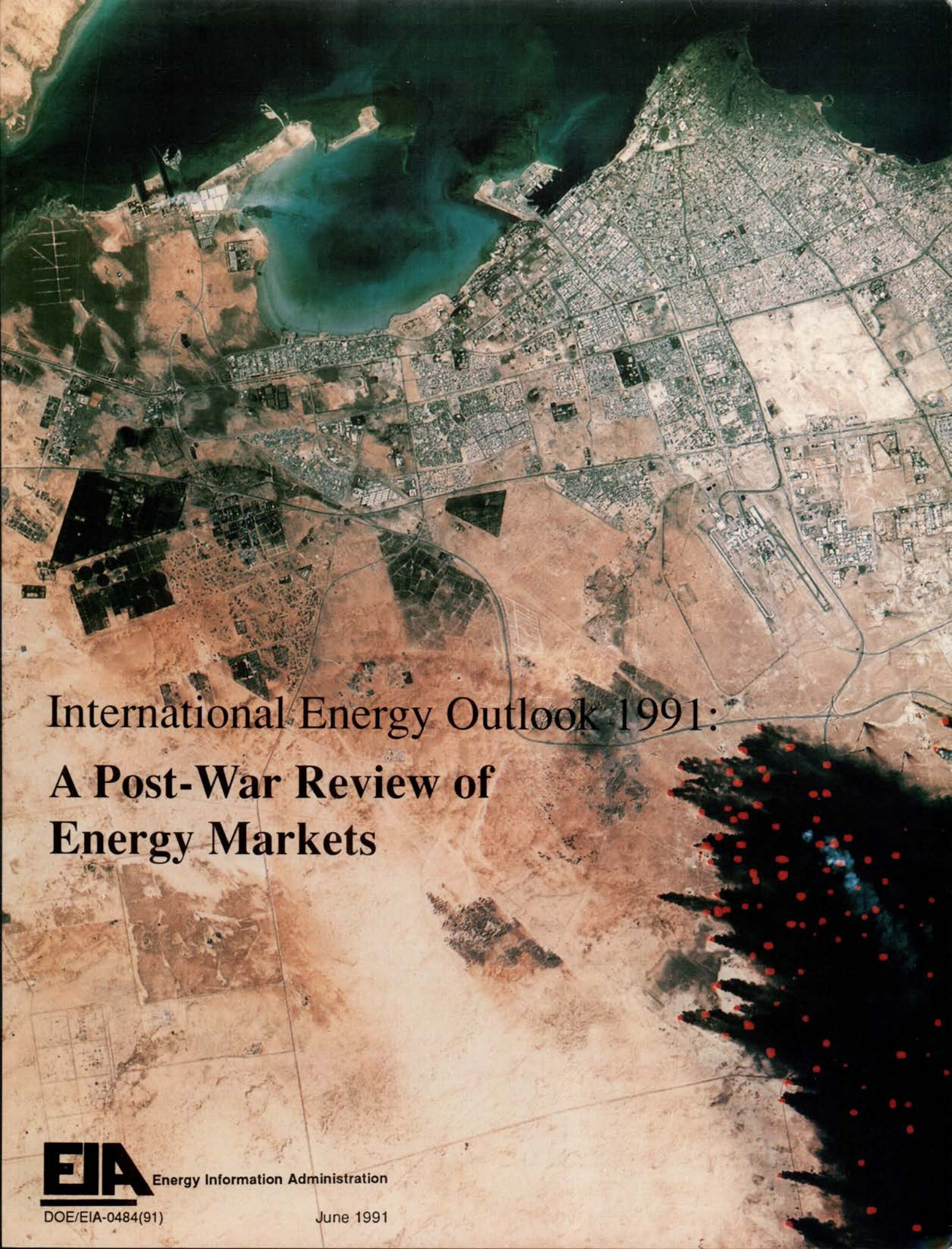

International Energy Outlook 1991:

A Post-War Review of Energy Markets

Energy Information Administration

DOE/EIA-0484(91)

June 1991

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Cover Photo: A Landsat satellite picture of Kuwait City taken on the morning of February 22, 1991. This was taken shortly after Iraqi forces ignited over 500 of Kuwait's oil wells producing unprecedented damage to Kuwait's oil production infrastructure. As of June 1991, about 150 of the well fires have been put out, but Kuwait has still not exported any oil. It is estimated that about 10 percent of the world's proved and probable oil reserves lie inside Kuwait.

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Energy Information Administration
Office of Energy Markets and End Use
U.S. Department of Energy
Washington, DC 20585

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Preface

This report presents the current Energy Information Administration (EIA) assessment of the long-term outlook for international energy markets. The report is provided, as are other EIA reports, as a statistical service for use by managers and international energy analysts and not as a government energy plan. Current United States Government policies and foreign government policies are assumed to hold over the projection interval, which extends to the year 2010.

The Persian Gulf war had a profound impact on world energy markets during the last several months and will continue to influence these markets to some degree in the future, particularly the world oil market. This report pays particular attention to post-war prospects for world oil markets and, as a result, contains domestic energy projections and world oil price projections that differ somewhat from those published in the *Annual Energy Outlook 1991 (AEO)*. These differences are discussed in this report. However, models used to make the domestic projections presented in the *AEO* are used here and incorporate the base world oil price projections presented here. Detailed discussions and projections of U.S. domestic energy markets are provided in the following EIA reports:

Annual Energy Outlook 1991

Annual Outlook for Oil and Gas 1991

Annual Outlook for U.S. Coal 1991

Annual Outlook for U.S. Electric Power 1991

Annual Prospects for World Coal Trade 1991

Commercial Nuclear Power 1991: Prospects for the United States and the World.

Several major EIA estimates determine, in large part, the resulting energy projections presented here. These include estimates of the energy intensity of economic activity; oil and natural gas production capacities; nuclear and hydroelectric generation capacities; international coal trade; and the rate of incremental energy requirements met by alternatives to oil. Uncertainty associated with any set of projections is conveyed here by corresponding projection ranges. Projected uncertainty ranges for world oil prices and energy consumption are derived by altering baseline assumptions concerning economic growth, energy demands, and energy supplies. First, the impacts of the variations are estimated individually. Next, a statistical procedure is used that generates a combined range of uncertainty that is greater than any single impact but less than the impact of all changes taken simultaneously. Projections for the United States in the *Annual Energy Outlook 1991* and for the U.S. projections presented here were prepared using a combination of models referred to as the Intermediate Future Forecasting System, the Gas Analysis Modeling System, and the Demand Evaluation Modeling System (IFFS/GAMS/DEMS). Projections of foreign oil production and consumption, and prices of world oil were prepared using the Oil Market Simulation (OMS) Model. Assumptions about total energy requirements of projected economic growth (energy/GDP ratios) and about marginal changes in the makeup of that total (fuel shares) are incorporated in a spreadsheet entitled World Energy Projection System (WEPS). Assumptions concerning primary electricity requirements (nuclear and hydroelectricity), including generating capacity, capacity utilization factors, and export adjustments, are also included in WEPS. Projections of foreign nuclear power consumption are based on capacity figures in EIA *Commercial Nuclear Power 1990: Prospects for the United States and the World.* Projections of foreign gross domestic product (GDP) are from Wharton Econometric Forecasting Associates *World Economic Outlook* (Philadelphia, PA, January and February 1991). Inquiries concerning the availability of EIA reports and models should be directed to EIA's National Energy Information Center (202/586-8800).

Certain country groupings are used frequently in the report. Former, evolving, and current **Centrally Planned Economies** (CPE's) include Albania, Bulgaria, Cambodia, China, Cuba, Czechoslovakia, East Germany, Hungary, Laos, Mongolia, North Korea, Poland, Romania, the Soviet Union, Vietnam, and Yugoslavia.

The **Organization for Economic Cooperation and Development** (OECD) includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, West Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

The **Organization of Petroleum Exporting Countries** (OPEC) includes Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.

The **Market Economies** consist of all countries other than the CPE countries. The **Developing Countries** consist of all Market Economy countries other than the OECD countries.

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Executive Summary

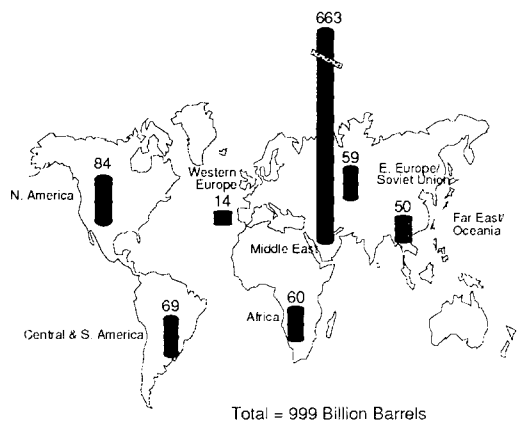
The Persian Gulf war, the major development to affect world energy markets in recent years, is expected to have only a limited effect on long-term world energy trends. Its major impact on oil markets is in the near term, as Iraq and Kuwait proceed with restoration of their oil production capacity. One consequence of the war will likely be a slowdown in economic growth in the Persian Gulf region over the next several years.

The 4.3 million barrels per day of lost production in Iraq and Kuwait eliminated most of the world's excess oil production capacity. Any additional event that threatens to disrupt oil supply, such as a major accident in the North Sea or loss of production and exports from the Soviet Union, could have a much greater near-term market impact than under normal conditions. For this reason, petroleum supply vulnerability will remain a concern until production is restored in both Iraq and Kuwait. The long-term impact will likely be limited, since production in Iraq and Kuwait will return and other countries such as Saudi Arabia can expand capacity and produce the oil needed to meet rising demand.

Restoring production in both Iraq and Kuwait could take several years. So far, however, the damage to production facilities and wells in Iraq appears to be limited. Even in Kuwait, where wells were set on fire, the possibility of long-term damage is probably limited. Though reliable estimates are not yet available, the loss of oil reserves in Kuwait may be as high as 10 percent. However, even this loss would account for only less than 1 percent of total world oil reserves. Because it is unlikely that large volumes of the oil reserves of either country were actually lost, the long-term implications on the world market are not great. While planned increases in productive capacity will likely be delayed significantly, increases are still expected to occur.

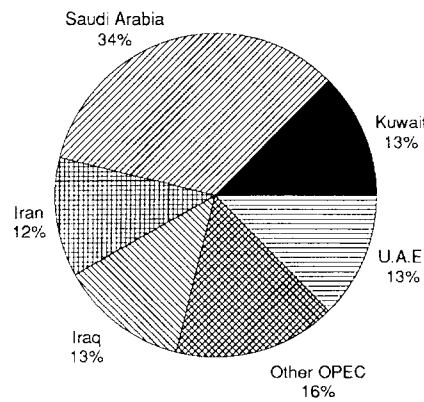
Thus, while it is always difficult to predict the long-term consequences of a major armed conflict, it does not appear at this time that the Persian Gulf war will have a serious long-term impact on the world oil market. Therefore, most of the oil market conditions and trends in supply and demand that existed prior to Iraq's August 2, 1990, invasion of Kuwait are expected to continue for the foreseeable future.

Figure ES1. World Oil Reserves, January 1, 1991 (Billion Barrels)



Total = 999 Billion Barrels

OPEC Proved Oil Reserves



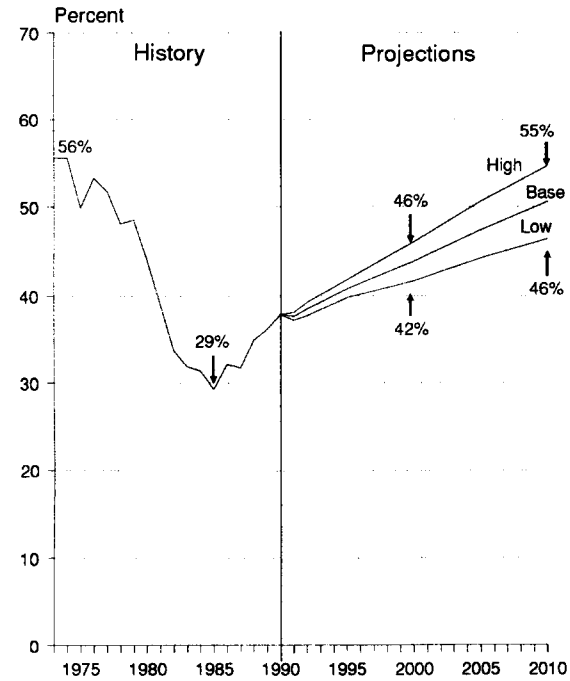
Total = 774 Billion Barrels

Source: *Oil and Gas Journal*, December 31, 1990.

An important oil market trend has been the Western World's increased reliance on oil from the Organization of Petroleum Exporting Countries (OPEC). Unless consuming countries radically change current energy policies, this trend is likely to continue because OPEC members (especially the Persian Gulf members) control the world's largest known oil reserves (Figure ES1). Furthermore, these reserves are relatively inexpensive to develop. Differences in oil well productivity between the Middle East and higher cost areas such as the United States provide a rough measure as to the relative expense of developing oil reserves. For example, prior to the Iraqi invasion, Kuwait produced about 2 million barrels per day of crude oil from about 1,000 oil wells. The United States, in contrast, produced about 7 million barrels per day of crude oil from 600,000 wells. These hard economic realities will continue to induce the Western World to consume Middle East oil.

The expected increase in reliance on OPEC oil is indicated in Figure ES2. As surplus production capacity in OPEC declines, in the next 10 years, increases in price will become necessary to balance demand and supply. Many factors will determine when this happens, including changes in the demand for oil due to economic growth, conservation, and fuel substitution; OPEC productive capacity; and non-OPEC supply, including net exports from the Centrally Planned Economies. Figure ES3 illustrates the price projections consistent with changes in these factors (all prices are expressed in 1990 dollars and represent the average imported refiner acquisition cost in the United States). This year and next, prices are expected to range from $14 to $21 per barrel. Prices are projected to increase to between $17 and $32 in 2000 and to between $23 and $40 in 2010. The Base Case does not represent a most likely case, but simply a representative mid-level case. Sustained prices outside of the projected price range should trigger market forces which will move prices back inside of the range. The low end of the price range is consistent with some combination of aggressive conservation, high non-OPEC production, and vigorous expansion of OPEC capacity. Conversely, the high end of the range is consistent with higher economic growth, less conservation, declines in non-OPEC production, and relatively low expansion of OPEC capacity.

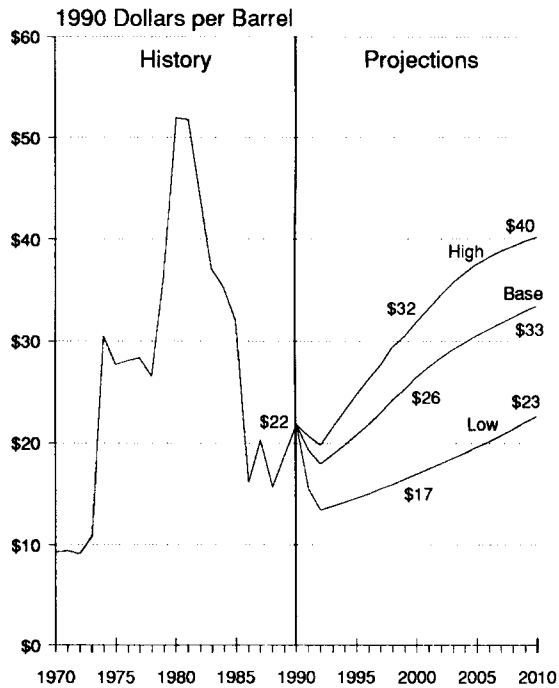
Figure ES2. OPEC Oil Production as a Percentage of World Oil Demand, 1973-2010



Sources: **History:** Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89); and *Annual Energy Review 1989*, DOE/EIA-0384(89).
Projections: Production levels from Table 2 and derived from Table 3 divided by world consumption from Table 2.

In addition to the impact of the Persian Gulf war, the other major area of uncertainty in the world energy market concerns the Soviet Union. The Soviet Union is the world's largest oil producer and second largest oil consumer. At present, it is undergoing tremendous political and economic changes, and the outcome of these events in either the near or the long term is highly uncertain. Therefore, the projections consider a wide range of Soviet oil consumption and production levels. Although the Soviet Union produced about 11.4 million barrels per day in 1990 (followed by the United States at about 8.9 million barrels per day), current estimates of reserves suggest that future production could decline quickly if aggressive drilling programs and oil-field development programs are not undertaken in the near future. With respect to oil consumption, two factors could influence future trends. First, the Soviet Union has vast quantities of natural gas which could,

Figure ES3. Range of World Oil Prices, 1970-2010



Note: All prices are the cost of imported crude oil to United States refineries.

Sources: **History:** Energy Information Administration, *Annual Energy Review 1989*, DOE/EIA-0384(89); and *Monthly Energy Review*, DOE/EIA-0035(91/04).
Projections: Table 1.

with sufficient investments, be used to displace much of current oil use. Second, the relatively low use of oil in the Soviet transportation sector could increase greatly if economic growth expands. The balance between these two opposing factors will determine future demand developments.

Next to the Persian Gulf war and uncertainties concerning energy prospects in the Soviet Union, possibly the most discussed energy issue of the day concerns the relationship among energy use, economic growth, and environmental integrity. The international response to perceived health and environmental issues will affect the long-term level and mix of energy production and consumption. The industrialized nations have already begun to address some of these concerns. Many developing countries will find it difficult to match these efforts, however, because of competing demands for limited resources.

It should be noted that the projections of world oil prices shown in Figure ES3 differ from those used in the *Annual Energy Outlook 1991 (AEO)* published in March 1991. As a result, the energy projections presented here for the United States also differ from those in the *AEO*. The reason for the difference in price assumptions is that prices fell dramatically on January 17, 1991, right after the onset of Operation Desert Storm. Price assumptions for the *AEO* were determined prior to this date. Price projections for the post-war analysis presented here were made after this date.

In the *AEO* Reference Case, world oil prices remain at $24 per barrel from 1991 through 1995. Base Case prices presented here remain below $20 per barrel until 1995, all prices in 1990 dollars. Both price paths converge to $26 per barrel by the year 2000 and follow similar paths through 2010. The impact of these different price paths on U.S. energy projections is primarily on oil production and consumption through 1995. Given higher prices, oil consumption is lower and oil production is higher in the *AEO*, both by about 600,000 barrels per day in 1995. As with prices, oil projections converge by the year 2000.

World Oil Market

Recent Price Developments

The year 1990 was a roller coaster year for crude oil prices. Cold weather in Europe followed by a frigid December 1989 in the United States contributed to strong demand in January, with prices averaging $20.51 per barrel for imported crude oil to U.S. refiners. In comparison, prices averaged $18.08 per barrel in 1989 and $14.56 per barrel in 1986, the year Saudi Arabia abandoned its role as swing producer for the Organization of Petroleum Exporting Countries (OPEC) in order to protect its market share.

In early 1990, however, demand softened due to a return of milder weather, and a slowdown in U.S. economic growth. At the same time, OPEC production escalated. Consequently, world oil prices dropped, to an average of $14.89 per barrel in June 1990.

In need of revenues, particularly after the long and bitter war with Iran, Iraq pressed OPEC members--to the point of moving troops to the Kuwaiti border--to moderate production and to raise prices. Intimidated by the Iraqi action, Kuwait and the United Arab Emirates agreed during the July 1990 OPEC meeting in Geneva to abide with production quotas and to raise, for the first time in 4 years, the OPEC target price from $18 to $21 per barrel. World oil prices proceeded up to $16.45 in July, the first average monthly increase in 1990.

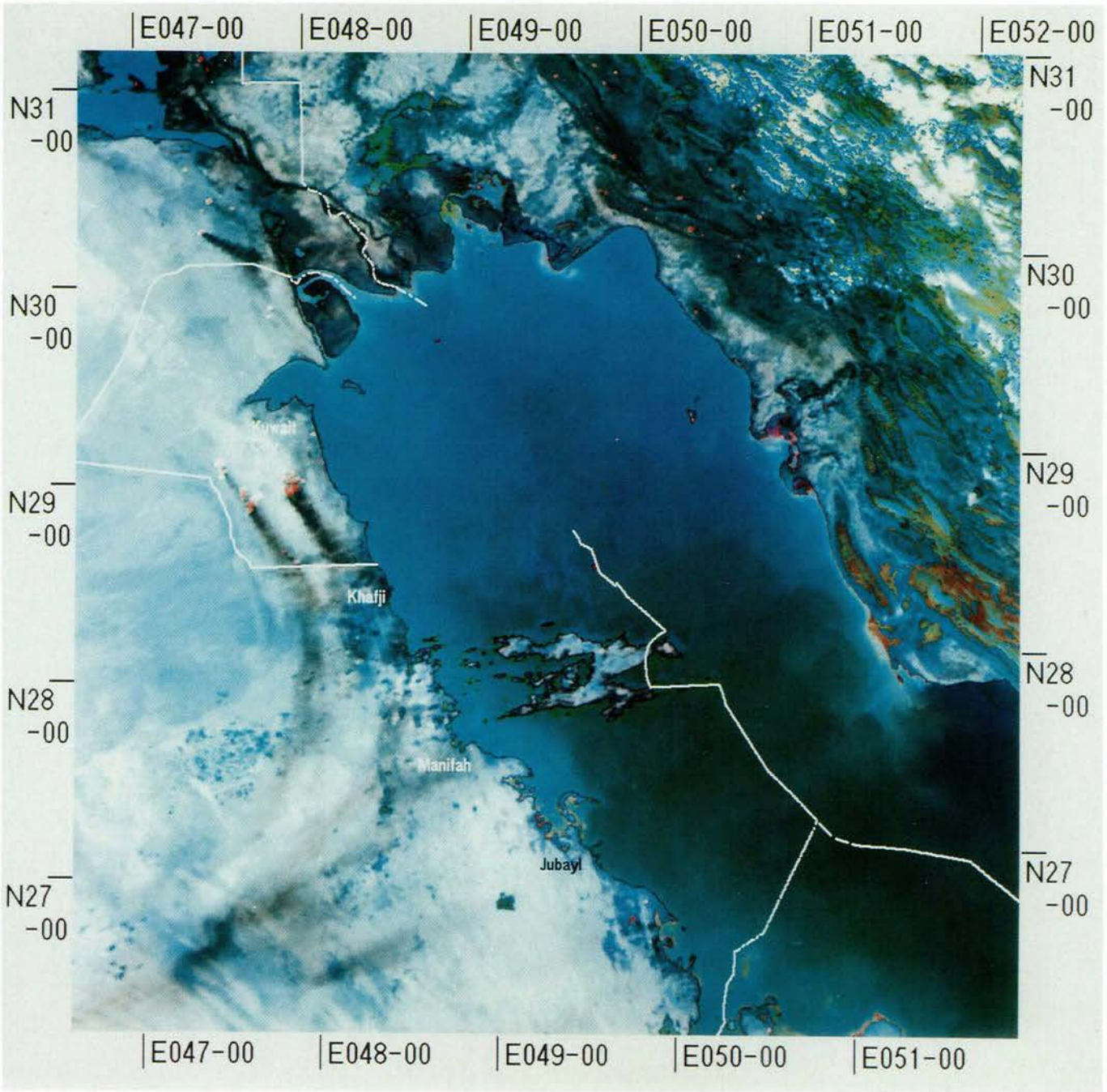
Oil markets changed abruptly on August 2, 1990, with the invasion of Kuwait by Iraq. This action and resulting sanctions on Iraqi oil exports removed about 4.3 million barrels per day from world supplies. World oil prices skyrocketed, and by October 1990 averaged $32.98 per barrel--almost double the July price. On a daily basis, the spot price for West Texas Intermediate crude oil peaked at just over $41 per barrel on October 11, 1990.

World oil markets and oil prices began to calm as it became clear that the loss of oil from Iraq and Kuwait was being made up by added production from other oil exporting countries. By September 1990, increased production from other OPEC members approached 3.5 million barrels per day and from non-OPEC producers exceeded half a million barrels per day. By November, more replacement oil was available to world markets than had been lost originally from Iraq and Kuwait. As a result, oil prices subsided, with the price of West Texas Intermediate dropping to just over $25 per barrel in mid-December.

The price for West Texas Intermediate crude oil drifted up once again through mid-January 1991, to about $32 per barrel, as the oil market fretted over uncertainties surrounding the Middle East crisis. This spot price fell dramatically to about $21 per barrel on January 17, 1991, however, right after the onset of Operation Desert Storm. The success of the military actions taken by the United Nations backed coalition was a major contributor to the decline in oil prices. Also contributing to lower prices during the early months of 1991 were the surplus of commercial stocks worldwide, estimated at 205 million barrels above the average level of the last 4 years, and the action by the International Energy Agency (IEA) to make available emergency oil supplies, including the U.S. Strategic Petroleum Reserve. The IEA response plan called for 2.5 million barrels of oil per day to be made available by participating nations as required to meet market needs.

Impact of the War On Prices

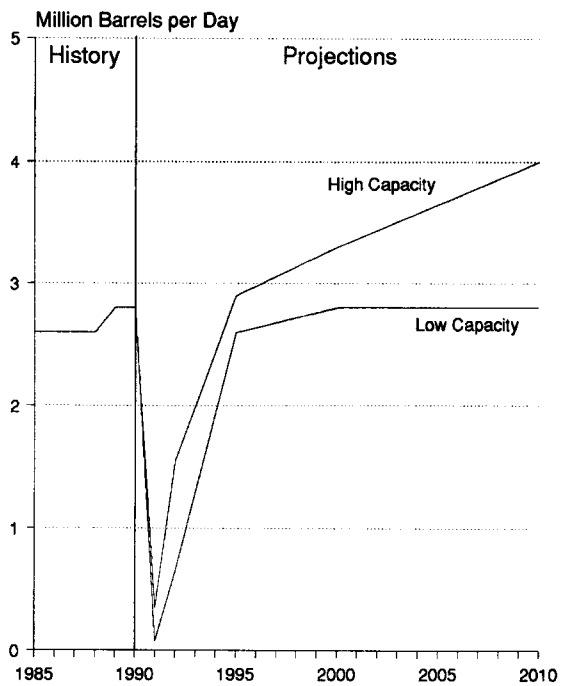
In the short term, world oil prices will be influenced by the willingness of Saudi Arabia to continue producing at increased levels and the pace at which production from Iraq and Kuwait is restored. Prior to the Iraqi invasion, Kuwait produced about 2 million barrels per day of oil. However, Kuwaiti oil production facilities have suffered considerable damage. The only Kuwaiti oil production that is expected to be available immediately is about 100,000 barrels per day from the offshore area of the Neutral Zone (an area on the border between Kuwait and Saudi Arabia). Based on currently available information, no other Kuwaiti production is expected to be on line for at least 6 months to a year after hostilities ended in February 1991. Damage reports have estimated that over 500 wells are on fire in



An infrared Landsat satellite picture taken in the afternoon of February 12, 1991, showing trails of black smoke and red squares of burning oil wells in the Persian Gulf region.

Kuwait, or almost half of the total onshore wells in Kuwait and the Neutral Zone. Preliminary estimates indicate that it could take 2 years or longer to put out these fires and bring the wells under control. Additional drilling may also be needed to restore full production. Kuwaiti export facilities and refineries have also been damaged, and these will have to be repaired or rebuilt to restore Kuwaiti exports to their pre-invasion level. Kuwait has already begun to repair its oil facilities.

Figure 1. Kuwaiti Oil Production Capacity, 1985-2010



Note: Includes production of natural gas liquids and the Kuwaiti share of the Neutral Zone.

Source: **History:** Energy Information Administration, *International Petroleum Statistics Report*, DOE/EIA-0520, selected issues. **Projections:** Energy Information Administration, "Energy Situation Analysis Report," March 4, 1991, and Table 3.

Due to the extensive damage, there is a wide range of uncertainty on the restoration of Kuwaiti production capacity (Figure 1). On the optimistic side, oil exports would begin in September 1991 when production would reach 25 percent of pre-invasion levels, about 500,000 barrels per day. Production would then increase to reach pre-invasion levels by the end of 1992. On the pessimistic side, oil exports would begin in 1992 when production could reach 20 percent of pre-invasion levels, about 400,000 barrels per day. By the end of 1992, production would increase to about half of pre-invasion levels. Full pre-invasion capacity levels are expected to be restored by the mid 1990's. By 2010, Kuwaiti production capacity (including the Kuwaiti portion of the Neutral Zone) is estimated to range between a pre-invasion level of 2.8 million barrels per day up to 4.0 million barrels per day.

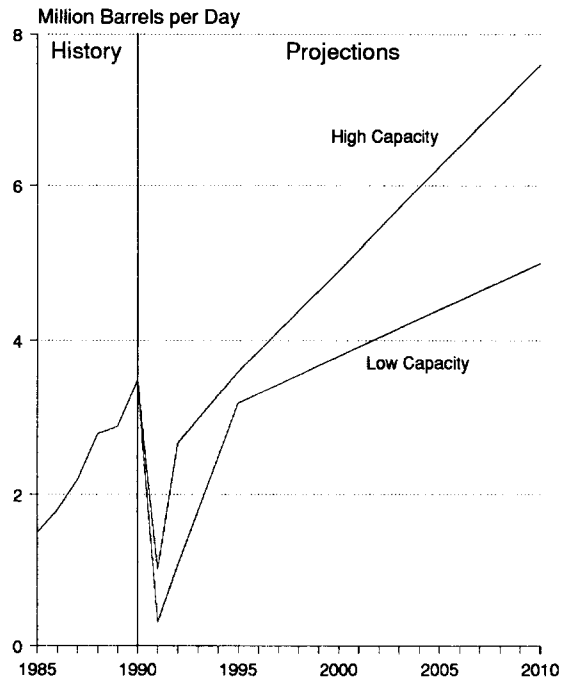
Prior to invading Kuwait, Iraq produced about 3.4 million barrels per day of crude oil. Although much of Iraqi crude oil production and pumping capacity is thought to be intact, most Iraqi exports have to go through two pipelines that run through Saudi Arabia and Turkey. As a result, a return of significant Iraqi oil exports to the world market will depend primarily on political considerations, including the lifting of the United Nations embargo, ability to finance reconstruction, and permission from host countries to use the two export pipelines.

An optimistic forecast sees that Iraqi oil production would increase to about 25 percent of pre-invasion levels beginning in April 1991 or about 850,000 barrels per day (Figure 2). Production would increase to pre-invasion levels by the end of 1992 for this to happen. Iraq would need access to both export pipelines for oil exports by the spring of 1992. In a pessimistic forecast, oil production is assumed to reach 25 percent of pre-invasion levels in January 1992 and then increase to about 40 percent of pre-invasion levels by the end of 1992. This assumes that only one export pipeline is necessary and available through 1992. In either case, Iraqi production capacity should be restored near pre-invasion levels of 3.5 million barrels per day by 1995. By 2010, production capacity is expected to range between 5.0 and 7.6 million barrels per day. These projections assume that Iraq remains a viable political entity and that, eventually, methods are found to finance oil field development projects.

The production profiles for both Kuwait and Iraq are highly uncertain and subject to revision as additional, more detailed information becomes available. However, these profiles are believed to represent the

general range of restoration possibilities. The analysis of these profiles suggests that:

Figure 2. Iraqi Oil Production Capacity, 1985-2010



Note: Includes production of natural gas liquids.
Source: **History:** Energy Information Administration, *International Petroleum Statistics Report*, DOE/EIA-0520, selected issues. **Projections:** Energy Information Administration, "Energy Situation Analysis Report," March 4, 1991, and Table 3.

- World oil prices will likely range between $15 and $22 per barrel through 1992 (in current dollars--unadjusted for inflation). Since these prices represent the imported acquisition cost to U.S. refiners, they are roughly equivalent to West Texas Intermediate prices of between $17 and $24 per barrel. These are annual average prices and therefore it is possible that prices could occur outside of the range on any given day or week. In addition, these projections are based on assumptions about supply and demand in the oil market and do not reflect psychological factors which could influence prices, especially for short periods of time.
- The chance of a sustained price collapse is low.
- Prices on the low side of this range could last through 1992 if restoration of Iraqi and Kuwaiti production is fast and other OPEC countries only partially limit their own production.
- If there is slow restoration of Iraqi and Kuwaiti production, prices could be sustained near the higher end of the range through 1992 even if other OPEC countries continue production near current levels.

Long-Term Price Trends

The long-term impact of the war on world oil markets and, therefore, on world oil prices is expected to be limited, because other countries such as Saudi Arabia can easily expand production capacity to make up any shortfalls from Iraq and Kuwait. Saudi Arabia has already announced plans to expand its production capacity from 8.5 million barrels per day in 1990, to 10 million barrels per day by 1995. In addition, Kuwait and Iraq are still expected to increase their production capacity in the future, although these increases will be delayed from their earlier plans. As a result, except for the near-term restoration of capacity in Iraq and Kuwait, most of the trends that existed prior to the August 2, 1990, invasion of Kuwait are expected to continue for the foreseeable future.

Beyond the mid-1990's, prices are expected to rise (Table 1). Non-OPEC production is expected to peak and level off by the end of the decade, while production in the United States continues to decline (Table 2). At the same time, world oil demand is expected to keep growing in response to the relatively low world oil prices of the last few years. Even with a firming of world oil prices over the next few years, prices would still be low compared with historical levels since the early 1970's. Based on past experience with price swings and the recent increases in demand, there is reason to believe that the relatively low prices expected through the mid-1990's will result in demand increases that could cause prices to rise yet again in the late 1990's.

These demand increases are expected to outweigh increases in production from non-OPEC sources, resulting in increased reliance on OPEC oil in the future. This increased reliance, which began in 1987, is expected to continue because OPEC countries contain most of the world's known oil reserves, and are relatively inexpensive to develop. Two-thirds of the world's known oil reserves are concentrated in the Persian Gulf.

The degree to which oil prices will rise depends largely on OPEC's behavior. Market share and revenue goals, as well as political and security considerations, will influence OPEC's production and capacity decisions. The most likely course is that the pressure to earn more revenue, along with the desire to gain leverage in OPEC's production decision-making process, will encourage OPEC member nations to expand their production capacities in the future. Saudi Arabia's announcement that it will expand production capacity to over 10 million barrels per day in the near future was heavily influenced by its desire to become the undisputed leader in making future OPEC decisions. Continued capacity expansion should moderate increases in oil prices in the future.

Growing Importance of Persian Gulf Oil

The events of last year stand as testimony to the world's political commitment to maintain stability in the Middle East. With respect to oil supply, an outcome of this commitment could be a longer period of both price and export stability than experienced during the upheavals of the last two decades. A stable Middle East, especially the Persian Gulf region, is important, given that two-thirds of world oil resources are located in the Persian Gulf and given the growing dependence on those resources to continue economic growth, to support a growing population, and to raise standards of living. Despite the pursuit of goals to conserve energy and protect the environment, Persian Gulf oil will continue to be the leading source of energy supply well into the 21st century.

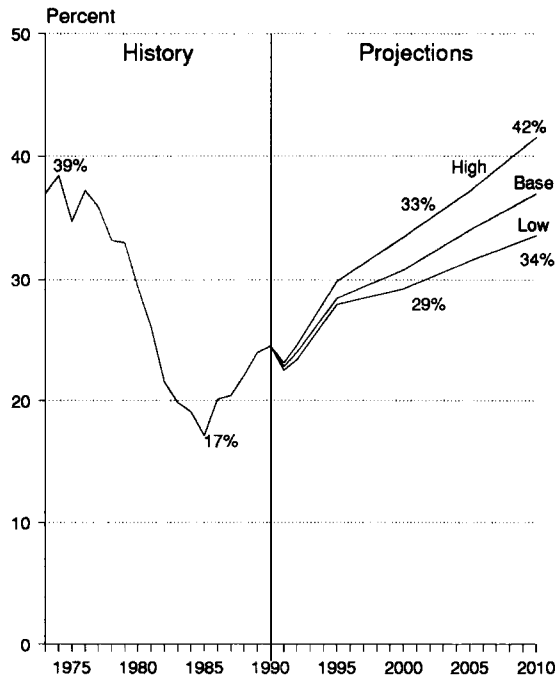
Even though Persian Gulf oil is becoming more and more important, vulnerability to short-lived disruptions may not be growing. Vulnerability to a supply disruption is not simply a matter of dependence on a particular supply source. Neither is it simply a regional concept. Oil supply vulnerability is a world concept due to a general linkage of world economies and the competition for remaining supplies. Vulnerability, therefore, can be defined as a combination of the likelihood of a disruption, global dependence on the supply source, the proportion of oil consumption per unit of gross domestic product (GDP), and the availability of oil supply-disruption offsets such as excess oil production capacity and petroleum stocks.

The likelihood of another disruption occurring in the Persian Gulf region in the near future has theoretically been reduced by the demise of Iraq's military might. Global dependence on the Persian Gulf for oil supplies, however, is increasing at a fast rate. In 1989, the Persian Gulf supplied almost one-fourth of the world's oil. By 2010, dependence could increase to 40 percent (Figure 3). At this rate, petroleum exports from the region would nearly double to over 22 to 29 million barrels per day, approximately 1 to 8 million barrels per day above the historic high in 1977 of 21 million barrels per day. The expansion of export pipeline facilities over the last several years and planned additions in the future would mean that flows through the Strait of Hormuz may be similar to those in the late 1970's.

Dependence on Persian Gulf oil varies considerably by region. In 1989, the United States imported over 10 percent from the Persian Gulf; Western Europe, 30 percent; and Japan, 65 percent. While dependence is increasing in volumetric terms, economic dependence in terms of oil per unit of GDP is forecast to be about even--that is, expected world economic growth is about the same as expected increases of Persian Gulf oil production.

For all practical purposes, vulnerability may be viewed as either increasing or decreasing depending on the growth of world petroleum stocks relative to consumption. This is measured by the number of days of supply covered by stock levels. At the end of 1990, the world had approximately 100 days of supply, with a world stock level of 5.6 billion barrels, of which about 1 billion barrels were government-controlled strategic stocks. In order to maintain this same level of days coverage in the future, world stocks would have to grow by 1 billion barrels (50

Figure 3. Persian Gulf Oil Production as a Percentage of World Oil Demand, 1973-2010



Sources: **History:** Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89); and *Annual Energy Review 1989*, DOE/EIA-0384(89). **Projections**: Production levels from Table 2 and derived from Table 3 divided by world consumption from Table 2.

million barrels per year) based on consumption increases anticipated over the next 20 years.

Assuming commercial stock levels are not reduced over the next decade (as has sometimes occurred in the past), the U.S. program to expand the U.S. Strategic Petroleum Reserve to between 750 million and 1 billion barrels (from the current level of 570 million barrels) would help maintain a sufficient stock cushion. By preserving the current status of petroleum supply vulnerability, this would prevent an increase in vulnerably as the world grows more and more dependent on the Persian Gulf.

Long-Term OPEC Capacity

Nearly all producing countries inside and outside of OPEC expanded production to offset the loss of oil due to the Iraqi invasion of Kuwait and the subsequent economic embargo. As a consequence, several OPEC countries, notably Saudi Arabia, have accelerated and raised their pre-invasion long-term plans to expand sustainable production capacity to meet a growing demand for oil (Table 3).

Following the short-term revenue gains achieved in response to replacement of lost Iraqi and Kuwaiti oil, several OPEC countries are now in a position to institute expansion plans. The long-term future of the world oil market now appears more profitable than envisioned following the price collapse of a few years ago. Joint ventures and downstream relationships will be instrumental characteristics of this future. Two important facts affecting OPEC's future in this evolution are:

- OPEC has three-quarters of the world's proved oil reserves with a high probability of much more left to be discovered.
- Reserves and production capacity outside of OPEC are declining.

The question is how fast will the demand for OPEC's oil grow? As long as world oil prices are below a sustained price of $30 to $40 per barrel, which would make many alternatives to oil uneconomical, OPEC may regain its position of the seventies. Demand for OPEC oil could grow between 1.5 and 2.0 percent per year, or between 10 and 15 million barrels per day by 2010 (and increasing beyond). That is likely as long as OPEC expands capacity to the level needed to maintain a reasonable level of excess capacity to meet unforeseen contingencies and maintain prices below replacement supply costs.

The major players in future oil market developments are the countries holding the largest reserves. Overall, the end-of-1990 OPEC reserve levels are the equivalent of about 95 years of crude oil production at current production rates, compared with 10 years for the United States, 13 for the North Sea, and 14 for the Soviet Union. OPEC countries have recently made significant upward revisions. In 1988, OPEC increased proved reserves by almost 200 billion

barrels and, in 1989, by another 100 billion barrels. The United States by contrast has slightly over 25 billion barrels of proved reserves. These revisions by OPEC over the last 2 years exceed the cumulative demand for their oil over the next 20 years. Even at the high production rates forecast, OPEC would have nearly 40 years of proved reserves still remaining in 2010.

As the world becomes more dependent on OPEC, OPEC's gross revenue will also grow, but not all OPEC countries face the same prospects for production and revenues in the future. Several OPEC countries may even become net oil importers (Ecuador, Gabon, Indonesia); several will have to invest in enhanced oil recovery methods (Algeria, Libya, Nigeria); and several will have to expand their export distribution capability (Saudi Arabia, Iraq, Venezuela).

Non - OPEC Production Potential

Non-OPEC production (excluding former Centrally Planned Economies) steadily increased until the mid to late 1980's when it reached a plateau of about 27 million barrels per day. This leveling off was largely the result of a series of accidents in the North Sea and a decline in U.S. production--which was accelerated by the collapse of world oil prices in 1986--offsetting production increases elsewhere. The decline in world oil prices led to the abandonment of many smaller wells in the United States and the deferring of exploration, development, and production programs worldwide. Exploratory drilling was affected more than developmental drilling by the drop in prices, because the cost of developing proved reserves and the rate of return on these investments involve less uncertainty and risk than does exploratory drilling. However, developmental programs were affected as well, and the effects of those deferrals are being felt now by delays in capacity addition in areas such as the United Kingdom's section of the North Sea.

The decline in U.S. production is expected to continue now that production in the Prudhoe Bay field in Alaska has peaked and companies have shifted a portion of their investment away from drilling in the United States to foreign areas. The pattern of general decline was broken briefly during the latter part of 1990 in response to events in the Middle East, with a rise in Alaskan production playing an important role. However, the decline is expected to resume, and most incremental supplies from new production projects are not expected from northern Alaska before the year 2000. In general, the cost of production in the United States is higher than elsewhere due to the size and age of its oil fields; most of the large oil fields have most likely been found, and the remaining smaller fields are not as easy to find or as attractive to develop as oil fields overseas. Development expenditures for oil production capacity in the United States for major American energy companies averaged $36,800 for each barrel of daily production capacity added between 1987 and 1989. These costs for American companies was $6,000 per barrel for capacity added in the Middle East and $11,100 per barrel for capacity added in other Eastern Hemisphere countries. In addition, environmental restrictions that affect leasing of U.S. offshore regions are expected to reduce potential production.

In the mid-1990's, non-OPEC production is expected to resume increasing as production gains in the North Sea, Syria, Yemen, Latin America, and other regions more than offset expected declines in U.S. production. The largest increases are expected from the North Sea, where production in the United Kingdom and Norway are each expected to increase by about half a million barrels per day. Production increases are expected from development programs that were deferred during the 1986 price collapse, from recent large discoveries, and from condensate rich gas fields in the area.

Additional production is expected during the mid-1990's from new discoveries in frontier areas where exploration is relatively new. For some of these regions, new discoveries are needed to offset declining production from more mature fields in other parts of the country. Australia, Egypt, India, Malaysia, and Oman are all expected to add capacity from currently non-producing frontier areas to offset declines elsewhere. Other areas, particularly Syria, Yemen, and later Papua-New Guinea, are expected to expand production capacity significantly as new fields are found and developed. Angola, Brazil, Colombia, and Mexico should also increase their production.

By the end of the decade, non-OPEC production should level off and begin a slow decline as decreased production from mature fields, particularly in the North Sea, offsets new discoveries. New discoveries

are expected to make smaller contributions, because most of the larger fields will have been found and fewer opportunities will exist to extend already discovered fields. Opportunities in most non-OPEC areas are expected to decline, with the exception of North America. Production in Canada and Mexico should slowly increase, and additional incremental supplies from new production projects in Alaska should slow the decline in the United States.

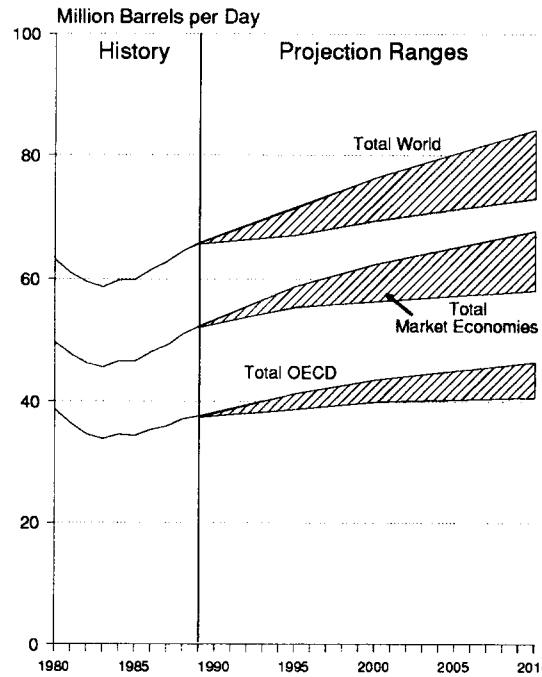
World Oil Consumption Trends

The demand for oil is expected to grow steadily in response to economic growth worldwide, and in response to world oil price changes (Figure 4 and Table 4). Oil consumption in the Market Economies, which accounted for over 80 percent of the oil consumed worldwide in 1990, will influence oil consumption trends in the future. Consumption in the Market Economies is expected to increase by about 1 percent a year over the projection period, while oil consumption in Eastern Europe and the Soviet Union is expected to grow more slowly at half a percent per year, as their economies struggle with the attempt to change to more market-oriented systems.

Oil consumption is expected to grow most rapidly in the developing countries. Consumption in these countries will be spurred by more rapid growth in economic activity relative to the OECD and CPE countries, particularly among the newly industrialized countries. Gross domestic product is expected to grow by over 4 percent per year in these countries, compared with OECD growth rates of around 2.8 percent.

Oil consumption in developing countries has been less responsive to changes in world oil prices, increasing steadily through the two price shocks of the 1970's. Consumers in the oil exporting developing countries, including OPEC, have been protected from much of the change in the price of oil sold on the world oil market. Many of the oil importing developing countries have not had the investment capital to shift from oil when prices rose. Oil consumption in the developing countries will continue to grow rapidly, particularly in the near term when prices are expected to remain relatively low.

Figure 4. World Oil Consumption, 1980-2010



Source: History: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89). Projections: Table 4.

Trends in Refining Capacity

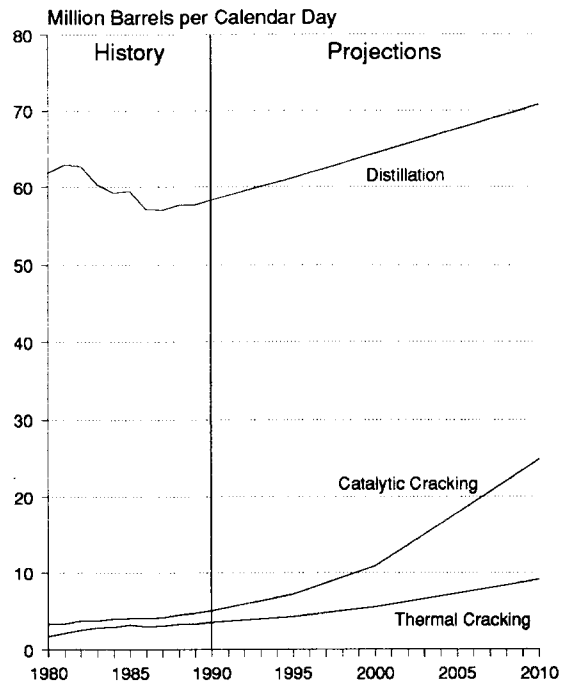
A general expansion in the world economy, an increasing preference for lighter petroleum products, and a growing concern for the environment are expected to lead to increased investment in refining operations. Based on forecasts for oil production, distillation and downstream capacity will have to be added at rates comparable to, if not greater than, rates in the late 1980's.

In the early 1980's, refining capacity declined following a decrease in petroleum consumption. With the Iranian revolution in 1979, crude oil prices increased, thereby depressing oil consumption. The price collapse of 1986 led to an increase in petroleum consumption and a rebound in refining capacity. In 1990, foreign refining capacity (including that in the CPE's) reached 58.3 million barrels per day, a level

last achieved in 1985 (Figure 5). This translates into an average annual growth rate of 0.5 percent since 1986. By comparison, U.S. refining capacity has remained fairly steady since 1985 after losing a half million barrels per day capacity between 1984 and 1985. In 1990, U.S. refining capacity was 15.6 million barrels per day.

Since 1975, world consumption of light products has increased (Figure 6). Though the foreign consumption share of light products has yet to match U.S. patterns, light products as a percent of total petroleum consumption have increased from 68.6 percent in 1975 to 76.5 percent in 1988. To meet the higher demand for gasoline, distillate, and jet fuel, foreign refiners have installed 4.3 percent more thermal cracking and 5.4 percent more catalytic cracking capacity annually since 1986.

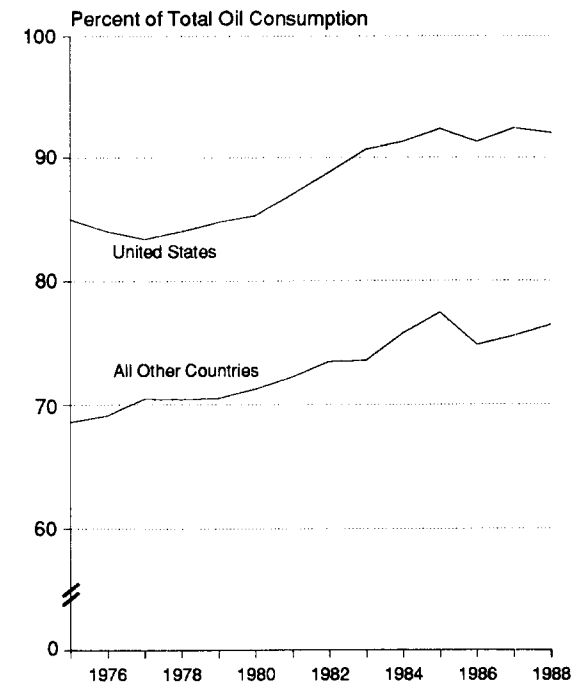
Figure 5. Foreign Refining Capacity, 1980-2010



Source: **History:** Energy Information Administration, *International Energy Annual*, DOE/EIA-0219, selected issues. **Projections:** Derived from Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89); *Petroleum Supply Annual*, DOE/EIA-0340(90)/1; AEO1991 Forecasting System Run IEO91F.D0501913; and Table 2.

To meet the expected increase in demand, foreign distillation capacity will have to increase almost one percent annually over the next 20 years, assuming the utilization rate remains near 88 percent. To achieve the current technical sophistication of U.S. refineries, thermal cracking capacity will have to be added at the same rate it was added between 1986 and 1990, while catalytic cracking capacity will have to be added at a rate one and a half times its rate between the same years. Some of the refining capacity could come from reactivations of shut-in capacity in the Caribbean. In the last several years, a number of Caribbean refineries have been reactivated because of their proximity to the U.S. East Coast. In addition, new refineries are likely to be constructed in Third World nations where a considerable increase in petroleum demand is expected.

Figure 6. World Light Petroleum Products Consumption, 1975-1988



Sources: Energy Information Administration, *International Energy Annual*, DOE/EIA-0219, selected issues; and predecessor publications.

Another concern for refiners is the production of fuels to new specifications aimed at reducing air pollution. In the United States, the sweeping changes in the Clean Air Act Amendments of 1990 require the

addition of oxygenates (to promote efficient burning) and the limitation of the benzene content (a known carcinogen) in gasoline in certain non-attainment areas. In the same body of legislation, diesel fuel is limited to a sulfur content of 0.05 percent sulfur and a 40 cetane level. Both of these regulations are aimed at reducing particulate matter emissions. Earlier versions of the Clean Air Act allow the U.S. Environmental Protection Agency to limit the lead content and the Reid Vapor Pressure (RVP) of gasoline. The RVP limit reduces evaporative emissions.

Canada has had unleaded gasoline since 1979 and has already limited RVP. Diesel desulfurization will occur by 1994, the same year as the United States. Western Europe is slowly phasing out leaded gasoline, requiring all new cars to operate on unleaded gasoline by 1992. RVP and diesel fuel sulfur limits are also being considered. In Mexico City, unleaded vehicles are being introduced. The Japanese government is paying refiners to build capacity to produce unleaded gasoline and reduced sulfur diesel fuel.

These initiatives will require the construction of downstream processing units. Many refiners are turning to methyl tertiary butyl ether (MTBE) as a way to increase the octane number of gasoline, while raising the oxygen content and limiting RVP. To reduce benzene, refiners may have to install units that either change the benzene molecular structure or extract the benzene altogether. Reducing the sulfur content of diesel fuel will require increased hydrotreating capacity.

These modifications may necessitate other adjustments to refinery operations such as the addition of plants to produce hydrogen for the saturation of sulfur, benzene, and other aromatics compounds plus isomerization units to produce a feedstock for MTBE. More sulfur plants to generate elemental sulfur from hydrogen sulfide may also be required.

Although costs vary from nation to nation, refining capacity is relatively expensive. A new complex refinery planned for Valdez, Alaska, is estimated to cost close to $6,000 per barrel of charge capacity. As reported in the *Oil and Gas Journal* (April 16, 1990), a hydrotreater planned for the United Kingdom is expected to cost $43 million, and an MTBE plant planned for Venezuela and a hydrogen plant planned for West Germany are expected to cost $25 and $21 million, respectively. An 18,000 barrels per day MTBE plant, one of the world's largest, planned for Saudi Arabia could cost even more.

Construction of these complex processing units can be time consuming. For example, the MTBE plant in Venezuela is expected to take two years from the engineering design phase to completion.

At the same time that refiners are modifying operations to meet changing demand patterns and new fuel specifications, refiners are also reducing site pollution to meet environmental regulations. In the future, a number of nations are expected to adopt regulations similar to U.S. regulations which affect air and waste water emissions and the disposal of solid wastes such as hazardous catalysts. In an extreme measure, the Mexican government recently ordered the closure of a refinery to reduce air pollution in Mexico City. Refiners may also face higher transportation costs as more nations require double-hulled vessels.

Table 1. World Oil Prices, 1979-2010
(1990 Dollars per Barrel)

Year	Price Cases		
	Low	Base	High
1979		$36.23	
1980		51.96	
1981		51.79	
1982		44.08	
1983		37.06	
1984		35.24	
1985		31.98	
1986		16.17	
1987		20.29	
1988		15.77	
1989		18.81	
1990		21.78	
1991	$15.40	17.60	$20.60
1992	14.10	18.80	20.60
1993	14.50	18.90	22.20
1994	14.90	19.80	23.70
1995	15.30	20.80	25.20
1996	15.70	21.80	26.70
1997	16.10	22.90	28.10
1998	16.50	24.00	29.50
1999	16.90	25.20	30.70
2000	17.40	26.40	31.80
2001	17.80	27.40	32.90
2002	18.30	28.30	34.00
2003	18.80	29.10	35.00
2004	19.30	29.80	36.00
2005	19.80	30.50	36.90
2006	20.30	31.10	37.70
2007	20.90	31.70	38.50
2008	21.40	32.30	39.20
2009	22.00	32.90	39.80
2010	22.60	33.40	40.20

Note: Prices represent the U.S. refiner acquisition cost of imported crude oil.
Source: **History**: Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(91/04) (1991).
Projections: Energy Information Administration, *Oil Market Simulation Model User's Manual* DOE/EIA-MO28(91) (1991).

Table 2. World Oil Consumption and Production: Base Case, 1988-2010
(Million Barrels per Day)

Supply and Disposition	History			Projections		
	1988	1989	Preliminary 1990	1995	2000	2010
Market Economies						
Production						
United States[a]	10.47	9.88	9.60	8.6	7.9	7.2
Canada	2.04	2.03	1.98	2.1	2.2	2.2
OECD Europe	4.48	4.41	4.50	5.4	5.1	3.9
OPEC	21.85	23.83	24.92	28.7	32.3	39.8
Other Countries[b]	10.06	10.33	10.76	11.6	11.6	10.4
Net CPE Exports	2.17	1.83	1.87	0.8	0.2	-0.6
Total	51.08	52.31	53.62	57.2	59.4	62.9
Consumption						
United States[a]	17.28	17.33	16.92	17.9	18.6	20.5
U.S. Territories	0.19	0.19	0.20	0.2	0.2	0.2
Canada	1.69	1.76	1.73	1.9	2.0	2.1
Japan	4.75	4.98	5.23	6.0	6.4	6.3
Australia and New Zealand	0.75	0.78	0.81	0.9	0.9	1.0
OECD Europe	12.43	12.56	12.67	13.6	13.8	13.7
Other Market Economies	13.90	14.70	15.40	16.9	17.8	19.4
Total	50.99	52.31	53.00	57.5	59.7	63.2
Discrepancy[c]	-0.08	-0.01	-0.67	0.3	0.3	0.3
Centrally Planned Economies (CPE)						
Production						
China	2.73	2.76	2.77	2.9	3.1	3.7
Soviet Union	12.50	12.14	11.43	9.6	9.9	10.2
Other	0.44	0.43	0.43	0.5	0.6	0.9
Total	15.67	15.33	14.63	12.9	13.6	14.8
Consumption						
China	2.15	2.28	2.31	2.7	3.3	4.1
Soviet Union	8.89	8.80	8.23	7.2	7.6	8.9
Other	2.47	2.42	2.23	2.3	2.6	2.5
Total	13.51	13.49	12.77	12.1	13.4	15.4
World Oil Consumption	64.50	65.80	65.77	69.7	73.2	78.7

[a]Includes the 50 States and the District of Columbia.
[b]Including Australia, New Zealand, and the U.S. Territories.
[c]Includes net stock withdrawals.
OECD=Organization for Economic Cooperation and Development.
OPEC=Organization of Petroleum Exporting Countries.
Notes: Production includes crude oil, natural gas liquids, refinery gains, hydrogen, and other hydrocarbons. Totals may not equal sum of components because of independent rounding.
Sources: **History**: Energy Information Administration, *International Energy Annual 1989, DOE/EIA-0219(89) (1991) and Monthly Energy Review*, DOE/EIA-0035(91/04)(1991); **Projections**: Energy Information Administration, *Oil Market Simulation Model User's Manual* DOE/EIA-MO28(91) (1991); and AEO 1991 Forecasting System run IEO91F.D0501913.

Table 3. Oil Production Capacity Assumptions, 1988-2010
(Million Barrels per Day)

Region/Country	1988	1989	Estimated 1990	Projection Ranges 1995 Low	1995 High	2000 Low	2000 High	2010 Low	2010 High
Non-OPEC									
United States	10.6	10.1	9.7	8.6	9.9	7.4	8.7	6.0	8.0
Canada	2.0	2.0	2.0	2.0	2.2	2.0	2.4	2.0	2.6
Mexico	2.9	3.0	3.0	2.8	3.2	2.9	3.5	3.2	3.6
North Sea	3.9	4.0	4.2	4.5	5.2	4.1	4.9	3.0	3.9
Other Non-OPEC	8.1	8.3	8.4	8.3	9.6	8.1	9.6	6.8	8.9
Total	27.5	27.4	27.3	27.2	29.2	25.8	28.0	22.7	25.8
OPEC									
Algeria	1.2	1.3	1.4	1.4	1.5	1.4	1.7	1.4	2.1
Ecuador	0.3	0.3	0.3	0.3	0.4	0.2	0.3	0.1	0.1
Gabon	0.2	0.2	0.3	0.2	0.3	0.1	0.1	0.0	0.0
Indonesia	1.5	1.5	1.5	1.5	1.7	1.5	2.0	0.7	1.0
Iran	3.0	3.0	3.2	3.2	3.5	3.2	4.0	3.3	5.0
Iraq[a]	2.8	2.9	3.5	3.2	3.6	3.8	4.9	5.0	7.6
Kuwait[a, b]	2.6	2.8	2.8	2.6	2.9	2.8	3.3	2.8	4.0
Libya	1.6	1.7	1.6	1.6	1.7	1.6	1.9	1.6	2.3
Nigeria	1.8	1.8	1.8	1.8	1.9	1.8	2.1	1.8	2.5
Qatar	0.5	0.5	0.5	0.5	0.6	0.5	0.6	0.5	0.7
Saudi Arabia[b]	8.0	8.8	8.5	9.2	10.7	10.2	13.1	11.0	16.8
United Arab Emirates	2.1	2.1	2.5	2.5	2.8	2.7	3.5	3.3	5.0
Venezuela	2.5	2.6	2.6	2.6	3.0	2.9	3.7	3.5	5.3
Persian Gulf	19.0	20.1	20.9	21.9	23.4	24.3	27.8	28.9	35.8
Total	28.1	29.5	30.4	31.5	33.1	34.7	38.3	39.9	47.1
Net CPE Exports.	2.2	1.8	1.9	0.3	1.2	-0.2	0.5	-1.4	0.2
Total Market Economies	57.8	58.7	59.5	60.0	62.7	61.4	65.7	63.1	71.2
Centrally Planned Economies									
China	2.7	2.8	2.8	2.8	3.0	2.8	3.4	3.2	4.2
Soviet Union	12.5	12.1	11.4	8.6	10.6	8.8	11.0	8.4	12.0
Other	0.4	0.4	0.4	0.3	0.5	0.5	0.7	0.8	1.0
Total	15.6	15.3	14.6	11.9	13.9	12.5	14.7	12.9	16.7
World Total	71.3	72.2	72.3	71.8	75.1	74.5	79.4	78.1	86.9

[a]1990 estimate is pre-Iraqi invasion capacity.
[b]Includes 50 percent of Neutral Zone capacity.
OPEC = Organization of Petroleum Exporting Countries.
Notes: Capacity is defined as maximum sustainable production capacity adjusted to reflect current operable capacity in selected countries. Production includes crude oil, natural gas liquids, refinery gains, hydrogen, and other hydrocarbons. All uncertainty ranges are derived independently and do not necessarily equal totals.
Source: Energy Information Administration, Office of Energy Markets and End Use, World Energy Projection System Spreadsheet, July 1991.

Table 4. World Oil Consumption, 1988-2010
(Million Barrels per Day)

Region/Country	History		Projection Ranges								
			1995			2000			2010		
	1988	1989	Base	Low	High	Base	Low	High	Base	Low	High
OECD											
United States[a]	17.3	17.3	17.9	16.6	17.9	18.6	17.6	19.1	20.5	18.9	21.8
Canada	1.7	1.8	1.9	1.7	2.1	2.0	1.6	2.4	2.1	1.5	2.6
Japan	4.8	5.0	6.0	5.4	6.5	6.4	5.2	7.2	6.3	4.8	7.7
Europe	12.4	12.6	13.6	12.8	14.1	13.8	12.6	15.0	13.7	11.9	15.4
United Kingdom	1.7	1.8	1.9	1.7	2.1	1.9	1.5	2.3	1.9	1.4	2.5
France	1.8	1.9	2.0	1.8	2.2	2.0	1.6	2.3	2.0	1.4	2.5
West Germany	2.4	2.3	2.5	2.2	2.8	2.5	2.0	3.0	2.5	1.9	3.3
Italy	1.8	1.9	2.1	1.9	2.3	2.1	1.7	2.4	2.1	1.6	2.6
Netherlands	0.7	0.7	0.8	0.7	0.9	0.8	0.7	1.0	0.8	0.6	1.0
Other Europe	4.0	4.0	4.4	3.7	4.7	4.4	3.5	5.2	4.4	3.0	5.5
Other OECD	0.9	1.0	1.1	0.9	1.2	1.1	0.8	1.4	1.2	0.8	1.6
Total OECD	37.1	37.6	40.5	38.8	41.3	41.9	39.9	43.5	43.8	40.8	46.5
OPEC	3.9	4.1	4.6	4.4	5.0	5.0	4.3	5.7	5.7	4.6	7.0
Other Developing Countries	10.0	10.6	12.3	11.0	13.4	12.9	10.4	14.9	13.7	9.9	17.2
Total Market Economies	51.0	52.3	57.5	55.3	58.8	59.7	56.4	62.4	63.2	58.3	67.8
Centrally Planned Economies											
China	2.1	2.3	2.7	2.5	2.9	3.3	2.9	3.7	4.1	3.3	4.9
Soviet Union	8.9	8.8	7.2	5.7	8.6	7.6	6.2	9.0	8.9	6.3	11.4
Other CPE	2.5	2.4	2.3	2.1	2.4	2.6	2.3	2.7	2.5	2.2	2.8
Total	13.5	13.5	12.1	10.7	13.6	13.4	12.0	15.0	15.4	12.7	18.1
World Total	64.5	65.8	69.7	67.0	71.6	73.2	69.6	76.3	78.7	73.0	84.0

[a]Includes the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

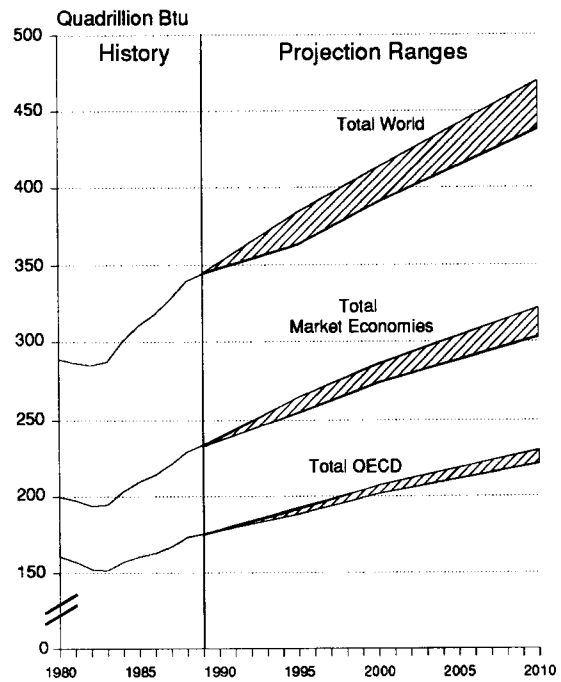
Notes: Uncertainty ranges for regional aggregates consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective sub-regions from their base value. Other totals may not equal sum of components because of independent rounding.

Sources: **History**: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89) (1991); and *Monthly Energy Review*, DOE/EIA-0035(91/04) (1991). **Projections**: Energy Information Administration, AEO 1991 Forecasting System run IEO91F.D0501913; *Annual Energy Outlook 1991*, DOE/EIA0383(91) (1991); Office of Energy Markets and End Use, *Oil Market Simulation Model User's Manual* DOE/EIA-MO28(91) (1991); and World Energy Projection System Spreadsheet, July 1991.

World Energy Consumption

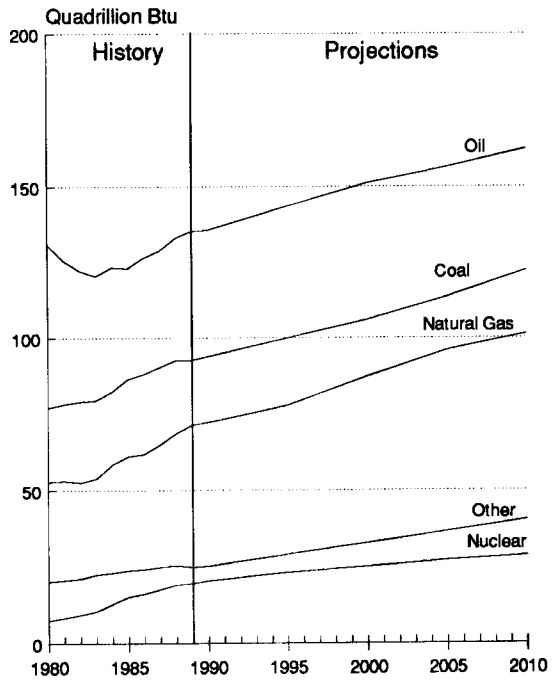
World consumption of total primary energy is projected to grow steadily between now and 2010 (Figure 7), spurred primarily by continued economic growth (Table 5). Oil will continue to be the most important single source of energy (Figure 8), but its relative importance--share of total energy consumed--is expected to decline. All other fossil fuels are expected to maintain or increase their relative importance moderately (Table 6). As with economic growth, energy consumption will grow much more rapidly in the developing countries than in the OECD countries or in the CPE's (Table 7).

Figure 7. World Energy Consumption by Region, 1980-2010



Source: History: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89). Projections: Table 7.

Figure 8. World Energy Consumption by Type, 1980-2010



Source: History: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89). Projections: Table 6.

In terms of total energy consumption, the United States, the Soviet Union, and OECD Europe were the largest consumers of energy in 1989 and will remain the largest consumers through 2010. OECD Europe though is projected to surpass the Soviet Union for second place in the next few years (Table 7). In absolute terms, growth in total energy consumption in 1989 occurred primarily in the OECD countries and the developing countries.

The United States is the world's largest consumer and also has the largest and most varied energy resource base among the OECD countries. In contrast, Japan must import much of the energy it consumes because of the virtual absence of indigenous energy resources.

As a result, Japan is expected to expand both nuclear production and natural gas imports substantially over the projection period. These actions will diversify Japan's sources of energy and, consequently, reduce its energy vulnerability. Europe is also expected to increase imports of natural gas to take advantage of its clean-burning characteristics, particularly relative to coal, and to diversify energy supplies. Large natural gas reserves exist in the Middle East and in the Soviet Union. Trade in natural gas could be one of the major developments in world energy markets over the next few decades, providing opportunities for the application of U.S. technology in this field.

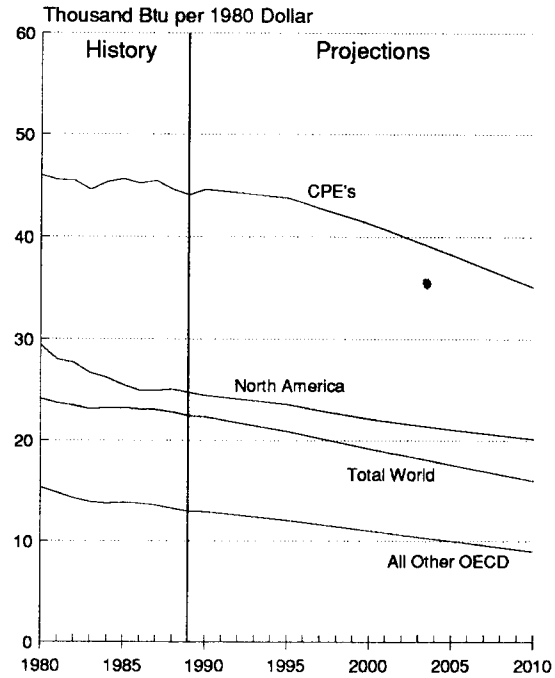
Rapid growth in total energy demand in the developing countries will result from higher population growth and increasing urbanization and industrialization. Economic growth will be particularly strong among the newly industrialized countries, particularly along the Pacific Rim, where manufacturing activities have flourished. Urbanization increases energy demand as the economy shifts from agriculture to industry and services, and from smaller to larger manufacturing operations. These shifts, in turn, require increased transportation, electrification, and mechanization, all energy-intensive activities.

Energy Intensity

The overall energy intensity of economic activity--defined as the ratio of energy consumption to gross domestic product (GDP)--is expected to decline in all major regions of the world through 2010 (Figure 9). The CPE's could experience the greatest reductions in energy intensity over the next 20 years, as energy resources become increasingly scarce and increasingly valuable as a source for export revenues--particularly in the Soviet Union--and if efforts at increasing overall efficiency and at general economic reform succeed. At the present, given current estimates of GDP (which are highly questionable), the CPE's are by far the world's most inefficient consumer of energy.

Rates of decline in energy intensity among the OECD countries will likely slow, as improvements to energy efficiency and energy conservation become more difficult to implement. As a result, technological innovation will be a key ingredient in reducing energy consumption in OECD countries, be it for buildings, appliances, transportation, or manufacturing activities.

Figure 9. Energy Consumption/GDP Ratio, 1980-2010



Sources: **History:** Wharton Econometric Forecasting Associates, *World Economic Service Historical Data* (1990); and Energy Information Administration, *International Energy Annual*, DOE/EIA-0219(89). **Projections:** Derived from Tables 5 and 7.

The mix of economic activity will also influence the energy intensity of economic activity around the world. In the OECD countries, recent changes in their economic structure from energy-intensive heavy manufacturing and resource development to less energy-intensive services and high-technology industries should continue. Traditional heavy manufacturing is expected to grow most rapidly in certain newly industrialized countries. In other developing countries, dependence on natural resource development and expected growth in motor transportation and in electrification could work against increasing energy efficiency.

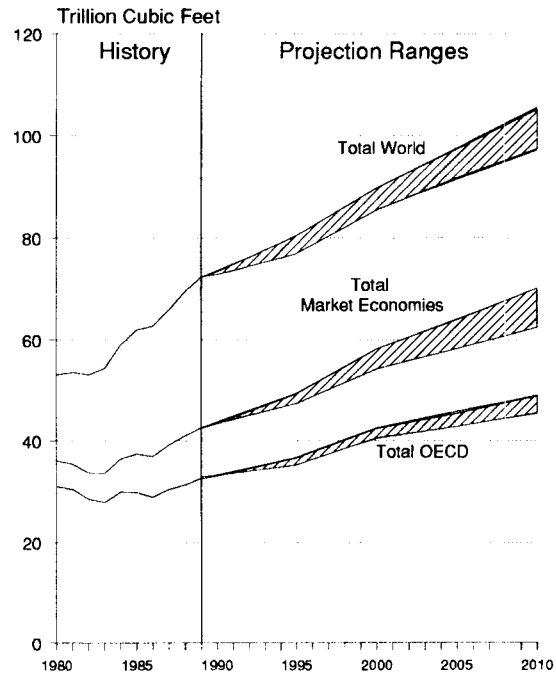
Electrification could also slow down the decline in the oil intensity of economic activity among the developing countries. Industrial countries are moving away from electricity generated by oil to electricity generated by nuclear, hydropower, and other fossil fuels. But, many developing countries, particularly those with large foreign debts, will find it difficult to obtain the front-end capital needed to switch away from oil. The oil-exporting developing countries, including OPEC, will contribute further to the overall oil intensity of economic activity, as they use oil to fuel economic growth. Petrochemical activities, for example, require large inputs of oil.

Prospects for Natural Gas

Natural gas is expected to be the fastest growing fossil fuel in the world between now and 2010 and could be the fastest growing overall energy source among the developing countries over this period (Table 8 and Figure 10). Natural gas has been the primary energy source in the Soviet Union since 1986 and should continue to be so through 2010. Reserves of natural gas are available worldwide but are particularly abundant in the Soviet Union and the Middle East which, together, account for about two-thirds of total reserves (Figure 11). This distribution of reserves indicates that trade between these regions and the major consumers of natural gas, particularly OECD Europe and Japan, will grow in importance over the years. Greater use of natural gas will diversify energy imports and reduce environmental problems associated with other fossil fuels in the consuming countries. Prospects for natural gas will also be influenced by its price relative to prices for other energy sources, the availability of capital to develop new sources and construct required distribution systems, the development of more competitive markets, and the overall growth in economic activity.

The environmental advantage of natural gas will provide incentives for greater use of this fuel in the residential, commercial, industrial, and electricity generating sectors. Environmental considerations are particularly important in densely populated areas. There, as elsewhere, increased use of gas-fired plants to generate electric power could come at the expense of generating capacity originally expected from coal-fired or from nuclear plants. The use of natural gas for electric power generation will be

Figure 10. World Natural Gas Consumption, 1980-2010

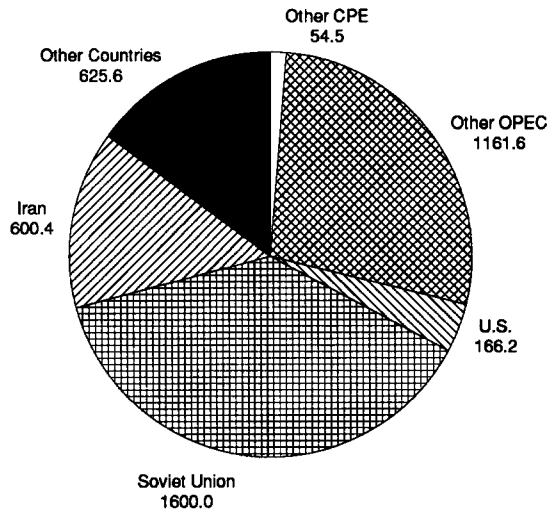


Source: History: Energy Information Administration *International Energy Annual 1989*, DOE/EIA-0219(89). Projections: Table 8.

encouraged further by relatively low capital costs and by improved technology, such as combined-cycle systems. Combined heat and power production in industry, and for district heating in certain European countries, that use more energy efficient technology could also increase the market for natural gas. Europe in particular is expected to look to natural gas to increase the diversity of its energy supplies and flexibility of its energy markets, the latter coming, for example, from the ability to shift fuel use relatively quickly using dual-fired capabilities. Finally, greater consumption of natural gas could result from its use as a transportation fuel, competing with gasoline and diesel fuel.

In the United States, growth in natural gas consumption will be due to a significant shift by electric utilities toward increased use of this fuel. However, growth of natural gas consumption in the residential and commercial sectors could be constrained by the continued penetration of electricity and efficiency gains in gas-fired heating and cooling

Figure 11. World Natural Gas Reserves, January 1, 1991 (Trillion Cubic Feet)



Source: *Oil and Gas Journal*, December 31, 1990.

equipment. Natural gas consumption in the 1990's will grow in concert with increased demand from cogeneration and higher industrial output. Growth could moderate afterwards due to expected growth in large electricity-intensive (as opposed to gas-intensive) industries, efficiency gains, and the increasing use of coal for cogeneration.

Imports of natural gas to the United States are expected to grow in importance. Domestic production of natural gas is expected to peak by 2005. Growth in Canadian exports to the United States is anticipated in the early 1990's before becoming relatively stable. Mexico is also expected to become an exporter of natural gas to the United States starting around 2000. Currently, Mexico's policy is to satisfy domestic demands before allowing export of any surplus. Imports to the United States of liquefied natural gas (LNG) are also expected to grow substantially between now and 2010, particularly in the 1990's. Algeria and Indonesia are the major suppliers of LNG worldwide, accounting for 36 percent and 26 percent of total world LNG capacity, respectively. Currently, the United States competes with Western Europe and certain Pacific Rim countries for available LNG supplies.

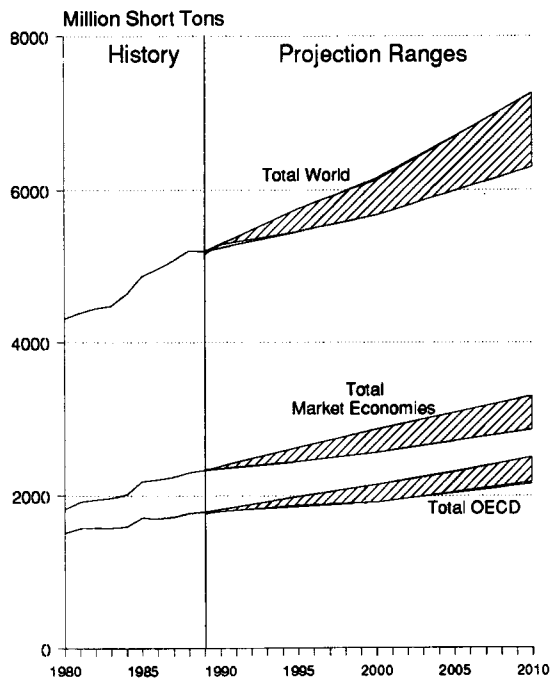
With relatively plentiful natural gas resources, North America is currently self-sufficient in natural gas. However, natural gas imports to all OECD countries together grew by about 9 percent in 1989, according to the International Energy Agency. Europe and the Pacific region (Japan, Australia, New Zealand) accounted for much of the increase in imports. Major suppliers to these regions were the Soviet Union, Algeria, and Indonesia. Significant additions to future natural gas supplies within the OECD countries are expected from the Northwest Shelf project in Australia, the Troll/Sleipner complex in Norway, and the Mackenzie Delta in northern Canada. Exports of LNG from the Northwest Shelf project to Japan began in 1989.

The consumption of natural gas will likely grow most rapidly in the developing countries, particularly in certain Middle East countries. These countries can exploit vast gas fields, collect associated gas from oil production, and use this gas, rather that oil, for industrial production and electricity generation. Expansion of industrial production for export markets through increased use of domestic natural gas resources is one method of indirectly exporting natural gas, which is difficult and expensive to transport. Outside selected Middle East countries, development of indigenous natural gas resources will be highly dependent on the availability of foreign investments.

Prospects for Coal

Consumption of coal is projected to grow steadily between now and 2010, maintaining its relative importance worldwide (Table 9 and Figure 12). However, other than oil, coal consumption is expected to grow at the slowest rate among the major energy sources. Except in the Soviet Union, coal is the most important source of energy in the Centrally Planned Economies (CPE's). Its relative importance should grow through 2010, as the oil share of total energy consumption in the CPE's declines. Contributing to growth in coal demand worldwide are increased use

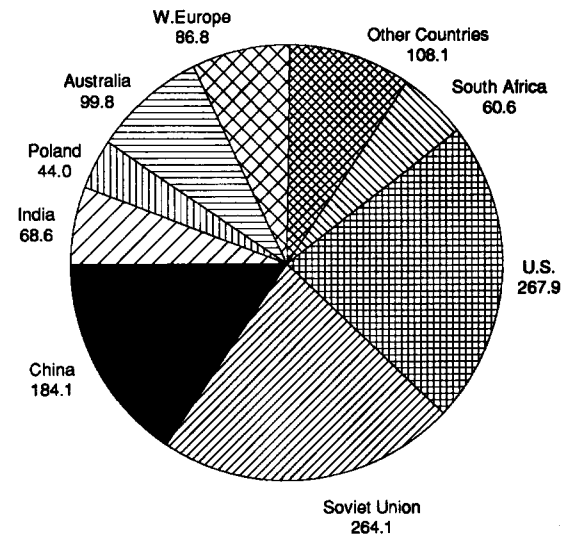
for the production of electricity and continued desire for supply diversification.



Source: History: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89). Projections: Table 9.

In 1989, China, the United States, and the Soviet Union accounted for about 56 percent of total coal production in the world. China was the leading producer at about 1.1 billion short tons, followed by the United States at 1.0 billion short tons, and the Soviet Union at 0.8 billion short tons. The distribution of coal reserves (Figure 13) compared with the areas of growing demands, primarily Western Europe, Japan, and other Pacific Rim countries, will result in increased international coal trade over the projection period. Major exporters include Australia, the United States, and South Africa. Currently, the United States and Australia account for about half of all internationally traded coal. Suppliers among the developing countries include Colombia and Venezuela. Coal exports from China should also increase over time, but those from Poland and the Soviet Union will likely decline.

Figure 13. World Coal Reserves (Billion Short Tons)



Source: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89).

Coal exports by the United States increased from 101 million short tons in 1989 to 106 million short tons in 1990 and are expected to approach 250 million short tons by the year 2010. Reflecting world coal consumption in general, the rise in U.S. exports of steam coal will increase, while exports of metallurgical coal will decrease. The electric power sector is by far the dominant market for coal and will continue to be the major user through 2010. Production of steel is expected to grow slowly worldwide, and new steelmaking technologies will further reduce the demand for coking coal.

A major reason for the expected increase in U.S. coal exports is the expected decline in coal production in Western Europe, as countries restructure their coal industries and phase out non-competitive coal production. Production in Europe (Belgium, Spain, the United Kingdom, and Germany) and in Japan is basically not competitive with internationally traded coal. As subsidies that sustain these industries and contracts with consuming countries are eliminated,

prospects for trade, including that for U.S. coal, will improve. Privatization of the electric supply industry in the United Kingdom should increase imports in that country as well.

Among the CPE's, coal is and will continue to be the primary source of energy for China and for Eastern Europe as a group. China is expected to use coal to meet ambitious goals for economic growth. Consumption of coal in Eastern Europe and the Soviet Union could be hampered by problems with transportation infrastructure and with the location of potential industrial users relative to coal supplies. Growth in the consumption of coal in China and in the world as a whole raises environmental concerns about the proliferation of sulphur dioxide (acid rain) and carbon dioxide (greenhouse gas) emissions and has caused some observers to stress the importance of research and development in clean coal-burning technology.

Prospects for Nuclear and Other Energy Sources

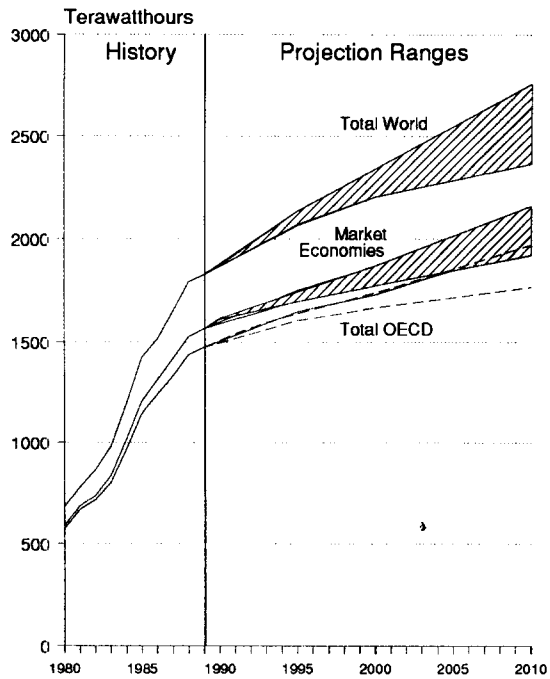
The nuclear power industry found itself at the beginning of 1991 in nearly the same position as a year earlier: current stagnation mixed with hope for the future. The problems with nuclear power revolve around three main issues: its low level of public acceptance, particularly since the 1986 Chernobyl disaster; its economics, especially in the context of relatively low fossil fuel prices; and its own unique environmental problems, particularly the disposal of radioactive waste. On the other hand, persistent concern over environmental problems associated with the burning of fossil fuels, particularly the "greenhouse effect," tends to work in favor of nuclear power, as does the desire to reduce dependence on relatively insecure oil supplies. Both concerns were reinforced by events of 1990, including another mild winter worldwide and another major oil supply disruption. These concerns may prove strong enough to provide a significant boost to nuclear power, particularly in the long run (Table 10). In the short term, however, it is probable that nuclear power will continue to stagnate.

Some of the same negatives facing the nuclear power industry at this time also confront the renewables sector. Hydroelectric power, for instance, has huge potential in many parts of the world, but its development is hampered by the same three issues hindering nuclear power: public acceptance, economics, and environmental problems, such as flooding large land areas and altering downstream flows. On the other hand, reliable supplies of affordable and, preferably, indigenous energy are of crucial importance to developing countries. Despite all the problems associated with nuclear and renewable power sources, it is likely that these countries will be forced to include them in their energy mix as a means of reducing energy dependence and maintaining desired levels of economic growth (Table 11).

Perhaps the most significant developments during 1990 regarding nuclear power and renewable energy stemmed directly from the historic changes taking place in Eastern Europe and the Soviet Union. The dramatic political and economic reforms occurring in these countries inevitably affected their energy economies. Greater freedom of expression has allowed environmental considerations, which were suppressed in the past, to play a larger role in energy planning throughout the region. Soviet anti-nuclear movements, for example, have become more active, forcing the abandonment or deferral of some planned nuclear capacity. Nuclear power programs in other Eastern European countries, such as the former East Germany, are currently in an uncertain state due primarily to heightened safety standards and public opposition. In general, political changes in the region during the past year have led to a reassessment of the current and future safety of Soviet-supplied nuclear reactors, and a desire to move towards western nuclear technology and safety standards. Finally, hydroelectric power projects have also been subjected to heightened public scrutiny and environmental concerns throughout the region. A 120-megawatt hydroelectric project has already been stopped on these grounds on the Danube River in Hungary, while the future of a 720-megawatt dam on the Czechoslovak side of the Danube has also been called into question.

The growth in nuclear power consumption is expected to slow after 1995, reflecting the drop in the growth rate of nuclear generating capacity (Figure 14). Nuclear power, which was estimated to account for 6 percent of total world energy consumption in 1989, is projected to maintain this share through 2010. France is currently exporting over 40 net terawatthours of

Figure 14. World Nuclear Energy Consumption, 1980-2010



Sources: **History:** Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89). **Projections:** Table 10.

nuclear-generated electricity to other European nations and may be exporting over 60 net terawatt-hours by 2010. Therefore, estimates of nuclear exports from France have been excluded from French nuclear consumption and have been included in the consumption figures for traditional French customers, including the United Kingdom, West Germany, Italy, The Netherlands, Belgium, Spain, and Switzerland. Thus, the projections of nuclear consumption for these countries (in particular, Italy) do not necessarily reflect the trends in their domestic nuclear power programs.

Overall prospects for nuclear power vary from country to country:

- The prospects for nuclear power in Italy remain uncertain. Current government policy suspends construction and operation through 1992. The country's last two nuclear power stations--Trino-Vercellese (260-megawatt capacity) and Caorso (860 megawatts)--were permanently shut down in 1990.

- Taiwan has decided to proceed with construction of its long-delayed fourth nuclear power plant. This decision was taken because of increased electricity demand and the availability of investment capital.

- Sweden has revised its timetable for phasing out nuclear power by 2010, acknowledging the great hardships the plan would have entailed. Nuclear power currently satisfies about 46 percent of total Swedish electricity demand. Already, the 1995 target for beginning the phaseout has been scrapped.

- Swiss voters in September 1990 approved a ten-year ban on the licensing of new nuclear power plants, while rejecting another proposition that would have phased out nuclear power entirely. This moratorium on nuclear construction, in combination with opposition to further hydroelectric power development and rapidly growing electricity demand, strongly implies a growing dependence on already high levels of electricity imports from France.

- Japan remains one of the countries most firmly committed to nuclear power, with over 56 gigawatts-electric (GWe) of nuclear generating capacity either in place or in the construction pipeline. The Japanese Ministry of International Trade and Industry (MITI) has adopted energy use targets for 2010 which would increase the share of nuclear power in the overall energy mix at the expense of oil. Despite growing opposition to nuclear power, especially in light of a recent series of incidents reported at Japanese nuclear plants, MITI still believes nuclear power to be a "reliable source of energy" for which it sees no real alternative.

- The rapidly growing economies of the Asian Pacific Rim may constitute a potential area of growth for nuclear power. Indonesia, for instance, recently decided to build but has

yet to order its first nuclear power plant--a 600-megawatt unit in central Java. This plant should be operational between 2010 and 2015. South Korea already has a substantial program of nuclear expansion in place.

The total installed hydroelectric generating capacity as of 1989 was 607 gigawatts-electric. Its share of world energy consumption, which was estimated at around 7 percent in 1989, is expected to reach about 9 percent by 2010. Among the countries with significant amounts of hydroelectric power capacity are: the United States, 90.3 gigawatts-electric; USSR, 63.5; Canada 57.5; Brazil, 45.2; Japan, 36.4; China, 29.0; Norway, 25.4; and France, 24.7. The world's largest hydroelectric plant is Itaipu, located on the border between Brazil and Paraguay, with an installed capacity of 10.5 gigawatts-electric. When the plant is fully completed in 1991, its total installed capacity will be 12.6 gigawatts-electric. Geothermal electricity generation constituted less than 1 percent of the world's total net electricity output in 1989.

Centrally Planned Economies

During the second half of 1990, the conflict in the Persian Gulf distracted attention from what was perhaps the most significant international development in many years: the end of the Cold War and the rapid changes occurring in the Soviet Union, Eastern Europe, and China. President Mikhail Gorbachev's perestroika (restructuring) process has led the Soviet Union away from a totally centrally planned economy towards a more market-oriented system. In Eastern Europe, democratization has led many countries to abandon communism, while East Germany has become part of a united Germany. China has avoided radical changes, but has undertaken economic reforms that have led to the rise of privately-owned firms, foreign-funded firms, "township industries" (collective industries not run centrally by the state), and the creation of a stock market in Shanghai. Taken together, these changes have called into question the coherence of a group of countries hitherto known as the Centrally Planned Economies (CPE's). However, these nations continue to maintain extensive political and trade relations (including energy) among themselves, and thus continue to be classified as CPE's for analytical purposes.

Economic Outlook

The economic outlook for the CPE's varies considerably by country. As a group, the CPE's represented about 16 percent of total world gross domestic output (GDP) in 1990. However, this total is expected to drop markedly to between 14 and 15 percent by 1995, and to remain at those levels through the next decade.

The primary reason for this drop is the negative growth rate expected for the Soviet Union for the next few years as a result of its economic crisis. With the shift away from a totally centrally planned economy and the transition to a market economy not yet complete, the Soviet Union currently has neither system in place to provide order to its economy. This Outlook assumes that the economy will stabilize in the mid-1990's, and then grow very slowly at between 1 and 2 percent (Table 5) throughout 2010.

With the dissolution of the Council for Mutual Economic Assistance (CMEA) last year, Eastern Europe lost its single most important trading mechanism, promising dramatic changes in trade flow and prices in all sectors. Eastern Europe imports much of its energy from the Soviet Union, and depends heavily on the reliability and affordability of Soviet energy supplies. The continuing switch to world market pricing will place additional short-term strains on fragile Eastern European economies, which are already in the midst of a contraction. The economic outlook for these countries is for no growth from 1990 to 1995, followed by an annual growth rate of almost 2 percent after the mid-1990's.

China has been one of the world's fastest growing economies, expanding at over 10 percent per year from 1980 to 1985 and over 7 percent from 1985 to 1990 (Table 5). Non state-owned township industries account for over one-quarter of industrial output and a rising share of exports. China is expected to continue its current annual growth rate of 7.5 percent until the end of the decade, and at over 6 percent during the following 10 years.

Oil Consumption

CPE oil demand represents over 19 percent of total world demand, but within the next 5 years this share

is expected to drop by 2 percent. The range of uncertainty over the size of the drop is very large, corresponding to uncertainty over the outcome of the Soviet perestroika. Soviet oil consumption is expected to drop and Eastern European consumption to stagnate at a time when other regions are expected to increase consumption (Table 2) in response to the relatively low world oil prices over the next 5 years.

The potential for energy efficiency improvements is very large, but the most significant and immediate changes in energy usage in the CPE's are more likely to come from shifts in production patterns rather than from efficiency gains. Reductions in economic activity levels, a restructuring of economies from industrial to consumer goods, and a shift to market-based systems with realistic energy prices will be the primary determinants of oil usage by the Soviet Union and Eastern Europe over the next few years.

With the expected stabilization of these economies, followed by slow economic growth, oil consumption should rise. The potential for increased demand for light products in the transportation sector is substantial because there has been a largely unmet demand for automobiles, and as more of these become available gasoline demand should rise. This rise in demand for light petroleum products could offset energy efficiency gains expected in the industrial sector, with the overall result that oil consumption should rise slowly as these economies grow.

The potential for growth in oil demand in China is greater than in the Soviet Union and Eastern Europe because of the high economic growth expected for China. Unlike many of the other CPE's, China is expected to avoid the traumatic restructuring of its economy and energy sectors. Changes in Chinese energy usage are instead more likely to resemble those of the other rapidly developing countries of Asia. As with many of these developing countries, China's level of energy efficiency is low by international standards. China is expected to become much more efficient in the future because of the economic reforms now underway.

Despite these expected efficiency gains, oil usage in China is expected to nearly double by 2010 because the size of China's economy should almost quadruple in the same time period. With this growth should come an increased demand for automobiles. In addition, increased oil demand is likely to result from a shift towards kerosene and away from firewood and dung for cooking, as new fuels are needed to supply the large and growing population (World Bank Staff Commodity Working Paper Number 23 (1990)).

Oil Production

The Soviet Union remained the world's largest oil producer in 1990, accounting for over 17 percent of the world's total. This level of production was achieved despite proved oil reserves of only 57 billion barrels (less than 6 percent of the world's total), a level of reserves equivalent to 14 years of oil production at current rates. With its proved reserve base declining, 1990 Soviet production levels fell by 700,000 barrels per day, following a 400,000 barrel per day drop in the previous year. The decline in Soviet oil production has been hastened by the use of short-term strategies to boost production, including the inordinate use of less efficient and potentially reservoir damaging techniques such as waterflooding, and the general deterioration of important infrastructure. In addition, the exploitation of many easily accessible reservoirs has left the Soviet Union with mature oil reservoirs that are declining in production and the majority of Soviet oil reserves concentrated in more remote areas. Few signs suggest that the decline in oil output can be reversed quickly without a massive infusion of financial resources into the oil industry, which already consumed 20 percent of Soviet investment expenditures in 1988. Finally, there is the broad issue as to the profitability of Soviet oil production under the current pricing system. Faced with an economic and political crisis and the need to shift additional investment funds into consumer goods, the Soviet Union cut back funding for the oil industry in 1990, and oil production plummeted. With the Soviet economy in turmoil, production is expected to continue falling.

In order to increase production in the future, the Soviet Union has sought assistance from the West. The Soviet Union is enormous, and much of the country's energy potential remains unexplored. In addition, known fields need to be developed, but the Soviet Union lacks the resources to develop them (Figure 15). The Tengiz field in the Caspian Sea Basin is the largest super-giant field discovered since Prudhoe Bay in Alaska in 1968, but has yet to produce any oil. The Soviet Union hopes that an

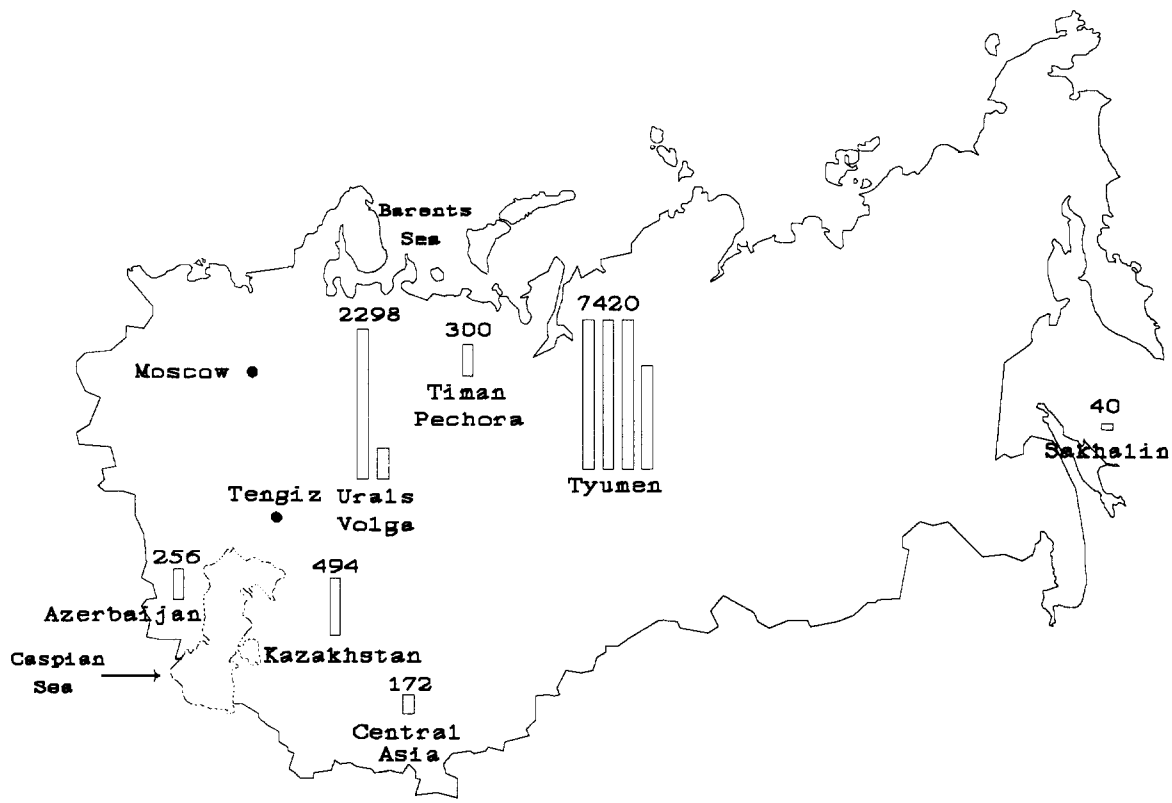
infusion of Western capital, technology, and management skills will enable it to develop fields such as Tengiz.

Western oil firms could help the Soviets out of their difficulties, but have been stymied so far by three main problems: Soviet ambivalence about Western ownership of the country's natural resources, Western concerns over Soviet legal/political problems and the risky investment climate, and the bitter battles between the republics and central government regarding ownership of mineral rights and dealings with Western firms.

No increased oil production as a result of Western involvement is therefore expected before the end of the decade. As a result, Soviet production is expected to continue declining until the mid-1990's. After this point, a wide range of outcomes is possible, with production capacity ranging between 8 and 12 million barrels per day in 2010, depending on the success of perestroika and the investment climate for Western firms (Table 3). The scenario used for the Base Case (Table 2) assumes that some Western help will be forthcoming, with the result that Soviet oil production stabilizes in the mid to late-1990's and increases slightly thereafter.

Among the other CPE's, only China has significant oil production. While Romania and the other Eastern European countries currently produce several hundred thousand barrels per day of oil, production has declined gradually during the past decade as fields

Figure 15. Oil Production for Major Fields in the Soviet Union, 1990 (Thousand Barrels per Day)



Source: PlanEcon, *Soviet Energy Outlook*, March 1991.

have matured and production techniques have remained antiquated. China, on the other hand, is expected to produce 2.4 million barrels per day during the next few years, and could increase this to between 3 and 4 million barrels per day by 2010. In order to increase production, China needs to offset expected declines in production during the 1990's from Daqing, its largest field, which produced over 1 million barrels per day in the 1970's. Some additional production could come from offshore areas, but the largest potential for additional capacity rests with the development of the recent discoveries in the Tarim Basin in far western China. Development of this remote, rugged frontier area would require a 3,000-mile pipeline. In order for such a pipeline to be feasible, it is believed that Western oil company participation would be required. Whether or not such participation occurs depends upon the political climate in China, particularly regarding further foreign participation in China's economic development. It is assumed in the Base Case scenario that Western companies will become more involved, both offshore and in the Tarim Basin.

CPE Exports

Given Western assistance, oil production in China is expected to increase. However, it is not expected to keep pace with growth in oil demand. As a result, it is expected that China will become a net importer of oil by the end of the decade. With Eastern Europe already importing considerable amounts of oil, only the Soviet Union would then remain an oil exporter among the CPE's.

The outlook for the Soviet Union is that exports of oil will continue in the future, but will decline from their current level of 3.2 million barrels per day to between 0 and 2 million barrels per day by 2010. This large range reflects the substantial uncertainties regarding the success of perestroika, the extent of Western involvement in the Soviet oil industry, and the extent to which consumption is reduced because of efficiency gains and economic restructuring. In all cases, however, the Soviet Union should continue to export oil as a means of generating hard currency. Soviet exports of oil to Western nations accounted for up to 60 percent of Soviet hard currency earnings in 1990.

Environmental Considerations

All hydrocarbon fuels, by definition, contain carbon, which is emitted into the atmosphere when the fuel is burned (i.e. combined with oxygen), mainly as carbon dioxide (CO_2). Concerns have been raised in recent years regarding the long-term effects of CO_2 and other gaseous emissions on the environment, particularly as they might help trap heat near the Earth's surface and thus contribute to what has become popularly known as the "greenhouse effect." These concerns center primarily in the possibility that large-scale anthropogenic emissions of so-called "greenhouse gases" (mainly CO_2, methane, nitrous oxide, tropospheric ozone, and chlorofluorocarbons, or CFCs) will result in an excessive level of global warming in coming years.

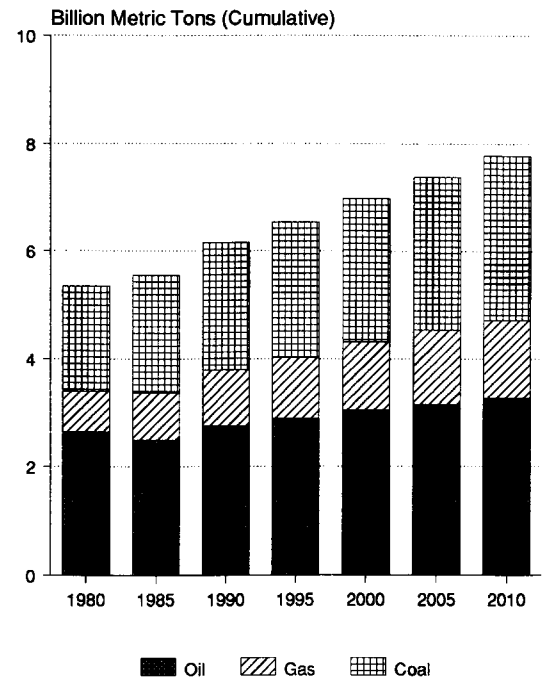
CO_2 alone is believed to be responsible for about half the greenhouse gas-emission problem. Increasing concentrations of CO_2 in the atmosphere result from (1) the destruction of forests, which releases stored carbon into the atmosphere and at the same time reduces the absorption of CO_2 and its conversion by photosynthesis into oxygen, and (2) the burning of fossil fuels, which converts vast quantities of stored carbon from solid to gaseous form. In these ways, the energy sector plays a central role in the global climate change issue, both in its cause as well as in its solution.

To understand the energy sector's effects on the environment it is necessary to measure carbon emissions as a function of world hydrocarbon energy consumption. Using Edmonds & Reilly, "Global Energy and CO_2 to the year 2050," (*Energy Journal*, vol. 4, no. 3, pp. 21-47), the derived average world carbon content for the fossil fuels is as follows: natural gas (14.5 million tons per quadrillion Btu), crude oil (20.3), and coal (25.1).

World carbon emissions from all fossil fuels have been increasing in recent decades. In 1990, oil was the largest single source of carbon emissions from the burning of fossil fuels. Although oil contains a much lower carbon content than coal, it makes up a far greater proportion of world energy consumption (Figure 16). By 2010, the share but not the absolute amount of emissions from coal should decline, as natural gas increases its share of world fossil fuel consumption. Other factors which contribute to

global warming include deforestation and CFC emissions. Deforestation, largely by burning, has been responsible for relatively high cumulative emissions of carbon dioxide; however, emissions from this source are expected to be relatively smaller during the next century. CFC's, which are used most often as coolants, often end up in the atmosphere, where they harm the ozone layer--the Earth's protection from solar radiation.

Figure 16. World Carbon Emissions by Fuel Type, 1980-2010



Sources: **History:** Consumption of oil, gas, and coal derived from *International Energy Annual*, and *The Energy Journal*, Volume 4, No. 3. **Projections:** Derived from *The Energy Journal*, Volume 4, No. 3, and Table 6.

Potential environmental problems associated with energy use include (1) acid precipitation, which results largely from the burning of fossil fuels containing relatively high sulfur and/or nitrogen concentrations; (2) photochemical smog, which is primarily caused by the reaction of sunlight with mainly automobile-emitted nitrogen oxides (NOx), methane (CH_4), and carbon monoxide (CO), (3) release of potentially toxic heavy metals, such as cadmium, lead, and mercury, at greatly increased rates, (4) environmental damage resulting from the construction and operation of hydroelectric power plants, (5) radioactivity potential from nuclear power plants, as well as from nuclear waste disposal, and (6) damage to local ecosystems resulting from oil spills, such as the *Exxon Valdez* incident or the recent Persian Gulf spill.

Trade and Technology Transfer

International relations in the energy sector focus on energy trade and technology transfer. In general, energy trade takes place within the broader context of trade relationships governed by multi-nation agreements such as the General Agreement on Tariffs and Trade (GATT), regional cooperation agreements such as trade policies of the European Community, and bilateral agreements between traditional trading partners such as the United States and Canada. The United States has been at the forefront of many new technology methods and techniques, and is therefore a key player in technology transfer to producing countries.

Oil is traded freely around the world, and is supported by an extensive infrastructure that includes pipelines, port facilities, tankers, and storage facilities. Most long-haul trade involves tanker shipments, which allow for great flexibility in trade routes. While most international petroleum trade currently involves crude oil transactions, increasing interest in downstream activities by producing countries and environmental concerns limiting expansion of refining capacity in industrialized nations suggest increasing volumes of petroleum product trade in the future.

Recent developments in Soviet oil production levels and export policy could result in some fundamental changes in the petroleum trade patterns that have developed in recent years. Beginning in 1991, Soviet oil is being supplied to the former Eastern Bloc countries on a hard currency basis, eliminating the price subsidies these nations had previously enjoyed. This, in turn, has encouraged countries in Eastern Europe to look elsewhere for their petroleum import requirements, including arrangements with Middle

East producers. In addition, the role of Soviet republics in the direct export of petroleum in the future remains unclear at this time.

Future levels of Soviet petroleum exports will depend, at least in part, on the extent to which problems within its oil industry can be resolved. Many of these involve the need to modernize production processes and adopt new technologies. U.S. companies have begun to explore joint venture projects with the Soviets. U.S. technology could enhance future petroleum production in other countries as well as in the Soviet Union. These new technologies include enhanced and tertiary recovery methods, horizontal and directional drilling, deep wells, and deep-water drilling.

Increased use of natural gas in technological applications such as combined cycle operating plants and as a substitute for petroleum products (e.g., compressed natural gas vehicles) could result in increasing trade. Natural gas trade possibilities are constrained by the availability of pipeline systems or special facilities for shipping liquefied natural gas (LNG) over long distances. LNG trade requires facilities for liquefying the natural gas for shipment by specially pressurized tankers to receiving facilities where it is regasified for distribution. Both shipping methods involve large financial investments and fairly long lead times for project construction.

The Netherlands, Norway, the Soviet Union, and Algeria are the main exporters of natural gas to Europe. Shipments are primarily by pipeline, with the exception of Algeria which also has LNG facilities on stream. European countries that currently have LNG import facilities include Spain, Belgium, France, Italy, and the United Kingdom.

Despite large domestic supplies, the United States imports natural gas by pipeline from Canada. The U.S.-Canada Free Trade Agreement facilitates these trade transactions. The recent recommissioning of the Lake Charles, Louisiana LNG receiving facility and the possible future reopening of LNG facilities at three other sites could result in increased U.S. imports of LNG from Algeria and other exporters. In addition, the National Energy Strategy proposes to eliminate the need for import licenses once all regulations on domestic production end on January 1, 1993.

Japan is the largest importer of LNG, due to its limited domestic energy supply and island geography. In addition to Algeria, countries with LNG export facilities currently onstream include Brunei, Abu Dhabi, Indonesia, Malaysia, and Australia, whose Northwest Shelf project was inaugurated in 1989. Countries that could become LNG exporters in the future include Nigeria, Venezuela, Norway, and Iran.

Iran currently has a pipeline to the Soviet Union, and may open a second line to serve growing markets in Eastern Europe. Some of this trade may involve "backout arrangements" whereby Iranian natural gas is shipped to the Soviet Union, and Soviet natural gas is shipped by pipeline to Eastern European countries. Other Middle East countries that may provide natural gas exports in the future include Iraq and Qatar.

Coal trade is primarily by ship or rail, so is less constrained by infrastructure considerations than natural gas trade. The primary exporters are Australia, the United States, and South Africa, and the primary destinations are Western Europe, Japan, and other Asian countries.

Technological changes could alter future trade patterns for coal. For example, increasing concerns about air quality could raise the demand for high-quality coal. Export levels of countries producing high-quality coal, including some developing countries, could therefore increase. In addition, use of steel-making technologies that require less hard coking coal could also influence future trade patterns. Transfer of U.S. clean-coal technology to other countries could maintain coal demand by satisfying some of the environmental concerns associated with coal use.

Comparison of EIA Projections

Projections of world oil prices shown in Table 1 and Figure ES3 differ from those published by the Energy Information Administration (EIA) in the *Annual Energy Outlook 1991 (AEO)* and related EIA publications, including 1991 issues of the *Annual Outlook for Oil and Gas, Annual Outlook for U.S. Coal, Annual Outlook for U.S. Electric Power, Annual Prospects for World Coal Trade*, and *Commercial Nuclear Power 1991: Prospects for the United States and the World.* As a result, the Base Case energy projections for the United States presented in this

International Energy Outlook 1991 (IEO) also differ from the Reference Case energy projections presented in the *AEO*. However, the *IEO* high and low range values for the consumption of oil, natural gas, coal, nuclear, other energy sources, and total energy in the United States correspond to the highest and lowest values projected for these energy sources in the *AEO*. These high and low range values reflect the Low Oil Price Case and High Oil Price Case results from the *AEO*. Energy projections for the United States were not generated using the high and low world oil prices in Table 1.

The major reason for the different projections of world oil prices presented in the *IEO* as compared to those in the *AEO* is that prices fell dramatically on January 17, 1991, right after the onset of Operation Desert Storm. Price assumptions for the *AEO* were determined prior to this date. Price projections for the post-war analysis in the *IEO* were made after this date. It became evident after this date that oil production in Saudi Arabia would not be affected by the war. Indeed, increased production from Saudi Arabia is a major contributor to offsetting lost supplies from Iraq and Kuwait. Additionally, Saudi Arabia has announced plans to accelerate expansion of its production capacity, from the current 8.5 million barrels per day to 10 million barrels per day or more by 1995. Other OPEC members are also expected to increase production capacity over the next several years. Though delayed, Iraq and Kuwait will increase production capacity in the future as well.

A comparison of *IEO* and *AEO* projections is presented in Table 12. The major differences in projected world oil prices occur between 1991 and 1995. In the *AEO* Reference Case, prices remain at $24 per barrel over this period. In the *IEO* Base Case, prices remain below $20 per barrel until 1995, when they reach $21 per barrel (all prices in constant 1990 dollars). Both price paths converge to $26 per barrel by the year 2000 and follow similar paths through 2010. The impact of these different price paths on U.S. energy projections is primarily on oil production and consumption through 1995. Given higher prices, oil consumption is lower and oil production is higher in the *AEO*, both by about 600,000 barrels per day in 1995. Consequently, net oil imports in 1995 are about a million barrels per day lower in the *AEO*, at 8.1 million barrels per day, than they are given the lower prices used in the *IEO*. However, as with world oil prices, oil projections in the two reports converge by the year 2000, including net oil imports.

Table 5. Annual Growth Rates of Real Gross Domestic Product (GDP): Base Case, 1970-2010
(Percent)

Country/Region	Average Annual GDP Growth Rates				
	1970-1980	1980-1985	1985-1990	1990-2000	2000-2010
World	3.7	2.2	3.2	3.0	3.1
Market Economies	3.6	2.1	3.4	3.2	3.0
Total OECD	3.1	2.4	3.5	2.9	2.7
United States[a]	2.7	2.7	2.8	2.3	2.1
Canada	4.6	2.9	3.2	2.5	2.8
Japan	4.6	3.9	4.5	4.3	3.8
OECD Europe	3.0	1.6	3.1	2.8	2.5
Developing Countries	5.5	1.1	3.2	4.4	4.2
OPEC	5.9	-1.0	2.8	4.5	4.6
Other	5.3	1.9	3.3	4.4	4.0
Centrally Planned Economies	3.9	2.7	2.0	1.8	3.1
Soviet Union.	3.2	2.2	1.7	0.1	1.7
China	NA	10.1	7.5	7.5	6.4

[a]Projected growth rates are of gross national product (GNP) as presented in the *Annual Energy Outlook 1991*.
OECD = Organization for Economic Cooperation and Development.
OPEC = Organization of Petroleum Exporting Countries.
NA = Not available.
Note: Aggregate growth rates are calculated from aggregate real gross domestic product in 1980 dollars at 1980 exchange rates.
Sources: **History**: Wharton Econometric Forecasting Associates, World Economic Service and *World Economic Service Historical Data*, April 1990 (1990). **Projections**: Energy Information Administration, *Annual Energy Outlook 1991*, DOE/EIA-0383(91) (1991); Derived from Wharton Econometric Forecasting Associates, World Economic Service and *World Economic Outlook* (January and February 1991).

Table 6. World Total Energy Consumption by Type, 1988-2010
(Quadrillion Btu)

	History		Projection Ranges								
			1995			2000			2010		
Energy Source	1988	1989	Base	Low	High	Base	Low	High	Base	Low	High
Market Economies											
Oil	104.1	106.5	118	111	120	123	114	129	130	117	141
Gas	42.0	43.8	50	48	50	57	54	60	68	64	71
Coal	45.6	46.3	49	48	51	52	51	56	60	57	64
Nuclear	16.3	16.7	19	18	19	20	19	20	23	21	23
Other	21.2	20.6	24	24	25	27	26	28	34	31	36
Total	229.2	233.8	260	254	265	280	274	286	313	303	322
Centrally Planned Economies											
Oil	28.6	28.5	26	23	29	29	25	32	33	27	39
Gas	26.8	27.9	28	27	30	30	27	31	33	29	37
Coal	47.2	46.6	51	48	52	53	49	56	63	52	68
Nuclear	3.0	3.0	4	4	4	5	5	5	6	5	7
Other	4.4	4.3	5	5	5	5	5	6	7	6	7
Total	110.1	110.3	114	104	123	122	112	132	141	128	153
World Total											
Oil	132.7	135.0	144	134	149	151	139	161	162	144	180
Gas	68.8	71.6	78	76	79	87	84	89	101	95	106
Coal	92.8	92.9	100	97	102	106	101	110	122	112	129
Nuclear	19.3	19.7	23	22	23	25	24	25	29	26	30
Other	25.5	24.9	29	29	30	33	32	34	40	37	43
Total	339.3	344.1	374	363	384	402	390	413	455	438	469

Notes: Energy totals include consumption of biofuels in the United States. Uncertainty ranges for these regional aggregates consist of the base value of each energy source adjusted by the quantity: the square root of the sum of the squared deviations of the respective sub-regions from their base value. Other totals may not equal sum of components because of independent rounding.

Sources: **History**: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89) (1991).
Projections: Energy Information Administration, Office of Energy Markets and End Use, World Energy Projection System Spreadsheet, July 1991.

Table 7. World Total Energy Consumption by Region, 1988-2010
(Quadrillion Btu)

Region/Country	History		Projection Ranges								
			1995			2000			2010		
	1988	1989	Base	Low	High	Base	Low	High	Base	Low	High
OECD											
United States[a]	83.9	84.7	90.0	87.0	90.2	95.5	92.8	96.7	107.3	101.3	108.8
Canada	10.5	10.8	11.7	11.4	11.9	12.8	12.1	13.3	15.2	13.3	16.6
Japan	17.0	17.5	20.9	20.4	21.4	22.8	21.9	23.7	25.4	24.0	26.9
Europe	57.6	58.1	64.3	63.7	64.9	68.4	67.4	69.4	73.7	72.1	75.3
United Kingdom	9.3	9.6	10.2	10.0	10.3	10.6	10.4	10.9	11.3	10.9	11.7
France	8.4	8.6	10.0	9.7	10.3	10.8	10.3	11.3	11.9	11.1	12.7
West Germany	12.4	12.1	13.5	13.2	13.8	14.3	13.9	14.7	15.3	14.6	16.0
Italy	6.6	6.9	7.7	7.5	7.8	8.3	8.0	8.6	9.1	8.6	9.6
Netherlands	3.2	3.3	3.6	3.5	3.7	3.8	3.7	3.9	4.1	3.9	4.3
Other Europe	17.7	17.7	19.4	19.0	19.7	20.5	19.9	21.1	22.0	21.1	23.0
Other OECD	4.5	4.6	5.2	5.0	5.3	5.6	5.4	5.8	6.2	5.8	6.5
Total OECD	173.6	175.9	192.0	188.9	192.9	205.0	201.9	206.9	227.7	221.1	230.7
OPEC	14.4	14.9	17.5	17.1	17.9	19.2	18.5	20.3	21.4	20.3	22.5
Other Developing Countries	41.3	43.0	50.3	45.9	54.9	55.8	50.2	61.6	64.1	56.0	71.8
Total Market Economies	229.2	233.8	259.8	254.4	264.5	280.0	273.6	286.2	313.2	302.7	321.6
Centrally Planned Economies											
China	25.5	25.9	32.4	31.0	32.8	36.8	33.6	38.1	48.1	38.2	54.7
Soviet Union	59.9	59.9	56.6	49.9	64.1	59.3	52.9	66.9	65.3	59.3	73.3
Other CPE	24.6	24.4	24.7	17.8	30.3	25.9	19.1	31.5	28.0	21.4	33.6
Total	110.1	110.3	113.7	104.0	123.1	121.9	112.1	131.5	141.4	128.1	153.2
World Total	339.3	344.1	373.6	362.5	384.0	401.9	390.2	413.3	454.6	437.6	469.0

[a]Geographic coverage is the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD." Includes biofuels.

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: Uncertainty ranges for regional aggregates consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective sub-regions from their base value. Other totals may not equal sum of components because of independent rounding.

Sources: **History**: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89) (1991). **Projections**: Energy Information Administration, AEO 1991 Forecasting System run IEO91F.D0501913; *Annual Energy Outlook 1991*, DOE/EIA0383(91) (1991); Office of Energy Markets and End Use, *Oil Market Simulation Model User's Manual* DOE/EIA-MO28(91) (1991); and World Energy Projection System Spreadsheet, July 1991.

Table 8. World Natural Gas Consumption, 1988-2010
(Trillion Cubic Feet)

Region/Country	History		Projection Ranges								
			1995			2000			2010		
	1988	1989	Base	Low	High	Base	Low	High	Base	Low	High
OECD											
United States[a]	18.0	18.8	19.9	19.6	20.0	21.5	20.8	21.6	21.8	20.7	21.9
Canada	2.2	2.3	2.1	1.9	2.3	2.4	2.0	2.8	3.0	2.4	3.6
Japan	1.6	1.6	1.9	1.7	2.1	2.5	2.1	2.9	4.0	3.2	4.8
Europe	9.0	9.3	11.5	11.0	12.0	14.2	13.3	15.1	17.2	15.8	18.7
United Kingdom	2.0	2.1	2.6	2.4	2.9	3.1	2.6	3.5	3.6	2.9	4.3
France	1.0	1.0	1.2	1.1	1.3	1.8	1.5	2.1	2.5	2.0	2.9
West Germany	2.1	2.2	2.9	2.6	3.2	3.4	2.9	3.9	3.8	3.1	4.6
Italy	1.5	1.5	1.7	1.5	1.8	2.0	1.7	2.3	2.4	1.9	2.9
Netherlands	1.4	1.5	1.6	1.5	1.8	1.8	1.5	2.0	2.0	1.6	2.4
Other Europe	1.0	1.0	1.5	1.4	1.7	2.1	1.8	2.4	3.0	2.4	3.6
Other OECD	0.7	0.7	0.8	0.7	1.0	0.9	0.7	1.2	1.1	0.7	1.3
Total OECD	31.4	32.7	36.2	35.6	36.8	41.5	40.2	42.6	47.1	45.0	48.9
OPEC	5.1	5.4	6.3	5.8	6.7	7.0	5.9	8.2	7.5	5.5	9.3
Other Developing Countries	4.4	4.6	5.7	5.2	6.3	7.5	6.4	8.6	11.4	9.1	13.7
Total Market Economies	41.0	42.6	48.5	47.3	49.2	56.0	54.0	58.1	66.0	62.4	69.7
Centrally Planned Economies											
China	0.5	0.5	0.7	0.6	0.7	0.9	0.7	1.0	1.2	1.0	1.5
Soviet Union	24.1	25.1	25.3	23.8	26.9	26.5	24.3	28.4	29.5	24.9	33.2
Other CPE	3.9	4.1	4.1	3.7	4.4	4.1	3.8	4.4	4.8	4.5	5.1
Total	28.6	29.7	30.0	28.6	31.7	31.5	29.3	33.4	35.5	30.9	39.2
World Total	69.5	72.3	78.3	76.5	80.2	87.5	84.5	90.3	101.5	95.7	106.8

[a]Geographic coverage is the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Note: Uncertainty ranges for regional aggregates consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective sub-regions from their base value. Other totals may not equal sum of components because of independent rounding.

Sources: **History**: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89) (1991); and *Monthly Energy Review*, DOE/EIA-0035(91/04) (1991). **Projections**: Energy Information Administration, AEO 1991 Forecasting System run IEO91F.D0501913; *Annual Energy Outlook 1991* DOE/EIA 0383(91) (1991); and Office of Energy Markets and End Use, World Energy Projection System Spreadsheet, July 1991.

Table 9. World Coal Consumption, 1988-2010
(Million Short Tons)

Region/Country	History		Projection Ranges								
			1995			2000			2010		
	1988	1989	Base	Low	High	Base	Low	High	Base	Low	High
OECD											
United States[a]	884	891	949	943	950	1,003	998	1,005	1,235	1,130	1,244
Canada	61	63	64	61	67	66	60	71	69	58	79
Japan	129	129	130	127	133	133	127	141	141	129	153
Europe	601	612	660	631	701	693	642	751	744	669	826
United Kingdom	127	128	128	115	140	128	108	147	131	104	157
France	28	33	33	29	36	28	24	32	24	19	29
West Germany	209	207	223	211	233	235	215	254	262	220	293
Italy	23	24	29	21	39	36	24	51	38	24	54
Netherlands	13	14	17	14	18	18	14	20	21	15	24
Other Europe	200	206	231	211	267	248	207	298	269	215	337
Other OECD	99	99	108	99	117	120	99	144	133	97	166
Total OECD	1,774	1,793	1,911	1,880	1,953	2,014	1,958	2,078	2,322	2,187	2,412
OPEC	6	6	15	14	17	21	18	24	25	20	31
Other Developing Countries	520	531	584	526	643	655	556	753	722	578	866
Total Market Economies	2,300	2,330	2,510	2,444	2,582	2,690	2,577	2,807	3,070	2,872	3,240
Centrally Planned Economies											
China	1,045	1,051	1,300	1,235	1,320	1,445	1,299	1,507	1,877	1,428	2,175
Soviet Union	822	789	736	663	810	736	626	847	755	604	905
Other CPE	1,043	1,034	1,046	941	1,150	1,060	901	1,219	1,127	901	1,352
Total	2,909	2,874	3,082	2,938	3,211	3,241	2,999	3,445	3,758	3,233	4,161
World Total	5,209	5,204	5,592	5,434	5,740	5,932	5,664	6,166	6,828	6,267	7,265

[a]Geographic coverage is the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: Uncertainty ranges for regional aggregates consist of the base value adjusted by the quantity: the square root of the sum of the squared deviations of the respective sub-regions from their base value. Other totals may not equal sum of the components because of independent rounding.

Sources: **History**: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89) (1991); and *Monthly Energy Review*, DOE/EIA-0035(91/04) (1991). **Projections**: Energy Information Administration, AEO 1991 Forecasting System run IEO91F.D0501913; *Annual Energy Outlook 1991*, DOE/EIA0383(91) (1991); and Office of Energy Markets and End Use, World Energy Projection System Spreadsheet, July 1991.

Table 10. World Net Nuclear Energy Power Consumption, 1988-2010
(Billion Kilowatthours)

Region/Country	History		Projection Ranges								
			1995			2000			2010		
	1988	1989	Base	Low	High	Base	Low	High	Base	Low	High
OECD											
United States[a]	527	529	570	570	570	593	592	594	611	611	654
Canada	78	75	100	100	100	101	101	114	127	127	178
Japan	174	175	242	217	242	270	246	270	318	306	318
Europe	660	693	738	720	738	758	731	758	863	726	863
United Kingdom	70	85	63	63	63	57	57	57	60	56	60
France	219	239	297	289	297	309	301	309	357	320	357
West Germany	148	144	144	144	144	145	145	145	160	147	160
Italy	18	21	25	25	25	32	29	32	51	50	51
Netherlands	5	6	6	6	6	6	6	6	9	6	9
Other Europe	199	198	203	193	203	208	192	208	224	147	224
Other OECD	0	0	0	0	0	0	0	0	0	0	0
Total OECD	1,439	1,472	1,651	1,607	1,651	1,721	1,670	1,736	1,918	1,770	2,012
OPEC	0	0	0	0	0	0	0	0	0	0	0
Other Developing Countries	89	92	105	96	105	135	109	135	185	157	185
Total Market Economies	1,528	1,564	1,755	1,704	1,755	1,856	1,778	1,871	2,103	1,926	2,197
Centrally Planned Economies											
China	0	0	13	12	13	13	12	13	13	11	16
Soviet Union	199	197	269	263	276	324	307	341	342	279	410
Other CPE	68	69	89	88	90	109	106	111	164	154	177
Total	267	266	371	362	379	445	425	466	519	444	602
World Total	1,795	1,830	2,126	2,066	2,135	2,301	2,204	2,336	2,622	2,370	2,799

[a]Geographic coverage is the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."
OECD = Organization for Economic Cooperation and Development.
OPEC = Organization of Petroleum Exporting Countries.
Notes: Totals may not equal sum of components because of independent rounding.
Sources: **History**: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89) (1991); and *Monthly Energy Review*, DOE/EIA-0035(91/04) (1991). **Projections**: Energy Information Administration, AEO 1991 Forecasting System run IEO91F.D0501913; *Annual Energy Outlook 1991*, DOE/EIA0383(91) (1991); and Office of Energy Markets and End Use, World Energy Projection System Spreadsheet, July 1991.

Table 11. World Other Energy Consumption, 1988-2010
(Quadrillion Btu)

Region/Country	History		Projection Ranges								
			1995			2000			2010		
	1988	1989	Base	Low	High	Base	Low	High	Base	Low	High
OECD											
United States[a]	6.6	6.5	8.1	8.0	8.1	9.4	9.4	9.4	12.5	12.4	12.6
Canada	2.8	2.9	3.2	3.2	3.3	3.9	3.7	4.1	5.1	4.6	5.7
Japan	0.9	0.9	1.0	1.0	1.1	1.2	1.1	1.3	1.6	1.4	1.8
Europe	5.2	4.6	4.8	4.7	5.0	5.0	4.8	5.3	5.5	4.9	6.1
United Kingdom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
France	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.6
West Germany	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
Italy	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.7	0.9
Netherlands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Europe	3.4	3.2	3.3	3.2	3.4	3.4	3.3	3.6	3.7	3.3	4.1
Other OECD	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.5	0.6
Total OECD	15.9	15.2	17.6	17.3	17.8	20.0	19.4	20.5	25.3	23.9	26.8
OPEC	0.5	0.5	0.8	0.8	0.8	0.9	0.8	0.9	1.0	0.9	1.1
Other Developing Countries	4.8	4.9	5.8	5.6	5.9	6.6	6.2	6.9	7.3	6.6	8.1
Total Market Economies	21.2	20.6	24.1	23.7	24.5	27.4	26.5	28.3	33.6	31.3	36.0
Centrally Planned Economies											
China	1.1	1.1	1.8	1.7	1.8	2.0	1.9	2.1	3.2	2.9	3.5
Soviet Union	2.3	2.3	2.2	2.2	2.3	2.2	2.1	2.3	2.2	2.0	2.5
Other CPE	1.0	0.9	1.0	0.9	1.0	1.0	0.9	1.1	1.2	1.0	1.3
Total	4.4	4.3	4.9	4.8	5.1	5.2	5.0	5.5	6.6	5.9	7.3
World Total	25.5	24.9	29.1	28.5	29.6	32.6	31.5	33.8	40.2	37.2	43.2

[a]Geographic coverage is the 50 States and the District of Columbia. U.S. Territories are included in "Other OECD."

OECD = Organization for Economic Cooperation and Development.

OPEC = Organization of Petroleum Exporting Countries.

Notes: Other energy consists of hydropower. U.S. amounts also include energy from geothermal, solar, wind, and biofuels. Totals may not equal sum of components because of independent rounding.

Sources: **History**: Energy Information Administration, *International Energy Annual 1989*, DOE/EIA-0219(89) (1991). **Projections**: Energy Information Administration, AEO 1991 Forecasting System run IEO91F.D0501913; *Annual Energy Outlook 1991*, DOE/EIA0383(91) (1991); and Office of Energy Markets and End Use, World Energy Projection System Spreadsheet, July 1991.

Table 12. Comparison of Selected U.S. Projections from the *IEO* and the *AEO*, 1995, 2000, and 2010

Projection	1995		2000		2010	
	IEO	*AEO*	*IEO*	*AEO*	*IEO*	*AEO*
Petroleum (million barrels per day)						
Consumption	17.9	17.3	18.6	18.5	20.5	20.3
Production	8.6	9.2	7.9	8.0	7.2	7.2
Consumption						
Natural Gas (trillion cubic feet)	19.9	20.0	21.5	21.6	21.8	21.7
Coal (million short tons)	949	948	1,003	1,003	1,235	1,244
Nuclear (billion kilowatthours)	570	570	593	594	611	611
Total Energy (quadrillion Btu)	90.0	89.1	95.5	95.6	107.2	106.9
World Oil Prices (1990 dollars per barrel)	$21	$24	$26	$26	$33	$34

IEO = *International Energy Outlook 1991*, Base Case.
AEO = *Annual Energy Outlook 1991*, Reference Case.
Sources: Energy Information Administration, *Annual Energy Outlook 1991*, DOE/EIA0383(91) (1991); and AEO Forecasting System run IEO91F.D050913.

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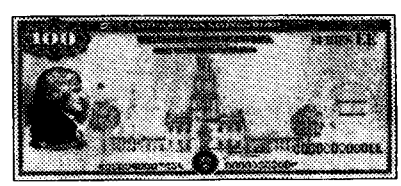

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