THE DIRECTOR OF CENTRAL INTELLIGENCE

WASHINGTON, D. C. 20505

National Intelligence Officers

21 September 1977

MEMORANDUM FOR: Director of Central Intelligence

VIA : Deputy to the DCI for National Intelligence

FROM : [redacted] O/D/DCI/NI

SUBJECT : "Allied Interdependence Project" Prospectus from Thomas A. Callaghan, Jr.

1. Action required: Signature on the letter to Callaghan attached.

2. By date of 26 July 1977, Callaghan sent you a copy of a statement he had made earlier that month before the Legislation and National Security Subcommittee of the House Government Operations Committee on NATO standardization. Your reply of 10 August informed him that DDI is engaged in defining two long-term study projects on "The Problem of Europe as a Military, Political, and Economic Partner" and "International Transfer Issues." Your letter also pointed out that these subjects are difficult for the U.S. intelligence community because of their dependence on policy decisions made by Congress and the State and Defense Departments.

3. Callaghan has now sent you a prospectus for what appears to be an expanded project relating standardization, as a policy objective, not only to more rational and economical NATO armament (which should make possible "credible, collective conventional force within reasonable defense budgets") but also to the prospect of greatly expanded world trade of benefit to the U.S. and its Atlantic allies. Though the prospectus refers to the need for funding, his letter asks for nothing, only saying that he hopes you will find his enclosure and the eventual output of his project "helpful."

4. The letter attached for your signature is intended to be supportive without giving Callahan a statement he can use for publicity purposes in support of his project. If you are satisfied with the letter, I shall send copies of the prospectus to the DDI officers concerned with the long-term studies: [redacted] OSR; [redacted] OER; and [redacted] ORPA.

[redacted]

Attachment

Distribution:
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Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

CHAIRMAN

77-2342

UNITED STATES INTERNATIONAL TRADE COMMISSION

WASHINGTON, D.C. 20436

Dear Member of Congress:

Attached is a USITC staff report, "Factors Affecting World Petroleum Prices to 1985,". This report was prepared with the primary purpose of presenting and discussing those factors which will impact the price of crude petroleum between now and 1985 and forecasting what that price will be in 1980 and 1985.

This staff report reaches the conclusion that although crude petroleum supplies may tighten between now and 1985, no shortage is foreseen assuming among other things that effective conservation programs are implemented. Assuming OPEC and Saudi Arabia increase production capacities and the U.S.S.R. remains self-sufficient in crude petroleum, world production will be able to satisfy world demand. Under these circumstances, no drastic rise such as the recent quadrupling in crude petroleum process is foreseen. However, our staff expects that the price will increase at the prevalent rate of inflation. Accordingly, the staff report concludes that the f.o.b. Saudi Arabia price of marker crude petroleum, currently at $12.70 per barrel, is forecast to be around $15 per barrel in 1980 and $20 per barrel in 1985. These forecast prices assume a future inflation rate of 5.5 percent per year and that this inflation rate is applicable to petroleum prices. If the inflation rate is higher, the forecast prices in 1980 and 1985 will also be higher.

We would appreciate any comments you might have.

I hope you have a nice day.

Yours sincerely,

(EXECUTIVE REGISTRY FILE) O/DCI/ [illegible]

Daniel Minchew
Chairman

Attachment

NEWS
(202) 523-0161
UNITED STATES INTERNATIONAL TRADE COMMISSION • Office of the Secretary • Washington, D.C. 20436

FOR USE AFTER 6 P.M.
September 11, 1977

CONTACT: Hal Sundstrom
(202) 523-0161

USITC 77-067

USITC REPORT RELEASED: "FACTORS AFFECTING WORLD PETROLEUM PRICES TO 1985"

The United States International Trade Commission today issued a report prepared by USITC staff analysts which discusses the more important supply and demand factors that will affect petroleum prices from now until 1985.

The report is titled Factors Affecting World Petroleum Prices To 1985. Its forecasts are based on certain qualifications and assumptions, including effective energy conservation programs; maximum contribution to energy supply by other energy sources; and that OPEC, and Saudi Arabia, will, if necessary, increase production capacity. Other assumptions are the U.S.S.R. will remain self-sufficient in crude petroleum production; no arbitrary governmental actions on price; and no disruptive embargoes, war, or other type of military action. The report also assumes that no major technological breakthrough will be achieved in the energy field.

With these assumptions, the report concludes that although crude petroleum supply and demand may tighten between now and 1985, world production will be able to satisfy world demand. Under these circumstances, no precipitous increase in crude petroleum prices is expected; rather, prices are expected to rise in consonance with inflation.

According to the report, world crude petroleum supply and demand equality is forecast for 1980 at 69 million barrels per day, and for 1985 at 86 million barrels per day. At these consumption levels, OPEC production will be sufficient when combined with non-OPEC production to

more

meet world demands. Should the non-OPEC nations and the Communist Bloc experience a decrease in production and/or an increase in consumption between 1980 and 1985, it appears that OPEC production will be able to balance supply with demand.

The report considers numerous important supply and demand factors that will affect petroleum prices from now until 1985. These include security of supply, world trade patterns, population, and gross national product. Also discussed are other energy sources such as natural gas, coal, nuclear energy, geothermal energy, oil shale, tar sands, hydro-electric power, and synthetic fuels. Changes in the ownership of crude petroleum produced in most of the producing-exporting countries and energy conservation are other factors considered.

Copies of the Commission report, Factors Affecting World Petroleum Prices to 1985 (USITC Publication 832), may be obtained from the Office of the Secretary, United States International Trade Commission, 701 E Street, NW, Washington, D.C. 20436.

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UNITED STATES INTERNATIONAL TRADE COMMISSION

FACTORS AFFECTING WORLD PETROLEUM PRICES TO 1985

USITC Publication 832
Washington, D.C.
September 1977

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

UNITED STATES INTERNATIONAL TRADE COMMISSION

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Address all communications to
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Washington, D. C. 20436

C O N T E N T S

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Tables--Continued

Tables--Continued

FOREWORD

Crude petroleum is a vast and complex subject with entire volumes written about any one of its many aspects, such as exploration, refining, or marketing. This report is not meant to be an exhaustive treatment of the subject and is limited in scope. Specifically, the report covers some of the more important factors affecting crude petroleum prices until 1985, emphasizing the discussion of economic considerations affecting petroleum supply and demand. Important factors such as politics, embargoes, and military conflict affect prices but are not discussed to any extent.

One difficulty in discussing petroleum prices is that very little definitive information is available on transfer and internal pricing policies of the major oil companies, although these factors greatly influence price. The new financial reporting system to be implemented by the Federal Energy Administration is intended to clear away some of the confusion surrounding these areas. The National Energy Plan stated 1/ that a "comprehensive reporting program would enable the Government to assess the performance of the industry and individual firms . . . would restore confidence within the Congress and among the American people...."

Further, the world crude petroleum market is not a free market. The Organization of Petroleum Exporting Countries (OPEC) is a cartel and essentially arbitrarily sets world price. However, even within OPEC variations in price occur between similar crude petroleums for no apparent reason. Thus far very little formal discussion has occurred within OPEC to decide on quality price differentials.

There have always been problems associated with petroleum product definitions. Even the term "crude petroleum" does not always mean the same thing; it especially does not always mean crude petroleum as it is piped from underground reservoirs. Crude petroleum is not always shipped as it is obtained at the wellhead; often it is desalted, dehydrated, topped, or has other hydrocarbons added. Yet, by most definitions it remains crude petroleum provided that its essential character is unchanged by the processing.

These difficulties illustrate the complexities involved in the preparation of an analysis of crude petroleum. This report deals with a number of intangible and unknown factors and makes a number of assumptions. Nevertheless, the conclusions and projections appearing in the report, in the absence of any major new developments that cannot be foreseen at the present time, portray a reasonable, balanced picture of the supply and demand of petroleum during 1977-85, and the factors which will affect petroleum prices during that period.

1/ Executive Office of the President, Energy Policy and Planning, The National Energy Plan, April 29, 1977, p. 86.

EXECUTIVE SUMMARY

Although crude petroleum supplies may tighten between now and 1985, no disruptive shortage is foreseen. World production will be able to satisfy world demand. Under these circumstances crude petroleum prices will not rise above the rate of general inflation. These conclusions are based on the belief that OPEC, and particularly Saudi Arabia, will increase production capacity and that the U.S.S.R. will remain self-sufficient in crude petroleum production. Saudi Arabia wishes to maintain its position of dominance with OPEC and will have an incentive to increase production capacity so that it might continue as the dominant producing country in OPEC and retain its control over OPEC price. The U.S.S.R. will increase its production by various means, including the purchase of overseas technology and equipment.

Although the world crude petroleum market will remain in balance and thus experience no drastic price increase through 1985, OPEC exports will continue to balance supply with demand in most of the world's petroleum-consuming nations. Therefore, in the absence of price controls, the world price for all crude petroleum will move toward the OPEC price.

The current price for Arabian light (so-called "marker" crude petroleum, to which all other OPEC prices are pegged) is $12.70 per barrel f.o.b. Saudi Arabia. Since no critical shortage of crude petroleum is expected, OPEC will not be able to increase prices arbitrarily without the loss of market and eventual disruption of the world's economies. The price of crude petroleum, however, will increase in consonance with the prevalent rate of inflation. This conclusion is substantiated by the observation that OPEC, in its "Solemn Declaration" of 1975, stated that petroleum prices would in fact be linked to inflation rates. Stable and moderate inflation rates in countries which export to OPEC would be instrumental in holding down the level of petroleum prices. Accordingly, the price of marker crude petroleum is forecast to be around $15 per barrel in 1980 and $20 per barrel in 1985. These forecast prices assume a future inflation rate of about 5.5 percent per year. If the actual rate is higher, as some economists expect it to be, future petroleum prices will reflect that higher rate. To both current price and future projections, transportation and related costs must be added to arrive at landed prices.

Although many of the OPEC nations desire to maximize crude petroleum export revenue because of large populations and extensive development plans, there is an upper limit on price. This limit is delineated by OPEC's need to avoid disrupting the world economy, by the cost of alternative energy sources, and by the increasing availability of crude petroleum in other markets as the price increases. Thus, while it appears that OPEC arbitrarily sets prices, a more realistic assessment might suggest that OPEC reacts to exogenous market factors.

The current sustainable upper limit on price is in the range of $20 to $25 per barrel. This price would bring forth increases in world crude petroleum reserves and production. Other energy sources, including

some of the more exotic such as oil shale and tar sands, would become economically viable. Thus, prices above $20 to $25 could not be maintained in the face of increasing energy supplies and decreasing demand. Projecting this price range indicates upper limit price ranges of $24 to $29 in 1980 and $31 to $38 in 1985. Of course, any technological breakthrough or discovery of large reserves would significantly lower these upper price limits. Conversely any action such as war or embargo would significantly increase these upper price limits.

Current OPEC crude petroleum production capacity of 38 million barrels per day will be able to supply OPEC's internal needs for 1980 and the balance of the world's supply shortfall. The OPEC production level forecast for 1980 would require Saudi Arabia to produce at a rate of only 8.5 million barrels per day versus its current production capacity of 11.4 million barrels per day. Additions to current production capacity in Saudi Arabia, as well as in Iraq, Nigeria, Indonesia and the United Arab Emirates, will enable OPEC to meet any world crude petroleum short-falls which are due to increasing world consumption and/or decreasing U.S.S.R. self-sufficiency through 1985.

World crude petroleum production is expected to increase, especially in the period after 1980. From now until 1980 there will occur an incubation period wherein the world will increasingly accept and learn to deal more effectively with higher costs, new technology, and hostile environments. That there are additional undiscovered but discoverable petroleum resources in the world is undeniable; these may amount to as much as 70 percent of the world's total crude petroleum potential. The only questions are how much and when the resources will be developed. It is probable that the world's remaining potential will be developed quickly enough to preclude any shortages that would trigger drastic price increases.

The more exotic energy forms, such as oil shale and tar sands, are not expected to contribute significantly to total energy supply by 1985. However, it is expected that coal, nuclear, hydroelectric, and geothermal sources will be aggressively further developed and will reduce the future demand for crude petroleum and natural gas.

Overall energy demand is forecast to grow at a rate which is slower than that exhibited prior to the Arab oil embargo, owing to higher prices and conservation. For the world, it is expected that the average annual growth rate for the 1975 to 1980 period will be 4.5 percent, and for the 1975 to 1985 period it will be 4.4 percent. This lower growth rate means that consumption in 1985 will be around 15 percent lower than historic energy trends would indicate.

For the United States, which currently accounts for almost 30 percent of the world's primary energy consumption, the future energy growth rates are expected to be 2.8 percent per year from 1975 to 1980 and 2.5 percent per year from 1975 to 1985; this assumes that serious efforts will be made to bring about major energy savings through conservations. Many of the other nations in the world will not be able to decrease energy consumption growth rates to anything near this level. These nations, and especially those classified as developing, will require faster energy consumption growth rates in order to maximize the rate of economic growth.

INTRODUCTION

Methodology of Study

This study looks into and assesses the factors associated with petroleum prices to 1985. It relies on published forecasts and sources of historical data, rather than generating new data and techniques. It should be noted that many sources of historical energy data do not agree with one another on specific items and that, often, different publications from the same source may disagree. Reasons for these disparities between data for the same items include the use of different conversion factors, different primary sources of the data, revisions and changes to original data, and definition of terms. The last reason can be illustrated by the use of the term "consumption" by some sources without any indication of whether it is total primary consumption or total final consumption. In addition, some sources define the term "consumption" differently from others, rendering comparisons difficult.

This study began with the projection of total energy demand to 1985. In order to project this demand for 16 selected countries and areas, data were gathered on the following four variables: energy demand in the past, gross domestic production (GDP) or gross national product (GNP), population, and energy conservation. Using the data and projections obtained for GDP, GNP, population, economic sectors (such as transport, industrial, household-commercial, and electricity generation), energy conservation measures, and energy consumption, various growth rates for future energy demand were developed. Selected growth rates were applied to 1975 energy demand for each country and area in order to arrive at total energy demand projections for 1980 and 1985.

The study progressed with the gathering of information and data on all energy sources that together satisfy energy demand. These energy sources include petroleum, natural gas, uranium, coal, geothermal, hydroelectric, tar sands, oil shale, and solar radiation. Estimates were then made, by key countries and areas, of the maximum probable contribution 1/ that each of the energy sources other than petroleum would make to satisfying forecast total energy demand. This was done considering past energy source use, energy source availability, and development plans for these energy sources. The forecast was also guided by the expectations of others writing in the petroleum field. The contribution by petroleum was then taken to be the difference between the expected contributions by all other energy sources and the total energy demand for each of the key countries and areas.

Petroleum supply was forecast separately from petroleum demand. Supply forecasts for the 19 major crude petroleum producing nations and the other producing nations were based on current production, production capacity, proved reserves, and the level of exploration and development activity in each. It was assumed that each producing nation would act in its own enlightened self interest, was covetous of its current position in the pecking order of world producers--OPEC, OAPEC, etc.--and would knowingly do nothing to relegate itself to an inferior position in

1/ It is assumed that because of the desire to reduce reliance on crude petroleum and imports, increasing effort will be directed to maximizing diversification of energy sources.

the future. It is believed these assumptions lead to neither the most pessimistic nor the most optimistic supply forecasts.

The forecast petroleum supply and demand data have been analyzed and a balance projected. On the basis of this balance, conclusions have been reached regarding possible future prices.

It has been assumed that, under almost any reasonable supply-demand scenario through 1985, prices will increase. Even under an adequate supply position, inflation and the tapping of increasingly inaccessible resources will increase prices. These price increases would become increasingly steep and arbitrary under progressively shorter supply positions. However, price would have some upper limits. These limits would be set by a necessity to keep some economic order in the world, by prices of alternate energy sources, by exporting country revenue requirements, and to a lesser extent by fear of military action against the exporting countries.

Organization of the Report

Three sections follow this introduction. All of the tables referred to in the text of these sections are found in appendix A. There are also appendixes entitled "Prices", "World Trade", "Supply Security", "Total Energy Demand Background", "Other Energy Sources", and "Changes in Ownership". The factors discussed in all of these appendixes affect petroleum prices and are either explicitly or implicitly included in the sections of the report.

The section entitled "Analysis of Projected Petroleum Price Trends", draws upon the data developed in the sections entitled "Forecast of World Energy Demand" and "World Petroleum Demand and Supply", and is organized around a survey of present and projected petroleum supply and demand. It contains comments on current and future prices based on the petroleum balance. This section also contains remarks on some of the recent controversial petroleum studies.

The section entitled "Forecast of World Energy Demand" delves into the factors affecting world energy demand, including economics, population, and conservation. The more important energy-consuming areas and countries are treated in detail.

The final section, entitled "World Petroleum Demand and Supply", contrasts the availability of energy resources with their use pattern. It develops independent petroleum consumption and supply forecasts based on these two factors as they interact with total forecast energy demand as arrived at in the previous section. This final section contains sub-sections on petroleum demand in the principal world markets and petroleum supply from the principal world suppliers. It indicates that the consumption centers are not the production centers and that world trade in petroleum will continue to be important.

ANALYSIS OF PROJECTED PETROLEUM PRICE TRENDS

That supply-demand balances are of prime importance in setting price is generally accepted. This has been stated many times but perhaps never more succinctly than as follows, ". . . realization that OPEC, like any other oligopolistic phenomenon, is ultimately governed by the forces of demand and supply in the market rather than by any peculiar or unique wickedness." 1/ The success that OPEC has had in recently quadrupling crude petroleum prices is directly traceable to the unique position it occupies among the world's crude petroleum suppliers. It has been, and will probably continue in the future to be, the source that balances supply from non-OPEC producers (i.e., all other crude petroleum producers in the world) with world demand. Any decline in world demand will reduce demand for OPEC petroleum. Any increase in non-OPEC supply of crude petroleum or any other energy source will also reduce demand for OPEC petroleum.

Because of the currently high price for crude petroleum most nations of the world are exploring for and developing crude petroleum resources, attempting to decrease consumption through conservation, and developing alternate energy sources. In spite of these efforts, many of the nations of the world will remain dependent on OPEC supply at least through 1985. Consumption cannot be drastically reduced without affecting economic growth. Alternate energy sources are expensive to develop and require a long lead time before they can contribute significantly to energy supply. Some new petroleum resources just now discovered will probably not be producing commercially until the 1980's. Nevertheless, conservation, new discoveries, and alternate energy sources will all have some effect on reducing the extent of future world demand for OPEC crude petroleum.

Forecast Supply-Demand Balance

World supply and demand equality is forecast for 1980 at 69 million barrels per day and for 1985 at 86 million barrels per day. (See table 1 of appendix A.) This forecast indicates that OPEC will be able to meet the non-OPEC supply shortfall. In fact, based on the current OPEC production capacity of 38 million barrels per day, OPEC could supply an additional 8 million barrels per day in 1980 and an additional 6 million in 1985. This additional supply could offset any comparable decrease in expected Communist Bloc, United States, or other non-OPEC production, or comparable increase in demand.

Should the non-OPEC nations and the Communist Bloc experience a decrease in supply and/or increase in demand in 1980 and 1985 to exceed the 8 million barrels per day and 6 million barrels per day surpluses indicated above, there is every indication that OPEC would be able to increase production to meet the shortfall. Even the recent pessimistic

1/ M. M. Sakbani and John J. Van Belle, "The Non-OPEC Oil Supply and Implications for OPEC's Control of the Market", Journal of Energy and Development, Autumn 1976, p. 76.

CIA report 1/ indicates that OPEC production capacity could increase by 10 million barrels per day in 1985 over the current level of 38 million barrels per day. 2/ Thus, future OPEC production capacity could supply an additional 16 million 3/ barrels per day in 1985. We believe this is more than enough to offset any reasonable change in our forecast supply-demand situation. Most nations are extremely conscious of, and are planning to reduce petroleum imports. For example the International Energy Agency (IEA) 4/ has reached a consensus that the IEA members' combined petroleum imports should be limited to 26 million barrels per day by 1985. 5/

Central Intelligence Agency Report

Table 1 gives a picture different from that given in the recent Central Intelligence Agency (CIA) report, The International Energy Situation: Outlook to 1985, issued in April of 1977. The demand estimates presented here are in line with those of the CIA, but forecasts of production in this report for the Communist Bloc and non-OPEC producers are higher. This forecast assumes that enhanced recovery projects and production from recently found reserves will push production higher than the CIA forecasts. The basic CIA premise was given by Admiral Turner: "We're assuming you cannot get any additional production out of untapped oil reserves until 1985." 6/

Communist Bloc.--This report assumes that the Communist Bloc will retain its current petroleum self-sufficiency through 1985, while the CIA sees it becoming a net importer. The CIA report is based on "highly sensitive intelligence sources unavailable to anybody else" according to CIA Director Stansfield Turner. 7/ Without access to these sources, there is no way to comment on the claim that Soviet crude petroleum production will suffer from water encroachment. The CIA's pessimistic assumption, however, has appeared in no other major study of the world petroleum situation.

Director Turner acknowledges that new and large U.S.S.R. fields will eventually be discovered but adds, "we doubt that the new discoveries will come on stream rapidly enough to do more than temporarily arrest

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1/ Central Intelligence Agency, The International Energy Situation: Outlook to 1985, April 1977.

2/ Of this 10 million barrel per day increase, 7 million barrels per day would be attributed to Saudi Arabia and 3 million barrels per day to the other 12 OPEC members.

3/ Arrived at by adding future production capacity increases of 10 million barrels per day to a surplus of current production capacity relative to expected 1985 demand of 6 million barrels per day.

4/ Participating nations are: United States, United Kingdom, West Germany, Japan, Canada, Italy, Sweden, Netherlands, Switzerland, Spain, Denmark, Belgium, Austria, Turkey, Ireland, New Zealand and Luxembourg.

5/ Platts' Oilgram News Service, June 3, 1977, p. 1.

6/ Oil and Gas Journal, May 2, 1977, p. 117.

7/ Oil and Gas Journal, May 2, 1977, p. 117.

the rapid slide of Soviet output". 1/ He further added that he would not dispute a U.N. report that indicates the world has sufficient petroleum and natural gas to last another 100 years, but that only reserves from which production could be obtained by 1985 were used in the CIA study.

Our forecast of 11 million barrels per day of U.S.S.R. production falls short of its announced 1980 goal of 12.3 million barrels per day. After 1980 we foresee a gradual buildup of production to the point where in 1985 it is just 2.7 million barrels per day greater than the goal set by the U.S.S.R. for 1980.

The U.S.S.R. has the potential resources to expand production significantly. Latest western sources estimate ultimate reserves of the U.S.S.R. at 250 billion barrels. 2/ While this figure includes offshore reserves, they are mainly those of the inland seas. The U.S.S.R. has the world's largest continental shelves, covering some 2.5 million square miles, and significant additional offshore reserves will also be discovered. These largely unexplored areas, plus the Arctic areas of the U.S.S.R, are believed to be the only remaining areas where the discovery of hydrocarbon reservoirs of Middle East proportions may yet be found. 3/ Help in developing these areas in the forms of financial and technical assistance may be forthcoming from other nations. For example, the Japanese are to train Soviet crews as part of a Sakhalin venture, a U.S. company has sold a semisubmersible rig to the U.S.S.R. and will provide subsea petroleum and natural gas technology, and discussions are underway for help from a British consortium in Caspian undertakings. 4/

Saudi Arabia.--The CIA report assumes that Saudi Arabia would be required to produce up to 12 million barrels per day in 1982 and 13 to 16 million barrels per day in 1983. The estimates in this report require OPEC production in 1980 and 1985 to be similar to OPEC production in 1976, which averaged 30.4 million barrels per day and to which Saudi Arabia contributed 8.6 million barrels per day. However, Saudi Arabia could supply additional production in the future if required. Based on a current production capacity of 11 million barrels per day, this additional supply could be up to 2.4 million barrels per day above the average 1976 production rate.

Massachusetts Institute of Technology

The Workshop on Alternative Energy Strategies (WAES) 5/issued an energy study, Energy: Global Prospects 1985-2000, that indicates

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1/ Oil and Gas Journal, May 2, 1977, pp. 117-118.
2/ E. N. Tiratsoo, Oilfields of the World, Scientific Press Ltd., 1976.
3/ Petroleum Economist, May 1, 1977, p. 191.
4/ Ibid., p. 192.
5/ Workshop on Alternative Energy Strategies, Massachusetts Institute of Technology, Energy: Global Prospects 1985-2000, 1977. U.S. participants in the study included high level industry executives, who were joined by representatives from Canada, Denmark, Finland, France, West Germany, Iran, Italy, Japan, Mexico, the Netherlands, Norway, Sweden, the United Kingdom and Venezuela. The study was funded by various foundations and business institutions.

the non-Communist world faces a petroleum shortage over the next 25 years unless it makes "massive investment" in energy development and "extraordinary efforts" at conservation. The report states that by the year 2000 the non-Communist world will be faced with a petroleum shortage of 15 to 20 million barrels per day, although shortfalls could occur as early as the mid-1980's. These forecasts assume petroleum is the swing fuel which will make up the energy supply shortage between projected energy demand and that supplied by other energy sources. The report also states that conservation must be taken seriously; development of energy sources other than petroleum must be expedited, including nuclear, oil sands, and oil shale; natural gas must be conserved and moved between the continents; and constraints on petroleum production must not be allowed to add to the shortage. The report concludes, "what we find is a range of opportunities for closing the gaps that all require enormous efforts in planning, intensive engineering efforts, and major capital investment - with lead times of usually 10 or more years. And most of these efforts should be well under way by 1980-85, which means starting them now." 1/

The most probable forecasts in this report for 1980 and 1985 assume a maximum contribution by other energy sources and maximum production in the Communist Bloc and non-OPEC nations. The forecast assumes an increasing world-wide recognition of the importance of conservation, resource development, and commercialization of all energy sources. It also rests on the assumption that strong energy policies will be implemented, free from conflicting influences of different special-interest factions.

U.S. Department of Commerce

A recent study, 2/ Forecast of Likely U.S. Energy Supply/Demand Balances for 1985 and 2000 and Implications for U.S. Energy Policy, prepared by the Office of Energy Programs, Domestic and International Business Administration, is concerned only with the United States. The key conclusion is that even with a reduced energy growth rate the United States will continue to rely on petroleum imports. It forecasts U.S. imports of 8 million barrels per day in 1985 (versus 7.2 million barrels per day estimated in this report), dropping to 6.1 million barrels per day in the year 2000. The CIA study previously cited indicates U.S. import figures of 10 million barrels per day in 1980, possibly rising to 12 to 15 million barrels per day in 1985. 3/

The Commerce Department report assumes--

a. That OPEC will continue to export 28 to 38 million barrels of crude petroleum per day until 1985. (By contrast, this report

1/ Oil and Gas Journal, May 23, 1977, p. 31.

2/ United States Department of Commerce, Domestic and International Business Administration, Forecast of Likely U.S. Energy Supply Demand Balance for 1985 and 2000 and Implications for U.S. Energy Policy, Washington, D.C., 1977.

3/ The International Energy Situation: Outlook to 1985, p. 15.

shows most probable OPEC exports of 30 million barrels per day in 1980 and 32 million barrels per day in 1985).

b. That OPEC will charge the highest price it can for these exports, but that this price will be equal to or only moderately more than the current price adjusted for inflation. The report then speculates that the world price for crude petroleum will rise 3 percent faster annually than the price of other commodities.

On these assumptions, the report states that world supply will be adequate to meet world demand through the intermediate term, although there always exists the possibility of a politically expedient OPEC production cut-back.

Price

There are many prices associated with crude petroleum. For example, there are wellhead prices, f.a.s. prices, f.o.b. prices, median prices, average prices, "old" crude petroleum price, and "new" crude petroleum price. The price addressed in this section is the price at which OPEC Arabian Light production has been available. This price has been the "marker" price to which all other OPEC crude petroleums are indexed. Table 2 contains a history of OPEC prices from 1970 to 1976. It shows the well-known fact that "marker" crude petroleum has quadrupled in price since the embargo and increased almost 7-fold since 1970.

Current

Some deviation from this "marker" concept occurred during the time of the "two-tier" OPEC price system. As a result of the Doha, Qatar, meeting of OPEC Ministers on December 15 to 17, 1976, Saudi Arabia and the U.A.E. held their price increase, to be effective January 1, 1977, to 5 percent, while the other eleven members agreed to a price increase of 10 percent. It became apparent that the percentage increases had not been applied across the board; new postings indicated a variety of increases, some of which were smaller and some of which were larger than those increases announced at the time of the Doha meeting. 1/ Many nations in OPEC, by offering different schemes, attempted to bring the pricing policies of the 2- and 11-nation factions closer together. Ultimately it was agreed that the 11 nations would forgo a planned 5 percent price rise scheduled for July 1, 1977, in return for which Saudi Arabia and the U.A.E. would bring their prices into line with those of the other 11 OPEC members.

This breakdown in the previously monolithic price structure of OPEC makes forecasting future price that much more difficult by adding another dimension. It has been shown that two members have overtly declined to follow the majority OPEC price decision, and in the future further individual actions may occur. Such actions, if they occur often or last long enough, could lead to an actual breakdown of OPEC.

1/ Oil and Gas Journal, January 10, 1977, p. 43.

Table 3 contains representative current prices for OPEC crude petroleum. Some crude petroleum has reportedly been moving above these prices, while most producers are resisting demands for discounts. The sweet African crude petroleums have been in strong demand, and there are indications that spot market sales are being made at premiums of 20 to 30 cents per barrel. 1/

A major U.K. North Sea producer is negotiating contracts at just over $14 per barrel, while the People's Republic of China is moving exports to Japan at $13.15 per barrel. 2/ The average wellhead price for crude petroleum in Canada is $9.75 per barrel (Canadian dollars). Table 4 contains representative data for the United States.

Forecast

Most forecasts of future crude petroleum price assume that there will be no large arbitrary price increases (i.e., doubling or tripling) such as occurred in 1973-74. They further assume that prices will rise in consonance with inflation. Production costs usually set the floor, while the cost of alternative energy sources and the revenue requirements of the OPEC nations will influence the upper limit. These forecasts usually do not take into account possible actions that the importing-consuming nations could take to limit imports.

The generally accepted high Persian Gulf price is based on the price of alternate energy sources and the revenue objectives of the OPEC nations. If OPEC should raise its price too high, alternate energy sources such as tar sands and oil shale as well as other sources would supply increasing shares of the total energy requirements. The net result would be that demand for OPEC crude petroleum would decrease and the OPEC nations' revenue requirements would not be met. For the United States, recent estimates indicate that, at crude petroleum prices of $12.00 to $15.00 per barrel, the threshold cost of resources in the large frontier deposits of crude petroleum is passed and production becomes economically feasible. 3/ At a price above $15.00 per barrel synthetic fuels production (from coal, etc.) also becomes viable. 4/ Furthermore, it is possible that the future price of the more exotic energy sources could be lower than now expected. 5/

The supply-demand forecasts in this report imply that there will be no drastic price increase between now and 1985, such as the arbitrary quadrupling of prices by OPEC in 1973-74. It indicates a rising demand

1/ Petroleum Economist, March 1977, p. 102.
2/ Ibid., p. 118.
3/ United States Senate, Committee on Interior and Insular Affairs. Estimates of the Economic Cost of Producing Crude Oil, 1976, p. 412. This compilation of documents and views was assembled because of the often acrimonious debate on petroleum price policy in the United States. In this debate one of the main issues has been the actual cost to the producers of producing crude petroleum from existing reserves and the cost of finding, developing, and producing crude petroleum from new sources of supply. Included in this compilation are the most authoritative recent studies and analyses of crude petroleum production cost.
4/ Ibid., p. 413.
5/ Platt's Oilgram News Service, July 6, 1977, p. 1.

for OPEC petroleum, but not of a magnitude that would allow OPEC to raise prices arbitrarily. If OPEC increases the price much above the general inflation rate, this would decrease consumption of petroleum or bring in new production and/or increase the energy share contribution of other energy sources.

On balance, it is estimated that the OPEC petroleum price will increase between now and 1985, but only at the average pace of inflation in the industrial countries. 1/ The OPEC state sales price for "marker" crude petroleum (i.e., Arabian Light) as of July 1, 1977, was $12.70 per barrel. At the inflation rate used in The National Energy Plan 2/ of 5.5 percent per year, the OPEC Arabian Light price f.o.b. Saudi Arabia would be $14.91 per barrel in 1980 and $19.49 per barrel in 1985. The landed prices in the United States would be equal to the above prices plus transportation (plus any applicable duties or fees), and would be close to the prices prepared by the White House for the Joint Committee on Taxation for U.S. "newly discovered" crude petroleum production--$16.78 per barrel in 1980 and $21.90 per barrel in 1985 (see table 5). 3/ The latter prices were developed by the Administration on the hypothesis that there would be no hike in world petroleum prices beyond normal inflation rates. 4/ As Mr. Schlesinger indicated, "We could have a small difference (between OPEC and U.S. prices) but not a significant difference." 5/

That petroleum prices will not rise drastically is also indicated by the estimated prices of alternate energy sources and by the increasing quantities of conventional fossil fuels available at higher prices. The Energy Research and Development Administration, in its Market Oriented Program Planning Study (MOPPS), indicated that 94 to 135 billion barrels of proved, inferred, and undiscovered U.S. crude petroleum are obtainable by conventional methods at a price of $15 per barrel. 6/ This is roughly 3 to 4 times current U.S. proved reserves. At $20 per barrel MOPPS estimated that up to 5 times current proved reserves are obtainable. 7/ Further, MOPPS indicated that large obtainable reserves of natural gas are also available at higher prices. Although some controversy still swirls about the actual quantities cited in MOPPS, that study does indicate the availability of additional reserves at higher prices; in this observation it is supported by other studies.

A meeting of U.S. industry specialists in May 1977 developed data that indicate additional fossil fuels are available through unconventional technology at higher prices. Shale oil in major quantities could be made available at $17 per barrel, coal liquids at $25 per barrel, and large

1/ See also Standard Oil Company (Indiana), Shareholder News, June, 1977, p. 5, and U.S. Department of Commerce, Forecast of Likely U.S. Energy Supply/Demand Balances for 1985 and 2000 and Implications for U.S. Energy Policy, January 20, 1977, p. 20.

2/ Executive Office of the President, Energy Policy and Planning, The National Energy Plan, Washington, D.C., 1977.

3/ Platt's Oilgram News Service, June 13, 1977, p. 3.

4/ Mr. Schlesinger before the Joint Economic Committee as reported in Platt's Oilgram News Service, May 26, 1977, p. 5.

5/ Ibid.

6/ Platt's Oilgram News Service, June 9, 1977, p. 2.

7/ Ibid.

quantities of natural gas from different sources at prices equivalent to around $18 per barrel of crude petroleum. 1/

It is conceivable that OPEC could arbitrarily increase crude petroleum prices and bring about a decrease in export demand, then reverse its policy and lower prices sufficiently to eliminate most other energy supplies on a price basis. In theory, OPEC would then recoup its revenues by exporting more crude petroleum at a lower price and would eliminate much of the competition from more costly energy alternatives. However, most nations under these circumstances would probably either institute a floor price for imports or levy duties sufficient to bring the price of imports up to that of domestic production or alternate energy supplies. The IEA, cognizant of this potential problem, has had a floor price under consideration for some time, but it has not gone beyond the stage of discussion.

Additional discussion of price can be found in appendix B, including the effects of controls, supply security, and transportation on price. Discussion of world trade patterns, including logistics, refining, and marketing, is contained in appendix C.

Import-Export Control

To prevent overdependence on any one or group of exporting nations, various schemes have been considered from time-to-time by major importing countries. One is an import quota system with the larger quotas given to those countries from which imports are favored. A system of tariffs and preferences designed to promote security of imports was advanced by the Cabinet Task Force on Oil Import Control. 2/

The Task Force report recommended that crude petroleum and products from Canada and Mexico be admitted at the lowest tariff rate, that other Western Hemisphere sources have a higher rate, and that Eastern Hemisphere sources have the highest rate. 3/ After a period of time this system would evolve into one with just two duty rates, i.e., a lower rate for Western Hemisphere sources which were considered more secure and a higher rate for Eastern Hemisphere sources.

In 1970 the United States still had an import quota on foreign lower priced crude petroleum in order to protect the domestic industry. There was a world surplus of supply and the exporting nations all wished to increase exports. Today imports are the highest priced supply source, and many exporting nations wish to decrease exports. Canada has repeatedly indicated an overriding interest in domestic energy self-sufficiency and has told the United States that exports to it will cease within the next few years; meanwhile, each year the allowable exports to the United States will decrease in volume. Venezuela has also voiced an interest in restricting production to increase the life expectancy of its petroleum resource base.

1/ Platt's Oilgram News Source, June 9, 1977, p.3.

2/ Cabinet Task Force on Oil Import Control, The Oil Import Question, February 1970, pp. 128 to 139.

3/ Ibid., p. 135.

Since these nations wish to limit exports, a U.S. duty system with the effect of draining Western Hemisphere supply would be met with resistance. This resistance could take the form of an export tax, such as Canada already has, which would equal the difference in duty rates between the Western and Eastern Hemispheres. Such a tax would negate the preferential tariff scheme.

Schemes currently or recently under consideration in the United States include source country quotas 1/ and Generalized System of Preferences (GSP) treatment for certain OPEC nations. 2/ While the latter is not directly related to petroleum, it is believed by some that those OPEC nations to which GSP treatment is extended would be favorably disposed to extend preferential petroleum export treatment to the United States.

International commodity agreements on petroleum have also been discussed over the years. 3/ The objectives of such agreements would be to stabilize prices, maximize producers' earnings, and insure adequate, steady supplies to consumers. Thus, to some extent the interests of both exporters and importers would be served. 4/

A more in-depth analysis of security of supply, of which import and export controls are but a part, is contained in appendix D. That appendix discusses the various tools by which supply security can be devised and further discusses the Task Force report.

1/ United States Senate, S.2806, 93d Congress, 1st Session, December 13, 1973, p. 59.

2/ United States Senate, S.1706, 94th Congress, 1st Session, May 12, 1975, and United States House of Representatives, H.R. 5897, 94th Congress, 1st Session, April 10, 1975.

3/ Carlos Loumiet, "Toward an International Commodity Agreement on Petroleum", Denver Journal of International Law and Policy, Fall 1975, p. 485.

4/ Ibid., p. 490.

FORECAST OF WORLD ENERGY DEMAND

Introduction

Projecting energy demand is a risky business. Even projections of energy demand 1 or 2 years in the future are tenuous at best, while projections 5 to 10 years in the future (as attempted in this study) have an even higher probability of being inaccurate. There are countless variables, both known and unknown, which have influenced energy demand and will continue to do so in the future; many of these variables cannot even be quantified, since they often involve political, social, and military decisions which do not always go hand-in-hand with economic factors.

Despite the dangers involved in projecting energy demand, such projections must be made in order for business and government to make decisions in the present which will help assure the attainment of various goals and needs in the future. Many studies have made projections of energy demand. Some of them make use of lengthy and intricate econometric models and analysis, others use a great deal of guesswork and personal judgment, and many use what is in effect a combination of the two.

Assumptions

The assumptions made for the projection of energy demand in this study are as follows:

a. Energy demand can be projected with reasonable accuracy by using the following measures and variables--past energy consumption trends, the ratio of energy consumption growth to real GDP or real GNP growth ("energy elasticity"), 1/ population trends, and the effects of conservation measures.

b. Governments and industry will make commitments to energy conservation by the introduction of energy-saving policies.

1/ This ratio has been considered in many other studies to be a good forecasting measure. However, the reliability of this measure varies from one country to another and can vary even within a given country, depending upon the time period used. Despite the measure's limitations in many instances, it has been used in this study as one of the estimators of energy demand.

c. As in a number of other studies of energy demand, price effects are absent. 1/ The price (f.o.b.) of Saudi Arabian light crude oil is assumed to remain constant at $12.70 per barrel in 1977 dollars, unless otherwise specified.

d. No significant new trade restrictions will be imposed during the 1977-85 period.

e. Environmental standards (which often lead to increased energy consumption) are not taken into account.

Factors Affecting World Energy Demand

Major factors affecting the level of world energy demand to 1985 include the rate of economic growth of industrialized countries, the effects of energy conservation measures, changing life styles, trends towards service-oriented economies, climate, energy supplies, and technical improvements which would lead to more efficient energy use. Population growth is also a factor, although not a major one; more important is the rate of increase of consumer demand for energy-intensive goods and services, and the level of overall economic growth and development. Most of the above-mentioned factors which affect the level of petroleum demand are difficult to quantify. For many of them there is a feedback effect with energy demand; for example, the rate of economic growth influences energy demand, and vice-versa. The price of energy (for each energy source and vis-a-vis other energy sources) also has an effect on energy demand; however, in this study, price effects are absent with regard to energy demand projections.

Using the data and projections obtained for GDP, GNP, population, economic sectors, energy conservation measures, and energy consumption, various growth rates for future energy demand were developed in this study. From this date, and from other government and private estimates, "high", "low", and "probable" growth rates were selected. These rates were applied to 1975 energy demand data for each country and area in order to arrive at energy demand projections for 1980 and 1985.

1/ From Energy Modeling, Milton F. Searl, Editor, Resources for the Future, Inc., Washington, D.C., March, 1973, p. 67. The studies referred to are:

(1) Morrison, Warren E. and Charles L. Readling, An Energy Model for the United States Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000, Bureau of Mines, U.S. Dept. of the Interior, Information Circular #8384, (Washington, 1968).

(2) National Economic Research Associates, Inc., Fuels for the Electric Utility Industry 1971-85, A Report of National Economic Research Associates to the Edison Electric Institute, (New York, 1972).

(3) National Petroleum Council, U.S. Energy Outlook, An Initial Appraisal, 1971-1985, vols. 1 and 2, and Demand Task Force Report, N.P.C. (Washington, D.C., 1971).

(4) National Petroleum Council, U.S. Energy Outlook: A Summary Report of the National Petroleum Council, vols. 1 and 2, (Washington, D.C., 1972).

Basic economic projections

Gross domestic product (GDP) was selected as the preferred measure of economic activity, although for some countries or areas gross national product (GNP) was used. Projections of real GDP or real GNP growth were obtained from international organizations, national economic plans, research studies, banks, and other sources; projections were also made by the staff of the U.S. International Trade Commission.

Projected growth rates of real GDP or real GNP appear in table 6 in appendix A. Growth rates in the 1975-85 period are generally expected to be equal to rates which prevailed in the 1965-75 period; the most prominent exception is the real GDP growth rate for Japan, which is expected to be 6.0 percent per year for the 1975-85 period compared with the growth rate of 8.3 percent per year during 1965-75. The projected growth rates of the various countries and areas will not in themselves lead to any significant departures from the rates of increase in energy demand which prevailed in the 1965-75 period. However, ratios of energy demand/GDP are expected to decrease during the period due to energy conservation measures, technological change, and more efficient use of resources. 1/

Population

Data on population growth rates were collected and projections were made in order to help arrive at total energy demand projections. Population in the countries and areas covered in this study is expected to increase from 3.9 billion in 1975 to 4.7 billion persons in 1985 at an average annual rate of 1.9 percent.

Energy conservation

Energy conservation policies will be the major factor influencing world energy demand to 1985, assuming the absence of price effects. Energy demand could be reduced significantly, especially in Organization for Economic Cooperation and Development (OECD) countries (which accounted for approximately 57 percent of world primary energy consumption in 1974), if serious commitments are made for energy conservation. Such commitments would in large part consist of government efforts to legislate mandatory energy-conserving measures and to awaken public opinion in order to create a more conducive psychological climate for energy conservation. 2/ Among the more general conservation policies that countries could adopt (other than energy-saving pricing policies, which are not dealt with here) would

1/ It is generally believed that in the next decade, due to increased efficiencies in the use of energy, the ratio of energy consumption to economic growth will be lower than in the past. The OECD, in its World Energy Outlook, projects an energy/GDP elasticity for OECD countries of 0.84 for the 1974-85 period, compared with 0.99 for the 1960-74 period.

2/ World Energy Outlook, OECD, Paris, 1977, p. 65.

(1) A high priority for conservation programs as compared with other policy goals, (2) taxation policies to provide energy-saving incentives, (3) increased research and development into new technologies for conservation, and (4) development of educational and/or information programs in order to further the cause of energy conservation. 1/

Various conservation measures could be implemented in the major sectors of each economy. For example, in the industrial sector, which accounted for 42 percent of energy consumption in the OECD area in 1974, such measures as consultation between industry and government (and the establishment of energy "targets"), financial and fiscal incentives for energy savings such as direct tax credits and loans and promotion of the necessity for energy conservation by industry, could be instrumental in lowering energy consumption. The OECD has estimated that a 15-20 percent energy savings could be realized by 1985 in the industrial sector of OECD countries if adequate and proper measures are taken by member-country governments. 2/

In the transportation sector, a number of measures could be taken to conserve energy, most of which could be directed towards energy savings in automobiles. Among the measures generally recommended are (1) raising the price of gasoline, (2) heavy taxes on fuel-inefficient automobiles, (3) incentives to purchase fuel-efficient automobiles (diesel or stratified-charge engines, etc.), (4) mandatory fuel economy standards and fuel efficiency labelling on automobiles, (5) speed limits. Also important for energy conservation are new and better public transit facilities and increased load factors and reduced speed in airplanes. 3/

In the residential/commercial sectors of many countries, the adoption of building codes for better insulation, fiscal or financial incentives for improving thermal efficiency, and efficiency labeling for home appliances would lead to energy savings, while in the energy sector, peak load pricing and increasing research and development into methods of reducing transmission losses and conversion losses would be beneficial. 4/

1/ World Energy Outlook, OECD, Paris, 1977, p. 65.
2/ World Energy Outlook, OECD, Paris, 1977, pp. 65, 67.
3/ Ibid., p. 70.
4/ Ibid., pp. 72-74.

Energy conservation in the United States

Much of the energy currently used in the United States is wasted; in 1975, according to one report, more fuel was wasted in the United States than was used by two-thirds of the world's population. 1/ Other developed countries such as Sweden and West Germany use about half as much energy per capita as the United States, and even they feel the need to conserve energy. 2/ There is ample opportunity for energy conservation in each sector of the U.S. economy. Possible conservation measures by sector for the U.S. economy appear in appendix E; the extent to which such measures are implemented could have a significant impact on energy demand, and hence on energy prices.

An important factor in energy conservation in the United States is the lifestyle that the American consumer desires or accepts. The comforts that most Americans generally desire in their homes (heating, air-conditioning, household appliances, hot and cold running water, television, etc.) and outside their homes (large, comfortable automobiles which are almost extensions of the home) are in large part responsible for the United States' role as the world's largest user of energy per capita. However, technological and social change, the environmental movement, and the simple realization that the United States cannot continue to expand energy usage at rates that have prevailed in the past, make it likely that the average American will increasingly adopt a more energy-efficient lifestyle, or at least a greater consciousness of the need for energy conservation. Accordingly, "lifestyle" will play an important role in energy conservation, although the major effects in lifestyle changes will probably not be felt until after 1985, since traditional standards of living and aspirations do not change very quickly.

Total Demand Projections

Total world primary energy demand in 1975 was approximately 44.6 billion barrels of crude oil equivalent. Energy demand in 1980 is projected to range from 51.6 to 60.3 billion barrels of crude oil equivalent, with a "probable" demand of 55.6 billion barrels; this "probable" figure represents an average annual growth rate of 4.5 percent for the 1975-80 period. Energy demand in 1985 is projected to range from 60.1 to 80.4 billion barrels of oil equivalent, with a "probable" demand of 68.8 billion barrels; this "probable" figure represents an annual average growth rate of 4.4 percent for the 1975-85 period.

1/ Middle-and Long-Term Energy Policies and Alternatives, Hearings before the Subcommittee on Energy and Power of the Committee on Interstate and Foreign Commerce, U.S. House of Representatives, Ninety-Fourth Congress, March 25-26, 1976, Serial No. 94-63, p. 84.

2/ Ibid., p. 85.

United States

The United States was by far the world's largest energy-consuming country in 1975. In that year, the United States, with 5.4 percent of world population, accounted for approximately 27.5 percent of world primary energy demand; this share is projected to decrease to 25 percent in 1980 and 23 percent in 1985, if adequate conservation measures are taken.

Primary energy demand in the United States was 12.3 billion barrels of oil equivalent in 1975. Demand is projected to increase to 14.0 billion barrels in 1980 and 15.7 billion barrels in 1985, representing annual average growth rates of 2.8 percent for the 1975-80 period and 2.5 percent for the 1975-85 period. The most important factor influencing energy demand in the United States during the 1975-85 period will be the extent to which government and industry make serious commitments to energy conservation.

Western Europe

Western Europe accounted for 19.5 percent of world primary energy demand in 1975; this share is projected to decrease slightly to 19.4 percent in 1980 and 19.3 percent in 1985. Probable primary energy demand levels are 10.8 billion barrels of oil equivalent in 1980 and 13.3 billion barrels in 1985, compared with 8.7 billion barrels in 1975. The average annual growth rate of energy demand is projected to be 4.4 percent for the 1975-80 period and 4.3 percent for the 1975-85 period.

The major energy-consuming country in Western Europe is West Germany, with approximately 1.8 billion barrels in 1975, followed by the United Kingdom, France, and Italy. The highest projected annual average growth rate of energy demand of these four countries during the 1975-85 period is that of Italy (5.3 percent), and the lowest is that of the United Kingdom (1.8 percent). Energy demand in Western Europe (excluding the four countries mentioned above), is projected to increase from 3.2 billion barrels of oil equivalent in 1975 to 5.4 billion barrels in 1985 at an annual average rate of 5.5 percent.

Japan

The major factor which will affect Japan's growth of energy demand in the 1975-85 period is the economic growth rate; real GDP is projected to be 6.1 percent for the 1976-80 period and 6.0 percent for the 1981-85 period, compared with 8.3 percent in the 1965-75 period. Accordingly, Japan's projected rate of energy demand will also be significantly lower than the rates which prevailed in the 1965-75 period.

Japan consumed 2.5 billion barrels of oil equivalent in 1975; demand is projected to increase to 3.3 billion barrels in 1980 (at an average annual rate of 5.7 percent) and to 4.2 billion barrels in 1985 (an average annual rate of 5.3 percent for the 1975-85 period). While Japan accounted for 5.6 percent of world energy demand in 1975, this ratio is expected to increase to 5.9 percent in 1980 and 6.1 percent in 1985.

The U.S.S.R.

Energy demand in the U.S.S.R. is projected to increase at an average annual rate of 5.1 percent in the 1975-80 period and at 5.0 percent in the 1975-85 period. The U.S.S.R. intends increasingly to substitute coal for oil during the periods mentioned; 1/ in this manner, demand for oil will increase at lower rates than the rates for total energy demand.

Primary energy demand in the U.S.S.R. was 7.5 billion barrels of oil equivalent in 1975; this represented 16.9 percent of world primary energy demand in that year. The percentage demanded by the U.S.S.R. is projected to be 17.4 percent in 1980 and 17.8 percent in 1985.

Eastern Europe

Eastern Europe consumed 2.9 billion barrels of oil equivalent in 1975. Demand is projected to increase to 3.5 billion barrels in 1980 and to 4.3 billion barrels in 1985; the rate of increase (3.8 percent per year) is approximately equal to the rate which prevailed during the 1965-73 period. Eastern European countries will increasingly depend on imported oil in order to meet energy demands; this oil will increasingly be imported from non-Soviet sources. 2/ However, in order to import increasing amounts of oil from non-Soviet sources, foreign exchange is necessary; if this foreign exchange is not obtained, there could be a reduction in economic growth in several Eastern European countries, 3/ which could in turn lead to decreased energy demand.

1/ World Energy Outlook, p. 81.
2/ Ibid.
3/ Ibid.

People's Republic of China

China was the world's third largest energy consumer in 1975, with total primary energy demand of 2.8 billion barrels of oil equivalent. Energy demand is projected to increase to 3.6 billion barrels in 1980 and to 4.4 billion barrels in 1985. China is self-sufficient in oil and has the ability to increase its oil exports in the future.

All other countries and areas

Total primary energy demand for all other countries and areas was 7.8 billion barrels of oil equivalent in 1975, corresponding to 17.5 percent of world primary energy demand in that year. It is projected that primary energy demand for the countries and areas will be 10.7 billion barrels of oil equivalent in 1980 and 14.7 billion barrels in 1985, representing average annual growth rates of 6.5 percent for the 1975-80 and 1975-85 periods. The countries and areas will account for 19 percent of world primary energy demand in 1980 and 21 percent in 1985. Energy demand in the future for the countries and areas will depend largely upon economic growth rates; government measures to conserve energy will generally be less important than in other areas of the world.

WORLD PETROLEUM DEMAND AND SUPPLY

Crude Petroleum and Other Energy Sources

World energy demand is satisfied by different energy sources. At present the commercially viable and most widely used are solid fuels (such as anthracite, bituminous coal, and lignite), natural gas, oil shale and tar sands, uranium, and crude petroleum. The use of a specific energy source in any one energy demand application is most often the result of the interplay of price and availability. However, certain applications may be able to use just one energy source. An example would be the automobile which is totally reliant on petroleum. Other uses, such as industrial applications, may be able to use a number of energy sources including coal, natural gas, and petroleum.

Available energy resources

A number of efforts have been made to quantify the relative proportions of each energy source available for exploitation. Most of them have concentrated on analyzing the recoverable energy reserves of the fossil fuels. Although this is a difficult task, it is easier than trying to estimate the energy recoverable from solar radiation, nuclear fusion, and nuclear breeder reactors. One recent compilation is given in table 7.

Overall, table 7 emphasizes the dominance of solid fuels in the world's reserves. It also indicates that most of the total energy reserves are in Asia, the U.S.S.R., and North America. The relative lack of energy reserves in South America and Oceania is evident.

From 1977 until around 1985 to 1990 the energy sources indicated in table 7, plus those based on environment (such as hydroelectric, geothermal, thermal gradient, and wind), will remain dominant. Even with the most common energy sources, the time necessary to bring additional energy supplies to the market is considerable. Lead time between the commencement of a project and the time of commercial significance is long and has been lengthening. 1/

The use of solar energy, fusion technology, and breeder reactors will probably come into its own only after the 1985 to 1990 period because of the apparent extraordinary lead times that will be necessary to develop those sources commercially. A further drawback is that as energy prices rise, production and the measured world recoverable energy reserves of coal, natural gas, and crude petroleum will increase as current marginal and sub-marginal resources are added. This increasing availability of the common energy sources will tend to retard the development of the more esoteric energy sources.

Consumption of energy resources

As table 9 indicates, world consumption of the various energy sources is not in proportion to their abundance (see table 7). For

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1/ See table 8 in the appendix. Although the data in the table are just for the United States, their significance is applicable to most nations of the world.

example, crude petroleum and natural gas accounted for 62.5 percent of all energy sources consumed in 1975, while they constituted percent of the measured world recoverable energy reserves in 1974. Crude petroleum and natural gas have been favored as energy sources because of their ready availability at relatively low prices until recently. In addition, natural gas is the cleanest burning of the fossil fuels and has been in even higher demand because of environmental restriction on furnace emission.

Overall, table 9 emphasizes the dominance of crude petroleum as a source of primary energy. It also indicates that most of the primary energy consumption occurs in North America and Europe. Primary energy consumption is all but negligible in world terms in South America and Africa. Asia, primarily owing to consumption in Japan, and the U.S.S.R. occupy a middle ground.

From 1977 until around 1985 to 1990, depending upon the degree of success of the conservation and conversion programs announced by most industrialized nations, it is expected that crude petroleum and natural gas will decrease their relative contributions to primary energy consumption in some nations. At the same time their shares will probably increase in the developing nations. Any share shortfall from that expected for any of the other energy sources in any nation will most likely be made up by the use of petroleum. Crude petroleum has been and will continue to be the swing fuel filling the shortage between energy demand and that supplied by other energy sources.

Appendix F contains material, including production and reserves data, on energy sources other than crude petroleum. An appreciation for the situation in the other energy sources is critical to forecasting future petroleum supply and demand.

Petroleum.--Crude petroleum accounted for 12 percent of the measured world recoverable energy reserves in 1974. In spite of this, it is widely consumed and in 1975 accounted for about 45 percent of the world's total primary energy consumption. The overall reasons for this popularity include the relative ease of transportation and handling of crude petroleum and petroleum products and the widespread use of petroleum products in the household and commercial sector, the industrial sector, and the transportation sector. In addition it has until recently been available at an attractive price which promoted its use.

Of the more than 20 billion barrels of petroleum consumed in the world in 1975, the United States, France, West Germany, Italy, the United Kingdom, and Japan accounted for over 54 percent. For the Free World, these six countries accounted for almost 66 percent of the total consumption of petroleum. The Communist Bloc accounted for about 18 percent of the total world primary energy consumption in 1975.

Refining.--When crude petroleum consumption is spoken of, what is usually meant is the consumption of crude petroleum in refineries to make petroleum products. These products are the familiar gasoline, lubricating oil, home heating oil, etc. Very little crude petroleum is used as such,

although small quantities are sometimes burned as a fuel oil. Thus, the demand for crude petroleum is derived from the demand for petroleum products.

The link between crude petroleum and petroleum products is the refinery. Actually, however, it is but one of the links between the well and the consumer. These links are usually indicated as production (producing the crude petroleum from the well), transportation (moving the crude petroleum from the well site to the refinery), refining (changing the crude petroleum into petroleum products), and finally marketing (moving the petroleum products from the refinery to the consumer). Other links are usually added. Before a well can produce, a field must be found (exploration) and the field developed (development). A vertically integrated oil company is one engaged in two or more of these links; a company that is fully integrated in a vertical sense operates in all of these links.

Table 10 contains data on the refining capacity in the world. Most of the refining capacity is located in or near the major petroleum products consumption centers rather than in or near the major crude petroleum production centers. A country would much rather import the crude petroleum and refine it in the country's own refineries than import the petroleum products. Aside from the increased employment, dependency on crude petroleum imports is not as all-encumbering as dependency on petroleum product imports. Presumably there are more sources of crude petroleum than there are sources at a specific time of the exact quantity and quality of a particular petroleum product.

Product demand.--Table 11 illustrates how consumption of various petroleum products varies by countries and regions and differs from the Free World average. In the United States, for example, gasoline accounted for almost 40 percent of the petroleum products consumed in 1975 versus 26.5 percent for the Free World. In Europe, gasoline represented below 20 percent of all petroleum products consumed. The difference is at least partially indicative of the greater use of automobiles, trucks, and buses in the United States as compared with Western Europe. However, the difference can also be explained to some extent by the greater use of diesel-powered automobiles, trucks, and buses in Western Europe. Diesel fuel is not classified as a gasoline but as a middle distillate. In Western Europe, middle distillates accounted for 34 percent of all petroleum products consumed in 1975, versus 25 percent in the United States.

Overall in the Free World in 1975, fuel oils were the most heavily consumed of the principal petroleum products, followed by middle distillates and then gasolines. In the future, conservation efforts will affect the consumption of different individual petroleum products and groups of petroleum products. For example, conservation efforts aimed at the automobile will presumably affect gasoline consumption, while those designed to increase the efficiency of industry should affect fuel oils consumption.

Also affecting the individual and total consumption of petroleum products will be future developments in alternate fuels. For example, more nuclear and/or coal-fueled electric generating plants could decrease the future percentage that fuel oil represents of the total petroleum products consumption.

Petroleum Demand

Demand for petroleum will continue to depend upon total energy demand, contributions to that demand by other energy sources, and the relative prices of the different energy sources. In the future, government actions such as controls on pollution, prices, imports, and end-uses, will increasingly affect petroleum demand. The interactions of the above-named factors, and others, will be different for each country in the world and will determine actual future consumption. Table 12 summarizes a forecast of these interactions in terms of petroleum demand. It is based on the tables (13 to 28) in appendix A, which in turn are based on the total energy projections developed in the section entitled "World Petroleum Demand and Supply." Since the petroleum demand forecasts given for 1980 and 1985 assume effective conservation programs and a maximum feasible contribution from other energy sources, actual demand in either year could be up to 15 percent higher. Because of current excess production capacity and expected future additions it is expected that the higher demand could be satisfied with little, if any, impact on price.

From table 12 it can be seen that in 1975 the United States, Europe, the U.S.S.R., and Japan consumed about three of every four gallons of petroleum consumed in the world. While this share of world consumption is forecast to decrease, these nations will remain the major petroleum consumption centers.

United States

Of all the petroleum-consuming sectors, the transportation sector is expected to continue to be the major one. In 1975 it accounted for over one out of every two gallons of petroleum consumed (table 29). The largest share of this sector's consumption was accounted for by the automobile. It will continue to be the largest consumer, for although the average future car will be smaller and give better mileage, these factors will tend to be offset by a larger number of cars. Overall, however, the transportation sector's share of future consumption is forecast to decrease between now and 1985. 1/

The household and commercial sector and the industrial sector both used about the same quantities of petroleum in 1975 (table 29). The household and commercial sector's consumption of petroleum is forecast to increase because of scarcity of natural gas and the probable phasing-out of coal consumption in this sector. The industrial sector's use of petroleum is expected to stabilize or decrease owing to an increasing use of coal and electricity, a possible increase in the manufacture of less energy-intensive products, and shifts to less energy-intensive production methods.

1/ U. S. Department of the Interior, Bureau of Mines, United States Energy Through the Year 2000, December 1975, p. 29.

The fourth major petroleum consuming sector, electricity generation and utilities, is forecast to decrease its use of petroleum. This will be especially true if the United States increases coal production and decreases nuclear capacity lead-time and siting problems.

Europe

In Europe the major petroleum-consuming countries are France, West Germany, Italy, and the United Kingdom. Together they accounted for 64 percent of Europe's consumption in 1975; this figure is expected to decrease to 59 percent by 1985 as a result of conservation and increasing use of petroleum in the other European nations.

From 1975 to 1985, petroleum is expected to supply a declining share of total energy requirements in Europe. The future requirements for petroleum could be even lower if nuclear generating capacity would expand at a greater rate.

The transportation sector is the largest single consuming sector and is forecast to continue as such. At least through 1985 there are no viable substitutes in this sector for the engine fueled by petroleum.

U.S.S.R.

The actual share of future energy consumption accounted for by petroleum will depend to large degree upon the future level of crude petroleum production and the quantity exported. The U.S.S.R. is blessed with abundant crude petroleum, coal, and natural gas; presumably, physical availability limitations should not be the determining factor in the future energy mix. It has been stated that the Soviet mineral policy is based on the principle of maximum self-sufficiency at any price. 1/

It is known that the U.S.S.R. intends to raise its standard of living and develop the Asian portion of the country. In this undertaking its increasingly petroleum-based, efficient industrial sector has been leading the way. 2/ Concern has been voiced by some that the growth of the energy-intensive industries has been exceeding the rate of growth of energy output. 3/ Accordingly, industry can be expected to use increasing quantities of coal, especially if crude petroleum (or products) exports are increased.

In the electricity generation sector it is planned to make greater use of coal and lignite to free crude petroleum and natural gas for exports. 4/ Plants are under construction near the Ekibastuz (Kazakhstan) and Kansk-Achinsk (Siberia) coal basins. 5/ Expansion is also scheduled in nuclear-fueled capacity and in hydropower plants. The hydropower plants are to be built both in Siberia and in European U.S.S.R.

1/ Technology Review, October/November, 1974, p. 20.
2/ United States Congress, Joint Committee on Atomic Energy, Towards Project Interdependence: Energy in the Coming Decade, December, 1975, p. 85.
3/ U.S. Bureau of Mines, Mineral Industries of the U.S.S.R., 1976, p. 4.
4/ Ibid.
5/ Ibid.

Japan

Japan has had a higher energy consumption growth rate than any of the other major countries. At the same time Japan is almost without any indigenous known energy sources. Therefore most of its energy, around 90 percent, is imported.

In 1975, Japan was dependent on petroleum for 70 percent of its primary energy requirements (table 24). This is the highest petroleum dependence of any of the major nations in the world.

In the future, the only real alternative to imported petroleum as an energy source to Japan is nuclear energy. Although the share of total energy supplied by this source is expected to increase significantly, petroleum will continue to be the dominant energy source at least through 1985.

Other nations

The share of the world's petroleum consumption accounted for by the other nations of the world is forecast to increase from just under 24 percent in 1975 to just over 30 percent in 1985. These other nations include industrial countries such as Canada and Australia as well as developing nations. The developing nations comprise the petroleum-exporting countries, the other mineral-exporting countries, and the balance of the developing nations.

The effect of higher petroleum prices on the majority of the developing nations (excluding the petroleum exporters) will probably decrease availability of foreign exchange for imports that will generate economic growth. Incremental cost of imported petroleum since 1973 to the developing nations, which contain around 80 percent of the total population of the developing world, is estimated at around $10 billion per year. 1/ This increased burden could endanger economic growth. A long-term solution could be the development of alternate energy sources. The nuclear alternative is particularly attractive to those nations with little or no fossil-fuel resources.

Those developing nations with current crude petroleum production or the prospects thereof will probably exhibit greater economic growth in the future. While domestic production of a sufficient magnitude to satisfy domestic requirements is the first objective, the ability to export petroleum will provide the greatest benefits.

Mexico is an example of a developing country which has recently achieved petroleum self-sufficiency; it will probably become a significant net exporter by 1980 and may join OPEC. Other nations with apparent similar potentials of self-sufficiency include Malaysia, Brunei, India,

1/ Edward R. Fried and Charles L. Schultze, "Overview", Higher Oil Prices and the World Economy, Washington, D.C., The Brookings Institution, 1975, p. 36.

Brazil, and Spain, although the last three will probably not become significant net exporters. In addition Egypt, Syria, Argentina, Oman, and Vietnam may become significant crude-petroleum producers.

Petroleum Supply

The projection of future crude petroleum supplies is based on the current and future availability of resources from which the crude petroleum can be produced. In the following paragraphs a discussion of current production and reserves leads into a forecast of future production.

Current production

In 1976, 66 nations in the world produced crude petroleum. The top ten producing countries were the U.S.S.R., Saudi Arabia, United States, Iran, Venezuela, Kuwait, Iraq, Nigeria, United Arab Emirates, and Libya, in that order (table 30). Together, these ten countries accounted for about 80 percent of the total world production, indicating a high concentration of crude petroleum production in a very few of the world's nations.

Recent changes in production

Since 1950 dramatic changes have occurred in the shares of world production of crude petroleum attributed to the various areas of the world, as is indicated in table 30. The most obvious changes are the decrease in importance of the Western Hemisphere and the increase in importance of Africa, the Communist Bloc, and particularly the Middle East. Most of the decrease of Western Hemisphere production is traceable to a reduction in the U.S. share of world production from 51.9 percent in 1950 to 14.3 percent in 1976. However, Latin American production also decreased by more than half from just over 18 percent of total world production in 1950 to under 8 percent in 1976. Most of the decrease in Latin American production was in Venezuela. The Communist Bloc, in particular the U.S.S.R. and the People's Republic of China, increased production dramatically over the period from 1950 to 1976, and in 1976 the Communist Bloc was second only to the Middle East in crude-petroleum production.

OPEC and OAPEC

Thirteen of the world's producing nations are members of the Organization of Petroleum Exporting Countries (OPEC), which was founded in 1960 by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. The other members joined as follows: Qatar in 1961, Indonesia and Libya in 1962, Abu Dhabi in 1967 (Abu Dhabi's place was later taken by the United Arab Emirates, of which it is a member), Algeria in 1969, Nigeria and Ecuador in 1971, and Gabon in 1975. 1/ The organization serves a consultative and fact-gathering function. Its primary objective, stated in the Statute of Organization, is to coordinate and unify the petroleum policies of its member countries and to determine the best means for safeguarding their individual and

1/ Mana Saseed Al-Otaiba, OPEC and the Petroleum Industry, Halsted Press, p. 80.

collective interests. The stabilization of prices, ensuring a steady income for its members and providing efficient, economic, and regular petroleum supplies to consuming nations are also stated objectives of the Organization. 1/ OPEC is particularly potent in the area of economic rather than political cooperation. 2/ Although 8 of its 13 members are Middle Eastern or North African, it is not correct to assume that OPEC serves as an instrument of pan-Arab policy, using control over crude petroleum supplies as its weapon.

Some members of OPEC, along with other Arab producing-exporting countries, have banded together to form the Organization of Arab Petroleum Exporting Countries (OAPEC). This organization was formed to further the Arab cause.

These two organizations are important in the world supply of crude petroleum. In 1976, OPEC accounted for 53 percent of the world crude petroleum production, and OAPEC for 33 percent. In terms of 1976 Free World crude petroleum production, these two organizations accounted for 68 percent and 42 percent, respectively. The world influence of these organizations is heightened because the nations composing the organizations use very little of the crude petroleum produced; almost all is exported to other nations that are dependent on it for economic survival. Within either organization, the dominant nation is Saudi Arabia, which accounted for 28 percent of OPEC's 1976 production and 46 percent of OAPEC's 1976 production.

Production ownership

Along with the increasing domination of world production by OPEC and OAPEC there has been occurring a change in ownership of this production. Increasingly, the production is owned by the producing nations rather than the producing companies. This important fact for understanding the world petroleum picture is further discussed in Appendix E.

Reserves

Just as current production is dominated by the countries of the Middle East and the Communist Bloc, so are current proved reserves (table 31 and 32). Table 33 indicates the importance of OPEC in both proved reserves and production.

The high reserves/production (R/P) ratio for OPEC shows that it has current proved reserves capable of sustaining the 1976 production rate for almost 40 years. In contrast, the non-OPEC producing nations could only sustain 1976 production rates for about 15 years. The R/P ratio for the Communist Bloc lies between those of OPEC and non-OPEC.

1/ C. Johnston, Law and Policy of Intergovernmental Primary Commodity Agreements, Vol. II, 1976, p. 98.

2/ United States Tariff Commission, World Oil Developments and U.S. Oil Imports Policies, October, 1973, p. 28. A good source on OPEC history and organization is F. Ronhani, A History of OPEC, 1971. See also D.A. Rustow and J. F. Mugno, OPEC: Success and Prospects, 1976

In developing future petroleum supply forecasts, different assumptions and problems are applicable to OPEC, non-OPEC, and Communist Bloc producers. Probably a safe, generally accepted assumption is that both the non-OPEC and Communist Bloc nations will tend to maximize production. No such assumption can be applied to OPEC producers.

Many studies have tried to make the difficult forecast of what the OPEC nations will produce. Most of these studies attempt to analyze what each of the OPEC nations requires in the way of petroleum export revenues to meet import requirements, domestic development plans, and other projects. 1/ They have also examined discount rates, population trends, government stability, per capita income, foreign exchange holdings, consumption capacity, petroleum reserve position, and capital absorption capacity. In general, all of the studies have found that Kuwait, the U.A.E., Qatar, and Saudi Arabia would be the OPEC nations most capable of voluntarily limiting production. However, what each nation's decision would be when faced with the problem of either increasing or decreasing production cannot be answered. Pertinent data on the OPEC countries in tables 38 and 39 are helpful when trying to analyse what a nation's future production policy might be.

Conclusions

Table 40 indicates the 1975 production for non-OPEC, Communist Bloc, and OPEC nations as well as upper and lower forecast limits for 1980 and 1985. The upper and lower limits are primarily influenced by just one or two countries in each region. For the non-OPEC region the United States is pivotal, while the U.S.S.R. and the People's Republic of China are critical to the Communist Bloc, as is Saudi Arabia to OPEC.

Overall, it is believed that non-OPEC production will be 23 million barrels per day in 1980, rising to 34 million barrels per day by 1985. The Communist Bloc output is forecast at 16 million barrels per day in 1980, rising to 22 million barrels per day by 1985. The difference between demand and supply will be made up by OPEC supply. This supply is expected to be around 30 million barrels per day in 1980 rising to a little over 32 million barrels per day by 1985.

Non-OPEC nations.--The principal producing nations have been the United States, Canada, and Mexico, which together accounted for around 72 percent of non-OPEC production in 1975, down from around 78 percent in 1972. It is expected they will remain the dominant non-OPEC producing nations, although new nations will join the ranks.

1/ See United States Congress, Joint Committee on Atomic Energy. Towards Project Interdependence: Energy in the Coming Decade, December, 1975. U.S. Treasury Department, Office of the Assistant Secretary of Trade, Energy, and Financial Resources. The Absorptive Capacity of the OPEC Countries, September 5, 1975. U.S. House of Representatives. Committee on Banking and Currency. Ad Hoc Committee on the Domestic and International Monetary Effect of Energy and other Natural Resource Pricing. Oil Imports and Energy Security: An Analysis of the Current Situation and Future Prospects, September, 1974.

Many studies have analyzed the crude petroleum supply in North America 1/ and they suggest that the supply elasticity for the United States may be above one and that supply in other than the short-term is quite responsive to price changes. 2/ However, another study indicates that this elasticity figure (i.e., above one) is overly optimistic under present circumstances and it assumes the optimistic crude petroleum supply long term elasticity for the United States and Canada to be 0.5 while it assumes the pessimistic elasticity to be 0.15. 3/ While these studies disagree on the actual elasticity of supply, all agree that it is positive; increasing prices in the United States will result in increasing production.

Mexico is just now commercially developing many of its recently discovered crude petroleum reserves. Because of the recent vintage of these reserves, 4/ most of which are not yet fully explored, published future forecasts of Mexican production tend to be conservative. Production will be significantly higher especially if Mexico becomes a major exporter.

Both Canada and the North Sea have the potential to increase production significantly. However, Canada and the principal North Sea producing countries, Norway and the United Kingdom, have all indicated an interest in reduced production and conservation of resources.

Optimistic North Sea production estimates suggest that the North Sea could supply the bulk of European crude petroleum requirements in the mid-1980's. 5/ Other technological and political factors, however, will in all probability result in more modest production. The extreme wave action and high winds tax current technology to the fullest, while the concept of national self-sufficiency and security of supply are viable political arguments against aggressive development of the North Sea resources.

In the future, other nations in addition to the United States, Canada, and Mexico will become significant crude petroleum producers. By the late 1970's, these producers will probably include Egypt, Syria, Brazil, Malaysia, India, Argentina, and Oman 6/ as well as Brunei, Spain, and Vietnam. It is uncertain whether these nations and Mexico will remain a part of the non-OPEC producing nations or join OPEC. It has been stated that all of these countries have "political and even economic affinities for OPEC." 7/ Even the United Kingdom and Norway, the two

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1/ Hendrik S. Houthakker, The World Price of Oil: A Medium-Term Analysis, American Enterprise Institute for Public Policy Research, Washington, D.C., October 1976, p. 11 and 13. See F.M. Fisher, Supply and Costs in the U.S. Petroleum Industry, Baltimore, 1964. E. W. Erickson and R. M. Spann, "Supply Response in a Regulated Market: The Case of Natural Gas", Bell Journal of Economics and Management Science Spring, 1971; and D.N. Epple, Petroleum Discoveries and Government Policy Cambridge, Massachusetts, 1975.

2/ Ibid., p. 13.

3/ Ibid., p. 19.

4/ Oilgram News Service, February 23, 1977, p. 1 and February 24, 1977, p. 3.

5/ Houthakker, op. cit., p. 17.

6/ M. M. Sakbani and John J. VanBelle, op. cit., p. 84.

7/ Ibid., p. 84.

principal North Sea producing nations, have indicated "more than passing interest" in OPEC should they become major crude petroleum exporting nations. 1/ However, should this occur, the self-sufficiency of these nations will decrease the world's crude petroleum import requirements. The analysis in this report has not included any of these nations as future OPEC memebers.

Communist Bloc nations.--Future Communist Bloc production is closely tied to each Communist nation's central plan. The announced 1980 goal for the U.S.S.R. is between 12.4 and 12.8 million barrels per day. Estimates by various sources of production that will be achieved in that year range from around 11 to 14 million barrels per day. It is assumed for this report to be around 12 million barrels per day. No official 1985 production goal is available; the current 5-year plan runs only to 1980. Assuming that the eastern Siberian fields are developed rather intensively and that the western fields continue to produce, production in 1985 could average as much as 20.0 million barrels per day. If either assumption is not attained this figure is optimistic, and if both assumptions fail it is quite possible the U.S.S.R. will be net importer. The forecast here is that production in 1985 will be between 13 and 14 million barrels per day.

The People's Republic of China has large, geographically dispersed reserves of good quality coal that is generally easily mined and available at a low price. It is estimated that a ton of coal can be supplied at around $8.50. At that price, crude petroleum would have to cost around $1.65 per barrel to be able to compete on a Btu basis. 2/ Unit production costs in the Taching field, only recently developed (late 1960's), are around $1.37 per barrel which is about 38 percent of the cost of production in the western oil fields. 3/ The price of crude petroleum supply is believed to be approximately $5.50 per barrel, which is around the costs of marginal producers. 4/ In this case the marginal producers are those with synthetic oil plants or crude petroleum production in the western fields. The use of the cost of production from these sources as the price assures a supply from these sources, while minimizing industrial subsidies. High profits have resulted for the lower cost producers.

With crude petroleum exports moving to Japan at $12.74 per barrel F.O.B., the eagerness of the People's Republic of China to export becomes understandable. 5/ If coal continues to be the principal domestic source of energy, future production of petroleum will be greatly influenced by the People's Republic of China's ability to export it.

1/ M. M. Sakbani and John J. VanBelle, op. cit., p. 84.
2/ Institute for Defense Analysis, Implications of Prospective Chinese Petroleum Developments to 1980, July, 1976, p. 20.
3/ Ibid., p. 22.
4/ Ibid., p. 22.
5/ Ibid., pp. 25 and 30.

Production in 1980 could be as low as 2 1/ million barrels per day, just 18 percent above the level in 1976, or as high as 8 2/ million barrels per day, or almost five times the 1976 rate (table 40). The probable rate will be between 4.0 and 4.5 million barrels per day. Although 1985 production is forecast as high as 10 3/ million barrels per day this report forecasts production at around 7 million barrels per day. While production will increase it will not more than double between 1980 and 1985 which a 10 million barrel per day rate in 1985 would indicate.

Although most of the other Communist Bloc countries have active exploration and development program, significant production increases are not expected. At best these other countries would probably be able to decrease their dependency upon imports from the U.S.S.R.

OPEC nations.--At any level of world demand for crude petroleum, the greater the production of non-OPEC producers the lower will be the demand for OPEC crude petroleum. Indeed, the principal constraint on OPEC's market power in the near term may not be price-induced declines in demand or substitution of alternate energy sources, but increasing non-OPEC crude petroleum production. 4/ The demand for crude petroleum will be determined not only by the level of total energy demand, but also by the contributions from other energy sources, e.g. nuclear, coal, natural gas. Thus, forecasts for OPEC crude petroleum reflect forecasts of total energy demand and the shares to be supplied by non-petroleum energy sources.

Current OPEC production capacity is 38 million barrels per day. If it is assumed that 38 million barrels per day could actually be produced, OPEC has the ability to expand its 1976 production by 8 million barrels per day. In addition, capacity expansions could easily add another 5 million barrels per day of production ability by 1980. Therefore, in 1980 the upper limit on OPEC production will probably be at least 43 million barrels per day.

While the upper limit on production is controlled by production capacity (assuming adequate demand) the lower limit on production is controlled by OPEC revenue requirements to meet commitments on imports, internal developments, and other programs. 5/ Assuming no drastic changes in the prices of crude petroleum or the goods that OPEC imports, OPEC will require an export market for at least 25 million barrels per day in 1980 and around 30 million barrels per day in 1985 (See Table 39).

Saudi Arabia.--At present Saudi Arabia with about 30 percent of OPEC's production capacity is by a considerable margin the largest OPEC

1/ M. M. Sakbani and John J. Van Belle.
2/ Oil and Gas Journal, August 11, 1975, p. 21.
3/ Toward Project Interdependence: Energy in the Coming Decade, op. cit., p. 84.
4/ M. M. Sakbani and John J. Van Belle.
5/ See table 40 for estimates.

crude petroleum producer. In recent months at least 10 percent 1/ of its capacity has been underutilized. The percent would have been larger except that Saudi Arabia chose to increase its production to prevent further OPEC price increases. If Saudi Arabia does not continue to increase its production capacity it would lose this dominate position in OPEC and with it the ability to control price. It is not expected that Saudi Arabia will easily or knowingly give up its dominant position in OPEC.

That Saudi Arabia has or could develop the necessary reserve potential to meet increasing demand between now and 1985 is not in doubt. It has been estimated that Saudi Arabia currently has about 25 billion barrels of possible reserves over and above its proved reserves. 2/ In addition it has around 450,000 square miles for which the potential discovery of new fields is relatively good. 3/ Further, enhanced recovery methods applied to current reserves are also capable of greatly expanding possible future production.

Other OPEC supply.--Aside from Saudi Arabia and the U.A.E. (and possibly Qatar and Kuwait) most of the other members of OPEC are in need of increased foreign exchange earnings because of large populations, development plans, and import needs. It has been suggested that Iran, Iraq, Indonesia, Ecuador, Venezuela, and Nigeria could usefully employ the additional revenue even if the current world price for crude petroleum were as high as $20 per barrel. 4/ Most of the studies previously cited in this report indicate that most of the members of OPEC are desirous of increasing crude petroleum export revenue.

1/ Saudi Arabian production varies. For the fourth quarter of 1976, 18.7 percent of its production capacity was not used. For the first quarter of 1977 the underutilization of production capacity averaged 18.3 percent, while for May 1977 it is estimated at 26.3 percent. See Central Intelligence Agency, International Oil Developments: Statistical Survey, July 27, 1977, p. 3 and Petroleum Economist, July 1977, p. 255.

2/ Thomas C. Barger, "Arab States of the Persian Gulf", Energy Policies of the World, Elseiver, New York, 1976, p. 185.

3/ Ibid.

4/ Eliot Janeway, "U.S. Policies Bolstering Faltering OPEC Gouge", The Washington Star, June 12, 1977, p. B-4.

APPENDIXES

Table 1.--World supply-demand: Actual 1975 and forecasts for 1980 and 1985

(In million barrels of crude petroleum per day)

Country	1975	1980	1985
Demand	1/ 55.2	69.0	86.1
United States	16.4	18.1	19.2
Western Europe	13.4	15.1	18.1
Japan	4.8	6.1	7.6
Communist Bloc	10.1	15.3	21.3
Rest of world	10.5	14.4	19.9
Supply	1/ 53.5	69.0	86.1
Non-OPEC:			
United States	8.4	11.0	12.0
Canada	1.4	2.0	3.0
Western Europe	0.5	4.5	6.0
Other non-OPEC	4.6	5.5	11.0
Communist Bloc	11.9	16.0	22.0
OPEC	26.7	30.0	32.1

1/ Difference between supply and demand is due to refinery processing gains, changes in stocks, statistical reporting differences due to the use of different conversion factors and rounding and unaccounted for differences between indicated supply and apparent demand.

Table 2.--Crude petroleum: Posted prices, 1970-1976

(In United States dollars per barrel F.O.B.)

Country	Crude petroleum	API gravity	1970 Aug. 31	1971 Feb. 15	1972 Jan. 20	1973 Jan. 1	1973 Oct. 1	1973 Oct. 16	1973 Nov. 1	1974 Jan. 1	1974 Jul. 1	1974 Nov. 1	1975 Jan. 1	1976 Jun. 30	1977 Jan. 1
Saudi Arabia	Light	34	1.800	2.180	2.479	2.591	3.011	5.116	5.176	11.651	11.251	11.251	11.251	12.376	13.000
Kuwait		31	1.590	2.085	2.373	2.482	2.884	4.903	4.957	11.545	11.545	11.145	11.145	12.360	N.A.
Abu Dhabi	Zakum	40	1.920	2.270	2.574	2.687	3.115	5.964	6.031	12.566	12.566	12.166	11.586	12.715	13.340
Iraq	Basrah	35	1.720	2.155	2.451	2.562	2.977	5.061	5.117	11.672	11.672	11.272	11.272	11.470	N.A.
Libya		40	2.180	2.550	3.673	3.777	4.604	8.925	9.061	15.768	15.768	15.768	15.768	16.060	18.250
Nigeria		34	2.170	2.420	3.176	3.561	4.287	8.310	8.404	14.691	14.691	14.691	14.691	13.709	N.A.
Indonesia 1/	Sumatra Light	34	1.700	1.700	2.260	2.960	4.750	4.750	6.000	10.800	12.600	12.600	12.600	12.800	13.550
Venezuela 2/	Tia Juana	26	2.011	2.090	2.951	3.094	4.925	4.925	7.261	13.836	14.312	14.312	13.541	14.643	N.A.

1/ State sales price.
2/ Reference price.

Source: American Petroleum Institute, Basic Petroleum Data Book, April 1977, section IV, table 6.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table 3.--Representative OPEC crude petroleum prices

(In United States dollars per barrel f.o.b.)

Country and crude petroleum	API gravity	State sales price	Effective date
Abu Dhabi (Zakum)	40°	12.41	1/1/77
Abu Dhabi (Murban)	39°	12.50	1/1/77
Abu Dhabi (Umm Shaif)	37°	12.28	1/1/77
Arabian Light	34°	12.09	1/1/77
Arabian Medium	31°	11.69	1/1/77
Arabian Heavy	27°	11.37	1/1/77
Iranian Light	34°	12.81	1/1/77
Iranian Medium/Heavy	31°	12.49	1/1/77
Iraq (Basrah)	35°	12.67	1/1/77
Iraq (Kirkuk)	35°	12.89	1/1/77
Kuwait	31°	12.37	1/1/77
Qatar (Dukhan)	40°	13.19	1/1/77
Qatar (Marine)	36°	13.00	1/1/77
Algerian Blend	44°	14.30	1/1/77
Libya (Brega)	40°	13.92	1/1/77
Nigerian Light	34°	14.22	1/1/77
Sumatran Light	35°	13.55	1/1/77
Venezuela (Oficina)	35°	13.99	1/1/77
Venezuela (Tia Juana)	31°	13.54	1/1/77
Venezuela (Tia Juana)	24°	12.39	1/1/77

Source: Petroleum Economist, March, 1977, p. 119.

Table 4.--Representative United States crude petroleum prices

(In dollars per barrel f.o.b.)

Field	API gravity	Old crude petroleum	Upper tier crude petroleum	Stripper well crude petroleum	Effective date
East Texas Flat------	-	5.20	11.53	13.90	1/9/76
West Texas Sour------	32°	5.12	11.12	13.15	1/9/76
South Louisiana Light	37°	5.28	11.47	13.90	1/9/76

Source: Petroleum Economist, March, 1977, p. 119.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table 5.--United States projected crude petroleum domestic wellhead prices: 1980 and 1985

(In current dollars per barrel)

Category	1980	1985
Newly discovered--	16.78	21.90
New----------	14.18	18.54
Lower tier--------	6.35	8.29
Tertiary----------	16.79	21.90
Stripper----------	16.66	21.74
North Slope-------	10.30	15.37
N.P. Reserves-----	16.79	21.90

Sources: The White House analysis of price trends prepared for one Joint Committee on Taxation as given in Platt's Oilgram News Service, June 13, 1977, p.3.

Table 6.--Gross domestic product (GDP): Projected average annual growth rates of real GDP for selected countries and areas, 1976-80 and 1981-85

Country or area	Average annual growth rate (percent)	
	1976-80	1981-85
United States	4.5	4.0
Canada	4.5	4.0
Other Western Hemisphere	6.3	6.3
France	5.9	5.3
Italy	6.1	5.5
West Germany	4.6	4.2
United Kingdom	3.5	3.0
U.S.S.R. 1/	6.0	6.1
Eastern Europe	4.7	4.7
China	5.8	5.8
Middle East	8.1	8.2
India	3.5	3.5
Japan	6.1	6.0
Africa	5.7	5.7

1/ Net material product.

Source: United States International Trade Commission, based on historical growth rates and estimates of the OECD, the Commission of the European Communities, various national economic plans, and other governmental sources.

Table 7.--Measured world recoverable energy reserves, 1974

(In percent)

Area	Solid fuels	Crude petroleum	Natural gas	Oil shale and tar sands 1/	Uranium (nonbreeder) 2/	Total
Africa	1.1	1.7	0.7	0.3	0.6	4.4
Asia	8.4	7.1	1.4	2.8	< 0.1	19.7
Europe	8.3	0.1	0.5	0.4	0.2	9.5
U.S.S.R.	10.0	1.1	1.9	0.5	Unknown	14.0
North America	16.3	1.0	1.2	29.2	1.4	49.0
South America	0.1	1.0	0.2	< 0.1	< 0.1	1.5
Oceania	1.5	< 0.1	< 0.1	< 0.1	0.3	1.9
Total	46.4	12.0	5.9	33.2	2.5	100.0

1/ Current economic recovery of a large percent of these reserves is not possible at present.

2/ Energy content using breeders is 60 to 100 times as great.

Source: United States Department of Interior, Energy Perspectives 2, June, 1976, p, 11.

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Table 8.--United States energy production facilities: Leadtimes

Resource	Activity/Facility/Area	Years to Commercial Significance	
		Maximum	Minimum
Petroleum	New outer continental shelf fields		
	Southern California	7	4
	Gulf of Mexico	5	3
	Atlantic	10	6
	Gulf of Alaska	12	8
	New onshore fields	3	1
Shale oil	Plants	9	6
Coal	Surface mines/		
	Private land	5	3
	Federal land	8	5
	Underground/		
	Private land	7	5
	Federal land	8	6
Synthetic fuel	Plants/		
	Low-BTU gas	6	4
	Pipeline gas	8	5
	Coal liquids	9	6
Electricity	Plants/		
	Nuclear	10	8
	Coal	6	5
	Petroleum	-	5
	Geothermal	7	5
	Hydroelectric	12	8

Source: U.S. Department of the Interior, Energy Perspectives 2, June 1976, p. 157.

Table 9.--Primary energy consumption by recoverable energy source, 1975

(In percent)

Area	Solid fuel	Crude petroleum	Natural gas	Oil shale and tar sands	Uranium (nonbreeder)	Total
Africa	0.9	0.9	0.1	-	-	1.9
Asia 1/	8.8	8.4	1.0	<0.1	0.1	18.3
Europe	8.3	12.3	3.3	-	0.4	24.3
U.S.S.R.	6.2	6.0	3.8	<0.1	<0.1	16.0
North America	5.6	14.8	8.3	-	0.7	29.4
South America	0.8	2.9	0.8	-	<0.1	4.5
Total	30.6	45.3	17.3	<0.1	1.2	2/ 94.4

1/ Includes Oceania.

2/ Does not equal 100 percent because the contribution from hydroelectric and geothermal sources is not included to make this table comparable to table 6.

Source: British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 10.--Refining capacity, January 1, 1976

Area/Country	Percent of crude refining capacity	Number of refineries	Refining capacity (Barrels per calendar day)		
			Crude	Cracking	Refining
North America, total	24.0	300	17253590	4640245	3428455
Canada	2.8	41	2023590	430570	312695
United States	21.2	259	15230000	4209675	3115760
Latin America, total	10.7	78	7689503	663091	376670
Venezuela	2.0	12	1450815	46589	17600
Other	8.7	66	6238688	616502	359070
Europe, total	27.8	161	19972306	959690	2350630
France	4.6	24	3311600	185200	465930
W. Germany	4.3	33	3103056	106540	396690
Italy	5.7	32	4082200	263300	366970
Netherlands	2.8	8	1984700	75000	176300
Spain	1.8	10	1322500	--	165100
United Kingdom	4.0	20	2888750	202950	407950
Other	4.6	34	3279500	126700	371690
Middle East, total	4.6	33	3284951	119253	196935
Africa, total	1.9	38	1328200	68900	160440
Asia-Pacific, total	13.7	108	9868344	539125	921835
Japan	7.5	47	5417094	310717	542877
Other	6.2	61	4451250	228408	378958
Communist, total	17.3	2/	12500000	2/	2/
U.S.S.R. 1/	12.9	2/	9300000	2/	2/
Peoples Republic of China	1.7	2/	1228000	2/	2/
Other	2.7	2/	1972000	2/	2/
Total	100.0	2/	71896894	2/	2/

1/ Oil and Gas Journal.
2/ Not available.
3/ National Council for U.S.-China Trade.

Source: U.S. Bureau of Mines for all areas expect the Communist Bloc Countries.

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Table 11.--Principal petroleum product demand, by country/region, 1975
(Percent of total petroleum demand)

Country/Region	Gasolines	Middle Distillates	Fuel oils	Other 1/	Total
United States--	39.9	24.9	16.7	18.5	100.0
Canada---------	34.3	30.5	18.6	16.6	100.0
Western Europe-	18.7	33.8	34.5	13.0	100.0
Japan----------	16.2	20.8	51.8	11.2	100.0
Australasia 2/-	34.0	29.5	22.2	14.3	100.0
Other----------	18.2	31.8	35.5	14.5	100.0
Total 3/-----	26.5	28.7	29.6	15.2	100.0

1/ Includes refinery gases, liquified petroleum gases, solvents, petroleum, coke, lubricants, bitumen, wax, refinery fuel, and loss.

2/ Includes Australia, Paupua, New Guinea, New Zealand, South West Pacific Islands.

3/ Excludes the U.S.S.R., People's Republic of China, and Eastern China.

Source: British Petroleum Limited, BP Statistical Review of the World Oil Industry: 1975

Table 12.--Petroleum consumed for primary energy production: Actual for 1975 and forecasts for 1980 and 1985

(Quantity in million barrels of oil equivalent)

Country	1975		1980		1985	
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total
United States	6,000	29.8	6,600	26.3	7,000	22.3
Europe	4,873	24.2	5,527	22.0	6,598	21.0
U.S.S.R.	2,677	13.3	3,890	15.5	5,500	17.5
Japan	1,758	8.7	2,211	8.8	2,792	8.9
Other	4,844	24.0	6,905	27.4	9,532	30.3
Total world	20,152	100.0	25,133	100.0	31,422	100.0

Source: Tables 13 to 28.

Table 13.--Primary energy consumption by source for the world in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	20,152	45.2	25,133	45.2	31,422	45.6
Natural gas	7,595	17.1	9,235	16.6	11,738	17.1
Coal	13,703	30.8	15,438	27.7	17,456	25.4
Nuclear	618	1.4	2,385	4.3	4,192	6.1
Hydroelectric and geothermal	2,402	5.4	3,233	5.8	3,595	5.2
Other	55	.1	198	0.4	442	0.6
Total	44,525	100.0	55,622	100.0	68,845	100.0
Communist Bloc	13,217	29.7	16,764	30.1	20,907	30.4
Other	31,308	70.3	38,858	69.9	47,938	69.6
Total	44,525	100.0	55,622	100.0	68,845	100.0

Source: Tables 14 to 28.

Table 14.--Primary energy consumption by source for the United States in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	6,000	48.9	6,600	47.0	7,000	44.6
Natural gas	3,350	27.3	2,950	21.0	3,300	21.0
Coal	2,363	19.3	2,950	21.0	3,400	21.7
Nuclear	293	2.4	845	6.0	1,225	7.8
Hydroelectric and geothermal	254	2.1	670	4.8	700	4.5
Other	-	-	27	0.2	69	0.4
Total	12,260	100.0	14,042	100.0	15,694	100.0

1/ U.S. Department of the Interior, Energy Perspectives 2, June, 1976, p. 61.

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Table 15.--Primary energy consumption by source for Canada in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	605	39.4	800	40.6	1,000	40.4
Natural gas	330	21.5	450	22.8	500	20.2
Coal	122	7.9	200	10.2	250	10.1
Nuclear	27	1.8	50	2.5	200	8.1
Hydroelectric and geothermal	452	29.4	450	22.8	450	18.2
Other	-	-	21	1.1	76	3.0
Total	1,536	100.0	1,971	100.0	2,476	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975 1976, p. 16.

Table 16.--Primary energy consumption by source for other Western Hemisphere countries in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	1,275	56.7	1,675	54.4	2,139	51.5
Natural gas	350	15.6	644	20.9	950	23.0
Coal	375	16.7	400	13.0	500	12.1
Nuclear	4	0.2	20	0.7	100	2.4
Hydroelectric and geothermal	243	10.8	300	9.7	350	8.5
Other	-	-	40	1.3	100	2.5
Total	2,247	100.0	3,079	100.0	4,139	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World oil Industry: 1975 1976, p. 16.

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Table 17.--Primary energy consumption by source for France in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	801	64.6	860	55.8	988	52.3
Natural gas	125	10.1	170	11.0	200	10.6
Coal	185	14.9	230	14.9	250	13.2
Nuclear	29	2.3	150	9.8	300	15.9
Hydroelectric and geothermal	100	8.1	130	8.5	150	8.0
Other	-	-	-	-	-	-
Total	1,240	100.0	1,540	100.0	1,888	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975 1976, p. 16.

Table 18.--Primary energy consumption by source for West Germany in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	943	53.1	997	47.0	1,111	44.3
Natural gas	242	13.6	350	16.5	400	16.0
Coal	515	29.0	550	25.9	700	27.9
Nuclear	36	2.0	180	8.5	250	10.0
Hydroelectric and geothermal	40	2.3	45	2.1	45	1.8
Other	-	-	-	-	-	-
Total	1,776	100.0	2,122	100.0	2,506	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 19.--Primary energy consumption by source for Italy in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	701	69.1	870	65.9	1,097	64.6
Natural gas	152	15.0	195	14.8	250	14.7
Coal	85	8.4	100	7.6	120	7.1
Nuclear	6	0.6	65	4.9	130	7.7
Hydroelectric and geothermal	70	6.9	90	6.8	100	5.9
Other	-	-	-	-	-	-
Total	1,014	100.0	1,320	100.0	1,697	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 20.--Primary energy consumption by source for the United Kingdom in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	675	45.0	700	42.7	717	40.0
Natural gas	241	16.1	329	20.1	430	24.0
Coal	524	35.0	500	30.5	450	25.1
Nuclear	50	3.3	100	6.1	180	10.1
Hydroelectric and geothermal	9	0.6	10	0.6	15	0.8
Other	-	-	-	-	-	-
Total	1,499	100.0	1,639	100.0	1,792	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 21.--Primary energy consumption by source for other Western Europe in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1970		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	1,753	55.2	2,100	50.5	2,685	49.5
Natural gas	371	11.7	540	13.1	760	14.0
Coal	498	15.7	720	17.3	975	18.0
Nuclear	67	2.0	200	4.8	350	6.5
Hydroelectric and geothermal	489	15.4	596	14.3	650	12.0
Other	-	-	-	-	-	-
Total	3,178	100.0	4,156	100.0	5,420	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 22.--Primary energy consumption by source for Africa in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	378	42.7	435	38.3	562	39.0
Natural gas	43	4.9	60	5.3	100	6.9
Coal	410	46.3	500	44.1	550	38.2
Nuclear	-	-	50	4.4	120	8.3
Hydroelectric and geothermal	54	6.1	90	7.9	110	7.6
Other	-	-	-	-	-	-
Total	885	100.0	1,135	100.0	1,442	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 23.--Primary energy consumption by source for the Middle East in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	517	67.8	725	55.1	1,200	53.9
Natural gas	220	28.8	525	39.9	906	40.7
Coal	14	1.8	15	1.2	20	0.9
Nuclear	12	1.6	50	3.8	100	4.5
Hydroelectric and geothermal	-	-	-	-	-	-
Other	-	-	-	-	-	-
Total	763	100.0	1,315	100.0	2,226	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 24.--Primary energy consumption by source for Japan
1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	1,758	70.3	2,211	67.0	2,792	66.6
Natural gas	57	2.3	198	6.0	272	6.5
Coal	503	20.1	429	13.0	461	11.0
Nuclear	43	1.7	330	10.0	537	12.8
Hydroelectric and geothermal	140	5.6	132	4.0	130	3.1
Other	-	-	-	-	-	-
Total	2,501	100.0	3,300	100.0	4,192	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 25.--Primary energy consumption by source for other Eastern Hemisphere in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	1,066	44.3	1,600	49.4	2,371	53.1
Natural gas	111	4.6	200	6.2	300	6.7
Coal	1,068	44.3	1,169	36.1	1,370	30.7
Nuclear	7	0.3	110	3.4	250	5.6
Hydroelectric and geothermal	157	6.5	160	4.9	175	3.9
Other	-	-	-	-	-	-
Total	2,409	100.0	3,239	100.0	4,466	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

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Table 26.--Primary energy consumption by source for People's Republic of China/ in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	387	13.5	895	25.1	1,360	30.8
Natural gas	34	1.2	79	2.2	170	3.9
Coal	2,359	82.9	2,400	67.3	2,500	56.6
Nuclear	-	-	70	2.0	150	3.3
Hydroelectric and geothermal	46	1.6	60	1.7	120	2.7
Other	20	0.7	60	1.7	120	2.7
Total	2,846	100.0	3,564	100.0	4,420	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

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Table 27.--Primary energy consumption by source for the U.S.S.R. in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	2,677	35.5	3,890	40.3	5,500	45.0
Natural gas	1,709	22.7	2,100	21.7	2,600	21.3
Coal	2,778	36.9	3,075	31.8	3,350	27.4
Nuclear	40	0.5	150	1.6	250	2.0
Hydroelectric and geothermal	298	3.9	400	4.1	450	3.7
Other	35	0.5	50	0.5	77	0.6
Total	7,537	100.0	9,665	100.0	12,227	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 28.--Primary energy consumption by source for Communist Eastern Europe in 1975, 1980, 1985

(Quantity in million barrels of oil equivalent)

Energy source	1975		1980		1985	
	Quantity 1/	Percent of total	Quantity	Percent of total	Quantity	Percent of total
Petroleum	616	21.7	775	21.9	900	21.1
Natural gas	260	9.2	445	12.6	600	14.1
Coal	1,904	67.2	2,200	62.2	2,560	60.1
Nuclear	4	.1	15	0.4	50	1.2
Hydroelectric and geothermal	50	1.8	100	2.9	150	3.5
Other	-	-	-	-	-	-
Total	2,834	100.0	3,535	100.0	4,260	100.0

1/ British Petroleum Company Limited, BP Statistical Review of the World Oil Industry: 1975, 1976, p. 16.

Table 29.--U.S. petroleum consumption by sectors, 1975

(Quantity in million barrels of petroleum)

Sector	Quantity	Percent of total consumption
Household and commercial	1,068	17.8
Industrial	1,032	17.2
Transportation	3,276	54.6
Electricity generation, utilities	606	10.1
Other	18	0.3
Total	6,000	100.0

Source: U.S. Department of Interior, Energy Perspectives 2, June 1976, pp. 57 and 61.

Table 30.--Crude Petroleum: Production

Country	1950	1960	1970	1971	1972	1973	1974	1975	1976
North America, total--	2,003	2,756	3,978	3,946	4,016	4,009	3,820	3,571	3,445
Canada	29	194	461	492	561	648	617	519	468
United States 1/	1,974	2,562	3,517	3,454	3,455	3,361	3,203	3,052	2,977
Latin America, total--	717	1,364	1,917	1,867	1,788	1,895	1,788	1,604	1,608
Ecuador	2/ 3	3	1	1	29	76	64	59	69
Mexico 3/	50	99	178	177	185	191	238	294	325
Venezuela	2/ 547	1,042	1,353	1,295	1,178	1,229	1,086	856	828
Other	117	220	385	394	396	399	400	395	386
Europe, total	25	105	137	132	138	139	142	199	247
Norway	-	-	-	2	12	11	13	69	73
United Kingdom	1	1	1	1	2/ 3	2/ 3	2/ 3	8	77
Other	24	104	136	129	123	125	126	122	97
Middle East, total	641	1,952	5,094	5,979	6,631	7,745	7,987	7,143	8,125
United Arab Emirates	-	-	284	387	440	559	616	618	712
Iran	2/ 242	390	1,397	1,662	1,839	2,139	2,198	1,953	2,166
Iraq	2/ 51	355	569	624	529	737	721	809	778
Kuwait	2/ 126	594	998	1,068	1,098	1,007	831	671	784
Neutral Zone	4/	49	184	199	207	191	198	181	4/
Saudi Arabia	2/ 200	456	1,295	1,642	2,098	2,677	2,997	2,492	3,145
Other	22	108	367	397	420	435	426	419	540
Africa, total	17	80	2,215	2,060	2,086	2,161	1,990	1,822	1,981
Algeria	-	67	376	280	385	401	368	351	356
Libya	-	-	1,209	1,008	820	794	555	551	701
Nigeria	-	6	396	558	665	750	823	652	751
Other	17	7	234	214	216	216	244	268	173
Asia-Pacific, total---	87	199	503	580	691	816	816	806	905
Indonesia	2/ 48	150	312	326	396	489	502	477	550
Other	31	49	191	254	295	327	314	329	355
Communist, total	314	1,195	2,875	3,099	3,251	3,603	3,995	4,328	4,623
People's Republic of China	5/	12	5/	186	216	365	475	572	618
U.S.S.R.	5/	1,080	5/	2,778	2,896	3,094	3,374	3,609	3,829
Other	5/	103	5/	135	139	144	146	147	176
Grand total	3,804	7,651	16,719	17,663	18,601	20,368	20,538	19,473	20,934

1/ Includes lease condensate.
2/ Organization of the Petroleum Exporting Countries, Annual Statistical Bulletin: 1974, June 1975, also Annual Statistical Bulletin: 1975.
3/ Includes condensate and absorption liquid production.
4/ Production divided between Saudi Arabia and Kuwait.
5/ Not available.

Source: U.S. Bureau of Mines: 1950, World Oil: 1960, U.S. Bureau of Mines: 1970 through 1975, Petroleum Economist: 1976, except United States data from World Oil.

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Table 31.--Crude petroleum: Proved reserves

(In millions of barrels)

Country	Dec. 31 1960	Dec. 31 1970	Dec. 31 1971	Dec. 31 1972	Dec. 31 1973	Dec. 31 1974	Jan. 1 1975	Dec. 31 1975	Jan. 1 1976
North America, total	35,216	47,560	46,397	46,062	42,974	41,421	44,700	39,335	40,100
Canada	3,497	8,559	8,334	9,723	7,674	7,171	9,400	6,653	7,100
United States	31,719	39,001	38,063	36,339	35,300	34,250	35,300	32,682	33,000
Latin America, total	22,504	28,456	29,075	28,976	23,421	28,469	40,577	28,988	35,368
Ecuador	25	6,000	6,070	5,964	1,500	1,445	2,500	1,387	2,450
Mexico	2,458	2,880	2,837	2,833	2,847	3,087	13,582	3,431	9,500
Venezuela	16,876	14,041	13,740	13,872	13,812	18,567	15,000	18,511	17,700
Other	3,145	5,535	6,428	6,307	5,262	5,370	9,495	5,559	5,718
Europe, total	1,517	6,239	6,790	9,920	17,048	15,482	25,814	18,225	25,488
Norway	-	2,000	2,000	2,300	4,500	5,500	7,300	6,003	7,000
United Kingdom	5	2,500	3,000	6,000	10,900	7,725	15,700	9,838	16,000
Other	1,512	1,739	1,790	1,620	1,648	2,257	2,814	2,384	2,488
Middle East, total	158,546	342,140	346,758	310,370	316,702	339,253	403,858	340,429	368,411
Abu Dhabi	1/	14,850	15,100	18,234	18,700	40,324	30,000	40,371	29,500
Iran	22,000	60,000	60,450	66,250	68,000	68,050	66,000	66,281	64,500
Iraq	1/	29,000	33,100	35,750	35,675	35,124	35,000	35,000	35,000
Kuwait	60,000	75,500	74,974	72,974	72,969	72,890	72,800	70,219	68,000
Neutral Zone	2,600	12,800	13,000	10,133	10,325	6,828	17,300	6,648	6,400
Saudi Arabia	48,000	138,673	137,040	92,992	96,922	103,480	164,500	107,857	148 600
Other	25,946	11,317	13,094	13,037	14,111	14,557	18,258	14,053	17,111
Africa, total	4,697	46,317	50,867	51,989	56,087	52,031	68,299	53,595	65,035
Algeria	3,000	8,098	9,840	9,750	9,329	9,035	7,700	10,000	7,370
Libya	1,500	30,000	28,900	24,100	23,208	23,000	26,600	24,000	26,100
Nigeria	110	5,600	10,000	12,600	18,250	13,000	20,900	13,000	20,200
Other	87	2,619	2,127	5,539	5,300	6,996	13,099	6,595	11,415
Asia-Pacific, total	8,886	13,347	14,228	16,586	19,144	19,226	21,048	19,144	21,234
Indonesia	8,000	10,000	10,673	10,700	11,500	12,000	15,000	12,000	14,000
Other	886	3,347	3,555	5,886	7,644	7,226	6,048	7,144	7,234
Communist, total	24,668	59,550	74,608	59,746	64,413	73,198	111,400	79,261	103,000
People's Republic of China	400	N.A.	12,500	12,500	14,800	14,800	25,000	17,242	20,000
U.S.S.R. 2/	23,000	58,000	60,000	45,000	47,500	56,341	83,400	58,875	80,400
Other	1,268	1,550	2,108	2,246	2,113	2,057	3,000	3,144	2,600
Total	256,034	543,609	568,723	523,649	539,789	569,080	715,696	578,977	658,686

1/ Included in other.

2/ Crude petroleum reserves figure are generally considered a state secret. As a result estimates vary widely. World Oil, August 15, 1975, p. 124.

Source: December 21, 1960, 1970, 1971, 1972, 1973, 1974, 1975 from World Oil; January 1, 1975, 1976 from U.S. Bureau of Mines, International Petroleum Annual.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table 32.--World crude petroleum: Proved reserves and production by major regions, 1970 and 1976

(In percent)

Item	1970		1976	
	Proved reserves	Production	Proved reserves	Production
North America--	8.8	23.8	6.1	16.5
Latin America--	5.2	11.5	5.4	7.7
Europe---------	1.1	0.7	3.9	1.2
Middle East----	62.9	30.5	55.9	38.8
Africa---------	8.5	13.3	10.0	9.4
Asia-Pacific---	2.5	3.0	3.2	4.3
Communist Bloc-	11.0	17.2	15.5	22.1
Total--------	100.0	100.0	100.0	100.0

Source: Compiled from official production statistics of the U.S. Bureau of Mines and proved reserves data as reported by the Oil and Gas Journal and World Oil.

Table 33.--Production and reserves

Item	Production 1976 (Percent of world total)	Proved reserves January 1, 1976 (Percent of world total)	Ratio of reserves to production (R/P) 1/
OPEC	53.0	67.0	39.8
Non-OPEC 2/	16.1	7.5	14.7
Communist Bloc 3/	21.2	15.2	22.6
Total	4/ 90.3	4/ 89.7	-

1/ There is a rate of production that is consistent with the maximum recovery of reserves and it is called the maximum efficient rate (MER). Production at rates above the MER could result in large quantities of crude petroleum becoming unrecoverable. An R/P ratio of between 10 and 15 has been found generally acceptable in the United States.

2/ United States, Canada, and Mexico.

3/ U.S.S.R. and the People's Republic of China.

4/ Balance of production and proved reserves held by many nations.

Table 34.--Crude petroleum: OAPEC 1/ and OPEC 2/ production capacity

(In thousands of barrels per day)

Country	Crude petroleum production capacity	Percent unused		
		June 1976	Aug. 1976	Dec. 1976
Saudi Arabia 3/	11,500	25.8	23.8	20.3
Kuwait 3/	3,500	47.1	45.1	5.1
Libya	2,500	19.6	17.6	16.8
Iraq	3,000	33.3	31.7	10.0
Abu Dhabi	2,000	21.5	19.5	17.5
Algeria	1,000	-	-	-
Qatar	700	30.0	25.7	28.6
Egypt	350	8.6	8.6	2.9
Syria	200	10.0	10.0	10.0
Bahrain	60	-	-	-
OAPEC total 4/	24,810	27.4	25.5	15.4
Iran	6,500	6.2	10.5	1.0
Venezuela	2,700	12.6	9.6	8.1
Nigeria	2,500	16.0	20.0	4.4
Indonesia	1,700	12.9	11.2	7.1
Dubai	330	-	3.0	3.0
Gabon	250	12.0	12.0	12.0
Ecuador	200	55.0	-	6.7
Sharjah	50	20.0	20.0	20.0
OPEC total 4/	38,430	21.5	20.7	11.3

1/ OAPEC = Organization of Arab Petroleum Exporting Countries.
2/ OPEC = Organization of Petroleum Exporting Countries.
3/ Including one-half of Neutral Zone production capacity.
4/ Egypt, Syria, and Bahrain are not members of OPEC.

Source: Compiled from official statistics of the U.S. Central Intelligence Agency.

Table 35.--Exploratory well completion 1/

Country	1970	1971	1972	1973	1974	1975
North America, total	9,230	8,456	9,172	9,685	10,354	7,753
Canada	1,537	1,534	1,633	2,219	1,735	1,649
United States	7,693	6,922	7,539	7,466	8,619	6,104
Latin America, total	574	548	542	488	503	495
Ecuador	20	15	20	8	5	3
Mexico	130	129	143	104	98	87
Venezuela	90	44	64	63	76	35
Other	334	360	315	313	324	370
Europe, total	159	199	210	217	243	296
Norway 2/	13	13	14	13	17	14
United Kingdom 2/	39	22	25	40	55	83
Other	107	164	171	164	171	199
Middle East, total	72	48	81	65	70	100
United Arab Emirates	7	10	22	8	3	0
Iran	11	6	2	18	27	26
Iraq	1	0	0	3	2	0
Kuwait	1	2	0	0	0	0
Neutral Zone	0	0	0	0	0	0
Saudi Arabia	2	2	6	3	4	9
Other	50	28	51	33	34	65
Africa, total	263	257	223	178	191	200
Algeria	37	25	10	13	9	17
Libya	51	41	34	25	32	36
Nigeria	31	55	61	45	51	33
Other	144	136	118	95	99	114
Asia-Pacific, total	246	261	312	342	338	288
Indonesia	84	135	137	169	176	186
Other	162	126	175	173	162	102
Total	10,544	9,769	10,540	10,975	11,699	9,132

1/ Includes oil, gas, and dry wells; includes new-field wildcats, new-pool wildcats, deeper pool tests, shallow pool tests and extensions.
2/ North Sea.

Source: Compiled from data prepared by the American Petroleum Institute.

Table 36.--Total well completions 1/

Country	1970 2/	1971 2/	1972 2/	1973 2/	1974 2/	1975 3/	1976 3/ Estimate
North America, total	32,575	30,475	32,303	32,223	37,120	42,700	44,029
Canada	3,108	3,175	3,548	4,621	4,227	4,313	4,485
United States	29,467	27,300	28,755	27,602	32,893	38,387	39,544
Latin America, total	2,331	2,361	2,134	2,060	2,138	1,999	2,048
Ecuador	37	81	59	58	37	19	12
Mexico	502	516	431	422	408	366	449
Venezuela	589	464	371	427	416	281	280
Other	1,203	1,300	1,273	1,153	1,277	1,333	1,307
Europe, total	362	418	459	400	489	588	655
Norway	15	14	16	17	36	45	51
United Kingdom	58	63	70	76	109	133	200
Other	289	341	373	307	344	410	404
Middle East, total	242	293	425	609	630	697	698
United Arab Emirates	7	28	55	57	84	4/	4/
Iran	44	104	61	81	100	105	120
Iraq	6	17	0	16	2	4/	4/
Kuwait	13	8	2	0	0	4/	4/
Neutral Zone	23	12	9	13	19	10	19
Saudi Arabia	43	56	178	323	300	225	163
Other	106	68	120	119	125	357	396
Africa, total	709	653	645	597	628	621	762
Algeria	115	109	80	83	79	130	200
Libya	250	87	77	74	79	74	87
Nigeria	168	207	258	239	249	187	200
Other	176	250	230	201	221	230	275
Asia-Pacific, total	246	579	535	698	810	1,031	1,071
Indonesia	84	422	312	501	630	630	600
Other	162	157	223	197	180	401	471
Total	36,465	34,779	36,501	36,587	41,815	47,636	49,263

1/ Includes oil, gas, and dry wells; exploratory and development.
2/ Complied from data prepared by the American Association of Petroleum Geologists.
3/ Compiled from data prepared by World Oil, February 15, 1976, p. 102.
4/ Includes United Arab Emirates, Iraq, and Kuwait.

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Table 37.--Geophysical exploration

(In crew months)

Item	1970	1971	1972	1973	1974	1975
North America, total--	4,379	4,201	4,789	4,894	5,951	5,061
Canada----------	806	334	503	585	487	1/ 597
United States-------	2,521	2,762	3,140	3,073	3,892	3,674
Latin America---------	1,052	1,105	1,146	1,236	1,572	1/ 790
Europe----------	725	738	692	627	702	1/ 679
Middle East----------	286	254	239	294	389	1/ 306
Africa----------	802	915	938	798	835	1/ 676
Asia-Pacific----------	1,009	1,578	957	950	1,008	1/ 440
Total----------	7,201	7,686	7,615	7,563	8,897	7,172

1/ Seismic activity only.

Table 38.--Statistics on OPEC nations

Country	Population 1/ mid-1975	Land Area 1/	Petroleum revenue per capita		Petroleum exports as a percent of total exports 4/	Petroleum revenue as a percent of GNP 5/	Petroleum revenue as a percent of total government revenue 6/
			1974 2/	1975 3/	1974	1973 estimate	1973 estimate
	(million)	(1,000 square meters)	(dollars)	(dollars)			
Algeria	16.8	2,382	227	-	90.9	17	-
Ecuador	7.1	270	-	-	57.6	-	-
Gabon	0.5	268	-	-	81.6	-	-
Indonesia	130.5	1,904	24	-	70.2	12	-
Iran	33.0	1,648	556	603	96.9	24	75
Iraq	11.1	438	631	684	94.9	35	85
Kuwait	1.0	16	7,527	8,061	96.2	55	90
Libya	2.4	1,760	3,393	2,131	99.7	65	95+
Nigeria	81.9	924	117	-	91.1	21	-
Qatar	0.2	22	17,778	8,182	98.2	95	95+
Saudi Arabia	8.0	2,240	5,000	3,338	99.9	80	95
United Arab Emirates	0.4	418	19,524	18,571	-	95	95+
Venezuela	12.0	912	911	-	95.2	-	-

1/ Organization of the Petroleum Exporting Countries, Annual Statistical Bulletin, June 1976, p. 1.
2/ Dankwart A. Rustow and John F. Mugno, OPEC: Success and Prospects, New York University Press, 1976, p. 131.
3/ Government revenue from Middle East Oil, August, 1976, p. 10.
4/ Annual Statistical Bulletin, June, 1976, pp. 3-5.
5/ U.S. House of Representatives Committee on Ways and Means. Background Readings on Energy Policy, March 1, 1975, p. 814.
6/ Exxon Corporation, Middle East Oil, August, 1976, p. 10.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table 39.--OPEC: Minimum petroleum exports to satisfy revenue requirements in 1980

(In millions of barrels per day)

Country	Source No. 1	Source No. 2	Source No. 3
Algeria	0.6	1.0	2.0
Ecuador	0.1	-	-
Gabon	-	-	-
Indonesia	1.4	-	-
Iran	3.1	4.5	7.4
Iraq	1.5	2.0	2.9
Kuwait	1.0	1.5	1.04
Libya	0.6	1.0	1.6
Nigeria	2.3	1.5	-
Qatar	0.2	-	0.15
Saudi Arabia	3.2	5.0	2.3
U.A.E.	0.6	1.5	1.19
Venezuela	2.0	-	-
Total	16.6	18.0	18.58

Source: No. 1 - Journal of Energy and Development, Autumn, 1975, p. 65.

No. 2 - Hendrik S. Houthakker, The World Price of Oil: A Medium-Term Analysis, American Enterprise Institute for Public Policy Research, Washington, D.C., October, 1976, p. 32.

No. 3 - United States Congress. Joint Committee on Atomic Energy. Towards Project Interdependence: Energy in the Coming Decade, 94th Congress, 1st Session, Washington, D.C., Government Printing Office, December, 1975, p. 111.

Note: A dash does not mean no minimum export requirement, but rather that the source did not indicate a figure.

Table 40.--World crude petroleum production for 1972, 1975 and 1976; forecasts for 1980 and 1985

(In millions of barrels per day)

Country/area	1972	1975	1976	1980	1985
Non-OPEC:					
United States	9.47	8.36	8.19	9.6-15.8	10.1-22.4
Canada	1.54	1.42	1.28	1.8-2.2	1.9-3.4
Mexico	0.51	0.81	0.89	1.0-1.5	1.5-2.0
North Sea	0.04	0.49	0.59	3.3-4.7	5.7-6.0
Other	3.03	3.75	3.37	5.0-6.0	6.0-7.0
Total Non-OPEC	14.59	14.83	14.32	20.7-30.2	25.2-40.8
Communist Bloc:					
U.S.S.R.	7.93	9.89	10.49	11.2-13.5	20.0-23.0
P.R.C.	0.59	1.57	1.69	2.2-8.0	8.0-10.0
Other	0.38	0.40	0.48	0.6-1.0	1.0-1.5
Total Communist Bloc	8.90	11.86	12.66	14.0-22.5	29.0-34.5
OPEC:					
Saudi Arabia	5.75	6.83	8.62	3.2-15.0	10.5-20.0
Iran	5.04	5.35	5.93	3.1-8.0	8.0-10.0
Venezuela	3.23	2.34	2.27	2.0-2.5	2.5-3.0
Kuwait	3.01	1.84	2.15	1.0-3.5	2.2-3.0
Iraq	1.45	2.21	2.13	1.5-5.0	4.0-6.0
Nigeria	1.82	1.79	2.06	2.3-3.0	3.2-4.0
U.A.E.	1.21	1.69	1.95	0.6-4.0	2.0-6.0
Libya	2.24	1.51	1.92	0.6-3.0	2.2-3.0
Indonesia	1.08	1.31	1.51	1.4-2.0	2.5-3.0
Algeria	1.05	0.96	0.97	0.6-2.0	1.6-2.0
Qatar	0.48	0.44	0.48	0.2-0.5	0.3-0.7
Gabon	0.13	0.22	0.22	0.2-0.3	0.3-0.6
Ecuador	0.08	0.16	0.19	0.2-0.3	0.3-0.5
Total OPEC	26.57	26.65	30.40	16.9-49.1	39.6-61.8
Grand total	50.06	53.34	57.38	51.6-101.8	93.8-137.1

Sources: Production data for 1972 and 1975 from the U.S. Bureau of Mines; for 1976 from the Petroleum Economist.

APPENDIX B
PRICE

Supply and Demand

In a free market, supply and demand determine price. The market clearing price is the price at which supply and demand balance. On the other hand, changes in price will affect the level of supply and demand.

The degree to which supply or demand changes in response to a given change in price is called elasticity of supply or elasticity of demand. Up until the large price increases at the time of the Arab oil embargo very little study had been given to the price elasticities of crude petroleum supply and demand.

It is known that there are different price elasticities associated with demand and supply depending upon the time interval involved. Over a short time period, even a quadrupling of prices such as occurred for crude petroleum in 1973-74 has very little effect upon demand or supply. Demand is locked into a consumption pattern and is relatively inelastic, that is, houses cannot be insulated immediately, gasoline inefficient cars are used for several more years before more efficient new ones are bought, petroleum-fuel furnaces cannot be converted overnight, etc. Similarly new reserves cannot be discovered immediately, nor can production be immediately increased. Over longer periods, the same price changes that had little effect in the short-term may produce profound changes in both supply and demand. A key unknown in forecasting future supply and demand is that no one yet knows what will be the longer term response of supply and demand to the 1973-74 price increase. For example, the level of demand has now partially recovered from the initial effect of the price increase as consumers have learned how to cope with the increase. Whether the rate of growth of demand will revert to the pre-price increase rate, however, is unknown. On the supply side, very little change in crude petroleum (or other energy source) supply has been noted. An incubation period is involved, and as yet, because of the long lead-times involved, very little of the increased investment has shown up in increased crude petroleum production (or the increased availability of other energy sources).

OPEC

Marginal production is controlled by the members of OPEC. These countries produce petroleum at levels that will maintain the agreed-upon OPEC price. Thus, it is obvious that OPEC can set just about any price for its crude petroleum, at least over a short time period. In order to achieve a higher price, OPEC members could either limit production or, as has been the case to date, set a price based on consultations within the context of OPEC. OPEC is in a position to do this because (1) petroluem is the world's most important energy source and the OPEC countries control

the major shares of world crude petroleum export trade; (2) the price elasticity of demand for petroleum is low in the short term; and (3) the price elasticity of non-OPEC petroleum supplies and of substitute energy sources is also low in the short term. 1/ Although the price elasticity of demand for petroleum will almost certainly increase in the medium term, OPEC should still have substantial power to control prices as long as petroleum prices remain below the prevailing prices for large-scale development of other energy sources (currently equivalent to about $15 to $25 per barrel of crude petroleum). In addition to price increases initiated by OPEC, prices could also increase in the future because of additional costs involved with production in hostile environments and inflation.

One determinant of the extent to which OPEC will raise petroleum prices is the rate of increase in the price of goods and services imported by the OPEC countries from petroleum-consuming (mainly OECD) countries. Inflation rates in OECD countries 2/ have led to an erosion of the purchasing power of some OPEC countries in recent years, as has the depreciation of the dollar, the currency used to express petroleum prices. 3/ Stable and moderate inflation rates in countries which export to OPEC would be instrumental in holding down the level of petroleum prices. One forecaster has stated "It is no exaggeration to say that the biggest contribution to lower prices which the governments of the industrial countries could make would be to control their own rate of domestically generated inflation." 4/

Transportation

To arrive at a landed price for a barrel of imported crude petroleum, the cost of transportation must be added to the price of the barrel at the import source. This transportation cost fluctuates according to the demand and supply of tankers and can vary significantly between times of tanker capacity surplus and shortage. Whereas it usually costs about $1.50 to $1.75 per barrel to move a barrel of Saudi Arabian crude petroleum to Europe on a 250,000 deadweight ton (DWT) vessel, the cost in today's depressed tanker market is less than $0.50 per barrel 5/ Thus, assuming the current price for Saudi Arabian "marker" crude petroleum, the landed price in Europe today

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1/ Guy de Carmoy, Energy for Europe: Economic and Political Implications, American Enterprise Institute for Public Policy Research, Washington, D.C., 1977, p. 32.

2/ It is estimated that increased petroleum prices caused about 12 percent of the inflation experienced by OECD countries in 1974. This means that there is a slight feedback effect upon OPEC when OPEC raises petroleum prices; i.e., increases in petroleum prices lead to somewhat higher rates of inflation in consuming countries, which leads to higher export prices of goods and services to OPEC countries.

3/ Guy de Carmoy, op. cit. p. 31.

4/ Colin Robinson, Energy Depletion and the Economics of OPEC, The Henley Centre for Forecasting, Henley, England, 1975, p. 28, as quoted in Guy de Carmoy, op. cit., p. 32.

5/ Oil and Gas Journal, newsletter, July 4, 1977.

would be around $13.20 per barrel versus a possible $14.20 to $14.45 under normal circumstances, or around 7.5 to 10 percent lower than normal.

In addition to the tanker supply and demand situation, transportation costs also depend upon the actual size of the tanker. All other things being equal, it costs less to transport a barrel of crude petroleum in a large tanker than a small tanker. Under normal circumstances the cost of transporting crude petroleum in a 200,000 DWT vessel is less than half that for a 50,000 DWT vessel, and such cost for a 300,000 DWT vessel is approximately a third that for a 50,000 DWT vessel. This lower cost has been a driving factor behind the push to construct superports [i.e., ports capable of handling very large crude carriers (VLCC)] in the United States.

Because of the stricter regulations, higher crew wages and construction costs applicable to U.S.-flag vessels, the cost of transportation in such vessels is higher than in foreign-flag vessels of comparable size. Therefore, at present, 97 percent 1/of the crude petroleum imported into the United States arrives in foreign-flag vessels. Legislation is currently under consideration which would require a certain percentage (depending on the bill under consideration) of all petroleum imports to be carried on U.S.-flag vessels. While such legislation might increase the security of imports it would also increase price.

The recent indications of current or future tanker fleet expansions by the U.S.S.R., OAPEC and OPEC 2/ are causing concern not only about material security but also about price. If crude petroleum can only be obtained from certain sources, and these sources also control the transportation, it is obvious these sources can not only charge almost any price for the crude petroleum but also for the transportation. Refusal to use the source's vessels could result in the supplies being unavailable.

Supply Security Impact

Most mechanisms to assure security of supply 3/ will impact price. These mechanisms which are designed to promote domestic production, decrease consumption, or limit imports, either directly or indirectly will usually result in a price increase.

Since these supply security tools may be arbitrarily imposed it is difficult to include an effect from the use of any one or a combination of these tools in price forecasts. However, since the import dependence of the United States is increasing it is possible that one or more of the tools to increase

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1/ Washington Star, June 8, 1977, p. A-22.
2/ See "World Trade", Appendix C.
3/ See "Supply Security", Appendix D.

supply security may be employed in the future. It is well to remember this point when world price forecasts are analyzed and future U.S. prices projected.

Price Controls

At present and under The National Energy Plan as issued by the White House on April 29, 1977, crude petroleum prices are controlled. It has been stated that "price controls on oil should be retained as long as world oil prices remain subject to arbitrary control, and domestic supplies are insufficient to meet domestic needs". 1/

Under a price control plan the relationship that forecast world marginal crude petroleum prices will have to U.S. prices is wholly dependent on the plan. In the case of The National Energy Plan it is planned that the price of newly discovered crude petroleum would be allowed to rise over a 3 year period to the current 1977 world crude petroleum price, adjusted to keep pace with the domestic price level. Therefore, in this case there will be a relationship between world and U.S. prices.

1/ Executive Office of the President, Energy Policy and Planning, The National Energy Plan, April 29, 1977, p. 50.

APPENDIX C
WORLD TRADE

World Trade Patterns

Current

In 1975, large movements of crude petroleum in international trade were made from the Middle East to Europe, North America and Japan; Indonesia to North America and Japan; West Africa to Europe and North America; North Africa to Europe and North America; South America to North America; and Canada to the United States.

The recent bulk of the world trade in crude petroleum was between OPEC nations and the rest of the world. Details on OPEC exports and destinations for 1970 and 1975 are in table C-1.

In 1975, although official OPEC data are not available on exports by destination from Iran and Iraq, import data by source are available from the Organization for Economic Cooperation and Development (OECD) for its members. 1/ These data combined indicate that OPEC exports increased significantly in 1975 over 1970 to North American, Latin American and the Asia-Pacific nations. The largest increase was to North American nations, principally the United States.

Table C-2 contains data on imports into the United States for 1970 and 1975. In 1970, United States imports from OPEC nations totaled 267 million barrels whereas in 1975 they had increased to 1,237 million barrels, a 4.6 fold increase. The largest volume increases were from Nigeria, 252 million barrels; Saudi Arabia, 224 million barrels; Indonesia, 118 million barrels; Iran, 104 million barrels and Algeria, 102 million barrels. Thus, these five nations accounted for around 82 percent of the United States' total increase in imports from OPEC between 1970 and 1975.

An analysis of past exports from the OPEC nations and their destinations indicate that each OPEC nation more or less had certain trade patterns. In the future, these established trading patterns could change significantly because of participation, the different role to be played by the multinational petroleum companies, the increasing demand for petroleum by certain developing nations, the increasing production by non-OPEC countries and possible international OPEC conflicts owing to pricing practices and different crude petroleum qualities.

Table C-3 indicates total OPEC exports in 1970 and 1975 and the quantities imported by the United States. Comparing tables it is interesting to note that although OPEC supplied 50.1 percent of the

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1/ Organization for Economic Cooperation and Development, 1975 Oil Statistics, Paris, 1976, pp. 44-47.

Table C-1.--OPEC: Crude petroleum exports: 1970 and 1975

(In million barrels)

Country	North American	Latin America	Western Europe	Eastern Europe	Africa	Asia Pacific	Middle East	Total
Algeria:								
1970	2.6	14.1	320.8	5.4	12.8	-	-	335.7
1975	97.0	9.6	198.1	6.8	3.8	4.5	-	1/ 320.3
Ecuador:								
1970	-	0.2	-	-	-	-	-	0.2
1975	20.4	32.9	-	-	-	-	-	53.3
Gabon:								
1970	.04	12.2	14.0	-	4.3	-	-	30.54
1975	14.3	22.0	36.8	-	1.8	-	-	74.9
Indonesia:								
1970	25.0	7.4	-	-	-	195.9	-	228.3
1975	129.1	45.3	0.8	-	-	187.8	-	363.0
Iran:								
1970	24.5	0.7	266.3	-	106.1	666.8	-	1/ 1,207.9
1975	2/	2/	2/	2/	2/	2/	2/	1,704.9
Iraq:								
1970	8.7	25.8	455.9	3.1	25.5	12.5	3/ 24.5	546.0
1975	2/	2/	2/	2/	2/	2/	2/	766.5
Kuwait:								
1970	15.4	20.2	582.2	-	1.1	303.4	4/ 19.4	941.7
1975	9.2	44.8	248.3	12.0	-	338.4	4/ 5.5	658.2
Libya:								
1970	34.3	34.0	1,137.2	0.4	-	2.9	-	1,208.8
1975	120.8	61.9	307.0	8.9	5.7	18.0	-	522.3
Nigeria:								
1970	59.4	50.8	270.2	-	2.6	0.4	-	383.4
1975	196.7	85.5	314.0	-	11.8	17.4	-	625.4
Qatar:								
1970	-	3.5	87.7	-	18.2	22.3	5/ 0.7	132.4
1975	32.2	5.4	85.8	-	7.2	28.1	5/ 0.6	1/ 156.3
Saudi Arabia:								
1970	20.8	50.6	624.1	-	37.3	371.5	6/ 69.9	1,174.2
1975	117.0	344.7	1,113.1	-	40.2	727.2	6/ 66.9	2,409.1
Abu Dhabi:								
1970	30.1	0.4	134.1	-	2.0	80.1	7.0	1/ 253.7
1975	42.7	14.2	258.7	5.1	5.8	172.1	5/ 0.9	499.5
Venezuela:								
1970	271.6	464.4	147.8	-	0.9	3.8	-	888.5
1975	241.7	235.6	58.4	-	-	1.6	-	537.3
Total:								
1970	492.44	684.3	4,030.3	8.9	210.8	1,659.6	121.5	7,351.34
1975	2/	2/	2/	2/	2/	2/	2/	8,691.0

1/ Includes "unspecified" exports.
2/ Exports by destination not available.
3/ Includes Lebanon and Southern Yemen.
4/ Includes Southern Yemen.
5/ All to Southern Yemen.
6/ To Bahrain, Jordan and Lebanon.

Source: OPEC, Annual Statistical Bulletin; 1975, June 1976, pp. 61-73.

Table C-2.--United States: Imports of crude petroleum by source, 1970 and 1975

(Quantity in thousands of barrels)

Source	1975		1970	
	Quantity	Percent	Quantity	Percent
Canada	230,953	14.5	237,832	44.5
Latin America, total:	271,941	17.2	166,403	31.2
Bolivia	1,929	0.1	267	0.1
Ecuador	23,355	1.5	-	-
Mexico	27,841	1.8	10,528	2.0
Trinidad	44,933	2.8	1,157	0.2
Venezuela	173,426	11.0	145,440	27.2
Other	457	nil	9,011	1.7
Africa, total:	509,044	32.2	44,921	8.4
Algeria	104,617	6.6	2,557	0.5
Angola	27,340	1.7	-	-
Egypt	1,692	0.1	7,679	1.4
Gabon	14,906	0.9	-	-
Libya	88,090	5.6	17,563	3.3
Nigeria	269,142	17.0	17,122	3.2
Tunisia	1,951	0.2	-	-
Other	1,306	0.1	-	-
Middle East, total:	421,182	26.6	58,760	11.0
Iran	115,435	7.3	11,618	2.2
Iraq	707	0.1	149	nil
Kuwait	5,259	0.3	10,808	2.0
Qatar	6,657	0.4	27,801	5.2
Saudi Arabia	232,254	14.7	8,384	1.6
United Arab Emirates	60,280	3.8	-	-
Other	491	nil	-	-
Europe, total:	6,104	0.4	-	-
Norway	6,102	0.4	-	-
Other	2	nil	-	-
Far East, total:	144,041	9.1	25,960	4.9
Indonesia	143,299	9.1	25,960	4.9
Malaysia	443	nil	-	-
Other	299	nil	-	-
Total	1,583,265	100.0	533,876	100.0

Source: Compiled from official statistics of the U.S. Bureau of Mines.

Table C-3.--United States crude petroleum imports from OPEC nations and total OPEC exports, 1970 and 1975

(Quantity in millions of barrels)

OPEC Nation	1970 Total	1970 United States	1970 Percent	1975 Total	1975 United States	1975 Percent
Algeria	355.7	2.6	0.7	320.3	104.6	32.7
Ecuador	0.2	-	-	53.3	23.4	43.9
Gabon	30.54	-	-	74.9	14.9	19.9
Indonesia	228.3	26.0	11.4	363.0	143.3	39.5
Iran	1,207.9	11.6	1.0	1,704.9	115.4	6.8
Iraq	546.0	nil	-	766.5	0.7	nil
Kuwait	941.7	10.8	1.2	658.2	5.3	0.8
Libya	1,208.8	17.6	1.5	522.3	88.1	16.9
Nigeria	383.4	17.1	4.5	625.4	269.1	43.0
Qatar	132.4	27.8	21.0	156.3	6.7	4.3
Saudi Arabia	1,174.2	8.4	0.7	2,409.1	232.3	9.6
Abu Dhabi	253.7	-	-	499.5	60.3	12.1
Venezuela	888.5	145.4	16.4	537.3	173.4	32.3
Total	7,351.34	267.3	3.6	8,691.0	1,237.5	14.2

Source: Tables in this report.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

total United States imports, this quantity only represented 3.6 percent of the total OPEC exports. Even in 1975, when OPEC supplied 78.2 percent of the total United States imports, this quantity still represented only 14.2 percent of the total OPEC exports. Thus, it would appear that the United States is quite dependent on OPEC source imports, while OPEC is not overly dependent on the United States as an export market.

In the case of individual OPEC nations, however, the situation is different. In 1975, Algeria depended on the United States for about a third of its total export market, as did Venezuela. For the same year Indonesia sent almost 40 percent of its imports to the United States and Nigeria surpassed that figure. On the other hand, the four largest OPEC exporters in 1975 (Saudi Arabia, Iran, Iraq and Kuwait) exported only 6.4 percent of their combined exports to the United States.

Future

The principal possible future changes in the current world crude petroleum trade pattern are the cessation of exports from Canada to the United States, and the increase in exports from the Communist Bloc, Mexico, the North Sea producers, and other traditional non-OPEC nations. More subtle changes could occur among OPEC members owing to price differences, quality differences, barter or exchange agreements, etc.

In addition to future changes in sources of imports because of price and quality differentials, new and expanded production in certain areas may also be important. Decreasing exports from Canada to the United States will, all other things being equal, presumably require the United States to import the difference from other sources. Thus, the expected increase in Mexican production could result in significantly larger United States imports from Mexico in the future. At the same time, the decreased Canadian exports should increase Canada's crude petroleum self-sufficiency. It could then import less. In 1975 Canada imported large quantities from Venezuela and the Middle East, particularly Saudi Arabia and Iran. 1/

Increasing production from the North Sea fields could back-out some OPEC exports to the Western European nations. The United Kingdom and Norway (possibly even the E.E.C.) could be close to crude petroleum self-sufficiency in the relatively near future. In 1975, both countries imported heavily from the Middle East. Most of the imports of the United Kingdom in 1975 came from Kuwait, Saudi Arabia and Iran, while the latter was the major import source for Norway.

If the U.S.S.R. and the People's Republic of China develop into significant crude petroleum exporting nations, important world trade

1/ Organization for Economic Cooperation and Development, 1975 Oil Statistics, Paris, 1976, p. 45.

pattern changes would occur. Even at prices comparable to those of OPEC, new international sources of imports would be favorably looked upon by those importing nations wishing to diversify their import sources to become less dependent on OPEC. Exports from the People's Republic of China could be expected to become particularly important in the Asia-Pacific area and become an important supply source to the many developing nations in the area. Increased exports to Japan by the People's Republic of China would decrease exports from the Middle East which in 1975 supplied 78 percent of Japan's crude petroleum imports. 1/

Increased U.S.S.R. exports would probably move to the United States and Western Europe. In both, the United States and Western Europe U.S.S.R. exports would tend to replace imports from the Middle East, which was the largest source of imports in 1975.

Dialogue has already started between the U.S.S.R. and the United States and in the future could involve the Science and Technology Agreement which is expected to be renegotiated in September 1977. 2/ The U.S.S.R. could benefit from U.S. petroleum technology as it gets more deeply involved in exploration and production in its frontier areas, while the United States could benefit from a diversification in its import sources. The U.S.S.R. also needs western credits, including access to the U.S. Export-Import Bank. 3/ Rising exports from the U.S.S.R. to Western Europe is helping to accomplish this; in 1976 exports to ten of these nations increased almost 85 percent over 1975. 4/ Japan, a logical market for exports from the U.S.S.R., will probably not be a future major market as it did not enter into a joint Siberian crude petroleum project. 5/ Japan has been the most important country customer for crude petroleum from the People's Republic of China since 1973 and although deliveries decreased in 1976 relative to 1975 6/ it is probable Japanese imports will increase as the production increases in the People's Republic of China.

Other Trade Factors

In addition to the future changes that may occur in so far as who imports from whom, other changes may also occur in the world trade pattern. Probably the most significant changes could be those that may occur in logistics, refining and marketing. At present the OPEC nations effectively control crude petroleum production destined for

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1/ 1975 Oil Statistics, op. cit. p. 45.
2/ Chemical and Engineering News, June 20, 1977, p. 18.
3/ United States Senate, Committee on Energy and Natural Resources and the United States House of Representatives, Committee on Interstate Commerce, Project Interdependence: U.S. and World Energy Outlook Through 1980, June 1977, p. 67.
4/ Petroleum Economist, July 1977, p. 279.
5/ United States Congress, Joint Committee on Atomic Energy, Towards Project Interdependence: Energy in the Coming Decade, December 1975, p. 85.
6/ Petroleum Economist, July 1977, p. 260.

world trade, while the industrial nations still maintain control of logistics, refining and marketing. 1/ It was only a relatively short time ago that the industrial nations also controlled the production of OPEC crude petroleum that entered world trade. Whether or perhaps more appropriately, how long, the industrial nations will maintain control of the other three functions is open to conjecture.

Logistics

Logistics as it affects the petroleum industry essentially means ocean transportation by tanker. Of the current total Free World petroleum traded internationally, which represents two-thirds of the Free World petroleum consumption, about 95 percent was at some point between well and consumer moved by tanker. 2/ Tankers will remain the main methods of moving petroleum, so that to those with the control of the tankers goes the ability to effectively control international movements of petroleum. Table D-4 indicates that Liberia, the United Kingdom and Japan were the principal flags of the world tanker fleet tonnage at the end of 1975. Most of the tonnage, regardless of flag, was owned by private firms or individuals. Petroleum companies owned but about one-third of the world's tanker tonnage. Governments owned even less, around 4 percent of the total.

It should be noted that table C-4 does not indicate the true "control" of the world tanker tonnage. Owners often register tankers under foreign flags of "convenience," so called because these foreign countries specialize in providing favorable tax and other treatment of the tanker industry. Data on "effective" nationality of world tankers is very difficult to obtain. 3/ Table C-5 contains one estimate of the "effective" United States-owned tanker fleet for 1974. It indicates that the United States controlled about 27 percent of the world's tanker fleet deadweight tonnage in 1974.

There appear to be two trends setting in which will affect the situation just outlined:

- o The U.S.S.R. is expanding its tanker fleet.
- o OPEC and OAPEC have indicated they will expand their tanker fleets. 4/

The expanded U.S.S.R. fleet will enable it to import crude petroleum from the Middle East should it need to do so, or to export its crude petroleum. It could also allow the U.S.S.R. to move crude petroleum between foreign ports in support of consuming nations, producing nations, multinational oil companies, etc. 5/

CPEC and OAPEC have indicated they will expand their tanker fleets as they take over more and more of the direct sales of their crude

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1/ United States Senate, Committee on Interior and Insular Affairs, Geopolitics of Energy, January 1977, p. 15.
2/ Ibid., p. 48.
3/ Ibid., p. 51.
4/ Ibid., pp. 52-53.
5/ Ibid., p. 52.

Table C-4.--World tanker fleet tonnage at the end of 1975 1/

(In million long tons deadweight)

Flag	Petroleum company	Private	Government	Other	Total
Liberia	25.6	63.7	-	0.3	89.6
United Kingdom	21.8	10.7	0.2	-	32.7
Japan	4.5	27.3	-	-	31.8
Norway	0.5	25.4	-	0.2	26.1
Greece	-	15.9	-	-	15.9
France	8.8	3.9	0.1	-	12.8
United States	4.4	4.9	1.3	-	10.6
Panama	4.8	4.0	-	-	8.8
Other Western Europe	13.8	21.5	0.1	0.2	35.6
Other Western Hemisphere	6.1	0.2	0.2	-	6.5
Communist Bloc	-	-	8.4	-	8.4
Other Eastern Hemisphere	4.8	7.6	0.2	-	12.6
Total	95.1	185.1	10.5	0.7	291.4

1/ 10,000 long tons deadweight and over; excludes 43.6 million deadwight tons of combined carriers.
2/ U.S.S.R., Eastern Europe and the People's Republic of China.

Source: The British Petroleum Co. Ltd., BP Statistical Review of the World Oil Industry; 1976, 1975, p.14.

Table C-5 .--Effective United States owned tanker fleet in 1974

(In million deadweight tons)

Flag	Number of vessels	Deadweight tonnage
Liberia	411	36
United States	306	10
United Kingdom	84	9
Panama	116	5
All other	135	9
Total	1,052	69

Source: United States Senate, Committee on Interior and Insular Affairs, Geopolitics of Energy, January 1977, p. 51.

petroleum to other nations from the multinational oil companies. Even if these fleets are but a small part of the world tanker fleet they could be used to influence future trade patterns. Presumably, a future petroleum embargo could be even more effective than the one of 1973-1974 if OPEC (OAPEC) had expanded control of the movements of the tankers used to carry its exports to other nations.

Once sufficient tanker fleets are controlled by OPEC and OAPEC, these organizations could mandate that a certain percent of their exports move in their bottoms. Under such an arrangement these organizations could charge just about any shipping rates desired. The alternative to paying these rates would be doing without the crude petroleum. Thus the future delivered price of the marginal barrel of petroleum could be greatly influenced by OAPEC and OPEC tanker rates.

Refining

Around 85 percent of the world trade in petroleum takes place in crude petroleum, with the balance accounted for by petroleum products. This indicates that most of the consuming nations have decided on refining self-sufficiency. However, for the United States in 1976, imports of petroleum products accounted for 28 percent of total imports, or above the world average. 1/ A large part of these product imports are from export refining centers in the Bahamas-Caribbean area where Latin American and Middle Eastern crude petroleum is the feedstock. World-wide other refining export centers are in the Middle East, Eastern Canada, Italy and Singapore. 2/

Future expansion could result in Middle East refining capacity of 5.6 million barrels per day by 1980 and 10.2 million barrels per day by 1985. 3/ Even if all of this expansion does not come to fruition, the trend is certain; the Middle East will be exporting more petroleum products in the future at the expense of crude petroleum exports.

The expansion of the other refining exporting centers combined with that of the Middle East center indicates that world trade in petroleum products will probably increase. Along with changes in the pattern of world movements of petroleum, it also means that refining capacity in some consuming centers could become redundant and requirements for products tankers could increase. Overall, increasing petroleum products movements could signal increasing dependence of consuming nations on particular refining centers, especially if these refining centers are in crude petroleum producing countries with their own tanker fleets.

1/ Federal Energy Administration, Monthly Energy Review, February 1977, pp.6 and 8.

2/ Federal Energy Administration, Trends in Refinery Capacity and Utilization, June, 1975, p. 25.

3/ Geopolitics of Energy, op. cit., p. 47.

Marketing

The multinational oil companies are the international marketers of petroleum in international trade. They are essentially responsible for the present global supply system which has responded admirably to the demands that have been placed upon it. 1/ This global system was originally set up to move host country production owned by multinational companies. It now moves production essentially owned by the producing nations. However, this international marketing system based on market knowledge and supported by tankers and storage facilities plus refining capacity has been invaluable in assuring the consuming countries a steady supply adequate to meet its requirements.

In the future as the producing nations become increasingly involved in international marketing, and supported by growing tanker fleets and refining capacity, supply patterns will begin to change. Exports from a producing nation to a certain national market that in the past may have been predicated on a knowledge of that consuming country's market by the multinational oil companies could be changed. The reason for these changes could range from conflicting national interests between producing and consuming countries to a lack of market knowledge. Whatever else can be said about the multinational oil companies' marketing efforts, the multinational oil companies have served some purpose as a buffer between producing and consuming nations' government.

1/ United States Congress Joint Economic Committee, Subcommittee on Energy. Multinational Oil Companies and OPEC: Implications for U.S. Policy, June 2, 3 and 8, 1976, p. 110.

APPENDIX D

SUPPLY SECURITY

United States Imports

The level of U.S. imports has been a topic of interest since the United States became a net importer of crude petroleum following World War II. This interest has increased as the ratio of imports to domestic consumption has increased from 8 percent in 1947 to an estimated 42 percent in 1976; the ratio is forecast to be 46 percent for 1977 1/. Table D-1 contains data on the increasing dependence on imports of the United States.

As total imports have increased in volume and as a percent of U.S. domestic demand, imports from the Eastern Hemisphere have increased even faster as a percent of total imports. Table D-2 indicates that imports from OPEC have gone from accounting for half of the 1970 U.S. imports to over three-quarters in 1975. This increasing reliance on OPEC imports is caused by the increasing dependence on imports in general as a source of supply and by decreasing ability or willingness of other nations to export. Based on production capacity and reserves, it is inevitable that the United States will become even more dependent on OPEC exports if it continues to increase its imports.

Mechanisms to Increase Supply Security

Because of the increasing dependence on imports considerable study has been devoted to ways in which this dependence can be decreased. In general, import dependence can be decreased either by decreasing petroleum consumption or increasing crude petroleum production, or a combination of the two. Petroleum consumption can be decreased by decreasing the use of items such as automobiles, which use petroleum directly. Petroleum consumption can also be decreased by substituting other energy forms such as coal. Both of these approaches are incorporated in the National Energy Plan. 2/

There are also other ways to deal with security of supply. These include:

(1) Bilateral treaties;
(2) International commodity agreements;
(3) Sharing of available supplies;
(4) Stockpiling;
(5) Super-tanker ports;
(6) Tanker fleets;
(7) Refining capacity.

The International Energy Agency, of which the United States is a member, has as one of its prime functions the development and implementation of an International Energy Program (IEP) which will share available petroleum

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1/ Federal Energy Administration, Monthly Energy Review, September 1976, p.2.
2/ Executive Office of the President, Energy Policy and Planning, The National Energy Plan, April 29, 1977, p.50.

Table D-1.-- United States dependence on imports: 1947 to 1977

(In thousand of barrels per day)

Year	Domestic demand	Imports	Ratio of imports to domestic demand
	Quantity	Quantity	(Percent)
1947--	5,451	437	8.0
1948--	5,775	514	8.9
1949--	5,803	645	11.1
1950--	6,507	850	13.1
1951--	7,041	844	12.0
1952--	7,280	952	13.1
1953--	7,604	1,034	13.6
1954--	7,760	1,052	13.6
1955--	8,459	1,248	14.8
1956--	8,779	1,436	16.4
1957--	8,818	1,574	17.8
1958--	9,083	1,700	18.7
1959--	9,451	1,780	18.7
1960--	9,661	1,911	19.8
1961--	9,806	1,917	19.5
1962--	10,234	2,082	20.3
1963--	10,551	2,130	20.2
1964--	10,816	2,259	20.9
1965--	11,304	2,468	21.8
1966--	11,850	2,573	21.7
1967--	12,560	2,537	20.2
1968--	13,393	2,837	21.2
1969--	14,137	3,166	22.4
1970--	14,697	3,419	23.3
1971--	15,212	3,926	25.8
1972--	16,367	4,741	29.0
1973--	17,308	6,256	36.1
1974--	16,629	6,112	36.8
1975--	16,288	5,993	36.8
1976--	17,185	7,217	42.0
1977--	18,039	8,324	46.1

Source: Federal Energy Administration, Monthly Energy Review, September 1976, p. 2.

Table D-2.--Imports from OPEC nations as a percentage of U.S. imports: 1970 and 1975

Country	Percent of U.S. imports	
	1970	1975
Algeria	0.5	6.6
Ecuador	-	1.5
Gabon	-	0.9
Indonesia	4.9	9.1
Iran	2.2	7.3
Iraq	nil	0.1
Kuwait	2.0	0.3
Libya	3.3	5.6
Nigeria	3.2	17.0
Qatar	5.2	0.4
Saudia Arabia	1.6	14.7
United Arab Emirates	-	3.8
Venezuela	27.2	11.0
Total	50.1	78.3

Source: Compiled from offical statistics of the U.S. Bureau of Mines.

supplies at times of supply disruption. In addition, the IEP is also concerned with conservation, alternate energy source development, stockpiles, and long range international cooperation.

The United States has also started to implement a strategic storage plan developed over the past 18 months. By the end of 1977 the purchase of the first 10 million barrels of a 500 million barrel crude petroleum reserve planned for 1982 should be completed. 1/ All of the storage sites thus far selected are salt domes and are located at Bayou Choctaw, West Hackberry, and Weeks Island, in Louisiana, and at Bryan Mound in Texas. 2/

Mechanisms to increase security of supply currently or recently under consideration in the United States also include source country quotas 3/ and Generalized System of Preferences (GSP) treatment for certain OPEC nations. 4/ Under the source country quota provisions, imports of petroleum articles from certain Arab countries were to be limited by license to a maximum of five percent of estimated United States consumption. GSP treatment would be extended to certain OPEC nations, such as those in the Western Hemisphere or those that did not participate in the 1973-74 embargo.

The United States has employed quotas and tariffs designed to reduce dependence on imports. From 1959 to 1973, imports of both crude petroleum and products were regulated by a mandatory program based on officially fixed quotas. In 1973 the quotas were replaced by fees, which are similar, if not identical, to tariffs 5/.

Import controls objectives

Import controls can be used for many purposes including the following: 2/

(1) The stimulation of domestic exploration for crude petroleum;
(2) The stimulation of domestic production of crude petroleum;
(3) An increase in domestic exports of petroleum products;
(4) An increase in domestic refinery capacity;
(5) An increase in imports of crude petroleum and/or petroleum products;
(6) The maintenance of given domestic prices for crude petroleum and/or petroleum products;
(7) The maximization of domestic tax revenues on petroleum and its products;
(8) The stimulation of substitute sources of crude petroleum, e.g., shale;
(9) Achievement of environmental or other broad, social goals on on which energy can have effect.
(10) Achievement of increased security of supply.

1/ Oil and Gas Journal, May 23, 1977, p. 26.
2/ Ibid., p. 26.
3/ United States Senate, S.2806, 93d Congress, 1st Session, December 13, 1973, p. 59.
4/ United States Senate, S.1706, 94th Congress, 1st Session, May 12, 1975, and United States House of Representatives, H.R.5897, 94th Congress, 1st Session, April 10, 1975.
5/ United States Tariff Commission, World Oil Developments and U.S. Oil Import Policies, October 1973, pp. 92-109.
6/ Ibid., p. 111.

The above purposes could also be achieved by various control mechanisms including the following 1/:

(1) Tariffs on imports;
(2) Quotas which place absolute limits on imports either by quantity or value, or both;
(3) Tariff-rate quotas;
(4) Subsidies to producers, users, importers, and/or exporters;
(5) Internal tax measures affecting participants in the petroleum industry;
(6) Domestic production, procurement, and/or usage standards, or U.S.-flag shipping requirements.

Tariffs and quotas

Of the above five control mechanisms, tariffs and quotas have traditionally been most specifically identified with import controls on crude petroleum and petroleum products. A tariff affects price directly and the quantity demanded or supplied indirectly, while a quota affects the quantity supplied directly and price indirectly. As the market is "cleared" at the price at which supply equals demand, the net result of both tariffs and quotas is some predetermined price or related level of imports. Theoretically a tariff can be devised such that were it substituted for a quota, the same volume of imports would be generated and the same price obtained.

Of the two, quotas are the preferable mechanism if some specific quantity of imports is the desired policy. Tariffs allow material to enter the country in any quantity so long as the tariff is paid. Tariffs also are administratively less flexible than quotas as they require legislative action. In addition tariffs are subject to conformity with GATT rules and can run into constitutional difficulties. Quotas are subject to none of these constraints. 2/.

Cabinet Level Task Force Report

Because of changing world conditions and apparent difficulties with the quota system then in effect the President created a Cabinet Level Task Force in March 1969, to conduct a comprehensive review of the situation. This Task Force issued its final report in February 1970. 3/ One of its primary concerns was security of supply to which a large part of the report was devoted.

The majority of the Task Force preferred tariffs over quotas. Thus they were recommending the replacement of the quotas then in effect by a tariff system. This did not occur as the report was essentially rejected by the President. However, about 3 years later, the quotas system was scrapped and replaced with a series of fees. As indicated earlier, it has been determined that the fee is similar, if not identical, to a tariff.

1/ United States Tariff Commission, op. cit., pp. 111-112.
2/ Ibid, p. 123.
3/ Cabinet Task Force on Oil Import Control, The Oil Import Question, February 1970.

In addition to preferring the tariff to the quota, the report expressed the fact that "preferences for particular sources or areas of supply should be based on an explicit security evaluation". 1/ It further stated that Canadian and Mexican petroleum is "nearly as secure politically and militarily as our own." 2/ The report therefore recommended that after an initial transition phase, that there be established two tariff rates with the lower rate applicable to supply sources in the Western Hemisphere and the higher applicable to sources in the Eastern Hemisphere. The initial increase in tariff on crude petroleum imports from non-preferred sources was recommended to be $1.35 per barrel. This tariff would have made insecure imports considerably more expensive than secure imports as the price of imports was then about $2.50 to $3.00 per barrel landed in the United States.

The preferential tariff rate for secure supply sources would have been effective in 1970 because most of the crude petroleum producing nations of the world desired to increase exports. The majority of the exporting countries needed additional revenue to pay for imports and development programs and, since a price increase was out of the question, the additional revenue could only be generated by increasing quantity.

Changed circumstances

Since 1970 many changes have occurred in the world petroleum market. The most important are:

(1) The desire of many of the crude petroleum producing-exporting nations to limit or at least not increase production;
(2) The increasing demand by the industrial and other nations of the world for exports from the producing-exporting nations;
(3) The quadrupling of price and the arbitrary setting of this price by OPEC.

Because of these changes it is doubtful that the Task Force's preferential tariff plan would be effective today. This is not to say that security of source of import supply is any less of a concern today in the United States; in fact it is of much more concern. However, the changes in circumstances from 1970 to 1977 probably make supply sharing, stock-piling, and the use of other mechanisms preferable to a two-tier tariff system.

To maintain the same relationship that the proposed $1.35 per barrel rate had to the 1970 crude petroleum price, the tariff differential today would have to be on the order of $6.50 per barrel. Thus, the price of the imported barrel of crude petroleum would be around $20.00. This high price would fuel inflation and act to decrease the competitiveness of U.S. energy intensive products such as chemicals in world trade.

Canada and Venezuela, both Western Hemisphere import sources and therefore more secure than Eastern Hemisphere sources, have indicated an interest

1/ Cabinet Task Force on Oil Import Control, op. cit., p. 134.
2/ Ibid., p. 135.

in decreasing exports. If a country sets an export limit, a lower import duty will do nothing to attract additional supplies. Further, there is every probability that such preferred sources of imports would increase price to the point that the combination of preferred tariff and price would equal that of tariff and price from the alternate less secure import source. Under such circumstances there would be no incentive for the U.S. importer to prefer the secure import supply source on the basis of price.

APPENDIX E
ENERGY DEMAND BACKGROUND

Countries And Areas For Which Projections Were Made

Basic economic data and energy consumption data were collected and projected for the countries and areas listed below. In some cases, data collected had to be changed (sometimes by assumption or extrapolation) in order to keep all data comparable and assure that they conform to the definitions of each area.

1. United States
2. Canada
3. Other Western Hemisphere (all countries and areas in the Western Hemisphere excluding the United States and Canada).
4. France
5. Italy
6. West Germany
7. United Kingdom
8. Other Western Europe:
   - Austria
   - Belgium
   - Denmark
   - Faeroe
   - Finland
   - Gibraltar
   - Greece
   - Iceland
   - Ireland
   - Luxembourg
   - Malta
   - Netherlands
   - Norway
   - Portugal
   - Spain
   - Sweden
   - Switzerland
9. U.S.S.R.
10. People's Republic of China
11. Eastern Europe:
    - Albania
    - Bulgaria
    - Czechoslovakia
    - East Germany
    - Hungary
    - Poland
    - Romania
    - Yugoslavia
12. Middle East:
    - Bahrain
    - Iran
    - Iraq
    - Israel
    - Jordan
    - Kuwait
    - Lebanon
    - Oman
    - Qatar
    - Saudi Arabia
    - Syria
    - Turkey
    - United Arab Republic
    - Yemen
    - Yemen, Democratic

13. India
14. Japan
15. Other Asia:

Afghanistan	Malaysia
Bangladesh	Mongolia
Bruner	Nepal
Burma	Pakistan
Democratic Kmpuchea	Philippines
Hong Kong	Portuguese Timor
Indonesia	Singapore
Korea, South	Sri Lanka
Korea, North	Thailand
Laos	Vietnam

16. Africa (all countries and areas on the continent of Africa)

Methodology

In order to project energy demand for 16 selected countries and areas, data were gathered on the following four variables: energy demand in the past, gross domestic product (GDP), population, and energy conservation measures. Other variables were also examined (industrial production, labor force data, productivity data, etc.) but were not used in the final projections for various reasons, usually because of lack of available data or because such variables were believed not to correlate as highly with energy demand.

Data collected on GDP appear in table 6 of appendix A. Growth rates by selected countries and areas (data on "Other Western Europe" and "Other Asia" were not gathered) are listed.

In table E-1, population data are assembled. Again, projections were made, for 1980 and 1985 in various countries and areas. These projections were later used in the section on projections of energy demand.

Pages E-4 to E-13 in this appendix analyze energy demand in various sectors (generally transportation, industry, household/commercial, and electrical generation) of the economies of selected countries. Projections obtained in this section were later used in projections of aggregate energy demand.

This appendix also analyzes factors influencing energy demand (mainly energy/GDP elasticities and the effects of government energy conservation measures). Projections were made which were of use in final projections of energy demand. In section E, projections are also made using population data and data on energy consumption per capita (it was assumed that energy consumption per capita to 1985 will continue to increase at the 1965-73 historical rate).

Table E-1.--Population: 1975 population, and projections to 1980 and 1985, by selected countries and areas

(Million persons)

Country or area	1975	1980	1985
United States	213.63	224.88	236.00
Canada	22.83	24.60	26.50
Other Western Hemisphere	319.36	367.71	422.30
France	52.74	55.12	57.38
Italy	55.81	57.54	59.51
West Germany	61.83	64.27	65.73
United Kingdom	55.96	57.61	58.77
Other Western Europe	116.99	120.88	124.79
U.S.S.R.	254.38	267.57	281.16
Eastern Europe	130.01	134.33	138.79
China	838.80	912.79	992.95
Middle East	119.24	137.43	158.25
India	598.10	667.94	744.83
Japan	110.95	116.74	122.65
Other Asia	562.32	637.83	723.76
Africa	1/ 391.00	456.55	518.56

1/ 1974 data.

Source: United States International Trade Commission, based on historical growth rates and data from the United Nations, the World Bank, and various government sources.

Basic Economic Projections

GDP

Table 6 in appendix A presents past and projected rates of growth of real GDP for those countries and areas for which such data was available. Although the major data sources were official publications of the United Nations and the OECD, a number of other data sources were consulted, including government publications and national economic plans.

Population

There is no hard-and-fast correlation between population growth and energy consumption; energy use grows faster than population due to technological change and rising living standards. Nevertheless, population growth is often used as a variable in forecasts of energy consumption, since population growth does contribute to greater energy usage (see Holdren in "Energy Conservation: Its Nature, Hidden Benefits and Hidden Barriers," L. Schipper, Lawrence Berkley Lab, UCID 3725, June 1975). 1/

Population data were collected and projected for each of the 16 countries and areas covered in this study (table E-1). The data were then used in projections of energy consumption. The principal source of population data was the United Nations' Monthly Bulletin of Statistics.

Sector analysis

In order to project world energy demand to 1985, data were gathered and projected for major energy-consuming sectors in the economies of selected countries and areas. The major sectors covered were the industrial, transport, residential, commercial, and electrical generation sectors. An analysis of energy demand by sector, with projections by sector, was a further method of determining potential future energy demand and of determining where energy conservation policies could be most effective.

United States.--Energy consumption data were obtained for the transportation, industrial, household/commercial, and electrical generation sectors of the economy. Table E-2 shows projected energy demand in 1980 and 1985, by sector, as well as total energy demand for the economy in those years. Energy demand is projected to increase between 2.5 and 5.1 percent per year for the 1975-80 period, and between 2.0 -

1/ Middle and Long-Term Energy Policies and Alternatives, Hearings before the Subcommittee on Energy and Power of the Committee on Interstate and Foreign Commerce, House of Representatives, Ninety-Fourth Congress, Serial No. 94-63, March 25 and 26, 1976, p. 516.

Table E-2 .--United States: Projected primary energy consumption, 1980 and 1985

Sector	Energy consumption, 1975 1/	Annual average growth rate of energy consumption				Projected energy consumption			
		1975-80		1975-85		1980		1985	
		High	Low	High	Low	High	Low	High	Low
	Quadrillion BTU	Percent	Percent	Percent	Percent	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU	Quadrillion BTU
Transportation	18.5	4.7	1.7	4.1	1.8	23.3	20.1	27.6	22.1
Industrial	19.0	5.0	3.0	4.4	1.8	24.3	22.0	29.3	22.8
Household/Commerical	13.5	3.1	2/	2.0	0.9	15.7	12.7	16.5	14.8
Electricity Generation	20.1	6.6	5.0	6.9	3.0	27.7	25.7	39.1	27.0
All sectors	71.1	5.1	2.5	4.7	2.0	91.0	80.5	112.5	86.7

1/ Energy Perspectives 2, U.S. Dept. of the Interior, June, 1976, p. 77.
2/ Growth will decrease at approximately one percent per year.

Source: U.S. International Trade Commission, based on data obtained from the U.S. Department of the Interior, the Federal Energy Administration, the OECD, and the Energy Policy Project of the Ford Foundation.

4.7 percent per year for the 1975-85 period. The electrical sector has the highest potential for increased energy consumption.

Energy demand in the U.S. transportation sector was 18.5 quadrillion BTU 1/ in 1975, accounting for 26 percent of total U.S. energy demand. The automobile is the largest consumer of energy in the sector and is also the principal possibility for energy conservation in the sector. In fact, the most important variable in future U.S. energy consumption in the transportation sector is the extent to which smaller, more fuel-efficient automobiles will replace the traditional large automobile. In the past, gasoline pricing and taxation policies have reinforced the apparent consumer preference for large, powerful automobiles; hopefully, mandatory conservation measures and pricing policies will decrease the demand for fuel-inefficient, wasteful automobiles. Fuel economy standards for new automobiles for 1980 and 1985 have been passed, with penalties for manufacturers and importers that do not comply. Unfortunately, fuel efficiency readings are based on EPA fuel-economy figures which are notorious for being well above actual highway mileage (due to dynamometer testing and other methods used by the EPA). Moreover, it still remains to be seen whether serious attention will be given to implementing the 1980 and 1985 fuel-efficiency requirements or whether there will be a resort to "escape clauses" in the legislation which enable the reduction of standards for various reasons. Other potential energy savings in the automotive portion of the transportation sector would be the abandonment of automatic transmissions and the mandatory use of radial tires; each of these measures would save 10 percent of total automotive fuel use. 2/ In addition, taxes could be placed on automobiles based on weight, horsepower, or vehicle fuel efficiency.

Further energy-saving policies in the transportation sector are increased efficiency of railroads and a greater commitment towards efficient mass-transit systems.

Energy demand in the industrial sector was 19.0 quadrillion BTU in 1975, accounting for 26.7 percent of total U.S. energy demand. 3/ Energy demand in the sector could be reduced to a 1.8 percent average annual growth rate for the 1975-85 period if proper conservation measures are taken. The Energy Policy Project of the Ford Foundation has estimated 4/ that approximately 22 percent of industrial energy

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1/ A BTU is the amount of heat necessary to raise the temperature of one pound of water 1 degree Farenheit under standardized pressure and temperature conditions.

2/ Middle- and Long-Term Energy Policies and Alternatives, p. 85.

3/ Energy Perspectives 2, U.S. Department of the Interior, June 1976, p. 77.

4/ A Time to Choose, Energy Policy Project of the Ford Foundation, Ballinger Publishing Co., Cambridge, Mass., 1974, p. 64.

use could be saved in 1985 (vis-a-vis the "historical growth" trend) if the following conservation measures were taken: more efficient processes in five major energy-intensive industries, onsite industrial cogeneration of steam and electricity, and "usage of heat recuperators and regenerators with direct use of fuels instead of electric resistive heat." 1/ Energy efficiencies for some of the principal U.S. industries are generally low in comparison with many other OECD countries, 2/ thus leaving ample room for the implementation of more energy-efficient measures. Although the United States adopted a mandatory reporting system for some large firms and voluntary targets for large energy-consuming industries, tax incentives for investment in energy-efficient equipment would be desirable, 3/ as would be further emphasis on industrial cogeneration of steam and electricity.

The household/commercial sector of the economy consumed 13.5 quadrillion BTU of energy in 1975, consisting of approximately 19.0 percent of U.S. energy consumption in that year. The principal usage of energy in the sector is in heating and cooling of homes and commercial establishments. 4/ Significant energy savings could be accomplished by the installation of better insulation and by increasing the efficiency of heating systems. A further important variable is the number and type of new housing units that are built, since heat (and cooling) losses from detached single family homes are significantly greater than losses from multifamily housing units. Another factor influencing energy demand in the sector is the extent to which there wil be increased usage and popularization of solar energy; however, solar energy is not likely to be a major factor in reduced energy demand during the 1977-85 period.

The electricity generation sector will most likely be the sector with the highest growth rates of energy demand during the 1975-80 and 1975-85 periods. This is due to the increasing demand for electricity and the resulting energy losses due to the conversion of energy into electricity. Total conversion losses are expected to increase since electric power will continue to increase its share of total energy consumption. 5/ The potential for efficiency increases in this sector is somewhat limited up to 1980 because of the nature of existing utility plants. However, by 1985, "a considerable improvement in efficiency may be achieved. Presumably, a greater emphasis will be placed on more efficient combined-cycle generating plants and supercritical (temperature) steam plants that have higher capital costs but are more efficient in the use of fuel." 6/

1/ Ibid., p. 64.
2/ Energy Conservation in the International Energy Agency, pp. 17, 18.
3/ Ibid., p. 35.
4/ A Time to Choose, pp. 432-440.
5/ "The Present and Future of Energy Resources," by Masao Sakisaka, in Energy, Inflation, and International Economic Relations, Atlantic Institute Studies--II, Praeger Publishers, New York, 1975, p. 31.
6/ U.S. Energy Outlook, National Petroleum Council, 1972, p. 50.

Canada.--The residential/commercial sector was Canada's largest energy user in 1972, with a consumption of 47.8 million metric tons of oil equivalent, or 30.8 percent of total Canadian primary energy consumption in that year. 1/ As in the United States, the sector with the greatest percentage increases in energy consumption to 1985 in Canada is the electricity-generation sector. Total energy demand in Canada, based on sector analysis, will grow at average annual rates of between 3.7-5.0 percent during the 1972-80 period. 2/

The OECD has estimated that by 1985, Canada could save 0.2 barrels of oil equivalent per day by establishing a 33 mile-per-imperial gallon fuel standard for automobiles, and a further 0.2 million barrels of oil equivalent per day by revising insulation standards, retrofitting old buildings, and by accelerating industrial conservation. 3/ Implementation of the above standards would result in a savings by 1985 of approximately 146 million barrels of oil equivalent per year.

Some energy conservation measures have already been adopted in the transportation sector, which accounted for 19.1 percent of total primary energy requirements in 1975. 4/ A progressive excise tax was recently imposed on automobiles weighing over 3,500 pounds, and a tax was placed on automotive air conditioners. 5/ It is hoped that fuel economy standards of 8.5 km/liter (24 mpg) will be reached by 1980 and 33 mpg (11.7km/l) will be reached by 1985. Further efficiencies could be obtained by improvement of vehicle load factors. 6/

The industrial sector consumed 26 percent of Canada's total primary energy requirements in 1974. Energy conservation measures already established are voluntary target and disclosure systems which include allowances for industries that make energy-efficient changes. 7/

In the residential/commercial sector, Canada could save substantial amounts of energy by 1985 by the implementation of measures designed to bring about better insulation, better heating control practice, and more energy-efficient household appliances. In fact, a new insulation code for buildings has been established, arrangements have been made for loans to consumers who want to implement energy savings in their homes, and there are now minimum efficiency standards on appliances and energy-efficiency labeling. 8/

1/ Energy Prospects to 1985, Volume II, OECD, Paris, 1974, pp. 17-19.
2/ U.S. International Trade Commission estimates, based on data in Energy Prospects to 1985.
3/ World Energy Outlook, p.20.
4/ Energy Conservation in the International Energy Agency, p. 15.
5/ World Energy Outlook, op. cit., p. 34.
6/ Energy Conservation in the International Energy Agency, p. 25.
7/ Ibid.
8/ Ibid.

France.--Data on France's total energy requirements appear in table E-3. The industrial sector was the largest energy-consuming sector in 1974, accounting for 27.8 percent of France's total energy requirements. The fastest-growing sector has been that of nonenergy uses, with annual average growth rates of 15.9 percent for the 1965-74 period and 18.5 percent for the 1965-73 period; growth in this sector will most likely diminish from the high levels of the past. Another sector in which growth could diminish is in the "road" section of the transportation sector, where energy savings could be realized through conservation measures.

Italy.--A sector breakdown of Italy's utilization of total energy requirements is shown in table E-4. The industrial sector (including nonenergy use) is Italy's largest energy-consuming sector, accounting for 34.4 percent of Italy's total primary energy in 1975. 1/

West Germany.--The industrial sector is West Germany's largest energy consumer by sector, accounting for 29.7 percent of total energy requirements in 1974 (table E-5). The fastest-growing sector has been that of nonenergy uses, with annual average growth rates of 10 percent or more during the 1965-74 periods.

United Kingdom.--Data on energy consumption by sector in the United Kingdom are shown in table E-6. The largest energy-consuming sector is the industrial sector, which accounted for approximately 25 percent of the United Kingdom's total energy requirements in 1974. The fastest-growing major sector has been that of "non-energy uses."

Japan.--Japan's national energy conservation program includes government and industry cooperation to set efficiency targets, loans for energy-efficient equipment for industry at below commercial rates, and tax incentives for smaller or lighter automobiles. Japan's Advisory Committee on Energy projects 2/ that energy demand in Japan can be limited to 760 million Kl (oil equivalent) by means of energy conservation. This translates into an annual average growth rate of 5.3 percent in energy demand for the 1973-85 period.

1/ Energy Conservation in the International Energy Agency, OECD, Paris, 1976, p. 17.

2/ "Energy in Japan," Quarterly Report No. 33, The Institute of Energy Economics, June, 1976, p. 18.

Table E-3 .--France: Sector analysis of utilization of total energy requirements, 1965-74

Sector	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Growth rate 1/ 1965-73	Growth rate 1/ 1965-74
	In millions of tons of oil equivalent										Percent	Percent
Total energy requirements	116.21	118.00	123.35	130.13	137.75	150.16	156.96	163.88	182.25	178.25	5.8	4.9
Electricity generation	20.59	21.11	20.87	21.11	20.07	22.76	25.18	24.93	27.66	27.29	3.8	3.2
Gas manufacture	0.26	0.31	0.35	0.34	0.28	0.38	0.39	0.46	0.37	0.34	4.5	3.0
Refineries	4.99	5.00	4.19	4.14	5.37	5.49	6.44	6.90	8.74	9.06	7.3	6.9
Other use by energy sector and losses	5.07	4.99	5.13	4.97	5.21	5.54	5.18	4.93	5.06	5.08	2/	0.1
Non-energy uses	3.55	3.98	5.15	5.62	6.79	8.27	9.06	10.04	13.48	12.88	18,5	15.9
Industry	37.76	38.32	39.96	42.76	46.06	49.83	46.69	46.27	48.94	49.56	3.3	3.1
Transportation	15.70	16.47	17.47	18.49	19.88	21.25	22.63	24.80	27.04	26.66	7.0	6.1
Road	11.34	12.44	13.64	14.92	16.02	17.47	19.08	20.99	23.07	23.12	9.3	8.2
Rail	2.82	2.37	2.02	1.69	1.70	1.44	1.20	1.28	1.32	1.33	2/	2/
Air	0.96	1.04	1.22	1.24	1.45	1.62	1.62	1.84	1.95	1.95	9.3	8.2
Navigation	0.58	0.61	0.60	0.64	0.71	0.72	0.72	0.70	0.71	0.26	2.6	2/
Other sectors	28.29	27.81	30.22	32.68	34.07	36.62	41.38	45.54	50.93	47.36	7.7	5.9

1/ USITC calculations.
2/ This sector experienced a decline in energy consumption.

Source: Energy Balances of OECD Countries, 1960/74, OECD, Paris 1976, pp. 241-250.

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Table E-4.--Italy: Sector analysis of utilization of total energy requirements, 1965-74

Sector	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Growth rate 1/ 1965-73	Growth rate 1/ 1965-74
	In millions of tons of oil equivalent										Percent	Percent
Total energy requirements	74.46	81.07	88.66	94.15	101.04	117.21	115.99	125.51	132.10	137.79	7.4	7.1
Electricity generation	12.39	13.42	15.50	16.15	16.41	18.18	17.89	18.61	19.83	19.69	6.0	5.3
Gas manufacture	0.29	0.17	0.19	0.16	0.16	0.16	0.15	0.14	0.12	0.07	2/	2/
Refineries	2.60	0.88	2.11	0.19	0.88	4.60	0.13	3.13	2.43	8.67	2/	14.3
Other use by energy sector and losses	2.21	2.33	2.42	2.52	2.78	3.57	3.31	4.08	3.94	4.41	7.5	8.0
Non-energy uses	4.74	9.46	7.56	7.64	8.92	9.56	11.82	10.43	11.46	10.58	11.7	9.3
Industry	26.25	28.83	29.53	33.35	35.83	38.85	37.01	40.15	43.15	43.66	6.4	5.8
Transportation	11.70	12.51	13.43	14.73	15.77	16.79	17.53	18.50	19.52	18.79	6.6	5.4
Road	9.34	10.08	11.03	12.15	13.16	14.18	14.65	15.66	16.66	16.18	7.5	6.3
Rail	0.87	0.81	0.71	0.60	0.62	0.66	0.72	0.65	0.63	0.55	2/	2/
Air	0.86	0.98	1.03	1.23	1.39	1.52	1.70	1.71	1.77	1.65	9.4	7.5
Navigation	0.64	0.64	0.66	0.75	0.60	0.43	0.46	0.47	0.46	0.40	2/	2/
Other sectors	14.26	15.22	17.91	19.40	22.04	25.49	28.15	30.48	31.65	31.93	10.5	9.4

1/ USITC calculations.

2/ This sector experienced a decline in energy consumption.

Source: Energy Balances of OECD Countries, 1960/74, OECD, Paris 1976, pp. 316-325.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table E-5.--West Germany: Sector analysis of utilization of total energy requirements, 1965-74

Sector	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Growth rate 1/	
											1965-73	1965-74
	In millions of tons of oil equivalent										Percent	Percent
Total energy requirements	184.64	186.83	186.71	201.81	222.33	236.19	238.54	250.09	266.73	259.50	4.7	3.9
Electricity generation	29.09	29.10	29.08	30.74	34.42	36.44	38.13	41.24	44.14	47.35	5.4	5.6
Gas manufacture	0.01	0.01	-	0.03	-	0.01	0.06	0.02	0.14	0.03	2/	2/
Refineries	6.01	6.70	7.83	9.57	10.61	11.90	11.59	10.77	10.07	9.13	6.7	4.8
Other use by energy sector and losses	11.18	9.22	8.09	8.37	8.65	8.43	8.60	8.09	7.96	8.46	3/	3/
Non-energy uses	8.52	10.21	9.99	11.93	14.35	14.60	14.97	16.98	20.14	20.10	10.6	10.0
Industry	56.60	55.77	56.02	60.17	64.16	67.69	66.32	68.68	75.52	77.05	3.7	3.5
Transportation	20.65	22.03	22.00	23.40	25.21	27.88	30.31	31.94	32.88	31.61	6.0	4.8
Road	15.48	17.11	17.63	19.18	20.96	22.97	25.34	26.42	27.21	26.18	7.3	6.0
Rail	3.67	3.24	2.52	2.18	2.03	2.05	1.82	2.20	2.09	1.96	3/	3/
Air	0.72	0.90	1.09	1.22	1.40	1.99	2.23	2.38	2.48	2.58	16.8	15.2
Navigation	0.78	0.78	0.77	0.81	0.82	0.88	0.92	0.95	1.10	0.90	4.4	1.6
Other sectors	49.02	50.34	51.11	55.07	62.61	67.13	66.57	70.41	74.29	65.77	5.3	3.3

1/ USITC calculations.
2/ Energy consumption is too small and too variable to have a meaningful growth rate.
3/ Energy consumption in this sector decreased.

Source: Energy Balances of OECD Countries, 1960/74, OECD, Paris 1976, pp. 256-265.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table E-6.--United Kingdom: Sector analysis of utilization of total energy requirements, 1965-74

Sector	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Growth rate 1/	
											1965-73	1965-74
	In millions of tons of oil equivalent										Percent	Percent
Total energy requirements	193.20	193.36	193.46	201.05	207.85	212.52	210.44	215.07	223.80	214.79	1.9	1.2
Electricity generation	38.19	39.36	39.49	41.50	42.77	45.72	45.13	46.54	48.27	46.15	3.0	2.4
Gas manufacture	5.48	5.28	4.87	4.08	3.35	1.81	0.96	0.66	0.54	0.28	2/	2/
Refineries	5.46	5.61	5.78	6.41	6.78	7.38	7.33	7.83	8.68	8.36	6.0	4.8
Other use by energy sector and losses	11.64	10.36	9.84	10.52	11.65	11.30	13.26	13.65	11.87	12.18	0.2	0.5
Non-energy uses	6.55	6.95	8.18	9.13	9.98	10.18	10.00	10.31	11.60	11.28	7.4	6.2
Industry	52.83	52.54	51.79	53.30	54.89	56.17	54.61	54.95	58.15	53.62	1.3	0.2
Transportation	22.60	23.00	23.78	24.76	25.57	26.81	27.87	28.95	30.84	29.73	4.0	3.1
Road	15.65	16.49	17.58	18.73	19.37	20.37	21.30	22.37	23.88	23.25	5.4	4.5
Rail	3.07	2.45	1.83	1.50	1.50	1.55	1.45	1.35	1.35	1.28	2/	2/
Air	2.58	2.79	3.13	3.41	3.54	3.68	4.03	4.29	4.57	4.01	7.4	5.0
Navigation	1.30	1.27	1.24	1.12	1.16	1.21	1.09	0.94	1.04	1.19	2/	2/
Other sectors	50.45	50.26	49.73	51.35	52.86	53.15	51.28	52.18	53.85	53.19	0.8	0.6

1/ USITC calculations.

2/ This sector experienced a decrease in energy consumption during the period.

Source: Energy Balances of OECD Countries, 1960/74, OECD, Paris 1976, pp. 436-445.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Energy/GNP (or GDP) Ratios

One indicator of energy consumption trends is energy consumed per dollar of GNP. The Bureau of Mines has calculated 1/ this ratio for the United States, using constant 1958 dollars as a measure of GNP. The ratio can be construed to be a measure of energy efficiency per GNP over time in the economy. The energy/GNP trend during the 1947-74 period is generally downward. Although the ratio increased somewhat in the late 1960's and early 1970's, it is believed that the longtime downward trend will continue. 2/ If so, the ratio could be projected and used as an estimator for future energy consumption.

A second possible estimator of energy consumption is the elasticity of energy consumption and real GNP. Figure E-1 shows the interdependence of energy consumption and GNP in the U.S. economy for the years 1948-74. Tables E-7 through E-18 show energy/GNP or energy/GDP ratios for selected countries and areas.

Energy Consumption

Data on energy consumption for each of the 16 countries and areas are covered in table E-19. Projections of energy consumption using historical data on per capita energy consumption applied to population projections appear in table E-20.

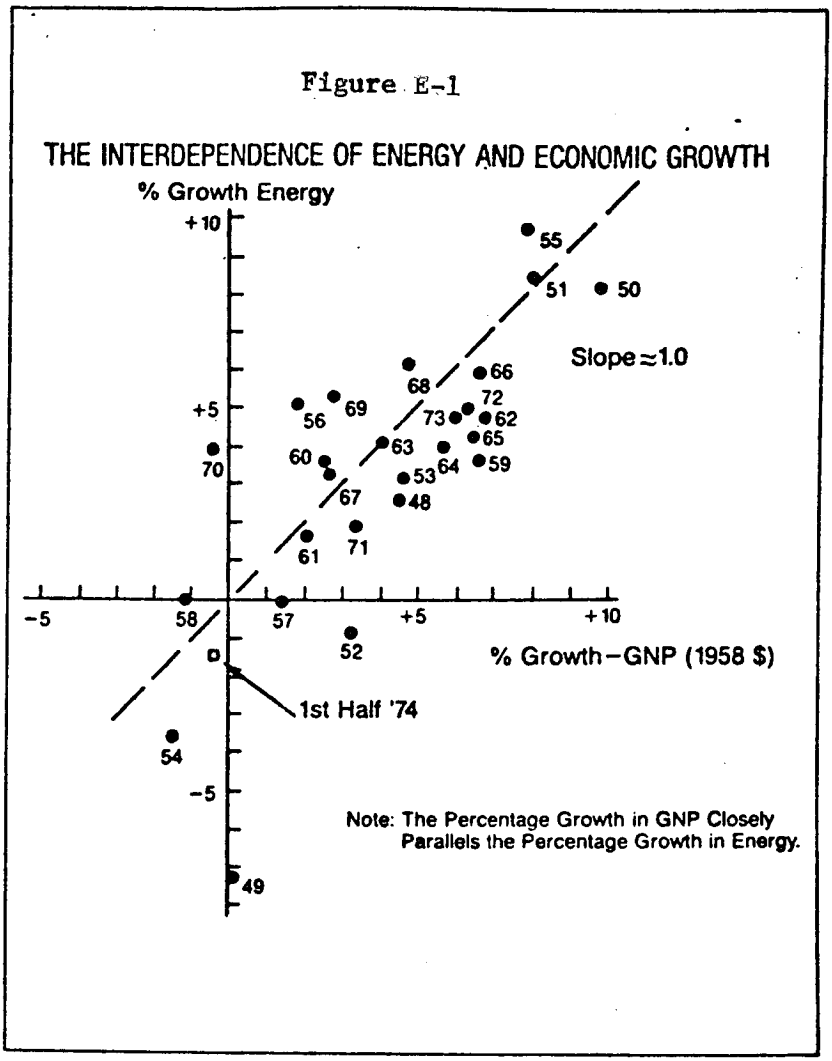
Total Demand Projections

Projections of primary energy consumption in 1980 and 1985 for each of the 16 countries and areas covered in this study are shown in table E-21. The projections were made from data gathered and evolved on GDP, population growth, and energy conservation in each area, as well as from projections obtained from government and private sources.

1/ United States Energy Through the Year 2000 (Revised), op. cit., p. 16.

2/ United States Energy Through the Year 2000 (Revised), op. cit., p. 20.

Figure E-1



Source: A Time To Choose, Energy Policy Project of the Ford Foundation, Ballinger Publishing Co., Cambridge, Mass., 1974, p. 368.

Table E-7.--United States: Energy/GNP ratios, 1965-75

Year	Gross energy inputs	Energy: percent change from previous year	Real GNP: percent change from previous year	Energy/GNP ratios (2) ÷ (3)
	Quadrillion BTU	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	53.3	-	-	-
1966	56.4	5.8	6.0	0.97
1967	58.3	3.4	2.7	1.26
1968	61.7	5.8	4.4	1.32
1969	65.0	5.3	2.6	2.04
1970	67.1	3.2	-0.3	-10.67
1971	68.7	2.4	3.0	0.80
1972	72.1	4.9	5.7	0.86
1973	74.7	3.6	5.3	0.68
1974	73.0	-2.3	-1.8	1.28
1975	71.1	-2.7	-1.9	1.42
Average		2.9	2.6	

Source: Energy Perspectives 2, U.S. Department of the Interior, June 1976, p. 207, and International Economic Report of the President, January 1977, Appendix B, Table 5, p. 141.

Table E-8.--Canada: Energy/GNP ratios, 1965-74

Year	Total energy requirements 1/	Total energy requirements: percent change from previous year	Real GNP: percent change from previous year 2/	Energy/GNP ratios (2) ÷ (3)
	Millions of tons of oil equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	118.4	-	-	-
1966	125.8	6.2	7.0	0.89
1967	130.9	4.1	3.3	1.24
1968	139.0	6.2	5.8	1.07
1969	145.4	4.6	5.4	0.85
1970	154.9	6.5	2.5	2.60
1971	162.1	4.6	6.5	0.71
1972	180.5	11.4	5.9	1.93
1973	194.0	7.5	7.1	1.06
1974	193.0	-0.5	3.3	-0.15
Average		5.6	5.2	

1/ From Energy Balances of OECD Countries 1960/74, Paris, OECD, 1976, p.22.

2/ Based on index numbers in International Economic Report of the President, January 1977, Appendix B, Table 5, p. 141.

Table E-9.--Other Western Hemisphere: Energy/GDP ratios, 1965-73

Year	Energy consumption 1/	Energy consumption: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Million metric tons of coal equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	181.18	-	-	-
1966	190.51	5.1	4.0	1.28
1967	205.14	7.7	5.1	1.51
1968	224.70	9.5	7.3	1.30
1969	238.44	6.1	6.8	0.90
1970	255.15	7.0	6.4	1.09
1971	271.57	6.4	6.0	1.07
1972	284.76	4.9	7.5	0.65
1973	301.67	5.9	7.0	0.85
Average		6.6	6.3	

1/ Statistical Yearbook 1974, United Nations, New York, 1975.
2/ U.N. Yearbook of National Accounts Statistics.

Table E-10.--France: Energy/GDP ratios, 1965-74

Year	Total energy requirements 1/	Total energy requirements: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Millions of tons of oil equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	116.2	-	-	-
1966	118.0	1.5	6.0	0.25
1967	123.4	4.6	5.0	0.92
1968	130.1	5.4	4.9	1.10
1969	137.8	5.9	7.6	0.78
1970	150.2	9.0	6.0	1.50
1971	157.0	4.5	5.8	0.78
1972	163.9	4.4	5.9	0.75
1973	182.3	11.2	6.0	1.87
1974	178.2	-2.2	2.7	-0.81
Average		4.9	5.6	

1/ From Energy Balances of OECD Countries 1960/74, Paris, OECD, 1976, p.22.

2/ Based on index numbers in International Economic Report of the President, January 1977, Appendix B, Table 5, p. 141.

Table E-11.--Italy: Energy/GDP ratios, 1965-74

Year	Total energy requirements 1/	Total energy requirements: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Millions of tons of oil equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	74.5	-	-	-
1966	81.1	8.9	5.8	1.53
1967	88.7	9.4	7.1	1.32
1968	94.2	6.2	6.3	0.98
1969	101.0	7.2	5.6	1.29
1970	117.2	16.0	5.1	3.14
1971	116.0	-0.9	1.5	-0.60
1972	125.5	8.2	3.2	2.56
1973	132.1	5.3	10.8	0.49
1974	137.8	4.3	-0.4	-10.75
Average		7.2	4.5	

1/ From Energy Balances of OECD Countries 1960/74, Paris, OECD, 1976, p.22.

2/ Based on index numbers in International Economic Report of the President, January 1977, Appendix B, Table 5, p. 141.

Table E-12.--West Germany: Energy/GDP ratios, 1965-74

Year	Total energy requirements 1/	Total energy requirements: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Millions of tons of oil equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	184.6	-	-	-
1966	186.8	1.2	2.9	0.41
1967	186.7	3/	-0.2	0.02
1968	201.8	8.1	7.3	1.11
1969	222.3	10.2	8.3	1.23
1970	236.2	6.3	5.8	1.09
1971	238.5	1.0	3.0	0.33
1972	250.1	4.9	3.3	1.48
1973	266.7	6.6	5.1	1.29
1974	259.5	-2.7	0.4	-6.75
Average		4.0	4.0	

1/ From Energy Balances of OECD Countries 1960/74, Paris, OECD, 1976, p.22.

2/ Based on index numbers in International Economic Report of the President, January 1977, Appendix B, Table 5, p. 141.

3/ -0.0005.

Table E-13.--United Kingdom: Energy/GDP ratios, 1965-74

Year	Total energy requirements 1/	Total energy requirements: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Millions of tons of oil equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	193.2	-	-	-
1966	193.4	0.1	2.0	0.05
1967	193.5	0.1	2.7	0.04
1968	201.1	3.9	3.5	1.11
1969	207.9	3.4	1.4	2.43
1970	212.5	2.2	2.3	0.96
1971	210.4	-1.0	2.5	-0.40
1972	215.1	2.2	2.6	0.85
1973	223.8	4.0	5.9	0.68
1974	214.8	-4.0	0.3	-1.33
Average		1.2	2.6	

1/ From Energy Balances of OECD Countries 1960/74, Paris, OECD, 1976, p.22.

2/ Based on index numbers in International Economic Report of the President, January 1977, Appendix B, Table 5, p. 141.

Table E-14.--U.S.S.R.: Energy/GDP ratios, 1965-73

Year	Energy consumption 1/	Energy consumption: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Million metric tons of coal equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	829.40	-	-	-
1966	883.93	6.6	7.2	0.92
1967	931.97	5.4	9.5	0.57
1968	965.21	3.6	7.4	0.49
1969	1,010.60	4.7	5.7	0.82
1970	1,054.69	4.4	8.7	0.51
1971	1,111.79	5.4	6.0	0.90
1972	1,179.56	6.1	3.8	1.61
1973	1,230.44	4.3	8.2	0.52
Average		5.1	7.1	

1/ Statistical Yearbooks of the United Nations.
2/ U.N. Yearbook of National Accounts Statistics.

Table E-15.--Middle East: Energy/GDP ratios, 1965-73

Year	Energy consumption 1/	Energy consumption: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Million metric tons of coal equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	45.11	-	-	-
1966	47.00	4.2	8.7	0.48
1967	50.00	6.4	5.3	1.21
1968	59.00	18.0	10.1	1.78
1969	70.00	18.6	6.9	2.70
1970	84.00	20.0	7.5	2.67
1971	90.00	7.1	10.0	0.71
1972	98.00	8.9	10.0	0.89
1973	110.00	12.2	9.1	1.34
Average		11.9	8.4	

1/ Statistical Yearbook 1974, United Nations, New York, 1975.
2/ U.N. Yearbook of National Accounts Statistics.

Table E-16.--India: Energy/GDP ratios, 1965-73

Year	Energy consumption 1/	Energy consumption: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Million metric tons of coal equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	83.55	-	-	-
1966	87.27	4.4	1.3	3.38
1967	90.04	3.2	10.0	0.32
1968	94.49	4.9	3.4	1.44
1969	101.25	7.2	5.5	1.31
1970	96.80	-4.4	4.2	-1.05
1971	101.50	4.9	2.0	2.45
1972	104.82	3.2	-1.0	-3.20
1973	107.93	3.0	3.0	1.00
Average		3.3	3.6	

1/ Statistical Yearbooks of the United Nations.
2/ U.N. Yearbook of National Accounts Statistics.

Table E-17.--Japan: Energy/GNP ratios, 1965-74

Year	Total energy requirements 1/	Total energy requirements: percent change from previous year	Real GNP: percent change from previous year 2/	Energy/GNP ratios (2) ÷ (3)
	Million tons of oil equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	151.4	-	-	-
1966	169.5	12.0	9.8	1.22
1967	194.6	14.8	13.0	1.14
1968	216.8	11.4	13.4	0.85
1969	249.7	15.2	10.8	1.41
1970	284.0	13.7	10.9	1.26
1971	290.6	2.3	7.4	0.31
1972	311.8	7.3	9.0	0.81
1973	336.4	7.9	9.9	0.80
1974	334.4	-0.6	-1.1	0.55
Average		9.3	9.2	

1/ From Energy Balances of OECD Countries 1960/74, Paris, OECD, 1976, p.22.

2/ Based on index numbers in International Economic Report of the President, January 1977, Appendix B, Table 5, p. 141.

Table E-18.--Africa: Energy/GDP ratios, 1965-73

Year	Energy consumption 1/	Energy consumption: percent change from previous year	Real GDP: percent change from previous year 2/	Energy/GDP ratios (2) ÷ (3)
	Million metric tons of coal equivalent	Percent	Percent	
	(1)	(2)	(3)	(4)
1965	88.48	-	-	-
1966	92.00	4.0	3.9	1.03
1967	93.00	1.1	3.8	0.29
1968	98.00	5.4	7.3	0.74
1969	102.00	4.1	5.7	0.72
1970	109.00	6.9	7.5	0.92
1971	121.00	11.0	5.0	2.20
1972	125.00	3.3	4.8	0.69
1973	132.00	5.6	4.5	1.24
Average		5.2	5.3	

1/ Statistical Yearbook 1974, United Nations, New York, 1975.
2/ U.N. Yearbook of National Accounts Statistics.

Table E-19.--Energy consumption, by selected countries and areas, 1965-73

Year	United States	Canada	Other Western Hemisphere	France	Italy	West Germany	United Kingdom	Other Western Europe	U.S.S.R.	Eastern Europe	China	Asian Middle East	India	Japan	Other Asia	Africa
	Millions of tons of oil equiv. 1/	Millions of tons of oil equiv. 1/	Million metric tons of coal equiv. 2/	Millions of tons of oil equiv. 1/	Millions of tons of oil equiv. 1/	Millions of tons of oil equiv. 1/	Millions of tons of oil equiv. 1/	Million metric tons of coal equiv. 2/	Million metric tons of coal equiv. 2/	Million metric tons of coal equiv. 2/	Million metric tons of coal equiv. 2/	Million metric tons of coal equiv. 2/	Million metric tons of coal equiv. 2/	Millions of tons of oil equiv. 1/	Million metric tons of coal equiv. 2/	Million metric tons of coal equiv. 2/
1965	1,225.5	118.4	181.18	116.2	74.5	184.6	193.2	255.14	829.40	394.58	337.12	45.11	83.55	151.4	65.48	88.48
1966	1,298.9	125.8	190.51	118.0	81.1	186.8	193.4	272.52	883.93	402.56	370.65	47.00	87.27	169.5	72.99	92.00
1967	1,336.6	130.9	205.14	123.4	88.7	186.7	193.5	279.71	931.97	407.45	268.95	50.00	90.04	194.6	78.03	93.00
1968	1,412.8	139.0	224.70	130.1	94.2	201.8	201.1	308.08	965.21	428.76	333.67	59.00	94.49	216.8	75.73	98.00
1969	1,502.6	145.4	238.44	137.8	101.0	222.3	207.9	332.23	1,010.60	456.55	372.74	70.00	101.25	249.7	83.49	102.00
1970	1,570.3	154.9	255.15	150.2	117.2	236.2	212.5	366.34	1,054.69	489.64	391.20	84.00	96.80	284.0	104.44	109.00
1971	1,613.6	162.1	271.57	157.0	116.0	238.5	210.4	377.87	1,111.79	512.00	429.12	90.00	101.50	290.6	110.84	121.00
1972	1,691.1	180.5	284.76	163.9	125.5	250.1	215.1	400.82	1,179.56	521.75	444.99	98.00	104.82	311.8	115.49	125.00
1973	1,756.4	194.0	301.67	182.3	132.1	266.7	223.8	425.27	1,230.44	536.44	474.40	110.00	107.93	336.4	120.19	132.00
1974	1,713.7	193.0	-	178.2	137.8	259.5	214.8	-	-	-	-	120.00	-	334.4	-	-
Growth rates (average annual rate, in percent:																
1965-73	4.6	6.4	6.6	5.8	7.4	4.7	1.8	6.6	5.1	3.9	4.4	11.8	3.3	10.5	7.9	5.1
1965-74	3.8	5.6	-	4.9	7.1	3.9	1.2	-	-	-	-	-	-	9.2	-	-

1/ From Energy Balances of OECD Countries, 1960/1974, OECD, Paris, 1976, p. 22.
2/ From Statistical Yearbook, 1974, United Nations, New York, 1975.

Source: OECD and the United Nations.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table E-20.--Energy consumption data and projections, by selected countries and areas

Country or area	Energy consumption per capita, average annual growth, 1965-73	Energy consumption per capita, 1975	Energy consumption per capita, projected to 1980 and 1985	Population projections	Energy consumption projections	Energy consumption, 1975	Annual average percent change in energy consumption over 1975
	Percent	Barrels of oil equivalent	Barrels of oil equivalent	Million persons	Million barrels of oil equivalent	Million barrels of oil equivalent	
United States	3.3	57.4				12,260	
1980			67.5	224.88	15,179		4.4
1985			79.4	236.00	18,738		4.3
Canada	5.1	67.3				1,536	
1980			86.3	24.60	2,123		6.7
1985			110.7	26.50	2,934		6.7
Other Western Hemisphere	3.6	7.0				2,247	
1980			8.4	367.71	3,089		6.6
1985			10.0	422.30	4,223		6.5
France	5.0	23.5				1,240	
1980			30.0	55.12	1,654		5.9
1985			38.3	57.38	2,198		5.9
Italy	5.6	18.2				1,014	
1980			23.9	57.54	1,375		6.3
1985			31.4	59.51	1,869		6.3
West Germany	4.0	28.7				1,776	
1980			34.9	64.27	2,243		4.8
1985			42.5	65.73	2,794		4.6
United Kingdom	1.5	26.8				1,499	
1980			28.9	57.61	1,665		2.1
1985			31.1	58.77	1,828		2.0
Other Western Europe	5.9	27.2				3,178	
1980			36.2	120.88	4,375		6.6
1985			48.3	124.79	6,022		6.6
U.S.S.R.	4.0	29.6				7,537	
1980			36.0	267.57	9,633		5.0
1985			43.8	281.16	12,315		5.0
China	2.6	3.4				2,846	
1980			3.9	912.79	3,561		4.6
1985			4.4	992.95	4,336		4.4
Eastern Europe	3.2	22.6				2,934	
1980			26.5	134.33	3,553		3.9
1985			31.0	138.79	4,301		3.9
Middle East	8.7	6.4				763	
1980			9.7	137.43	1,333		11.8
1985			14.7	158.25	2,326		11.8
India	1.0	1.0				1/ 599	
1980			1.1	667.94	736		4.2
1985			1.1	744.83	819		3.2
Japan	9.3	22.5				2,501	
1980			35.1	116.74	4,098		10.4
1985			54.7	122.65	6,709		10.4
Other Asia	5.2	1.7				1/ 935	
1980			2.2	637.83	1,403		8.5
1985			2.8	723.76	2,027		8.0
Africa	2.4	2.2				885	
1980			2.5	456.55	1,141		5.2
1985			2.8	518.56	1,452		5.1

1/ Estimated.

Source: U.S. International Trade Commission.

Table E-21.--Projected primary energy consumption, 1980 and 1985, by selected countries and areas

	United States	Canada	Other Western Hemisphere	France	Italy	West Germany	United Kingdom	Other Western Europe	U.S.S.R.	Eastern Europe	China	Middle East	India	Japan	Other Asia	Africa
Energy consumption in million barrels of crude oil:													1974 data		1974 data	
1975:	12,260	1,536	2,247	1,240	1,014	1,776	1,499	3,178	7,537	2,934	2,846	763	(582)	2,501	(905)	885
1980:																
High	17,195	2,154	3,286	1,667	1,483	2,332	1,671	4,375	9,758	3,553	3,632	1,469	736	4,349	1,436	1,184
Low	13,404	1,842	2,760	1,473	1,282	2,089	1,560	4,156	8,826	3,375	3,530	1,050	687	3,300	1,397	1,066
Probable	14,042	1,971	3,079	1,540	1,320	2,122	1,639	4,156	9,665	3,535	3,564	1,315	703	3,300	1,420	1,135
1985:																
High	21,749	3,022	4,762	2,242	2,109	2,948	1,845	6,022	12,632	4,301	4,548	2,731	887	6,974	2,089	1,585
Low	14,654	2,188	3,326	1,699	1,545	2,410	1,623	5,420	10,031	3,871	4,336	1,341	780	4,113	1,964	1,248
Probable	15,694	2,476	4,139	1,888	1,697	2,506	1,792	5,420	12,277	4,260	4,420	2,226	859	4,192	2,068	1,442

Source: United States International Trade Commission.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

APPENDIX F
OTHER ENERGY SOURCES

Coal

Coal is the most abundant fossil fuel. Together with lignite it consitutes solid fuel. Tables F-1 and F-2 cover respectively recoverable coal reserves and coal production.

Recoverable coal reserves are principally held by the United States, Western Europe (West Germany and the United Kingdom) and the Communist Bloc. In 1974 these holdings combined accounted for almost 90 percent of the total recoverable coal reserves. Communist Bloc recoverable reserves were about 1.4 times as large as those of the United States.

Coal production in 1974 was also concentrated in these same locations. Together the United States, Western Europe and the Communist Bloc produced almost 90 percent of the world's production. However, the Communist Bloc produced over 3.3 times the quantity produced in the United States. The Communist Bloc is exploiting its coal reserves more vigorously than the United States.

One drawback to increased coal consumption is its lack of end-use application versatility. High transportation costs dictate that its most economical use is at or near its mining site. Further, coal is most cost efficient in relatively large consuming plants such as those associated with electric utilities and metal smelters. Environmental concerns including those over strip mining also affect its use. The combustion of coal emits more pollutants than the combustion of the other fossil fuels. Sulfur dioxide and particulates emissions are especially heavy. Stack gas scrubbers and precipitators can be used to reduce emissions, but add to the cost of using coal, and the technology is far from completely developed, so companies want to hold off immediate investment.

However, in spite of the drawbacks of coal, it will continue to be an important energy source. With most nations desirous of reducing petroleum import levels, those with coal reserves will increasingly exploit them as one means of doing so. In addition, any decrease in expected nuclear capacity for electricity generation, which would ordinarily be made up by expansion of petroleum based electricity generating capacity, will at least be in part substituted for by coal based capacity.

In spite of all of this, in certain areas and countries of the world, such as the People's Republic of China, the U.S.S.R. and the Communist Eastern European countries, coal will provide a significantly lower future share of primary energy consumption. Increasing industrialization will require other fuels for certain applications.

Because of the difficulties associated with the use of coal considerable research and development has been and will continue to be expended

Table F-1.--Coal: Recoverable reserves, 1/ 1974

Area	Quantity		Percent of	
	Billion short tons	Billion barrels of oil equivalent	World total	Free World total
United States--	218	903	32.6	60.3
Other Western Hemisphere---	9	37	1.3	2.5
Western Europe-	72	298	10.8	19.9
Africa---------	17	70	2.5	4.7
Middle East----	nil	nil	nil	nil
Asia-Pacific---	46	190	6.9	12.6
Communist Bloc-	307	1,271	45.9	-
Total--------	669	2,769	100.0	100.0

1/ Known to be recoverable with current technology under present economic conditions.

Source: U.S. Department of the Interior, Energy Perspectives 2, June 1976, p. 37.

Table F-2.--Anthracite, bituminous coal, and lignite: Production, 1950, 1960, 1970 to 1974

(million short tons)

Area	1950	1960	1970	1971	1972	1973	1974
United States	560	434	613	561	602	599	608
Other Western Hemisphere	26	21	28	30	33	35	38
Western Europe	592	618	500	496	458	466	438
Africa	33	48	66	70	70	75	78
Middle East	6	11	10	10	11	12	13
Asia-Pacific	117	189	240	226	234	233	247
Communist Bloc	664	1,578	1,861	1,991	1,930	1,984	2,029
Total	1,998	2,899	3,317	3,385	3,339	3,404	3,450

Source: U.S. Department of the Interior, Energy Perspectives 2, June 1976, p.37.

to obtain economically viable processes to produce synthetic crude petroleum (syncrude) and synthetic natural gas (SNG) from coal. A drawback is that in the conversion of one type of energy to another type there is almost always a loss of Btu's. In essence it takes energy to convert energy forms and at a time of energy scarcity this is wasting energy. The synthetic fuels are discussed on page 23 of this appendix.

Natural Gas

Aside from crude petroleum and coal, natural gas is the other major fossil fuel that is widely used. Natural gas is easily transported by pipeline and its combustion is the least environmentally damaging of all of the fossil fuels.

In terms of reserves the Communist Bloc, the Middle East and North America contained over three-quarters of the world's total in 1975 (see tables F-3 and F-4). Africa, Western Europe, Asia-Pacific and Latin America accounted for the balance. By individual country, the U.S.S.R., Iran, and the United States held just over 60 percent of the reserves in 1975 (see tables F-4 and F-5). Ten countries--the three above, plus Algeria, the Netherlands, Saudi Arabia, Canada, Nigeria, Qatar and Venezuela--held just under 81 percent of the total.

Gross production 1/ in 1975 centered in North America, the Communist Bloc and Western Europe which together accounted for 80 percent of the world's total (see tables F-6 and F-7). A significant observation is that the Middle East, with the world's second largest reserves, was but the world's fourth largest producer. Additionally, Western Europe, ranked but fifth in reserves, was the world's third leading producing area and North America with but 13 percent of the world's reserves, produced almost 44 percent of the world's production. A comparison of tables would indicate that those areas overproducing were Western Europe, North America, and Latin America, while those underproducing were the Communist Bloc, the Middle East, Africa and Asia-Pacific. The significance is that all other things being equal, more rapid production means more rapid depletion of reserves.

Perhaps of even more significance to a world deeply dependent on energy is that only about 30 percent of the gross production in the Middle East is marketed. Most of the production is flared (burned-off at the production site). This means that natural gas is being produced but not being commercially used. Flared natural gas is relatively more available for commercial usage than reserves not yet developed. Table F-8 indicates that only in North America, the Communist Bloc and Western Europe does almost all of the gross production get to market.

1/ Gross production is comprised of marketed production, vented gas, flared gas, reinjected gas and gas used to drive turbines.

Table F-3.--Natural gas: Reserves, leading areas, 1975

Rank	Area	Reserves (trillion cubic feet)	Percent of:	
			World total	Free world
1---	Communist Bloc	750	34.6	-
2---	Middle East	619	28.5	43.6
3---	North America	285	13.1	20.1
4---	Africa	206	9.5	14.5
5---	Western Europe	140	6.5	9.9
6---	Asia-Pacific	90	4.2	6.3
7---	Latin America	80	3.6	5.6
	Total	2,170	100.0	100.0

Source: World Oil.

Table F-4.--Natural gas: Reserves 1/ on Dec. 31 of 1970-75
(billion cubic feet)

Country	1970	1971	1972	1973	1974	1975
North America, total:	344,122	334,268	319,021	302,407	293,841	285,175
Canada	53.376	55,462	52,936	52,457	56,708	56,075
United States	290,746	278,806	266,085	249,950	237,133	228,200
Latin America, total:	67,450	72,372	82,096	75,388	77,649	80,342
Argentina	6,357	7,275	7,275	6,036	7,095	7,100
Mexico	11,396	10,969	10,752	10,812	11,185	11,924
Venezuela	31,659	31,625	41,134	40,105	40,000	42,000
Other	18,038	22,503	22,935	18,435	19,369	19,318
Europe, total:	104,585	161,100	166,033	138,120	141,035	139,981
W. Germany	12,670	13,700	12,400	11,500	11,124	10,806
Netherlands	87,210	88,210	78,000	65,933	68,387	65,269
Norway	2,000	14,000	15,500	18,000	19,400	20,106
United Kingdom	33,000	39,750	46,000	28,000	26,911	28,785
Other	5,705	5,440	14,133	14,687	15,213	15,015
Middle East, total:	261,363	285,953	445,416	581,781	575,702	618,632
Abu Dhabi	8,600	9,750	58,000	19,569	31,018	31,018
Iran	110,000	130,000	240,000	376,164	374,400	374,794
Iraq	18,000	20,000	21,000	22,000	27,467	27,160
Kuwait	40,000	39,500	39,798	39,275	38,139	37,778
Neutral Zone	5,740	6,870	17,500	52,000	19,838	19,749
Qatar	7,300	8,100	8,100	7,954	7,808	47,808
Saudi Arabia	68,635	67,731	52,638	56,126	59,861	63,500
Other	3,088	4,002	8,380	8,693	17,171	16,825
Africa, total:	179,315	197,607	226,772	189,665	190,823	206,261
Algeria	145,000	156,000	140,000	100,000	100,200	115,500
Libya	26,000	27,100	28,050	28,750	28,255	28,454
Nigeria	5,400	10,000	41,000	48,380	50,244	50,225
Other	2,915	4,507	19,722	12,535	12,124	12,082
Asia-Pacific, total:	46,691	50,560	85,764	86,695	81,216	89,783
Australia	13,838	13,945	29,066	28,937	26,372	30,200
Indonesia	5,000	5,200	5,500	10,000	15,000	18,000
Malaysia	4,800	6,500	10,000	11,400	11,000	12,000
Pakistan	21,000	21,200	16,281	15,680	11,060	11,054
Other	2,053	3,715	24,917	20,678	17,784	18,529
Communist, total:	431,571	637,738	726,271	687,982	737,680	750,000
People's Republic of China	2/	2/	4,500	16,500	17,000	19,405
U.S.S.R.	423,000	636,000	658,000	649,800	699,800	710,000
Other	8,571	17,380 3/	63,771	21,682	20,880	20,595
Total	1,471,097	1,755,240	2,051,373	2,062,038	2,097,946	2,170,174

1/ There is no international standard defining categories of natural gas reserves.
2/ Data from certain eastern European countries were withheld.
3/ Data from People's Republic of China were not available.

Source: World Oil.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table F-5.--Natural gas: Reserves, leading nations, 1975

Rank	Country	Reserves (trillion cubic feet)	Percent of World total
1---	U.S.S.R.	710	32.7
2---	Iran	375	17.3
3---	U.S.	228	10.5
4---	Algeria	116	5.4
5---	Netherlands	65	3.0
6---	Saudi Arabia	64	3.0
7---	Canada	57	2.6
8---	Nigeria	50	2.3
9---	Qatar	48	2.2
10---	Venezuela	42	1.9
	Total	1,755	80.9

Source: World Oil.

Table F-6.--Natural Gas: Production, gross and marketed, leading areas, 1975

Rank	Area	Production (billion cubic feet) Gross	Marketed	Marketed production as a percent of gross prodduction	Gross production as percent of World Total	Free World
1--	North America	24,593	23,185	94.3	43.6	58.3
2--	Communist Bloc	14,242	13,276	93.2	25.3	-
3--	Western Europe	6,207	5,967	96.1	11.0	14.8
4--	Middle East	4,702	1,436	30.5	8.4	11.2
5--	Latin America	3,238	1,735	53.6	5.8	7.7
6--	Africa	2,086	670	32.1	3.7	5.0
7--	Asia-Pacific	1,255	938	74.7	2.2	3.0
	Total	56,232	47,207	83.8	100.0	100.0

Source: Compiled from official statistics of the U.S. Bureau of Mines

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Table F-7.--Natural gas: Production
(Billion cubic feet)

Country	1971		1972		1973		1974		1975 P	
	Gross 1/	Marketed 2/	Gross 1/	Marketed 2/	Gross 1/	Marketed 2/	Gross 1/	Marketed 2/	Gross 1/	Marketed 2/
North America, total:	26,914	24,992	27,332	25,446	27,634	25,767	26,337	24,638	24,593	23,185
Canada	2,826	2,499	3,316	2,914	3,567	3,119	3,487	3,037	3,489	3,076
United States	24,088	22,493	24,016	22,532	24,067	22,648	22,850	21,601	21,104	20,109
Latin America, total:	3,204	1,297	3,198	1,389	3,380	1,551	3,362	1,597	3,238	1,735
Argentina	287	228	278	218	315	238	333	256	383	272
Mexico	643	479	660	496	677	542	745	561	786	584
Venezuela	1,680	368	1,625	388	1,746	460	1,640	476	1,342	450
Other	594	222	635	287	642	311	644	304	727	429
Europe, total:	3,692	3,540	4,627	4,457	5,256	5,101	5,955	5,786	6,207	5,967
W. Germany	563	555	646	637	706	706	735	713	645	639
Netherlands	1,547	1,536	2,063	2,052	2,501	2,495	2,957	2,957	3,208	3,208
Norway	3	-	18	-	17	-	20	-	107	-
United Kingdom	657	657	939	939	1,018	1,018	1,230	1,230	1,208	1,208
Other	922	792	961	829	1,014	882	1,013	886	1,039	912
Middle East, total:	3,824	699	4,264	912	5,011	1,286	5,130	1,463	4,702	1,436
Abu Dhabi	366	40	412	45	520	55	570	65	432	38
Iran	1,305	299	1,470	448	1,699	702	1,767	787	1,603	771
Iraq	220	31	185	33	250	43	230	46	369	58
Kuwait (includes one half neutral zone)	644	157	648	182	581	186	467	187	382	184
Qatar	644	157	648	182	581	186	467	187	382	184
Saudi Arabia (includes one-half neutral zone	159	35	180	39	246	56	225	60	192	78
Other	938	96	1,127	99	1,440	160	1,570	219	1,335	200
	938	96	1,127	99	1,440	160	1,570	219	1,335	200
	192	41	242	66	275	84	301	99	389	107
Africa, total:	1,346	142	1,525	414	1,762	577	1,917	599	2,086	670
Algeria	260	105	350	120	360	168	335	211	740	210
Libya	557	25	496	275	563	385	425	345	489	383
Nigeria	458	4	605	10	736	11	1,018	14	659	16
Other	71	8	74	9	103	13	139	29	198	61
Asia-Pacific, total:	688	476	810	487	932	655	1,010	703	1,255	938
Australia	79	79	113	113	145	145	165	165	177	177
Indonesia	121	44	146	44	186	28	200	40	222	82
Malaysia	25	2	35	3	35	3	31	3	38	3
Paskistan	108	108	119	119	132	132	175	175	164	164
Other	355	243	397	208	434	347	439	320	554	512
Communist, total:	10,222	9,662	10,964	10,358	11,987	11,279	13,281	12,458	14,242	13,276
People's Republic of China	650	550	880	750	1,100	950	1,400	1,200	1,600	1,400
U.S.S.R.	650	550	880	750	1,100	950	1,400	1,200	1,600	1,400
Other	7,900	7,500	8,200	7,818	8,800	8,346	9,700	9,201	10,760	10,206
Grand total	1,672	1,612	1,885	1,790	2,087	1,983	2,181	2,057	1,882	1,670
	49,890	40,811	52,721	43,463	55,962	46,216	56,992	47,244	56,323	47,207

1/ Includes marketed production, plus gas vented to the atmosphere, flared, reinjected for repressuring and used to drive turbines (without being burned).

2/ Includes all gas used as fuel or feedstock, including gas used in oil and/or gas field operations as a fuel by producers.
P=Preliminary

Source: Compiled from official statistics of the U.S. Bureau of Mines.

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The United States, by itself, accounted for almost 43 percent of the world's marketed production in 1975 (table F-8). The closest country was the U.S.S.R. with almost 22 percent of the total. The concentration of marketed production in these two countries is illustrated by the fact that combined they accounted for almost 65 percent of the world's total marketed production, while the next 8 producers combined accounted for but about 24 percent.

The average of marketed production as a percent of gross production for the top ten producing nations in 1974 was almost 89 percent. Significantly below this were the world's fifth, sixth and seventh largest gross natural gas producers. Together, Iran, Venezuela and Saudi Arabia marketed just about 33 percent of their combined gross production. Saudi Arabia had the lowest percent at 15, while Iran had the highest at 48 percent.

Historically the United States has been the world's natural gas consumption center. It had the reserves, and demand was stimulated by low prices. In the future, Western Europe and the U.S.S.R. in particular are forecast to increase their demands for natural gas with the result that the United States will account for a smaller part of the world's total consumption of this fossil fuel. Japan is also expected to increase its natural gas consumption and together with the United States and Western Europe form the principal future Free World demand centers.

Since demand has and is forecast to consistently outstrip production in the latter three areas, imports are forecast to become increasingly more important. While the bulk of the world's imports will be supplied by pipeline wherever possible, international trade in liquified natural gas (LNG) is expected to increase. Potentially large LNG movements are expected to be those from the Middle East to the U.S. east and west coasts, from Africa to the U.S. east coast, from Alaska, Brunei and Australia to the U.S. west coast, and from Alaska, Brunei, the Middle East, Indonesia and Australia to Japan. LNG import plans have also been made by France, Italy, Spain and the United Kingdom. 1/

At present the following movements of LNG are taking place: 2/

(1) Alaska and Borneo to Japan;
(2) Algeria to the United States;
(3) Libya and Algeria to France, the United Kingdom, Italy, and Spain.

About 30 LNG carriers are in service and another 40 are under construction or on order. LNG carriers and plants require huge investments. For example, a system (consisting of a liquefaction plant, carrier and receiving terminal) capable of moving around 6 billion cubic meters of natural gas per year would cost well over $1 billion. 3/

1/ Petroleum Economist, July 1976, p. 249.
2/ Hydrocarbon Processing, July 1977, p. 17.
3/ Ibid.

Table F-8.--Natural gas: Gross and marketed production, leading nations, 1975

Rank by Gross Production	Country	Gross production (billion cubic feet)	Percent of world total	Marketed production (billion cubic feet)	Percent of world total	Marketed production as percent of gross production
1-----	United States	21,104	37.5	20,109	42.6	95.3
2-----	U.S.S.R	10,760	19.1	10,206	21.6	94.9
3-----	Canada	3,489	6.2	3,076	6.5	88.2
4-----	Netherlands	3,208	5.7	3,208	6.8	100.0
5-----	Iran	1,603	2.9	771	1.6	48.1
6-----	Peo. Rep. of China	1,600	2.8	1,400	3.0	87.5
7-----	Venezuela	1,342	2.4	450	1.0	33.5
8-----	Saudi Arabia	1,335	2.4	200	0.4	15.0
9-----	United Kingdom	1,208	2.1	1,208	2.6	100.0
10-----	Romania	1,166	2.1	954	2.0	81.8
	Total	46,815	83.2	41,682	88.1	88.8

Source: Compiled from official statistics of the U.S. Bureau of Mines.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

According to the U.S. Bureau of Mines the Netherlands, Canada, Iran and the U.S.S.R. accounted for 84 percent of the total international natural gas trade in 1973. About 10 percent of the international trade was in the form of LNG. 1/ However, based on reserves the nations of OPEC (including Iran) loom as the major sources of any expanded international natural gas trade. The possibility is real of these countries exerting the same type of future control over the price of these natural gas movements as they currently do over international crude petroleum movements.

Nuclear

Nuclear energy usage is fairly widespread at present. Its sole commerical application is in the generation of electricity. It has been stated that over 30 countries already have, or have begun work on, nuclear power reactors. 2/ Many other nations have, or are close to having, some type of nuclear capability.

From 1974 to 1975 the share of world primary energy consumption supplied from nuclear sources increased from 1 percent to 1.3 percent. This increase means that nuclear energy consumption increased about one-third from 1974 to 1975.

Table F-9 gives the leading nuclear energy nations of the world. It can be seen that in 1975 five nations accounted for over three-fourths of the consumption of nuclear generated primary energy. The United States accounted for almost half by itself. The dominance of the United States is evident from the fact that the second ranking country, the United Kingdom, accounted for less than 10 percent of the world total.

Nuclear energy was once looked upon to be the great energy hope in light of dwindling fossil fuel supplies, but of late it has become increasingly controversial. Fear of nuclear energy plant explosions and possible nuclear holocosts, caused by core upset as a result of a seismic disturbance has resulted in nuclear plant siting problems. Fear of terrorists stealing or somehow obtaining nuclear material, constructing a bomb, and extorting money or carrying out terrorist acts has resulted in many speaking out against nuclear energy plant proliferation. Still others fear that nuclear energy plants will enable some nations to gain a nuclear weapons capability which would otherwise be unobtainable. It has been estimated, for example, that by 2000 the plutonium equivalent of 1 million atomic bombs will be produced as by-product from nuclear power. 3/

In The National Energy Plan, 4/ President Carter indicated a policy "- - to defer any U.S. commitment to advanced nuclear technologies that are based on the use of plutonium, while the United States seeks a better approach to the next generation of nuclear power than is provided by plutonium recycle and the plutonium breeder."

1/ Bureau of Mines, "Natural Gas," Preprinted from Mineral Facts and Problems, 1975, p. 1.

2/ Committee for Economic Development, Research and Policy Committee, Nuclear Energy and National Security, September 1976, p. 7.

3/ Nuclear Energy and National Security, op. cit., p. 8.

4/ Executive Office of the President, Energy Policy and planning, The National Energy Plan, April 29, 1977, p. 1.

Table F-9.--Nuclear energy: Leading nations, 1975

Country	Percent of country's primary energy consumption that was based on nuclear energy	Percent of world's primary energy based on nuclear energy accounted for by the country.
United States	2.3	48.4
United Kingdom	3.3	8.2
Japan	1.7	7.1
U.S.S.R.	0.5	6.7
West Germany	2.0	5.9
Other	-	23.7
		100.0

Source: British Petroleum Company Limited, Statistical Review of the World Oil Industry, 1975, p. 16

Nevertheless, it appears that until solar energy becomes a commercial reality, or some other as yet undiscovered non-polluting energy source is discovered, nuclear energy must be an important part of the world's total energy systems. Steps will have to be taken, in the meantime, to deal with both the political and technical problems of nuclear energy. These steps will make the cost-benefit of nuclear energy expansion acceptable to the majority of the world's peoples for whom there may be no energy alternative.

Most discussion of nuclear energy at present includes the breeder reactor under development in France, Britain, West Germany, Italy, Japan and the U.S.S.R. The breeder reactor is important to the future of nuclear energy as it can use the U-238 that comprises 99.3 percent of natural uranium, not just the balance found in nature that is in the form of fissionable U-235. Conventional nuclear reactors require U-235 as fuel. A breeder reactor using plutonium as a fuel would, in addition to the generation of heat and electricity, converts U-238 to fissionable plutonium. Thus the breeder reactor would essentially make all uranium useful fuel, not just the U-235. 1/ Under these conditions the supply of uranium would never be a limiting factor in the expansion of nuclear energy.

At the present time non-Communist uranium reserves, production capacity and production are centered in the United States (table F-10). These reserves, however, may be of insufficient size to meet requirements over the next 25 to 50 years. Total uranium requirements through the balance of this century could range from 3 to 4 million tons. 2/ Today's proven and additional reserves are estimated at 3.5 million tons. Cumulative requirements through the end of the century could easily be 10 million tons.

Additional exploration, with the discovery of new reserves will be necessary. The questions are whether new exploration will discover an adequate resource base, if the necessary capital requirements will be forthcoming, and if both of the aforementioned are met whether the long lead times (up to 15 years) from start of exploration to start of production will allow the new discoveries to be of significant commercial use in meeting requirements during the next 50 years. 3/ After the next 50 years uranium demand may decline due to the lower fuel requirements of breeder reactors, or because of replacement of nuclear fission by some other energy source such as fusion or solar.

Production capacity and production are also currently centered in the United States (table F-10). The current non-Communist capacity is expected to increase from 26 thousand metric tons in 1975 to 60 thousand metric tons in 1980 and to 86 to 87 thousand metric tons in 1985. To maintain production at the latter figure for more than a few years will necssitate the additional reserves previously discussed.

Slightly over 40 percent of all nuclear power reactors in operation are located in North America (table F-11). Of those reactors located in North America, 91 percent are in the United States.

1/ Nuclear Energy and National Security, op. cit., pp. 34-35.
2/ Petroleum Economist, May 1976, p. 174.
3/ Ibid., p. 1.

Table F-10.--Uranium: Reserves, production capacity, production, exploration

Country	Reserves (1,000 MT U) 1/1/75				Production capacity (MT U)			Production	Exploration
	Reasonably assured <$15/lb U_3O_8	Assured $15-30/lb U_3O_8	Estimated <$14/lb U_3O_8	Additional $15-30/lb U_3O_8	1975 E	1980 F	1985 F	1975 E (MTU)	1975 E (1,000 feet)
North America, total	464.0	156.0	824.0	407.0	18,500	35,000	51,500	13,700	33,191.0
Canada	144.0	22.0	324.0	95.0	6,500	10,000	11,500	4,700	-
United States	320.0	134.0	500.0	312.0	12,000	25,000	40,000	9,000	33,191.0
Latin America, total	24.0	13.0	23.8	24.0	60	920	1,720	60	645.9
Argentina	9.3	11.3	15.0	24.0	60	600	720	60	122.8
Brazil	9.7	0.7	8.8	-	-	-	-	-	-
Mexico	5.0	1.0	-	-	-	320	1,000	-	523.1
Europe, total	54.4	422.9	34.8	131.0	2,309	4,180	to 5,350 to 6,350	1,959	1,247.7
Denmark	-	6.0	-	10.0	-	-	to 1,000	-	-
Finland	-	1.9	-	-	-	-	to 1,500	-	9.9
France	37.0	18.0	25.0	15.0	1,800	3,000	to 3,000 to 3,500	1,700	858.0
W. Germany	0.5	0.5	1.0	3.0	250	250	250	-	-
Italy	-	1.2	-	1.0	-	120	120	-	53.1
Portugal	6.9	-	-	-	115	130	300	115	-
Spain	10.0	93.5	8.8	98.0	144	680	680	144	280.5
Sweden	-	300.0	-	-	-	-	-	-	46.2
United Kingdom	-	1.8	-	4.0	-	-	-	-	-
Middle East, total	2.6	0.5	0.4	-	-	-	1,300	-	60.4
Turkey	2.6	0.5	0.4	-	-	-	1,300	-	60.4
Africa, total	283.8	100.0	40.7	83.0	4,700	16,450	21,000	4,600	-
Algeria	28.0	-	-	-	-	-	-	-	-
Central African Republic	8.0	-	8.0	-	-	-	-	-	-
Gabon	20.0	-	5.0	5.0	800	1,200	1,200	800	-
Niger	40.0	10.0	20.0	10.0	1,200	4,000	6,000	1,200	-
South Africa	186.0	90.0	6.0	68.0	2,700	11,250	13,800	2,600	-
Zaire	1.8	-	1.7	-	-	-	-	-	-
Asia-Pacific, total	247.5	34.8	80.8	22.5	30	3,290	5,030	-	80.3
Australia	243.0	-	80.0	-	-	3,260	5,000	-	-
India	3.4	25.8	0.8	22.5	-	-	-	-	49.2
Japan	1.1	6.6	-	-	30	30	30	4	26.1
Korea	-	2.4	-	-	-	-	-	-	5.0
Communist, total									
Yogoslavia	4.2	2.3	-	15.2	-	120	180	-	30.0
Grand total	1,080.5	729.5	1,004.5	682.7	25,599	59,960	86,800 to 87,080	20,323	35,253.3

E=Estimate
F=Forecast

Source: OECD, Uranium: Resources, Production and Demand, December, 1975.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

Table F-11.--Nuclear power: Reactors in operation and under construction or on order

Country	Reactors in Operation		Reactors under construction or on order	
	Number	Capacity (MW)	Number	Capacity (MW)
North America, total:	70	48,849	164	173,322
Canada	6	2,512	14	9,324
United States	64	46,337	150	163,998
Latin America, total:	1	319	6	4,546
Argentina	1	319	1	600
Brazil	-	-	3	2,626
Mexico	-	-	2	1,320
Europe, total:	70	23,314	79	70,747
Austria	-	-	1	692
Belgium	3	1,650	4	3,797
Finland	-	-	4	2,160
France	10	2,818	20	18,478
West Germany	9	4,869	17	18,393
Italy	4	1,387	5	3,908
Luxembourg	-	-	1	1,300
Netherlands	2	532	-	-
Spain	3	1,073	8	7,242
Sweden	5	3,169	6	5,180
Switzerland	3	1,006	5	4,847
United Kingdom	31	6,810	8	4,950
Middle East, total:	-	-	4	4,200
Iran	-	-	4	4,200
Asia-Pacific, total:	16	7,123	28	18,165
India	3	602	5	1,082
Japan	12	6,396	12	9,109
South Korea	-	-	3	1,798
Pakistan	1	125	-	-
Philippines	-	-	2	1,252
Taiwan	-	-	6	4,924
Communist Bloc, total:	16	5,225	32	18,735
Bulgaria	2	880	2	880
Czechoslovakia	1	110	4	1,760
East Germany	3	950	4	1,760
Hungary	-	-	4	1,760
Poland	-	-	1	440
Romania	-	-	1	440
U.S.S.R.	10	3,285	15	11,080
Yugoslavia	-	-	1	615
Grand total	173	84,830	313	289,715

Source: Chemical and Engineering News, October 4, 1976, p. 8.

Western Europe has the same number of nuclear power reactors in operation as does North America. However, the capacity of the 70 Western European reactors is but 48 percent of the capacity of the 70 North American reactors. The average European reactor is much smaller than the average North American reactor.

North America and Western Europe together have 80 percent of the reactors in operation in the world and 85 percent of the capacity. Latin America has one reactor in operation, while the Communist Bloc and Asia-Pacific areas each have sixteen. The Middle East at the time of the survey had no reactor in operation.

In the immediate future, nuclear power, judging by the number of reactors under construction or on order, will remain more important in the United States than anywhere else in the world. Of the number of reactors in this category, the United States accounts for 48 percent. Based on capacity, the United States had 57 percent of the capacity of all reactors under construction or on order in the world.

However, there is expected to be growth in both the number of nuclear power reactors and capacity in all sectors of the world. Not one sector has fewer reactors under construction or on order than are now in operation. Even the Middle East, where there were no operational reactors at the time of the survey, four are under construction or on order.

Shale oil

Major oil shale deposits are found in at least 25 nations. However, the major resources are located in the United States, Brazil, U.S.S.R., Congo, Canada, Sicily and the People's Republic of China. Of these resource holders, the United States is by far the largest with an estimated 75 to 80 percent 1/ of the shale oil-in-place. As can be seen in table F-12, North America has almost 80 percent of the world's shale oil resources.

It is estimated that production took place in 4 countries in the world in 1975: the United States and Brazil in the Western Hemisphere and the U.S.S.R. and the People's Republic of China in the Eastern Hemisphere. 2/ In the past, France, Scotland, Australia, Sweden, Spain, the Republic of South Africa, and Germany had oil shale industries of some type; all failed because of competition from lower priced crude petroleum. 3/

While the oil potential of oil shale is significant certain obstacles must be overcome if this potential is to be even partially realized. The

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1/ Joseph D. Parent and Henry R. Linden, A Survey of United States and Total World Production, Proved Reserves and Remaining Recoverable Resources of Fossil Fuel and Uranium as of December 31, 1975, January 1977, p. 22.

2/ U. S. Bureau of Mines, Shale Oil, 1975, p. 13.

3/ Ibid., p. 2.

Table F-12.--World shale oil: Resources

(Billion barrels)

Region	A 1/	B 2/	C 3/
Africa	10	90	-
Asia	20	70	2
Australia and New Zealand	small	small	-
Europe	30	40	100
North America	80	520	900
South America	50	small	-
Total	190	720	1,002

1/ Known and currently recoverable, 10 to 100 gallons/ton.
2/ Know marginal, 25 to 100 gallons/ton.
3/ Possible extensions of known resources, 25 to 100 gallons/tons.

Source: Joseph D. Parent and Henry R. Linden, A survey of United States and total World Production, Proved Reserves and Remaining Recoverable Resources of Fossil Fuel and Uranium as of December 31, 1975, January 11, 1977, p. 22.

oil in shale is present in a solid form called kerogen. The kerogen decomposes at a temperature of around 700 F to 900 F and yields a light shale oil. This light shale oil has many of the characteristics of a light crude petroleum and can be used as a refinery feedstock and in other processes.

Oil shale deposits may be found at considerable depths and the oil yield per ton of shale can vary between 10 and 100 gallons. Shale oil may be recovered from the shale by in situ methods or by mining followed by retorting of the shale on the surface. The in situ methods all have in common the heating of the shale below the surface to decompose the kerogen into a light oil and the recovery of this oil at the surface. The great advantage of the in situ methods is that they render unnecessary the mining of great quantities of shale, the handling and processing of the shale on the surface and the eventual disposal of the extracted shale. Many authorities believe that the true potential of shale oil may never be achieved if all oil shale must be obtained through strip or deep mining. 1/

In the future shale oil is expected to be a significant energy source only in the United States, Brazil, the U.S.S.R. and the People's Republic of China, and in the first two countries only if the current price of crude petroleum increases or some other form of subsidy is forthcoming. Modified in situ processes and multimineral processes at from $8 to $12 per barrel 2/ production costs offer the most promise and may be competitive with the cost of imported crude petroleum. No one knows for sure because no large scale plant is in operation and there is hesitation on building one because of the high investment involved.

Tar Sands

Major tar sands resources are found in eight countries. Canada and Venezuela, however, account for about 99.5 percent of the world's total resources (table F-13).

At present only Canada has an operational commercial-sized tar sand plant. Another is planned to be on-stream sometime within the next two years, 3/ while the possibility of a third is being investigated. 4/ Positive government actions, including a guaranteed price could elevate the statue of tar sands to where it could be a significant (but small) energy source by 1985 to 1990.

1/ Chemical Economy and Engineering Review, August 1974, p. 11.
2/ Oil and Gas Journal, January 17, 1977, p. 24.
3/ Oil and Gas Journal, September 27, 1976, p. 22.
4/ Oil and Gas Journal, November 29, 1976, p. 41.

Table F-13.--Tar sands: Major resources

Country	Oil-in-place (million barrels)	Percent of: World total	Percent of: Free World total
North America, total:	723,717	78.2	78.2
Canada:	1/ 721,600	77.9	77.9
United States:	2,117	0.3	0.3
Latin America, total:	200,122	21.6	21.6
Venezuela:	2/ 200,062	21.6	21.6
Trinidad:	60	nil	nil
Africa, total:	1,750	0.2	0.2
Malagasy:	1,750	0.2	0.2
Communist, total:	420	nil	nil
Albania:	371	nil	nil
Romania:	25	nil	nil
U.S.S.R.:	24	nil	nil
Grand total:	926,101	100.0	100.0

1/ Estimated as high as 900 billion barrels by some sources.
2/ Estimated as high as 700 billion barrels to 3 54illion barrels by some sources.

Source: Kirk-Othmer, Encyclopedia of Chemical Technology, 2d Ed., vol. II, 1969.

Of the other tar sands nations, only in Venezuela does it appear possible that commercially significant operations could be underway by 1985. The Orinoco heavy-oil deposits are extensive. The deciding factor in favor of their development could be the opening of investment to private entities by the Venezuelan government.

The oil recoverable from tar sands is similar to conventional crude petroleum, but usually of a low gravity and high viscosity. These physical characteristics prevent the oil from being produced by conventional oil well processes.

Three techniques are used to extract oil from tar sands. One technique heats the oil underground by various methods to decrease its viscosity so that it might be pumped to the surface by conventional equipment. Another technique uses diluents and emulsifiers to effect a reduction in viscosity so it might be recovered as above. The third technique is to remove the tar sands and to extract the oil in a separate surface process. As in the case of oil shale, the first two in situ methods decrease tar sands handling and processing, and eventual disposal problems of the spent tar sands.

Hydroelectric Power

Hydroelectric power is limited to those countries that have streams and rivers. While most nations would meet this qualification, not all would, and even in those that do the stream flows would differ, as would potential hydroelectric power generation capabilities.

Ranked by potential hydroelectric power capacity, Asia would be first and Oceania last (table F-14). Ranked by potential hydroelectric power capacity actually developed, Europe would be first and Africa last. Overall, the world has developed but 13.6 percent of its potential hydroelectric power capacity. While this figure is low it must be remembered that much of the potential capacity is in areas that have little or no market for electric power. As standards of living increase, industry is developed and electric power grids are established, additional potential will be developed.

Geothermal Resources

The development of geothermal resources started in the 1950's. It received added impetus from the first UN symposium in 1970 and the Arab oil embargo of late 1973-early 1974. At the latest UN symposium held in 1975 it was indicated that although geothermal energy was important in certain areas numerous obstacles must be overcome before it will play a significant rate in the overall world energy picture.

Table F-14.--Hydroelectric power: Capacity, total and developed, 1974

Area	Total capacity (MW)	Percent of total world capacity	Developed capacity (MW)	Percent of capacity developed
Africa	437,104	19.3	8,154	1.9
Asia (less U.S.S.R.)	684,337	30.3	47,118	6.9
Europe (less U.S.S.R.)	215,407	9.5	103,998	48.3
U.S.S.R.	269,000	11.9	31,500	11.7
North America	330,455	14.7	90,210	27.3
South America	288,289	12.7	18,773	6.5
Oceania	36,515	1.6	7,609	20.8
Total	2,261,107	100.0	307,362	13.6

Source: U.S. Department of the Interior, Energy Perspectives 2, June 1976, p.39.

At the present time, geothermal resources are being used in Iceland, Italy, Japan, Mexico, New Zealand, the U.S.S.R. and the United States. Exploration and development is underway in Chile, El Salvador, Ethiopia, India, Indonesia, Kenya, the Philippines and Turkey. 1/ In spite of all of this activity, only a little more than 1,000 MW (about the size of one nuclear generating plant) of geothermal electric generating capacity exists in the world today. About half is located at the Geysers field in the United States. 2/ The balance is located at the Larderello field in Italy and in Japan. 3/

Plans are underway to increase the generating capacity of the Geysers. The initial expansion will increase capacity from around 500 MW to 1,200 MW by 1980 and 1,800 MW by 1985. 4/ Industry sources indicate that geothermal systems may provide 3,000 MW by 1985 and about twice that by 1990. 5/ More optimistic estimates by government sources show a possible 10,000 to 15,000 MW by 1985 and up to 100,000 MW by 2000. 6/

Although often considered to be pollution-free, geothermal energy development could result in air, water and noise pollution. 7/ Emission of trace elements and radioactive materials is possible at geothermal plants. Iceland and Hawaii have reported high mercury emissions in areas of natural geothermal activity. 8/

Synthetic Fuel

Synthetic fuels (sometimes called substitute fuels) are those fuels usually derived from another fuel. They would include synthetic natural gas (SNG) from coal, naphtha, and liquified petroleum gas (LPG), synthetic crude petroleum (syncrude) from coal, methanol from coal, etc. Indeed, shale oil and tar sands oil (previously separately discussed) are sometimes also referred to as synthetic fuels.

Most observers do not believe that gaseous and liquid fuels from coal and oil shale will contribute much to the total energy picture until after the mid-1980's. In the United States, the government estimates that work must begin now in order to have commercial synthetic fuels capability for 1985 and later. 9/ One U.S. government spokesman looks forward to the availability of 4 to 5 million barrels per day

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1/ Chemical and Engineering News, June 9, 1975, p. 21.
2/ Chemical and Engineering News, June 9, 1975, p. 21.
3/ Energy Economics Division of the Chase Manhattan Bank, Energy Report from Chase, August 1976, p. 2.
4/ Ibid., p. 2.
5/ Ibid., p. 3.
6/ Ibid.
7/ Bureau of National Affairs, Energy Users Report, May 29, 1975, p. D-4.
8/ Ibid.
9/ Bureau of National Affairs, Energy Users Report, August 26, 1976, p. A-14 and U.S. House of Representative, Committee on Science and Technology, Near Term Energy R & D-1976 ERDA Plan and Program, January 1976, p. 130.

of synthetic fuels by the mid-1990's. 1/

There are numerous environmental and technological obstacles to be overcome if synthetic fuels are ever to supply a significant portion of world energy demand. Another problem in most countries is the current marginally attractive economics without some sort of government aid and in the way of floor price, guaranteed price, loan guarantees, etc. A recent U.S. government report, for example, stated that "Synthetic fuels production is not cost effective in that the total cost of output is not price competitive with foreign oil. Nor does it look attractive on the basis of present knowledge when compared to other technologies on an actual, or incremental, price basis." 2/ Industry and financial community comments are that multi-billion dollar synthetic fuel plants cannot be financed without some government help. 3/

Solar Energy

Solar energy may be the long-term solution to the world's energy needs. However, it does not loom large in the 1985 energy picture. In fact in the United States, where there is considerable development activity, the government has indicated that no more than 7 percent of the total U.S. energy demand in 2000 may be satisfied by solar energy. 4/ But, given success in certain government research and development activities in direct thermal applications, solar electrical application and biomass fuels, solar energy could supply one-quarter of U.S. energy demand in 2020. 5/

Other Energy Sources

There are also other potential energy sources that probably will not contribute much to the total energy supply by 1985, but may become important in the period thereafter. These sources include wind and wave action, the thermal gradient in the seas, garbage and other waste conversion and biomass (such as forests) conversion.

The use of garbage, and other wastes as sources of energy is particularly attractive. The idea of waste materials being used to supply energy appeals to almost everyone. In addition, at least some technology is currently available which can effect the transformation of many wastes into energy. However, it is generally true that all of these processes have the

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1/ Oil and Gas Journal, September 6, 1976, p. 84.
2/ Bureau of National Affairs, Energy Users Report, August 26, 1976, p. A-10.
3/ Oil and Gas Journal, October 1976, pp. 52-53.
4/ Bureau of National Affairs, Energy Users Report, August 18, 1975, p. A-1.
5/ Oil and Gas Journal, August 25, 1975, p. 25.

drawback of producing energy at a cost above that of energy from other sources. Future technological breakthroughs, investment incentives, subsidies and similar mechanisms might hasten the date at which these potential energy sources will be commercially developed.

It has been stated that the world supply of biomass exceeds current energy consumption, but much of it is inaccessible, there is no technology to convert it, and there is competiton for biomass as a source of food. 1/ However, in Brazil alcohol is made from sugar cane and cassava and used in a ratio of about one in twenty with gasoline as an automotive fuel. 2/ Grain sorghum is under consideration for similar use in the United States.

1/ Chemical and Engineering News, February 28, 1977, p. 21.
2/ Flower and Garden, September 1977, p. 52.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

APPENDIX G
CHANGES IN OWNERSHIP

The relatively recent changes in crude petroleum production "ownership" will be treated with in this appendix. Originally, most nations with petroleum resources (so-called host countries) gave concessions or entered into other types of agreements with one or more firms, usually foreign, who were to explore for and develop the host countries' crude petroleum resources. The host countries benefited from increased employment, local spending of payrolls, additions to the infrastructure often financed by the operating firms to support their employees, and through taxes and royalties on the extracted crude petroleum paid by the firms. 1/ However, after all was done the crude petroleum produced belonged to the firms that produced it. This has been changing, especially since the early 1970's. No longer do most of the producing firms own all or in some cases any part of the crude petroleum they produce in many of the world's leading crude petroleum producing nations.

Nationalization of and participation in the producing companies by many of the host countries has drastically reduced the quantities of crude petroleum owned by the producing firms. Although in many cases when the private companies lost control of the crude petroleum produced they were extended exclusive marketing rights. This action by the host countries has reduced the producing profit previously made by the producing companies. This fact is often lost to the observer as production is assumed to belong to such firms. Actually such firms may be merely operators under service contracts to a government entity with all of the production belonging to that entity. Alternatively even though the firm produced all the crude petroleum, some portion actually belongs to the host nation by reason of participation or some other agreement. Table G-1 traces the changes in crude petroleum production ownership in OPEC over the period of most rapid change from 1970 to 1975. It can be seen that in 1970 private firms owned almost 98 percent of OPEC production, with the range spanning 100 percent (or close to it) ownership in many nations to a low of 85 percent in Algeria. By 1975 private ownership in OPEC had decreased to just over 39 percent. Government ownership ranged from a high of almost 96 percent in Iran to a low of over 25 percent in Ecuador. This trend to government ownership continued on January 1, 1976 when Venezuela nationalized the assets of all private oil companies operating in Venezuela.

1/ "Royalties" paid to host governments are analogous to the royalties paid by crude petroleum producers in the United States--i.e., they are a form of compensation to the "landowner"--a sovereignty in this case--for depletion of natural resource. "Taxes," as paid to host governments are either income taxes if based on actual prices or excise taxes if based on fictitious posted prices.

Table G-1.--Producing companies' estimated ownership of crude petroleum production in OPEC, 1970-1975 1/

(Percent)

Country	1970		1971		1972		1973		1974		1975	
	P	G	P	G	P	G	P	G	P	G	P	G
Algeria	85.4	14.6	30.4	69.6	23.1	76.9	23.5	76.5	24.2	75.8	25.5	74.5
Ecuador	2/	2/	2/	2/	98.7	1.3	99.5	0.5	74.6	25.4	74.5	25.5
Indonesia	88.3	11.7	87.8	12.2	83.6	16.2	76.9	23.1	69.5	30.5	66.3	33.7
Iran	95.5	4.5	95.5	4.5	95.0	5.0	3.9	96.1	3.8	96.2	4.3	95.7
Iraq	100	-	100	-	46.2	53.8	29.2	70.8	22.8	77.2	14.7	85.3
Kuwait	98.8	1.2	98.9	1.1	98.7	1.3	75.9	24.1	44.9	55.1	45.5	54.5
Libya	100	-	99.9	0.1	96.4	3.6	44.1	55.9	39.3	60.7	37.4	62.6
Nigeria	100	-	100	-	100	-	75.2	24.8	45.1	54.9	45.1	54.9
Qatar	100	-	100	-	100	-	74.9	25.1	40.0	60.0	40.2	59.8
Saudi Arabia	99.9	0.1	99.9	0.1	99.9	0.1	75.3	24.7	41.5	58.5	41.6	58.4
United Arab Emirates	100	-	100	-	100	-	78.7	21.3	50.5	49.5	52.1	47.9
Total-OPEC	97.7	2.3	96.1	3.9	91.7	8.3	57.7	42.3	40.5	59.5	39.1	60.9

P= Private companies
G= Governments or national companies
1/ Gabon has had zero government ownership through 1975. Venezuela has had between 1.2 and 2.5 percent government ownership through 1975. However, as of January 1, 1976 all assets of private companies have been nationalized.
2/ Small total production: percents are misleading and insignificant.

Source: Organization of the Petroleum Exporting Countries, Annual Statistical Bulletin, 1975, June, 1976, pp. 38-40.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

APPENDIX H
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Library Cataloging Data

U.S. International Trade Commission.
Factors affecting world petroleum prices to 1985. [Washington, 1977]

" USITC Publication 832"

1. Petroleum. 2. Petroleum--Prices.
3. Petroleum--Statistics. I. Title.

Approved For Release 2004/03/23 : CIA-RDP80M00165A002400060003-0

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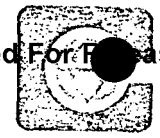

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1 September 1977

THE ALLIED INTERDEPENDENCE PROJECT

A Prospectus

The Center for Strategic and International Studies
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THE ALLIED INTERDEPENDENCE PROJECT

A PROSPECTUS

PURPOSE OF PROJECT. The Georgetown Center's Allied Interdependence Project is the only effort underway on either side of the Atlantic which concentrates upon the vast government-funded marketplace for military and civil technology and products.

These last and largest frontiers of world trade are not yet seen as possible trading markets. They are politically sensitive to constituency interests and pressures, and are heavily protected. But they are also far more technologically dynamic than the world's commercial and industrial markets. Opening these markets offers large-scale opportunities for job creation and economic growth, the magnitude of which has never been fully explored.

The protected military markets of the nations of the North Atlantic Alliance have made it impossible to produce a credible, collective, conventional war-fighting capability, despite the fact that NATO spends as much on conventional weapons as does the Warsaw Pact. Protectionist military trade practices have also made it impossible for the nations of the Alliance to share equitably the financial burdens of Allied Defense, as well as the economic benefits (jobs, technological and industrial progress) of defense development and production.

The equally protected civil markets have made it impossible for Europe and North America (and ultimately the other OECD countries) to share the research and development costs of new energy sources, and new methods of using energy more efficiently. In an interdependent world, most government-funded civil technological needs are still met on a national (rather than a cooperative international) basis. With unnecessary and wasteful duplication, the totality of the output is less than the sum of the national efforts, and far less than the sum of the national needs.

Protected government markets make it impossible for nations to buy from, and sell to, the other the goods which each can produce more efficiently. Comparative advantage has had but limited application in the government marketplace. Since government markets are closed to products, but always open to technology transfers--jobs and technology are exported, rather than technological products produced by indigenous labor.

The Allied Interdependence Project aims to promote an informed discussion and debate among opinion leaders from the governmental, legislative, industrial, labor, military and academic sectors--in Europe and North America--on the need

for, and the advantages and disadvantages of, trade and cooperation in the government funded markets of the western world.

PURPOSE OF PROSPECTUS. The continued success (see below) of the Allied Interdependence Project requires adequate and balanced financial support. With adequate funds, a team consisting of a Project Director, a research assistant, and a secretary can be supported. Adequate funds are also required for publishing and distributing reports, for conducting seminars on each side of the Atlantic, for information exchange, for travel, and for necessary Center overhead. Monographs and reports can be produced on a more timely basis. With balanced funding from North American and European sources--together with the interest which financial participation generates--the Project will continue to be balanced in both its input and output.

This Prospectus describes the objectives of the Project, and seeks adequate and balanced funding support from North America and Europe (1) to insure that the objectives can be met, and (2) that they be met at a reasonably productive pace.

THE CALLAGHAN REPORT--BACKGROUND, AND IMPACT. The report entitled "U.S./European Economic Cooperation in Military and Civil Technology" by THOMAS A. CALLAGHAN, JR., was prepared under State Department contract, with funds provided by the Defense Advanced Research Projects Agency (ARPA) and the Department of the Air Force.

In August, 1974, an initial distribution of 75 copies was made within the State and Defense Departments, and among the embassies of the NATO Allies. As requests for copies multiplied, the government put the first edition through four printings totalling over 1,000 copies. Circulating largely through governmental circles in North America and Europe, the report has been briefed to, or read by, every NATO Foreign and Defense Minister.

The Georgetown Center commissioned a revised and expanded edition of the Callaghan Report in September, 1975, in order to bring it to a much wider public and political audience on each side of the Atlantic. The first printing was quickly exhausted, and a second is nearly so. With many more copies available, the report has been discussed in meetings of the NATO Defense Planning Committee, the EuroGroup, the European Programme Group, the NATO Industrial Advisory Group (NIAG), and committees of the American Congress, the North Atlantic Assembly, the Western European Union, and the European Parliament. It has also been studied in the State and Defense Departments, the National Security Council staff, the Office of Management and Budget, the Congressional Budget Office and the General Accounting Office.

The British Broadcasting Corporation (BBC) made a documentary based upon the report. The report has been critically cited (pro and con) in books, articles, periodicals, seminars, reports and official documents in both Europe and North America.

Government officials, here and in Europe, credit the report with having been a catalyst in stimulating renewed efforts towards achieving the standardization of weapons and equipment, and the equitable sharing of Allied defense burdens and benefits, which have eluded the Alliance for the past 28 years.

P.H. SCOTT, Research Associate of the International Institute for Strategic Studies in London, discussed the Callaghan Report impact in the January, 1976 issue of The World Today. Referring to the EuroGroup Communique of 5 November 1975, he wrote that "the first obvious point is the similarity between the ideas expressed in the communique, and even some of the language used, and [the Callaghan Report]." He then adds:

> There can be few, if any, precedents for an independent report leading so rapidly to action, not by one government only, but by several....
>
> The advantage of the Callaghan proposal, and the reason for the response to it, is that it offers a simultaneous answer to all these problems: the need of the Alliance as a whole to achieve a more convincing conventional posture without more money or manpower; the need for the Europeans to be seen to be making a more rational and convincing response to their defense needs, and to maintain an advanced defense industry and the technologies associated with it.

The issues raised in the Callaghan Report go far beyond Allied cooperation in armaments. This is one of the reasons why the report has generated so much interest. It proposes major conceptual and structural changes in the organization of the western world; cooperation in civil technology, with priority given to a Project Interdependence (rather than a Project Independence) in the energy field; civil technological cooperation between NATO and the Warsaw Pact, whenever the Soviet Union is prepared to reduce its forces to a non-threatening threshold, so NATO and the Pact can divert military expenditures to civil technological investment; and open, competitive procurement in the vast government-funded marketplace of the OECD countries.

UNIQUE ROLE OF THE GEORGETOWN CENTER. The Georgetown Center plays a unique role in communicating, clarifying and circulating ideas whose time has come.

Much of the intellectual capital upon which the postwar world has been built has been exhausted. Insecurity, inflation, unemployment and protectionism are becoming ever more stubborn and unmanageable. There is growing evidence in many areas that merely tinkering with the postwar international system won't suffice. Fundamental structural changes are necessary. New insights, new concepts and new approaches to seemingly intractable problems need to be called forth, if the security, stability, growth and progress of the postwar world is to continue.

It has always been the mission of the Georgetown Center to seek out this new intellectual capital, to bring it to public and political attention, and to subject it to challenge in a variety of forums where the practicability and viability of the concepts can be tested. Thus, the Center sees itself in the business of intellectual capital formation, of marketing the concepts and anticipating the issues that will contribute to a better understanding of (and possible solutions to) the strategic, political and economic challenges of our time.

This is why the Georgetown Center first brought the issues raised in the Callaghan Report to public attention. The Center has sponsored broader understanding of these issues through seminars, conferences, lectures, reports and articles for congressional, parliamentary, governmental, industrial, military and academic audiences.

The Allied Interdependence Project was established by the Center to focus attention initially on the standardization issue, and then later on the other structural and conceptual issues raised in the Callaghan Report.

In the standardization area, the Project has several aims: first, to stimulate public and political discussion and debate on the need for Allied partnership in armaments development, production, trade and support; second, to emphasize to American opinion leaders that the United States cannot, by its resources alone, maintain the conventional force balance between NATO and the Warsaw Pact; third, to emphasize to European opinion leaders that the defense and security of Europe requires its twelve Alliance nation-states to establish a single European defense procurement organization and market; and fourth, to demonstrate that North America and Europe, through economic cooperation in armaments, can produce a credible, collective conventional force within reasonable defense budgets.

The Georgetown Center's "multiplier effect" technique (illustrated in the Progress Report below) has been fully employed to achieve these standardization aims.

ALLIED INTERDEPENDENCE PROJECT PROGRESS. The Allied Interdependence Project was launched during the 1976 American election campaign. As a new Administration and Congress convened in Washington, the Center's efforts concentrated on explaining why the Alliance must standardize. Significant progress has been made. There is today a far greater public and political awareness of the need for transatlantic military trade and cooperation--on each side of the Atlantic--than many would have thought possible a year ago.

In the United States, there have been governmental initiatives, congressional hearings, and policy changes. In Europe, the pace has been slower, but there is a growing realization that fundamental changes are taking place in American military procurement practices. The Center has played a role in these developments, sometimes in the forefront, often in the background, and generally working with policymakers and opinion leaders to achieve an informed and knowledgeable "multiplier effect". The examples which follow illustrate

the pattern of activity this past year.

BBC Documentary. The interest in weapons standardization generated by the Callaghan Report led to the BBC Documentary, "NATO and the Price of Peace", by ROBERT MACNEIL. First televised in June, 1975, it is having its greatest impact in private showings by the Georgetown Center to political, military and industrial audiences. They see the extent of Allied military-industrial duplication, with its consequent loss of military effectiveness. They hear the pros and cons of a two-way street in military trade. They're brought face-to-face with the growing danger of nuclear war, if the fourteen armed nations of the Alliance don't begin to cooperate in armaments procurement.

Although the Center has three film copies of the documentary, interest is so high that showings are booked weeks in advance. With the exclusive right to show it to private, non-commerical audiences, the Center has shown it over one thousand times to members of Congress and their staffs, to Defense and Military Department Secretaries, to military service chiefs, to key military and civilian officials, to defense industry executives, to the State Department, the Office of Management and Budget, the Congressional Budget Office, the General Accounting Office, the National War College, the Industrial College of the Armed Forces--and, to the North Atlantic Assembly, to over 100 members of the Canadian Parliament, and the NATO Defense College.

In September-October, 1977, with the assistance of the United States Information Service (USIS), the Center will begin showing the documentary for the first time to European parliamentary, governmental and industrial audiences.

Transatlantic Seminar. In January, 1977, the Center conducted a seminar on Capitol Hill on "Allied Partnership in Armaments". SENATOR SAM NUNN (author or co-author of much of the standardization legislation) and REPRESENTATIVE CHARLES E. BENNETT (second ranking member of the House Armed Services Committee) co-chaired the seminar, and keynoted the discussion. Standardization was the major theme. There was a standing-room-only audience in the large Senate Committee roon.

AMBASSADOR ROBERT W. KOMER (now a Special Consultant to DEFENSE SECRETARY HAROLD BROWN) led off by describing the need for Alliance nations to prepare for "coalition warfare", for fighting in concert with their Allies. American GENERAL JAMES HOLLINGSWORTH (consultant to the Senate Armed Services Committee) and German GENERAL JOHANNES STEINHOFF (former Chairman of the NATO Military Committee) then addressed the military needs of the Alliance. Dutch PARLIAMENTARIAN KLAAS G. deVRIES then described the cooperative defense procurement efforts underway in the EuroGroup and the European Programme Group. MR. CALLAGHAN concluded by arguing the need for economic cooperation in armaments between Europe and North America.

Then the members of the Center's Transatlantic Policy Panel (see below) and the members of the Defense Cooperation Subcommittee of the North Atlantic Assembly joined in a panel discussion of the same subjects. Their views, and those of the speakers, were summarized in a report of the seminar which the Center distributed widely in the United States, Canada and Europe.

Transatlantic Policy Panel. With encouragement from both the Legislative and Executive Branches of the U.S. Government, and with high interest among European officials, the Georgetown Center established a Transatlantic Policy Panel. The Panel includes twenty-two distinguished American and European leaders from Allied parliaments and legislatures, and from the industrial, labor, financial and military sectors of Allied countries. The names of the members are included at the end of this Prospectus.

The American Co-Chairman of the Panel is ADMIRAL THOMAS H. MOORER, USN (Ret.), former Chairman of the Joint Chiefs of Staff. The HONORABLE ALAN LEE WILLIAMS Chairman of the Parliamentary Labour Party Defence Group in the British House of Commons, is the European Co-Chairman.

The Panel met on Capitol Hill in January, 1977, prior to the Transatlantic Seminar. In their first report, "Allied Interdependence: Trade and Cooperation in Military Equipment", they formulated a statement of Military and Industrial Objectives for the Alliance, and recommended that they be adopted by all Allied nations.

Their report has been widely distributed in Europe and North America, and has received many favorable official comments. The entire report was read into the record of the first of a series of hearings on standardization conducted in July, 1977 by the House of Representatives' Legislation and National Security Subcommittee, chaired by REPRESENTATIVE JACK BROOKS (Dem. Tex.).

The Panel concluded their first report by indicating that their next effort would be the preparation of an "Agenda for Political Action". They stated that "the actions that must be taken to create the needed new transatlantic structure are political; and it is to that end that priority for future activities must be given".

National Debate Topic. The Center believes that real progress can be made towards Allied Interdependence, if the idealism of youth can be focused on the need for Allied partnership in armaments.

Using the "multiplier effect" approach, the Center sought to have the standardization issue debated in more than 700 American colleges and universities. Each year they vote on five questions from which they select a single national debate topic for all intramural and intercollegiate debates, and the regional and national debating tournaments.

For the second year in a row, the Center joined with NATO SECRETARY GENERAL JOSEPH LUNS and the American Debate Community to make the standardization question attractive to college youth still disdainful of defense matters because of Vietnam. DR. LUNS again agreed to make $15,000 available to finance expense paid trips to Europe for the outstanding debate teams and their coaches, including all four finalists in the National Debate Tournament. The Georgetown Center received permission to solicit donations to augment NATO's grant so that many more winning teams could visit NATO facilities in Europe, and receive NATO briefings. Officials of the North Atlantic Assembly agreed to explore the possibility of having European Parliaments invite prize

winners to come to their countries to meet university youth also interested in Allied cooperation in armaments.

Last year the standardization question placed a poor third. This year it placed second in the closest vote in the Debate Community's history. Even in losing, we have made the issue known to students, to their debate coaches, and to faculties and parents.

Ideally, standardization should be debated in every country in the Alliance. Unfortunately, only Britain, Canada and the United States have a collegiate debating tradition, and only the United States selects a single debate topic annually.

Several European parliamentarians from the North Atlantic Assembly expressed keen interest in the debate, believing that if the standardization topic were selected, and the winning teams came to their countries to debate the question before European university audiences, it might be the first step towards establishing a debating tradition across national boundaries. Some see a debating tradition as a powerful counterweight to the polemic tradition favored by the European communists. In turn, the leaders of the American Debate Community welcomed the possibility that one day the college age youth of the western world might be able to debate together the many crucial issues of war and peace which confront their generation in an interdependent world.

The Center will ask the Secretary General to make seed money prizes available once again in the 1978-79 scholastic year. We believe a standardization question will win next year.

Allied Interdependence Information Exchange. One of the most important functions of the Allied Interdependence Project is to bring relevant European official reports and documents, and articles by leading European opinion leaders to the attention of American policymakers, and vice versa. To date, the Georgetown Center has provided this service not only for member countries of the Alliance, but also for the European Community, the North Atlantic Assembly, the Western European Union, and the European Parliament.

Because of funding constraints, this service has not been thorough and comprehensive, nor has it been done on a formal, organized basis. It should be. Government channels do not adequately meet this need. Establishing this service on a large scale (and ultimately on a self-sustaining basis) for governments, for industry, for academia, and for the foreign policy community, is one of the priority aims of the Allied Interdependence Project, when funds become available for this purpose.

Other Allied Interdependence Project Activities. During the past year, the Center, or its Allied Interdependence principals, have conducted seminars for members of the North Atlantic Assembly and the Western European Union; provided briefings for European journalists; addressed the National War College on "Economic Cooperation in Armaments--A Prime Item for the NATO Summit Agenda", and distributed copies widely to American, Canadian and European foreign and

defense officials; taught the first course on standardization at the Industrial College of the Armed Forces; testified before the House of Representatives' Legislation and National Security Subcommittee; provided material for a special standardization report of the House of Representatives' Europe and Middle East Subcommittee; participated in meetings of the North Atlantic Assembly; briefed several Congressional committee staffs on the standardization issue; and wrote articles for the NATO Review and other publications.

ALLIED INTERDEPENDENCE PROJECT MONOGRAPH SERIES. In its first year, the Allied Interdependence Project has succeeded in securing greater public and political awareness of why NATO must standardize. While the Project will continue to argue the need for standardization until finally there is a broad-based constituency for Allied economic cooperation in armaments on each side of the Atlantic, Project emphasis in the future will shift to the structural aspects of how to cooperate.

A series of seven new monographs are planned which will develop the conceptual and structural recommendations contained in the original Callaghan Report in far greater detail. Each new monograph will be complete in itself. But the series as a whole will present a coherent program for harnessing the enormous economic energy now trapped in the protected government-funded markets of the western world.

The first two monographs will continue to emphasize Allied partnership in armaments. The next five will deal with cooperation in civil technology, and open government procurement. Thus the entire series will respond to the prescient view SENATOR ARTHUR VANDENBERG expressed to his Senate colleagues in 1949 during the North Atlantic Treaty ratification debate, when he said:

> Unless the treaty becomes far more than a purely military alliance it will be at the mercy of the first plausible Soviet peace offensive.

SENATOR VANDENBERG was right. The euphoric expectations of detente in the early 70's almost lulled Allied nations into ignoring the massive Warsaw Pact military build-up because the Soviet Union had declared its intentions to be peaceful. If the ability of Allied nations to help one another in wartime is to have credibility, then we must demonstrate an ability to work together in peacetime. We have yet to do so. The monograph series will show how it can be done.

I. The Callaghan Report--Questions & Answers. Now nearing completion, this first monograph will contain a revised and up-dated summary of the original report. Then, in question-and-answer format, it will cover every significant aspect of the Callaghan Report.

This is not a sterile exercise. Since early 1975, MR. CALLAGHAN has appeared

before hundreds of government, parliamentary, military, industrial and academic audiences, expounding his views, and subjecting them to challenge from the audience. A pattern of questions evolved which reflected the major interests and concerns on each side of the Atlantic. The answers reflected a constant refinement of his ideas as he responded to constructive criticism.

The question-and-answer format will clarify and expand upon points originally made; will remove ambiguities; will meet objections head-on; and will help Europeans and North Americans have a better understanding of the problems that concern the other. It will also make it clear that there is no economic reason for NATO's conventional forces to be inferior to those of the Warsaw Pact.

II. STANDARDIZATION: Le Defi Americain a l'Europe. The October, 1976 issue of the NATO Review contains an article of the same title as this monograph, which summarizes the points to be made in this second monograph.

Too many Europeans see standardization and military trade as merely an opportunity to sell weapons and equipment to the United States. Too few see the challenge which standardization poses to Europe to solve two very critical problems:

> First, large-scale military trade with Europe must provide American forces with weapons at least equal in quality to, and not costing more than, weapons which could be developed and produced in the United States.
>
> Second, a "two-way street" with Europe means there must be one west-bound lane from Europe to North America--not twelve separate lanes west-bound, and one lane east-bound.

Thus, standardization poses an American challenge to Europe; to strengthen Europe's defense technology base; to improve the productivity of Europe's defense industries; to aggregate Europe's defense market through a strong, fully-staffed European Programme Group.

But standardization also poses a European challenge to the United States to meet Europe half-way. It is not sufficient for American officials to ask, "What have they got we can buy?" American officials should be asking: "What policies should my government initiate which will make it as easy as possible for the twelve armed European nations of the Alliance to establish a single European defense procurement structure?"

Like the NATO Review article, the analysis of European defense industrial weaknesses will draw almost exclusively upon European sources. In other words, this monograph will not be an American's critique of why Europe is not more like the Americans. Instead it will be a European assessment of why Europe has not achieved the economic promise, and military capability,

of its large but fragmented technological industrial base.

It is intended that a European consultant will participate in the preparation of this monograph.

III. Making Detente a Fearless Reality. The nations of the North Atlantic Alliance comprise the two most technologically advanced industrial economies in the world. Yet they lack a coherent geopolitical, technological and industrial strategy for countering the military build-up of the Warsaw Pact. As a consequence they oscillate between extremes of alarms and exertions when frightened, and complacent neglect when not.

The enormous industrial resources of the west are not properly employed for our common defense, nor are they properly employed for the solution of our many pressing civil technological problems. Yet the nations of the Alliance could achieve both ends, if they cooperated economically in both military and civil technology. But the backward economies of the Warsaw Pact can do one or the other, but not both. And that is the key to fashioning a coherent geopolitical, technological and industrial strategy for the west.

To lay the groundwork for such a strategy, this monograph will first analyze and contrast the quite different postwar armament policies of Great Britain, Japan, the Soviet Union and the United States. Three of these countries tried to span the entire spectrum of conventional and nuclear weapons technology. Britain, like the United States, tried to pursue autarchic weapons development policies, while building a strong civil technological base as well. Britain finally failed, leaving the weapons competition to the superpowers. Japan was spared heavy investment in defense technology, while the Soviet Union neglected its civil technology.

Each country pursued different military and civil technological strategies towards their Allies and trading partners. Political-economic priorities were different, as were the political-economic results. The results demonstrate that there is an economic benefit from military burden-sharing, and an economic cost from military autarchy. The military-industrial experiences of these four countries offer policy options which Europe and the United States have never even considered.

The first two monographs will have made the case for armaments cooperation. This monograph will argue the case for economic cooperation in all civil technological areas between the European Community and the United States, with priority given to the energy field. It will argue that civil technological cooperation should not be exclusive. In time it should be extended to all OECD countries. OPEC participation should be sought. And, in the spirit of the Marshall Plan offer which Stalin rejected, civil technological cooperation should also be available to the Warsaw Pact.

The Soviet Union badly needs western civil technology. They can acquire it by hard currency purchase, or Allied credits, as at present. As long as Allied economic assistance is available to the Soviet Union in this fashion,

there is little need for them to divert resources from defense. Allied conventional force weaknesses might tempt them to acquire civil technology by extending Soviet dominion over Western Europe, if (rightly or wrongly) they were ever to conclude that the risks of nuclear war were acceptable. But they could also acquire it through technological cooperation between NATO and the Warsaw Pact, whenever the Pact was prepared to reduce its forces to a non-threatening threshold, so both NATO and the Pact could divert resources from military to civil technological investment.

The Cold War will go on forever unless Europe and North America can demonstrate to the Soviet Union that no wedge can be driven between them. Allied economic cooperation in armaments is needed to convince the Soviet Union that we cannot be out-produced; that we cannot be blackmailed; and that we cannot be overwhelmed by conventional force attack. But Allied partnership in armaments will not be sufficient to offer the Soviet Union an inducement to make detente a fearless reality.

To do that, Europe and North America must also cooperate to solve their civil technological problems--and hold out the promise of such cooperation to the Warsaw Pact, whenever the Soviet Union is prepared to discuss meaningful reductions in mankind's armaments burdens.

IV. Government Incentives for High Technology Industries. It has been said that everyone is entitled to his own opinion, but not his own set of facts. Agreed facts are hard to come by when incentives for high technology industries are discussed. This is a somewhat emotional subject: so much so that what we do for our industries are called incentives; what they do are called subsidies; and vice versa.

This monograph will first examine the role of the U.S. Government in sponsoring and attaining trade and other economic benefits from the technological revolution. In little more than a decade the U.S. Government created the world's largest marketplace for technology. The result was not only superiority in defense technology, but civil technological predominance that continues to this day in the world's technology-intensive commercial markets. How was this done?

The monograph will itemize U.S. Government practice in all industrial incentive areas, including the following:

Plant and equipment facilitization assistance
Manufacturing research
Independent research & development
Government research & development
Early markets for high technology products
Protected domestic market with internal competition
Technological building blocks
Competitive vendor structures
Demanding product standards

A European consultant will concurrently examine the practices of Britain, France, Germany, and the European Community in the same or similar areas.

The end result will be a comparability analysis of the incentives which American and European governments have provided their high technology industries over the past two decades. It would not include tax, duty or other incentives generally available to industry, unless they had significantly greater impact on high technology industries.

Such a comparability study is a necessary first step towards removing the technological fears that thwart the GATT non-tariff barrier negotiations in the government procurement area. It is also a step towards devising more effective government policies based upon assessing what did and did not work, and why.

V. (A) An American Technological Investment Policy

(B) A European Technological Investment Policy

Based upon the data derived from the fourth monograph (the incentives comparability analysis), two separate monographs will be prepared, coordinated in their methodology and approach, and issued at the same time. The Georgetown Center will prepare the American monograph; a European consultant will prepare the European version.

Each will complement the other. They will recommend long-term technological investment policies for Europe and the United States. From quite different perspectives, they will distinguish between what governments can and should do in this area, and what governments should not try to do.

VI. The Last and Largest Frontiers of World Trade. It is a measure of the opacity of the government marketplace that the best estimate of the size of the combined government funded markets of the fifteen nations of the North Atlantic Alliance totals between $150.0 and $200.0 billion per year. This compares with the global $40.0 billion commercial and industrial markets of the Kennedy Round. Thus the government procurement markets are the last and largest frontiers of world trade. And the least known.

As the predominant technological power in the world, the United States should benefit from the removal of all "Buy National" procurement restrictions in every country. At the present time, the U.S. Congress and significant segments of the American public believe American industry is best served by the "Buy American" Act. This monograph will argue that government procurement restrictions--our own, and others--are inimical to American labor, industry and the public in four ways:

> First, they keep foreign government procurement markets closed to American technology-intensive products.

Second, they encourage the sale of technology, instead of the sale of the products of technology--thereby exporting jobs.

Third, they lead to costly copy-cat engineering, here and abroad.

Fourth, they limit competition, thereby wasting the taxpayers' government expenditures.

Europe argues for the removal of American government procurement restrictions, while fearing that removal of its own "Buy National" government procurement policies would lead to American domination of its high technology markets.

With fears and suspicions on both sides, little progress is likely until the facts underlying these fears are brought out into the open for public and political examination and debate on each side of the Atlantic. This monograph will examine the size and scope of the government procurement markets; will assess the conceptual, technological and market scale obstacles to opening government procurement markets to trade; and will analyze the trade and economic costs of "Buy National" policies.

Sooner, rather than later, policymakers must face the paradox that efforts to reduce trade barriers in the commercial sphere will have but limited effect if the most dynamic, most technologically-intensive government-funded procurement markets continue to be highly protected.

MONOGRAPH PUBLICATION AND DISTRIBUTION. Each of these seven monographs will be published when completed. If funds are available for translations, they will be published in at least the two Alliance languages, French as well as English. Other languages will also be employed, if funds are available.

It is intended that each monograph would be presented for public, media and political review through seminars in Europe and Canada, as well as the United States, shortly after publication. The number and extent of the seminars will also depend upon funding availability.

PROJECT DIRECTION AND SUPPORT. The Allied Interdependence Project is under the direction of THOMAS A. CALLAGHAN, JR., an Associate of the Georgetown Center, and President of Ex-Im Tech, Inc., Washington, D.C..

For a number of reasons, funds for the Project will be solicited for Ex-Im Tech directly, as well as for the Georgetown Center. It is hoped that, as a minimum, funds for Ex-Im Tech will be sufficient to employ MR. CALLAGHAN full-time, with a secretary. A research assistant, also needed, can be employed either by Ex-Im Tech or by the Center. A European consultant can be employed directly by the European donor, or by Ex-Im Tech.

The arrangements between the Center and Ex-Im Tech are intended to be

sufficiently flexible and mutually advantageous to insure MR. CALLAGHAN'S full-time dedication to the Allied Interdependence Project.

Each monograph will be prepared under the guidance of informed advisors nominated by the principal donees. With representation balanced between Europe and North America, the advisors would insure balance in the research approach, balance in the facts presented, and balance in the opinions cited. It would insure that every significant issue of importance to either Europe or North America was fully and fairly presented. The conclusions and recommendations, however, would be those of the Project Director.

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