37	-4.10
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-0.67	-0.43	-0.37	-0.43	-0.44	-0.37	-0.40	-0.45
8. MACRO LOSS (BILLION 1985 DOLLARS)		-18.79	-14.83	-12.33	-11.83	-11.36	-11.58	-11.89	-12.31
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.58
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.86
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		8.49	8.74	9.14	9.67	10.18	11.21	12.06	12.43
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	17.55	1.126357	2.051783	2.569178	2.60294	2.592492	2.454182	2.240908	1.913297
12. WELFARE LOSS	-2.43	-0.60925	-0.35637	-0.27896	-0.2946	-0.27077	-0.2112	-0.20315	-0.2082
13. MACRO LOSS	-72.12	-17.0842	-12.2551	-9.26107	-8.07821	-7.05529	-6.53854	-6.10095	-5.74317
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.62	0	0	0	0	0	0	0	0.620452
B. SAVINGS FROM LOWER IMPORTS	2.60	0	0	0	0	0	0	0	2.604597
C. MACROECONOMIC BENEFITS	2.27	0	0	0	0	0	0	0	2.267681
15. GROSS REVENUE FROM FEE	53.05	7.714773	7.224587	6.869459	6.606448	6.323152	6.325213	6.190355	5.79787

Table B5: $10 FEE VS HIGHER PRICE CASE

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE									3.10
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
HIGHER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		18.51	20.51	22.51	23.51	24.51	25.51	26.51	27.51
TOTAL PRODUCTION (MILLION BBL/DAY)		10.48	10.28	10.08	9.82	9.59	9.29	9.01	8.89
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		15.97	15.73	15.71	15.85	15.93	16.05	16.25	16.38
NET IMPORTS (MILLION BBL/DAY)		5.51	5.45	5.66	6.08	6.39	6.81	7.29	7.54
REAL GNP (BILLION 1982 DOLLARS)		3875	3943	4049	4172	4275	4372	4474	4581
FEE CASE WORLD OIL PRICE		17.25	18.01	19.14	19.89	20.66	21.81	23.03	24.33
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		27.25	28.01	29.14	29.89	30.66	31.81	33.03	34.33
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		8.74	7.50	6.63	6.38	6.15	6.30	6.52	6.82
2. CHANGE IN WOP (1985 DOLLARS)		-1.26	-2.50	-3.37	-3.62	-3.85	-3.70	-3.48	-3.18
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.63	0.71	0.75	0.86	0.88	0.80	0.73	0.89
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-0.81	-0.66	-0.61	-0.64	-0.68	-0.65	-0.68	-0.66
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-1.57	-1.36	-1.35	-1.50	-1.56	-1.46	-1.41	-1.56
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-1.81	-3.73	-5.30	-6.05	-6.79	-7.23	-7.47	-6.94
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-2.50	-1.86	-1.63	-1.75	-1.75	-1.68	-1.68	-1.94
8. MACRO LOSS (BILLION 1985 DOLLARS)		-34.95	-28.68	-24.41	-23.40	-22.36	-22.54	-22.98	-23.70
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.93
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.86
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		14.38	14.93	15.73	16.72	17.63	19.53	21.46	21.83
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	28.21	1.647278	3.084401	3.983107	4.133293	4.214415	4.078423	3.832663	3.238021
12. WELFARE LOSS	-10.04	-2.27657	-1.53843	-1.22725	-1.1929	-1.08717	-0.94755	-0.86096	-0.9058
13. MACRO LOSS	-139.25	-31.7711	-23.7018	-18.3385	-15.9795	-13.8822	-12.7243	-11.7938	-11.0565
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.54	0	0	0	0	0	0	0	0.544831
B. SAVINGS FROM LOWER IMPORTS	5.57	0	0	0	0	0	0	0	5.565989
C. MACROECONOMIC BENEFITS	2.27	0	0	0	0	0	0	0	2.267681
15. GROSS REVENUE FROM FEE	91.81	13.07364	12.3376	11.81931	11.41794	10.94653	11.02276	11.0134	10.18246

Table C1: $10 FEE VS LOWER PRICE CASE; AN IMPORT FEE HAS NO EFFECT ON WOP

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.20
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FEE CASE WORLD OIL PRICE		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		24.49	25.00	25.49	26.69	27.90	29.10	30.31	31.51
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
2. CHANGE IN WOP (1985 DOLLARS)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.68	0.92	0.68	0.52	0.56	0.41	0.74	0.71
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-1.12	-1.30	-1.37	-1.44	-1.46	-1.59	-2.23	-1.71
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-1.98	-2.23	-2.04	-1.93	-2.02	-2.00	-2.97	-2.41
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-3.30	-3.36	-2.81	-2.43	-2.32	-2.23	-3.30	-2.77
8. MACRO LOSS (BILLION 1985 DOLLARS)		-47.73	-47.42	-47.63	-46.37	-45.01	-43.77	-42.68	-41.74
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.67
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.99
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.38
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		15.95	16.79	20.03	22.18	23.67	25.55	25.78	28.42
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	0.00	0	0	0	0	0	0	0	0
12. WELFARE LOSS	-15.23	-3.00295	-2.77521	-2.11157	-1.65784	-1.43914	-1.2568	-1.69509	-1.29409
13. MACRO LOSS	-244.07	-43.3952	-39.1915	-35.7824	-31.6712	-27.9454	-24.7053	-21.9019	-19.4725
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	5.91	0	0	0	0	0	0	0	5.911615
B. SAVINGS FROM LOWER IMPORTS	9.79	0	0	0	0	0	0	0	9.792864
C. MACROECONOMIC BENEFITS	20.70	0	0	0	0	0	0	0	20.70448
15. GROSS REVENUE FROM FEE	114.17	14.49944	13.87512	15.04853	15.14961	14.69538	14.42231	13.22879	13.25582

Table C2: FEE VS LOWER PRICE CASE; Double the Demand & Supply Elasticity

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DOUBLE OR HALF DEMAND AND SUPPLY ELASTICITY	2.00								
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE									3.10
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FEE CASE WORLD OIL PRICE		13.63	13.25	13.03	13.57	14.20	15.20	16.41	17.83
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		23.63	23.25	23.03	23.57	24.20	25.20	26.41	27.83
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		9.14	8.25	7.54	6.88	6.30	6.10	6.10	6.32
2. CHANGE IN WOP (1985 DOLLARS)		-0.86	-1.75	-2.46	-3.12	-3.70	-3.90	-3.90	-3.68
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		1.24	1.52	1.02	0.72	0.70	0.50	0.90	0.90
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-2.04	-2.14	-2.06	-1.98	-1.84	-1.94	-2.72	-2.16
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-3.62	-3.68	-3.08	-2.66	-2.54	-2.44	-3.62	-3.04
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-0.86	-2.01	-4.00	-6.09	-8.05	-9.34	-9.12	-9.60
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-6.04	-5.54	-4.24	-3.34	-2.92	-2.72	-4.03	-3.51
8. MACRO LOSS (BILLION 1985 DOLLARS)		-44.50	-40.72	-37.96	-34.14	-30.62	-28.85	-28.04	-28.20
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.53
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.97
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		9.96	11.50	16.24	19.53	21.75	23.94	23.40	26.10
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	29.04	0.779043	1.662862	3.001995	4.161314	4.997783	5.271148	4.682381	4.480281
12. WELFARE LOSS	-22.58	-5.4894	-4.57909	-3.18425	-2.28119	-1.81332	-1.5333	-2.06801	-1.63573
13. MACRO LOSS	-188.79	-40.4544	-33.6493	-28.5219	-23.3153	-19.0155	-16.2868	-14.3879	-13.1555
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.79	0	0	0	0	0	0	0	0.789914
B. SAVINGS FROM LOWER IMPORTS	12.38	0	0	0	0	0	0	0	12.37818
C. MACROECONOMIC BENEFITS	2.32	0	0	0	0	0	0	0	2.320648
15. GROSS REVENUE FROM FEE	95.31	9.058636	9.502066	12.20323	13.33755	13.50752	13.51576	12.0061	12.17468

Table C3: $10 FEE VS LOWER PRICE CASE; Different Disruption Probabilities and Prices without OPEC Retaliation

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE				0.33					3.10
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FEE CASE WORLD OIL PRICE		13.63	13.25	13.03	13.57	14.20	15.20	16.41	17.83
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		23.63	23.25	23.03	23.57	24.20	25.20	26.41	27.83
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		9.14	8.25	7.54	6.88	6.30	6.10	6.10	6.32
2. CHANGE IN WOP (1985 DOLLARS)		-0.86	-1.75	-2.46	-3.12	-3.70	-3.90	-3.90	-3.68
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.62	0.76	0.51	0.36	0.35	0.25	0.45	0.45
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-1.02	-1.07	-1.03	-0.99	-0.92	-0.97	-1.36	-1.08
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-1.81	-1.84	-1.54	-1.33	-1.27	-1.22	-1.81	-1.52
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-1.43	-3.19	-5.38	-7.61	-9.76	-11.07	-11.70	-11.65
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-3.02	-2.77	-2.12	-1.67	-1.46	-1.36	-2.01	-1.75
8. MACRO LOSS (BILLION 1985 DOLLARS)		-44.50	-40.72	-37.96	-34.14	-30.62	-28.85	-28.04	-28.20
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.12	0.00	0.00	0.00	0.00	1.69
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	12.34	0.00	0.00	0.00	0.00	13.27
C. MACROECONOMIC BENEFITS		0.00	0.00	0.52	0.00	0.00	0.00	0.00	4.97
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		16.57	18.21	21.86	24.38	26.39	28.40	30.00	31.65
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	36.92	1.295551	2.634184	4.040887	5.195809	6.062747	6.251453	6.00455	5.432732
12. WELFARE LOSS	-11.29	-2.7447	-2.28955	-1.59212	-1.1406	-0.90666	-0.76665	-1.034	-0.81787
13. MACRO LOSS	-188.79	-40.4544	-33.6493	-28.5219	-23.3153	-19.0155	-16.2868	-14.3879	-13.1555
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.88	0	0	0.093563	0	0	0	0	0.789914
B. SAVINGS FROM LOWER IMPORTS	15.46	0	0	9.269851	0	0	0	0	6.18909
C. MACROECONOMIC BENEFITS	2.71	0	0	0.387136	0	0	0	0	2.320648
15. GROSS REVENUE FROM FEE	125.77	15.06455	15.05248	16.42637	16.65323	16.3858	16.02937	15.39628	14.76286

Table C4: $10 FEE VS LOWER PRICE CASE; Different Disruption Probabilities Prices with OPEC Retaliation

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE		8.45	8.45	20.00	8.45	8.45	8.45	8.45	23.20
BAU GNP ELASTICITY	-0.021								
DISRUPTED GNP ELASTICITY	-0.021								
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FEE CASE WORLD OIL PRICE		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		24.49	25.00	25.49	26.69	27.90	29.10	30.31	31.51
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
2. CHANGE IN WOP (1985 DOLLARS)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.68	0.92	0.68	0.52	0.56	0.41	0.74	0.71
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-1.12	-1.30	-1.37	-1.44	-1.46	-1.59	-2.23	-1.71
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-1.98	-2.23	-2.04	-1.93	-2.02	-2.00	-2.97	-2.41
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-3.30	-3.36	-2.81	-2.43	-2.32	-2.23	-3.30	-2.77
8. MACRO LOSS (BILLION 1985 DOLLARS)		-47.73	-47.42	-47.63	-46.37	-45.01	-43.77	-42.68	-41.74
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	7.55	0.00	0.00	0.00	0.00	12.67
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	16.36	0.00	0.00	0.00	0.00	20.99
C. MACROECONOMIC BENEFITS		0.00	0.00	39.14	0.00	0.00	0.00	0.00	44.38
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		15.95	16.79	20.03	22.18	23.67	25.55	25.78	28.42
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	0.00	0	0	0	0	0	0	0	0
12. WELFARE LOSS	-15.23	-3.00295	-2.77521	-2.11157	-1.65784	-1.43914	-1.2568	-1.69509	-1.29409
13. MACRO LOSS	-244.07	-43.3952	-39.1915	-35.7824	-31.6712	-27.9454	-24.7053	-21.9019	-19.4725
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	11.58	0	0	5.670473	0	0	0	0	5.911615
B. SAVINGS FROM LOWER IMPORTS	22.09	0	0	12.29423	0	0	0	0	9.792864
C. MACROECONOMIC BENEFITS	50.11	0	0	29.4058	0	0	0	0	20.70448
15. GROSS REVENUE FROM FEE	114.17	14.49944	13.87512	15.04853	15.14961	14.69538	14.42231	13.22879	13.25582

Table C5: $10 FEE VS LOWER PRICE CASE; Macro Loss Derived from MINMAC Results.

	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSUMPTIONS:									
DISRUPTION PROBABILITY		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
DISRUPTION PRICE		40.00	50.00	60.00	62.00	64.00	66.00	68.00	70.00
CHANGE IN DISRUPTION PRICE									3.10
BAU GNP ELASTICITY									
DISRUPTED GNP ELASTICITY									
LOWER PRICE BASE CASE VALUES:									
WORLD OIL PRICE (1985 DOLLARS)		14.49	15.00	15.49	16.69	17.90	19.10	20.31	21.51
TOTAL PRODUCTION (MILLION BBL/DAY)		9.99	9.60	9.22	8.91	8.51	8.30	7.87	7.57
TOTAL PRODUCT SUPPLIED (MILLION BBL/DAY)		16.27	16.38	16.67	16.86	16.95	17.24	17.83	17.72
NET IMPORTS (MILLION BBL/DAY)		6.35	6.83	7.53	8.01	8.50	9.00	10.03	10.19
REAL GNP (BILLION 1982 DOLLARS)		3906	3986	4105	4239	4351	4459	4572	4688
FEE CASE WORLD OIL PRICE		13.63	13.25	13.03	13.57	14.20	15.20	16.41	17.83
FEE CASE REFINERY ACQUISITION COST (RAC 1985 DOLLARS)		23.63	23.25	23.03	23.57	24.20	25.20	26.41	27.83
FEE CASE MINUS BASE CASE:									
1. CHANGE IN RAC (1985 DOLLARS)		9.14	8.25	7.54	6.88	6.30	6.10	6.10	6.32
2. CHANGE IN WOP (1985 DOLLARS)		-0.86	-1.75	-2.46	-3.12	-3.70	-3.90	-3.90	-3.68
3. CHANGE IN PRODUCTION (MILLION BBL/DAY)		0.62	0.76	0.51	0.36	0.35	0.25	0.45	0.45
4. CHANGE IN CONSUMPTION (MILLION BBL/DAY)		-1.02	-1.07	-1.03	-0.99	-0.92	-0.97	-1.36	-1.08
5. CHANGE IN IMPORTS (MILLION BBL/DAY)		-1.81	-1.84	-1.54	-1.33	-1.27	-1.22	-1.81	-1.52
6. CHANGE IN IMPORT COST (BILLION 1985 DOLLARS)		-1.43	-3.19	-5.38	-7.61	-9.76	-11.07	-11.70	-11.65
7. WELFARE LOSS (BILLION 1985 DOLLARS)		-3.02	-2.77	-2.12	-1.67	-1.46	-1.36	-2.01	-1.75
8. MACRO LOSS (BILLION 1985 DOLLARS)		-25.65	-28.99	-31.22	-33.45	-35.68	-40.14	-44.60	-42.37
9. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69
B. SAVINGS FROM LOWER IMPORTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.27
C. MACROECONOMIC BENEFITS		0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.97
10. GROSS REVENUE FROM FEE (BILLION 1985 DOLLARS)		16.57	18.21	21.86	24.38	26.39	28.40	30.00	31.65
PRESENT VALUE OF COST AND BENEFITS IN 1987 (BILLION 1985 DOLLARS, DISCOUNT RATE 10%)									
11. REDUCTION IN IMPORT COST	36.92	1.295551	2.634184	4.040887	5.195809	6.062747	6.251453	6.00455	5.432732
12. WELFARE LOSS	-11.29	-2.7447	-2.28955	-1.59212	-1.1406	-0.90666	-0.76665	-1.034	-0.81787
13. MACRO LOSS	-181.04	-23.3136	-23.9587	-23.456	-22.8468	-22.1545	-22.658	-22.8869	-19.7659
14. SECURITY BENEFIT(BILLION 1985 DOLLARS)									
A. SAVINGS FROM LOWER DISRUPTED OIL PRICES	0.79	0	0	0	0	0	0	0	0.789914
B. SAVINGS FROM LOWER IMPORTS	6.19	0	0	0	0	0	0	0	6.18909
C. MACROECONOMIC BENEFITS	2.32	0	0	0	0	0	0	0	2.320648
15. GROSS REVENUE FROM FEE	125.77	15.06455	15.05248	16.42637	16.65323	16.3858	16.02937	15.39628	14.76286

Estimation of Domestic Crude Oil Production for Various Import Fee and Motor Fuel Tax Cases

Production estimates for the $5 and $10 oil import fee cases were taken from modeling already in place from the AEO. Since the fee cases are bracketed by the AEO cases, this procedure was used in lieu of actual PROLOG runs because of time and personnel constraints. Estimates for the $22 floor case were provided by the PROLOG model. Three sets of Annual Energy Outlook 1986 (AEO) price and oil production numbers (the low-price case, the mid-price case, and the high-price case) originally generated from the PROLOG model are used as the basis in the estimation of domestic crude oil production for the $5 fee case and the $l0 fee case. The assumed U.S. prices for the $5 and $l0 fee case are calculated by adding the fee ($5 or $l0) to the "equilibrium world oil price."

The estimation method first computes the simple per dollar rate of change of production between the low-price case and mid-price case and between the mid-price case and high-price case. Second, the per dollar rate of change of production calculated for the low-price and mid-price case is used to estimate crude oil production in the lower price $5 fee $10 fee, and motor fuel tax cases and the per dollar rate of change calculated from the mid-price and high-price case is used to estimate the production level in the higher price $5 fee and $10 fee cases. Note that only the rates of change calculated from the low-price to mid-price and the mid-price to high-price case are used in the estimation of crude oil production. These rates of change are then applied to a base level of production which comes from the appropriate PROLOG model estimate for either the lower price or higher price case.

For example, in 1988 the projected price and quantity for the AEO low-price case are $11.47 per barrel and 8.01 million barrels per day respectively, and the projected price and quantity for the mid-price case are $15.80 per barrel and 8.30 million barrels per day. The per dollar rate of change is:

(8.01-8.30)/(11.47-l5.80)=0.0670.

This rate of change is then multiplied by the difference in U.S. price between the $5 fee case and the lower price no-fee case and the product is added to the PROLOG estimate of production for the lower price no fee case. This gives an estimate of production that is calibrated to PROLOG and that reflects the supply price response that is used in the AEO runs. 1988 oil production for the $5 fee case is equal to:

7.66-0.0670*(14.49-18.98)=7.96.

The production estimates for the lower price fee and motor fuel tax cases production price response are computed from the AEO low-price and mid-price case. The production estimates for the higher price fee cases use the per dollar rate of change computed from the AEO mid-price and high-price case.

While this approach is considered to provide reasonably accurate production estimates, it is effective only if the price profile of the case for which the crude oil production is to be estimated is generally comparable with the price profile of low-price, mid-price, or high-price case. The estimation error could be significant if the new price profile bears no resemblance to the already known price profile.

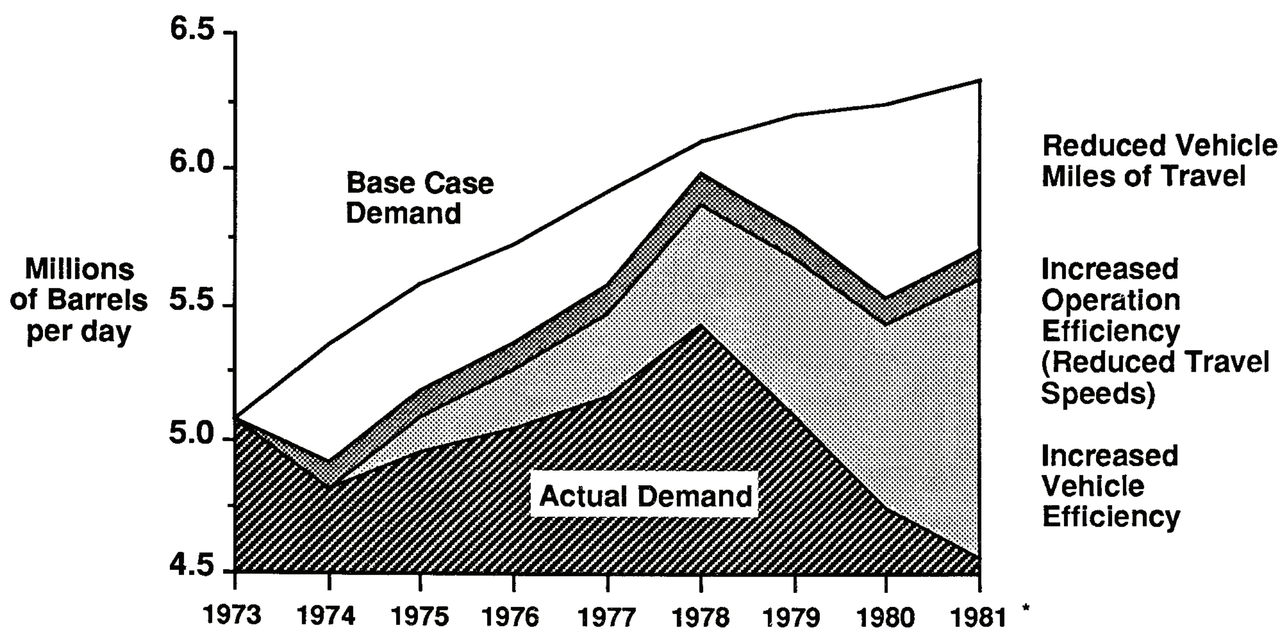
Introduction and Overview

A tax on gasoline and diesel fuel* increases the cost of highway travel and reduces motor fuel demand. In the short-term, reduced motor fuel demand would result entirely from reduced vehicle miles of travel (VMT). In the long term, vehicle fuel economy would also improve. More automobile and truck fuel economy technologies would become cost effective at higher fuel prices and consumer interest in fuel efficient vehicles would increase. Therefore, with higher gasoline prices new car fuel efficiency would increase. As more efficient new vehicles enter service the average fuel economy of all vehicles increases, but at a slower rate. If the gasoline tax is maintained over time, average fleet fuel economy keeps increasing until it becomes a more important factor in reducing motor fuel demand than reduced vehicle miles of travel (VMT).

These effects are shown in the Figure. Relative to a projected base case of passenger car motor fuel demand the fuel price increase in 1973-1974 caused VMT to drop sharply. However, after 1974 the effect of improved vehicle efficiency became increasingly more important relative to reduced VMT. With the fuel price increases of 1978-1979, VMT again declined and this decline was subsequently mitigated by further improvements in vehicle efficiency.

Gasoline taxes have other important effects beyond reducing gasoline demand. They reduce consumers' disposable income and consequently reduce consumer expenditures and economic activity. GNP is reduced and inflation increases. Unemployment increases as a result of reduced consumer expenditures.

Passenger Car Motor Fuel Demand



* through mid-1981

*A tax on gasoline and diesel fuel used in highways. For ease of exposition this will be subsequently referred to as a gasoline tax. Industries consume a disproportionate share of gasoline and diesel fuel such as the trucking and taxi industry.

Lower gasoline consumption will result in reduced oil imports. Because of the importance of U.S. demand in the world oil market, significant decreases of U.S. demand will result in lower world oil prices. Therefore, gasoline taxes that cause a significant reduction in U.S. oil imports will reduce the cost of the remaining oil imports to the U.S. and other countries.

Gasoline taxes will affect individuals and businesses differently. Low-income automobile users pay a disproportionately large share of their income for gasoline. Gasoline taxes are therefore quite regressive. Many businesses are travel related and will experience reduced activity as a result of less travel. Vehicle sales by the automobile manufacturers will decline if fuel prices increase. Manufacturers will tend to sell smaller vehicles and increase the fuel economy in all vehicles produced. Eventually, as the improved fuel efficiency of new cars causes the cost of driving to return to pre-tax levels, the effect of the gasoline tax on automobile sales dissipates.

The industry most adversely affected by a gasoline tax is the petroleum industry due to lower world oil prices and reduced gasoline and diesel fuel demand. Refiners' profit margins may be reduced as refinery utilization declines and competition for the remaining gasoline market drives wholesale gasoline prices down.

Summary of Effects of Gasoline Tax

Benefits:

- Decreased gasoline demand, reduced oil imports.
- Reduced payments for oil imports lower world oil price.
- Small reduction in oil consumption base in event of a disruption.
- Small reduction in peak price in the event of a disruption.
- Increased Treasury revenue and reduced Federal deficit.

Disadvantages:

- Reduced economic activity.
- Increased unemployment.
- Increased inflation.
- Regressive tax, hurts (low income gasoline users).
- Reduces oil industry revenue and profits (also motor vehicle, travel and other industries).

Benefits of Gasoline Tax

Decreased Gasoline Demand

The estimated reduction of gasoline and diesel fuel demand resulting from a 10¢/gallon and 25¢/gallon gasoline tax imposed on January 1, 1988 is:

Reduced Gasoline and Diesel Fuel Consumption
(Thousand Barrels/Day)

	10¢/Gallon		25¢/Gallon	
	Low Estimate	High Estimate	Low Estimate	High Estimate
1990	160	210	290	490
1995	130	270	220	630

The low estimate is based on the EIA Intermediate Future Forecasting System (IFFS) which estimates the impact of the higher cost of gasoline on vehicle miles of travel. The impact of the tax, under the low estimate, is lower in 1995 from 1990 because the real value of the $0.10/gallon and $0.25/gallon nominal tax will have declined between 1990 and 1995. The high estimate is based on other econometric studies which have estimated the long term impact of gasoline price changes. The high estimate is, like the low estimate, an exponential equation, that changes each year after the tax is imposed to reflect the increased penetration of more fuel efficient vehicles into the fleet. Therefore, the high estimate reflects a larger reduction of demand in 1995 than in 1990. However, much of the increase is mitigated by the declining real value of the tax resulting in a net increase of 29 percent between 1990 and 1995 as compared to a decrease of 24 percent occurring in the low estimate (25¢/gallon tax).

Reduced Payments for Oil Imports

Reduced gasoline demand will cause U.S. oil imports to decrease. The decrease is slightly lower than the reduction in gasoline demand since some domestic production is curtailed and the decreased price of petroleum caused distillate demand to increase slightly. Lower oil imports directly reduce payments for the imported oil which is not purchased and indirectly reduces payments for the imported oil which is still purchased but at a lower price. The world price of oil is lower after the gasoline tax because of reduced U.S. demand for oil in the world market. U.S. demand is such a large component of total world oil demand that when it goes up or down, the world price for oil also goes up or down. In 1990, the 10¢/gallon tax is estimated to reduce the world price of oil by $.21 to $.37 per barrel and the 25¢/gallon tax is estimated to reduce the world price of oil by $.51 to $.94 per barrel.

The effects of the 10¢/gallon and 25¢/gallon motor fuel tax on reduced oil import payments are shown in the following table.

Effects of Gasoline Tax

	1990		1995	
	Low Estimate	High Estimate	Low Estimate	High Estimate
Reduced Oil Imports (Thousand B/D)				
--10¢/Gal. Tax	100	180	80	250
--25¢/Gal. Tax	250	460	200	615
Reduced Expenditures on Oil Not Purchased (Millions of 1985 $)				
--10¢/Gal tax	565	1,020	628	1,960
--25¢/Gal. tax	1,410	2,600	1,570	4,830
Reduced Expenditures on Oil Purchased At Lower World Price (Millions of 1985 $)				
--10¢/Gal Tax	577	993	0	1,850
--25¢/Gal Tax	1,360	2,580	365	4,400

The reduction in oil import expenditures from each effect (oil not purchased and oil purchased at a lower price) is approximately equal. For a 25¢/gallon motor fuel tax we would likely spend between $3 to $5 billion less on oil imports in 1990 and between $2 to $9 billion less in 1995 as a result of both effects.

Benefits if an Oil Supply Disruption Occurs*

Reduced U.S. oil consumption would affect the cost of an oil supply disruption with reduced oil dependency, peak prices reached during a disruption would be lowered. Since economic losses come from price increases, enacting a motor fuel tax tends to reduce potential economic losses in the event a disruption occurs. However, if a gasoline tax lowers world oil prices, oil consumption in the rest of the world may rise as U.S. consumption falls. Higher oil consumption outside the U.S. would offset the effects of reduced U.S. consumption in mitigating the effects of an oil supply disruption. A U.S. gasoline tax, combined with higher consumption outside the U.S., will leave our exposure to disruption consequences little changed, despite a gasoline tax.

*The estimated national security benefits are estimated using the low estimate of reduced oil consumption resulting from a gasoline tax. Use of the high estimate would produce higher estimated national security benefits.

The effect of the gasoline tax on world oil prices during a disruption was estimated by the Energy Information Administration Disruption Impact Simulator. A disruption of world oil supplies in 1995 was assumed which would raise the world price of oil to $70/barrel from base case price of $21.51/barrel.

The estimated security benefit in 1995 resulting from lower world oil prices is extremely small due to the very small impacts on world price that the 10¢/gallon or 25¢/gallon tax is expected to have. The 25¢/gallon gasoline tax will produce only a $50 million security benefit while the 10¢/gallon tax is expected to have no impact on world oil prices in 1995 and therefore provide no security benefit. For all practical purposes, these effects can be regarded as zero compared to the effects of the gasoline tax on GNP, tax revenues and oil payments.

The disruption impact simulator was also used to estimate the benefit to the U.S. during a disruption of having a lower base level of oil imports. This is calculated by estimating the savings in import costs during a disruption with and without a tax. In 1995 a 10¢/gallon tax is estimated to produce a $0.7 billion security benefit and a $1.7 billion benefit from a $25¢/gallon tax.

Lastly, the disruption impact simulater was used to estimate the macroeconomic benefits of entering a disruption with a lower world oil price. However, since the effect of the gasoline tax in the world oil price at the time of a disruption is so slight, the effects on the economy are correspondingly slight. A 10¢/gallon tax produces no macroeconomic benefit due to the fact that the 1995 price was estimated to be unaffected as a result of the tax while the 25¢/gallon tax produces a $0.13 billion increase of GNP during a disruption assumed to occur in 1995.

Impact on the Federal Deficit

A gasoline tax would raise substantial direct revenues based on anticipated consumption levels through 1995. However, the impact of a gasoline tax on the economy, through higher energy costs, reduces other federal revenues. Based on EIA analysis and the DRI model of the U.S. economy, a gasoline tax of 25 cents per gallon could raise revenues of $157 billion and reduce the federal deficit by $93 billion over the period 1988 to 1995. A gasoline tax does not reduce the deficit by the full amount of collections because higher gasoline costs slow the economy and reduce collections from other revenue sources. In addition, federal expenditures indexed to the CPI may rise.

Reduced Economic Activity

The gasoline tax will have significant negative impact on gross national product. For example in the first year of enactment the 10¢/gallon tax is expected to reduce GNP by $10 billion (real 1985 $) and the 25¢/gallon tax would reduce GNP by $23 billion.

The annual GNP loss for 1988-1995 is shown in the following table:

Macroeconomic Loss
(Billion 1985 $)

	10¢/Gallon Tax	25¢/Gallon Tax
1988	9.9	22.8
1989	9.3	21.1
1990	9.0	21.0
1991	8.4	19.8
1992	8.0	18.9
1993	7.5	17.8
1994	7.3	17.2
1995	7.2	16.4

Increased Inflation

Gasoline taxes will increase prices for gasoline and diesel fuel which are a relatively large percentage of total expenditures on all goods and services. Therefore, the increase in gasoline prices will show up in the rate of inflation during the year it is enacted and will continue to cause prices to the higher than they otherwise would have been. Since some of the motor fuel is also used as an input for other economic activity (trucking transportation, etc), the increased price of fuel will also be reflected in higher priced goods and services.

Welfare Loss

A gasoline tax increases the cost of purchasing gasoline. Most of the increased cost to gasoline consumers is a transfer to the government. However, due to the reduced demand for gasoline, some of the increased cost is a welfare loss to consumers related to travel opportunities foregone by not purchasing as much gasoline as they would have without the gasoline tax. This loss is measured as lost consumer surplus. It has been estimated to be as follows:

Welfare Loss

(Billion 1985 $)

	10¢/Gallon Tax	25¢/Gallon Tax
1988	-0.3	-1.7
1989	-0.3	-1.3
1990	-0.3	-1.4
1991	-0.2	-1.2
1992	-0.2	-0.9
1993	-0.1	-0.9
1994	-0.2	-0.9
1995	-0.1	-0.8

Regressivity of Tax

Low income motor fuel users spend a disproportionately high percentage of their disposible income on motor fuel. For example, the average auto-using household with income less than $5000 per year spends about $770/year on motor fuel compared to $1,140/year for an average auto-using household with income of more than $25,000 per year(1984 data).

Reduced Oil Industry Revenue

The domestic oil industry is adversely affected by a motor fuel tax. Reduced demand for motor fuel reduces refiners' gross revenue. In addition, refiners are likely to face reduced profit margins in order to maintain their market share in the face of increased competition for a smaller motor fuel market.

Domestic oil producers will also experience lower revenues because of the lower world oil price caused by the motor fuel tax. Estimates of reduced domestic oil producer revenues are shown in the following table.

Reduced Oil Production Revenues

(Million of 1985 $)

	10¢/Gal. Tax	25¢ Gal./Tax
1990 (Low Estimate)	704	1,710
1990 (High Estimate)	1,240	3,150

Cost Effectiveness of Gasoline Tax in Increasing Energy Security

The gasoline tax is not a cost effective way to increase energy security. As shown in the following table, the costs produced by a gasoline tax are an order of magnitude higher than the benefits. Even if the costs and benefits were estimated with substantial error, the outcome would be no different since the present value of the macroeconomic loss is estimated to over 100 times as high as the estimated energy security benefits.

Total Present Value of Costs and Benefits in 1987*

(Billion 1985 $)

	10¢/Gallon Tax	25¢/Gallon Tax
Costs		
Input cost Savings	+2.3	+5.7
Welfare Loss	-1.1	-6.5
Macroeconomic Loss	-45.5	-105.8
Energy Security Benefit		
Lower Disrupted Oil Price	-0.01	+0.02
Lower Oil Imports	+0.33	+0.81
Macroeconomic Benefits	-0.03	+0.06

*Based on an assumed oil supply disruption in 1995 which raises the world price of oil to $70/barrel from a base case price of $21.51/barrel.

Reference

Energy Information Administration, Draft Service Report, "The Impact of Motor Fuel Taxes Relative to a More Dependent Case," Office of Energy Markets and End Use, February 10, 1987.

PUBLIC COMMENTS AND REFERENCES

BACKGROUND

During the past few months, the Department of Energy has been pleased to receive considerable public input into the formulation of national energy policy. Through a *Federal Register* Notice on October 17, 1986, the Department solicited public comments on the preparation of the biennial *National Energy Policy Plan* in accordance with Title VIII of the Department of Energy Organization Act of 1977. The Department received 50 sets of written comments from state and local government officials, trade associations and industry representatives, public interest groups, university and research organizations, and private citizens. In addition, a series of five public hearings were held in Salina (Kansas), Philadelphia, New Orleans, Chicago, and Sacramento. During the week of November 17 to 21, 1986, 32 people testified at these hearings.

A second *Federal Register* notice two weeks later, on October 31, 1986, solicited comments on a "Study of Crude Oil Production and Refining Capacity in the United States" as required by the Consolidated Omnibus Reconciliation Act of 1986, and the Department received 28 sets of comments.

In addition, DOE received over 250 documents for review as input to the energy security review. The three sets of commenters covered the full range of energy-related issues, offering both broad policy guidance and specific programmatic recommendations. The comments, which do not necessarily reflect the views of the Administration, fell into six broad issue areas which are summarized below.

SUMMARY OF COMMENTS

Oil

Given the recent major shifts in oil prices and the subject of the second *Federal Register* notice, it's not surprising that the most frequent topic for discussion was oil import restrictions. Several respondents acknowledged a potential risk to national security arising from growing dependence on imported oil, although distinctions were made between reliable sources, such as North American and North Sea suppliers, and comparatively unreliable suppliers in the Middle East and North Africa. A growing reliance on insecure oil sources also affects U.S. foreign policy.

Proposals included import fees on crude oil and petroleum products, target prices for imported crude oil, variable oil import license fees, and oil import quotas. Commenters advocating the imposition of oil import fees noted that the increase in revenues could be used to stimulate domestic exploration or reduce the deficit, and that the resultant higher prices would stimulate conservation measures. Those opposing the fee proposals noted the interference with free markets, the increased cost impact on consumers, and the adverse effects as energy-intensive domestic industries were placed in a less competitive position abroad.

Imported goods (such as steel, chemicals, and automobiles) contain embodied energy required in their manufacture. A broad-based energy import fee, which would include the energy content of these goods as well as the crude oil, gas, and petroleum products more generally included in the notion of an energy import fee, was also suggested.

Respondents suggested the repeal of the Windfall Profit Tax, retention of the oil depletion allowances, and the opening of more federal lands for oil and gas exploration and development, including the aggressive continuation of the OCS leasing program. Environmental Protection Agency (EPA) regulatory impediments to oil and gas exploration and production were also mentioned.

Commenters emphasized the need for research and development expenditures in the areas of enhanced oil recovery, carbon dioxide flooding, and shale oil.

Gas

Consistent with the comments received for the fifth *National Energy Policy Plan*, commenters urged decontrol of natural gas. Other natural gas comments included a call to repeal the Fuel Use Act, especially the limitations of gas usage, and the Federal Energy Regulatory Commission (FERC) was urged to address the take-or-pay provisions to ensure that the cost of take-or-pay settlements would not have to be borne entirely by the natural gas pipelines.

Conservation and Renewables

Commenters supported federal funding of residential conservation and energy efficiency programs, especially weatherization programs. The areas most frequently cited for continued research and development funding in the areas of energy conservation and renewable energy sources were photovoltaics, solar, geothermal, ocean thermal, and wind energy, and biomass.

Coal and Electricity

Continued and increased funding for the clean coal technology program was suggested by several commenters, and comments supporting the deregulation of the electric utility industry were presented. Commenters also mentioned the need to expand the present electricity transmission/generation network.

Emergency Preparedness

On the topic of emergency preparedness for an oil supply disruption, the commenters supported the market-based emergency preparedness policy with continued reliance on the Strategic Petroleum Reserve (SPR), encouraging SPR fill while supplies are available at reduced cost.

Nuclear Energy

Responding to the post-Chernobyl prospects for the nuclear power option, interest was expressed both in public information programs to promote the desirability and safety of the nuclear power option and programs to assist industry to evaluate technologies for safer and more efficient nuclear energy. Particular interest was expressed in fusion technology research. Again this year, some commenters urged nuclear licensing reform and the removal of other institutional barriers to revitalize the nuclear industry.

The process of national energy policy development benefits greatly from the wide range of views on energy issues presented by commenters. The Department of Energy appreciates the insights offered and will continue to solicit public comment on national energy policy issues.

Transcripts of the hearings and copies of the comments sent in response to both *Federal Register* notices are available in the Department of Energy's Freedom of Information Office Reading Room in Washington, D.C.

The following is a partial list of publicly available documents used in the preparation of this study.

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American Gas Association, "Energy Analysis: Implications of Falling Crude Oil Prices for the U.S. Natural Gas Industry—1986 Update," Arlington, Virginia (April 18, 1986)

American Gas Association, "Energy Analysis: Historical and Projected Natural Gas Prices—1986 Update," Arlington, Virginia (June 10, 1986)

American Gas Association, "Energy Analysis: Short Term Gas Supply Potential," Arlington, Virginia (September 26, 1986)

American Gas Association, "Economic Analysis: Projected Impacts on the Natural Gas Industry of an Increase in the Federal Gasoline Excise Tax," Arlington, Virginia (May 23, 1986)

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